# SUEWS - UMEP

SUEWS v2016a

The current version of SUEWS is v2016a (released 21 June 2016).

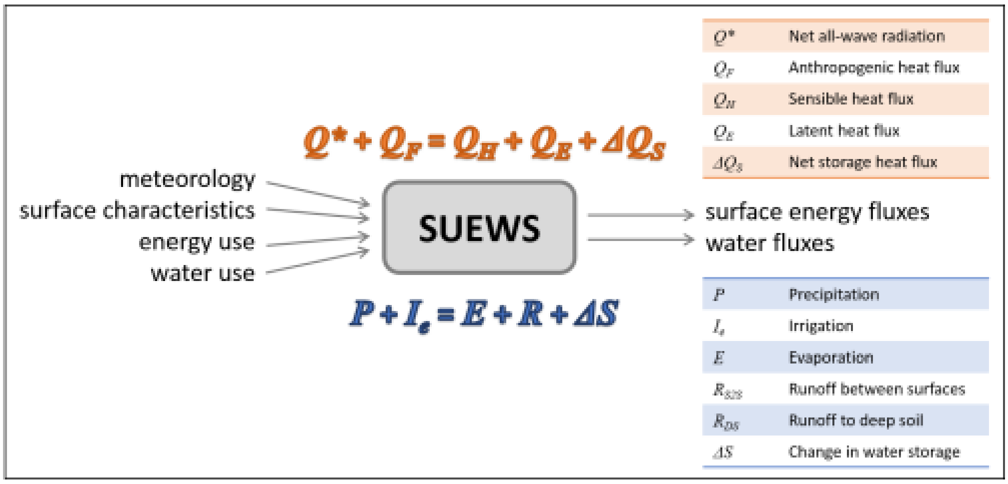
This wiki page is regularly updated with new developments. The manual for SUEWS_V2016a can be accessed here and should be referenced as follows:

```
Ward HC, L Järvi, S Onomura, F Lindberg, A Gabey, CSB Grimmond 2016 SUEWS Manual V2016a, http://urban-climate.net/umep/SUEWS Department of Meteorology, Unversity of Reading, Reading, UK
```

To download the latest version of SUEWS please complete the online form.

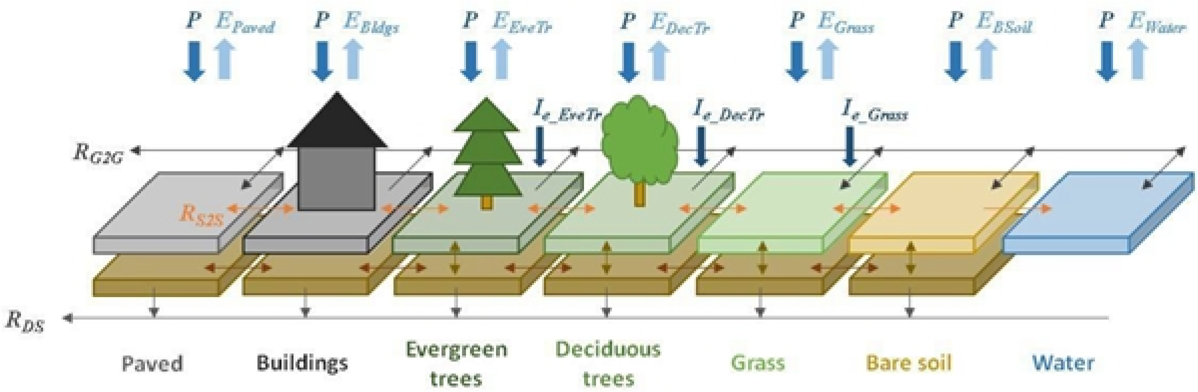
- NEW in this version: see Version history.

Introduction




Overview of SUEWS

Surface Urban Energy and Water Balance Scheme (**SUEWS**) (Järvi et al. 2011[1], Ward et al. 2016[2]) is able to simulate the urban radiation, energy and water balances using only commonly measured meteorological variables and information about the surface cover. SUEWS utilizes an evaporation-interception approach (Grimmond et al. 1991[3]), similar to that used in forests, to model evaporation from urban surfaces.




Surfaces Considered in 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. The user can specify the model timestep, but 5 min is strongly recommended. The main output file is provided at a resolution of 60 min by default. Timestamps refer to the end of the averaging period. The model provides the radiation and energy balance components, surface and soil wetness, surface and soil runoff and the drainage for each surface.

Processes in the modelNet all-wave radiation

1. **NARP** (Net All-wave Radiation Parameterization, Offerle et al. 2003[4] , Loridan et al. 2011[5] ) radiation scheme.
2. Observed net all-wave radiation can be provided as input instead of calculated by the model. 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.

| Flux | Methods | Comments |
|---|---|---|
| Incoming solar radiation | Observed | A required input variable |
| | Re-analysis data | WFD, WFDEI |
| Outgoing shortwave radiation | Modelled | Dependent on the surface albedo |
| | Observed | Possible to use observations |
| Incoming longwave radiation | Modelled | Options: Loridan et al. 2011[5] |
| | Observed | Possible to use observations |
| | Re-analysis data | WFD, WFDEI |
| Outgoing longwave radiation | Modelled | Options: Loridan et al. 2011[5] |
| | Observed | Possible to use observations |

Anthropogenic heat flux

1. Modelled within SUEWS using simple anthropogenic heat flux sub-models (two options):
   - Järvi et al. (2011)[1] approach, based on heating and cooling degree days (allows distinction between weekdays and weekends).
   - Loridan et al. (2011)[5] approach, based on linear piece-wise relation with air temperature.

2. Pre-calculated values can be supplied with the meteorological forcing data, for example,
   - **LUCY** (Allen et al. 2011[6], Lindberg et al. 2013[7])
   - **GreaterQF** (Iamarino et al. 2011[8])

1. - **OHM** (Objective Hysteresis Model, Grimmond et al. 1991[9], Grimmond & Oke 1999a[10], 2002[11]).
   - **ESTM** (Element Surface Temperature Method, Offerle et al. 2005[12]). (**Not available in v2016a**)
   - **AnOHM** (Analytical Objective Hysteresis Model) (**Not available in v2016a**)

2. Alternatively observations can be supplied with the meteorological forcing data.

Turbulent heat fluxes

1. **LUMPS** (Local-scale Urban Meteorological Parameterization Scheme, Grimmond & Oke 2002[11]) provides a simple means of estimating sensible and latent heat fluxes.
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 turbulent sensible and latent heat flux.

For more details see Differences between SUEWS, LUMPS and FRAISE. Sensible and latent heat fluxes from both LUMPS and SUEWS are provided in the model output.

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[1][2].

Water balance

The running water balance at each time step is based on the urban water balance model of Grimmond et al. (1986)[13] and urban evaporation-interception scheme of Grimmond and Oke (1991)[3].

- Precipitation is a required variable in the meteorological forcing file.
- Drainage equations and coefficients to use must be specified in the input files.
- Irrigation can be modelled[1] or observed values can be provided if data are available.
- Soil moisture can be calculated by the model or observations can be provided (**Use of observed soil moisture not possible in v2016a**).
- Runoff is permitted:
  - between surface types within each model grid
  - between model grids (**Not implemented in v2016a**)
  - to deep soil
  - to pipes.

Convective boundary layer

A convective boundary layer (CBL) slab model (Cleugh and Grimmond 2001[14]) calculates the CBL height, temperature and humidity during daytime (Onomura et al. 2015[15]).

Snowmelt

The snowmelt model within SUEWS is described in Järvi et al. (2014)[16]. Due to changes in the new model version V2016a when compared to the older versions, the snow calculation has slightly changed. The main difference is that previously all surface state could freeze in 1-h time step but now the amount of freezing surface state is calculated similar way as melt water can freeze within the snow pack. Also the snow melt related coefficients have slighly changed (see SUEWS_Snow.txt).

Thermal comfort

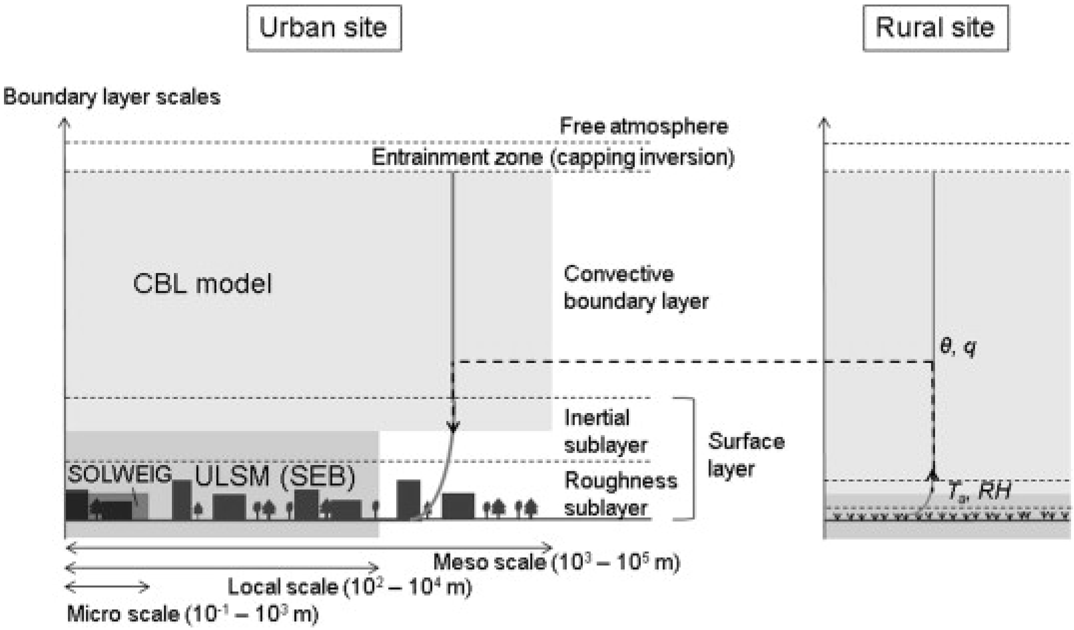
SOLWEIG (Solar and longwave environmental irradiance geometry model, Lindberg et al. 2008[17], Lindberg and Grimmond 2011[18]) is a 2D radiation model to estimate mean radiant temperature.

Using the model

The model distributed with this manual can be run in two standard ways:

1. for an individual area
2. for multiple areas

There is no requirement for the areas to be of any particular shape but here we refer to them as 'grids'.




Overview of scales Source:[15]

Model applicability: Local scale – so forcing data should be above the height of the roughness elements (trees, buildings).

Preparing to run the model

The following provides some comments to help with the model setup.

Preparatory reading

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

- Järvi L, Grimmond CSB & Christen A (2011) The Surface Urban Energy and Water Balance Scheme (SUEWS): Evaluation in Los Angeles and Vancouver. J. Hydrol. 411, 219-237. doi:10.1016/j.jhydrol.2011.10.00
- Järvi L, Grimmond CSB, Taka M, Nordbo A, Setälä H & Strachan IB (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-7-1691-2014
- Ward HC, Kotthaus S, Järvi L and Grimmond CSB (2016) Surface Urban Energy and Water Balance Scheme (SUEWS): development and evaluation at two UK sites. Urban Climate (in press)

Decide what type of model run you are interested in

| | **Available in this release** |
|---|---|
| LUMPS | Yes – not standalone |
| 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 |
| SUEWS with SOLWEIG | No |
| SUEWS with SOLWEIG and BL | No |

Important considerations:

- Fractions of different land cover types
- Heights of buildings
- Surface characteristics
- Source of meteorological forcing data
- External water use - Does this occur? (e.g. street cleaning, garden irrigation)
- Anthropogenic heat flux - Is this likely to be important? (e.g. energy emissions from transport, buildings, metabolism, etc)
- (If using snow option) Does snow clearing occur?

Download the program and example data files
Visit the website to receive a link to download the program and example data files. Select the appropriate compiled version of the model to download. For windows there is an installation version which will put the programs and all the files into the appropriate place. There is also a version linked to QGIS: UMEP.

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 given for the Vancouver Sunset site, 1987 data (denoted Vs87)

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

| Filename | Description | Input/output |
|---|---|---|
| SSss_data.txt | Meteorological input file (60-min) | Input |
| SSss_YYYY_data_5.txt | Meteorological input file (5-min) | Input |
| InitialConditionsSSss_YYYY.nml(+) | Initial conditions file | Input |
| SUEWS_v2016a_SiteInfo_SSss.xlsm | Spreadsheet containing all other input information | Input |
| RunControl.nml | Sets model run options | Input (located in main directory) |
| SS_Filechoices.txt | Summary of model run options | Output |
| SSss_YYYY_5.txt | (Optional) 5-min resolution output file | Output |
| SSss_YYYY_60.txt | 60-min resolution output file | Output |
| SSss_DailyState.txt | Daily state variables (all years in one | Output |

| | |
|---|---|
| | 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.

Run the model for example data

Before running the model for your own data it is good to make certain that you can run the test data and get the same results as in the example files provided. It is recommended that you make a copy of the example output files and put them somewhere else 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.

```
SuewsWrapper.exe
```

Please see Troubleshooting if you have problems running the model.

Preparation of data

This section describes the information required to run SUEWS for your site. The input data can be summarised as follows:

1. *Meteorological forcing data* for the entire period to be modelled and knowledge of the surface state and meteorological conditions immediately before the start of the run (if these initial conditions are not known, it is usually possible to determine suitable values by running the model and using the output at the end of the run to infer the conditions at the start of the run).
2. The *location of the site* (latitude, longitude, altitude).
3. 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).
4. Information about *human behaviour*, including energy use and water use (e.g. for irrigation) and snow clearing (if applicable). The anthropogenic energy use and water use may be provided as a time series in the meteorological forcing file 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).

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. (Note in SUEWS_SiteSelect.txt the first column is labelled

'Grid' and can contain repeat values for different years.) See Input files for details.

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 | SUEWS_NonVeg.txt |
| | Building surfaces | SUEWS_NonVeg.txt |
| | Bare soil surfaces | SUEWS_NonVeg.txt |
| Vegetation | Evergreen trees and shrubs | SUEWS_Veg.txt |
| | Deciduous trees and shrubs | SUEWS_Veg.txt |
| | Grass | SUEWS_Veg.txt |
| Water | Water | SUEWS_Water.txt |
| Snow | Snow | SUEWS_Snow.txt |

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

The population density is needed as an input for LUMPS and SUEWS to calculate QF. If you have no information about the population of the site we recommend that you use the LUCY model[6] [7] to estimate the anthropogenic heat flux which can then be provided as input SUEWS along with the meteorological forcing data. The LUCY model can be downloaded from here.

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 on 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. Data can be entered into the spreadsheet **SUEWS_SiteInfo.xlsm** and the input text files generated by running the macro.
3. Use UMEP.

**To run the xlsm macro:** Enter the data for your site into the xlsm spreadsheet **SUEWS_v2016a_SiteInfo.xlsm** and then use the macro to create the text files which will appear the same directory.

If there is a problem

- Make sure none of the text files to be generated are open.
- It is recommended to close the spreadsheet before running the actual model code.

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.
- All files should 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 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_60.txt (remember to add the last backslash in windows and slash in Linux/Mac).
```

If the file paths are not correct the program will return an error when run (Run-time Error, File path not found, see error messages) and write the error to the problems.txt file.

Preparation of the Meteorological forcing data

The model is designed to use (60 min) hourly input data, which is interpolated to the model time step specified in RunControl.nml (e.g. 5 min). See details about the meteorological forcing data 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.

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. One file is needed for each grid. For details see InitialConditions.

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.

```
SuewsWrapper.exe
```

Please see Troubleshooting if you have problems running the model.

Analyse the output

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

| Characteristic | Things to check |
|---|---|
| Albedo | Is the bulk albedo correct?<br>• This is critical because a small error has an impact on all the fluxes (energy and hydrology)<br>• If you have measurements of outgoing shortwave radiation compare these with the modelled values.<br>• How do the values compare to literature values for your area? |
| Leaf area index | Does the phenology look appropriate (i.e. what does the seasonal cycle of leaf area index (LAI) look like?)<br>• Are the leaves on the trees at approximately the right time of the year? |

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) representing the site name, ss is the grid identification (integer values between 0 and 99999) and YYYY is the year.

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 boundary layer 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
```

| Filename | Description | Location | Option |
|---|---|---|---|
| **Program** | | | |

| | | | |
|---|---|---|---|
| SUEWSWrapper.exe | Runs SUEWS (also prepares the input and averages output data) | Directory where the program will run | |
| SUEWS_V2016a.exe | Actual SUEWS program | Directory where the program will run | |
| **Input files** | | | |
| RunControl.nml | Specifies options for the model run | Same directory as the program | 1/run |
| SUEWS_SiteSelect.txt | Main input file for this site | Input directory | 1/run |
| SUEWS_NonVeg.txt | Inputs for non-vegetated surfaces | Input directory | 1/run |
| SUEWS_Veg.txt | Inputs for vegetated surfaces | Input directory | 1/run |
| SUEWS_Water.txt | Inputs for water surfaces | Input directory | 1/run |
| SUEWS_Snow.txt | Inputs for snow | Input directory | 1/run |
| SUEWS_Soil.txt | Inputs for sub-surface soil | Input directory | 1/run |
| SUEWS_AnthropogenicHeat.txt | Inputs for anthropogenic heat flux | Input directory | 1/run |
| SUEWS_Irrigation.txt | Inputs for irrigation | Input directory | 1/run |
| SUEWS_Profiles.txt | Inputs for hourly profiles (energy use, water use, snow-clearing) | Input directory | 1/run |
| SUEWS_WithinGridWaterDist.txt | Inputs describing within-grid water distribution | Input directory | 1/run |
| SUEWS_OHMCoefficients.txt | Inputs for OHM coefficients | Input directory | 1/run |
| | | Input | |

| | | | |
|---|---|---|---|
| SUEWS_Conductance.txt | Inputs for surface conductance | directory | 1/run |
| SUEWS_SiteInfo.xlsm | (Optional) spreadsheet for creating input files | Anywhere, but the input files created must be in the input directory | - |
| SSss_YYYY_data_tt.txt | Meteorological input file at model time step tt (when using SUEWS_V2016a.exe) | Input directory | 1/grid/year or 1/year |
| SSss_data.txt | Meteorological input file at resolution greater than model time step (when using SUEWSWrapper.exe) | Input directory | 1/grid/run or 1/run |
| InitialConditionsSSss_YYYY.nml | Initial conditions file | Input directory | 1/run for each grid |
| ESTMinput.nml | Specifies options and inputs for ESTM model | Input directory | 1/run [E] |
| SUEWS_ESTMCoefficients.txt | Inputs for ESTM coefficients | Input directory | 1/run [E] |
| SSss_YYYY_ESTM_Ts_data_tt.txt | Surface temperature data input file at model time step tt (when using SUEWS_V2016a.exe) | Input directory | 1/grid/year or 1/year [E] |
| SSss_ESTM_Td_data.txt | Meteorological input file at resolution greater than model time step (when using SUEWSWrapper.exe) | Input directory | 1/grid/run or 1/run [E] |
| CBLinput.nml | Specifies options and inputs for CBL model | Input directory | 1/run [B] |
| CBL_initial_data.txt | Initial data for CBL model | Input directory | 1/day [B] |
| **Output files** | | | |
| SSss_YYYY_tt.txt | Model output with time step tt (produced by SUEWS_V2016a.exe) | Output directory | 1/grid/year |
| SSss_YYYY_60.txt | Model output at 60-min resolution (produced by SUEWSWrapper_V2016a.exe) | Output directory | 1/grid/year |

| | | | |
|---|---|---|---|
| SSss_DailyState.txt | Status of the daily storages and other status values | Output directory | 1/grid |
| InitialConditionsSSss_YYYY+1.nml | New InitialConditions file written at the end of each year for multi-year runs. If the run finishes before the end of the year the InitialConditions file is still written and the file name is appended with '_EndofRun' | Input directory | 1/grid/year |
| SS_FileChoices.txt | Summary of model run options | Output directory | 1/run |
| SSss_YYYY_ESTM_tt.txt | Model output with time step tt (produced by SUEWS_V2016a.exe) | Output directory | 1/grid/year [E] |
| SSss_YYYY_ESTM_60.txt | Model output at 60-min resolution (produced by SUEWSWrapper_V2016a.exe) | Output directory | 1/grid/year [E] |
| CBL_id.txt | CBL model output file for day of year id | Output directory | 1/day [B] |

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' to be set (i.e. changed from the example) for your site/model domain.

RunControl.nml

The file **RunControl.nml** is a namelist that specifies the options for the model run (plus two default variable values). It must be located in the same directory as the executable file.

The format should be:

```
&RunControl
Parameters and variables (see table below)
/
```

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.

| Name | Description |
|---|---|
| *Model run options* | |

<table>
<tr><td rowspan="4">AnthropHeatChoice</td><td colspan="2">Determines method for QF calculation.</td></tr>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td><ul><li>Uses values provided in the meteorological forcing file (SSss_data.txt). If values are missing then defaultQf will be used.</li><li>Set values in the meteorological forcing file to zero to prevent calculation of QF.</li></ul></td></tr>
<tr><td>1</td><td><ul><li>Currently not recommended!</li><li>Calculated according to Loridan et al. (2011)[5] using coefficients specified in SUEWS_AnthropogenicHeat.txt.</li><li>Modelled values will be used even if QF is provided in the meteorological forcing file.</li></ul></td></tr>
<tr><td></td><td>2</td><td><ul><li>Recommended</li><li>Calculated according to Järvi et al. (2011)[1] using coefficients specified in SUEWS_AnthropogenicHeat.txt and diurnal patterns specified in SUEWS_Profiles.txt.</li><li>Modelled values will be used even if QF is provided in the meteorological forcing file.</li></ul></td></tr>
<tr><td rowspan="9">CBLuse</td><td colspan="2">Determines whether a CBL slab model is used to calculate temperature and humidity.</td></tr>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>CBL model NOT used. SUEWS and LUMPS use temperature and humidity provided in the meteorological forcing file.</td></tr>
<tr><td>1</td><td>CBL model is used to calculate temperature and humidity used in SUEWS and LUMPS.</td></tr>
<tr><td colspan="2">Determines method for calculation of radiation fluxes.</td></tr>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>Uses observed values of Q* supplied in meteorological forcing file.</td></tr>
<tr><td>1</td><td><ul><li>Q* modelled with L↓ observations supplied in meteorological forcing file.</li><li>Zenith angle not accounted for in albedo calculation.</li></ul></td></tr>
<tr><td>2</td><td><ul><li>Q* modelled with L↓ modelled using cloud cover fraction supplied in meteorological forcing file (Loridan et al. 2011[5]).</li></ul></td></tr>
</table>

| | | |
|---|---|---|
| NetRadiationChoice | | • Zenith angle **not** accounted for in albedo calculation. |
| | 3 | • Q* modelled with L↓ modelled using air temperature and relative humidity supplied in meteorological forcing file (Loridan et al. 2011[5]).<br>• Zenith angle **not** accounted for in albedo calculation. |
| | 100 | • Q* modelled with L↓ observations supplied in meteorological forcing file.<br>• Zenith angle accounted for in albedo calculation.<br>• SSss_YYYY_NARPOut.txt file produced.<br>• **Not recommended in this release** |
| | 200 | • Q* modelled with L↓ modelled using cloud cover fraction supplied in meteorological forcing file (Loridan et al. 2011[5]).<br>• Zenith angle accounted for in albedo calculation.<br>• SSss_YYYY_NARPOut.txt file produced.<br>• **Not recommended in this release** |
| | 300 | • Q* modelled with L↓ modelled using air temperature and relative humidity supplied in meteorological forcing file (Loridan et al. 2011[5]).<br>• Zenith angle accounted for in albedo calculation.<br>• SSss_YYYY_NARPOut.txt file produced.<br>• **Not recommended in this release** |
| gsChoice | **Determines functional form of surface conductance calculation. Surface conductance parameters set in SUEWS_Conductance.txt must be compatible with gsChoice. Users can provide their own coefficients for either form.** | |
| | Value | Comments |
| | 1 | • Surface conductance calculated according to Järvi et al. (2011)[1].<br>• Use with Code 100 in SUEWS_Conductance.txt. |
| | 2 | • Surface conductance calculated according to Ward et al. (2016)[2].<br>• Use with Code 200 in SUEWS_Conductance.txt. |
| | **Determines method for calculating storage heat flux ΔQS.** | |
| | Value | Comments |
| | | ΔQS modelled using the objective hysteresis model (OHM)[9][10][11] |

| | | |
|---|---|---|
| **QSChoice** | 1 | using parameters specified for each surface type. |
| | 2 | Uses observed values of ΔQS supplied in meteorological forcing file. |
| | 3 | ΔQS modelled using AnOHM. **Not available in v2016a** |
| | 4 | ΔQS modelled using the Element Surface Temperature Method (ESTM) (Offerle et al. 2005[12]). **Not available in v2016a** |
| **OHMIncQF** | **Determines whether the storage heat flux calculation uses Q* or (Q*+QF).** | |
| | Value | Comments |
| | 0 | ΔQS modelled Q* only. |
| | 1 | ΔQS modelled using Q*+QF. |
| **RoughLen_heat** | **Determines method for calculating roughness length for heat.** | |
| | Value | Comments |
| | 1 | Uses value of 0.1z0m. |
| | 2 | **Recommended** Calculated according to Kawai et al. (2009)[19]. |
| | 3 | Calculated according to Voogt and Grimmond (2000)[20]. |
| | 4 | Calculated according to Kanda et al. (2007)[21]. |
| **SMD_Choice** | **Determines method for calculating soil moisture deficit (SMD).** | |
| | Value | Comments |
| | 0 | • **Recommended**<br>• SMD modelled using parameters specified in SUEWS_Soil.txt. |
| | 1 | • **Not recommended in current release**<br>• Observed SM provided in the meteorological forcing file is used.<br>• Data are provided as *volumetric* soil moisture content. Metadata must be provided in SUEWS_Soil.txt. |
| | | • **Not recommended in current release**<br>• Observed SM provided in the meteorological forcing file is used. |

| | | |
|---|---|---|
| | 2 | • Data are provided as *gravimetric* soil moisture content. Metadata must be provided in SUEWS_Soil.txt. |
| **SnowFractionChoice** | **Determines method for calculating snow plan area fraction. Used only if SnowUse=1.** | |
| | Value | Comments |
| | 2 | Set to 2 in current release. |
| **SnowUse** | **Determines whether the snow part of the model runs.** | |
| | Value | Comments |
| | 0 | Snow calculations are **not** performed. |
| | 1 | Snow calculations are performed. |
| **SOLWEIGUse** | **Determines whether a high resolution radiation model to calculate mean radiant temperate should be used (SOLWEIG). NOTE: this option will considerably slow down the model since SOLWEIG is a 2D model.** | |
| | 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. |
| **StabilityMethod** | **Defines which atmospheric stability functions are used.** | |
| | Value | Comments |
| | 0 | Not used. |
| | 1 | Not used. |
| | 2 | • **Recommended**<br>• Momentum - unstable: Dyer (1974)[22] modified by Högstrom (1988)[23]; stable: Van Ulden and Holtslag (1985)[24]<br>• Heat - Dyer (1974)[22] modified by Högstrom (1988)[23] |
| | | • Momentum: Campbell and Norman (Eq 7.27, Pg97) [25]<br>• Heat - unstable: Campbell and Norman[25]; stable: Dyer (1974)[22] |

| | | |
|---|---|---|
| | 3 | modified by Högstrom (1988)[23] |
| | 4 | • Momentum: Businger et al. (1971)[26] modified by Högstrom (1988)[23]<br>• Heat: Businger et al. (1971)[26] modified by Högstrom (1988)[23] |
| **WUChoice** | **Defines how external water use is calculated.** | |
| | Value | Comments |
| | 0 | External water use modelled using parameters specified in SUEWS_Irrigation.txt. |
| | 1 | Observations of external water use provided in the meteorological forcing file are used. |
| **z0_method** | **Determines how aerodynamic roughness length (z0m) and zero displacement height (zdm) are calculated.** | |
| | Value | Comments |
| | 1 | • Values specified in SUEWS_SiteSelect.txt are used.<br>• z0m and zd are adjusted with time to account for seasonal variation in porosity of deciduous trees. |
| | 2 | • z0m and zd are calculated using 'rule of thumb' (Grimmond and Oke 1999[27]) using mean building and tree height specified in SUEWS_SiteSelect.txt. |
| | 3 | • z0m and zd are calculated based on the MacDonald et al. (1998)[28] method using mean building and tree heights, plan area fraction and frontal areal index specified in SUEWS_SiteSelect.txt. |

*File-related options*

| | |
|---|---|
| **FileChoice** | **Two-letter site identification code (e.g. He, Sc, Kc).** |
| **FileInputPath** | **Input directory.** |
| **FileOutputPath** | **Output directory.** |
| **SkipHeaderSiteInfo** | **Number of header lines to skip in SUEWS_SiteInfo text files (2 by default).** |
| **SkipHeaderMet** | **Number of header lines to skip meteorological forcing file (1 by default).** |

| | |
|---|---|
| **MultipleMetFiles** | **Specifies whether one single meteorological forcing file is used for all grids or a separate met file is provided for each grid.**<br><br>Value \| Comments<br>0 \| • Single meteorological forcing file used for all grids. • The single file should be named with the first grid.<br>1 \| • Separate meteorological forcing files used for each grid. • The grid number should appear in the file name. |
| **KeepTstepFilesIn** | **Specifies whether input meteorological forcing files at the resolution of the model time step should be kept when using the wrapper.**<br><br>Value \| Comments<br>0 \| • Meteorological forcing files at model time step deleted. • Recommended to save disk space as (e.g. 5-min) files can be large.<br>1 \| • Meteorological forcing files at model time step are **not** deleted. |
| **KeepTstepFilesOut** | **Specifies whether output meteorological forcing files at the resolution of the model time step should be kept when using the wrapper.**<br><br>Value \| Comments<br>0 \| • Output files at model time step deleted. • Recommended to save disk space as (e.g. 5-min) files can be large.<br>1 \| • Output files at model time step are **not** deleted. |
| **WriteSurfsFile** | **Specifies whether an output file at the resolution of the model time step containing all the water balance, energy balance and snow variables for each surface type should be written.**<br><br>Value \| Comments<br>0 \| • Output files for each surface type **not** written. • Recommended to save disk space as (e.g. 5-min) files can be large.<br>1 \| • Output files for each surface type written. • **Not available in current release.** |

*Time-related options*

| | |
|---|---|
| **TimeZone** | **Time zone [h] for site relative to UTC (east is positive).** |

| | |
|---|---|
| **Tstep** | **Specifies the model time step [s]. 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).** |
| *Data-related options* | |
| **z** | **Height [m] of the meteorological forcing data. The most important height is that of the wind speed measurement. Must be greater than the displacement height. Forcing data should be representative of the local-scale, i.e. above the height of the roughness element.** |

SUEWS_SiteSelect.txt

For each year and each grid, site specific surface cover information and other input parameters is 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 (before the two rows of '-9') will be read by the model and run. In this file the **column order is important**. '!' 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.

| Use | Column |
|---|---|
| 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. Set any parameters that are not used/not known to '-999'. |
| L | Codes that are used to link between the input files. These codes are required but their values are completely arbitrary, providing that they link the input files in the correct way. The user should choose these codes, bearing in mind that the codes they match up with in column 1 of the corresponding input file must be unique within that file. Codes must be integers. Note that the codes must 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. |

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| | | | | Grid number (any integer 0-99999) identifying the current grid.<br>• Grid numbers do not need to be consecutive and do not need to start at a particular value.<br>• Each grid must have a unique grid number.<br>• All grids must be present for all years. |

| | | | | |
|---|---|---|---|---|
| 1 | MU | Grid | 1 | • These grid numbers are referred to in GridConnections (columns 58-73) (not available in this release!)<br><br>The two last lines in this column must read '-9' to indicate that the last lines have been reached (using two lines allows differences in computer file savings to be dealt with). |
| 2 | MU | Year | 2011 | Year [YYYY]<br>Years must be continuous. |
| 3 | MU | StartDLS | 86 | Start of the day light savings [DOY]<br>In northern hemisphere example, day light saving starts on day of year 86. See section on Day Light Savings. |
| 4 | MU | EndDLS | 303 | End of the day light savings [DOY]<br>In northern hemisphere example, day light saving finishes on 303. See section on Day Light Savings. |
| 5 | MU | lat | 60.00 | Latitude for the centre of the grid [decimal degrees]<br>• Use coordinate system WGS84.<br>• Positive values are northern hemisphere (negative southern hemisphere).<br>• Used in radiation calculations.<br>• 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. |
| 6 | MU | lng | -18.20 | Longitude for the centre of the grid [decimal degrees]<br>• Use coordinate system WGS84.<br>• Positive values are to the west (negative values are to the east).<br>• See latitude for more details. |
| 7 | MU | SurfaceArea | 75.3 | Area of the grid [ha]. |
| | | | | Altitude [m]<br>Mean topographic height above sea-level. |

| | | | | |
|---|---|---|---|---|
| 8 | MU | Alt | 25.0 | • Used for both the radiation and water flow between grids. |
| 9 | MD | id | 1 | Day [DOY]<br>Set to 1 in this version |
| 10 | MD | ih | 0 | Hour [H]<br>Set to 0 in this version |
| 11 | MD | imin | 0 | Minute [M]<br>Set to 0 in this version |
| 12 | MU | Fr_Paved | 0.20 | Surface cover fraction of paved surfaces [-]<br>Areal cover fraction of paved surfaces (roads, pavements, car parks). e.g. 20% of the grid is covered with paved surfaces.<br>• **Columns 12 to 18 must sum to 1**. |
| 13 | MU | Fr_Bldgs | 0.20 | Surface cover fraction of buildings [-] |
| 14 | MU | Fr_EveTr | 0.10 | Surface cover fraction of evergreen trees and shrubs [-] |
| 15 | MU | Fr_DecTr | 0.10 | Surface cover fraction of deciduous trees and shrubs [-] |
| 16 | MU | Fr_Grass | 0.30 | Surface cover fraction of grass [-] |
| 17 | MU | Fr_Bsoil | 0.05 | Surface cover fraction of bare soil or unmanaged land [-] |
| 18 | MU | Fr_Water | 0.05 | Surface cover fraction of open water [-]<br>(e.g. river, lakes, ponds, swimming pools) |
| 19 | MU | IrrFr_EveTr | 0.50 | Fraction of evergreen trees that are irrigated [-]<br>e.g. 50% of the evergreen trees/shrubs are irrigated |
| 20 | MU | IrrFr_DecTr | 0.20 | Fraction of deciduous trees that are irrigated [-] |
| 21 | MU | IrrFr_Grass | 0.70 | Fraction of grass that is irrigated [-] |
| 22 | MU | H_Bldgs | 10 | Mean building height [m] |
| 23 | MU | H_EveTr | 15 | Mean height of evergreen trees [m] |

| | | | | |
|---|---|---|---|---|
| 24 | MU | H_DecTr | 15 | Mean height of deciduous trees [m] |
| 25 | O | z0 | 0.6 | Roughness length for momentum [m]<br>Value supplied here is used if z0_method = 1 in RunControl.nml; otherwise set to '-999' and a value will be calculated by the model (z0_method = 2, 3). |
| 26 | O | Zd | 1.5 | Zero-plane displacement [m]<br>Value supplied here is used if z0_method = 1 in RunControl.nml; otherwise set to '-999' and a value will be calculated by the model (z0_method = 2, 3). |
| 27 | O | FAI_Bldgs | 0.1 | Frontal area index for buildings [-]<br>Required if z0_method = 3 in RunControl.nml. |
| 28 | O | FAI_EveTr | 0.2 | Frontal area index for evergreen trees [-]<br>Required if z0_method = 3 in RunControl.nml. |
| 29 | O | FAI_DecTr | 0.2 | Frontal area index for deciduous trees [-]<br>Required if z0_method = 3 in RunControl.nml. |
| 30 | O | PopDensDay | 30.7 | Daytime population density (i.e. workers, tourists) [people ha-1]<br>Not used in current version of the model. |
| 31 | O | PopDensNight | 10.2 | Night-time population density (i.e. residents) [people ha-1]<br>Required if AnthropHeatChoice = 2 in RunControl.nml. |
| 32 | L | Code_Paved | 331 | Code for Paved surface characteristics<br>Provides the link to column 1 of SUEWS_NonVeg.txt, 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 SUEWS_NonVeg.txt. e.g. 331 means use the characteristics specified in the row of input file SUEWS_NonVeg.txt which has 331 in column 1 (Code). |
| | | | | Code for Bldgs surface characteristics<br>Provides the link to column 1 of SUEWS_NonVeg.txt, which contains the attributes describing buildings in |

| | | | | |
|---|---|---|---|---|
| 33 | L | Code_Bldgs | 332 | this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_NonVeg.txt. |
| 34 | L | Code_EveTr | 331 | Code for EveTr surface characteristics<br>Provides the link to column 1 of SUEWS_Veg.txt, 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 SUEWS_Veg.txt. |
| 35 | L | Code_DecTr | 332 | Code for DecTr surface characteristics<br>Provides the link to column 1 of SUEWS_Veg.txt, 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 SUEWS_Veg.txt. |
| 36 | L | Code_Grass | 333 | Code for Grass surface characteristics<br>Provides the link to column 1 of SUEWS_Veg.txt, 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 SUEWS_Veg.txt. |
| 37 | L | Code_Bsoil | 333 | Code for BSoil surface characteristics<br>Provides the link to column 1 of SUEWS_NonVeg.txt, which contains the attributes describing bare soil in this grid for this year. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_NonVeg.txt. |
| 38 | L | Code_Water | 331 | Code for Water surface characteristics<br>Provides the link to column 1 of SUEWS_Water.txt, 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 SUEWS_Water.txt. |
| 39 | MD | LUMPS_DrRate | 0.25 | Drainage rate of bucket for LUMPS [mm h-1]<br>Used for LUMPS surface wetness control. Default recommended value of 0.25 mm h-1 from Loridan et al. (2011)[5]. |

| | | | | |
|---|---|---|---|---|
| 40 | MD | LUMPS_Cover | 1 | Limit when surface totally covered with water [mm]<br>Used for LUMPS surface wetness control. Default recommended value of 1 mm from Loridan et al. (2011)[5]. |
| 41 | MD | LUMPS_MaxRes | 10 | Maximum water bucket reservoir [mm]<br>Used for LUMPS surface wetness control. Default recommended value of 10 mm from Loridan et al. (2011)[5]. |
| 42 | MD | NARP_Trans | 1 | Atmospheric transmissivity for NARP [-]<br>Value must in the range 0-1. Default recommended value of 1. |
| 43 | L | CondCode | 33 | Code for surface conductance parameters<br>Provides the link to column 1 of SUEWS_Conductance.txt, 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 SUEWS_Conductance.txt. e.g. 33 means use the characteristics specified in the row of input file SUEWS_Conductance.txt which has 33 in column 1 (Code). |
| 44 | L | SnowCode | 33 | Code for snow surface characteristics<br>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. |
| 45 | L | SnowClearingProfWD | 331 | Code for snow clearing profile (weekdays)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. e.g. 331 means use the characteristics specified in the row of input file SUEWS_Profiles.txt which has 331 in column 1 (Code). |
| | | | | Code for snow clearing profile (weekends) |

| | | | | |
|---|---|---|---|---|
| 46 | L | SnowClearingProfWE | 332 | Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. e.g. 332 means use the characteristics specified in the row of input file SUEWS_Profiles.txt which has 332 in column 1 (Code). Providing the same code for SnowClearingProfWD and SnowClearingProfWE would link to the same row in SUEWS_Profiles.txt, i.e. the same profile would be used for weekdays and weekends. |
| 47 | L | AnthropogenicCode | 33 | Code for modelling anthropogenic heat flux<br>Provides the link to column 1 of SUEWS_AnthropogenicHeat.txt, which contains the model coefficients for estimation of the anthropogenic heat flux (used if AnthropHeatChoice = 1, 2 in RunControl.nml). Value of integer is arbitrary but must match code specified in column 1 of SUEWS_AnthropogenicHeat.txt. |
| 48 | L | EnergyUseProfWD | 333 | Code for energy use profile (weekdays)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |
| 49 | L | EnergyUseProfWE | 334 | Code for energy use profile (weekends)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |
| 50 | L | IrrigationCode | 33 | 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 RunControl.nml). Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Irrigation.txt. |
| 51 | L | WaterUseProfManuWD | 335 | Code for water use profile (manual irrigation, weekdays)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |

| | | | | |
|---|---|---|---|---|
| 52 | L | WaterUseProfManuWE | 336 | Code for water use profile (manual irrigation, weekends)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |
| 53 | L | WaterUseProfAutoWD | 337 | Code for water use profile (automatic irrigation, weekdays)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |
| 54 | L | WaterUseProfAutoWE | 338 | Code for water use profile (automatic irrigation, weekends)<br>Provides the link to column 1 of SUEWS_Profiles.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Profiles.txt. |
| 55 | MD | FlowChange | 0 | Difference in input and output flows for water surface [mm h-1]<br>Used to indicate river or stream flow through the grid. **Currently not fully tested!** |
| 56 | MD,MU | RunoffToWater | 0.1 | Fraction of above-ground runoff flowing to water surface during flooding [-]<br>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. |
| 57 | MD,MU | PipeCapacity | 100 | Storage capacity of pipes [mm]<br>Runoff amounting to less than the value specified here is assumed to be removed by pipes. |
| | | | | Number of the grid where water can flow to [-]<br>• The next 8 pairs of columns specify the water flow between grids.<br>• 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.<br>• The fraction (i.e. amount) of water transferred may be estimated based on elevation, the length |

| | | | | |
|---|---|---|---|---|
| 58 | MD,MU | GridConnection1of8 | 2 | of connecting surface between grids, presence of walls, etc.<br>• 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.<br>• If there is no water flow between grids, or a single grid is run, set to 0.<br>• See section on Grid Connections<br><br>**Not currently implemented!** |
| 59 | MD,MU | Fraction1of8 | 0.2 | Fraction of water that can flow to the grid specified in previous column [-] |
| 60 | MD,MU | GridConnection2of8 | 0 | Number of the grid where water can flow to |
| 61 | MD,MU | Fraction2of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 62 | MD,MU | GridConnection3of8 | 0 | Number of the grid where water can flow to |
| 63 | MD,MU | Fraction3of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 64 | MD,MU | GridConnection4of8 | 0 | Number of the grid where water can flow to |
| 65 | MD,MU | Fraction4of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 66 | MD,MU | GridConnection5of8 | 0 | Number of the grid where water can flow to |
| 67 | MD,MU | Fraction5of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 68 | MD,MU | GridConnection6of8 | 0 | Number of the grid where water can flow to |
| 69 | MD,MU | Fraction6of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 70 | MD,MU | GridConnection7of8 | 0 | Number of the grid where water can flow to |
| 71 | MD,MU | Fraction7of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 72 | MD,MU | GridConnection8of8 | 0 | Number of the grid where water can flow to |
| 73 | MD,MU | Fraction8of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |

| | | | | |
|---|---|---|---|---|
| 74 | L | WithinGridPavedCode | 331 | Code that links to the fraction of water that flows from Paved surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| 75 | L | WithinGridBldgsCode | 332 | Code that links to the fraction of water that flows from Bldgs surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| 76 | L | WithinGridEveTrCode | 333 | Code that links to the fraction of water that flows from EveTr surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| 77 | L | WithinGridDecTrCode | 334 | Code that links to the fraction of water that flows from DecTr surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| 78 | L | WithinGridGrassCode | 335 | Code that links to the fraction of water that flows from Grass surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| 79 | L | WithinGridBSoilCode | 336 | Code that links to the fraction of water that flows from BSoil surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |
| | | | | Code that links to the fraction of water that flows |

| | | | | |
|---|---|---|---|---|
| 80 | L | WithinGridWaterCode | 337 | from Water surfaces to surfaces in columns 2-10 of SUEWS_WithinGridWaterDist.txt.<br>Value of integer is arbitrary but must match code specified in column 1 of SUEWS_WithinGridWaterDist.txt. |

Day Light Savings (DLS)

The dates for DLS normally vary each year 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.

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

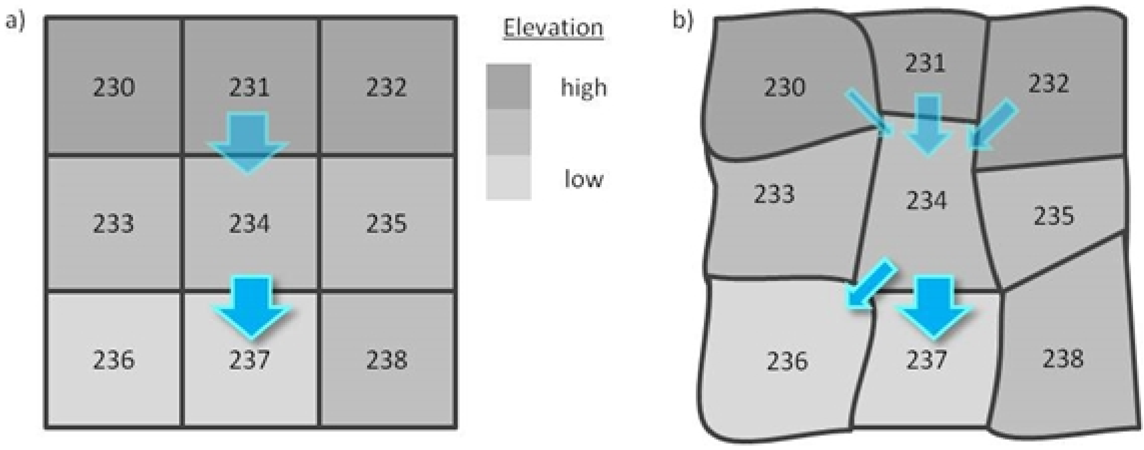
```
for northern hemisphere, use: 180 181
for southern hemisphere, use:  365 1
```

| Example: | Year | start of daylight savings | end of daylight savings |
|---|---|---|---|
| when running multiple years (in this case 2008 and 2009) | 2008 | 170 | 240 |
| | 2009 | 172 | 242 |
| when daylight saving **does not occur** in Northern hemisphere | 2008 | 180 | 181 |
| when daylight saving occurs in Southern hemisphere | 2004 | 275 | 93 |
| when daylight saving **does not occur** in Southern hemisphere | 2008 | 365 | 1 |

Grid Connections (water flow between grids)

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.




Example grid connections showing water flow between grids. 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.

| 1 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grid | GridConnection 1of8 | Fraction1of8 | GridConnection 2of8 | Fraction2of8 | GridConnection 3of8 | Fraction3of8 | GridConnection 4of8 | Fraction4of8 | GridConnection 5of8 | Fraction5of8 | GridConnection 6of8 | Fraction6of8 | GridConnection 7of8 | Fraction7of8 | GridConnection 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 |

Example values for the grid connections part of SUEWS_SiteSelect.txt for the grids.

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. Use Column name Example Description Code linking to SUEWS_SiteSelect.txt 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 SUEWS_SiteSelect.txt.

2 MU AlbedoMin 0-1 Minumum albedo of this surface [-]
Effective surface albedo (middle of the day value) for wintertime (not including snow).

- View factors should be taken into account.
- Not currently used for non-vegetated surfaces – set the same as AlbedoMax.

3 MU AlbedoMax 0-1

- Effective surface albedo (middle of the day value) for summertime.
- View factors should be taken into account.

4 MU Emissivity 0-1 5 MD StorageMin

- 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).

| Example values [mm] | |
|---|---|
| 0.48 | Paved |
| 0.25 | Bldgs |
| 0.80 | BSoil |

6 MD StorageMax

- 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 StorageMin.

| Example values [mm] | |
|---|---|
| 0.48 | Paved |
| 0.25 | Bldgs |
| 0.80 | BSoil |

7 MD WetThreshold Threshold for a completely wet surface [mm]

- Depth of water which determines whether evaporation occurs from a partially wet or completely wet surface.

| Example values [mm] | |
|---|---|
| 0.6 | Paved |
| 0.6 | Bldgs |
| 1.0 | BSoil |

8 MD StateLimit

- **Currently only used for the water surface**
- **WaterState** specified in the InitialConditions file must not exceed this value.

9 MD DrainageEq 1, 2, 3 Drainage equation to use for this surface.

| Options | | |
|---|---|---|
| 1 | Falk and Niemczynowicz (1978)[29] | |
| 2 | Halldin et al. (1979)[30] (Rutter eqn corrected for c=0, see Calder & Wright (1986)[31]) | Recommended[3] for BSoil |

| | | | |
|---|---|---|---|
| 3 | Falk and Niemczynowicz (1978)[29] | | Recommended[3] for Paved and Bldgs |

- Coefficients are specified in the following two columns.

10 MD DrainageCoef1 Coefficient for drainage equation [units vary according to DrainageEq specified in previous column]

| Example values | | DrainageEq | |
|---|---|---|---|
| 10 | Coefficient D0 [mm h-1] | 3 | Recommended[3] for Paved and Bldgs |
| 0.013 | Coefficient D0 [mm h-1] | 2 | Recommended[3] for BSoil |

11 MD DrainageCoef2 Coefficient for drainage equation [units vary according to DrainageEq specified in previous column]

| Example values | | DrainageEq | |
|---|---|---|---|
| 3 | Coefficient b [-] | 3 | Recommended[3] for Paved and Bldgs |
| 1.71 | Coefficient b [mm-1] | 2 | Recommended[3] for BSoil |

12 L SoilTypeCode Code for soil characteristics below this surface
Provides the link to column 1 of SUEWS_Soil.txt, 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 SUEWS_Soil.txt.

13 O SnowLimPatch Maximum SWE [mm]
Limit of snow water equivalent when the surface is fully covered with snow.

| Example values [mm] | | |
|---|---|---|
| 190 | Paved | Järvi et al. (2014)[16] |
| 190 | Bldgs | Järvi et al. (2014)[16] |
| 190 | BSoil | Järvi et al. (2014)[16] |

- Not needed if SnowUse = 0 in RunControl.nml.

14 O SnowLimRemove SWE when snow is removed from this surface [mm]
Limit of snow water equivalent when snow is removed from paved surfaces and buildings

- **Currently not implemented for BSoil surface**

| Example values [mm] | | |
|---|---|---|
| 40 | Paved | Järvi et al. (2014)[16] |
| 100 | Bldgs | Järvi et al. (2014)[16] |

- Not needed if SnowUse = 0 in RunControl.nml.

15 L OHMCode_SummerWet Code for OHM coefficients to use for this surface during wet conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

16 L OHMCode_SummerDry Code for OHM coefficients to use for this surface during dry conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

17 L OHMCode_WinterWet Code for OHM coefficients to use for this surface during wet conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

18 L OHMCode_WinterDry Code for OHM coefficients to use for this surface during dry conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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. Use Column name Example Description

- Coefficients are specified in the following four columns.
- N.B. North and South hemispheres are treated slightly differently.
- **Currently only the DecTr values are used; values for other surfaces ignored!**

22 MD LeafGrowthPower1 Coefficient (power) for leaf growth [-]
See Appendix A Järvi et al. (2014)[16] for more details.

| Example values | | LAIEq |
|---|---|---|
| 0.03 | Järvi et al. (2011)[1] | 0 |
| 0.04 | Järvi et al. (2014)[16] | 1 |

- **Currently only the DecTr values are used; values for other surfaces ignored!**

23 MD LeafGrowthPower2 Constant in the leaf growth equation [°C-1]
See Appendix A Järvi et al. (2014)[16] for more details.

| Example values [°C-1] | | LAIEq |
|---|---|---|
| 0.0005 | Järvi et al. (2011)[1] | 0 |

| | | |
|---|---|---|
| 0.0010 | Järvi et al. (2014)[16] | 1 |

- **Currently only the DecTr values are used; values for other surfaces ignored!**

24 MD LeafOffPower1 Coefficient (power) for leaf off [-]
See Appendix A Järvi et al. (2014)[16] for more details.

| Example values | | LAIEq |
|---|---|---|
| 0.03 | Järvi et al. (2011)[1] | 0 |
| -1.5 | Järvi et al. (2014)[16] | 1 |

- **Currently only the DecTr values are used; values for other surfaces ignored!**

25 MD LeafOffPower2 Constant in the leaf off equation [°C-1]
See Appendix A Järvi et al. (2014)[16] for more details.

| Example values [°C-1] | | LAIEq |
|---|---|---|
| 0.0005 | Järvi et al. (2011)[1] | 0 |
| 0.0015 | Järvi et al. (2014)[16] | 1 |

- **Currently only the DecTr values are used; values for other surfaces ignored!**

26 L OHMCode_SummerWet Code for OHM coefficients to use for this surface during wet conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

27 L OHMCode_SummerDry Code for OHM coefficients to use for this surface during dry conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

28 L OHMCode_WinterWet Code for OHM coefficients to use for this surface during wet conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

29 L OHMCode_WinterDry Code for OHM coefficients to use for this surface during dry conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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. Use Column name Example Description

- 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).
- **WaterState** specified in the Initial Conditions file must not exceed this value.

9 MD DrainageEq -999 Drainage equation to use for this surface.

- Not currently used for water surface.

10 MD DrainageCoef1 -999 Coefficient for drainage equation [units vary according to equation]

- Not currently used for water surface

11 MD DrainageCoef2 -999 Coefficient for drainage equation [units vary according to equation]

- Not currently used for water surface

12 L OHMCode_SummerWet Code for OHM coefficients to use for this surface during wet conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

13 L OHMCode_SummerDry Code for OHM coefficients to use for this surface during dry conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

14 L OHMCode_WinterWet Code for OHM coefficients to use for this surface during wet conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

15 L OHMCode_WinterDry Code for OHM coefficients to use for this surface during dry conditions in winter.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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)[16]. *In the current release SnowUse should be set to 0.*

No. Use Column name Example Description Code for OHM coefficients to use for this surface during wet conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

17 L OHMCode_SummerDry Code for OHM coefficients to use for this surface during dry conditions in summer.
Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

18 L OHMCode_WinterWet Code for OHM coefficients to use for this surface during wet conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

19 L OHMCode_WinterDry Code for OHM coefficients to use for this surface during dry conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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 soi store below the water surfaces. Note that these sub-surface soil stores are different to the bare soil/unmamnaged 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 (smd_choice = 1 or 2 in RunControl.nml) and providing some metadata information here (OBS_ columns), or modelled by SUEWS (smd_choice = 0 in RunControl.nml). **- Note, the option to use observational data is not operational in the current release!**

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| 1 | L | Code | 331 | Code linking to the SoilTypeCode column in SUEWS_NonVeg.txt (for Paved, Bldgs and BSoil surfaces) and SUEWS_Veg.txt (for EveTr, DecTr and Grass surfaces). Value of integer is arbitrary but must match code specified in SUEWS_SiteSelect.txt. |
| 2 | MD | SoilDepth | 350 | Depth of sub-surface soil store [mm]<br>i.e. the depth of soil beneath the surface |
| 3 | MD | SoilStoreCap | 150 | Capacity of sub-surface soil store [mm]<br>i.e. how much water can be stored in the sub-surface soil when at maximum capacity.<br>• SoilStoreCap must not be greater than SoilDepth. |
| 4 | MD | SatHydraulicCond | 0.0005 | Hydraulic conductivity for saturated soil [mm s-1] |
| 5 | MD | SoilDensity | 1.16 | Soil density [kg m-3] |
| 6 | O | InfiltrationRate | -999 | Infiltration rate [mm h-1]<br>• Not currently used |
| | | | | Depth of soil moisture measurements [mm] |

| | | | | |
|---|---|---|---|---|
| 7 | O | OBS_SMDepth | | • Use only if soil moisture is observed and provided in the met forcing file and smd_choice = 1 or 2.<br>• **Use of observed soil moisture not currently tested** |
| 8 | O | OBS_SMCap | | Maxiumum observed soil moisture [m3 m-3 or kg kg-1]<br>• Use only if soil moisture is observed and provided in the met forcing file and smd_choice = 1 or 2.<br>• **Use of observed soil moisture not currently tested** |
| 9 | O | OBS_SoilNotRocks | | Fraction of soil without rocks [-]<br>• Use only if soil moisture is observed and provided in the met forcing file and smd_choice = 1 or 2.<br>• **Use of observed soil moisture not currently tested** |

SUEWS_Conductance.txt

SUEWS_Conductance.txt contains the parameters needed for the 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)[1]) and should be used with **gsChoice=1** in RunControl.nml. An alternative formulation (gsChoice=2) uses slightly different functional forms and different coefficients (with different units).

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| 1 | L | Code | | Code linking to the CondCode column in SUEWS_SiteSelect.txt. Value of integer is arbitrary but must match code specified in SUEWS_SiteSelect.txt. |
| 2 | MD | G1 | 16.4764 | Related to maximum surface conductance [mm s-1] |
| 3 | MD | G2 | 566.0923 | Related to Kdown dependence [W m-2] |
| 4 | MD | G3 | 0.2163 | Related to VPD dependence [units depend on gsChoice in RunControl.nml ] |
| 5 | MD | G4 | 3.3649 | Related to VPD dependence [units depend on gsChoice in RunControl.nml ] |
| 6 | MD | G5 | 11.0764 | Related to temperature dependence [°C] |
| 7 | MD | G6 | 0.0176 | Related to soil moisture dependence [mm-1] |
| 8 | MD | TH | 40 | Upper air temperature limit [°C] |
| 9 | MD | TL | 0 | Lower air temperature limit [°C] |

| | | | | |
|---|---|---|---|---|
| 10 | MD | S1 | 0.45 | Related to soil moisture dependence [-]<br>*These will change in the future to ensure consistency with soil behaviour* |
| 11 | MD | S2 | 15 | Related to soil moisture dependence [mm]<br>*These will change in the future to ensure consistency with soil behaviour* |
| 12 | MD | Kmax | 1200 | Maximum incoming shortwave radiation [W m-2] |

SUEWS_AnthropogenicHeat.txt
SUEWS_AnthropogenicHeatFlux.txt provides the parameters needed to model the anthropogenic heat flux using either the method of Järvi et al. (2011) based on heating and cooling degree days (AnthropHeatChoice = 2 in 4.1 RunControl.nml) or the method of Loridan et al. (2011) based on air temperature (AnthropHeatChoice = 1 in RunControl.nml). 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 AnthropHeatChoice = 0 in RunControl.nml), in which case all columns here except Code and BaseTHDD should be set to '-999'.

No. Use Column name Example Description SUEWS_Irrigation.txt
SUEWS includes a simple model for external water use if observed data are not available. The model 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 sub-daily pattern of water use is modelled according to the daily cycles specified in SUEWS_Profiles.txt.

Alternatively, if available, the external water use can be provided in the met forcing file (and set WU_choice = 1 in RunControl.nml), in which case all columns here except Code should be set to '-999'.

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| 1 | L | Code | | Code linking to [[#SUEWS_SiteSelect.txt\|SUEWS_SiteSelect.txt] for irrigation modelling (IrrigationCode).<br>Value of integer is arbitrary but must match codes specified in SUEWS_SiteSelect.txt. |
| 2 | MU | Ie_start | 1-366 | Day when irrigation starts [DOY] |
| 3 | MU | Ie_end | 1-366 | Day when irrigation ends [DOY] |
| 4 | MU | InternalWaterUse | 0 | Internal water use [mm h-1] |
| 5 | MU | Faut | 0-1 | Fraction of irrigated area that is irrigated using automated systems (e.g. sprinklers). |
| 6 | MD | Ie_a1 | -84.54 | Coefficient for automatic irrigation model [mm d-1] |

| | | | | |
|---|---|---|---|---|
| 7 | MD | Ie_a2 | 9.96 | Coefficient for automatic irrigation model [mm d-1 °C-1] |
| 8 | MD | Ie_a3 | 3.67 | Coefficient for automatic irrigation model [mm d-2] |
| 9 | MD | Ie_m1 | -25.36 | Coefficient for manual irrigation model [mm d-1] |
| 10 | MD | Ie_m2 | 3.00 | Coefficient for manual irrigation model [mm d-1 °C-1] |
| 11 | MD | Ie_m3 | 1.10 | Coefficient for manual irrigation model [mm d-2] |
| 12 | MU | DayWat(1) | 0 or 1 | Irrigation allowed on Sundays [1], if not [0] |
| 13 | MU | DayWat(2) | 0 or 1 | Irrigation allowed on Mondays [1], if not [0] |
| 14 | MU | DayWat(3) | 0 or 1 | Irrigation allowed on Tuesdays [1], if not [0] |
| 15 | MU | DayWat(4) | 0 or 1 | Irrigation allowed on Wednesdays [1], if not [0] |
| 16 | MU | DayWat(5) | 0 or 1 | Irrigation allowed on Thursdays [1], if not [0] |
| 17 | MU | DayWat(6) | 0 or 1 | Irrigation allowed on Fridays [1], if not [0] |
| 18 | MU | DayWat(7) | 0 or 1 | Irrigation allowed on Saturdays [1], if not [0] |
| 19 | MU | DayWatPer(1) | 0-1 | Fraction of properties using irrigation on Sundays [0-1] |
| 20 | MU | DayWatPer(2) | 0-1 | Fraction of properties using irrigation on Mondays [0-1] |
| 21 | MU | DayWatPer(3) | 0-1 | Fraction of properties using irrigation on Tuesdays [0-1] |
| 22 | MU | DayWatPer(4) | 0-1 | Fraction of properties using irrigation on Wednesdays [0-1] |
| 23 | MU | DayWatPer(5) | 0-1 | Fraction of properties using irrigation on Thursdays [0-1] |
| 24 | MU | DayWatPer(6) | 0-1 | Fraction of properties using irrigation on Fridays [0-1] |
| 25 | MU | DayWatPer(7) | 0-1 | Fraction of properties using irrigation on Saturdays [0-1] |

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 interpolate the hourly energy and water use profiles to the resolution of the model time step and normalize the values provided. Thus it does not matter whether columns 2-25 add up to, say 1, 24, or another number, because the model will handle this. Currently, the snow clearing profiles are not interpolated as these are effectively a switch (0 or 1).

If the anthropogenic heat flux and water use are specified in the met forcing file, the energy and water use profiles are not used.

Profiles are specified for the following

- Anthropogenic heat flux (weekday and weekend)
- Water use (weekday and weekend; manual and automatic irrigation)

- Snow removal (weekday and weekend)

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| 1 | L | Code | | Code linking to the following columns in SUEWS_SiteSelect.txt:<br>• EnergyUseProfWD : Anthropogenic heat flux, weekdays<br>• EnergyUseProfWE : Anthropogenic heat flux, weekends<br>• WaterUseProfManuWD : Manual irrigaton, weekdays<br>• WaterUseProfManuWE : Manual irrigaton, weekends<br>• WaterUseProfAutoWD : Automatic irrigaton, weekdays<br>• WaterUseProfAutoWE: Automatic irrigaton, weekends<br>• SnowClearingProfWD : Snow clearing, weekdays<br>• SnowClearingProfWE: Snow clearing, weekends<br>• Value of integer is arbitrary but must match codes specified in SUEWS_SiteSelect.txt. |
| 2-25 | MU | 0-23 | | Multiplier for each hour of the day [-] for energy and water use.<br>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 SUEWS_NonVeg.txt (SnowLimRemove column) are exceeded. |

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 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).

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | ToPaved | ToBuilt | ToEveTr | ToDecTr | ToGrass | ToBSoil | ToWater | ToRunoff | ToSoilStore | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | ! |
| 20 | 0.06 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0.9 | 0 | ! |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ! |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ! |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ! |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | ! |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ! |

Storage heat flux related

Depending on how the storage heat flux is calculated (specified by **QSChoice** in RunControl.nml), different input files are required.

| Option | QSChoice | Files needed |
|---|---|---|
| OHM | 1 | Coefficients specified in SUEWS_OHMCoefficients.txt |
| Observations | 2 | Add data to meteorological forcing file |
| AnOHM | 3 | Properties specified with other site characteristics. |
| ESTM | 4 | Properties specified in SUEWS_ESTMCoefficients.txt<br>Model options specified in ESTMinput.nml<br>Surface temperatures provided in SS_YYYY_ESTM_Ts_data.txt |

OHM

OHM, the Objective Hysteresis Model (Grimmond et al. 1991)[9] calculates the storage heat flux as a function of net all-wave radiation and surface characteristics.

SUEWS_OHMCoefficients.txt

- For each surface, OHM requires three model coefficients (a1, a2, a3). The three should be selected as a set.
- A variety of values has been derived for different materials and can be found in the literature (see: Typical Values).

- The **SUEWS_OHMCoefficients.txt** file provides these coefficients for each surface type.
- Coefficients can be changed depending on:

1. surface wetness state (wet/dry) based on the calculated surface wetness state in the model.
2. season (summer/winter) based on a 5-day running average of mean air temperature. If greater than 10 °C then the summer coefficients are used.

- To use the same coefficients irrespective of wet/dry and summer/winter conditions, use the same code for all four OHM linking columns (OHMCode_SummerWet, OHMCode_SummerDry, OHMCode_WinterWet and OHMCode_WinterDry).

| No. | Use | Column name | Example | Description |
|---|---|---|---|---|
| 1 | L | Code | 331 | Code linking to the OHMCode_SummerWet, OHMCode_SummerDry, OHMCode_WinterWet and OHMCode_WinterDry columns in SUEWS_NonVeg.txt, SUEWS_Veg,txt, SUEWS_Water.txt and SUEWS_Snow.txt files.<br>Value of integer is arbitrary but must match code specified in SUEWS_SiteSelect.txt. |
| 2 | MU | a1 | | Coefficient for Q* term [-] |
| 3 | MU | a2 | | Coefficient for dQ*/dt term [h] |
| 4 | MU | a3 | | Constant term [W m-2] |

AnOHM - not available in v2016aESTM - not available in v2016a
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).

Initial Conditions file
To start the model, information about the conditions at the start of the run is required. An InitialConditions file is needed for the first time period for each grid. After that, new InitialConditionsSSss_YYYY.nml files will be written for the following years. It is recommended that you look at this output (located in the input directory) to check the status of various surfaces at the end or 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'.

InitialConditionsSSss_YYYY.nml

- Variables can be in any order

| Parameters | Used for | Unit | Comments |
|---|---|---|---|
| DaysSinceRain | Wateruse | days | Number of days since rainfall occurred.<br>• **important** to use correct value if starting in summer season<br>• if starting when external water use is not occurring it will be reset with the first rain so can just be set to 0. |
| Temp_C0 | Water use, QF | °C | Daily mean temperature [°C] for the day before the run starts |
| Id_prev | A | Day | Day of year before the run starts (i.e. previous day)<br>• If start of year use 0 |
| GDD_1_0 | LAI | °C | Growing degree days for leaf growth.<br>• Cannot be negative.<br>• If leaves are already full, then this should be the same as GDDFull in SUEWS_Veg.txt.<br>• If *winter*, set to 0.<br>• It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter). |
| GDD_2_0 | LAI | °C | Growing degree days for senescence growth.<br>• Cannot be positive<br>• If the leaves are full but in early/mid summer then set to 0.<br>• If *late summer or autumn*, this should be a negative value.<br>• If *leaves are off*, then use the values of SDDFull in SUEWS_Veg.txt to guide your minimum value.<br>• It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter). |
| **Above Ground State** | | | |
| PavedState | | | Initial wetness state of paved surface (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |
| BldgsState | W | mm | Initial wetness state for buildings (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |

| | | | |
|---|---|---|---|
| EveTrState | W | mm | Initial wetness state of evergreen trees (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |
| DecTrState | W | mm | Initial wetness state of deciduous trees (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |
| GrassState | W | mm | Initial wetness state of grass (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |
| BSoilState | W | mm | Initial wetness state of bare soil surface (0 indicates dry, wet otherwise).<br>• If unknown, set to zero as the model will update these states quickly. |
| WaterState | W | mm | Initial state of water surface (must be set > 0, as 0 indicates dry surface).<br>• 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.<br>• This value must not exceed **StateLimit** in SUEWS_Water.txt. |
| LAIinitialEveTr | W | m2 m-2 | Initial LAI for evergreen trees |
| LAIinitialDecTr | W | m2 m-2 | Initial LAI for deciduous trees |
| LAIinitialGrass | W | m2 m-2 | Initial LAI for irrigated grass |
| **Below Ground State** | | | Note: no soil store below water surface. |
| SoilstorePavedState | W | mm | Initial state of the soil water storage under paved surfaces |
| SoilstoreBldgsState | W | mm | Initial state of the soil water storage under buildings |
| SoilstoreEveTrState | W | mm | Initial state of the soil water storage under evergreen trees |

| | | | |
|---|---|---|---|
| SoilstoreDecTrState | W | mm | Initial state of the soil water storage under deciduous trees |
| SoilstoreGrassState | W | mm | Initial state of the soil water storage under grass |
| SoilstoreBSoilState | W | mm | Initial state of the soil water storage under bare soil surfaces |
| **Vegetation state** | | | This should be consistent with albedo and DecTr storage capacities and time of year |
| albEveTr0 | R | - | Albedo of evergreen surface on day 0 of run |
| albDecTr0 | R | - | Albedo of deciduous surface on day 0 of run |
| albGrass0 | R | - | Albedo of grass surface on day 0 of run |
| decidCap0 | A | mm | Deciduous storage capacity on day 0 of run |
| porosity0 | E | - | Porosity of deciduous vegetation on day 0 of run |
| **Snow** | | | **Currently should be set to zero** **LJ ***** |
| SnowWaterPavedState | | mm | Initial amount of liquid water in the snow on paved surfaces |
| SnowWaterBldgsState | | mm | Initial amount of liquid water in the snow on buildings |
| SnowWaterEveTrState | | mm | Initial amount of liquid water in the snow on evergreen trees |
| SnowWaterDecTrState | | mm | Initial amount of liquid water in the snow on deciduous trees |
| SnowWaterGrassState | | mm | Initial amount of liquid water in the snow on grass surfaces |
| SnowWaterBSoilState | | mm | Initial amount of liquid water in the snow on bare soil surfaces |
| SnowWaterWaterState | | mm | Initial amount of liquid water in the snow in water |
| SnowPackPaved | | mm | Initial snow water equivalent if the snow on paved surfaces |
| SnowPackBldgs | | mm | Initial snow water equivalent if the snow on buildings |
| SnowPackEveTr | | mm | Initial snow water equivalent if the snow on evergreen trees |
| SnowPackDecTr | | mm | Initial snow water equivalent if the snow on deciduous trees |
| SnowPackGrass | | mm | Initial snow water equivalent if the snow on grass surfaces |
| SnowPackBSoil | | mm | Initial snow water equivalent if the snow on bare soil surfaces |
| SnowPackWater | | mm | Initial snow water equivalent if the snow on water |
| SnowFracPaved | | - | Initial plan area fraction of snow on paved surfaces |
| SnowFracBldgs | | - | Initial plan area fraction of snow on buildings |
| SnowFracEveTr | | - | Initial plan area fraction of snow on evergreen trees |
| SnowFracDecTr | | - | Initial plan area fraction of snow on deciduous trees |

| | | | |
|---|---|---|---|
| SnowFracGras | | - | Initial plan area fraction of snow on grass surfaces |
| SnowFracBSoil | | - | Initial plan area fraction of snow on bare soil surfaces |
| SnowFracWater | | - | Initial plan area fraction of snow on water |
| SnowDensPaved | | kg m-3 | Initial snow density on paved surfaces |
| SnowDensBldgs | | kg m-3 | Initial snow density on buildings |
| SnowDensEveTr | | kg m-3 | Initial snow density on evergreen trees |
| SnowDensDecTr | | kg m-3 | Initial snow density on deciduous trees |
| SnowDensGrass | | kg m-3 | Initial snow density on grass surfaces |
| SnowDensBSoil | | kg m-3 | Initial snow density on bare soil surfaces |
| SnowDensWater | | kg m-3 | Initial snow density on water |

Meteorological input file
SUEWS is designed to run using commonly measured meteorological variables.

- Required inputs must be continuous – i.e. **gap fill** any missing data.
- The table below gives the required (R) and optional (O) additional input variables.
- If an optional input variable is not available or will not be used by the model, enter '-999.0' for this column.

- One single meteorological file can be used for all grids (**MultipleMetFiles=0** in RunControl.nml) if appropriate for the study area, or
- separate met files can be used for each grid if data are available (**MultipleMetFiles=1** in RunControl.nml).

- 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 and hourly resolution dataset, the number of lines in the metdata-file should be 8760 and begin and end with:

```
iy      id      it      imin
2011    1       1       0 …
…
2012    1       0       0 …
```

SSss_YYYY_data.txt

Main meteorological data file.

| No. | Use | Column name | Description |
|---|---|---|---|
| 1 | R | iy | Year [YYYY] |
| 2 | R | id | Day of year [DOY] |
| 3 | R | it | Hour [H] |
| 4 | R | imin | Minute [M] |
| 5 | O | qn | Net all-wave radiation [W m-2]<br>• Required if **NetRadiationChoice** = 1. |
| 6 | O | qh | Sensible heat flux [W m-2] |
| 7 | O | qe | Latent heat flux [W m-2] |
| 8 | O | qs | Storage heat flux [W m-2] |
| 9 | O | qf | Anthropogenic heat flux [W m-2] |
| 10 | R | U | Wind speed [m s-1]<br>• Height of the wind speed measurement (Z) is needed in RunControl.nml. |
| 11 | R | RH | Relative Humidity [%] |
| 12 | R | Tair | Air temperature [°C] |
| 13 | R | pres | Barometric pressure [kPa] |
| 14 | R | rain | Rainfall [mm] |
| 15 | R | kdown | Incoming shortwave radiation [W m-2]<br>• Must be > 0 W m-2. |
| 16 | O | snow | Snow [mm]<br>• Required if **SnowUse** = 1 |
| 17 | O | ldown | Incoming longwave radiation [W m-2] |
| 18 | O | fcld | Cloud fraction [tenths] |
| 19 | O | Wuh | External water use [m3] |
| 20 | O | xsmd | Observed soil moisture [m3 m-3 or kg kg-1] |
| 21 | O | lai | Observed leaf area index [m2 m-2] |

| | | | |
|---|---|---|---|
| 22 | O | kdiff | Diffuse radiation [W m-2]<br>• Recommended if **SOLWEIGUse** = 1 |
| 23 | O | kdir | Direct radiation [W m-2]<br>• Recommended if **SOLWEIGUse** = 1 |
| 24 | O | wdir | Wind direction [°]<br>• Currently not implemented |

CBL input files

Main references for this part of the model: Onomura et al. (2015)[15] and Cleugh and Grimmond (2001)[14].

If CBL slab model is used (CBLuse=1 in RunControl.nml) the following files are needed:

| Filename | Purpose |
|---|---|
| CBL_initial_data.txt | Gives initial data every morning when CBL slab model starts running.<br>• filename must match the InitialData_FileName in CBLInput.nml.<br>• fixed format. |
| CBLInput.nml | Specifies run options, parameters and input file names.<br>• 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 (K m-1) |
| 4 | gamq_gkgm | vertical gradient of specific humidity (g kg-1 m-1) |
| 5 | Theta+_K | potential temperature at the top of CBL (K) |
| 6 | q+_gkg | specific humidity at the top of CBL (g kg-1) |
| 7 | Theta_K | potential temperature in CBL (K) |
| 8 | q_gkg | specific humidiy in CBL (g kg-1) |

- gamt_Km and gamq_gkgm written to two significant figures are required for the model performance in appropriate ranges[15].

| id | zi0 | gamt_Km | gamq_gkgm | Theta+_K | q+_gkg | theta_K | q_gkg |
|---|---|---|---|---|---|---|---|
| 234 | 188 | 0.032 | 0.00082 | 290.4 | 9.6 | 288.7 | 8.3 |
| 235 | 197 | 0.089 | 0.089 | 290.2 | 8.4 | 288.3 | 8.7 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

CBL_Input.nml

<table>
<tr><th>Name</th><th>Description</th></tr>
<tr><td></td><td></td></tr>
<tr><td>EntrainmentType</td><td>Determines entrainment scheme. See Cleugh and Grimmond 2000[14] for details.
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Tennekes and Driedonks (1981) - Recommended</td></tr>
<tr><td>2</td><td>McNaughton and Springs (1986)</td></tr>
<tr><td>3</td><td>Rayner and Watson (1991)</td></tr>
<tr><td>4</td><td>Tennekes (1973)</td></tr>
</table></td></tr>
<tr><td>QH_Choice</td><td>Determines QH used for CBL model.
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>QH modelled by SUEWS</td></tr>
<tr><td>2</td><td>QH modelled by LUMPS</td></tr>
<tr><td>3</td><td>Observed QH values are used from the meteorological input file</td></tr>
</table></td></tr>
<tr><td>Wsb</td><td>Subsidence velocity (m s-1) in eq. 1 and 2 of Onomura et al. (2015)[15]. (-0.01 m s-1 recommended)</td></tr>
<tr><td>CBLday(id)</td><td>CBL model is used for the days you choose.
<ul><li>Set CBLday(id) = 1</li>
<li>If CBL model is set to run for DOY 175–177, CBLday(175) = 1, CBLday(176) = 1, CBLday(177) = 1</li></ul></td></tr>
<tr><td>CO2_included</td><td>Set to zero in current version</td></tr>
<tr><td></td><td>Determines initial values (see CBL_Initial_data.txt)</td></tr>
</table>

<table>
<tr><td rowspan="4">InitialData_use</td><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>All initial values are calculated. (Not available in current release.)</td></tr>
<tr><td>1</td><td>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.</td></tr>
<tr><td>2</td><td>Take all initial values from input data file (see CBL_Initial_data.txt).</td></tr>
<tr><td>InitialData_FileName</td><td colspan="2">If InitialData_use ≥ 1, write the file name including the path from site directory e.g. InitialData_FileName='CBLinputfiles\CBL_initial_data.txt'</td></tr>
<tr><td rowspan="3">Sondeflag</td><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>Does not read radiosonde vertical profile data -recommended</td></tr>
<tr><td>1</td><td>Reads radiosonde vertical profile data</td></tr>
<tr><td>FileSonde(id)</td><td colspan="2">If Sondeflag=1, write the file name including the path from site directory e.g. FileSonde(id)= 'CBLinputfiles\XXX.txt', XXX is an arbitrary name.</td></tr>
</table>

SOLWEIG input files
If the SOLWEIG model option is used (SOLWEIGout=1), spatial data and a SOLWEIGInput.nml file need to be prepared. The Digital Surface Models (DSMs) as well as derivatives originating from DSMs, e.g. Sky View Factors (SVF) must have the same spatial resolution and extent. Since SOLWEIG is a 2D model it will considerably increase computation time and should be used with care.

Description of choices in SOLWEIGinput_file.nml file. The file can be in any order.

<table>
<tr><th>Name</th><th>Units</th><th colspan="2">Description</th></tr>
<tr><td rowspan="3">Posture</td><td rowspan="3">-</td><td colspan="2">Determines the posture of a human for which the radiant fluxes should be considered</td></tr>
<tr><td>1</td><td>Standing (default)</td></tr>
<tr><td>2</td><td>Sitting</td></tr>
<tr><td>absL</td><td>-</td><td colspan="2">Absorption coefficient of longwave radiation of a person.<br>• Recommended value: 0.97</td></tr>
<tr><td>absK</td><td>-</td><td colspan="2">Absorption coefficient of shortwave radiation of a person.<br>• Recommended value: 0.70</td></tr>
<tr><td>heightgravity</td><td>m</td><td colspan="2">Centre of gravity for a person.<br>• Recommended value for a standing man: 1.1 m</td></tr>
</table>

| | | | |
|---|---|---|---|
| usevegdem | - | Vegetation scheme | |
| | | 1 | Vegetation scheme is active (Lindberg and Grimmond 2011[18]) |
| | | 2 | No vegetation scheme used |
| DSMPath | - | Path to Digital Surface Models (DSM). | |
| DSMname | - | Ground and Building DSM | |
| CDSMname | - | Vegetation canopy DSM | |
| TDSMname | - | Vegetation trunk zone DSM | |
| TransMin | - | Tranmissivity of K through deciduous vegetation (leaf on)<br>• Recommended value: 0.02 (Konarska et al. 2014[37]) | |
| TransMax | - | Tranmissivity of K through deciduous vegetation (leaf off)<br>• Recommended value: 0.50 (Konarska et al. 2014[37]) | |
| SVFPath | - | Path to SVFs matrices (See Lindberg and Grimmond (2011)[18] for details) | |
| SVFSuffix | - | Suffix used (if any) | |
| BuildingName | - | Boolean matrix for locations of building pixels | |
| row | - | X coordinate for point of interest. Here all variables from the model will written to SOLWEIGpoiOUT.txt | |
| col | - | Y coordinate for point of interest. Here all variables from the model will written to SOLWEIGpoiOUT.txt | |
| onlyglobal | - | Global radiation | |
| | | 0 | Diffuse and direct shortwave radiation taken from met forcing file. |
| | | 1 | Diffuse and direct shortwave radiation calculated from Reindl et al. (1990)[38] |
| SOLWEIGpoi_out | - | Write output variables at point of interest (see below) | |
| | | 0 | No POI output |
| Tmrt_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |
| Lup2d_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |

| | | | |
|---|---|---|---|
| Ldown2d_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |
| Kup2d_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |
| Kdown2d_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |
| GVF_out | - | 0 | No grid output |
| | | 1 | Write grid to file (saves as ERSI Ascii grid) |
| SOLWEIG_ldown | - | 0 | Not active (use SUEWS to estimate Ldown above canyon) |
| | | 1 | Use SOLWEIG to estimate Ldown above canyon |
| OutInterval | min | Output interval. Set to 60 in current version. | |
| RunForGrid | - | Grid for which SOLWEIG should be run. | |
| | | -999 | All grids (use with care) |

Output filesError Messages: problems.txt
If there are problems with running the program an error message will be written to problems.txt. Serious problems will usually cause the program to stop after writing the error message. If the program encounters a more minor issue it will not stop but a warning may be written to problems.txt.

We have 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 to problems.txt please capture the details so we can hopefully provide better error messages.

See Troubleshooting section for help solving problems. If the file paths are not correct the program will return an error when run (see Preparing to run the model).

Model parameters: SS_FileChoices.txt
For each run, the model parameters specified in RunControl, InitialConditions and SiteInfo files are written out to the file SS_FileChoices.txt.

Model output filesSSss_YYYY_tt.txt
SUEWS produces the main output file (SSss_YYYY_tt.txt) with time resolution (tt min) defined by the model time step (set in RunControl).

| Column | Name | Description |
|---|---|---|
| 1 | iy | Year [YYYY] |

| | | |
|---|---|---|
| 2 | id | Day of year [DOY] |
| 3 | it | Hour [H] |
| 4 | imin | Minute [M] |
| 5 | dectime | Decimal time [-] |
| 6 | kdown | Incoming shortwave radiation [W m-2] |
| 7 | kup | Outgoing shortwave radiation [W m-2] |
| 8 | ldown | Incoming longwave radiation [W m-2] |
| 9 | lup | Outgoing longwave radiation [W m-2] |
| 10 | Tsurf | Surface temperature [°C] |
| 11 | qn | Net all-wave radiation [W m-2] |
| 12 | h_mod | Sensible heat flux (calculated using LUMPS) [W m-2] |
| 13 | e_mod | Latent heat flux (calculated using LUMPS) [W m-2] |
| 14 | qs | Storage heat flux [W m-2] |
| 15 | qf | Anthropogenic heat flux [W m-2] |
| 16 | qh | Sensible heat flux (calculated using SUEWS) [W m-2] |
| 17 | qe | Latent heat flux (calculated using SUEWS) [W m-2] |
| 18 | P/i | Rain [mm] |
| 19 | Ie/i | External water use in the study area [mm] |
| 20 | E/i | Evaporation [mm] |
| 21 | Dr/i | Drainage [mm] |
| 22 | St/i | Surface moisture state [mm] |
| 23 | NWSt/i | Land surface state (i.e. Water surface excluded) [mm] |
| 24 | surfCh/i | Change in surface moisture store [mm] |
| 25 | totCh/i | Change in surface and soil moisture stores [mm] |
| 26 | RO/i | Runoff [mm] |
| 27 | ROsoil/i | Soil runoff (sub-surface) [mm] |
| 28 | ROpipe | Runoff received by pipes [mm] |
| 29 | ROpav | Above ground runoff on paved surfaces [mm] |

| | | |
|---|---|---|
| 30 | ROveg | Above ground runoff on vegetated surfaces [mm] |
| 31 | ROwater | Runoff occurring through water body [mm] |
| 32 | AdditionalWater | Water flow received from other grids [mm] |
| 33 | FlowChange | Difference in input and output flows of water body [mm] |
| 34 | WU_int | Internal water use [mm] |
| 35 | WU_EveTr | Water use for irrigation of evergreen trees [mm] |
| 36 | WU_DecTr | Water use for irrigation of deciduous trees [mm] |
| 37 | WU_Grass | Water use for irrigation of grass [mm] |
| 38 | ra | Aerodynamic resistance [s m-1] |
| 39 | rs | Surface resistance [s m-1] |
| 40 | ustar | Friction velocity [m s-1] |
| 41 | l_Ob | Obukhov length [m] |
| 42 | Fcld | Cloud fraction [tenths] |
| 43 | SoilSt | Soil moisture [mm] |
| 44 | smd | Soil moisture deficit [mm] |
| 45 | smd_Paved | Soil moisture deficit of paved surface [mm] |
| 46 | smd_Bldgs | Soil moisture deficit of building surface [mm] |
| 47 | smd_EveTr | Soil moisture deficit of evergreen surface [mm] |
| 48 | smd_DecTr | Soil moisture deficit of deciduous surface [mm] |
| 49 | smd_Grass | Soil moisture deficit of grass surface [mm] |
| 50 | smd_BSoil | Soil moisture deficit of bare soil surface [mm] |
| 51 | St_Paved | State of paved surface [mm] |
| 52 | St_Bldgs | State of building surface [mm] |
| 53 | St_EveTr | State of evergreen surface [mm] |
| 54 | St_DecTr | State of deciduous surface [mm] |
| 55 | St_Grass | State of grass surface [mm] |
| 56 | St_BSoil | State of bare soil surface [mm] |
| 57 | St_Water | State of the water body [mm] |

| | | |
|---|---|---|
| 58 | LAI | Leaf area index [m2 m-2] |
| 59 | z0m | Roughness length for momentum [m] |
| 60 | zdm | Displacement height [m] |
| 61 | qn1_SF | Net all-wave radiation for snow-free area [W m-2] |
| 62 | qn1_S | Net all-wave radiation for snow surface [W m-2] |
| 63 | Qm | Snow related heat exchange [W m-2] |
| 64 | QmFreez | Internal energy change [W m-2] |
| 65 | QmRain | Heat release by rain on snow [W m-2] |
| 66 | SWE | Snow water equivalent [mm] |
| 67 | Mw | Meltwater [mm] |
| 68 | MwStore | Meltwater store [mm] |
| 69 | snowRem_Paved | Snow removal from paved surfaces [mm] |
| 70 | snowRem_Bldgs | Snow removal from buildings [mm] |
| 71 | ChSnow/i | Change in snowpack [mm] |
| 72 | SnowAlb | Snow albedo [-] |

SSss_DailyState.txt
Contains information about the state of the surface and soil parameters at a time resolution of one day. One file is written for each grid so may contain multiple years.

| Column | Name | Description |
|---|---|---|
| 1 | iy | Year [YYYY] |
| 2 | id | Day of year [DOY] |
| 3 | HDD1_h | Heating degree days [°C] |
| 4 | HDD2_c | Cooling degree days [°C] |
| 5 | HDD3_Tmean | Average daily air temperature [°C] |
| 6 | HDT4_T5d | 5-day running-mean air temperature [°C] |
| 7 | P/day | Daily total precipitation [mm] |
| 8 | DaysSR | Days since rain [days] |
| 9 | GDD1_g | Growing degree days for leaf growth [°C] |

| | | |
|---|---|---|
| 10 | GDD2_s | Growing degree days for senescence [°C] |
| 11 | GDD3_Tmin | Daily minimum temperature [°C] |
| 12 | GDD4_Tmax | Daily maximum temperature [°C] |
| 13 | GDD5_DayLHrs | Day length [h] |
| 14 | LAI_EveTr | Leaf area index of evergreen trees [m2 m-2] |
| 15 | LAI_DecTr | Leaf area index of deciduous trees [m2 m-2] |
| 16 | LAI_Grass | Leaf area index of grass [m2 m-2] |
| 17 | DecidCap | Moisture storage capacity of deciduous trees [mm] |
| 18 | Porosity | Porosity of deciduous trees [-] |
| 19 | AlbEveTr | Albedo of evergreen trees [-] |
| 20 | AlbDecTr | Albedo of deciduous trees [-] |
| 21 | AlbGrass | Albedo of grass [-] |
| 22 | WU_EveTr(1) | Total water use for evergreen trees [mm] |
| 23 | WU_EveTr(2) | Automatic water use for evergreen trees [mm] |
| 24 | WU_EveTr(3) | Manual water use for evergreen trees [mm] |
| 25 | WU_DecTr(1) | Total water use for deciduous trees [mm] |
| 26 | WU_DecTr(2) | Automatic water use for deciduous trees [mm] |
| 27 | WU_DecTr(3) | Manual water use for deciduous trees [mm] |
| 28 | WU_Grass(1) | Total water use for grass [mm] |
| 29 | WU_Grass(2) | Automatic water use for grass [mm] |
| 30 | WU_Grass(3) | Manual water use for grass [mm] |
| 31 | deltaLAI | Change in leaf area index (normalised 0-1) [-] |
| 32 | LAIlumps | Leaf area index used in LUMPS (normalised 0-1) [-] |
| 33 | AlbSnow | Snow albedo [-] |
| 34 | DensSnow_Paved | Snow density - paved surface [kg m-3] |
| 35 | DensSnow_Bldgs | Snow density - building surface [kg m-3] |
| 36 | DensSnow_EveTr | Snow density - evergreen surface [kg m-3] |
| 37 | DensSnow_DecTr | Snow density - deciduous surface [kg m-3] |

| | | |
|---|---|---|
| 38 | DensSnow_Grass | Snow density - grass surface [kg m-3] |
| 39 | DensSnow_BSoil | Snow density - bare soil surface [kg m-3] |
| 40 | DensSnow_Water | Snow density - water surface [kg m-3] |

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 (located in the input folder), see InitialConditionsSSss_YYYY.nml

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_60.txt

| Column | Name | Description |
|---|---|---|
| 1 | iy | Year [YYYY] |
| 2 | id | Day of year [DOY] |
| 3 | it | Hour [H] |
| 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-1] |
| 14 | Mw_Bldgs | Meltwater – building surface [mm h-1] |
| 15 | Mw_EveTr | Meltwater – evergreen surface [mm h-1] |
| 16 | Mw_DecTr | Meltwater – deciduous surface [mm h-1] |
| 17 | Mw_Grass | Meltwater – grass surface [mm h-1] |
| 18 | Mw_BSoil | Meltwater – bare soil surface [mm h-1] |

| | | |
|---|---|---|
| 19 | Mw_Water | Meltwater – water surface [mm h-1] |
| 20 | Qm_Paved | Snowmelt-related heat – paved surface [W m-2] |
| 21 | Qm_Bldgs | Snowmelt-related heat – building surface [W m-2] |
| 22 | Qm_EveTr | Snowmelt-related heat – evergreen surface [W m-2] |
| 23 | Qm_DecTr | Snowmelt-related heat – deciduous surface [W m-2] |
| 24 | Qm_Grass | Snowmelt-related heat – grass surface [W m-2] |
| 25 | Qm_BSoil | Snowmelt-related heat – bare soil surface [W m-2] |
| 26 | Qm_Water | Snowmelt-related heat – water surface [W m-2] |
| 27 | Qa_Paved | Advective heat – paved surface [W m-2] |
| 28 | Qa_Bldgs | Advective heat – building surface [W m-2] |
| 29 | Qa_EveTr | Advective heat – evergreen surface [W m-2] |
| 30 | Qa_DecTr | Advective heat – deciduous surface [W m-2] |
| 31 | Qa_Grass | Advective heat – grass surface [W m-2] |
| 32 | Qa_BSoil | Advective heat – bare soil surface [W m-2] |
| 33 | Qa_Water | Advective heat – water surface [W m-2] |
| 34 | QmFr_Paved | Heat related to freezing of surface store – paved surface [W m-2] |
| 35 | QmFr_Bldgs | Heat related to freezing of surface store – building surface [W m-2] |
| 36 | QmFr_EveTr | Heat related to freezing of surface store – evergreen surface [W m-2] |
| 37 | QmFr_DecTr | Heat related to freezing of surface store – deciduous surface [W m-2] |
| 38 | QmFr_Grass | Heat related to freezing of surface store – grass surface [W m-2] |
| 39 | QmFr_BSoil | Heat related to freezing of surface store – bare soil surface [W m-2] |
| 40 | QmFr_Water | Heat related to freezing of surface store – water [W m-2] |
| 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_Bdgs | 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] |
| 53 | RainSn_Water | Rain on snow – water surface [mm] |
| 54 | qn_PavedSnow | Net all-wave radiation – paved surface [W m-2] |
| 55 | qn_BldgsSnow | Net all-wave radiation – building surface [W m-2] |
| 56 | qn_EveTrSnow | Net all-wave radiation – evergreen surface [W m-2] |
| 57 | qn_DecTrSnow | Net all-wave radiation – deciduous surface [W m-2] |
| 58 | qn_GrassSnow | Net all-wave radiation – grass surface [W m-2] |
| 59 | qn_BSoilSnow | Net all-wave radiation – bare soil surface [W m-2] |
| 60 | qn_WaterSnow | Net all-wave radiation – water surface [W m-2] |
| 61 | kup_PavedSnow | Reflected shortwave radiation – paved surface [W m-2] |
| 62 | kup_BldgsSnow | Reflected shortwave radiation – building surface [W m-2] |
| 63 | kup_EveTrSnow | Reflected shortwave radiation – evergreen surface [W m-2] |
| 64 | kup_DecTrSnow | Reflected shortwave radiation – deciduous surface [W m-2] |
| 65 | kup_GrassSnow | Reflected shortwave radiation – grass surface [W m-2] |
| 66 | kup_BSoilSnow | Reflected shortwave radiation – bare soil surface [W m-2] |
| 67 | kup_WaterSnow | Reflected shortwave radiation – water surface [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_EveTt | 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 [kg m-3] |
| 83 | DensSnow_Bldgs | Snow density – building surface [kg m-3] |
| 84 | DensSnow_EveTr | Snow density – evergreen surface [kg m-3] |
| 85 | DensSnow_DecTr | Snow density – deciduous surface [kg m-3] |
| 86 | DensSnow_Grass | Snow density – grass surface [kg m-3] |
| 87 | DensSnow_BSoil | Snow density – bare soil surface [kg m-3] |
| 88 | DensSnow_Water | Snow density – water surface [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 [°C] |
| 97 | Tsnow_Bldgs | Snow surface temperature – building surface [°C] |
| 98 | Tsnow_EveTr | Snow surface temperature – evergreen surface [°C] |
| 99 | Tsnow_DecTr | Snow surface temperature – deciduous surface [°C] |
| 100 | Tsnow_Grass | Snow surface temperature – grass surface [°C] |
| 101 | Tsnow_BSoil | Snow surface temperature – bare soil surface [°C] |
| 102 | Tsnow_Water | Snow surface temperature – water surface [°C] |

SSss_YYYY_BL.txt

Meteorological variables modelled by CBL portion of the model are output in to this file created for each day with time step (see section CBL Input).

CBL model output file format: SSss_YYYY_BL.txt

| Col | Header | Name | 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 | Convectibe boundary layer height | m |
| 7 | Theta | Potential temperature in the inertial sublayer | K |
| 8 | Q | Specific humidity in the inertial sublayer | g kg-1 |
| 9 | theta+ | Potential temperature just above the CBL | K |
| 10 | q+ | Specific humidity just above the CBL | g kg-1 |
| 11 | Temp_C | Air temperature | °C |
| 12 | RH | Relative humidity | % |
| 13 | QH_use | Sensible heat flux used for calculation | W m-2 |
| 14 | QE_use | Latent heat flux used for calculation | W m-2 |
| 15 | Press_hPa | Pressure used for calculation | hPa |
| 16 | avu1 | Wind speed used for calculation | m s-1 |
| 17 | ustar | Friction velocity used for calculation | m s-1 |
| 18 | avdens | Air density used for calculation | kg m-3 |
| 19 | lv_J_kg | Latent heat of vaporization used for calculation | J kg-1 |
| 20 | avcp | Specific heat capacity used for calculation | J kg-1 K-1 |
| 21 | gamt | Vertical gradient of potential temperature | K m-1 |
| 22 | gamq | Vertical gradient of specific humidity | kg kg-1 m-1 |

SOLWEIGpoiOut.txt

Calculated variables from POI, point of interest (row, col) stated in SOLWEIGinput.nml.

SOLWEIG model output file format: SOLWEIGpoiOUT.txt

| Col | Header | Name | Units |
|---|---|---|---|
| 1 | id | Day of year | |
| 2 | dectime | Decimal time | |
| 3 | azimuth | Azimuth angle of the Sun | ° |
| 4 | altitude | Altitude angle of the Sun | ° |
| 5 | GlobalRad | Input Kdn | W m-2 |
| 6 | DiffuseRad | Diffuse shortwave radiation | W m-2 |
| 7 | DirectRad | Direct shortwave radiation | W m-2 |
| 8 | Kdown2d | Incoming shortwave radiation at POI | W m-2 |
| 9 | Kup2d | Outgoing shortwave radiation at POI | W m-2 |
| 10 | Ksouth | Shortwave radiation from south at POI | W m-2 |
| 11 | Kwest | Shortwave radiation from west at POI | W m-2 |
| 12 | Knorth | Shortwave radiation from north at POI | W m-2 |
| 13 | Keast | Shortwave radiation from east at POI | W m-2 |
| 14 | Ldown2d | Incoming longwave radiation at POI | W m-2 |
| 15 | Lup2d | Outgoing longwave radiation at POI | W m-2 |
| 16 | Lsouth | Longwave radiation from south at POI | W m-2 |
| 17 | Lwest | Longwave radiation from west at POI | W m-2 |
| 18 | Lnorth | Longwave radiation from north at POI | W m-2 |
| 19 | Least | Longwave radiation from east at POI | W m-2 |
| 20 | Tmrt | Mean Radiant Temperature | °C |
| 21 | I0 | theoretical value of maximum incoming solar radiation | W m-2 |
| 22 | CI | clearness index for Ldown (Lindberg et al. 2008) | |
| 23 | gvf | Ground view factor (Lindberg and Grimmond 2011) | |
| 24 | shadow | Shadow value (0= shadow, 1 = sun) | |
| 25 | svf | Sky View Factor from ground and buildings | |
| 26 | svfbuveg | Sky View Factor from ground, buildings and vegetation | |

| | | | |
|---|---|---|---|
| 27 | Ta | Air temperature | °C |
| 28 | Tg | Surface temperature | °C |

SSss_YYYY_ESTM_tt.txt

If the ESTM model option is run, the following output file is created. ESTM output file format

| Col | Header | Name | 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-2 |
| 7 | QSair | Storage heat flux into air | W m-2 |
| 8 | QSwall | Storage heat flux into wall | W m-2 |
| 9 | QSroof | Storage heat flux into roof | W m-2 |
| 10 | QSground | Storage heat flux into ground | W m-2 |
| 11 | QSibld | Storage heat flux into internal elements in buildling | W m-2 |
| 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 |
| 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 |

TroubleshootingHow to create a directory?
please search the web using this phrase if you do not know how to create a folder or directory

How to unzip a file
please search the web using this phrase if you do not know how to unzip a file

A text editor
is 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

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/](http://dosprompt.info/)

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.

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.

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 and in calculation of water vapour pressure parameterization is used. You don’t need to worry if the temperature should be 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.

“Reference to undefined variable, array element or function result”

- Parameter(s) missing from input files.

See also the error messages provided in problems.txt

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- Past Contributors:
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- Users who have brought things to our attention to improve this manual and the model:
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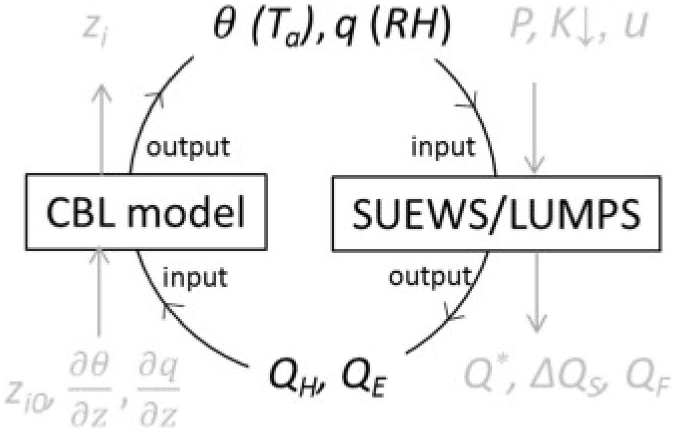
Notation

| | Definition |
|---|---|
| *λF* | frontal area index |
| *ΔQS* | storage heat flux |
| | Boundary Layer part of SUEWS |

| | |
|---|---|
| BLUEWS | <br>Relation between BLUEWS and SUEWS Source: [15] |
| Bldgs | Building surface |
| CBL | Convective boundary layer |
| DEM | Digital Elevation Model |
| DSM | Digital surface model |
| DTM | Digital Terrain Model |
| DecTr | deciduous trees and shrubs |
| EveTr | Evergreen trees and shrubs |
| ESTM | Element Surface Temperature Method (Offerle et al., 2005[12]) |
| Grass | Grass surface |
| BSoil | Unmanaged land and/or bare soil |
| L↓ | incoming longwave radiation |
| LAI | Leaf area index |
| LUMPS | Local scale Urban Meteorological Parameterization Scheme (Loridan et al. 2011[5]) |
| NARP | Net All-wave Radiation Parameterization (Offerle et al. 2003[4], Loridan et al. 2011[5]) |
| OHM | Objective Hysteresis Model (Grimmond et al. 1991[9], Grimmond & Oke 1999a[10], 2002[11]) |
| Paved | Paved surface |
| 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 et al. 2008[17], Lindberg and Grimmond 2011[18]) |

| | |
|---|---|
| SVF | Sky view factor |
| theta | potential temperature |
| tt | time step of data |
| UMEP | Urban Multi-scale Environmental Predictor |
| Water | Water surface |
| zi | Convective boundary layer height |

DevelopmentVersion HistoryNew in SUEWS Version 2016a (released 15 June 2016)

1. Major changes to the input file formats to facilitate the running of multiple grids and multiple years. Surface characteristics are provided in 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

New in SUEWS Version 2014b (released 8 October 2014)

[V2014 manual] 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 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-7-1691-2014.

New in SUEWS Version 2014a.1 (released February 26, 2014)

1. Please see the large number of changes made in the 2014a release.
2. This is a minor change to address installing the software.
3. Minor updates to the manual

New in SUEWS Version 2014a (released 21 Feb 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. 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 FunctionalTypes. 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

New in SUEWS 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

New in SUEWS 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 defaultFcld=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

New in SUEWS 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

New in SUEWS Version2011b

1. Storage heat flux (ΔQs) and anthropogenic heat flux (QF) can be set to be 0 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

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 ΔQs 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 AnthropHeatChoice = 1

V2012a this became obsolete OHM file (SSss_YYYY.ohm)

Differences between SUEWS, LUMPS and FRAISE
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. **The model can run LUMPS alone without running SUEWS (Table 4.1 – SuewsStatus).**

Similarities and differences between LUMPS and SUEWS.

| | LUMPS | SUEWS |
|---|---|---|
| Net all-wave radiation (Q*) | Input or NARP | Input or NARP |
| Storage heat flux (ΔQS) | 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 |

FRAISE Flux Ratio – Active Index Surface Exchange
FRAISE provides an estimate of mean midday (±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)[39] for further details.

| Topic | FRAISE | LUMPS | SUEWS |
|---|---|---|---|
| **Complexity** | Simplest: FRAISE | | More complex: SUEWS |
| **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) | hourly | 5 min-hourly-annual |
| Unique features: | calculates active surface – and fluxes | radiation and energy balances | radiation, energy and water balance (includes LUMPS) |