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# **SUEWS Documentation**

***Release v2020a***

**SUEWS dev team led by Prof Sue Grimmond**

**2023-10-07**



## FOR USERS

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## WHAT IS SUEWS?

Surface Urban Energy and Water Balance Scheme (SUEWS) [Järvi *et al.*, 2011, Ward *et al.*, 2016] is a neighbourhood/local-scale urban land surface model to simulate the urban radiation, energy and water balances using only commonly measured meteorological variables and information about the surface cover. SUEWS utilises an evaporation-interception approach [Grimmond and Oke, 1991], similar to that used in forests, to model evaporation from urban surfaces.

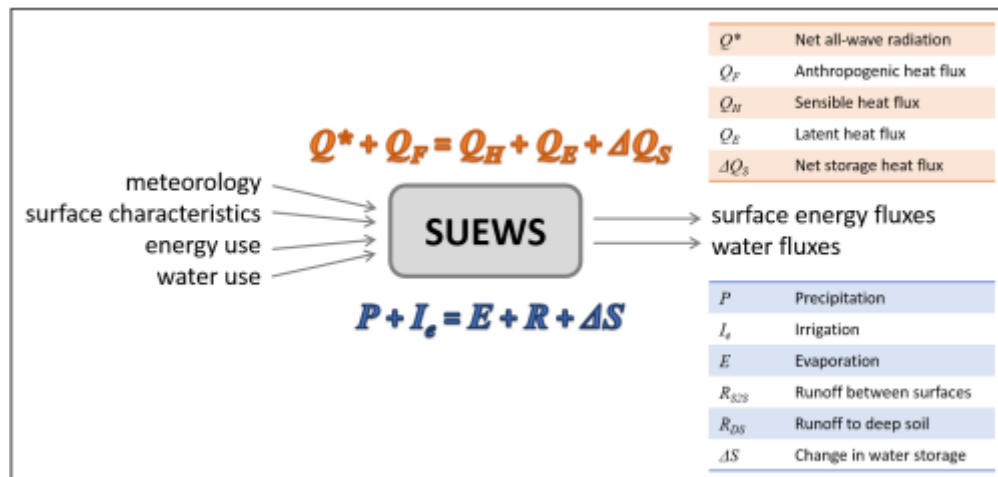


Fig. 1.1: Overview of SUEWS

The model uses seven surface types: paved, buildings, evergreen trees/shrubs, deciduous trees/shrubs, grass, bare soil and water. The surface state for each surface type at each time step is calculated from the running water balance of the canopy where the evaporation is calculated from the Penman-Monteith equation. The soil moisture below each surface type (excluding water) is taken into account. Horizontal movement of water above and below ground level is allowed.

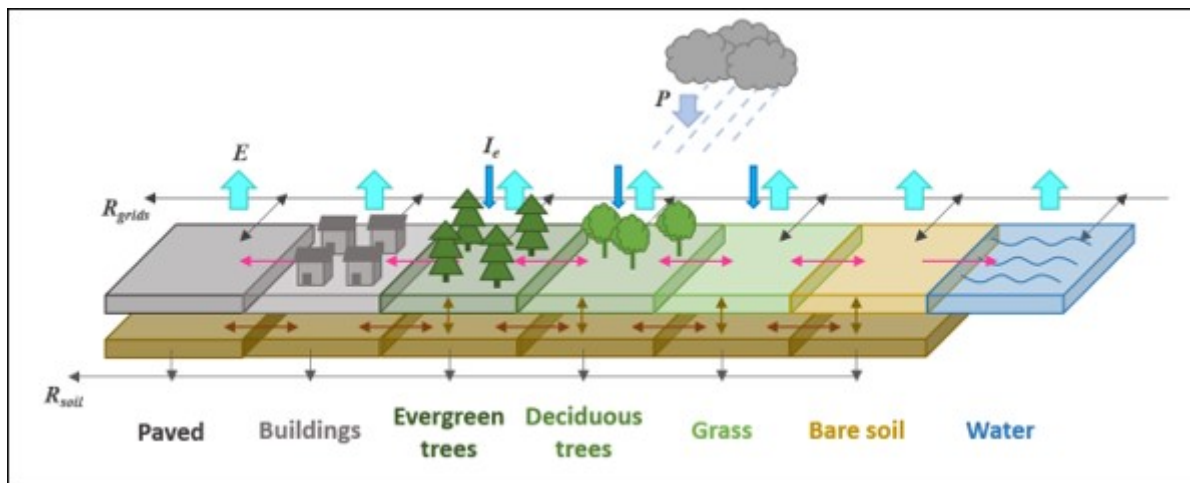


Fig. 1.2: The seven surface types considered in SUEWS



## HOW TO GET SUEWS?

Please follow the guidance in *Installation* to get SUEWS.



## HOW TO USE SUEWS?

- **For existing users:**

Overview of changes in this version, see [Version 2020a \(released on 14 May 2020\)](#). If these changes impact your existing simulations, please see appropriate parts of the manual. It may be necessary to adapt some of your input files for the current version.

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**Tip:** A helper python script, [SUEWS table converter](#), is provided to help facilitate the conversion of input files between different SUEWS versions.

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Additionally, the manuals for previous versions can be accessed in respective sections under [Version History](#).

- **For new users:**

Before performing SUEWS simulations, new users should read the overview [Introduction](#), then follow the steps in [Workflow of using SUEWS](#) to prepare *input files* for SUEWS.

Note there are tutorials learning about running SUEWS available [the tutorial](#).



## HOW TO GET HELP IN USING SUEWS?

Please let us know in the [UMEP Community](#). The developers and other users are willing to help you.



## HOW HAS SUEWS BEEN USED?

The scientific details and application examples of SUEWS can be found in *SUEWS-related Publications*.





## HOW TO CITE SUEWS?

Please go to [our Zenodo repository](#) for a proper citation of SUEWS.

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**Tip:** Visit the repositories below for different citation styles.

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## HOW TO SUPPORT SUEWS?

1. *Cite SUEWS* appropriately in your work.
2. Contribute to the *development*.
3. Report issues via the [GitHub page](#).
4. Provide *suggestions and feedback*.

### 7.1 Installation

#### 7.1.1 Formal releases

Since 2023, SUEWS is available as a command line tool via its Python wrapper package [SuPy \(SUEWS in Python\)](#) on [PyPI](#) and [conda-forge](#).

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**Note:** The Fortran-based binaries build prior to 2023 are still available at the [SUEWS download page](#). However, they are not maintained anymore so users are encouraged to use the Python-based packages instead.

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#### Installing Python

These instructions will set you up with [mamba](#), which makes it easy to install and manage Python packages.

To install the [mamba](#) Python distribution follow [the mamba installation instructions](#).

This makes installing [supy](#) and many other packages in the scientific Python ecosystem much easier and quicker. It also provides many pre-compiled binaries that are not available on [PyPI](#).

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**Tip:** [mamba](#) is a drop-in replacement for [conda](#) (another widely used Python package manager): [mamba](#) is faster and solves some common problems with [conda](#). More details about [mamba](#) can be found at [mamba](#).

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## Installing SuPy

One can install supy using pip:

```
python3 -m pip install supy --upgrade
```

### 7.1.2 Development build

The development build can be highly unstable and is not recommended for production use. However, it is automatically constructed every week for testing purposes and we are happy to receive feedback on the development build.

To install the development build of SUEWS, you need to install supy in the development mode:

1. git clone the repository:

```
git clone https://github.com/UMEP-dev/SUEWS.git
```

2. navigate to the directory of the cloned repository:

```
cd SUEWS
```

3. install the package in the development mode:

```
make dev
```

## 7.2 Workflow of using SUEWS

The following is to help with the model setup. Note that there are also starting [tutorials](#) for the version of SUEWS in UMEP. The version there is the same (i.e. the executable) as the standalone version so you can swap to that later once you have some familiarity.

### 7.2.1 Preparatory reading

Read the manual and relevant papers (and references therein):

- Järvi, L., Grimmond, C. S. B., Taka, M., Nordbo, A., Setälä, H., and Strachan, I. B. Development of the surface urban energy and water balance scheme (SUEWS) for cold climate cities. *Geosci. Model Dev.*, 7(4):1691–1711, August 2014. doi:10.5194/gmd-7-1691-2014.
- Järvi, L., Grimmond, C.S.B., and Christen, A. The surface urban energy and water balance scheme (SUEWS): Evaluation in Los Angeles and Vancouver. *J. Hydrol.*, 411(3-4):219–237, December 2011. doi:10.1016/j.jhydrol.2011.10.001.
- Ward, H.C., Kotthaus, S., Järvi, L., and Grimmond, C.S.B. Surface urban energy and water balance scheme (SUEWS): Development and evaluation at two UK sites. *Urban Clim.*, 18:1–32, December 2016. doi:10.1016/j.uclim.2016.05.001.

*See other publications with example applications*

## 7.2.2 Decide what type of model run you are interested in

|  | Available in this release |
|--|---------------------------|
| SUEWS at a point or for an individual area | Yes                       |
| SUEWS for multiple grids or areas          | Yes                       |
| SUEWS with Boundary Layer (BL)             | Yes                       |
| SUEWS with snow                            | Yes                       |

## 7.2.3 Download the program and example data files

Visit the [SUEWS download page](#) to receive a link to download the program and example data files. Select the appropriate compiled version for your platform to download. There is also a python-based version in [UMEP](#) under the QGIS environment. For python users, SuPy - a python wrapper for SUEWS - is also available.

Note, as the definition of long double precision varies between computers (e.g. Mac vs Windows) slightly different results may occur in the output files.

Test/example files are shipped in the archive with the SUEWS executable, which are based on measurements of the London KCL site, 2011 data (denoted Kc11)

In the following, SS is the site code (e.g. Kc), ss the grid ID, YYYY the year and tt the time interval.

| Filename                     | Description             | Input/output  |
|------------------------------|-------------------------|---|
| <i>SSss_data.txt</i>         | Meteorological input    | Input file (60-min)                                     |
| <i>SSss_YYYY_data_5.txt</i>  | Meteorological input    | Input file (5-min)                                      |
| <i>InitialConditionsSSss</i> | Initial conditions      | Input - _YYYY.nml(+) file                               |
| <i>SUEWS_***.txt</i>         | Property look-up tables | Input text files containing all other input information |
| <i>RunControl.nml</i>        | Sets model run          | Input (located in options main directory)               |
| <i>SS_Filechoices.txt</i>    | Summary of model run    | Output options  |
| <i>SSss_YYYY_5.txt</i>       | (Optional) 5-min        | Output resolution output file                           |
| <i>SSss_YYYY_60.txt</i>      | 60-min resolution       | Output output file                                      |
| <i>SSss_DailyState.txt</i>   | Daily state variables   | Output (all years in one file)                          |

(+) There is a second file *InitialConditionsSSss\_YYYY\_EndOfRun.nml* or *InitialConditionsSSss\_YYYY+1.nml* in the input directory. At the end of the run, and at the end of each year of the run, these files are written out so that this information could be used to initialize further model runs.

## 7.2.4 Run the model for example data

Before running the model with your own data, check that you get the same results as the test run example files provided. Copy the example output files elsewhere so you can compare the results. When you run the program it will write over the supplied files.

To run the model you can use **Command Prompt** (in the directory where the programme is located type the model name) or just double click the executable file.

Please see [Troubleshooting](#) if you have problems running the model.

## 7.2.5 Preparation of data

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**Tip:** If you need help preparing the data you can use some of the [UMEP](#) tools.

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The information required to run SUEWS for your site consists of:

- Continuous *meteorological forcing data* for the entire period to be modelled without gaps.
- Knowledge of the *surface and soil conditions immediately prior to the first model timestep*.

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**Note:** If these initial conditions are unknown, model spin-up can help; i.e. run the model and use the output at the end of the run to infer the conditions at the start of the main run). Spin-up is important for getting appropriate initial conditions for the model. An example of a spin-up can be found in Kokkonen *et al.* [2018].

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- The *location of the site* (latitude, longitude, altitude).
- Information about the *characteristics of the surface*, including land cover, heights of buildings and trees, radiative characteristics (e.g. albedo, emissivity), drainage characteristics, soil characteristics, snow characteristics, phenological characteristics (e.g. seasonal cycle of LAI).

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**Note:** For guidance on how to derive parameters related to LAI, albedo, surface conductance and surface roughness, the reader is referred to this [link](#).

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- Information about *human behaviour*, including energy use and water use (e.g. for irrigation or street cleaning) and snow clearing (if applicable).

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**Note:** The anthropogenic energy use and water use may be provided as a time series in the meteorological forcing file (by setting `EmissionsMethod` = 0) if these data are available or modelled based on parameters provided to the model, including population density, hourly and weekly profiles of energy and water use, information about the proportion of properties using irrigation and the type of irrigation (automatic or manual).

---

It is particularly important to ensure the following input information is appropriate and representative of the site:

- Fractions of different land cover types and (less so) heights of buildings [Ward *et al.*, 2016]
- Accurate meteorological forcing data, particularly precipitation and incoming shortwave radiation [Kokkonen *et al.*, 2018]
- Initial soil moisture conditions [Best and Grimmond, 2014]
- Anthropogenic heat flux parameters, particularly if there are considerable energy emissions from transport, buildings, metabolism, etc [Ward *et al.*, 2016].
- External water use (if irrigation or street cleaning occurs)
- Snow clearing (if running the snow option)
- Surface conductance parameterisation [Järvi *et al.*, 2011, Ward *et al.*, 2016]

SUEWS can be run either for an individual area or for multiple areas. There is no requirement for the areas to be of any particular shape but here we refer to them as model ‘grids’.

## Preparation of site characteristics and model parameters

The area to be modelled is described by a set of characteristics that are specified in the *SUEWS\_SiteSelect.txt* file. Each row corresponds to one model grid for one year (i.e. running a single grid over three years would require three rows; running two grids over two years would require four rows). Characteristics are often selected by a code for a particular set of conditions. For example, a specific soil type (links to *SUEWS\_Soil.txt*) or characteristics of deciduous trees in a particular region (links to *SUEWS\_Veg.txt*). The intent is to build a library of characteristics for different types of urban areas. The codes are specified by the user, must be integer values and must be unique within the first column of each input file, otherwise the model will return an error.

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**Note:** The first column of *SUEWS\_SiteSelect.txt* is labelled 'Grid' and can contain repeat values for different years. See *Input files* for details. Note *UMEP* may be helpful for components of this.

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## Land cover

For each grid, the land cover must be classified using the following surface types:

| Classification | Surface type    | File where characteristics are specified |
|----------------|-----------------|--|
| Non-vegetated  | Paved surfaces  | <i>SUEWS_NonVeg.txt</i>                  |
|                | Building        | <i>SUEWS_NonVeg.txt</i>                  |
|                | Bare soil       | <i>SUEWS_NonVeg.txt</i>                  |
| Vegetation     | Evergreen trees | <i>SUEWS_Veg.txt</i>                     |
|                | Deciduous trees | <i>SUEWS_Veg.txt</i>                     |
|                | Grass           | <i>SUEWS_Veg.txt</i>                     |
| Water          | Water           | <i>SUEWS_Water.txt</i>                   |
| Snow           | Snow            | <i>SUEWS_Snow.txt</i>                    |

The surface cover fractions (i.e. proportion of the grid taken up by each surface) must be specified in *SUEWS\_SiteSelect.txt*. The surface cover fractions are **critical**, so make certain that the different surface cover fractions are appropriate for your site.

For some locations, land cover information may be already available (e.g. from various remote sensing resources). If not, websites like Bing Maps and Google Maps allow you to see aerial images of your site and can be used to estimate the relative proportion of each land cover type. If detailed spatial datasets are available, *UMEP* allows for a direct link to a GIS environment using QGIS.

## Anthropogenic heat flux ( $Q_F$ )

You can either model  $Q_F$  within SUEWS or provide it as an input.

- To model it population density is needed as an input for LUMPS and SUEWS to calculate  $Q_F$ .
- If you have no information about the population of the site we recommend that you use the *LUCY* model [Allen *et al.*, 2010, Lindberg *et al.*, 2013] to estimate the anthropogenic heat flux which can then be provided as input SUEWS along with the meteorological forcing data.

Alternatively, you can use the updated version of LUCY called *LQF*, which is included in *UMEP*.

## Other information

The surface cover fractions and population density can have a major impact on the model output. However, it is important to consider the suitability of all parameters for your site. Using inappropriate parameters may result in the model returning an error or, worse, generating output that is simply not representative of your site. Please read the section on *Input files*. Recommended or reasonable ranges of values are suggested for some parameters, along with important considerations for how to select appropriate values for your site.

## Data Entry

To create the series of input text files describing the characteristics of your site, there are three options:

1. Data can be entered directly into the input text files. The example (.txt) files provide a template to create your own files which can be edited with *A text editor* directly.
2. Use *UMEP*.

Note that in all txt files:

- The first two rows are headers: the first row is the column number; the second row is the column name.
- The names and order of the columns should not be altered from the templates, as these are checked by the model and errors will be returned if particular columns cannot be found.
- Since v2017a it is no longer necessary for the meteorological forcing data to have two rows with -9 in column 1 as their last two rows.
- “!” indicates a comment, so any text following “!” on the same line will not be read by the model.
- If data are unavailable or not required, enter the value -999 in the correct place in the input file.
- Ensure the units are correct for all input information. See *Input files* for a description of parameters.

In addition to these text files, the following files are also needed to run the model.

## Preparation of the RunControl file

In the *RunControl.nml* file the site name (SS) and directories for the model input and output are given. This means **before running** the model (even the with the example datasets) you must either

1. open the *RunControl.nml* file and edit the input and output file paths and the site name (with a *A text editor*) so that they are correct for your setup, or
2. create the directories specified in the RunControl.nml file

From the given site identification the model identifies the input files and generates the output files. For example if you specify:

```
FileOutputPath = "C:\FolderName\SUEWSOutput\"
```

and use site code SS the model creates an output file:

```
C:\FolderName\SUEWSOutput\SSss_YYYY_TT.txt
```

---

**Note:** The path separator differs between Windows (backslash: \) and Linux/Mac (slash, or forward slash: /).

---

If the file paths are not correct the program will return an error when run and write the error to the *Error messages: problems.txt* file.



## Preparation of the Meteorological forcing data

The model time-step is specified in *RunControl.nml* (5 min is highly recommended). If meteorological forcing data are not available at this resolution, SUEWS has the option to downscale (e.g. hourly) data to the time-step required. See details about the *SSss\_YYYY\_data\_tt.txt* to learn more about choices of data input. Each grid can have its own meteorological forcing file, or a single file can be used for all grids. The forcing data should be representative of the local-scale, i.e. collected (or derived) above the height of the roughness elements (buildings and trees).

## Preparation of the InitialConditions file

Information about the surface state and meteorological conditions just before the start of the run are provided in the Initial Conditions file. At the very start of the run, each grid can have its own Initial Conditions file, or a single file can be used for all grids. For details see *Initial Conditions file*.

### 7.2.6 Run the model for your site

To run the model you can use **Command Prompt** (in the directory where the programme is located type the model name) or just double click the executable file.

Please see *Troubleshooting* if you have problems running the model.

### 7.2.7 Analyse the output

It is a good idea to perform initial checks that the model output looks reasonable.

| Characteristic  | Things to check   |
|-----------------|---|
| Leaf area index | <b>Does the phenology look appropriate?</b> <ul style="list-style-type: none"> <li>what does the seasonal cycle of <i>leaf area index (LAI)</i> look like?</li> <li>Are the leaves on the trees at approximately the right time of the year?</li> </ul>   |
| Kdown           | <b>Is the timing of diurnal cycles correct for the incoming solar radiation?</b> <ul style="list-style-type: none"> <li>Although Kdown is a required input, it is also included in the output file. It is a good idea to check that the timing of Kdown in the output file is appropriate, as problems can indicate errors with the timestamp, incorrect time settings or problems with the disaggregation. In particular, make sure the sign of the longitude is specified correctly in <i>SUEWS_SiteSelect.txt</i>.</li> <li>Checking solar angles (zenith and azimuth) can also be a useful check that the timing is correct.</li> </ul> |
| Albedo          | <b>Is the bulk albedo correct?</b> <ul style="list-style-type: none"> <li>This is critical because a small error has an impact on all the fluxes (energy and hydrology).</li> <li>If you have measurements of outgoing shortwave radiation compare these with the modelled values.</li> <li>How do the values compare to literature values for your area?</li> </ul>  |

## 7.2.8 Summary of files

The table below lists the files required to run SUEWS and the output files produced. SS is the two-letter code (specified in *RunControl.nml*) representing the site name, ss is the grid identification (integer values between 0 and 2,147,483,647 (largest 4-byte integer)) and YYYY is the year. TT is the resolution of the input/output file and tt is the model time-step.

The last column indicates whether the files are needed/produced once per run (1/run), or once per day (1/day), for each year (1/year) or for each grid (1/grid):

```
[B] indicates files used with the CBL part of SUEWS (BLUEWS) and therefore are only needed/  
→ produced if this option is selected  
[E] indicates files associated with ESTM storage heat flux models and therefore are only needed/  
→ produced if this option is selected
```

## 7.2.9 Get in contact

For issues met in using SUEWS, we recommend the following ways to get in contact with the developers and the SUEWS community:

1. Report issues on our [GitHub](#) page.
2. Ask for help by joining the [Email-list](#) for SUEWS.

## 7.3 Input files

SUEWS allows you to input a large number of parameters to describe the characteristics of your site. You should not assume that the example values provided in files or in the tables below are appropriate. Values marked with ‘MD’ are examples of recommended values (see the suggested references to help decide how appropriate these are for your site/model domain); values marked with ‘MU’ need to be set (i.e. changed from the example) for your site/model domain.

### 7.3.1 RunControl.nml

The file **RunControl.nml** is a namelist that specifies the options for the model run. It must be located in the same directory as the executable file.

A sample file of **RunControl.nml** looks like

```
&RunControl  
CBLUse=0  
SnowUse=0  
SOLWEIGUse=0  
NetRadiationMethod=3  
EmissionsMethod=2  
StorageHeatMethod=3  
OHMIncQF=0  
StabilityMethod=2  
RoughLenHeatMethod=2  
RoughLenMomMethod=2  
SMDMethod=0  
WaterUseMethod=0  
FileCode='Saeve'
```

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```

FileInputPath="./Input/"
FileOutputPath="./Output/"
MultipleMetFiles=0
MultipleInitFiles=0
MultipleESTMFiles=1
KeepTstepFilesIn=1
KeepTstepFilesOut=1
WriteOutOption=2
ResolutionFilesOut=3600
Tstep=300
ResolutionFilesIn=3600
ResolutionFilesInESTM=3600
DisaggMethod=1
RainDisaggMethod=100
DisaggMethodESTM=1
SuppressWarnings=1
KdownZen=0
diagnose=0
/

```

**Note:**

- In *Linux* and *Mac*, please add an empty line after the end slash.
- The file is not case-sensitive.
- The parameters and variables can appear in any order.

The parameters and their setting instructions are provided through the links below:

- *Scheme options*

- |                             |                             |
|-----------------------------|-----------------------------|
| – <i>CBLUse</i>             | – <i>StabilityMethod</i>    |
| – <i>SnowUse</i>            | – <i>RoughLenHeatMethod</i> |
| – <i>NetRadiationMethod</i> | – <i>RoughLenMomMethod</i>  |
| – <i>BaseTMethod</i>        | – <i>SMDMethod</i>          |
| – <i>EmissionsMethod</i>    | – <i>WaterUseMethod</i>     |
| – <i>StorageHeatMethod</i>  | – <i>DiagMethod</i>         |
| – <i>OHMIncQF</i>           |                             |

- *File related options*

- |                            |                            |
|----------------------------|----------------------------|
| – <i>FileCode</i>          | – <i>MultipleESTMFiles</i> |
| – <i>FileInputPath</i>     | – <i>KeepTstepFilesIn</i>  |
| – <i>FileOutputPath</i>    | – <i>KeepTstepFilesOut</i> |
| – <i>MultipleMetFiles</i>  | – <i>WriteOutOption</i>    |
| – <i>MultipleInitFiles</i> | – <i>SuppressWarnings</i>  |

- *Time related options*

- *Tstep*
- *ResolutionFilesIn*
- *ResolutionFilesInESTM*
- *ResolutionFilesOut*

- *Options related to disaggregation of input data*

- *DisaggMethod*
- *KdownZen*
- *RainDisaggMethod*
- *RainAmongN*
- *MultRainAmongN*
- *MultRainAmongNUpperI*
- *DisaggMethodESTM*

## Scheme options

### CBLUse

**Requirement** Required

**Description** Determines whether a CBL slab model is used to calculate temperature and humidity.

**Configuration**

### SnowUse

**Requirement** Required

**Description** Determines whether the snow part of the model runs.

**Configuration**

| Value | Comments                             |
|-------|--------------------------------------|
| 0     | Snow calculations are not performed. |
| 1     | Snow calculations are performed.     |

### NetRadiationMethod

**Requirement** Required

**Description** Determines method for calculation of radiation fluxes.

**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Uses observed values of $Q^*$ supplied in meteorological forcing file.   |
| 1     | $Q^*$ modelled with $L_{\downarrow}$ observations supplied in meteorological forcing file. Zenith angle not accounted for in albedo calculation.   |
| 2     | $Q^*$ modelled with $L_{\downarrow}$ modelled using cloud cover fraction supplied in meteorological forcing file [Loridan <i>et al.</i> , 2011]. Zenith angle not accounted for in albedo calculation.   |
| 3     | $Q^*$ modelled with $L_{\downarrow}$ modelled using air temperature and relative humidity supplied in meteorological forcing file [Loridan <i>et al.</i> , 2011]. Zenith angle not accounted for in albedo calculation.  |
| 11    | Same as 1 but with $L_{\uparrow}$ modelled using surface temperature <b>Not recommended in this version.</b>   |
| 12    | Same as 2 but with $L_{\uparrow}$ modelled using surface temperature <b>Not recommended in this version.</b>   |
| 13    | Same as 3 but with $L_{\uparrow}$ modelled using surface temperature <b>Not recommended in this version.</b>   |
| 100   | $Q^*$ modelled with $L_{\downarrow}$ observations supplied in meteorological forcing file. Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. <b>Not recommended in this version.</b>  |
| 200   | $Q^*$ modelled with $L_{\downarrow}$ modelled using cloud cover fraction supplied in meteorological forcing file [Loridan <i>et al.</i> , 2011]. Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. <b>Not recommended in this version.</b>                  |
| 300   | $Q^*$ modelled with $L_{\downarrow}$ modelled using air temperature and relative humidity supplied in meteorological forcing file [Loridan <i>et al.</i> , 2011]. Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. <b>Not recommended in this version.</b> |
| 1001  | $Q^*$ modelled with <i>SPARTACUS-Surface (SS)</i> but with $L_{\downarrow}$ modelled as in 1. <b>Experimental in this version.</b>   |
| 1002  | $Q^*$ modelled with <i>SPARTACUS-Surface (SS)</i> but with $L_{\downarrow}$ modelled as in 2. <b>Experimental in this version.</b>   |
| 1003  | $Q^*$ modelled with <i>SPARTACUS-Surface (SS)</i> but with $L_{\downarrow}$ modelled as in 3. <b>Experimental in this version.</b>   |

## BaseTMethod

**Requirement** Required

**Description** Determines method for base temperature used in HDD/CDD calculations.

**Configuration**

| Value | Comments  |
|-------|---|
| 1     | V-shape approach: a single <i>BaseT_HC</i> is used  |
| 2     | U-shape approach: <i>TCritic_Heating_WD</i> ( <i>TCritic_Heating_WE</i> ) and <i>TCritic_Cooling_WD</i> ( <i>TCritic_Cooling_WE</i> ) are used for HDD and CDD calculations in weekdays (weekends), respectively. |

## EmissionsMethod

**Requirement** Required

**Description** Determines method for QF calculation.

**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Uses values provided in the meteorological forcing file (SSss_YYYY_data_tt.txt). If you do not want to include QF to the calculation of surface energy balance, you should set values in the meteorological forcing file to zero to prevent calculation of QF. UMEP provides two methods to calculate QF LQF which is simpler GQF which is more complete but requires more data inputs                                       |
| 1     | <b>Not recommended in this version.</b> Calculated according to Loridan <i>et al.</i> [2011] using coefficients specified in <i>SUEWS_AnthropogenicEmission.txt</i> . Modelled values will be used even if QF is provided in the meteorological forcing file.  |
| 2     | <b>Recommended in this version.</b> Calculated according to Järvi <i>et al.</i> [2011] using coefficients specified in <i>SUEWS_AnthropogenicEmission.txt</i> and diurnal patterns specified in <i>SUEWS_Profiles.txt</i> . Modelled values will be used even if QF is provided in the meteorological forcing file.  |
| 3     | Updated Loridan <i>et al.</i> [2011] method using daily (not instantaneous) air temperature (HDD(id-1,3)) using coefficients specified in <i>SUEWS_AnthropogenicEmission.txt</i> .   |
| 4     | Järvi <i>et al.</i> [2019] method, in addition to anthropogenic heat due to building energy use calculated by Järvi <i>et al.</i> [2011], that due to metabolism and traffic is also calculated using coefficients specified in <i>SUEWS_AnthropogenicEmission.txt</i> and diurnal patterns specified in <i>SUEWS_Profiles.txt</i> . Modelled values will be used even if QF is provided in the meteorological forcing file. |

**StorageHeatMethod****Requirement** Required**Description** Determines method for calculating storage heat flux QS.**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Uses observed values of QS supplied in meteorological forcing file.  |
| 1     | QS modelled using the objective hysteresis model (OHM) [Grimmond <i>et al.</i> , 1991] using parameters specified for each surface type. |
| 3     | QS modelled using AnOHM [Sun <i>et al.</i> , 2017]. <b>Not recommended in this version.</b>  |
| 4     | QS modelled using the Element Surface Temperature Method (ESTM) [Offerle <i>et al.</i> , 2005]. <b>Not recommended in this version.</b>  |

**OHMIncQF****Requirement** Required**Description** Determines whether the storage heat flux calculation uses  $Q^*$  or ( $Q^* + QF$ ).**Configuration**

| Value | Comments                       |
|-------|--------------------------------|
| 0     | QS modelled $Q^*$ only.        |
| 1     | QS modelled using $Q^* + QF$ . |

**StabilityMethod****Requirement** Required

**Description** Defines which atmospheric stability functions are used.

#### Configuration

| Value | Comments  |
|-------|---|
| 0     | Not used.   |
| 1     | Not used.   |
| 2     | <ul style="list-style-type: none"> <li>• Momentum: <ul style="list-style-type: none"> <li>– unstable: Dyer [1974] modified by Högström [1988]</li> <li>– stable: Van Ulden and Holtslag [1985]</li> </ul> </li> <li>• Heat: Dyer [1974] modified by Högström [1988]</li> </ul> <p><b>Not recommended in this version.</b></p> |
| 3     | <ul style="list-style-type: none"> <li>• Momentum: Campbell and Norman [1998] (Eq 7.27, Pg97)</li> <li>• Heat <ul style="list-style-type: none"> <li>– unstable: Campbell and Norman [1998]</li> <li>– stable: Campbell and Norman [1998]</li> </ul> </li> </ul> <p><b>Recommended in this version.</b></p>                   |
| 4     | <ul style="list-style-type: none"> <li>• Momentum: Businger <i>et al.</i> [1971] modified by Högström [1988]</li> <li>• Heat: Businger <i>et al.</i> [1971] modified by Högström [1988]</li> </ul> <p><b>Not recommended in this version.</b></p>   |

#### RoughLenHeatMethod

**Requirement** Required

**Description** Determines method for calculating roughness length for heat.

#### Configuration

| Value | Comments   |
|-------|--|
| 1     | Uses value of $0.1 \cdot z_{0m}$ .   |
| 2     | Calculated according to Kawai <i>et al.</i> [2009].  |
| 3     | Calculated according to Voogt and Grimmond [2000].   |
| 4     | Calculated according to Kanda <i>et al.</i> [2007].  |
| 5     | Adaptively using $z_{0m}$ based on pervious coverage: if fully pervious, use method 1; otherwise, use method 2.<br><b>Recommended in this version.</b> |

#### RoughLenMomMethod

**Requirement** Required

**Description** Determines how aerodynamic roughness length ( $z_{0m}$ ) and zero displacement height ( $z_{dm}$ ) are calculated.

#### Configuration

| Value | Comments   |
|-------|--|
| 1     | <p>Values specified in <i>SUEWS_SiteSelect.txt</i> are used.</p> <hr/> <p><b>Tip:</b> Note that UMEP provides tools to calculate these. See Kent <i>et al.</i> [2017] for recommendations on methods. Kent <i>et al.</i> [2017] have developed a method to include vegetation which is also available within UMEP.</p> <hr/> |
| 2     | z0m and zd are calculated using ‘rule of thumb’ [Grimmond and Oke, 1999] using mean building and tree height specified in <i>SUEWS_SiteSelect.txt</i> . z0m and zd are adjusted with time to account for seasonal variation in porosity of deciduous trees.  |
| 3     | z0m and zd are calculated based on the Macdonald <i>et al.</i> [1998] method using mean building and tree heights, plan area fraction and frontal area index specified in <i>SUEWS_SiteSelect.txt</i> . z0m and zd are adjusted with time to account for seasonal variation in porosity of deciduous trees.                  |

**SMDMethod****Requirement** Required**Description** Determines method for calculating soil moisture deficit (SMD).**Configuration**

| Value | Comments  |
|-------|---|
| 0     | SMD modelled using parameters specified in <i>SUEWS_Soil.txt</i> . <b>Recommended in this version.</b>  |
| 1     | Observed SM provided in the meteorological forcing file is used. Data are provided as volumetric soil moisture content. Metadata must be provided in <i>SUEWS_Soil.txt</i> .  |
| 2     | Observed SM provided in the meteorological forcing file is used. Data are provided as gravimetric soil moisture content. Metadata must be provided in <i>SUEWS_Soil.txt</i> . |

**SOLWEIGUse**

Deprecated since version v2020a.

**Requirement** Required**Description** Determines whether SOLWEIG is used to calculate detailed radiation balance of all facets.**Configuration**

| Value | Comments   |
|-------|--|
| 0     | SOLWEIG calculations are not performed.  |
| 1     | SOLWEIG calculations are performed. A grid of mean radiant temperature (Tmrt) is calculated based on high resolution digital surface models. |



**WaterUseMethod****Requirement** Required**Description** Defines how external water use is calculated.**Configuration**

| Value | Comments   |
|-------|--|
| 0     | External water use modelled using parameters specified in <i>SUEWS_Irrigation.txt</i> .  |
| 1     | Observations of external water use provided in the meteorological forcing file are used. |

**DiagMethod****Requirement** Required**Description** Defines how near surface diagnostics are calculated.**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Use MOST to calculate near surface diagnostics.  |
| 1     | Use RST to calculate near surface diagnostics.   |
| 2     | Use a set of criteria based on plan area index, frontal area index and heights of roughness elements to determine if RSL or MOST should be used. |

**Time related options****Tstep****Requirement** Required**Description** Specifies the model time step [s].**Configuration** A value of 300 s (5 min) is strongly recommended. The time step cannot be less than 1 min or greater than 10 min, and must be a whole number of minutes that divide into an hour (i.e. options are 1, 2, 3, 4, 5, 6, 10 min or 60, 120, 180, 240, 300, 360, 600 s).**ResolutionFilesIn****Requirement** Required**Description** Specifies the resolution of the input files [s] which SUEWS will disaggregate to the model time step.**Configuration** 1800 s for 30 min or 3600 s for 60 min are recommended.

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**Note:** If *ResolutionFilesIn* is not provided, SUEWS assumes *ResolutionFilesIn* = Tstep.

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**ResolutionFilesInESTM****Requirement** Optional**Description** Specifies the resolution of the ESTM input files [s] which SUEWS will disaggregate to the model time step.

**Configuration** The same as for *ResolutionFilesIn*.

#### ResolutionFilesOut

**Requirement** Required

**Description** Specifies the resolution of the output files [s].

**Configuration** 1800 s for 30 min or 3600 s for 60 min are recommended.

### File related options

#### FileCode

**Requirement** Required

**Description** Alphabetical site identification code (e.g. He, Sc, Kc).

**Configuration** This must be consistent with names of *meteorological input file* and *initial condition files*

#### FileInputPath

**Requirement** Required

**Description** Input directory.

**Configuration** This can be set either as an absolute path or a relative path where the program is initiated.

#### FileOutputPath

**Requirement** Required

**Description** Output directory.

**Configuration** This can be set either as an absolute path or a relative path where the program is initiated.

#### MultipleMetFiles

**Requirement** Required

**Description** Specifies whether one single meteorological forcing file is used for all grids or a separate met file is provided for each grid.

**Configuration**

| Value | Comments  |
|-------|---|
| 0     | Single meteorological forcing file used for all grids. No grid number should appear in the file name.     |
| 1     | Separate meteorological forcing files used for each grid. The grid number should appear in the file name. |

#### MultipleInitFiles

**Requirement** Required

**Description** Specifies whether one single initial conditions file is used for all grids at the start of the run or a separate initial conditions file is provided for each grid.

**Configuration**

| Value | Comments  |
|-------|---|
| 0     | Single initial conditions file used for all grids. No grid number should appear in the file name.     |
| 1     | Separate initial conditions files used for each grid. The grid number should appear in the file name. |

**MultipleESTMFiles****Requirement** Optional**Description** Specifies whether one single ESTM forcing file is used for all grids or a separate file is provided for each grid.**Configuration**

| Value | Comments  |
|-------|---|
| 0     | Single ESTM forcing file used for all grids. No grid number should appear in the file name.     |
| 1     | Separate ESTM forcing files used for each grid. The grid number should appear in the file name. |

**KeepTstepFilesIn****Requirement** Optional**Description** Specifies whether input meteorological forcing files at the resolution of the model time step should be saved.**Configuration**

| Value | Comments  |
|-------|---|
| 0     | Meteorological forcing files at model time step are not written out. This is the default option Recommended to reduce processing time and save disk space as (e.g. 5-min) files can be large. |
| 1     | Meteorological forcing files at model time step are written out.  |

**KeepTstepFilesOut****Requirement** Optional**Description** Specifies whether output meteorological forcing files at the resolution of the model time step should be saved.**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Output files at model time are not saved. This is the default option. Recommended to save disk space as (e.g. 5-min) files can be large. |
| 1     | Output files at model time step are written out.   |

**WriteOutOption****Requirement** Optional

**Description** Specifies which variables are written in the output files.

**Configuration**

| Value | Comments  |
|-------|---|
| 0     | All (except snow-related) output variables written. This is the default option.   |
| 1     | All (including snow-related) output variables written.  |
| 2     | Writes out a minimal set of output variables (use this to save space or if information about the different surfaces is not required). |

**SuppressWarnings**

**Requirement** Optional

**Description** Controls whether the warnings.txt file is written or not.

**Configuration**

| Value | Comments   |
|-------|--|
| 0     | The warnings.txt file is written. This is the default option.                                    |
| 1     | No warnings.txt file is written. May be useful for large model runs as this file can grow large. |

**Options related to disaggregation of input data**

**DisaggMethod**

**Requirement** Optional

**Description** Specifies how meteorological variables in the input file (except rain and snow) are disaggregated to the model time step. Wind direction is not currently downscaled so non -999 values will cause an error.

**Configuration**

| Value | Comments   |
|-------|--|
| 1     | Linear downscaling of averages for all variables, additional zenith check is used for Kdown. This is the default option.                     |
| 2     | Linear downscaling of instantaneous values for all variables, additional zenith check is used for Kdown.                                     |
| 3     | WFDEI setting: average Kdown (with additional zenith check); instantaneous for Tair, RH, pres and U. (N.B. WFDEI actually provides Q not RH) |

**KdownZen**

**Requirement** Optional

**Description** Can be used to switch off zenith checking in Kdown disaggregation. Note that the zenith calculation requires location information obtained from *SUEWS\_SiteSelect.txt*. If a single met file is used for all grids, the zenith is calculated for the first grid and the disaggregated data is then applied for all grids.

**Configuration**

| Value | Comments   |
|-------|--|
| 0     | No zenith angle check is applied.  |
| 1     | Disaggregated Kdown is set to zero when zenith angle exceeds 90 degrees (i.e. sun below horizon) and redistributed over the day. This is the default option. |

### RainDisaggMethod

**Requirement** Optional

**Description** Specifies how rain in the meteorological forcing file are disaggregated to the model time step. If present in the original met forcing file, snow is currently disaggregated in the same way as rainfall.

**Configuration**

| Value | Comments   |
|-------|--|
| 100   | Rainfall is evenly distributed among all subintervals in a rainy interval. This is the default option.   |
| 101   | Rainfall is evenly distributed among among RainAmongN subintervals in a rainy interval – also requires RainAmongN to be set.   |
| 102   | Rainfall is evenly distributed among among RainAmongN subintervals in a rainy interval for different intensity bins – also requires MultRainAmongN and MultRainAmongNUpperI to be set. |

### RainAmongN

**Requirement** Optional

**Description** Specifies the number of subintervals (of length tt) over which to distribute rainfall in each interval (of length TT).

**Configuration** Must be an integer value. Use with RainDisaggMethod = 101.

### MultRainAmongN

**Requirement** Optional

**Description** Specifies the number of subintervals (of length tt) over which to distribute rainfall in each interval (of length TT) for up to 5 intensity bins. Must take integer values.

**Configuration** Use with RainDisaggMethod = 102. e.g. MultRainAmongN(1) = 5, MultRainAmongN(2) = 8, MultRainAmongN(3) = 12

### MultRainAmongNUpperI

**Requirement** Optional

**Description** Specifies upper limit for each intensity bin to apply MultRainAmongN.

**Configuration** Any intensities above the highest specified intensity will use the last MultRainAmongN value and write a warning to *Warning messages: warnings.txt*. Use with RainDisaggMethod = 102. e.g. MultRainAmongNUpperI(1) = 0.5, MultRainAmongNUpperI(2) = 2.0, MultRainAmongNUpperI(3) = 50.0

### DisaggMethodESTM

**Requirement** Optional

**Description** Specifies how ESTM-related temperatures in the input file are disaggregated to the model time step.

### Configuration

| Value | Comments                                    |
|-------|---|
| 1     | Linear downscaling of averages.             |
| 2     | Linear downscaling of instantaneous values. |

## 7.3.2 SUEWS Site Information

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### Note:

1. We use the following codes for denoting the requirement level of various input variables/parameters for SUEWS throughout this section:

#### **MU**

Parameters which must be supplied and must be specific for the site/grid being run.

#### **MD**

Parameters which must be supplied and must be specific for the site/grid being run (but default values may be ok if these values are not known specifically for the site).

#### **O**

Parameters that are optional, depending on the model settings in *RunControl.nml*. Set any parameters that are not used/not known to ‘-999’.

#### **L**

Codes that are used to link between the input files, which must

- be specified in the correct way to link the *main* and *sub-reference* files (similar to key-value pairs);
- be integers and unique in column 1 of corresponding input files; and
- match up with column 1 of the corresponding input file, even if those parameters are not used (in which case set all columns except column 1 to ‘-999’ in the corresponding input file), otherwise the model run will fail.

2. We use the following codes for denoting the typical land cover/entity types of SUEWS throughout this section:

#### **Paved**

Paved surface

#### **Bldgs**

Building surface

#### **EveTr**

Evergreen trees and shrubs

#### **DecTr**

Deciduous trees and shrubs

#### **Grass**

Grass surface

#### **BSoil**

Unmanaged land and/or bare soil

#### **Water**

Water surface

**Runoff**

The water that drains freely off the impervious surface

**SoilStore**

The water stored in the underlying soil that infiltrates from the pervious surface

The following text files provide SUEWS with information about the study area.

**SUEWS\_AnthropogenicEmission.txt**

**Note:** Changed in version v2019a: this file is renamed from `SUEWS_AnthropogenicHeat.txt` (prior to v2019a) to include more emission related settings.

*SUEWS\_AnthropogenicEmission.txt* provides the parameters needed to model the anthropogenic heat flux using either the method of Loridan *et al.* [2011] based on air temperature (*EmissionsMethod* = 1 in *RunControl.nml*) or the method of Järvi *et al.* [2011] based on heating and cooling degree days (*EmissionsMethod* = 2 in *RunControl.nml*).

For the method of Järvi *et al.* [2011] (*EmissionsMethod* = 2 in *RunControl.nml*), one can further configure the scheme for calculating *HDD/ CDD* via *BaseTMethod* in *RunControl.nml*:

- *BaseTMethod* = 1 (“V-shape” approach): a single *BaseT\_HC* is used by omitting the comfort range where neither heating nor cooling is activated.
- *BaseTMethod* = 2 (“U-shape” approach): *TCritic\_Heating\_WD* (*TCritic\_Heating\_WE*) and *TCritic\_Cooling\_WD* (*TCritic\_Cooling\_WE*) are used for HDD and CDD calculations in weekdays (weekends), respectively, which allows a comfort range between *TCritic\_Heating\_WD* (*TCritic\_Heating\_WE*) and *TCritic\_Cooling\_WD* (*TCritic\_Cooling\_WE*).

The sub-daily variation in anthropogenic heat flux is modelled according to the daily cycles specified in *SUEWS\_Profiles.txt*.

Alternatively, if available, the anthropogenic heat flux can be provided in the met forcing file (and set *EmissionsMethod* = 0 in *RunControl.nml*) by filling the *qf* column with valid values.

| No. | Column Name     | Use                   | Description  |
|-----|-----------------|-----------------------|--|
| 1.0 | <i>Code</i>     | <i>L</i>              | Code linking to a corresponding look-up table.   |
| 2.0 | <i>BaseT_HC</i> | <i>MU</i>             | Base temperature for heating degree days [°C]  |
| 3.0 | <i>QF_A_WD</i>  | <i>MU</i><br><i>O</i> | Base value for QF on weekdays [ $\text{W m}^{-2}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ]                                      |
| 4.0 | <i>QF_B_WD</i>  | <i>MU</i><br><i>O</i> | Parameter related to cooling degree days on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ] |
| 5.0 | <i>QF_C_WD</i>  | <i>MU</i><br><i>O</i> | Parameter related to heating degree days on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ] |
| 6.0 | <i>QF_A_WE</i>  | <i>MU</i><br><i>O</i> | Base value for QF on weekends [ $\text{W m}^{-2}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ]                                      |
| 7.0 | <i>QF_B_WE</i>  | <i>MU</i><br><i>O</i> | Parameter related to cooling degree days on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ] |
| 8.0 | <i>QF_C_WE</i>  | <i>MU</i><br><i>O</i> | Parameter related to heating degree days on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ (Cap $\text{ha}^{-1}$ ) $^{-1}$ ] |
| 9.0 | <i>AHMin_WD</i> | <i>MU</i><br><i>O</i> | Minimum QF on weekdays [ $\text{W m}^{-2}$ ]   |

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Table 7.1 – continued from previous page

| No.  | Column Name                 | Use                   | Description  |
|------|-----------------------------|-----------------------|--|
| 10.0 | <i>AHMin_WE</i>             | <i>MU</i><br><i>0</i> | Minimum QF on weekends [ $\text{W m}^{-2}$ ]   |
| 11.0 | <i>AHSlope_Heating_WD</i>   | <i>MU</i><br><i>0</i> | Heating slope of QF on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ ]  |
| 12.0 | <i>AHSlope_Heating_WE</i>   | <i>MU</i><br><i>0</i> | Heating slope of QF on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ ]  |
| 13.0 | <i>AHSlope_Cooling_WD</i>   | <i>MU</i><br><i>0</i> | Cooling slope of QF on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ ]  |
| 14.0 | <i>AHSlope_Cooling_WE</i>   | <i>MU</i><br><i>0</i> | Cooling slope of QF on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ ]  |
| 15.0 | <i>TCritic_Heating_WD</i>   | <i>MU</i><br><i>0</i> | Critical heating temperature on weekdays [ $^{\circ}\text{C}$ ]  |
| 16.0 | <i>TCritic_Heating_WE</i>   | <i>MU</i><br><i>0</i> | Critical heating temperature on weekends [ $^{\circ}\text{C}$ ]  |
| 17.0 | <i>TCritic_Cooling_WD</i>   | <i>MU</i><br><i>0</i> | Critical cooling temperature on weekdays [ $^{\circ}\text{C}$ ]  |
| 18.0 | <i>TCritic_Cooling_WE</i>   | <i>MU</i><br><i>0</i> | Critical cooling temperature on weekends [ $^{\circ}\text{C}$ ]  |
| 19.0 | <i>EnergyUseProfWD</i>      | <i>MU</i><br><i>0</i> | Code linking to <i>EnergyUseProfWD</i> in <i>SUEWS_Profiles.txt</i> .  |
| 20.0 | <i>EnergyUseProfWE</i>      | <i>MU</i><br><i>0</i> | Code linking to <i>EnergyUseProfWE</i> in <i>SUEWS_Profiles.txt</i> .  |
| 21.0 | <i>ActivityProfWD</i>       | <i>MU</i><br><i>0</i> | Code linking to <i>ActivityProfWD</i> in <i>SUEWS_Profiles.txt</i> .   |
| 22.0 | <i>ActivityProfWE</i>       | <i>MU</i><br><i>0</i> | Code linking to <i>ActivityProfWE</i> in <i>SUEWS_Profiles.txt</i> .   |
| 23.0 | <i>TraffProfWD</i>          | <i>MU</i><br><i>0</i> | Code for traffic activity profile (weekdays) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> . Not used in v2018a. |
| 24.0 | <i>TraffProfWE</i>          | <i>MU</i><br><i>0</i> | Code for traffic activity profile (weekends) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> . Not used in v2018a. |
| 25.0 | <i>PopProfWD</i>            | <i>MU</i><br><i>0</i> | Code for population density profile (weekdays) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .                   |
| 26.0 | <i>PopProfWE</i>            | <i>MU</i><br><i>0</i> | Code for population density profile (weekends) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .                   |
| 27.0 | <i>MinQFMetab</i>           | <i>MU</i><br><i>0</i> | Minimum value for human heat emission. [ $\text{W m}^{-2}$ ]   |
| 28.0 | <i>MaxQFMetab</i>           | <i>MU</i><br><i>0</i> | Maximum value for human heat emission. [ $\text{W m}^{-2}$ ]   |
| 29.0 | <i>MinFCMetab</i>           | <i>MU</i><br><i>0</i> | Minimum (night) $\text{CO}_2$ from human metabolism. [ $\mu\text{mol s}^{-1} \text{cap}^{-1}$ ]                        |
| 30.0 | <i>MaxFCMetab</i>           | <i>MU</i><br><i>0</i> | Maximum (day) $\text{CO}_2$ from human metabolism. [ $\mu\text{mol s}^{-1} \text{cap}^{-1}$ ]                          |
| 31.0 | <i>FrPDDwe</i>              | <i>MU</i><br><i>0</i> | Fraction of weekend population to weekday population. [-]  |
| 32.0 | <i>FrFossilFuel_Heat</i>    | <i>MU</i><br><i>0</i> | Fraction of fossil fuels used for building heating [-]   |
| 33.0 | <i>FrFossilFuel_NonHeat</i> | <i>MU</i><br><i>0</i> | Fraction of fossil fuels used for building energy use [-]  |
| 34.0 | <i>EF_umolCO2perJ</i>       | <i>MU</i><br><i>0</i> | Emission factor for fuels used for building heating. [ $\mu\text{mol CO}_2 \text{J}^{-1}$ ]                            |

continues on next page



Table 7.1 – continued from previous page

| No.  | Column Name           | Use                   | Description  |
|------|-----------------------|-----------------------|--|
| 35.0 | <i>EnEF_v_Jkm</i>     | <i>MU</i><br><i>O</i> | Emission factor for heat from traffic [ $\text{J k m}^{-1}$ ].   |
| 36.0 | <i>FcEF_v_kgkmWD</i>  | <i>MU</i><br><i>O</i> | CO2 emission factor for traffic on weekdays [ $\text{kg km}^{-1}$ ]  |
| 37.0 | <i>FcEF_v_kgkmWE</i>  | <i>MU</i><br><i>O</i> | CO2 emission factor for traffic on weekends [ $\text{kg km}^{-1}$ ]  |
| 38.0 | <i>CO2PointSource</i> | <i>MU</i><br><i>O</i> | CO2 emission point source within the grid [ $\text{kgC day}^{-1}$ ]  |
| 39.0 | <i>TrafficUnits</i>   | <i>MU</i><br><i>O</i> | Units for the traffic rate for the study area. 1 = [ $\text{veh km m}^{-2} \text{ day}^{-1}$ ] 2 = [ $\text{veh km cap}^{-1} \text{ day}^{-1}$ ]). Not used in v2018a. |

An example *SUEWS\_AnthropogenicEmission.txt* can be found in the online version.

### SUEWS\_BiogenCO2.txt

**Caution:** The BiogenCO2 part is under development and not ready for use.

*SUEWS\_BiogenCO2.txt* provides the parameters needed to model the Biogenic CO2 characteristics of vegetation surfaces.

| No. | Column Name      | Use                   | Description   |
|-----|------------------|-----------------------|---|
| 1.0 | <i>Code</i>      | <i>L</i>              | Code linking to a corresponding look-up table.  |
| 2.0 | <i>alpha</i>     | <i>MU</i><br><i>O</i> | The mean apparent ecosystem quantum. Represents the initial slope of the light-response curve. Not in use   |
| 3.0 | <i>beta</i>      | <i>MU</i><br><i>O</i> | The light-saturated gross photosynthesis of the canopy describing the maximum photosynthesis the certain vegetation can have. [ $\text{umol m}^{-2} \text{ s}^{-1}$ ] |
| 4.0 | <i>theta</i>     | <i>MU</i><br><i>O</i> | The convexity of the curve at light saturation. Not in use.   |
| 5.0 | <i>alpha_enh</i> | <i>MU</i><br><i>O</i> | Part of the <i>alpha</i> coefficient related to the fraction of vegetation.   |
| 6.0 | <i>beta_enh</i>  | <i>MU</i><br><i>O</i> | Part of the <i>beta</i> coefficient related to the fraction of vegetation.  |
| 7.0 | <i>resp_a</i>    | <i>MU</i><br><i>O</i> | Soil and vegetation respiration coefficient a.  |
| 8.0 | <i>resp_b</i>    | <i>MU</i><br><i>O</i> | Soil and vegetation respiration coefficient b - related to air temperature dependency.  |
| 9.0 | <i>min_respi</i> | <i>MU</i><br><i>O</i> | Minimum soil and vegetation respiration rate (for cold-temperature limit) [ $\text{umol m}^{-2} \text{ s}^{-1}$ ].  |

An example *SUEWS\_BiogenCO2.txt* can be found online

## SUEWS\_Conductance.txt

SUEWS\_Conductance.txt contains the parameters needed for the Jarvis (1976) [Jarvis, 1976] surface conductance model used in the modelling of evaporation in SUEWS. These values should **not** be changed independently of each other. The suggested values below have been derived using datasets for Los Angeles and Vancouver (see Järvi *et al.* [2011]) and should be used with `gsModel` = 1. An alternative formulation ( `gsModel` =2) uses slightly different functional forms and different coefficients (with different units).

| No.  | Column Name          | Use             | Description   |
|------|----------------------|-----------------|---|
| 1.0  | <code>Code</code>    | <code>L</code>  | Code linking to a corresponding look-up table.                    |
| 2.0  | <code>G1</code>      | <code>MD</code> | Related to maximum surface conductance [ $\text{mm s}^{-1}$ ]     |
| 3.0  | <code>G2</code>      | <code>MD</code> | Related to Kdown dependence [ $\text{W m}^{-2}$ ]                 |
| 4.0  | <code>G3</code>      | <code>MD</code> | Related to VPD dependence [units depend on <code>gsModel</code> ] |
| 5.0  | <code>G4</code>      | <code>MD</code> | Related to VPD dependence [units depend on <code>gsModel</code> ] |
| 6.0  | <code>G5</code>      | <code>MD</code> | Related to temperature dependence [ $^{\circ}\text{C}$ ]          |
| 7.0  | <code>G6</code>      | <code>MD</code> | Related to soil moisture dependence [ $\text{mm}^{-1}$ ]          |
| 8.0  | <code>TH</code>      | <code>MD</code> | Upper air temperature limit [ $^{\circ}\text{C}$ ]                |
| 9.0  | <code>TL</code>      | <code>MD</code> | Lower air temperature limit [ $^{\circ}\text{C}$ ]                |
| 10.0 | <code>S1</code>      | <code>MD</code> | A parameter related to soil moisture dependence [-]               |
| 11.0 | <code>S2</code>      | <code>MD</code> | A parameter related to soil moisture dependence [mm]              |
| 12.0 | <code>Kmax</code>    | <code>MD</code> | Maximum incoming shortwave radiation [ $\text{W m}^{-2}$ ]        |
| 13.0 | <code>gsModel</code> | <code>MD</code> | Formulation choice for conductance calculation.                   |

An example `SUEWS_Conductance.txt` can be found online

## SUEWS\_Irrigation.txt

External water use may be used for a wide range of reasons (e.g. cleaning roads, irrigating plants, fountains, washing cars).

SUEWS has two options for External Water use (if non-zero):

- 1) provide observed data in meteorological forcing file in the `Wuh` column with valid values by setting `WaterUseMethod` = 1 in `RunControl.nml`
- 2) a simple model that calculates daily water use from the mean daily air temperature, number of days since rain and fraction of irrigated area using automatic/manual irrigation. The user needs to supply coefficients (XXX) for these relations.
  - a) sub-daily pattern of water use is determined from the daily cycles specified in `SUEWS_Profiles.txt`.
  - b) surface that the water can be applied to is specified by XX.
  - c) water can pond.

| No.  | Column Name             | Use       | Description  |
|------|-------------------------|-----------|--|
| 1.0  | <i>Code</i>             | <i>L</i>  | Code linking to a corresponding look-up table.   |
| 2.0  | <i>Ie_start</i>         | <i>MU</i> | Day when irrigation starts [DOY]   |
| 3.0  | <i>Ie_end</i>           | <i>MU</i> | Day when irrigation ends [DOY]   |
| 4.0  | <i>InternalWaterUse</i> | <i>MU</i> | Internal water use [mm h <sup>-1</sup> ]   |
| 5.0  | <i>Faut</i>             | <i>MU</i> | Fraction of irrigated area that is irrigated using automated systems   |
| 6.0  | <i>H_maintain</i>       | <i>MU</i> | water depth to maintain used in automatic irrigation (e.g., ponding water due to flooding irrigation in rice crop-field) [mm]. |
| 7.0  | <i>Ie_a1</i>            | <i>MD</i> | Coefficient for automatic irrigation model [mm d <sup>-1</sup> ]   |
| 8.0  | <i>Ie_a2</i>            | <i>MD</i> | Coefficient for automatic irrigation model [mm d <sup>-1</sup> K <sup>-1</sup> ]   |
| 9.0  | <i>Ie_a3</i>            | <i>MD</i> | Coefficient for automatic irrigation model [mm d <sup>-2</sup> ]   |
| 10.0 | <i>Ie_m1</i>            | <i>MD</i> | Coefficient for manual irrigation model [mm d <sup>-1</sup> ]  |
| 11.0 | <i>Ie_m2</i>            | <i>MD</i> | Coefficient for manual irrigation model [mm d <sup>-1</sup> K <sup>-1</sup> ]  |
| 12.0 | <i>Ie_m3</i>            | <i>MD</i> | Coefficient for manual irrigation model [mm d <sup>-2</sup> ]  |
| 13.0 | <i>DayWat(1)</i>        | <i>MU</i> | Irrigation allowed on Sundays [1], if not [0]  |
| 14.0 | <i>DayWat(2)</i>        | <i>MU</i> | Irrigation allowed on Mondays [1], if not [0]  |
| 15.0 | <i>DayWat(3)</i>        | <i>MU</i> | Irrigation allowed on Tuesdays [1], if not [0]   |
| 16.0 | <i>DayWat(4)</i>        | <i>MU</i> | Irrigation allowed on Wednesdays [1], if not [0]   |
| 17.0 | <i>DayWat(5)</i>        | <i>MU</i> | Irrigation allowed on Thursdays [1], if not [0]  |
| 18.0 | <i>DayWat(6)</i>        | <i>MU</i> | Irrigation allowed on Fridays [1], if not [0]  |
| 19.0 | <i>DayWat(7)</i>        | <i>MU</i> | Irrigation allowed on Saturdays [1], if not [0]  |
| 20.0 | <i>DayWatPer(1)</i>     | <i>MU</i> | Fraction of properties using irrigation on Sundays [0-1]   |
| 21.0 | <i>DayWatPer(2)</i>     | <i>MU</i> | Fraction of properties using irrigation on Mondays [0-1]   |
| 22.0 | <i>DayWatPer(3)</i>     | <i>MU</i> | Fraction of properties using irrigation on Tuesdays [0-1]  |
| 23.0 | <i>DayWatPer(4)</i>     | <i>MU</i> | Fraction of properties using irrigation on Wednesdays [0-1]  |
| 24.0 | <i>DayWatPer(5)</i>     | <i>MU</i> | Fraction of properties using irrigation on Thursdays [0-1]   |
| 25.0 | <i>DayWatPer(6)</i>     | <i>MU</i> | Fraction of properties using irrigation on Fridays [0-1]   |
| 26.0 | <i>DayWatPer(7)</i>     | <i>MU</i> | Fraction of properties using irrigation on Saturdays [0-1]   |

An example *SUEWS\_Irrigation.txt* can be found in the online version.

### SUEWS\_NonVeg.txt

*SUEWS\_NonVeg.txt* specifies the characteristics for the non-vegetated surface cover types (*Paved*, *Bldgs*, *BSoil*) by linking codes in column 1 of *SUEWS\_NonVeg.txt* to the codes specified in *SUEWS\_SiteSelect.txt* (*Code\_Paved*, *Code\_Bldgs*, *Code\_BSoil*). Each row should correspond to a particular surface type. For suggestions on how to complete this table, see: *Typical Values*.

| No. | Column Name         | Use       | Description   |
|-----|---------------------|-----------|---|
| 1.0 | <i>Code</i>         | <i>L</i>  | Code linking to a corresponding look-up table.  |
| 2.0 | <i>AlbedoMin</i>    | <i>MU</i> | Effective surface albedo (middle of the day value) for wintertime (not including snow).                         |
| 3.0 | <i>AlbedoMax</i>    | <i>MU</i> | Effective surface albedo (middle of the day value) for summertime.  |
| 4.0 | <i>Emissivity</i>   | <i>MU</i> | Effective surface emissivity.   |
| 5.0 | <i>StorageMin</i>   | <i>MD</i> | Minimum water storage capacity for upper surfaces (i.e. canopy).  |
| 6.0 | <i>StorageMax</i>   | <i>MD</i> | Maximum water storage capacity for upper surfaces (i.e. canopy)   |
| 7.0 | <i>WetThreshold</i> | <i>MD</i> | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface [mm]. |
| 8.0 | <i>StateLimit</i>   | <i>MD</i> | Upper limit to the surface state. [mm]  |
| 9.0 | <i>DrainageEq</i>   | <i>MD</i> | Calculation choice for Drainage equation  |

continues on next page

Table 7.2 – continued from previous page

| No.  | Column Name              | Use       | Description  |
|------|--------------------------|-----------|--|
| 10.0 | <i>DrainageCoef1</i>     | <i>MD</i> | Coefficient D0 [mm h <sup>-1</sup> ] used in <i>DrainageEq</i>   |
| 11.0 | <i>DrainageCoef2</i>     | <i>MD</i> | Coefficient b [-] used in <i>DrainageEq</i>  |
| 12.0 | <i>SoilTypeCode</i>      | <i>L</i>  | Code for soil characteristics below this surface linking to <i>Code</i> of <i>SUEWS_Soil.txt</i>                                 |
| 13.0 | <i>SnowLimPatch</i>      | <i>O</i>  | Limit for the snow water equivalent when snow cover starts to be patchy [mm]   |
| 14.0 | <i>SnowLimRemove</i>     | <i>O</i>  | Limit of the snow water equivalent for snow removal from roads and roofs [mm]  |
| 15.0 | <i>OHMCode_SummerWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 16.0 | <i>OHMCode_SummerDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 17.0 | <i>OHMCode_WinterWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 18.0 | <i>OHMCode_WinterDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 19.0 | <i>OHMThresh_SW</i>      | <i>MD</i> | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C]  |
| 20.0 | <i>OHMThresh_WD</i>      | <i>MD</i> | Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]   |
| 21.0 | <i>ESTMCode</i>          | <i>L</i>  | Code for ESTM coefficients linking to <i>SUEWS_ESTMCoefficients.txt</i>  |
| 22.0 | <i>AnOHM_Cp</i>          | <i>MU</i> | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ]   |
| 23.0 | <i>AnOHM_Kk</i>          | <i>MU</i> | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ]   |
| 24.0 | <i>AnOHM_Ch</i>          | <i>MU</i> | Bulk transfer coefficient for this surface to use in AnOHM [-]   |

An example *SUEWS\_NonVeg.txt* can be found in the online version.

### SUEWS\_OHMCoefficients.txt

OHM, the Objective Hysteresis Model [Grimmond *et al.*, 1991] calculates the storage heat flux as a function of net all-wave radiation and surface characteristics.

- For each surface, OHM requires three model coefficients (a1, a2, a3). The three should be selected as a set.
- The *SUEWS\_OHMCoefficients.txt* file provides these coefficients for each surface type.
- A variety of values has been derived for different materials and can be found in the literature (see: *Typical Values*).
- **Coefficients can be changed depending on:**
  1. surface wetness state (wet/dry) based on the calculated surface wetness state and soil moisture.
  2. season (summer/winter) based on a 5-day running mean air temperature.
- To use the same coefficients irrespective of wet/dry and summer/winter conditions, use the same code for all four OHM columns (*OHMCode\_SummerWet*, *OHMCode\_SummerDry*, *OHMCode\_WinterWet* and *OHMCode\_WinterDry*).

#### Note:

1. AnOHM (set in *RunControl.nml* by *StorageHeatMethod* = 3) does not use the coefficients specified in *SUEWS\_OHMCoefficients.txt* but instead requires three parameters to be specified for each surface type

(including snow): heat capacity (*AnOHM\_Cp*), thermal conductivity (*AnOHM\_Kk*) and bulk transfer coefficient (*AnOHM\_Ch*). These are specified in *SUEWS\_NonVeg.txt*, *SUEWS\_Veg.txt*, *SUEWS\_Water.txt* and *SUEWS\_Snow.txt*. No additional files are required for AnOHM.

2. AnOHM is under development in v2018b and should NOT be used!

| No. | Column Name | Use       | Description                                    |
|-----|-------------|-----------|--|
| 1.0 | <i>Code</i> | <i>L</i>  | Code linking to a corresponding look-up table. |
| 2.0 | <i>a1</i>   | <i>MU</i> | Coefficient for $Q^*$ term [-]                 |
| 3.0 | <i>a2</i>   | <i>MU</i> | Coefficient for $dQ^*/dt$ term [h]             |
| 4.0 | <i>a3</i>   | <i>MU</i> | Constant term [ $W\ m^{-2}$ ]                  |

An example *SUEWS\_OHMCoefficients.txt* can be found in the online version.

### SUEWS\_Profiles.txt

*SUEWS\_Profiles.txt* specifies the daily cycle of variables related to human behaviour (energy use, water use and snow clearing). Different profiles can be specified for weekdays and weekends. The profiles are provided at hourly resolution here; the model will then linearly interpolate the profiles to the resolution of the model time step; some profiles may be normalized either by sum or by mean depending on the activity type while others not (see Normalisation method column of *table below*). Thus it does not matter whether columns 2-25 add up to, say 1, 24, or another number, because the model will eventually use the normalised values to rescale the results.

#### Note:

1. Currently, the snow clearing profiles are not interpolated as these are effectively a switch (0 for off and 1 for on).
2. If the anthropogenic heat flux and water use are specified in the met forcing file, the energy and water use profiles are ignored.

| Activity               | Description   | Normali-<br>sation<br>method | Week-<br>day<br>option    | Week-<br>end<br>option    |
|------------------------|---|------------------------------|---------------------------|---------------------------|
| Energy use             | This profile, in junction with population density ( <i>PopDensDay</i> and <i>PopDensNight</i> ), determines the overall anthropogenic heat.             | mean                         | <i>EnergyUseProfWD</i>    | <i>EnergyUseProfWE</i>    |
| Population density     | This profile, in junction with human activity ( <i>ActivityProfWD</i> and <i>ActivityProfWE</i> ), determines the anthropogenic heat due to metabolism. | None                         | <i>PopProfWD</i>          | <i>PopProfWE</i>          |
| Human activity         | This profile, in junction with population density ( <i>PopProfWD</i> and <i>PopProfWE</i> ), determines the anthropogenic heat due to metabolism.       | None                         | <i>ActivityProfWD</i>     | <i>ActivityProfWE</i>     |
| Traffic                | This profile determines the anthropogenic heat due to traffic.  | mean                         | <i>TraffProfWD</i>        | <i>TraffProfWE</i>        |
| Water use (manual)     | This profile determines the irrigation under manual operation.  | sum                          | <i>WaterUseProfManWD</i>  | <i>WaterUseProfManWE</i>  |
| Water use (auto-matic) | This profile determines the irrigation under automatic operation.   | sum                          | <i>WaterUseProfAutoWD</i> | <i>WaterUseProfAutoWE</i> |
| Snow removal           | This profile determines if snow removal is conducted at the end of each hour.   | None                         | <i>SnowClearingProfWD</i> | <i>SnowClearingProfWE</i> |

- Anthropogenic heat flux (weekday and weekend)
- Water use (weekday and weekend; manual and automatic irrigation)
- Snow removal (weekday and weekend)
- Human activity (weekday and weekend).

| No. | Column Name          | Use                | Description   |
|-----|----------------------|--------------------|---|
| 1   | <a href="#">Code</a> | <a href="#">L</a>  | Code linking to a corresponding look-up table.  |
| 2   | 2-25                 | <a href="#">MU</a> | Multiplier for each hour of the day [-] for energy and water use. For SnowClearing, set those hours to 1 when snow removal from paved and roof surface is allowed (0 otherwise) if the snow removal limits set in the <a href="#">SUEWS_NonVeg.txt</a> (SnowLimR remove column) are exceeded. |

An example [SUEWS\\_Profiles.txt](#) can be found in the online version.

### SUEWS\_SiteSelect.txt

For each year and each grid, site specific surface cover information and other input parameters are provided to SUEWS by [SUEWS\\_SiteSelect.txt](#). The model currently requires a new row for each year of the model run. All rows in this file will be read by the model and run.

| No.  | Column Name                 | Use                | Description   |
|------|-----------------------------|--------------------|---|
| 1.0  | <a href="#">Grid</a>        | <a href="#">MU</a> | a unique number to represent grid   |
| 2.0  | <a href="#">Year</a>        | <a href="#">MU</a> | Year [YYYY]   |
| 3.0  | <a href="#">StartDLS</a>    | <a href="#">MU</a> | Start of the day light savings [DOY]  |
| 4.0  | <a href="#">EndDLS</a>      | <a href="#">MU</a> | End of the day light savings [DOY]  |
| 5.0  | <a href="#">lat</a>         | <a href="#">MU</a> | Latitude [deg].   |
| 6.0  | <a href="#">lng</a>         | <a href="#">MU</a> | longitude [deg]   |
| 7.0  | <a href="#">Timezone</a>    | <a href="#">MU</a> | Time zone [h] for site relative to UTC (east is positive). This should be set according to the times given in the meteorological forcing file(s). |
| 8.0  | <a href="#">SurfaceArea</a> | <a href="#">MU</a> | Area of the grid [ha].  |
| 9.0  | <a href="#">Alt</a>         | <a href="#">MU</a> | Altitude of grids [m].  |
| 10.0 | <a href="#">z</a>           | <a href="#">MU</a> | Measurement height [m] for all atmospheric forcing variables set in <a href="#">SSss_YYYY_data_tt.txt</a> .                                       |
| 11.0 | <a href="#">id</a>          | <a href="#">MD</a> | Day of year [DOY]   |
| 12.0 | <a href="#">ih</a>          | <a href="#">MD</a> | Hour [H]  |
| 13.0 | <a href="#">imin</a>        | <a href="#">MD</a> | Minute [M]  |
| 14.0 | <a href="#">Fr_Paved</a>    | <a href="#">MU</a> | Surface cover fraction of <a href="#">Paved</a> surfaces [-]  |
| 15.0 | <a href="#">Fr_Bldgs</a>    | <a href="#">MU</a> | Surface cover fraction of buildings [-]   |
| 16.0 | <a href="#">Fr_EveTr</a>    | <a href="#">MU</a> | Surface cover fraction of <a href="#">EveTr</a> : evergreen trees and shrubs [-]  |
| 17.0 | <a href="#">Fr_DecTr</a>    | <a href="#">MU</a> | Surface cover fraction of deciduous trees and shrubs [-]  |
| 18.0 | <a href="#">Fr_Grass</a>    | <a href="#">MU</a> | Surface cover fraction of <a href="#">Grass</a> [-]   |
| 19.0 | <a href="#">Fr_Bsoil</a>    | <a href="#">MU</a> | Surface cover fraction of bare soil or unmanaged land [-]   |
| 20.0 | <a href="#">Fr_Water</a>    | <a href="#">MU</a> | Surface cover fraction of open water [-]  |
| 21.0 | <a href="#">IrrFr_Paved</a> | <a href="#">MU</a> | Fraction of <a href="#">Paved</a> that is irrigated [-]   |
| 22.0 | <a href="#">IrrFr_Bldgs</a> | <a href="#">MU</a> | Fraction of <a href="#">Bldgs</a> that is irrigated [-]   |
| 23.0 | <a href="#">IrrFr_EveTr</a> | <a href="#">MU</a> | Fraction of <a href="#">EveTr</a> that is irrigated [-]   |
| 24.0 | <a href="#">IrrFr_DecTr</a> | <a href="#">MU</a> | Fraction of <a href="#">DecTr</a> that is irrigated [-]   |
| 25.0 | <a href="#">IrrFr_Grass</a> | <a href="#">MU</a> | Fraction of <a href="#">Grass</a> that is irrigated [-]   |
| 26.0 | <a href="#">IrrFr_BSoil</a> | <a href="#">MU</a> | Fraction of <a href="#">BSoil</a> that is irrigated [-]   |

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Table 7.3 – continued from previous page

| No.  | Column Name               | Use       | Description  |
|------|---------------------------|-----------|--|
| 27.0 | <i>IrrFr_Water</i>        | <i>MU</i> | Fraction of <i>Water</i> that is irrigated [-]   |
| 28.0 | <i>H_Bldgs</i>            | <i>MU</i> | Mean building height [m]   |
| 29.0 | <i>H_EveTr</i>            | <i>MU</i> | Mean height of evergreen trees [m]   |
| 30.0 | <i>H_DecTr</i>            | <i>MU</i> | Mean height of deciduous trees [m]   |
| 31.0 | <i>z0</i>                 | <i>O</i>  | Roughness length for momentum [m]  |
| 32.0 | <i>zd</i>                 | <i>O</i>  | Zero-plane displacement [m]  |
| 33.0 | <i>FAI_Bldgs</i>          | <i>O</i>  | Frontal area index for buildings [-]   |
| 34.0 | <i>FAI_EveTr</i>          | <i>O</i>  | Frontal area index for evergreen trees [-]   |
| 35.0 | <i>FAI_DecTr</i>          | <i>O</i>  | Frontal area index for deciduous trees [-]   |
| 36.0 | <i>PopDensDay</i>         | <i>O</i>  | Daytime population density (i.e. workers, tourists) [people ha <sup>-1</sup> ]   |
| 37.0 | <i>PopDensNight</i>       | <i>O</i>  | Night-time population density (i.e. residents) [people ha <sup>-1</sup> ]  |
| 38.0 | <i>TrafficRate_WD</i>     | <i>O</i>  | Weekday traffic rate [veh km m <sup>-2</sup> s <sup>-1</sup> ] Can be used for CO2 flux calculation - not used in v2018a.  |
| 39.0 | <i>TrafficRate_WE</i>     | <i>O</i>  | Weekend traffic rate [veh km m <sup>-2</sup> s <sup>-1</sup> ] Can be used for CO2 flux calculation - not used in v2018a.  |
| 40.0 | <i>QF0_BEU_WD</i>         | <i>O</i>  | Building energy use [W m <sup>-2</sup> ]   |
| 41.0 | <i>QF0_BEU_WE</i>         | <i>O</i>  | Building energy use [W m <sup>-2</sup> ]   |
| 42.0 | <i>Code_Paved</i>         | <i>L</i>  | Code for <i>Paved</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_NonVeg.txt</i>  |
| 43.0 | <i>Code_Bldgs</i>         | <i>L</i>  | Code for <i>Bldgs</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_NonVeg.txt</i>  |
| 44.0 | <i>Code_EveTr</i>         | <i>L</i>  | Code for <i>EveTr</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_Veg.txt</i>   |
| 45.0 | <i>Code_DecTr</i>         | <i>L</i>  | Code for <i>DecTr</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_Veg.txt</i>   |
| 46.0 | <i>Code_Grass</i>         | <i>L</i>  | Code for <i>Grass</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_Veg.txt</i>   |
| 47.0 | <i>Code_BSoil</i>         | <i>L</i>  | Code for <i>BSoil</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_NonVeg.txt</i>  |
| 48.0 | <i>Code_Water</i>         | <i>L</i>  | Code for <i>Water</i> surface characteristics linking to <i>Code</i> of <i>SUEWS_Water.txt</i>   |
| 49.0 | <i>LUMPS_DrRate</i>       | <i>MD</i> | Drainage rate of bucket for LUMPS [mm h <sup>-1</sup> ]  |
| 50.0 | <i>LUMPS_Cover</i>        | <i>MD</i> | Limit when surface totally covered with water for LUMPS [mm]   |
| 51.0 | <i>LUMPS_MaxRes</i>       | <i>MD</i> | Maximum water bucket reservoir [mm] Used for LUMPS surface wetness control.  |
| 52.0 | <i>NARP_Trans</i>         | <i>MD</i> | Atmospheric transmissivity for NARP [-]  |
| 53.0 | <i>CondCode</i>           | <i>L</i>  | Code for surface conductance parameters linking to <i>Code</i> of <i>SUEWS_Conductance.txt</i>   |
| 54.0 | <i>SnowCode</i>           | <i>L</i>  | Code for snow surface characteristics linking to <i>Code</i> of <i>SUEWS_Snow.txt</i>  |
| 55.0 | <i>SnowClearingProfWD</i> | <i>L</i>  | Code for snow clearing profile (weekdays) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .  |
| 56.0 | <i>SnowClearingProfWE</i> | <i>L</i>  | Code for snow clearing profile (weekends) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .  |
| 57.0 | <i>AnthropogenicCode</i>  | <i>L</i>  | Code for modelling anthropogenic heat flux linking to <i>Code</i> of <i>SUEWS_AnthropogenicEmission.txt</i> , which contains the model coefficients for estimation of the anthropogenic heat flux (used if <i>EmissionsMethod</i> = 1, 2 in <i>RunControl.nml</i> ). |
| 58.0 | <i>IrrigationCode</i>     | <i>L</i>  | Code for modelling irrigation linking to <i>Code</i> of <i>SUEWS_Irrigation.txt</i>  |
| 59.0 | <i>WaterUseProfManuWD</i> | <i>L</i>  | Code for water use profile (manual irrigation, weekdays) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .   |
| 60.0 | <i>WaterUseProfManuWE</i> | <i>L</i>  | Code for water use profile (manual irrigation, weekends) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> .   |

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Table 7.3 – continued from previous page

| No.  | Column Name                | Use                    | Description   |
|------|----------------------------|------------------------|---|
| 61.0 | <i>WaterUseProfAutoWD</i>  | <i>L</i>               | Code for water use profile (automatic irrigation, weekdays) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in <i>Code</i> of <i>SUEWS_Profiles.txt</i> . |
| 62.0 | <i>WaterUseProfAutoWE</i>  | <i>L</i>               | Code for water use profile (automatic irrigation, weekends) linking to <i>Code</i> of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in <i>Code</i> of <i>SUEWS_Profiles.txt</i> . |
| 63.0 | <i>FlowChange</i>          | <i>MD</i>              | Difference in input and output flows for water surface [mm h <sup>-1</sup> ]  |
| 64.0 | <i>RunoffToWater</i>       | <i>MD</i><br><i>MU</i> | Fraction of above-ground runoff flowing to water surface during flooding [-]  |
| 65.0 | <i>PipeCapacity</i>        | <i>MD</i><br><i>MU</i> | Storage capacity of pipes [mm]  |
| 66.0 | <i>GridConnection1of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 1st grid where water can flow to  |
| 67.0 | <i>Fraction1of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection1of8</i> [-]  |
| 68.0 | <i>GridConnection2of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 2nd grid where water can flow to  |
| 69.0 | <i>Fraction2of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection2of8</i> [-]  |
| 70.0 | <i>GridConnection3of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 3rd grid where water can flow to  |
| 71.0 | <i>Fraction3of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection3of8</i> [-]  |
| 72.0 | <i>GridConnection4of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 4th grid where water can flow to  |
| 73.0 | <i>Fraction4of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection4of8</i> [-]  |
| 74.0 | <i>GridConnection5of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 5th grid where water can flow to  |
| 75.0 | <i>Fraction5of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection5of8</i> [-]  |
| 76.0 | <i>GridConnection6of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 6th grid where water can flow to  |
| 77.0 | <i>Fraction6of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection6of8</i> [-]  |
| 78.0 | <i>GridConnection7of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 7th grid where water can flow to  |
| 79.0 | <i>Fraction7of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection7of8</i> [-]  |
| 80.0 | <i>GridConnection8of8</i>  | <i>MD</i><br><i>MU</i> | Number of the 8th grid where water can flow to  |
| 81.0 | <i>Fraction8of8</i>        | <i>MD</i><br><i>MU</i> | Fraction of water that can flow to <i>GridConnection8of8</i> [-]  |
| 82.0 | <i>WithinGridPavedCode</i> | <i>L</i>               | Code that links to the fraction of water that flows from <i>Paved</i> surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> .  |
| 83.0 | <i>WithinGridBldgsCode</i> | <i>L</i>               | Code that links to the fraction of water that flows from <i>Bldgs</i> surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i>  |
| 84.0 | <i>WithinGridEveTrCode</i> | <i>L</i>               | Code that links to the fraction of water that flows from <i>EveTr</i> surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> .  |

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Table 7.3 – continued from previous page

| No.   | Column Name                           | Use       | Description   |
|-------|---------------------------------------|-----------|---|
| 85.0  | <a href="#">WithinGridDecTrCode</a>   | <i>L</i>  | Code that links to the fraction of water that flows from <i>DecTr</i> surfaces to surfaces in columns 2-10 of <a href="#">SUEWS_WithinGridWaterDist.txt</a> . |
| 86.0  | <a href="#">WithinGridGrassCode</a>   | <i>L</i>  | Code that links to the fraction of water that flows from <i>Grass</i> surfaces to surfaces in columns 2-10 of <a href="#">SUEWS_WithinGridWaterDist.txt</a> . |
| 87.0  | <a href="#">WithinGridBSoilCode</a>   | <i>L</i>  | Code that links to the fraction of water that flows from <i>BSoil</i> surfaces to surfaces in columns 2-10 of <a href="#">SUEWS_WithinGridWaterDist.txt</a> . |
| 88.0  | <a href="#">WithinGridWaterCode</a>   | <i>L</i>  | Code that links to the fraction of water that flows from <i>Water</i> surfaces to surfaces in columns 2-10 of <a href="#">SUEWS_WithinGridWaterDist.txt</a> . |
| 89.0  | <a href="#">AreaWall</a>              | <i>MU</i> | Area of wall within grid (needed for ESTM calculation) [ m <sup>2</sup> ].  |
| 90.0  | <a href="#">Fr_ESTMClass_Paved1</a>   | <i>MU</i> | Surface cover fraction of <i>Paved</i> surface class 1 used in ESTM calculations  |
| 91.0  | <a href="#">Fr_ESTMClass_Paved2</a>   | <i>MU</i> | Surface cover fraction of <i>Paved</i> surface class 2 used in ESTM calculations  |
| 92.0  | <a href="#">Fr_ESTMClass_Paved3</a>   | <i>MU</i> | Surface cover fraction of <i>Paved</i> surface class 3 used in ESTM calculations  |
| 93.0  | <a href="#">Code_ESTMClass_Paved1</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 94.0  | <a href="#">Code_ESTMClass_Paved2</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 95.0  | <a href="#">Code_ESTMClass_Paved3</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 96.0  | <a href="#">Fr_ESTMClass_Bldgs1</a>   | <i>MU</i> | Surface cover fraction of building class 1 used in ESTM calculations  |
| 97.0  | <a href="#">Fr_ESTMClass_Bldgs2</a>   | <i>MU</i> | Surface cover fraction of building class 2 used in ESTM calculations  |
| 98.0  | <a href="#">Fr_ESTMClass_Bldgs3</a>   | <i>MU</i> | Surface cover fraction of building class 3 used in ESTM calculations  |
| 99.0  | <a href="#">Fr_ESTMClass_Bldgs4</a>   | <i>MU</i> | Surface cover fraction of building class 4 used in ESTM calculations  |
| 100.0 | <a href="#">Fr_ESTMClass_Bldgs5</a>   | <i>MU</i> | Surface cover fraction of building class 5 used in ESTM calculations  |
| 101.0 | <a href="#">Code_ESTMClass_Bldgs1</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 102.0 | <a href="#">Code_ESTMClass_Bldgs2</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 103.0 | <a href="#">Code_ESTMClass_Bldgs3</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 104.0 | <a href="#">Code_ESTMClass_Bldgs4</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 105.0 | <a href="#">Code_ESTMClass_Bldgs5</a> | <i>L</i>  | Code linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |

**Attention:**

- Two rows of -9 should be placed at end of this file.
- In this file the **column order is important**.
- Surface cover fractions specified from [Fr\\_Paved](#) to [Fr\\_Water](#) should sum up to 1.
- Surface cover fractions specified from [Fr\\_ESTMClass\\_Paved1](#) to [Fr\\_ESTMClass\\_Paved3](#) should sum up to 1.
- Surface cover fractions specified from [Fr\\_ESTMClass\\_Bldgs1](#) to [Fr\\_ESTMClass\\_Bldgs5](#) should sum up to 1.
- In this file the **row order is important** for simulations of **multiple grids and multiple years**. Ensure the rows in are arranged so that all grids for a particular year appear on consecutive lines (rather than grouping all years together for a particular grid). See below for a valid example:

```
Grid  Year  ...
1     2001  ...
2     2001  ...
1     2002  ...
2     2002  ...
```

**Tip:** ! can be used to indicate comments in the file. Comments are not read by the programme so they can be used

by the user to provide notes for their interpretation of the contents. This is strongly recommended.

---

## Day Light Savings (DLS)

The dates for DLS normally vary for each year and country as they are often associated with a specific set of Sunday mornings at the beginning of summer and autumn. Note it is important to remember leap years. You can check <http://www.timeanddate.com/time/dst/> for your city.

---

**Tip:** If DLS does not occur give a start and end day immediately after it. Make certain the dummy dates are correct for the hemisphere

- For northern hemisphere, use: 180 181
  - For southern hemisphere, use: 365 1
- 

Example when running multiple years (in this case 2008 and 2009 in Canada):

| Year | start of daylight savings | end of daylight savings |
|------|---------------------------|-------------------------|
| 2008 | 170                       | 240                     |
| 2009 | 172                       | 242                     |

## Grid Connections (water flow between grids)

### Caution:

- **Not available in this version.**
- columns between *GridConnection1of8* and *GridConnection8of8* in *SUEWS\_SiteSelect.txt* can be set to zero.

This section gives an example of water flow between grids, calculated based on the relative elevation of the grids and length of the connecting surface between adjacent grids. For the square grids in the figure, water flow is assumed to be zero between diagonally adjacent grids, as the length of connecting surface linking the grids is very small. Model grids need not be square or the same size.

The table gives example values for the grid connections part of *SUEWS\_SiteSelect.txt* for the grids shown in the figure. For each row, only water flowing out of the current grid is entered (e.g. water flows from 234 to 236 and 237, with a larger proportion of water flowing to 237 because of the greater length of connecting surface between 234 and 237 than between 234 and 236. No water is assumed to flow between 234 and 233 or 235 because there is no elevation difference between these grids. Grids 234 and 238 are at the same elevation and only connect at a point, so no water flows between them. Water enters grid 234 from grids 230, 231 and 232 as these are more elevated.

---

**Note:** Arrows indicate the water flow in to and out of grid 234, but note that only only water flowing out of each grid is entered in *SUEWS\_SiteSelect.txt*

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An example *SUEWS\_SiteSelect.txt* can be found in the online version.

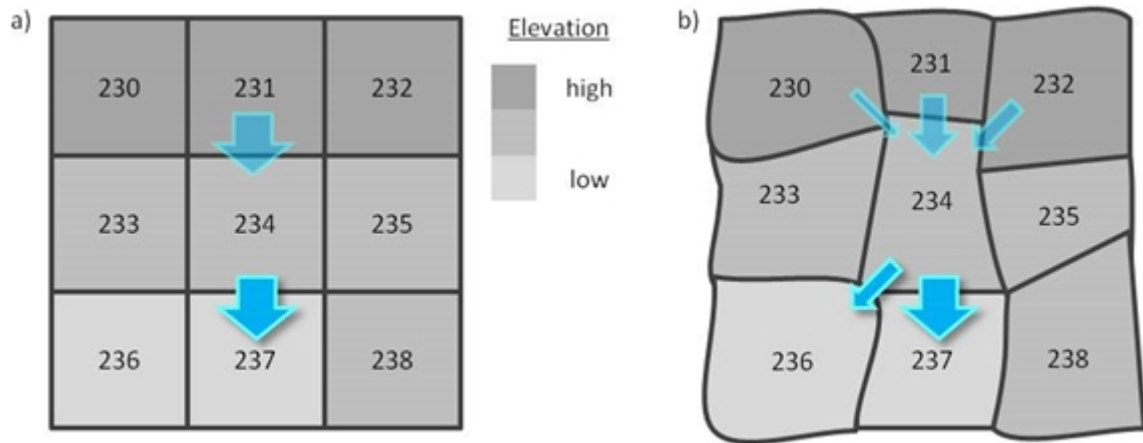


Fig. 7.1: Example grid connections showing water flow between grids.

| Grid | GridConnection<br>1of8 | Fraction1of8 | GridConnection<br>2of8 | Fraction2of8 | GridConnection<br>3of8 | Fraction3of8 | GridConnection<br>4of8 | Fraction4of8 | GridConnection<br>5of8 | Fraction5of8 | GridConnection<br>6of8 | Fraction6of8 | GridConnection<br>7of8 | Fraction7of8 | GridConnection<br>8of8 | Fraction8of8 |
|------|------------------------|--------------|------------------------|--------------|------------------------|--------------|------------------------|--------------|------------------------|--------------|------------------------|--------------|------------------------|--------------|------------------------|--------------|
| 230  | 233                    | 0.90         | 234                    | 0.10         | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 231  | 234                    | 1.00         | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 232  | 234                    | 0.20         | 235                    | 0.80         | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 233  | 236                    | 1.00         | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 234  | 236                    | 0.10         | 237                    | 0.90         | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 235  | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 236  | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 237  | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |
| 238  | 237                    | 1.0          | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            | 0                      | 0            |

Fig. 7.2: Example values for the grid connections part of *SUEWS\_SiteSelect.txt* for the grids.

## SUEWS\_Snow.txt

SUEWS\_Snow.txt specifies the characteristics for snow surfaces when *SnowUse=1* in *RunControl.nml*. If the snow part of the model is not run, fill this table with ‘-999’ except for the first (Code) column and set *SnowUse=0* in *RunControl.nml*. For a detailed description of the variables, see Järvi et al. (2014) [Järvi *et al.*, 2014].

| No.  | Column Name              | Use       | Description  |
|------|--------------------------|-----------|--|
| 1.0  | <i>Code</i>              | <i>L</i>  | Code linking to a corresponding look-up table.   |
| 2.0  | <i>RadMeltFactor</i>     | <i>MU</i> | Hourly radiation melt factor of snow [ $\text{mm W}^{-1} \text{h}^{-1}$ ]  |
| 3.0  | <i>TempMeltFactor</i>    | <i>MU</i> | Hourly temperature melt factor of snow [ $\text{mm K}^{-1} \text{h}^{-1}$ ]  |
| 4.0  | <i>AlbedoMin</i>         | <i>MU</i> | Effective surface albedo (middle of the day value) for wintertime (not including snow).  |
| 5.0  | <i>AlbedoMax</i>         | <i>MU</i> | Effective surface albedo (middle of the day value) for summertime.   |
| 6.0  | <i>Emissivity</i>        | <i>MU</i> | Effective surface emissivity.  |
| 7.0  | <i>tau_a</i>             | <i>MD</i> | Time constant for snow albedo aging in cold snow [-]   |
| 8.0  | <i>tau_f</i>             | <i>MD</i> | Time constant for snow albedo aging in melting snow [-]  |
| 9.0  | <i>PrecipLimAlb</i>      | <i>MD</i> | Limit for hourly precipitation when the ground is fully covered with snow [mm]   |
| 10.0 | <i>SnowDensMin</i>       | <i>MD</i> | Fresh snow density [ $\text{kg m}^{-3}$ ]  |
| 11.0 | <i>SnowDensMax</i>       | <i>MD</i> | Maximum snow density [ $\text{kg m}^{-3}$ ]  |
| 12.0 | <i>tau_r</i>             | <i>MD</i> | Time constant for snow density ageing [-]  |
| 13.0 | <i>CRWMin</i>            | <i>MD</i> | Minimum water holding capacity of snow [mm]  |
| 14.0 | <i>CRWMax</i>            | <i>MD</i> | Maximum water holding capacity of snow [mm]  |
| 15.0 | <i>PrecipLimSnow</i>     | <i>MD</i> | Temperature limit when precipitation falls as snow [ $^{\circ}\text{C}$ ]  |
| 16.0 | <i>OHMCode_SummerWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 17.0 | <i>OHMCode_SummerDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 18.0 | <i>OHMCode_WinterWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 19.0 | <i>OHMCode_WinterDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 20.0 | <i>OHMThresh_SW</i>      | <i>MD</i> | Temperature threshold determining whether summer/winter OHM coefficients are applied [ $^{\circ}\text{C}$ ]                      |
| 21.0 | <i>OHMThresh_WD</i>      | <i>MD</i> | Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]   |
| 22.0 | <i>ESTMCode</i>          | <i>L</i>  | Code for ESTM coefficients linking to <i>SUEWS_ESTMCoefficients.txt</i>  |
| 23.0 | <i>AnOHM_Cp</i>          | <i>MU</i> | Volumetric heat capacity for this surface to use in AnOHM [ $\text{J m}^{-3}$ ]  |
| 24.0 | <i>AnOHM_Kk</i>          | <i>MU</i> | Thermal conductivity for this surface to use in AnOHM [ $\text{W m K}^{-1}$ ]  |
| 25.0 | <i>AnOHM_Ch</i>          | <i>MU</i> | Bulk transfer coefficient for this surface to use in AnOHM [-]   |

An example *SUEWS\_Snow.txt* can be found in the online version.

## SUEWS\_Soil.txt

SUEWS\_Soil.txt specifies the characteristics of the sub-surface soil below each of the non-water surface types (Paved, Bldgs, EveTr, DecTr, Grass, BSoil). The model does not have a soil store below the water surfaces. Note that these sub-surface soil stores are different to the bare soil/unmanaged surface cover type. Each of the non-water surface types need to link to soil characteristics specified here. If the soil characteristics are assumed to be the same for all surface types, use a single code value to link the characteristics here with the SoilTypeCode columns in *SUEWS\_NonVeg.txt* and *SUEWS\_Veg.txt*.

Soil moisture can either be provided using observational data in the met forcing file (the *xsmd* column when *SMDMethod* = 1 or 2 in *RunControl.nml*) and providing some soil properties here, or modelled by SUEWS (*SMDMethod* = 0 in *RunControl.nml*).

| No. | Column Name             | Use       | Description   |
|-----|-------------------------|-----------|---|
| 1.0 | <i>Code</i>             | <i>L</i>  | Code linking to a corresponding look-up table.  |
| 2.0 | <i>SoilDepth</i>        | <i>MD</i> | Depth of soil beneath the surface [mm]  |
| 3.0 | <i>SoilStoreCap</i>     | <i>MD</i> | Limit value for <i>SoilDepth</i> [mm]   |
| 4.0 | <i>SatHydraulicCond</i> | <i>MD</i> | Hydraulic conductivity for saturated soil [ $\text{mm s}^{-1}$ ]                          |
| 5.0 | <i>SoilDensity</i>      | <i>MD</i> | Soil density [ $\text{kg m}^{-3}$ ]   |
| 6.0 | <i>InfiltrationRate</i> | <i>O</i>  | Infiltration rate.  |
| 7.0 | <i>OBS_SMDepth</i>      | <i>O</i>  | The depth of soil moisture measurements. [mm]   |
| 8.0 | <i>OBS_SMCap</i>        | <i>O</i>  | The maximum observed soil moisture. [ $\text{m}^3 \text{m}^{-3}$ or $\text{kg kg}^{-1}$ ] |
| 9.0 | <i>OBS_SoilNotRocks</i> | <i>O</i>  | Fraction of soil without rocks. [-]   |

An example *SUEWS\_Soil.txt* can be found in the online version.

## SUEWS\_Veg.txt

SUEWS\_Veg.txt specifies the characteristics for the vegetated surface cover types (EveTr, DecTr, Grass) by linking codes in column 1 of SUEWS\_Veg.txt to the codes specified in *SUEWS\_SiteSelect.txt* (Code\_EveTr, Code\_DecTr, Code\_Grass). Each row should correspond to a particular surface type. For suggestions on how to complete this table, see: *Typical Values*.

| No.  | Column Name          | Use       | Description   |
|------|----------------------|-----------|---|
| 1.0  | <i>Code</i>          | <i>L</i>  | Code linking to a corresponding look-up table.  |
| 2.0  | <i>AlbedoMin</i>     | <i>MU</i> | Effective surface albedo (middle of the day value) for wintertime (not including snow).                         |
| 3.0  | <i>AlbedoMax</i>     | <i>MU</i> | Effective surface albedo (middle of the day value) for summertime.  |
| 4.0  | <i>Emissivity</i>    | <i>MU</i> | Effective surface emissivity.   |
| 5.0  | <i>StorageMin</i>    | <i>MD</i> | Minimum water storage capacity for upper surfaces (i.e. canopy).  |
| 6.0  | <i>StorageMax</i>    | <i>MD</i> | Maximum water storage capacity for upper surfaces (i.e. canopy)   |
| 7.0  | <i>WetThreshold</i>  | <i>MD</i> | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface [mm]. |
| 8.0  | <i>StateLimit</i>    | <i>MD</i> | Upper limit to the surface state. [mm]  |
| 9.0  | <i>DrainageEq</i>    | <i>MD</i> | Calculation choice for Drainage equation  |
| 10.0 | <i>DrainageCoef1</i> | <i>MD</i> | Coefficient D0 [ $\text{mm h}^{-1}$ ] used in <i>DrainageEq</i>   |
| 11.0 | <i>DrainageCoef2</i> | <i>MD</i> | Coefficient b [-] used in <i>DrainageEq</i>   |
| 12.0 | <i>SoilTypeCode</i>  | <i>L</i>  | Code for soil characteristics below this surface linking to <i>Code</i> of <i>SUEWS_Soil.txt</i>                |
| 13.0 | <i>SnowLimPatch</i>  | <i>O</i>  | Limit for the snow water equivalent when snow cover starts to be patchy [mm]                                    |

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Table 7.5 – continued from previous page

| No.  | Column Name              | Use       | Description  |
|------|--------------------------|-----------|--|
| 14.0 | <i>BaseT</i>             | <i>MU</i> | Base Temperature for initiating growing degree days (GDD) for leaf growth. [°C]  |
| 15.0 | <i>BaseTe</i>            | <i>MU</i> | Base temperature for initiating sensesance degree days (SDD) for leaf off. [°C]  |
| 16.0 | <i>GDDFull</i>           | <i>MU</i> | The growing degree days (GDD) needed for full capacity of the leaf area index (LAI) [°C].  |
| 17.0 | <i>SDDFull</i>           | <i>MU</i> | The sensesance degree days (SDD) needed to initiate leaf off. [°C]   |
| 18.0 | <i>LAIMin</i>            | <i>MD</i> | leaf-off wintertime value  |
| 19.0 | <i>LAIMax</i>            | <i>MD</i> | full leaf-on summertime value  |
| 20.0 | <i>PorosityMin</i>       | <i>MD</i> | leaf-off wintertime value Used only for <i>DecTr</i> (can affect roughness calculation)  |
| 21.0 | <i>PorosityMax</i>       | <i>MD</i> | full leaf-on summertime value Used only for <i>DecTr</i> (can affect roughness calculation)                                      |
| 22.0 | <i>MaxConductance</i>    | <i>MD</i> | The maximum conductance of each vegetation or surface type. [mm s <sup>-1</sup> ]  |
| 23.0 | <i>LAIEq</i>             | <i>MD</i> | LAI calculation choice.  |
| 24.0 | <i>LeafGrowthPower1</i>  | <i>MD</i> | a parameter required by LAI calculation in <i>LAIEq</i>  |
| 25.0 | <i>LeafGrowthPower2</i>  | <i>MD</i> | a parameter required by LAI calculation [K <sup>-1</sup> ] in <i>LAIEq</i>   |
| 26.0 | <i>LeafOffPower1</i>     | <i>MD</i> | a parameter required by LAI calculation [K <sup>-1</sup> ] in <i>LAIEq</i>   |
| 27.0 | <i>LeafOffPower2</i>     | <i>MD</i> | a parameter required by LAI calculation [K <sup>-1</sup> ] in <i>LAIEq</i>   |
| 28.0 | <i>OHMCode_SummerWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 29.0 | <i>OHMCode_SummerDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in summer, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 30.0 | <i>OHMCode_WinterWet</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 31.0 | <i>OHMCode_WinterDry</i> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in winter, linking to <i>SUEWS_OHMCoefficients.txt</i> . |
| 32.0 | <i>OHMThresh_SW</i>      | <i>MD</i> | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C]  |
| 33.0 | <i>OHMThresh_WD</i>      | <i>MD</i> | Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]   |
| 34.0 | <i>ESTMCode</i>          | <i>L</i>  | Code for ESTM coefficients linking to <i>SUEWS_ESTMCoefficients.txt</i>  |
| 35.0 | <i>AnOHM_Cp</i>          | <i>MU</i> | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ]   |
| 36.0 | <i>AnOHM_Kk</i>          | <i>MU</i> | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ]   |
| 37.0 | <i>AnOHM_Ch</i>          | <i>MU</i> | Bulk transfer coefficient for this surface to use in AnOHM [-]   |
| 38.0 | <i>BiogenCO2Code</i>     | <i>MU</i> | Code linking to the <i>Code</i> column in <i>SUEWS_BiogenCO2.txt</i> .   |

An example *SUEWS\_Veg.txt* can be found in the online version.

## SUEWS\_Water.txt

*SUEWS\_Water.txt* specifies the characteristics for the water surface cover type by linking codes in column 1 of *SUEWS\_Water.txt* to the codes specified in *SUEWS\_SiteSelect.txt* (*Code\_Water*).

| No. | Column Name      | Use       | Description   |
|-----|------------------|-----------|---|
| 1.0 | <i>Code</i>      | <i>L</i>  | Code linking to a corresponding look-up table.  |
| 2.0 | <i>AlbedoMin</i> | <i>MU</i> | Effective surface albedo (middle of the day value) for wintertime (not including snow). |
| 3.0 | <i>AlbedoMax</i> | <i>MU</i> | Effective surface albedo (middle of the day value) for summertime.                      |

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Table 7.6 – continued from previous page

| No.  | Column Name                       | Use       | Description   |
|------|-----------------------------------|-----------|---|
| 4.0  | <a href="#">Emissivity</a>        | <i>MU</i> | Effective surface emissivity.   |
| 5.0  | <a href="#">StorageMin</a>        | <i>MD</i> | Minimum water storage capacity for upper surfaces (i.e. canopy).  |
| 6.0  | <a href="#">StorageMax</a>        | <i>MD</i> | Maximum water storage capacity for upper surfaces (i.e. canopy)   |
| 7.0  | <a href="#">WetThreshold</a>      | <i>MD</i> | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface [mm].                           |
| 8.0  | <a href="#">StateLimit</a>        | <i>MU</i> | Upper limit to the surface state. [mm]  |
| 9.0  | <a href="#">WaterDepth</a>        | <i>MU</i> | Water depth [mm].   |
| 10.0 | <a href="#">DrainageEq</a>        | <i>MD</i> | Calculation choice for Drainage equation  |
| 11.0 | <a href="#">DrainageCoef1</a>     | <i>MD</i> | Coefficient D0 [mm h <sup>-1</sup> ] used in <a href="#">DrainageEq</a>   |
| 12.0 | <a href="#">DrainageCoef2</a>     | <i>MD</i> | Coefficient b [-] used in <a href="#">DrainageEq</a>  |
| 13.0 | <a href="#">OHMCode_SummerWet</a> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in summer, linking to <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| 14.0 | <a href="#">OHMCode_SummerDry</a> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in summer, linking to <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| 15.0 | <a href="#">OHMCode_WinterWet</a> | <i>L</i>  | Code for OHM coefficients to use for this surface during wet conditions in winter, linking to <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| 16.0 | <a href="#">OHMCode_WinterDry</a> | <i>L</i>  | Code for OHM coefficients to use for this surface during dry conditions in winter, linking to <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| 17.0 | <a href="#">OHMThresh_SW</a>      | <i>MD</i> | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C]   |
| 18.0 | <a href="#">OHMThresh_WD</a>      | <i>MD</i> | Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]  |
| 19.0 | <a href="#">ESTMCode</a>          | <i>L</i>  | Code for ESTM coefficients linking to <a href="#">SUEWS_ESTMCoefficients.txt</a>  |
| 20.0 | <a href="#">AnOHM_Cp</a>          | <i>MU</i> | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ]  |
| 21.0 | <a href="#">AnOHM_Kk</a>          | <i>MU</i> | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ]  |
| 22.0 | <a href="#">AnOHM_Ch</a>          | <i>MU</i> | Bulk transfer coefficient for this surface to use in AnOHM [-]  |

An example [SUEWS\\_Water.txt](#) can be found in the online version.

### SUEWS\_WithinGridWaterDist.txt

SUEWS\_WithinGridWaterDist.txt specifies the movement of water between surfaces within a grid/area. It allows impervious connectivity to be taken into account.

Each row corresponds to a surface type (linked by the Code in column 1 to the [SUEWS\\_SiteSelect.txt](#) columns: WithinGridPavedCode, WithinGridBldgsCode, ..., WithinGridWaterCode). Each column contains the fraction of water flowing from the surface type to each of the other surface types or to runoff or the sub-surface soil store.

#### Note:

- The sum of each row (excluding the Code) must equal 1.
- Water **CANNOT** flow from one surface to that same surface, so the diagonal elements should be zero.
- The row corresponding to the water surface should be zero, as there is currently no flow permitted from the water surface to other surfaces by the model.
- Currently water **CANNOT** go to both runoff and soil store (i.e. it must go to one or the other – [Runoff](#) for impervious surfaces; [SoilStore](#) for pervious surfaces).

In the table below, for example,

- All flow from paved surfaces goes to runoff;
- 90% of flow from buildings goes to runoff, with small amounts going to other surfaces (mostly paved surfaces as buildings are often surrounded by paved areas);
- All flow from vegetated and bare soil areas goes into the sub-surface soil store;
- The row corresponding to water contains zeros (as it is currently not used).

| No. | Column Name        | Use       | Description                                 |
|-----|--------------------|-----------|---|
| 1.0 | <i>ToPaved</i>     | <i>MU</i> | Fraction of water going to <i>Paved</i>     |
| 2.0 | <i>ToBldgs</i>     | <i>MU</i> | Fraction of water going to Bldgs            |
| 3.0 | <i>ToEveTr</i>     | <i>MU</i> | Fraction of water going to <i>EveTr</i>     |
| 4.0 | <i>ToDecTr</i>     | <i>MU</i> | Fraction of water going to DecTr            |
| 5.0 | <i>ToGrass</i>     | <i>MU</i> | Fraction of water going to <i>Grass</i>     |
| 6.0 | <i>ToBSoil</i>     | <i>MU</i> | Fraction of water going to BSoil            |
| 7.0 | <i>ToWater</i>     | <i>MU</i> | Fraction of water going to <i>Water</i>     |
| 8.0 | <i>ToRunoff</i>    | <i>MU</i> | Fraction of water going to <i>Runoff</i>    |
| 9.0 | <i>ToSoilStore</i> | <i>MU</i> | Fraction of water going to <i>SoilStore</i> |

An example *SUEWS\_WithinGridWaterDist.txt* can be found in the online version.

## Input Options

a1

**Description** Coefficient for  $Q^*$  term [-]

**Configuration**

| Referencing Table                | Requirement | Comment                        |
|----------------------------------|-------------|--------------------------------|
| <i>SUEWS_OHMCoefficients.txt</i> | <i>MU</i>   | Coefficient for $Q^*$ term [-] |

a2

**Description** Coefficient for  $dQ^*/dt$  term [h]

**Configuration**

| Referencing Table                | Requirement | Comment                            |
|----------------------------------|-------------|------------------------------------|
| <i>SUEWS_OHMCoefficients.txt</i> | <i>MU</i>   | Coefficient for $dQ^*/dt$ term [h] |

a3

**Description** Constant term [ $W\ m^{-2}$ ]

**Configuration**

| Referencing Table                | Requirement | Comment                       |
|----------------------------------|-------------|-------------------------------|
| <i>SUEWS_OHMCoefficients.txt</i> | <i>MU</i>   | Constant term [ $W\ m^{-2}$ ] |



**ActivityProfWD**

**Description** Code linking to *ActivityProfWD* in *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>L</i>    | Code for human activity profile (weekdays) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . Used for CO2 flux calculation. |

**ActivityProfWE**

**Description** Code linking to *ActivityProfWE* in *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>L</i>    | Code for human activity profile (weekends) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Look the codes Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . Used for CO2 flux calculation. |

**AHMin\_WD**

**Description** Minimum QF on weekdays [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AHMin\_WE**

**Description** Minimum QF on weekends [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AHSlope\_Heating\_WD**

**Description** Heating slope of QF on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AHSlope\_Heating\_WE**

**Description** Heating slope of QF on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AHSlope\_Cooling\_WD**

**Description** Cooling slope of QF on weekdays [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AHSlope\_Cooling\_WE**

**Description** Cooling slope of QF on weekends [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**AlbedoMax**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Effective surface albedo (middle of the day value) for summertime. View factors should be taken into account. |

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Table 7.18 – continued from previous page

| Referencing Table      | Requirement | Comment   |
|------------------------|-------------|---|
| <i>SUEWS_Veg.txt</i>   | <i>MU</i>   | Example values [-]<br><ul style="list-style-type: none"> <li>• 0.1 EveTr [Oke, 2002]</li> <li>• 0.18 DecTr [Oke, 2002]</li> <li>• 0.21 Grass [Oke, 2002]</li> </ul> |
| <i>SUEWS_Water.txt</i> | <i>MU</i>   | Example values [-]<br><ul style="list-style-type: none"> <li>• 0.1 Water [Oke, 2002]</li> </ul>   |
| <i>SUEWS_Snow.txt</i>  | <i>MU</i>   | Example values [-]<br><ul style="list-style-type: none"> <li>• 0.85 [Järvi <i>et al.</i>, 2014]</li> </ul>  |

**AlbedoMin**

**Description** Effective surface albedo (middle of the day value) for wintertime (not including snow).

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Not currently used for non-vegetated surfaces – set the same as AlbedoMax.  |
| <i>SUEWS_Veg.txt</i>    | <i>MU</i>   | Example values [-]<br><ul style="list-style-type: none"> <li>• 0.1 EveTr [Oke, 2002]</li> <li>• 0.18 DecTr [Oke, 2002]</li> <li>• 0.21 Grass [Oke, 2002]</li> </ul> |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Not currently used for water surface - set same as AlbedoMax.   |
| <i>SUEWS_Snow.txt</i>   | <i>MU</i>   | Example values [-]<br><ul style="list-style-type: none"> <li>• 0.18 [Järvi <i>et al.</i>, 2014]</li> </ul>  |

**alpha**

**Description** The mean apparent ecosystem quantum. Represents the initial slope of the light-response curve. Not in use [ $\mu\text{mol CO}_2 \mu\text{mol photons}^{-1}$ ].

**Configuration**

| Referencing Table          | Requirement | Comment  |
|----------------------------|-------------|--|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example values:<br><i>EmissionsMethod</i> = 11,<br>12, 13, 14, 15 or 16:<br><ul style="list-style-type: none"> <li>• 0.044 [Ruimy <i>et al.</i>, 1995]</li> <li>• 0.0593 [Schmid, 2000]</li> <li>• 0.0205 [Flanagan <i>et al.</i>, 2002]</li> </ul> <i>EmissionsMethod</i> = 21, 22, 23,<br>24, 25, or 26: 0.031 [Bellucco <i>et al.</i> , 2017] <i>EmissionsMethod</i> =<br>31, 32, 33, 34, 35, 36: 0.005 [Bellucco <i>et al.</i> , 2017] |

**Alt**

**Description** Altitude of grids [m].

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Used for both the radiation and water flow between grids. <b>Not available in this version.</b> |

**AnOHM\_Ch**

**Description** Bulk transfer coefficient for this surface to use in AnOHM [-]

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Bulk transfer coefficient for this surface to use in AnOHM [-] |
| <i>SUEWS_Veg.txt</i>    | <i>MU</i>   | Bulk transfer coefficient for this surface to use in AnOHM [-] |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Bulk transfer coefficient for this surface to use in AnOHM [-] |
| <i>SUEWS_Snow.txt</i>   | <i>MU</i>   | Bulk transfer coefficient for this surface to use in AnOHM [-] |

**AnOHM\_Cp**

**Description** Volumetric heat capacity for this surface to use in AnOHM [J m<sup>-3</sup>]

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ] |
| <i>SUEWS_Veg.txt</i>    | <i>MU</i>   | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ] |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ] |
| <i>SUEWS_Snow.txt</i>   | <i>MU</i>   | Volumetric heat capacity for this surface to use in AnOHM [J m <sup>-3</sup> ] |

**AnOHM\_Kk**

**Description** Thermal conductivity for this surface to use in AnOHM [W m K<sup>-1</sup>]

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ] |
| <i>SUEWS_Veg.txt</i>    | <i>MU</i>   | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ] |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ] |
| <i>SUEWS_Snow.txt</i>   | <i>MU</i>   | Thermal conductivity for this surface to use in AnOHM [W m K <sup>-1</sup> ] |

**AnthropogenicCode**

**Description** Code for modelling anthropogenic heat flux linking to *Code* of *SUEWS\_AnthropogenicEmission.txt*, which contains the model coefficients for estimation of the anthropogenic heat flux (used if *EmissionsMethod* = 1, 2 in *RunControl.nml*).

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_AnthropogenicEmission.txt</i> . |

**AreaWall**

**Description** Area of wall within grid (needed for ESTM calculation) [ m<sup>2</sup> ].

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Area of wall within grid (needed for ESTM calculation). [ m <sup>2</sup> ] |

**BaseT**

**Description** Base Temperature for initiating growing degree days (GDD) for leaf growth. [°C]

**Configuration**

| Referencing Table             | Requirement        | Comment  |
|-------------------------------|--------------------|--|
| <a href="#">SUEWS_Veg.txt</a> | <a href="#">MU</a> | See section 2.2 Järvi et al. (2011); Appendix A of Järvi et al. [2014]. Example values: 5 for EveTr [Järvi et al., 2011] |

**BaseTe**

**Description** Base temperature for initiating sensesance degree days (SDD) for leaf off. [°C]

**Configuration**

| Referencing Table             | Requirement        | Comment   |
|-------------------------------|--------------------|---|
| <a href="#">SUEWS_Veg.txt</a> | <a href="#">MU</a> | See section 2.2 Järvi et al. [2011] ; Appendix A Järvi et al. [2014] . Example values: 10 EveTr Järvi et al. [2011] |

**BaseT\_HC**

**Description** Base temperature for heating degree days [°C]

**Configuration**

| Referencing Table                               | Requirement        | Comment  |
|---|--------------------|--|
| <a href="#">SUEWS_AnthropogenicEmission.txt</a> | <a href="#">MU</a> | Base temperature for heating degree days [°C] e.g. Sailor and Vasireddy [2006] |

**beta**

**Description** The light-saturated gross photosynthesis of the canopy describing the maximum photosynthesis the certain vegetation can have. [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]

**Configuration**

| Referencing Table          | Requirement | Comment   |
|----------------------------|-------------|---|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | <p>Example values:<br/> <i>EmissionsMethod</i> = 45 (Recommended): - 8.35 (Street tree Tilia) [Havu <i>et al.</i>, 2022] - 13.18 (Street tree Alnus) [Havu <i>et al.</i>, 2022] - 5.5 (Lawn): [Zheng <i>et al.</i>, 2023]</p> <p>Not recommended:<br/> <i>EmissionsMethod</i> = 11 - 16:</p> <ul style="list-style-type: none"> <li>• 43.35 [Ruimy <i>et al.</i>, 1995]</li> <li>• 35 [Schmid, 2000]</li> <li>• 16.3 [Flanagan <i>et al.</i>, 2002]</li> </ul> <p><i>EmissionsMethod</i> = 21 - 26: 17.793 [Bellucco <i>et al.</i>, 2017]<br/> <i>EmissionsMethod</i> = 31 - 36: 8.474 [Bellucco <i>et al.</i>, 2017]</p> |

**theta**

**Description** The convexity of the curve at light saturation. Not in use.

**Configuration**

| Referencing Table          | Requirement | Comment  |
|----------------------------|-------------|--|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | <p>Example value:<br/> <i>EmissionsMethod</i> = 21, 22, 23, 24, 25, 26: 0.723 [Bellucco <i>et al.</i>, 2017]<br/> <i>EmissionsMethod</i> = 31, 32, 33, 34, 35, 36: 0.96 [Bellucco <i>et al.</i>, 2017]</p> |

**alpha\_enh**

**Description** Part of the *alpha* coefficient related to the fraction of vegetation.

**Configuration**

| Referencing Table          | Requirement | Comment  |
|----------------------------|-------------|--|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example value: 0.016 [Bellucco <i>et al.</i> , 2017] |

**beta\_enh**

**Description** Part of the *beta* coefficient related to the fraction of vegetation.

**Configuration**

| Referencing Table          | Requirement | Comment   |
|----------------------------|-------------|---|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example values: 33.454 [Bel-lucco <i>et al.</i> , 2017] |

**resp\_a**

**Description** Soil and vegetation respiration coefficient a.

**Configuration**

| Referencing Table          | Requirement | Comment  |
|----------------------------|-------------|--|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example values: <ul style="list-style-type: none"> <li>• 1.08 (broadleaf forest, US) [Schmid, 2000]</li> <li>• 2.1 (lawn, Helsinki) [Järvi <i>et al.</i>, 2019]</li> </ul> |
| • 0.78 (Tilia street tree  | no soil     | Helsinki) [Havu <i>et al.</i> , 2022]”   |
| • 1.11 (Alnus street tree  | no soil     | Helsinki) [Havu <i>et al.</i> , 2022]”   |
|                            |             |  |

**resp\_b**

**Description** Soil and vegetation respiration coefficient b - related to air temperature dependency.

**Configuration**

| Referencing Table          | Requirement | Comment   |
|----------------------------|-------------|---|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example values: <ul style="list-style-type: none"> <li>• 0.0064 (deciduous forest, US) [Schmid, 2000]</li> <li>• 0.06 (lawn, Helsinki) [Järvi <i>et al.</i>, 2019]</li> </ul> |
| • 0.08 (Tilia street tree  | no soil     | Helsinki) [Havu <i>et al.</i> , 2022]”  |
| • 0.08 (Alnus street tree  | no soil     | Helsinki) [Havu <i>et al.</i> , 2022]”  |
|                            |             |   |

**min\_respi**

**Description** Minimum soil and vegetation respiration rate (for cold-temperature limit) [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ].



**Configuration**

| Referencing Table          | Requirement | Comment   |
|----------------------------|-------------|---|
| <i>SUEWS_BiogenCO2.txt</i> | <i>MU 0</i> | Example values: 0.6 estimate from Hyytiälä forest site. |

**BiogenCO2Code**

**Description** Code linking to the *Code* column in *SUEWS\_BiogenCO2.txt*.

**Configuration**

| Referencing Table    | Requirement | Comment  |
|----------------------|-------------|--|
| <i>SUEWS_Veg.txt</i> | <i>L</i>    | Code linking to the <i>Code</i> column in <i>SUEWS_BiogenCO2.txt</i> . |

**QF0\_BEU\_WD**

**Description** Building energy use [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | Weekday building energy use [ $\text{W m}^{-2}$ ] Can be used for CO2 flux calculation. |

**QF0\_BEU\_WE**

**Description** Building energy use [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table           | Requirement | Comment                               |
|-----------------------------|-------------|---------------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | Can be used for CO2 flux calculation. |

**CO2PointSource**

**Description** CO2 emission point source within the grid [ $\text{kgC day}^{-1}$ ]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | CO2 emission point source within the grid [ $\text{kgC day}^{-1}$ ] |

## Code

**Description** Code linking to a corresponding look-up table.

**Configuration**

| Referencing Table            | Requirement | Comment   |
|------------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i>      | <i>L</i>    | Code linking to <i>SUEWS_SiteSelect.txt</i> for paved surfaces (Code_Paved), buildings (Code_Bldgs) and bare soil surfaces (Code_BSoil). Value of integer is arbitrary but must match codes specified in <i>SUEWS_SiteSelect.txt</i> .                                |
| <i>SUEWS_Veg.txt</i>         | <i>L</i>    | Code linking to <i>SUEWS_SiteSelect.txt</i> for evergreen trees and shrubs (Code_EveTr), deciduous trees and shrubs (Code_DecTr) and grass surfaces (Code_Grass). Value of integer is arbitrary but must match codes specified in <i>SUEWS_SiteSelect.txt</i> .       |
| <i>SUEWS_Water.txt</i>       | <i>L</i>    | Code linking to <i>SUEWS_SiteSelect.txt</i> for water surfaces (Code_Water). Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> .   |
| <i>SUEWS_Snow.txt</i>        | <i>L</i>    | Code linking to <i>SUEWS_SiteSelect.txt</i> for snow surfaces (SnowCode). Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> .  |
| <i>SUEWS_Soil.txt</i>        | <i>L</i>    | Code linking to the SoilTypeCode column in <i>SUEWS_NonVeg.txt</i> (for Paved, Bldgs and BSoil surfaces) and <i>SUEWS_Veg.txt</i> (for EveTr, DecTr and Grass surfaces). Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> . |
| <i>SUEWS_Conductance.txt</i> | <i>L</i>    | Code linking to the CondCode column in <i>SUEWS_SiteSelect.txt</i> . Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> .   |

continues on next page

Table 7.41 – continued from previous page

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>L</i>    | Code linking to the <i>AnthropogenicCode</i> column in <i>SUEWS_SiteSelect.txt</i> . Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> .  |
| <i>SUEWS_Irrigation.txt</i>            | <i>L</i>    | Code linking to <i>SUEWS_SiteSelect.txt</i> for irrigation modelling ( <i>IrrigationCode</i> ). Value of integer is arbitrary but must match codes specified in <i>SUEWS_SiteSelect.txt</i> .  |
| <i>SUEWS_OHMCoefficients.txt</i>       | <i>L</i>    | Code linking to the <i>OHMCode_SummerWet</i> , <i>OHMCode_SummerDry</i> , <i>OHMCode_WinterWet</i> and <i>OHMCode_WinterDry</i> columns in <i>SUEWS_NonVeg.txt</i> , <i>SUEWS_Veg.txt</i> , <i>SUEWS_Water.txt</i> and <i>SUEWS_Snow.txt</i> files. Value of integer is arbitrary but must match code specified in <i>SUEWS_SiteSelect.txt</i> . |
| <i>SUEWS_ESTMCoefficients.txt</i>      | <i>L</i>    | For buildings and paved surfaces, set to zero if there is more than one ESTM class per grid and the codes and surface fractions specified in <i>SUEWS_SiteSelect.txt</i> will be used instead.   |
| <i>SUEWS_BiogenCO2.txt</i>             | <i>L</i>    | Code linking to the <i>BiogenCO2Code</i> column in <i>SUEWS_Veg.txt</i> .  |

**Code\_Bldgs**

**Description** Code for *Bldgs* surface characteristics linking to *Code* of *SUEWS\_NonVeg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for Bldgs surface characteristics Provides the link to column 1 of <i>SUEWS_NonVeg.txt</i> , which contains the attributes describing buildings in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_NonVeg.txt</i> . |

**Code\_BSoil**

**Description** Code for *BSoil* surface characteristics linking to *Code* of *SUEWS\_NonVeg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_NonVeg.txt</i> . |

**Code\_DecTr**

**Description** Code for *DecTr* surface characteristics linking to *Code* of *SUEWS\_Veg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for DecTr surface characteristics Provides the link to column 1 of <i>SUEWS_Veg.txt</i> , which contains the attributes describing deciduous trees and shrubs in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Veg.txt</i> . |

**Code\_ESTMClass\_Bldgs1**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Bldgs2**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Bldgs3**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Bldgs4**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Bldgs5**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Paved1**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Paved2**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_ESTMClass\_Paved3**

**Description** Code linking to *SUEWS\_ESTMCoefficients.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code linking to <i>SUEWS_ESTMCoefficients.txt</i> |

**Code\_EveTr**

**Description** Code for *EveTr* surface characteristics linking to *Code* of *SUEWS\_Veg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for EveTr surface characteristics Provides the link to column 1 of <i>SUEWS_Veg.txt</i> , which contains the attributes describing evergreen trees and shrubs in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Veg.txt</i> . |

**Code\_Grass**

**Description** Code for *Grass* surface characteristics linking to *Code* of *SUEWS\_Veg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for Grass surface characteristics Provides the link to column 1 of <i>SUEWS_Veg.txt</i> , which contains the attributes describing grass surfaces in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Veg.txt</i> . |

**Code\_Paved**

**Description** Code for *Paved* surface characteristics linking to *Code* of *SUEWS\_NonVeg.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for Paved surface characteristics Provides the link to column 1 of <i>SUEWS_NonVeg.txt</i> , which contains the attributes describing paved areas in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_NonVeg.txt</i> . e.g. 331 means use the characteristics specified in the row of input file <i>SUEWS_NonVeg.txt</i> which has 331 in column 1 (Code). |

**Code\_Water**

**Description** Code for *Water* surface characteristics linking to *Code* of *SUEWS\_Water.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for Water surface characteristics Provides the link to column 1 of <i>SUEWS_Water.txt</i> , which contains the attributes describing open water in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Water.txt</i> . |

**CondCode**

**Description** Code for surface conductance parameters linking to *Code* of *SUEWS\_Conductance.txt*

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <i>L</i>    | Code for surface conductance parameters Provides the link to column 1 of <a href="#">SUEWS_Conductance.txt</a> , which contains the parameters for the Jarvis [1976] parameterisation of surface conductance. Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_Conductance.txt</a> . e.g. 33 means use the characteristics specified in the row of input file <a href="#">SUEWS_Conductance.txt</a> which has 33 in column 1 (Code). |

**CRWMax**

**Description** Maximum water holding capacity of snow [mm]

**Configuration**

| Referencing Table              | Requirement | Comment                                     |
|--------------------------------|-------------|---|
| <a href="#">SUEWS_Snow.txt</a> | <i>MD</i>   | Maximum water holding capacity of snow [mm] |

**CRWMin**

**Description** Minimum water holding capacity of snow [mm]

**Configuration**

| Referencing Table              | Requirement | Comment                                     |
|--------------------------------|-------------|---|
| <a href="#">SUEWS_Snow.txt</a> | <i>MD</i>   | Minimum water holding capacity of snow [mm] |

**DayWat (1)**

**Description** Irrigation allowed on Sundays [1], if not [0]

**Configuration**

| Referencing Table                    | Requirement | Comment                                       |
|--------------------------------------|-------------|---|
| <a href="#">SUEWS_Irrigation.txt</a> | <i>MU</i>   | Irrigation allowed on Sundays [1], if not [0] |

**DayWat (2)**

**Description** Irrigation allowed on Mondays [1], if not [0]



**Configuration**

| Referencing Table           | Requirement | Comment                                       |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Mondays [1], if not [0] |

**DayWat (3)**

**Description** Irrigation allowed on Tuesdays [1], if not [0]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Tuesdays [1], if not [0] |

**DayWat (4)**

**Description** Irrigation allowed on Wednesdays [1], if not [0]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Wednesdays [1], if not [0] |

**DayWat (5)**

**Description** Irrigation allowed on Thursdays [1], if not [0]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Thursdays [1], if not [0] |

**DayWat (6)**

**Description** Irrigation allowed on Fridays [1], if not [0]

**Configuration**

| Referencing Table           | Requirement | Comment                                       |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Fridays [1], if not [0] |

**DayWat (7)**

**Description** Irrigation allowed on Saturdays [1], if not [0]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Irrigation allowed on Saturdays [1], if not [0] |

**DayWatPer(1)**

**Description** Fraction of properties using irrigation on Sundays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Sundays [0-1] |

**DayWatPer(2)**

**Description** Fraction of properties using irrigation on Mondays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Mondays [0-1] |

**DayWatPer(3)**

**Description** Fraction of properties using irrigation on Tuesdays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Tuesdays [0-1] |

**DayWatPer(4)**

**Description** Fraction of properties using irrigation on Wednesdays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Wednesdays [0-1] |

**DayWatPer(5)**

**Description** Fraction of properties using irrigation on Thursdays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Thursdays [0-1] |

**DayWatPer(6)**

**Description** Fraction of properties using irrigation on Fridays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Fridays [0-1] |

**DayWatPer(7)**

**Description** Fraction of properties using irrigation on Saturdays [0-1]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of properties using irrigation on Saturdays [0-1] |

**DrainageCoef1**

**Description** Coefficient  $D0$  [ $\text{mm h}^{-1}$ ] used in *DrainageEq*

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | <ul style="list-style-type: none"> <li>Example values:               <ul style="list-style-type: none"> <li><i>DrainageEq</i> = 3, 10 for <i>Paved</i> and <i>Bldgs</i>;</li> <li><i>DrainageEq</i> = 2, 0.013 for <i>BSoil</i></li> </ul> </li> </ul> |

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Table 7.74 – continued from previous page

| Referencing Table      | Requirement | Comment   |
|------------------------|-------------|---|
| <i>SUEWS_Veg.txt</i>   | <i>MD</i>   | <ul style="list-style-type: none"> <li>• Example values: <ul style="list-style-type: none"> <li>– <i>DrainageEq</i> = 3, 10 for <i>Grass</i> (irrigated);</li> <li>– <i>DrainageEq</i> = 2, 0.013 for <i>EveTr</i>, <i>DecTr</i>, <i>Grass</i> (unirrigated)</li> </ul> </li> </ul> |
| <i>SUEWS_Water.txt</i> | <i>MD</i>   | Not currently used for water surface  |

**DrainageCoef2****Description** Coefficient b [-] used in *DrainageEq***Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | <ul style="list-style-type: none"> <li>• Example values: <ul style="list-style-type: none"> <li>– <i>DrainageEq</i> = 3, 3 for <i>Paved</i> and <i>Bldgs</i></li> <li>– <i>DrainageEq</i> = 2, 1.71 for <i>BSoil</i></li> </ul> </li> </ul>                                      |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | <ul style="list-style-type: none"> <li>• Example values: <ul style="list-style-type: none"> <li>– <i>DrainageEq</i> = 3, 3 for <i>Grass</i> (irrigated)</li> <li>– <i>DrainageEq</i> = 2, 1.71 for <i>EveTr</i>, <i>DecTr</i>, <i>Grass</i> (unirrigated)</li> </ul> </li> </ul> |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Not currently used for water surface   |

**DrainageEq****Description** Calculation choice for Drainage equation**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | <ul style="list-style-type: none"> <li>Options: <ul style="list-style-type: none"> <li>1: Falk and Niemczynowicz [1978]</li> <li>2: Halldin <i>et al.</i> [1979] (Rutter eqn corrected for <math>c=0</math>, see Calder and Wright [1986])</li> <li>3: for <i>BSoil</i> [Falk and Niemczynowicz, 1978] ; for <i>Paved</i> and <i>Bldgs</i> Coefficients are specified in the following two columns. <b>Recommended in this version.</b></li> </ul> </li> </ul>  |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | <ul style="list-style-type: none"> <li>Options: <ul style="list-style-type: none"> <li>1: Falk and Niemczynowicz [1978]</li> <li>2: Halldin <i>et al.</i> [1979] (Rutter eqn corrected for <math>c=0</math>, see Calder &amp; Wright (1986) [Calder and Wright, 1986] )</li> <li>3: for <i>EveTr</i>, <i>DecTr</i>, <i>Grass</i> (unirrigated) see Falk and Niemczynowicz [1978]. Coefficients are specified in the following two columns. <b>Recommended in this version.</b></li> </ul> </li> </ul> |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Not currently used for water surface.   |

**EF\_umolCO2perJ**

**Description** Emission factor for fuels used for building heating. [umol CO<sub>2</sub> J<sup>-1</sup>]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Used with EmissionMethod = 4 to calculate building CO <sub>2</sub> emissions. |

**Emissivity**

**Description** Effective surface emissivity.

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>MU</i>   | Effective surface emissivity. View factors should be taken into account.  |
| <i>SUEWS_Veg.txt</i>    | <i>MU</i>   | Example values [-] <ul style="list-style-type: none"><li>• 0.98 EveTr [Oke, 2002]</li><li>• 0.98 DecTr [Oke, 2002]</li><li>• 0.93 Grass [Oke, 2002]</li></ul> |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Example values [-] <ul style="list-style-type: none"><li>• 0.95 Water [Oke, 2002]</li></ul>   |
| <i>SUEWS_Snow.txt</i>   | <i>MU</i>   | Example values [-] <ul style="list-style-type: none"><li>• 0.99 [Järvi <i>et al.</i>, 2014]</li></ul>   |

**EndDLS**

**Description** End of the day light savings [DOY]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | End of the day light savings [DOY] See <i>Day Light Savings (DLS)</i> . |

**EnEF\_v\_Jkm**

**Description** Emission factor for heat from traffic [ $\text{J k m}^{-1}$ ].

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>0</i>    | Emission factor for heat [ $\text{J k m}^{-1}$ ]. Example values: 3.97e6 Sailor and Lu (2004) [Sailor and Lu, 2004] |

**EnergyUseProfWD**

**Description** Code linking to *EnergyUseProfWD* in *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table                               | Requirement | Comment   |
|---|-------------|---|
| <a href="#">SUEWS_AnthropogenicEmission.txt</a> | <i>L</i>    | Code for energy use profile (weekdays) Provides the link to column 1 of <a href="#">SUEWS_Profiles.txt</a> . Look the codes Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_Profiles.txt</a> . |

**EnergyUseProfWE**

**Description** Code linking to [EnergyUseProfWE](#) in [SUEWS\\_Profiles.txt](#).

**Configuration**

| Referencing Table                               | Requirement | Comment  |
|---|-------------|--|
| <a href="#">SUEWS_AnthropogenicEmission.txt</a> | <i>L</i>    | Code for energy use profile (weekends) Provides the link to column 1 of <a href="#">SUEWS_Profiles.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_Profiles.txt</a> . |

**ESTMCode**

**Description** Code for ESTM coefficients linking to [SUEWS\\_ESTMCoefficients.txt](#)

**Configuration**

| Referencing Table                | Requirement | Comment   |
|----------------------------------|-------------|---|
| <a href="#">SUEWS_NonVeg.txt</a> | <i>L</i>    | For paved and building surfaces, it is possible to specify multiple codes per grid (3 for paved, 5 for buildings) using <a href="#">SUEWS_SiteSelect.txt</a> . In this case, set ESTMCode here to zero.                           |
| <a href="#">SUEWS_Veg.txt</a>    | <i>L</i>    | Code for ESTM coefficients to use for this surface. Links to <a href="#">SUEWS_ESTMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_ESTMCoefficients.txt</a> . |

continues on next page

Table 7.83 – continued from previous page

| Referencing Table      | Requirement | Comment   |
|------------------------|-------------|---|
| <i>SUEWS_Water.txt</i> | <i>L</i>    | Code for ESTM coefficients to use for this surface. Links to <i>SUEWS_ESTMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_ESTMCoefficients.txt</i> . |
| <i>SUEWS_Snow.txt</i>  | <i>L</i>    | For paved and building surfaces, it is possible to specify multiple codes per grid (3 for paved, 5 for buildings) using <i>SUEWS_SiteSelect.txt</i> . In this case, set ESTM code here to zero.                 |

**FAI\_Bldgs****Description** Frontal area index for buildings [-]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | Frontal area index for buildings [-] Required if <i>RoughLenMomMethod</i> = 3 in <i>RunControl.nml</i> . |

**FAI\_DecTr****Description** Frontal area index for deciduous trees [-]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | Frontal area index for deciduous trees [-] Required if <i>RoughLenMomMethod</i> = 3 in <i>RunControl.nml</i> . |

**FAI\_EveTr****Description** Frontal area index for evergreen trees [-]**Configuration**



| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Frontal area index for ever-green trees [-] Required if <i>RoughLenMomMethod</i> = 3 in <i>RunControl.nml</i> . |

**Faut**

**Description** Fraction of irrigated area that is irrigated using automated systems

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Fraction of irrigated area that is irrigated using automated systems (e.g. sprinklers). |

**FcEF\_v\_kgkmWD**

**Description** CO2 emission factor for traffic on weekdays [kg km<sup>-1</sup>]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | CO2 emission factor for weekdays [kg km <sup>-1</sup> ] Can be used for CO2 flux calculation. |

**FcEF\_v\_kgkmWE**

**Description** CO2 emission factor for traffic on weekends [kg km<sup>-1</sup>]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | CO2 emission factor for weekdays [kg km <sup>-1</sup> ] Can be used for CO2 flux calculation. |

**FcEF\_v\_Jkm**

**Description** Traffic emission factor for CO2.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Weekday building energy use [ $\text{W m}^{-2}$ ] Can be used for CO2 flux calculation. |

**fcld**

**Description** Cloud fraction [tenths]

**Configuration**

| Referencing Table            | Requirement | Comment                 |
|------------------------------|-------------|-------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Cloud fraction [tenths] |

**FlowChange**

**Description** Difference in input and output flows for water surface [ $\text{mm h}^{-1}$ ]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | MD          | Difference in input and output flows for water surface [ $\text{mm h}^{-1}$ ] Used to indicate river or stream flow through the grid. Currently not fully tested! |

**Fraction1of8**

**Description** Fraction of water that can flow to *GridConnection1of8* [-]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | MD MU       | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction2of8**

**Description** Fraction of water that can flow to *GridConnection2of8* [-]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | MD MU       | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction3of8**

**Description** Fraction of water that can flow to [GridConnection3of8](#) [-]

**Configuration**

| Referencing Table                    | Requirement           | Comment  |
|--------------------------------------|-----------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD MU</a> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction4of8**

**Description** Fraction of water that can flow to [GridConnection4of8](#) [-]

**Configuration**

| Referencing Table                    | Requirement           | Comment  |
|--------------------------------------|-----------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD MU</a> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction5of8**

**Description** Fraction of water that can flow to [GridConnection5of8](#) [-]

**Configuration**

| Referencing Table                    | Requirement           | Comment  |
|--------------------------------------|-----------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD MU</a> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction6of8**

**Description** Fraction of water that can flow to [GridConnection6of8](#) [-]

**Configuration**

| Referencing Table                    | Requirement           | Comment  |
|--------------------------------------|-----------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD MU</a> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction7of8**

**Description** Fraction of water that can flow to [GridConnection7of8](#) [-]

**Configuration**

| Referencing Table           | Requirement  | Comment  |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fraction8of8**

**Description** Fraction of water that can flow to *GridConnection8of8* [-]

**Configuration**

| Referencing Table           | Requirement  | Comment  |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Fraction of water that can flow to the grid specified in previous column [-] |

**Fr\_Bldgs**

**Description** Surface cover fraction of buildings [-]

**Configuration**

| Referencing Table           | Requirement | Comment                                 |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of buildings [-] |

**Fr\_Bsoil**

**Description** Surface cover fraction of bare soil or unmanaged land [-]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of bare soil or unmanaged land [-] |

**Fr\_DecTr**

**Description** Surface cover fraction of deciduous trees and shrubs [-]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of deciduous trees and shrubs [-] |

**Fr\_ESTMClass\_Bldgs1**

**Description** Surface cover fraction of building class 1 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 94-98 must add up to 1 |

**Fr\_ESTMClass\_Bldgs2**

**Description** Surface cover fraction of building class 2 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 94-98 must add up to 1 |

**Fr\_ESTMClass\_Bldgs3**

**Description** Surface cover fraction of building class 3 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 94-98 must add up to 1 |

**Fr\_ESTMClass\_Bldgs4**

**Description** Surface cover fraction of building class 4 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 94-98 must add up to 1 |

**Fr\_ESTMClass\_Bldgs5**

**Description** Surface cover fraction of building class 5 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 94-98 must add up to 1 |

**Fr\_ESTMClass\_Paved1**

**Description** Surface cover fraction of *Paved* surface class 1 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 88-90 must add up to 1 |

**Fr\_ESTMClass\_Paved2**

**Description** Surface cover fraction of *Paved* surface class 2 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 88-90 must add up to 1 |

**Fr\_ESTMClass\_Paved3**

**Description** Surface cover fraction of *Paved* surface class 3 used in ESTM calculations

**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 88-90 must add up to 1 |

**Fr\_EveTr**

**Description** Surface cover fraction of *EveTr*: evergreen trees and shrubs [-]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of evergreen trees and shrubs [-] |

**Fr\_Grass**

**Description** Surface cover fraction of *Grass* [-]

**Configuration**

| Referencing Table           | Requirement | Comment                             |
|-----------------------------|-------------|-------------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of grass [-] |

**Fr\_Paved**

**Description** Surface cover fraction of *Paved* surfaces [-]

**Configuration**

| Referencing Table           | Requirement | Comment                          |
|-----------------------------|-------------|----------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Columns 14 to 20 must sum to 1 . |

**Fr\_Water**

**Description** Surface cover fraction of open water [-]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Surface cover fraction of open water [-] (e.g. river, lakes, ponds, swimming pools) |

**FrFossilFuel\_Heat**

**Description** Fraction of fossil fuels used for building heating [-]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Weekday building energy use [ $\text{W m}^{-2}$ ] Can be used for CO2 flux calculation. |

**FrFossilFuel\_NonHeat**

**Description** Fraction of fossil fuels used for building energy use [-]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Weekday building energy use [ $\text{W m}^{-2}$ ] Can be used for CO2 flux calculation. |

**FrPDDwe**

**Description** Fraction of weekend population to weekday population. [-]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU</i> 0 | Fraction of weekend population to weekday population. [-] |

**G1**

**Description** Related to maximum surface conductance [ $\text{mm s}^{-1}$ ]

**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to maximum surface conductance [mm s <sup>-1</sup> ] |

G2

**Description** Related to Kdown dependence [W m<sup>-2</sup>]**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to Kdown dependence [W m <sup>-2</sup> ] |

G3

**Description** Related to VPD dependence [units depend on *gsModel*]**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to VPD dependence [units depend on gsChoice in <i>RunControl.nml</i> ] |

G4

**Description** Related to VPD dependence [units depend on *gsModel*]**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to VPD dependence [units depend on gsChoice in <i>RunControl.nml</i> ] |

G5

**Description** Related to temperature dependence [°C]**Configuration**

| Referencing Table            | Requirement | Comment                                |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to temperature dependence [°C] |



G6

**Description** Related to soil moisture dependence [ $\text{mm}^{-1}$ ]**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to soil moisture dependence [ $\text{mm}^{-1}$ ] |

gamq\_gkgm

**Description** vertical gradient of specific humidity [ $\text{g kg}^{-1} \text{ m}^{-1}$ ]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | vertical gradient of specific humidity ( $\text{g kg}^{-1} \text{ m}^{-1}$ ) |

gamt\_Km

**Description** vertical gradient of potential temperature [ $\text{K m}^{-1}$ ]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | vertical gradient of potential temperature ( $\text{K m}^{-1}$ ) strength of the inversion |

GDDFull

**Description** The growing degree days (GDD) needed for full capacity of the leaf area index (LAI) [ $^{\circ}\text{C}$ ].**Configuration**

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MU</i>   | This should be checked carefully for your study area using modelled LAI from the DailyState output file compared to known behaviour in the study area. See section 2.2 Järvi <i>et al.</i> [2011] ; Appendix A Järvi <i>et al.</i> [2014] for more details. Example values: 300 for <i>EveTr</i> Järvi <i>et al.</i> [2011] |

## Grid

**Description** a unique number to represent grid

### Configuration

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Grid numbers do not need to be consecutive and do not need to start at a particular value. Each grid must have a unique grid number. All grids must be present for all years. These grid numbers are referred to in Grid-Connections (columns 64-79) ( N.B. <b>Not available in this version.</b> ) |

## GridConnection1of8

**Description** Number of the 1st grid where water can flow to The next 8 pairs of columns specify the water flow between grids. The first column of each pair specifies the grid that the water flows to (from the current grid, column 1); the second column of each pair specifies the fraction of water that flow to that grid. The fraction (i.e. amount) of water transferred may be estimated based on elevation, the length of connecting surface between grids, presence of walls, etc. Water cannot flow from the current grid to the same grid, so the grid number here must be different to the grid number in column 1. Water can flow to a maximum of 8 other grids. If there is no water flow between grids, or a single grid is run, set to 0. See section on Grid Connections

### Configuration

| Referencing Table           | Requirement  | Comment   |
|-----------------------------|--------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | The next 8 pairs of columns specify the water flow between grids. The first column of each pair specifies the grid that the water flows to (from the current grid, column 1); the second column of each pair specifies the fraction of water that flow to that grid. The fraction (i.e. amount) of water transferred may be estimated based on elevation, the length of connecting surface between grids, presence of walls, etc. Water cannot flow from the current grid to the same grid, so the grid number here must be different to the grid number in column 1. Water can flow to a maximum of 8 other grids. If there is no water flow between grids, or a single grid is run, set to 0. See section on Grid Connections |

**GridConnection2of8**

**Description** Number of the 2nd grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection3of8**

**Description** Number of the 3rd grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection4of8**

**Description** Number of the 4th grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection5of8**

**Description** Number of the 5th grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection6of8**

**Description** Number of the 6th grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection7of8**

**Description** Number of the 7th grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**GridConnection8of8**

**Description** Number of the 8th grid where water can flow to

**Configuration**

| Referencing Table           | Requirement  | Comment                                    |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Number of the grid where water can flow to |

**gsModel**

**Description** Formulation choice for conductance calculation.

**Configuration**

| Referencing Table  | Requirement                             | Comment   |
|--|---|---|
| <i>SUEWS_Conductance.txt</i>   | <i>MD</i>                               | <ul style="list-style-type: none"> <li>• 1 [Järvi <i>et al.</i>, 2011]</li> <li>• 2 [Ward <i>et al.</i>, 2016] <b>Recommended in this version.</b></li> </ul> |
| <ul style="list-style-type: none"> <li>• 3 as in [Järvi <i>et al.</i>, 2011]</li> </ul>                                    | but using<br>2 meter air<br>temperature |   |
| <ul style="list-style-type: none"> <li>• 4 as in [Ward <i>et al.</i>, 2016] <b>Recommended in this version.</b></li> </ul> | but using<br>2 meter air<br>temperature |   |

**H\_Bldgs****Description** Mean building height [m]**Configuration**

| Referencing Table           | Requirement | Comment                  |
|-----------------------------|-------------|--------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Mean building height [m] |

**H\_DecTr****Description** Mean height of deciduous trees [m]**Configuration**

| Referencing Table           | Requirement | Comment                            |
|-----------------------------|-------------|------------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Mean height of deciduous trees [m] |

**H\_EveTr****Description** Mean height of evergreen trees [m]**Configuration**

| Referencing Table           | Requirement | Comment                            |
|-----------------------------|-------------|------------------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Mean height of evergreen trees [m] |

**H\_maintain****Description** water depth to maintain used in automatic irrigation (e.g., ponding water due to flooding irrigation in rice crop-field) [mm].

**Note:**

1. *H\_maintain* can be positive (e.g., ponding water due to flooding irrigation in rice crop-field) or negative (e.g., soil water store level to maintain: *SoilStoreCap* + *H\_maintain* ) or zero (e.g., to maintain a maximum soil store level, i.e., *SoilStoreCap*).
2. Disable this feature by setting this parameter to -999: then no restrictions will be applied to maintain available water level.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | water depth to maintain used in automatic irrigation. |

**id****Description** Day of year [DOY]**Configuration**

| Referencing Table                    | Requirement | Comment                             |
|--------------------------------------|-------------|-------------------------------------|
| <i>SUEWS_SiteSelect.txt</i>          | <i>MD</i>   | Not used: set to 1 in this version. |
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Day of year [DOY]                   |
| <i>SSss_YYYY_data_tt.txt</i>         | <i>MU</i>   | Day of year [DOY]                   |
| <i>CBL_initial_data.txt</i>          | <i>MU</i>   | Day of year [DOY]                   |

**Ie\_a1****Description** Coefficient for automatic irrigation model [ $\text{mm d}^{-1}$  ]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for automatic irrigation model [ $\text{mm d}^{-1}$ ] |

**Ie\_a2****Description** Coefficient for automatic irrigation model [ $\text{mm d}^{-1} \text{K}^{-1}$ ]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for automatic irrigation model [ $\text{mm d}^{-1} \text{K}^{-1}$ ] |

**Ie\_a3****Description** Coefficient for automatic irrigation model [ $\text{mm d}^{-2}$ ]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for automatic irrigation model [ $\text{mm d}^{-2}$ ] |

**Ie\_end****Description** Day when irrigation ends [DOY]**Configuration**

| Referencing Table           | Requirement | Comment                        |
|-----------------------------|-------------|--------------------------------|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Day when irrigation ends [DOY] |

**Ie\_m1****Description** Coefficient for manual irrigation model [ $\text{mm d}^{-1}$ ]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for manual irrigation model [ $\text{mm d}^{-1}$ ] |

**Ie\_m2****Description** Coefficient for manual irrigation model [ $\text{mm d}^{-1} \text{K}^{-1}$ ]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for manual irrigation model [ $\text{mm d}^{-1} \text{K}^{-1}$ ] |

**Ie\_m3****Description** Coefficient for manual irrigation model [ $\text{mm d}^{-2}$ ]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MD</i>   | Coefficient for manual irrigation model [ $\text{mm d}^{-2}$ ] |

**Ie\_start**

**Description** Day when irrigation starts [DOY]

**Configuration**

| Referencing Table           | Requirement | Comment                          |
|-----------------------------|-------------|----------------------------------|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Day when irrigation starts [DOY] |

**ih**

**Description** Hour [H]

**Configuration**

| Referencing Table           | Requirement | Comment                                      |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD</i>   | Hour [H] Not used: set to 0 in this version. |

**imin**

**Description** Minute [M]

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i>          | <i>MD</i>   | Minute [M] Not used: set to 0 in this version. |
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Minute [M]                                     |
| <i>SSss_YYYY_data_tt.txt</i>         | <i>MU</i>   | Minute [M]                                     |

**InfiltrationRate**

**Description** Infiltration rate.

**Configuration**

| Referencing Table     | Requirement | Comment            |
|-----------------------|-------------|--------------------|
| <i>SUEWS_Soil.txt</i> | <i>O</i>    | Not currently used |

**Internal\_albedo**

**Description** Albedo of all internal elements for building surfaces only

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Albedo of all internal elements for building surfaces only |



**Internal\_CHbld**

**Description** Bulk transfer coefficient of internal building elements [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Bulk transfer coefficient of internal building elements [ $\text{W m}^{-2} \text{K}^{-1}$ ] (for building surfaces only and if <i>IbldCHmod</i> == 0 in <i>ESTMinput.nml</i> ) |

**Internal\_CHroof**

**Description** Bulk transfer coefficient of internal roof [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Bulk transfer coefficient of internal roof [ $\text{W m}^{-2} \text{K}^{-1}$ ] (for building surfaces only and if <i>IbldCHmod</i> == 0 in <i>ESTMinput.nml</i> ) |

**Internal\_CHwall**

**Description** Bulk transfer coefficient of internal wall [ $\text{W m}^{-2} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Bulk transfer coefficient of internal wall [ $\text{W m}^{-2} \text{K}^{-1}$ ] (for building surfaces only and if <i>IbldCHmod</i> == 0 in <i>ESTMinput.nml</i> ) |

**Internal\_emissivity**

**Description** Emissivity of all internal elements for building surfaces only

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Emissivity of all internal elements for building surfaces only |

**Internal\_k1**

**Description** Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Internal\_k2**

**Description** Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Internal\_k3**

**Description** Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Internal\_k4**

**Description** Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Internal\_k5**

**Description** Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Internal\_rhoCp1**

**Description** Volumetric heat capacity of the first layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Volumetric heat capacity of the first layer[J m <sup>-3</sup> K <sup>-1</sup> ] |

**Internal\_rhoCp2**

**Description** Volumetric heat capacity of the second layer [J m<sup>-3</sup> K<sup>-1</sup>]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the second layer [J m <sup>-3</sup> K <sup>-1</sup> ] |

**Internal\_rhoCp3**

**Description** Volumetric heat capacity of the third layer[J m<sup>-3</sup> K<sup>-1</sup>]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the third layer[J m <sup>-3</sup> K <sup>-1</sup> ] |

**Internal\_rhoCp4**

**Description** Volumetric heat capacity of the fourth layer [J m<sup>-3</sup> K<sup>-1</sup>]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fourth layer [J m <sup>-3</sup> K <sup>-1</sup> ] |

**Internal\_rhoCp5**

**Description** Volumetric heat capacity of the fifth layer [J m<sup>-3</sup> K<sup>-1</sup>]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fifth layer [J m <sup>-3</sup> K <sup>-1</sup> ] |

**Internal\_thick1**

**Description** Thickness of the first layer [m] for building surfaces only

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thickness of the first layer [m] for building surfaces only; set to -999 for all other surfaces |

**Internal\_thick2**

**Description** Thickness of the second layer [m]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the second layer [m] (if no second layer, set to -999.) |

**Internal\_thick3**

**Description** Thickness of the third layer [m]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the third layer [m] (if no third layer, set to -999.) |

**Internal\_thick4**

**Description** Thickness of the fourth layer [m]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the fourth layer [m] (if no fourth layer, set to -999.) |

**Internal\_thick5**

**Description** Thickness of the fifth layer [m]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the fifth layer [m] (if no fifth layer, set to -999.) |

**InternalWaterUse****Description** Internal water use [mm h<sup>-1</sup>]**Configuration**

| Referencing Table           | Requirement | Comment                                  |
|-----------------------------|-------------|--|
| <i>SUEWS_Irrigation.txt</i> | <i>MU</i>   | Internal water use [mm h <sup>-1</sup> ] |

**IrrFr\_Paved****Description** Fraction of *Paved* that is irrigated [-]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of paved surfaces that are irrigated [-] |

**IrrFr\_Bldgs****Description** Fraction of *Bldgs* that is irrigated [-]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of rooftop of buildings (e.g., green roofs) that are irrigated [-] |

**IrrFr\_DecTr****Description** Fraction of *DecTr* that is irrigated [-]**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of deciduous trees that are irrigated [-] |

**IrrFr\_EveTr****Description** Fraction of *EveTr* that is irrigated [-]**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of evergreen trees that are irrigated [-] e.g. 50% of the evergreen trees/shrubs are irrigated |

**IrrFr\_Grass**

**Description** Fraction of *Grass* that is irrigated [-]

**Configuration**

| Referencing Table           | Requirement | Comment                                 |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of grass that is irrigated [-] |

**IrrFr\_BSoil**

**Description** Fraction of *BSoil* that is irrigated [-]

**Configuration**

| Referencing Table           | Requirement | Comment                                      |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of bare soil that are irrigated [-] |

**IrrFr\_Water**

**Description** Fraction of *Water* that is irrigated [-]

**Configuration**

| Referencing Table           | Requirement | Comment                                  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Fraction of water that are irrigated [-] |

**IrrigationCode**

**Description** Code for modelling irrigation linking to *Code* of *SUEWS\_Irrigation.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for modelling irrigation<br>Provides the link to column 1 of SUEWS_Irrigation.txt, which contains the model coefficients for estimation of the water use (used if WU_Choice = 0 in <i>Run-Control.nml</i> ). Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Irrigation.txt. |

**it****Description** Hour [H]**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|----------|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Hour [H] |
| <i>SSss_YYYY_data_tt.txt</i>         | <i>MU</i>   | Hour [H] |

**iy****Description** Year [YYYY]**Configuration**

| Referencing Table                    | Requirement | Comment     |
|--------------------------------------|-------------|-------------|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Year [YYYY] |
| <i>SSss_YYYY_data_tt.txt</i>         | <i>MU</i>   | Year [YYYY] |

**kdiff****Description** Diffuse radiation [ $\text{W m}^{-2}$ ].**Configuration**

| Referencing Table            | Requirement | Comment                       |
|------------------------------|-------------|-------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>0</i>    | Recommended if SOLWEIGUse = 1 |

**kdir****Description** Direct radiation [ $\text{W m}^{-2}$ ].**Configuration**

| Referencing Table            | Requirement | Comment                       |
|------------------------------|-------------|-------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Recommended if SOLWEIGUse = 1 |

**kdown**

**Description** Incoming shortwave radiation [ $\text{W m}^{-2}$ ].

**Configuration**

| Referencing Table            | Requirement | Comment                          |
|------------------------------|-------------|----------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Must be $> 0 \text{ W m}^{-2}$ . |

**Kmax**

**Description** Maximum incoming shortwave radiation [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Maximum incoming shortwave radiation [ $\text{W m}^{-2}$ ] |

**lai**

**Description** Observed leaf area index [ $\text{m}^{-2} \text{ m}^{-2}$ ]

**Configuration**

| Referencing Table            | Requirement | Comment   |
|------------------------------|-------------|---|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Observed leaf area index [ $\text{m}^{-2} \text{ m}^{-2}$ ] |

**LAIEq**

**Description** LAI calculation choice.

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**Note:** North and South hemispheres are treated slightly differently.

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**Configuration**



| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | Coefficients are specified in the following parameters: <i>LeafGrowthPower1</i> , <i>LeafGrowthPower2</i> , <i>LeafOffPower1</i> and <i>LeafOffPower2</i> .<br>Options <ul style="list-style-type: none"> <li>• 0 Järvi <i>et al.</i> [2011]</li> <li>• 1 Järvi <i>et al.</i> [2014]</li> </ul> |

**LAI<sub>Max</sub>**

**Description** full leaf-on summertime value

**Configuration**

| Referencing Table    | Requirement | Comment  |
|----------------------|-------------|--|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | full leaf-on summertime value<br>Example values: - 5.1 EveTr Breuer <i>et al.</i> (2003) [Breuer <i>et al.</i> , 2003] - 5.5 DecTr Breuer <i>et al.</i> (2003) [Breuer <i>et al.</i> , 2003] - 5.9 Grass Breuer <i>et al.</i> (2003) [Breuer <i>et al.</i> , 2003] |

**LAI<sub>Min</sub>**

**Description** leaf-off wintertime value

**Configuration**

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | leaf-off wintertime value<br>Example values: - 4. EveTr [Järvi <i>et al.</i> , 2011] - 1. DecTr [Järvi <i>et al.</i> , 2011] - 1.6 Grass [Grimmond and Oke, 1991] |

**lat**

**Description** Latitude [deg].

**Configuration**

| Referencing Table                    | Requirement        | Comment  |
|--------------------------------------|--------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MU</a> | Use coordinate system WGS84. Positive values are northern hemisphere (negative southern hemisphere). Used in radiation calculations. Note, if the total modelled area is small the latitude and longitude could be the same for each grid but small differences in radiation will not be determined. If you are defining the latitude and longitude differently between grids make certain that you provide enough decimal places. |

**ldown**

**Description** Incoming longwave radiation [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table                     | Requirement       | Comment   |
|---------------------------------------|-------------------|---|
| <a href="#">SSss_YYYY_data_tt.txt</a> | <a href="#">0</a> | Incoming longwave radiation [ $\text{W m}^{-2}$ ] |

**LeafGrowthPower1**

**Description** a parameter required by LAI calculation in [LAIEq](#)

**Configuration**

| Referencing Table             | Requirement        | Comment  |
|-------------------------------|--------------------|--|
| <a href="#">SUEWS_Veg.txt</a> | <a href="#">MD</a> | Example values <ul style="list-style-type: none"><li>• <a href="#">LAIEq</a> = 0: 0.03 [Järvi <i>et al.</i>, 2011]</li><li>• <a href="#">LAIEq</a> = 1: 0.04 [Järvi <i>et al.</i>, 2014]</li></ul> |

**LeafGrowthPower2**

**Description** a parameter required by LAI calculation [ $\text{K}^{-1}$ ] in [LAIEq](#)

**Configuration**

| Referencing Table    | Requirement | Comment  |
|----------------------|-------------|--|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | Example values <ul style="list-style-type: none"> <li>• <i>LAIEq</i> = 0: 0.0005 [Järvi <i>et al.</i>, 2011]</li> <li>• <i>LAIEq</i> = 1: 0.001 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**LeafOffPower1**

**Description** a parameter required by LAI calculation [ $K^{-1}$ ] in *LAIEq*

**Configuration**

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | Example values <ul style="list-style-type: none"> <li>• <i>LAIEq</i> = 0: 0.03 [Järvi <i>et al.</i>, 2011]</li> <li>• <i>LAIEq</i> = 1: -1.5 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**LeafOffPower2**

**Description** a parameter required by LAI calculation [ $K^{-1}$ ] in *LAIEq*

**Configuration**

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | Example values <ul style="list-style-type: none"> <li>• <i>LAIEq</i> = 0: 0.0005 [Järvi <i>et al.</i>, 2011]</li> <li>• <i>LAIEq</i> = 1: 0.0015 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**lng**

**Description** longitude [deg]

**Configuration**

| Referencing Table                    | Requirement        | Comment   |
|--------------------------------------|--------------------|---|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MU</a> | Use coordinate system WGS84. For compatibility with GIS, negative values are to the west, positive values are to the east (e.g. Vancouver = -123.12; Shanghai = 121.47) Note this is a change of sign convention between v2016a and v2017a See latitude for more details. |

#### LUMPS\_Cover

**Description** Limit when surface totally covered with water for LUMPS [mm]

##### Configuration

| Referencing Table                    | Requirement        | Comment  |
|--------------------------------------|--------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD</a> | Limit when surface totally covered with water [mm] Used for LUMPS surface wetness control. Default recommended value of 1 mm from Loridan <i>et al.</i> [2011] . |

#### LUMPS\_DrRate

**Description** Drainage rate of bucket for LUMPS [mm h<sup>-1</sup>]

##### Configuration

| Referencing Table                    | Requirement        | Comment  |
|--------------------------------------|--------------------|--|
| <a href="#">SUEWS_SiteSelect.txt</a> | <a href="#">MD</a> | Drainage rate of bucket for LUMPS [mm h <sup>-1</sup> ] Used for LUMPS surface wetness control. Default recommended value of 0.25 mm h <sup>-1</sup> from Loridan <i>et al.</i> [2011] . |

#### LUMPS\_MaxRes

**Description** Maximum water bucket reservoir [mm] Used for LUMPS surface wetness control.

##### Configuration

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD</i>   | Maximum water bucket reservoir [mm] Used for LUMPS surface wetness control. Default recommended value of 10 mm from Loridan <i>et al.</i> [2011] . |

**MaxQFMetab**

**Description** Maximum value for human heat emission. [ $\text{W m}^{-2}$ ]

Example values: 175 Sailor and Lu (2004) [Sailor and Lu, 2004]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>0</i>    | Maximum value for human heat emission. [ $\text{W m}^{-2}$ ] |

**MaxFCMetab**

**Description** Maximum (day) CO<sub>2</sub> from human metabolism. [ $\mu\text{mol s}^{-1} \text{cap}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>0</i>    | Maximum (day) CO <sub>2</sub> from human metabolism. [ $\text{W m}^{-2}$ ] |

**MaxConductance**

**Description** The maximum conductance of each vegetation or surface type. [ $\text{mm s}^{-1}$ ]

**Configuration**

| Referencing Table    | Requirement | Comment  |
|----------------------|-------------|--|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | Example values [ $\text{mm s}^{-1}$ ] <ul style="list-style-type: none"> <li>• 7.4: EveTr [Järvi <i>et al.</i>, 2011]</li> <li>• 11.7: DecTr [Järvi <i>et al.</i>, 2011]</li> <li>• 33.1: Grass (unirrigated) [Järvi <i>et al.</i>, 2011]</li> <li>• 40.: Grass (irrigated) [Järvi <i>et al.</i>, 2011]</li> </ul> |

**MinQFMetab**

**Description** Minimum value for human heat emission. [ $\text{W m}^{-2}$ ]

Example values: 75 Sailor and Lu (2004) [Sailor and Lu, 2004]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | Minimum value for human heat emission. [ $\text{W m}^{-2}$ ]. |

**MinFCMetab**

**Description** Minimum (night) CO<sub>2</sub> from human metabolism. [ $\text{umol s}^{-1} \text{cap}^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | Minimum (night) CO <sub>2</sub> from human metabolism. [ $\text{W m}^{-2}$ ] |

**NARP\_Trans**

**Description** Atmospheric transmissivity for NARP [-]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | MD          | Atmospheric transmissivity for NARP [-] Value must in the range 0-1. Default recommended value of 1. |

**nroom**

**Description** Number of rooms per floor for building surfaces only [-]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | MU          | Number of rooms per floor for building surfaces only |

**OBS\_SMCap**

**Description** The maximum observed soil moisture. [ $\text{m}^3 \text{m}^{-3}$  or  $\text{kg kg}^{-1}$ ]

**Configuration**

| Referencing Table              | Requirement | Comment   |
|--------------------------------|-------------|---|
| <a href="#">SUEWS_Soil.txt</a> | 0           | Use only if soil moisture is observed and provided in the met forcing file and <a href="#">SMDMethod</a> = 1 or 2. Use of observed soil moisture not currently tested |

**OBS\_SMDepth**

**Description** The depth of soil moisture measurements. [mm]

**Configuration**

| Referencing Table              | Requirement | Comment   |
|--------------------------------|-------------|---|
| <a href="#">SUEWS_Soil.txt</a> | 0           | Use only if soil moisture is observed and provided in the met forcing file and <a href="#">SMDMethod</a> = 1 or 2. Use of observed soil moisture not currently tested |

**OBS\_SoilNotRocks**

**Description** Fraction of soil without rocks. [-]

**Configuration**

| Referencing Table              | Requirement | Comment   |
|--------------------------------|-------------|---|
| <a href="#">SUEWS_Soil.txt</a> | 0           | Use only if soil moisture is observed and provided in the met forcing file and <a href="#">SMDMethod</a> = 1 or 2. Use of observed soil moisture not currently tested |

**OHMCode\_SummerDry**

**Description** Code for OHM coefficients to use for this surface during dry conditions in summer, linking to [SUEWS\\_OHMCoefficients.txt](#).

**Configuration**

| Referencing Table                | Requirement | Comment  |
|----------------------------------|-------------|--|
| <a href="#">SUEWS_NonVeg.txt</a> | L           | Code for OHM coefficients to use for this surface during dry conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |

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Table 7.213 – continued from previous page

| Referencing Table      | Requirement | Comment  |
|------------------------|-------------|--|
| <i>SUEWS_Veg.txt</i>   | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| <i>SUEWS_Water.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| <i>SUEWS_Snow.txt</i>  | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |

**OHMCode\_SummerWet**

**Description** Code for OHM coefficients to use for this surface during wet conditions in summer, linking to [SUEWS\\_OHMCoefficients.txt](#).

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |
| <i>SUEWS_Veg.txt</i>    | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in summer. Links to <a href="#">SUEWS_OHMCoefficients.txt</a> . Value of integer is arbitrary but must match code specified in column 1 of <a href="#">SUEWS_OHMCoefficients.txt</a> . |

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Table 7.214 – continued from previous page

| Referencing Table      | Requirement | Comment  |
|------------------------|-------------|--|
| <i>SUEWS_Water.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in summer. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Snow.txt</i>  | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in summer. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |

**OHMCode\_WinterDry**

**Description** Code for OHM coefficients to use for this surface during dry conditions in winter, linking to *SUEWS\_OHMCoefficients.txt*.

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Veg.txt</i>    | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Water.txt</i>  | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |

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Table 7.215 – continued from previous page

| Referencing Table     | Requirement | Comment  |
|-----------------------|-------------|--|
| <i>SUEWS_Snow.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during dry conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |

**OHMCode\_WinterWet**

**Description** Code for OHM coefficients to use for this surface during wet conditions in winter, linking to *SUEWS\_OHMCoefficients.txt*.

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Veg.txt</i>    | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Water.txt</i>  | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |
| <i>SUEWS_Snow.txt</i>   | <i>L</i>    | Code for OHM coefficients to use for this surface during wet conditions in winter. Links to <i>SUEWS_OHMCoefficients.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_OHMCoefficients.txt</i> . |

**OHMThresh\_SW**

**Description** Temperature threshold determining whether summer/winter OHM coefficients are applied [°C]

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C] If 5-day running mean air temperature is greater than or equal to this threshold, OHM coefficients for summertime are applied; otherwise coefficients for wintertime are applied. |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C] If 5-day running mean air temperature is greater than or equal to this threshold, OHM coefficients for summertime are applied; otherwise coefficients for wintertime are applied. |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Temperature threshold determining whether summer/winter OHM coefficients are applied [°C] If 5-day running mean air temperature is greater than or equal to this threshold, OHM coefficients for summertime are applied; otherwise coefficients for wintertime are applied. |
| <i>SUEWS_Snow.txt</i>   | <i>MD</i>   | Not actually used for Snow surface as winter wet conditions always assumed.   |

**OHMThresh\_WD**

**Description** Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Not actually used for building and paved surfaces (as impervious).               |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Note that OHM coefficients for wet conditions are applied if the surface is wet. |

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Table 7.218 – continued from previous page

| Referencing Table      | Requirement | Comment   |
|------------------------|-------------|---|
| <i>SUEWS_Water.txt</i> | <i>MD</i>   | Not actually used for water surface (as no soil surface beneath).           |
| <i>SUEWS_Snow.txt</i>  | <i>MD</i>   | Not actually used for Snow surface as winter wet conditions always assumed. |

**PipeCapacity**

**Description** Storage capacity of pipes [mm]

**Configuration**

| Referencing Table           | Requirement  | Comment   |
|-----------------------------|--------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Storage capacity of pipes [mm]<br>Runoff amounting to less than the value specified here is assumed to be removed by pipes. |

**PopDensDay**

**Description** Daytime population density (i.e. workers, tourists) [people ha<sup>-1</sup>]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>0</i>    | Daytime population density (i.e. workers, tourists) [people ha <sup>-1</sup> ]<br>Population density is required if EmissionsMethod = 2 in <i>RunControl.nml</i> . The model will use the average of daytime and night-time population densities, unless only one is provided. If daytime population density is unknown, set to -999. |

**PopDensNight**

**Description** Night-time population density (i.e. residents) [people ha<sup>-1</sup>]

**Configuration**

| Referencing Table                           | Requirement | Comment  |
|---|-------------|--|
| <a href="#"><i>SUEWS_SiteSelect.txt</i></a> | 0           | Night-time population density (i.e. residents) [people ha <sup>-1</sup> ]<br>Population density is required if EmissionsMethod = 2 in <a href="#"><i>Run-Control.nml</i></a> . The model will use the average of daytime and night-time population densities, unless only one is provided. If night-time population density is unknown, set to -999. |

**PopProfWD**

**Description** Code for population density profile (weekdays) linking to [Code](#) of [\*SUEWS\\_Profiles.txt\*](#).

**Configuration**

| Referencing Table                                      | Requirement | Comment   |
|--|-------------|---|
| <a href="#"><i>SUEWS_AnthropogenicEmission.txt</i></a> | 0           | Code for population density profile (weekdays). |

**PopProfWE**

**Description** Code for population density profile (weekends) linking to [Code](#) of [\*SUEWS\\_Profiles.txt\*](#).

**Configuration**

| Referencing Table                                      | Requirement | Comment  |
|--|-------------|--|
| <a href="#"><i>SUEWS_AnthropogenicEmission.txt</i></a> | 0           | Code for population density profile (weekends) |

**PorosityMax**

**Description** full leaf-on summertime value Used only for [DecTr](#) (can affect roughness calculation)

**Configuration**

| Referencing Table                    | Requirement | Comment   |
|--------------------------------------|-------------|---|
| <a href="#"><i>SUEWS_Veg.txt</i></a> | MD          | full leaf-on summertime value<br>Used only for DecTr (can affect roughness calculation) |

**PorosityMin**

**Description** leaf-off wintertime value Used only for [DecTr](#) (can affect roughness calculation)

**Configuration**

| Referencing Table    | Requirement | Comment  |
|----------------------|-------------|--|
| <i>SUEWS_Veg.txt</i> | <i>MD</i>   | leaf-off wintertime value Used only for DecTr (can affect roughness calculation) |

**PrecipLimAlb**

**Description** Limit for hourly precipitation when the ground is fully covered with snow [mm]

**Configuration**

| Referencing Table     | Requirement | Comment  |
|-----------------------|-------------|--|
| <i>SUEWS_Snow.txt</i> | <i>MD</i>   | Limit for hourly precipitation when the ground is fully covered with snow. Then snow albedo is reset to AlbedoMax [mm] |

**PrecipLimSnow**

**Description** Temperature limit when precipitation falls as snow [°C]

**Configuration**

| Referencing Table     | Requirement | Comment     |
|-----------------------|-------------|-------------|
| <i>SUEWS_Snow.txt</i> | <i>MD</i>   | Auer [1974] |

**pres**

**Description** Barometric pressure [kPa]

**Configuration**

| Referencing Table            | Requirement | Comment                   |
|------------------------------|-------------|---------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Barometric pressure [kPa] |

**qe**

**Description** Latent heat flux [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table            | Requirement | Comment                                |
|------------------------------|-------------|--|
| <i>SSss_YYYY_data_tt.txt</i> | <i>O</i>    | Latent heat flux [ $\text{W m}^{-2}$ ] |

**qf**

**Description** Anthropogenic heat flux [ $\text{W m}^{-2}$ ]

**Configuration**

| Referencing Table            | Requirement | Comment                                       |
|------------------------------|-------------|---|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Anthropogenic heat flux [ $\text{W m}^{-2}$ ] |

**QF\_A\_WD**

**Description** Base value for QF on weekdays [ $\text{W m}^{-2} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | MU 0        | Use with <i>EmissionsMethod</i> = 2<br>Example values: <ul style="list-style-type: none"> <li>• 0.3081 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.1 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**QF\_A\_WE**

**Description** Base value for QF on weekends [ $\text{W m}^{-2} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | MU 0        | Use with <i>EmissionsMethod</i> = 2<br>Example values: <ul style="list-style-type: none"> <li>• 0.3081 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.1 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**QF\_B\_WD**

**Description** Parameter related to cooling degree days on weekdays [ $\text{W m}^{-2} \text{K}^{-1} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | MU 0        | Use with <i>EmissionsMethod</i> = 2<br>Example values: <ul style="list-style-type: none"> <li>• 0.0099 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.0099 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**QF\_B\_WE**

**Description** Parameter related to cooling degree days on weekends [ $\text{W m}^{-2} \text{K}^{-1} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 2<br>Example values: <ul style="list-style-type: none"> <li>• 0.0099 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.0099 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**QF\_C\_WD**

**Description** Parameter related to heating degree days on weekdays [ $\text{W m}^{-2} \text{K}^{-1} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 2<br>Example values: <ul style="list-style-type: none"> <li>• 0.0102 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.0102 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**QF\_C\_WE**

**Description** Parameter related to heating degree days on weekends [ $\text{W m}^{-2} \text{K}^{-1} (\text{Cap ha}^{-1})^{-1}$ ]

**Configuration**

| Referencing Table                      | Requirement | Comment  |
|--|-------------|--|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Example values: <ul style="list-style-type: none"> <li>• 0.0102 [Järvi <i>et al.</i>, 2011]</li> <li>• 0.0102 [Järvi <i>et al.</i>, 2014]</li> </ul> |

**q+\_gkg**

**Description** specific humidity at the top of CBL [ $\text{g kg}^{-1}$ ]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | specific humidity at the top of CBL ( $\text{g kg}^{-1}$ ) |

**q\_gkg**

**Description** specific humidity in CBL [ $\text{g kg}^{-1}$ ]



**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | specific humidity in CBL ( $\text{g kg}^{-1}$ ) |

**qh****Description** Sensible heat flux [ $\text{W m}^{-2}$ ]**Configuration**

| Referencing Table            | Requirement | Comment                                  |
|------------------------------|-------------|--|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Sensible heat flux [ $\text{W m}^{-2}$ ] |

**qn****Description** Net all-wave radiation [ $\text{W m}^{-2}$ ]**Configuration**

| Referencing Table            | Requirement | Comment                                    |
|------------------------------|-------------|--|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Required if <i>NetRadiationMethod</i> = 1. |

**qs****Description** Storage heat flux [ $\text{W m}^{-2}$ ]**Configuration**

| Referencing Table            | Requirement | Comment                                 |
|------------------------------|-------------|---|
| <i>SSss_YYYY_data_tt.txt</i> | 0           | Storage heat flux [ $\text{W m}^{-2}$ ] |

**RadMeltFactor****Description** Hourly radiation melt factor of snow [ $\text{mm W}^{-1} \text{h}^{-1}$ ]**Configuration**

| Referencing Table     | Requirement | Comment   |
|-----------------------|-------------|---|
| <i>SUEWS_Snow.txt</i> | <i>MU</i>   | Hourly radiation melt factor of snow [ $\text{mm W}^{-1} \text{h}^{-1}$ ] |

**rain****Description** Rainfall [mm]

**Configuration**

| Referencing Table            | Requirement | Comment       |
|------------------------------|-------------|---------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Rainfall [mm] |

**RH****Description** Relative Humidity [%]**Configuration**

| Referencing Table            | Requirement | Comment               |
|------------------------------|-------------|-----------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Relative Humidity [%] |

**RunoffToWater****Description** Fraction of above-ground runoff flowing to water surface during flooding [-]**Configuration**

| Referencing Table           | Requirement  | Comment  |
|-----------------------------|--------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MD MU</i> | Fraction of above-ground runoff flowing to water surface during flooding [-] Value must be in the range 0-1. Fraction of above-ground runoff that can flow to the water surface in the case of flooding. |

**S1****Description** A parameter related to soil moisture dependence [-]**Configuration**

| Referencing Table            | Requirement | Comment   |
|------------------------------|-------------|---|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to soil moisture dependence [-] These will change in the future to ensure consistency with soil behaviour |

**S2****Description** A parameter related to soil moisture dependence [mm]**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Related to soil moisture dependence [mm] These will change in the future to ensure consistency with soil behaviour |

**SatHydraulicCond**

**Description** Hydraulic conductivity for saturated soil [mm s<sup>-1</sup>]

**Configuration**

| Referencing Table     | Requirement | Comment   |
|-----------------------|-------------|---|
| <i>SUEWS_Soil.txt</i> | <i>MD</i>   | Hydraulic conductivity for saturated soil [mm s <sup>-1</sup> ] |

**SDDFull**

**Description** The sensesence degree days (SDD) needed to initiate leaf off. [°C]

**Configuration**

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | <i>MU</i>   | This should be checked carefully for your study area using modelled LAI from the DailyState output file compared to known behaviour in the study area. See section 2.2 of Järvi <i>et al.</i> [2011] and Appendix A of Järvi <i>et al.</i> [2014] for more details.<br>Example values: <ul style="list-style-type: none"> <li>• -450: <i>EveTr</i> [Järvi <i>et al.</i>, 2011]</li> <li>• -450: <i>DecTr</i> [Järvi <i>et al.</i>, 2011]</li> <li>• -450: <i>Grass</i> [Järvi <i>et al.</i>, 2011]</li> </ul> |

**snow**

**Description** Snowfall [mm]

**Configuration**

| Referencing Table            | Requirement | Comment                        |
|------------------------------|-------------|--------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>0</i>    | Required if <i>SnowUse</i> = 1 |

**SnowClearingProfWD**

**Description** Code for snow clearing profile (weekdays) linking to *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for snow clearing profile (weekdays) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . e.g. 1 means use the characteristics specified in the row of input file <i>SUEWS_Profiles.txt</i> which has 1 in column 1 (Code). |

**SnowClearingProfWE**

**Description** Code for snow clearing profile (weekends) linking to *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for snow clearing profile (weekends) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . e.g. 1 means use the characteristics specified in the row of input file <i>SUEWS_Profiles.txt</i> which has 1 in column 1 (Code). Providing the same code for <i>SnowClearingProfWD</i> and <i>SnowClearingProfWE</i> would link to the same row in <i>SUEWS_Profiles.txt</i> , i.e. the same profile would be used for weekdays and weekends. |

**SnowCode**

**Description** Code for snow surface characteristics linking to *Code* of *SUEWS\_Snow.txt*

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for snow surface characteristics Provides the link to column 1 of SUEWS_Snow.txt, which contains the attributes describing snow surfaces in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Snow.txt. |

**SnowDensMax**

**Description** Maximum snow density [ $\text{kg m}^{-3}$ ]

**Configuration****SnowDensMin**

**Description** Fresh snow density [ $\text{kg m}^{-3}$ ]

**Configuration****SnowLimPatch**

**Description** Limit for the snow water equivalent when snow cover starts to be patchy [mm]

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>0</i>    | Limit of snow water equivalent when the surface is fully covered with snow. Not needed if <i>SnowUse</i> = 0 in <i>RunControl.nml</i> .<br>Example values: <ul style="list-style-type: none"> <li>• 190: Paved [Järvi <i>et al.</i>, 2014]</li> <li>• 190: Bldgs [Järvi <i>et al.</i>, 2014]</li> <li>• 190: BSoil [Järvi <i>et al.</i>, 2014]</li> </ul> |

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Table 7.254 – continued from previous page

| Referencing Table    | Requirement | Comment   |
|----------------------|-------------|---|
| <i>SUEWS_Veg.txt</i> | 0           | Limit of snow water equivalent when the surface is fully covered with snow. Not needed if <i>SnowUse</i> = 0 in <i>RunControl.nml</i> .<br>Example values: <ul style="list-style-type: none"> <li>• 190: EveTr [Järvi <i>et al.</i>, 2014]</li> <li>• 190: DecTr [Järvi <i>et al.</i>, 2014]</li> <li>• 190: Grass [Järvi <i>et al.</i>, 2014]</li> </ul> |

**SnowLimRemove**

**Description** Limit of the snow water equivalent for snow removal from roads and roofs [mm]

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | 0           | Not needed if <i>SnowUse</i> = 0 in <i>RunControl.nml</i> . <b>Not available in this version.</b><br>Example values [mm] <ul style="list-style-type: none"> <li>• 40: <i>Paved</i> [Järvi <i>et al.</i>, 2014]</li> <li>• 100: <i>Bldgs</i> [Järvi <i>et al.</i>, 2014]</li> </ul> |

**SoilDensity**

**Description** Soil density [kg m<sup>-3</sup>]

**Configuration**

| Referencing Table     | Requirement | Comment                            |
|-----------------------|-------------|------------------------------------|
| <i>SUEWS_Soil.txt</i> | MD          | Soil density [kg m <sup>-3</sup> ] |

**SoilDepth**

**Description** Depth of soil beneath the surface [mm]

**Configuration**

| Referencing Table     | Requirement | Comment   |
|-----------------------|-------------|---|
| <i>SUEWS_Soil.txt</i> | <i>MD</i>   | Depth of sub-surface soil store [mm] i.e. the depth of soil beneath the surface |

**SoilStoreCap**

**Description** Limit value for *SoilDepth* [mm]

**Configuration**

| Referencing Table     | Requirement | Comment  |
|-----------------------|-------------|--|
| <i>SUEWS_Soil.txt</i> | <i>MD</i>   | SoilStoreCap must not be greater than SoilDepth. |

**SoilTypeCode**

**Description** Code for soil characteristics below this surface linking to *Code* of *SUEWS\_Soil.txt*

**Configuration**

| Referencing Table       | Requirement | Comment   |
|-------------------------|-------------|---|
| <i>SUEWS_NonVeg.txt</i> | <i>L</i>    | Code for soil characteristics below this surface Provides the link to column 1 of <i>SUEWS_Soil.txt</i> , which contains the attributes describing sub-surface soil for this surface type. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Soil.txt</i> . |
| <i>SUEWS_Veg.txt</i>    | <i>L</i>    | Code for soil characteristics below this surface Provides the link to column 1 of <i>SUEWS_Soil.txt</i> , which contains the attributes describing sub-surface soil for this surface type. Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Soil.txt</i> . |

**StartDLS**

**Description** Start of the day light savings [DOY]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Start of the day light savings [DOY] See <i>Day Light Savings (DLS)</i> . |

**StateLimit**

**Description** Upper limit to the surface state. [mm]

Currently only used for the water surface. Set to a large value (e.g. 20000 mm = 20 m) if the water body is substantial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallow (e.g. fountains). WaterDepth (column 9) must not exceed this value.

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Currently only used for the water surface  |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Currently only used for the water surface  |
| <i>SUEWS_Water.txt</i>  | <i>MU</i>   | Surface state cannot exceed this value. Set to a large value (e.g. 20000 mm = 20 m) if the water body is substantial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallow (e.g. fountains). WaterDepth (column 9) must not exceed this value. |

**StorageMax**

**Description** Maximum water storage capacity for upper surfaces (i.e. canopy)

**Configuration**



| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Maximum water storage capacity for upper surfaces (i.e. canopy) Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces). Not currently used for non-vegetated surfaces - set the same as <i>StorageMin</i> .<br>Example values: <ul style="list-style-type: none"> <li>• 0.48 <i>Paved</i></li> <li>• 0.25 <i>Bldgs</i></li> <li>• 0.8 <i>BSoil</i></li> </ul>   |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Maximum water storage capacity for upper surfaces (i.e. canopy) Min/max values are to account for seasonal variation (e.g. leaf-off/leaf-on differences for vegetated surfaces) Only used for <i>DecTr</i> surfaces - set <i>EveTr</i> and <i>Grass</i> values the same as <i>StorageMin</i> .<br>Example values: <ul style="list-style-type: none"> <li>• 1.3: <i>EveTr</i> [Breuer <i>et al.</i>, 2003]</li> <li>• 0.8: <i>DecTr</i> [Breuer <i>et al.</i>, 2003]</li> <li>• 1.9: <i>Grass</i> [Breuer <i>et al.</i>, 2003]</li> </ul> |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Maximum water storage capacity for upper surfaces (i.e. canopy) Min and max values are to account for seasonal variation - not used for water surfaces so set same as <i>StorageMin</i> .  |

### StorageMin

**Description** Minimum water storage capacity for upper surfaces (i.e. canopy).

### Configuration

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Minimum water storage capacity for upper surfaces (i.e. canopy). Min/max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces). Not currently used for non-vegetated surfaces - set the same as <i>StorageMax</i> .<br>Example values: <ul style="list-style-type: none"> <li>• 0.48 <i>Paved</i></li> <li>• 0.25 <i>Bldgs</i></li> <li>• 0.8 <i>BSoil</i></li> </ul>  |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Minimum water storage capacity for upper surfaces (i.e. canopy). Min/max values are to account for seasonal variation (e.g. leaf-off/leaf-on differences for vegetated surfaces).<br>Example values: <ul style="list-style-type: none"> <li>• 1.3 <i>EveTr</i> [Breuer <i>et al.</i>, 2003]</li> <li>• 0.3 <i>DecTr</i> [Breuer <i>et al.</i>, 2003]</li> <li>• 1.9 <i>Grass</i> [Breuer <i>et al.</i>, 2003]</li> </ul> |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Minimum water storage capacity for upper surfaces (i.e. canopy). Min/max values are to account for seasonal variation - not used for water surfaces.<br>Example values: <ul style="list-style-type: none"> <li>• -0.5 <i>Water</i></li> </ul>  |

## SurfaceArea

**Description** Area of the grid [ha].

### Configuration

| Referencing Table           | Requirement | Comment                |
|-----------------------------|-------------|------------------------|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Area of the grid [ha]. |

## Surf\_k1

**Description** Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

### Configuration

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Surf\_k2**

**Description** Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Surf\_k3**

**Description** Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Surf\_k4**

**Description** Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Surf\_k5**

**Description** Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Surf\_rhoCp1**

**Description** Volumetric heat capacity of the first layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Volumetric heat capacity of the first layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Surf\_rhoCp2**

**Description** Volumetric heat capacity of the second layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the second layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Surf\_rhoCp3**

**Description** Volumetric heat capacity of the third layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the third layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Surf\_rhoCp4**

**Description** Volumetric heat capacity of the fourth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fourth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Surf\_rhoCp5**

**Description** Volumetric heat capacity of the fifth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fifth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Surf\_thick1**

**Description** Thickness of the first layer [m] for roofs (building surfaces) and ground (all other surfaces)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thickness of the first layer [m] for roofs (building surfaces) and ground (all other surfaces) |

**Surf\_thick2**

**Description** Thickness of the second layer [m] (if no second layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the second layer [m] (if no second layer, set to -999.) |

**Surf\_thick3**

**Description** Thickness of the third layer [m] (if no third layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the third layer [m] (if no third layer, set to -999.) |

**Surf\_thick4**

**Description** Thickness of the fourth layer [m] (if no fourth layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thickness of the fourth layer [m] (if no fourth layer, set to -999.) |

**Surf\_thick5**

**Description** Thickness of the fifth layer [m] (if no fifth layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thickness of the fifth layer [m] (if no fifth layer, set to -999.) |

**Tair**

**Description** Air temperature [°C]

**Configuration**

| Referencing Table            | Requirement | Comment              |
|------------------------------|-------------|----------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Air temperature [°C] |

**tau\_a**

**Description** Time constant for snow albedo aging in cold snow [-]

**Configuration**

| Referencing Table     | Requirement | Comment  |
|-----------------------|-------------|--|
| <i>SUEWS_Snow.txt</i> | <i>MD</i>   | Time constant for snow albedo aging in cold snow [-] |

**tau\_f**

**Description** Time constant for snow albedo aging in melting snow [-]

**Configuration**

| Referencing Table     | Requirement | Comment   |
|-----------------------|-------------|---|
| <i>SUEWS_Snow.txt</i> | <i>MD</i>   | Time constant for snow albedo aging in melting snow [-] |

**tau\_r**

**Description** Time constant for snow density ageing [-]

**Configuration**

| Referencing Table     | Requirement | Comment                                   |
|-----------------------|-------------|---|
| <i>SUEWS_Snow.txt</i> | <i>MD</i>   | Time constant for snow density ageing [-] |

**TCritic\_Heating\_WD**

**Description** Critical heating temperature on weekdays [°C]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**TCritic\_Heating\_WE**

**Description** Critical heating temperature on weekends [°C]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**TCritic\_Cooling\_WD**

**Description** Critical cooling temperature on weekdays [°C]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**TCritic\_Cooling\_WE**

**Description** Critical cooling temperature on weekends [°C]

**Configuration**

| Referencing Table                      | Requirement | Comment                             |
|--|-------------|-------------------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | <i>MU 0</i> | Use with <i>EmissionsMethod</i> = 1 |

**TempMeltFactor**

**Description** Hourly temperature melt factor of snow [mm K<sup>-1</sup> h<sup>-1</sup>]

**Configuration**

| Referencing Table     | Requirement | Comment   |
|-----------------------|-------------|---|
| <i>SUEWS_Snow.txt</i> | <i>MU</i>   | Hourly temperature melt factor of snow [mm K <sup>-1</sup> h <sup>-1</sup> ] (In previous model version, this parameter was 0.12) |

**TH**

**Description** Upper air temperature limit [°C]

**Configuration**

| Referencing Table            | Requirement | Comment                          |
|------------------------------|-------------|----------------------------------|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Upper air temperature limit [°C] |

**Theta+\_K**

**Description** potential temperature at the top of CBL [K]

**Configuration**

| Referencing Table           | Requirement | Comment                                     |
|-----------------------------|-------------|---|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | potential temperature at the top of CBL (K) |

**Theta\_K**

**Description** potential temperature in CBL [K]

**Configuration**

| Referencing Table           | Requirement | Comment                          |
|-----------------------------|-------------|----------------------------------|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | potential temperature in CBL (K) |

**Ti<sub>air</sub>**

**Description** Indoor air temperature [C]

**Configuration**

| Referencing Table                    | Requirement | Comment                    |
|--------------------------------------|-------------|----------------------------|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Indoor air temperature [C] |

**Timezone**

**Description** Time zone [h] for site relative to UTC (east is positive). This should be set according to the times given in the meteorological forcing file(s).

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Time zone [h] for site relative to UTC (east is positive). This should be set according to the times given in the meteorological forcing file(s). |

**TL**

**Description** Lower air temperature limit [°C]



**Configuration**

| Referencing Table            | Requirement | Comment                          |
|------------------------------|-------------|----------------------------------|
| <i>SUEWS_Conductance.txt</i> | <i>MD</i>   | Lower air temperature limit [°C] |

**ToBldgs****Description** Fraction of water going to Bldgs**Configuration**

| Referencing Table                    | Requirement | Comment                                 |
|--------------------------------------|-------------|---|
| <i>SUEWS_WithinGridWaterDist.txt</i> | <i>MU</i>   | Fraction of water going to <i>Bldgs</i> |

**ToBSoil****Description** Fraction of water going to BSoil**Configuration**

| Referencing Table                    | Requirement | Comment                                 |
|--------------------------------------|-------------|---|
| <i>SUEWS_WithinGridWaterDist.txt</i> | <i>MU</i>   | Fraction of water going to <i>BSoil</i> |

**ToDecTr****Description** Fraction of water going to DecTr**Configuration**

| Referencing Table                    | Requirement | Comment                                 |
|--------------------------------------|-------------|---|
| <i>SUEWS_WithinGridWaterDist.txt</i> | <i>MU</i>   | Fraction of water going to <i>DecTr</i> |

**ToEveTr****Description** Fraction of water going to *EveTr***Configuration**

| Referencing Table                    | Requirement | Comment                                 |
|--------------------------------------|-------------|---|
| <i>SUEWS_WithinGridWaterDist.txt</i> | <i>MU</i>   | Fraction of water going to <i>EveTr</i> |

**ToGrass****Description** Fraction of water going to *Grass***Configuration**

| Referencing Table                             | Requirement | Comment                                 |
|---|-------------|---|
| <a href="#">SUEWS_WithinGridWaterDist.txt</a> | <i>MU</i>   | Fraction of water going to <i>Grass</i> |

**ToPaved**

**Description** Fraction of water going to *Paved*

**Configuration**

| Referencing Table                             | Requirement | Comment                                 |
|---|-------------|---|
| <a href="#">SUEWS_WithinGridWaterDist.txt</a> | <i>MU</i>   | Fraction of water going to <i>Paved</i> |

**ToRunoff**

**Description** Fraction of water going to *Runoff*

**Configuration**

| Referencing Table                             | Requirement | Comment                                  |
|---|-------------|--|
| <a href="#">SUEWS_WithinGridWaterDist.txt</a> | <i>MU</i>   | Fraction of water going to <i>Runoff</i> |

**ToSoilStore**

**Description** Fraction of water going to *SoilStore*

**Configuration**

| Referencing Table                             | Requirement | Comment                                     |
|---|-------------|---|
| <a href="#">SUEWS_WithinGridWaterDist.txt</a> | <i>MU</i>   | Fraction of water going to <i>SoilStore</i> |

**ToWater**

**Description** Fraction of water going to *Water*

**Configuration**

| Referencing Table                             | Requirement | Comment                                 |
|---|-------------|---|
| <a href="#">SUEWS_WithinGridWaterDist.txt</a> | <i>MU</i>   | Fraction of water going to <i>Water</i> |

**TraffProfWD**

**Description** Code for traffic activity profile (weekdays) linking to *Code* of [SUEWS\\_Profiles.txt](#). Not used in v2018a.

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | Used with EmissionMethod=4 to calculate CO2 and heat emissions. |

**TraffProfWE**

**Description** Code for traffic activity profile (weekends) linking to *Code* of *SUEWS\_Profiles.txt*. Not used in v2018a.

**Configuration**

| Referencing Table                      | Requirement | Comment   |
|--|-------------|---|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | Used with EmissionMethod=4 to calculate CO2 and heat emissions. |

**TrafficUnits**

**Description** Units for the traffic rate for the study area. 1 = [veh km m<sup>-2</sup> day<sup>-1</sup>] 2 = [veh km cap<sup>-1</sup> day<sup>-1</sup>]). Not used in v2018a.

**Configuration**

| Referencing Table                      | Requirement | Comment                     |
|--|-------------|-----------------------------|
| <i>SUEWS_AnthropogenicEmission.txt</i> | 0           | Used with EmissionMethod=4. |

**TrafficRate\_WD**

**Description** Weekday traffic rate [veh km m<sup>-2</sup> s<sup>-1</sup>] Can be used for CO2 flux calculation - not used in v2018a.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Weekday traffic rate [veh km m <sup>-2</sup> s <sup>-1</sup> ]. Used with EmissionMethod=4 to calculate CO2 and heat emissions. |

**TrafficRate\_WE**

**Description** Weekend traffic rate [veh km m<sup>-2</sup> s<sup>-1</sup>] Can be used for CO2 flux calculation - not used in v2018a.

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Weekend traffic rate [veh km m <sup>-2</sup> s <sup>-1</sup> ]. Used with Emission-Method=4 to calculate CO2 and heat emissions. |

**Troad**

**Description** Ground surface temperature [C] (used when *TsurfChoice* = 1 or 2)

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Ground surface temperature [C] (used when <i>TsurfChoice</i> = 1 or 2) |

**Troof**

**Description** Roof surface temperature [C] (used when *TsurfChoice* = 1 or 2)

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Roof surface temperature [C] (used when <i>TsurfChoice</i> = 1 or 2) |

**Tsurf**

**Description** Bulk surface temperature [C] (used when *TsurfChoice* = 0)

**Configuration**

| Referencing Table                    | Requirement | Comment   |
|--------------------------------------|-------------|---|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Bulk surface temperature [C] (used when <i>TsurfChoice</i> = 0) |

**Twall**

**Description** Wall surface temperature [C] (used when *TsurfChoice* = 1)

**Configuration**

| Referencing Table                    | Requirement | Comment   |
|--------------------------------------|-------------|---|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | Wall surface temperature [C] (used when <i>TsurfChoice</i> = 1) |

**Twall\_e**

**Description** East-facing wall surface temperature [C] (used when *TsurfChoice* = 2)

**Configuration**

| Referencing Table                    | Requirement | Comment   |
|--------------------------------------|-------------|---|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | East-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |

**Twall\_n**

**Description** North-facing wall surface temperature [C] (used when *TsurfChoice* = 2)

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | North-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |

**Twall\_s**

**Description** South-facing wall surface temperature [C] (used when *TsurfChoice* = 2)

**Configuration**

| Referencing Table                    | Requirement | Comment  |
|--------------------------------------|-------------|--|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | South-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |

**Twall\_w**

**Description** West-facing wall surface temperature [C] (used when *TsurfChoice* = 2)

**Configuration**

| Referencing Table                    | Requirement | Comment   |
|--------------------------------------|-------------|---|
| <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> | <i>MU</i>   | West-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |

**U**

**Description** Wind speed. [m s<sup>-1</sup>. ]Height of the wind speed measurement (*z*) is needed in *SUEWS\_SiteSelect.txt* .

**Configuration**

| Referencing Table            | Requirement | Comment   |
|------------------------------|-------------|---|
| <i>SSss_YYYY_data_tt.txt</i> | <i>MU</i>   | Height of the wind speed measurement (z) is needed in <i>SUEWS_SiteSelect.txt</i> . |

**Wall\_k1**

**Description** Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thermal conductivity of the first layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Wall\_k2**

**Description** Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the second layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Wall\_k3**

**Description** Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the third layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Wall\_k4**

**Description** Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>0</i>    | Thermal conductivity of the fourth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Wall\_k5**

**Description** Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thermal conductivity of the fifth layer [ $\text{W m}^{-1} \text{K}^{-1}$ ] |

**Wall\_rhoCp1**

**Description** Volumetric heat capacity of the first layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Volumetric heat capacity of the first layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Wall\_rhoCp2**

**Description** Volumetric heat capacity of the second layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the second layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Wall\_rhoCp3**

**Description** Volumetric heat capacity of the third layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the third layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Wall\_rhoCp4**

**Description** Volumetric heat capacity of the fourth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fourth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Wall\_rhoCp5**

**Description** Volumetric heat capacity of the fifth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ]

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Volumetric heat capacity of the fifth layer [ $\text{J m}^{-3} \text{K}^{-1}$ ] |

**Wall\_thick1**

**Description** Thickness of the first layer [m] for building surfaces only; set to -999 for all other surfaces

**Configuration**

| Referencing Table                 | Requirement | Comment   |
|-----------------------------------|-------------|---|
| <i>SUEWS_ESTMCoefficients.txt</i> | <i>MU</i>   | Thickness of the first layer [m] for building surfaces only; set to -999 for all other surfaces |

**Wall\_thick2**

**Description** Thickness of the second layer [m] (if no second layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thickness of the second layer [m] (if no second layer, set to -999.) |

**Wall\_thick3**

**Description** Thickness of the third layer [m] (if no third layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thickness of the third layer [m] (if no third layer, set to -999.) |

**Wall\_thick4**

**Description** Thickness of the fourth layer [m] (if no fourth layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thickness of the fourth layer [m] (if no fourth layer, set to -999.) |



**Wall\_thick5**

**Description** Thickness of the fifth layer [m] (if no fifth layer, set to -999.)

**Configuration**

| Referencing Table                 | Requirement | Comment  |
|-----------------------------------|-------------|--|
| <i>SUEWS_ESTMCoefficients.txt</i> | 0           | Thickness of the fifth layer [m] (if no fifth layer, set to -999.) |

**WaterDepth**

**Description** Water depth [mm].

**Configuration**

| Referencing Table      | Requirement | Comment  |
|------------------------|-------------|--|
| <i>SUEWS_Water.txt</i> | <i>MU</i>   | Set to a large value (e.g. 20000 mm = 20 m) if the water body is substantial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallow (e.g. fountains). This value must not exceed StateLimit (column 8). |

**WaterUseProfAutoWD**

**Description** Code for water use profile (automatic irrigation, weekdays) linking to *Code* of *SUEWS\_Profiles.txt*. Value of integer is arbitrary but must match code specified in *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for water use profile (automatic irrigation, weekdays) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . |

**WaterUseProfAutoWE**

**Description** Code for water use profile (automatic irrigation, weekends) linking to *Code* of *SUEWS\_Profiles.txt*. Value of integer is arbitrary but must match code specified in *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for water use profile (automatic irrigation, weekends) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . |

**WaterUseProfManuWD**

**Description** Code for water use profile (manual irrigation, weekdays) linking to *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for water use profile (manual irrigation, weekdays) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . |

**WaterUseProfManuWE**

**Description** Code for water use profile (manual irrigation, weekends) linking to *Code* of *SUEWS\_Profiles.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code for water use profile (manual irrigation, weekends) Provides the link to column 1 of <i>SUEWS_Profiles.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_Profiles.txt</i> . |

**wdir**

**Description** Wind direction [deg].

**Configuration**

| Referencing Table            | Requirement | Comment                               |
|------------------------------|-------------|---------------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>0</i>    | <b>Not available in this version.</b> |

**WetThreshold**

**Description** Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface [mm].

**Configuration**

| Referencing Table       | Requirement | Comment  |
|-------------------------|-------------|--|
| <i>SUEWS_NonVeg.txt</i> | <i>MD</i>   | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface.<br>Example values: <ul style="list-style-type: none"> <li>• 0.6 Paved</li> <li>• 0.6 Bldgs</li> <li>• 1. BSoil</li> </ul> |
| <i>SUEWS_Veg.txt</i>    | <i>MD</i>   | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface.<br>Example values: <ul style="list-style-type: none"> <li>• 1.8 EveTr</li> <li>• 1. DecTr</li> <li>• 2. Grass</li> </ul>  |
| <i>SUEWS_Water.txt</i>  | <i>MD</i>   | Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface.<br>Example values: <ul style="list-style-type: none"> <li>• 0.5 Water</li> </ul>  |

**WithinGridBldgsCode**

**Description** Code that links to the fraction of water that flows from *Bldgs* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from Bldgs surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

#### WithinGridBSoilCode

**Description** Code that links to the fraction of water that flows from *BSoil* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

#### Configuration

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from BSoil surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

#### WithinGridDecTrCode

**Description** Code that links to the fraction of water that flows from *DecTr* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

#### Configuration

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from DecTr surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

#### WithinGridEveTrCode

**Description** Code that links to the fraction of water that flows from *EveTr* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from EveTr surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

**WithinGridGrassCode**

**Description** Code that links to the fraction of water that flows from *Grass* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from Grass surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

**WithinGridPavedCode**

**Description** Code that links to the fraction of water that flows from *Paved* surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from Paved surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

**WithinGridWaterCode**

**Description** Code that links to the fraction of water that flows from Water surfaces to surfaces in columns 2-10 of *SUEWS\_WithinGridWaterDist.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>L</i>    | Code that links to the fraction of water that flows from Water surfaces to surfaces in columns 2-10 of <i>SUEWS_WithinGridWaterDist.txt</i> . Value of integer is arbitrary but must match code specified in column 1 of <i>SUEWS_WithinGridWaterDist.txt</i> . |

**Wuh**

**Description** External water use [m<sup>3</sup>]

**Configuration**

| Referencing Table            | Requirement | Comment                               |
|------------------------------|-------------|---------------------------------------|
| <i>SSss_YYYY_data_tt.txt</i> | <i>0</i>    | External water use [ m <sup>3</sup> ] |

**xsmd**

**Description** Observed soil moisture; can be provided either as volumetric ([m<sup>3</sup> m<sup>-3</sup>] when *SMDMethod* = 1) or gravimetric quantity ([kg kg<sup>-1</sup>] when *SMDMethod* = 2). This should be used in conjunction with other soil properties in *SUEWS\_Soil.txt*.

**Configuration**

| Referencing Table            | Requirement | Comment  |
|------------------------------|-------------|--|
| <i>SSss_YYYY_data_tt.txt</i> | <i>0</i>    | Observed soil moisture [ m <sup>3</sup> m <sup>-3</sup> or kg kg <sup>-1</sup> ] |

**Year**

**Description** Year [YYYY]

**Configuration**

| Referencing Table           | Requirement | Comment   |
|-----------------------------|-------------|---|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | Year [YYYY] Years must be continuous. If running multiple years, ensure the rows in <i>SUEWS_SiteSelect.txt</i> are arranged so that all grids for a particular year appear on consecutive lines (rather than grouping all years together for a particular grid). |

**z**

**Description** Measurement height [m] for all atmospheric forcing variables set in *SSss\_YYYY\_data\_tt.txt*.

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | <i>MU</i>   | z must be greater than the displacement height. Forcing data should be representative of the local-scale, i.e. above the height of the roughness elements. |

**z0**

**Description** Roughness length for momentum [m]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Value supplied here is used if <i>RoughLenMomMethod</i> = 1 in <i>RunControl.nml</i> ; otherwise set to '-999' and a value will be calculated by the model ( <i>RoughLenMomMethod</i> = 2, 3). |

**zd**

**Description** Zero-plane displacement [m]

**Configuration**

| Referencing Table           | Requirement | Comment  |
|-----------------------------|-------------|--|
| <i>SUEWS_SiteSelect.txt</i> | 0           | Value supplied here is used if <i>RoughLenMomMethod</i> = 1 in <i>RunControl.nml</i> ; otherwise set to -999 and a value will be calculated by the model ( <i>RoughLenMomMethod</i> = 2, 3). |

zi0

**Description** initial convective boundary layer height (m)**Configuration**

| Referencing Table           | Requirement | Comment                                      |
|-----------------------------|-------------|--|
| <i>CBL_initial_data.txt</i> | <i>MU</i>   | initial convective boundary layer height [m] |

**Typical Values**

Other values to add - please let us know

**Generic Properties**

| Property                       | General Type  | Value | Description         | Reference                     |
|--------------------------------|---------------|-------|---------------------|-------------------------------|
| Albedo                         | Non Vegetated | 0.09  | Paved Helsinki      | Järvi <i>et al.</i> [2014]    |
|                                | Non Vegetated | 0.15  | Buildings Helsinki  | Järvi <i>et al.</i> [2014]    |
|                                | Non Vegetated | 0.19  | Bare Soil, Helsinki | Järvi <i>et al.</i> [2014]    |
|                                | Non Vegetated | 0.12  | Paved               | Oke [2002]                    |
|                                | Non Vegetated | 0.15  | Buildings           | Oke [2002]                    |
|                                | Non Vegetated | 0.21  | Bare Soil           | Oke [2002]                    |
| Emissivity                     | Non Vegetated | 0.95  | Paved               | Oke [2002]                    |
|                                | Non Vegetated | 0.91  | Buildings           | Oke [2002]                    |
|                                | Non Vegetated | 0.93  | Bare Soil           | Oke [2002]                    |
| Surface Water storage capacity | Non Vegetated | 0.48  | Paved               | Davies and Hollis [1981]      |
|                                | Non Vegetated | 0.25  | Buildings           | Falk and Niemczynowicz [1978] |
| Albedo                         | Vegetation    | 0.1   | EveTr               |                               |
|                                | Vegetation    | 0.12  | DecTr               |                               |
|                                | Vegetation    | 0.18  | Grass               |                               |
|                                | Vegetated     | 0.1   | EveTr Helsinki      | Järvi <i>et al.</i> [2014]    |
|                                | Vegetated     | 0.16  | DecTr Helsinki      | Järvi <i>et al.</i> [2014]    |
|                                | Vegetated     | 0.19  | Grass Helsinki      | Järvi <i>et al.</i> [2014]    |
|                                | Vegetated     | 0.1   | EveTr               | Oke [2002]                    |
|                                | Vegetated     | 0.18  | DecTr               | Oke [2002]                    |
|                                | Vegetated     | 0.21  | Grass               | Oke [2002]                    |
| Emissivity                     | Vegetated     | 0.98  | EveTr               | Oke [2002]                    |

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Table 7.354 – continued from previous page

| Property  | General Type | Value | Description    | Reference                   |
|---|--------------|-------|----------------|-----------------------------|
|   | Vegetated    | 0.98  | DecTr          | Oke [2002]                  |
|   | Vegetated    | 0.93  | Grass          | Oke [2002]                  |
| water Storage<br>Minimum capacity<br>(mm)   | Vegetated    | 1.3   | EveTr          | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 0.3   | DecTr          | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 1.9   | Grass          | Breuer <i>et al.</i> [2003] |
| Maximum water<br>storage capacity<br>of this surface<br>[mm]  | Vegetated    | 1.3   | EveTr          | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 0.8   | DecTr          | Grimmond and Oke<br>(1991)  |
|   | Vegetated    | 1.9   | Grass          | Breuer <i>et al.</i> [2003] |
| Albedo Max (leaf<br>on)   | Vegetated    | 0.12  | DecTr          |                             |
|   | Vegetated    | 0.18  | Grass          |                             |
|   | Vegetated    | 0.1   | EveTr Helsinki | Järvi <i>et al.</i> [2014]  |
|   | Vegetated    | 0.16  | DecTr Helsinki | Järvi <i>et al.</i> [2014]  |
|   | Vegetated    | 0.19  | Grass Helsinki | Järvi <i>et al.</i> [2014]  |
|   | Vegetated    | 0.1   | EveTr          | Oke [2002]                  |
|   | Vegetated    | 0.18  | DecTr          | Oke [2002]                  |
|   | Vegetated    | 0.21  | Grass          | Oke [2002]                  |
| Emissivity *View<br>factors should be<br>taken into account   | Vegetated    | 0.98  | EveTr          | Oke [2002]                  |
| Emissivity *View<br>factors should be<br>taken into account   | Vegetated    | 0.98  | DecTr          | Oke [2002]                  |
| Emissivity *View<br>factors should be<br>taken into account   | Vegetated    | 0.93  | Grass          | Oke [2002]                  |
| Minimum water<br>storage capacity<br>of this surface<br>[mm]<br>• Min & max<br>values are<br>to account<br>for seasonal<br>variation<br>(e.g. leaf-<br>on/leaf-off<br>differences<br>for veg-<br>etated<br>surfaces). | Vegetated    | 1.3   | EveTr          | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 0.3   | DecTr          | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 1.9   | Grass          | Breuer <i>et al.</i> [2003] |

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Table 7.354 – continued from previous page

| Property  | General Type | Value  | Description   | Reference                   |
|---|--------------|--------|---|-----------------------------|
|   | Vegetated    | 1.3    | EveTr   | Breuer <i>et al.</i> [2003] |
|   | Vegetated    | 0.8    | DecTr   | Grimmond and Oke (1991)     |
|   | Vegetated    | 1.9    | Grass   | Breuer <i>et al.</i> [2003] |
| AlbedoMin   | Water        | 0.1    | Water   | Oke [2002]                  |
| AlbedoMax   | Water        | 0.1    | Water   | Oke [2002]                  |
| Emissivity  | Water        | 0.95   | Water   | Oke [2002]                  |
| Minimum water storage capacity of this surface [mm]   | Water        | 0.5    | Water   |                             |
| Maximum water storage capacity for upper surfaces (i.e. canopy)   | Water        | 0.5    | Water   |                             |
| WetThreshold  | water        | 0.5    | Water   |                             |
| StateLimit <ul style="list-style-type: none"> <li>• Upper limit to the surface state [mm]</li> <li>• State cannot exceed this value.</li> <li>• Set to a large value (e.g. 20000 mm = 20 m) if the water body is substantial (lake  river  etc) or a small value (e.g. 10 mm) if water bodies are very shallow (e.g. fountains).</li> </ul> | Water        | 20000  | Water   |                             |
| RadMeltFactor   | Snow         | 0.0016 | Hourly radiation melt factor of snow [mm W <sup>-1</sup> h <sup>-1</sup> ]    |                             |
| TempMeltFactor  | Snow         | 0.12   | Hourly temperature melt factor of snow [mm °C <sup>-1</sup> h <sup>-1</sup> ] |                             |
| AlbedoMin   | Snow         | 0-1    | Minimum snow albedo [-] - 0.18  | Järvi <i>et al.</i> [2014]  |

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Table 7.354 – continued from previous page

| Property   | General Type | Value | Description  | Reference                  |
|--|--------------|-------|--|----------------------------|
| AlbedoMax * Maximum snow albedo (fresh snow) [-]                                       | Snow         | 0.85  |  | Järvi <i>et al.</i> [2014] |
| Emissivity * Effective surface emissivity. * View factors should be taken into account | Snow         | 0.99  | Snow   | Järvi <i>et al.</i> [2014] |
| tau_a * Time constant for snow albedo aging in cold snow [-]                           | Snow         | 0.018 |  | Järvi <i>et al.</i> [2014] |
| tau_f * Time constant for snow albedo aging in melting snow [-]                        | Snow         | 0.11  |  | Järvi <i>et al.</i> [2014] |
| PrecipiLimAlb  | Snow         | 2     | Limit for hourly precipitation when the ground is fully covered with snow. Then snow albedo is reset to AlbedoMax [mm] |                            |
| snowDensMin  | Snow         | 100   | Fresh snow density [kg m-3]  |                            |
| snowDensMax  | Snow         | 400   | Maximum snow density [kg m-3]  |                            |
| tau_r * Time constant for snow density ageing [-]                                      | Snow         | 0.043 |  | Järvi <i>et al.</i> [2014] |
| CRWMin * Minimum water holding capacity of snow [mm]                                   | Snow         | 0.05  |  | Järvi <i>et al.</i> [2014] |
| CRWMax * Maximum water holding capacity of snow [mm]                                   | Snow         | 0.2   |  | Järvi <i>et al.</i> [2014] |
| PrecipLimSnow  | Snow         | 2.2   | Temperature limit when precipitation falls as snow [°C]  | Auer [1974]                |
| SoilDepth  | Snow         | 350   | Depth of sub-surface soil store [mm] *depth of soil beneath the surface  |                            |
| SoilStoreCap   | Soil         | 150   | Capacity of sub-surface soil store [mm]  |                            |

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Table 7.354 – continued from previous page

| Property         | General Type | Value  | Description  | Reference |
|------------------|--------------|--------|--|-----------|
|                  |              |        | how much water can be stored in the sub-surface soil when at maximum capacity. |           |
|                  |              |        | (SoilStoreCap must not be greater than SoilDepth.)                             |           |
| SatHydraulicCond | Soil         | 0.0005 | Hydraulic conductivity for saturated soil [mm s-1]                             |           |
| SoilDensity      | Soil         | 1.16   | Soil density [kg m-3]  |           |
| InfiltrationRate | Soil         |        | Infiltration rate [mm h-1]   |           |
| OBS_SMDepth      | Soil         |        | Depth of soil moisture measurements [mm]                                       |           |
| OBS_SMCap        | Soil         |        | Maximum observed soil moisture [m3 m-3 or kg kg-1]                             |           |
| OBS_SoilNotRocks | Soil         |        | Fraction of soil without rocks [-]   |           |

### Storage Heat Flux Related

- Values determined from the literature
- If you have recommendations for others to be included please let us know.
- In the model run, canyons are excluded

| Surface type | Description   | a1   | a2    | a3    | Reference                    |
|--------------|---|------|-------|-------|------------------------------|
| Canyon       | E-W canyon  | 0.71 | 0.04  | -39.7 | Yoshida <i>et al.</i> [1990] |
|              | N-S canyon  | 0.32 | 0.01  | -27.7 | Nunez and Oke [1977]         |
| Vegetation   | Mixed forest  | 0.11 | 0.11  | -12.3 | McCaughy [1985]              |
|              | Short grass   | 0.32 | 0.54  | -27.4 | Doll <i>et al.</i> [1985]    |
|              | Bare soil   | 0.38 | 0.56  | -27.3 | Novak [1981]                 |
|              | Bare soil (wet)                                     | 0.33 | 0.07  | -34.9 | Fuchs and Hadas [1972]       |
|              | Bare soil (dry)                                     | 0.65 | 0.43  | -36.5 | Fuchs and Hadas [1972]       |
|              | Bare soil   | 0.36 | 0.27  | -42.4 | Asaeda and Ca [1993]         |
|              | Water Shallow – Turbid                              | 0.5  | 0.21  | -39.1 | South <i>et al.</i> [1998]   |
|              | Unirrigated grass (Crops)                           | 0.21 | 0.11  | -16.1 | Grimmond [1992]              |
| Roof         | Short irrigated grass                               | 0.35 | -0.01 | -26.3 | Grimmond [1992]              |
|              | Tar and gravel, Vancouver                           | 0.17 | 0.1   | -17   | Yap [1973]                   |
|              | Uppsala   | 0.44 | 0.57  | -28.9 | Taesler [1980]               |
|              | Membrane and concrete, Kyoto                        | 0.82 | 0.34  | -55.7 | Yoshida <i>et al.</i> [1990] |
|              | Average gravel/tar/conc. flat industrial, Vancouver | 0.25 | 0.92  | -22   | Meyn and Oke [2009]          |
|              | Dry –gravel/tar/conc. flat industrial, Vancouver    | 0.25 | 0.7   | -22   | Meyn and Oke [2009]          |

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Table 7.355 – continued from previous page

| Surface type | Description   | a1   | a2    | a3    | Reference                   |
|--------------|---|------|-------|-------|-----------------------------|
|              | Wet – gravel/tar/conc. flat industrial, Vancouver       | 0.25 | 0.7   | -22   | Meyn and Oke [2009]         |
|              | Bitumen spread over flat industrial membrane, Vancouver | 0.06 | 0.28  | -3    | Meyn and Oke [2009]         |
|              | Asphalt shingle on plywood residential roof , Vancouver | 0.14 | 0.33  | -6    | Meyn and Oke [2009]         |
|              | Star – high albedo asphalt shingle residential roof     | 0.09 | 0.18  | -1    | Meyn and Oke [2009]         |
|              | Star - Ceramic Tile                                     | 0.07 | 0.26  | -6    | Meyn and Oke [2009]         |
|              | Star - Slate Tile                                       | 0.08 | 0.32  | 0     | Meyn and Oke [2009]         |
|              | Helsinki – Suburban                                     | 0.19 | 0.54  | -15.1 | Järvi <i>et al.</i> [2014]  |
|              | Montreal – Suburban                                     | 0.12 | 0.24  | -4.5  | Järvi <i>et al.</i> [2014]  |
|              | Montreal – Urban  | 0.26 | 0.85  | -21.4 | Järvi <i>et al.</i> [2014]  |
| Impervious   | Concrete  | 0.81 | 0.1   | -79.9 | Doll <i>et al.</i> [1985]   |
|              | Concrete  | 0.85 | 0.32  | -28.5 | Asaeda and Ca [1993]        |
|              | Asphalt   | 0.36 | 0.23  | -19.3 | NARITA <i>et al.</i> [1984] |
|              | Asphalt   | 0.64 | 0.32  | -43.6 | Asaeda and Ca [1993]        |
|              | Asphalt   | 0.82 | 0.68  | -20.1 | Anandakumar [1999]          |
|              | Asphalt (winter)  | 0.72 | 0.54  | -40.2 | Anandakumar [1999]          |
|              | Asphalt (summer)  | 0.83 | -0.83 | -24.6 | Anandakumar [1999]          |

The above text files (used to be stored as worksheets in **SUEWS\_SiteInfo.xlsm** for versions prior to v2018a) can be edited directly (see [Data Entry](#)). Please note this file is subject to possible changes from version to version due to new features, modifications, etc. Please be aware of using the correct copy of this worksheet that are always shipped with the SUEWS public release.

---

**Tip:**

1. See [SUEWS input converter](#) for conversion of input file between different versions.
  2. Typical values for various properties [can be found here](#).
- 

### 7.3.3 Initial Conditions file

To start the model, information about the conditions at the start of the run is required. This information is provided in initial conditions file. One file can be specified for each grid ([MultipleInitFiles=1](#) in [RunControl.nml](#), filename includes grid number) or, alternatively, a single file can be specified for all grids (MultipleInitFiles=0 in [RunControl.nml](#), no grid number in the filename). After that, a new InitialConditionsSSss\_YYYY.nml file will be written for each grid for the following years. It is recommended that you look at these files (written to the input directory) to check the status of various surfaces at the end of the run. This may help you get more realistic starting values if you are uncertain what they should be. Note this file will be created for each year for multiyear runs for each grid. If the run finishes before the end of the year the InitialConditions file is still written and the file name is appended with ‘\_EndofRun’.

A sample file of **InitialConditionsSSss\_YYYY.nml** looks like

```
&InitialConditions
LeavesOutInitially=0
SoilstorePavedState=150
SoilstoreBldgsState=150
SoilstoreEveTrstate=150
SoilstoreDecTrState=150
SoilstoreGrassState=150
SoilstoreBSoilState=150
```

(continues on next page)

(continued from previous page)

```
BoInit=10  
/
```

The two most important pieces of information in the initial conditions file is the soil moisture and state of vegetation at the start of the run. This is the minimal information required; other information can be provided if known, otherwise SUEWS will make an estimate of initial conditions.

The parameters and their setting instructions are provided through the links below:

---

**Note:** Variables can be in any order

---

- *Soil moisture states*

- |                              |                              |
|------------------------------|------------------------------|
| – <i>SoilstorePavedState</i> | – <i>SoilstoreDecTrState</i> |
| – <i>SoilstoreBldgsState</i> | – <i>SoilstoreGrassState</i> |
| – <i>SoilstoreEveTrState</i> | – <i>SoilstoreBSoilState</i> |

- *Vegetation parameters*

- |                             |                    |
|-----------------------------|--------------------|
| – <i>LeavesOutInitially</i> | – <i>albEveTr0</i> |
| – <i>GDD_1_0</i>            | – <i>albDecTr0</i> |
| – <i>GDD_2_0</i>            | – <i>albGrass0</i> |
| – <i>LAIinitialEveTr</i>    | – <i>decidCap0</i> |
| – <i>LAIinitialDecTr</i>    | – <i>porosity0</i> |
| – <i>LAIinitialGrass</i>    |                    |

- *Recent meteorology*

- |                        |                  |
|------------------------|------------------|
| – <i>DaysSinceRain</i> | – <i>Temp_C0</i> |
|------------------------|------------------|

- *Above ground state*

- |                     |                     |
|---------------------|---------------------|
| – <i>PavedState</i> | – <i>GrassState</i> |
| – <i>BldgsState</i> | – <i>BSoilState</i> |
| – <i>EveTrState</i> | – <i>WaterState</i> |
| – <i>DecTrState</i> |                     |

- *Snow related parameters*

- |                              |                        |
|------------------------------|------------------------|
| – <i>SnowInitially</i>       | – <i>SnowPackDecTr</i> |
| – <i>SnowWaterPavedState</i> | – <i>SnowPackGrass</i> |
| – <i>SnowWaterBldgsState</i> | – <i>SnowPackBSoil</i> |
| – <i>SnowWaterEveTrState</i> | – <i>SnowPackWater</i> |
| – <i>SnowWaterDecTrState</i> | – <i>SnowFracPaved</i> |
| – <i>SnowWaterGrassState</i> | – <i>SnowFracBldgs</i> |
| – <i>SnowWaterBSoilState</i> | – <i>SnowFracEveTr</i> |
| – <i>SnowWaterWaterState</i> | – <i>SnowFracDecTr</i> |
| – <i>SnowPackPaved</i>       | – <i>SnowFracGrass</i> |
| – <i>SnowPackBldgs</i>       | – <i>SnowFracBSoil</i> |
| – <i>SnowPackEveTr</i>       | – <i>SnowFracWater</i> |

- *SnowDensPaved*
- *SnowDensBldgs*
- *SnowDensEveTr*
- *SnowDensDecTr*
- *SnowDensGrass*
- *SnowDensBSoil*
- *SnowDensWater*
- *SnowAlb0*

## Soil moisture states

### SoilstorePavedState

**Requirement** Required

**Description** Initial water stored in soil beneath *Paved* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

### SoilstoreBldgsState

**Requirement** Required

**Description** Initial water stored in soil beneath *Bldgs* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

### SoilstoreEveTrState

**Requirement** Required

**Description** Initial water stored in soil beneath *EveTr* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

### SoilstoreDecTrState

**Requirement** Required

**Description** Initial water stored in soil beneath *DecTr* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

### SoilstoreGrassState

**Requirement** Required

**Description** Initial water stored in soil beneath *Grass* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

### SoilstoreBSoilState

**Requirement** Required

**Description** Initial water stored in soil beneath *BSoil* surface [mm]

**Configuration** For maximum values, see the used soil code in *SUEWS\_Soil.txt*

## Vegetation parameters

### LeavesOutInitially

**Requirement** Optional

**Description** Flag for initial leave status [1 or 0]

**Configuration** If the model run starts in winter when trees are bare, set *LeavesOutInitially* = 0 and the vegetation parameters will be set accordingly based on the values set in *SUEWS\_SiteInfo.xlsm*. If the model run starts in summer when leaves are fully out, set *LeavesOutInitially* = 1 and the vegetation parameters will be set accordingly based on the values set in *SUEWS\_SiteInfo.xlsm*. Not *LeavesOutInitially* can only be set to 0, 1 or -999 (fractional values cannot be used to indicate partial leaf-out). The value of *LeavesOutInitially* overrides any values provided for the individual vegetation parameters. To prevent *LeavesOutInitially* from setting the initial conditions, either omit it from the namelist or set to -999. If values are provided individually, they should be consistent the information provided in *SUEWS\_Veg.txt* and the time of year. If values are provided individually, values for all required surfaces must be provided (i.e. specifying only *albGrass0* but not *albDecTr0* nor *albEveTr0* is not permitted).

### GDD\_1\_0

**Requirement** Optional

**Description** GDD related initial value

**Configuration** Cannot be negative. If leaves are already full, then this should be the same as *GDDFull* in *SUEWS\_Veg.txt*. If winter, set to 0. It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter).

### GDD\_2\_0

**Requirement** Optional

**Description** GDD related initial value

**Configuration** Cannot be positive If the leaves are full but in early/mid summer then set to 0. If late summer or autumn , this should be a negative value. If leaves are off , then use the values of *SDDFull* in *SUEWS\_Veg.txt* to guide your minimum value. It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter).

### LAIinitialEveTr

**Requirement** Optional

**Description** Initial LAI for evergreen trees *EveTr*.

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

### LAIinitialDecTr

**Requirement** Optional

**Description** Initial LAI for deciduous trees *DecTr*.

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

### LAIinitialGrass

**Requirement** Optional

**Description** Initial LAI for irrigated grass *Grass*.



**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

#### albEveTr0

**Requirement** Optional

**Description** Albedo of evergreen surface *EveTr* on day 0 of run

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

#### albDecTr0

**Requirement** Optional

**Description** Albedo of deciduous surface *DecTr* on day 0 of run

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

#### albGrass0

**Requirement** Optional

**Description** Albedo of grass surface *Grass* on day 0 of run

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

#### decidCap0

**Requirement** Optional

**Description** Storage capacity of deciduous surface *DecTr* on day 0 of run.

**Configuration** The recommended values can be found from *SUEWS\_Veg.txt*

#### porosity0

**Requirement** Optional

**Description** Porosity of deciduous vegetation on day 0 of run.

**Configuration** This varies between 0.2 (leaf-on) and 0.6 (leaf-off). The recommended values can be found from *SUEWS\_Veg.txt*

### Recent meteorology

#### DaysSinceRain

**Requirement** Optional

**Description** Days since rain [d]

**Configuration** Important to use correct value if starting in summer season If starting when external water use is not occurring it will be reset with the first rain so can just be set to 0. If unknown, SUEWS sets to zero by default. Used to model irrigation.

#### Temp\_C0

**Requirement** Optional

**Description** Initial air temperature [degC]

**Configuration** If unknown, SUEWS uses the mean temperature for the first day of the run.

## Above ground state

### PavedState

**Requirement** Optional

**Description** Initial wetness condition on *Paved*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### BldgsState

**Requirement** Optional

**Description** Initial wetness condition on *Bldgs*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### EveTrState

**Requirement** Optional

**Description** Initial wetness condition on *EveTr*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### DecTrState

**Requirement** Optional

**Description** Initial wetness condition on *DecTr*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### GrassState

**Requirement** Optional

**Description** Initial wetness condition on *Grass*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### BSoilState

**Requirement** Optional

**Description** Initial wetness condition on *BSoil*

**Configuration** If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

### WaterState

**Requirement** Optional

**Description** Initial wetness condition on *Water*

**Configuration** For a large water body (e.g. river, sea, lake) set WaterState to a large value, e.g. 20000 mm; for small water bodies (e.g. ponds, fountains) set WaterState to smaller value, e.g. 1000 mm. This value must not exceed StateLimit specified in SUEWS\_Water.txt . If unknown, model uses value of WaterDepth specified in SUEWS\_Water.txt .

## Snow related parameters

### SnowInitially

**Requirement** Optional

**Description** Flag for initial snow status [0 or 1]

**Configuration** If the model run starts when there is no snow on the ground, set *SnowInitially* = 0 and the snow-related parameters will be set accordingly. If the model run starts when there is snow on the ground, the following snow-related parameters must be set appropriately. The value of *SnowInitially* overrides any values provided for the individual snow-related parameters. To prevent *SnowInitially* from setting the initial conditions, either omit it from the namelist or set to -999. If values are provided individually, they should be consistent the information provided in *SUEWS\_Snow.txt*.

### SnowWaterPavedState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on paved surfaces *Paved*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### SnowWaterBldgsState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on buildings *Bldgs*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### SnowWaterEveTrState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on evergreen trees *EveTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### SnowWaterDecTrState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on deciduous trees *DecTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### SnowWaterGrassState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on grass surfaces *Grass*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### SnowWaterBSoilState

**Requirement** Optional

**Description** Initial amount of liquid water in the snow on bare soil surfaces *BSoil*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowWaterWaterState**

**Requirement** Optional

**Description** Initial amount of liquid water in the snow in water *Water*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackPaved**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on paved surfaces *Paved*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackBldgs**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on buildings *Bldgs*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackEveTr**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on evergreen trees *EveTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackDecTr**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on deciduous trees *DecTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackGrass**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on grass surfaces *Grass*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackBSoil**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on bare soil surfaces *BSoil*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### **SnowPackWater**

**Requirement** Optional

**Description** Initial snow water equivalent if the snow on water *Water*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracPaved**

**Requirement** Optional

**Description** Initial plan area fraction of snow on paved surfaces *Paved*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracBldgs**

**Requirement** Optional

**Description** Initial plan area fraction of snow on buildings *Bldgs*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracEveTr**

**Requirement** Optional

**Description** Initial plan area fraction of snow on evergreen trees *EveTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracDecTr**

**Requirement** Optional

**Description** Initial plan area fraction of snow on deciduous trees *DecTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracGrass**

**Requirement** Optional

**Description** Initial plan area fraction of snow on grass surfaces *Grass*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracBSoil**

**Requirement** Optional

**Description** Initial plan area fraction of snow on bare soil surfaces *BSoil*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowFracWater**

**Requirement** Optional

**Description** Initial plan area fraction of snow on water *Water*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

**SnowDensPaved**

**Requirement** Optional

**Description** Initial snow density on paved surfaces *Paved*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensBldgs

**Requirement** Optional

**Description** Initial snow density on buildings *Bldgs*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensEveTr

**Requirement** Optional

**Description** Initial snow density on evergreen trees *EveTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensDecTr

**Requirement** Optional

**Description** Initial snow density on deciduous trees *DecTr*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensGrass

**Requirement** Optional

**Description** Initial snow density on grass surfaces *Grass*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensBSoil

**Requirement** Optional

**Description** Initial snow density on bare soil surfaces *BSoil*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowDensWater

**Requirement** Optional

**Description** Initial snow density on *Water*

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

#### SnowAlb0

**Requirement** Optional

**Description** Initial snow albedo

**Configuration** The recommended values can be found from *SUEWS\_Snow.txt*

### 7.3.4 Meteorological Input File

SUEWS is designed to run using commonly measured meteorological variables (e.g. incoming solar radiation, air temperature, relative humidity, pressure, wind speed, etc.).

When preparing this input file, please note the following:

- Required inputs must be continuous – i.e. **gap fill** any missing data.
- Temporal information (i.e., `iy`, `id`, `it` and `imin`) should be in **local time** and indicate the ending timestamp of corresponding periods: e.g. for hourly data, `2021-09-12 13:00` indicates a record for the period between `2021-09-12 12:00` (inclusive) and `2021-09-12 13:00` (exclusive).
- The [table](#) below gives the must-use (*MU*) and optional (*O*) additional input variables. If an optional input variable (*O*) is not available or will not be used by the model, enter ‘-999’ for this column.
- One single meteorological file can be used for all grids (**MultipleMetFiles=0** in [RunControl.nml](#), no grid number in file name) if appropriate for the study area.
- Separate met files can be used for each grid if data are available (**MultipleMetFiles=1** in [RunControl.nml](#), file-name includes grid number).
- The meteorological forcing file names should be appended with the temporal resolution in minutes: `tt` in `SS_YYYY_data_tt.txt` (or `SSss_YYYY_data_tt.txt` for multiple grids).
- Separate met forcing files should be provided for each year.
- Files do not need to start/end at the start/end of the year, but they must contain a whole number of days.
- The meteorological input file should match the information given in [SUEWS\\_SiteSelect.txt](#).
- If a *partial year* is used that specific year must be given in `SUEWS_SiteSelect.txt`.
- If *multiple years* are used, all years should be included in `SUEWS_SiteSelect.txt`.
- If a *whole year* (e.g. 2011) is intended to be modelled using an hourly resolution dataset, the number of lines in the met data file should be 8760 and begin and end with:

```
iy    id  it  imin
2011   1   1   0 ...
...
2012   1   0   0 ...
```

#### SSss\_YYYY\_data\_tt.txt

Changed in version v2017a: Since v2017a forcing files no longer need to end with two rows containing ‘-9’ in the first column.

Main meteorological data file.

| No. | Use       | Column Name | Description  |
|-----|-----------|-------------|--|
| 1   | <i>MU</i> | iy          | Year [YYYY]  |
| 2   | <i>MU</i> | id          | Day of year [DOY]  |
| 3   | <i>MU</i> | it          | Hour [H]   |
| 4   | <i>MU</i> | imin        | Minute [M]   |
| 5   | <i>O</i>  | qn          | Net all-wave radiation [ $\text{W m}^{-2}$ ] (Required if <i>NetRadiationMethod</i> = 0.)                          |
| 6   | <i>O</i>  | qh          | Sensible heat flux [ $\text{W m}^{-2}$ ]   |
| 7   | <i>O</i>  | qe          | Latent heat flux [ $\text{W m}^{-2}$ ]   |
| 8   | <i>O</i>  | qs          | Storage heat flux [ $\text{W m}^{-2}$ ]  |
| 9   | <i>O</i>  | qf          | Anthropogenic heat flux [ $\text{W m}^{-2}$ ]  |
| 10  | <i>MU</i> | U           | Wind speed [ $\text{m s}^{-1}$ ] (measurement height ( <i>z</i> ) is needed in <i>SUEWS_SiteSelect.txt</i> )       |
| 11  | <i>MU</i> | RH          | Relative Humidity [%] (measurement height ( <i>z</i> ) is needed in <i>SUEWS_SiteSelect.txt</i> )                  |
| 12  | <i>MU</i> | Tair        | Air temperature [ $^{\circ}\text{C}$ ] (measurement height ( <i>z</i> ) is needed in <i>SUEWS_SiteSelect.txt</i> ) |
| 13  | <i>MU</i> | pres        | Barometric pressure [kPa] (measurement height ( <i>z</i> ) is needed in <i>SUEWS_SiteSelect.txt</i> )              |
| 14  | <i>MU</i> | rain        | Rainfall [mm] (measurement height ( <i>z</i> ) is needed in <i>SUEWS_SiteSelect.txt</i> )                          |
| 15  | <i>MU</i> | kdown       | Incoming shortwave radiation [ $\text{W m}^{-2}$ ] Must be $> 0 \text{ W m}^{-2}$ .                                |
| 16  | <i>O</i>  | snow        | Snow cover fraction (0 – 1) [-] (Required if <i>SnowUse</i> = 1)   |
| 17  | <i>O</i>  | ldown       | Incoming longwave radiation [ $\text{W m}^{-2}$ ]  |
| 18  | <i>O</i>  | fcld        | Cloud fraction [tenths]  |
| 19  | <i>O</i>  | Wuh         | External water use [ $\text{m}^3$ ]  |
| 20  | <i>O</i>  | xsmc        | Observed soil moisture [ $\text{m}^3 \text{ m}^{-3}$ ] or [ $\text{kg kg}^{-1}$ ]                                  |
| 21  | <i>O</i>  | lai         | Observed leaf area index [ $\text{m}^2 \text{ m}^{-2}$ ]   |
| 22  | <i>O</i>  | kdiff       | Diffuse radiation [ $\text{W m}^{-2}$ ] <b>Recommended in this version.</b> if <i>SOLWEIGUse</i> = 1               |
| 23  | <i>O</i>  | kdir        | Direct radiation [ $\text{W m}^{-2}$ ] <b>Recommended in this version.</b> if <i>SOLWEIGUse</i> = 1                |
| 24  | <i>O</i>  | wdir        | Wind direction [ $^{\circ}$ ] <b>Not available in this version.</b>  |

### 7.3.5 CBL input files

Main references for this part of the model: Onomura *et al.* [2015] and Cleugh and Grimmond [2001].

If CBL slab model is used (*CBLUse* = 1 in *RunControl.nml*) the following files are needed.

| Filename                    | Purpose  |
|-----------------------------|--|
| <i>CBL_initial_data.txt</i> | Gives initial data every morning * when CBL slab model starts running. * filename must match the InitialData_FileName in CBLInput.nml * fixed formats. |
| <i>CBLInput.nml</i>         | Specifies run options, parameters and input file names. * Can be in any order  |



## CBL\_initial\_data.txt

This file should give initial data every morning when CBL slab model starts running. The file name should match the InitialData\_FileName in CBLInput.nml.

Definitions and example file of initial values prepared for Sacramento.

| No. | Column name | Description  |
|-----|-------------|--|
| 1   | id          | Day of year [DOY]  |
| 2   | zi0         | Initial convective boundary layer height (m)   |
| 3   | gamt_Km     | Vertical gradient of potential temperature ( $\text{K m}^{-1}$ ) strength of the inversion |
| 4   | gamq_gkgm   | Vertical gradient of specific humidity ( $\text{g kg}^{-1} \text{ m}^{-1}$ )               |
| 5   | Theta+_K    | Potential temperature at the top of CBL (K)  |
| 6   | q+_gkg      | Specific humidity at the top of CBL ( $\text{g kg}^{-1}$ )                                 |
| 7   | Theta_K     | Potential temperature in CBL (K)   |
| 8   | q_gkg       | Specific humidity in CBL ( $\text{g kg}^{-1}$ )  |

- gamt\_Km and gamq\_gkgm written to two significant figures are required for the model performance in appropriate ranges [Onomura *et al.*, 2015].

| id  | zi0 | gamt_Km | gamq_gkgm | Theta+_K | q+_gkg | theta_K | q_gkg |
|-----|-----|---------|-----------|----------|--------|---------|-------|
| 234 | 188 | 0.0032  | 0.00082   | 290.4    | 9.6    | 288.7   | 8.3   |
| 235 | 197 | 0.0089  | 0.089     | 290.2    | 8.4    | 288.3   | 8.7   |
|     |     |         |           |          |        |         |       |
|     |     |         |           |          |        |         |       |
|     |     |         |           |          |        |         |       |

## CBLInput.nml

sample file of **CBLInput.nml** looks like

```
&CBLInput
EntrainmentType=1      ! 1.Tennekes and Driedonks(1981), 2.McNaughton and
↳Springgs(1986), 3.Rayner and Watson(1991),4.Tennekes(1973),
QH_choice=1            ! 1.suews 2.lumps 3.obs
CO2_included=0
cblday(236)=1
cblday(258)=1
cblday(259)=1
cblday(260)=1
cblday(285)=1
cblday(297)=1
wsb=-0.01
InitialData_use=1
InitialDataFileName='CBLinputfiles/CBL_initial_data.txt'
sondeflag=0
FileSonde(234)='CBLinputfiles\Sonde_Sc_1991_0822_0650.txt'
FileSonde(235)='CBLinputfiles\Sonde_Sc_1991_0823_0715.txt'
FileSonde(236)='CBLinputfiles\Sonde_Sc_1991_0824_0647.txt'
FileSonde(238)='CBLinputfiles\Sonde_Sc_1991_0826_0642.txt'
FileSonde(239)='CBLinputfiles\Sonde_Sc_1991_0827_0640.txt'
FileSonde(240)='CBLinputfiles\Sonde_Sc_1991_0828_0640.txt'
/
```

---

**Note:** The file contents can be in any order.

---

The parameters and their setting instructions are provided through *the links below*:

- [EntrainmentType](#)
- [QH\\_Choice](#)
- [InitialData\\_use](#)
- [Sondeflag](#)
- [CBLday\(id\)](#)
- [CO2\\_included](#)
- [FileSonde\(id\)](#)
- [InitialDataFileName](#)
- [Wsb](#)

## CBLinput

### EntrainmentType

**Requirement** Required

**Description** Determines entrainment scheme. See Cleugh and Grimmond 2000 [16] for details.

**Configuration**

| Value | Comments  |
|-------|---|
| 1     | Tennekes and Driedonks (1981) - <b>Recommended in this version.</b> |
| 2     | McNaughton and Springs (1986)                                       |
| 3     | Rayner and Watson (1991)  |
| 4     | Tennekes (1973)   |

### QH\_Choice

**Requirement** Required

**Description** Determines QH used for CBL model.

**Configuration**

| Value | Comments   |
|-------|--|
| 1     | QH modelled by SUEWS   |
| 2     | QH modelled by LUMPS   |
| 3     | Observed QH values are used from the meteorological input file |

### InitialData\_use

**Requirement** Required

**Description** Determines initial values (see [CBL\\_initial\\_data.txt](#))

**Configuration**

| Value | Comments   |
|-------|--|
| 0     | All initial values are calculated. <b>Not available in this version.</b>   |
| 1     | Take zi0, gamt_Km and gamq_gkgm from input data file. Theta+_K, q+_gkg, Theta_K and q_gkg are calculated using Temp_C, avrh and Pres_kPa in meteorological input file. |
| 2     | Take all initial values from input data file (see <a href="#">CBL_Initial_data.txt</a> ).  |

**Sondeflag****Requirement** Required**Description** to fill**Configuration**

| Value | Comments   |
|-------|--|
| 0     | Does not read radiosonde vertical profile data - <b>Recommended in this version.</b> |
| 1     | Reads radiosonde vertical profile data   |

**CBLday(id)****Requirement** Required**Description** Set CBLday(id) = 1 If CBL model is set to run for DOY 175–177, CBLday(175) = 1, CBLday(176) = 1, CBLday(177) = 1**Configuration** to fill**C02\_included****Requirement** Required**Description** Set to zero in current version**Configuration** to fill**FileSonde(id)****Requirement** Required**Description** If Sondeflag=1, write the file name including the path from site directory e.g. FileSonde(id)= 'CBLinputfilesXXX.txt', XXX is an arbitrary name.**Configuration** to fill**InitialDataFileName****Requirement** Required**Description** If InitialData\_use 1, write the file name including the path from site directory e.g. InitialDataFileName='CBLinputfilesCBL\_initial\_data.txt'**Configuration** to fill**Wsb****Requirement** Required**Description** Subsidence velocity ( $\text{m s}^{-1}$ ) in eq. 1 and 2 of Onomura et al. (2015) [17] . ( $-0.01 \text{ m s}^{-1}$  **Recommended in this version.**)**Configuration** to fill

### 7.3.6 ESTM input files

#### SUEWS\_ESTMCoefficients.txt

**Note** ESTM is under development in this release and should not be used!

The Element Surface Temperature Method (ESTM) [Offerle *et al.*, 2005] calculates the net storage heat flux from surface temperatures. In the method the three-dimensional urban volume is reduced to four 1-d elements (i.e. building roofs, walls, and internal mass and ground (road, vegetation, etc)). The storage heat flux is calculated from the heat conduction through the different elements. For the inside surfaces of the roof and walls, and both surfaces for the internal mass (ceilings/floors, internal walls), the surface temperature of the element is determined by setting the conductive heat transfer out of (in to) the surface equal to the radiative and convective heat losses (gains). Each element (roof, wall, internal element and ground) can have maximum five layers and each layer has three parameters tied to it: thickness (x), thermal conductivity (k), volumetric heat capacity (rhoCp).

If ESTM is used (*StorageHeatMethod* =4), the files *SUEWS\_ESTMCoefficients.txt*, *ESTMinput.nml* and *SSss\_YYYY\_ESTM\_Ts\_data\_tt.txt* should be prepared.

SUEWS\_ESTMCoefficients.txt contains the parameters for the layers of each of the elements (roofs, wall, ground, internal mass).

- If less than five layers are used, the parameters for unused layers should be set to -999.
- The ESTM coefficients with the prefix *Surf\_* must be specified for each surface type (plus snow) but the *Wall\_* and *Internal\_* variables apply to the building surfaces only.
- For each grid, one set of ESTM coefficients must be specified for each surface type; for paved and building surfaces it is possible to specify up to three and five sets of coefficients per grid (e.g. to represent different building materials) using the relevant columns in *SUEWS\_SiteSelect.txt*. For the model to use these columns in site select, the ESTMCode column in *SUEWS\_NonVeg.txt* should be set to zero.

The following input files are required if ESTM is used to calculate the storage heat flux.

#### ESTMinput.nml

ESTMinput.nml specifies the model settings and default values.

A sample file of **ESTMinput.nml** looks like

```
&ESTMinput
TsurfChoice= 0
evolveTibld= 0      ! !!!!!FO!!!! 0 originally
ibldCHmod  = 0
LBC_soil   = 13.00      !!FO!! 4, 8 or 17 degC - could be set as the annual mean_
↳air temperature (12.8 degC for London)
THEAT_ON   = 18.
THEAT_OFF  = 22.
THEAT_FIX  = 19.
/
```

---

**Note:** The file contents can be in any order.

---

The parameters and their setting instructions are provided through *the links below*:

- *TsurfChoice*
- *evolveTibld*
- *IbldCHmod*
- *LBC\_soil*
- *Theat\_fix*
- *Theat\_off*
- *Theat\_on*

## ESTMinput

### TsurfChoice

**Requirement** Required

**Description** Source of surface temperature data used.

**Configuration**

| Value | Comments  |
|-------|---|
| 0     | <i>Tsurf</i> in <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> used for all surface elements. |
| 1     | Input surface temperature are different for ground, roof and wall.                  |
| 2     | Wall surface temperature is different for four directions.                          |

### evolveTibld

**Requirement** Required

**Description** Source of internal building temperature (Tibld)

**Configuration**

| Value | Comments  |
|-------|---|
| 0     | <i>Tiair</i> in <i>SSss_YYYY_ESTM_Ts_data_tt.txt</i> used.              |
| 1     | Tibld calculated considering the effect of anthropogenic heat from HVAC |
| 2     | Tibld calculated without considering the influence of HVAC.             |

### IbldCHmod

**Requirement** Required

**Description** Method to calculate internal convective heat exchange coefficients (CH) for internal building, wall and roof if evolveTibld is 1 or 2.

**Configuration**

| Value | Comments                                      |
|-------|---|
| 0     | CHs are read from SUEWS_ESTMcoefficients.txt. |
| 1     | CHs are calculated based on ASHRAE (2001)     |
| 2     | CHs are calculated based on Awbi (1998).      |

### LBC\_soil

**Requirement** Required

**Description** Soil temperature at lowest boundary condition [C]

**Configuration** to fill

**Theat\_fix****Requirement** Required**Description** Ideal internal building temperature [C]**Configuration** to fill**Theat\_off****Requirement** Required**Description** Temperature at which heat control is turned off (used when evolveTibld=1) [C]**Configuration** to fill**Theat\_on****Requirement** Required**Description** Temperature at which heat control is turned on (used when evolveTibld =1) [C]**Configuration** to fill**SSss\_YYYY\_ESTM\_Ts\_data\_tt.txt**

*SSss\_YYYY\_ESTM\_Ts\_data\_tt.txt* contains a time-series of input surface temperature for roof, wall, ground and internal elements.

| No. | Column Name    | Use       | Description  |
|-----|----------------|-----------|--|
| 1   | <i>iy</i>      | <i>MU</i> | Year [YYYY]  |
| 2   | <i>id</i>      | <i>MU</i> | Day of year [DOY]  |
| 3   | <i>it</i>      | <i>MU</i> | Hour [H]   |
| 4   | <i>imin</i>    | <i>MU</i> | Minute [M]   |
| 5   | <i>Tiair</i>   | <i>MU</i> | Indoor air temperature [C]   |
| 6   | <i>Tsurf</i>   | <i>MU</i> | Bulk surface temperature [C] (used when <i>TsurfChoice</i> = 0)              |
| 7   | <i>Troof</i>   | <i>MU</i> | Roof surface temperature [C] (used when <i>TsurfChoice</i> = 1 or 2)         |
| 8   | <i>Troad</i>   | <i>MU</i> | Ground surface temperature [C] (used when <i>TsurfChoice</i> = 1 or 2)       |
| 9   | <i>Twall</i>   | <i>MU</i> | Wall surface temperature [C] (used when <i>TsurfChoice</i> = 1)              |
| 10  | <i>Twall_n</i> | <i>MU</i> | North-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |
| 11  | <i>Twall_e</i> | <i>MU</i> | East-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2)  |
| 12  | <i>Twall_s</i> | <i>MU</i> | South-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2) |
| 13  | <i>Twall_w</i> | <i>MU</i> | West-facing wall surface temperature [C] (used when <i>TsurfChoice</i> = 2)  |

### 7.3.7 SUEWS-SPARTACUS (SS) input files

To run SUEWS-SS the SS specific files that need to be modified are:

- *RunControl.nml*
- *SUEWS\_SPARTACUS.nml*

Non-SS specific SUEWS input file parameters also need to have appropriate values. For example, LAI, albedos and emissivities are used by SUEWS-SS as explained in *More background information*.

## RunControl.nml

See *NetRadiationMethod* (sensible values are 1001, 1002 or 1003) in *RunControl.nml* parameter.

## SUEWS\_SPARTACUS.nml

This file is used to specify the SS model options when coupled to SUEWS.

A sample file of **SUEWS\_SPARTACUS.nml** is shown below:

```
&Spartacus
nlayers = 1
use_sw_direct_albedo = false
n_vegetation_region_urban = 1
nsw = 1
nlw = 1
nspec = 1
n_stream_sw_urban = 8
n_stream_lw_urban = 8
sw_dn_direct_frac = 0.0
air_ext_sw = 0.0
air_ssa_sw = 0.95
veg_ssa_sw = 0.13
air_ext_lw = 0.0
air_ssa_lw = 0.0
veg_ssa_lw = 0.01
ground_albedo_dir_mult_fact = 1.
/
```

The parameters and their setting instructions are provided through the links below:

### Geometry-related options

- |  |                                     |
|--|-------------------------------------|
| • <code>nlayers</code>                   | • <code>veg_frac</code>             |
| • <code>n_vegetation_region_urban</code> | • <code>veg_scale</code>            |
| • <code>height</code>                    | • <code>veg_contact_fraction</code> |
| • <code>building_frac</code>             | • <code>wall_specular_frac</code>   |
| • <code>building_scale</code>            |                                     |

### Shortwave-related options

- |                                     |  |
|-------------------------------------|--|
| • <code>use_sw_direct_albedo</code> | • <code>veg_ssa_sw</code>                  |
| • <code>sw_dn_direct_frac</code>    | • <code>ground_albedo_dir_mult_fact</code> |
| • <code>n_stream_sw_urban</code>    | • <code>roof_albedo</code>                 |
| • <code>air_ext_sw</code>           | • <code>wall_albedo</code>                 |
| • <code>air_ssa_sw</code>           |  |

## Longwave-related options

- `n_stream_lw_urban`
- `air_ext_lw`
- `air_ssa_lw`
- `veg_ssa_lw`
- `veg_fsd`
- `roof_emissivity`
- `wall_emissivity`
- `roof_albedo_dir_mult_fact`

### 7.3.8 SUEWS input converter

---

**Note:** The SUEWS table converter has been integrated into SuPy as a command line tool `suews-convert` since v2020a. Please install SuPy and run `suews-convert` to convert input tables from an older version to a newer one.

---

#### Usage

Please refer to the [SuPy API page](#).

#### Example (from 2018a to 2020a)

Assuming your 2018a files are all included in the folder `your_2018a_folder` and your desirable converted files should be placed in a new folder `your_2020a_folder`, please do the following in your command line tool:

```
suews-convert -f 2018a -t 2020a -i your_2018a_folder -o your_2020a_folder
```

---

**Tip:** `suews-convert` will use the `RunControl.nml` file in your original folder to determine the location of input tables.

---

## 7.4 Output files

### 7.4.1 Runtime diagnostic information

#### Error messages: `problems.txt`

If there are problems running the program serious error messages will be written to `problems.txt`.

- Serious problems will usually cause the program to stop after writing the error message. If this is the case, the last line of *Error messages: `problems.txt`* will contain a non-zero number (the error code).
- If the program runs successfully, `problems.txt` file ends with:

```
Run completed.
```

```
0
```

SUEWS has a large number of error messages included to try to capture common errors to help the user determine what the problem is. If you encounter an error that does not provide an error message please capture the details so we can hopefully provide better error messages in future.

See [Troubleshooting](#) section for help solving problems. If the file paths are not correct the program will return an error when run (see [Workflow of using SUEWS](#)).



### Warning messages: warnings.txt

- If the program encounters a more minor issue it will not stop but a warning may be written to warnings.txt. It is advisable to check the warnings to ensure there is not a more serious problem.
- The warnings.txt file can be large (over several GBs) given warning messages are written out during a large scale simulation, you can use `tail/head` to view the ending/starting part without opening the whole file on Unix-like systems (Linux/mac OS), which may slow down your system.
- To prevent warnings.txt from being written, set `SuppressWarnings` to 1 in `RunControl.nml`.
- Warning messages are usually written with a grid number, timestamp and error count. If the problem occurs in the initial stages (i.e. before grid numbers and timestamps are assigned, these are printed as 00000).

### Summary of model parameters: SS\_FileChoices.txt

For each run, the model parameters specified in the input files are written out to the file `SS_FileChoices.txt`.

## 7.4.2 Model output files

**Note:** Temporal information in output files (i.e., `iy`, `id`, `it` and `imin` if existing) are in **local time** (i.e. consistent with *Meteorological Input File*) and indicate the ending timestamp of corresponding periods: e.g. for hourly data, `2021-09-12 13:00` indicates a record for the period between `2021-09-12 12:00` (inclusive) and `2021-09-12 13:00` (exclusive).

### SSss\_YYYY\_SUEWS\_TT.txt

SUEWS produces the main output file (`SSss_YYYY_SUEWS_tt.txt`) with time resolution (`TT` min) set by `ResolutionFilesOut` in `RunControl.nml`.

Before these main data files are written out, SUEWS provides a summary of the column names, units and variables included in the file `Ss_YYYY_TT_OutputFormat.txt` (one file per run).

The variables included in the main output file are determined according to `WriteOutOption` set in `RunControl.nml`.

| Column | Name    | WriteOutOption | Description   |
|--------|---------|----------------|---|
| 1      | Year    | 0,1,2          | Year [YYYY]   |
| 2      | DOY     | 0,1,2          | Day of year [DOY]   |
| 3      | Hour    | 0,1,2          | Hour [H]  |
| 4      | Min     | 0,1,2          | Minute [M]  |
| 5      | Dectime | 0,1,2          | Decimal time [-]  |
| 6      | Kdown   | 0,1,2          | Incoming shortwave radiation [ $\text{W m}^{-2}$ ]                |
| 7      | Kup     | 0,1,2          | Outgoing shortwave radiation [ $\text{W m}^{-2}$ ]                |
| 8      | Ldown   | 0,1,2          | Incoming longwave radiation [ $\text{W m}^{-2}$ ]                 |
| 9      | Lup     | 0,1,2          | Outgoing longwave radiation [ $\text{W m}^{-2}$ ]                 |
| 10     | Tsurf   | 0,1,2          | Bulk surface temperature [ $^{\circ}\text{C}$ ]                   |
| 11     | QN      | 0,1,2          | Net all-wave radiation [ $\text{W m}^{-2}$ ]                      |
| 12     | QF      | 0,1,2          | Anthropogenic heat flux [ $\text{W m}^{-2}$ ]                     |
| 13     | QS      | 0,1,2          | Storage heat flux [ $\text{W m}^{-2}$ ]                           |
| 14     | QH      | 0,1,2          | Sensible heat flux (calculated using SUEWS) [ $\text{W m}^{-2}$ ] |

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| Column | Name      | WriteOutOption | Description   |
|--------|-----------|----------------|---|
| 15     | QE        | 0,1,2          | Latent heat flux (calculated using SUEWS) [ $\text{W m}^{-2}$ ]               |
| 16     | QHlumps   | 0,1            | Sensible heat flux (calculated using LUMPS) [ $\text{W m}^{-2}$ ]             |
| 17     | QElumps   | 0,1            | Latent heat flux (calculated using LUMPS) [ $\text{W m}^{-2}$ ]               |
| 18     | QHresis   | 0,1            | Sensible heat flux (calculated using resistance method) [ $\text{W m}^{-2}$ ] |
| 19     | Rain      | 0,1,2          | Rain [mm]   |
| 20     | Irr       | 0,1,2          | Irrigation [mm]   |
| 21     | Evap      | 0,1,2          | Evaporation [mm]  |
| 22     | RO        | 0,1,2          | Runoff [mm]   |
| 23     | TotCh     | 0,1,2          | Change in surface and soil moisture stores [mm]                               |
| 24     | SurfCh    | 0,1,2          | Change in surface moisture store [mm]   |
| 25     | State     | 0,1,2          | Surface wetness state [mm]  |
| 26     | NWtrState | 0,1,2          | Surface wetness state (for non-water surfaces) [mm]                           |
| 27     | Drainage  | 0,1,2          | Drainage [mm]   |
| 28     | SMD       | 0,1,2          | Soil moisture deficit [mm]  |
| 29     | FlowCh    | 0,1            | Additional flow into water body [mm]  |
| 30     | AddWater  | 0,1            | Additional water flow received from other grids [mm]                          |
| 31     | ROSoil    | 0,1            | Runoff to soil (sub-surface) [mm]   |
| 32     | ROPipe    | 0,1            | Runoff to pipes [mm]  |
| 33     | ROImp     | 0,1            | Above ground runoff over impervious surfaces [mm]                             |
| 34     | ROVeg     | 0,1            | Above ground runoff over vegetated surfaces [mm]                              |
| 35     | ROWater   | 0,1            | Runoff for water body [mm]  |
| 36     | WUInt     | 0,1            | Internal water use [mm]   |
| 37     | WUEveTr   | 0,1            | Water use for irrigation of evergreen trees [mm]                              |
| 38     | WUDecTr   | 0,1            | Water use for irrigation of deciduous trees [mm]                              |
| 39     | WUGrass   | 0,1            | Water use for irrigation of grass [mm]  |
| 40     | SMDPaved  | 0,1            | Soil moisture deficit for paved surface [mm]                                  |
| 41     | SMDBldgs  | 0,1            | Soil moisture deficit for building surface [mm]                               |
| 42     | SMDEveTr  | 0,1            | Soil moisture deficit for evergreen surface [mm]                              |
| 43     | SMDDecTr  | 0,1            | Soil moisture deficit for deciduous surface [mm]                              |
| 44     | SMDGrass  | 0,1            | Soil moisture deficit for grass surface [mm]                                  |
| 45     | SMDBSoil  | 0,1            | Soil moisture deficit for bare soil surface [mm]                              |
| 46     | StPaved   | 0,1            | Surface wetness state for paved surface [mm]                                  |
| 47     | StBldgs   | 0,1            | Surface wetness state for building surface [mm]                               |
| 48     | StEveTr   | 0,1            | Surface wetness state for evergreen tree surface [mm]                         |
| 49     | StDecTr   | 0,1            | Surface wetness state for deciduous tree surface [mm]                         |
| 50     | StGrass   | 0,1            | Surface wetness state for grass surface [mm]                                  |
| 51     | StBSoil   | 0,1            | Surface wetness state for bare soil surface [mm]                              |
| 52     | StWater   | 0,1            | Surface wetness state for water surface [mm]                                  |
| 53     | Zenith    | 0,1,2          | Solar zenith angle [ $^{\circ}$ ]   |
| 54     | Azimuth   | 0,1,2          | Solar azimuth angle [ $^{\circ}$ ]  |
| 55     | AlbBulk   | 0,1,2          | Bulk albedo [-]   |
| 56     | Fcld      | 0,1,2          | Cloud fraction [-]  |
| 57     | LAI       | 0,1,2          | Leaf area index [ $\text{m}^2 \text{m}^{-2}$ ]                                |
| 58     | z0m       | 0,1            | Roughness length for momentum [m]   |
| 59     | zdm       | 0,1            | Zero-plane displacement height [m]  |
| 60     | ustar     | 0,1,2          | Friction velocity [ $\text{m s}^{-1}$ ]                                       |
| 61     | Lob       | 0,1,2          | Obukhov length [m]  |
| 62     | RA        | 0,1            | Aerodynamic resistance [ $\text{s m}^{-1}$ ]                                  |
| 63     | RS        | 0,1            | Surface resistance [ $\text{s m}^{-1}$ ]                                      |

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| Column | Name       | WriteOutOption | Description   |
|--------|------------|----------------|---|
| 64     | Fc         | 0,1,2          | CO <sub>2</sub> flux [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]                     |
| 65     | FcPhoto    | 0,1            | CO <sub>2</sub> flux from photosynthesis [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ] |
| 66     | FcRespi    | 0,1            | CO <sub>2</sub> flux from respiration [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]    |
| 67     | FcMetab    | 0,1            | CO <sub>2</sub> flux from metabolism [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]     |
| 68     | FcTraff    | 0,1            | CO <sub>2</sub> flux from traffic [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]        |
| 69     | FcBuild    | 0,1            | CO <sub>2</sub> flux from buildings [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]      |
| 70     | FcPoint    | 0,1            | CO <sub>2</sub> flux from point source [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]   |
| 71     | QNSnowFr   | 1              | Net all-wave radiation for snow-free area [ $\text{W m}^{-2}$ ]                   |
| 72     | QNSnow     | 1              | Net all-wave radiation for snow area [ $\text{W m}^{-2}$ ]                        |
| 73     | AlbSnow    | 1              | Snow albedo [-]   |
| 74     | QM         | 1              | Snow-related heat exchange [ $\text{W m}^{-2}$ ]                                  |
| 75     | QMFreeze   | 1              | Internal energy change [ $\text{W m}^{-2}$ ]                                      |
| 76     | QMRain     | 1              | Heat released by rain on snow [ $\text{W m}^{-2}$ ]                               |
| 77     | SWE        | 1              | Snow water equivalent [mm]  |
| 78     | MeltWater  | 1              | Meltwater [mm]  |
| 79     | MeltWStore | 1              | Meltwater store [mm]  |
| 80     | SnowCh     | 1              | Change in snow pack [mm]  |
| 81     | SnowRPaved | 1              | Snow removed from paved surface [mm]  |
| 82     | SnowRBldgs | 1              | Snow removed from building surface [mm]   |
| 83     | Ts         | 0,1,2          | Skin temperature [ $^{\circ}\text{C}$ ]   |
| 84     | T2         | 0,1,2          | Air temperature at 2 m agl [ $^{\circ}\text{C}$ ]                                 |
| 85     | Q2         | 0,1,2          | Air specific humidity at 2 m agl [ $\text{g kg}^{-1}$ ]                           |
| 86     | U10        | 0,1,2          | Wind speed at 10 m agl [ $\text{m s}^{-1}$ ]                                      |
| 87     | RH2        | 0,1,2          | Relative humidity at 2 m agl [%]  |

**SSss\_DailyState.txt**

Contains information about the state of the surface and soil and vegetation parameters at a time resolution of one day. One file is written for each grid so it may contain multiple years.

| Column | Name       | Description   |
|--------|------------|---|
| 1      | Year       | Year [YYYY]   |
| 2      | DOY        | Day of year [DOY]   |
| 3      | Hour       | Hour of the last timestep of a day [HH]                                   |
| 4      | Min        | Minute of the last timestep of a day [MM]                                 |
| 5      | HDD1_h     | Heating degree days [ $^{\circ}\text{C d}$ ]                              |
| 6      | HDD2_c     | Cooling degree days [ $^{\circ}\text{C d}$ ]                              |
| 7      | HDD3_Tmean | Average daily air temperature in forcing data [ $^{\circ}\text{C}$ ]      |
| 8      | HDD4_T5d   | 5-day running-mean air temperature in forcing data [ $^{\circ}\text{C}$ ] |
| 9      | P_day      | Daily total precipitation [mm]  |
| 10     | DaysSR     | Days since rain [days]  |
| 11     | GDD_EveTr  | Growing degree days for evergreen tree [ $^{\circ}\text{C d}$ ]           |
| 12     | GDD_DecTr  | Growing degree days for deciduous tree [ $^{\circ}\text{C d}$ ]           |
| 13     | GDD_Grass  | Growing degree days for grass [ $^{\circ}\text{C d}$ ]                    |
| 14     | SDD_EveTr  | Senescence degree days for evergreen tree [ $^{\circ}\text{C d}$ ]        |
| 15     | SDD_DecTr  | Senescence degree days for deciduous tree [ $^{\circ}\text{C d}$ ]        |
| 16     | SDD_Grass  | Senescence degree days for grass [ $^{\circ}\text{C d}$ ]                 |
| 17     | Tmin       | Daily minimum temperature in forcing data [ $^{\circ}\text{C}$ ]          |

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| Column | Name           | Description  |
|--------|----------------|--|
| 18     | Tmax           | Daily maximum temperature in forcing data [°C]                       |
| 19     | DLHrs          | Day length [h]   |
| 20     | LAI_EveTr      | Leaf area index of evergreen trees [ $\text{m}^{-2} \text{m}^{-2}$ ] |
| 21     | LAI_DecTr      | Leaf area index of deciduous trees [ $\text{m}^{-2} \text{m}^{-2}$ ] |
| 22     | LAI_Grass      | Leaf area index of grass [ $\text{m}^{-2} \text{m}^{-2}$ ]           |
| 23     | DecidCap       | Moisture storage capacity of deciduous trees [mm]                    |
| 24     | Porosity       | Porosity of deciduous trees [-]                                      |
| 25     | AlbEveTr       | Albedo of evergreen trees [-]  |
| 26     | AlbDecTr       | Albedo of deciduous trees [-]  |
| 27     | AlbGrass       | Albedo of grass [-]  |
| 28     | WU_EveTr1      | Total water use for evergreen trees [mm]                             |
| 29     | WU_EveTr2      | Automatic water use for evergreen trees [mm]                         |
| 30     | WU_EveTr3      | Manual water use for evergreen trees [mm]                            |
| 31     | WU_DecTr1      | Total water use for deciduous trees [mm]                             |
| 32     | WU_DecTr2      | Automatic water use for deciduous trees [mm]                         |
| 33     | WU_DecTr3      | Manual water use for deciduous trees [mm]                            |
| 34     | WU_Grass1      | Total water use for grass [mm]                                       |
| 35     | WU_Grass2      | Automatic water use for grass [mm]                                   |
| 36     | WU_Grass3      | Manual water use for grass [mm]                                      |
| 37     | LAIlumps       | Leaf area index used in LUMPS (normalised 0-1) [-]                   |
| 38     | AlbSnow        | Snow albedo [-]  |
| 39     | DensSnow_Paved | Snow density - paved surface [ $\text{kg m}^{-3}$ ]                  |
| 40     | DensSnow_Bldgs | Snow density - building surface [ $\text{kg m}^{-3}$ ]               |
| 41     | DensSnow_EveTr | Snow density - evergreen surface [ $\text{kg m}^{-3}$ ]              |
| 42     | DensSnow_DecTr | Snow density - deciduous surface [ $\text{kg m}^{-3}$ ]              |
| 43     | DensSnow_Grass | Snow density - grass surface [ $\text{kg m}^{-3}$ ]                  |
| 44     | DensSnow_BSoil | Snow density - bare soil surface [ $\text{kg m}^{-3}$ ]              |
| 45     | DensSnow_Water | Snow density - water surface [ $\text{kg m}^{-3}$ ]                  |
| 46     | a1             | OHM coefficient a1 [-]   |
| 47     | a2             | OHM coefficient a2 [ $\text{W m}^{-2} \text{h}^{-1}$ ]               |
| 48     | a3             | OHM coefficient a3 [ $\text{W m}^{-2}$ ]                             |

**InitialConditionsSSss\_YYYY.nml**

At the end of the model run (or the end of each year in the model run) a new InitialConditions file is written out (to the input folder) for each grid, see *Initial Conditions file*

**SSss\_YYYY\_snow\_TT.txt**

SUEWS produces a separate output file for snow (when *SnowUse* = 1 in *RunControl.nml*) with details for each surface type.

File format of SSss\_YYYY\_snow\_TT.txt

| Column | Name | Description       |
|--------|------|-------------------|
| 1      | iy   | Year [YYYY]       |
| 2      | id   | Day of year [DOY] |
| 3      | it   | Hour [H]          |

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Table 7.358 – continued from previous page

| Column | Name         | Description  |
|--------|--------------|--|
| 4      | imin         | Minute [M]   |
| 5      | dectime      | Decimal time [-]   |
| 6      | SWE_Paved    | Snow water equivalent – paved surface [mm]   |
| 7      | SWE_Bldgs    | Snow water equivalent – building surface [mm]                                      |
| 8      | SWE_EveTr    | Snow water equivalent – evergreen surface [mm]                                     |
| 9      | SWE_DecTr    | Snow water equivalent – deciduous surface [mm]                                     |
| 10     | SWE_Grass    | Snow water equivalent – grass surface [mm]   |
| 11     | SWE_BSoil    | Snow water equivalent – bare soil surface [mm]                                     |
| 12     | SWE_Water    | Snow water equivalent – water surface [mm]   |
| 13     | Mw_Paved     | Meltwater – paved surface [mm h <sup>-1</sup> ]                                    |
| 14     | Mw_Bldgs     | Meltwater – building surface [mm h <sup>-1</sup> ]                                 |
| 15     | Mw_EveTr     | Meltwater – evergreen surface [mm h <sup>-1</sup> ]                                |
| 16     | Mw_DecTr     | Meltwater – deciduous surface [mm h <sup>-1</sup> ]                                |
| 17     | Mw_Grass     | Meltwater – grass surface [mm h <sup>-1</sup> ]                                    |
| 18     | Mw_BSoil     | Meltwater – bare soil surface [mm h <sup>-1</sup> ]                                |
| 19     | Mw_Water     | Meltwater – water surface [mm h <sup>-1</sup> ]                                    |
| 20     | Qm_Paved     | Snowmelt-related heat – paved surface [W m <sup>-2</sup> ]                         |
| 21     | Qm_Bldgs     | Snowmelt-related heat – building surface [W m <sup>-2</sup> ]                      |
| 22     | Qm_EveTr     | Snowmelt-related heat – evergreen surface [W m <sup>-2</sup> ]                     |
| 23     | Qm_DecTr     | Snowmelt-related heat – deciduous surface [W m <sup>-2</sup> ]                     |
| 24     | Qm_Grass     | Snowmelt-related heat – grass surface [W m <sup>-2</sup> ]                         |
| 25     | Qm_BSoil     | Snowmelt-related heat – bare soil surface [W m <sup>-2</sup> ]                     |
| 26     | Qm_Water     | Snowmelt-related heat – water surface [W m <sup>-2</sup> ]                         |
| 27     | Qa_Paved     | Advective heat – paved surface [W m <sup>-2</sup> ]                                |
| 28     | Qa_Bldgs     | Advective heat – building surface [W m <sup>-2</sup> ]                             |
| 29     | Qa_EveTr     | Advective heat – evergreen surface [W m <sup>-2</sup> ]                            |
| 30     | Qa_DecTr     | Advective heat – deciduous surface [W m <sup>-2</sup> ]                            |
| 31     | Qa_Grass     | Advective heat – grass surface [W m <sup>-2</sup> ]                                |
| 32     | Qa_BSoil     | Advective heat – bare soil surface [W m <sup>-2</sup> ]                            |
| 33     | Qa_Water     | Advective heat – water surface [W m <sup>-2</sup> ]                                |
| 34     | QmFr_Paved   | Heat related to freezing of surface store – paved surface [W m <sup>-2</sup> ]     |
| 35     | QmFr_Bldgs   | Heat related to freezing of surface store – building surface [W m <sup>-2</sup> ]  |
| 36     | QmFr_EveTr   | Heat related to freezing of surface store – evergreen surface [W m <sup>-2</sup> ] |
| 37     | QmFr_DecTr   | Heat related to freezing of surface store – deciduous surface [W m <sup>-2</sup> ] |
| 38     | QmFr_Grass   | Heat related to freezing of surface store – grass surface [W m <sup>-2</sup> ]     |
| 39     | QmFr_BSoil   | Heat related to freezing of surface store – bare soil surface [W m <sup>-2</sup> ] |
| 40     | QmFr_Water   | Heat related to freezing of surface store – water [W m <sup>-2</sup> ]             |
| 41     | fr_Paved     | Fraction of snow – paved surface [-]   |
| 42     | fr_Bldgs     | Fraction of snow – building surface [-]  |
| 43     | fr_EveTr     | Fraction of snow – evergreen surface [-]   |
| 44     | fr_DecTr     | Fraction of snow – deciduous surface [-]   |
| 45     | fr_Grass     | Fraction of snow – grass surface [-]   |
| 46     | Fr_BSoil     | Fraction of snow – bare soil surface [-]   |
| 47     | RainSn_Paved | Rain on snow – paved surface [mm]  |
| 48     | RainSn_Bldgs | Rain on snow – building surface [mm]   |
| 49     | RainSn_EveTr | Rain on snow – evergreen surface [mm]  |
| 50     | RainSn_DecTr | Rain on snow – deciduous surface [mm]  |
| 51     | RainSn_Grass | Rain on snow – grass surface [mm]  |
| 52     | RainSn_BSoil | Rain on snow – bare soil surface [mm]  |

continues on next page

Table 7.358 – continued from previous page

| Column | Name           | Description   |
|--------|----------------|---|
| 53     | RainSn_Water   | Rain on snow – water surface [mm]                                       |
| 54     | qn_PavedSnow   | Net all-wave radiation – paved surface [ $\text{W m}^{-2}$ ]            |
| 55     | qn_BldgsSnow   | Net all-wave radiation – building surface [ $\text{W m}^{-2}$ ]         |
| 56     | qn_EveTrSnow   | Net all-wave radiation – evergreen surface [ $\text{W m}^{-2}$ ]        |
| 57     | qn_DecTrSnow   | Net all-wave radiation – deciduous surface [ $\text{W m}^{-2}$ ]        |
| 58     | qn_GrassSnow   | Net all-wave radiation – grass surface [ $\text{W m}^{-2}$ ]            |
| 59     | qn_BSoilSnow   | Net all-wave radiation – bare soil surface [ $\text{W m}^{-2}$ ]        |
| 60     | qn_WaterSnow   | Net all-wave radiation – water surface [ $\text{W m}^{-2}$ ]            |
| 61     | kup_PavedSnow  | Reflected shortwave radiation – paved surface [ $\text{W m}^{-2}$ ]     |
| 62     | kup_BldgsSnow  | Reflected shortwave radiation – building surface [ $\text{W m}^{-2}$ ]  |
| 63     | kup_EveTrSnow  | Reflected shortwave radiation – evergreen surface [ $\text{W m}^{-2}$ ] |
| 64     | kup_DecTrSnow  | Reflected shortwave radiation – deciduous surface [ $\text{W m}^{-2}$ ] |
| 65     | kup_GrassSnow  | Reflected shortwave radiation – grass surface [ $\text{W m}^{-2}$ ]     |
| 66     | kup_BSoilSnow  | Reflected shortwave radiation – bare soil surface [ $\text{W m}^{-2}$ ] |
| 67     | kup_WaterSnow  | Reflected shortwave radiation – water surface [ $\text{W m}^{-2}$ ]     |
| 68     | frMelt_Paved   | Amount of freezing melt water – paved surface [mm]                      |
| 69     | frMelt_Bldgs   | Amount of freezing melt water – building surface [mm]                   |
| 70     | frMelt_EveTr   | Amount of freezing melt water – evergreen surface [mm]                  |
| 71     | frMelt_DecTr   | Amount of freezing melt water – deciduous surface [mm]                  |
| 72     | frMelt_Grass   | Amount of freezing melt water – grass surface [mm]                      |
| 73     | frMelt_BSoil   | Amount of freezing melt water – bare soil surface [mm]                  |
| 74     | frMelt_Water   | Amount of freezing melt water – water surface [mm]                      |
| 75     | MwStore_Paved  | Melt water store – paved surface [mm]                                   |
| 76     | MwStore_Bldgs  | Melt water store – building surface [mm]                                |
| 77     | MwStore_EveTr  | Melt water store – evergreen surface [mm]                               |
| 78     | MwStore_DecTr  | Melt water store – deciduous surface [mm]                               |
| 79     | MwStore_Grass  | Melt water store – grass surface [mm]                                   |
| 80     | MwStore_BSoil  | Melt water store – bare soil surface [mm]                               |
| 81     | MwStore_Water  | Melt water store – water surface [mm]                                   |
| 82     | DensSnow_Paved | Snow density – paved surface [ $\text{kg m}^{-3}$ ]                     |
| 83     | DensSnow_Bldgs | Snow density – building surface [ $\text{kg m}^{-3}$ ]                  |
| 84     | DensSnow_EveTr | Snow density – evergreen surface [ $\text{kg m}^{-3}$ ]                 |
| 85     | DensSnow_DecTr | Snow density – deciduous surface [ $\text{kg m}^{-3}$ ]                 |
| 86     | DensSnow_Grass | Snow density – grass surface [ $\text{kg m}^{-3}$ ]                     |
| 87     | DensSnow_BSoil | Snow density – bare soil surface [ $\text{kg m}^{-3}$ ]                 |
| 88     | DensSnow_Water | Snow density – water surface [ $\text{kg m}^{-3}$ ]                     |
| 89     | Sd_Paved       | Snow depth – paved surface [mm]   |
| 90     | Sd_Bldgs       | Snow depth – building surface [mm]                                      |
| 91     | Sd_EveTr       | Snow depth – evergreen surface [mm]                                     |
| 92     | Sd_DecTr       | Snow depth – deciduous surface [mm]                                     |
| 93     | Sd_Grass       | Snow depth – grass surface [mm]   |
| 94     | Sd_BSoil       | Snow depth – bare soil surface [mm]                                     |
| 95     | Sd_Water       | Snow depth – water surface [mm]   |
| 96     | Tsnow_Paved    | Snow surface temperature – paved surface [ $^{\circ}\text{C}$ ]         |
| 97     | Tsnow_Bldgs    | Snow surface temperature – building surface [ $^{\circ}\text{C}$ ]      |
| 98     | Tsnow_EveTr    | Snow surface temperature – evergreen surface [ $^{\circ}\text{C}$ ]     |
| 99     | Tsnow_DecTr    | Snow surface temperature – deciduous surface [ $^{\circ}\text{C}$ ]     |
| 100    | Tsnow_Grass    | Snow surface temperature – grass surface [ $^{\circ}\text{C}$ ]         |
| 101    | Tsnow_BSoil    | Snow surface temperature – bare soil surface [ $^{\circ}\text{C}$ ]     |

continues on next page

Table 7.358 – continued from previous page

| Column | Name        | Description                                   |
|--------|-------------|---|
| 102    | Tsnow_Water | Snow surface temperature – water surface [°C] |

**SSss\_YYYY\_RSL\_TT.txt**

SUEWS produces a separate output file for wind, temperature and humidity profiles in the roughness sublayer at 30 levels (see *Wind, Temperature and Humidity Profiles in the Roughness Sublayer* level details).

File format of SSss\_YYYY\_RSL\_TT.txt:

| Column | Name    | Description                                |
|--------|---------|--|
| 1      | Year    | Year [YYYY]                                |
| 2      | DOY     | Day of year [DOY]                          |
| 3      | Hour    | Hour [H]                                   |
| 4      | Min     | Minute [M]                                 |
| 5      | Dectime | Decimal time [-]                           |
| 6      | z_1     | Height at level 1 [m]                      |
| 7      | z_2     | Height at level 2 [m]                      |
| 8      | z_3     | Height at level 3 [m]                      |
| 9      | z_4     | Height at level 4 [m]                      |
| 10     | z_5     | Height at level 5 [m]                      |
| 11     | z_6     | Height at level 6 [m]                      |
| 12     | z_7     | Height at level 7 [m]                      |
| 13     | z_8     | Height at level 8 [m]                      |
| 14     | z_9     | Height at level 9 [m]                      |
| 15     | z_10    | Height at level 10 [m]                     |
| 16     | z_11    | Height at level 11 [m]                     |
| 17     | z_12    | Height at level 12 [m]                     |
| 18     | z_13    | Height at level 13 [m]                     |
| 19     | z_14    | Height at level 14 [m]                     |
| 20     | z_15    | Height at level 15 [m]                     |
| 21     | z_16    | Height at level 16 [m]                     |
| 22     | z_17    | Height at level 17 [m]                     |
| 23     | z_18    | Height at level 18 [m]                     |
| 24     | z_19    | Height at level 19 [m]                     |
| 25     | z_20    | Height at level 20 [m]                     |
| 26     | z_21    | Height at level 21 [m]                     |
| 27     | z_22    | Height at level 22 [m]                     |
| 28     | z_23    | Height at level 23 [m]                     |
| 29     | z_24    | Height at level 24 [m]                     |
| 30     | z_25    | Height at level 25 [m]                     |
| 31     | z_26    | Height at level 26 [m]                     |
| 32     | z_27    | Height at level 27 [m]                     |
| 33     | z_28    | Height at level 28 [m]                     |
| 34     | z_29    | Height at level 29 [m]                     |
| 35     | z_30    | Height at level 30 [m]                     |
| 36     | U_1     | Wind speed at level 1 [m s <sup>-1</sup> ] |
| 37     | U_2     | Wind speed at level 2 [m s <sup>-1</sup> ] |
| 38     | U_3     | Wind speed at level 3 [m s <sup>-1</sup> ] |
| 39     | U_4     | Wind speed at level 4 [m s <sup>-1</sup> ] |

continues on next page

Table 7.359 – continued from previous page

| Column | Name | Description                                 |
|--------|------|---|
| 40     | U_5  | Wind speed at level 5 [m s <sup>-1</sup> ]  |
| 41     | U_6  | Wind speed at level 6 [m s <sup>-1</sup> ]  |
| 42     | U_7  | Wind speed at level 7 [m s <sup>-1</sup> ]  |
| 43     | U_8  | Wind speed at level 8 [m s <sup>-1</sup> ]  |
| 44     | U_9  | Wind speed at level 9 [m s <sup>-1</sup> ]  |
| 45     | U_10 | Wind speed at level 10 [m s <sup>-1</sup> ] |
| 46     | U_11 | Wind speed at level 11 [m s <sup>-1</sup> ] |
| 47     | U_12 | Wind speed at level 12 [m s <sup>-1</sup> ] |
| 48     | U_13 | Wind speed at level 13 [m s <sup>-1</sup> ] |
| 49     | U_14 | Wind speed at level 14 [m s <sup>-1</sup> ] |
| 50     | U_15 | Wind speed at level 15 [m s <sup>-1</sup> ] |
| 51     | U_16 | Wind speed at level 16 [m s <sup>-1</sup> ] |
| 52     | U_17 | Wind speed at level 17 [m s <sup>-1</sup> ] |
| 53     | U_18 | Wind speed at level 18 [m s <sup>-1</sup> ] |
| 54     | U_19 | Wind speed at level 19 [m s <sup>-1</sup> ] |
| 55     | U_20 | Wind speed at level 20 [m s <sup>-1</sup> ] |
| 56     | U_21 | Wind speed at level 21 [m s <sup>-1</sup> ] |
| 57     | U_22 | Wind speed at level 22 [m s <sup>-1</sup> ] |
| 58     | U_23 | Wind speed at level 23 [m s <sup>-1</sup> ] |
| 59     | U_24 | Wind speed at level 24 [m s <sup>-1</sup> ] |
| 60     | U_25 | Wind speed at level 25 [m s <sup>-1</sup> ] |
| 61     | U_26 | Wind speed at level 26 [m s <sup>-1</sup> ] |
| 62     | U_27 | Wind speed at level 27 [m s <sup>-1</sup> ] |
| 63     | U_28 | Wind speed at level 28 [m s <sup>-1</sup> ] |
| 64     | U_29 | Wind speed at level 29 [m s <sup>-1</sup> ] |
| 65     | U_30 | Wind speed at level 30 [m s <sup>-1</sup> ] |
| 66     | T_1  | Air temperature at level 1 [°C]             |
| 67     | T_2  | Air temperature at level 2 [°C]             |
| 68     | T_3  | Air temperature at level 3 [°C]             |
| 69     | T_4  | Air temperature at level 4 [°C]             |
| 70     | T_5  | Air temperature at level 5 [°C]             |
| 71     | T_6  | Air temperature at level 6 [°C]             |
| 72     | T_7  | Air temperature at level 7 [°C]             |
| 73     | T_8  | Air temperature at level 8 [°C]             |
| 74     | T_9  | Air temperature at level 9 [°C]             |
| 75     | T_10 | Air temperature at level 10 [°C]            |
| 76     | T_11 | Air temperature at level 11 [°C]            |
| 77     | T_12 | Air temperature at level 12 [°C]            |
| 78     | T_13 | Air temperature at level 13 [°C]            |
| 79     | T_14 | Air temperature at level 14 [°C]            |
| 80     | T_15 | Air temperature at level 15 [°C]            |
| 81     | T_16 | Air temperature at level 16 [°C]            |
| 82     | T_17 | Air temperature at level 17 [°C]            |
| 83     | T_18 | Air temperature at level 18 [°C]            |
| 84     | T_19 | Air temperature at level 19 [°C]            |
| 85     | T_20 | Air temperature at level 20 [°C]            |
| 86     | T_21 | Air temperature at level 21 [°C]            |
| 87     | T_22 | Air temperature at level 22 [°C]            |
| 88     | T_23 | Air temperature at level 23 [°C]            |

continues on next page



Table 7.359 – continued from previous page

| Column | Name | Description   |
|--------|------|---|
| 89     | T_24 | Air temperature at level 24 [°C]                    |
| 90     | T_25 | Air temperature at level 25 [°C]                    |
| 91     | T_26 | Air temperature at level 26 [°C]                    |
| 92     | T_27 | Air temperature at level 27 [°C]                    |
| 93     | T_28 | Air temperature at level 28 [°C]                    |
| 94     | T_29 | Air temperature at level 29 [°C]                    |
| 95     | T_30 | Air temperature at level 30 [°C]                    |
| 96     | q_1  | Specific humidity at level 1 [g kg <sup>-1</sup> ]  |
| 97     | q_2  | Specific humidity at level 2 [g kg <sup>-1</sup> ]  |
| 98     | q_3  | Specific humidity at level 3 [g kg <sup>-1</sup> ]  |
| 99     | q_4  | Specific humidity at level 4 [g kg <sup>-1</sup> ]  |
| 100    | q_5  | Specific humidity at level 5 [g kg <sup>-1</sup> ]  |
| 101    | q_6  | Specific humidity at level 6 [g kg <sup>-1</sup> ]  |
| 102    | q_7  | Specific humidity at level 7 [g kg <sup>-1</sup> ]  |
| 103    | q_8  | Specific humidity at level 8 [g kg <sup>-1</sup> ]  |
| 104    | q_9  | Specific humidity at level 9 [g kg <sup>-1</sup> ]  |
| 105    | q_10 | Specific humidity at level 10 [g kg <sup>-1</sup> ] |
| 106    | q_11 | Specific humidity at level 11 [g kg <sup>-1</sup> ] |
| 107    | q_12 | Specific humidity at level 12 [g kg <sup>-1</sup> ] |
| 108    | q_13 | Specific humidity at level 13 [g kg <sup>-1</sup> ] |
| 109    | q_14 | Specific humidity at level 14 [g kg <sup>-1</sup> ] |
| 110    | q_15 | Specific humidity at level 15 [g kg <sup>-1</sup> ] |
| 111    | q_16 | Specific humidity at level 16 [g kg <sup>-1</sup> ] |
| 112    | q_17 | Specific humidity at level 17 [g kg <sup>-1</sup> ] |
| 113    | q_18 | Specific humidity at level 18 [g kg <sup>-1</sup> ] |
| 114    | q_19 | Specific humidity at level 19 [g kg <sup>-1</sup> ] |
| 115    | q_20 | Specific humidity at level 20 [g kg <sup>-1</sup> ] |
| 116    | q_21 | Specific humidity at level 21 [g kg <sup>-1</sup> ] |
| 117    | q_22 | Specific humidity at level 22 [g kg <sup>-1</sup> ] |
| 118    | q_23 | Specific humidity at level 23 [g kg <sup>-1</sup> ] |
| 119    | q_24 | Specific humidity at level 24 [g kg <sup>-1</sup> ] |
| 120    | q_25 | Specific humidity at level 25 [g kg <sup>-1</sup> ] |
| 121    | q_26 | Specific humidity at level 26 [g kg <sup>-1</sup> ] |
| 122    | q_27 | Specific humidity at level 27 [g kg <sup>-1</sup> ] |
| 123    | q_28 | Specific humidity at level 28 [g kg <sup>-1</sup> ] |
| 124    | q_29 | Specific humidity at level 29 [g kg <sup>-1</sup> ] |
| 125    | q_30 | Specific humidity at level 30 [g kg <sup>-1</sup> ] |

**SSss\_YYYY\_BL\_TT.txt**

Meteorological variables modelled by CBL portion of the model are output in to this file created for each day with time step (see *CBL input files*).

| Column | Name      | Description                                      | Units                               |
|--------|-----------|--|-------------------------------------|
| 1      | iy        | Year [YYYY]                                      |                                     |
| 2      | id        | Day of year [DoY]                                |                                     |
| 3      | it        | Hour [H]   |                                     |
| 4      | imin      | Minute [M]                                       |                                     |
| 5      | dectime   | Decimal time [-]                                 |                                     |
| 6      | zi        | Convective boundary layer height                 | m                                   |
| 7      | Theta     | Potential temperature in the inertial sublayer   | K                                   |
| 8      | Q         | Specific humidity in the inertial sublayer       | g kg <sup>-1</sup>                  |
| 9      | theta+    | Potential temperature just above the CBL         | K                                   |
| 10     | q+        | Specific humidity just above the CBL             | g kg <sup>-1</sup>                  |
| 11     | Temp_C    | Air temperature                                  | °C                                  |
| 12     | RH        | Relative humidity                                | %                                   |
| 13     | QH_use    | Sensible heat flux used for calculation          | W m <sup>-2</sup>                   |
| 14     | QE_use    | Latent heat flux used for calculation            | W m <sup>-2</sup>                   |
| 15     | Press_hPa | Pressure used for calculation                    | hPa                                 |
| 16     | avul      | Wind speed used for calculation                  | m s <sup>-1</sup>                   |
| 17     | ustar     | Friction velocity used for calculation           | m s <sup>-1</sup>                   |
| 18     | avdens    | Air density used for calculation                 | kg m <sup>-3</sup>                  |
| 19     | lv_J_kg   | Latent heat of vaporization used for calculation | J kg <sup>-1</sup>                  |
| 20     | avcp      | Specific heat capacity used for calculation      | J kg <sup>-1</sup> K <sup>-1</sup>  |
| 21     | gamt      | Vertical gradient of potential temperature       | K m <sup>-1</sup>                   |
| 22     | gamq      | Vertical gradient of specific humidity           | kg kg <sup>-1</sup> m <sup>-1</sup> |

### SSss\_YYYY\_ESTM\_TT.txt

If the ESTM model option is run, the following output file is created.

---

**Note:** First time steps of storage output could give NaN values during the initial converging phase.

---

ESTM output file format

| Column | Name     | Description  | Units             |
|--------|----------|--|-------------------|
| 1      | iy       | Year   |                   |
| 2      | id       | Day of year  |                   |
| 3      | it       | Hour   |                   |
| 4      | imin     | Minute   |                   |
| 5      | dectime  | Decimal time   |                   |
| 6      | QSnet    | Net storage heat flux (QSwall+QSGround+QS)           | W m <sup>-2</sup> |
| 7      | QSair    | Storage heat flux into air                           | W m <sup>-2</sup> |
| 8      | QSwall   | Storage heat flux into wall                          | W m <sup>-2</sup> |
| 9      | QSroof   | Storage heat flux into roof                          | W m <sup>-2</sup> |
| 10     | QSGround | Storage heat flux into ground                        | W m <sup>-2</sup> |
| 11     | QSibld   | Storage heat flux into internal elements in building | W m <sup>-2</sup> |
| 12     | Twall1   | Temperature in the first layer of wall (outer-most)  | K                 |
| 13     | Twall2   | Temperature in the first layer of wall               | K                 |
| 14     | Twall3   | Temperature in the first layer of wall               | K                 |
| 15     | Twall4   | Temperature in the first layer of wall               | K                 |
| 16     | Twall5   | Temperature in the first layer of wall (inner-most)  | K                 |

continues on next page

Table 7.360 – continued from previous page

| Column | Name     | Description   | Units |
|--------|----------|---|-------|
| 17     | Troof1   | Temperature in the first layer of roof (outer-most)   | K     |
| 18     | Troof2   | Temperature in the first layer of roof                | K     |
| 19     | Troof3   | Temperature in the first layer of roof                | K     |
| 20     | Troof4   | Temperature in the first layer of roof                | K     |
| 21     | Troof5   | Temperature in the first layer of ground (inner-most) | K     |
| 22     | Tground1 | Temperature in the first layer of ground (outer-most) | K     |
| 23     | Tground2 | Temperature in the first layer of ground              | K     |
| 24     | Tground3 | Temperature in the first layer of ground              | K     |
| 25     | Tground4 | Temperature in the first layer of ground              | K     |
| 26     | Tground5 | Temperature in the first layer of ground (inner-most) | K     |
| 27     | Tibld1   | Temperature in the first layer of internal elements   | K     |
| 28     | Tibld2   | Temperature in the first layer of internal elements   | K     |
| 29     | Tibld3   | Temperature in the first layer of internal elements   | K     |
| 30     | Tibld4   | Temperature in the first layer of internal elements   | K     |
| 31     | Tibld5   | Temperature in the first layer of internal elements   | K     |
| 32     | Tabld    | Air temperature in buildings                          | K     |

**SSss\_YYYY\_SPARTACUS\_TT.txt**

If the SPARTACUS model option is run, the following output file is created.

SPARTACUS output file format

| Column | Name      | Description   |
|--------|-----------|---|
| 1      | Year      | Year [YYYY]   |
| 2      | DOY       | Day of year [DOY]   |
| 3      | Hour      | Hour [H]  |
| 4      | Min       | Minute [M]  |
| 5      | Dectime   | Decimal time [-]  |
| 6      | alb       | Albedo at top-of-canopy. Average of diffuse and direct albedos weighted by the amount of diffuse and direct radiation |
| 7      | emis      | Emissivity at top-of-canopy   |
| 8      | Lemission | Longwave upward emission at top-of-canopy [ $\text{W m}^{-2}$ ]   |
| 9      | Lup       | Longwave upward (emission+reflected) at top-of-canopy [ $\text{W m}^{-2}$ ]   |
| 10     | Kup       | Shortwave upward (reflected) at top-of-canopy [ $\text{W m}^{-2}$ ]   |
| 11     | Qn        | Net all-wave radiation at top-of-canopy [ $\text{W m}^{-2}$ ]   |
| 12     | LCAAbs1   | Longwave absorption rate in clear-air part of layer 1 [ $\text{W m}^{-2}$ ]   |
| 13     | LCAAbs2   | Longwave absorption rate in clear-air part of layer 2 [ $\text{W m}^{-2}$ ]   |
| 14     | LCAAbs3   | Longwave absorption rate in clear-air part of layer 3 [ $\text{W m}^{-2}$ ]   |
| 15     | LCAAbs4   | Longwave absorption rate in clear-air part of layer 4 [ $\text{W m}^{-2}$ ]   |
| 16     | LCAAbs5   | Longwave absorption rate in clear-air part of layer 5 [ $\text{W m}^{-2}$ ]   |
| 17     | LCAAbs6   | Longwave absorption rate in clear-air part of layer 6 [ $\text{W m}^{-2}$ ]   |
| 18     | LCAAbs7   | Longwave absorption rate in clear-air part of layer 7 [ $\text{W m}^{-2}$ ]   |
| 19     | LCAAbs8   | Longwave absorption rate in clear-air part of layer 8 [ $\text{W m}^{-2}$ ]   |
| 20     | LCAAbs9   | Longwave absorption rate in clear-air part of layer 9 [ $\text{W m}^{-2}$ ]   |
| 21     | LCAAbs10  | Longwave absorption rate in clear-air part of layer 10 [ $\text{W m}^{-2}$ ]  |
| 22     | LCAAbs11  | Longwave absorption rate in clear-air part of layer 11 [ $\text{W m}^{-2}$ ]  |
| 23     | LCAAbs12  | Longwave absorption rate in clear-air part of layer 12 [ $\text{W m}^{-2}$ ]  |
| 24     | LCAAbs13  | Longwave absorption rate in clear-air part of layer 13 [ $\text{W m}^{-2}$ ]  |
| 25     | LCAAbs14  | Longwave absorption rate in clear-air part of layer 14 [ $\text{W m}^{-2}$ ]  |

Table 7.361 – continued from previous page

| Column | Name       | Description  |
|--------|------------|--|
| 26     | LCAAbs15   | Longwave absorption rate in clear-air part of layer 15 [ $\text{W m}^{-2}$ ] |
| 27     | LWallNet1  | Net longwave flux into walls in layer 1 [ $\text{W m}^{-2}$ ]                |
| 28     | LWallNet2  | Net longwave flux into walls in layer 2 [ $\text{W m}^{-2}$ ]                |
| 29     | LWallNet3  | Net longwave flux into walls in layer 3 [ $\text{W m}^{-2}$ ]                |
| 30     | LWallNet4  | Net longwave flux into walls in layer 4 [ $\text{W m}^{-2}$ ]                |
| 31     | LWallNet5  | Net longwave flux into walls in layer 5 [ $\text{W m}^{-2}$ ]                |
| 32     | LWallNet6  | Net longwave flux into walls in layer 6 [ $\text{W m}^{-2}$ ]                |
| 33     | LWallNet7  | Net longwave flux into walls in layer 7 [ $\text{W m}^{-2}$ ]                |
| 34     | LWallNet8  | Net longwave flux into walls in layer 8 [ $\text{W m}^{-2}$ ]                |
| 35     | LWallNet9  | Net longwave flux into walls in layer 9 [ $\text{W m}^{-2}$ ]                |
| 36     | LWallNet10 | Net longwave flux into walls in layer 10 [ $\text{W m}^{-2}$ ]               |
| 37     | LWallNet11 | Net longwave flux into walls in layer 11 [ $\text{W m}^{-2}$ ]               |
| 38     | LWallNet12 | Net longwave flux into walls in layer 12 [ $\text{W m}^{-2}$ ]               |
| 39     | LWallNet13 | Net longwave flux into walls in layer 13 [ $\text{W m}^{-2}$ ]               |
| 40     | LWallNet14 | Net longwave flux into walls in layer 14 [ $\text{W m}^{-2}$ ]               |
| 41     | LWallNet15 | Net longwave flux into walls in layer 15 [ $\text{W m}^{-2}$ ]               |
| 42     | LRfNet1    | Net longwave flux into roofs in layer 1 [ $\text{W m}^{-2}$ ]                |
| 43     | LRfNet2    | Net longwave flux into roofs in layer 2 [ $\text{W m}^{-2}$ ]                |
| 44     | LRfNet3    | Net longwave flux into roofs in layer 3 [ $\text{W m}^{-2}$ ]                |
| 45     | LRfNet4    | Net longwave flux into roofs in layer 4 [ $\text{W m}^{-2}$ ]                |
| 46     | LRfNet5    | Net longwave flux into roofs in layer 5 [ $\text{W m}^{-2}$ ]                |
| 47     | LRfNet6    | Net longwave flux into roofs in layer 6 [ $\text{W m}^{-2}$ ]                |
| 48     | LRfNet7    | Net longwave flux into roofs in layer 7 [ $\text{W m}^{-2}$ ]                |
| 49     | LRfNet8    | Net longwave flux into roofs in layer 8 [ $\text{W m}^{-2}$ ]                |
| 50     | LRfNet9    | Net longwave flux into roofs in layer 9 [ $\text{W m}^{-2}$ ]                |
| 51     | LRfNet10   | Net longwave flux into roofs in layer 10 [ $\text{W m}^{-2}$ ]               |
| 52     | LRfNet11   | Net longwave flux into roofs in layer 11 [ $\text{W m}^{-2}$ ]               |
| 53     | LRfNet12   | Net longwave flux into roofs in layer 12 [ $\text{W m}^{-2}$ ]               |
| 54     | LRfNet13   | Net longwave flux into roofs in layer 13 [ $\text{W m}^{-2}$ ]               |
| 55     | LRfNet14   | Net longwave flux into roofs in layer 14 [ $\text{W m}^{-2}$ ]               |
| 56     | LRfNet15   | Net longwave flux into roofs in layer 15 [ $\text{W m}^{-2}$ ]               |
| 57     | LRfIn1     | Longwave flux into roofs in layer 1 [ $\text{W m}^{-2}$ ]                    |
| 58     | LRfIn2     | Longwave flux into roofs in layer 2 [ $\text{W m}^{-2}$ ]                    |
| 59     | LRfIn3     | Longwave flux into roofs in layer 3 [ $\text{W m}^{-2}$ ]                    |
| 60     | LRfIn4     | Longwave flux into roofs in layer 4 [ $\text{W m}^{-2}$ ]                    |
| 61     | LRfIn5     | Longwave flux into roofs in layer 5 [ $\text{W m}^{-2}$ ]                    |
| 62     | LRfIn6     | Longwave flux into roofs in layer 6 [ $\text{W m}^{-2}$ ]                    |
| 63     | LRfIn7     | Longwave flux into roofs in layer 7 [ $\text{W m}^{-2}$ ]                    |
| 64     | LRfIn8     | Longwave flux into roofs in layer 8 [ $\text{W m}^{-2}$ ]                    |
| 65     | LRfIn9     | Longwave flux into roofs in layer 9 [ $\text{W m}^{-2}$ ]                    |
| 66     | LRfIn10    | Longwave flux into roofs in layer 10 [ $\text{W m}^{-2}$ ]                   |
| 67     | LRfIn11    | Longwave flux into roofs in layer 11 [ $\text{W m}^{-2}$ ]                   |
| 68     | LRfIn12    | Longwave flux into roofs in layer 12 [ $\text{W m}^{-2}$ ]                   |
| 69     | LRfIn13    | Longwave flux into roofs in layer 13 [ $\text{W m}^{-2}$ ]                   |
| 70     | LRfIn14    | Longwave flux into roofs in layer 14 [ $\text{W m}^{-2}$ ]                   |
| 71     | LRfIn15    | Longwave flux into roofs in layer 15 [ $\text{W m}^{-2}$ ]                   |
| 72     | LTopNet    | Top-of-canopy net longwave flux [ $\text{W m}^{-2}$ ]                        |
| 73     | LGrndNet   | Net longwave flux into the ground [ $\text{W m}^{-2}$ ]                      |
| 74     | LTopDn     | Top-of-canopy downwelling longwave flux [ $\text{W m}^{-2}$ ]                |

Table 7.361 – continued from previous page

| Column | Name       | Description   |
|--------|------------|---|
| 75     | KCAAbs1    | Shortwave absorption rate in clear-air part of layer 1 [ $\text{W m}^{-2}$ ]  |
| 76     | KCAAbs2    | Shortwave absorption rate in clear-air part of layer 2 [ $\text{W m}^{-2}$ ]  |
| 77     | KCAAbs3    | Shortwave absorption rate in clear-air part of layer 3 [ $\text{W m}^{-2}$ ]  |
| 78     | KCAAbs4    | Shortwave absorption rate in clear-air part of layer 4 [ $\text{W m}^{-2}$ ]  |
| 79     | KCAAbs5    | Shortwave absorption rate in clear-air part of layer 5 [ $\text{W m}^{-2}$ ]  |
| 80     | KCAAbs6    | Shortwave absorption rate in clear-air part of layer 6 [ $\text{W m}^{-2}$ ]  |
| 81     | KCAAbs7    | Shortwave absorption rate in clear-air part of layer 7 [ $\text{W m}^{-2}$ ]  |
| 82     | KCAAbs8    | Shortwave absorption rate in clear-air part of layer 8 [ $\text{W m}^{-2}$ ]  |
| 83     | KCAAbs9    | Shortwave absorption rate in clear-air part of layer 9 [ $\text{W m}^{-2}$ ]  |
| 84     | KCAAbs10   | Shortwave absorption rate in clear-air part of layer 10 [ $\text{W m}^{-2}$ ] |
| 85     | KCAAbs11   | Shortwave absorption rate in clear-air part of layer 11 [ $\text{W m}^{-2}$ ] |
| 86     | KCAAbs12   | Shortwave absorption rate in clear-air part of layer 12 [ $\text{W m}^{-2}$ ] |
| 87     | KCAAbs13   | Shortwave absorption rate in clear-air part of layer 13 [ $\text{W m}^{-2}$ ] |
| 88     | KCAAbs14   | Shortwave absorption rate in clear-air part of layer 14 [ $\text{W m}^{-2}$ ] |
| 89     | KCAAbs15   | Shortwave absorption rate in clear-air part of layer 15 [ $\text{W m}^{-2}$ ] |
| 90     | KWallNet1  | Net shortwave flux into walls in layer 1 [ $\text{W m}^{-2}$ ]                |
| 91     | KWallNet2  | Net shortwave flux into walls in layer 2 [ $\text{W m}^{-2}$ ]                |
| 92     | KWallNet3  | Net shortwave flux into walls in layer 3 [ $\text{W m}^{-2}$ ]                |
| 93     | KWallNet4  | Net shortwave flux into walls in layer 4 [ $\text{W m}^{-2}$ ]                |
| 94     | KWallNet5  | Net shortwave flux into walls in layer 5 [ $\text{W m}^{-2}$ ]                |
| 95     | KWallNet6  | Net shortwave flux into walls in layer 6 [ $\text{W m}^{-2}$ ]                |
| 96     | KWallNet7  | Net shortwave flux into walls in layer 7 [ $\text{W m}^{-2}$ ]                |
| 97     | KWallNet8  | Net shortwave flux into walls in layer 8 [ $\text{W m}^{-2}$ ]                |
| 98     | KWallNet9  | Net shortwave flux into walls in layer 9 [ $\text{W m}^{-2}$ ]                |
| 99     | KWallNet10 | Net shortwave flux into walls in layer 10 [ $\text{W m}^{-2}$ ]               |
| 100    | KWallNet11 | Net shortwave flux into walls in layer 11 [ $\text{W m}^{-2}$ ]               |
| 101    | KWallNet12 | Net shortwave flux into walls in layer 12 [ $\text{W m}^{-2}$ ]               |
| 102    | KWallNet13 | Net shortwave flux into walls in layer 13 [ $\text{W m}^{-2}$ ]               |
| 103    | KWallNet14 | Net shortwave flux into walls in layer 14 [ $\text{W m}^{-2}$ ]               |
| 104    | KWallNet15 | Net shortwave flux into walls in layer 15 [ $\text{W m}^{-2}$ ]               |
| 105    | KRfNet1    | Net shortwave flux into roofs in layer 1 [ $\text{W m}^{-2}$ ]                |
| 106    | KRfNet2    | Net shortwave flux into roofs in layer 2 [ $\text{W m}^{-2}$ ]                |
| 107    | KRfNet3    | Net shortwave flux into roofs in layer 3 [ $\text{W m}^{-2}$ ]                |
| 108    | KRfNet4    | Net shortwave flux into roofs in layer 4 [ $\text{W m}^{-2}$ ]                |
| 109    | KRfNet5    | Net shortwave flux into roofs in layer 5 [ $\text{W m}^{-2}$ ]                |
| 110    | KRfNet6    | Net shortwave flux into roofs in layer 6 [ $\text{W m}^{-2}$ ]                |
| 111    | KRfNet7    | Net shortwave flux into roofs in layer 7 [ $\text{W m}^{-2}$ ]                |
| 112    | KRfNet8    | Net shortwave flux into roofs in layer 8 [ $\text{W m}^{-2}$ ]                |
| 113    | KRfNet9    | Net shortwave flux into roofs in layer 9 [ $\text{W m}^{-2}$ ]                |
| 114    | KRfNet10   | Net shortwave flux into roofs in layer 10 [ $\text{W m}^{-2}$ ]               |
| 115    | KRfNet11   | Net shortwave flux into roofs in layer 11 [ $\text{W m}^{-2}$ ]               |
| 116    | KRfNet12   | Net shortwave flux into roofs in layer 12 [ $\text{W m}^{-2}$ ]               |
| 117    | KRfNet13   | Net shortwave flux into roofs in layer 13 [ $\text{W m}^{-2}$ ]               |
| 118    | KRfNet14   | Net shortwave flux into roofs in layer 14 [ $\text{W m}^{-2}$ ]               |
| 119    | KRfNet15   | Net shortwave flux into roofs in layer 15 [ $\text{W m}^{-2}$ ]               |
| 120    | KRfIn1     | Shortwave flux into roofs in layer 1 [ $\text{W m}^{-2}$ ]                    |
| 121    | KRfIn2     | Shortwave flux into roofs in layer 2 [ $\text{W m}^{-2}$ ]                    |
| 122    | KRfIn3     | Shortwave flux into roofs in layer 3 [ $\text{W m}^{-2}$ ]                    |
| 123    | KRfIn4     | Shortwave flux into roofs in layer 4 [ $\text{W m}^{-2}$ ]                    |

Table 7.361 – continued from previous page

| Column | Name       | Description   |
|--------|------------|---|
| 124    | KRfln5     | Shortwave flux into roofs in layer 5 [ $\text{W m}^{-2}$ ]              |
| 125    | KRfln6     | Shortwave flux into roofs in layer 6 [ $\text{W m}^{-2}$ ]              |
| 126    | KRfln7     | Shortwave flux into roofs in layer 7 [ $\text{W m}^{-2}$ ]              |
| 127    | KRfln8     | Shortwave flux into roofs in layer 8 [ $\text{W m}^{-2}$ ]              |
| 128    | KRfln9     | Shortwave flux into roofs in layer 9 [ $\text{W m}^{-2}$ ]              |
| 129    | KRfln10    | Shortwave flux into roofs in layer 10 [ $\text{W m}^{-2}$ ]             |
| 130    | KRfln11    | Shortwave flux into roofs in layer 11 [ $\text{W m}^{-2}$ ]             |
| 131    | KRfln12    | Shortwave flux into roofs in layer 12 [ $\text{W m}^{-2}$ ]             |
| 132    | KRfln13    | Shortwave flux into roofs in layer 13 [ $\text{W m}^{-2}$ ]             |
| 133    | KRfln14    | Shortwave flux into roofs in layer 14 [ $\text{W m}^{-2}$ ]             |
| 134    | KRfln15    | Shortwave flux into roofs in layer 15 [ $\text{W m}^{-2}$ ]             |
| 135    | KTopDnDir  | Direct shortwave flux into roofs [ $\text{W m}^{-2}$ ]                  |
| 136    | KTopNet    | Top-of-canopy net shortwave flux [ $\text{W m}^{-2}$ ]                  |
| 137    | KGrndDnDir | Direct downwelling shortwave flux into the ground [ $\text{W m}^{-2}$ ] |
| 138    | KGrndNet   | Net shortwave flux into the ground [ $\text{W m}^{-2}$ ]                |

## 7.5 Troubleshooting

### 7.5.1 How to report an issue of this manual?

Please submit your issue via our [GitHub](#) page.

### 7.5.2 How to join your email-list?

Please join our email-list [here](#).

### 7.5.3 How to create a directory?

Please search the web using this phrase if you do not know how to create a folder or directory

### 7.5.4 How to unzip a file

Please search the web using this phrase if you do not know how to unzip a file

### 7.5.5 A text editor

A program to edit plain text files. If you search on the web using the phrase ‘text editor’ you will find numerous programs. These include for example, NotePad, EditPad, Text Pad etc

### 7.5.6 Command prompt

From Start select run –type cmd – this will open a window. Change directory to the location of where you stored your files. The following website may be helpful if you do not know what a command prompt is: <http://dosprompt.info/>

### 7.5.7 Day of year [DOY]

January 1st is day 1, February 1st is day 32. If you search on the web using the phrase ‘day of year calendar’ you will find tables that allow rapid conversions. Remember that after February 28th DOY will be different between leap years and non-leap years.

### 7.5.8 ESTM output

First time steps of storage output could give NaN values during the initial converging phase.

### 7.5.9 First things to Check if the program seems to have problems

- Check the problems.txt file.
- Check file options – in RunControl.nml.
- Look in the output directory for the SS\_FileChoices.txt. This allows you to check all options that were used in the run. You may want to compare it with the original version supplied with the model.
- Note there can not be missing time steps in the data. If you need help with this you may want to checkout **‘UMEP’**

#### A pop-up saying “file path not found”

This means the program cannot find the file paths defined in RunControl.nml file. Possible solutions:

- Check that you have created the folder that you specified in RunControl.nml.
- Check does the output directory exist?
- Check that you have a single or double quotes around the FileInputPath, FileOutputPath and FileCode

====“%sat\_vap\_press.f temp=0.0000 pressure dectime”==== Temperature is zero in the calculation of water vapour pressure parameterization.

- You don’t need to worry if the temperature should be (is) 0°C.
- If it should not be 0°C this suggests that there is a problem with the data.

### %T changed to fit limits

- [TL =0.1]/ [TL =39.9] You may want to change the coefficients for surface resistance. If you have data from these temperatures, we would happily determine them.

### %Iteration loop stopped for too stable conditions.

- [zL]/[USTAR] This warning indicates that the atmospheric stability gets above 2. In these conditions [MO theory](#) is not necessarily valid. The iteration loop to calculate the [Obukhov length](#) and [friction velocity](#) is stopped so that stability does not get too high values. This is something you do not need to worry as it does not mean wrong input data.

### “Reference to undefined variable, array element or function result”

- Parameter(s) missing from input files.

See also the error messages provided in `problems.txt` and `warnings.txt`

## 7.6 SUEWS-related Software

### 7.6.1 SuPy: SUEWS that speaks Python

- **What is SuPy?**

SuPy is a Python-enhanced urban climate model with [SUEWS](#) as its computation core.

The scientific rigour in SuPy results is thus guaranteed by SUEWS (see [SUEWS publications](#) and [Parameterisations and sub-models within SUEWS](#)).

Meanwhile, the data analysis ability of SuPy is greatly enhanced by the Python-based [SciPy Stack](#), notably [numpy](#) and [pandas](#).

More details are described in [our SuPy paper](#).

- **How to get SuPy?**

SuPy is available on all major platforms (macOS, Windows, Linux) for Python 3.7+ (64-bit only) via [PyPI](#):

```
python3 -m pip install supy --upgrade
```

- **How to use SuPy?**

- Please follow [Quickstart of SuPy](#) and [other tutorials](#).
- Please see [API reference](#) for details.
- Please see [FAQ](#) if any issue.

- **How to contribute to SuPy?**

- Add your development via [Pull Request](#)



- Report issues via the [GitHub page](#).
- Cite our [SuPy paper](#).
- Provide [suggestions and feedback](#).

## Tutorials

To familiarise users with SuPy urban climate modelling and to demonstrate the functionality of SuPy, we provide the following tutorials in [Jupyter notebooks](#):

### Quickstart of SuPy

This quickstart demonstrates the essential and simplest workflow of `supy` in SUEWS simulation:

1. *load input files*
2. *run simulation*
3. *examine results*

More advanced use of `supy` are available in the [tutorials](#)

Before we start, we need to load the following necessary packages.

```
[1]: import matplotlib.pyplot as plt
import supy as sp
import pandas as pd
import numpy as np
from pathlib import Path

%matplotlib inline

/opt/homebrew/Caskroom/mambaforge/base/envs/supy/lib/python3.9/site-packages/pandas/core/
↳ reshape/merge.py:916: FutureWarning: In a future version, the Index constructor will
↳ not infer numeric dtypes when passed object-dtype sequences (matching Series behavior)
key_col = Index(lvals).where(~mask_left, rvals)
```

```
[2]: sp.show_version()

SuPy versions
-----
supy: 2022.9.19.dev1-dirty
supy_driver: 2021a15
```

### Load input files

#### For existing SUEWS users:

First, a path to `SUEWS RunControl.nml` should be specified, which will direct `supy` to locate input files.

```
[3]: path_runcontrol = Path('../sample_run') / 'RunControl.nml'

[4]: df_state_init = sp.init_supy(path_runcontrol)
```

```
2022-09-20 23:04:30,116 - SuPy - INFO - All cache cleared.
```

A sample `df_state_init` looks below (note that `.T` is used here to produce a nicer tableform view):

```
[5]: df_state_init.filter(like='method').T
```

```
[5]: grid                                1
var                                ind_dim
aerodynamicresistancemethod  0      2
basetmethod                  0      1
evapmethod                   0      2
diagmethod                   0      2
emissionsmethod              0      2
netradiationmethod           0      3
roughlenheatmethod           0      2
roughlenmommommethod         0      2
smdmethod                    0      0
stabilitymethod              0      3
storageheatmethod            0      1
waterusemethod               0      0
```

Following the convention of SUEWS, `supy` loads meteorological forcing (met-forcing) files at the grid level.

```
[6]: grid = df_state_init.index[0]
df_forcing = sp.load_forcing_grid(path_runcontrol, grid)
# by default, two years of forcing data are included;
# to save running time for demonstration, we only use one year in this demo
df_forcing=df_forcing.loc['2012'].iloc[1:]
```

```
2022-09-20 23:04:30,731 - SuPy - INFO - All cache cleared.
```

### For new users to SUEWS/SuPy:

To ease the input file preparation, a helper function `load_SampleData` is provided to get the sample input for SuPy simulations

```
[7]: df_state_init, df_forcing = sp.load_SampleData()
grid = df_state_init.index[0]
# by default, two years of forcing data are included;
# to save running time for demonstration, we only use one year in this demo
df_forcing=df_forcing.loc['2012'].iloc[1:]
```

```
2022-09-20 23:04:34,398 - SuPy - INFO - All cache cleared.
```

## Overview of SuPy input

### df\_state\_init

df\_state\_init includes model Initial state consisting of:

- surface characteristics (e.g., albedo, emissivity, land cover fractions, etc.; full details refer to [SUEWS documentation](#))
- model configurations (e.g., stability; full details refer to [SUEWS documentation](#))

Detailed description of variables in df\_state\_init refers to *SuPy input*

Surface land cover fraction information in the sample input dataset:

```
[8]: df_state_init.loc[:, ['bldgh', 'evetreeh', 'dectreeh']]
```

```
[8]: var      bldgh evetreeh dectreeh
ind_dim      0          0          0
grid
1           22.0      13.1      13.1
```

```
[9]: df_state_init.filter(like='sfr_surf')
```

```
[9]: var      sfr_surf
ind_dim    (0,) (1,) (2,) (3,) (4,) (5,) (6,)
grid
1           0.43  0.38  0.0  0.02  0.03  0.0  0.14
```

### df\_forcing

df\_forcing includes meteorological and other external forcing information.

Detailed description of variables in df\_forcing refers to *SuPy input*.

Below is an overview of forcing variables of the sample data set used in the following simulations.

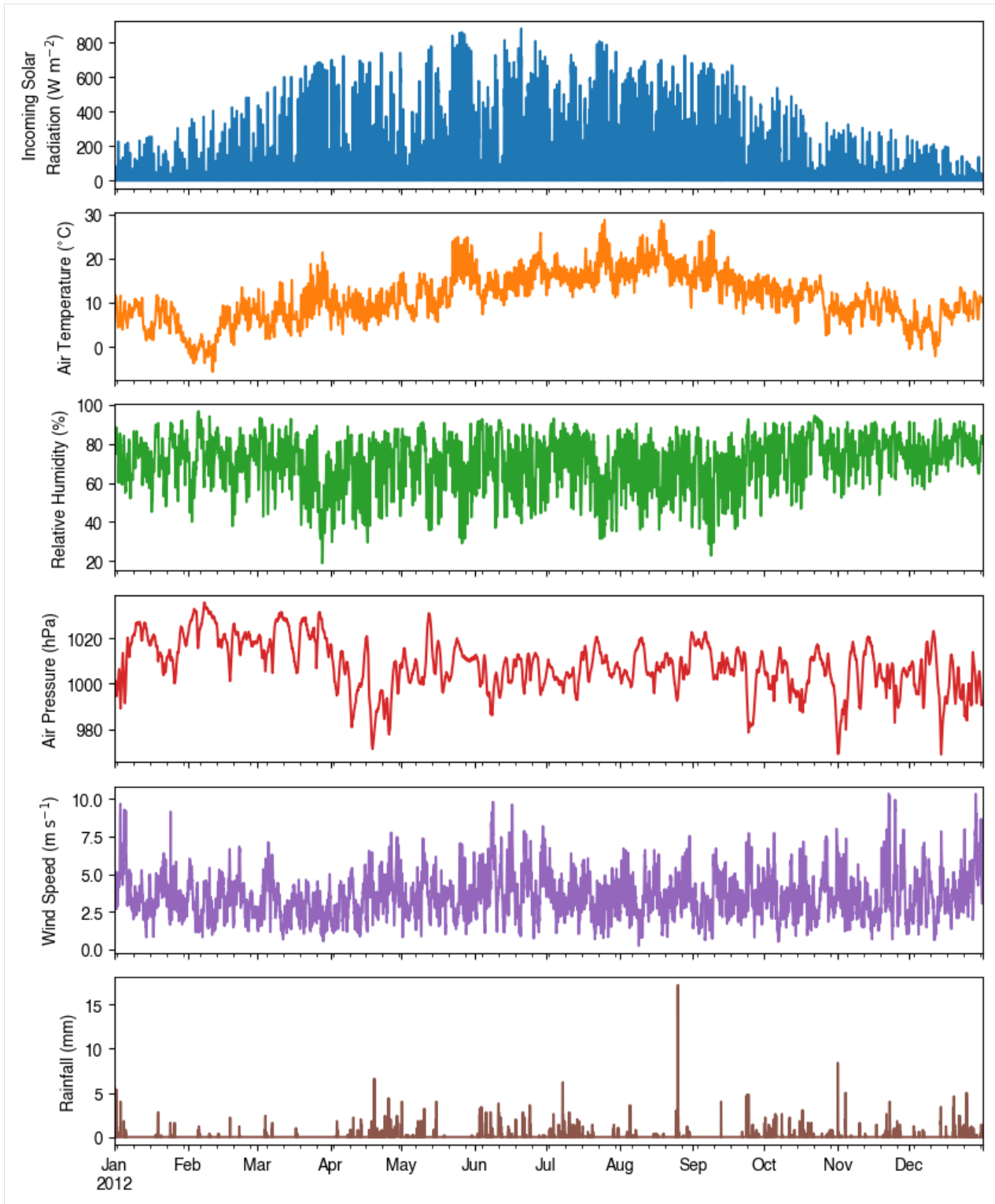
```
[10]: list_var_forcing = [
        "kdown",
        "Tair",
        "RH",
        "pres",
        "U",
        "rain",
    ]
dict_var_label = {
    "kdown": "Incoming Solar\n Radiation ( $\mathrm{W \ m^{-2}}$ )",
    "Tair": "Air Temperature ( $^{\circ}\mathrm{C}$ )",
    "RH": "Relative Humidity (%)",
    "pres": "Air Pressure (hPa)",
    "rain": "Rainfall (mm)",
    "U": "Wind Speed ( $\mathrm{m \ s^{-1}}$ )",
}
df_plot_forcing_x = (
    df_forcing.loc[:, list_var_forcing].copy().shift(-1).dropna(how="any")
```

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```
)
df_plot_forcing = df_plot_forcing_x.resample("1h").mean()
df_plot_forcing["rain"] = df_plot_forcing_x["rain"].resample("1h").sum()

axes = df_plot_forcing.plot(subplots=True, figsize=(8, 12), legend=False,)
fig = axes[0].figure
fig.tight_layout()
fig.autofmt_xdate(bottom=0.2, rotation=0, ha="center")
for ax, var in zip(axes, list_var_forcing):
    _ = ax.set_ylabel(dict_var_label[var])
```



## Modification of SuPy input

Given `pandas.DataFrame` is the core data structure of SuPy, all operations, including modification, output, demonstration, etc., on SuPy inputs (`df_state_init` and `df_forcing`) can be done using `pandas`-based functions/methods.

Specifically, for modification, the following operations are essential:

### locating data

Data can be located in two ways, namely: 1. by name via `.loc` <[http://pandas.pydata.org/pandas-docs/stable/user\\_guide/indexing.html#selection-by-label](http://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#selection-by-label)>`; 2. by position via `.iloc` <[http://pandas.pydata.org/pandas-docs/stable/user\\_guide/indexing.html#selection-by-position](http://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#selection-by-position)>`.

```
[11]: # view the surface fraction variable: `sfr`  
df_state_init.loc[:, 'sfr_surf']
```

```
[11]: ind_dim  (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1          0.43  0.38   0.0  0.02  0.03   0.0  0.14
```

```
[12]: # view the second row of `df_forcing`, which is a pandas Series  
df_forcing.iloc[1]
```

```
[12]: iy          2012.000000  
id           1.000000  
it           0.000000  
imin         10.000000  
qn          -999.000000  
qh          -999.000000  
qe          -999.000000  
qs          -999.000000  
qf          -999.000000  
U            5.176667  
RH           86.195000  
Tair         11.620000  
pres        1001.833333  
rain         0.000000  
kdown        0.173333  
snow        -999.000000  
ldown        -999.000000  
fcld        -999.000000  
Wuh          0.000000  
xsm         -999.000000  
lai         -999.000000  
kdiff        -999.000000  
kdir         -999.000000  
wdir         -999.000000  
isec         0.000000  
Name: 2012-01-01 00:10:00, dtype: float64
```

```
[13]: # view a particular position of `df_forcing`, which is a value  
df_forcing.iloc[8,9]
```

```
[13]: 4.78
```

### setting new values

Setting new values is very straightforward: after locating the variables/data to modify, just set the new values accordingly:

```
[14]: # modify surface fractions
df_state_init.loc[:, 'sfr_surf'] = [.1, .1, .2, .3, .25, .05, 0]
# check the updated values
df_state_init.loc[:, 'sfr_surf']
```

```
[14]: ind_dim  (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1          0.1   0.1   0.2   0.3   0.25  0.05   0
```

### Run simulations

Once met-forcing (via `df_forcing`) and initial conditions (via `df_state_init`) are loaded in, we call `sp.run_supy` to conduct a SUEWS simulation, which will return two pandas DataFrames: `df_output` and `df_state`.

```
[15]: df_output, df_state_final = sp.run_supy(df_forcing, df_state_init)

2022-09-20 23:04:39,021 - SuPy - INFO - =====
2022-09-20 23:04:39,021 - SuPy - INFO - Simulation period:
2022-09-20 23:04:39,022 - SuPy - INFO -   Start: 2012-01-01 00:05:00
2022-09-20 23:04:39,022 - SuPy - INFO -   End: 2012-12-31 23:55:00
2022-09-20 23:04:39,023 - SuPy - INFO -
2022-09-20 23:04:39,023 - SuPy - INFO - No. of grids: 1
2022-09-20 23:04:39,024 - SuPy - INFO - SuPy is running in serial mode
2022-09-20 23:04:49,343 - SuPy - INFO - Execution time: 10.3 s
2022-09-20 23:04:49,344 - SuPy - INFO - =====
```

### df\_output

`df_output` is an ensemble output collection of major SUEWS output groups, including:

- SUEWS: the essential SUEWS output variables
- DailyState: variables of daily state information
- snow: snow output variables (effective when `snowuse = 1` set in `df_state_init`)

Detailed description of variables in `df_output` refers to [SuPy output](#)

```
[16]: df_output.columns.levels[0]
```

```
[16]: Index(['SUEWS', 'snow', 'RSL', 'BEERS', 'debug', 'SPARTACUS', 'ESTMExt',
        'DailyState'],
        dtype='object', name='group')
```

## df\_state\_final

df\_state\_final is a DataFrame for holding:

1. all model states if `save_state` is set to `True` when calling `sp.run_supy` (supy may run significantly slower for a large simulation);
2. or, only the final state if `save_state` is set to `False` (the default setting), in which mode `supy` has a similar performance as the standalone compiled SUEWS executable.

Entries in `df_state_final` have the same data structure as `df_state_init` and can thus be used for other SUEWS simulations starting at the timestamp as in `df_state_final`.

Detailed description of variables in `df_state_final` refers to [SuPy output](#)

```
[17]: df_state_final.T.head()
```

```
[17]: datetime          2012-01-01 00:05:00 2013-01-01 00:00:00
      grid                                1                                1
      var      ind_dim
      ah_min      (0,)              15.0              15.0
              (1,)              15.0              15.0
      ah_slope_cooling (0,)              2.7              2.7
              (1,)              2.7              2.7
      ah_slope_heating (0,)              2.7              2.7
```

## Examine results

Thanks to the functionality inherited from `pandas` and other packages under the [PyData](#) stack, compared with the standard SUEWS simulation workflow, `supy` enables more convenient examination of SUEWS results by statistics calculation, resampling, plotting (and many more).

## Output structure

`df_output` is organised with `MultiIndex (grid,timestamp)` and `(group,variable)` as index and columns, respectively.

```
[18]: df_output.head()
```

```
[18]: group      SUEWS
      var      Kdown      Kup      Ldown      Lup \
      grid datetime
      1  2012-01-01 00:05:00  0.176667  0.02332  344.179805  371.582645
          2012-01-01 00:10:00  0.173333  0.02288  344.190048  371.657938
          2012-01-01 00:15:00  0.170000  0.02244  344.200308  371.733243
          2012-01-01 00:20:00  0.166667  0.02200  344.210586  371.808562
          2012-01-01 00:25:00  0.163333  0.02156  344.220882  371.883893

      group
      var      Tsurf      QN      QF      QS \
      grid datetime
      1  2012-01-01 00:05:00  11.607452 -27.249493  40.574001 -6.382243
          2012-01-01 00:10:00  11.622405 -27.317436  39.724283 -6.228797
          2012-01-01 00:15:00  11.637359 -27.385375  38.874566 -6.082788
```

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```

2012-01-01 00:20:00 11.652312 -27.453309 38.024849 -5.943907
2012-01-01 00:25:00 11.667265 -27.521237 37.175131 -5.811855

group
var
grid datetime
1 2012-01-01 00:05:00 19.664156 0.042594 ... DailyState \
2012-01-01 00:10:00 18.593922 0.041722 ... DensSnow_Paved
2012-01-01 00:15:00 17.531131 0.040849 ...
2012-01-01 00:20:00 16.475472 0.039975 ...
2012-01-01 00:25:00 15.426648 0.039101 ...

group
var
grid datetime
1 2012-01-01 00:05:00 NaN NaN NaN
2012-01-01 00:10:00 NaN NaN NaN
2012-01-01 00:15:00 NaN NaN NaN
2012-01-01 00:20:00 NaN NaN NaN
2012-01-01 00:25:00 NaN NaN NaN

group
var
grid datetime
1 2012-01-01 00:05:00 NaN NaN NaN NaN NaN
2012-01-01 00:10:00 NaN NaN NaN NaN NaN
2012-01-01 00:15:00 NaN NaN NaN NaN NaN
2012-01-01 00:20:00 NaN NaN NaN NaN NaN
2012-01-01 00:25:00 NaN NaN NaN NaN NaN

group
var
grid datetime
1 2012-01-01 00:05:00 NaN
2012-01-01 00:10:00 NaN
2012-01-01 00:15:00 NaN
2012-01-01 00:20:00 NaN
2012-01-01 00:25:00 NaN

[5 rows x 924 columns]
```

Here we demonstrate several typical scenarios for SUEWS results examination.

The essential SUEWS output collection is extracted as a separate variable for easier processing in the following sections. More [advanced slicing techniques](#) are available in [pandas documentation](#).

```
[19]: df_output_suews = df_output['SUEWS']
```

## Statistics Calculation

We can use the `.describe()` method for a quick overview of the key surface energy balance budgets.

```
[20]: df_output_suews.loc[:, ['QN', 'QS', 'QH', 'QE', 'QF']].describe()
```

```
[20]: var      QN      QS      QH      QE  \
count  105407.000000  105407.000000  105407.000000  105407.000000
mean    39.883231    5.830107    62.666636    50.411038
std     132.019300    49.161894    77.074237    78.484562
min     -86.331686   -75.287258   -177.705269    0.000000
25%     -42.499510   -27.895414    16.069451    0.676206
50%     -25.749393    -8.183901    43.844985    14.712552
75%      74.815479    19.121287    85.722951    69.135212
max      679.848644   237.932439   480.795771   624.179069

var      QF
count  105407.000000
mean    79.024549
std     31.231867
min     26.327536
25%     50.058031
50%     82.883410
75%    104.812507
max    160.023207
```

## Plotting

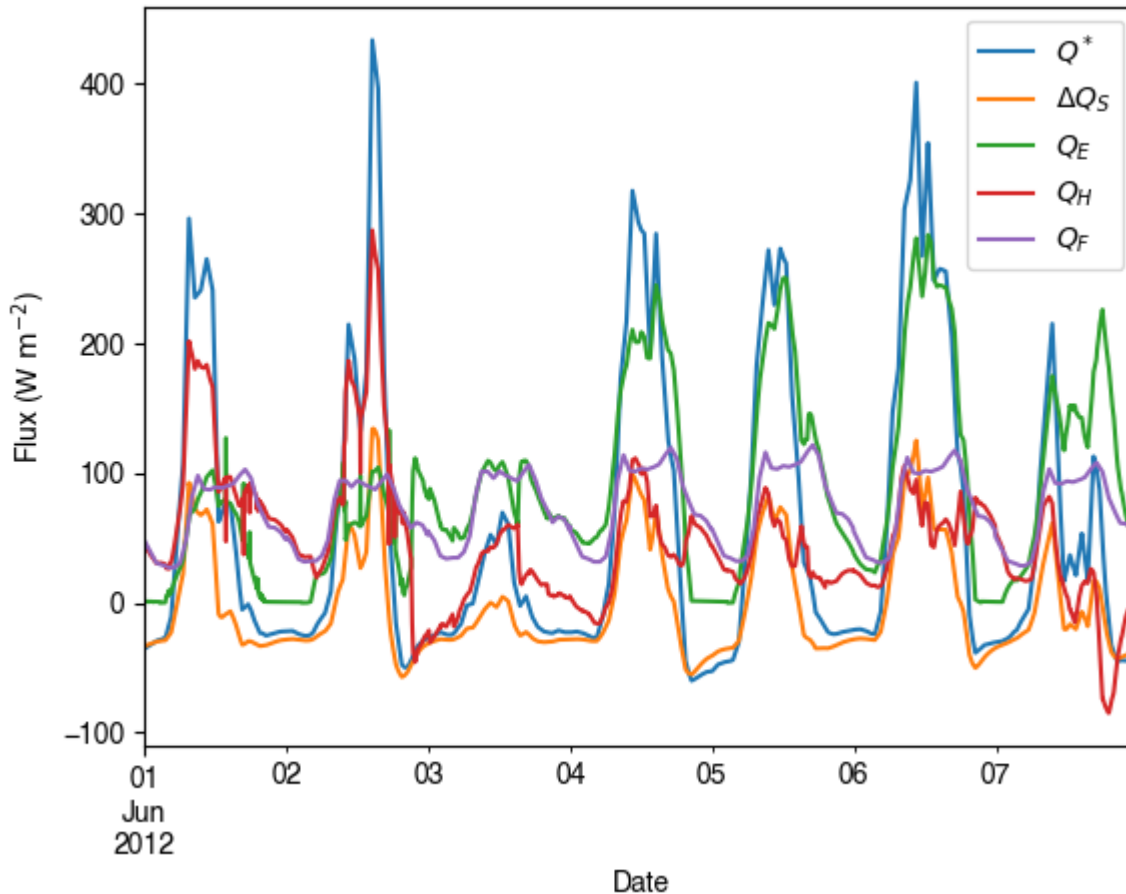
### Basic example

Plotting is very straightforward via the `.plot` method bounded with `pandas.DataFrame`. Note the usage of `loc` for two slices of the output `DataFrame`.

```
[21]: # a dict for better display variable names
dict_var_disp = {
    'QN': '$Q^{*}$',
    'QS': r'$\Delta Q_S$',
    'QE': '$Q_E$',
    'QH': '$Q_H$',
    'QF': '$Q_F$',
    'Kdown': r'$K_{\downarrow}$',
    'Kup': r'$K_{\uparrow}$',
    'Ldown': r'$L_{\downarrow}$',
    'Lup': r'$L_{\uparrow}$',
    'Rain': '$P$',
    'Irr': '$I$',
    'Evap': '$E$',
    'RO': '$R$',
    'TotCh': '$\Delta S$',
}
```

Quick look at the simulation results:

```
[22]: ax_output = df_output_suews\
      .loc[grid]\
      .loc['2012 6 1':'2012 6 7',
           ['QN', 'QS', 'QE', 'QH', 'QF']]\
      .rename(columns=dict_var_disp)\
      .plot()
_ = ax_output.set_xlabel('Date')
_ = ax_output.set_ylabel('Flux ($ \mathrm{W \ m^{-2}}$)')
_ = ax_output.legend()
```



### More examples

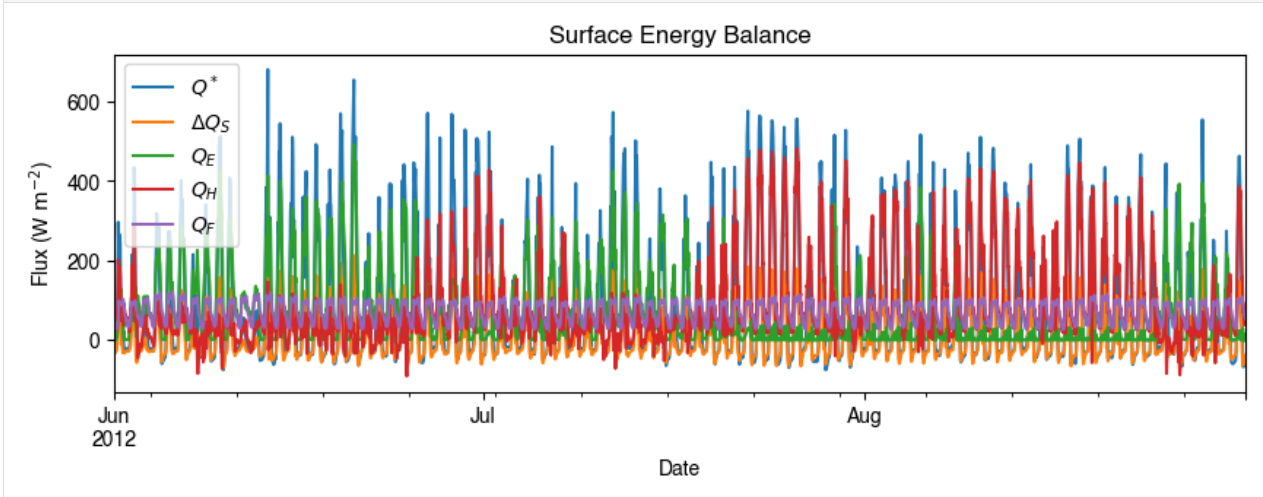
Below is a more complete example for examination of urban energy balance over the whole summer (June to August).

```
[23]: # energy balance
ax_output = (
    df_output_suews.loc[grid]
    .loc["2012 6":"2012 8", ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Energy Balance",)
)
_ = ax_output.set_xlabel("Date")
```

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```
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```



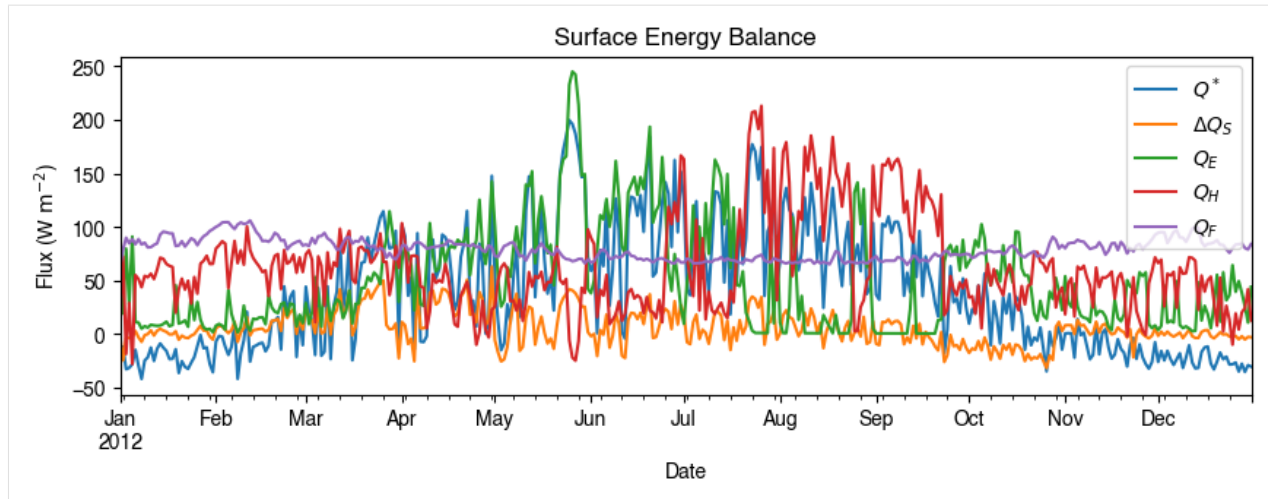
## Resampling

The suggested runtime/simulation frequency of SUEWS is 300 s, which usually results in a large output and may be over-weighted for storage and analysis. Also, you may feel an apparent slowdown in producing the above figure as a large amount of data were used for the plotting. To slim down the result size for analysis and output, we can **resample** the default output very easily.

```
[24]: rsmpl_1d = df_output_suews.loc[grid].resample("1d")
# daily mean values
df_1d_mean = rsmpl_1d.mean()
# daily sum values
df_1d_sum = rsmpl_1d.sum()
```

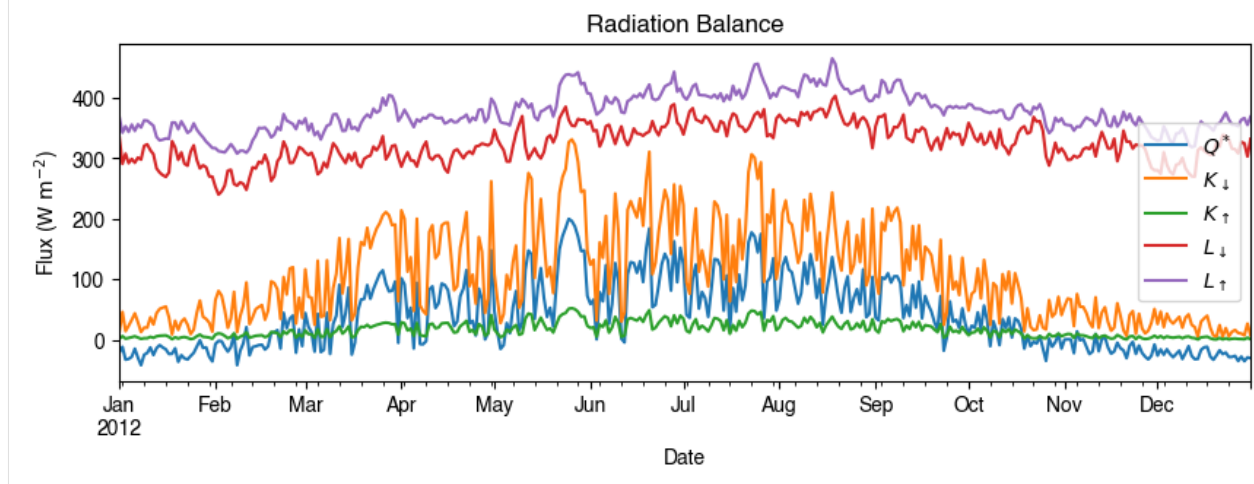
We can then re-examine the above energy balance at hourly scale and plotting will be significantly faster.

```
[25]: # energy balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Energy Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```

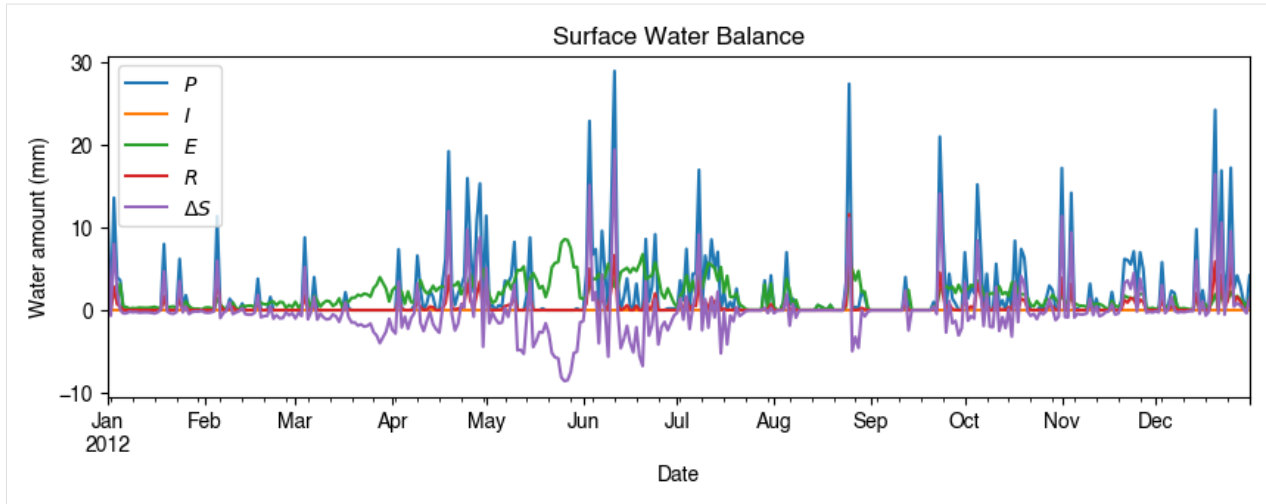


Then we use the hourly results for other analyses.

```
[26]: # radiation balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "Kdown", "Kup", "Ldown", "Lup"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Radiation Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```



```
[27]: # water balance
ax_output = (
    df_1d_sum.loc[:, ["Rain", "Irr", "Evap", "RO", "TotCh"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Water Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Water amount (mm)")
_ = ax_output.legend()
```



Get an overview of partitioning in energy and water balance at monthly scales:

```
[28]: # get a monthly Resampler
df_plot = df_output_suews.loc[grid].copy()
df_plot.index = df_plot.index.set_names("Month")
rsmpl_1M = df_plot.shift(-1).dropna(how="all").resample("1M", kind="period")
# mean values
df_1M_mean = rsmpl_1M.mean()
# sum values
df_1M_sum = rsmpl_1M.sum()

[29]: # month names
name_mon = [x.strftime("%b") for x in rsmpl_1M.groups]
# create subplots showing two panels together
fig, axes = plt.subplots(2, 1, sharex=True)
# surface energy balance
df_1M_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]].rename(columns=dict_var_disp).plot(
    ax=axes[0], # specify the axis for plotting
    figsize=(10, 6), # specify figure size
    title="Surface Energy Balance",
    kind="bar",
)
# surface water balance
df_1M_sum.loc[:, ["Rain", "Irr", "Evap", "RO", "TotCh"]].rename(
    columns=dict_var_disp
).plot(
    ax=axes[1], # specify the axis for plotting
    title="Surface Water Balance",
    kind="bar",
)

# annotations
_ = axes[0].set_ylabel("Mean Flux ($ \mathrm{W \ m^{-2}}$)")
_ = axes[0].legend()
_ = axes[1].set_xlabel("Month")
_ = axes[1].set_ylabel("Total Water Amount (mm)")
```

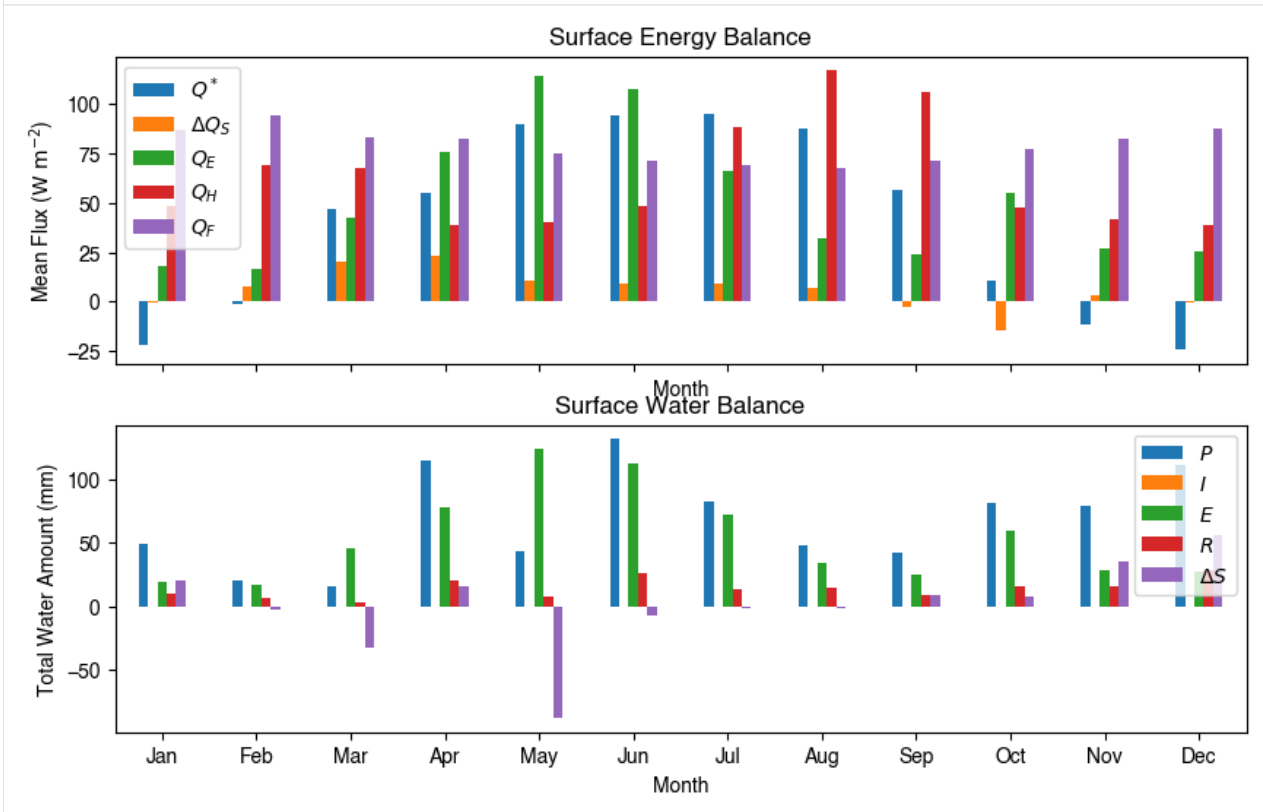
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```
_ = axes[1].axis.set_ticklabels(name_mon, rotation=0)
_ = axes[1].legend()
```

```
[29]: <AxesSubplot:title={'center':'Surface Energy Balance'}, xlabel='Month'>
```

```
[29]: <AxesSubplot:title={'center':'Surface Water Balance'}, xlabel='Month'>
```



## Output

The supy output can be saved as txt files for further analysis using supy function `save_supy`.

```
[30]: df_output
```

```
[30]: group          SUEWS      Kup      Ldown      Lup
var          Kdown
grid datetime
1  2012-01-01 00:05:00  0.176667  0.02332  344.179805  371.582645
   2012-01-01 00:10:00  0.173333  0.02288  344.190048  371.657938
   2012-01-01 00:15:00  0.170000  0.02244  344.200308  371.733243
   2012-01-01 00:20:00  0.166667  0.02200  344.210586  371.808562
   2012-01-01 00:25:00  0.163333  0.02156  344.220882  371.883893
...
   2012-12-31 23:35:00  0.000000  0.00000  330.263407  363.676342
   2012-12-31 23:40:00  0.000000  0.00000  330.263407  363.676342
   2012-12-31 23:45:00  0.000000  0.00000  330.263407  363.676342
   2012-12-31 23:50:00  0.000000  0.00000  330.263407  363.676342
   2012-12-31 23:55:00  0.000000  0.00000  330.263407  363.676342
```

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```

group
var          Tsurf          QN          QF          QS          \
grid datetime
1  2012-01-01 00:05:00  11.607452 -27.249493  40.574001 -6.382243
   2012-01-01 00:10:00  11.622405 -27.317436  39.724283 -6.228797
   2012-01-01 00:15:00  11.637359 -27.385375  38.874566 -6.082788
   2012-01-01 00:20:00  11.652312 -27.453309  38.024849 -5.943907
   2012-01-01 00:25:00  11.667265 -27.521237  37.175131 -5.811855
...
   2012-12-31 23:35:00  10.140000 -33.412935  53.348682 -4.399144
   2012-12-31 23:40:00  10.140000 -33.412935  52.422737 -4.397669
   2012-12-31 23:45:00  10.140000 -33.412935  51.496792 -4.395831
   2012-12-31 23:50:00  10.140000 -33.412935  50.570847 -4.393681
   2012-12-31 23:55:00  10.140000 -33.412935  46.174492 -4.391264

group
var          QH          QE          DailyState          \
grid datetime          DensSnow_Paved
1  2012-01-01 00:05:00  19.664156  0.042594  ...          NaN
   2012-01-01 00:10:00  18.593922  0.041722  ...          NaN
   2012-01-01 00:15:00  17.531131  0.040849  ...          NaN
   2012-01-01 00:20:00  16.475472  0.039975  ...          NaN
   2012-01-01 00:25:00  15.426648  0.039101  ...          NaN
...
   2012-12-31 23:35:00  0.904146  23.430745  ...          NaN
   2012-12-31 23:40:00  0.394992  23.012479  ...          NaN
   2012-12-31 23:45:00 -0.121686  22.601374  ...          NaN
   2012-12-31 23:50:00 -0.645680  22.197273  ...          NaN
   2012-12-31 23:55:00 -2.949124  20.101945  ...          0.0

group
var          DensSnow_Bldgs DensSnow_EveTr DensSnow_DecTr \
grid datetime
1  2012-01-01 00:05:00          NaN          NaN          NaN
   2012-01-01 00:10:00          NaN          NaN          NaN
   2012-01-01 00:15:00          NaN          NaN          NaN
   2012-01-01 00:20:00          NaN          NaN          NaN
   2012-01-01 00:25:00          NaN          NaN          NaN
...
   2012-12-31 23:35:00          NaN          NaN          NaN
   2012-12-31 23:40:00          NaN          NaN          NaN
   2012-12-31 23:45:00          NaN          NaN          NaN
   2012-12-31 23:50:00          NaN          NaN          NaN
   2012-12-31 23:55:00          0.0          0.0          0.0

group
var          DensSnow_Grass DensSnow_BSoil DensSnow_Water \
grid datetime
1  2012-01-01 00:05:00          NaN          NaN          NaN
   2012-01-01 00:10:00          NaN          NaN          NaN
   2012-01-01 00:15:00          NaN          NaN          NaN

```

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|                             |                     |         |        |        |
|-----------------------------|---------------------|---------|--------|--------|
|                             | 2012-01-01 00:20:00 | NaN     | NaN    | NaN    |
|                             | 2012-01-01 00:25:00 | NaN     | NaN    | NaN    |
| ...                         |                     | ...     | ...    | ...    |
|                             | 2012-12-31 23:35:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:40:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:45:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:50:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:55:00 | 0.0     | 0.0    | 0.0    |
| group                       |                     |         |        |        |
| var                         |                     | a1      | a2     | a3     |
| grid datetime               |                     |         |        |        |
| 1                           | 2012-01-01 00:05:00 | NaN     | NaN    | NaN    |
|                             | 2012-01-01 00:10:00 | NaN     | NaN    | NaN    |
|                             | 2012-01-01 00:15:00 | NaN     | NaN    | NaN    |
|                             | 2012-01-01 00:20:00 | NaN     | NaN    | NaN    |
|                             | 2012-01-01 00:25:00 | NaN     | NaN    | NaN    |
| ...                         |                     | ...     | ...    | ...    |
|                             | 2012-12-31 23:35:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:40:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:45:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:50:00 | NaN     | NaN    | NaN    |
|                             | 2012-12-31 23:55:00 | 0.36935 | 0.3242 | 8.0995 |
| [105407 rows x 924 columns] |                     |         |        |        |

```
[31]: list_path_save = sp.save_supy(df_output, df_state_final)
```

```
[32]: for file_out in list_path_save:
        print(file_out.name)
```

```
1_2012_DailyState.txt
1_2012_SUEWS_60.txt
1_2012_RSL_60.txt
1_2012_BEERS_60.txt
1_2012_debug_60.txt
1_2012_ESTMExt_60.txt
df_state.csv
```

## Impact Studies Using SuPy

### Aim

In this tutorial, we aim to perform sensitivity analysis using supy in a parallel mode to investigate the impacts on urban climate of

1. surface properties: the physical attributes of land covers (e.g., albedo, water holding capacity, etc.)
2. background climate: longterm meteorological conditions (e.g., air temperature, precipitation, etc.)

### load supy and sample dataset

```
[1]: from dask import dataframe as dd
import supy as sp

import pandas as pd
import numpy as np

from time import time

/opt/homebrew/Caskroom/mambaforge/base/envs/supy/lib/python3.9/site-packages/pandas/core/
↳ reshape/merge.py:916: FutureWarning: In a future version, the Index constructor will
↳ not infer numeric dtypes when passed object-dtype sequences (matching Series behavior)
    key_col = Index(lvals).where(~mask_left, rvals)

[2]: # load sample datasets
df_state_init, df_forcing = sp.load_SampleData()

# by default, two years of forcing data are included;
# to save running time for demonstration, we only use one year in this demo
df_forcing=df_forcing.loc['2012'].iloc[1:]

# perform an example run to get output samples for later use
df_output, df_state_final = sp.run_supy(df_forcing, df_state_init)

2022-06-15 21:25:48,325 - SuPy - INFO - All cache cleared.
2022-06-15 21:25:49,399 - SuPy - INFO - =====
2022-06-15 21:25:49,399 - SuPy - INFO - Simulation period:
2022-06-15 21:25:49,400 - SuPy - INFO -     Start: 2012-01-01 00:05:00
2022-06-15 21:25:49,400 - SuPy - INFO -     End: 2012-12-31 23:55:00
2022-06-15 21:25:49,400 - SuPy - INFO -
2022-06-15 21:25:49,401 - SuPy - INFO - No. of grids: 1
2022-06-15 21:25:49,401 - SuPy - INFO - SuPy is running in serial mode
2022-06-15 21:25:54,675 - SuPy - INFO - Execution time: 5.3 s
2022-06-15 21:25:54,676 - SuPy - INFO - =====
```

### Surface properties: surface albedo

#### Examine the default albedo values loaded from the sample dataset

```
[3]: df_state_init.alb

[3]: ind_dim  (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1          0.1  0.12   0.1  0.18  0.21  0.18   0.1
```

**Copy the initial condition DataFrame to have a *clean slate* for our study**

Note: `DataFrame.copy()` defaults to `deepcopy`

```
[16]: df_state_init_test = df_state_init.copy()
```

**Set the Bldg land cover to 100% for this study**

```
[17]: df_state_init_test.sfr_surf = 0
df_state_init_test.loc[:, ('sfr_surf', '(1,)')] = 1
df_state_init_test.sfr_surf
```

```
[17]: ind_dim  (0,)  (1,)  (2,)  (3,)  (4,)  (5,)  (6,)
grid
1          0     1     0     0     0     0     0
```

**Construct a `df_state_init_x` dataframe to perform supy simulations with specified albedo**

```
[18]: # create a `df_state_init_x` with different surface properties
n_test = 48
list_alb_test = np.linspace(0.1, 0.8, n_test).round(2)
df_state_init_x = df_state_init_test.append(
    [df_state_init_test]*(n_test-1), ignore_index=True)

# here we modify surface albedo
df_state_init_x.loc[:, ('alb', '(1,)')] = list_alb_test
df_state_init_x.index=df_state_init_x.index.rename('grid')
```

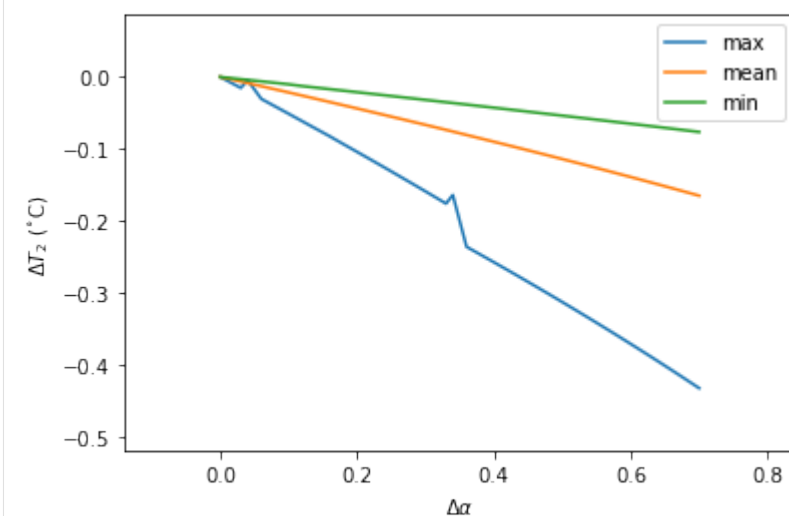
**Conduct simulations with supy**

```
[20]: df_forcing_part = df_forcing.loc["2012 01":"2012 07"]
df_res_alb_test, df_state_final_x = sp.run_supy(
    df_forcing_part,
    df_state_init_x,
    logging_level=90,
)
```

## Examine the simulation results

```
[21]: # choose results of July 2012 for analysis
df_res_alb_test_july = df_res_alb_test.SUEWS.unstack(0).loc["2012 7"]
df_res_alb_T2_stat = df_res_alb_test_july.T2.describe()
df_res_alb_T2_diff = df_res_alb_T2_stat.transform(
    lambda x: x - df_res_alb_T2_stat.iloc[:, 0]
)
df_res_alb_T2_diff.columns = list_alb_test - list_alb_test[0]
```

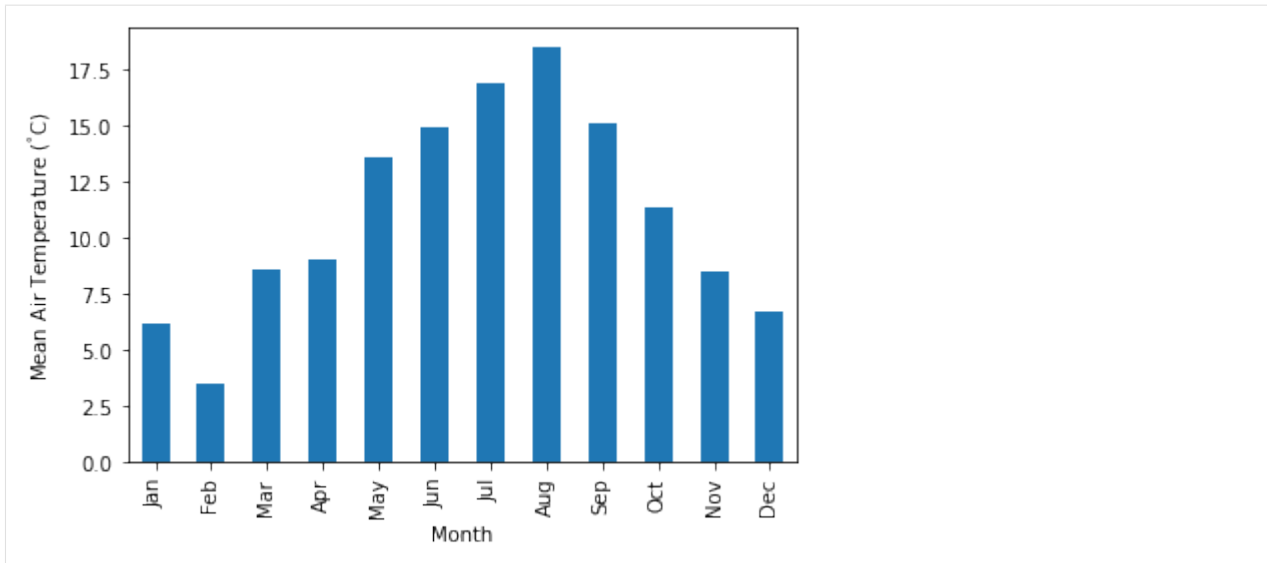
```
[22]: ax_temp_diff = df_res_alb_T2_diff.loc[["max", "mean", "min"]].T.plot()
_ = ax_temp_diff.set_ylabel("$\Delta T_2$ ($^{\circ}\text{C}$)")
_ = ax_temp_diff.set_xlabel(r"$\Delta\alpha$")
ax_temp_diff.margins(x=0.2, y=0.2)
```



## Background climate: air temperature

### Examine the monthly climatology of air temperature loaded from the sample dataset

```
[23]: df_plot = df_forcing.Tair.loc["2012"].resample("1m").mean()
ax_temp = df_plot.plot.bar(color="tab:blue")
_ = ax_temp.set_xticklabels(df_plot.index.strftime("%b"))
_ = ax_temp.set_ylabel("Mean Air Temperature ($^{\circ}\text{C}$)")
_ = ax_temp.set_xlabel("Month")
```



**Construct a function to perform parallel supy simulations with specified `diff_airtemp_test`: the difference in air temperature between the one used in simulation and loaded from sample dataset.**

#### Note

forcing data `df_forcing` has different data structure from `df_state_init`; so we need to modify `run_supy_mgrids` to implement a `run_supy_mclims` for different climate scenarios\*

Let's start the implementation of `run_supy_mclims` with a small problem of four forcing groups (i.e., climate scenarios), where the air temperatures differ from the baseline scenario with a constant bias.

```
[24]: # save loaded sample datasets
df_forcing_part_test = df_forcing.loc['2012 1':'2012 7'].copy()
df_state_init_test = df_state_init.copy()

[25]: from dask import delayed
# create a dict with four forcing conditions as a test
n_test = 4
list_TairDiff_test = np.linspace(0., 2, n_test).round(2)
dict_df_forcing_x = {
    tairdiff: df_forcing_part_test.copy()
    for tairdiff in list_TairDiff_test}
for tairdiff in dict_df_forcing_x:
    dict_df_forcing_x[tairdiff].loc[:, 'Tair'] += tairdiff

dd_forcing_x = {
    k: delayed(sp.run_supy)(df, df_state_init_test, logging_level=90)[0]
    for k, df in dict_df_forcing_x.items()}

df_res_tairdiff_test0 = delayed(pd.concat)(
    dd_forcing_x,
```

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```

    keys=list_TairDiff_test,
    names=['tairdiff'],
)

```

```

[26]: # test the performance of a parallel run
t0 = time()
df_res_tairdiff_test = df_res_tairdiff_test0\
    .compute(scheduler='threads')\
    .reset_index('grid', drop=True)
t1 = time()
t_par = t1 - t0
print(f'Execution time: {t_par:.2f} s')

```

```
Execution time: 12.16 s
```

```

[27]: # function for multi-climate `run_supy`
# wrapping the above code into one
def run_supy_mclims(df_state_init, dict_df_forcing_mclims):
    dd_forcing_x = {
        k: delayed(sp.run_supy)(df, df_state_init_test, logging_level=90)[0]
        for k, df in dict_df_forcing_x.items()}
    df_output_mclims0 = delayed(pd.concat)(
        dd_forcing_x,
        keys=list(dict_df_forcing_x.keys()),
        names=['clm'],
    ).compute(scheduler='threads')
    df_output_mclims = df_output_mclims0.reset_index('grid', drop=True)

    return df_output_mclims

```

### Construct dict\_df\_forcing\_x with multiple forcing DataFrames

```

[28]: # save loaded sample datasets
df_forcing_part_test = df_forcing.loc['2012 1':'2012 7'].copy()
df_state_init_test = df_state_init.copy()

# create a dict with a number of forcing conditions
n_test = 12 # can be set with a smaller value to save simulation time
list_TairDiff_test = np.linspace(0., 2, n_test).round(2)
dict_df_forcing_x = {
    tairdiff: df_forcing_part_test.copy()
    for tairdiff in list_TairDiff_test}
for tairdiff in dict_df_forcing_x:
    dict_df_forcing_x[tairdiff].loc[:, 'Tair'] += tairdiff

```

## Perform simulations

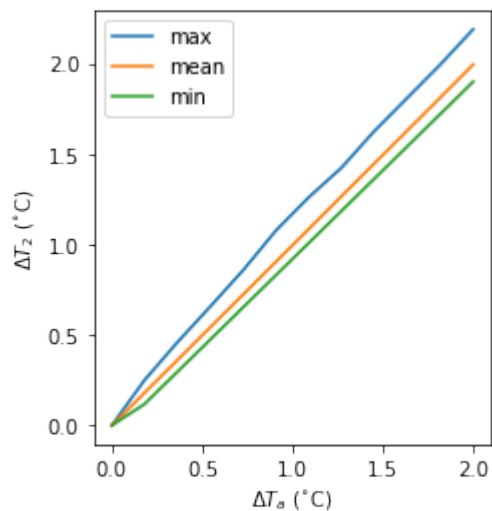
```
[29]: # run parallel simulations using `run_supy_mclims`
t0 = time()
df_airtemp_test_x = run_supy_mclims(df_state_init_test, dict_df_forcing_x)
t1 = time()
t_par = t1-t0
print(f'Execution time: {t_par:.2f} s')
```

Execution time: 35.35 s

## Examine the results

```
[30]: df_airtemp_test = df_airtemp_test_x.SUEWS.unstack(0)
df_temp_diff = df_airtemp_test.T2.transform(lambda x: x - df_airtemp_test.T2[0.0])
df_temp_diff_ana = df_temp_diff.loc["2012 7"]
df_temp_diff_stat = df_temp_diff_ana.describe().loc[["max", "mean", "min"]].T
```

```
[31]: ax_temp_diff_stat=df_temp_diff_stat.plot()
_=ax_temp_diff_stat.set_ylabel('$\\Delta T_2$ ($^{\\circ}$C)')
_=ax_temp_diff_stat.set_xlabel('$\\Delta T_a$ ($^{\\circ}$C)')
ax_temp_diff_stat.set_aspect('equal')
```



The  $T_2$  results indicate the increased  $T_a$  has different impacts on the  $T_2$  metrics (minimum, mean and maximum) but all increase linearly with  $T_a$ . The maximum  $T_2$  has the stronger response compared to the other metrics.

## Interaction between SuPy and external models

### Introduction

SUEWS can be coupled to other models that provide or require forcing data using the SuPy single timestep running mode. We demonstrate this feature with a simple online anthropogenic heat flux model.

Anthropogenic heat flux ( $Q_F$ ) is an additional term to the surface energy balance in urban areas associated with human activities (Gabey et al., 2018; Grimmond, 1992; Nie et al., 2014; 2016; Sailor, 2011). In most cities, the largest emission source is from buildings (Hamilton et al., 2009; Iamarino et al., 2011; Sailor, 2011) and is highly dependent on outdoor ambient air temperature.

### load necessary packages

```
[1]: import supy as sp
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.dates as mdates
import seaborn as sns

%matplotlib inline
# sp.show_version()
```

### run SUEWS with default settings

```
[2]: # load sample run dataset
df_state_init, df_forcing = sp.load_SampleData()
# turn off the snow module as unnecessary at the sample site
df_state_init.loc[:, "snowuse"] = 0

# copy `df_state_init` as the basis for later simulations
df_state_init_def = df_state_init.copy()

# by default, two years of forcing data are included;
# to save running time for demonstration, we only use one year in this demo
df_forcing = df_forcing.loc["2012"].iloc[1:]

# set QF as zero for later comparison
df_forcing_def = df_forcing.copy()
grid = df_state_init_def.index[0]
df_state_init_def.loc[:, "emissionsmethod"] = 0
df_forcing_def["qf"] = 0

# run supy
df_output, df_state = sp.run_supy(df_forcing_def, df_state_init_def)
df_output_def = df_output.loc[grid, "SUEWS"]
```



```

2020-07-06 10:55:01,875 - SuPy - INFO - All cache cleared.
2020-07-06 10:55:05,017 - SuPy - INFO - =====
2020-07-06 10:55:05,018 - SuPy - INFO - Simulation period:
2020-07-06 10:55:05,019 - SuPy - INFO -     Start: 2012-01-01 00:05:00
2020-07-06 10:55:05,019 - SuPy - INFO -     End: 2012-12-31 23:55:00
2020-07-06 10:55:05,020 - SuPy - INFO -
2020-07-06 10:55:05,021 - SuPy - INFO - No. of grids: 1
2020-07-06 10:55:05,021 - SuPy - INFO - SuPy is running in serial mode
2020-07-06 10:55:20,390 - SuPy - INFO - Execution time: 15.4 s
2020-07-06 10:55:20,391 - SuPy - INFO - =====

```

## a simple QF model: QF\_simple

### model description

For demonstration purposes we have created a very simple model instead of using the SUEWS  $Q_F$  (Järvi et al. 2011) with feedback from outdoor air temperature. The simple  $Q_F$  model considers only building heating and cooling:

$$Q_F = \begin{cases} (T_2 - T_C) \times C_B, & T_2 > T_C \\ (T_H - T_2) \times H_B, & T_2 < T_H \\ Q_{F0} \end{cases}$$

where  $T_C$  ( $T_H$ ) is the cooling (heating) threshold temperature of buildings,  $C_B$  ( $H_B$ ) is the building cooling (heating) rate, and  $Q_{F0}$  is the baseline anthropogenic heat. The parameters used are:  $C$  ( $H$ ) set as 20 °C (10 °C),  $B$  ( $B$ ) set as 1.5 W m<sup>-2</sup> K<sup>-1</sup> (3 W m<sup>-2</sup> K<sup>-1</sup>) and  $Q_{F0}$  is set as 0 W m<sup>-2</sup>, implying other building activities (e.g. lighting, water heating, computers) are zero and therefore do not change the temperature or change with temperature.

### implementation

```

[3]: def QF_simple(T2):
      qf_cooling = (T2-20)*5 if T2 > 20 else 0
      qf_heating = (10-T2)*10 if T2 < 10 else 0
      qf_res = np.max([qf_heating, qf_cooling])*0.3
      return qf_res

```

Visualise the QF\_simple model:

```

[4]: ser_temp = pd.Series(np.arange(-5, 45, 0.5),
                          index=np.arange(-5, 45, 0.5)).rename('temp_C')
ser_qf_heating = ser_temp.loc[-5:10].map(QF_simple).rename(
    r'heating:$(T_H-T_a) \times H_B$')
ser_qf_cooling = ser_temp.loc[20:45].map(QF_simple).rename(
    r'cooling: $(T_a-T_C) \times C_B$')
ser_qf_zero = ser_temp.loc[10:20].map(QF_simple).rename('baseline: $Q_{F0}$')
df_temp_qf = pd.concat([ser_temp, ser_qf_cooling, ser_qf_heating, ser_qf_zero],
                       axis=1).set_index('temp_C')
ax_qf_func = df_temp_qf.plot()
_=ax_qf_func.set_xlabel('$T_2$ ($^\circ\text{C}$)')
_=ax_qf_func.set_ylabel('$Q_F$ ($\text{W m}^{-2}$)')

```

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```

_=ax_qf_func.legend(title='simple $Q_F$')
_=ax_qf_func.annotate(
    "$T_C$",
    xy=(20, 0),
    xycoords='data',
    xytext=(25, 5),
    textcoords='data',
    arrowprops=dict(
        arrowstyle="->",
        color="0.5",
        shrinkA=5,
        shrinkB=5,
        patchA=None,
        patchB=None,
        connectionstyle='arc3',
    ),
)

_=ax_qf_func.annotate(
    "$T_H$",
    xy=(10, 0),
    xycoords='data',
    xytext=(5, 5),
    textcoords='data',
    arrowprops=dict(
        arrowstyle="->",
        color="0.5",
        shrinkA=5,
        shrinkB=5,
        patchA=None,
        patchB=None,
        connectionstyle='arc3',
    ),
)

_=ax_qf_func.annotate(
    "slope: $C_B$",
    xy=(30, QF_simple(30)),
    xycoords='data',
    xytext=(20, 20),
    textcoords='data',
    arrowprops=dict(
        arrowstyle="->",
        color="0.5",
        shrinkA=5,
        shrinkB=5,
        patchA=None,
        patchB=None,
        connectionstyle='arc3, rad=0.3',
    ),
)

_=ax_qf_func.annotate(
    "slope: $H_B$",

```

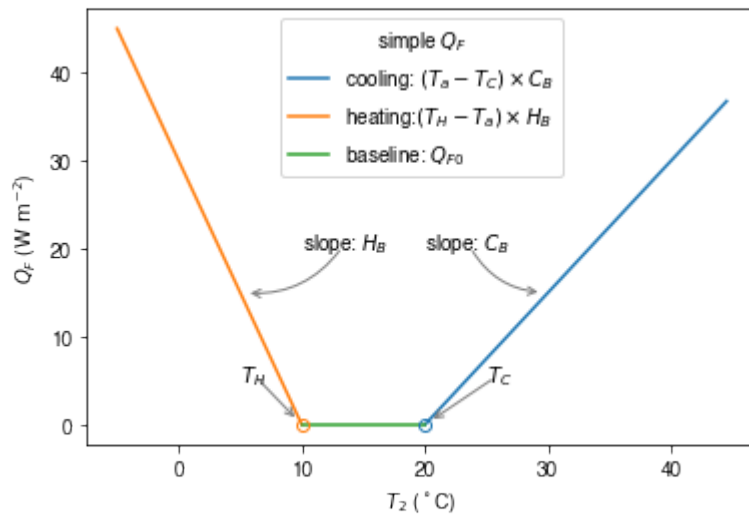
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```

xy=(5, QF_simple(5)),
xycoords='data',
xytext=(10, 20),
textcoords='data',
arrowprops=dict(
    arrowstyle="->",
    color="0.5",
    shrinkA=5,
    shrinkB=5,
    patchA=None,
    patchB=None,
    connectionstyle='arc3, rad=-0.3',
),
)
_=ax_qf_func.plot(10, 0, 'o', color='C1', fillstyle='none')
_ = ax_qf_func.plot(20, 0, 'o', color='C0', fillstyle='none')

```



## communication between supy and QF\_simple

### construct a new coupled function

The coupling between the simple  $Q_F$  model and SuPy is done via the low-level function `suews_cal_tstep`, which is an interface function in charge of communications between SuPy frontend and the calculation kernel. By setting SuPy to receive external  $Q_F$  as forcing, at each timestep, the simple  $Q_F$  model is driven by the SuPy output  $T_2$  and provides SuPy with  $Q_F$ , which thus forms a two-way coupled loop.

```

[5]: # load extra low-level functions from supy to construct interactive functions
from supy._post import pack_df_output, pack_df_state
from supy._run import suews_cal_tstep, pack_grid_dict

def run_supy_qf(df_forcing_test, df_state_init_test):
    grid = df_state_init_test.index[0]

```

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```

df_state_init_test.loc[grid, 'emissionsmethod'] = 0

df_forcing_test = df_forcing_test\
    .assign(
        metforcingdata_grid=0,
        ts5mindata_ir=0,
    )\
    .rename(
        # remanae is a workaround to resolve naming inconsistency between
        # suews fortran code interface and input forcing file headers
        columns={
            '%' + 'iy': 'iy',
            'id': 'id',
            'it': 'it',
            'imin': 'imin',
            'qn': 'qn1_obs',
            'qh': 'qh_obs',
            'qe': 'qe',
            'qs': 'qs_obs',
            'qf': 'qf_obs',
            'U': 'avul',
            'RH': 'avrh',
            'Tair': 'temp_c',
            'pres': 'press_hpa',
            'rain': 'precip',
            'kdown': 'avkdn',
            'snow': 'snowfrac_obs',
            'ldown': 'ldown_obs',
            'fcld': 'fcld_obs',
            'Wuh': 'wu_m3',
            'xsmd': 'xsmd',
            'lai': 'lai_obs',
            'kdiff': 'kdiff',
            'kdir': 'kdir',
            'wdir': 'wdir',
        }
    )

t2_ext = df_forcing_test.iloc[0].temp_c
qf_ext = QF_simple(t2_ext)

# initialise dicts for holding results
dict_state = {}
dict_output = {}

# starting timestep
t_start = df_forcing_test.index[0]
# convert df to dict with `itertuples` for better performance
dict_forcing = {
    row.Index: row._asdict()
    for row in df_forcing_test.itertuples()
}

```

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```

# dict_state is used to save model states for later use
dict_state = {(t_start, grid): pack_grid_dict(series_state_init)
               for grid, series_state_init in df_state_init_test.iterrows()}

# just use a single grid run for the test coupling
for tstep in df_forcing_test.index:
    # load met forcing at `tstep`
    met_forcing_tstep = dict_forcing[tstep]
    # inject `qf_ext` to `met_forcing_tstep`
    met_forcing_tstep['qf_obs'] = qf_ext

    # update model state
    dict_state_start = dict_state[(tstep, grid)]

    dict_state_end, dict_output_tstep = suews_cal_tstep(
        dict_state_start, met_forcing_tstep)
    # the fourth to the last is `T2` stored in the result array
    t2_ext = dict_output_tstep['dataoutlinesuews'][-4]
    qf_ext = QF_simple(t2_ext)

    dict_output.update({(tstep, grid): dict_output_tstep})
    dict_state.update({(tstep + tstep.freq, grid): dict_state_end})

# pack results as easier DataFrames
df_output_test = pack_df_output(dict_output).swaplevel(0, 1)
df_state_test = pack_df_state(dict_state).swaplevel(0, 1)
return df_output_test.loc[grid, 'SUEWS'], df_state_test

```

## simulations for summer and winter months

The simulation using SuPy coupled is performed for London 2012. The data analysed are a summer (July) and a winter (December) month. Initially  $Q_F$  is 0 W m<sup>-2</sup> the  $T_2$  is determined and used to determine  $Q_{F[1]}$  which in turn modifies  $T_{2[1]}$  and therefore modifies  $Q_{F[2]}$  and the diagnosed  $T_{2[2]}$ .

## spin-up run (January to June) for summer simulation

```

[6]: df_output_june, df_state_jul = sp.run_supy(
      df_forcing.loc['2012 6'], df_state_init)

2020-07-06 10:55:20,909 - SuPy - INFO - =====
2020-07-06 10:55:20,909 - SuPy - INFO - Simulation period:
2020-07-06 10:55:20,910 - SuPy - INFO -   Start: 2012-01-01 00:05:00
2020-07-06 10:55:20,911 - SuPy - INFO -   End: 2012-06-30 23:55:00
2020-07-06 10:55:20,911 - SuPy - INFO -
2020-07-06 10:55:20,912 - SuPy - INFO - No. of grids: 1
2020-07-06 10:55:20,913 - SuPy - INFO - SuPy is running in serial mode
2020-07-06 10:55:27,168 - SuPy - INFO - Execution time: 6.3 s
2020-07-06 10:55:27,169 - SuPy - INFO - =====

```

### spin-up run (July to October) for winter simulation

```
[7]: df_output_oct, df_state_dec = sp.run_supy(
      df_forcing.loc['2012 7':'2012 11'], df_state_jul)

2020-07-06 10:55:27,176 - SuPy - INFO - =====
2020-07-06 10:55:27,177 - SuPy - INFO - Simulation period:
2020-07-06 10:55:27,178 - SuPy - INFO -   Start: 2012-07-01 00:00:00
2020-07-06 10:55:27,179 - SuPy - INFO -   End: 2012-11-30 23:55:00
2020-07-06 10:55:27,179 - SuPy - INFO -
2020-07-06 10:55:27,180 - SuPy - INFO - No. of grids: 1
2020-07-06 10:55:27,181 - SuPy - INFO - SuPy is running in serial mode
2020-07-06 10:55:33,139 - SuPy - INFO - Execution time: 6.0 s
2020-07-06 10:55:33,140 - SuPy - INFO - =====
```

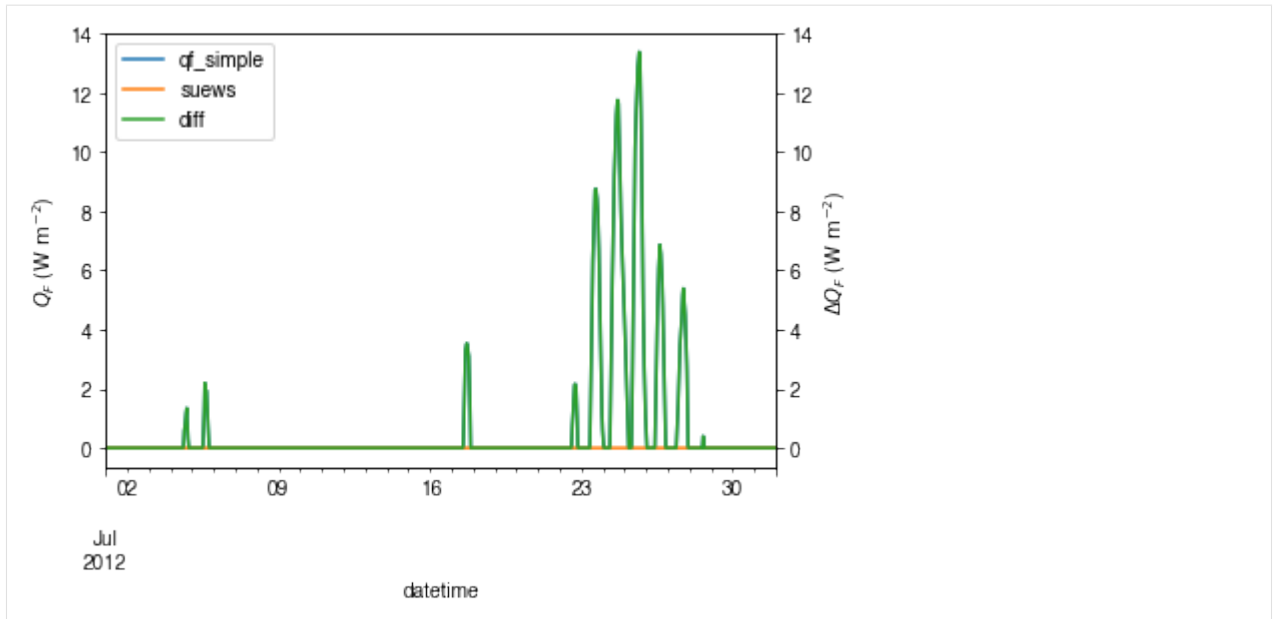
### coupled simulation

```
[8]: df_output_test_summer, df_state_summer_test = run_supy_qf(
      df_forcing.loc["2012-07"], df_state_jul.copy()
    )
df_output_test_winter, df_state_winter_test = run_supy_qf(
      df_forcing.loc["2012-12"], df_state_dec.copy()
    )
```

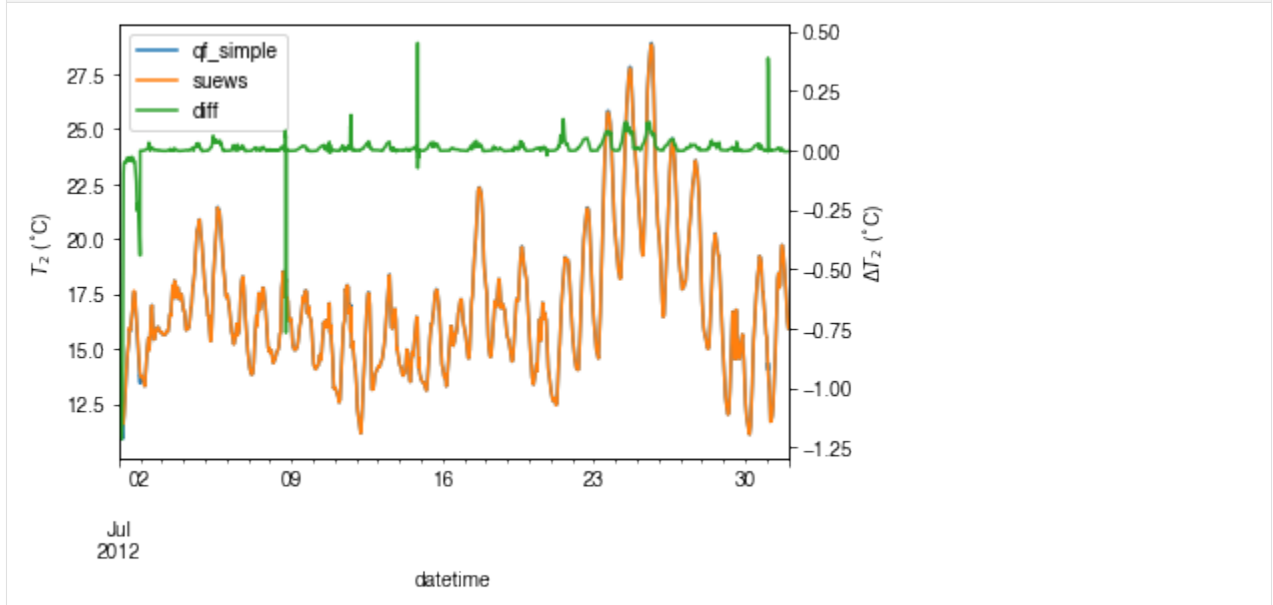
### examine the results

#### sumer

```
[9]: var = "QF"
var_label = "$Q_F$ ($ \mathrm{W \ m^{-2}}$)"
var_label_right = "$\Delta Q_F$ ($ \mathrm{W \ m^{-2}}$)"
period = "2012-07"
df_test = df_output_test_summer
y1 = df_test.loc[period, var].rename("qf_simple")
y2 = df_output_def.loc[period, var].rename("suews")
y3 = (y1 - y2).rename("diff")
df_plot = pd.concat([y1, y2, y3], axis=1)
ax = df_plot.plot(secondary_y="diff")
_ = ax.set_ylabel(var_label)
_ = ax.right_ax.set_ylabel(var_label_right)
lines = ax.get_lines() + ax.right_ax.get_lines()
_ = ax.legend(lines, [l.get_label() for l in lines], loc="best")
```

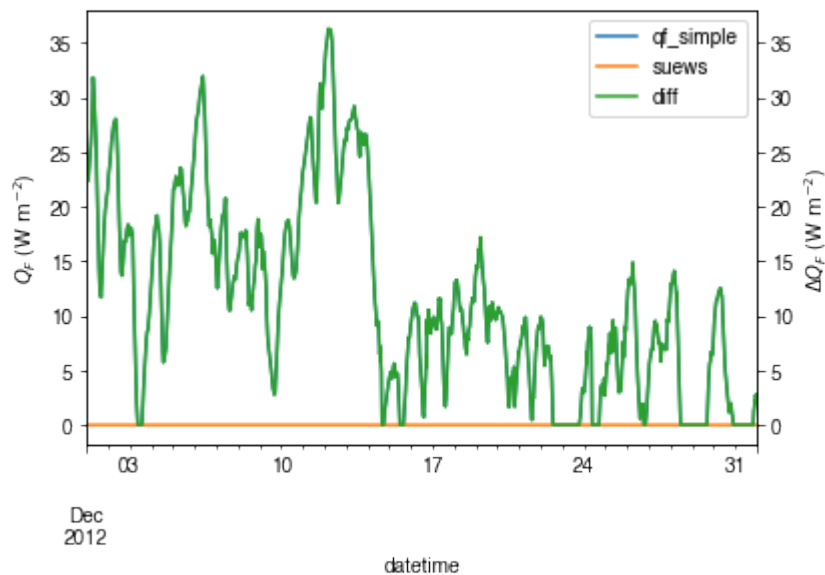


```
[10]: var = "T2"
var_label = "$T_2$ ($^{\circ}$C)"
var_label_right = "$\Delta T_2$ ($^{\circ}$C)"
period = "2012-07"
df_test = df_output_test_summer
y1 = df_test.loc[period, var].rename("qf_simple")
y2 = df_output_def.loc[period, var].rename("suews")
y3 = (y1 - y2).rename("diff")
df_plot = pd.concat([y1, y2, y3], axis=1)
ax = df_plot.plot(secondary_y="diff")
_ = ax.set_ylabel(var_label)
_ = ax.right_ax.set_ylabel(var_label_right)
lines = ax.get_lines() + ax.right_ax.get_lines()
_ = ax.legend(lines, [l.get_label() for l in lines], loc="best")
```



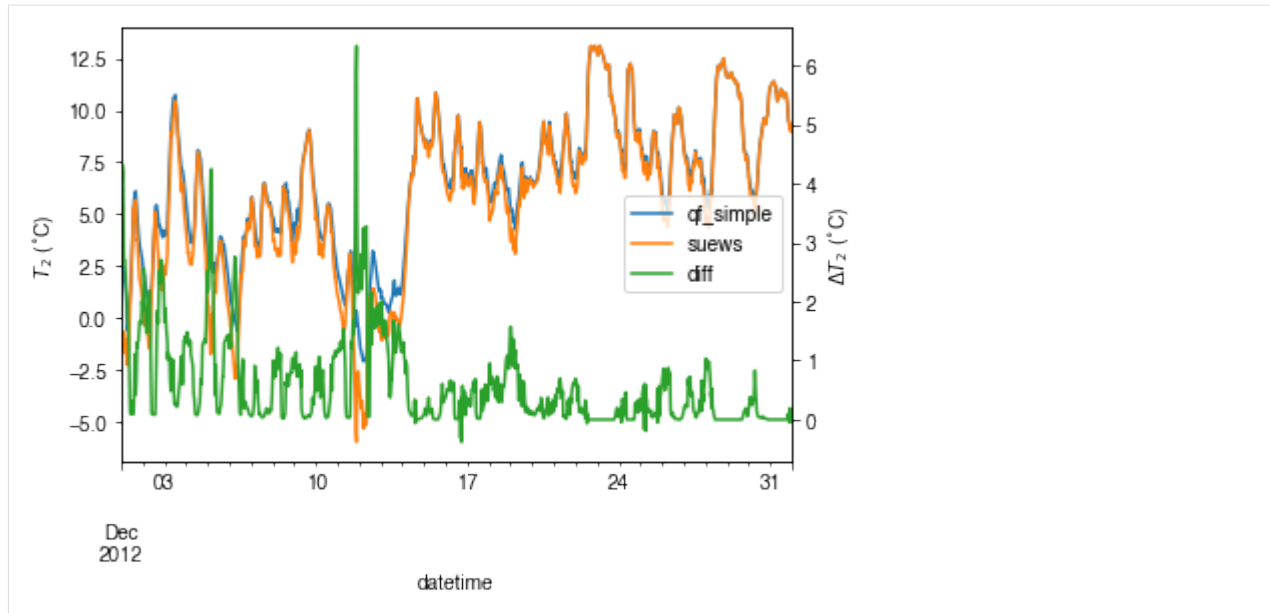
## winter

```
[11]: var = "QF"
var_label = "$Q_F$ ($ \mathrm{W \ m^{-2}}$)"
var_label_right = "$\Delta Q_F$ ($ \mathrm{W \ m^{-2}}$)"
period = "2012 12"
df_test = df_output_test_winter
y1 = df_test.loc[period, var].rename("qf_simple")
y2 = df_output_def.loc[period, var].rename("suews")
y3 = (y1 - y2).rename("diff")
df_plot = pd.concat([y1, y2, y3], axis=1)
ax = df_plot.plot(secondary_y="diff")
_ = ax.set_ylabel(var_label)
_ = ax.right_ax.set_ylabel(var_label_right)
lines = ax.get_lines() + ax.right_ax.get_lines()
_ = ax.legend(lines, [l.get_label() for l in lines], loc="best")
```



```
[12]: var = "T2"
var_label = "$T_2$ ($^{\circ}\text{C}$)"
var_label_right = "$\Delta T_2$ ($^{\circ}\text{C}$)"
period = "2012 12"
df_test = df_output_test_winter
y1 = df_test.loc[period, var].rename("qf_simple")
y2 = df_output_def.loc[period, var].rename("suews")
y3 = (y1 - y2).rename("diff")
df_plot = pd.concat([y1, y2, y3], axis=1)
ax = df_plot.plot(secondary_y="diff")
_ = ax.set_ylabel(var_label)
_ = ax.right_ax.set_ylabel(var_label_right)
lines = ax.get_lines() + ax.right_ax.get_lines()
_ = ax.legend(lines, [l.get_label() for l in lines], loc="center right")
```





### comparison in $\Delta Q_F$ - $\Delta T_2$ feedback between summer and winter

```
[13]: # filter results using `where` to choose periods when `QF_simple` is effective
# (i.e. activated by outdoor air temperatures)
df_diff_summer = (
    (df_output_test_summer - df_output_def)
    .where(df_output_def.T2 > 20, np.nan)
    .dropna(how="all", axis=0)
)
df_diff_winter = (
    (df_output_test_winter - df_output_def)
    .where(df_output_test_winter.T2 < 10, np.nan)
    .dropna(how="all", axis=0)
    .loc["20121215":]
)

df_diff_season = pd.concat(
    [df_diff_winter.assign(season="winter"), df_diff_summer.assign(season="summer"),]
).loc[:, ["season", "QF", "T2"]]
g = sns.lmplot(
    data=df_diff_season,
    x="QF",
    y="T2",
    hue="season",
    height=4,
    truncate=False,
    markers="o",
    legend_out=False,
    scatter_kws={"s": 1, "zorder": 0, "alpha": 0.8,},
```

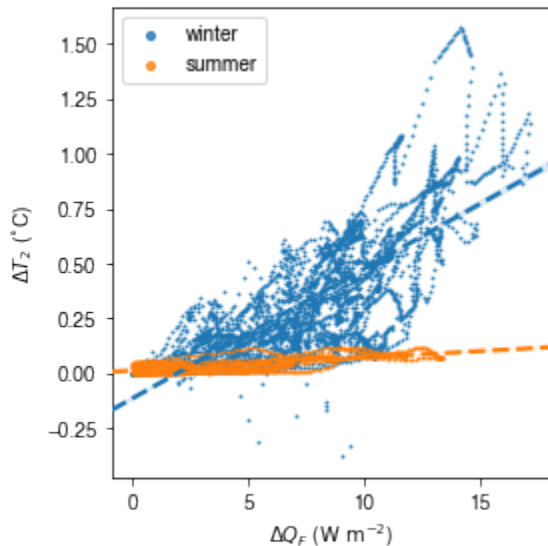
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```

    line_kws={"zorder": 6, "linestyle": "--"},
)
_ = g.set_axis_labels(
    "\Delta Q_F$ ($ \mathrm{W \ m^{-2}}$)", "\Delta T_2$ ($^{\circ}\mathrm{C}$)",
)
_ = g.ax.legend(markerscale=4)
_ = g.despine(top=False, right=False)

```



The above figure indicates a positive feedback, as  $Q_F$  is increased there is an elevated  $T_2$  but with different magnitudes given the non-linearity in the SUEWS modelling system. Of particular note is the positive feedback loop under warm air temperatures: the anthropogenic heat emissions increase which in turn elevates the outdoor air temperature causing yet more anthropogenic heat release. Note that London is relatively cool so the enhancement is much less than it would be in warmer cities.

## Set up SuPy for Your Own Site

This tutorial aims to demonstrate how to set up SuPy for your own site to model the surface energy balance (SEB).

Please note: **SuPy** is a Python-enhanced urban climate model with **SUEWS**, **Surface Urban Energy and Water Balance Scheme**, as its computation core.

**We thus strongly recommend/encourage users to have a good understanding of SUEWS first before diving into the SuPy world.**

In this tutorial, We will use an **AmeriFlux** site **US-AR1** as example:

starting by preparation of input data, we show how to specify site characteristics and choose proper scheme options, then conduct simulations, finally provide some demo figures to help understand the simulation results.

A brief structure is as follows:

1. *Preparing the input data;*
2. *Running a simulation;*
3. *Examination of results;* and
4. *Further exploration*

## Boilerplate code

```
[1]: import matplotlib.pyplot as plt
import supy as sp
import pandas as pd
import numpy as np
from pathlib import Path
%matplotlib inline
```

## Prepare input data

### Site-specific configuration of surface parameters

Given `pandas.DataFrame` as the core data structure of SuPy, all operations, including modification, output, demonstration, etc., on SuPy inputs (`df_state_init` and `df_forcing`) can be done using pandas-based functions/methods. Please see [SuPy quickstart](#) for methods to do so.

Below we will modify several key properties of the chosen site with appropriate values to run SuPy. First, we copy the `df_state_init` to have a new `DataFrame` for manipulation.

```
[2]: df_state_init,df_forcing=sp.load_SampleData()
df_state_amf = df_state_init.copy()

2020-07-06 11:24:40,102 - SuPy - INFO - All cache cleared.
```

```
[3]: # site identifier
name_site = 'US-AR1'
```

Details for determining the proper values of selected physical parameters can be found [here](#).

## location

```
[4]: # latitude
df_state_amf.loc[:, 'lat'] = 41.37
# longitude
df_state_amf.loc[:, 'lng'] = -106.24
# altitude
df_state_amf.loc[:, 'alt'] = 611.
```

## land cover fraction

Land covers in SUEWS

```
[5]: # view the surface fraction variable: `sfr`
df_state_amf.loc[:, 'sfr'] = 0
df_state_amf.loc[:, ('sfr', '(4,)')] = 1
df_state_amf.loc[:, 'sfr']
```

```
[5]: ind_dim (0,) (1,) (2,) (3,) (4,) (5,) (6,)
      grid
      1      0.0  0.0  0.0  0.0  1.0  0.0  0.0
```

## albedo

```
[6]: # we only set values for grass as the modelled site has a single land cover type: grass.
      df_state_amf.albmax_grass = 0.19
      df_state_amf.albmin_grass = 0.14
```

```
[7]: # initial albedo value
      df_state_amf.loc[:, 'albgrass_id'] = 0.14
```

## LAI/phenology

```
[8]: df_state_amf.filter(like='lai')
```

```
[8]: var      laimax      laimin      laipower      ... \
      ind_dim (0,) (1,) (2,) (0,) (1,) (2,) (0, 0) (0, 1) (0, 2) (1, 0) ...
      grid
      1      5.1  5.5  5.9  4.0  1.0  1.6  0.04  0.04  0.04  0.001 ...

      var
      ind_dim (3, 0) (3, 1) (3, 2) (0,) (1,) (2,) 0 (0,) (1,) (2,)
      grid
      1      0.0015 0.0015 0.0015 1.0 1.0 1.0 1 4.0 1.0 1.6

[1 rows x 25 columns]
```

```
[9]: # properties to control vegetation phenology
      # you can skip the details for and just set them as provided below

      # LAI paramters
      df_state_amf.loc[:, ('laimax', '(2,)')] = 1
      df_state_amf.loc[:, ('laimin', '(2,)')] = 0.2
      # initial LAI
      df_state_amf.loc[:, ('lai_id', '(2,)')] = 0.2

      # BaseT
      df_state_amf.loc[:, ('baset', '(2,)')] = 5
      # BaseTe
      df_state_amf.loc[:, ('basete', '(2,)')] = 20

      # SDDFull
      df_state_amf.loc[:, ('sddfull', '(2,)')] = -1000
      # GDDFull
      df_state_amf.loc[:, ('gddfull', '(2,)')] = 1000
```

### surface resistance

```
[10]: # parameters to model surface resistance
df_state_amf.maxconductance = 18.7
df_state_amf.g1 = 1
df_state_amf.g2 = 104.215
df_state_amf.g3 = 0.424
df_state_amf.g4 = 0.814
df_state_amf.g5 = 36.945
df_state_amf.g6 = 0.025
```

### measurement height

```
[11]: # height where forcing variables are measured/collected
df_state_amf.z = 2.84
```

### urban feature

```
[12]: # disable anthropogenic heat by setting zero population
df_state_amf.popdensdaytime = 0
df_state_amf.popdensnighttime = 0
```

### check df\_state

```
[13]: # this procedure is to double-check proper values are set in `df_state_amf`
sp.check_state(df_state_amf)

2020-07-06 11:24:43,372 - SuPy - INFO - SuPy is validating `df_state`...
2020-07-06 11:24:43,574 - SuPy - INFO - All checks for `df_state` passed!
```

### prepare forcing conditions

Here we use the SuPy utility function `read_forcing` to read in forcing data from an external file in the format of SUEWS input. Also note, this `read_forcing` utility will also resample the forcing data to a proper temporal resolution to run SuPy/SUEWS, which is usually 5 min (300 s).

### load and resample forcing data

---

UMEP workshop users: please note the AMF file path might be DIFFERENT from yours; please set it to the location where your downloaded file is placed.

---

```
[15]: # load forcing data from an external file and resample to a resolution of 300 s.
# Note this dataset has been gap-filled.
df_forcing_amf = sp.util.read_forcing("data/US-AR1_2010_data_60.txt", tstep_mod=300)

# this procedure is to double-check proper forcing values are set in `df_forcing_amf`
_ = sp.check_forcing(df_forcing_amf)

2020-07-06 11:24:44,453 - SuPy - INFO - SuPy is validating `df_forcing`...
2020-07-06 11:24:46,299 - SuPy - ERROR - Issues found in `df_forcing`:
`kdown` should be between [0, 1400] but `-1.298` is found at 2010-01-01 00:05:00
```

The checker detected invalid values in variable kdown: negative incoming solar radiation is found. We then need to fix this as follows:

```
[16]: # modify invalid values
df_forcing_amf.kdown = df_forcing_amf.kdown.where(df_forcing_amf.kdown > 0, 0)
```

```
[17]: # check `df_forcing` again
_ = sp.check_forcing(df_forcing_amf)

2020-07-06 11:24:46,312 - SuPy - INFO - SuPy is validating `df_forcing`...
2020-07-06 11:24:48,523 - SuPy - INFO - All checks for `df_forcing` passed!
```

## examine forcing data

We can examine the forcing data:

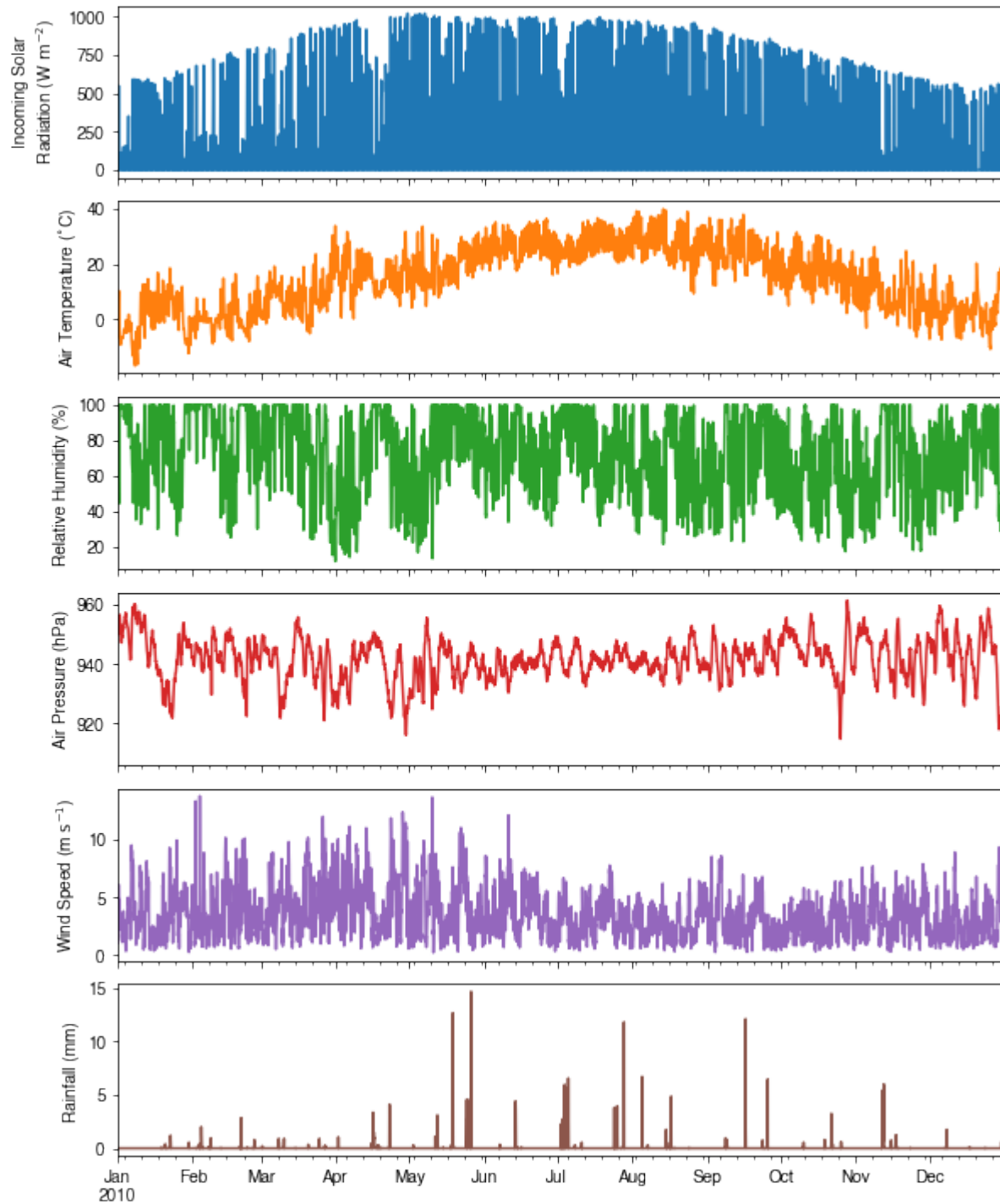
```
[18]: list_var_forcing = [
    "kdown",
    "Tair",
    "RH",
    "pres",
    "U",
    "rain",
]
dict_var_label = {
    "kdown": "Incoming Solar\n Radiation ( $\mathrm{W \ m^{-2}}$ )",
    "Tair": "Air Temperature ( $^{\circ}\mathrm{C}$ )",
    "RH": "Relative Humidity (%)",
    "pres": "Air Pressure (hPa)",
    "rain": "Rainfall (mm)",
    "U": "Wind Speed ( $\mathrm{m \ s^{-1}}$ )",
}
df_plot_forcing_x = (
    df_forcing_amf.loc[:, list_var_forcing].copy().shift(-1).dropna(how="any")
)
df_plot_forcing = df_plot_forcing_x.resample("1h").mean()
df_plot_forcing["rain"] = df_plot_forcing_x["rain"].resample("1h").sum()

axes = df_plot_forcing.plot(subplots=True, figsize=(8, 12), legend=False,)
fig = axes[0].figure
fig.tight_layout()
```

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```
fig.autofmt_xdate(bottom=0.2, rotation=0, ha="center")
for ax, var in zip(axes, list_var_forcing):
    _ = ax.set_ylabel(dict_var_label[var])
```



## Run simulations

Once met-forcing (via `df_forcing_amf`) and initial conditions (via `df_state_amf`) are loaded in, we call `sp.run_supy` to conduct a SUEWS simulation, which will return two pandas DataFrames: `df_output` and `df_state_final`.

```
[19]: df_output, df_state_final = sp.run_supy(df_forcing_amf, df_state_amf)

2020-07-06 11:24:51,973 - SuPy - INFO - =====
2020-07-06 11:24:51,974 - SuPy - INFO - Simulation period:
2020-07-06 11:24:51,975 - SuPy - INFO -   Start: 2010-01-01 00:05:00
2020-07-06 11:24:51,975 - SuPy - INFO -   End: 2011-01-01 00:00:00
2020-07-06 11:24:51,976 - SuPy - INFO -
2020-07-06 11:24:51,977 - SuPy - INFO - No. of grids: 1
2020-07-06 11:24:51,977 - SuPy - INFO - SuPy is running in serial mode
2020-07-06 11:25:01,975 - SuPy - INFO - Execution time: 10.0 s
2020-07-06 11:25:01,976 - SuPy - INFO - =====
```

### df\_output

`df_output` is an ensemble output collection of major SUEWS output groups, including:

- SUEWS: the essential SUEWS output variables
- DailyState: variables of daily state information
- snow: snow output variables (effective when `snowuse = 1` set in `df_state_init`)
- RSL: profile of air temperature, humidity and wind speed within roughness sub-layer.

Detailed description of variables in `df_output` refers to [SuPy output](#)

```
[20]: df_output.columns.levels[0]
```

```
[20]: Index(['SUEWS', 'snow', 'RSL', 'SOLWEIG', 'DailyState'], dtype='object', name='group')
```

### df\_state\_final

`df_state_final` is a DataFrame for holding:

1. all model states if `save_state` is set to `True` when calling `sp.run_supy` (supy may run significantly slower for a large simulations);
2. or, only the final state if `save_state` is set to `False` (the default setting) in which mode supy has a similar performance as the standalone compiled SUEWS executable.

Entries in `df_state_final` have the same data structure as `df_state_init` and can thus be used for other SUEWS simulations starting at the timestamp as in `df_state_final`.

Detailed description of variables in `df_state_final` refers to [SuPy output](#)

```
[21]: df_state_final.T.head()
```

```
[21]: datetime          2010-01-01 00:05:00 2011-01-01 00:05:00
      grid                      1                      1
```

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| var              | ind_dim |      |      |
|------------------|---------|------|------|
| ah_min           | (0,)    | 15.0 | 15.0 |
|                  | (1,)    | 15.0 | 15.0 |
| ah_slope_cooling | (0,)    | 2.7  | 2.7  |
|                  | (1,)    | 2.7  | 2.7  |
| ah_slope_heating | (0,)    | 2.7  | 2.7  |

## Examine results

Thanks to the functionality inherited from `pandas` and other packages under the [PyData](#) stack, compared with the standard SUEWS simulation workflow, `supy` enables more convenient examination of SUEWS results by statistics calculation, resampling, plotting (and many more).

## Ouput structure

`df_output` is organised with `MultiIndex (grid,timestamp)` and `(group,variable)` as index and columns, respectively.

[22]: `df_output.head()`

```
[22]: group          SUEWS
var          Kdown  Kup      Ldown      Lup  Tsurf      QN  \
grid datetime
1  2010-01-01 00:05:00  0.0  0.0  265.492652  305.638434 -1.593 -40.145783
   2010-01-01 00:10:00  0.0  0.0  265.492652  305.638434 -1.593 -40.145783
   2010-01-01 00:15:00  0.0  0.0  265.492652  307.825865 -1.593 -42.333213
   2010-01-01 00:20:00  0.0  0.0  265.492652  307.825865 -1.593 -42.333213
   2010-01-01 00:25:00  0.0  0.0  265.492652  307.825865 -1.593 -42.333213

group          ...  \
var          QF      QS      QH      QE      ...  \
grid datetime
1  2010-01-01 00:05:00  0.0 -9.668746 -24.387976  1.284400 ...
   2010-01-01 00:10:00  0.0 -9.424108  -6.676973  1.618190 ...
   2010-01-01 00:15:00  0.0 -0.545992  16.458627  11.833592 ...
   2010-01-01 00:20:00  0.0 -0.536225  15.988621  11.830741 ...
   2010-01-01 00:25:00  0.0 -0.525680  15.537087  11.827934 ...

group          DailyState
var          DensSnow_Paved DensSnow_Bldgs DensSnow_EveTr
grid datetime
1  2010-01-01 00:05:00      NaN      NaN      NaN
   2010-01-01 00:10:00      NaN      NaN      NaN
   2010-01-01 00:15:00      NaN      NaN      NaN
   2010-01-01 00:20:00      NaN      NaN      NaN
   2010-01-01 00:25:00      NaN      NaN      NaN

group          \
var          DensSnow_DecTr DensSnow_Grass DensSnow_BSoil
grid datetime
```

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```

1    2010-01-01 00:05:00      NaN      NaN      NaN
    2010-01-01 00:10:00      NaN      NaN      NaN
    2010-01-01 00:15:00      NaN      NaN      NaN
    2010-01-01 00:20:00      NaN      NaN      NaN
    2010-01-01 00:25:00      NaN      NaN      NaN

group
var          DensSnow_Water  a1  a2  a3
grid datetime
1    2010-01-01 00:05:00      NaN NaN NaN NaN
    2010-01-01 00:10:00      NaN NaN NaN NaN
    2010-01-01 00:15:00      NaN NaN NaN NaN
    2010-01-01 00:20:00      NaN NaN NaN NaN
    2010-01-01 00:25:00      NaN NaN NaN NaN

[5 rows x 371 columns]
```

Here we demonstrate several typical scenarios for SUEWS results examination.

The essential SUEWS output collection is extracted as a separate variable for easier processing in the following sections. More [advanced slicing techniques](#) are available in [pandas documentation](#).

```
[23]: grid = df_state_amf.index[0]
      df_output_suews = df_output.loc[grid, 'SUEWS']
```

## Statistics Calculation

We can use `.describe()` method for a quick overview of the key surface energy balance budgets.

```
[24]: df_output_suews.loc[:, ['QN', 'QS', 'QH', 'QE', 'QF']].describe()
```

```
[24]: var          QN          QS          QH          QE          QF
count  105120.000000  105120.000000  105120.000000  105120.000000  105120.0
mean    118.207887    19.047648    38.349672    62.790798    0.0
std     214.335328    61.955598    85.050755    112.585643    0.0
min     -104.566267   -81.170768   -212.925432   -15.483971    0.0
25%     -33.437969   -23.174678   -15.992876    0.341017    0.0
50%      -1.894385    -2.603727    9.862241     3.042328    0.0
75%     248.960723    52.299898    68.130871    65.272384    0.0
max      749.868243   218.450452   414.514498   559.472107    0.0
```

## Plotting

### Basic example

Plotting is very straightforward via the `.plot` method bounded with `pandas.DataFrame`. Note the usage of `loc` for to slices of the output `DataFrame`.

```
[25]: # a dict for better display variable names
      dict_var_disp = {
```

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```

"QN": "$Q^*$",
"QS": r"$\Delta Q_S$",
"QE": "$Q_E$",
"QH": "$Q_H$",
"QF": "$Q_F$",
"Kdown": r"$K_{\downarrow}$",
"Kup": r"$K_{\uparrow}$",
"Ldown": r"$L_{\downarrow}$",
"Lup": r"$L_{\uparrow}$",
"Rain": "$P$",
"Irr": "$I$",
"Evap": "$E$",
"RO": "$R$",
"TotCh": "$\Delta S$",
}

```

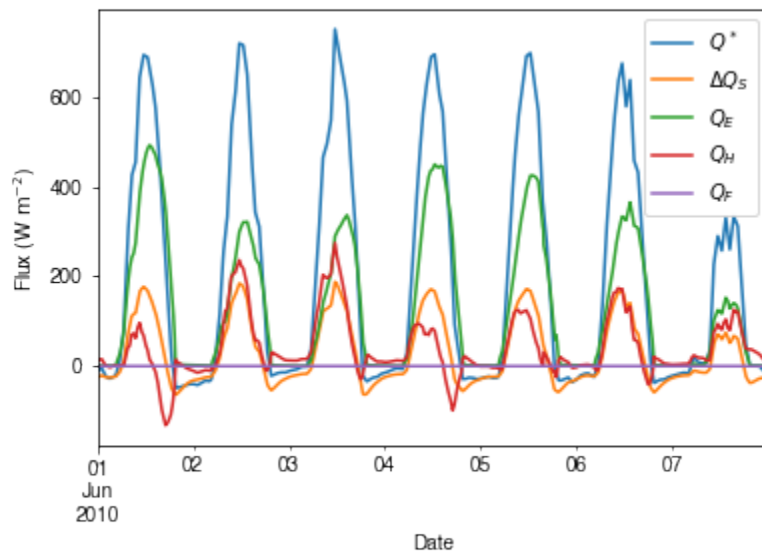
Peek at the simulation results:

```
[26]: grid = df_state_init.index[0]
```

```

[27]: ax_output = (
    df_output_suews.loc["2010-06-01":"2010-06-07", ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot()
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()

```



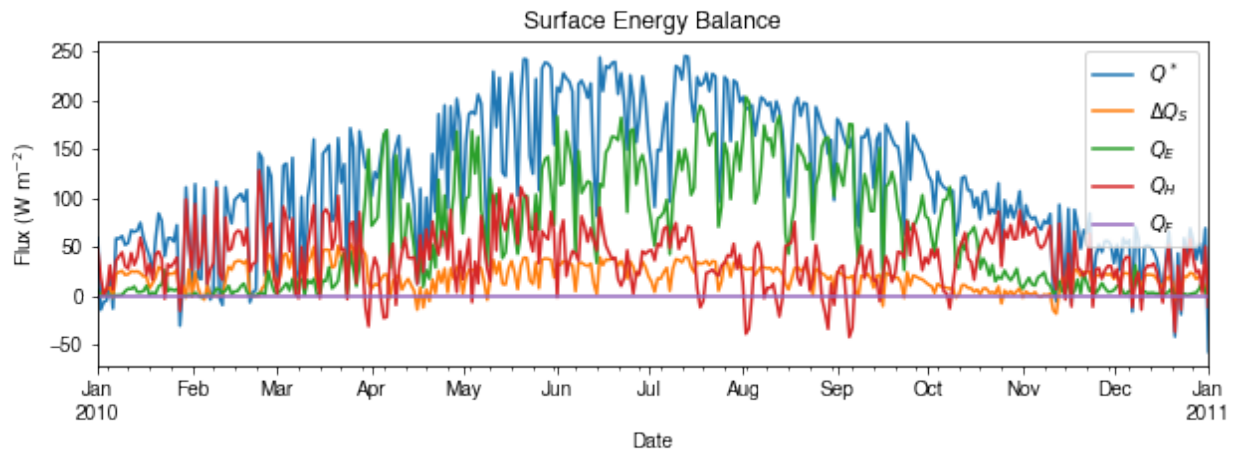
## Plotting after resampling

The suggested runtime/simulation frequency of SUEWS is 300 s, which usually results in a large output and may be over-weighted for storage and analysis. Also, you may feel an apparent slowdown in producing the above figure as a large amount of data were used for the plotting. To slim down the result size for analysis and output, we can **resample** the default output very easily.

```
[28]: rsmpl_1d = df_output_suews.resample("1d")
# daily mean values
df_1d_mean = rsmpl_1d.mean()
# daily sum values
df_1d_sum = rsmpl_1d.sum()
```

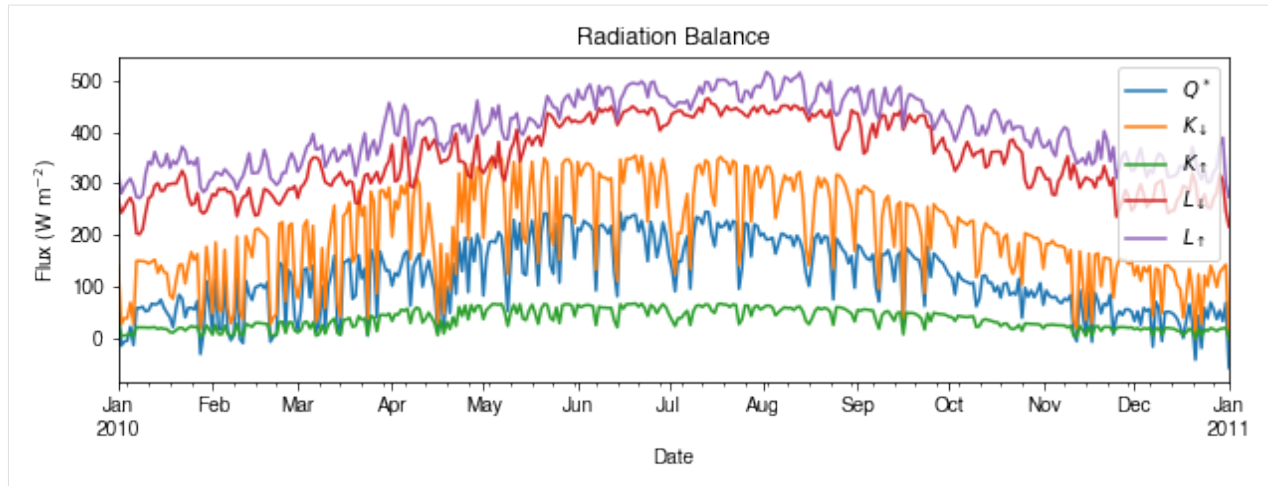
We can then re-examine the above energy balance at hourly scale and plotting will be significantly faster.

```
[29]: # energy balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Energy Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```

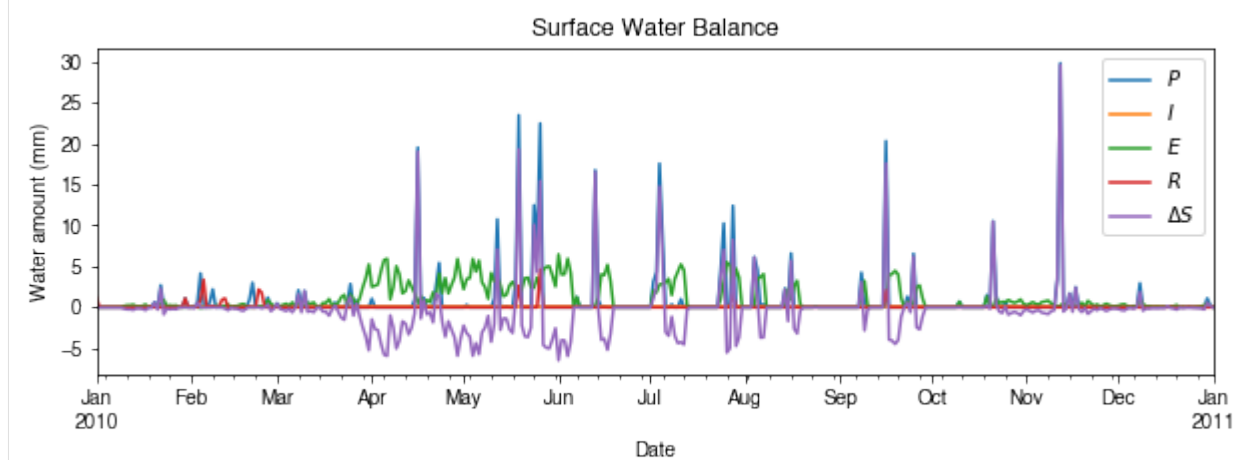


Then we use the hourly results for other analyses.

```
[30]: # radiation balance
ax_output = (
    df_1d_mean.loc[:, ["QN", "Kdown", "Kup", "Ldown", "Lup"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Radiation Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Flux ($ \mathrm{W \ m^{-2}}$)")
_ = ax_output.legend()
```



```
[31]: # water balance
ax_output = (
    df_1d_sum.loc[:, ["Rain", "Irr", "Evap", "R0", "TotCh"]]
    .rename(columns=dict_var_disp)
    .plot(figsize=(10, 3), title="Surface Water Balance",)
)
_ = ax_output.set_xlabel("Date")
_ = ax_output.set_ylabel("Water amount (mm)")
_ = ax_output.legend()
```

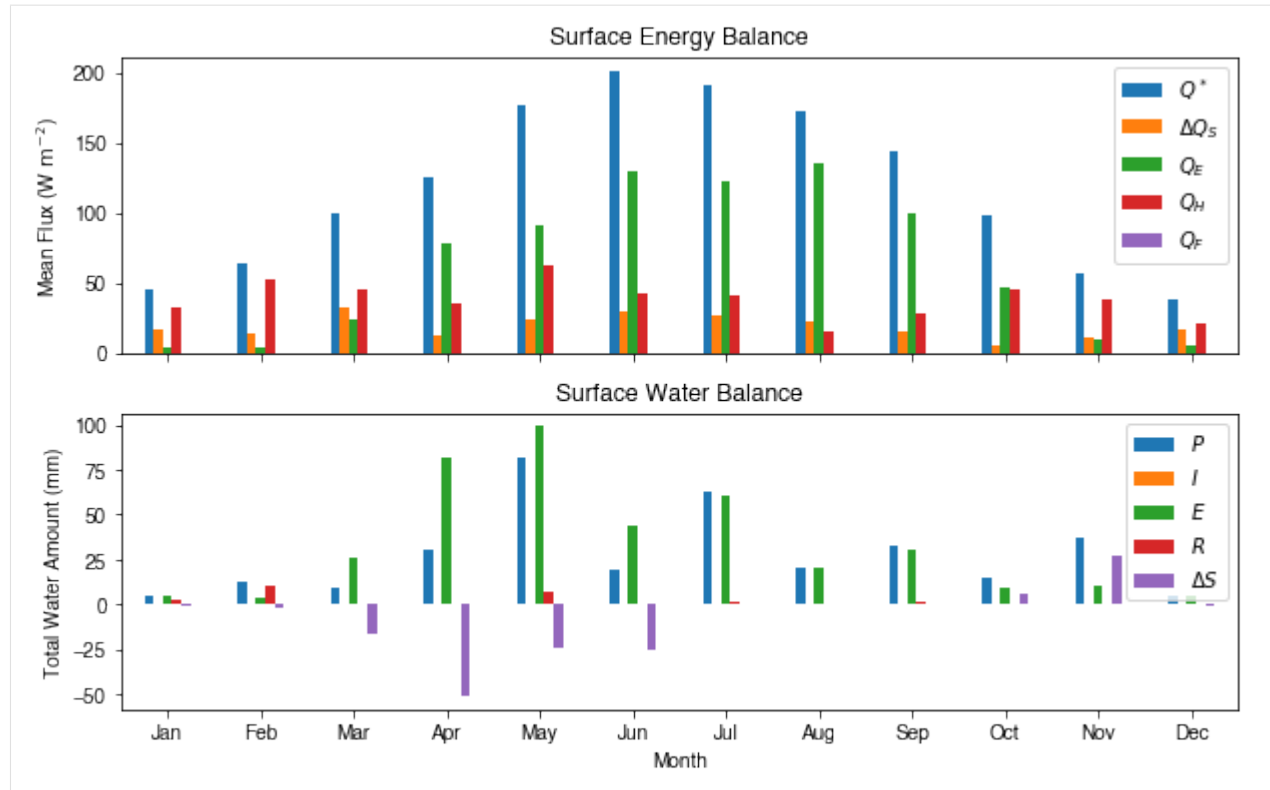


Get an overview of partitioning in energy and water balance at monthly scales:

```
[32]: # get a monthly Resampler
df_plot = df_output_suews.copy()
df_plot.index = df_plot.index.set_names("Month")
rsmp_1M = df_plot.shift(-1).dropna(how="all").resample("1M", kind="period")
# mean values
df_1M_mean = rsmp_1M.mean()
# sum values
df_1M_sum = rsmp_1M.sum()
```

```
[33]: # month names
name_mon = [x.strftime("%b") for x in rsmp_1M.groups]
# create subplots showing two panels together
fig, axes = plt.subplots(2, 1, sharex=True)
# surface energy balance
_ = (
    df_1M_mean.loc[:, ["QN", "QS", "QE", "QH", "QF"]]
    .rename(columns=dict_var_disp)
    .plot(
        ax=axes[0], # specify the axis for plotting
        figsize=(10, 6), # specify figure size
        title="Surface Energy Balance",
        kind="bar",
    )
)
# surface water balance
_ = (
    df_1M_sum.loc[:, ["Rain", "Irr", "Evap", "RO", "TotCh"]]
    .rename(columns=dict_var_disp)
    .plot(
        ax=axes[1], # specify the axis for plotting
        title="Surface Water Balance",
        kind="bar",
    )
)

# annotations
_ = axes[0].set_ylabel("Mean Flux ( $\mathrm{W \ m^{-2}}$ )")
_ = axes[0].legend()
_ = axes[1].set_xlabel("Month")
_ = axes[1].set_ylabel("Total Water Amount (mm)")
_ = axes[1].xaxis.set_ticklabels(name_mon, rotation=0)
_ = axes[1].legend()
```



### Save results to external files

The supy output can be saved as txt files for further analysis using supy function `save_supy`.

```
[34]: list_path_save = sp.save_supy(df_output, df_state_final)
```

```
[35]: for file_out in list_path_save:
        print(file_out.name)
```

```
1_2010_DailyState.txt
1_2010_SUEWS_60.txt
1_2010_snow_60.txt
1_2010_RSL_60.txt
1_2010_SOLWEIG_60.txt
df_state.csv
```

### More explorations into simulation results

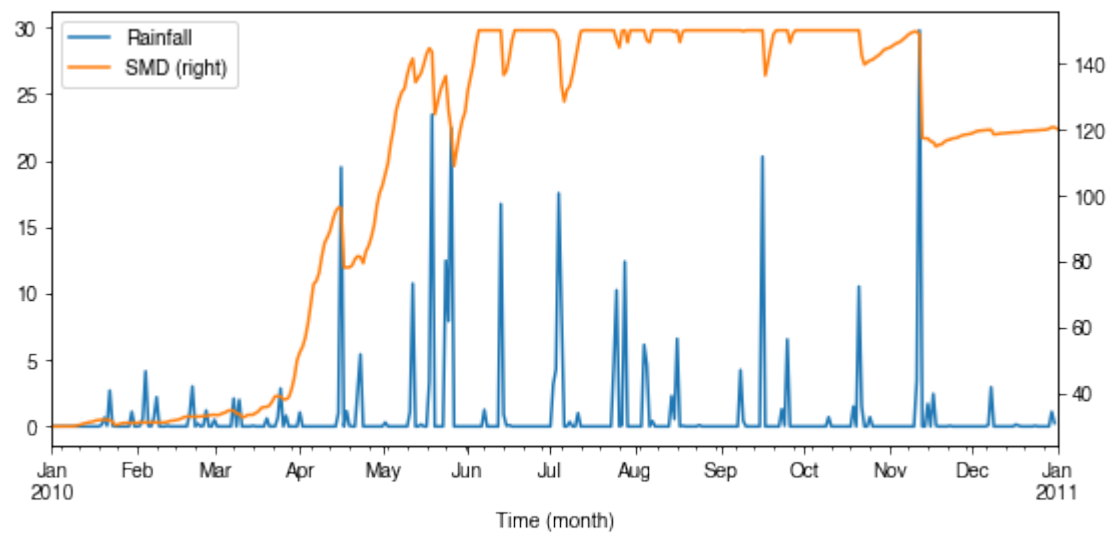
In this section, we will use the simulation results to explore more features revealed by SuPy/SUEWS simulations but *unavailable in your simple model*.

## Dynamics in rainfall and soil moisture deficit (SMD)

```
[36]: df_dailystate = (
        df_output.loc[grid, "DailyState"].dropna(how="all").resample("1d").mean()
    )

[37]: # daily rainfall
ser_p = df_dailystate.P_day.rename("Rainfall")
ser_smd = df_output_suews.SMD
ser_smd_dmax = ser_smd.resample("1d").max().rename("SMD")

ax = pd.concat([ser_p, ser_smd_dmax], axis=1).plot(secondary_y="SMD", figsize=(9, 4))
_ = ax.set_xlabel("Time (month)")
```

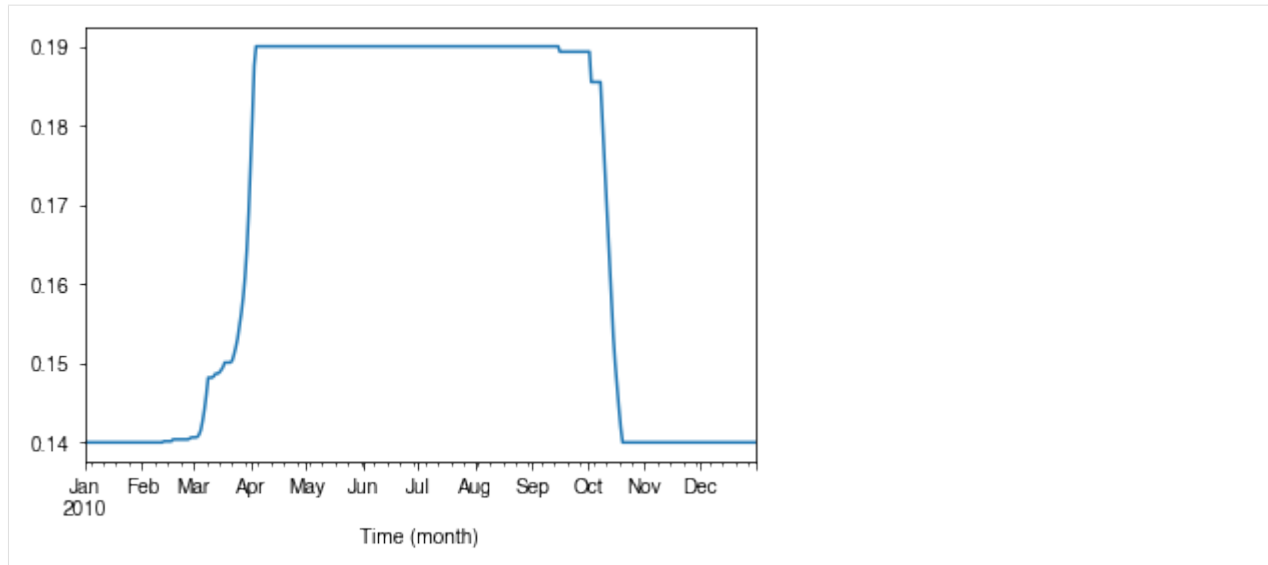


## Variability in albedo

### How does albedo change over time?

```
[38]: ser_alb = df_dailystate.AlbGrass
ax = ser_alb.plot()
_ = ax.set_xlabel("Time (month)")
```

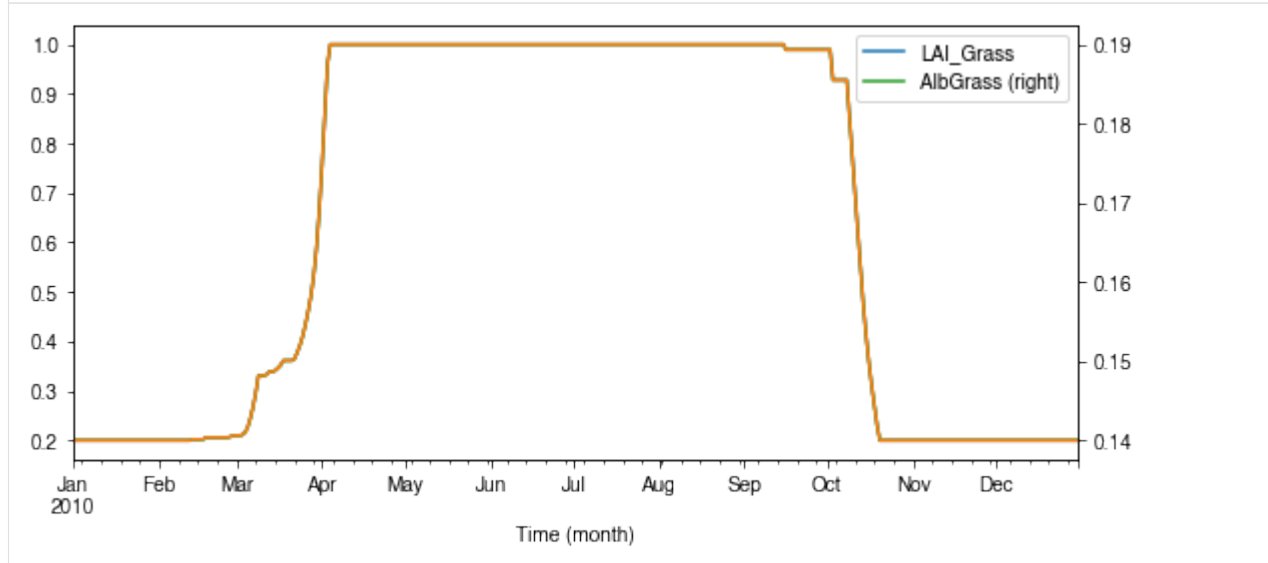




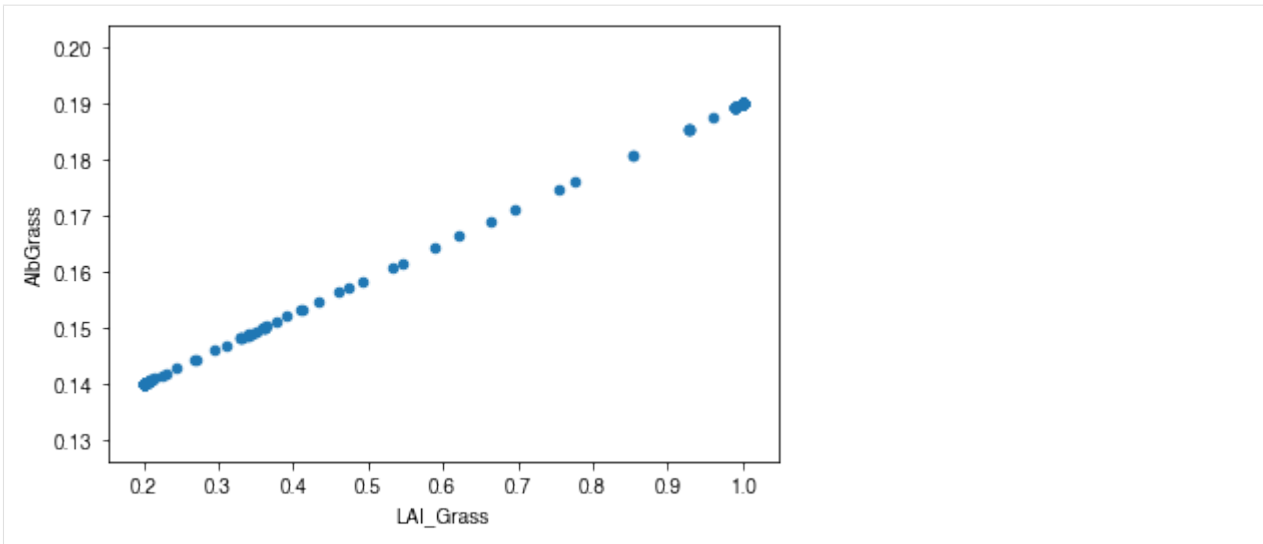
### How is albedo associated with vegetation phenology?

```
[39]: ser_lai = df_dailystate.LAI_Grass
pd.concat([ser_lai, ser_alb], axis=1).plot(secondary_y="AlbGrass", figsize=(9, 4))
ax = ser_lai.plot()
_ = ax.set_xlabel("Time (month)")
```

```
[39]: <matplotlib.axes._subplots.AxesSubplot at 0x7f8969449978>
```



```
[40]: ax_alb_lai = df_dailystate[["LAI_Grass", "AlbGrass"]].plot.scatter(
    x="LAI_Grass", y="AlbGrass",
)
ax_alb_lai.set_aspect("auto")
```



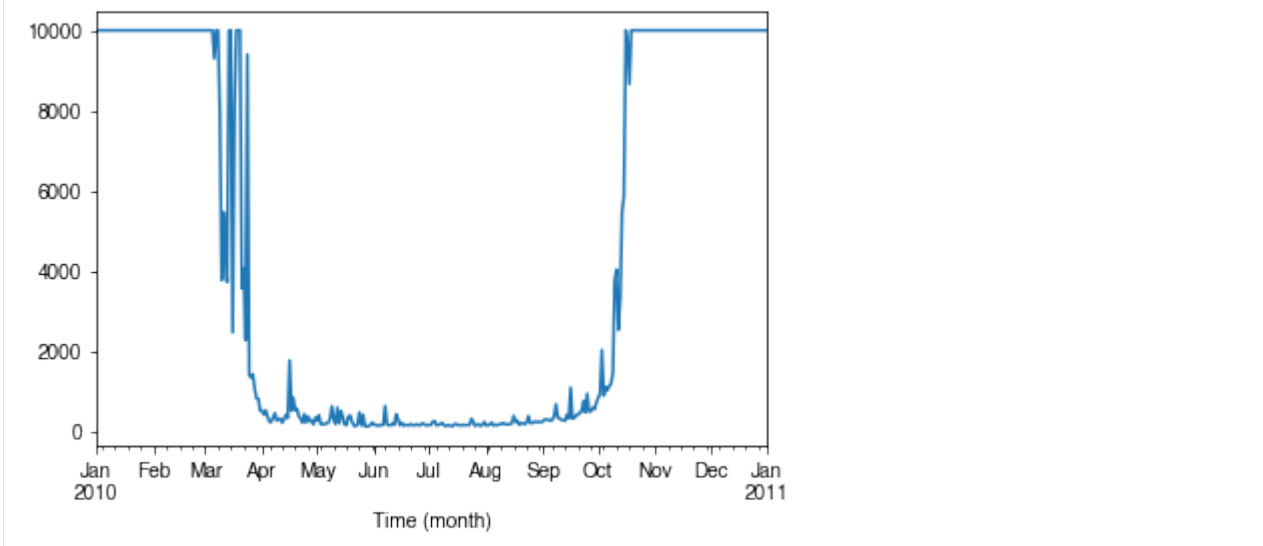
## Variability in surface resistance

### How does surface resistance vary over time?

```
[41]: ser_rs = df_output_suews.RS
```

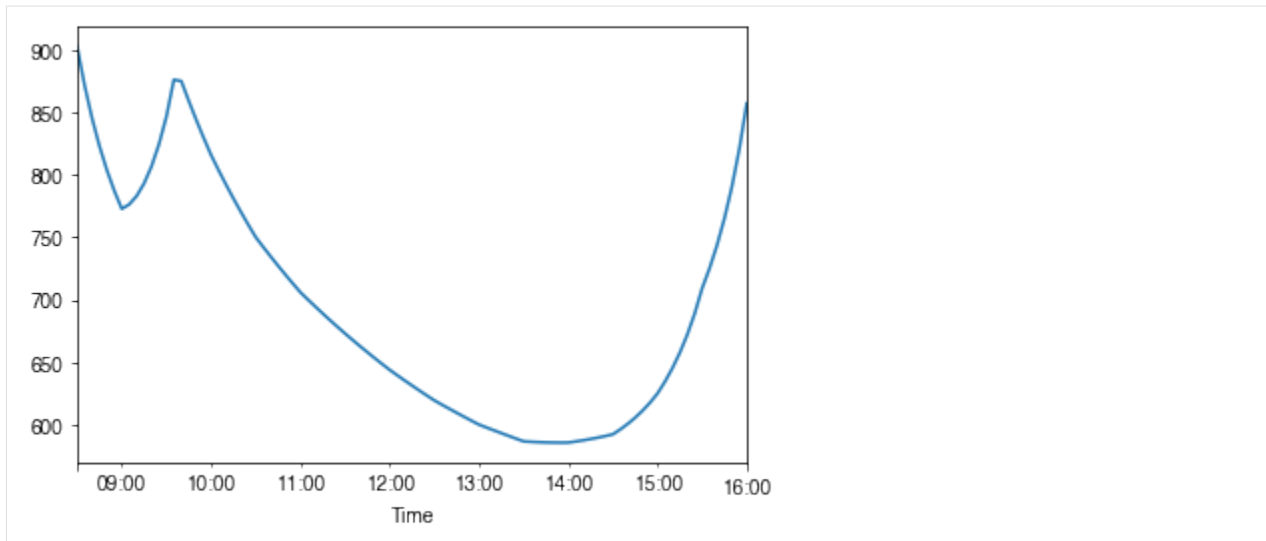
- intra-annual

```
[42]: ax = ser_rs.resample("1d").median().plot()  
_ = ax.set_xlabel("Time (month)")
```

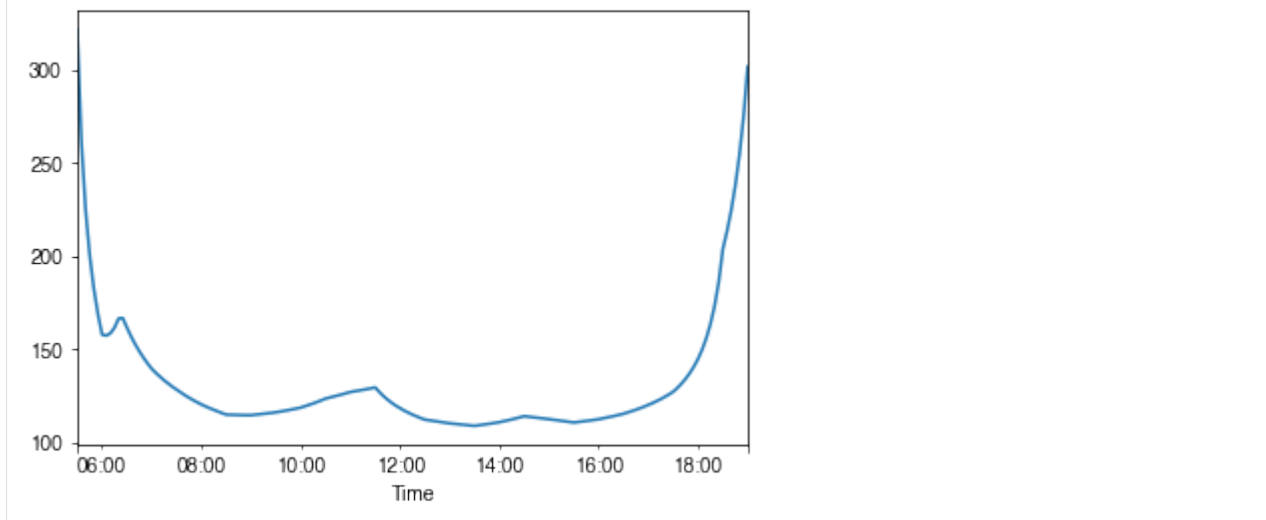


- intra-daily

```
[43]: # a winter day  
ax = ser_rs.loc["2010-01-22"].between_time("0830", "1600").plot()  
_ = ax.set_xlabel("Time")
```

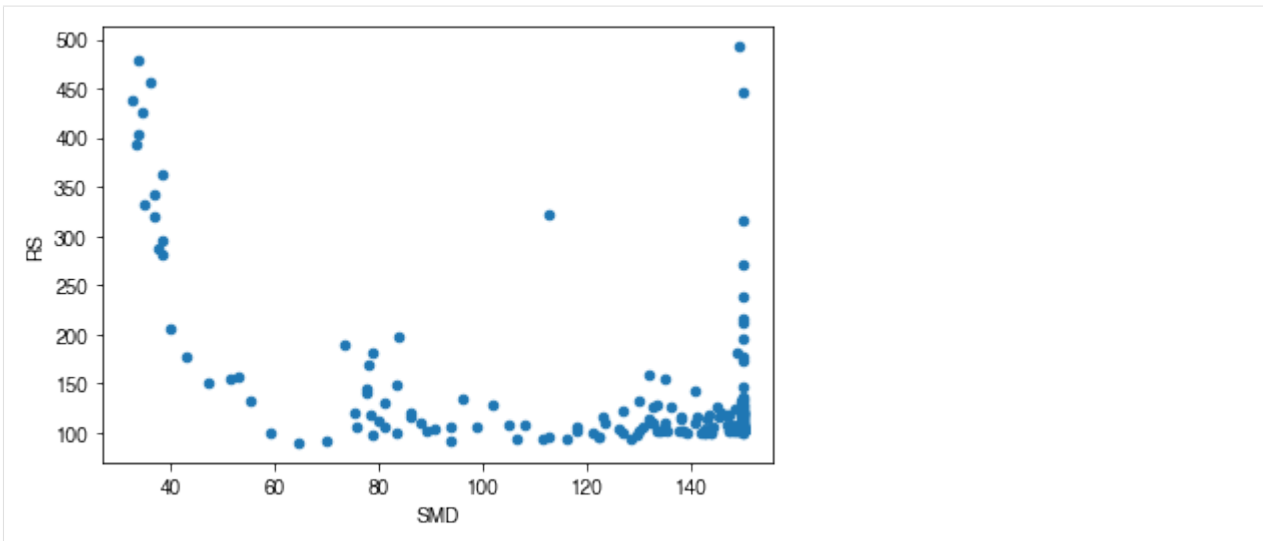


```
[44]: # a summer day
ax = ser_rs.loc["2010-07-01"].between_time("0530", "1900").plot()
_ = ax.set_xlabel("Time")
```

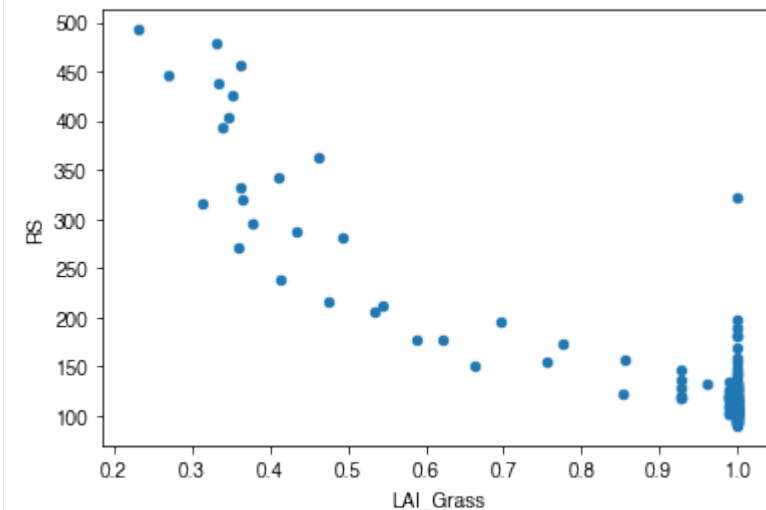


### How is surface resistance associated with other surface properties?

```
[45]: # SMD
ser_smd = df_output_suews.SMD
df_x = (
    pd.concat([ser_smd, ser_rs], axis=1)
    .between_time("1000", "1600")
    .resample("1d")
    .mean()
)
df_x = df_x.loc[df_x.RS < 500]
_ = df_x.plot.scatter(x="SMD", y="RS",)
```



```
[46]: # LAI
df_x = pd.concat(
    [ser_lai, ser_rs.between_time("1000", "1600").resample("1d").mean()], axis=1
)
df_x = df_x.loc[df_x.RS < 500]
_ = df_x.plot.scatter(x="LAI_Grass", y="RS",)
```



**How is surface resistance dependent on meteorological conditions?**

```
[47]: cmap_sel = plt.cm.get_cmap('RdBu', 12)
```

```
[48]: # solar radiation
# colour by season
ser_kdown = df_forcing_amf.kdown
df_x = pd.concat([ser_kdown, ser_rs], axis=1).between_time('1000', '1600')
```

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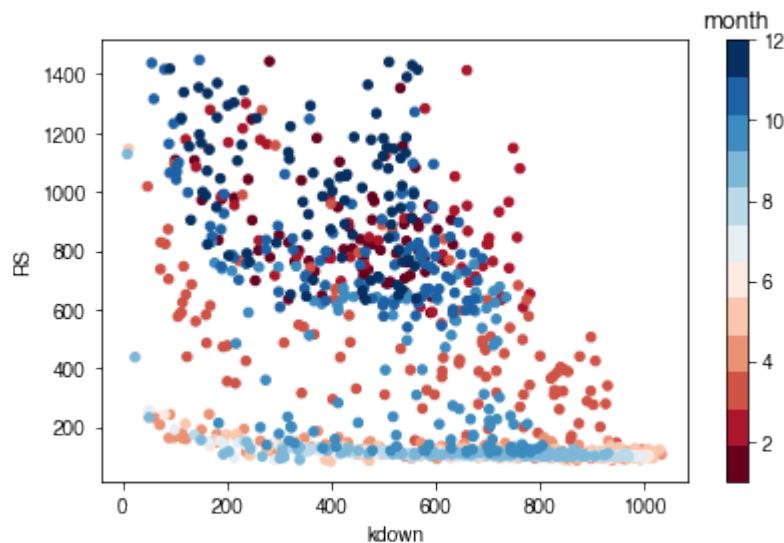
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```

df_x = df_x.loc[df_x.RS < 1500]
df_plot = df_x.iloc[:20]
ax = df_plot.plot.scatter(x='kdown',
                          y='RS',
                          c=df_plot.index.month,
                          cmap=cmap_sel,
                          sharex=False)

fig = ax.figure
_ = fig.axes[1].set_title('month')
fig.tight_layout()

```

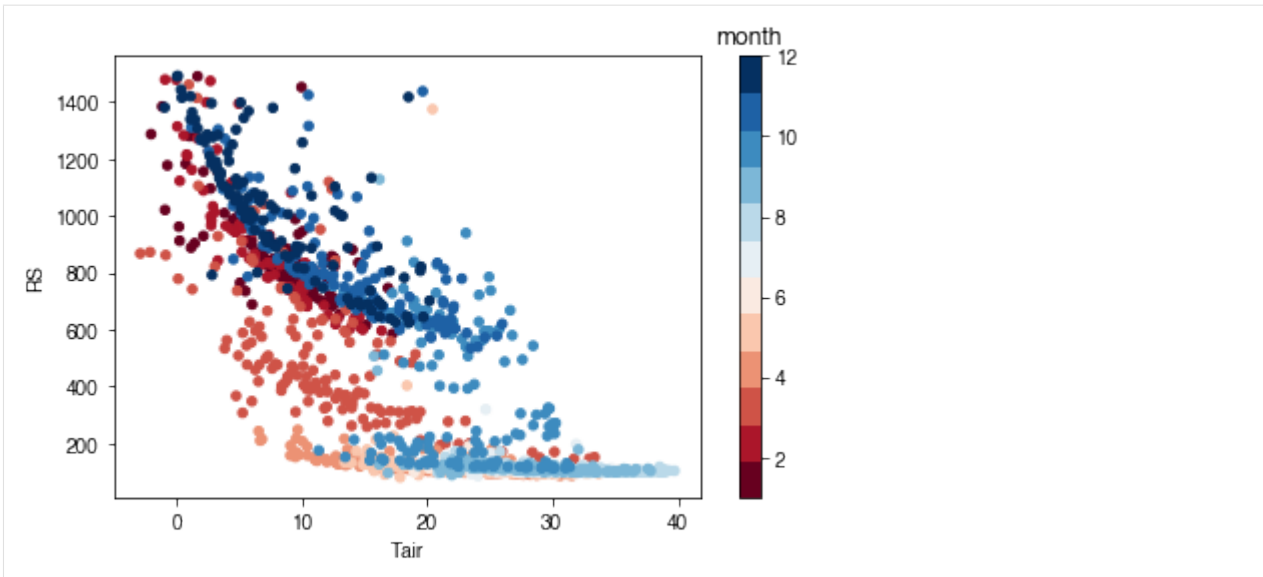


```

[49]: # air temperature
ser_ta = df_forcing_amf.Tair
df_x = pd.concat([ser_ta, ser_rs], axis=1).between_time('1000', '1600')
df_x = df_x.loc[df_x.RS < 1500]
df_plot = df_x.iloc[:15]
ax = df_plot.plot.scatter(x='Tair',
                          y='RS',
                          c=df_plot.index.month,
                          cmap=cmap_sel,
                          sharex=False)

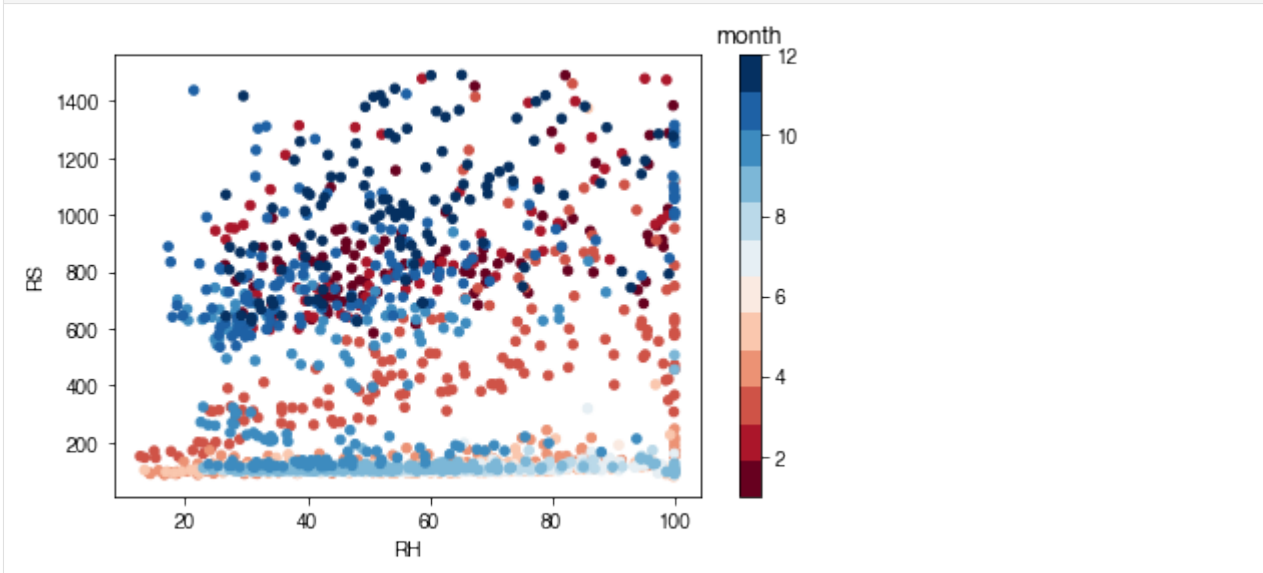
fig = ax.figure
_ = fig.axes[1].set_title('month')
fig.tight_layout()

```



```
[50]: # air humidity
ser_rh = df_forcing_amf.RH
df_x = pd.concat([ser_rh, ser_rs], axis=1).between_time('1000', '1600')
df_x = df_x.loc[df_x.RS < 1500]
df_plot = df_x.iloc[:15]
ax = df_plot.plot.scatter(x='RH',
                          y='RS',
                          c=df_plot.index.month,
                          cmap=cmap_sel,
                          sharex=False)

fig = ax.figure
_ = fig.axes[1].set_title('month')
fig.tight_layout()
```



- **Task:**

Based on the above plots showing RS vs. met. conditions, explore these relationships again at the intra-daily scales.

**Note:**

1. The Anaconda distribution is suggested as the scientific Python 3 environment for its completeness in necessary packages. Please follow the official guide for its [installation](#).
  2. Users with less experience in Python are suggested to go through the following section first before using SuPy.
- 

## Python 101 before SuPy

Admittedly, this header is somewhat misleading: given the enormity of Python, it's more challenging to get this section *correct* than coding SuPy per se. As such, here a collection of data analysis oriented links to useful Python resources is provided to help novices start using Python and **then** SuPy.

- [The gist of Python](#): a quick introductory blog that covers Python basics for data analysis.
- Jupyter Notebook: Jupyter Notebook provides a powerful notebook-based data analysis environment that SuPy users are strongly encouraged to use. Jupyter notebooks can run in browsers (desktop, mobile) either by easy local configuration or on remote servers with pre-set environments (e.g., [Google Colaboratory](#), [Microsoft Azure Notebooks](#)). In addition, Jupyter notebooks allow great shareability by incorporating source code and detailed notes in one place, which helps users to organise their computation work.

- Installation

Jupyter notebooks can be installed with pip on any desktop/server system and open .ipynb notebook files locally:

```
python3 -m pip install jupyter -U
```

- Extensions: To empower your Jupyter Notebook environment with better productivity, please check out the [Unofficial Jupyter Notebook Extensions](#). Quick introductory blogs can be found [here](#) and [here](#).
- pandas: [pandas](#) is heavily used in SuPy and thus better understanding of pandas is essential in SuPy workflows.
  - Introductory blogs:
    - \* [Quick dive into Pandas for Data Science](#): introduction to pandas.
    - \* [Basic Time Series Manipulation with Pandas](#): pandas-based time series manipulation.
    - \* [Introduction to Data Visualization in Python](#): plotting using pandas and related libraries.
  - A detailed tutorial in Jupyter Notebooks:
    - \* [Introduction to pandas](#)
    - \* [pandas fundamentals](#)
    - \* [Data Wrangling with pandas](#)

## Key IO Data Structures in SuPy

### Introduction

The cell below demonstrates a minimal case of SuPy simulation with all key IO data structures included:

```
[1]: import supy as sp
df_state_init, df_forcing = sp.load_SampleData()
df_output, df_state_final = sp.run_supy(df_forcing, df_state_init)
```

- Input: SuPy requires two DataFrames to perform a simulation, which are:

- `df_state_init`: model initial states;
- `df_forcing`: forcing data.

These input data can be loaded either through calling `load_SampleData()` as shown above or using `init_supy`. Or, based on the loaded sample DataFrames, you can modify the content to create new DataFrames for your specific needs.

- Output: The output data by SuPy consists of two DataFrames:

- `df_output`: model output results; this is usually the basis for scientific analysis.
- `df_state_final`: model final states; any of its entries can be used as a `df_state_init` to start another SuPy simulation.

### Input

#### `df_state_init`: model initial states

```
[2]: df_state_init.head()
```

```
[2]: var      ah_min      ah_slope_cooling      ah_slope_heating      ahprof_24hr  \
ind_dim  (0,) (1,)      (0,) (1,)      (0,) (1,)      (0, 0)
grid
98      15.0  15.0      2.7  2.7      2.7  2.7      0.57

var      ... tair24hr  \
ind_dim (0, 1) (1, 0) (1, 1) (2, 0) (2, 1) (3, 0) (3, 1) (4, 0) ... (275,)
grid
98      0.65  0.45  0.49  0.43  0.46  0.4  0.47  0.4 ... 273.15

var      \
ind_dim (276,) (277,) (278,) (279,) (280,) (281,) (282,) (283,)
grid
98      273.15 273.15 273.15 273.15 273.15 273.15 273.15 273.15

var      numcapita gridiv
ind_dim (284,) (285,) (286,) (287,)      0      0
grid
98      273.15 273.15 273.15 273.15      204.58      98

[1 rows x 1200 columns]
```



`df_state_init` is organised with **grids** in **rows** and **their states** in **columns**. The details of all state variables can be found in [the description page](#).

Please note the properties are stored as *flattened values* to fit into the tabular format due to the nature of `DataFrame` though they may actually be of higher dimension (e.g. `ahprof_24hr` with the dimension `{24, 2}`). To indicate the variable dimensionality of these properties, SuPy use the `ind_dim` level in columns for indices of values:

- 0 for scalars;
- (`ind_dim1`, `ind_dim2`, ...) for arrays (for a generic sense, vectors are 1D arrays).

Take `ohm_coef` below for example, it has a dimension of `{8, 4, 3}` according to the description, which implies the actual values used by SuPy in simulations are passed in a layout as an array of the dimension `{8, 4, 3}`. As such, to get proper values passed in, users should follow the dimensionality requirement to prepare/modify `df_state_init`.

```
[3]: df_state_init.loc[:, 'ohm_coef']
```

```
[3]: ind_dim (0, 0, 0) (0, 0, 1) (0, 0, 2) (0, 1, 0) (0, 1, 1) (0, 1, 2) \
grid
98          0.719      0.194      -36.6      0.719      0.194      -36.6

ind_dim (0, 2, 0) (0, 2, 1) (0, 2, 2) (0, 3, 0) (0, 3, 1) (0, 3, 2) \
grid
98          0.719      0.194      -36.6      0.719      0.194      -36.6

ind_dim (1, 0, 0) (1, 0, 1) (1, 0, 2) ... (6, 3, 0) (6, 3, 1) \
grid
98          0.238      0.427      -16.7 ...      0.5      0.21

ind_dim (6, 3, 2) (7, 0, 0) (7, 0, 1) (7, 0, 2) (7, 1, 0) (7, 1, 1) \
grid
98          -39.1      0.25      0.6      -30.0      0.25      0.6

ind_dim (7, 1, 2) (7, 2, 0) (7, 2, 1) (7, 2, 2) (7, 3, 0) (7, 3, 1) \
grid
98          -30.0      0.25      0.6      -30.0      0.25      0.6

ind_dim (7, 3, 2)
grid
98          -30.0

[1 rows x 96 columns]
```

### df\_forcing: forcing data

`df_forcing` is organised with **temporal records** in **rows** and **forcing variables** in **columns**. The details of all forcing variables can be found in [the description page](#).

The missing values can be specified with `-999s`, which are the default NANs accepted by SuPy and its backend SUEWS.

```
[4]: df_forcing.head()
```

```
[4]:          iy  id  it  imin    qn    qh    qe    qs    qf \
2012-01-01 00:05:00 2012   1   0     5 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:10:00 2012   1   0    10 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:15:00 2012   1   0    15 -999.0 -999.0 -999.0 -999.0 -999.0
```

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```

2012-01-01 00:20:00 2012 1 0 20 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:25:00 2012 1 0 25 -999.0 -999.0 -999.0 -999.0 -999.0

      U      RH      Tair      pres  rain      kdown  \
2012-01-01 00:05:00 4.515 85.463333 11.77375 1001.5125 0.0 0.153333
2012-01-01 00:10:00 4.515 85.463333 11.77375 1001.5125 0.0 0.153333
2012-01-01 00:15:00 4.515 85.463333 11.77375 1001.5125 0.0 0.153333
2012-01-01 00:20:00 4.515 85.463333 11.77375 1001.5125 0.0 0.153333
2012-01-01 00:25:00 4.515 85.463333 11.77375 1001.5125 0.0 0.153333

      snow  ldown  fclld  Wuh  xsmd  lai  kdiff  kdir  \
2012-01-01 00:05:00 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:10:00 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:15:00 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:20:00 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
2012-01-01 00:25:00 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0

      wdir  isec
2012-01-01 00:05:00 -999.0 0.0
2012-01-01 00:10:00 -999.0 0.0
2012-01-01 00:15:00 -999.0 0.0
2012-01-01 00:20:00 -999.0 0.0
2012-01-01 00:25:00 -999.0 0.0

```

**Note:**

The index of `df_forcing` **SHOULD BE** strictly of `DatetimeIndex` type if you want create a `df_forcing` for SuPy simulation. The SuPy runtime time-step size is instructed by the `df_forcing` with its index information.

The infomation below indicates SuPy will run at a 5 min (i.e. 300 s) time-step if driven by this specific `df_forcing`:

```

[5]: freq_forcing=df_forcing.index.freq
      freq_forcing
[5]: <300 * Seconds>

```

**Output****df\_output: model output results**

`df_output` is organised with **temporal records of grids** in rows and **output variables of different groups** in columns. The details of all forcing variables can be found in [the description page](#).

```

[6]: df_output.head()
[6]: group          SUEWS          Kup          Ldown          Lup          \
      var          Kdown          Kup          Ldown          Lup
      grid datetime
98    2012-01-01 00:05:00 0.153333 0.018279 344.310184 371.986259
      2012-01-01 00:10:00 0.153333 0.018279 344.310184 371.986259

```

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|               |                     |                |                |                |                |           |
|---------------|---------------------|----------------|----------------|----------------|----------------|-----------|
|               | 2012-01-01 00:15:00 | 0.153333       | 0.018279       | 344.310184     | 371.986259     |           |
|               | 2012-01-01 00:20:00 | 0.153333       | 0.018279       | 344.310184     | 371.986259     |           |
|               | 2012-01-01 00:25:00 | 0.153333       | 0.018279       | 344.310184     | 371.986259     |           |
| group         |                     |                |                |                |                | \         |
| var           |                     | Tsurf          | QN             | QF             | QS             |           |
| grid datetime |                     |                |                |                |                |           |
| 98            | 2012-01-01 00:05:00 | 11.775615      | -27.541021     | 40.574001      | -46.53243      |           |
|               | 2012-01-01 00:10:00 | 11.775615      | -27.541021     | 39.724283      | -46.53243      |           |
|               | 2012-01-01 00:15:00 | 11.775615      | -27.541021     | 38.874566      | -46.53243      |           |
|               | 2012-01-01 00:20:00 | 11.775615      | -27.541021     | 38.024849      | -46.53243      |           |
|               | 2012-01-01 00:25:00 | 11.775615      | -27.541021     | 37.175131      | -46.53243      |           |
| group         |                     |                |                |                |                | \         |
| var           |                     | QH             | QE             | QHlumps        | QElumps        | QHresis   |
| grid datetime |                     |                |                |                |                |           |
| 98            | 2012-01-01 00:05:00 | 62.420064      | 3.576493       | 49.732605      | 9.832804       | 0.042327  |
|               | 2012-01-01 00:10:00 | 61.654096      | 3.492744       | 48.980360      | 9.735333       | 0.042294  |
|               | 2012-01-01 00:15:00 | 60.885968      | 3.411154       | 48.228114      | 9.637861       | 0.042260  |
|               | 2012-01-01 00:20:00 | 60.115745      | 3.331660       | 47.475869      | 9.540389       | 0.042226  |
|               | 2012-01-01 00:25:00 | 59.343488      | 3.254200       | 46.723623      | 9.442917       | 0.042192  |
| group         |                     |                |                |                |                | \         |
| var           |                     | Rain           | Irr            | ... DailyState | WU_Grass2      | WU_Grass3 |
| grid datetime |                     |                |                | ...            | deltaLAI       |           |
| 98            | 2012-01-01 00:05:00 | 0.0            | 0.0            | ...            | NaN            | NaN       |
|               | 2012-01-01 00:10:00 | 0.0            | 0.0            | ...            | NaN            | NaN       |
|               | 2012-01-01 00:15:00 | 0.0            | 0.0            | ...            | NaN            | NaN       |
|               | 2012-01-01 00:20:00 | 0.0            | 0.0            | ...            | NaN            | NaN       |
|               | 2012-01-01 00:25:00 | 0.0            | 0.0            | ...            | NaN            | NaN       |
| group         |                     |                |                |                |                | \         |
| var           |                     | LAIlumps       | AlbSnow        | DensSnow_Paved | DensSnow_Bldgs |           |
| grid datetime |                     |                |                |                |                |           |
| 98            | 2012-01-01 00:05:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:10:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:15:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:20:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:25:00 | NaN            | NaN            | NaN            | NaN            |           |
| group         |                     |                |                |                |                | \         |
| var           |                     | DensSnow_EveTr | DensSnow_DecTr | DensSnow_Grass |                |           |
| grid datetime |                     |                |                |                |                |           |
| 98            | 2012-01-01 00:05:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:10:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:15:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:20:00 | NaN            | NaN            | NaN            | NaN            |           |
|               | 2012-01-01 00:25:00 | NaN            | NaN            | NaN            | NaN            |           |
| group         |                     |                |                |                |                |           |
| var           |                     | DensSnow_BSoil | DensSnow_Water | a1             | a2             | a3        |
| grid datetime |                     |                |                |                |                |           |

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```

98    2012-01-01 00:05:00      NaN      NaN NaN NaN NaN
      2012-01-01 00:10:00      NaN      NaN NaN NaN NaN
      2012-01-01 00:15:00      NaN      NaN NaN NaN NaN
      2012-01-01 00:20:00      NaN      NaN NaN NaN NaN
      2012-01-01 00:25:00      NaN      NaN NaN NaN NaN

```

```
[5 rows x 218 columns]
```

`df_output` are recorded at the same temporal resolution as `df_forcing`:

```
[7]: freq_out = df_output.index.levels[1].freq
      (freq_out, freq_out == freq_forcing)
```

```
[7]: (<300 * Seconds>, True)
```

### `df_state_final`: model final states

`df_state_final` has the identical data structure as `df_state_init` except for the extra level `datetime` in index, which stores the temporal information associated with model states. Such structure can facilitate the reuse of it as initial model states for other simulations (e.g., diagnostics of runtime model states with `save_state=True` set in `run_supy`; or simply using it as the initial conditions for future simulations starting at the ending times of previous runs).

The meanings of state variables in `df_state_final` can be found in [the description page](#).

```
[8]: df_state_final.head()
```

```

[8]: var                aerodynamicresistancemethod ah_min      \
ind_dim                                0  (0,)  (1,)
datetime                grid
2012-01-01 00:05:00 98      2   15.0  15.0
2013-01-01 00:05:00 98      2   15.0  15.0

var                ah_slope_cooling      ah_slope_heating      \
ind_dim                                (0,) (1,)              (0,) (1,)
datetime                grid
2012-01-01 00:05:00 98      2.7  2.7              2.7  2.7
2013-01-01 00:05:00 98      2.7  2.7              2.7  2.7

var                ahprof_24hr      \
ind_dim                (0, 0) (0, 1) (1, 0) (1, 1) (2, 0) (2, 1)
datetime                grid
2012-01-01 00:05:00 98      0.57  0.65  0.45  0.49  0.43  0.46
2013-01-01 00:05:00 98      0.57  0.65  0.45  0.49  0.43  0.46

var                ... wuprofm_24hr      \
ind_dim                (3, 0) (3, 1) ...      (18, 0) (18, 1) (19, 0)
datetime                grid      ...
2012-01-01 00:05:00 98      0.4  0.47 ...      -999.0 -999.0 -999.0
2013-01-01 00:05:00 98      0.4  0.47 ...      -999.0 -999.0 -999.0

var
ind_dim                (19, 1) (20, 0) (20, 1) (21, 0) (21, 1) (22, 0)

```

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```

datetime      grid
2012-01-01 00:05:00 98   -999.0  -999.0  -999.0  -999.0  -999.0  -999.0
2013-01-01 00:05:00 98   -999.0  -999.0  -999.0  -999.0  -999.0  -999.0

var
ind_dim      (22, 1) (23, 0) (23, 1)    0      0      0
datetime      grid
2012-01-01 00:05:00 98   -999.0  -999.0  -999.0  49.6    1.9    14.2
2013-01-01 00:05:00 98   -999.0  -999.0  -999.0  49.6    1.9    14.2

[2 rows x 1200 columns]
```

## API reference

### Top-level Functions

|  |   |
|--|---|
| <code>init_supy(path_init[, force_reload, check_input])</code> | Initialise supy by loading initial model states.  |
| <code>load_forcing_grid(path_runcontrol, grid[, ...])</code>   | Load forcing data for a specific grid included in the index of <code>df_state_init</code> . |
| <code>run_supy(df_forcing, df_state_init[, ...])</code>        | Perform supy simulation.  |
| <code>save_supy(df_output, df_state_final[, ...])</code>       | Save SuPy run results to files  |
| <code>load_sampleData()</code>                                 | Load sample data for quickly starting a demo run.   |
| <code>show_version([mode, as_json])</code>                     | print <i>SuPy</i> and <code>supy_driver</code> version information.                         |

### supy.init\_supy

`supy.init_supy(path_init: str, force_reload=True, check_input=False) → pandas.core.frame.DataFrame`

Initialise supy by loading initial model states.

**path\_init** [str]

**Path to a file that can initialise SuPy, which can be either of the follows:**

- SUEWS RunControl.nml: a namelist file for SUEWS configurations
- SuPy `df_state.csv`: a CSV file including model states produced by a SuPy run via `supy.save_supy()`

**force\_reload: boolean, optional** Flag to force reload all initialisation files by clearing all cached states, with default value `True` (i.e., force reload all files). Note: If the number of simulation grids is large (e.g., > 100), `force_reload=False` is strongly recommended for better performance.

**check\_input: boolean, optional** flag for checking validity of input: `df_forcing` and `df_state_init`. If set to `True`, any detected invalid input will stop SuPy simulation; a `False` flag will bypass such validation and may incur kernel error if any invalid input. *Note: such checking procedure may take some time if the input is large.* (the default is `False`, which bypasses the validation).

**df\_state\_init: pandas.DataFrame** Initial model states. See *df\_state variables* for details.

1. Use RunControl.nml to initialise SuPy

```
>>> path_init = "~/SUEWS_sims/RunControl.nml"
>>> df_state_init = supy.init_supy(path_init)
```

2. Use `df_state.csv` to initialise SuPy

```
>>> path_init = "~/SuPy_res/df_state_test.csv"
>>> df_state_init = supy.init_supy(path_init)
```

## supy.load\_forcing\_grid

`supy.load_forcing_grid(path_runcontrol: str, grid: int, check_input=False, force_reload=True) → pandas.core.frame.DataFrame`

Load forcing data for a specific grid included in the index of `df_state_init`.

**path\_runcontrol** [str] Path to SUEWS RunControl.nml

**grid** [int] Grid number

**check\_input** [bool, optional] flag for checking validity of input: `df_forcing` and `df_state_init`. If set to `True`, any detected invalid input will stop SuPy simulation; a `False` flag will bypass such validation and may incur kernel error if any invalid input. *Note: such checking procedure may take some time if the input is large.* (the default is `False`, which bypasses the validation).

**df\_forcing:** `pandas.DataFrame` Forcing data. See *df\_forcing variables* for details.

```
>>> path_runcontrol = "~/SUEWS_sims/RunControl.nml" # a valid path to `RunControl.
↪nml`
>>> df_state_init = supy.init_supy(path_runcontrol) # get `df_state_init`
>>> grid = df_state_init.index[0] # first grid number included in `df_state_init`
>>> df_forcing = supy.load_forcing_grid(path_runcontrol, grid) # get df_forcing
```

## supy.run\_supy

`supy.run_supy(df_forcing: pandas.core.frame.DataFrame, df_state_init: pandas.core.frame.DataFrame, save_state=False, chunk_day=3660, logging_level=20, check_input=False, serial_mode=False) → Tuple[pandas.core.frame.DataFrame, pandas.core.frame.DataFrame]`

Perform supy simulation.

**df\_forcing** [pandas.DataFrame] forcing data for all grids in `df_state_init`.

**df\_state\_init** [pandas.DataFrame] initial model states; or a collection of model states with multiple timestamps, whose last temporal record will be used as the initial model states.

**save\_state** [bool, optional] flag for saving model states at each time step, which can be useful in diagnosing model runtime performance or performing a restart run. (the default is `False`, which instructs supy not to save runtime model states).

**chunk\_day** [int, optional] chunk size (`chunk_day` days) to split simulation periods so memory usage can be reduced. (the default is 3660, which implies ~10-year forcing chunks used in simulations).

**logging\_level: logging level** one of these values [50 (CRITICAL), 40 (ERROR), 30 (WARNING), 20 (INFO), 10 (DEBUG)]. A lower value informs SuPy for more verbose logging info.

**check\_input** [bool, optional] flag for checking validity of input: `df_forcing` and `df_state_init`. If set to `True`, any detected invalid input will stop SuPy simulation; a `False` flag will bypass such validation and may incur kernel error if any invalid input. *Note: such checking procedure may take some time if the input is large.* (the default is `False`, which bypasses the validation).

**serial\_mode** [bool, optional] If set to `True`, SuPy simulation will be conducted in serial mode; a `False` flag will try parallel simulation if possible (Windows not supported, i.e., always serial). (the default is `False`).

**df\_output, df\_state\_final** [Tuple[pandas.DataFrame, pandas.DataFrame]]

- `df_output`: *output results*
- `df_state_final`: *final model states*

```
>>> df_output, df_state_final = supy.run_supy(df_forcing, df_state_init)
```

### supy.save\_supy

`supy.save_supy(df_output: pandas.core.frame.DataFrame, df_state_final: pandas.core.frame.DataFrame, freq_s: int = 3600, site: str = "", path_dir_save: str = PosixPath('.'), path_runcontrol: str = None, save_tstep=False, logging_level=50, output_level=1, debug=False) → list`

Save SuPy run results to files

**df\_output** [pandas.DataFrame] DataFrame of output

**df\_state\_final** [pandas.DataFrame] DataFrame of final model states

**freq\_s** [int, optional] Output frequency in seconds (the default is 3600, which indicates hourly output)

**site** [str, optional] Site identifier (the default is "", which indicates site identifier will be left empty)

**path\_dir\_save** [str, optional] Path to directory to saving the files (the default is Path('.'), which indicates the current working directory)

**path\_runcontrol** [str, optional] Path to SUEWS RunControl.nml, which, if set, will be preferably used to derive `freq_s`, `site` and `path_dir_save`. (the default is None, which is unset)

**save\_tstep** [bool, optional] whether to save results in temporal resolution as in simulation (which may result very large files and slow progress), by default False.

**logging\_level: logging level** one of these values [50 (CRITICAL), 40 (ERROR), 30 (WARNING), 20 (INFO), 10 (DEBUG)]. A lower value informs SuPy for more verbose logging info.

**output\_level** [integer, optional] option to determine selection of output variables, by default 1. Notes: 0 for all but snow-related; 1 for all; 2 for a minimal set without land cover specific information.

**debug** [bool, optional] whether to enable debug mode (e.g., writing out in serial mode, and other debug uses), by default False.

**list** a list of paths of saved files

1. save results of a supy run to the current working directory with default settings

```
>>> list_path_save = supy.save_supy(df_output, df_state_final)
```

2. save results according to settings in RunControl.nml

```
>>> list_path_save = supy.save_supy(df_output, df_state_final, path_runcontrol=
↳ 'path/to/RunControl.nml')
```

3. save results of a supy run at resampling frequency of 1800 s (i.e., half-hourly results) under the site code Test to a customised location 'path/to/some/dir'

```
>>> list_path_save = supy.save_supy(df_output, df_state_final, freq_s=1800, site=
↳ 'Test', path_dir_save='path/to/some/dir')
```

## supy.load\_SampleData

supy.load\_SampleData() → Tuple[pandas.core.frame.DataFrame, pandas.core.frame.DataFrame]

Load sample data for quickly starting a demo run.

**df\_state\_init, df\_forcing:** Tuple[pandas.DataFrame, pandas.DataFrame]

- df\_state\_init: *initial model states*
- df\_forcing: *forcing data*

```
>>> df_state_init, df_forcing = supy.load_SampleData()
```

## supy.show\_version

supy.show\_version(mode='simple', as\_json=False)

print *SuPy* and *supy\_driver* version information.

## Utility Functions

### ERA-5 Data Downloader

|  |   |
|--|---|
| <code>download_era5(lat_x, lon_x, start, end, ...)</code>      | Generate ERA-5 cdsapi-based requests and download data for area of interests. |
| <code>gen_forcing_era5(lat_x, lon_x, start, end[, ...])</code> | Generate SUEWS forcing files using ERA-5 data.                                |

## supy.util.download\_era5

supy.util.download\_era5(*lat\_x: float, lon\_x: float, start: str, end: str, simple\_mode: bool, dir\_save=PosixPath('.')*, *grid=None, scale=0, logging\_level=20*) → dict

Generate ERA-5 cdsapi-based requests and download data for area of interests.

**lat\_x** [float] Latitude of centre at the area of interest.

**lon\_x** [float] Longitude of centre at the area of interest.

**start** [str] Any datetime-like string that can be parsed by `pandas.daterange()`.

**end** [str] Any datetime-like string that can be parsed by `pandas.daterange()`.

**grid** [list, optional] grid size used in CDS request API, by default [0.125, 0.125].



**scale** [int, optional] scaling factor that determines the area of interest (i.e., `area=grid[0]*scale`), by default 0.

**dir\_save:** **Path or path-like string** path to directory for saving downloaded ERA5 netCDF files.

**logging\_level:** **logging level** one of these values [50 (CRITICAL), 40 (ERROR), 30 (WARNING), 20 (INFO), 10 (DEBUG)]. A lower value informs SuPy for more verbose logging info.

**dict** key: name of downloaded file. value: CDS API request used for downloading the file named by the corresponding key.

This function uses CDS API to download ERA5 data; follow this for configuration first: <https://cds.climate.copernicus.eu/api-how-to>

### supy.util.gen\_forcing\_era5

`supy.util.gen_forcing_era5(lat_x: float, lon_x: float, start: str, end: str, dir_save=PosixPath('.'), grid=None, hgt_agl_diag=100.0, scale=0, force_download=True, simple_mode=True, pressure_level=None, logging_level=20) → list`

Generate SUEWS forcing files using ERA-5 data.

**lat\_x** [float] Latitude of centre at the area of interest.

**lon\_x** [float] Longitude of centre at the area of interest.

**start** [str] Any datetime-like string that can be parsed by `pandas.daterange()`.

**end** [str] Any datetime-like string that can be parsed by `pandas.daterange()`.

**dir\_save:** **Path or path-like string** path to directory for saving downloaded ERA5 netCDF files.

**grid** [list, optional] grid size used in CDS request API, by default [0.125, 0.125].

**hgt\_agl\_diag:** **float** height above ground level to diagnose forcing variables, by default 100; the ground level is taken from ERA5 grid altitude.

**scale** [int, optional] scaling factor that determines the area of interest (i.e., `area=grid[0]*scale`), by default 0

**force\_download:** **boolean, optional** flag to determine whether to download required ERA5 netCDF files; if **False**, all ERA5-related nc files in `dir_save` will be picked up for generation. by default **True**.

**simple\_mode:** **boolean** if use the *simple* mode for diagnosing the forcing variables, by default **True**. In the simple mode, temperature is diagnosed using environmental lapse rate 6.5 K/km and wind speed using MOST under neutral condition. If **False**, MOST with consideration of stability conditions will be used to diagnose forcing variables.

**pressure\_level:** **float** pressure level to retrieve ERA5 atmospheric data, by default **None**. If **None**, this option is ignored. If not **None**, calculations implied by `simple_mode` will be skipped: the data at specified pressure level will be used as forcing data and the mean altitude of the pressure level between specified `start` and `end` will be assumed to be the forcing height (i.e., `hgt_agl_diag` will be ignored if set).

**logging\_level:** **logging level** one of these values [50 (CRITICAL), 40 (ERROR), 30 (WARNING), 20 (INFO), 10 (DEBUG)]. A lower value informs SuPy for more verbose logging info.

**List** A list of files in SUEWS forcing input format.

1. This function uses CDS API to download ERA5 data; follow this for configuration first: <https://cds.climate.copernicus.eu/api-how-to>

2. The generated forcing files can be imported using `supy.util.read_forcing` to get simulation-ready `pandas.DataFrame`s`.
3. See Section 3.10.2 and 3.10.3 in the reference for details of diagnostics calculation.
4. For `start/end`, it is recommended to use the format `YYYY-MM-DD` to avoid confusion in day/month-first conversions (an [upstream known issue](#) due to the `dateutil` behavior)

ECMWF, S. P. (2016). In IFS documentation CY41R2 Part IV: Physical Processes. ECMWF: Reading, UK, 111-113. <https://www.ecmwf.int/en/elibrary/16648-part-iv-physical-processes>

## Typical Meteorological Year

|   |  |
|---|--|
| <code>gen_epw(df_output, lat, lon[, tz, path_epw])</code> | Generate an <code>epw</code> file of uTMY (urbanised Typical Meteorological Year) using SUEWS simulation results |
| <code>read_epw(path_epw)</code>                           | Read in <code>epw</code> file as a <code>DataFrame</code>  |

### `supy.util.gen_epw`

`supy.util.gen_epw(df_output: pandas.core.frame.DataFrame, lat, lon, tz=0, path_epw=PosixPath('uTMY.epw'))`  
 → `Tuple[pandas.core.frame.DataFrame, str, pathlib.Path]`

Generate an `epw` file of uTMY (urbanised Typical Meteorological Year) using SUEWS simulation results

**df\_output** [pd.DataFrame] SUEWS simulation results.

**path\_epw** [Path, optional] Path to store generated `epw` file, by default `Path('./uTMY.epw')`.

**lat: float** Latitude of the site, used for calculating solar angle.

**lon: float** Longitude of the site, used for calculating solar angle.

**tz: float** time zone represented by time difference from UTC+0 (e.g., 8 for UTC+8), by default 0 (i.e., UTC+0)

**df\_epw, text\_meta, path\_epw: Tuple[pd.DataFrame, str, Path]**

- `df_epw`: uTMY result
- `text_meta`: meta-info text
- `path_epw`: path to generated `epw` file

### `supy.util.read_epw`

`supy.util.read_epw(path_epw: pathlib.Path) → pandas.core.frame.DataFrame`

Read in `epw` file as a `DataFrame`

**path\_epw** [Path] path to `epw` file

**df\_tmy: pd.DataFrame** TMY results of `epw` file

## Gap Filling

|   |  |
|---|--|
| <code>fill_gap_all</code> ( <i>ser_to_fill</i> [, <i>freq</i> , ...]) | Fill all gaps in a time series using data from neighbouring divisions of ' <i>freq</i> ' |
|---|--|

### `supy.util.fill_gap_all`

`supy.util.fill_gap_all`(*ser\_to\_fill*: *pandas.core.series.Series*, *freq*='1D', *limit\_fill*=1, *thresh\_ratio*=0.8) → *pandas.core.series.Series*

Fill all gaps in a time series using data from neighbouring divisions of '*freq*'

**ser\_to\_fill** [pd.Series] Time series to gap-fill

**freq** [str, optional] Frequency to identify gapped divisions, by default '1D'

**limit\_fill**: int, optional Maximum number of consecutive NaNs to fill. Any number less than one means no pre-gap-filling interpolation will be done.

**ser\_test\_filled**: pd.Series Gap-filled time series.

010: missing data in division between others with no missing data 01: missing data in division after one with no missing data 10: division with missing data before one with no missing data

## OHM

|  |  |
|--|--|
| <code>derive_ohm_coef</code> ( <i>ser_QS</i> , <i>ser_QN</i> )             | A function to linearly fit two independant variables to a dependent one. |
| <code>sim_ohm</code> ( <i>ser_qn</i> , <i>a1</i> , <i>a2</i> , <i>a3</i> ) | Calculate QS using OHM (Objective Hysteresis Model).                     |

### `supy.util.derive_ohm_coef`

`supy.util.derive_ohm_coef`(*ser\_QS*, *ser\_QN*)

A function to linearly fit two independant variables to a dependent one.

**ser\_QS** [pd.Series] The dependent variable QS (Surface heat storage).

**ser\_QN** [pd.Series] The first independent variable (Net all wave radiation).

**Tuple** *a1*, *a2* coefficients and *a3* (intercept)

### `supy.util.sim_ohm`

`supy.util.sim_ohm`(*ser\_qn*: *pandas.core.series.Series*, *a1*: float, *a2*: float, *a3*: float) → *pandas.core.series.Series*  
Calculate QS using OHM (Objective Hysteresis Model).

**ser\_qn** [pd.Series] net all-wave radiation.

**a1** [float] *a1* of OHM coefficients.

**a2** [float] *a2* of OHM coefficients.

**a3** [float] a3 of OHM coefficients.

**pd.Series** heat storage flux calculated by OHM.

## Surface Conductance

|  |   |
|--|---|
| <code>cal_gs_suews(kd, ta_c, rh, pa, smd, lai, ...)</code>     | Model surface conductance/resistance using phenology and atmospheric forcing conditions.    |
| <code>cal_gs_obs(qh, qe, ta, rh, pa, ra)</code>                | Calculate surface conductance based on observations, notably turbulent fluxes.              |
| <code>calib_g(df_fc_suews, ser_ra, g_max, lai_max, ...)</code> | Calibrate parameters for modelling surface conductance over vegetated surfaces using LMFIT. |

### supy.util.cal\_gs\_suews

`supy.util.cal_gs_suews(kd, ta_c, rh, pa, smd, lai, g_cst, g_max, lai_max, wp_smd, debug=False)`

Model surface conductance/resistance using phenology and atmospheric forcing conditions.

**kd** [numeric] Incoming solar radiation [W m<sup>-2</sup>]

**ta\_c** [numeric] Air temperature [degC]

**rh** [numeric] Relative humidity [%]

**pa** [numeric] Air pressure [Pa]

**smd** [numeric] Soil moisture deficit [mm]

**lai** [numeric] Leaf area index [m<sup>2</sup> m<sup>-2</sup>]

**g\_cst** [size-6 array] Parameters to determine surface conductance/resistance: **g\_lai** (LAI related), **g\_kd** (solar radiation related), **g\_dq\_base** (humidity related), **g\_dq\_shape** (humidity related), **g\_ta** (air temperature related), **g\_smd** (soil moisture related)

**g\_max** [numeric] Maximum surface conductance [mm s<sup>-1</sup>]

**lai\_max** [numeric] Maximum LAI [m<sup>2</sup> m<sup>-2</sup>]

**wp\_smd** [numeric] Wilting point indicated as soil moisture deficit [mm]

**numeric** Modelled surface conductance [mm s<sup>-1</sup>]

### supy.util.cal\_gs\_obs

`supy.util.cal_gs_obs(qh, qe, ta, rh, pa, ra)`

Calculate surface conductance based on observations, notably turbulent fluxes.

**qh** [numeric] Sensible heat flux [W m<sup>-2</sup>]

**qe** [numeric] Latent heat flux [W m<sup>-2</sup>]

**ta** [numeric] Air temperature [degC]

**rh** [numeric] Relative humidity [%]

**pa** [numeric] Air pressure [Pa]

**numeric** Surface conductance based on observations [mm s-1]

## supy.util.calib\_g

`supy.util.calib_g(df_fc_suews, ser_ra, g_max, lai_max, wp_smd, method='cobyla', prms_init=None, debug=False)`

Calibrate parameters for modelling surface conductance over vegetated surfaces using LMFIT.

**df\_fc\_suews** [pandas.DataFrame] DataFrame in [SuPy forcing](#) format

**ser\_ra:** **pandas.Series** Series with RA, aerodynamic resistance, [s m-1]

**g\_max** [numeric] Maximum surface conductance [mm s-1]

**lai\_max** [numeric] Maximum LAI [m2 m-2]

**wp\_smd** [numeric] Wilting point indicated as soil moisture deficit [mm]

**method:** **str, optional** Method used in minimisation by `lmfit.minimize`: details refer to its method.

**prms\_init:** **lmfit.Parameters, optional** Initial parameters for calibration

**debug** [bool, optional] Option to output final calibrated `ModelResult`, by default False

**dict, or ModelResult if debug==True**

1. dict: {parameter\_name -> best\_fit\_value}
2. `ModelResult`

**Note:** Parameters for surface conductance: `g_lai` (LAI related), `g2` (solar radiation related), `g_dq_base` (humidity related), `g_dq_shape` (humidity related), `g_ta` (air temperature related), `g_smd` (soil moisture related)

For calibration validity, turbulent fluxes, QH and QE, in `df_fc_suews` should ONLY be observations, i.e., interpolated values should be avoided. To do so, please place `np.nan` as missing values for QH and QE.

## WRF-SUEWS

|  |   |
|--|---|
| <code>extract_reclassification(path_nml)</code>                | Extract reclassification info from <code>path_nml</code> as a DataFrame.                    |
| <code>plot_reclassification(path_nml[, path_save, ...])</code> | Produce Sankey Diagram to visualise the reclassification specified in <code>path_nml</code> |

## supy.util.extract\_reclassification

`supy.util.extract_reclassification(path_nml: str) → pandas.core.frame.DataFrame`

Extract reclassification info from `path_nml` as a DataFrame.

**path\_nml** [str] Path to `namelist.suews`

**pd.DataFrame** Reclassification DataFrame with rows for WRF land covers while columns for SUEWS.

### supy.util.plot\_reclassification

`supy.util.plot_reclassification(path_nml: str, path_save='LC-WRF-SUEWS.png', width=800, height=360, top=10, bottom=10, left=280, right=130)`

Produce Sankey Diagram to visualise the reclassification specified in `path_nml`

**path\_nml** [str] Path to `namelist.suews`

**path\_save** [str, optional] Path to save Sankey diagram, by default 'LC-WRF-SUEWS.png'

**width** [int, optional] Width of diagram, by default 800

**height** [int, optional] Height of diagram, by default 360

**top** [int, optional] Top margin of diagram, by default 10

**bottom** [int, optional] Bottom margin of diagram, by default 10

**left** [int, optional] Left margin of diagram, by default 260

**right** [int, optional] Right margin of diagram, by default 60

**Sankey Diagram** Sankey Diagram showing the reclassification.

### Plotting

|   |  |
|---|--|
| <code>plot_comp(df_var[, scatter_kws, kde_kws, ...])</code> | Produce a scatter plot with linear regression line to compare simulation results and observations. |
| <code>plot_day_clm(df_var[, fig, ax, show_dif, ...])</code> | Produce a ensemble diurnal climatologies with uncertainties shown in inter-quartile ranges.        |
| <code>plot_rsl(df_output[, var, fig, ax])</code>            | Produce a quick plot of RSL results  |

### supy.util.plot\_comp

`supy.util.plot_comp(df_var, scatter_kws={'alpha': 0.1, 'color': 'k', 's': 0.3}, kde_kws={'levels': 4, 'shade': True, 'shade_lowest': False}, show_pdf=False, fig=None, ax=None)`

Produce a scatter plot with linear regression line to compare simulation results and observations.

**df\_var** [pd.DataFrame] DataFrame containing variables to plot with datetime as index. Two columns, 'Obs' and 'Sim' for observations and simulation results, respectively, must exist.

**scatter\_kws: dict** keyword arguments passed to `sns.regplot`. By default, `{"alpha": 0.1, "s": 0.3, "color": "k"}`.

**show\_pdf: boolean** if a PDF overlay should be added. By default, `False`.

**kde\_kws: dict** `kde_kws` passed to `sns.kdeplot` when `show_pdf=True`

**MPL.figure** figure showing 1:1 line plot

### supy.util.plot\_day\_clm

`supy.util.plot_day_clm(df_var, fig=None, ax=None, show_dif=False, col_ref='Obs')`

Produce a ensemble diurnal climatologies with uncertainties shown in inter-quartile ranges.

**df\_var** [pd.DataFrame] DataFrame containing variables to plot with datetime as index.

**show\_dif: boolean** flag to determine if differences against `col_ref` should be plotted.

**col\_ref: str** name of column that is used as reference to show differences instead of original values.

**MPL.figure** figure showing median lines and IQR in shadings

### supy.util.plot\_rsl

`supy.util.plot_rsl(df_output, var=None, fig=None, ax=None)`

Produce a quick plot of RSL results

**df\_output** [pandas.DataFrame] SuPy output dataframe with RSL results.

**var** [str, optional] Variable to plot; must be one of 'U', 'T', or 'q'; or use `None` to plot all; by default `None`

**tuple** (fig, ax) of plot.

**issue** If an invalid variable is specified, an issue will be raised.

## Roughness Calculation

|   |  |
|---|--|
| <code>cal_z0zd</code> (ser_qh, ser_ustar, ser_ta_c, ..., ...) | Calculates surface roughness and zero plane displacement height.       |
| <code>cal_neutral</code> (ser_qh, ser_ustar, ser_ta_c, ...)   | Calculates the rows associated with neutral condition (threshold=0.01) |

### supy.util.cal\_z0zd

`supy.util.cal_z0zd(ser_qh, ser_ustar, ser_ta_c, ser_rh_pct, ser_pres_hpa, ser_ws, z_meas, h_sfc, debug=False)`

Calculates surface roughness and zero plane displacement height. Refer to <https://suews-parameters-docs.readthedocs.io/en/latest/steps/roughness-SuPy.html> for example

**ser\_qh: pd.DataFrame** sensible heat flux [W/m<sup>2</sup>]

**ser\_ustar: pd.Series** friction velocity [m/s]

**ser\_ta\_c: pd.Series** air temperature [°C]

**ser\_rh\_pct: pd.Series** relative humidity [%]

**ser\_pres\_hpa: pd.Series** air pressure [hPa]

**z\_meas: number** measurement height in m

**h\_sfc: number** vegetation height in m

**debug** [bool, optional] Option to output final calibrated `ModelResult`, by default `False`

**z0** surface roughness length for momentum

**zd** zero displacement height

### **supy.util.cal\_neutral**

**supy.util.cal\_neutral**(*ser\_qh*, *ser\_ustar*, *ser\_ta\_c*, *ser\_rh\_pct*, *ser\_pres\_hpa*, *ser\_ws*, *z\_meas*, *h\_sfc*)

Calculates the rows associated with neutral condition (threshold=0.01)

**ser\_qh: pd.DataFrame** sensible heat flux [ $\text{W/m}^2$ ]

**ser\_ustar: pd.Series** friction velocity [m/s]

**ser\_ta\_c: pd.Series** air temperature [ $^{\circ}\text{C}$ ]

**ser\_rh\_pct: pd.Series** relative humidity [%]

**ser\_pres\_hpa: pd.Series** air pressure [hPa]

**ser\_ws: pd.Series** wind speed [m/s]

**z\_meas** measurement height [m]

**h\_sfc** vegetation height [m]

**ser\_ws\_neutral: pd.Series** observation time series of WS (Neutral conditions)

**ser\_ustar\_neutral: pd.Series** observation time series of  $u^*$  (Neutral conditions)

## **Command-Line Tools**

### **suews-run**

Run SUEWS simulation using settings in PATH\_RUNCONTROL (default: “./RunControl.nml”, i.e., the RunControl namelist file in the current directory).

Examples:

1. Run SUEWS simulation using the RunControl namelist file in the current directory:

```
$ suews-run -p ./RunControl.nml
```

2. Run SUEWS simulation using an arbitray RunControl namelist file by specifying the path to the RunControl namelist file:

```
$ suews-run -p /path/to/RunControl.nml
```

```
suews-run [OPTIONS]
```



## Options

**-p, --path\_runcontrol** <path\_runcontrol>  
Path to the RunControl namelist file (default: ./RunControl.nml).

## suews-convert

Convert SUEWS input tables from older versions to newer ones (one-way only).

```
suews-convert [OPTIONS]
```

## Options

**-f, --from** <fromVer>  
**Required** Version to convert from  
**Options** 2021a | 2020a | 2019b | 2019a | 2018c | 2018b | 2018a | 2017a | 2016a

**-t, --to** <toVer>  
**Required** Version to convert to  
**Options** 2023a | 2021a | 2020a | 2019b | 2019a | 2018c | 2018b | 2018a | 2017a

**-i, --input** <fromDir>  
**Required** Original directory to convert, which must have the *RunControl.nml* file

**-o, --output** <toDir>  
**Required** New directory to create for converted tables. Note: the created directory will have the same structure as the original one; however, forcing files and output folder won't be included.

## Key Data Structures

### df\_state variables

---

**Note:** Data structure of df\_state is explained [here](#).

---

### aerodynamicresistancemethod

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

### ah\_min

**Description** Minimum QF values.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables [AHMin\\_WD](#), [AHMin\\_WE](#)

#### **ah\_slope\_cooling**

**Description** Cooling slope of QF calculation.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables [AHSlope\\_Cooling\\_WD](#), [AHSlope\\_Cooling\\_WE](#)

#### **ah\_slope\_heating**

**Description** Heating slope of QF calculation.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables [AHSlope\\_Heating\\_WD](#), [AHSlope\\_Heating\\_WE](#)

#### **ahprof\_24hr**

**Description** Hourly profile values used in energy use calculation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

SUEWS-related variables [EnergyUseProfWD](#), [EnergyUseProfWE](#)

#### **air\_ext\_lw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### **air\_ext\_sw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### **air\_ssa\_lw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### **air\_ssa\_sw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

**alb**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *AlbedoMax*

**albdectr\_id**

**Description** Albedo of deciduous surface *DecTr* on day 0 of run

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *albDecTr0*

**albevetr\_id**

**Description** Albedo of evergreen surface *EveTr* on day 0 of run

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *albEveTr0*

**albgrass\_id**

**Description** Albedo of grass surface *Grass* on day 0 of run

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *albGrass0*

**albmax\_dectr**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *AlbedoMax*

**albmax\_evetr**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *AlbedoMax*

**albmax\_grass**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [AlbedoMax](#)

#### **albmin\_dectr**

**Description** Effective surface albedo (middle of the day value) for wintertime (not including snow).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [AlbedoMin](#)

#### **albmin\_evetr**

**Description** Effective surface albedo (middle of the day value) for wintertime (not including snow).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [AlbedoMin](#)

#### **albmin\_grass**

**Description** Effective surface albedo (middle of the day value) for wintertime (not including snow).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [AlbedoMin](#)

#### **alpha\_bioco2**

**Description** The mean apparent ecosystem quantum. Represents the initial slope of the light-response curve.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [alpha](#)

#### **alpha\_enh\_bioco2**

**Description** Part of the [alpha](#) coefficient related to the fraction of vegetation.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [alpha\\_enh](#)

#### **alt**

**Description** Altitude of grids [m].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [Alt](#)

**baset**

**Description** Base Temperature for initiating growing degree days (GDD) for leaf growth. [°C]

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *BaseT*

**baset\_cooling**

**Description** Critical cooling temperature.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: { Weekday, Weekend }

**SUEWS-related variables** *TCritic\_Cooling\_WD*, *TCritic\_Cooling\_WE*

**baset\_hc**

**Description** Base temperature for heating degree days [°C]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *BaseT\_HC*

**baset\_heating**

**Description** Critical heating temperature.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: { Weekday, Weekend }

**SUEWS-related variables** *TCritic\_Heating\_WD*, *TCritic\_Heating\_WE*

**basete**

**Description** Base temperature for initiating sensesance degree days (SDD) for leaf off. [°C]

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *BaseTe*

**basetmethod**

**Description** Determines method for base temperature used in HDD/CDD calculations.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *BaseTMethod*

**beta\_bioco2**

**Description** The light-saturated gross photosynthesis of the canopy. [ $\mu\text{mol m}^{-2} \text{s}^{-1}$ ]

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *beta*

**beta\_enh\_bioco2**

**Description** Part of the *beta* coefficient related to the fraction of vegetation.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *beta\_enh*

**bldgh**

**Description** Mean building height [m]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *H\_Bldgs*

**capmax\_dec**

**Description** Maximum water storage capacity for upper surfaces (i.e. canopy)

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *StorageMax*

**capmin\_dec**

**Description** Minimum water storage capacity for upper surfaces (i.e. canopy).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *StorageMin*

**chanohm**

**Description** Bulk transfer coefficient for this surface to use in AnOHM [-]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *AnOHM\_Ch*

**co2pointsource**

**Description** CO2 emission factor [kg km<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *CO2PointSource*

**cpanohm**

**Description** Volumetric heat capacity for this surface to use in AnOHM [J m<sup>-3</sup>]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *AnOHM\_Cp*

**crwmax**

**Description** Maximum water holding capacity of snow [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [CRWMax](#)

**crwmin**

**Description** Minimum water holding capacity of snow [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [CRWMin](#)

**daywat**

**Description** Irrigation flag: 1 for on and 0 for off.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: {Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday}

**SUEWS-related variables** [DayWat\(1\)](#), [DayWat\(2\)](#), [DayWat\(3\)](#), [DayWat\(4\)](#), [DayWat\(5\)](#),  
[DayWat\(6\)](#), [DayWat\(7\)](#)

**daywatper**

**Description** Fraction of properties using irrigation for each day of a week.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: {Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday}

**SUEWS-related variables** [DayWatPer\(1\)](#), [DayWatPer\(2\)](#), [DayWatPer\(3\)](#), [DayWatPer\(4\)](#),  
[DayWatPer\(5\)](#), [DayWatPer\(6\)](#), [DayWatPer\(7\)](#)

**decidcap\_id**

**Description** Storage capacity of deciduous surface [DecTr](#) on day 0 of run.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [decidCap0](#)

**dectreeh**

**Description** Mean height of deciduous trees [m]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [H\\_DecTr](#)

**diagmethod**

**Description** Defines how near surface diagnostics are calculated.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *DiagMethod*

#### diagnose

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### diagqn

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### diagqs

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

#### drainrt

**Description** Drainage rate of bucket for LUMPS [mm h<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *LUMPS\_DrRate*

#### ef\_umolco2perj

**Description** Emission factor for fuels used for building heating.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *EF\_umolCO2perJ*

#### emis

**Description** Effective surface emissivity.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

SUEWS-related variables *Emissivity*

#### emissionsmethod

**Description** Determines method for QF calculation.

**Dimensionality** 0

**Dimensionality Remarks** Scalar



SUEWS-related variables [EmissionsMethod](#)

**enddls**

**Description** End of the day light savings [DOY]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [EndDLS](#)

**enef\_v\_jkm**

**Description** Emission factor for heat [ $\text{J k m}^{-1}$ ].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [EnEF\\_v\\_Jkm](#)

**evapmethod**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables None

**evetreesh**

**Description** Mean height of evergreen trees [m]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [H\\_EveTr](#)

**faibldg**

**Description** Frontal area index for buildings [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FAI\\_Bldgs](#)

**faidectree**

**Description** Frontal area index for deciduous trees [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FAI\\_DecTr](#)

**faievetree**

**Description** Frontal area index for evergreen trees [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FAI\\_EveTr](#)

#### **faut**

**Description** Fraction of irrigated area that is irrigated using automated systems

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [Faut](#)

#### **fcef\_v\_kgkm**

**Description** CO2 emission factor for weekdays [kg km<sup>-1</sup>];;CO2 emission factor for weekends [kg km<sup>-1</sup>]

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables [FCEF\\_v\\_kgkmWD](#), [FCEF\\_v\\_kgkmWE](#)

#### **flowchange**

**Description** Difference in input and output flows for water surface [mm h<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FlowChange](#)

#### **frfossilfuel\_heat**

**Description** Fraction of fossil fuels used for building heating [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FrFossilFuel\\_Heat](#)

#### **frfossilfuel\_nonheat**

**Description** Fraction of fossil fuels used for building energy use [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [FrFossilFuel\\_NonHeat](#)

#### **g1**

**Description** Related to maximum surface conductance [mm s<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables [G1](#)

#### **g2**

**Description** Related to Kdown dependence [W m<sup>-2</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [G2](#)

**g3**

**Description** Related to VPD dependence [units depend on [gsModel](#)]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [G3](#)

**g4**

**Description** Related to VPD dependence [units depend on [gsModel](#)]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [G4](#)

**g5**

**Description** Related to temperature dependence [°C]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [G5](#)

**g6**

**Description** Related to soil moisture dependence [mm<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [G6](#)

**gddfull**

**Description** The growing degree days (GDD) needed for full capacity of the leaf area index (LAI) [°C].

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [GDDFull](#)

**ground\_albedo\_dir\_mult\_fact**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

**gsmodel**

**Description** Formulation choice for conductance calculation.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [gsModel](#)

**h\_maintain**

**Description** water depth to maintain used in automatic irrigation (e.g., ponding water due to flooding irrigation in rice crop-field) [mm].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [H\\_maintain](#)

**humactivity\_24hr**

**Description** Hourly profile values used in human activity calculation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

**SUEWS-related variables** [ActivityProfWD](#), [ActivityProfWE](#)

**ie\_a**

**Description** Coefficient for automatic irrigation model.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [Ie\\_a1](#), [Ie\\_a2](#), [Ie\\_a3](#)

**ie\_end**

**Description** Day when irrigation ends [DOY]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [Ie\\_end](#)

**ie\_m**

**Description** Coefficient for manual irrigation model.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [Ie\\_m1](#), [Ie\\_m2](#), [Ie\\_m3](#)

**ie\_start**

**Description** Day when irrigation starts [DOY]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [Ie\\_start](#)

#### internalwateruse\_h

**Description** Internal water use [mm h<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [InternalWaterUse](#)

#### irrfracbldgs

**Description** Fraction of [Bldgs](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_Bldgs](#)

#### irrfracbsoil

**Description** Fraction of [BSoil](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_BSoil](#)

#### irrfracdectr

**Description** Fraction of [DecTr](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_DecTr](#)

#### irrfacevetr

**Description** Fraction of [EveTr](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_EveTr](#)

#### irrfracgrass

**Description** Fraction of [Grass](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_Grass](#)

#### irrfracpaved

**Description** Fraction of [Paved](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_Paved](#)

#### **irrfracwater**

**Description** Fraction of [Water](#) that is irrigated [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [IrrFr\\_Water](#)

#### **kkanohm**

**Description** Thermal conductivity for this surface to use in AnOHM [ $\text{W m K}^{-1}$ ]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { [Paved](#), [Bldgs](#), [EveTr](#), [DecTr](#), [Grass](#), [BSoil](#), [Water](#) }

**SUEWS-related variables** [AnOHM\\_Kk](#)

#### **kmax**

**Description** Maximum incoming shortwave radiation [ $\text{W m}^{-2}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [Kmax](#)

#### **lai\_id**

**Description** Initial LAI values.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [LAIinitialDecTr](#), [LAIinitialEveTr](#), [LAIinitialGrass](#)

#### **laicalcyes**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **laimax**

**Description** full leaf-on summertime value

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [LAIMax](#)

#### **laimin**

**Description** leaf-off wintertime value

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *LAIMin*

## laipower

**Description** parameters required by LAI calculation.

**Dimensionality** (4, 3)

**Dimensionality Remarks** 4: { *LeafGrowthPower1*, *LeafGrowthPower2*, *LeafOffPower1*, *LeafOffPower2* }

3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *LeafGrowthPower1*, *LeafGrowthPower2*, *LeafOffPower1*, *LeafOffPower2*

## laitype

**Description** LAI calculation choice.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *LAIEq*

## lat

**Description** Latitude [deg].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *lat*

## lng

**Description** longitude [deg]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *lng*

## maxconductance

**Description** The maximum conductance of each vegetation or surface type. [ $\text{mm s}^{-1}$ ]

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *MaxConductance*

## maxfcmetab

**Description** Maximum (day) CO<sub>2</sub> from human metabolism. [ $\text{W m}^{-2}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *MaxFCMetab*

**maxqfmetab**

**Description** Maximum value for human heat emission. [ $\text{W m}^{-2}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *MaxQFMetab*

**min\_res\_bioco2**

**Description** Minimum soil respiration rate (for cold-temperature limit) [ $\text{umol m}^{-2} \text{s}^{-1}$ ].

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *min\_respi*

**minfcmetab**

**Description** Minimum (night) CO<sub>2</sub> from human metabolism. [ $\text{W m}^{-2}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *MinFCMetab*

**minqfmetab**

**Description** Minimum value for human heat emission. [ $\text{W m}^{-2}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *MinQFMetab*

**n\_stream\_lw\_urban**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

**n\_stream\_sw\_urban**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

**n\_vegetation\_region\_urban**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None



**narp\_emis\_snow**

**Description** Effective surface emissivity.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *Emissivity*

**narp\_trans\_site**

**Description** Atmospheric transmissivity for NARP [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *NARP\_Trans*

**netradiationmethod**

**Description** Determines method for calculation of radiation fluxes.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *NetRadiationMethod*

**ohm\_coef**

**Description** Coefficients for OHM calculation.

**Dimensionality** (8, 4, 3)

**Dimensionality Remarks** 8: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water*, one extra land cover type (currently NOT used)}

4: {SummerWet, SummerDry, WinterWet, WinterDry}

3: {a1, a2, a3}

**SUEWS-related variables** *a1*, *a2*, *a3*

**ohm\_threshw**

**Description** Temperature threshold determining whether summer/winter OHM coefficients are applied [°C]

**Dimensionality** (8,)

**Dimensionality Remarks** 8: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water*, one extra land cover type (currently NOT used)}

**SUEWS-related variables** *OHMThresh\_SW*

**ohm\_threshwd**

**Description** Soil moisture threshold determining whether wet/dry OHM coefficients are applied [-]

**Dimensionality** (8,)

**Dimensionality Remarks** 8: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water*, one extra land cover type (currently NOT used)}

**SUEWS-related variables** *OHMThresh\_WD*

**ohmincqf**

**Description** Determines whether the storage heat flux calculation uses  $Q^*$  or ( $Q^* + QF$ ).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*OHMIncQF\*](#)

**pipecapacity**

**Description** Storage capacity of pipes [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*PipeCapacity\*](#)

**popdensdaytime**

**Description** Daytime population density (i.e. workers, tourists) [people ha<sup>-1</sup>]

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

**SUEWS-related variables** [\*PopDensDay\*](#)

**popdensnighttime**

**Description** Night-time population density (i.e. residents) [people ha<sup>-1</sup>]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*PopDensNight\*](#)

**popprof\_24hr**

**Description** Hourly profile values used in dynamic population estimation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

**SUEWS-related variables** [\*PopProfWD\*](#), [\*PopProfWE\*](#)

**pormax\_dec**

**Description** full leaf-on summertime value Used only for [\*DecTr\*](#) (can affect roughness calculation)

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*PorosityMax\*](#)

**pormin\_dec**

**Description** leaf-off wintertime value Used only for [\*DecTr\*](#) (can affect roughness calculation)

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *PorosityMin*

#### porosity\_id

**Description** Porosity of deciduous vegetation on day 0 of run.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *porosity0*

#### preciplimit

**Description** Temperature limit when precipitation falls as snow [°C]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *PrecipLimSnow*

#### preciplimitalb

**Description** Limit for hourly precipitation when the ground is fully covered with snow [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *PrecipLimAlb*

#### qf0\_beu

**Description** Building energy use [W m<sup>-2</sup>]

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables *QF0\_BEU\_WD*, *QF0\_BEU\_WE*

#### qf\_a

**Description** Base value for QF calculation.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables *QF\_A\_WD*, *QF\_A\_WE*

#### qf\_b

**Description** Parameter related to heating degree days.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables *QF\_B\_WD*, *QF\_B\_WE*

#### qf\_c

**Description** Parameter related to heating degree days.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

SUEWS-related variables *QF\_C\_WD*, *QF\_C\_WE*

#### radmeltfact

**Description** Hourly radiation melt factor of snow [ $\text{mm W}^{-1} \text{h}^{-1}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *RadMeltFactor*

#### raincover

**Description** Limit when surface totally covered with water for LUMPS [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *LUMPS\_Cover*

#### rainmaxres

**Description** Maximum water bucket reservoir [mm] Used for LUMPS surface wetness control.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *LUMPS\_MaxRes*

#### resp\_a

**Description** Respiration coefficient a.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

SUEWS-related variables *resp\_a*

#### resp\_b

**Description** Respiration coefficient b - related to air temperature dependency.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

SUEWS-related variables *resp\_b*

#### roughlenheatmethod

**Description** Determines method for calculating roughness length for heat.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *RoughLenHeatMethod*

#### roughlenmommethod

**Description** Determines how aerodynamic roughness length ( $z_0$ m) and zero displacement height ( $z_{dm}$ ) are calculated.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [RoughLenMomMethod](#)

#### runofftewater

**Description** Fraction of above-ground runoff flowing to water surface during flooding [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [RunoffToWater](#)

#### s1

**Description** A parameter related to soil moisture dependence [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [S1](#)

#### s2

**Description** A parameter related to soil moisture dependence [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [S2](#)

#### sathydraulicconduct

**Description** Hydraulic conductivity for saturated soil [mm s<sup>-1</sup>]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { [Paved](#), [Bldgs](#), [EveTr](#), [DecTr](#), [Grass](#), [BSoil](#), [Water](#) }

**SUEWS-related variables** [SatHydraulicCond](#)

#### sddfll

**Description** The sensesence degree days (SDD) needed to initiate leaf off. [°C]

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { [EveTr](#), [DecTr](#), [Grass](#) }

**SUEWS-related variables** [SDDFull](#)

#### sfr\_surf

**Description** Surface cover fractions.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { [Paved](#), [Bldgs](#), [EveTr](#), [DecTr](#), [Grass](#), [BSoil](#), [Water](#) }

**SUEWS-related variables** [Fr\\_Bldgs](#), [Fr\\_Bsoil](#), [Fr\\_DecTr](#), [Fr\\_EveTr](#), [Fr\\_Grass](#), [Fr\\_Paved](#), [Fr\\_Water](#)

**smdmethod**

**Description** Determines method for calculating soil moisture deficit (SMD).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*SMDMethod\*](#)

**snowalb**

**Description** Initial snow albedo

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*SnowAlb0\*](#)

**snowalbmax**

**Description** Effective surface albedo (middle of the day value) for summertime.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*AlbedoMax\*](#)

**snowalbmin**

**Description** Effective surface albedo (middle of the day value) for wintertime (not including snow).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*AlbedoMin\*](#)

**snowdens**

**Description** Initial snow density of each land cover.

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** [\*SnowDensBldgs\*](#), [\*SnowDensPaved\*](#), [\*SnowDensDecTr\*](#),  
[\*SnowDensEveTr\*](#), [\*SnowDensGrass\*](#), [\*SnowDensBSoil\*](#), [\*SnowDensWater\*](#)

**snowdensmax**

**Description** Maximum snow density [ $\text{kg m}^{-3}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [\*SnowDensMax\*](#)

**snowdensmin**

**Description** Fresh snow density [ $\text{kg m}^{-3}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *SnowDensMin*

#### snowfrac

**Description** Initial plan area fraction of snow on each land cover`

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved, Bldgs, EveTr, DecTr, Grass, BSoil, Water* }

SUEWS-related variables *SnowFracBldgs*, *SnowFracPaved*, *SnowFracDecTr*,  
*SnowFracEveTr*, *SnowFracGrass*, *SnowFracBSoil*, *SnowFracWater*

#### snowlimbldg

**Description** Limit of the snow water equivalent for snow removal from roads and roofs [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *SnowLimRemove*

#### snowlimpaved

**Description** Limit of the snow water equivalent for snow removal from roads and roofs [mm]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

SUEWS-related variables *SnowLimRemove*

#### snowpack

**Description** Initial snow water equivalent on each land cover

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved, Bldgs, EveTr, DecTr, Grass, BSoil, Water* }

SUEWS-related variables *SnowPackBldgs*, *SnowPackPaved*, *SnowPackDecTr*,  
*SnowPackEveTr*, *SnowPackGrass*, *SnowPackBSoil*, *SnowPackWater*

#### snowpacklimit

**Description** Limit for the snow water equivalent when snow cover starts to be patchy [mm]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved, Bldgs, EveTr, DecTr, Grass, BSoil, Water* }

SUEWS-related variables *SnowLimPatch*

#### snowprof\_24hr

**Description** Hourly profile values used in snow clearing.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: { Weekday, Weekend }

SUEWS-related variables *SnowClearingProfWD*, *SnowClearingProfWE*

**snowuse**

**Description** Determines whether the snow part of the model runs.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *SnowUse*

**snowwater**

**Description** Initial amount of liquid water in the snow on each land cover

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *SnowWaterBldgsState*, *SnowWaterPavedState*,  
*SnowWaterDecTrState*, *SnowWaterEveTrState*, *SnowWaterGrassState*,  
*SnowWaterBSoilState*, *SnowWaterWaterState*

**soildepth**

**Description** Depth of soil beneath the surface [mm]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *SoilDepth*

**soilstore\_surf**

**Description** Initial water stored in soil beneath *Bldgs* surface [mm];;Initial water stored in soil beneath *Paved* surface [mm];;Initial water stored in soil beneath *DecTr* surface [mm];;Initial water stored in soil beneath *EveTr* surface [mm];;Initial water stored in soil beneath *Grass* surface [mm];;Initial water stored in soil beneath *BSoil* surface [mm]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *SoilstoreBldgsState*, *SoilstorePavedState*,  
*SoilstoreDecTrState*, *SoilstoreEveTrState*, *SoilstoreGrassState*,  
*SoilstoreBSoilState*

**soilstorecap\_surf**

**Description** Limit value for *SoilDepth* [mm]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *SoilStoreCap*

**stabilitymethod**

**Description** Defines which atmospheric stability functions are used.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *StabilityMethod*



**startdls**

**Description** Start of the day light savings [DOY]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *StartDLS*

**state\_surf**

**Description** Initial wetness condition on *Bldgs*;Initial wetness condition on *Paved*;Initial wetness condition on *DecTr*;Initial wetness condition on *EveTr*;Initial wetness condition on *Grass*;Initial wetness condition on *BSoil*;Initial wetness condition on *Water*

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *BldgsState*, *PavedState*, *DecTrState*, *EveTrState*, *GrassState*, *BSoilState*, *WaterState*

**statelimit\_surf**

**Description** Upper limit to the surface state. [mm]

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *StateLimit*

**storageheatmethod**

**Description** Determines method for calculating storage heat flux QS.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *StorageHeatMethod*

**storedrainprm**

**Description** Coefficients used in drainage calculation.

**Dimensionality** (6, 7)

**Dimensionality Remarks** 6: { *StorageMin*, *DrainageEq*, *DrainageCoef1*, *DrainageCoef2*, *StorageMax*, current storage }

7: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water* }

**SUEWS-related variables** *DrainageCoef1*, *DrainageCoef2*, *DrainageEq*, *StorageMax*, *StorageMin*

**surfacearea**

**Description** Area of the grid [ha].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *SurfaceArea*

**sw\_dn\_direct\_frac**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

**tau\_a**

**Description** Time constant for snow albedo aging in cold snow [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *tau\_a*

**tau\_f**

**Description** Time constant for snow albedo aging in melting snow [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *tau\_f*

**tau\_r**

**Description** Time constant for snow density ageing [-]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *tau\_r*

**tempmeltfact**

**Description** Hourly temperature melt factor of snow [ $\text{mm K}^{-1} \text{h}^{-1}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *TempMeltFactor*

**th**

**Description** Upper air temperature limit [ $^{\circ}\text{C}$ ]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *TH*

**theta\_bioco2**

**Description** The convexity of the curve at light saturation.

**Dimensionality** (3,)

**Dimensionality Remarks** 3: { *EveTr*, *DecTr*, *Grass* }

**SUEWS-related variables** *theta*

**timezone**

**Description** Time zone [h] for site relative to UTC (east is positive). This should be set according to the times given in the meteorological forcing file(s).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *Timezone*

**tl**

**Description** Lower air temperature limit [°C]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *TL*

**traffirate**

**Description** Traffic rate used for CO2 flux calculation.

**Dimensionality** (2,)

**Dimensionality Remarks** 2: {Weekday, Weekend}

**SUEWS-related variables** *TrafficRate\_WD, TrafficRate\_WE*

**trafficunits**

**Description** Units for the traffic rate for the study area. Not used in v2018a.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *TrafficUnits*

**traffprof\_24hr**

**Description** Hourly profile values used in traffic activity calculation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

**SUEWS-related variables** *TraffProfWD, TraffProfWE*

**tstep**

**Description** Specifies the model time step [s].

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *Tstep*

**use\_sw\_direct\_albedo**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **veg\_contact\_fraction\_const**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **veg\_fsd\_const**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **veg\_ssa\_lw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **veg\_ssa\_sw**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **veg\_type**

**Description** Internal use. Please DO NOT modify

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** None

#### **waterdist**

**Description** Fraction of water redistribution

**Dimensionality** (8, 6)

**Dimensionality Remarks** 8: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*, *Water*, one extra land cover type (currently NOT used)}

6: { *Paved*, *Bldgs*, *EveTr*, *DecTr*, *Grass*, *BSoil*}

**SUEWS-related variables** *ToBSoil*, *ToBldgs*, *ToDecTr*, *ToEveTr*, *ToGrass*, *ToPaved*, *ToRunoff*, *ToSoilStore*, *ToWater*

**waterusemethod**

**Description** Defines how external water use is calculated.

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [WaterUseMethod](#)

**wetthresh\_surf**

**Description** Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface [mm].

**Dimensionality** (7,)

**Dimensionality Remarks** 7: { [Paved](#), [Bldgs](#), [EveTr](#), [DecTr](#), [Grass](#), [BSoil](#), [Water](#) }

**SUEWS-related variables** [WetThreshold](#)

**wuprofa\_24hr**

**Description** Hourly profile values used in automatic irrigation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

**SUEWS-related variables** [WaterUseProfAutoWD](#), [WaterUseProfAutoWE](#)

**wuprofm\_24hr**

**Description** Hourly profile values used in manual irrigation.

**Dimensionality** (24, 2)

**Dimensionality Remarks** 24: hours of a day

2: {Weekday, Weekend}

**SUEWS-related variables** [WaterUseProfManuWD](#), [WaterUseProfManuWE](#)

**z**

**Description** Measurement height [m] for all atmospheric forcing variables set in [SSss\\_YYYY\\_data\\_tt.txt](#).

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [z](#)

**z0m\_in**

**Description** Roughness length for momentum [m]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** [z0](#)

**zdm\_in**

**Description** Zero-plane displacement [m]

**Dimensionality** 0

**Dimensionality Remarks** Scalar

**SUEWS-related variables** *zd*

## **df\_forcing variables**

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**Note:** Data structure of df\_forcing is explained [here](#).

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**RH**

**Description** Relative Humidity [%] (measurement height (*z*) is needed in *SUEWS\_SiteSelect.txt*)

**Tair**

**Description** Air temperature [°C] (measurement height (*z*) is needed in *SUEWS\_SiteSelect.txt*)

**U**

**Description** Wind speed [m s<sup>-1</sup>] (measurement height (*z*) is needed in *SUEWS\_SiteSelect.txt*)

**Wuh**

**Description** External water use [m<sup>3</sup>]

**fcld**

**Description** Cloud fraction [tenths]

**id**

**Description** Day of year [DOY]

**imin**

**Description** Minute [M]

**isec**

**Description** Second [S]

**it**

**Description** Hour [H]

**iy**

**Description** Year [YYYY]

**kdiff**

**Description** Diffuse radiation [W m<sup>-2</sup>] **Recommended in this version.** if *SOLWEIGUse* = 1

**kdir**

**Description** Direct radiation [W m<sup>-2</sup>] **Recommended in this version.** if *SOLWEIGUse* = 1

**kdown**

**Description** Incoming shortwave radiation [ $\text{W m}^{-2}$ ] Must be  $> 0 \text{ W m}^{-2}$ .

**lai**

**Description** Observed leaf area index [ $\text{m}^{-2} \text{ m}^{-2}$ ]

**ldown**

**Description** Incoming longwave radiation [ $\text{W m}^{-2}$ ]

**pres**

**Description** Barometric pressure [kPa] (measurement height ( $z$ ) is needed in *SUEWS\_SiteSelect.txt*)

**qe**

**Description** Latent heat flux [ $\text{W m}^{-2}$ ]

**qf**

**Description** Anthropogenic heat flux [ $\text{W m}^{-2}$ ]

**qh**

**Description** Sensible heat flux [ $\text{W m}^{-2}$ ]

**qn**

**Description** Net all-wave radiation [ $\text{W m}^{-2}$ ] (Required if *NetRadiationMethod* = 0.)

**qs**

**Description** Storage heat flux [ $\text{W m}^{-2}$ ]

**rain**

**Description** Rainfall [mm] (measurement height ( $z$ ) is needed in *SUEWS\_SiteSelect.txt*)

**snow**

**Description** Snow cover fraction ( $0 - 1$ ) [-] (Required if *SnowUse* = 1)

**wdir**

**Description** Wind direction [ $^{\circ}$ ] **Not available in this version.**

**xsm**

**Description** Observed soil moisture [ $\text{m}^3 \text{ m}^{-3}$ ] or [ $\text{kg kg}^{-1}$ ]

**df\_output variables**


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**Note:** Data structure of df\_output is explained [here](#).

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**AddWater**

**Description** Additional water flow received from other grids [mm]

**Group** SUEWS

**AlbBulk**

**Description** Bulk albedo [-]

**Group** SUEWS

**AlbDecTr**

**Description** Albedo of deciduous trees [-]

**Group** DailyState

**AlbEveTr**

**Description** Albedo of evergreen trees [-]

**Group** DailyState

**AlbGrass**

**Description** Albedo of grass [-]

**Group** DailyState

**AlbSnow**

**Description** Snow albedo [-]

**Group** DailyState

**AlbSnow**

**Description** Snow albedo [-]

**Group** SUEWS

**Azimuth**

**Description** Solar azimuth angle [°]

**Group** SUEWS

**CI**

**Description** clearness index for Ldown (Lindberg et al. 2008)

**Group** BEERS

**DLHrs**

**Description** Day length [h]

**Group** DailyState

**DaysSR**

**Description** Days since rain [days]

**Group** DailyState

**DecidCap**

**Description** Moisture storage capacity of deciduous trees [mm]

**Group** DailyState



**DensSnow\_BSoil**

**Description** Snow density – bare soil surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_BSoil**

**Description** Snow density - bare soil surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_BSoil**

**Description** Snow density – bare soil surface [kg m<sup>-3</sup>]

**Group** snow

**DensSnow\_BSoil**

**Description** Snow density - bare soil surface [kg m<sup>-3</sup>]

**Group** snow

**DensSnow\_Bldgs**

**Description** Snow density – building surface [kg m<sup>-3</sup>]

**Group** snow

**DensSnow\_Bldgs**

**Description** Snow density - building surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_Bldgs**

**Description** Snow density - building surface [kg m<sup>-3</sup>]

**Group** snow

**DensSnow\_Bldgs**

**Description** Snow density – building surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_DecTr**

**Description** Snow density – deciduous surface [kg m<sup>-3</sup>]

**Group** snow

**DensSnow\_DecTr**

**Description** Snow density - deciduous surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_DecTr**

**Description** Snow density – deciduous surface [kg m<sup>-3</sup>]

**Group** DailyState

**DensSnow\_DecTr**

**Description** Snow density - deciduous surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_EveTr**

**Description** Snow density - evergreen surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_EveTr**

**Description** Snow density – evergreen surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_EveTr**

**Description** Snow density - evergreen surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_EveTr**

**Description** Snow density – evergreen surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Grass**

**Description** Snow density - grass surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Grass**

**Description** Snow density – grass surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Grass**

**Description** Snow density - grass surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_Grass**

**Description** Snow density – grass surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_Paved**

**Description** Snow density - paved surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Paved**

**Description** Snow density – paved surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_Paved**

**Description** Snow density - paved surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_Paved**

**Description** Snow density – paved surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Water**

**Description** Snow density - water surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DensSnow\_Water**

**Description** Snow density – water surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Water**

**Description** Snow density - water surface [ $\text{kg m}^{-3}$ ]

**Group** DailyState

**DensSnow\_Water**

**Description** Snow density – water surface [ $\text{kg m}^{-3}$ ]

**Group** snow

**DiffuseRad**

**Description** Diffuse shortwave radiation

**Group** BEERS

**DirectRad**

**Description** Direct shortwave radiation

**Group** BEERS

**Drainage**

**Description** Drainage [mm]

**Group** SUEWS

**Evap**

**Description** Evaporation [mm]

**Group** SUEWS

**Fc**

**Description** CO<sub>2</sub> flux [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcBuild**

**Description** CO2 flux from buildings [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcMetab**

**Description** CO2 flux from metabolism [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcPhoto**

**Description** CO2 flux from photosynthesis [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcPoint**

**Description** CO2 flux from point source [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcRespi**

**Description** CO2 flux from respiration [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**FcTraff**

**Description** CO2 flux from traffic [ $\text{umol m}^{-2} \text{s}^{-1}$ ]

**Group** SUEWS

**Fcld**

**Description** Cloud fraction [-]

**Group** SUEWS

**FlowCh**

**Description** Additional flow into water body [mm]

**Group** SUEWS

**GDD\_DecTr**

**Description** Growing degree days for deciduous tree [ $^{\circ}\text{C d}$ ]

**Group** DailyState

**GDD\_EveTr**

**Description** Growing degree days for evergreen tree [ $^{\circ}\text{C d}$ ]

**Group** DailyState

**GDD\_Grass**

**Description** Growing degree days for grass [ $^{\circ}\text{C d}$ ]

**Group** DailyState

**GlobalRad**

**Description** Input Kdn

**Group** BEERS

**HDD1\_h**

**Description** Heating degree days [ $^{\circ}\text{C d}$ ]

**Group** DailyState

**HDD2\_c**

**Description** Cooling degree days [ $^{\circ}\text{C d}$ ]

**Group** DailyState

**HDD3\_Tmean**

**Description** Average daily air temperature in forcing data [ $^{\circ}\text{C}$ ]

**Group** DailyState

**HDD4\_T5d**

**Description** 5-day running-mean air temperature in forcing data [ $^{\circ}\text{C}$ ]

**Group** DailyState

**I0**

**Description** theoretical value of maximum incoming solar radiation

**Group** BEERS

**Irr**

**Description** Irrigation [mm]

**Group** SUEWS

**Kdown**

**Description** Incoming shortwave radiation [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**Kdown2d**

**Description** Incoming shortwave radiation at POI

**Group** BEERS

**Keast**

**Description** Shortwave radiation from east at POI

**Group** BEERS

**Knorth**

**Description** Shortwave radiation from north at POI

**Group** BEERS

**Ksouth**

**Description** Shortwave radiation from south at POI

**Group** BEERS

**Kup**

**Description** Outgoing shortwave radiation [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**Kup**

**Description** Outgoing shortwave radiation [ $\text{W m}^{-2}$ ]

**Group** SPARTACUS

**Kup2d**

**Description** Outgoing shortwave radiation at POI

**Group** BEERS

**Kwest**

**Description** Shortwave radiation from west at POI

**Group** BEERS

**LAI**

**Description** Leaf area index [ $\text{m}^2 \text{m}^{-2}$ ]

**Group** SUEWS

**LAI\_DecTr**

**Description** Leaf area index of deciduous trees [ $\text{m}^2 \text{m}^{-2}$ ]

**Group** DailyState

**LAI\_EveTr**

**Description** Leaf area index of evergreen trees [ $\text{m}^2 \text{m}^{-2}$ ]

**Group** DailyState

**LAI\_Grass**

**Description** Leaf area index of grass [ $\text{m}^2 \text{m}^{-2}$ ]

**Group** DailyState

**LAIlumps**

**Description** Leaf area index used in LUMPS (normalised 0-1) [-]

**Group** DailyState

**Ldown**

**Description** Incoming longwave radiation [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**Ldown2d**

**Description** Incoming longwave radiation at POI

**Group** BEERS

**Least**

**Description** Longwave radiation from east at POI

**Group** BEERS

**Lnorth**

**Description** Longwave radiation from north at POI

**Group** BEERS

**Lob**

**Description** Obukhov length [m]

**Group** SUEWS

**Lsouth**

**Description** Longwave radiation from south at POI

**Group** BEERS

**Lup**

**Description** Outgoing longwave radiation [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**Lup**

**Description** Outgoing longwave radiation [ $\text{W m}^{-2}$ ]

**Group** SPARTACUS

**Lup2d**

**Description** Outgoing longwave radiation at POI

**Group** BEERS

**Lwest**

**Description** Longwave radiation from west at POI

**Group** BEERS

**MeltWStore**

**Description** Meltwater store [mm]

**Group** SUEWS

**MeltWater**

**Description** Meltwater [mm]

**Group** SUEWS

**MwStore\_BSoil**

**Description** Melt water store – bare soil surface [mm]

**Group** snow

**MwStore\_Bldgs**

**Description** Melt water store – building surface [mm]

**Group** snow

**MwStore\_DecTr**

**Description** Melt water store – deciduous surface [mm]

**Group** snow

**MwStore\_EveTr**

**Description** Melt water store – evergreen surface [mm]

**Group** snow

**MwStore\_Grass**

**Description** Melt water store – grass surface [mm]

**Group** snow

**MwStore\_Paved**

**Description** Melt water store – paved surface [mm]

**Group** snow

**MwStore\_Water**

**Description** Melt water store – water surface [mm]

**Group** snow

**Mw\_BSoil**

**Description** Meltwater – bare soil surface [mm h<sup>-1</sup>]

**Group** snow

**Mw\_Bldgs**

**Description** Meltwater – building surface [mm h<sup>-1</sup>]

**Group** snow

**Mw\_DecTr**

**Description** Meltwater – deciduous surface [mm h<sup>-1</sup>]

**Group** snow

**Mw\_EveTr**

**Description** Meltwater – evergreen surface [mm h<sup>-1</sup>]

**Group** snow



**Mw\_Grass****Description** Meltwater – grass surface [ $\text{mm h}^{-1}$ ]**Group** snow**Mw\_Paved****Description** Meltwater – paved surface [ $\text{mm h}^{-1}$ ]**Group** snow**Mw\_Water****Description** Meltwater – water surface [ $\text{mm h}^{-1}$ ]**Group** snow**NWtrState****Description** Surface wetness state (for non-water surfaces) [mm]**Group** SUEWS**P\_day****Description** Daily total precipitation [mm]**Group** DailyState**Porosity****Description** Porosity of deciduous trees [-]**Group** DailyState**Q2****Description** Air specific humidity at 2 m agl [ $\text{g kg}^{-1}$ ]**Group** SUEWS**QE****Description** Latent heat flux (calculated using SUEWS) [ $\text{W m}^{-2}$ ]**Group** SUEWS**QElumps****Description** Latent heat flux (calculated using LUMPS) [ $\text{W m}^{-2}$ ]**Group** SUEWS**QF****Description** Anthropogenic heat flux [ $\text{W m}^{-2}$ ]**Group** SUEWS**QH****Description** Sensible heat flux (calculated using SUEWS) [ $\text{W m}^{-2}$ ]**Group** SUEWS

**QHlumps**

**Description** Sensible heat flux (calculated using LUMPS) [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QHresis**

**Description** Sensible heat flux (calculated using resistance method) [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QM**

**Description** Snow-related heat exchange [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QMFreeze**

**Description** Internal energy change [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QMRain**

**Description** Heat released by rain on snow [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QN**

**Description** Net all-wave radiation [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QNSnow**

**Description** Net all-wave radiation for snow area [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QNSnowFr**

**Description** Net all-wave radiation for snow-free area [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**QS**

**Description** Storage heat flux [ $\text{W m}^{-2}$ ]

**Group** SUEWS

**Qa\_BSoil**

**Description** Advective heat – bare soil surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_Bldgs**

**Description** Advective heat – building surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_DecTr**

**Description** Advective heat – deciduous surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_EveTr**

**Description** Advective heat – evergreen surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_Grass**

**Description** Advective heat – grass surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_Paved**

**Description** Advective heat – paved surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qa\_Water**

**Description** Advective heat – water surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_BSoil**

**Description** Heat related to freezing of surface store – bare soil surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_Bldgs**

**Description** Heat related to freezing of surface store – building surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_DecTr**

**Description** Heat related to freezing of surface store – deciduous surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_EveTr**

**Description** Heat related to freezing of surface store – evergreen surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_Grass**

**Description** Heat related to freezing of surface store – grass surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_Paved**

**Description** Heat related to freezing of surface store – paved surface [ $\text{W m}^{-2}$ ]

**Group** snow

**QmFr\_Water**

**Description** Heat related to freezing of surface store – water [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_BSoil**

**Description** Snowmelt-related heat – bare soil surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_Bldgs**

**Description** Snowmelt-related heat – building surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_DecTr**

**Description** Snowmelt-related heat – deciduous surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_EveTr**

**Description** Snowmelt-related heat – evergreen surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_Grass**

**Description** Snowmelt-related heat – grass surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_Paved**

**Description** Snowmelt-related heat – paved surface [ $\text{W m}^{-2}$ ]

**Group** snow

**Qm\_Water**

**Description** Snowmelt-related heat – water surface [ $\text{W m}^{-2}$ ]

**Group** snow

**RA**

**Description** Aerodynamic resistance [ $\text{s m}^{-1}$ ]

**Group** SUEWS

**RA**

**Description** Aerodynamic resistance [ $\text{s m}^{-1}$ ]

**Group** debug

**RH2**

**Description** Relative humidity at 2 m agl [%]

**Group** SUEWS

**RO****Description** Runoff [mm]**Group** SUEWS**ROImp****Description** Above ground runoff over impervious surfaces [mm]**Group** SUEWS**ROPipe****Description** Runoff to pipes [mm]**Group** SUEWS**ROSoil****Description** Runoff to soil (sub-surface) [mm]**Group** SUEWS**ROVeg****Description** Above ground runoff over vegetated surfaces [mm]**Group** SUEWS**ROWater****Description** Runoff for water body [mm]**Group** SUEWS**RS****Description** Surface resistance [ $\text{s m}^{-1}$ ]**Group** SUEWS**RS****Description** Surface resistance [ $\text{s m}^{-1}$ ]**Group** debug**Rain****Description** Rain [mm]**Group** SUEWS**RainSn\_BSoil****Description** Rain on snow – bare soil surface [mm]**Group** snow**RainSn\_Bldgs****Description** Rain on snow – building surface [mm]**Group** snow

**RainSn\_DecTr**

**Description** Rain on snow – deciduous surface [mm]

**Group** snow

**RainSn\_EveTr**

**Description** Rain on snow – evergreen surface [mm]

**Group** snow

**RainSn\_Grass**

**Description** Rain on snow – grass surface [mm]

**Group** snow

**RainSn\_Paved**

**Description** Rain on snow – paved surface [mm]

**Group** snow

**RainSn\_Water**

**Description** Rain on snow – water surface [mm]

**Group** snow

**SDD\_DecTr**

**Description** Senescence degree days for deciduous tree [°C d]

**Group** DailyState

**SDD\_EveTr**

**Description** Senescence degree days for evergreen tree [°C d]

**Group** DailyState

**SDD\_Grass**

**Description** Senescence degree days for grass [°C d]

**Group** DailyState

**SMD**

**Description** Soil moisture deficit [mm]

**Group** SUEWS

**SMDBSoil**

**Description** Soil moisture deficit for bare soil surface [mm]

**Group** SUEWS

**SMDBldgs**

**Description** Soil moisture deficit for building surface [mm]

**Group** SUEWS

**SMDDecTr**

**Description** Soil moisture deficit for deciduous surface [mm]

**Group** SUEWS

**SMDEveTr**

**Description** Soil moisture deficit for evergreen surface [mm]

**Group** SUEWS

**SMDGrass**

**Description** Soil moisture deficit for grass surface [mm]

**Group** SUEWS

**SMDPaved**

**Description** Soil moisture deficit for paved surface [mm]

**Group** SUEWS

**SWE**

**Description** Snow water equivalent [mm]

**Group** SUEWS

**SWE\_BSoil**

**Description** Snow water equivalent – bare soil surface [mm]

**Group** snow

**SWE\_Bldgs**

**Description** Snow water equivalent – building surface [mm]

**Group** snow

**SWE\_DecTr**

**Description** Snow water equivalent – deciduous surface [mm]

**Group** snow

**SWE\_EveTr**

**Description** Snow water equivalent – evergreen surface [mm]

**Group** snow

**SWE\_Grass**

**Description** Snow water equivalent – grass surface [mm]

**Group** snow

**SWE\_Paved**

**Description** Snow water equivalent – paved surface [mm]

**Group** snow

**SWE\_Water**

**Description** Snow water equivalent – water surface [mm]

**Group** snow

**Sd\_BSoil**

**Description** Snow depth – bare soil surface [mm]

**Group** snow

**Sd\_Bldgs**

**Description** Snow depth – building surface [mm]

**Group** snow

**Sd\_DecTr**

**Description** Snow depth – deciduous surface [mm]

**Group** snow

**Sd\_EveTr**

**Description** Snow depth – evergreen surface [mm]

**Group** snow

**Sd\_Grass**

**Description** Snow depth – grass surface [mm]

**Group** snow

**Sd\_Paved**

**Description** Snow depth – paved surface [mm]

**Group** snow

**Sd\_Water**

**Description** Snow depth – water surface [mm]

**Group** snow

**SnowCh**

**Description** Change in snow pack [mm]

**Group** SUEWS

**SnowRBldgs**

**Description** Snow removed from building surface [mm]

**Group** SUEWS

**SnowRPaved**

**Description** Snow removed from paved surface [mm]

**Group** SUEWS



**StBSoil**

**Description** Surface wetness state for bare soil surface [mm]

**Group** SUEWS

**StBldgs**

**Description** Surface wetness state for building surface [mm]

**Group** SUEWS

**StDecTr**

**Description** Surface wetness state for deciduous tree surface [mm]

**Group** SUEWS

**StEveTr**

**Description** Surface wetness state for evergreen tree surface [mm]

**Group** SUEWS

**StGrass**

**Description** Surface wetness state for grass surface [mm]

**Group** SUEWS

**StPaved**

**Description** Surface wetness state for paved surface [mm]

**Group** SUEWS

**StWater**

**Description** Surface wetness state for water surface [mm]

**Group** SUEWS

**State**

**Description** Surface wetness state [mm]

**Group** SUEWS

**SurfCh**

**Description** Change in surface moisture store [mm]

**Group** SUEWS

**T2**

**Description** Air temperature at 2 m agl [°C]

**Group** SUEWS

**T\_1**

**Description** Air temperature at level 1 [°C]

**Group** RSL

**T\_10**

**Description** Air temperature at level 10 [°C]

**Group** RSL

**T\_11**

**Description** Air temperature at level 11 [°C]

**Group** RSL

**T\_12**

**Description** Air temperature at level 12 [°C]

**Group** RSL

**T\_13**

**Description** Air temperature at level 13 [°C]

**Group** RSL

**T\_14**

**Description** Air temperature at level 14 [°C]

**Group** RSL

**T\_15**

**Description** Air temperature at level 15 [°C]

**Group** RSL

**T\_16**

**Description** Air temperature at level 16 [°C]

**Group** RSL

**T\_17**

**Description** Air temperature at level 17 [°C]

**Group** RSL

**T\_18**

**Description** Air temperature at level 18 [°C]

**Group** RSL

**T\_19**

**Description** Air temperature at level 19 [°C]

**Group** RSL

**T\_2**

**Description** Air temperature at level 2 [°C]

**Group** RSL

**T\_20****Description** Air temperature at level 20 [°C]**Group** RSL**T\_21****Description** Air temperature at level 21 [°C]**Group** RSL**T\_22****Description** Air temperature at level 22 [°C]**Group** RSL**T\_23****Description** Air temperature at level 23 [°C]**Group** RSL**T\_24****Description** Air temperature at level 24 [°C]**Group** RSL**T\_25****Description** Air temperature at level 25 [°C]**Group** RSL**T\_26****Description** Air temperature at level 26 [°C]**Group** RSL**T\_27****Description** Air temperature at level 27 [°C]**Group** RSL**T\_28****Description** Air temperature at level 28 [°C]**Group** RSL**T\_29****Description** Air temperature at level 29 [°C]**Group** RSL**T\_3****Description** Air temperature at level 3 [°C]**Group** RSL

**T\_30****Description** Air temperature at level 30 [°C]**Group** RSL**T\_4****Description** Air temperature at level 4 [°C]**Group** RSL**T\_5****Description** Air temperature at level 5 [°C]**Group** RSL**T\_6****Description** Air temperature at level 6 [°C]**Group** RSL**T\_7****Description** Air temperature at level 7 [°C]**Group** RSL**T\_8****Description** Air temperature at level 8 [°C]**Group** RSL**T\_9****Description** Air temperature at level 9 [°C]**Group** RSL**Ta****Description** Air temperature**Group** BEERS**Tg****Description** Surface temperature**Group** BEERS**Tmax****Description** Daily maximum temperature in forcing data [°C]**Group** DailyState**Tmin****Description** Daily minimum temperature in forcing data [°C]**Group** DailyState

**Tmrt**

**Description** Mean Radiant Temperature

**Group** BEERS

**TotCh**

**Description** Change in surface and soil moisture stores [mm]

**Group** SUEWS

**Ts**

**Description** Skin temperature [°C]

**Group** SUEWS

**Tsnow\_BSoil**

**Description** Snow surface temperature – bare soil surface [°C]

**Group** snow

**Tsnow\_Bldgs**

**Description** Snow surface temperature – building surface [°C]

**Group** snow

**Tsnow\_DecTr**

**Description** Snow surface temperature – deciduous surface [°C]

**Group** snow

**Tsnow\_EveTr**

**Description** Snow surface temperature – evergreen surface [°C]

**Group** snow

**Tsnow\_Grass**

**Description** Snow surface temperature – grass surface [°C]

**Group** snow

**Tsnow\_Paved**

**Description** Snow surface temperature – paved surface [°C]

**Group** snow

**Tsnow\_Water**

**Description** Snow surface temperature – water surface [°C]

**Group** snow

**Tsurf**

**Description** Bulk surface temperature [°C]

**Group** SUEWS

**U10**

**Description** Wind speed at 10 m agl [m s<sup>-1</sup>]

**Group** SUEWS

**U\_1**

**Description** Wind speed at level 1 [m s<sup>-1</sup>]

**Group** RSL

**U\_10**

**Description** Wind speed at level 10 [m s<sup>-1</sup>]

**Group** RSL

**U\_11**

**Description** Wind speed at level 11 [m s<sup>-1</sup>]

**Group** RSL

**U\_12**

**Description** Wind speed at level 12 [m s<sup>-1</sup>]

**Group** RSL

**U\_13**

**Description** Wind speed at level 13 [m s<sup>-1</sup>]

**Group** RSL

**U\_14**

**Description** Wind speed at level 14 [m s<sup>-1</sup>]

**Group** RSL

**U\_15**

**Description** Wind speed at level 15 [m s<sup>-1</sup>]

**Group** RSL

**U\_16**

**Description** Wind speed at level 16 [m s<sup>-1</sup>]

**Group** RSL

**U\_17**

**Description** Wind speed at level 17 [m s<sup>-1</sup>]

**Group** RSL

**U\_18**

**Description** Wind speed at level 18 [m s<sup>-1</sup>]

**Group** RSL

**U\_19**

**Description** Wind speed at level 19 [m s<sup>-1</sup>]

**Group** RSL

**U\_2**

**Description** Wind speed at level 2 [m s<sup>-1</sup>]

**Group** RSL

**U\_20**

**Description** Wind speed at level 20 [m s<sup>-1</sup>]

**Group** RSL

**U\_21**

**Description** Wind speed at level 21 [m s<sup>-1</sup>]

**Group** RSL

**U\_22**

**Description** Wind speed at level 22 [m s<sup>-1</sup>]

**Group** RSL

**U\_23**

**Description** Wind speed at level 23 [m s<sup>-1</sup>]

**Group** RSL

**U\_24**

**Description** Wind speed at level 24 [m s<sup>-1</sup>]

**Group** RSL

**U\_25**

**Description** Wind speed at level 25 [m s<sup>-1</sup>]

**Group** RSL

**U\_26**

**Description** Wind speed at level 26 [m s<sup>-1</sup>]

**Group** RSL

**U\_27**

**Description** Wind speed at level 27 [m s<sup>-1</sup>]

**Group** RSL

**U\_28**

**Description** Wind speed at level 28 [m s<sup>-1</sup>]

**Group** RSL

U\_29

**Description** Wind speed at level 29 [m s<sup>-1</sup>]

**Group** RSL

U\_3

**Description** Wind speed at level 3 [m s<sup>-1</sup>]

**Group** RSL

U\_30

**Description** Wind speed at level 30 [m s<sup>-1</sup>]

**Group** RSL

U\_4

**Description** Wind speed at level 4 [m s<sup>-1</sup>]

**Group** RSL

U\_5

**Description** Wind speed at level 5 [m s<sup>-1</sup>]

**Group** RSL

U\_6

**Description** Wind speed at level 6 [m s<sup>-1</sup>]

**Group** RSL

U\_7

**Description** Wind speed at level 7 [m s<sup>-1</sup>]

**Group** RSL

U\_8

**Description** Wind speed at level 8 [m s<sup>-1</sup>]

**Group** RSL

U\_9

**Description** Wind speed at level 9 [m s<sup>-1</sup>]

**Group** RSL

WUDecTr

**Description** Water use for irrigation of deciduous trees [mm]

**Group** SUEWS

WUEveTr

**Description** Water use for irrigation of evergreen trees [mm]

**Group** SUEWS



**WUGrass**

**Description** Water use for irrigation of grass [mm]

**Group** SUEWS

**WUInt**

**Description** Internal water use [mm]

**Group** SUEWS

**WU\_DecTr1**

**Description** Total water use for deciduous trees [mm]

**Group** DailyState

**WU\_DecTr2**

**Description** Automatic water use for deciduous trees [mm]

**Group** DailyState

**WU\_DecTr3**

**Description** Manual water use for deciduous trees [mm]

**Group** DailyState

**WU\_EveTr1**

**Description** Total water use for evergreen trees [mm]

**Group** DailyState

**WU\_EveTr2**

**Description** Automatic water use for evergreen trees [mm]

**Group** DailyState

**WU\_EveTr3**

**Description** Manual water use for evergreen trees [mm]

**Group** DailyState

**WU\_Grass1**

**Description** Total water use for grass [mm]

**Group** DailyState

**WU\_Grass2**

**Description** Automatic water use for grass [mm]

**Group** DailyState

**WU\_Grass3**

**Description** Manual water use for grass [mm]

**Group** DailyState

**Zenith**

**Description** Solar zenith angle [°]

**Group** SUEWS

**a1**

**Description** OHM coefficient a1 - [-]

**Group** DailyState

**a2**

**Description** OHM coefficient a2 [ $\text{W m}^{-2} \text{h}^{-1}$ ]

**Group** DailyState

**a3**

**Description** OHM coefficient a3 - [ $\text{W m}^{-2}$ ]

**Group** DailyState

**altitude**

**Description** Altitude angle of the Sun

**Group** BEERS

**azimuth**

**Description** Azimuth angle of the Sun

**Group** BEERS

**deltaLAI**

**Description** Change in leaf area index (normalised 0-1) [-]

**Group** DailyState

**frMelt\_BSoil**

**Description** Amount of freezing melt water – bare soil surface [mm]

**Group** snow

**frMelt\_Bldgs**

**Description** Amount of freezing melt water – building surface [mm]

**Group** snow

**frMelt\_DecTr**

**Description** Amount of freezing melt water – deciduous surface [mm]

**Group** snow

**frMelt\_EveTr**

**Description** Amount of freezing melt water – evergreen surface [mm]

**Group** snow

**frMelt\_Grass**

**Description** Amount of freezing melt water – grass surface [mm]

**Group** snow

**frMelt\_Paved**

**Description** Amount of freezing melt water – paved surface [mm]

**Group** snow

**frMelt\_Water**

**Description** Amount of freezing melt water – water surface [mm]

**Group** snow

**fr\_Bldgs**

**Description** Fraction of snow – building surface [-]

**Group** snow

**fr\_DecTr**

**Description** Fraction of snow – deciduous surface [-]

**Group** snow

**fr\_EveTr**

**Description** Fraction of snow – evergreen surface [-]

**Group** snow

**fr\_Grass**

**Description** Fraction of snow – grass surface [-]

**Group** snow

**fr\_Paved**

**Description** Fraction of snow – paved surface [-]

**Group** snow

**kup\_BSoilSnow**

**Description** Reflected shortwave radiation – bare soil surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_BldgsSnow**

**Description** Reflected shortwave radiation – building surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_DecTrSnow**

**Description** Reflected shortwave radiation – deciduous surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_EveTrSnow**

**Description** Reflected shortwave radiation – evergreen surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_GrassSnow**

**Description** Reflected shortwave radiation – grass surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_PavedSnow**

**Description** Reflected shortwave radiation – paved surface [ $\text{W m}^{-2}$ ]

**Group** snow

**kup\_WaterSnow**

**Description** Reflected shortwave radiation – water surface [ $\text{W m}^{-2}$ ]

**Group** snow

**q\_1**

**Description** Specific humidity at level 1 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_10**

**Description** Specific humidity at level 10 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_11**

**Description** Specific humidity at level 11 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_12**

**Description** Specific humidity at level 12 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_13**

**Description** Specific humidity at level 13 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_14**

**Description** Specific humidity at level 14 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_15**

**Description** Specific humidity at level 15 [ $\text{g kg}^{-1}$ ]

**Group** RSL

**q\_16**

**Description** Specific humidity at level 16 [g kg<sup>-1</sup>]

**Group** RSL

**q\_17**

**Description** Specific humidity at level 17 [g kg<sup>-1</sup>]

**Group** RSL

**q\_18**

**Description** Specific humidity at level 18 [g kg<sup>-1</sup>]

**Group** RSL

**q\_19**

**Description** Specific humidity at level 19 [g kg<sup>-1</sup>]

**Group** RSL

**q\_2**

**Description** Specific humidity at level 2 [g kg<sup>-1</sup>]

**Group** RSL

**q\_20**

**Description** Specific humidity at level 20 [g kg<sup>-1</sup>]

**Group** RSL

**q\_21**

**Description** Specific humidity at level 21 [g kg<sup>-1</sup>]

**Group** RSL

**q\_22**

**Description** Specific humidity at level 22 [g kg<sup>-1</sup>]

**Group** RSL

**q\_23**

**Description** Specific humidity at level 23 [g kg<sup>-1</sup>]

**Group** RSL

**q\_24**

**Description** Specific humidity at level 24 [g kg<sup>-1</sup>]

**Group** RSL

**q\_25**

**Description** Specific humidity at level 25 [g kg<sup>-1</sup>]

**Group** RSL

q\_26

**Description** Specific humidity at level 26 [g kg<sup>-1</sup>]

**Group** RSL

q\_27

**Description** Specific humidity at level 27 [g kg<sup>-1</sup>]

**Group** RSL

q\_28

**Description** Specific humidity at level 28 [g kg<sup>-1</sup>]

**Group** RSL

q\_29

**Description** Specific humidity at level 29 [g kg<sup>-1</sup>]

**Group** RSL

q\_3

**Description** Specific humidity at level 3 [g kg<sup>-1</sup>]

**Group** RSL

q\_30

**Description** Specific humidity at level 30 [g kg<sup>-1</sup>]

**Group** RSL

q\_4

**Description** Specific humidity at level 4 [g kg<sup>-1</sup>]

**Group** RSL

q\_5

**Description** Specific humidity at level 5 [g kg<sup>-1</sup>]

**Group** RSL

q\_6

**Description** Specific humidity at level 6 [g kg<sup>-1</sup>]

**Group** RSL

q\_7

**Description** Specific humidity at level 7 [g kg<sup>-1</sup>]

**Group** RSL

q\_8

**Description** Specific humidity at level 8 [g kg<sup>-1</sup>]

**Group** RSL

**q\_9**

**Description** Specific humidity at level 9 [g kg<sup>-1</sup>]

**Group** RSL

**z0m**

**Description** Roughness length for momentum [m]

**Group** SUEWS

**z\_1**

**Description** Height at level 1 [m]

**Group** RSL

**z\_10**

**Description** Height at level 10 [m]

**Group** RSL

**z\_11**

**Description** Height at level 11 [m]

**Group** RSL

**z\_12**

**Description** Height at level 12 [m]

**Group** RSL

**z\_13**

**Description** Height at level 13 [m]

**Group** RSL

**z\_14**

**Description** Height at level 14 [m]

**Group** RSL

**z\_15**

**Description** Height at level 15 [m]

**Group** RSL

**z\_16**

**Description** Height at level 16 [m]

**Group** RSL

**z\_17**

**Description** Height at level 17 [m]

**Group** RSL

**z\_18**

**Description** Height at level 18 [m]

**Group** RSL

**z\_19**

**Description** Height at level 19 [m]

**Group** RSL

**z\_2**

**Description** Height at level 2 [m]

**Group** RSL

**z\_20**

**Description** Height at level 20 [m]

**Group** RSL

**z\_21**

**Description** Height at level 21 [m]

**Group** RSL

**z\_22**

**Description** Height at level 22 [m]

**Group** RSL

**z\_23**

**Description** Height at level 23 [m]

**Group** RSL

**z\_24**

**Description** Height at level 24 [m]

**Group** RSL

**z\_25**

**Description** Height at level 25 [m]

**Group** RSL

**z\_26**

**Description** Height at level 26 [m]

**Group** RSL

**z\_27**

**Description** Height at level 27 [m]

**Group** RSL



**z\_28**

**Description** Height at level 28 [m]

**Group** RSL

**z\_29**

**Description** Height at level 29 [m]

**Group** RSL

**z\_3**

**Description** Height at level 3 [m]

**Group** RSL

**z\_30**

**Description** Height at level 30 [m]

**Group** RSL

**z\_4**

**Description** Height at level 4 [m]

**Group** RSL

**z\_5**

**Description** Height at level 5 [m]

**Group** RSL

**z\_6**

**Description** Height at level 6 [m]

**Group** RSL

**z\_7**

**Description** Height at level 7 [m]

**Group** RSL

**z\_8**

**Description** Height at level 8 [m]

**Group** RSL

**z\_9**

**Description** Height at level 9 [m]

**Group** RSL

**zdm**

**Description** Zero-plane displacement height [m]

**Group** SUEWS

## FAQ

### Contents

- *I cannot install SuPy following the docs, what is wrong there?*
- *How do I know which version of SuPy I am using?*
- *A kernel may have died exception happened, where did I go wrong?*
- *How can I upgrade SuPy to an up-to-date version?*
- *How to deal with `KeyError` when trying to load initial model states?*

### I cannot install SuPy following the docs, what is wrong there?

please check if your environment meets the following requirements:

1. Operating system (OS):

- a. is it 64 bit? only 64 bit systems are supported.
- b. is your OS up to date? only recent desktop systems are supported:
  - Windows 10 and above
  - macOS 10.13 and above
  - Linux: no restriction; If SuPy cannot run on your specific Linux distribution, please report it to us.

You can get the OS information with the following code:

```
import platform
platform.platform()
```

2. Python interpreter:

- a. is your Python interpreter 64 bit?

Check running mode with the following code:

```
import struct
struct.calcsize('P')*8
```

- b. is your Python version above 3.5?

Check version info with the following code:

```
import sys
sys.version
```

If your environment doesn't meet the requirement by SuPy, please use a proper environment; otherwise, **`please report your issue`**\_\_.

## How do I know which version of SuPy I am using?

Use the following code:

```
import supy
supy.show_version()
```

---

**Note:** `show_version` is only available after v2019.5.28.

---

## A kernel may have died exception happened, where did I go wrong?

The issue is highly likely due to invalid input to SuPy and SUEWS kernel. We are trying to avoid such exceptions, but unfortunately they might happen in some edge cases.

Please [report such issues to us](#) with your input files for debugging. Thanks!

## How can I upgrade SuPy to an up-to-date version?

Run the following code in your terminal:

```
python3 -m pip install supy --upgrade
```

## How to deal with KeyError when trying to load initial model states?

Please see [:issue:`28`](#)

## Version History

### Version 2022.9.22

- **New**
  - Added experimental support SPARTACUS module.
- **Improvement**
  - None.
- **Changes**
  - None.
- **Fix**
  - None.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

## Version 2021.11.22

- **New**  
None.
- **Improvement**  
None.
- **Changes**  
None.
- **Fix**
  1. Fixed an issue in incorrect pressure unit in *gen\_forcing\_era5* for pressure mode. (Thank to @XiaoxiongXie for fixing via **:PR: #39**)
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

## Version 2021.11.20

- **New**
  1. Added option `pressure_level` in *gen\_forcing\_era5*.
- **Improvement**  
None.
- **Changes**  
None.
- **Fix**
  1. Fixed an issue in generating ERA5 forcing due to xarray update in merge.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

**Version 2021.7.22**

- **New**  
None.
- **Improvement**  
None.
- **Changes**  
None.
- **Fix**
  1. Fixed an issue in loading parameter table caused by recent update of pandas to 1.3.x.
  2. Fixed an issue in ERA5 download due to renaming of orography to geopotential.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

**Version 2021.5.26**

- **New**
  1. Update supy-driver to 2021a iteration.
- **Improvement**
  1. a new method for calculating roughness length for momentum and displacement height (roughlenmommeth=4) based on plan area index as illustrated in figure 1a of GO99.
- **Changes**  
None.
- **Fix**  
None.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

### Version 2020.11.3

- **New**
  1. Update supy-driver to 2020b iteration.
  2. Add function for plotting RSL variables `supy.util.plot_rsl`.
- **Improvement**
  1. The RSL related functions are more robust in dealing with broader urban morphology settings.
  2. Internal changes to conform with recent upgrades in `pandas`.
- **Changes**

None.
- **Fix**
  1. Fix an issue in `supy.util.read_forcing` that improper resampling could be conducted if input temporal resolution is the same as the desirable resampling time step `tstep_mod`.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

### Version 2020.5.29

- **New**
  1. Update supy-driver to 2020a iteration.
  2. Add function for plotting RSL variables `supy.util.plot_rsl`.
- **Improvement**

None.
- **Changes**

None.
- **Fix**
  1. Fix the humidity variable in ERA5-based forcing generation.
  2. Fix the impact study tutorial.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

## Version 2020.2.2

- **New**
  1. A checker to validate input DataFrame`s. See option ``check_input`` in [run\\_supy](#).
  2. Utilities to generate forcing data using ERA-5 data. See [download\\_era5](#) and [gen\\_forcing\\_era5](#).
- **Improvement**
  1. Improved performance of the parallel mode.
- **Changes**

None.
- **Fix**

None.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Simulation in parallel mode is NOT supported on Windows due to system limitation.

## Version 2019.8.29

- **New**
  1. added WRF-SUEWS related functions.
  2. added [diagnostics of canyon profiles](#).
- **Improvement**

None.
- **Changes**
  1. synchronised with v2019a interface: minimum supy\_driver v2019a2.
- **Fix**

None.
- **Known issue**
  1. ESTM is not supported yet.
  2. BLUEWS, a CBL modules in SUEWS, is not supported yet.
  3. Performance in parallel mode can be worse than serial mode sometimes due to heavy (de)-serialisation loads.

### Version 2019.7.17

- **New**
  1. added OHM related functions.
  2. added surface conductance related functions.
- **Improvement**

None.
- **Changes**

None.
- **Fix**
  1. Fixed a bug in unit conversion for TMY data generation.
- **Known issue**

ESTM is not supported yet.

### Version 2019.6.8

- **New**

None.
- **Improvement**

None.
- **Changes**

None.
- **Fix**
  1. Fixed a bug in rescaling Kdown when loading forcing data.
- **Known issue**

ESTM is not supported yet.

### Version 2019.5.28

Spring house cleaning with long-await command line tools (more on the way!).

- **New**
  1. Added version info function: `show_version`.
  2. Added command line tools:
    - `suews-run`: SuPy wrapper to mimic SUEWS-binary-based simulation.
    - `suews-convert`: convert input tables from older versions to newer ones (one-way only).
- **Improvement**

None.



- **Changes**

None.

- **Fix**

1. Fixed a bug in writing out multi-grid output files caused by incorrect dropping of temporal information by pandas .

- **Known issue**

ESTM is not supported yet.

### Version 2019.4.29

Parallel run.

- **New**

Added support for parallel run on the fly.

- **Improvement**

None.

- **Changes**

None.

- **Fix**

None.

- **Known issue**

None

### Version 2019.4.17

UMEP compatibility tweaks.

- **New**

None.

- **Improvement**

None.

- **Changes**

*Error messages: [problems.txt](#)* will be written out in addition to the console error message similarly as SUEWS binary.

- **Fix**

Incorrect caching of input libraries.

- **Known issue**

None

### Version 2019.4.15

ERA-5 download.

- **New**  
Added experimental support for downloading and processing ERA-5 data to force supy simulations.
- **Improvement**  
Improved compatibility with earlier `pandas` version in resampling output.
- **Changes**  
None.
- **Fix**  
None.
- **Known issue**  
None

### Version 2019.3.21

TMY generation.

- **New**  
Added preliminary support for generating TMY dataset with SuPy output.
- **Improvement**  
None.
- **Changes**  
None.
- **Fix**  
None.
- **Known issue**  
None

### Version 2019.3.14

This release improved memory usage.

- **New**  
None.
- **Improvement**  
Optimised memory consumption for longterm simulations.
- **Changes**  
None.

- **Fix**  
None.
- **Known issue**  
None

### Version 2019.2.25

This release dropped support for Python 3.5 and below.

- **New**  
None.
- **Improvement**  
None.
- **Changes**  
Dropped support for Python 3.5 and below.
- **Fix**  
None.
- **Known issue**  
None

### Version 2019.2.24

This release added the ability to save output files.

- **New**
  1. Added support to save output files. See: [`supy.save\_supy\(\)`](#)
  2. Added support to initialise SuPy from saved `df_state.csv`. See: [`supy.init\_supy\(\)`](#)
- **Improvement**  
None.
- **Changes**  
None.
- **Fix**  
None.
- **Known issue**  
None

## Version 2019.2.19

This is a release that improved the exception handling due to fatal error in `supy_driver`.

- **New**

Added support to handle python kernel crash caused by fatal error in `supy_driver` kernel; so python kernel won't crash any more even `supy_driver` is stopped.

- **Improvement**

None.

- **Changes**

None

- **Fix**

None.

- **Known issue**

None

## Version 2019.2.8

This is a release that fixes recent bugs found in SUEWS that may lead to abnormal simulation results of storage heat flux, in particular when [SnowUse](#) is enabled (i.e., `snowuse=1`).

- **New**

None.

- **Improvement**

Improved the performance in loading initial model state from a large number of grids (>1k)

- **Changes**

Updated `SampleRun` dataset by: 1. setting surface fractions (`sfr`) to a more realistic value based on London KCL case; 2. enabling snow module (`snowuse=1`).

- **Fix**

1. Fixed a bug in the calculation of storage heat flux.
2. Fixed a bug in loading `popdens` for calculating anthropogenic heat flux.

- **Known issue**

None

**Version 2019.1.1 (preview release, 01 Jan 2019)**

- **New**
  1. Slimmed the output groups by excluding unsupported *ESTM* results
  2. SuPy documentation
    - Key IO data structures documented:
    - *df\_output variables* (:issue:`9`)
    - *df\_state variables* (:issue:`8`)
    - *df\_forcing variables* (:issue:`7`)
    - Tutorial of parallel SuPy simulations for impact studies
- **Improvement**
  1. Improved calculation of OHM-related radiation terms
- **Changes**

None.
- **Fix**

None
- **Known issue**

None

Version 2018.12.15 (internal test release in December 2018) —————=====

- **New**
  1. Preview release of SuPy based on the computation kernel of SUEWS 2018b
- **Improvement**
  1. Improved calculation of OHM-related radiation terms
- **Changes**

None.
- **Fix**

None
- **Known issue**
  1. The heat storage modules AnOHM and ESTM are not supported yet.

## 7.6.2 SUEWS in UMEP

SUEWS can be run as a standalone model but also can be used within UMEP. There are numerous tools included within UMEP to help a user get started. The **SUEWS (Simple)** within UMEP is a fast way to start using SUEWS.

The version of SUEWS within UMEP is the complete model. Thus all options that are listed in this manual are available to the user. In the UMEP **SUEWS (Simple)** runs all options are set to values to allow initial exploration of the model behaviour.

- **Pre-Processor**

- **Meteorological Data**

- \* **Prepare Existing Data** Transforms meteorological data into UMEP format
    - \* **Download data (WATCH)** Prepare meteorological dataset from *WATCH*

- **Spatial Data**

- \* **Spatial Data Downloader** Plugin for retrieving geodata from online services suitable for various UMEP related tools - **LCZ Converter** Conversion from Local Climate Zones (LCZs) in the WUDAPT database into SUEWS input data

- **Urban land cover**

- \* **Land Cover Reclassifier** Reclassifies a grid into UMEP format land cover grid. Land surface models
    - \* **Land Cover Fraction (Point)** Land cover fractions estimates from a land cover grid based on a specific point in space
    - \* **Land Cover Fraction (Grid)** Land cover fractions estimates from a land cover grid based on a polygon grid

- **Urban Morphology**

- \* **Morphometric Calculator (Point)** Morphometric parameters from a DSM based on a specific point in space
    - \* **Morphometric Calculator (Grid)** Morphometric parameters estimated from a DSM based on a polygon grid
    - \* **Source Area Model (Point)** Source area calculated from a DSM based on a specific point in space.

- **SUEWS input data**

- \* **SUEWS Prepare** Preprocessing and preparing input data for the SUEWS model

- **Processor**

- **Anthropogenic Heat ( $Q_F$ )**

- \* **LQF** Spatial variations anthropogenic heat release for urban areas
    - \* **GQF** Anthropogenic Heat ( $Q_F$ ).

- **Urban Energy Balance**

- \* **SUEWS (Simple)** Urban Energy and Water Balance.
    - \* **SUEWS (Advanced)** Urban Energy and Water Balance.

- **Post-Processor**

- **Urban Energy Balance**

- \* **SUEWS analyser** Plugin for plotting and statistical analysis of model results from SUEWS simple and SUEWS advanced

– **Benchmark**

- \* **Benchmark System** For statistical analysis of model results, such as SUEWS

### 7.6.3 Differences between SUEWS and LUMPS

The largest difference between LUMPS and SUEWS is that the latter simulates the urban water balance in detail while LUMPS takes a simpler approach for the sensible and latent heat fluxes and the water balance (“water bucket”). The calculation of evaporation/latent heat in SUEWS is more biophysically based. Due to its simplicity, LUMPS requires less parameters in order to run. SUEWS gives turbulent heat fluxes calculated with both models as an output.

Similarities and differences between LUMPS and SUEWS.

|                                  | LUMPS   | SUEWS  |
|----------------------------------|---|--|
| Net all-wave radiation ( $Q^*$ ) | Input or NARP                                   | Input or NARP  |
| Storage heat flux (QS)           | Input or from OHM                               | Input or from OHM  |
| Anthropogenic heat flux (QF)     | Input or calculated                             | Input or calculated  |
| Latent heat (QE)                 | DeBruin and Holtslag (1982)                     | Penman-Monteith equation2  |
| Sensible heat flux (QH)          | DeBruin and Holtslag (1982)                     | Residual from available energy minus QE  |
| Water balance                    | No water balance included                       | Running water balance of canopy and water balance of soil                                |
| Soil moisture                    | Not considered                                  | Modelled   |
| Surface wetness                  | Simple water bucket model                       | Running water balance  |
| Irrigation                       | Only fraction of surface area that is irrigated | Input or calculated with a simple model  |
| Surface cover                    | Buildings, paved, vegetation                    | Buildings, paved, coniferous and deciduous trees/shrubs, irrigated and unirrigated grass |

### 7.6.4 Differences between SUEWS and FRAISE

FRAISE, Flux Ratio – Active Index Surface Exchange scheme, provides an estimate of mean midday ( $\pm 3$  h around solar noon) energy partitioning from information on the surface characteristics and estimates of the mean midday incoming radiative energy and anthropogenic heat release. Please refer to Loridan and Grimmond [2012] for further details.

| Topic             | FRAISE   | LUMPS                            | SUEWS   |
|-------------------|--|----------------------------------|---|
| Complexity        | Simplest   | Moderate                         | More complex  |
| Software provided | R code   | Windows exe (written in Fortran) | Windows exe (written in Fortran) - other versions available |
| Applicable period | Midday (within 3 h of solar noon)<br>Calculates active surface | hourly                           | 5 min-hourly-annual   |
| Unique features   | Calculates active surface and fluxes                           | Radiation and energy balances    | Radiation, energy and water balance (includes LUMPS)        |

## 7.7 Tutorials

### 7.7.1 SUEWS

To help users getting started with SUEWS, the community is working on setting up tutorials and instructions for different parts of SUEWS and related tool.

The tutorials are available are found in the table below.

---

**Note:** the following tutorials are hosted on a separate website including other UMEP related tutorials.

---

| Topic                               | Application   |
|-------------------------------------|---|
| <a href="#">IntroductionToSuews</a> | Energy, water and radiation fluxes for one location               |
| <a href="#">SUEWSAdvanced</a>       | Energy, water and radiation fluxes for one location               |
| <a href="#">SUEWSSpatial</a>        | Energy, water and radiation fluxes for a spatial grid             |
| <a href="#">SUEWSWUDAPT</a>         | Making use of <a href="#">WUDAPT</a> local climate zones in SUEWS |

### 7.7.2 SuPy

For Python users, a Python package [SuPy](#) with SUEWS as the calculation kernel is available to conduct SUEWS simulations. SuPy tutorials are provided at [its tutorial site](#).

## 7.8 Benchmark Report

Since [v2018a](#), SUEWS is benchmarked against observations for assessment of model performance. A site based benchmark report generation system is introduced in [v2018c](#) to produce detailed reports for testing sites; the number of sites is expanding and more cases will be added as they are benchmarked.

Each report includes the following parts:

1. **Overall performance:**

1. Performance Score: Large scores indicate better performance. The scores are calculated according to weighted averages of statistics for selected benchmark variables.
2. Detailed Statistics: Grids are coloured based relative performance between different versions: a **greener** grid indicates better performance in the chosen variable using the specific release whereas a **redder** one shows poorer performance; and those with **gray** backgrounds indicate the same performance across different releases.

2. **Cross-comparison in model variables between releases:**

1. Detailed statistics tables: statistics for each variable.
2. Pair plots: comparison in simulation results between different version-pairs.
3. Time series plots: comparison in simulated monthly climatologies of diurnal cycles of each variable between different version-pairs.

The latest benchmark reports are available at [the SUEWS Benchmark site](#).



## 7.9 Notation

**F** Frontal area index

**QS** Storage heat flux

**BLUEWS** Boundary Layer part of SUEWS

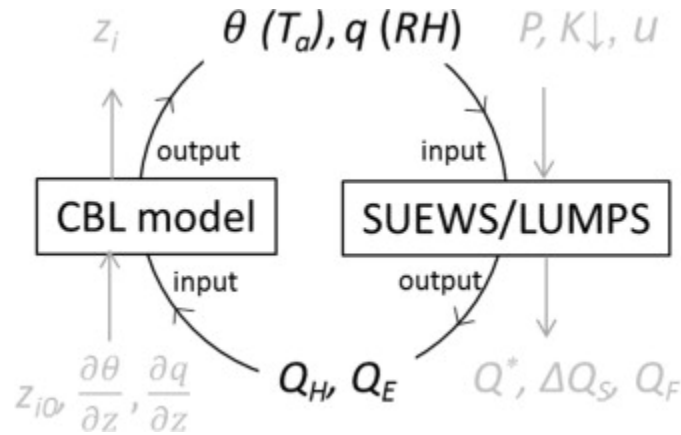


Fig. 7.3: Relation between BLUEWS and SUEWS

**CDD** Cooling degree days

**GDD** Growing degree days

**HDD** Heating degree days

**CBL** Convective boundary layer

**DEM** Digital Elevation Model

**DSM** Digital surface model

**DTM** Digital Terrain Model

**ESTM** Element Surface Temperature Method [Offerle *et al.*, 2005]

**L $\downarrow$**  Incoming longwave radiation

**LAI** Leaf area index

**LUMPS** Local-scale Urban Meteorological Parameterization Scheme [Loridan *et al.*, 2011]

**NARP** Net All-wave Radiation Parameterization [Loridan *et al.*, 2011, Offerle *et al.*, 2003]

**OHM** Objective Hysteresis Model [Grimmond and Oke, 1999, Grimmond and Oke, 2002, Grimmond *et al.*, 1991]

**Q $^*$**  Net all-wave radiation

**QE** Latent heat flux

**QF** Anthropogenic heat flux

**QH** Sensible heat flux

**SOLWEIG** The solar and longwave environmental irradiance geometry model [Lindberg and Grimmond, 2011, Lindberg *et al.*, 2008]

**SVF** Sky view factor

Potential temperature

**tt** Time step of data

**UMEP** [Urban Multi-scale Environmental Predictor](#)

**WATCH** The WATCH project has produced a large number of data sets which should be of considerable use in regional and global studies of climate and water. see [WATCH webpage](#)

**zi** Convective boundary layer height

## 7.10 Contributing Guide

---

**Note:** This guide is heavily inspired by the excellent work by the [xarray](#) project: much appreciated!

---

**Warning:** This guide is incomplete and under construction: information here might be INCORRECT.

We welcome all contributions – bug reports/fixes, documentation corrections/improvements, enhancements, and ideas – as long as they apply to the SUEWS domain, please follow these guides:

### 7.10.1 Bug reports and enhancement requests

where to report a bug?

how to report a bug? what to be included? - version info - MWE (minimal working example) to reproduce the issue

### 7.10.2 Documentation Guide

### 7.10.3 Development Guide

---

**Note:** If you are interested in contributing to the code please open a new discussion in the [UMEP Community](#) to illustrate your proposal: we are happy to collaborate in an open development mode.

---

#### Essential pre-requisites

compilation

git

testing

## Code guidelines

If you are interested in contributing to the code please contact Sue Grimmond.

## Coding

1. Core physics and calculation schemes of SUEWS are written in Fortran 90
2. Code is hosted in GitHub as private repository
3. Variables
  - Names should be defined at least in one place in the code – ideally when defined
  - Implicit None should be used in all subroutines
  - Variable name should include units. e.g. Temp\_C, Temp\_K
  - Output variable attributes should be provided in the TYPE structure defined in the ctrl\_output module as follows:

```

: TYPE varAttr
: CHARACTER(len = 15) :: header ! short name in headers
: CHARACTER(len = 12) :: unit   ! unit
: CHARACTER(len = 14) :: fmt    ! output format
: CHARACTER(len = 50) :: longNm ! long name for detailed description
: CHARACTER(len = 1)  :: aggreg ! aggregation method
: CHARACTER(len = 10) :: group  ! group: datetime, default, ESTM, Snow,
→etc.
: INTEGER              :: level ! output priority level: 0 for highest
→(default output)
: END TYPE varAttr

```

4. Code should be written generally
5. Data set for testing should be provided
6. Demonstration that the model performance has improved when new code has been added or that any deterioration is warranted.
7. Additional requirements for modelling need to be indicated in the manual
8. All code should be commented in the program (with initials of who made the changes – name specified somewhere and institution)
9. The references used in the code and in the equations will be collected to a webpage
10. Current developments that are being actively worked on

## Testing

1. The testing of SUEWS is done using Python 3
2. The following tests are done for each release of SUEWS:
  1. Working status of *all physics schemes*
  2. Year-grid looping logic
  3. Identity of output results with internal test dataset

Please use pre-defined `make test` option to check if your code can pass all tests or not. If not, the correctness of added code should be justified with caution.

## Preparation of SUEWS Manual

1. The SUEWS manual is written in `reStructuredText` (aka `rst`) with a `Sphinx` flavour
2. The SUEWS manual is hosted by [readthedocs.org](http://readthedocs.org)
3. CSV tables used in following pages are automatically generated from the *Description* field in *Input Options* by each build, so **DON'T** manually edit them as your edits will be swiped automatically:
  - *SUEWS\_AnthropogenicEmission.txt*
  - *SUEWS\_BiogenCO2.txt*
  - *SUEWS\_Conductance.txt*
  - *SUEWS\_Irrigation.txt*
  - *SUEWS\_NonVeg.txt*
  - *SUEWS\_OHMCoefficients.txt*
  - *SUEWS\_Profiles.txt*
  - *SUEWS\_SiteSelect.txt*
  - *SUEWS\_Snow.txt*
  - *SUEWS\_Soil.txt*
  - *SUEWS\_Veg.txt*
  - *SUEWS\_Water.txt*
  - *SUEWS\_WithinGridWaterDist.txt*

## F2PY tips

This includes several **DON'T**'s that have never been mentioned by F2PY docs:

1. DON'T mix comments as lines into argument list of Fortran subroutines/functions:

DONT:

```
subroutine(&  
! DONT DO this  
args&  
)
```

OK:

```
subroutine(&  
args& ! OK this way  
)
```

2. DON'T end a subroutine as ENDSUBROUTINE. Instead, leave a space in between to form END SUBROUTINE. Otherwise, the subroutines won't be correctly parsed and picked up by F2PY.

## 7.11 API

[This link](#) redirects to the SUEWS API site, which provides documentation of SUEWS source code automatically generated by [Doxygen](#).

SUEWS developers are strongly suggested to use the API site as the main reference for understanding SUEWS source code.

## 7.12 Acknowledgements

### 7.12.1 Contributors

| Name                 | Affiliation  | Contributions   | Versions         | Remarks   |
|----------------------|--|---|------------------|---|
| Prof Sue Grimmond    | University of Reading, UK; prior: Indiana University, USA, King's College London, UK, University of British Columbia, Canada | OHM, Evaporation-Interception, Resistances, NARP, irrigation, anthropogenic heat, etc | v2011b – onwards | Team Leader   |
| Dr Ting Sun          | University of Reading, UK  | AnOHM; Documentation system; WRF-SUEWS coupling; SuPy (python wrapper of SUEWS)       | v2017b – onwards | Current Lead Developer                                |
| Dr Leena Järvi       | University of Helsinki, Finland  | Snow-related physics; Anthropogenic emission calculation, CO <sub>2</sub>             | v2011b – v2019a  | Lead Developer of v2011b – v2014b                     |
| Dr Helen Ward        | University of Reading, UK  | OHM improvement; Resistance calculation; Anthropogenic heat calculation               | v2016a – v2017b  | Lead Developer of v2016a – v2017                      |
| Dr Fredrik Lindberg  | Göteborg University, Sweden  | UMEP-related work, NARP, ESTM   | v2011b – onwards | Lead Developer of UMEP                                |
| Dr Lewis Blunn       | University of Reading, UK  | SUEWS-SPARTACUS coupling; RSL improvement   | v2021a           | Major contributor to SUEWS-SPARTACUS coupling         |
| Dr Hamidreza Omidvar | University of Reading, UK  | WRF-SUEWS coupling; Documentation system  | v2018c – v2019a  | Major contributor to WRF(v4.0)-SUEWS(v2018c) coupling |
| Minttu P. Havu       | University of Helsinki, Finland  | CO <sub>2</sub>   | v2018c – v2019a  |   |
| Dr Zhenkun Li        | Shanghai Climate Centre, China   | WRF-SUEWS coupling  | v2018b – v2018c  | Major contributor to WRF(v3.9)-SUEWS(v2018b) coupling |
| Yihao Tang           | University of Reading, UK  | Stability, air temperature  | v2018b – v2018c  |   |
| Dr Shiho Onomura     | Göteborg University, Sweden  | BLUEWS, ESTM  | v2016a           |   |
| Dr Thomas Loridan    | King's College London, UK  | NARP  | v2011a           |   |
| Dr Brian Offerle     | Indiana University, USA  | ESTM, NARP  | v2011a           |   |

## 7.12.2 Dependency Libraries

**Note:** We gratefully acknowledge the libraries/code that SUEWS uses as dependency and greatly appreciate their developers for the excellent work. Please let us know if any inappropriate use of these code and we will remove/modify the related parts accordingly.

| Library                                      | Remarks                                      |
|--|--|
| datetime-fortran                             | date and time related processing             |
| minpack                                      | AnOHM-related sinusoidal curve fitting       |
| Recursive Fortran 95 quicksort routine       | netCDF output for QGIS-compliant grid layout |
| Fortran Strings Module by Dr George Benthien | string processing                            |

## 7.12.3 Funding

**Note:** The following grants are acknowledged for their contribution to **model development (D)** and/or **supportive observations (O)**.

| Funder                | Project   | D , O |
|-----------------------|---|-------|
| ERC Synergy           | urbisphere 855005   | D,O   |
| NERC                  | APEX  | D     |
| NERC                  | COSMA NE/S005889/   | D     |
| UKRI                  | GCRF Urban Disaster Risk Hub  | D     |
| Newton/Met Office     | CSSP-China (AJYG-DX4P1V HRC,AJYF-2GLAMK EUN, others)  | D, O  |
| NERC                  | ClearfLo Clean Air for London NE/H003231/1  | O     |
| NERC/Belmont          | TRUC NE/L008971/1, G8MUREFU3FP-2201-075   | D, O  |
| EPSRC                 | LoHCool Low carbon climate-responsive Heating and Cooling of Cities EP/N009797/1                      | D     |
| NERC                  | Independent Research Fellowship   | D     |
| NSF                   | BCS-0095284, ATM-0710631, BCS-0221105   | D, O  |
| EPSRC                 | Data Assimilation for the REsilient City (DARE) EP/P002331/1  | O     |
| Royal Society/Newton  | Mobility funding  | O     |
| H2020                 | UrbanFluxes (637519)  | D, O  |
| EUf7                  | BRIDGE (211345)   | D, O  |
| EUf7                  | emBRACE (283201)  | D, O  |
| University of Reading | Sue Grimmond  | O, D  |
| KCL                   | Sue Grimmond  | O     |
| EPSRC                 | EP/I00159X/1 EP/I00159X/2 Materials Innovation Hub: Connecting Materials Culture to Materials Science | O     |
| NERC                  | Field Spectroscopy Facility (FSF) 616.1110 Investigating the Urban Energy Balance of London           | O     |
| EUf7                  | MEGAPOLI 212520   | D     |
| NERC                  | Airborne Remote Sensing Facility & Field Spectroscopy Facility (GB08/19)                              | O     |
| CFCAS                 | Environmental Prediction for Canadian Cities  | D, O  |

## 7.13 Version History

**Warning:** Information here is ONLY for developers.

### 7.13.1 Version 2021a (in development)

- **Improvement**
  1. Added a new *RoughLenMomMethod* (4) to calculate roughness and displacement height as a function of plan area index and effective height of roughness elements following the ensemble mean of Fig 1a in [Grimmond and Oke, 1999]
  2. Coupled *SPARCATUS* into SUEWS for detailed modelling of radiation balance.
  3. Added a new option *DiagMethod* in *RunControl.nml* to control the output of radiation balance.
- **Changes**
  1. TO ADD
- **Fix**
  1. fixed a bug in radiation scheme: observed incoming longwave radiation cannot be used.
- **Known issues**
  1. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.2 Version 2020a (released on 14 May 2020)

---

**Note:** In a future release, we will **ONLY** deliver SUEWS along with *SuPy* as a command line tool *suews-run*: release of standalone SUEWS binaries **will be stopped** to ease our maintenance load and to facilitate rapid developments. Users will need to have Python 3.6+ to install *SuPy*:

```
python3 -m pip install -U supy
```

However, as the source code of SUEWS are public, users can feel free to compile standalone binaries for platforms of their own interests.

---

- **Improvement**
  1. A ponding water scheme is added in the automatic irrigation calculation; useful when a certain depth of ponding water to maintain in irrigation (e.g., flooding irrigation in rice crop-field).
  2. Irrigation fraction can be specified for all surfaces (previously only available for vegetated surfaces)
  3. A U-shape approach for calculating HDD/CDD is introduced to account for a wide comfort zone between heating and cooling critical temperatures.
- **Changes**
  1. A new *RoughLenHeatMethod* option 5: adaptively choose option 1 for fully pervious surface or 2 otherwise (if any impervious surface exists).
  2. A new column *H\_maintain* is added in *SUEWS\_Irrigation.txt* to set ponding water depth.
  3. New columns to specify irrigation fractions for non-vegetated surfaces in *SUEWS\_SiteSelect.txt*.



4. A new scheme option `BaseTMethod` in `RunControl.nml` to set calculation scheme for HDD/CDD.

- **Fix**

NONE.

- **Known issues**

1. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.3 Version 2019a (released on 15 November 2019)

[Download page \(under assets\)](#)

- **Improvement**

1. An anthropogenic emission module is added. Module details refer to Järvi et al. (2019) [Järvi *et al.*, 2019].
2. A canyon profile module is added. Module details refer to Theeuwes et al. (2019) [Theeuwes *et al.*, 2019].

- **Changes**

1. Input file `SUEWS_AnthropogenicHeat.txt` is renamed to `SUEWS_AnthropogenicEmission.txt` with new parameters added: `MinFCMetab`, `MaxFCMetab`, `FrPDDwe`, `FCEF_v_kgkmWD` and `FCEF_v_kgkmWE`.
2. BLUEWS has been recovered; set `CBLUse` to use it.
3. Removed features:
  - SOLWEIG: fully removed from code.
  - netCDF: fully removed as this is very infrequently used; users who need this are suggested to use `SuPy` with help from `pandas` and `xarray` to save results in netCDF more elegantly.

- **Fix**

1. Fixed a bug in LAI calculation for longterm runs.
2. Fixed a bug in net all-wave radiation differential calculation for OHM.
3. Fixed a bug in GDD/SDD calculation that different vegetative land covers could unexpectedly affect each other.
4. Fixed water redistribution bug in snow module.

- **Known issues**

1. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.4 Version 2018c (released on 21 February 2019)

[Download page \(under assets\)](#)

- **Improvement**

1. SuPy (SUEWS in Python): a Python-enhanced wrapper of SUEWS, which can facilitate a more fluent workflow of SUEWS-centred urban climate research. More details refer to [SuPy documentation site](#).
2. Improved benchmark report: More testing sites are added thanks to an automated benchmark report system.

- **Changes**

None.

- **Fix**

1. Fixed a bug in LAI calculation for longterm runs.
2. Fixed a bug in net all-wave radiation differential calculation for OHM.
3. Fixed water redistribution bug in snow module.

- **Known issues**

1. BLUEWS is disabled
2. Observed soil moisture can not be used as an input
3. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.5 Version 2018b (released on 17 December 2018)

[Download page \(under assets\)](#)

- **Improvement**

1. Improved calculation of OHM-related radiation terms:

The temporal difference term  $dQ^*/dt$  is now calculated using the time-step-weighted  $dQ^*$  of previous time step instead of a series of  $Q^*$  values from previous time steps, which improves the usage of memory and allows time-step-varying simulations (needed by WRF-SUEWS coupling).

- **Changes**

None.

- **Fix**

1. Fixed a bug in picking up external water use from meteorological forcing file.

- **Known issues**

1. BLUEWS is disabled
2. Observed soil moisture can not be used as an input
3. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.6 Version 2018a (released on 2 August 2018)

- **New**

1. Many under-the-hood improvements:
  - Added explicit interface intent for confusion-less coupling between SUEWS modules
  - Restructured layout of physics schemes for better modularity
  - Improved the alignment in output txt files
2. New `readthedocs.org`-based documentation system
3. Added *SUEWS input converter* for conversion of input files between versions
4. Added *Benchmark Report* for recent releases.

- **Improvement**

1. Improved the near surface diagnostics scheme (T2, Q2, U10)
2. Improved skin temperature calculation (Ts)

- **Changes**

1. *StabilityMethod*: recommended option is change from 2 to 3 as options other than 3 have been noticed with numerical issues under several scenarios, which will be fixed in the next release.
2. Model run - changes in selections moved from *SUEWS\_SiteSelect.txt* to *SUEWS\_AnthropogenicHeat.txt*: *EnergyUseProfWD*, *EnergyUseProfWE*, *ActivityProfWD*, *ActivityProfWE*.
3. *BiogenCO2Code* is added to *SUEWS\_Veg.txt* for looking up biogenic characteristics in the new *SUEWS\_BiogenCO2.txt* file.
4. *TrafficRate* and *BuildEnergyUse* in *SUEWS\_SiteSelect.txt* are expanded to allow weekday and weekend values: *TrafficRate\_WD*, *TrafficRate\_WE*, *QF0\_BEU\_WD*, *QF0\_BEU\_WE*.
5. *AnthropCO2Method* is removed from *RunControl.nml*.
6. *AnthropHeatMethod* is renamed to *EmissionsMethod*.
7. *AHMin*, *AHSlope* and *TCritic* are expanded to allow weekday and weekend values by adding *\_WD* and *\_WE* as suffix, of which *AHSlope* and *TCritic* are also expanded to allow cooling and heating settings.

- **Known issues**

1. BLUEWS is disabled
2. Observed soil moisture can not be used as an input
3. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.7 Version 2017b (released on 2 August 2017)

PDF Manual for v2017b

1. Surface-level diagnostics: T2 (air temperature at 2 m agl), Q2 (air specific humidity at 2 m agl) and U10 (wind speed at 10 m agl) added as default output.
2. Output in netCDF format. Please note this feature is **NOT** enabled in the public release due to the dependency of netCDF library. Assistance in enabling this feature may be requested to the development team via [SUEWS mail list](#).
3. Edits to the manual.
4. New capabilities being developed, including two new options for calculating storage heat flux (AnOHM, ESTM) and modelling of carbon dioxide fluxes. These are currently under development and **should not be used** in Version 2017b.
5. Known issues
  1. BLUEWS parameters need to be checked
  2. Observed soil moisture can not be used as an input
  3. Wind direction is not currently downscaled so non -999 values will cause an error.

### 7.13.8 Version 2017a (released on 1 Feb 2017)

1. Changes to input file formats (including RunControl.nml and InitialConditions files) to facilitate setting up and running the model. Met forcing files no longer need two rows of -9 at the end to indicate the end of the file.
2. Changes to output file formats (now option to write out only a subset of variables, rather than all variables).
3. SUEWS can now disaggregate forcing files to the model time-step and aggregate output at the model time-step to lower resolution. This removes the need for the python wrapper used with previous versions.
4. InitialConditions format and requirements changed. A single file can now be provided for multiple grids. SUEWS will approximate most (but not all) of the required initial conditions if values are unknown. (However, if detailed information about the initial conditions is known, this can still be provided to and used by SUEWS.)
5. Leaf area index calculations now use parameters provided for each vegetated surface (previously only the deciduous tree LAI development parameters were applied to all vegetated surfaces).
6. For compatibility with GIS, **the sign convention for longitude has been changed**. Now negative values are to the west, positive values are to the east. Note this appears to have been incorrectly coded in previous versions (but may not necessarily have been problematic).
7. Storage heat flux calculation adapted for shorter (sub-hourly) model time-step: hysteresis calculation now based on running means over the previous hour.
8. Improved error handling, including separate files for serious errors (problems.txt) and less critical issues (warnings.txt).
9. Edits to the manual.
10. New capabilities being developed, including two new options for calculating storage heat flux (AnOHM, ESTM) and modelling of carbon dioxide fluxes. These are currently under development and **should not be used** in Version 2017a.

### 7.13.9 Version 2016a (released on 21 June 2016)

#### PDF Manual for v2016a

1. Major changes to the input file formats to facilitate the running of multiple grids and multiple years. Surface characteristics are provided in *SUEWS\_SiteSelect.txt* and other input files are cross-referenced via codes or profile types.
2. The surface types have been altered:
  - Previously, grass surfaces were entered separately as irrigated grass and unirrigated grass surfaces, whilst the ‘unmanaged’ land cover fraction was assumed by the model to behave as unirrigated grass. There is now a single surface type for grass (total for irrigated plus unirrigated) and a new bare soil surface type.
  - The proportion of irrigated vegetation must now be specified for grass, evergreen trees and deciduous trees individually.
3. The entire model now runs at a time step specified by the user. Note that 5 min is strongly recommended. (Previously only the water balance calculations were done at 5 min with the energy balance calculations at 60 min).
4. Surface conductance now depends on the soil moisture under the vegetated surfaces only (rather than the total soil moisture for the whole study area as previously).
5. Albedo of evergreen trees and grass surfaces can now change with leaf area index as was previously possible for deciduous trees only.
6. New suggestions in Troubleshooting section.

7. Edits to the manual.
8. CBL model included.
9. SUEWS has been incorporated into [UMEP](#)

### 7.13.10 Version 2014b (released on 8 October 2014)

PDF Manual for v2014b

These affect the run configuration if previously run with older versions of the model:

1. New input of three additional columns in the Meteorological input file (diffusive and direct solar radiation, and wind direction)
2. Change of input variables in InitialConditions.nml file. Note we now refer to CT as ET (ie. Evergreen trees rather than coniferous trees)
3. In GridConnectionsYYYY.txt, the site names should now be without the underscore (e.g Sm and not Sm\_)

Other issues:

1. Number of grid areas that can be modelled (for one grid, one year 120; for one grid two years 80)
2. Comment about Time interval of input data
3. Bug fix: Column headers corrected in 5 min file
4. Bug fix: Surface state 60 min file - corrected to give the last 5 min of the hour (rather than cumulating through the hour)
5. Bug fix: units in the Horizontal soil water transfer
6. ErrorHints: More have been added to the problems.txt file.
7. Manual: new section on running the model appropriately
8. Manual: notation table updated
9. Possibility to add snow accumulation and melt: new paper

Järvi L, Grimmond CSB, Taka M, Nordbo A, Setälä H, and Strachan IB Version 2014: Development of the Surface Urban Energy and Water balance Scheme (SUEWS) for cold climate cities, Geosci. Model Dev. 7, 1691-1711, doi:10.5194/gmd-7-1691-Version 2014.

### 7.13.11 Version 2014a.1 (released 26 February 2014)

1. Please see the large number of changes made in the Version 2014a release.
2. This is a minor change to address installing the software.
3. Minor updates to the manual

### 7.13.12 Version 2014a (released on 21 February 2014)

1. Bug fix: External irrigation is calculated as combined from automatic and manual irrigation and during precipitation events the manual irrigation is reduced to 60% of the calculated values. In previous version of the model, the irrigation was in all cases taken 60% of the calculated value, but now this has been fixed.
2. In previous versions of the model, irrigation was only allowed on the irrigated grass surface type. Now, irrigation is also allowed on evergreen and deciduous trees/shrubs surfaces. These are not however treated as separate surfaces, but the amount of irrigation is evenly distributed to the whole surface type in the modelled area. The amount of water is calculated using same equation as for grass surface (equation 5 in Järvi et al. Version 2011), and the fraction of irrigated trees/shrubs (relative to the area of tree/shrubs surface) is set in the gis file (See Table 4.11: SSss\_YYYY.gis)
3. In the current version of the model, the user is able to adjust the leaf-on and leaf-off lengths in the Functional-Types. nml file. In addition, user can choose whether to use temperature dependent functions or combination of temperature and day length (advised to be used at high-latitudes)
4. In the gis-file, there is a new variable Alt that is the area altitude above sea level. If not known exactly use an approximate value.
5. Snow removal profile has been added to the HourlyProfileSSss\_YYYY.txt. Not yet used!
6. Model time interval has been changed from minutes to seconds. Preferred interval is 3600 seconds (1 hour)
7. Manual correction: input variable Soil moisture said soil moisture deficit in the manual – word removed
8. Multiple compiled versions of SUEWS released. There are now users in Apple, Linux and Windows environments. So we will now release compiled versions for more operating systems (section 3).
9. There are some changes in the output file columns so please, check the respective table of each used output file.
10. Bug fix: with very small amount of vegetation in an area – impacted Phenology for LUMPS

### 7.13.13 Version 2013a

1. Radiation selection bug fixed
2. Aerodynamic resistance – when very low - no longer reverts to neutral (which caused a large jump) – but stays low
3. Irrigation day of week fixed
4. New error messages
5. min file – now includes a decimal time column – see Section 5.4 – Table 5.3

### 7.13.14 Version 2012b

1. Error message generated if all the data are not available for the surface resistance calculations
2. Error message generated if wind data are below zero plane displacement height.
3. All error messages now written to ‘Problem.txt’ rather than embedded in an ErrorFile. Note some errors will be written and the program will continue others will stop the program.
4. Default variables removed (see below). Model will stop if any data are problematic. File should be checked to ensure that reasonable data are being used. If an error occurs when there should not be one let us know as it may mean we have made the limits too restrictive.

Contents no longer used File defaultFcd=0.1 defaultPres=1013 defaultRH=50 defaultT=10 defaultU=3 RunControl.nml

- Just delete lines from file
- Values you had were likely different from these example value shown here

### 7.13.15 Version 2012a

1. Improved error messages when an error is encountered. Error message will generally be written to the screen and to the file 'problems.txt'
2. Format of all input files have changed.
3. New excel spreadsheet and R programme to help prepare required data files. (Not required)
4. Format of coef flux (OHM) input files have changed.
  - This allows for clearer identification for users of the coefficients that are actually to be used
  - This requires an additional file with coefficients. These do not need to be adjusted but new coefficients can be added. We would appreciate receiving additional coefficients so they can be included in future releases – Please email Sue.
5. Storage heat flux (OHM) coefficients can be changed by
  - time of year (summer, winter)
  - surface wetness state
6. New files are written: DailyState.txt
  - Provides the status of variables that are updated on a daily or basis or a snapshot at the end of each day.
7. Surface Types
  - Clarification of surface types has been made. See GIS and OHM related files

### 7.13.16 Version 2011b

1. Storage heat flux (Qs) and anthropogenic heat flux (QF) can be set to be  $0 \text{ W m}^{-2}$
2. Calculation of hydraulic conductivity in soil has been improved and HydraulicConduct in SUEWSInput.nml is replaced with name SatHydraulicConduct
3. Following removed from HeaderInput.nml
  - HydraulicConduct
  - GrassFractionIrrigated
  - PavedFractionIrrigated
  - TreeFractionIrrigated

The lower three are now determined from the water use behaviour used in SUEWS

1. Following added to HeaderInput.nml
  - SatHydraulicConduct
  - defaultQf
  - defaultQs
2. If Qs and QF are not calculated in the model but are given as an input, the missing data is replaced with the default values.

3. Added to SAHP input file

- AHDIUPRF – diurnal profile used if EmissionsMethod = 1

Version 2012a this became obsolete OHM file (SSss\_YYYY.ohm)

## 7.14 Parameterisations and sub-models within SUEWS

### 7.14.1 Net all-wave radiation, $Q^*$

There are several options for modelling or using observed radiation components depending on the data available. As a minimum, SUEWS requires incoming shortwave radiation to be provided.

1. Observed net all-wave radiation can be provided as input instead of being calculated by the model.
2. Observed incoming shortwave and incoming longwave components can be provided as input, instead of incoming longwave being calculated by the model.
3. Other data can be provided as input, such as cloud fraction (see options in *RunControl.nml*).
4. **NARP** (Net All-wave Radiation Parameterization) [Loridan *et al.*, 2011, Offerle *et al.*, 2003] scheme calculates outgoing shortwave and incoming and outgoing longwave radiation components based on incoming shortwave radiation, temperature, relative humidity and surface characteristics (albedo, emissivity).
5. *SPARTACUS-Surface (SS)* computes the 3D interaction of shortwave and longwave radiation with complex surface canopies, including vegetated and urban canopies (with or without vegetation). More details can be found in the *SPARTACUS-Surface (SS)* section.

### 7.14.2 Anthropogenic heat flux, $Q_F$

1. Two simple anthropogenic heat flux sub-models exist within SUEWS:
  - Järvi *et al.* [2011] approach, based on heating and cooling degree days and population density (allows distinction between weekdays and weekends).
  - Loridan *et al.* [2011] approach, based on a linear piece-wise relation with air temperature.
2. Pre-calculated values can be supplied with the meteorological forcing data, either derived from knowledge of the study site, or obtained from other models, for example:
  - **LUCY** [Allen *et al.*, 2010, Lindberg *et al.*, 2013]. A new version has been now included in UMEP. To distinguish it is referred to as **LQF**
  - **GreaterQF** [Iamarino *et al.*, 2011]. A new version has been now included in UMEP. To distinguish it is referred to as **GQF**

### 7.14.3 Storage heat flux, $Q_S$

1. Three sub-models are available to estimate the storage heat flux:
  - **OHM** (Objective Hysteresis Model) [Grimmond and Oke, 1999, Grimmond and Oke, 2002, Grimmond *et al.*, 1991]. Storage heat flux is calculated using empirically-fitted relations with net all-wave radiation and the rate of change in net all-wave radiation.
  - **AnOHM** (Analytical Objective Hysteresis Model) [Sun *et al.*, 2017]. OHM approach using analytically-derived coefficients. **Not recommended in this version.**



- **ESTM** (Element Surface Temperature Method) [Offerle *et al.*, 2005]. Heat transfer through urban facets (roof, wall, road, interior) is calculated from surface temperature measurements and knowledge of material properties. **Not recommended in this version.**

2. Alternatively, ‘observed’ storage heat flux can be supplied with the meteorological forcing data.

#### 7.14.4 Turbulent heat fluxes, $Q_H$ and $Q_E$

1. **LUMPS** (Local-scale Urban Meteorological Parameterization Scheme) [Grimmond and Oke, 2002] provides a simple means of estimating sensible and latent heat fluxes based on the proportion of vegetation in the study area.
2. **SUEWS** adopts a more biophysical approach to calculate the latent heat flux; the sensible heat flux is then calculated as the residual of the energy balance. The initial estimate of stability is based on the LUMPS calculations of sensible and latent heat flux. Future versions will have alternative sensible heat and storage heat flux options.

Sensible and latent heat fluxes from both LUMPS and SUEWS are provided in the *Output files*. Whether the turbulent heat fluxes are calculated using LUMPS or SUEWS can have a major impact on the results. For SUEWS, an appropriate surface conductance parameterisation is also critical [Järvi *et al.*, 2011] [Ward *et al.*, 2016]. For more details see *Differences\_between\_SUEWS\_LUMPS\_and\_FRAISE*.

#### 7.14.5 Water balance

The running water balance at each time step is based on the urban water balance model of Grimmond *et al.* [1986] and urban evaporation-interception scheme of Grimmond and Oke [1991].

- Precipitation is a required variable in the meteorological forcing file.
- Irrigation can be modelled [Järvi *et al.*, 2011] or observed values can be provided if data are available.
- Drainage equations and coefficients to use must be specified in the input files.
- Soil moisture can be calculated by the model.
- Runoff is permitted:
  - between surface types within each model grid
  - between model grids (**Not available in this version.**)
  - to deep soil
  - to pipes.

#### 7.14.6 Snowmelt

The snowmelt model is described in Järvi *et al.* [2014]. Changes since v2016a: 1) previously all surface states could freeze in 1-h time step, now the freezing surface state is calculated similarly as melt water and can freeze within the snow pack. 2) Snowmelt-related coefficients have also slightly changed (see *SUEWS\_Snow.txt*).

### 7.14.7 Convective boundary layer

A convective boundary layer (CBL) slab model [Cleugh and Grimmond, 2001] calculates the CBL height, temperature and humidity during daytime [Onomura *et al.*, 2015].

### 7.14.8 Wind, Temperature and Humidity Profiles in the Roughness Sublayer

A diagnostic RSL scheme for calculating the wind, temperature and humidity profiles in the roughness sublayer is implemented in 2020a following Harman and Finnigan [2007], Harman and Finnigan [2008] and Theeuwes *et al.* [2019]. An recent application of this RSL scheme can be found in Tang *et al.* [2021].

The diagnostic profiles are outputted in 30 uneven levels between the ground and forcing height, which are divided into two groups:

- One group of levels are evenly distributed within the urban canopy layer characterised by mean height of roughness elements (e.g. buildings, trees, etc.)  $z_H$ , which determines the number of layers within urban canopy  $n_{can}$ :

$$n_{can} = \begin{cases} 3 & \text{if } z_H \leq 2 \text{ m} \\ 10 & \text{if } 2 \text{ m} < z_H \leq 10 \text{ m} \\ 15 & \text{if } z_H > 10 \text{ m} \end{cases}$$

- The other levels are evenly distributed between the urban canopy layer top and forcing height.

---

**Note:** All the diagnostic profiles (wind speed, temperature and humidity) are calculated from the forcing data down into the canopy. Therefore it is assumed that the forcing temperature and humidity are above the blending height.

---

Common near-surface diagnostics:

- T2: air temperature at 2 m agl
- Q2: air specific humidity at 2 m agl
- RH2: air relative humidity at 2 m agl
- U10: wind speed at 10 m agl

are calculated by the *RSL scheme* by interpolating RSL profile results to the corresponding diagnostic heights.

### 7.14.9 SPARTACUS-Surface (SS)

**Warning:** This module is highly experimental and not yet fully tested: description here is not yet complete, either. Please refer to the original [SPARTACUS-Surface page](#) for more details, which may differ from the coupled version in SUEWS described below due to possibly different implementations.

---

**Note:** Future Work

- New SUEWS input table containing SPARTACUS profiles
  - Add check for consistency of SUEWS and SS surface fractions
  - Include snow
-

## Introduction to SS

The **SPARTACUS-Surface** module computes the 3D interaction of shortwave and longwave radiation with complex surface canopies, including vegetated and urban canopies (with or without vegetation).

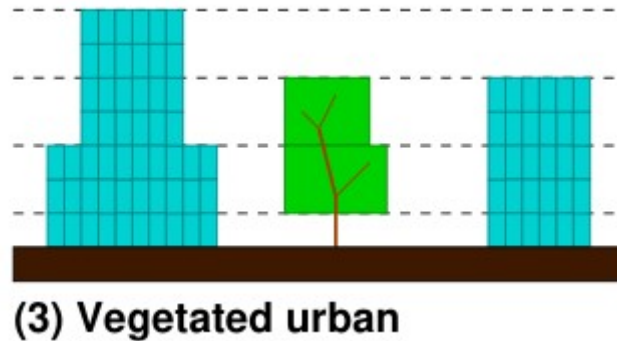


Fig. 7.4: Multi-layer structure (horizontal dashed lines) used in SS to characterise differences in the canopy (Cyan building, Green – vegetation). Source: [SPARTACUS-Surface GH page](#)

It uses a multi-layer description of the canopy (Fig. 7.4), with a statistical description of the horizontal distribution of trees and buildings. Assumptions include:

- Trees are randomly distributed.
- Wall-to-wall separation distances follow an exponential probability distribution.
- From a statistical representation of separation distances one can determine the probabilities of light being intercepted by trees, walls and the ground.

In the tree canopy (i.e. between buildings) there are two or three regions (based on user choice) (Fig. 7.5): clear-air and either one vegetated region or two vegetated regions of equal fractional cover but different extinction coefficient. Assumptions include:

- The rate of exchange of radiation between the clear and vegetated parts of a layer are assumed to be proportional to the length of the interface between them.
- Likewise for the rate of interception of radiation by building walls.

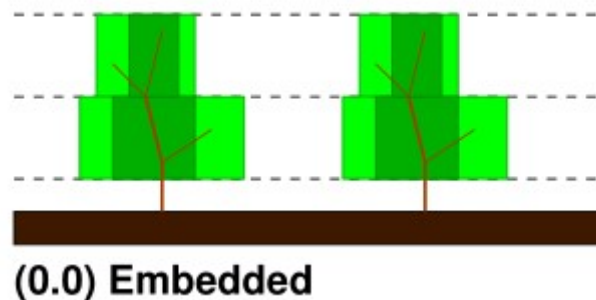


Fig. 7.5: Areas between trees. Source: [SPARTACUS-Surface GH page](#)

Each time light is intercepted it can undergo diffuse or specular reflection, be absorbed or be transmitted (as diffuse radiation). The probabilities for buildings and the ground are determined by albedos and emissivities, and for trees are determined by extinction coefficients and single scattering albedos.

## SUEWS-SS Implementation

- Maximum of 15 vertical layers.
- Building and tree fractions, building and tree dimensions, building albedo and emissivity, and diffuse versus specular reflection, can be treated as vertically heterogeneous or uniform with height depending on parameter choices.
- As tree fraction increases towards 1 it is assumed that the tree crown merges when calculating tree perimeters.
- Representing horizontal heterogeneity in the tree crowns is optional. When represented it is assumed that heterogeneity in leaf area index is between the core and periphery of the tree, not between trees.
- When calculating building perimeters it is assumed that buildings do not touch (analogous to crown shyness) as building fraction increases towards 1.
- Vegetation extinction coefficients (calculated from leaf area index, LAI) are assumed to be the same in all vegetated layers.
- Building facet and ground temperatures are equal to SUEWS TSfc\_C (i.e. surface temperature) **[#estm\_coupling]**.
- Leaf temperatures are equal to SUEWS temp\_C (i.e. air temperature within the canopy) **[#rsl\_layers]**.
- Ground albedo and emissivity are an area weighted average of SUEWS paved, grass, bare soil and water values.
- Inputs from SUEWS: sfr, zenith\_deg, TSfc\_C, avKdn, ldown, temp\_c, alb\_next, emis, LAI\_id.
- SS specific input parameters: read in from *SUEWS\_SPARTACUS.nml*.
- Outputs used by SUEWS: alb\_spc, emis\_spc, lw\_emission\_spc.
- Although the radiation is calculated in multiple vertical layers within SS it is only the upwelling top-of-canopy fluxes: alb\_spc\*avKdn, (emis\_spc)\*ldown, and lw\_emission\_spc that are used by SUEWS.
- Output variables (including multi-layer ones) are in SUEWS-SS output file SSss\_YYYY\_SPARTACUS.txt. **[#ss\_output]**

## RSL and SS Canopy Representation Comparison

- The RSL has 30 levels but when the average building height is <2 m, < 12 m and > 12 m there are 3, 10 and 15 evenly spaced layers in the canopy.
- The remaining levels are evenly spaced up to the forcing level (Fig. 7.6).
- The buildings are assumed to be uniform height.

A maximum of 15 layers are used by SS (vertical\_layers\_SS-RSL), with the top of the highest layer at the tallest building height. The layer heights are user defined and there is no limit on maximum building height. The buildings are allowed to vary in height.



Fig. 7.6: SUEWS-RSL module assumes the RSL has 30 layers that are spread between the canopy and within the atmosphere above



Fig. 7.7: Vertical layers used by SS

## How to use SUEWS-SS

### Inputs

To run SUEWS-SS the SS specific files that need to be modified are:

- *RunControl.nml* (see *NetRadiationMethod*)
- *SUEWS\_SPARTACUS.nml*

---

**Note:** Non-SS specific SUEWS input file parameters also need to have appropriate values. For example, LAI, albedos and emissivities are used by SUEWS-SS as explained in *More background information*.

---

### Outputs

See *SSss\_YYYY\_SPARTACUS\_TT.txt*.

## More background information

### Vegetation single scattering albedo (SSA)

The **shortwave** broadband SSA is equal to the sum of the broadband reflectance  $R$  and broadband transmittance  $T$  [Yang *et al.*, 2020]. Given reflectance  $r$  and transmittance  $t$  spectra the SSA is calculated to modify equation

$$\text{SSA} = \frac{\int_{\sim 400 \text{ nm}}^{\sim 2200 \text{ nm}} r \times Sd}{\int_{\sim 400 \text{ nm}}^{\sim 2200 \text{ nm}} Sd} + \frac{\int_{\sim 400 \text{ nm}}^{\sim 2200 \text{ nm}} t \times Sd}{\int_{\sim 400 \text{ nm}}^{\sim 2200 \text{ nm}} Sd}$$

where  $S$  clear-sky surface spectrum .

The integrals are performed between 400 nm and 2200 nm because this is the spectral range that RAMI5<sup>5</sup> Järvelja birch stand forest spectra are available. This is a reasonable approximation since it is where the majority of incoming SW energy resides (as seen from the clear-sky surface spectrum in Fig. 6).

Users can use the default value of 0.46, from RAMI5 Järvelja birch stand forest tree types or calculate their own SSA (Fig. 7.8). There are more tree R and T profiles [here](#)<sup>5</sup>,

The **longwave** broadband SSA could be calculated in the same way but with the integral over the thermal infra-red (8-14 m),  $S$  replaced with the Plank function at Earth surface temperature, and  $r$  and  $t$  for the spectra for the thermal infra-red. The approximation that  $R + T = 2R$  can be made.  $r$  for different materials is available at <https://speclib.jpl.nasa.gov/library>. The peak in the thermal infra-red is ~10 m. Based on inspection of  $r$  profiles for several tree species SSA=0.06 is the default value.

### Building albedo and emissivity

Use broadband values in Table C.1 of Kotthaus *et al.* [2014]. Full spectra can be found in the [spectral library documentation](#).

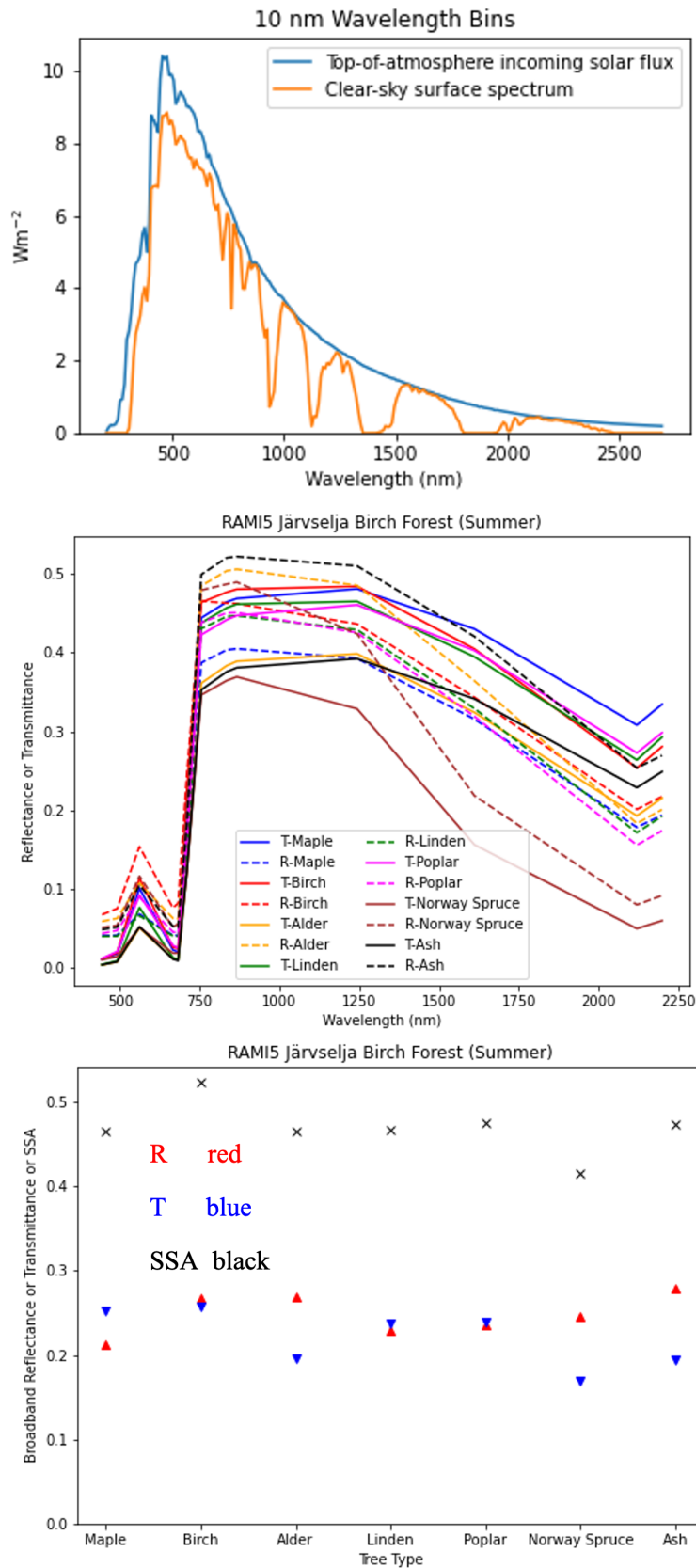


Fig. 7.8: RAMI5<sup>5</sup> data used to calculate R, T, and SSA, and R, T, and SSA values: (a) top-of-atmosphere incoming solar flux and clear-sky surface spectrum [Fogel and Matricardi, 2020] (b) RAMI5 r and t spectra, and (c) calculated broadband R, T, and SSA values.

## Ground albedo and emissivity

In SUEWS-SS this is calculated as:

```
((1)*sfr(PavSurf)+(5)*sfr(GrassSurf)+(6)*sfr(BSoilSurf)+(7)*sfr(WaterSurf))/  
↪(sfr(PavSurf) + sfr(GrassSurf) + sfr(BSoilSurf) + sfr(WaterSurf))
```

where is either the ground albedo or emissivity.

values for the surfaces should be set by specifying surface codes in *SUEWS\_SiteSelect.txt*. Codes should correspond to existing appropriate surfaces in *SUEWS\_NonVeg.txt* and *SUEWS\_NonVeg.txt*. Alternatively, new surfaces can be made in *SUEWS\_NonVeg.txt* and *SUEWS\_NonVeg.txt* with values obtained for example from the spectral library.

## Consistency of SUEWS and SS parameters

SUEWS building and tree (evergreen+deciduous) fractions in *SUEWS\_SiteSelect.txt* should be consistent with the *SUEWS\_SPARTACUS.nml* building\_frac and veg\_frac of the lowest model layer.

## Leaf area index (LAI)

The total vertically integrated LAI provided by SUEWS is used in SS to determine the LAI and vegetation extinction coefficient in each layer. Surface codes in *SUEWS\_SiteSelect.txt* should correspond to appropriate LAI values in *SUEWS\_Veg.txt*.

# 7.15 SUEWS-related Publications

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### Note:

1. If you have papers to add to this list please let us and others know via the [email list](#).
  2. The following list is sorted in a reversed chronological order.
- 

- Zheng, Y., Havu, M., Liu, H., Cheng, X., Wen, Y., Lee, H. S., Ahongshangbam, J., and Järvi, L. Simulating heat and CO<sub>2</sub> fluxes in Beijing using SUEWS V2020b: sensitivity to vegetation phenology and maximum conductance. *Geoscientific Model Development*, 16(15):4551–4579, August 2023. doi:10.5194/gmd-16-4551-2023.
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## Symbols

--from  
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