SUEWS Documentation

Release 2018a

Sue Grimmond, Ting Sun

Mar 24, 2018

CONTENTS

The current version of SUEWS is v2017b. The software can be downloaded by completing this form.

This documentation site (page **??**) is regularly updated with new developments. For what's new in this version, see *New in SUEWS Version 2018a* (page 95).

The **latest formal** release of SUEWS is **v2017b** (released 1 August 2017).

The manual for SUEWS v2017b can be accessed here and should be referenced as follows:

> Ward HC, L Järvi, T Sun, S Onomura, F Lindberg, F Olofson, A Gabey, CSB Grimmond (2017). SUEWS Manual V2017b Department of Meteorology, University of Reading, Reading, UK

Please refer to Ward et al. (2017) for further details v2017a:

> Ward HC, Yin San Tan, AM Gabey, S Kotthaus, WTJ Morrison, CSB Grimmond. Impact of temporal resolution of precipitation forcing data on modelled urban-atmosphere exchanges and surface conditions. International Journal of Climatology. doi: 10.1002/joc.5200

Note: See other publications in the next section (if you have papers that could be added, please send them through)

CHAPTER

ONE

RECENT PUBLICATIONS

Note: If you have papers to add to this list please let us and others know via the email list.

- Järvi et al. (2017)

  topic Application and evalution in cold climates. Implications of warming

  citation Järvi L, S Grimmond, JP McFadden, A Christen, I Strachan, M Taka, L Warsta, M Heimann 2017: Warming effects on the urban hydrology in cold climate regions Scientific Reports 7: 5833

- Kokkonen et al. (2017)

  topic Downscaling climate (rainfall) data to 1 h

  citation Kokkonen T, CSB Grimmond, O Räty, HC Ward, A Christen, T Oke, S Kotthaus, L Järvi 2017: Sensitivity of Surface Urban Energy and Water Balance Scheme (SUEWS)

- Ward and Grimmond (2017)

  topic for example applications:

  citation Ward HC, S Grimmond 2017: Using biophysical modelling to assess the impact of various scenarios on summertime urban climate across Greater London Landscape and Urban Planning 165, 142–161

- Demuzere et al. 2017

  topic evaluation in Singapore and comparison with other urban land surface models

  citation Demuzere M, S Harshan, L Järvi, M Roth, CSB Grimmond, V Masson, KW Oleson, E Velasco H Wouters 2017: Impact of urban canopy models and external parameters on the modelled urban energy balance QJRMS, 143, Issue 704, Part A, 1581–1596

- Ward et al.(2016)

  topic Evaluation of SUEWS model

  citation 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

- Ao et al. (2016)

  topic Evaluation of radiation in Shanghai

  citation Ao XY, CSB Grimmond, DW Liu, ZH Han, P Hu, YD Wang, XR Zhen, JG Tan 2016: Radiation fluxes in a business district of Shanghai JAMC, 55, 2451-2468

- Onomura et al. (2015)

  topic Boundary layer modelling

  citation Onomura S, Grimmond CSB, Lindberg F, Holmer B & Thorsson S (2015) Meteorological forcing data for urban outdoor thermal comfort models from a coupled convective boundary layer and surface energy balance scheme Urban Climate, 11, 1-23

- Järvi et al. (2014)

  topic Snow melt model development

  citation 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

Other papers

CHAPTER TWO

INTRODUCTION

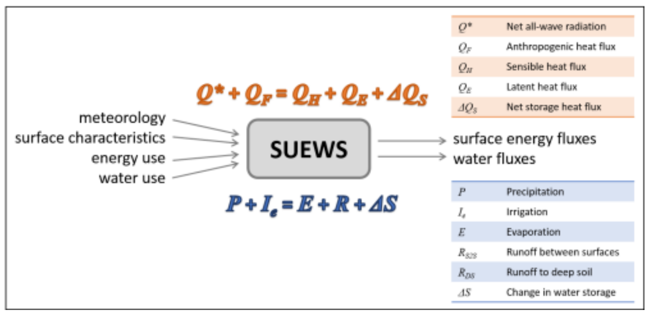


Fig. 2.1: Overview of SUEWS

Surface Urban Energy and Water Balance Scheme (**SUEWS**) (Järvi et al. 2011 *[J11]* (page 103), Ward et al. 2016 *[W16]* (page 103)) 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 *[G91]* (page 103)), similar to that used in forests, to model evaporation from urban surfaces.

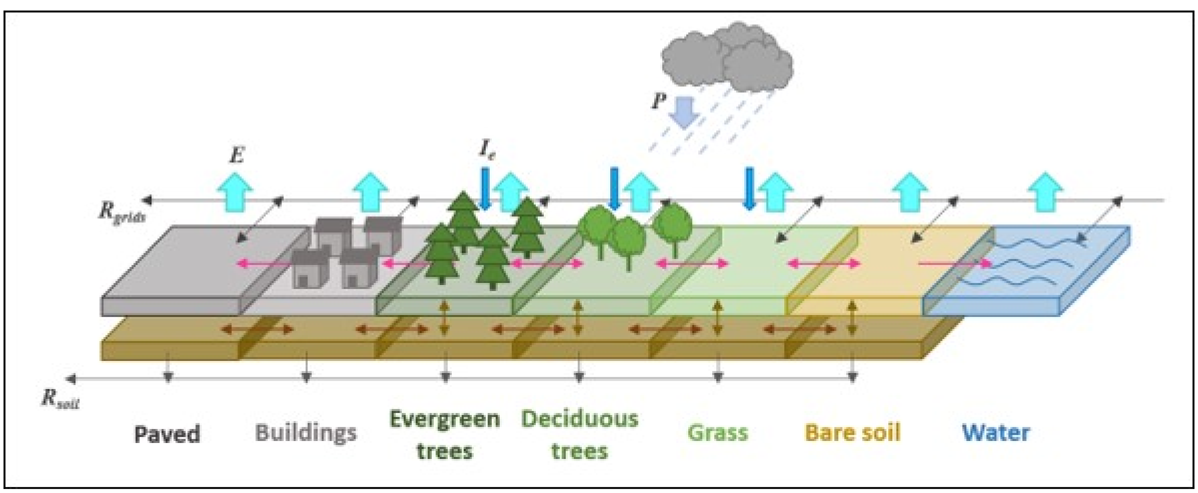


Fig. 2.2: The seven surface types considered in SUEWS

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

Model applicability: SUEWS is a neighbourhood-scale or local-scale model.

CHAPTER

THREE

SUEWS AND UMEP

SUEWS can be run as a standalone model but also can be used within UMEP. There are numerous tools included within UMEP to help a user get started. The SUEWS simple within UMEP is a fast way to start using SUEWS.

The version of SUEWS within UMEP is the complete model. Thus all options that are listed in this manual are available to the user. In the UMEP SUEWS simple runs all options are set to values to allow intial exploration of the model behaviour.

The version of SUEWS within UMEP is a more recent release of the model than the independent SUEWS release.

UMEP			Description
Pre-Processor	Meteorological Data	Prepare Existing Data	Transforms meteorological data into UMEP format
		Download data (WATCH)	Prepare meteorological dataset from WATCH
	Spatial Data	Spatial Data Downloader	Plugin for retrieving geodata from online services suitable for various UMEP related tools
		LCZ Converter	Conversion from Local Climate Zones (LCZs) in the WUDAPT database into SUEWS input data
	Urban land cover	Land Cover Reclassifier	Reclassifies a grid into UMEP format land cover grid. *Land surface models*
		Land Cover Fraction (Point)	Land cover fractions estimates from a land cover grid based on a specific point in space
		Land Cover Fraction (Grid)	Land cover fractions estimates from a land cover grid based on a polygon grid
	Urban Morphology	Morphometric Calculator (Poi nt)	Morphometric parameters from a DSM based on a specific point in space
		Morphometric Calculator (Grid)	Morphometric parameters estimated from a DSM based on a polygon grid
		Source Area Model (Point)	Source area calculated from a DSM based on a specific point in space.
	SUEWS Prepare		Preprocessing and preparing input data for the SUEWS model
Processor	Urban Energy Balance	Anthropogenic Heat (Q:sub:F) (LQF)	Spatial variations anthropogenic heat release for urban areas
		GQF	Anthropogenic Heat (Q :sub:F).
		SUEWS (Simple)	Urban Energy and Water Balance.
		SUEWS (Advanced)	Urban Energy and Water Balance.
Post-Processor	Urban Energy Balance	SUEWS analyser	Plugin for plotting and statistical analysis of model results from SUEWS simple and SUEWS advanced
	Benchmark	Benchmark System	For statistical analysis of model results, such as SUEWS

CHAPTER

FOUR

PARAMETERISATIONS AND SUB-MODELS WITHIN SUEWS

4.1 Net all-wave radiation, Q*

There are several options for modelling or using observed radiation components depending on the data available. As a minimum, SUEWS requires incoming shortwave radiation to be provided.

1. Observed net all-wave radiation can be provided as input instead of being calculated by the model.
2. Observed incoming shortwave and incoming longwave components can be provided as input, instead of incoming longwave being calculated by the model.
3. Other data can be provided as input, such as cloud fraction (see options in *RunControl* (page **??**)).
4. **NARP** (Net All-wave Radiation Parameterization, Offerle et al. 2003 *[O2003]* (page 103) , Loridan et al. 2011 *[L2011]* (page 103)) scheme calculates outgoing shortwave and incoming and outgoing longwave radiation components based on incoming shortwave radiation, temperature, relative humidity and surface characteristics (albedo, emissivity).

4.2 Anthropogenic heat flux, Q_F

1. Two simple anthropogenic heat flux sub-models exist within SUEWS:
   - Järvi et al. (2011) *[J11]* (page 103) approach, based on heating and cooling degree days and population density (allows distinction between weekdays and weekends).
   - Loridan et al. (2011) *[L2011]* (page 103) approach, based on a linear piece-wise relation with air temperature.
2. Pre-calculated values can be supplied with the meteorological forcing data, either derived from knowledge of the study site, or obtained from other models, for example:
   - **LUCY** (Allen et al. 2011 *[lucy]* (page 103), Lindberg et al. 2013 *[lucy2]* (page 103)). A new version has been now included in UMEP. To distinguish it is referred to as **LQF**
   - **GreaterQF** (Iamarino et al. 2011 *[I11]* (page 103)). A new version has been now included in UMEP. To distinguish it is referred to as **GQF**

4.3 Storage heat flux, ΔQ_S

1. Three sub-models are available to estimate the storage heat flux:

- **OHM** (Objective Hysteresis Model, Grimmond et al. 1991 *[G91OHM]* (page 103), Grimmond & Oke 1999a *[GO99QS]* (page 103), 2002 *[GO2002]* (page 103)). Storage heat heat flux is calculated using empirically-fitted relations with net all-wave radiation and the rate of change in net all-wave radiation.
- **AnOHM** (Analytical Objective Hysteresis Model, Sun et al. 2017 *[AnOHM17]* (page 103)). OHM approach using analytically-derived coefficients. (**Not recommended in v2017b**)
- **ESTM** (Element Surface Temperature Method, Offerle et al. 2005 *[Oaf2005]* (page 103)). Heat transfer through urban facets (roof, wall, road, interior) is calculated from surface temperature measurements and knowledge of material properties. (**Not recommended in v2017b**)

2. Alternatively, 'observed' storage heat flux can be supplied with the meteorological forcing data.

4.4 Turbulent heat fluxes, Q_H and Q_E

1. **LUMPS** (Local-scale Urban Meteorological Parameterization Scheme, Grimmond & Oke 2002 *[GO2002]* (page 103)) provides a simple means of estimating sensible and latent heat fluxes based on the proportion of vegetation in the study area.
2. **SUEWS** adopts a more biophysical approach to calculate the latent heat flux; the sensible heat flux is then calculated as the residual of the energy balance. The initial estimate of stability is based on the LUMPS calculations of sensible and latent heat flux. Future versions will have alternative sensible heat and storage heat flux options.

Sensible and latent heat fluxes from both LUMPS and SUEWS are provided in the *Output files* (page 77). 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 *[J11]* (page 103) *[W16]* (page 103). For more details see *Differences between SUEWS, LUMPS and FRAISE* (page **??**).

4.5 Water balance

The running water balance at each time step is based on the urban water balance model of Grimmond et al. (1986) *[G86]* (page 103) and urban evaporation-interception scheme of Grimmond and Oke (1991) *[G91]* (page 103).

- Precipitation is a required variable in the meteorological forcing file.
- Irrigation can be modelled *[J11]* (page 103) or observed values can be provided if data are available.
- Drainage equations and coefficients to use must be specified in the input files.
- Soil moisture can be calculated by the model (**Use of observed soil moisture is not possible in v2017b**).
- Runoff is permitted:
  - between surface types within each model grid
  - between model grids (**Not implemented in v2017b**)
  - to deep soil
  - to pipes.

4.6 Snowmelt

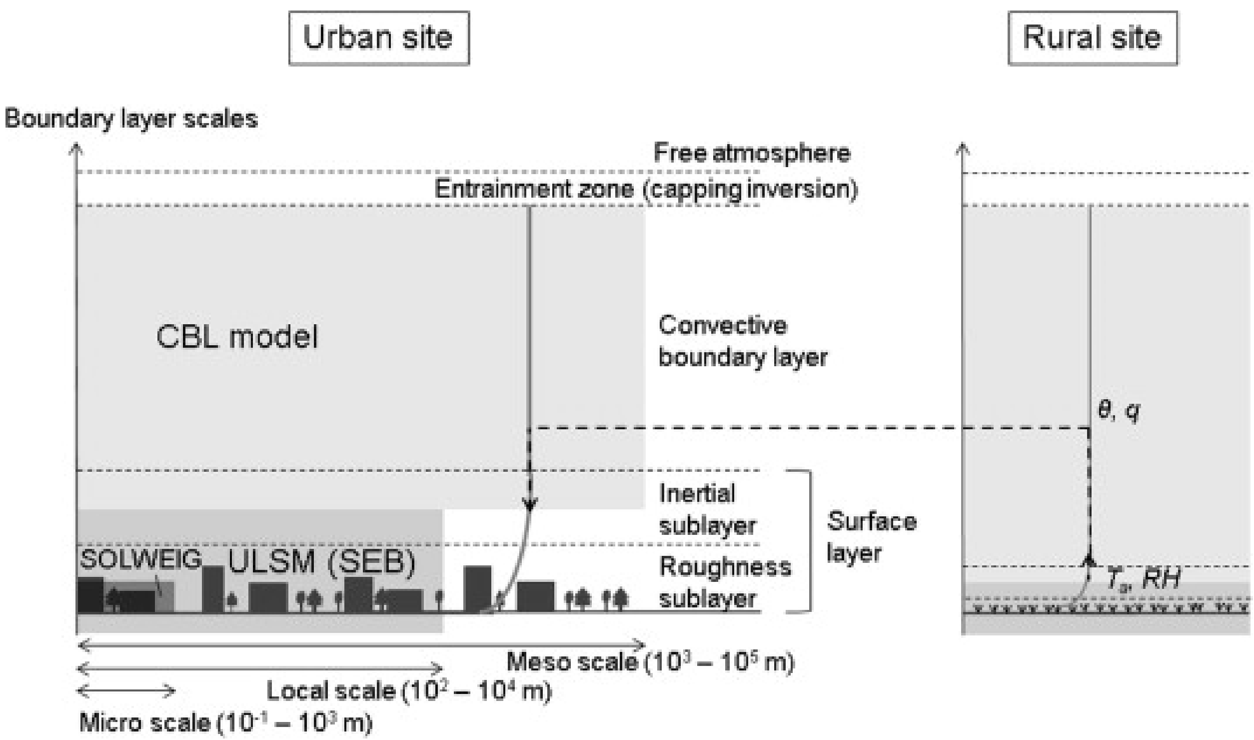
The snowmelt model within SUEWS is described in Järvi et al. (2014) *[Leena2014]* (page 104). Due to changes in the new model version (since v2016a) when compared to the older versions, the snow calculation has slightly changed. The main difference is that previously all surface state could freeze in 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 snowmelt-related coefficients have slightly changed (see *SUEWS_Snow.txt* (page **??**)).

4.7 Convective boundary layer

A convective boundary layer (CBL) slab model (Cleugh and Grimmond 2001 *[CG2001]* (page 104)) calculates the CBL height, temperature and humidity during daytime (Onomura et al. 2015 *[Shiho2015]* (page 104)).

4.8 Thermal comfort

SOLWEIG (Solar and longwave environmental irradiance geometry model, Lindberg et al. 2008 *[FL2008]* (page 104), Lindberg and Grimmond 2011 *[FL2011]* (page 104)) is a 2D radiation model to estimate mean radiant temperature.



CHAPTER FIVE

PREPARING TO RUN THE MODEL

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

5.1 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 18, 1-32. doi:10.1016/j.uclim.2016.05.001

See other publications with example applications

5.2 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

5.3 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 London KCL site, 2011 data (denoted Kc11)

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

Filename	Description	Input/output
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_SiteInfo_SSss.x lsm	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 file)	Output

(+) 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.

5.4 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.

Please see *Troubleshooting* (page **??**) if you have problems running the model.

5.5 Preparation of data

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

1. Continuous *meteorological forcing data* for the entire period to be modelled. Note you can not have gaps in the meteorological data. If you need help with preparing the data you may want to use some of the tools in UMEP.
2. Knowledge of the *surface and soil 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).
3. The *location of the site* (latitude, longitude, altitude).

4. 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).
5. Information about *human behaviour*, including energy use and water use (e.g. for irrigation or street cleaning) 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).

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

- Fractions of different land cover types and (less so) heights of buildings *[W16]* (page 103)
- Accurate meteorological forcing data, particularly precipitation and incoming shortwave radiation *[Ko17]* (page 104)
- Initial soil moisture conditions *[Best2014]* (page 104)
- Anthropogenic heat flux parameters, particularly if there are considerable energy emissions from transport, buildings, metabolism, etc *[W16]* (page 103)
- External water use (if irrigation or street cleaning occurs)
- Snow clearing (if running the snow option)
- Surface conductance parameterisation *[J11]* (page 103) *[W16]* (page 103)

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

5.5.1 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* (page **??**) 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* (page **??**)) or characteristics of deciduous trees in a particular region (links to *SUEWS_Veg.txt* (page **??**)). 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* (page **??**) the first column is labelled 'Grid' and can contain repeat values for different years.) See *Input files* (page **??**) for details. Note UMEP maybe helpful for components of this.

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	SUEWS_NonVeg.tx t]]
	Building surfaces	[[#SUEWS_NonVeg .txt	SUEWS_NonVeg.tx t]]
	Bare soil surfaces	[[#SUEWS_NonVeg .txt	SUEWS_NonVeg.tx t]]
Vegetation	Evergreen trees and shrubs	[[#SUEWS_Veg.tx t	SUEWS_Veg.txt]]
	Deciduous trees and shrubs	[[#SUEWS_Veg.tx t	SUEWS_Veg.txt]]
	Grass	[[#SUEWS_Veg.tx t	SUEWS_Veg.txt]]
Water	Water	[[#SUEWS_Water. txt	SUEWS_Water.txt]]
Snow	Snow	[[#SUEWS_Snow.t xt	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* (page **??**). The surface cover fractions are **critical**, so make certain that the different surface cover fractions are appropriate for your site.

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

Anthropogenic heat flux (Q:sub:*F*)

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

- To model it population density is needed as an input for LUMPS and SUEWS to calculate Q_F.
- If you have no information about the population of the site we recommend that you use the LUCY model *[lucy]* (page 103) *[lucy2]* (page 103) 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.

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

Other information

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

Data Entry

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

1. Data can be entered directly into the input text files. The example (.txt) files provide a template to create your own files which can be edited with a *text editor* (page **??**) directly.
2. Data can be entered into the spreadsheet **SUEWS_SiteInfo.xlsm** and the input text files generated by running the macro.
3. Use [http://urban-climate.net/umep/UMEP| UMEP].

To run the xlsm macro: Enter the data for your site into the xlsm spreadsheet **SUEWS_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.
- Since v2017a it is no longer necessary for the meteorological forcing data to have two rows with -9 in column 1 as their last two rows.
- "!" indicates a comment, so any text following "!" on the same line will not be read by the model.
- If data are unavailable or not required, enter the value -999 in the correct place in the input file.
- Ensure the units are correct for all input information. See *Input files* (page **??**) for a description of parameters.

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

5.5.2 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* (page **??**)) 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:FolderNameSUEWSOutput"'''' and use site code SS the model creates an output file ''
"C:FolderNameSUEWSOutputSSss_YYYY_TT.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 (see *error messages* (page **??**)) and write the error to the problems.txt file.

5.5.3 Preparation of the Meteorological forcing data

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

5.5.4 Preparation of the InitialConditions file

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

5.6 Run the model for your site

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

Please see *Troubleshooting* (page **??**) if you have problems running the model.

5.7 Analyse the output

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

Characteristic	Things to check	
Leaf area index	Does the phenology look appropriate (i.e. what does the seasonal cycle of leaf area index (LAI) look like?) - Are the leaves on the trees at approximately the right time of the year?	
Kdown	Is the timing of the diurnal cycle correct for the incoming solar radiation? *Although Kdown is a required input, it is also included in the output file. It is a good idea to check that the timing of Kdown in the output file is appropriate, as problems can indicate errors with the timestamp, incorrect time settings or problems with the disaggregation. In particular, make sure the sign of the longitude is specified correctly in [[#SUEWS_SiteSelect.txt	SUEWS_SiteSelect.txt]]. - Checking solar angles (zenith and azimuth) can also be a useful check that the timing is correct.
Albedo	Is the bulk albedo correct? - This is critical because a small error has an impact on all the fluxes (energy and hydrology). - If you have measurements of outgoing shortwave radiation compare these with the modelled values. - How do the values compare to literature values for your area?	

5.8 Summary of files

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

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

```
[B] indicates files used with the CBL part of SUEWS (BLUEWS) and therefore are only needed/
produced if this option is selected
```

```
[E] indicates files associated with ESTM storage heat flux models and therefore are only needed/
produced if this option is selected
```

Filename	Description	Location	Option
Program			
SUEWS_V2017 b.exe	SUEWS executable	Directory where the program will run	
[[#Input files	**Input files**]]		
RunControl. nml	Specifies options for the model run	Same directory as executable	1/run
SUEWS_SiteS elect.txt	Main input file for this site	Input directory	1/run
SUEWS_NonVe g.txt	Inputs for non-vegetat ed surfaces	Input directory	1/run
SUEWS_Veg.t xt	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_Anthr opogenicHea t.txt	Inputs for anthropogen ic heat flux	Input directory	1/run
SUEWS_Irrig ation.txt	Inputs for irrigation	Input directory	1/run
SUEWS_Profi les.txt	Inputs for hourly profiles (energy use, water use, snow-cleari ng)	Input directory	1/run
SUEWS_Withi nGrid-WaterD ist.txt	Inputs describing within-grid water distributio n	Input directory	1/run
SUEWS_OHMCo efficients. txt	Inputs for OHM coefficient s	Input directory	1/run
SUEWS_Condu ctance.txt	Inputs for surface conductance	Input directory	1/run

Continued on next page

Table 5.1 – continued from previous page

Filename	Description	Location	Option
SUEWS_SiteI nfo.xlsm	(Optional) spreadsheet for creating input files	Anywhere, but the input files created must be in the input directory	•
SSss_YYYY_d ata_tt.txt / SSss_YYYY_d ata_TT.txt	Meteorologi cal input file at model time-step (tt) / lower resolution (TT)	Input directory	1/grid/year or 1/year
InitialCond **ition-sSSss_** YYYY.nml	Initial conditions file	Input directory	1/grid/run or 1/run
ESTMinput.n ml	Specifies options and inputs for ESTM model	Input directory	1/run [E]
SUEWS_ESTMC oefficients .txt	Inputs for ESTM coefficient s	Input directory	1/run [E]
SSss_YYYY_E STM_Ts_data _tt.txt	Surface temperature data input file at model time-step (tt) / lower resolution (TT)	Input directory	1/grid/year or 1/year [E]
CBLinput.nm l	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	**Output files**]]		
SSss_YYYY_t t.txt	Model output at model time-step (optional)	Output directory	1/grid/year
SSss_YYYY_T T.txt	Model output at resolution specified by ResolutionF ilesOut	Output directory	1/grid/year
SSss_DailyS tate.txt	Status at a daily time step	Output directory	1/grid
InitialCond **ition-sSSss_** YYYY+1.nml	New InitialCond itions file written for each grid at the end of each year for multi-year runs. If the run finishes before the end of the year the InitialCond itions file is still written and the file name is appended with '_EndofRun'	Input directory	1/grid/year
SS_FileChoi ces.txt	Summary of model run options	Output directory	1/run
SS_YYYY_TT_ OutputForma t.txt	Describes header, units and formatting of the main output file	Output directory	1/run
SSss_YYYY_E STM_tt.txt	Model output at model time-step (optional)	Output directory	1/grid/year [E]
SSss_YYYY_E STM_TT.txt	Model output at resolution specified by ResoltuionF ilesOut	Output directory	1/grid/year [E]

Continued on next page

Table 5.1 – continued from previous page

Filename	Description	Location	Option
problems.tx t	Contains details of serious errors encountered in the model run	Same directory as executable	1/run
warnings.tx t	List of potential issues encountered in the model run	Same directory as executable	1/run
CBL_id.txt	CBL model output file for day of year id	Output directory	1/day [B]

CHAPTER

SIX

INPUT FILES

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

6.1 RunControl.nml

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

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

```
&RunControl
CBLUse=0
SnowUse=0
SOLWEIGUse=0
NetRadiationMethod=3
EmissionsMethod=2
StorageHeatMethod=3
OHMIncQF=0
StabilityMethod=2
RoughLenHeatMethod=2
RoughLenMomMethod=2
SMDMethod=0
WaterUseMethod=0
FileCode='Saeve'
FileInputPath="./Input/"
FileOutputPath="./Output/"
MultipleMetFiles=0
MultipleInitFiles=0
MultipleESTMFiles=1
KeepTstepFilesIn=1
KeepTstepFilesOut=1
WriteOutOption=2
ResolutionFilesOut=3600
Tstep=300
ResolutionFilesIn=3600
ResolutionFilesInESTM=3600  !NEW
DisaggMethod=1          !NEW  (1 = default value, so don't actually need here)
RainDisaggMethod=100    !NEW  (100 = default value, so don't actually need here)
DisaggMethodESTM=1      !NEW  (1 = default value, so don't actually need here)
```

(continues on next page)

(continued from previous page)

```
SuppressWarnings=1      !NEW
KdownZen=0
diagnose=0
/
```

Note:

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

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

6.1.1 Model run options

CBLuse

Requirement Required

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

Configuration

Value	Comments
0	CBL model not used. SUEWS and LUMPS use temperature and humidity provided in the meteorological forcing file.
1	CBL model is used to calculate temperature and humidity used in SUEWS and LUMPS.

SnowUse

Requirement Required

Description Determines whether the snow part of the model runs.

Configuration

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

SOLWEIGUse

Requirement Required

Description 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.

Configuration

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

`NetRadiationMethod`

Requirement Required

Description Determines method for calculation of radiation fluxes.

Configuration

Value	Comments
0	Uses observed values of Q* supplied in meteorological forcing file.
1	Q* modelled with L↓ observations supplied in meteorological forcing file. Zenith angle not accounted for in albedo calculation.
2	Q* modelled with L↓ modelled using cloud cover fraction supplied in meteorological forcing file (Loridan et al. 2011 [5]). 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]). Zenith angle not accounted for in albedo calculation.
100	Q* modelled with L↓ observations supplied in meteorological forcing file. Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. 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]). Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. 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]). Zenith angle accounted for in albedo calculation. SSss_YYYY_NARPOut.txt file produced. Not recommended in this release

`AnthropHeatMethod`

Requirement Required

Description Determines method for QF calculation.

Configuration

Value	Comments
0	Uses values provided in the meteorological forcing file (SSss_YYYY_data_tt.txt). If you do not want to include QF to the calculation of surface energy balance, you should set values in the meteorological forcing file to zero to prevent calculation of QF. UMEP provides two methods to calculate QF LQF which is simpler GQF which is more complete but requires more data inputs
1	Currently not recommended! Calculated according to Loridan et al. (2011) [5] using coefficients specified in SUEWS_AnthropogenicHeat.txt. Modelled values will be used even if QF is provided in the meteorological forcing file.
2	Recommended Calculated according to Järvi et al. (2011) [1] using coefficients specified in SUEWS_AnthropogenicHeat.txt and diurnal patterns specified in SUEWS_Profiles.txt. Modelled values will be used even if QF is provided in the meteorological forcing file.

`AnthropCO2Method`

Requirement Required

Description Determines method for CO2 calculation.

Configuration

Value	Comments
1	Not used.
2	Under development - not recommended in v2017b Calculate CO2 emissions from traffic based on QF calculation.
3	Under development - not recommended in v2017b Calculate CO2 emissions from traffic from input data provided.

`StorageHeatMethod`

Requirement Required

Description Determines method for calculating storage heat flux ΔQS.

Configuration

Value	Comments
1	ΔQS modelled using the objective hysteresis model (OHM) [9] [10] [11] 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 v2017b
4	ΔQS modelled using the Element Surface Temperature Method (ESTM) (Offerle et al. 2005 [13]). Not recommended in v2017b

`OHMIncQF`

Requirement Required

Description Determines whether the storage heat flux calculation uses Q* or (Q*+QF).

Configuration

Value	Comments
0	ΔQS modelled Q* only.
1	ΔQS modelled using Q*+QF.

`StabilityMethod`

Requirement Required

Description Defines which atmospheric stability functions are used.

Configuration

Value	Comments
0	Not used.
1	Not used.
2	Recommended Momentum - unstable: Dyer (1974) [22] modified by Högstrom (1988) [23] ; stable: Van Ulden and Holtslag (1985) [24] Heat - Dyer (1974) [22] modified by Högstrom (1988) [23]
3	Momentum: Campbell and Norman (Eq 7.27, Pg97) [25] Heat - unstable: Campbell and Norman [25] ; stable: Dyer (1974) [22] modified by Högstrom (1988) [23]
4	Momentum: Businger et al. (1971) [26] modified by Högstrom (1988) [23] Heat: Businger et al. (1971) [26] modified by Högstrom (1988) [23]

`RoughLenHeatMethod`

Requirement Required

Description Determines method for calculating roughness length for heat.

Configuration

Value	Comments
1	Uses value of 0.1z0m.
2	Recommended Calculated according to Kawai et al. (2009) [27] .
3	Calculated according to Voogt and Grimmond (2000) [28] .
4	Calculated according to Kanda et al. (2007) [29] .

`RoughLenMomMethod`

Requirement Required

Description Determines how aerodynamic roughness length (z0m) and zero displacement height (zdm) are calculated.

Configuration

Value	Comments
1	Values specified in SUEWS_SiteSelect.txt are used. Note that UMEP provides tools to calculate these]. See Kent et al. (2017a) for recommendations on methods. Kent et al. (2017b) have developed a method to include vegetation which is also avaialble within UMEP. Kent CW, CSB Grimmond, J Barlow, D Gatey, S Kotthaus, F Lindberg, CH Halios 2017a: Evaluation of urban local-scale aerodynamic parameters: implications for the vertical profile of wind and source areas Boundary Layer Meteorology 164,183–213 doi: 10.1007/s10546-017-0248-z Kent CW, S Grimmond, D Gatey 2017b: Aerodynamic roughness parameters in cities: inclusion of vegetation Journal of Wind Engineering & Industrial Aerodynamics http://dx.doi.org/10.1016/j.jweia.2017.07.016
2	z0m and zd are calculated using 'rule of thumb' (Grimmond and Oke 1999 [30]) using mean building and tree height specified in SUEWS_SiteSelect.txt . z0m and zd are adjusted with time to account for seasonal variation in porosity of deciduous trees.
3	z0m and zd are calculated based on the MacDonald et al. (1998) [31] method using mean building and tree heights, plan area fraction and frontal areal index specified in SUEWS_SiteSelect.txt . z0m and zd are adjusted with time to account for seasonal variation in porosity of deciduous trees.

`SMDMethod`

Requirement Required

Description Determines method for calculating soil moisture deficit (SMD).

Configuration

Value	Comments
0	Recommended SMD modelled using parameters specified in SUEWS_Soil.txt .
1	Not currently implemented - do not use! Observed SM provided in the meteorological forcing file is used. Data are provided as volumetric soil moisture content. Metadata must be provided in SUEWS_Soil.txt .
2	Not currently implemented - do not use! Observed SM provided in the meteorological forcing file is used. Data are provided as gravimetric soil moisture content. Metadata must be provided in SUEWS_Soil.txt .

`WaterUseMethod`

Requirement Required

Description Defines how external water use is calculated.

Configuration

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.

6.1.2 Time related options

`Tstep`

Requirement Required

Description 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).

Configuration to fill

`ResolutionFilesIn`

Requirement Required

Description Specifies the resolution of the input files [s] which SUEWS will disaggregate to the model time step. 1800 s for 30 min or 3600 s for 60 min are recommended. (N.B. if ResolutionFilesIn is not provided, SUEWS assumes ResolutionFilesIn = Tstep.)

Configuration to fill

`ResolutionFilesInESTM`

Requirement Optional

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

Configuration to fill

`ResolutionFilesOut`

Requirement Required

Description Specifies the resolution of the output files [s]. 1800 s for 30 min or 3600 s for 60 min are recommended.

Configuration to fill

6.1.3 File related options

`FileCode`

Requirement Required

Description Two-letter site identification code (e.g. He, Sc, Kc).

Configuration to fill

`FileInputPath`

Requirement Required

Description Input directory.

Configuration to fill

`FileOutputPath`

Requirement Required

Description Output directory.

Configuration to fill

`MultipleMetFiles`

Requirement Required

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

Configuration

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

`MultipleInitFiles`

Requirement Required

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

Configuration

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

`MultipleESTMFiles`

Requirement Optional

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

Configuration

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

`KeepTstepFilesIn`

Requirement Optional

Description Specifies whether input meteorological forcing files at the resolution of the model time step should be saved.

Configuration

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

`KeepTstepFilesOut`

Requirement Optional

Description Specifies whether output meteorological forcing files at the resolution of the model time step should be saved.

Configuration

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

`WriteOutOption`

Requirement Optional

Description Specifies which variables are written in the output files.

Configuration

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

`SuppressWarnings`

Requirement Optional

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

Configuration

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

6.1.4 Options related to disaggregation of input data

`DisaggMethod`

Requirement Optional

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

Configuration

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

`KdownZen`

Requirement Optional

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

Configuration

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

`RainDisaggMethod`

Requirement Optional

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

Configuration

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

`RainAmongN`

Requirement Optional

Description Specifies the number of subintervals (of length tt) over which to distribute rainfall in each interval (of length TT). Must be an integer value. Use with RainDisaggMethod = 101.

Configuration to fill

`MultRainAmongN`

Requirement Optional

Description Specifies the number of subintervals (of length tt) over which to distribute rainfall in each interval (of length TT) for up to 5 intensity bins. Must take integer values. Use with RainDisaggMethod = 102. e.g. MultRainAmongN(1) = 5, MultRainAmongN(2) = 8, MultRainAmongN(3) = 12

Configuration to fill

`MultRainAmongNUpperI`

Requirement Optional

Description Specifies upper limit for each intensity bin to apply MultRainAmongN. Any intensities above the highest specified intensity will use the last MultRainAmongN value and write a warning to warnings.txt. Use with RainDisaggMethod = 102. e.g. MultRainAmongNUpperI(1) = 0.5, MultRainAmongNUpperI(2) = 2.0, MultRainAmongNUpperI(3) = 50.0

Configuration to fill

`DisaggMethodESTM`

Requirement Optional

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

Configuration

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

6.1.5 netCDF related options

`ncMode`

Requirement Optional

Description Determine if the output files should be written in netCDF format.

Configuration

Value	Comments
0	Output files are kept as plain text files (i.e., .txt).
1	Output files will be written in netCDF format (i.e., .nc).

`nRow`

Requirement Optional

Description Number of rows (e.g., 36) in the output layout (only applicable when ncMode=1).

Configuration to fill

`nCol`

Requirement Optional

Description Number of columns (e.g., 47) in the output layout (only applicable when ncMode=1).

Configuration to fill

6.2 SUEWS_SiteInfo.xlsm

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

6.2.1 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 (AnthropHeatMethod = 2 in 4.1 *RunControl.nml* (page **??**)) or the method of Loridan et al. (2011) based on air temperature (AnthropHeatMethod = 1 in *RunControl.nml* (page **??**)). 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 AnthropHeatMethod = 0 in *RunControl.nml* (page **??**)), in which case all columns here except Code and BaseTHDD should be set to '-999'.

No.	Use	Column name	Example	Descripti on		
1	L	Code	331	Code linking to the Anthropog enicCode column in [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt]]. Value of integer is arbitrary but must match code specified in SUEWS_Sit eSelect.t xt.	
2	MU	BaseTHDD	18.2	Base temperatu re for heating degree days [°C] e.g. Sailor and Vasireddy (2006) [4 26]_		
3	MU, O	QF_A_Weekday		Base value for QF on weekdays [W m:sup:‘ -2‘ (Cap ha:sup: *-1*):s up:-*1*] - Use with Anthro pHeatChoi ce = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ (C a p h a - 1) : s u p : ‘ - 1 ‘] 0 . 3 0 8 1 0 . 1 0 0 0	J ä r v i e t a l . (2 0 1 1) [4 2 9] _ J ä r v i e t a l . (2 0 1 4) [4 3 0] _
4	MU, O	QF_B_Weekday		Parameter related to cooling degree days on weekdays [W m:sup:‘ -2‘ K:sup:‘ -1‘ (Cap ha:sup: *-1*):s up:-*1*] - Use with Anthro pHeatMeth od = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ K : s u p : ‘ - 1 ‘ (C a p h a : s u p : ‘ - 1 ‘) : s u p : ‘ - 1 ‘] 0 . 0 0 9 9 0 . 0 0 9 9	J ä r v i e t a l . (2 0 1 1) [4 3 3] _ J ä r v i e t a l . (2 0 1 4) [4 3 4] _
5	MU, O	QF_C_Weekday		Parameter related to heating degree days on weekdays [W m:sup:‘ -2‘ K:sup:‘ -1‘ (Cap ha:sup: *-1*):s up:-*1*] - Use with Anthro pHeatMeth od = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ K : s u p : ‘ - 1 ‘ (C a p h a : s u p : ‘ - 1 ‘) : s u p : ‘ - 1 ‘] 0 . 0 1 0 2 0 . 0 1 0 2	J ä r v i e t a l . (2 0 1 1) [4 3 7] _ J ä r v i e t a l . (2 0 1 4) [4 3 8] _
6	MU, O	QF_A_Weekend		Base value for QF on weekends [W m:sup:‘ -2‘ (Cap ha:sup: *-1*):s up:-*1*] - Use with Anthro pHeatMeth od = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ (C a p h a : s u p : ‘ - 1 ‘) : s u p : ‘ - 1 ‘] 0 . 3 0 8 1 0 . 1 0 0 0	J ä r v i e t a l . (2 0 1 1) [4 4 1] _ J ä r v i e t a l . (2 0 1 4) [4 4 2] _
7	MU, O	QF_B_Weekend	0-1	Parameter related to cooling degree days on weekends [W m:sup:‘ -2‘ K:sup:‘ -1‘ (Cap ha:sup: *-1*):s up:-*1*] - Use with Anthro pHeatMeth od = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ K : s u p : ‘ - 1 ‘ (C a p h a : s u p : ‘ - 1 ‘) : s u p : ‘ - 1 ‘] 0 . 0 0 9 9 0 . 0 0 9 9	J ä r v i e t a l . (2 0 1 1) [4 4 5] _ J ä r v i e t a l . (2 0 1 4) [4 4 6] _
8	MU, O	QF_C_Weekend		Parameter related to heating degree days on weekends [W m:sup:‘ -2‘ K:sup:‘ -1‘ (Cap ha:sup: *-1*):s up:-*1*] Use with AnthropHe atMethod = 2 +—+—+ +===+ +—+—+ +—+—+ +—+—+	E x a m p l e v a l u e s [W m : s u p : ‘ - 2 ‘ K : s u p : ‘ - 1 ‘ (C a p h a : s u p : ‘ - 1 ‘) : s u p : ‘ - 1 ‘] 0 . 0 1 0 2 0 . 0 1 0 2	J ä r v i e t a l . (2 0 1 1) [4 4 9] _ J ä r v i e t a l . (2 0 1 4) [4 5 0] _
9	MU, O	AH-Min	15	Minimum QF [W m:sup:‘ -2‘] - Use with Anthro pHeatMeth od = 1 e.g. Loridan et al. (2011) [4 51]_		
10	MU, O	AH-S-lope	2.7	Slope of QF versus air temperatu re [W m:sup:‘ -2‘ K:sup:‘ -1‘] - Use with Anthro pHeatMeth od = 1 e.g. Loridan et al. (2011) [4 52]_		
11	MU, O	TCritic	7	Critical temperatu re [°C] - Use with Anthro pHeatMeth od = 1 e.g. Loridan et al. (2011) [4 53]_		

6.2.2 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) *[J11]* (page 103)) and should be used with **gsModel=1**. An alternative formulation (gsModel=2) uses slightly different functional forms and different coefficients (with different units).

No.	Use	Column name	Example	Descripti on	
1	L	Code		Code linking to the CondCode column in [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt]]. Value of integer is arbitrary but must match code specified in SUEWS_Sit eSelect.t xt.
2	MD	G1	16.4764	Related to maximum surface conductan ce [mm s:sup:‘ -1‘]	
3	MD	G2	566.0923	Related to Kdown dependenc e [W m:sup:‘ -2‘]	
4	MD	G3	0.2163	Related to VPD dependenc e [units depend on gsChoice in [[#RunCon trol.nml	RunContro l.nml]]]
5	MD	G4	3.3649	Related to VPD dependenc e [units depend on gsChoice in [[#RunCon trol.nml	RunContro l.nml]]]
6	MD	G5	11.0764	Related to temperatu re dependenc e [°C]	
7	MD	G6	0.0176	Related to soil moisture dependenc e [mm:sup:‘ -1‘]	
8	MD	TH	40	Upper air temperatu re limit [°C]	
9	MD	TL	0	Lower air temperatu re limit [°C]	
10	MD	S1	0.45	Related to soil moisture dependenc e [-] *These will change in the future to ensure consisten cy with soil behaviour *	
11	MD	S2	15	Related to soil moisture dependenc e [mm] *These will change in the future to ensure consisten cy with soil behaviour *	
12	MD	Kmax	1200	Maximum incoming shortwave radiation [W m:sup:‘ -2‘]	
13	MD	gsModel	1	Determine s which surface conductan ce parameter isation to use - 1 = Järvi et al. (2011) *[J11]* (page 103) - 2 = Ward et al. (2016) *[W16]* (page 103) **Reco mmended.* * **The parameter isation specified here must match the coefficie nts specified in the other columns of SUEWS_Con ductance. txt.**	

6.2.3 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* (page **??**).

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

No.	Use	Column name	Example	Descripti on	
1	L	Code		Code linking to [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt] for irrigatio n modelling (Irrigati onCode). Value of integer is arbitrary but must match codes specified in SUEWS_Sit eSelect.t xt.
2	MU	Ie_start	1-366	Day when irrigatio n starts [DOY]	
3	MU	Ie_end	1-366	Day when irrigatio n ends [DOY]	
4	MU	InternalW aterUse	0	Internal water use [mm h:sup:‘ -1‘]	
5	MU	Faut	0-1	Fraction of irrigated area that is irrigated using automated systems (e.g. sprinkler s).	
6	MD	Ie_a1	-84.54	Coefficie nt for automatic irrigatio n model [mm d:sup:‘ -1‘]	
7	MD	Ie_a2	9.96	Coefficie nt for automatic irrigatio n model [mm d:sup:‘ -1‘ °C:sup: *-1*]	
8	MD	Ie_a3	3.67	Coefficie nt for automatic irrigatio n model [mm d:sup:‘ -2‘]	
9	MD	Ie_m1	-25.36	Coefficie nt for manual irrigatio n model [mm d:sup:‘ -1‘]	
10	MD	Ie_m2	3.00	Coefficie nt for manual irrigatio n model [mm d:sup:‘ -1‘ °C:sup: *-1*]	
11	MD	Ie_m3	1.10	Coefficie nt for manual irrigatio n model [mm d:sup:‘ -2‘]	
12	MU	DayWat(1)	0 or 1	Irrigatio n allowed on Sundays [J11], if not [0]	
13	MU	DayWat(2)	0 or 1	Irrigatio n allowed on Mondays [J11], if not [0]	
14	MU	DayWat(3)	0 or 1	Irrigatio n allowed on Tuesdays [J11], if not [0]	
15	MU	DayWat(4)	0 or 1	Irrigatio n allowed on Wednesday s [J11], if not [0]	
16	MU	DayWat(5)	0 or 1	Irrigatio n allowed on Thursdays [J11], if not [0]	
17	MU	DayWat(6)	0 or 1	Irrigatio n allowed on Fridays [J11], if not [0]	
18	MU	DayWat(7)	0 or 1	Irrigatio n allowed on Saturdays [J11], if not [0]	
19	MU	DayWat-	0-1	Fraction of propertie s using irrigatio n on Sundays	

6.2.4 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	Descrip tion			
1	L	Code	333	Code linking to SUEWS_S ite-Sele ct.txt for paved surface s (Code_P aved), buildin gs (Code_B ldgs) and bare soil surface s (Code_B Soil). Value of integer is arbitra ry but must match codes specifi ed in SUEWS_S iteSele ct.txt.			
2	MU	AlbedoM in	0-	Minumum albedo of this surface [-] - Effe ctive surf ace albe do (mid dle of the day valu e) for wint ertime (not incl uding snow). - View fact ors shou ld be take n into acco unt. - Not curr ently used for non- vegetat ed surf aces – set the same as Albe doMax.			
3	MU	AlbedoM ax	0-	Maximum albedo of this surface [-] - Effe ctive surf ace albe do (mid dle of the day valu e) for summ ertime. - View fact ors shou ld be take n into acco unt.			
4	MU	Emis- siv ity	- 0-1	Emissiv ity of this surface [-] - Effe ctive surf ace emis sivity. - View fact ors shou ld be take n into acco unt.			
5	MD	Stor- age Min		Minimum water storage capacit y of this surface [mm] - Mini mum wate r stor age capa city for uppe r surf aces (i.e . cano py). - Min/ max valu es are to acco unt for seas onal vari ation (e.g . leaf -on/lea f-off diff erences for vege tated surf aces). - Not curr ently used for non-vegetat ed surf aces - set the same as Stor ageMax. +—+--+ +===+== =+ +—+- -+ +—+- -+ +—+- -+	E x a m p l e v a l u e s [m m] 0 . 4 8 0 . 2 5 0 . 8 0	P a v e d B l d g s B S o i l	
6	MD	Stor- age Max		Maximum water storage capacit y of this surface [mm] - Maxi mum wate r stor age capa city for uppe r surf aces (i.e . cano py) - Min and max valu es are to acco unt for seas onal vari ation (e.g . leaf -on/lea f-off diff erences for vege tated surf aces). - Not curr ently used for non-vegetat ed surf aces - set the same as Stor ageMin. +—+--+ +===+== =+ +—+- -+ +—+- -+ +—+- -+	E x a m p l e v a l u e s [m m] 0 . 4 8 0 . 2 5 0 . 8 0	P a v e d B l d g s B S o i l	
7	MD	Wet- Thre sh- old		Thresho ld for a complet ely wet surface [mm] - Dept h of wate r whic h dete rmines whet her evap oration occu rs from a part	E x a m p l e v a l u e s [m m] 0 . 6 0 . 6 1 . 0	P a v e d B l d g s B S o i l	

6.2.5 SUEWS_OHMCoefficients.txt

OHM, the Objective Hysteresis Model (Grimmond et al. 1991) *[G91OHM]* (page 103) calculates the storage heat flux as a function of net all-wave radiation and surface characteristics.

- For each surface, OHM requires three model coefficients (a1, a2, a3). The three should be selected as a set.
- The **SUEWS_OHMCoefficients.txt** file provides these coefficients for each surface type.
- A variety of values has been derived for different materials and can be found in the literature (see: [http://urban-climate.net/umep/TypicalValues#OHM_Coefficients| Typical Values]).
- Coefficients can be changed depending on:

:# surface wetness state (wet/dry) based on the calculated surface wetness state and soil moisture.

:# season (summer/winter) based on a 5-day running mean air temperature.

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

Note, **AnOHM** does not use the coefficients specified in SUEWS_OHMCoefficients.txt but instead requires three parameters to be specified for each surface type (including snow): heat capacity, thermal conductivity and bulk transfer coefficient. These are specified in *SUEWS_NonVeg.txt* (page **??**), *SUEWS_Veg.txt* (page **??**), *SUEWS_Water.txt* (page **??**) and *SUEWS_Snow.txt* (page **??**). No additional files are required for AnOHM.

Note AnOHM is under development in v2017a and should not be used!

No.	Use	Column name	Example	Description
1	L	Code	331	Code linking to the OHMCode_Sum merWet, OHMCode_Sum merDry, OHMCode_Win terWet and OHMCode_Win terDry columns in SUEWS_NonVe g.txt, SUEWS_Veg,t xt, SUEWS_Water .txt and SUEWS_Snow. txt files. Value of integer is arbitrary but must match code specified in SUEWS_SiteS elect.txt.
2	MU	a1		Coefficient for Q* term [-]
3	MU	a2		Coefficient for dQ*/dt term [h]
4	MU	a3		Constant term [W m:sup:‘-2 ‘]

6.2.6 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)
- Human activity (weekday and weekend) **- not used in v2017a**.

No.	Use	Column name	Example	Descripti on	
1	L	Code		Code linking to the following columns in [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt]]: - Energy UseProfWD : Anthro pogenic heat flux, weekda ys - Energy UseProfWE : Anthro pogenic heat flux, weeken ds - WaterU seProfMan uWD : Manual irriga tion, weekda ys - WaterU seProfMan uWE : Manual irriga tion, weeken ds - WaterU seProfAut oWD : Automa tic irriga tion, weekda ys - WaterU seProfAut oWE: Automa tic irriga tion, weeken ds - SnowCl earingPro fWD : Snow cleari ng, weekda ys - SnowCl earingPro fWE: Snow cleari ng, weeken ds - Activi tyProfWD: Human activi ty, weekda ys - Activi tyProfWE: Human activi ty, weeken ds - Value of intege r is arbitr ary but must match codes specif ied in **SUEWS_** SiteSelec t.txt.
2-25	MU	0-23		Multiplie r for each hour of the day [-] for energy and water use. For SnowClear ing, 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_Non Veg.txt (SnowLimR emove column) are exceeded.	

6.2.7 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.

No.	Use	Column name	Example	Descrip tion
1	MU	Grid	1	Grid number (any integer 0-2,147 ,483,64 7 (larges t 4-byte int
2	MU	Year	2011	Year [YYYY] Years must be continu ous. If running multipl e
3	MU	StartDL S	86	Start of the day light savings [DOY] See section on [[#Day Lig
4	MU	EndDLS	303	End of the day light savings [DOY] See section on [[#Day Lig
5	MU	lat	60.00	Latitud e for the centre of the grid [decima l degrees] - Use co

No.	Use	Column name	Example	Descrip tion
6	MU	lng	-18.20	Longitu de for the centre of the grid [decima l degrees] - Use
7	MU	Timezon e	0	Time zone [h] for site relativ e to UTC (east is positiv e). Thi
8	MU	Surface Area	75.3	Area of the grid [ha].
9	MU	Alt	25.0	Altitud e [m] Mean topogra phic height above sea-lev el. - Use
10	MU	z	20.5	Height [m] of the meteoro logical forcing data. The most impo
11	MD	id	1	Day [DOY] Not used: set to 1 in this version .
12	MD	ih	0	Hour [H] Not used: set to 0 in this version .
13	MD	imin	0	Minute [M] Not used: set to 0 in this version .
14	MU	Fr_Pave d	0.20	Surface cover fractio n of paved surface s [-] Areal cover fractio
15	MU	Fr_Bldg s	0.20	Surface cover fractio n of buildin gs [-]
16	MU	Fr_EveT r	0.10	Surface cover fractio n of evergre en trees and shrubs [-]
17	MU	Fr_DecT r	0.10	Surface cover fractio n of deciduo us trees and shrubs [-]
18	MU	Fr_Gras s	0.30	Surface cover fractio n of grass [-]
19	MU	Fr_Bsoi l	0.05	Surface cover fractio n of bare soil or unmanag ed land [-]
20	MU	Fr_Wate r	0.05	Surface cover fractio n of open water [-] (e.g. river, lakes, pond
21	MU	IrrFr_E veTr	0.50	Fractio n of evergre en trees that are irrigat ed [-] e.g. 50% of
22	MU	IrrFr_D ecTr	0.20	Fractio n of deciduo us trees that are irrigat ed [-]
23	MU	IrrFr_G rass	0.70	Fractio n of grass that is irrigat ed [-]
24	MU	H_Bldgs	10	Mean buildin g height [m]
25	MU	H_EveTr	15	Mean height of evergre en trees [m]
26	MU	H_DecTr	15	Mean height of deciduo us trees [m]
27	O	z0	0.6	Roughne ss length for momentu m [m] Value supplie d here is
28	O	zd	1.5	Zero-pl ane displac ement [m] Value supplie d here is used if F
29	O	FAI_Bld gs	0.1	Frontal area index for buildin gs [-] Require d if RoughLe nMo
30	O	FAI_Eve Tr	0.2	Frontal area index for evergre en trees [-] Require d if RoughL
31	O	FAI_Dec Tr	0.2	Frontal area index for deciduo us trees [-] Require d if RoughL
32	O	PopDens Day	30.7	Daytime populat ion density (i.e. workers , tourist s) [people h
33	O	PopDens Night	10.2	Night-t ime populat ion density (i.e. residen ts) [people ha:su
34	O	Traffic Rate		Traffic rate [veh km m-2 s-1] Can be used for CO2 flux calcula
35	O	BuildEn ergyUse		Buildin g energy use [W m-2] Can be used for CO2 flux calcul
36	L	Code_Pa ved	331	Code for Paved surface charact eristic s Provide s the link to c
37	L	Code_Bl dgs	332	Code for Bldgs surface charact eristic s Provide s the link to c
38	L	Code_Ev eTr	331	Code for EveTr surface charact eristic s Provide s the link to c
39	L	Code_De cTr	332	Code for DecTr surface charact eristic s Provide s the link to c
40	L	Code_Gr ass	333	Code for Grass surface charact eristic s Provide s the link to c
41	L	Code_Bs oil	333	Code for BSoil surface charact eristic s Provide s the link to c
42	L	Code_Wa ter	331	Code for Water surface charact eristic s Provide s the link to c
43	MD	LUMPS_D rRate	0.25	Drainag e rate of bucket for LUMPS [mm h:sup *:-1*] Used for L
44	MD	LUMPS_C over	1	Limit when surface totally covered with water [mm] Used for L
45	MD	LUMPS_M axRes	10	Maximum water bucket reservo ir [mm] Used for LUMPS surf
46	MD	NARP_Tr ans	1	Atmosph eric transmi ssivity for NARP [-] Value must in the r
47	L	CondCod e	33	Code for surface conduct ance paramet ers Provide s the link t
48	L	SnowCod e	33	Code for snow surface charact eristic s Provide s the link to co
49	L	SnowCle aringPr ofWD	1	Code for snow clearin g profile (weekda ys) Provide s the link
50	L	SnowCle aringPr ofWE	1	Code for snow clearin g profile (weeken ds) Provide s the link
51	L	Anthrop ogenicC ode	33	Code for modelli ng anthrop ogenic heat flux Provide s the lin
52	L	EnergyU seProfW D	333	Code for energy use profile (weekda ys) Provide s the link to c
53	L	EnergyU seProfW E	334	Code for energy use profile (weeken ds) Provide s the link to c
54	L	Activit yProfWD	333	Code for human activit y profile (weekda ys) Provide s the lin

No.	Use	Column name	Example	Descrip tion
55	L	Activit yProfWE	333	Code for human activit y profile (weeken ds) Provide s the lin
56	L	Irrigat ionCode	33	Code for modelli ng irrigat ion Provide s the link to column 1
57	L	WaterUs eProfMa nuWD	335	Code for water use profile (manual irrigat ion, weekday s) Pro
58	L	WaterUs eProfMa nuWE	336	Code for water use profile (manual irrigat ion, weekend s) Pro
59	L	WaterUs eProfAu toWD	337	Code for water use profile (automa tic irrigat ion, weekday s)
60	L	WaterUs eProfAu toWE	338	Code for water use profile (automa tic irrigat ion, weekend s)
61	MD	FlowCha nge	0	Differe nce in input and output flows for water surface [mm h
62	MD,MU	RunoffT oWater	0.1	Fractio n of above-g round runoff flowing to water surface dur
63	MD,MU	PipeCap acity	100	Storage capacit y of pipes [mm] Runoff amounti ng to less tha
64	MD,MU	GridCon nection 1of8	2	Number of the grid where water can flow to [-] - The next 8 p
65	MD,MU	Fractio n1of8	0.2	Fractio n of water that can flow to the grid specifi ed in previo
66	MD,MU	GridCon nection 2of8	0	Number of the grid where water can flow to
67	MD,MU	Fractio n2of8	0	Fractio n of water that can flow to the grid specifi ed in previo
68	MD,MU	GridCon nection 3of8	0	Number of the grid where water can flow to
69	MD,MU	Fractio n3of8	0	Fractio n of water that can flow to the grid specifi ed in previo
70	MD,MU	GridCon nection 4of8	0	Number of the grid where water can flow to
71	MD,MU	Fractio n4of8	0	Fractio n of water that can flow to the grid specifi ed in previo
72	MD,MU	GridCon nection 5of8	0	Number of the grid where water can flow to
73	MD,MU	Fractio n5of8	0	Fractio n of water that can flow to the grid specifi ed in previo
74	MD,MU	GridCon nection 6of8	0	Number of the grid where water can flow to
75	MD,MU	Fractio n6of8	0	Fractio n of water that can flow to the grid specifi ed in previo
76	MD,MU	GridCon nection 7of8	0	Number of the grid where water can flow to
77	MD,MU	Fractio n7of8	0	Fractio n of water that can flow to the grid specifi ed in previo
78	MD,MU	GridCon nection 8of8	0	Number of the grid where water can flow to
79	MD,MU	Fractio n8of8	0	Fractio n of water that can flow to the grid specifi ed in previo
80	L	WithinG ridPave dCode	331	Code that links to the fractio n of water that flows from Pave
81	L	WithinG ridBldg sCode	332	Code that links to the fractio n of water that flows from Bldg
82	L	WithinG ridEveT rCode	333	Code that links to the fractio n of water that flows from EveT
83	L	WithinG ridDecT rCode	334	Code that links to the fractio n of water that flows from DecT
84	L	WithinG ridGras sCode	335	Code that links to the fractio n of water that flows from Grass
85	L	WithinG ridBSoi lCode	336	Code that links to the fractio n of water that flows from BSoil
86	L	WithinG ridWate rCode	337	Code that links to the fractio n of water that flows from Wate
87	MU	AreaWal l	1.08	Area of wall within grid (needed for ESTM calcula tion).
88	MU	Fr_ESTM Class_P aved1		Fractio n of paved surface classif ied as ESTM class 1 - Colu n
89	MU	Fr_ESTM Class_P aved2		Fractio n of paved surface classif ied as ESTM class 2 - Colu n
90	MU	Fr_ESTM Class_P aved3		Fractio n of paved surface classif ied as ESTM class 3 - Colu n
91	L	Code_ES TMClass _Paved1		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
92	L	Code_ES TMClass _Paved2		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
93	L	Code_ES TMClass _Paved3		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
94	MU	Fr_ESTM Class_B ldgs1		Fractio n of buildin g surface classif ied as ESTM class 1 - Col
95	MU	Fr_ESTM Class_B ldgs2		Fractio n of buildin g surface classif ied as ESTM class 2 - Col
96	MU	Fr_ESTM Class_B ldgs3		Fractio n of buildin g surface classif ied as ESTM class 3 - Col
97	MU	Fr_ESTM Class_B ldgs4		Fractio n of buildin g surface classif ied as ESTM class 4 - Col
98	MU	Fr_ESTM Class_B ldgs5		Fractio n of buildin g surface classif ied as ESTM class 5 - Col
99	L	Code_ES TMClass _Bldgs1		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
100	L	Code_ES TMClass _Bldgs2		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
101	L	Code_ES TMClass _Bldgs3		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
102	L	Code_ES TMClass _Bldgs4		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t
103	L	Code_ES TMClass _Bldgs5		Code linking to [[#SUEW S_ESTMC oeffici ents.tx t

No.	Use	Column name	Example	Descrip tion

Day Light Savings (DLS)

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

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

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

Example:	Year	start of daylight savings	end of daylight savings
when running multiple years (in this case 2008 and 2009 in Canada)	2008	170	240
	2009	172	242

Grid Connections (water flow between grids)

N.B. not currently implemented - columns 64-79 of *SUEWS_SiteSelect.txt* (page **??**) can be set to zero.

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

The table gives example values for the grid connections part of *SUEWS_SiteSelect.txt* (page **??**) 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.

[[File:GridConnections_1.jpg%7Cframe|

```
Example grid connections showing water flow between grids. Arrows indicate the water flow in to and out
but note that only only water flowing out of each grid is entered in SUEWS_SiteSelect.
txt.|none]]
```

6.2.8 SUEWS_Snow.txt

SUEWS_Snow.txt specifies the characteristics for snow surfaces when SnowUse=1 in *RunControl.nml* (page **??**). If the snow part of the model is not run, fill this table with '-999' except for the first (Code)

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

column and set SnowUse=0 in *RunControl.nml* (page **??**). For a detailed description of the variables, see Järvi et al. (2014) *[Leena2014]* (page 104). *In the current release SnowUse should be set to 0.*

No.	Use	Column name	Example	Descrip tion		
1	L	Code	331	Code linking to [[#SUEW S_SiteS elect.t xt	SUEWS_S iteSele ct.txt]] for snow surface s (SnowCo de). Value of integer is arbitra ry but must match code specifi ed in SUEWS_S iteSele ct.txt.	
2	MU	RadMeltFactor	0.0016	Hourly radiati on melt factor of snow [mm W:sup :-*1* h:sup :-*1*]		
3	MU	TempMeltFactor	0.07	Hourly tempera ture melt factor of snow [mm °C:su p:-*1* h:sup :-*1*] (In previou s model version , this paramet er was 0.12)		
4	MU	AlbedoMin	0.1	Minimum snow albedo [-] +—+– -+ +===+ +—+– -+ +—+– -+	E x a m p l e v a l u e s [-] 0 . 1 8	J ä r v i e t a l . (2 0 1 4) [3 8 7] _
5	MU	AlbedoMax	0.1	Maximum snow albedo (fresh snow) [-] +—+– -+ +===+ +—+– -+ +—+– -+	E x a m p l e v a l u e s [-] 0 . 8 5	J ä r v i e t a l . (2 0 1 4) [3 8 9] _
6	MU	Emissivity	0-1	Emissiv ity of this surface [-] - Effe ctive surf ace emis sivity. - View fact ors shou ld be take n into acco unt +—+– -+ +===+ +—+– -+ +—+– -+	E x a m p l e v a l u e s [-] 0 . 9 9	J ä r v i e t a l . (2 0 1 4) [3 9 1] _
7	MD	tau_a	0.018	Time constan t for snow albedo aging in cold snow [-]		
8	MD	tau_f	0.11	Time constan t for snow albedo aging in melting snow [-]		
9	MD	PrecipiLimAlb	2	Limit for hourly precipi tation when the ground is fully covered with snow. Then snow albedo is reset to AlbedoM ax [mm]		
10	MD	snowDensMin	100	Fresh snow density [kg m:sup :-*3*]		
11	MD	snowDensMax	400	Maximum snow density [kg m:sup :-*3*]		
12	MD	tau_r	0.043	Time constan t for snow density ageing [-]		
13	MD	CRWMin	0.05	Minimum water holding capacit y of snow [mm]		
14	MD	CRWMax	0.20	Maximum water holding capacit y of snow [mm]		

6.2.9 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* (page **??**) and *SUEWS_Veg.txt* (page **??**).

Soil moisture can either be provided using observational data in the met forcing file (smd_choice = 1 or 2 in *RunControl.nml* (page **??**)) and providing some metadata information here (OBS_ columns), or modelled by SUEWS (smd_choice = 0 in *RunControl.nml* (page **??**)). **- 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 SoilType-Cod e column in SUEWS_NonVe g.txt (for Paved, Bldgs and BSoil surfaces) and SUEWS_Veg.t xt (for EveTr, DecTr and Grass surfaces). Value of integer is arbitrary but must match code specified in SUEWS_SiteS elect.txt.
2	MD	SoilDepth	350	Depth of sub-surface soil store [mm] i.e. the depth of soil beneath the surface
3	MD	SoilStoreCa p	150	Capacity of sub-surface soil store [mm] i.e. how much water can be stored in the sub-surface soil when at maximum capacity. • SoilStor **eCap** must not be greater than SoilDept 8.
4	MD	SatHydrauli cCond	0.0005	Hydraulic conductivit y for saturated soil [mm s:sup:'-1 ']
5	MD	SoilDensity	1.16	Soil density [kg m:sup:'-3 ']
6	O	Infiltratio nRate	-999	Infiltratio n rate [mm h:sup:'-1 '] • Not currentl **y** used
7	O	OBS_SMDepth		Depth of soil moisture measurement s [mm] • Use only if soil moisture is observed and provided in the met forcing file and smd_choi **ce** = 1 or 2.

6.2.10 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* (page **??**) (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	Descripti on
1	L	Code	333	Code linking to [[#SUEWS_ SiteSelec t.txt
2	MU	AlbedoMin	0-1	Minimum albedo of this surface [-] - Effect ive surfac e albedo (middl
3	MU	AlbedoMax	0-1	Maxmium albedo of this surface [-] - Effect ive surfac e albedo (middl
4	MU	Emissivit y	0-1	Emissivit y of this surface [-] - Effect ive surfac e emissi vity. - View fa
5	MD	StorageMi n		Minimum water storage capacity of this surface [mm] - Minimu m wat
6	MD	StorageMa x		Maximum water storage capacity of this surface [mm] - Maximu m wa
7	MD	WetThresh old		Threshold for a completel y wet surface [mm] - Depth of water which
8	MD	StateLimi t		Upper limit to the surface state [mm] **- Curr ently only used for th**
9	MD	DrainageE q	1, 2, 3	Drainage equation to use for this surface. +—+—+ —+ +===+ +–
10	MD	DrainageC oef1		Coefficie nt for drainage equation [units vary according to DrainageE
11	MD	DrainageC oef2		Coefficie nt for drainage equation [units vary according to DrainageE
12	L	SoilTypeC ode		Code for soil character istics below this surface Provides the link to co
13	O	SnowLimPa tch		Maximum SWE [mm] - Limit of snow water equiva lent when the surf
14	MU	BaseT		Base temperatu re for initiatin g growing degree days for leaf growth [
15	MU	BaseTe		Base temperatu re for initiatin g senescenc e degree days for leaf off [°
16	MU	GDDFull		Growing degree days needed for full capacity of the leaf area index [°C
17	MU	SDDFull		Senescenc e degree days needed to initiate leaf off [°C] *This should be
18	MD	LAIMin		Minimum leaf area index [m:sup:- *2* m:sup:‘ -2‘] - leaf-o ff winter time
19	MD	LAIMax		Maximum leaf area index [m:sup:- *2* m:sup:‘ -2‘] - full leaf-o n summer
20	MD	PorosityM in	0.2	Minimum porosity [-] - leaf-o ff winter time value - Used only for DecT
21	MD	PorosityM ax	0.6	Maximum porosity [-] - full leaf-o n summer time value - Used only fo
22	MD	MaxConduc tance		Maximum conductan ce for each surface [mm s:sup:‘ -1‘] Used to calcu
23	MD	LAIEq	0, 1	LAI equation to use for this surface. +—+—+ +===+ +—+—+ +-
24	MD	LeafGrowt hPower1		Coefficie nt (power) for leaf growth [-] See Appendix A Järvi et al. (20
25	MD	LeafGrowt hPower2		Constant in the leaf growth equation [°C:sup:‘ -1‘] See Appendix A Jä
26	MD	LeafOffPo wer1		Coefficie nt (power) for leaf off [-] See Appendix A Järvi et al. (2014)
27	MD	LeafOffPo wer2		Constant in the leaf off equation [°C:sup:‘ -1‘] See Appendix A Järvi e
28	L	OHMCode_S ummerWet		Code for OHM coefficie nts to use for this surface during wet conditio
29	L	OHMCode_S ummerDry		Code for OHM coefficie nts to use for this surface during dry conditio
30	L	OHMCode_W interWet		Code for OHM coefficie nts to use for this surface during wet conditio
31	L	OHMCode_W interDry		Code for OHM coefficie nts to use for this surface during dry conditio
32	MD	OHMThresh _SW	10	Temperatu re threshold determini ng whether summer/wi nter OHM c
33	MD	OHMThresh _WD	0.9	Soil moisture threshold determini ng whether wet/dry OHM coefficie n
34	L	ESTMCode		Code for ESTM coefficie nts to use for this surface. Links to [[#SUEW
35	MU	AnOHM_Cp		Volumetri c heat capacity for this surface to use in AnOHM [J m:sup:
36	MU	AnOHM_Kk		Thermal conductiv ity for this surface to use in AnOHM [W m K:sup:
37	MU	AnOHM_Ch		Bulk transfer coefficie nt for this surface to use in AnOHM [-]

6.2.11 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	Descripti on		
1	L	Code	331	Code linking to [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt]] for water surfaces (Code_Wat er). Value of integer is arbitrary but must match code specified in SUEWS_Sit eSelect.t xt.	
2	MU	AlbedoMin	0.	Minimum albedo of this surface [-] - View factor s should be taken into accoun t. - Not curren tly used for water surfac e - set same as Albedo Max.		
3	MU	Albedo Max	0-1	Albedo of this surface [-] - Effect ive albedo of the water surfac e. - View factor s should be taken into accoun t. +—+—+ —+ +===+ O k e (1 9 8 7) [3 7 8] _ +—+—+ —+	E x a m p l e v a l u e s [-] 0 . 1	W a t e r
4	MU	Emissivity	0-1	Emissivit y of this surface [-] - Effect ive surfac e emissi vity. - View factor s should be taken into accoun t +—+—+ —+ +===+ O k e (1 9 8 7) [3 8 0] _ +—+—+ —+	E x a m p l e v a l u e s [-] 0 . 9 5	W a t e r
5	MD	StorageMin		Minimum water storage capacity of this surface [mm] - Minimu m water storag e capaci ty for upper surfac es (i.e. canopy). - Min/ma x values are to accoun t for season al variat ion - not used for water surfac es. +—+—+ —+ +===+ +—+—+ —+	E x a m p l e v a l u e s [m m] 0 . 5	W a t e r
6	MD	StorageMax		Maximum water storage capacity of this surface [mm] - Maximu m water storag e capaci ty for upper surfac es (i.e. canopy) - Min and max values are to accoun t for season al variat ion - not used for water surfac es so set same as Storag eMin.		
7	MD	WetThreshold		Threshold for a completel y wet surface [mm] - Depth of water which determ ines whethe r evapor ation occurs from a partia lly wet or comple tely wet surfac e. +—+—+ —+ +===+ +—+—+ —+	E x a m p l e v a l u e s [m m] 0 . 5	W a t e r
8	MU	StateLimit		Upper limit to the surface state [mm] - Surfac e state cannot exceed this value. - Set to a large value (e.g. 20000 mm = 20 m) if the water body is substa ntial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallo w (e.g. founta ins). - **Wate rDepth** (colum n 9) must not exceed this value.		
9	MU	WaterDepth		Typical depth for the water surface [mm] - Set to a large value (e.g. 20000 mm = 20 m) if the water body is substa ntial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallo w (e.g. founta ins). - This value must not exceed **Stat eLimit** (colum n 8).		
10	MD	DrainageEq	999	Drainage equation to use for this surface. - Not curren tly used for water surfac e.		
11	MD	DrainageCoef1	999	Coefficie nt for drainage equation [units vary according to equation] - Not curren tly used for water surfac e		
12	MD	DrainageCoef2	999	Coefficie nt for drainage equation [units vary according to equation] - Not curren tly used for water surfac e		
13	L	OHMCode_Sum-		Code for OHM coefficie nts to use for this surface during wet condition s in summer. Links to suews-ohmcoefficients-txt Value of integer is arbitrary but	SUEWS_OHM Coefficie nts.txt]] .	

6.2.12 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* (page **??**) 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	
Co de	To Pa ve d	To Bu il t	To Ev eT r	To De cT r	To Gr as s	To BS oi l	To Wa te r	To Ru no ff	To So il St or e	
10	0	0	0	0	0	0	0	1	0	Pa ve d
20	0. 06	0	0. 01	0. 01	0. 01	0. 01	0	0. 9	0	Bl dg s
30	0	0	0	0	0	0	0	0	1	Ev eT r
40	0	0	0	0	0	0	0	0	1	De cT r
50	0	0	0	0	0	0	0	0	1	Gr as s
60	0	0	0	0	0	0	0	0	1	BS oi l
70	0	0	0	0	0	0	0	0	0	Wa te r

These text files are stored as worksheets in **SUEWS_SiteInfo.xlsm** and can be either edited using Excel and then generated using the macro, or edited directly (see *Data Entry* (page **??**)). Please note this file is subject to possible changes from version to version due to new features, modifications, etc. Please be aware of using the correct copy of this worksheet that are always shipped with the SUEWS public release.

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.

6.3 Initial Conditions file

To start the model, information about the conditions at the start of the run is required. This information is provided in initial conditions file. One file can be specified for each grid (*MultipleInitFiles=1* (page 31) in RunControl.nml, filename includes grid number) or, alternatively, a single file can be specified for all grids (MultipleInitFiles=0 in RunControl.nml, no grid number in the filename). After that, a new InitialConditionsSSss_YYYY.nml file will be written for each grid for the following years. It is recommended that you look at these files (written to the input directory) to check the status of various surfaces at the end 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'.

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

```
&InitialConditions
LeavesOutInitially=0
SoilstorePavedState=150
SoilstoreBldgsState=150
SoilstoreEveTrstate=150
SoilstoreDecTrState=150
SoilstoreGrassState=150
SoilstoreBSoilState=150
BoInit=10
/
```

The two most important pieces of information in the initial conditions file is the soil moisture and state of vegetation at the start of the run. This is the minimal information required; other information can be provided if known, otherwise SUEWS will make an estimate of initial conditions.

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

Note: Variables can be in any order

- *Soil moisture states* (page 55)
  - *SoilstorePavedState* (page 55)
  - *SoilstoreBldgsState* (page 55)
  - *SoilstoreEveTrState* (page 55)

– *SnowDensBldgs* (page 61)
– *SnowDensEveTr* (page 61)
– *SnowDensDecTr* (page 61)
– *SnowDensGrass* (page 61)
– *SnowDensBSoil* (page 62)
– *SnowDensWater* (page 62)

6.3.1 Soil moisture states

SoilstorePavedState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

SoilstoreBldgsState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

SoilstoreEveTrState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

SoilstoreDecTrState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

SoilstoreGrassState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

SoilstoreBSoilState

Requirement Required

Description For maximum values, see the used soil code in SUEWS_Soil.txt

Configuration to fill

6.3.2 Vegetation parameters

LeavesOutIntially

Requirement Optional

Description If the model run starts in winter when trees are bare, set LeavesOutIntially = 0 and the vegetation parameters will be set accordingly based on the values set in SUEWS_SiteInfo.xlsm. If the model run starts in summer when leaves are fully out, set LeavesOutIntially = 1 and the vegetation parameters will be set accordingly based on the values set in SUEWS_SiteInfo.xlsm. Not LeavesOutInitially can only be set to 0, 1 or -999 (fractional values cannot be used to indicate partial leaf-out). The value of LeavesOutInitially overrides any values provided for the individual vegetation parameters. To prevent LeavesOutInitially from setting the initial conditions, either omit it from the namelist or set to -999. If values are provided individually, they should be consistent the information provided in SUEWS_Veg.txt and the time of year. If values are provided individually, values for all required surfaces must be provided (i.e. specifying only albGrass0 but not albDecTr0 nor albEveTr0 is not permitted).

Configuration to fill

`GDD_1_0`

Requirement Optional

Description Cannot be negative. If leaves are already full, then this should be the same as GDDFull in SUEWS_Veg.txt. If winter , set to 0. It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter).

Configuration to fill

`GDD_2_0`

Requirement Optional

Description Cannot be positive If the leaves are full but in early/mid summer then set to 0. If late summer or autumn , this should be a negative value. If leaves are off , then use the values of SDDFull in SUEWS_Veg.txt to guide your minimum value. It is important that the vegetation characteristics are set correctly (i.e. for the start of the run in summer/winter).

Configuration to fill

`LAIinitialEveTr`

Requirement Optional

Description Initial LAI for evergreen trees. The recommended values can be found from SUEWS_Veg.txt

Configuration to fill

`LAIinitialDecTr`

Requirement Optional

Description Initial LAI for deciduous trees. The recommended values can be found from SUEWS_Veg.txt

Configuration to fill

`LAIinitialGrass`

Requirement Optional

Description Initial LAI for irrigated grass. The recommended values can be found from SUEWS_Veg.txt

Configuration to fill

`albEveTr0`

Requirement Optional

Description Albedo of evergreen surface on day 0 of run

Configuration to fill

`albDecTr0`

Requirement Optional

Description Albedo of deciduous surface on day 0 of run

Configuration to fill

`albGrass0`

Requirement Optional

Description Albedo of grass surface on day 0 of run

Configuration to fill

`decidCap0`

Requirement Optional

Description Deciduous storage capacity on day 0 of run.

Configuration to fill

`porosity0`

Requirement Optional

Description Porosity of deciduous vegetation on day 0 of run. This varies between 0.2 (leaf-on) and 0.6 (leaf-off).

Configuration to fill

6.3.3 Recent meteorology

`DaysSinceRain`

Requirement Optional

Description Important to use correct value if starting in summer season If starting when external water use is not occurring it will be reset with the first rain so can just be set to 0. If unknown, SUEWS sets to zero by default. Used to model irrigation.

Configuration to fill

`Temp_C0`

Requirement Optional

Description If unknown, SUEWS uses the mean temperature for the first day of the run.

Configuration to fill

6.3.4 Above Ground State

`PavedState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`BldgsState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`EveTrState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`DecTrState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`GrassState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`BSoilState`

Requirement Optional

Description If unknown, model assumes dry surfaces (acceptable as rainfall or irrigation will update these states quickly).

Configuration to fill

`WaterState`

Requirement Optional

Description For a large water body (e.g. river, sea, lake) set WaterState to a large value, e.g. 20000 mm; for small water bodies (e.g. ponds, fountains) set WaterState to smaller value, e.g. 1000 mm. This value must not exceed StateLimit specified in SUEWS_Water.txt . If unknown, model uses value of WaterDepth specified in SUEWS_Water.txt .

Configuration to fill

6.3.5 Snow related parameters

`SnowIntially`

Requirement Optional

Description If the model run starts when there is no snow on the ground, set SnowIntially = 0 and the snow-related parameters will be set accordingly. If the model run starts when there is snow on the ground, the following snow-related parameters must be set appropriately. The value of SnowInitially overrides any values provided for the individual snow-related parameters. To prevent SnowInitially from setting the initial conditions, either omit it from the namelist or set to -999. If values are provided individually, they should be consistent the information provided in SUEWS_Snow.txt .

Configuration to fill

`SnowWaterPavedState`

Requirement Optional

Description Initial amount of liquid water in the snow on paved surfaces.

Configuration to fill

`SnowWaterBldgsState`

Requirement Optional

Description Initial amount of liquid water in the snow on buildings

Configuration to fill

`SnowWaterEveTrState`

Requirement Optional

Description Initial amount of liquid water in the snow on evergreen trees

Configuration to fill

`SnowWaterDecTrState`

Requirement Optional

Description Initial amount of liquid water in the snow on deciduous trees

Configuration to fill

`SnowWaterGrassState`

Requirement Optional

Description Initial amount of liquid water in the snow on grass surfaces

Configuration to fill

`SnowWaterBSoilState`

Requirement Optional

Description Initial amount of liquid water in the snow on bare soil surfaces

Configuration to fill

`SnowWaterWaterState`

Requirement Optional

Description Initial amount of liquid water in the snow in water

Configuration to fill

`SnowPackPaved`

Requirement Optional

Description Initial snow water equivalent if the snow on paved surfaces

Configuration to fill

`SnowPackBldgs`

Requirement Optional

Description Initial snow water equivalent if the snow on buildings

Configuration to fill

`SnowPackEveTr`

Requirement Optional

Description Initial snow water equivalent if the snow on evergreen trees

Configuration to fill

`SnowPackDecTr`

Requirement Optional

Description Initial snow water equivalent if the snow on deciduous trees

Configuration to fill

`SnowPackGrass`

Requirement Optional

Description Initial snow water equivalent if the snow on grass surfaces

Configuration to fill

`SnowPackBSoil`

Requirement Optional

Description Initial snow water equivalent if the snow on bare soil surfaces

Configuration to fill

`SnowPackWater`

Requirement Optional

Description Initial snow water equivalent if the snow on water

Configuration to fill

`SnowFracPaved`

Requirement Optional

Description Initial plan area fraction of snow on paved surfaces

Configuration to fill

`SnowFracBldgs`

Requirement Optional

Description Initial plan area fraction of snow on buildings

Configuration to fill

`SnowFracEveTr`

Requirement Optional

Description Initial plan area fraction of snow on evergreen trees

Configuration to fill

`SnowFracDecTr`

Requirement Optional

Description Initial plan area fraction of snow on deciduous trees

Configuration to fill

`SnowFracGras`

Requirement Optional

Description Initial plan area fraction of snow on grass surfaces

Configuration to fill

`SnowFracBSoil`

Requirement Optional

Description Initial plan area fraction of snow on bare soil surfaces

Configuration to fill

`SnowFracWater`

Requirement Optional

Description Initial plan area fraction of snow on water

Configuration to fill

`SnowDensPaved`

Requirement Optional

Description Initial snow density on paved surfaces

Configuration to fill

`SnowDensBldgs`

Requirement Optional

Description Initial snow density on buildings

Configuration to fill

`SnowDensEveTr`

Requirement Optional

Description Initial snow density on evergreen trees

Configuration to fill

`SnowDensDecTr`

Requirement Optional

Description Initial snow density on deciduous trees

Configuration to fill

`SnowDensGrass`

Requirement Optional

Description Initial snow density on grass surfaces

Configuration to fill

`SnowDensBSoil`

Requirement Optional

Description Initial snow density on bare soil surfaces

Configuration to fill

`SnowDensWater`

Requirement Optional

Description Initial snow density on water

Configuration to fill

6.4 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.
- Since v2017a forcing files no longer need to end with two rows containing '-9' in the first column.
- One single meteorological file can be used for all grids (**MultipleMetFiles=0** in *RunControl.nml* (page **??**), no grid number in file name) 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* (page **??**), filename includes grid number).
- The meteorological forcing file names should be appended with the temporal resolution in minutes (SS_YYYY_data_tt.txt, or SSss_YYYY_data_tt.txt for multiple grids).
- Separate met forcing files should be provided for each year.
- Files do not need to start/end at the start/end of the year, but they must contain a whole number of days.
- The meteorological input file should match the information given in *SUEWS_SiteSelect.txt* (page **??**).
- 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 met data file should be 8760 and begin and end with:

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

6.4.1 SSss_YYYY_data_tt.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 $^{-2}$] - Required if **NetRad iationMetho d** = 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	Anthropogen ic heat flux [W m $^{-2}$]
10	R	U	Wind speed [m s $^{-1}$] *Height of the wind speed measurement (z) is needed in [[#SUEWS_Si teSelect.tx t]
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}] - Must be > 0 W m:sup: *-2*.
16	O	snow	Snow [mm] - Required if **SnowUs e** = 1
17	O	ldown	Incoming longwave radiation [W m^{-2}]
18	O	fcld	Cloud fraction [tenths]
19	O	Wuh	External water use [m :sup:*3*]
20	O	xsmd	Observed soil moisture [m :sup:*3*m :sup:-*3*] or [kg kg :sup:-*1*]
21	O	lai	Observed leaf area index [m :sup:-*2*m^{-2}]
22	O	kdiff	Diffuse radiation [W m $^{-2}$] - Recommended if **SOLWEIGUse** = 1
23	O	kdir	Direct radiation [W m $^{-2}$] - Recommended if **SOLWEIGUse** = 1
24	O	wdir	Wind direction [°] - Currently not implemented

6.5 CBL input files

Main references for this part of the model: Onomura et al. (2015) *[Shiho2015]* (page 104) and Cleugh and Grimmond (2001) *[CG2001]* (page 104).

If CBL slab model is used (`CBLuse = 1` (page 25) in *RunControl.nml* (page 23)) the following files are needed:

Filename	Purpose
CBL_initial_data.txt	Gives initial data every morning when CBL slab model starts running. - filename must match the InitialData_FileName in CBLInput.nml. - fixed format.
CBLIn-put.nml	Specifies run options, parameters and input file names. - Can be in any order

6.5.1 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}) strength of the inversion
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 *[Shiho2015]* (page 104).

id	zi0	gamt_Km	gamq_gkgm	Theta+_K	q+_gkg	theta_K	q_gkg
234	188	0.0032	0.00082	290.4	9.6	288.7	8.3
235	197	0.0089	0.089	290.2	8.4	288.3	8.7

6.5.2 CBL_Input.nml

Name	Description
EntrainmentType	Determines entrainment scheme. See Cleugh and Grimmond 2000 *[CG2001]* (page 104) for details.
Value	Comments
1	Tennekes and Driedonks (1981) - **Recommended**
2	McNaughton and Springs (1986)
3	Rayner and Watson (1991)
4	Tennekes (1973)
QH_Choice	Determines QH used for CBL model.
Value	Comments
1	QH modelled by SUEWS
2	QH modelled by LUMPS
3	Observed QH values are used from the meteorological input file
Wsb	Subsidence velocity (m s^{-1}) in eq. 1 and 2 of Onomura et al. (2015) *[Shiho2015]* (page 104). (-0.01 m s^{-1} recommended)
CBLday(id)	CBL model is used for the days you choose. - Set CBLday(id) = 1 - If CBL model is set to run for DOY 175–177, CBLday(175) = 1, CBLday(176) = 1, CBLday(177) = 1
CO2_included	Set to zero in current version
InitialData_use	Determines initial values (see CBL_Initial_data.txt)
Value	Comments
0	All initial values are calculated. (Not available in current release.)
1	Take zi0, gamt_Km and gamq_gkgm from input data file. Theta+_K, q+_gkg, Theta_K and q_gkg are calculated using Temp_C, avrh and Pres_kPa in meteorological input file.
2	Take all initial values from input data file (see CBL_Initial_data.txt).
InitialDataFileName	If InitialData_use 1, write the file name including the path from site directory e.g. InitialDataFileName='CBLinputfile sCBL_initial_data.txt'
Sondeflag	
Value	Comments
0	Does not read radiosonde vertical profile data **-recommended**
1	Reads radiosonde vertical profile data
FileSonde(id)	If Sondeflag=1, write the file name including the path from site directory e.g. FileSonde(id)= 'CBLinputfilesXXX.txt', XXX is an arbitrary name.

6.6 ESTM-related files

6.6.1 SUEWS_ESTMCoefficients.txt

Note ESTM is under development in v2017a and should not be used!

The Element Surface Temperature Method (ESTM) (Offerle et al., 2005) calculates the net storage heat flux from surface temperatures. In the method the three-dimensional urban volume is reduced to four 1-d elements (i.e. building roofs, walls, and internal mass and ground (road, vegetation, etc)). The storage heat flux is calculated from the heat conduction through the different elements. For the inside surfaces of the roof and walls, and both surfaces for the internal mass (ceilings/floors, internal walls), the surface temperature of the element is determined by setting the conductive heat transfer out of (in to) the surface equal to the radiative and convective heat losses (gains). Each element (roof, wall, internal element and ground) can have maximum five layers and each layer has three parameters tied to it: thickness (x), thermal conductivity (k), volumetric heat capacity (rhoCp).

If ESTM is used (QSchoice=4), the files *SUEWS_ESTMCoefficients.txt* (page **??**), *ESTMinput.nml* (page **??**) and *SS_YYYY_ESTM_Ts_data_tt.txt* (page **??**) should be prepared.

SUEWS_ESTMCoefficients.txt contains the parameters for the layers of each of the elements (roofs, wall, ground, internal mass).

- If less than five layers are used, the parameters for unused layers should be set to -999.
- The ESTM coefficients with the prefix *Surf_* must be specified for each surface type (plus snow) but the *Wall_* and *Internal_* variables apply to the building surfaces only.
- For each grid, one set of ESTM coefficients must be specified for each surface type; for paved and building surfaces it is possible to specify up to three and five sets of coefficients per grid (e.g. to represent different building materials) using the relevant columns in *SUEWS_SiteSelect.txt* (page **??**). For the model to use these columns in site select, the ESTMCode column in *SUEWS_NonVeg.txt* (page **??**) should be set to zero.

No.	Use	Column name	Example	Descripti on	
1	L	Code	331	Code linking to the ESTMCode column in SUEWS_Non Veg.txt, SUEWS_Veg ,txt, SUEWS_Wat er.txt and SUEWS_Sno w.txt files. * For buildings and paved surfaces, **set to zero** if there is more than one ESTM class per grid and the codes and surface fractions specified in [[#SUEWS_ SiteSelec t.txt	SUEWS_Sit eSelect.t xt]] will be used instead.
2	MU	Surf_thic k1	0.2	Thickness of the first layer [m] for roofs (building surfaces) and ground (all other surfaces)	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
3	MU	Surf_k1	0.5	Thermal conductiv ity of the first layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
4	MU	Surf_rhoC p1	840000	Volumetri c heat capacity of the first layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
5	O	Surf_thic k2	•	Thickness of the second layer [m] (if no second layer, set to -999.)	
6	O	Surf_k2	•	Thermal conductiv ity of the second layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
7	O	Surf_rhoC p2	•	Volumetri c heat capacity of the second layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
8	O	Surf_thic k3	•	Thickness of the third layer [m] (if no third layer, set to -999.)	
9	O	Surf_k3	•	Thermal conductiv ity of the third layer[W m:sup:‘ -1‘ K:sup:‘ -1‘]	
10	O	Surf_rhoC p3	•	Volumetri c heat capacity of the third layer[J m:sup:‘ -3‘ K:sup:‘ -1‘]	
11	O	Surf_thic k4	•	Thickness of the fourth layer [m] (if no fourth layer, set to -999.)	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
12	O	Surf_k4	•	Thermal conductiv ity of the fourth layer[W m:sup:' -1' K:sup:' -1']	
13	O	Surf_rhoC p4	•	Volumetri c heat capacity of the fourth layer [J m:sup:' -3' K:sup:' -1']	
14	O	Surf_thic k5	•	Thickness of the fifth layer [m] (if no fifth layer, set to -999.)	
15	O	Surf_k5	•	Thermal con- ductiv ity of the fifth layer [W m:sup:' -1' K:sup:' -1']	
16	O	Surf_rhoC p5	•	Volumetri c heat capac- ity of the fifth layer [J m:sup:' -3' K:sup:' -1']	
17	MU	Wall_thic k1	•	Thickness of the first layer [m] for build- ing surfaces only; set to -999 for all other surfaces	
18	MU	Wall_k1	•	Thermal con- ductiv ity of the first layer [W m:sup:' -1' K:sup:' -1']	
19	MU	Wall_rhoC p1	•	Volumetri c heat capac- ity of the first layer [J m:sup:' -3' K:sup:' -1']	
20	O	Wall_thic k2	•	Thickness of the second layer [m] (if no second layer, set to -999.)	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
21	O	Wall_k2	•	Thermal conductiv ity of the second layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
22	O	Wall_rhoC p2	•	Volumetri c heat capacity of the second layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
23	O	Wall_thic k3	•	Thickness of the third layer [m] (if no third layer, set to -999.)	
24	O	Wall_k3	•	Thermal conductiv ity of the third layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
25	O	Wall_rhoC p3	•	Volumetri c heat capacity of the third layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
26	O	Wall_thic k4	•	Thickness of the fourth layer [m] (if no fourth layer, set to -999.)	
27	O	Wall_k4	•	Thermal conductiv ity of the fourth layer[W m:sup:‘ -1‘ K:sup:‘ -1‘]	
28	O	Wall_rhoC p4	•	Volumetri c heat capacity of the fourth layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
29	O	Wall_thic k5	•	Thickness of the fifth layer [m] (if no fifth layer, set to -999.)	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
30	O	Wall_k5	•	Thermal conductiv ity of the fifth layer[W m:sup:‘ -1‘ K:sup:‘ -1‘]	
31	O	Wall_rhoC p5	•	Volumetri c heat capacity of the fifth layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
32	MU	**Internal_** thick1	•	Thickness of the first layer [m] for building surfaces only; set to -999 for all other surfaces	
33	MU	**Internal_** k1	•	Thermal conductiv ity of the first layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
34	MU	**Internal_** rhoCp1	•	Volumetri c heat capacity of the first layer[J m:sup:‘ -3‘ K:sup:‘ -1‘]	
35	O	**Internal_** thick2	•	Thickness of the second layer [m] (if no second layer, set to -999.)	
36	O	**Internal_** k2	•	Thermal conductiv ity of the second layer [W m:sup:‘ -1‘ K:sup:‘ -1‘]	
37	O	**Internal_** rhoCp2	•	Volumetri c heat capacity of the second layer [J m:sup:‘ -3‘ K:sup:‘ -1‘]	
38	O	**Internal_** thick3	•	Thickness of the third layer [m] (if no third layer, set to -999.)	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
39	O	**Internal_** k3	•	Thermal conductiv ity of the third layer [W m:sup:' -1' K:sup:' -1']	
40	O	**Internal_** rhoCp3	•	Volumetri c heat capacity of the third layer[J m:sup:' -3' K:sup:' -1']	
41	O	**Internal_** thick4	•	Thickness of the fourth layer [m] (if no fourth layer, set to -999.)	
42	O	**Internal_** k4	•	Thermal conductiv ity of the fourth layer [W m:sup:' -1' K:sup:' -1']	
43	O	**Internal_** rhoCp4	•	Volumetri c heat capacity of the fourth layer [J m:sup:' -3' K:sup:' -1']	
44	O	**Internal_** thick5	•	Thickness of the fifth layer [m] (if no fifth layer, set to -999.)	
45	O	**Internal_** k5	•	Thermal conductiv ity of the fifth layer [W m:sup:' -1' K:sup:' -1']	
46	O	**Internal_** rhoCp5	•	Volumetri c heat capacity of the fifth layer [J m:sup:' -3' K:sup:' -1']	
47	MU	nroom	•	Number of rooms per floor for building surfaces only	
48	MU	**Internal_** albedo	•	Albedo of all internal elements for building surfaces only	

Continued on next page

Table 6.3 – continued from previous page

No.	Use	Column name	Example	Descripti on	
49	MU	**Internal__** emissivit y	•	Emissivit y of all internal elements for building surfaces only	
50	O	**Internal__** CHwall		Bulk transfer coefficie nt of internal wall [W m:sup:‘ -2‘ K:sup:‘ -1‘] (for building surfaces only and if Ibld-CHmod == 0 in [[#ESTMin put.nml	ESTMinput .nml]]
51	O	**Internal__** CHroof		Bulk transfer coefficie nt of internal roof [W m:sup:‘ -2‘ K:sup:‘ -1‘] (for building surfaces only and if Ibld-CHmod == 0 in [[#ESTMin put.nml	ESTMinput .nml]]
52	O	**Internal__** CHbld		Bulk transfer coefficie nt of internal building elements [W m:sup:‘ -2‘ K:sup:‘ -1‘] (for building surfaces only and if Ibld-CHmod == 0 in [[#ESTMin put.nml	ESTMinput .nml]]

Note ESTM is under development in v2017a and should not be used!

The following input files are required if ESTM is used to calculate the storage heat flux.

6.6.2 ESTMinput.nml

ESTMinput.nml specifies the model settings and default values.

- The file contents can be in any order.

Name	Description	
Tsurf-Choice	Source of surface temperature data used.	
0	*Tsurf in [[#SSss_YYYY_ESTM_Ts_ data_tt.txt	SSss_YYYY_ESTM_Ts_dat a_tt.txt]] used for **all** surface elements.
1	*Tground, Troof and Twall in [[#SSss_YYYY_ESTM_Ts_ data_tt.txt	SSss_YYYY_ESTM_Ts_dat a_tt.txt]] used. - Input surface temperature are different for ground, roof and wall.
2	*Tground, Troof, Twall_n, Twall_e, Twall_s and Twall_w in [[#SSss_YYYY_ESTM_Ts_ data_tt.txt	SSss_YYYY_ESTM_Ts_dat a_tt.txt]] used. - Wall surface temperature is different for four directions.
evol-veTibld	Source of internal building temperature (Tibld)	
0	*Tiair in [[#SSss_YYYY_ESTM_Ts_ data_tt.txt	SSss_YYYY_ESTM_Ts_dat a_tt.txt]] used.
1	*Tibld calculated considering the effect of anthropogenic heat from HVAC	
2	*Tibld calculated without considering the influence of HVAC.	
Ibld-CH-mod	Method to calculate internal convective heat exchange coefficients (CH) for internal building, wall and roof if evolveTibld is 1 or 2.	
0	CHs are read from SUEWS_ESTMcoefficient s.txt.	
1	CHs are calculated based on ASHRAE (2001)	
2	CHs are calculated based on Awbi (1998).	
LBC_soil	Soil temperature at lowest boundary condition [$^\circ$C]	
Theat_on	Temperature at which heat control is turned on (used when evolveTibld =1) [$^\circ$C]	
Theat_off	Temperature at which heat control is turned off (used when evolveTibld=1) [$^\circ$C]	
Theat_fix	Ideal internal building temperature [$^\circ$C]	

6.6.3 SSss_YYYY_ESTM_Ts_data_tt.txt

SSss_YYYY_ESTM_Ts_data_tt.txt contains a time-series of input surface temperature for roof, wall, ground and internal elements.

No.	Column name	Description
1	iy	Year [YYYY]
2	id	Day of year [DOY]
3	it	Hour [H]
4	imin	Minute [M]
5	Tiair	Indoor air temperature [$^\circ$ C]
6	Tsurf	Bulk surface temperature [$^\circ$ C] (used when TsurfCoice = 0)
7	Troof	Roof surface temperature [$^\circ$ C] (used when TsurfChoice = 1 or 2)
8	Troad	Ground surface temperature [$^\circ$ C] (used when TsurfChoice = 1 or 2)
9	Twall	Wall surface temperature [$^\circ$ C] (used when TsurfChoice = 1)
10	Twall_n	North-facing wall surface temperature [$^\circ$ C] (used when TsurfChoice = 2)
11	Twall_e	East-facing wall surface temperature [$^\circ$ C] (used when TsurfChoice = 2)
12	Twall_s	South-facing wall surface temperature [$^\circ$ C] (used when TsurfChoice = 2)
13	Twall_w	West-facing wall surface temperature [$^\circ$ C] (used when TsurfChoice = 2)

6.7 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.

Name	Units	Description
Posture	•	Determines the posture of a human for which the radiant fluxes should be considered
1	Standing (default)	
2	Sitting	
absL	•	Absorption coefficient of long-wave radiation of a person. - Recommended value: 0.97
absK	•	Absorption coefficient of short-wave radiation of a person. - Recommended value: 0.70
heightgravity	m	Centre of gravity for a person. - Recommended value for a standing man: 1.1 m
usevegdem	•	Vegetation scheme
1	Vegetation scheme is active (Lindberg and Grimmond 2011 [FL2011] (page 104))	
2	No vegetation scheme used	
DSMPath	•	Path to Digital Surface Models (DSM).

Continued on next page

Table 6.4 – continued from previous page

Name	Units	Description
DSMname	•	Ground and Building DSM
CDSMname	•	Vegetation canopy DSM
TDSMname	•	Vegetation trunk zone DSM
TransMin	•	Tranmissivity of K through deciduous vegetation (leaf on) - Recommended value: 0.02 (Konarska et al. 2014 *[Ko14]* (page 105))
TransMax	•	Tranmissivity of K through deciduous vegetation (leaf off) - Recommended value: 0.50 (Konarska et al. 2014 *[Ko14]* (page 105))
SVFPath	•	Path to SVFs matrices (See Lindberg and Grimmond (2011) *[FL2011]* (page 104) 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 SOLWEIG-poiOUT.txt
col	•	Y coordinate for point of interest. Here all variables from the model will written to SOLWEIG-poiOUT.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) *[Re90]* (page 105)	
SOLWEIGpoi_out	•	Write output variables at point of interest (see below)
0	No POI output	

Continued on next page

Table 6.4 – continued from previous page

Name	Units	Description
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)	

CHAPTER

SEVEN

OUTPUT FILES

7.1 Runtime diagnostic information

7.1.1 Error messages: problems.txt

see this *Output files* (page 77)

If there are problems running the program serious error messages will be written to problems.txt.

- Serious problems will usually cause the program to stop after writing the error message. If this is the case, the last line of problems.txt will contain a non-zero number (the error code).
- If the program runs successfully, problems.txt file ends with

```
Run completed.
0
```

SUEWS has a large number of error messages included to try to capture common errors to help the user determine what the problem is. If you encounter an error that does not provide an error message please capture the details so we can hopefully provide better error messages in future.

See *Troubleshooting* (page **??**) 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* (page **??**)).

7.1.2 Warning messages: warnings.txt

- If the program encounters a more minor issue it will not stop but a warning may be written to warnings.txt. It is advisable to check the warnings to ensure there is not a more serious problem.
- The warnings.txt file can be large (over several GBs) given warning messages are written out during a large scale simulation, you can use `tail`/`head` to view the ending/starting part without opening the whole file on Unix-like systems (Linux/mac OS), which may slow down your system.
- To prevent warnings.txt from being written, set **SuppressWarnings** to 1 in *RunControl.nml* (page **??**).
- Warning messages are usually written with a grid number, timestamp and error count. If the problem occurs in the initial stages (i.e. before grid numbers and timestamps are assigned, these are printed as 00000).

7.1.3 Summary of model parameters: SS_FileChoices.txt

For each run, the model parameters specified in the input files are written out to the file SS_FileChoices.txt.

7.2 Model output files

7.2.1 SSss_YYYY_TT.txt

SUEWS produces the main output file (SSss_YYYY_tt.txt) with time resolution (TT min) set by **ResolutionFilesOut** in *RunControl* (page **??**).

Before these main data files are written out, SUEWS provides a summary of the column names, units and variables included in the file Ss_YYYY_TT_OutputFormat.txt (one file per run).

The variables included in the main output file are determined according to **WriteOutOption** set in *RunControl.nml* (page **??**).

Column	Name	WriteOutOption	Description
1	Year	0,1,2	Year [YYYY]
2	DOY	0,1,2	Day of year [DOY]
3	Hour	0,1,2	Hour [H]
4	Min	0,1,2	Minute [M]
5	Dectime	0,1,2	Decimal time [-]
6	Kdown	0,1,2	Incoming shortwave radiation [W m^{-2}]
7	Kup	0,1,2	Outgoing shortwave radiation [W m^{-2}]
8	Ldown	0,1,2	Incoming longwave radiation [W m^{-2}]
9	Lup	0,1,2	Outgoing longwave radiation [W m^{-2}]
10	Tsurf	0,1,2	Bulk surface temperature [°C]
11	QN	0,1,2	Net all-wave radiation [W m^{-2}]
12	QF	0,1,2	Anthropogen ic heat flux [W m^{-2}]
13	QS	0,1,2	Storage heat flux [W m^{-2}]
14	QH	0,1,2	Sensible heat flux (calculated using SUEWS) [W m^{-2}]
15	QE	0,1,2	Latent heat flux (calculated using SUEWS) [W m^{-2}]
16	QHlumps	0,1	Sensible heat flux (calculated using LUMPS) [W m^{-2}]
17	QElumps	0,1	Latent heat flux (calculated using LUMPS) [W m^{-2}]
18	QHresis	0,1	Sensible heat flux (calculated using resistance method) [W m^{-2}] **Do not use i**
19	Rain	0,1,2	Rain [mm]
20	Irr	0,1,2	Irrigation [mm]
21	Evap	0,1,2	Evaporation [mm]
22	RO	0,1,2	Runoff [mm]
23	TotCh	0,1,2	Change in surface and soil moisture stores [mm]
24	SurfCh	0,1,2	Change in surface moisture store [mm]
25	State	0,1,2	Surface wetness state [mm]
26	NWtrState	0,1,2	Surface wetness state (for non-water surfaces) [mm]
27	Drainage	0,1,2	Drainage [mm]
28	SMD	0,1,2	Soil moisture deficit [mm]
29	FlowCh	0,1	Additional flow into water body [mm]
30	AddWater	0,1	Additional water flow received from other grids [mm]
31	ROSoil	0,1	Runoff to soil (sub-surfac e) [mm]
32	ROPipe	0,1	Runoff to pipes [mm]

Continued o

Table 7.1 – continued from previous page

Column	Name	WriteOutOption	Description
33	ROImp	0,1	Above ground runoff over impervious surfaces [mm]
34	ROVeg	0,1	Above ground runoff over vegetated surfaces [mm]
35	ROWater	0,1	Runoff for water body [mm]
36	WUInt	0,1	Internal water use [mm]
37	WUEveTr	0,1	Water use for irrigation of evergreen trees [mm]
38	WUDecTr	0,1	Water use for irrigation of deciduous trees [mm]
39	WUGrass	0,1	Water use for irrigation of grass [mm]
40	SMDPaved	0,1	Soil moisture deficit for paved surface [mm]
41	SMDBldgs	0,1	Soil moisture deficit for building surface [mm]
42	SMDEveTr	0,1	Soil moisture deficit for evergreen surface [mm]
43	SMDDecTr	0,1	Soil moisture deficit for deciduous surface [mm]
44	SMDGrass	0,1	Soil moisture deficit for grass surface [mm]
45	SMDBSoil	0,1	Soil moisture deficit for bare soil surface [mm]
46	StPaved	0,1	Surface wetness state for paved surface [mm]
47	StBldgs	0,1	Surface wetness state for building surface [mm]
48	StEveTr	0,1	Surface wetness state for evergreen tree surface [mm]
49	StDecTr	0,1	Surface wetness state for deciduous tree surface [mm]
50	StGrass	0,1	Surface wetness state for grass surface [mm]
51	StBSoil	0,1	Surface wetness state for bare soil surface [mm]
52	StWater	0,1	Surface wetness state for water surface [mm]
53	Zenith	0,1,2	Solar zenith angle [°]
54	Azimuth	0,1,2	Solar azimuth angle [°]
55	AlbBulk	0,1,2	Bulk albedo [-]
56	Fcld	0,1,2	Cloud fraction [-]
57	LAI	0,1,2	Leaf area index [m ^{2} m $^{-2}$]
58	z0m	0,1	Roughness length for momentum [m]
59	zdm	0,1	Zero-plane displacemen t height [m]
60	ustar	0,1,2	Friction velocity [m s^{-1}]
61	Lob	0,1,2	Obukhov length [m]
62	ra	0,1	Aerodynamic resistance [s m^{-1}]
63	rs	0,1	Surface resistance [s m^{-1}]
64	Fc	0,1,2	CO2 flux [umol m^{-2}s^{-1}] *Do not use in v2017b*
65	FcPhoto	0,1	CO2 flux from photosynthe sis [umol m^{-2}s^{-1}] *Do not use in v2017b*
66	FcRespi	0,1	CO2 flux from respiration [umol m^{-2}s^{-1}] *Do not use in v2017b*
67	FcMetab	0,1	CO2 flux from metabolism [umol m^{-2}s^{-1}] *Do not use in v2017b*
68	FcTraff	0,1	CO2 flux from traffic [umol m^{-2} s^{-1}] *Do not use in v2017b*
69	FcBuild	0,1	CO2 flux from buildings [umol m^{-2}s^{-1}] *Do not use in v2017b*
70	QNSnowFr	1	Net all-wave radiation for snow-free area [W m^{-2}]
71	QNSnow	1	Net all-wave radiation for snow area [W m^{-2}]
72	AlbSnow	1	Snow albedo [-]
73	QM	1	Snow-relate d heat exchange [W m^{-2}]
74	QMFreeze	1	Internal energy change [W m^{-2}]
75	QMRain	1	Heat released by rain on snow [W m^{-2}]
76	SWE	1	Snow water equivalent [mm]
77	MeltWater	1	Meltwater [mm]
78	MeltWStore	1	Meltwater store [mm]
79	SnowCh	1	Change in snow pack [mm]
80	SnowRPaved	1	Snow removed from paved surface [mm]
81	SnowRBldgs	1	Snow removed from building surface [mm]

Continued o

Table 7.1 – continued from previous page

Column	Name	WriteOutOption	Description
82	T2	0,1,2	Air temperature at 2 m agl [°C]
83	Q2	0,1,2	Air specific humidity at 2 m agl [g kg^{-1}]
84	U10	0,1,2	Wind speed at 10 m agl [m s^{-1}]

7.2.2 SSss_YYYY_nn_TT.nc

UEWS can also produce the main output file in netCDF format by setting ncMode=1 (set in *RunControl* (page **??**)).

As the date and time information is incorporated in the netCDF output as separate dimension, the first five variables in the normal text output file (in .txt) are not included in the netCDF output but other variables are all kept.

N.B., considering the file size limit by the classic netCDF format, the output frequency is determined automatically by the internal SUEWS program setting to avoid the oversize problem in the netCDF files.

7.2.3 SSss_DailyState.txt

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

Column	Name	Description
1	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 [m:sup:*2* m^{-2}]
15	LAI_DecTr	Leaf area index of deciduous trees [m:sup:*2*m^{-2}]
16	LAI_Grass	Leaf area index of grass [m:sup:*2* 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]

Continued on next page

Table 7.2 – continued from previous page

Column	Name	Description
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}]

7.2.4 InitialConditionsSSss_YYYY.nml

At the end of the model run (or the end of each year in the model run) a new InitialConditions file is written out (to the input folder) for each grid, see *InitialConditionsSSss_YYYY.nml* (page **??**)

7.2.5 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}]

Continued on next page

Table 7.3 – continued from previous page

Column	Name	Description
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]

Continued on next page

Table 7.3 – continued from previous page

Column	Name	Description
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]

7.2.6 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).

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}

7.2.7 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}

Continued on next page

Table 7.4 – continued from previous page

Col	Header	Name	Units
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

7.2.8 SSss_YYYY_ESTM_TT.txt

If the ESTM model option is run, the following output file is created. **Note: First time steps of storage output could give NaN values during the initial converging phase.**

ESTM output file format

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+QSgroun d+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

Continued on next page

Table 7.5 – continued from previous page

Col	Header	Name	Units
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

CHAPTER

EIGHT

TROUBLESHOOTING

8.1 How to create a directory?

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

8.2 How to unzip a file

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

8.3 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

8.4 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/

8.5 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.

8.6 ESTM output

First time steps of storage output could give NaN values during the initial converging phase.

8.7 First things to Check if the program seems to have problems

- Check the problems.txt file.
- Check file options – in RunControl.nml.
- Look in the output directory for the SS_FileChoices.txt. This allows you to check all options that were used in the run. You may want to compare it with the original version supplied with the model.
- Note there can not be missing time steps in the data. If you need help with this you may want to checkout UMEP

8.7.1 A pop-up saying "file path not found"

This means the program cannot find the file paths defined in RunControl.nml file. Possible solutions:

- Check that you have created the folder that you specified in RunControl.nml.
- Check does the output directory exist?
- Check that you have a single or double quotes around the FileInputPath, FileOutputPath and FileCode

===="%sat_vap_press.f temp=0.0000 pressure dectime"==== Temperature is zero in the calculation of water vapour pressure parameterization.

- You don't need to worry if the temperature should be (is) 0°C.
- If it should not be 0°C this suggests that there is a problem with the data.

8.7.2 %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.

8.7.3 %Iteration loop stopped for too stable conditions.

- [zL]/[USTAR] This warning indicates that the atmospheric stability gets above 2. In these conditions MO theory is not necessarily valid. The iteration loop to calculate the Obukhov length and friction velocity is stopped so that stability does not get too high values. This is something you do not need to worry as it does not mean wrong input data.

8.7.4 "Reference to undefined variable, array element or function result"

- Parameter(s) missing from input files.

See also the error messages provided in problems.txt and warnings.txt

8.7.5 Email list

- SUEWS email list

https://www.lists.reading.ac.uk/mailman/listinfo/met-suews

- UMEP email list

https://www.lists.reading.ac.uk/mailman/listinfo/met-umep

CHAPTER

NINE

ACKNOWLEDGEMENTS

- People who have contributed to the development of SUEWS (plus co-authors of papers):
- Current contributors:
  - Prof C.S.B. Grimmond (University of Reading; previously Indiana University, King's College London, UK); Dr Leena Järvi (University of Helsinki, Finland); Dr Helen Ward (University of Reading), Dr Fredrik Lindberg (Göteborg University, Sweden), Dr Andy Gabey (Reading), Dr Ting SUN (Reading), Dr Jie PENG (SIMS), Dr Natalie Theeuwes (Reading),
- Past Contributors:
  - Dr Brian Offerle (Indiana University), Dr Thomas Loridan (King's College London),Dr Shiho Onomura (Göteborg University, Sweden)
- Users who have brought things to our attention to improve this manual and the model:
  - Dr Andy Coutts (Monash University, Australia), Kerry Nice (Monash University, Australia), Shiho Onomura (Göteborg University, Sweden), Dr Stefan Smith (University of Reading, UK), Dr Helen Ward (King's College London, UK; University of Reading, UK); Duick Young (King's College London), Dr Ning Zhang (Nanjing University, China)
- Funding to support development:
  - National Science Foundation (USA, BCS-0095284, ATM-0710631), EU Framework 7 BRIDGE (211345), EUf7 emBRACE; UK Met Office; NERC ClearfLo, NERC/Belmont TRUC, Newton/Met Office CSSP-China, H2020 UrbanFluxes, EPSRC LoHCool

CHAPTER

TEN

NOTATION

λF frontal area index

ΔQS* storage heat flux

BLUEWS Boundary Layer part of SUEWS

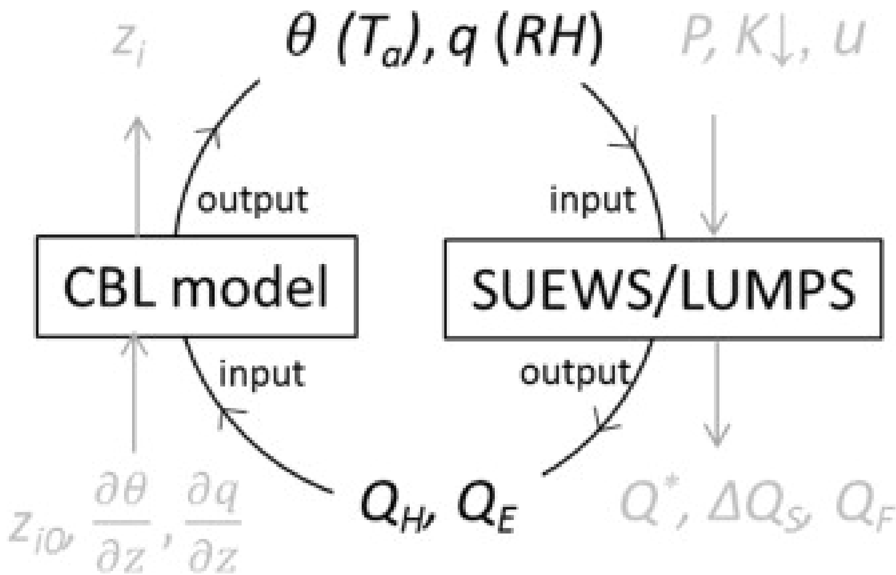


Fig. 10.1: Relation between BLUEWS and SUEWS

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 *[Oaf2005]* (page 103))

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 *[L2011]* (page 103))

NARP Net All-wave Radiation Parameterization (Offerle et al. 2003 *[O2003]* (page 103), Loridan et al. 2011 *[L2011]* (page 103))

OHM Objective Hysteresis Model (Grimmond et al. 1991 *[G91OHM]* (page 103), Grimmond & Oke 1999a *[GO99QS]* (page 103), 2002 *[GO2002]* (page 103))

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 *[FL2008]* (page 104), Lindberg and Grimmond 2011 *[FL2011]* (page 104))

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

CHAPTER

ELEVEN

DEVELOPMENT, SUGGESTIONS AND SUPPORT

1. [http://urban-climate.net/umep/DevelopmentGuidelines#Coding_Guidelines| Coding Guidelines]
2. Recommendations, Errors, Help/Updates - please join our email list
   (a) www.lists.reading.ac.uk/mailman/listinfo/met-suews
   (b) As UMEP has a number of tools to support SUEWS you may want to join that list also www.lists.reading.ac.uk/mailman/listinfo/met-umep

CHAPTER

TWELVE

VERSION HISTORY

12.1 New in SUEWS Version 2018a

see *Version History* (page 95).

12.2 New in SUEWS Version 2017b (released 2 August 2017)

PDF Manual for v2017b

1. Surface-level diagnostics: T2 (air temperature at 2 m agl), Q2 (air specific humidity at 2 m agl) and U10 (wind speed at 10 m agl) added as default output.
2. Output in netCDF format. Please note this feature is **NOT** enabled in the public release due to the dependency of netCDF library. Assistance in enabling this feature may be requested to the development team via SUEWS mail list.
3. Edits to the manual.
4. New capabilities being developed, including two new options for calculating storage heat flux (AnOHM, ESTM) and modelling of carbon dioxide fluxes. These are currently under development and **should not be used** in v2017b.
5. Known issues
   (a) BLUEWS parameters need to be checked
   (b) Observed soil moisture can not be used as an input
   (c) Wind direction is not currently downscaled so non -999 values will cause an error.

12.3 New in SUEWS Version 2017a (Feb 2017)

1. Changes to input file formats (including RunControl.nml and InitialConditions files) to facilitate setting up and running the model. Met forcing files no longer need two rows of -9 at the end to indicate the end of the file.
2. Changes to output file formats (now option to write out only a subset of variables, rather than all variables).
3. SUEWS can now disaggregate forcing files to the model time-step and aggregate output at the model time-step to lower resolution. This removes the need for the python wrapper used with previous versions.

4. InitialConditions format and requirements changed. A single file can now be provided for multiple grids. SUEWS will approximate most (but not all) of the required initial conditions if values are unknown. (However, if detailed information about the initial conditions is known, this can still be provided to and used by SUEWS.)
5. Leaf area index calculations now use parameters provided for each vegetated surface (previously only the deciduous tree LAI development parameters were applied to all vegetated surfaces).
6. For compatibility with GIS, **the sign convention for longitude has been changed**. Now negative values are to the west, positive values are to the east. Note this appears to have been incorrectly coded in previous versions (but may not necessarily have been problematic).
7. Storage heat flux calculation adapted for shorter (sub-hourly) model time-step: hysteresis calculation now based on running means over the previous hour.
8. Improved error handling, including separate files for serious errors (problems.txt) and less critical issues (warnings.txt).
9. Edits to the manual.
10. New capabilities being developed, including two new options for calculating storage heat flux (AnOHM, ESTM) and modelling of carbon dioxide fluxes. These are currently under development and **should not be used** in v2017a.

12.4 New in SUEWS Version 2016a (released 21 June 2016)

PDF Manual for v2016a

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

12.5 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.

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

12.7 New in SUEWS Version 2014a (released 21 February 2014)

1. Bug fix: External irrigation is calculated as combined from automatic and manual irrigation and during precipitation events the manual irrigation is reduced to 60% of the calculated values. In previous version of the model, the irrigation was in all cases taken 60% of the calculated value, but now this has been fixed.
2. In previous versions of the model, irrigation was only allowed on the irrigated grass surface type. Now, irrigation is also allowed on evergreen and deciduous trees/shrubs surfaces. These are not however treated as separate surfaces, but the amount of irrigation is evenly distributed to the whole surface type in the modelled area. The amount of water is calculated using same equation as for grass surface

(equation 5 in Järvi et al. 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

12.8 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

12.9 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

12.10 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

12.11 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
    - HydraulicConduct
    - GrassFractionIrrigated
    - PavedFractionIrrigated
    - TreeFractionIrrigated

The lower three are now determined from the water use behaviour used in SUEWS

1. Following added to HeaderInput.nml
    - SatHydraulicConduct
    - defaultQf
    - defaultQs
2. If 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)

CHAPTER

THIRTEEN

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

13.1 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) *[LG2012]* (page 105) 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-annu al
Unique features:	calculates active surface – and fluxes	radiation and energy balances	radiation, energy and water balance (includes LUMPS)

REFERENCES

[J11] 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.

[W16] 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. 18, 1-32 doi: 10.1016/j.uclim.2016.05.001

[G91] Grimmond CSB & Oke TR (1991) An Evaporation-Interception Model for Urban Areas. Water Resour. Res. 27, 1739-1755.

[O2003] Offerle B, Grimmond CSB & Oke TR (2003) Parameterization of Net All-Wave Radiation for Urban Areas. J. Appl. Meteorol. 42, 1157-1173.

[L2011] Loridan T, CSB Grimmond, BD Offerle, DT Young, T Smith, L Järvi, F Lindberg (2011) Local-Scale Urban Meteorological Parameterization Scheme (LUMPS): longwave radiation parameterization & seasonality related developments. Journal of Applied Meteorology & Climatology 50, 185-202, doi: 10.1175/2010JAMC2474.1

[lucy] Allen L, F Lindberg, CSB Grimmond (2011) Global to city scale model for anthropogenic heat flux, International Journal of Climatology, 31, 1990-2005.

[lucy2] Lindberg F, Grimmond CSB, Nithiandamdan Y, Kotthaus S, Allen L (2013) Impact of city changes and weather on anthropogenic heat flux in Europe 1995–2015, Urban Climate,4,1-13 paper

[I11] Iamarino M, Beevers S & Grimmond CSB (2011) High-resolution (space, time) anthropogenic heat emissions: London 1970-2025. International J. of Climatology. 32, 1754-1767.

[G91OHM] Grimmond CSB, Cleugh HA & Oke TR (1991) An objective urban heat storage model and its comparison with other schemes. Atmos. Env. 25B, 311-174.

[GO99QS] Grimmond CSB & Oke TR (1999a) Heat storage in urban areas: Local-scale observations and evaluation of a simple model. J. Appl. Meteorol. 38, 922-940.

[GO2002] Grimmond CSB & Oke TR (2002) Turbulent Heat Fluxes in Urban Areas: Observations and a Local-Scale Urban Meteorological Parameterization Scheme (LUMPS) J. Appl. Meteorol. 41, 792-810.

[AnOHM17] Sun T, Wang ZH, Oechel W & Grimmond CSB (2017) The Analytical Objective Hysteresis Model (AnOHM v1.0): Methodology to Determine Bulk Storage Heat Flux Coefficients. Geosci. Model Dev. Discuss. doi: 10.5194/gmd-2016-300.

[Oaf2005] Offerle B, CSB Grimmond, K Fortuniak (2005) Heat storage & anthropogenic heat flux in relation to the energy balance of a central European city center. International J. of Climatology. 25: 1405–1419 doi: 10.1002/joc.1198

[G86] Grimmond CSB, Oke TR and Steyn DG (1986) Urban water-balance 1. A model for daily totals. Water Resour Res 22: 1397-1403.

[Leena2014] 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.

[CG2001] Cleugh HA & Grimmond CSB (2001) Modelling regional scale surface energy exchanges and CBL growth in a heterogeneous, urban-rural landscape. Bound.-Layer Meteor. 98, 1-31.

[Shiho2015] Onomura S, Grimmond CSB, Lindberg F, Holmer B & Thorsson S (2015) Meteorological forcing data for urban outdoor thermal comfort models from a coupled convective boundary layer and surface energy balance scheme Urban Climate,11, 1-23 doi:10.1016/j.uclim.2014.11.001

[FL2008] Lindberg F, Holmer B & Thorsson S (2008) SOLWEIG 1.0 – Modelling spatial variations of 3D radiant fluxes and mean radiant temperature in complex urban settings. International Journal of Biometeorology 52, 697–713.

[FL2011] Lindberg F & Grimmond C (2011) The influence of vegetation and building morphology on shadow patterns and mean radiant temperature in urban areas: model development and evaluation. Theoretical and Applied Climatology 105:3, 311-323.

[Ko17] Kokkonen TV, Grimmond CSB, Räty O, Ward HC, Christen A, Oke TR, Kotthaus S & Järvi L (in review) Sensitivity of Surface Urban Energy and Water Balance Scheme (SUEWS) to downscaling of reanalysis forcing data.

[Best2014] Best MJ & Grimmond CSB (2014) Importance of initial state and atmospheric conditions for urban land surface models' performance. Urban Climate 10: 387-406. doi: 10.1016/j.uclim.2013.10.006.

[D74] Dyer AJ (1974) A review of flux-profile relationships. Boundary-Layer Meteorol. 7, 363-372.

[H88] Högström U (1988) Non-dimensional wind and temperature profiles in the atmospheric surface layer: A re-evaluation. Boundary-Layer Meteorol. 42, 55–78.

[VUH85] Van Ulden AP & Holtslag AAM (1985) Estimation of atmospheric boundary layer parameters for boundary layer applications. J. Clim. Appl. Meteorol. 24, 1196-1207.

[CNstab] Campbell GS & Norman JM (1998) Introduction to Environmental Biophysics. Springer Science, US.

[B71] Businger JA, Wyngaard JC, Izumi Y & Bradley EF (1971) Flux-Profile Relationships in the Atmospheric Surface Layer. J. Atmos. Sci., 28, 181–189.

[Ka09] Kawai T, Ridwan MK & Kanda M (2009) Evaluation of the simple urban energy balance model using selected data from 1-yr flux observations at two cities. J. Appl. Meteorol. Clim. 48, 693-715.

[VG00] Voogt JA & Grimmond CSB (2000) Modeling surface sensible heat flux using surface radiative temperatures in a simple urban terrain. J. Appl. Meteorol. 39, 1679-1699.

[Ka07] Kanda M, Kanega M, Kawai T, Moriwaki R & Sugawara H (2007). Roughness lengths for momentum and heat derived from outdoor urban scale models. J. Appl. Meteorol. Clim. 46, 1067-1079.

[GO99] Grimmond CSB & Oke TR (1999) Aerodynamic properties of urban areas derived from analysis of surface form. J. Appl. Meteorol. 38, 1262-1292.

[Mc98] MacDonald RW, Griffiths RF & Hall DJ (1998) An improved method for estimation of surface roughness of obstacle arrays. Atmos. Env. 32, 1857-1864.

[FN78] Falk J & Niemczynowicz J, (1978) Characteristics of the above ground runoff in sewered catchments, in Urban Storm Drainage, edited by Helliwell PR, Pentech, London

[Ha79] Halldin S, Grip H & Perttu K. (1979) Model for energy exchange of a pine forest canopy. In: Halldin S (Ed.), Comparison of Forest Water and Energy Exchange Models. International Society of Ecological Modeling

[CW86] Calder IR and Wright IR (1986) Gamma Ray Attenuation Studies of Interception From Sitka Spruce: Some Evidence for an Additional Transport Mechanism. Water Resour. Res., 22(3), 409–417.

[Ok87] Oke TR (1987) Boundary Layer Climates. Routledge, London, UK

[Br03] Breuer L, Eckhardt K and Frede H-G (2003) Plant parameter values for models in temperate climates. Ecol. Model. 169, 237-293.

[Ja76] Jarvis PG (1976) The interpretation of the variations in leaf water potential and stomatal conductance found in canopies in the field. Philos. Trans. R. Soc. London, Ser. B., 273, 593-610.

[Au74] Auer AH (1974) The rain versus snow threshold temperatures. Weatherwise, 27, 67.

[SV06] Sailor DJ and Vasireddy C (2006) Correcting aggregate energy consumption data account for variability in local weather. Environ. Modell. Softw. 21, 733-738.

[Ko14] Konarska J, Lindberg F, Larsson A, Thorsson S and Holmer B (2014) Transmissivity of solar radiation through crowns of single urban trees—application for outdoor thermal comfort modelling. Theor Appl Climatol 117:363–376.

[Re90] Reindl DT, Beckman WA and Duffie JA (1990) Diffuse fraction correlation. Sol Energy 45:1–7.

[LG2012] Loridan T and Grimmond CSB (2012) Characterization of energy flux partitioning in urban environments: links with surface seasonal properties. J. of Applied Meteorology and Climatology 51,219-241 doi: 10.1175/JAMC-D-11-038.1

INDEX

D

E

F

G

K

L

M

T

U

W

Z