SUEWS Manual: Version 2015a

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*Please do not redistribute the contents of the zip file (data or model). If someone else would like these* [*please have them contact us*](#email)*.*

# Introduction

**S**urface **U**rban **E**nergy and **W**ater Balance **S**cheme (SUEWS) ([Järvi et al. 2011](#Jarvi2011)) 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](#GCO1991)), similar to that used in forests, to model evaporation from urban surfaces.

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 are allowed. The user can specify the model timestep, but 5-min is strongly recommended. The main output file is provided at a resolution of 60 min by default. Timestamps refer to the end of the averaging period. The model provides the radiation and energy balance components, surface and soil wetness and drainage of each surface, and surface and soil runoff (see [section 5](#_Output_files)).

The following sub-models are used within SUEWS:

1. NARP (*Net All-wave Radiation Parameterization,* [Offerle et al. 2003](#OGO03), [Loridan et al. 2010](#LGOUSJL10)) radiation scheme.
2. OHM (O*bjective Hysteresis Model* ([Grimmond et al. 1991](#GCO1991), [Grimmond & Oke 1999a](#G099a), [2002](#G02002)) for the storage heat flux.
3. LUMPS(*Local-scale Urban Meteorological Parameterization Scheme,* [Grimmond & Oke 2002](#G02002)) does the initial turbulent sensible and latent heat fluxes calculation for stability ([Appendix](#_Appendix_E:_Differences) D gives the differences between SUEWS and LUMPS). Note both models’ outputs are provided in all runs.
4. Two simple anthropogenic heat flux models ([Järvi et al. 2011](#Jarvi2011)).
5. A simple urban water-use model([Grimmond and Oke 1991](#G01991)).
6. A convective boundary layer (CBL) slab model ([Cleugh and Grimmond 2001](#CG2001)) calculates the CBL height, temperature and humidity during daytime ([Onomura et al. 2015](#Onomura2014))
7. A snowmelt model ([Järvi et al. 2014](#Jarvi2014)).
8. SOLWEIG: The solar and longwave environmental irradiance geometry model (Lindberg et al. 2008, Lindberg and Grimmond 2011), a 2D radiation model to estimate mean radiant temperature.

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

1. for an individual area
2. for multiple areas that are contiguous

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

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

|  |  |
| --- | --- |
| Figure 1: SUEWS (a) main components of the SUEWS model (b) surfaces considered (c) processes within the model (d) relation between the boundary layer (BL)/SUEWS and SOLWEIG (e,f) relation between SUEWS and the BL. | |
| a |  |
| b |  |
| c |  |
|  | *Modified from Järvi et al. (2011)* |
| d | *Lindberg et al. (in preparation)* |
| e | http://ars.els-cdn.com/content/image/1-s2.0-S2212095514000856-gr2.jpg[*Onomura et al. (2015*](#Onomura2014)*)* |
| f | http://ars.els-cdn.com/content/image/1-s2.0-S2212095514000856-gr1.jpg  [*Onomura et al. (2015*](#Onomura2014)*)* |

## New in SUEWS Version 2015a (released XXXX)

1. Major changes to the input file formats to facilitate the running of multiple grids or multiple years. Surface characteristics are provided in [SiteSelect.txt](#_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. In v2015a, there is now a single surface type for grass (total for irrigated plus unirrigated) and a bare soil surface type, and 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. New suggestions in Troubleshooting section
5. Edits to the manual
6. CBL model included.

Previous version changes: see [Appendix B](#_Appendix_D:_Version). [Please let us know](#_Contact_Information) if you find problems or have suggestions for the manual.

# Notation (in alphabetical order)

|  |  |
| --- | --- |
| *italics* | variables names in the tables |
| **bold** | input/output filenames |
| *λF* | frontal area index |
| Δ*Q*S | storage heat flux |
| BLUEWS | Boundary Layer version of SUEWS |
| *B* | coefficient in drainage equation |
| BLDG | Building surface |
| CBL | Convective boundary layer |
| *D*0 | coefficient in drainage equation |
| *DSM* | Digital surface model |
| DecTr | deciduous trees and shrubs |
| EveTr | Evergreen trees and shrubs |
| Grass | irrigated grass |
| UnmanBare | Umanaged and/or Bare Soil |
| HL | high-latitude |
| *Id* | day of year |
| *L↓* | incoming longwave radiation |
| LAI | Leaf area index. - **depends on the local phenology** of the area of interest. |
| LUMPS | Local scale Urban Meteorological Parameterization Scheme |
| NARP | Net All-wave Radiation Parameterization ([Offerle et al. 2003](#OGO03), [Loridan et al. 2010](#LGOUSJL10)) |
| OHM | Objective Hysteresis Model ([Grimmond et al. 1991](#GCO1991), [Grimmond & Oke 1999a](#G099a), [2002](#G02002)) |
| PAV | paved surface |
| *Q\** | net all-wave radiation |
| *QE* | latent heat flux |
| *QF* | anthropogenic heat flux |
| *QH* | sensible heat flux |
| *Q* | specific humidity |
| *SS* | two letter code for the measurement site |
| *Ss* | model area (Grid) identification code |
| SOLWEIG | The solar and longwave environmental irradiance geometry model (Lindberg et al. 2008, Lindberg and Grimmond 2011) |
| SVF | Sky view factor |
| *theta* | potential temperature |
| *tt* | time step of data |
| W | water surface |
| WB | water balance |
| *YYYY* | Year |
| *zi* | Convective boundary layer height |
| *z0m* | roughness length for momentum |

## Contact Information

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# Preparing to run the model

The following provides some comments to help with the model setup. The model 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 in blue are examples of recommended values (see the appropriate reference to help decide how appropriate these are for your site/model domain); values in green **need** to be set (i.e. changed from the example) for your site/model domain.

Values given are examples of recommended values

Values given are example values and need to be changed for your site/model domain.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Read the relevant papers and the manual.  Decide what type of model run you are interested   |  |  |  | | --- | --- | --- | |  | Other decisions (see below for options that are relevant for | Available in this release | | LUMPS |  | Yes – but not standalone? | | SUEWS – point or one area | Fractions of different land cover types  Heights of buildings | Yes | | SUEWS – multiple grids or areas |  | Yes | |  |  |  | | SUEWS/ with Boundary Layer (BL) |  | Yes | | SUEWS with snow | Does snow clearing occur? | No | | SUEWS with SOLWEIG |  | Yes | | SUEWS with SOLWEIG and BL |  | No | | **Other decisions** | These need to be considered in all of the above options |  | | External water use | Does this occur? Eg street washing, garden irrigation | Yes | | Anthropogenic heat flux | Is this liekltly oe be important? Energy use from transport, buildings etc | Yes | |
| 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. *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.*  Compiled versions of SUEWS  **Note- for windows there is an installation version which will put the programs and all the files into the appropriate place**  If you are not using the Windows setup release **– see** [**Appendix F**](#_Appendix_F:_Information) |
| Files and Example data | Files included consist of   * Programme and required libraries * Test/Example Input files * Test/Example Output files  |  |  |  | | --- | --- | --- | | **Example File names** | **Used for** | **Brief Description** | | Sm  “Sm”, year is 2011 | SUEWS single grid |  | |  | SUEWS muliple grid |  | |  | Snow |  | | “Sc”, year is 1991 | CBL | Data set are for Sacramento (see Onomura et al. 2015) for more details.  The setting for CBL model is done in CBLinput.nml.  Initial data file name and its path is set in [CBLinput.nml](#_CBL_input_file).  The format of output file is “SSss\_YYYY\_BL.txt”. | | Subfolders **DSMs** and **SVFs** | SOLWEIG | In this release, example data from Göteborg, Sweden is included. Model domain is 200 x 200 m and the pixel resolution is 1 m. The data could be used for any other location.  Files and subfolders names is set in SOLWEIGinput.nml. Subfolder **DSMs** includes digital surface models of  1. Ground and buildings  2. Vegetation canopy heights  3. Vegetation trunks zone height.  Also a grid specifying location of building pixels should be included. Subfolder **SVFs** included sky view factor grids that are used. We recommend to use the SOLWEIG interface to create SVF grids  <http://gvc.gu.se/english/research/climate/urban-climate/software/solweig>) to create SVF grids. Consult the SOLWEIG-manual for more information. |  |  |  |  |  | | --- | --- | --- | --- | | Filename | Description | Intut/Output | Part of model | | Sm1\_2010\_data\_tt.txt | Meteorological input file | Input | SUEWS single grid | | InitialConditionsSm1\_2010\_2010.nml[[1]](#footnote-1) | Initial conditions | Input | SUEWS single grid | |  |  |  |  | | Sm\_Filechoices.txt | Run options | Output |  | | Sm\_2011\_5min.txt | (Optional) 5-min resolution | Output |  | | Sm\_2011\_60.txt | 60-min output file | Output |  | | Sm\_DailyState.txt | Daily state variables for each year | Output |  | | CBL\_initial\_data.txt (\*) | Initial data for CBL model | Input | BL | | Sonde\_SS\_YYYY\_MMDD\_HHMM.txt (\*) | Optional: file for radiosondes data | Input | BL | | Sc1\_1991\_BL.txt | CBL model output file | Output | BL |   (\*) filename is set in [CBLinput.nml](#_CBL_input_file). |
| Run test 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.  To run the model you can use [Command Prompt](#_Troubleshooting) (in the directory where the programme is located type the model name) or just double click the [executable file](#exe). Please see [Troubleshooting](#_Troubleshooting) if you have problems running the model.  **Suews\_Wrapper\_V2015a.exe**  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. |
|  | |  |  |  | | --- | --- | --- | | Filename | Purpose | Place to put it | | SUEWS\_wrapper\_V2015a.exe | This runs the program and prepares files and output | Directory where run programme | | SUEWS\_V2015a.exe | Actual program | Directory where run programme | | RunControl.nml | Model run options | Same directory as programme | | SUEWS\_AnthropogenicHeat.txt | Inputs for anthropogenic heat flux | Input directory | | SUEWS\_Conductance.txt | Inputs for surface conductances | Input directory | | SUEWS\_NonVeg.txt | Inputs for non-vegetated areas | Input directory | | SUEWS\_Irrigation.txt | Input for irrigation | Input directory | | SUEWS\_OHMCoefficients.txt | OHM coefficients | Input directory | | SUEWS\_Veg.txt | Inputs for vegetated areas | Input directory | | SUEWS\_Profiles.txt | Inputs for profiles | Input directory | | SUEWS\_SiteInfo.xlsm | Spreadsheet for creating data files | (anywhere) for creating input files | | SUEWS\_SiteSelect.txt | \*\*\* Main site file\*\*\*\*\* | Input directory | | SUEWS\_Snow.txt | Inputs for snow | Input directory | | SUEWS\_Soil.txt | Inputs for soil area | Input directory | | SUEWS\_Water.txt | Inputs for water areas | Input directory | | SUEWS\_WithinGridWaterDist.txt | \*\*\* Within grid water distribution \*\* | Input directory | |
| Prepare the data | Gather the data required for the **SUEWS\_SiteSelect.txt**  To describe an area to be modelled that grid has a set of characteristics that are specified in the [SUEWS\_SiteSelect.txt](#_SiteSelect.txt) file on one row. The choices are often selected by a code for a particular set of conditions. For example, a soil type (links to SUEWS\_Soil.txt), characteristics of deciduous trees ((links to SUEWS\_Veg.txt), etc. The intent is to build a library of characteristics for different types of urban areas. The codes must be integer values and must be unique within all files except SUEWS\_SiteSelect.txt (otherwise the model will return an error). |
| Land cover | For each grid, the land cover must be classified using the following surface types:   |  |  |  | | --- | --- | --- | | *General Type* | *Specific Type* | *File where characteristics are specified* | | *Non-vegetated* | *Built area* | [*SUEWS\_NonVeg.txt*](#_SUEWS_Impervious.txt) | |  | *Paved area* | *SUEWS\_NonVeg.txt* | |  | *Bare soil* | *SUEWS\_NonVeg.txt* | |  |  |  | | *Vegetated* | *Evergreen trees and shrubs* | [*SUEWS\_Veg.txt*](#_SUEWS_Pervious.txt) | |  | *Deciduous trees and shrubs* | *SUEWS\_Veg.txt* | |  | *Grass* | *SUEWS\_Veg.txt* | |  |  |  | | *Water* | *Water* | *SUEWS\_Water.txt* | |  |  |  | | *Snow* | *Snow* | *SUEWS\_Snow.txt* |   The surface cover fractions are critical. Make certain that the different surface cover fractions are appropriate for your site.  *How to check?*  Websites like Bing Maps and Google Maps allow you to see aerial images of your sites or areas of interest. These allow you to determine the land cover types and their relative proportions. There are additionally a number of remote sensing resources that can be used. |
| Anthropogenic heat flux | The population density is needed as an input for LUMPS and SUEWS to calculate QF. If you have no information about the population of the site we recommend that you use the LUCY model to get a first estimate of QF. For more information, see the following sources:   * Allen L, F Lindberg, CSB Grimmond (2011) Global to city scale model for anthropogenic heat flux*, International Journal of Climatology,* 31, 1990-2005. * 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 <http://dx.doi.org/10.1016/j.uclim.2013.03.002> * http://www.met.reading.ac.uk/micromet/ |
| Enter the data into the spreadsheet and run the macro, or edit the text (txt) files | Enter the data for your site into the xlsm spreadsheet **SUEWS\_SiteInfo.xlsm** and then use the macro to create the text files. The macro needs to be edited *to indicate which directory the fi*les are to be saved to otherwise you will get an error saying it cannot write the files.  **Method to run Macro**  When you are ready to run the macro (after entering your data in the spreadsheet).   1. Enable the content – you are normally asked this when you open the spreadsheet. Up till this time it does not need to be enabled. 2. Under View – select Macros 3. There you will see “ SaveAllSheets” 4. Select Edit 5. You will then see the Macro content (the part highlighted in cyan below need to be changed to the directory where you want the output files to go to:  |  | | --- | | Sub SaveAllSheets()  For Each Sheet In ActiveWorkbook.Sheets  Sheet.Select  ActiveWorkbook.SaveAs Filename:=" C:\InputDataForSUEWS\" & Sheet.Name & ".txt", FileFormat:=xlText  Next Sheet  End Sub |  1. Save this 2. Close 3. Then Run   If there is a problem – check that the location you have identified is a location that you have permission to write to/exists.  It is **recommended** to close the spreadsheet before running the actual model code.  **Alternatively**, the text (txt) files can be edited directly. The sample files provide a template to create your own files which can be edited with a text editor[[2]](#footnote-2) directly.  Note that in all txt files:   * The first two rows are headers. The first row is the column number; the second row is the column name. * The names and order of the columns should not be altered from the templates, as these are checked by the model and errors will be returned if particular columns cannot be found. * All files should have two rows with -9 in column 1 as their last two rows. * “!” indicates a comment – so after that the material will not be read by the model. * If data is unavailable or not required, enter the value -999 in the correct place in the input file(s). * Ensure that the codes used to link between txt files are unique for each of the txt files (i.e. for all files except SiteSelect.txt, each row must have a unique code). * Ensure the units are correct for all input information! * See the [individual file descriptions for details](#_SiteSelect.txt) * See [example help](#_Further_help_with)   In addition to these text files, the following files are also needed to run the model. |
| Prepare the **RunControl.nml** file | In the **RunControl.nml** file the site name (*SS*\_) and file paths for the model input as well as output are given.  This means before running the model (even the sample) 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](#TextEditor)) so that they are correct for your setup 2. or 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](#_Input_and_output).    For example if you specify FileOutputPath = “C:\FolderName\SUEWSOutput\” and use site identification code (e.g. Sm\_2011, where Sm is *SS*) the model creates an output file C:\FolderName\SUEWSOutput\Sm\_2011\_60.txt. (*Remember to add the last backslash in windows and slash in Linux/Mac*):  If the file paths are not correct the program will return an error (Run-time Error, File path not found, see section 5.1 for error messages) when run, and write the error to the **problems.txt** file. Note that when running multiple grids all files should be in the same input directory. |
| Prepare the **meteorological forcing** data | The model is designed to use (60 min) hourly input data, which is interpolated to the model time step (e.g. 5 min). See details about the [meteorological data](#_4.5_SUEWS_FunctionalTypes.txt) to learn more about choices of data input. Each grid can have its own meteorological forcing file, or a single file can be used for all grids. |
| Prepare the **Initial Conditions** file | Information about the surface state and meteorological conditions just before the start of the run are provided in the Initial Conditions file. An Initial Conditions file is needed for each grid. |
| Run the model | To run the model you can use [Command Prompt](#_Troubleshooting) (in the directory where the programme is located type the model name) or just double click the [executable file](#exe). Please see [Troubleshooting](#_Troubleshooting) if you have problems running the model.  **Suews\_Wrapper\_V2015a.exe**  Or you can double click the file and it will run **Suews\_Wrapper\_V2015a.exe** |
| Analyse the output | |  |  | | --- | --- | | Albedo | **Is the bulk albedo correct?**  This is critical because a small error has an impact on all the fluxes (energy and hydrology)  *How to check?*  If you have measurements of outgoing shortwave radiation compare these with the modelled values.  How do the values compare to literature vales for your area? | | LAI | **Does the phenology look appropriate? What does the Leaf area index look like?**  Are the leaves on the trees at approximately the right time of the year  Plot the results from the daily state | |

## Further help with starting to prepare the data

The input data required for SUEWS can be summarised as follows:

* *Meteoroglocial forcing data* for the entire period to be modelled and knowledge of the surface state and meteorological conditions immediately before the start of the run (if these initial conditions are not known, it is usually possible to determine suitable values by running the model and using the output at the end of the run to infer the conditions at the start of the run).
* The *location of the site* (latitude, longitude, altitude).
* Information about the *characteristics of the surface*, including land cover, heights of buildings and trees, radiative characteristics (e.g. albedo, emissivity), drainage characteristics, soil characteristics (soil moisture can either be provided as a timeseries of observed soil moisture in the meteorological forcing file if these data are available, or modelled based on characteristics specificed in **SUEWS\_SiteInfo.xlsm**), snow characteristics, phenological characteristics (e.g. seasonal cycle of LAI).
* Information about *human behaviour*, including energy use and water use (e.g. for irrigation), and snow clearing (if applicable). The anthropogenic energy use and water use may be provided as a timeseries in the meteorological forcing file if these data are available, or modelled based on details provided in **SUEWS\_SiteInfo.xlsm**. These details include 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).

A table is provided in [Appendix E](#_Appendix_E:_Recommended) to record the availability of input data and aid completion of the input files needed for the model. See Section 0 for details about files.

## Input and output files

The input files required for SUEWS are listed in Table 4.1 (see other tables in this and the following section). For the user defined filenames (i.e. *SSss\_YYYY)* *SSss* represents a site name (usually a relevant two letter code is applied), and *YYYY* the year (four digit year is used) or grid identification. The last column indicates whether the input file is needed one per run (1/run), for each year (1/year) or once per day (1/day)

**Table 3.1:** Input and Output files (input filenames are hyperlinked to the appropriate section where more detail is provided) [B] indicates that this is assocated with the boundary layer part of the program [BLUEWS and therefore is only relevant if this is selected](#Bluews)

|  |  |  |  |
| --- | --- | --- | --- |
| File Name | Description |  | When Needed [Used] |
| *Input (see* [*section 4*](#_Input_files)*)* |  |  |  |
| [RunControl.nml](#_4.1__) | Namelist file paths and run options. | | 1/run |
|  |  |  |  |
| SUEWS\_AnthropogenicHeat.txt | Inputs for anthropogenic heat flux | | 1/run |
| SUEWS\_Conductance.txt | Inputs for surface conductances | | 1/run |
| SUEWS\_NonVeg.txt | Inputs for non-vegetated areas | | 1/run |
| SUEWS\_Irrigation.txt | Inputs for irrigation |  | 1/run |
| SUEWS\_OHMCoefficients.txt | OHM coefficients |  | 1/run |
| SUEWS\_Veg.txt | Inputs for vegetated areas | | 1/run |
| SUEWS\_Profiles.txt | Inputs for profiles |  | 1/run |
| SUEWS\_SiteInfo.xlsm | Spreadsheet for creating data files | | --- |
| [SUEWS\_SiteSelect.txt](#_SiteSelect.txt) | \*\*\* **Main file to specify all areas for run** \*\*\*\*\*  List of the characteristics for each grid for each time period | | 1/run |
| SUEWS\_Snow.txt | Inputs for snow |  | 1/run |
| SUEWS\_Soil.txt | Inputs for soil area |  | 1/run |
| SUEWS\_Water.txt | Inputs for water areas |  | 1/run |
| SUEWS\_WithinGridWaterDist.txt | Within grid water distribution | | 1/run |
|  |  |  |  |
| InitialConditionsSm1\_2010\_2010.nml | Initial conditions |  | 1/grid |
| Sm1\_2010\_data\_tt.txt, Sm2\_2010\_data\_tt.txt, etc | Meteorological input file |  | 1/grid/year or 1/year |
| [CBLinput.nml](#_4.13_CBL_input) | Namelist file paths, run options and input parameters for CBL model | | 1/run [B] |
| [CBL\_initial\_data.txt](#_4.14_CBL_initial_data.txt) | Initial data for CBL model | | 1/day [B] |
| *Output (see* [*section 5*](#_Output_files)*)* |  |  |  |
| *SSss\_YYYY*\_*tt*.txt | Model output with timestep *tt* | |  |
| *SSss*\_DailyState.txt | Status of the daily storages and other status values | |  |
| *SS\_*FileChoices.txt | Run choice options | |  |
| InitialState*SSss\_YYYY*.nml | At the end of the run a file is written that is the initial conditions (it is also written at the end of each year). This goes into the input directory, YYYY**Z** is typically the year +1 otherwise it will be the same yearend | |  |
| CBL\_*id*.txt | CBL model output files | | [B] |

# Input files

**Hint:** All files except those with .nml as their extensions should have two lines of -9 in column 1. This allows files saved using different operating systems to be read.

## 4.1 RunControl.nml

The file **RunControl.nml** contains the model run options and two default variable values (Table 4.1). This file should be located in the same directory as the executable file. The type of this folder should be

&RunControl

Parameters and variables from Table 4.1 in any order

/

In Linux and Mac, please add an empty line after the end Slash. This file is not case sensitive.

**Table 4.1:** Variables and parameters in **RunControl.nml**. (these can be in any order)

VI: Variable that the parameter influences [F- anthropogenic heat flux, A – all fluxes, R radiation, S – Heat storage, W –multiple water balance fluxes, L- LUMPS, M – multiple heat fluxes, N – no fluxes].

ET = evergreen trees and shrubs, DT = deciduous trees and shrubs, GR = grass, W = water

|  |  |  |  |
| --- | --- | --- | --- |
| Name | | VI | Description |
| *Model run options* | | | |
| *AnthropHeatChoice* | | F | Determines if *QF* and how is calculated   |  |  | | --- | --- | | Value | Comments | | 0 | * Uses values provided in the forcing file (***SSss\_YYYY*\_data.txt**). * If value missing, the *defaultQf* will be used * If user does not want to calculate *QF* or supply values, then the values in the meteorological input file should be zero. | | 1 | * Calculated according to Loridan et al. (2011) * Coefficients are selected in SUEWS\_SiteSelect.txt from SUEWS\_AnthropognicHeat.txt * If values are provided in the Meteorological input file (*SSss\_YYYY*\_data.txt) the modelled values will be used. | | 2 | * **Recommended!** * Calculated according to Järvi et al. (2011) * Coefficients are set in SUEWS\_siteSelect.txt from SUEWS\_AnthropognicHeat.txt Diurnal pattern in SUEWS\_**Profiles.txt** * If values are provided in the Meteorological input file (***SSss\_YYYY*\_data.txt**) the modelled values will be used. | |
| *CBLuse* | |  | Determines if a CBL slab model is used to calculate temperature and humidity.   |  |  | | --- | --- | | Value | Comments | | 0 | * CBL model is NOT used. * SUEWS and LUMPS use temperature and humidity provided in Meteorological input file. | | 1 | * CBL model is used. * SUEWS and LUMPS use the modelled temperature and humidity. | |
| *NetRadiationChoice* | | R | Determines if radiation is observed or modelled (NARP) ([Offerle et al. 2003](#OGO03), [Loridan et al. 2010](#LGOUSJL10))  *L↓* downwelling longwave radiation  Q\* net all wave radiation   |  |  | | --- | --- | | Value | Comments | | 0 | Observed values of *Q\** used | | 1 | * Modelled, but *L↓* observations supplied in forcing data * Albedo zenith angle not accounted for | | 2 | * Modelled with *L↓* modelled using cloud cover fraction supplied in forcing data file (see Loridan et al. 2010) * Albedo zenith angle not accounted for | | 3 | * Modelled with *L↓* modelled using air temperature and relative humidity data (see Loridan et al. 2010) * Albedo zenith angle not accounted for | | The following are not recommended in this release | | | 100 | * Modelled but *L↓* observations supplied in forcing data * Albedo zenith angle modelled * ***SSss*\_*YYYY*\_NARPOut.txt** file | | 200 | * Modelled with *L↓* modelled using cloud cover fraction supplied in forcing data file * Albedo zenith angle accounted for * ***SSss*\_*YYYY*\_NARPOut.txt** file | | 300 | * Modelled with *L↓* modelled using air temperature and relative humidity data (see Loridan et al. 2010) * Albedo zenith angle accounted for * ***SSss*\_*YYYY*\_NARPOut.txt** file | |
| *QSChoice* | | S | Selects which method is used to determine storage heat flux Δ*QS*   |  |  | | --- | --- | | Value | Comments | | 0 | Not used | | 1 | Modelled using the objective hysteresis model (OHM) ) ([Grimmond et al. 1991](#GCO1991), [Grimmond & Oke 1999a](#G099a), [2002](#G02002))  The model is based on surface types | | 2 | *Observed* Δ*Qs* values are used from the meteorological input file  see also*defaultQs* | |
| *OHMIncQF* | | S | Specifies whether the storage heat flux calculation uses Q\* (0) or Q\* + QF (1, recommended) |
| *RoughLen\_heat* | | M | Method to calculate roughness length for heat to be used   |  |  | | --- | --- | | Value | Comments | | 0 | Not used | | 1 | as 0.1*z0m* | | 2 | according to [Kawai et al. (2009](#Kawai)) **(recommended)** | | 3 | according to [Voogt and Grimmond (2000](#Voogt)) | | 4 | according to [Kanda et al. (2007](#Kawai)) | |
| *smd\_choice* | | W | Soil moisture deficit   |  |  | | --- | --- | | Value | Comments | | 0 | Modelled – need to provide values for *SoilDepth*, *SoilStoreCap* and *SatHydraulicConduct* in **SUEWS\_Soil.txt. (Recommended in current release).** | | 1 | Measured Volumetric data supplied in meteorological data file – need values for *SoilDepthMeas*, *SoilRocks* and *smCap* in **SUEWS\_soil.txt**  *Observed SM options need checking* | | 2 | Measured Gravimetric data supplied in forcing data file  Need to supply values for *SoilDensity*, *SoilDepthMeas*, *SoilRocks* and *smCap* in **SUEWS\_soil.txt** *Observed SM options need checking* | |
| *SnowFractionChoice* | | M | Defines the method to calculate snow plan area fraction (set to 2). Used only if *SnowUse*=1. |
| *SnowUse* | | M | 1 = snow calculations are done, 0 = no snow calculations are done |
| *SOLWEIGuse* | | N | |  |  | | --- | --- | | Determines if a high resolution radiation model to calculate mean radiant temperate should be used (SOLWEIG). NOTE: this option will considerably slow down the model since SOLWEIG is a 2D model. | | | Value | Comments | | 1 | Grid of mean radiant temperature (Tmrt) are calculated and saved based on high resolution digital surface models. | | 0 | No Tmrt is calculated | |
| *StabilityMethod* | | M | Defines which atmospheric stability functions are used   |  |  | | --- | --- | | Value | Comments | | 0-1 | Not used | | 2 | **Recommended!**  Momentum: Unstable: [Dyer (1974](#Dyer)), modified by [Högstrom (1988)](#Hogstrom)  Stable: [Van Ulden & Holtslag (1985](#VUH))  Heat: Dyer (1974), modified by [Högstrom (1988](#Hogstrom)) | | 3 | Momentum: [Campbell & Norman](#Campbell) eqn 7.27 p 97  Heat: Unstable: [Campbell & Norman](#Campbell)  Stable: [Dyer (1974)](#Dyer) modifed by [Högstrom (1988)](#Hogstrom) | | 4 | Momentum [Businger *et al.* (1971](#Businger)) modifed by [Högstrom (1988)](#Hogstrom)  Heat: [Businger *et al.* (1971)](#Businger) modifed by [Högstrom (1988)](#Hogstrom) | |
| *WU\_choice* | | W | External water use   |  |  | | --- | --- | | Value | Comments | | 0 | Modelled using options set in SUEWS\_Irrigation.txt | | 1 | Observations are used | |
| *z0\_method* | | A | Determines how aerodynamic roughness length (*z0m*) and zero displacement height (*zd*) are obtained   |  |  | | --- | --- | | Value | Comments | | 1 | Values in ***SUEWS\_SiteSelect.txt*** file are used  (*z0m* and *zd* are adjusted with time to account for seasonal variation in porosity of deciduous trees) | | 2 | Calculated from mean building and tree heights with “Rule of Thumb” ([Grimmond and Oke 1999](#G01999))  Heights must be given in GIS file | | 3 | Calculated using heights, plan area fraction and frontal areal index based on the [MacDonald et al. (1998)](#Madonald) method  Heights and Frontal area Index must be given in GIS file | |
| *File related* | | | |
| *FileCode* | | A | Total site identification code (e.g. *SSss*) |
| *FileInputPath* | | A | File path with the required input files. |
| *FileOutputPath* | | A | File path where the output files are created. |
| *SkipHeaderSiteInfo* | | A | Number of header lines to skip in SiteSelect input file (2 by default) |
| *SkipHeaderMet* | | A | Number of header lines to skip in meteorological input file (1 by default) |
| *MultipleMetFiles* | | A | Specifies whether one single met file is used for all grids (0) or a separate met file is provided for each grid (1). If met files are provided for each grid, the grid number should appear in the file name (e.g. Sm1\_2010\_data\_tt.txt, Sm2\_2010\_data\_tt.txt, etc); otherwise the grid number should be that of the first grid (e.g. Sm1\_2010\_data\_tt.txt). |
| *KeepTstepFilesIn* | |  | Specifies whether input files at the resolution of the model timestep should be deleted (0) or kept (1). These files may be large, so to save disk space set to 0. |
| *KeepTstepFilesOut* | |  | Specifies whether output files at the resolution of the model timestep should be deleted (0) or kept (1). These files may be large, so to save disk space set to 0. |
| *WriteSurfsFile* | |  | Specifies whether an output file at the resolution of the model timestep containing all the water balance, energy balance and snow variables for each of the surfaces should be written (1) or not (0). These files may be large, so to save disk space set to 0.  \*\*Not currently used, set to 0.\*\* |
| Time related | | | |
| *TIMEZONE* | R | | Time zone relative to UTC (Note: east is positive) [Units: h] |
| *Tstep* | A | | Model timestep. 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 minutes or 60, 120, 180, 240, **300,** 360, 600 s). [Units: s] |
| Height | | | |
| *z* | M | | Height of the meteorological forcing data – the most important height is that of the **wind** speed measurement [Units: m] |

## SUEWS\_SiteSelect.txt

For each time period and each grid area SUEWS needs to have the site specific surface cover information and other input parameters may vary. The purpose of file **SUEWS\_SiteSelect.txt** is to list for each time period and grid area these characteristics. *In this file the column order is important*.The model currently requires a new row for each year of the model run. All rows in SiteSelect will be read by the model and run.

USE Column

|  |  |
| --- | --- |
| MU | Parameters which must be supplied and must be specific for the site/grid being run (i.e. unique to that grid). |
| 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. |

In the example below “!” indicates 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** | **Description** |
| 1 | MU | Grid | 1 | Number of the grid area that is being characterized.  Grid numbers must be consecutive but they do not need to start at 1 (e.g. 33404, 33405, 33406, etc).  All grids must be present for all years.  These grid numbers are referred to in **GridConnections** (columns 58-73).  **The two last lines in this column must read: -9**  **This indicates that the last lines have been reached (using two lines allows differences in computer file savings to be dealt with).** |
| 2 | MU | Year | 2011 | Year [YYYY]  Years must be continuous. |
| 3 | MU | StartDLS | 86 | Start of the day light savings [DOY]  In **northern hemisphere** example, day light saving starts on day of year 86.  See section on [Day Light Savings](#_Day_Lights_Savings) |
| 4 | MU | EndDLS | 303 | End of the day light savings [DOY]  In **northern hemisphere** example, day light saving finishes on 303.  See section on [Day Light Savings](#_Day_Lights_Savings) |
| 5 | MU | lat | 60.00 | Latitude for the centre of the grid [decimal degrees]  Use coordinate system WGS84.  Positive values are northern hemisphere (negative southern hemisphere).  Used in radiation calculations.  Note, if the total modelled area is small the latitude and longitude could be the same for each grid but small differences in radiation will not be determined. If you are defining the latitude and longitude differently between grids make certain that you provide enough decimal places. |
| 6 | MU | lng | -18.20 | Longitude for the centre of the grid [decimal degrees]  Use coordinate system WGS84.  Positive values are to the west (negative values are to the east).  See latitude for more details. |
| 7 | MU | SurfaceArea | 75.3 | SurfaceArea [ha]  The area of the grid. |
| 8 | MU | Alt | 25.0 | Altitude [m]  Mean topographic height above sea-level.  Used for both the radiation and water flow between grids. |
| 9 | MD | id | 1 | Day [DOY]  Set to 1 in this version |
| 10 | MD | ih | 0 | Hour  Set to 0 in this version |
| 11 | MD | imin | 0 | Minute  Set to 0 in this version |
| 12 | MU | Fr\_Paved | 0.20 | Surface cover fraction of paved surfaces [-]  Areal cover fraction of paved surfaces (roads, pavements, car parks).  e.g. 20% of the grid is covered with paved surfaces.  **Columns 12 to 18 must sum to 1.** |
| 13 | MU | Fr\_Bldgs | 0.20 | Surface cover fraction of buildings [-] |
| 14 | MU | Fr\_EveTr | 0.10 | Surface cover fraction of evergreen trees and shrubs [-] |
| 15 | MU | Fr\_DecTr | 0.10 | Surface cover fraction of deciduous trees and shrubs [-] |
| 16 | MU | Fr\_Grass | 0.30 | Surface cover fraction of grass [-] |
| 17 | MU | Fr\_Bsoil | 0.05 | Surface cover fraction of bare soil or unmanaged land [-] |
| 18 | MU | Fr\_Water | 0.05 | Surface cover fraction of open water [-]  (e.g. river, lakes, ponds, swimming pools) |
| 19 | MU | IrrFr\_EveTr | 0.50 | Fraction of evergreen trees that are irrigated [-]  e.g. 50% of the evergreen trees/shrubs are irrigated |
| 20 | MU | IrrFr\_DecTr | 0.20 | Fraction of deciduous trees that are irrigated [-] |
| 21 | MU | IrrFr\_Grass | 0.70 | Fraction of grass that is irrigated [-] |
| 22 | MU | H\_Bldgs | 10 | Mean building height [m] |
| 23 | MU | H\_EveTr | 15 | Mean height of evergreen trees [m] |
| 24 | MU | H\_DecTr | 15 | Mean height of deciduous trees [m] |
| 25 | O | z0 | 0.6 | Roughness length for momentum [m]  Value supplied here is used if z0\_method = 1 in **4.1 RunControl**.nml; otherwise set to -999 and a value will be calculated by the model (z0\_method = 2, 3). |
| 26 | O | Zd | 1.5 | Zero-plane displacement [m]  Value supplied here is used if z0\_method = 1 in **4.1 RunControl**.nml; otherwise set to -999 and a value will be calculated by the model (z0\_method = 2, 3). |
| 27 | O | FAI\_Bldgs | 0.1 | Frontal area index for buildings [-]  Required if z0\_method = 3 in **4.1 RunControl**.nml. |
| 28 | O | FAI\_EveTr | 0.2 | Frontal area index for evergreen trees [-]  Required if z0\_method = 3 in **4.1 RunControl**.nml. |
| 29 | O | FAI\_DecTr | 0.2 | Frontal area index for deciduous trees [-]  Required if z0\_method = 3 in **4.1 RunControl**.nml. |
| 30 | O | PopDensDay | 30.7 | Daytime population density (i.e. workers, tourists) [people ha-1]  Required if AnthropHeatChoice = 2 in **4.1 RunControl**.nml. |
| 31 | O | PopDensNight | 10.2 | Night-time population density (i.e. residents) [people ha-1]  \*\*Not implemented in current version of the model\*\* |
| 32 | L | Code\_Paved | 331 | Code for Paved surface characteristics  Provides the link to column 1 of **SUEWS\_NonVeg.txt**, which contains the attributes describing paved areas in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_NonVeg.txt.  e.g. 331 means use the characteristics specified in the row of input file SUEWS\_NonVeg.txt which has 331 in column 1 (Code). |
| 33 | L | Code\_Bldgs | 332 | Code for Bldgs surface characteristics  Provides the link to column 1 of SUEWS\_NonVeg.txt, which contains the attributes describing buildings in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_NonVeg.txt. |
| 34 | L | Code\_EveTr | 331 | Code for EveTr surface characteristics  Provides the link to column 1 of SUEWS\_Veg.txt, which contains the attributes describing evergreen trees and shrubs in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Veg.txt. |
| 35 | L | Code\_DecTr | 332 | Code for DecTr surface characteristics  Provides the link to column 1 of SUEWS\_Veg.txt, which contains the attributes describing deciduous trees and shrubs in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Veg.txt. |
| 36 | L | Code\_Grass | 333 | Code for Grass surface characteristics  Provides the link to column 1 of SUEWS\_Veg.txt, which contains the attributes describing grass surfaces in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Veg.txt. |
| 37 | L | Code\_Bsoil | 333 | Code for BSoil surface characteristics  Provides the link to column 1 of SUEWS\_NonVeg.txt, which contains the attributes describing bare soil in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_NonVeg.txt. |
| 38 | L | Code\_Water | 331 | Code for Water surface characteristics  Provides the link to column 1 of SUEWS\_Water.txt, which contains the attributes describing open water in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Water.txt. |
| 39 | MD | LUMPS\_DrRate | 0.25 | Drainage rate of bucket for LUMPS [mm h-1]  Used for LUMPS surface wetness control.  Default recommended value of 0.25 mm h-1 from Offerle (2002), Loridan et al. (2011). |
| 40 | MD | LUMPS\_Cover | 1 | Limit when surface totally covered with water [mm]  Used for LUMPS surface wetness control.  Default recommended value of 1 mm from Offerle (2002), Loridan et al. (2011). |
| 41 | MD | LUMPS\_MaxRes | 10 | Maximum water bucket reservoir [mm]  Used for LUMPS surface wetness control.  Default recommended value of 10 mm from Offerle (2002), Loridan et al. (2011). |
| 42 | MD | NARP\_Trans | 1 | Atmospheric transmissivity for NARP [-]  Value must in the range 0-1.  Default recommended value of 1. |
| 43 | L | CondCode | 33 | Code for surface conductance parameters  Provides the link to column 1 of SUEWS\_Conductance.txt, which contains the parameters for the Jarvis (1976) parameterisation of surface conductance.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Conductance.txt.  e.g. 33 means use the characteristics specified in the row of input file SUEWS\_Conductance.txt which has 33 in column 1 (Code). |
| 44 | L | SnowCode | 33 | Code for snow surface characteristics  Provides the link to column 1 of SUEWS\_Snow.txt, which contains the attributes describing snow surfaces in this grid for this year.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Snow.txt. |
| 45 | L | SnowClearingProfWD | 331 | Code for snow clearing profile (weekdays)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt.  e.g. 331 means use the characteristics specified in the row of input file SUEWS\_Profiles.txt which has 331 in column 1 (Code). |
| 46 | L | SnowClearingProfWE | 332 | Code for snow clearing profile (weekends)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt.  e.g. 332 means use the characteristics specified in the row of input file SUEWS\_Profiles.txt which has 332 in column 1 (Code). Providing the same code for SnowClearingProfWD and SnowClearingProfWE would link to the same row in SUEWS\_Profiles.txt, i.e. the same profile would be used for weekdays and weekends. |
| 47 | L | AnthropogenicCode | 33 | Code for modelling anthropogenic heat flux  Provides the link to column 1 of SUEWS\_AnthropogenicHeat.txt, which contains the model coefficients for estimation of the anthropogenic heat flux (used if AnthropHeatChoice = 2, 3 in **4.1 RunControl**.nml**)**.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_AnthropogenicHeat.txt. |
| 48 | L | EnergyUseProfWD | 333 | Code for energy use profile (weekdays)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 49 | L | EnergyUseProfWE | 334 | Code for energy use profile (weekends)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 50 | L | IrrigationCode | 33 | Code for modelling irrigation  Provides the link to column 1 of SUEWS\_Irrigation.txt, which contains the model coefficients for estimation of the water use (used if WU\_Choice = 0 in RunControl).  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Irrigation.txt. |
| 51 | L | WaterUseProfManuWD | 335 | Code for water use profile (manual irrigation, weekdays)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 52 | L | WaterUseProfManuWE | 336 | Code for water use profile (manual irrigation, weekends)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 53 | L | WaterUseProfAutoWD | 337 | Code for water use profile (automatic irrigation, weekdays)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 54 | L | WaterUseProfAutoWE | 338 | Code for water use profile (automatic irrigation, weekends)  Provides the link to column 1 of SUEWS\_Profiles.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Profiles.txt. |
| 55 | MD | FlowChange | 0 | Difference in input and output flows for water surface [mm h-1]  Used to indicate river or stream flow through the grid.  \*\*Currently not fully tested\*\* |
| 56 | MD,MU | RunoffToWater | 0.1 | Fraction of above-ground runoff flowing to water surface during flooding [-]  Value must be in the range 0-1.  Fraction of above-ground runoff that can flow to the water surface in the case of flooding. |
| 57 | MD,MU | PipeCapacity | 100 | Storage capacity of pipes [mm]  Runoff amounting to less than the value specified here is assumed to be removed by pipes. |
| 58 | MD,MU | GridConnection1of8 | 2 | Number of the grid where water can flow to  The next 8 pairs of columns specify the water flow between grids.The first column of each pair specifies the grid that the water flows to (from the current grid, column 1); the second column of each pair specifies the fraction of water that flow to that grid.  The fraction (i.e. amount) of water transferred may be estimated based on elevation, the length of connecting surface between grids, presence of walls, etc.  Water cannot flow from the current grid to the same grid, so the grid number here must be different to the grid number in column 1. Water can flow to a maximum of 8 other grids.  If there is no water flow between grids, or a single grid is run, set to 0.  See section on Grid Connections  \*\*Not currently implemented\*\* |
| 59 | MD,MU | Fraction1of8 | 0.2 | Fraction of water that can flow to the grid specified in previous column [-] |
| 60 | MD,MU | GridConnection2of8 | 0 | Number of the grid where water can flow to |
| 61 | MD,MU | Fraction2of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 62 | MD,MU | GridConnection3of8 | 0 | Number of the grid where water can flow to |
| 63 | MD,MU | Fraction3of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 64 | MD,MU | GridConnection4of8 | 0 | Number of the grid where water can flow to |
| 65 | MD,MU | Fraction4of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 66 | MD,MU | GridConnection5of8 | 0 | Number of the grid where water can flow to |
| 67 | MD,MU | Fraction5of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 68 | MD,MU | GridConnection6of8 | 0 | Number of the grid where water can flow to |
| 69 | MD,MU | Fraction6of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 70 | MD,MU | GridConnection7of8 | 0 | Number of the grid where water can flow to |
| 71 | MD,MU | Fraction7of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 72 | MD,MU | GridConnection8of8 | 0 | Number of the grid where water can flow to |
| 73 | MD,MU | Fraction8of8 | 0 | Fraction of water that can flow to the grid specified in previous column [-] |
| 74 | L | WithinGridPavedCode | 331 | Code that links to the fraction of water that flows from Paved surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 75 | L | WithinGridBldgsCode | 332 | Code that links to the fraction of water that flows from Bldgs surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 76 | L | WithinGridEveTrCode | 333 | Code that links to the fraction of water that flows from EveTr surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 77 | L | WithinGridDecTrCode | 334 | Code that links to the fraction of water that flows from DecTr surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 78 | L | WithinGridGrassCode | 335 | Code that links to the fraction of water that flows from Grass surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 79 | L | WithinGridBSoilCode | 336 | Code that links to the fraction of water that flows from BSoil surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |
| 80 | L | WithinGridWaterCode | 337 | Code that links to the fraction of water that flows from Water surfaces to surfaces in columns 2-10 of SUEWS\_WithinGridWaterDist.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_WithinGridWaterDist.txt. |

### Day Light Saving (DLS)

The dates for DLS normally vary each year as they are often associated with a specific set of Sunday mornings at the beginning of summer and autumn. Note it is important to remember leap years.

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

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

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

2008 170 240 ! Year -start of daylight savings -end of daylight savings

2009 172 242

Example: when daylight saving does not occur in Northern hemisphere:

2008 180 181 ! Year -start of daylight savings -end of daylight savings

Example: when daylight saving occurs in Southern hemisphere

2004 275 93 ! Year -start of daylight savings -end of daylight savings

Example: when daylight saving does not occur in Southern hemisphere

2008 365 1 ! Year -start of daylight Savings -end of daylight savings

### Grid Connections (water flow between grids)

This section gives an example of water flow between grids, calculated based on the relative elevation of the grids and length of the connecting surface between adjacent grids. For the square grids in Figure 1a, 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, as illustrated in (Figure 1b).

Table gives example values for the grid connections part of SiteSelect.txt for the grids in Figure 1b. For each row of SiteSelect.txt, 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.

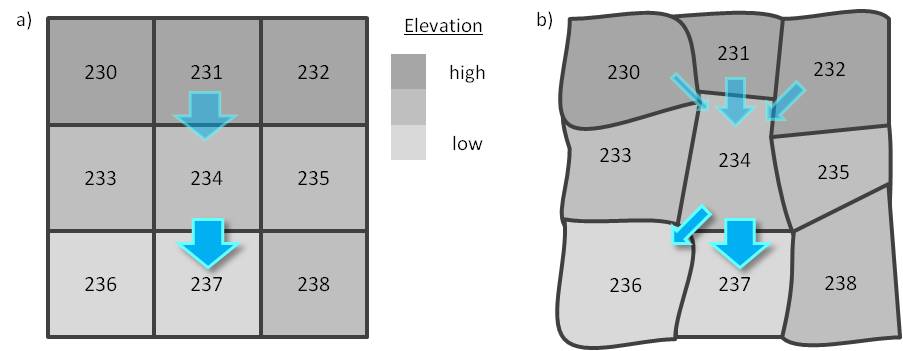
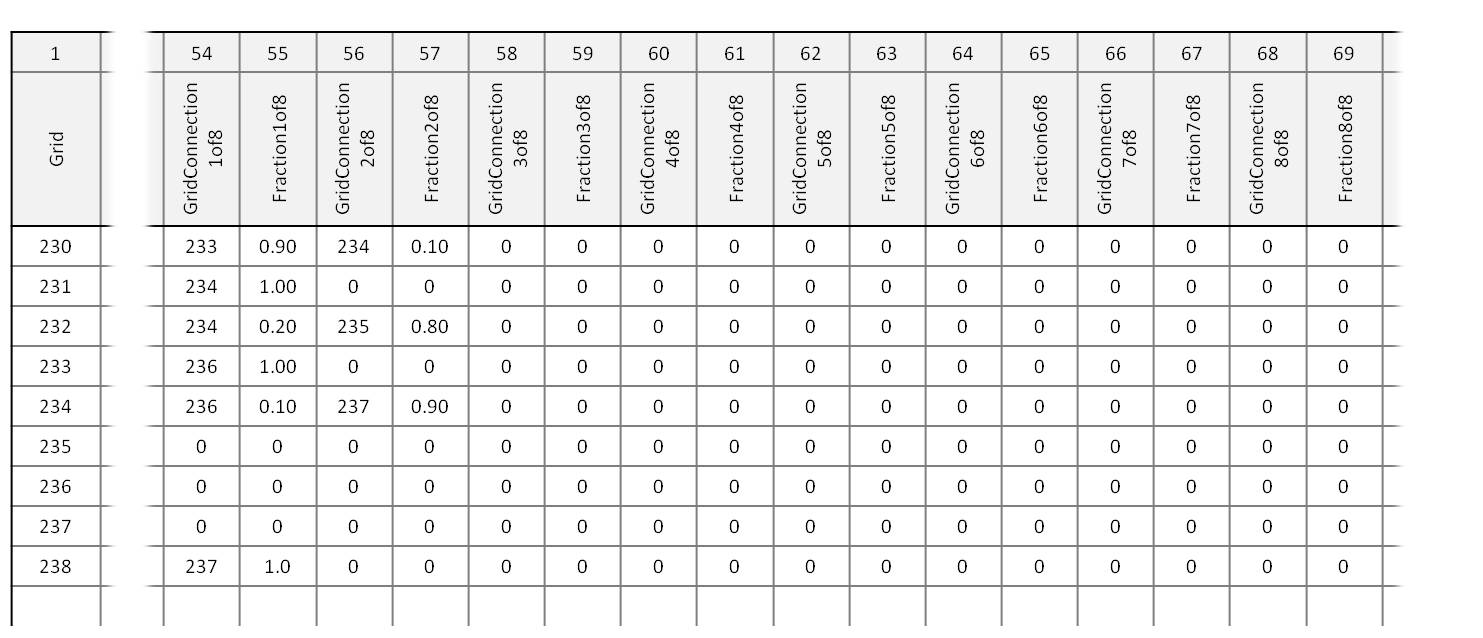


Figure 1 Example grid connections showing water flow between grids. Arrows indicate the water flow in to and out of grid 234, but note that only only water flowing out of each grid is entered in SUEWS\_SiteSelect.txt.

Table 4.3.2.1 Example values for the grid connections part of SUEWS\_SiteSelect.txt for the grids in Figure 1b.



### 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.

Values given are examples of recommended values

Values given are example values and need to be changed for your site/model domain.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331  332  333 | Code linking to SUEWS\_SiteSelect.txt for paved surfaces (Code\_Paved), buildings (Code\_Bldgs) and bare soil surfaces (Code\_BSoil).  Value of integer is arbitrary but must match codes specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | Albedo | 0-1 | Albedo of this surface [-]  Effective surface albedo (full leaf-on, middle of the day value).  View factors should be taken into account.   |  |  | | --- | --- | | 0.09 | !Paved, Helsinki, Järvi et al. (2014) | | 0.15 | !Bldgs, Helsinki, Järvi et al. (2014) | | 0.19 | !BSoil, Helsinki, Järvi et al. (2014) | | 0.12 | !Paved, Oke (1987) | | 0.15 | !Bldgs, Oke (1987) | | 0.21 | !BSoil, Oke (1987) | |
| 3 | MU | Emissivity | 0-1 | Emissivity of this surface [-]  Effective surface emissivity.  View factors should be taken into account   |  |  | | --- | --- | | 0.95 | !Paved, Oke (1987) | | 0.91 | !Bldgs, Oke (1987) | | 0.93 | !BSoil, Oke (1987) | |
| 4 | MD | StorageMin |  | Minimum water storage capacity of this surface [mm]  Minimum water storage capacity for upper surfaces (i.e. canopy).  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces).   |  |  | | --- | --- | | 0.48 | !Paved, Davies and Hollis (1981) | | 0.25 | !Bldgs, Falk and Niemczynowicz (1978) | |
| 5 | MD | StorageMax |  | Maximum water storage capacity of this surface [mm]  Maximum water storage capacity for upper surfaces (i.e. canopy)  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces)   |  |  | | --- | --- | | 0.48 | !Paved, Davies and Hollis (1981) | | 0.25 | !Bldgs, Falk and Niemczynowicz (1978) | |
| 6 | MD | StateLimit |  | Upper limit to the surface state [mm]  \*\*Currently only used for the water suface\*\* |
| 7 | MD | DrainageEq | 1, 2, 3 | Drainage equation to use for this surface. Coefficients specified in the following two columns.  Options for drainage equations:  1 - Falk and Niemczynowicz (1978)  2 - Halldin et al. (1979) (Rutter eqn corrected for c=0, see Calder & Wright (1986))  3 - Falk and Niemczynowicz (1978)   |  |  | | --- | --- | | 3 | !Paved, Grimmond and Oke (1991) | | 3 | !Bldgs, Grimmond and Oke (1991) | | 2 | !BSoil, Grimmond and Oke (1991) | |
| 8 | MD | DrainageCoef1 |  | Coefficient for drainage equation [units vary according to equation]   |  |  | | --- | --- | | 10 | !Paved, coefficient D0, Grimmond and Oke (1991) | | 10 | !Bldgs, coefficient D0, Grimmond and Oke (1991) | | 0.013 | !BSoil, Grimmond and Oke (1991) [mm h-1] | |
| 9 | MD | DrainageCoef2 |  | Coefficient for drainage equation [units vary according to equation]   |  |  | | --- | --- | | 3 | !Paved, coefficient b, Grimmond and Oke (1991) | | 3 | !Bldgs, coefficient b, Grimmond and Oke (1991) | | 1.71 | !BSoil, Grimmond and Oke (1991) [mm-1] | |
| 10 | L | SoilTypeCode |  | Code for soil characteristics below this surface  Provides the link to column 1 of SUEWS\_Soil.txt, which contains the attributes describing sub-surface soil for this surface type.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Soil.txt. |
| 11 | O | SnowLimPatch |  | Maximum SWE [mm]  Limit of snow water equivalent when the surface is fully covered with snow.   |  |  | | --- | --- | | 190 | !Paved, Järvi et al. (2014) | | 190 | !Bldgs, Järvi et al. (2014) | | 190 | !BSoil, Järvi et al. (2014) |   Not needed if SnowUse = 0 in **4.1 RunControl**.nml**.** |
| 12 | O | SnowLimRemove |  | SWE when snow is removed from this surface [mm]  Limit of snow water equivalent when snow is removed from paved surfaces and buildings  \*\*Currently not implemented for BSoil surface\*\*   |  |  | | --- | --- | | 40 | !Paved, Järvi et al. (2014) | | 100 | !Bldgs, Järvi et al. (2014) | | -999 | !BSoil [not used] |   Not needed if SnowUse = 0 in **4.1 RunControl**.nml**.** |
| 13 | L | OHMCode\_SummerWet |  | Code for OHM coefficients to use for this surface during wet conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 14 | L | OHMCode\_SummerDry |  | Code for OHM coefficients to use for this surface during dry conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 15 | L | OHMCode\_WinterWet |  | Code for OHM coefficients to use for this surface during wet conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 16 | L | OHMCode\_WinterDry |  | Code for OHM coefficients to use for this surface during dry conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |

### SUEWS\_Veg.txt

SUEWS\_Veg.txt specifies the characteristics for the vegetated surface cover types (EveTr, DecTr, Grass) by linking codes in column 1 of SUEWS\_Veg.txt to the codes specified in SUEWS\_SiteSelect.txt (Code\_EveT, Code\_DecTr, Code\_Grass). Each row should correspond to a particular surface type.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331  332  333 | Code linking to **SUEWS\_SiteSelect.txt** for evergreen trees and shrubs (Code\_EveTr), deciduous trees and shrubs (Code\_DecTr) and grass surfaces (Code\_Grass).  Value of integer is arbitrary but must match codes specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | Albedo | 0-1 | Albedo of this surface [-]  Effective surface albedo (full leaf-on, middle of the day value).  View factors should be taken into account.   |  |  | | --- | --- | | 0.10 | !EveTr, Helsinki, Järvi et al. (2014) | | 0.16 | !DecTr, Helsinki, Järvi et al. (2014) | | 0.19 | !Grass, Helsinki, Järvi et al. (2014) | | 0.10 | !EveTr, Oke (1987) | | 0.18 | !DecTr, Oke (1987) | | 0.21 | !Grass, Oke (1987) | |
| 3 | MU | Emissivity | 0-1 | Emissivity of this surface [-]  Effective surface emissivity.  View factors should be taken into account   |  |  | | --- | --- | | 0.98 | !EveTr, Oke (1987) | | 0.98 | !DecTr, Oke (1987) | | 0.93 | !Grass, Oke (1987) | |
| 4 | MD | StorageMin |  | Minimum water storage capacity of this surface [mm]  Minimum water storage capacity for upper surfaces (i.e. canopy).  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces).   |  |  | | --- | --- | | 1.3 | !EveTr, Breuer et al. (2003) | | 0.3 | !DecTr, Breuer et al. (2003) | | 1.9 | !Grass, Breuer et al. (2003) | |
| 5 | MD | StorageMax |  | Maximum water storage capacity of this surface [mm]  Maximum water storage capacity for upper surfaces (i.e. canopy)  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces)   |  |  | | --- | --- | | 1.3 | !EveTr, Breuer et al. (2003) | | 0.8 | !DecTr, Grimmond and Oke (1991) | | 1.9 | !Grass, Breuer et al. (2003) | |
| 6 | MD | StateLimit |  | Upper limit to the surface state [mm]  \*\*Currently only used for the water suface\*\* |
| 7 | MD | DrainageEq | 1, 2, 3 | Drainage equation to use for this surface. Coefficients specified in the following two columns.  Options for drainage equations:  1 - Falk and Niemczynowicz (1978)  2 - Halldin et al. (1979) (Rutter eqn corrected for c=0, see Calder & Wright (1986))  3 - Falk and Niemczynowicz (1978)   |  |  | | --- | --- | | 2 | !EveTr, Grimmond and Oke (1991) | | 2 | !DecTr, Grimmond and Oke (1991) | | 2 | !Grass (unirrigated), Grimmond and Oke (1991) | | 3 | !Grass (irrigated), Grimmond and Oke (1991) | |
| 8 | MD | DrainageCoef1 |  | Coefficient for drainage equation [units vary according to equation]   |  |  | | --- | --- | | 0.013 | !EveTr, Grimmond and Oke (1991) [mm h-1] | | 0.013 | !DecTr, Grimmond and Oke (1991) [mm h-1] | | 0.013 | !Grass (unirrigated), Grimmond and Oke (1991) [mm h-1] | | 10 | !Grass (irrigated), coefficient D0, Grimmond and Oke (1991) | |
| 9 | MD | DrainageCoef2 |  | Coefficient for drainage equation [units vary according to equation]   |  |  | | --- | --- | | 1.71 | !EveTrl, Grimmond and Oke (1991) [mm-1] | | 1.71 | !DecTr, Grimmond and Oke (1991) [mm-1] | | 1.71 | !Grass (unirrigated), Grimmond and Oke (1991) [mm-1] | | 3 | !Grass (irrigated), coefficient D0, Grimmond and Oke (1991) | |
| 10 | L | SoilTypeCode |  | Code for soil characteristics below this surface  Provides the link to column 1 of SUEWS\_Soil.txt, which contains the attributes describing sub-surface soil for this surface type.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_Soil.txt. |
| 11 | O | SnowLimPatch |  | Maximum SWE [mm]  Limit of snow water equivalent when the surface surface is fully covered with snow.   |  |  | | --- | --- | | 190 | !EveTr, Järvi et al. (2014) | | 190 | !DecTr, Järvi et al. (2014) | | 190 | !Grass, Järvi et al. (2014) |   Not needed if SnowUse = 0 in **4.1 RunControl**.nml**.** |
| 12 | MU | BaseT |  | Base temperature for initiating growing degree days for leaf growth [°C]  See section 2.2 Järvi et al. (2011); Appendix A Järvi et al. (2014).   |  |  | | --- | --- | | 5 | !EveTr, Järvi et al. (2011) | | 5 | !DecTr, Järvi et al. (2011) | | 5 | !Grass, Järvi et al. (2011) | |
| 13 | MU | BaseTe |  | Base temperature for initating senescence degree days for leaf off [°C]  See section 2.2 Järvi et al. (2011); Appendix A Järvi et al. (2014).   |  |  | | --- | --- | | 10 | !EveTr, Järvi et al. (2011) | | 10 | !DecTr, Järvi et al. (2011) | | 10 | !Grass, Järvi et al. (2011) | |
| 14 | MU | GDDFull |  | Growing degree days needed for full capacity of the leaf area index [°C]  This should be **checked carefully for your study area**. Modelled LAI from the **DailyState.txt** output file can be checked relative to known behaviour in the study area.  See section 2.2 Järvi et al. (2011); Appendix A Järvi et al. (2014) for more details.   |  |  | | --- | --- | | 300 | !EveTr, Järvi et al. (2011) | | 300 | !DecTr, Järvi et al. (2011) | | 300 | !Grass, Järvi et al. (2011) | |
| 15 | MU | SDDFull |  | Senescencedegree days needed to initiate leaf off [°C]  This should be **checked carefully for your study area**. Modelled LAI from the **DailyState.txt** output file can be checked relative to known behaviour in the study area.  See section 2.2 Järvi et al. (2011); Appendix A Järvi et al. (2014) for more details.   |  |  | | --- | --- | | -450 | !EveTr, Järvi et al. (2011) | | -450 | !DecTr, Järvi et al. (2011) | | -450 | !Grass, Järvi et al. (2011) | |
| 16 | MD | LAIMin |  | Minimum leaf area index [m2 m-2]  i.e leaf-off wintertime value   |  |  | | --- | --- | | 4 | !EveTr, Järvi et al. (2011) | | 1 | !DecTr, Järvi et al. (2011) | | 1.6 | !Grass, refs within Grimmond and Oke (1991) | |
| 17 | MD | LAIMax |  | Maximum leaf area index [m2 m-2]  i.e. full leaf-on summertime value   |  |  | | --- | --- | | 5.1 | !EveTr, Breuer et al. (2003) | | 5.5 | !DecTr, Breuer et al. (2003) | | 5.9 | !Grass, Breuer et al. (2003) | |
| 18 | MD | MaxConductance |  | Maximum conductance for each surface [mm s-1]  Used to calculate the surface conductance using the Jarvis (1976) model. See Eq 15 Järvi et al. (2011).   |  |  | | --- | --- | | 7.4 | !EveTr, Järvi et al. (2011) | | 11.7 | !DecTr, Järvi et al. (2011) | | 33.1 | !Grass (unirrigated), Järvi et al. (2011) | | 40.0 | !Grass (irrigated), Järvi et al. (2011) | |
| 19 | MD | LAIEq | 0, 1 | LAI equation to use for this surface. Coeffiecients specified in the following four columns.  Options for LAI equations:  0 - Järvi et al. (2011)  1 - Järvi et al. (2014)  N.B. North and South hemispheres treated slightly differently. |
| 20 | MD | LeafGrowthPower1 |  | Coefficient (power) for leaf growth [-]  See Appendix A Järvi et al. (2014) for more details.   |  |  | | --- | --- | | 0.03 | !Järvi et al. (2011), use if LAIEq = 0 | | 0.04 | !Järvi et al. (2014), use if LAIEq = 1 | |
| 21 | MD | LeafGrowthPower2 |  | Constant in the leaf growth equation [°C-1]   |  |  | | --- | --- | | 0.0005 | !Järvi et al. (2011), use if LAIEq = 0 | | 0.001 | !Järvi et al. (2014), use if LAIEq = 1 | |
| 22 | MD | LeafOffPower1 |  | Coefficient (power) for leaf off [-]   |  |  | | --- | --- | | 0.03 | !Järvi et al. (2011), use if LAIEq = 0 | | -1.5 | !Järvi et al. (2014), use if LAIEq = 1 | |
| 23 | MD | LeafOffPower2 |  | Constant in the leaf off equation [°C-1]   |  |  | | --- | --- | | 0.0005 | !Järvi et al. (2011), use if LAIEq = 0 | | 0.0015 | !Järvi et al. (2014), use if LAIEq = 1 | |
| 24 | L | OHMCode\_SummerWet |  | Code for OHM coefficients to use for this surface during wet conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 25 | L | OHMCode\_SummerDry |  | Code for OHM coefficients to use for this surface during dry conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 26 | L | OHMCode\_WinterWet |  | Code for OHM coefficients to use for this surface during wet conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 27 | L | OHMCode\_WinterDry |  | Code for OHM coefficients to use for this surface during dry conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |

### **SUEWS\_Water.txt**

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331 | Code linking to SUEWS\_SiteSelect.txt for water surfaces (Code\_Water).  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | Albedo | 0-1 | Albedo of this surface [-]  Effective surface albedo (full leaf-on, middle of the day value).  View factors should be taken into account.   |  |  | | --- | --- | | 0.1 | !Water, Oke (1987) | |
| 3 | MU | Emissivity | 0-1 | Emissivity of this surface [-]  Effective surface emissivity.  View factors should be taken into account   |  |  | | --- | --- | | 0.95 | !Water, Oke (1987) | |
| 4 | MD | StorageMin |  | Minimum water storage capacity of this surface [mm]  Minimum water storage capacity for upper surfaces (i.e. canopy).  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces).   |  |  | | --- | --- | | 0.5 | !Water | |
| 5 | MD | StorageMax |  | Maximum water storage capacity of this surface [mm]  Maximum water storage capacity for upper surfaces (i.e. canopy)  Min and max values are to account for seasonal variation (e.g. leaf-on/leaf-off differences for vegetated surfaces)   |  |  | | --- | --- | | 0.5 | !Water | |
| 6 | MU | StateLimit |  | Upper limit to the surface state [mm]  State cannot exceed this value. Set to a large value (e.g. 20000 mm = 20 m) if the water body is substantial (lake, river, etc) or a small value (e.g. 10 mm) if water bodies are very shallow (e.g. fountains).   |  |  | | --- | --- | | 20000 | !Water | |
| 7 | MD | DrainageEq | -999 | Drainage equation to use for this surface. Coefficients specified in the following two columns.  \*\*Not currently used for water suface\*\* |
| 8 | MD | DrainageCoef1 | -999 | Coefficient for drainage equation [units vary according to equation]  \*\*Not currently used for water suface\*\* |
| 9 | MD | DrainageCoef2 | -999 | Coefficient for drainage equation [units vary according to equation]  \*\*Not currently used for water suface\*\* |
| 10 | L | OHMCode\_SummerWet |  | Code for OHM coefficients to use for this surface during wet conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 11 | L | OHMCode\_SummerDry |  | Code for OHM coefficients to use for this surface during dry conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 12 | L | OHMCode\_WinterWet |  | Code for OHM coefficients to use for this surface during wet conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 13 | L | OHMCode\_WinterDry |  | Code for OHM coefficients to use for this surface during dry conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |

### **SUEWS\_Snow.txt**

SUEWS\_Snow.txt specifies the characteristics for snow surfaces when SnowUse=1 in **4.1 RunControl**.nml. If the snow part of the model is not run, fill this table with ‘-999’ except for the first (Code) column and set SnowUse=0 in **4.1 RunControl**.nml.

For a detailed description of the variables, see Järvi et al. (2014). In the current version SnowUse should be set to 0.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331 | Code linking to SUEWS\_SiteSelect.txt for snow surfaces (SnowCode).  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | RadMeltFactor | 0.0016 | Hourly radiation melt factor of snow [mm W-1 h-1] |
| 3 | MU | TempMeltFactor | 0.12 | Hourly temperature melt factor of snow [mm °C -1 h-1] |
| 4 | MU | AlbedoMin | 0-1 | Minimum snow albedo [-]  e.g. 0.18, Järvi et al. (2014) |
| 5 | MU | AlbedoMax | 0-1 | Maximum snow albedo (fresh snow) [-]  e.g. 0.85, Järvi et al. (2014) |
| 6 | MU | Albedo | 0-1 | Albedo of this surface [-]  Effective surface albedo (full leaf-on, middle of the day value).  View factors should be taken into account.   |  |  | | --- | --- | | 0.5 | !Snow, Järvi et al. (2014) | |
| 7 | MU | Emissivity | 0-1 | Emissivity of this surface [-]  Effective surface emissivity.  View factors should be taken into account   |  |  | | --- | --- | | 0.99 | !Snow, Järvi et al. (2014) | |
| 8 | MD | tau\_a |  | Time constant for snow albedo aging in cold snow [-]   |  |  | | --- | --- | | 0.018 | !Järvi et al. (2014) | |
| 9 | MD | tau\_f |  | Time constant for snow albedo aging in melting snow [-]   |  |  | | --- | --- | | 0.11 | !Järvi et al. (2014) | |
| 10 | MD | PrecipiLimAlb | 2 | Limit for hourly precipitation when the ground is fully covered with snow. Then snow albedo is reset to AlbedoMax [mm] |
| 11 | MD | *snowDensMin* | 100 | Fresh snow density [kg m-3] |
| 12 | MD | *snowDensMax* | 400 | Maximum snow density [kg m-3] |
| 13 | MD | tau\_r |  | Time constant for snow density ageing [-]   |  |  | | --- | --- | | 0.043 | !Järvi et al. (2014) | |
| 14 | MD | CRWMin |  | Minimum water holding capacity of snow [mm]   |  |  | | --- | --- | | 0.05 | !Järvi et al. (2014) | |
| 15 | MD | CRWMax |  | Maximum water holding capacity of snow [mm]   |  |  | | --- | --- | | 0.20 | !Järvi et al. (2014) | |
| 16 | MD | PrecipLimSnow | 2.2 | Temperature limit when precipitation falls as snow [°C] !Auer 1974 |
| 17 | L | OHMCode\_SummerWet |  | Code for OHM coefficients to use for this surface during wet conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 18 | L | OHMCode\_SummerDry |  | Code for OHM coefficients to use for this surface during dry conditions in summer.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 19 | L | OHMCode\_WinterWet |  | Code for OHM coefficients to use for this surface during wet conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |
| 20 | L | OHMCode\_WinterDry |  | Code for OHM coefficients to use for this surface during dry conditions in winter.  Links to SUEWS\_OHMCoefficients.txt.  Value of integer is arbitrary but must match code specified in column 1 of SUEWS\_OHMCoefficients.txt. |

### **SUEWS\_Soil.txt**

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

Soil moisture can either be provided using observational data in the met forcing file (smd\_choice = 1 or 2 in 4.1 RunControl.nml) and providing some metadata information here (OBS\_ columns), or modelled by SUEWS (smd\_choice = 0 in 4.1 RunControl.nml).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331 | Code linking to the SoilTypeCode column in SUEWS\_NonVeg.txt (for Paved, Bldgs and BSoil surfaces) and SUEWS\_Veg.txt (for EveTr, DecTr and Grass surfaces).  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MD | SoilDepth | 350 | Depth of sub-surface soil store [mm]  i.e. the depth of soil beneath the surface |
| 3 | MD | SoilStoreCap | 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.  (SoilStoreCap must not be greater than SoilDepth.) |
| 4 | MD | SatHydraulicCond | 0.0005 | Hydraulic conductivity for saturated soil [mm s-1] |
| 5 | MD | SoilDensity | 1.16 | Soil density [kg m-3] |
| 6 | O | InfiltrationRate | -999 | Infiltration rate [mm h-1]  \*\*Not currently used\*\* |
| 7 | O | OBS\_SMDepth |  | Depth of soil moisture measurements [mm]  Use only if soil moisture is observed and provided in the met forcing file and smd\_choice = 1 or 2.  \*\*Use of observed soil moisture not currently tested\*\* |
| 8 | O | OBS\_SMCap |  | Maxiumum observed soil moisture [m3 m-3 or kg kg-1]  Use only if soil moisture is observed and provided in the met forcing file and smd\_choice = 1 or 2.  \*\*Use of observed soil moisture not currently tested\*\* |
| 9 | O | OBS\_SoilNotRocks |  | Fraction of soil without rocks [-]  Use only if soil moisture is observed and provided in the met forcing file and smd\_choice = 1 or 2.  \*\*Use of observed soil moisture not currently tested\*\* |

### **SUEWS\_Conductance.txt**

SUEWS\_Conductance.txt contains the parameters needed for the Jarvis (1976) surface conductance model used in the modelling of evaporation in SUEWS. These values should not be changed independently of each other. The suggested values below have been derived using datasts for Los Angeles and Vancouver (see Järvi et al. (2011)).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code |  | Code linking to the CondCode column in SUEWS\_SiteSelect.txt.  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MD | G1 | 16.4764 | Related to maximum surface conductance [mm s-1] |
| 3 | MD | G2 | 566.0923 | Related to Kdown dependence [W m-2] |
| 4 | MD | G3 | 0.2163 | Related to VPD dependence [kg g-1] |
| 5 | MD | G4 | 3.3649 | Related to VPD dependence [g kg-1] |
| 6 | MD | G5 | 11.0764 | Related to temperature dependence [°C] |
| 7 | MD | G6 | 0.0176 | Related to soil moisture dependence [mm-1] |
| 8 | MD | TH | 40 | Upper air temperature limit [°C] |
| 9 | MD | TL | 0 | Lower air temperature limit [°C] |
| 10 | MD | S1 | 0.45 | Related to soil moisture dependence [-]  \*\*These will change in the future to ensure consistency with soil behaviour\*\* |
| 11 | MD | S2 | 15 | Related to soil moisture dependence [mm]  \*\*These will change in the future to ensure consistency with soil behaviour\*\* |
| 12 | MD | Kmax | 1200 | Maximum incoming shortwave radiation [W m-2] |

### **SUEWS\_AnthropogenicHeat.txt**

SUEWS\_AnthropogenicHeatFlux.txt provides the parameters needed to model the anthropogenic heat flux using either the method of Järvi et al. (2011) based on heating and cooling degree days (AnthropHeatChoice = 2 in 4.1 RunControl.nml) or the method of Loridan et al. (2011) based on air temperature (AnthropHeatChoice = 1 in 4.1 RunControl.nml). The sub-daily variation in anthropogenic heat flux is modelled according to the daily cycles specified in **SUEWS\_Profiles.txt**.

Alternatively, if available, the anthropogenic heat flux can be provided in the met forcing file (and set AnthropHeatChoice = 0 in 4.1 RunControl.nml), in which case all columns here except Code and BaseTHDD should be set to ’-999’.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331 | Code linking to the AnthropogenicCode column in SUEWS\_SiteSelect.txt.  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | BaseTHDD |  | Base temperature for heating degree days [°C]   |  |  | | --- | --- | | 18.2 | !Sailor and Vasireddy (2006) | |
| 3 | MU, O | QF\_A\_Weekday |  | Base value for QF on weekdays [W m-2 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.3081 | !Järvi et al. (2011) | | 0.100 | !Järvi et al. (2014) | |
| 4 | MU, O | QF\_B\_Weekday |  | Parameter related to cooling degree days on weekdays [W m-2 K-1 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.0099 | !Järvi et al. (2011) | | 0.0099 | !Järvi et al. (2014) | |
| 5 | MU, O | QF\_C\_Weekday |  | Parameter related to heating degree days on weekdays [W m-2 K-1 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.0102 | !Järvi et al. (2011) | | 0.0102 | !Järvi et al. (2014) | |
| 6 | MU, O | QF\_A\_Weekend |  | Base value for QF on weekends [W m-2 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.3081 | !Järvi et al. (2011) | | 0.100 | !Järvi et al. (2014) | |
| 7 | MU, O | QF\_B\_Weekend | 0-1 | Parameter related to cooling degree days on weekends [W m-2 K-1 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.0099 | !Järvi et al. (2011) | | 0.0099 | !Järvi et al. (2014) | |
| 8 | MU, O | QF\_C\_Weekend |  | Parameter related to heating degree days on weekends [W m-2 K-1 (Cap ha-1)-1]  Use with AnthropHeatChoice = 2   |  |  | | --- | --- | | 0.0102 | !Järvi et al. (2011) | | 0.0102 | !Järvi et al. (2014) | |
| 9 | MU, O | AHMin |  | Minimum QF [W m-2]  Use with AnthropHeatChoice = 1   |  |  | | --- | --- | | 15 | !Loridan et al. (2011) | |
| 10 | MU, O | AHSlope |  | Slope of QF versus air temperatur e [W m-2 K-1]  Use with AnthropHeatChoice = 1   |  |  | | --- | --- | | 2.7 | !Loridan et al. (2011) | |
| 11 | MU, O | TCritic |  | Critical temperature [°C]  Use with AnthropHeatChoice = 1   |  |  | | --- | --- | | 7 | !Loridan et al. (2011) | |

### **SUEWS\_Irrigation.txt**

SUEWS includes a simple model for external water use if observed data are not available. The model calculates daily water use from the mean daily air temperature, number of days since rain and fraction of irrigated area using automatic/manual irrigation. The sub-daily pattern of water use is modelled according to the daily cycles specified in **SUEWS\_Profiles.txt**.

Alternatively, if available, the external water use can be provided in the met forcing file (and set WU\_choice = 1 in 4.1 RunControl.nml), in which case all columns here except Code should be set to ’-999’.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code |  | Code linking to **SUEWS\_SiteSelect.txt** for irrigation modelling (IrrigationCode).  Value of integer is arbitrary but must match codes specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | Ie\_start | 1-366 | Day when irrigation starts [DOY] |
| 3 | MU | Ie\_end | 1-366 | Day when irrigation ends [DOY] |
| 4 | MU | InternalWaterUse | 0 | Internal water use [mm h-1] |
| 5 | MU | Faut | 0-1 | Fraction of irrigated area that is irrigated using automated systems (e.g. sprinklers). |
| 6 | MD | Ie\_a1 | -84.54 | Coefficient for automatic irrigation model [mm d-1] |
| 7 | MD | Ie\_a2 | 9.96 | Coefficient for automatic irrigation model [mm d-1 °C-1] |
| 8 | MD | Ie\_a3 | 3.67 | Coefficient for automatic irrigation model [mm d-2] |
| 9 | MD | Ie\_m1 | -25.36 | Coefficient for manual irrigation model [mm d-1] |
| 10 | MD | Ie\_m2 | 3.00 | Coefficient for manual irrigation model [mm d-1 °C-1] |
| 11 | MD | Ie\_m3 | 1.10 | Coefficient for manual irrigation model [mm d-2] Units/values need checking for these coefficients |
| 12 | MU | DayWat(1) | 0 or 1 | Irrigation allowed on Sundays [1], if not [0] |
| 13 | MU | DayWat(2) | 0 or 1 | Irrigation allowed on Mondays [1], if not [0] |
| 14 | MU | DayWat(3) | 0 or 1 | Irrigation allowed on Tuesdays [1], if not [0] |
| 15 | MU | DayWat(4) | 0 or 1 | Irrigation allowed on Wednesdays [1], if not [0] |
| 16 | MU | DayWat(5) | 0 or 1 | Irrigation allowed on Thursdays [1], if not [0] |
| 17 | MU | DayWat(6) | 0 or 1 | Irrigation allowed on Fridays [1], if not [0] |
| 18 | MU | DayWat(7) | 0 or 1 | Irrigation allowed on Saturdays [1], if not [0] |
| 19 | MU | DayWatPer(1) | 0-1 | Fraction of properties using irrigation on Sundays [0-1] |
| 20 | MU | DayWatPer(2) | 0-1 | Fraction of properties using irrigation on Mondays [0-1] |
| 21 | MU | DayWatPer(3) | 0-1 | Fraction of properties using irrigation on Tuesdays [0-1] |
| 22 | MU | DayWatPer(4) | 0-1 | Fraction of properties using irrigation on Wednesdays [0-1] |
| 23 | MU | DayWatPer(5) | 0-1 | Fraction of properties using irrigation on Thursdays [0-1] |
| 24 | MU | DayWatPer(6) | 0-1 | Fraction of properties using irrigation on Fridays [0-1] |
| 25 | MU | DayWatPer(7) | 0-1 | Fraction of properties using irrigation on Saturdays [0-1] |

### **SUEWS\_Profiles.txt**

SUEWS\_Profiles.txt specifies the daily cycle of variables related to human behaviour (energy use, water use and snow clearning). Different profiles can be specified for weekdays and weekends. The profiles are provided at hourly resolution here, then model will then interpolate the hourly energy and water use profiles to the resolution of the model timestep and normalize the values provided. Thus it does not matter whether columns 2-25 add up to, say 1, 24, or another number, because the model will handle this. Currently, the snow clearing profiles are not interpolated as these are effectively a switch (0 or 1).

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

Profiles are specified for the following

* Anthropogenic heat flux (weekday and weekend)
* Water use (weekday and weekend; manual and automatic irrigation)
* Snow removal (weekday and weekend)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code |  | Code linking to the following columns in SUEWS\_SiteSelect.txt:  EnergyUseProfWD : Anthropogenic heat flux, weekdays  EnergyUseProfWE : Anthropogenic heat flux, weekends  WaterUseProfManuWD : Manual irrigaton, weekdays  WaterUseProfManuWE : Manual irrigaton, weekends  WaterUseProfAutoWD : Automatic irrigaton, weekdays  WaterUseProfAutoWE: Automatic irrigaton, weekends  SnowClearingProfWD : Snow clearing, weekdays  SnowClearingProfWE: Snow clearing, weekends  Value of integer is arbitrary but must match codes specified in SUEWS\_SiteSelect.txt. |
| 2-25 | MU | 0-23 |  | Multiplier for each hour of the day [-] for energy and water use.  For SnowClearing, set those hours to 1 when snow removal from paved and roof surface is allowed (0 otherwise) if the snow removal limits set in the SUEWS\_NonVeg.txt (SnowLimRemove column) are exceeded. |

### **SUEWS\_WithinGridWaterDist.txt**

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

Each row corresponds to a surface type (linked by the Code in column 1 to the SiteSelect.txt columns: WithinGridPavedCode, WithinGridBuiltCode, …, WithinGridBSoilCode, WithinGridWaterCode). Each column then 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 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 areas goes into the sub-surface soil store
* the row corresponding to water contains zeros (\*\*as it is currently not used\*\*)

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

### **SUEWS\_OHMCoefficients.txt**

OHM, the Objective Hysteresis Model ([Grimmond et al. 1991](#GCO1991)), is used to calculate the storage heat flux. For each surface, OHM requires three model coefficients (a1, a2, a3). A variety of values has been derived for different materials and can be found in the literature. The SUEWS\_OHMCoefficients.txt file provides these coefficients for each surface type. The coefficients can be changed depending on the surface wetness state (wet/dry) based on the calculated surface wetness state in the model. The coefficients also can change with season (summer/winter) based on a 5-day running average of mean air temperature. If greater than 5 °C then the summer coefficients are used. To use the same coefficients irrespective of wet/dry and summer/winter conditions, use the same code for all four OHM linking columns (OHMCode\_SummerWet, OHMCode\_SummerDry, OHMCode\_WinterWet and OHMCode\_WinterDry).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | USE | Column name | Example | Description |
| 1 | L | Code | 331 | Code linking to the OHMCode\_SummerWet, OHMCode\_SummerDry, OHMCode\_WinterWet and OHMCode\_WinterDry columns in SUEWS\_NonVeg.txt, SUEWS\_Veg,txt, SUEWS\_Water.txt and SUEWS\_Snow.txt files.  Value of integer is arbitrary but must match code specified in SUEWS\_SiteSelect.txt. |
| 2 | MU | a1 |  | Coefficient for Q\* term [-] |
| 3 | MU | a2 |  | Coefficient for dQ\*/dt term [h] |
| 4 | MU | a3 |  | Constant term [W m-2] |

**Table 4.13:** Values from the literature for the OHM Coefficients (if you have recommendations for others to be included [please let us know](#email)) In the model run, canyons are excluded.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Surface type** | | **Author** | **a1** | **a2** | **a3** |
| Canyon | E-W canyon | Yoshida *et al.* (1990, 1991) | 0.71 | 0.04 | -39.7 |
| N-S canyon | Nunez (1974) | 0.32 | 0.01 | -27.7 |
| Vegetation | Mixed forest | McCaughey (1985) | 0.11 | 0.11 | -12.3 |
| Short grass | Doll *et al.* (1985) | 0.32 | 0.54 | -27.4 |
| Bare soil | Novak (1982) | 0.38 | 0.56 | -27.3 |
| Bare soil (wet) | Fuchs & Hadas (1972) | 0.33 | 0.07 | -34.9 |
| Bare soil (dry) | Fuchs & Hadas (1972) | 0.65 | 0.43 | -36.5 |
| Bare soil | Asaeda & Ca (1993) | 0.36 | 0.27 | -42.4 |
| Water Shallow – Turbid | Souch *et al.* (1998) | 0.50 | 0.21 | -39.1 |
| Unirrigated grass (Crops) | Grimmond et al. (1993) | 0.21 | 0.11 | -16.1 |
| Short irrigated grass | Grimmond et al. (1993) | 0.35 | -0.01 | -26.3 |
| Roof | Tar and gravel, Vancouver | Yap (1973) | 0.17 | 0.10 | -17.0 |
| Uppsala | Taesler (1980) | 0.44 | 0.57 | -28.9 |
| Membrane and concrete, Kyoto | Yoshida et al. (1990,1991) | 0.82 | 0.34 | -55.7 |
| Average gravel/tar/conc. flat industrial, Vancouver | Meyn (2000) | 0.25 | 0.92 | -22.0 |
| Dry --gravel/tar/conc. flat industrial, Vancouver | Meyn (2000) | 0.25 | 0.70 | -22.0 |
| Wet -- gravel/tar/conc. flat industrial, Vancouver | Meyn (2000) | 0.25 | 0.70 | -22.0 |
| Bitumen spread over flat industrial membrane, Vancouver | Meyn (2000) | 0.06 | 0.28 | -3.0 |
| Asphalt shingle on plywood residential roof , Vancouver | Meyn (2000) | 0.14 | 0.33 | -6.0 |
| Star – high albedo asphalt shingle residential roof | Meyn (2000) | 0.09 | 0.18 | -1.0 |
| Star - Ceramic Tile | Meyn (2000) | 0.07 | 0.26 | -6.0 |
| Star - Slate Tile | Meyn (2000) | 0.08 | 0.32 | 0.0 |
| Helsinki – Suburban | Järvi et al. (2014) | 0.19 | 0.54 | -15.1 |
| Montreal – Suburban | Järvi et al. (2014) | 0.12 | 0.24 | -4.5 |
| Montreal – Urban | Järvi et al. (2014) | 0.26 | 0.85 | -21.4 |
| Impervious | Concrete | Doll *et al.* (1985) | 0.81 | 0.10 | -79.9 |
| Concrete | Asaeda & Ca (1993) | 0.85 | 0.32 | -28.5 |
| Asphalt | Narita *et al.* (1984) | 0.36 | 0.23 | -19.3 |
| Asphalt | Asaeda & Ca (1993) | 0.64 | 0.32 | -43.6 |
| Asphalt | Anandakumar (1999) | 0.82 | 0.68 | -20.1 |
| Asphalt (winter) | Anandakumar (1999) | 0.72 | 0.54 | -40.2 |
| Asphalt (summer) | Anandakumar (1999) | 0.83 | -0.83 | -24.6 |

## Holidays.txt

(\*\*currently not used\*\*)

List of days to be treated as non workdays for some reason (e.g. strikes, holidays etc)

This will influence anthropogenic heat and some water use.

|  |  |  |  |
| --- | --- | --- | --- |
| Column | Description | Example | Comment |
| 1 | Year | 2011 |  |
| 2 | Day of year | 1 | New Year |
| 3 | Use | 1 | 0 or 1 – this file will have multiple holidays added with time if they are not relevant to your site then put a 0  1 Use  0 - ignore |
|  |  |  |  |
|  |  |  |  |

## InitialConditionsSSss\_YYYY.nml

To start the model, information about the conditions at the start of the run is required. An Initial Condiitions file is needed for the first time period for each grid. After that, new **InitialConditions*SSss\_YYYY*.nml** files will be written for the following years. It is **recommended** that you look at this output (located in the input directory) to check the status of various surfaces at the end or the run. This may help you get more realistic starting values if you are uncertain what they should be. Note this file will be created for each year for multiyear runs for each grid.

**Table 4.4:** **InitialConditions*SSss*\_*YYYY*.nml**. Variables can be in any order.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Used for | Unit | Comments |
| DaysSinceRain | Wateruse | days | Number of days since rainfall occurred –   * important if starting in summer season that this is correct * if starting when external water use is not occurring it will be reset with the first rain so can just be set to 0 |
| Temp\_C0 | Water use, QF | °C | Daily mean temperature (°C) for the day before the run starts |
| Id\_prev | A | Day | Day of year before the run starts (i.e. previous day)  If start of year – use 0 |
| GDD\_1\_0 | [LAI](#LAI) | °C | Growing degree days for leaf growth   * If leaves are already full, then this should be the same as GDDFull in **SUEWS\_Veg.txt** * If winter, set to 0 * Needs to be a positive number   It is important that the vegetation characteristics are set correctly (i.e. is the starting period winter or summer). |
| GDD\_2\_0 | LAI | °C | Growing degree days for senescence growth   * 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 * Needs to be a negative number or 0   It is important that the vegetation characteristics are set correctly (i.e. is the starting period winter or summer). |
| Above Ground State | | | |
| PavedState |  |  | Initial wetness state of paved surface (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| BldgsState | W | mm | Initial wetness state for buildings (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| EveTrState | W | mm | Initial wetness state of evergreen trees (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| DecTrState | W | mm | Initial wetness state of deciduous trees (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| GrassState | W | mm | Initial wetness state of grass (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| BSoilState | W | mm | Initial wetness state of bare soil surface (0 indicates dry, wet otherwise).  If unknown, set to zero as the model will update these states quickly. |
| WaterState | W | mm | Initial state of water surface (must be set > 0, as 0 indicates dry surface).  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. |
| LAIinitialEveTr | W | m2 m-2 | Initial LAI for evergreen trees |
| LAIinitialDecTr | W | m2 m-2 | Initial LAI for deciduous trees |
| LAIinitialGrass | W | m2 m-2 | Initial LAI for irrigated grass |
| Below Ground State  Note! No soil store below water. Horizontal movements are permitted between the soil stores (see section 4.5) | | | |
| SoilstorePavedState | W | mm | Initial state of the soil water storage under paved surfaces |
| SoilstoreBldgsState | W | mm | Initial state of the soil water storage under buildings |
| SoilstoreEveTrState | W | mm | Initial state of the soil water storage under evergreen trees |
| SoilstoreDecTrState | W | mm | Initial state of the soil water storage under deciduous trees |
| SoilstoreGrassState | W | mm | Initial state of the soil water storage under grass |
| SoilstoreBSoilState | W | mm | Initial state of the soil water storage under bare soil surfaces |
| Deciduous Vegetation state  This should be consistent with albedo and DecTr storage capacities and time of year | | | |
| albDec0 | R | - | Deciduous albedo on day 0 of run |
| decidCap0 | A | mm | Deciduous storage capacity on day 0 of run |
| porosity0 | E | - | Porosity of deciduous vegetation on day 0 of run |
| Snow (Currently should be set to zero) | | | |
| SnowWaterPavedState |  | mm | Initial amount of liquid water in the snow on paved surfaces |
| SnowWaterBldgsState |  | mm | Initial amount of liquid water in the snow on buildings |
| SnowWaterEveTrState |  | mm | Initial amount of liquid water in the snow on evergreen trees |
| SnowWaterDecTrState |  | mm | Initial amount of liquid water in the snow on deciduous trees |
| SnowWaterGrassState |  | mm | Initial amount of liquid water in the snow on grass surfaces |
| SnowWaterBSoilState |  | mm | Initial amount of liquid water in the snow on bare soil surfaces |
| SnowWaterWaterState |  | mm | Initial amount of liquid water in the snow in water |
| SnowPackPaved |  | mm | Initial snow water equivalent if the snow on paved surfaces |
| SnowPackBldgs |  | mm | Initial snow water equivalent if the snow on buildings |
| SnowPackEveTr |  | mm | Initial snow water equivalent if the snow on evergreen trees |
| SnowPackDecTr |  | mm | Initial snow water equivalent if the snow on deciduous trees |
| SnowPackGrass |  | mm | Initial snow water equivalent if the snow on grass surfaces |
| SnowPackBSoil |  | mm | Initial snow water equivalent if the snow on bare soil surfaces |
| SnowPackWater |  | mm | Initial snow water equivalent if the snow on water |
| SnowFracPaved |  | - | Initial plan area fraction of snow on paved surfaces |
| SnowFracBldgs |  | - | Initial plan area fraction of snow on buildings |
| SnowFracEveTr |  | - | Initial plan area fraction of snow on evergreen trees |
| SnowFracDecTr |  | - | Initial plan area fraction of snow on deciduous trees |
| SnowFracGras |  | - | Initial plan area fraction of snow on grass surfaces |
| SnowFracBSoil |  | - | Initial plan area fraction of snow on bare soil surfaces |
| SnowFracWater |  | - | Initial plan area fraction of snow on water |
| SnowDensPaved |  | kg m-3 | Initial snow density on paved surfaces |
| SnowDensBldgs |  | kg m-3 | Initial snow density on buildings |
| SnowDensEveTr |  | kg m-3 | Initial snow density on evergreen trees |
| SnowDensDecTr |  | kg m-3 | Initial snow density on deciduous trees |
| SnowDensGrass |  | kg m-3 | Initial snow density on grass surfaces |
| SnowDensBSoil |  | kg m-3 | Initial snow density on bare soil surfaces |
| SnowDensWater |  | kg m-3 | Initial snow density on water |

## Meteorological input file (SSss\_YYYY\_data.txt)

SUEWS is designed to run using commonly measured meteorological variables. Required inputs must be continuous – i.e. gap fill any missing data. The table below gives the required (R) and optional (O) additional input variables. If an optional input variable is not available or will not be used by the model, enter ‘-999.0’ for this column.

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

|  |  |  |  |
| --- | --- | --- | --- |
| 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 NetRadiationChoice = 1. |
| 6 | O | qh | Sensible heat flux [W m-2] |
| 7 | O | qe | Latent heat flux [W m-2] |
| 8 | O | qs | Storage heat flux [W m-2] |
| 9 | O | qf | Anthrpogenic heat flux [W m-2] |
| 10 | **R** | **U** | Wind speed [m s-1]  The height of the wind speed measurement (Z) is needed in 4.1 RunControl.nml. |
| 11 | **R** | **RH** | Relative Humidity [%] |
| 12 | **R** | **Tair** | Air temperature [°C] |
| 13 | **R** | **pres** | Barometric pressure [kPa] |
| 14 | **R** | **rain** | Rainfall [mm] |
| 15 | **R** | **kdown** | Incoming shortwave radiation [W m-2]  Must be > 0 W m-2. |
| 16 | O | snow | Snow [mm]  Required if SnowUse = 1 |
| 17 | O | ldown | Incoming longwave radiation [W m-2] |
| 18 | O | fcld | Cloud fraction [tenths] |
| 19 | O | Wuh | External water use [m3] |
| 20 | O | xsmd | Observed soil moisture [m3 m-3 or kg kg-1] |
| 21 | O | lai | Observed leaf area index [m2 m-2] |
| 22 | O | kdiff | Diffuse radiation [W m-2]  Required if CBLUse = 1 |
| 23 | O | kdir | Direct radiation [W m-2]  Required if CBLUse = 1 |
| 24 | O | wdir | Wind direction [°]  Required if CBLUse = 1 |

**Note**: The meteorological input file must match the information given in SUEWS\_SiteSelect.txt. For example, if a whole year (e.g. 2011) is intended to be modelled using and hourly resolution dataset, the number of lines in the metdata-file should be 8760 and begin and end with:

*iy id it imin*

2011 1 1 0 …

…

2012 1 0 0 …

## CBL input file (CBLInput.nml)

If CBL slab model is used (CBLuse=1 in RunControl.nml), this file needs to be prepared. This includes the run options, parameters and input file names. Main reference for this part of the model [*Onomura et al. (2015*](#Onomura2014)*) and Cleugh and Grimmond (2000).*

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

|  |  |  |
| --- | --- | --- |
| Name | Units | Explanation/Details/ Description |
| *EntrainmentType* | - | Determines an entrainment scheme (see Cleugh and Grimmond 2000) for discusson   |  |  | | --- | --- | | 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 | Q*H* values modelled by SUEWS | | 2 | Q*H* values modelled by LUMPS | | 3 | *Observed* Q*H* values are used from the meteorological input file | |
| *Wsb* | m s-1 | Subsidence velocity in eq. 1 and 2 of [*Onomura et al. (2015*](#Onomura2014)*)*   |  | | --- | | Subsidence velocity | | -0.01 **Recommended** | |
| *CBLday(id)* | - | CBL model is used for the days you choose. Set CBLday(id) = 1  e.g. if CBL model is set to run during 175 – 177 (Day of year),  CBLday(175) = 1, CBLday(176) = 1, CBLday(177) = 1 |
| *CO2\_included* | - | In the current version, it should be set to zero. |
| *InitialData\_use* | - | Determines initial values (zi0, gamt\_Km, gamq\_gkgm, Theta+\_K, q+\_gkg, Theta\_K and q\_gkg) (see [CBL\_Initial\_data.txt](#_CBL_initial_data.txt)).   |  |  | | --- | --- | | Value | Comments | | 0 | All initial values are calculated. This is NOT available yet in this version. | | 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](#_CBL_initial_data.txt)). | |
| *InitialData\_FileName* | - | If InitialData\_use ≥ 1, write the file name including the path from site directory  e.g. InitialData\_FileName='CBLinputfiles\CBL\_initial\_data.txt' |
| *Sondeflag* | - | 0 does not read radiosonde vertical profile data, 1 if does.  The data file is prepared for a test run with Sacramento data in example zip folder (see [*Onomura et al. (2015*](#Onomura2014)*)*) but **recommend to set 0** thus not to use this option for the other sites. |
| *FileSonde(id)* | - | If sondeflag=1, write the file name including the path from site directory  e.g. FileSonde(id)= 'CBLinputfiles\XXX.txt', XXX is an arbitrary name. |

## CBL\_initial\_data.txt

If CBL slab model is used (CBLuse=1), this file needs to be prepared. This file should give initial data every morning when CBL slab model starts running. The file name should match the *InitialData\_FileName* in [CBLInput](#_CBL_input_file).nml.

Definitions and example file of initial values prepared for Sacramento

|  |  |
| --- | --- |
| zi0 | initial convective boundary layer height (m) |
| gamt\_Km | vertical gradient of potential temperature (K m-1) |
| gamq\_gkgm | vertical gradient of specific humidity (g kg-1 m-1) |
| Theta+\_K | potential temperature at the top of CBL (K) |
| q+\_gkg | specific humidity at the top of CBL (g kg-1) |
| Theta\_K | potential temperature in CBL (K) |
| 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 Onomura et al. (2015).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| id | zi0 | gamt\_Km | gamq\_gkgm | Theta+\_K | q+\_gkg | theta\_K | q\_gkg |
| 234 | 188 | 0.032 | 0.00082 | 290.4 | 9.6 | 288.7 | 8.3 |
| 235 | 197 | 0.089 | 0.089 | 290.2 | 8.4 | 288.3 | 8.7 |
| ⁞ | ⁞ | ⁞ | ⁞ | ⁞ | ⁞ | ⁞ | ⁞ |
|  |  |  |  |  |  |  |  |

## SOLWEIG input files

If the SOLWEIG model output is used (SOLWEIGout=1), spatial data and a SOLWEIGInput.nml file needs 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 | Explanation/Details/ Description |
| *Posture* | - | Determines the posture of a human for which the radiant fluxes should be considered   |  |  | | --- | --- | | Value | Comments | | 1 | Standing (default) | | 2 | Sitting | |
| *absL* | - | |  | | --- | | Absorption coefficient of longwave radiation of a person. | | 0.97 **Recommended.** | |
| *absK* | - | |  | | --- | | Absorption coefficient of shortwave radiation of a person | | 0.70 **Recommended.** | |
| *heightgravity* | m | |  | | --- | | Center of gravity for a person | | 1.1 **Recommended for a standing man.** | |
| *usevegdem* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Vegetation scheme is active (Lindberg and Grimmond 2011) | | 2 | No vegetation scheme is used | |
| *DSMPath* | - | Path to Digital Surface Models (DSM). |
| *DSMname* | - | Ground and Building DSM |
| *CDSMname* | - | Vegetation canopy DSM |
| *TDSMname* | - | Vegetation trunk zone DSM |
| *TransMin* | - | |  | | --- | | Tranmissivity of K through decidious vegetation (leaf on) | | 0.02 **Recommended** Konarska et al. 2014) | |
| *TransMax* | - | |  | | --- | | Tranmissivity of K through decidious vegetation (leaf off) | | 0.50 **Recommended** Konarska et al. 2014) | |
| *SVFPath* | - | Path to SVFs matrises. See Lindberg and Grimmond (2011) for details. |
| *SVFsuffix* | - | Suffix used (if any) |
| *buildingname* | - | Boolean matrix for locations of building pixels |
| *row* | - | X coordinate for point of interest. Here all variables from the model will written to SOLWEIGpoiOUT.txt |
| *col* | - | Y coordinate for point of interest. Here all variables from the model will written to SOLWEIGpoiOUT.txt |
| *onlyglobal* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Diffuse and direct shortwave radiation is calculated from Reindl et al. (1990) | | 0 | Taken from met-inputfile | |
| *SOLWEIGpoi\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write output variables at point of interest (see below) | | 0 | No POI output | |
| *Tmrt\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *Lup2d\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *Ldown2d\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *Kup2d\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *Kdown2d\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *GVF\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *GVF\_out* | - | |  |  | | --- | --- | | Value | Comments | | 1 | Write grid to file (saves as ERSI Ascii grid) | | 0 | No gridI output | |
| *SOLWEIG\_ldown* | - | |  |  | | --- | --- | | Value | Comments | | 1 | use SOLWEIG to estimate Ldown above canyon | | 0 | **NOT ACTIVE** (use SUEWS to estimate Ldown above canyon) | |
| *OutInterval* | min | **Should be 60**. Will change in upcoming versions |
| *RunForGrid* | - | |  |  | | --- | --- | | Value | Comments | | X | Grid that SOLWEIG should be runned for | | -999 | All grids. **This should be used with care**. | |

# Output files

## 5.1 Error Messages: PROBLEMS.TXT

If there are problems with running the programme an error message will be written to **PROBLEMS.TXT**. In most cases the programme will stop after that.

We have a large number of error messages included to try and capture common errors to help the user determine what the probable problem is**. If you encounter an error that does not provide an error message to *Problem.txt* please capture the details so we can hopefully provide better error messages**.

See [Troubleshooting](#_Troubleshooting_1) section for help solving problems.

If the file paths are not correct the program will return an error when run (see How to run the model).

## 5.2 Model output files

SUEWS produces the main output file(***SSss\_YYYY\_tt*.txt**) with time resultion (tt min) defined by the model timestep.

|  |  |  |
| --- | --- | --- |
|  | Column name | Description |
| 1 | iy | Year [YYYY] |
| 2 | id | Day of year [DOY] |
| 3 | it | Hour [H] |
| 4 | imin | Minute [M] |
| 5 | dectime | Decimal time [-] |
| 6 | kdown | Incoming shortwave radiation [W m-2] |
| 7 | kup | Outgoing shortwave radiation [W m-2] |
| 8 | ldown | Incoming longwave radiation [W m-2] |
| 9 | lup | Outgoing longwave radiation [W m-2] |
| 10 | Tsurf | Surface temperature [°C] |
| 11 | qn | Net all-wave radiation [W m-2] |
| 12 | h\_mod | Sensible heat flux (calculated using LUMPS) [W m-2] |
| 13 | e\_mod | Latent heat flux (calculated using LUMPS) [W m-2] |
| 14 | qs | Storage heat flux [W m-2] |
| 15 | qf | Anthropogenic heat flux [W m-2] |
| 16 | qh | Sensible heat flux (SUEWS) [W m-2] |
| 17 | qe | Latent heat flux (SUEWS) [W m-2] |
| 18 | p/i | Rain [mm] |
| 19 | Ie/i | External water use in the study area [mm] |
| 20 | E/i | Evaporation [mm] |
| 21 | Dr/i | Drainage [mm] |
| 22 | St/i | Surface state [mm] |
| 23 | NWSt/i | Land surface state (i.e. Water surface excluded) [mm] |
| 24 | surfCh/i | Change in surface stores [mm] |
| 25 | totCh/i | Change in surface and soil stores [mm] |
| 26 | RO/i | Runoff [mm] |
| 27 | ROsoil/i | Soil runoff (sub-surface) [mm] |
| 28 | ROpipe | Runoff received by pipes [mm] |
| 29 | ROpav | Above ground runoff on paved surfaces [mm] |
| 30 | ROveg | Above ground runoff on vegetation surfaces [mm] |
| 31 | ROwater | Runoff occurring through water body [mm] |
| 32 | AdditionalWater | Water flow received from other grids [mm] |
| 33 | FlowChange | Difference in input and output flows of water body [mm] |
| 34 | WU\_int | Internal water use [mm] |
| 35 | WU\_EveTr | Water use for irrigation of evergreen trees [mm] |
| 36 | WU\_DecTr | Water use for irrigation of deciduous trees [mm] |
| 37 | WU\_Grass | Water use for irrigation of grass [mm] |
| 38 | ra | Aerodynamic resistance [s m-1] |
| 39 | rs | Surface resistance [s m-1] |
| 40 | ustar | Friction velocity [m s-1] |
| 41 | l\_mod | Modelled Obukhov length [m] |
| 42 | fcld | Cloud fraction [tenths] |
| 43 | SoilSt | Soil moisture [mm] |
| 44 | smd | Soil moisture deficit [mm] |
| 45 | SoilSt\_Paved | Soil moisture deficit of paved surfaces [mm] |
| 46 | SoilSt\_Bldgs | Soil moisture deficit of building surfaces [mm] |
| 47 | SoilSt\_EveTr | Soil moisture deficit of evergreen surfaces [mm] |
| 48 | SoilSt\_DecTr | Soil moisture deficit of deciduous surfaces [mm] |
| 49 | SoilSt\_Grass | Soil moisture deficit of grass surfaces [mm] |
| 50 | SoilSt\_BSoil | Soil moisture deficit of bare soil surfaces [mm] |
| 51 | St\_Paved | State of paved surface [mm] |
| 52 | St\_Bldgs | State of building surface [mm] |
| 53 | St\_EveTr | State of evergreen surface [mm] |
| 54 | St\_DecTr | State of deciduous surface [mm] |
| 55 | St\_Grass | State of grass surface [mm] |
| 56 | St\_BSoil | State of bare soil surface [mm] |
| 57 | St\_Water | State of the water body [mm] |
| 58 | LAI | Leaf area index [m2 m-2] |
| 59 | qn1\_sf | Net all-wave radiation for snow-free area [W m-2] |
| 60 | qn1\_s | Net all-wave radiation for snow surface [W m-2] |
| 61 | Qm | Snow related heat exchange [W m-2] |
| 62 | QmFreez | Internal energy change [W m-2] |
| 63 | QmRain | Heat release by rain on snow [W m-2] |
| 64 | SWE | Snow water equivalent [mm] |
| 65 | Mw | Meltwater [mm] |
| 66 | Mwstore | Meltwater store [mm] |
| 67 | SnowRem\_Paved | Snow removal from paved surfaces [mm] |
| 68 | SnowRem\_Bldgs | Snow removal from buildings [mm] |
| 69 | ChSnow/i | Change in snowpack [mm] |
| 70 | albSnow | Snow albedo [-] |
| 71 | *delta\_Qi* | Change of snow internal energy |

## 5.3 SSss\_YYYY\_SnowOut.txt

(not in current relase)

The program prints out a separate output file for snow (*snowUse* = 1 in **runcontrol.nml**)

File format of ***SSss*\_YYYY\_SnowOut.txt**

|  |  |  |  |
| --- | --- | --- | --- |
| Col | Header | Name | Units |
| 1 | *Year* | Year of run |  |
| 2 | *Doy* | Day of year |  |
| 3 | *It* | Time |  |
| 4 | *Dectime* | Decimal time |  |
| 5 | *SWE\_pav* | Snow water equivalent – paved | mm |
| 6 | *SWE\_bldgs* | Snow water equivalent – buildings | mm |
| 7 | *SWE\_EveTr* | Snow water equivalent – evergreen | mm |
| 8 | *SWE\_DecTr* | Snow water equivalent – deciduous | mm |
| 9 | *SWE\_Grass* | Snow water equivalent – irrigated grass | mm |
| 10 | *SWE\_BSoil* | Snow water equivalent – unirrigated grass | mm |
| 11 | *SWE\_wtr* | Snow water equivalent – water surface | mm |
| 12 | *Mw\_pav* | Meltwater – paved | mm h-1 |
| 13 | *Mw\_bldgs* | Meltwater – buildings | mm h-1 |
| 14 | *Mw\_EveTr* | Meltwater – evergreen | mm h-1 |
| 15 | *Mw\_DecTr* | Meltwater – deciduous | mm h-1 |
| 16 | *Mw\_Grass* | Meltwater – irrigated grass | mm h-1 |
| 17 | *Mw\_BSoil* | Meltwater – unirrigated grass | mm h-1 |
| 18 | *Mw\_wtr* | Meltwater – water surface | mm h-1 |
| 19 | *Qm\_pav* | Snowmelt related heat – paved | W m-2 |
| 20 | *Qm\_bldgs* | Snowmelt related heat – buildings | W m-2 |
| 21 | *Qm\_EveTr* | Snowmelt related heat – evergreen | W m-2 |
| 22 | *Qm\_DecTt* | Snowmelt related heat – deciduous | W m-2 |
| 23 | *Qm\_Grass* | Snowmelt related heat – irrigated grass | W m-2 |
| 24 | *Qm\_BSoil* | Snowmelt related heat – unirrigated grass | W m-2 |
| 25 | *Qm\_wtr* | Snowmelt related heat – water surface | W m-2 |
| 26 | *Qa\_pav* | Advective heat – paved | W m-2 |
| 27 | *Qa\_bldgs* | Advective heat – buildings | W m-2 |
| 28 | *Qa\_EveTr* | Advective heat – evergreen | W m-2 |
| 29 | *Qa\_DecTr* | Advective heat – deciduous | W m-2 |
| 30 | *Qa\_Grass* | Advective heat – irrigated grass | W m-2 |
| 31 | *Qa\_BSoil* | Advective heat – unirrigated grass | W m-2 |
| 32 | *Qa \_wtr* | Advective heat – water surface | W m-2 |
| 33 | *QmFr\_pav* | Heat related to freezing of surface store – paved | W m-2 |
| 34 | *QmFr\_bldgs* | Heat related to freezing of surface store – buildings | W m-2 |
| 35 | *QmFr\_EveTr* | Heat related to freezing of surface store – evergreen | W m-2 |
| 36 | *QmFr\_DecTr* | Heat related to freezing of surface store – deciduous | W m-2 |
| 37 | *QmFr\_Grass* | Heat related to freezing of surface store – irrigated grass | W m-2 |
| 38 | *QmFr\_BSoil* | Heat related to freezing of surface store – unirrigated grass | W m-2 |
| 39 | *QmFr\_wtr* | Heat related to freezing of surface store – water | W m-2 |
| 40 | *fr\_pav* | Fraction of snow – paved | - |
| 41 | *fr\_bldgs* | Fraction of snow – buildings | - |
| 42 | *fr\_EveTr* | Fraction of snow – evergreen | - |
| 43 | *fr\_DecTr* | Fraction of snow – deciduous | - |
| 44 | *fr\_Grass* | Fraction of snow – irrigated grass | - |
| 45 | *fr\_BSoil* | Fraction of snow – unirrigated grass | - |
| 46 | *RainSn\_pav* | Rain on snow – paved | mm |
| 47 | *RainSn\_bldgs* | Rain on snow – buildings | mm |
| 48 | *RainSn\_EveTr* | Rain on snow – evergreen | mm |
| 49 | *RainSn\_DecTr* | Rain on snow – deciduous | mm |
| 50 | *RainSn\_Grass* | Rain on snow – irrigated grass | mm |
| 51 | *RainSn\_BSoil* | Rain on snow – unirrigated grass | mm |
| 52 | *RainSn\_wtr* | Rain on snow – water surface | mm |
| 53 | *qn\_pavSnow* | Net all-wave radiation – paved | W m-2 |
| 54 | *qn\_blgsSnow* | Net all-wave radiation – buildings | W m-2 |
| 55 | *qn\_EveTrSnow* | Net all-wave radiation – evergreen | W m-2 |
| 56 | *qn\_DecTrSnow* | Net all-wave radiation – deciduous | W m-2 |
| 57 | *qn\_GrassSnow* | Net all-wave radiation – irrigated grass | W m-2 |
| 58 | *qn\_BSoilSnow* | Net all-wave radiation – unirrigated grass | W m-2 |
| 59 | *qn\_wtrSnow* | Net all-wave radiation – water body | W m-2 |
| 60 | *kup\_pav* | Reflected shortwave radiation – paved | W m-2 |
| 61 | *kup\_blgs* | Reflected shortwave radiation – buildings | W m-2 |
| 62 | *kup\_EveTtSnow* | Reflected shortwave radiation – evergreen | W m-2 |
| 63 | *kup\_DecTrSnow* | Reflected shortwave radiation – deciduous | W m-2 |
| 64 | *kup\_GrassSnow* | Reflected shortwave radiation – irrigated grass | W m-2 |
| 65 | *kup\_BSoilSnow* | Reflected shortwave radiation – unirrigated grass | W m-2 |
| 66 | *kup\_wtrSnow* | Reflected shortwave radiation – water body | W m-2 |
| 67 | *frMelt\_pav* | Amount of freezing melt water – paved | mm |
| 68 | *frMelt\_bldgs* | Amount of freezing melt water – buildings | mm |
| 69 | *frMelt\_EveTr* | Amount of freezing melt water – evergreen | mm |
| 70 | *frMelt\_DecTr* | Amount of freezing melt water – deciduous | mm |
| 71 | *frMelt\_Grass* | Amount of freezing melt water – irrigated grass | mm |
| 72 | *frMeltBSoil* | Amount of freezing melt water – unirrigated grass | mm |
| 73 | *frMelt\_wtr* | Amount of freezing melt water – water | mm |
| 74 | *MwStore\_pav* | Melt water store – paved | mm |
| 75 | *MwStore\_bldgs* | Melt water store – buildings | mm |
| 76 | *MwStore\_EveTr* | Melt water store – evergreen | mm |
| 77 | *MwStore\_DecTr* | Melt water store – deciduous | mm |
| 78 | *MwStore\_Grass* | Melt water store – irrigated grass | mm |
| 79 | *MwStore\_BSoil* | Melt water store – unirrigated grass | mm |
| 80 | *MwStore\_wtr* | Melt water store – water | mm |
| 81 | *densSnow\_pav* | Snow density – paved | kg m-3 |
| 82 | *densSnow\_bldgs* | Snow density – buildings | kg m-3 |
| 83 | *densSnow\_EveTr* | Snow density – evergreen | kg m-3 |
| 84 | *densSnow\_DecTr* | Snow density – deciduous | kg m-3 |
| 85 | *densSnow\_Grass* | Snow density – irrigated grass | kg m-3 |
| 86 | *densSnow\_BSoil* | Snow density – unrrigated grass | kg m-3 |
| 87 | *densSnow\_wtr* | Snow density – water | kg m-3 |
| 88 | *Sd\_pav* | Snow depth – paved | mm |
| 89 | *Sd\_bldgs* | Snow depth – buildings | mm |
| 90 | *Sd\_EveTr* | Snow depth – evergreen | mm |
| 91 | *Sd\_DecTr* | Snow depth – deciduous | mm |
| 92 | *Sd\_Grass* | Snow depth – irrigated grass | mm |
| 93 | *Sd\_BSoil* | Snow depth – unirrigated grass | mm |
| 94 | *Sd\_wtr* | Snow depth – water body | mm |
| 95 | *Tsnow\_pav* | Snow surface temperature – paved | °C |
| 96 | *Tsnow\_bldgs* | Snow surface temperature – buildings | °C |
| 97 | *Tsnow\_EveTt* | Snow surface temperature – evergreen | °C |
| 98 | *Tsnow\_DecTr* | Snow surface temperature – deciduous | °C |
| 99 | *Tsnow\_Grass* | Snow surface temperature – Irrigated grass | °C |
| 100 | *Tsnow\_BSoil* | Snow surface temperature – unirrigated grass | °C |
| 101 | *Tsnow\_wtr* | Snow surface temperature – water body | °C |

## SSss\_DailyState.txt

Contains information about the state of the surface and soil parameters at a time resolution of one day.

|  |  |  |
| --- | --- | --- |
|  | Column name | Description |
| 1 | iy | Year [YYYY] |
| 2 | id | Day of year [DOY] |
| 3 | HDD1\_h | Heating degree days [°C] |
| 4 | HDD2\_c | Cooling degree days [°C] |
| 5 | HDD3\_Tmean | Average daily air temperature [°C] |
| 6 | HDT4\_T5d | 5-day running-mean air temperature [°C] |
| 7 | P/day | Daily total precipitation [mm] |
| 8 | DaysSR | Days since rain [days] |
| 9 | GDD1\_g | Growing degree days for leaf growth [°C] |
| 10 | GDD2\_s | Growing degree days for senescence [°C] |
| 11 | GDD3\_Tmin | Daily minimum temperature [°C] |
| 12 | GDD4\_Tmax | Daily maximum temperature [°C] |
| 13 | GDD5\_DayLHrs | Day length [h] |
| 14 | LAI\_EveTr | Leaf area index of evergreen trees [m2 m-2] |
| 15 | LAI\_DecTr | Leaf area index of deciduous trees [m2 m-2] |
| 16 | LAI\_Grass | Leaf area index of grass [m2 m-2] |
| 17 | DecidCap | Storage capacity of deciduous trees [mm] |
| 18 | Porosity | Porosity of deciduous trees [-] |
| 19 | AlbDec | Albedo of deciduous trees [-] |
| 20 | WU\_EveTr(1) | Total water use for evergreen trees [mm] |
| 21 | WU\_EveTr(2) | Automatic water use for evergreen trees [mm] |
| 22 | WU\_EveTr(3) | Manual water use for evergreen trees [mm] |
| 23 | WU\_DecTr(1) | Total water use for deciduous trees [mm] |
| 24 | WU\_DecTr(2) | Automatic water use for deciduous trees [mm] |
| 25 | WU\_DecTr(3) | Manual water use for deciduous trees [mm] |
| 26 | WU\_Grass(1) | Total water use for grass [mm] |
| 27 | WU\_Grass(2) | Automatic water use for grass [mm] |
| 28 | WU\_Grass(3) | Manual water use for grass [mm] |
| 29 | deltaLAI | Change in leaf area index (normalised 0-1) [-] |
| 30 | LAIlumps | Leaf area index used in LUMPS (normalised 0-1) [-] |
| 31 | albSnow | Snow albedo [-] |
| 32 | *dens\_snow\_pav* | Snow density in paved surface |
| 33 | *dens\_snow\_bldg* | Snow density in building surface |
| 34 | *dens\_snow\_EveTr* | Snow density in evergreen surface |
| 35 | *dens\_snow\_DecTr* | Snow density in deciduous surface |
| 36 | *dens\_snow\_Grass* | Snow density in grass surface |
| 37 | *dens\_snow\_Sbare* | Snow density in bare soil |
| 38 | *dens\_snow\_wtr* | Snow density in water surface |

## SSss\_YYYY\_BL.txt

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

CBL model output file format**:SSss\_YYYY\_BL.txt**

|  |  |  |  |
| --- | --- | --- | --- |
| Col | Header | Name | Units |
| 1 | *iy* | Year [YYYY] |  |
| 2 | *id* | Day of year [DoY] |  |
| 3 | *it* | Hour [H] |  |
| 4 | *imin* | Minute [M] |  |
| 5 | *dectime* | Decimal time [-] |  |
| 6 | *zi* | Convectibe boundary layer height | m |
| 7 | *Theta* | Potential temperature in the inertial sublayer | K |
| 8 | *Q* | Specific humidity in the inertial sublayer | g kg-1 |
| 9 | *theta+* | Potential temperature just above the CBL | K |
| 10 | *q+* | Specific humidity just above the CBL | g kg-1 |
| 11 | *Temp\_C* | Air temperature | °C |
| 12 | *RH* | Relative humidity | % |
| 13 | *QH\_use* | Sensible heat flux used for calculation | W m-2 |
| 14 | *QE\_use* | Latent heat flux used for calculation | W m-2 |
| 15 | *Press\_hPa* | Pressure used for calculation | hPa |
| 16 | *avu1* | Wind speed used for calculation | m s-1 |
| 17 | *ustar* | Friction velocity used for calculation | m s-1 |
| 18 | *avdens* | Air density used for calculation | kg m-3 |
| 19 | *lv\_J\_kg* | Latent heat of vaporization used for calculation | J kg-1 |
| 20 | *avcp* | Specific heat capacity used for calculation | J kg-1 K-1 |
| 21 | *gamt* | Vertical gradient of potential temperature | K m-1 |
| 22 | *gamq* | Vertical gradient of specific humidity | kg kg-1 m-1 |

## SOLWEIGpoiOut.txt

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

SOLWEIG model output file format: ***SOLWEIGpoiOUT*.txt**

|  |  |  |  |
| --- | --- | --- | --- |
| Col | Header | Name | Units |
| 1 | *id* | Day of year |  |
| 2 | *dectime* | Decimal time |  |
| 3 | *azimuth* | Azimuth angle of the Sun | ° |
| 4 | *altitude* | Altitude angle of the Sun | ° |
| 5 | *GlobalRad* | Input Kdn | W m-2 |
| 6 | *DiffuseRad* | Diffuse shortwave radiation | W m-2 |
| 7 | *DirectRad* | Direct shortwave radiation | W m-2 |
| 8 | *Kdown2d* | Incoming shortwave radiation at POI | W m-2 |
| 9 | *Kup2d* | Outgoing shortwave radiation at POI | W m-2 |
| 10 | *Ksouth* | Shortwave radiation from south at POI | W m-2 |
| 11 | *Kwest* | Shortwave radiation from west at POI | W m-2 |
| 12 | *Knorth* | Shortwave radiation from north at POI | W m-2 |
| 13 | *Keast* | Shortwave radiation from east at POI | W m-2 |
| 14 | *Ldown2d* | Incoming longwave radiation at POI | W m-2 |
| 15 | *Lup2d* | Outgoing longwave radiation at POI | W m-2 |
| 16 | *Lsouth* | Longwave radiation from south at POI | W m-2 |
| 17 | *Lwest* | Longwave radiation from west at POI | W m-2 |
| 18 | *Lnorth* | Longwave radiation from north at POI | W m-2 |
| 19 | *Least* | Longwave radiation from east at POI | W m-2 |
| 20 | *Tmrt* | Mean Radiant Temperature | °C |
| 21 | *I0* | theoretical value of maximum incoming solar radiation | W m-2 |
| 22 | *CI* | clearness index for Ldown (Lindberg et al. 2008) |  |
| 23 | *gvf* | Ground view factor (Lindberg and Grimmond 2011) |  |
| 24 | *shadow* | Shadow value (0= shadow, 1 = sun) |  |
| 25 | *svf* | Sky View Factor from ground and buildings |  |
| 26 | *svfbuveg* | Sky View Factor from ground, buildings and vegetation |  |
| 27 | *Ta* | Air temperature | °C |
| 28 | *Tg* | Surface temperature | °C |

# Troubleshooting

|  |  |
| --- | --- |
|  | How to create a directory please search the web using this phrase if you do not know how to create a folder or directory |
|  | How **to unzip a file** - please search the web using this phrase if you do not know how to unzip a file |
|  | A **Text editor** is a program to edit plain text files. If you search on the web using the phrase ‘text editor’ you will find numerous programs. These include for example, NotePad, EditPad, Text Pad etc |
|  | **Command prompt**: From Start select run –type cmd – this will open a window. Change directory to the location of where you stored your files. The following website may be helpful if you do not know what a command prompt is: <http://dosprompt.info/> |
|  | SUEWSV2015a.exe - this is the actual program  The program is now run using the wrapper version as this prepares the data for the model (more capabilities for this will come with the next version |
|  | Website: <http://LondonClimate.info>  http://www.met.reading.ac.uk/micromet/ |
|  | **Day of year** – 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. Note remember that in a Leap year the days will be different after February 28th. |
|  | Check the **PROBLEMS.TXT** file (see section 5.1 and this section) |
|  | 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 supplied version. |
|  | Check file options – in **RunControl.nml** (see section 4.1) |
|  | 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 quote’s around the FileInputPath, FileOutputPath and FileCode |
|  | How should I **setup** my filenames if I want to run only **one time period for one area**  Example: If your forcing data are for 2005 and your site identification code is Ab01  ModelledYears.txt  1 !Number of modelled years/time periods  2005  GridConnections2005.txt  2 !Number of grid connections listed below  'Ab01\_2005' 0 'none'  !From fraction To  The rest of the input files for this location should be   |  |  |  | | --- | --- | --- | | HeaderInputAb01\_2005.nml  SUEWSInputAb01\_2005.nml  CanopyMoistureInputAb01\_2005.nml  WaterUseProfileAb01\_2005.txt | Ab01\_2005.gis  Ab01\_2005.ohm  Ab01\_2005sahp.nml   |  | | --- | | Ab01\_2005\_data.txt | | |
| |  |  |  | | --- | --- | --- | | 13 | “*%sat\_vap\_press.f temp=0.0000 pressure dectime*” | Temperature is zero and in calculation of water vapour pressure parameterization is used. You don’t need to worry if the temperature should be 0°C. If it should not be 0°C this suggests that there is a problem with the data. | | 14 | %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. | | *17* | *“Reference to undefined variable, array element or function result”* | Parameter(s) missing from Input files. See also the error messages provided in **Problems.txt** | | |

Old Error Messages (the following should no longer occur)

|  |  |  |
| --- | --- | --- |
| ***18*** | *Program received signal SIGSEGV: Segmentation fault - invalid memory reference.*  *Backtrace for this error:*  *#0 0x1017c2f92*  *#1 0x1017c375e*  *#2 0x7fff9438a909*  *#3 0x1011ecf04*  *#4 0x1011e3dcb*  *#5 0x1011b2223*  *#6 0x1011b22cb*  *Segmentation fault: 11* | This message appears if you try to run more years and grids that your computer is able to with the 5 minute output file. In this case, you set write5min = 0 in the RunControl.nml. |
| ***15*** | *“salflibc.dll is either not designed to run on Windows or it contains an error. Contact your system administrator or the software vendor for support.”* | In this situation, your computer does not support the type of dll file and you are advised to download the Silverfrost compiler from the internet for free (http://www.silverfrost.com/32/ftn95/ftn95\_personal\_edition.aspx) |
| ***16*** | *Salford run-time library.*  *Insufficient memory available for CHECK mode. Fatal run-time error* | In this situation, your computer does not support the type of dll file and you are advised to download the Silverfrost compiler from the internet for free (<http://www.silverfrost.com/32/ftn95/ftn95_personal_edition.aspx>)  *(this should no longer be an issue)* |
| ***19*** | *Problems with the example files* | If you are having a problem with example files (e.g on an Apple computer) – you may need to enter an extra line in the \*.gis file |

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Current contributors:

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Past Contributors:

Dr Brian Offerle (previously Indiana University, USA; now FluxSense Sweden)

Dr Thomas Loridan (King’s College London, now RMS London)

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# Appendix A: Coding Guidelines

If you are interested in contributing to the code please contact Sue Grimmond.

1. Code written in Fortran – currently Fortran 95
2. Variables
   1. Names should be defined at least in one place in the code – ideally when defined
   2. Implicit None should be used in all subroutines
   3. Variable name should include units. e.g. Temp\_C, Temp\_K
3. Code should be written generally
4. Data set for testing should be provided
5. Demonstration that the model performance has improved when new code has been added or that any deterioration is warranted.
6. Additional requirements for modelling need to be indicated in the manual
7. All code should be commented in the program (with initials of who made the changes – name specified somewhere and institution)
8. The references used in the code and in the equations will be collected to a webpage
9. Current developments that are being actively worked on

|  |  |  |
| --- | --- | --- |
| **Topic** | **Status** | **Lead** |
| Snow | Completed | Univ Helsinki |
| Convective boundary layer development | Active | Göteborg Univ |
| Mean radiant temperature model | Active | Göteborg Univ |
|  |  |  |

# Appendix B: Version History

|  |
| --- |
| **New in SUEWS Version 2014b (released 8 October 2014)** |
| These affect the run configuration if previously run with older versions of the model:   1. New input of three additional columns in the Meteorological input file (diffusive and direct solar radiation, and wind direction) 2. Change of input variables in InitialConditions.nml file. Note we now refer to CT as ET (ie. Evergreen trees rather than coniferous trees) 3. In GridConnectionsYYYY.txt, the site names should now be without the underscore (e.g “Sm” and not “Sm\_”)   Other issues:   1. Number of grid areas that can be modelled (for one grid, one year 120; for one grid two years 80) 2. Comment about Time interval of input data 3. Bug fix: Column headers corrected in 5 min file 4. Bug fix: Surface state 60 min file - corrected to give the last 5 min of the hour (rather than cumulating through the hour) 5. Bug fix: units in the Horizontal soil water transfer 6. ErrorHints: More have been added to the problems.txt file. 7. Manual: new section on running the model appropriately 8. Manual: notation table updated 9. **Possibility to add snow accumulation and melt**: new paper   Järvi L, Grimmond CSB, Taka M, Nordbo A, Setälä H, and Strachan IB 2014: Development of the Surface Urban Energy and Water balance Scheme (SUEWS) for cold climate cities, *Geosci. Model Dev*. 7, 1691-1711, doi:10.5194/gmd-7-1691-2014. |
| **New in SUEWS Version 2014a.1 (released February 26, 2014)** |
| 1. Please see the large number of changes made in the 2014a release in Appendix C 2. This is a minor change to address installing the software. 3. Minor updates to the manual |
| **New in SUEWS Version 2014a (released 21 Feb 2014)** |
| 1. Bug fix: External **irrigation** is calculated as combined from automatic and manual irrigation and during precipitation events the manual irrigation is reduced to 60% of the calculated values. In previous version of the model, the irrigation was in all cases taken 60% of the calculated value, but now this has been fixed. 2. In previous versions of the model, **irrigation** was only allowed on the irrigated grass surface type. Now, irrigation is also allowed on evergreen and deciduous trees/shrubs surfaces. These are not however treated as separate surfaces, but the amount of irrigation is evenly distributed to the whole surface type in the modelled area. The amount of water is calculated using same equation as for grass surface (equation 5 in Järvi et al. 2011), and the fraction of irrigated trees/shrubs (relative to the area of tree/shrubs surface) is set in the gis file (See **Table 4.11: *SSss\_YYYY*.gis**) 3. In the current version of the model, the user is able to adjust the leaf-on and leaf-off lengths in the FunctionalTypes. nml file. In addition, user can choose whether to use temperature dependent functions or combination of temperature and day length (advised to be used at high-latitudes) 4. In the gis-file, there is a new variable **Alt** that is the area altitude above sea level. If not known exactly use an approximate value. 5. Snow removal profile has been added to the HourlyProfile*SSss*\_*YYYY*.txt. Not yet used! 6. Model time interval has been changed from minutes to seconds. Preferred interval is 3600 seconds (1 hour) 7. Manual correction: input variable Soil moisture said soil moisture deficit in the manual – word removed 8. Multiple compiled versions of SUEWS released. There are now users in Apple, Linux and Windows environments. So we will now release compiled versions for more operating systems (section 3). 9. There are some changes in the output file columns so please, check the respective table of each used output file. 10. Bug fix: with very small amount of vegetation in an area – impacted Phenology for LUMPS |
| **New in SUEWS Version 2013a** |
| 1. Radiation selection bug fixed 2. Aerodynamic resistance – when very low - no longer reverts to neutral (which caused a large jump) – but stays low 3. Irrigation day of week fixed 4. New error messages   5 min file – now includes a decimal time column – see Section 5.4 – Table 5.3 |
| **New in SUEWS Version 2012b** |
| 1. Error message generated if all the data are not available for the surface resistance calculations 2. Error message generated if wind data are below zero plane displacement height. 3. All error messages now written to ‘Problem.txt’ rather than embedded in an ErrorFile. Note some errors will be written and the program will continue others will stop the program. 4. Default variables removed (see below). Model will stop if any data are problematic. File should be checked to ensure that reasonable data are being used. If an error occurs when there should not be one let us know as it may mean we have made the limits too restrictive.  |  |  | | --- | --- | | Contents no longer used | File | | defaultFcld=0.1  defaultPres=1013  defaultRH=50  defaultT=10  defaultU=3 | RunControl.nml   * Just delete lines from file * Values you had were likely different from these example value shown here | |
| **New in SUEWS Version 2012a** |
| 1. Improved error messages when an error is encountered. Error message will generally be written to the screen and to the file ‘problems.txt’ 2. **Format of all input files have changed**. 3. New excel spreadsheet and R programme to help prepare required data files. (Not required) 4. Format of coef flux (OHM) input files have changed.    1. This allows for clearer identification for users of the coefficients that are actually to be used    2. 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. This file replaces the content of Appendix B1 5. Storage heat flux (OHM) coefficients can be changed by    1. time of year (summer, winter)    2. surface wetness state 6. New files are written: DailyState.txt    1. 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    1. Clarification of surface types has been made. See GIS and OHM related files |
| **New in SUEWS Version2011b** |
| 1. Storage heat flux (Δ*Qs*) 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    1. *HydraulicConduct*    2. *GrassFractionIrrigated*    3. *PavedFractionIrrigated*    4. *TreeFractionIrrigated*   The lower three are now determined from the water use behaviour used in SUEWS   1. Following added to HeaderInput.nml    1. *SatHydraulicConduct*    2. *defaultQf*    3. *defaultQs* 2. If Δ*Qs* and *QF* are not calculated in the model but are given as an input, the missing data is replaced with the default values. 3. Added to SAHP input file    1. AHDIUPRF – diurnal profile used if *AnthropHeatChoice* = 1 |
| **V2012a** this became obsolete OHM file (SSss\_YYYY.ohm)  The OHM file contains information on how the different surface types are taken into account in the calculation of net storage heat flux. That is what values should be used for the parameters in the OHM equation5,6. The possible choices (Table 4.7 old) are followed by examples of OHM files.  Table 4.7-old: Description of choices in ***SSss\_YYYY*.ohm** file   |  |  |  | | --- | --- | --- | | Statement | Choice options | Comment | | Are canyons included | [1] Yes  [2] No |  | | Calculation of the coefficients for canyons | [2] Mean  [3] Yoshida *et al.* (1990, 1991) – E-W canyon  [4] Nunez (1974) – N-S canyon | Line added in the ohm-file only if **YES** was chosen on the previous line | | Vegetation is calculated | [1] one  [2] separated to grass/trees & shrubs/water |  | | Calculation of the coefficients for vegetation | [1] Mean  [2] Mixed forest – McCaughey (1985)  [3] Short grass -- Doll *et al.* (1985)  [4] Bare soil -- Novak (1982)  [5] Bare soil (wet) -- Fuchs & Hadas (1972)  [6] Bare soil (dry) -- Fuchs & Hadas (1972)  [7] Bare soil -- Asaeda & Ca (1993)  [8] Water Shallow - Turbid -- Souch *et al.*(1998) | If option [1] is **NOT** used, put as many choices in the following rows as you want to take into account and add zero when finished | | Calculation of the coefficients for roof | [1] Mean of all  [2] Tar and gravel -- Yap (1973)  [3] Taseler (1980)  [4] Yoshida et al. (1990, 1991)  [5] Average gravel/tar/conc. flat industrial -- Meyn (2000)  [6] Dry -- gravel/tar/conc. flat industrial -- Meyn (2000)  [7] Wet -- gravel/tar/conc. flat industrial -- Meyn (2000)  [8] Bitumen spread over flat industrial membrane -- Meyn (2000)  [9] Asphalt shingle on plywood residential roof – Meyn (2000)  [10] Star - high albedo asphalt shingle residential roof -- Meyn (2000)  [11] Star - Ceramic Tile -- Meyn (2000)  [12] Star - Slate Tile -- Meyn (2000) | If option [1] is **NOT** used, put as many choices in the following rows as you want to take into account and add zero when finished | | Impervious areas are calculated as | [1] one  [2] separated to concrete & asphalt |  | | Calculation of the coefficients for impervious areas | [1] Mean  [2] Concrete – Doll *et al.* (1985)  [3] Concrete -- Asaeda & Ca (1993)  [4] Asphalt – Narita et al. (1984)  [5] Asphalt -- Asaeda & Ca (1993)  [6] Asphalt – Anandakumar (1999)  [7] Asphalt (winter) – Anandakumar (1999)  [8] Asphalt (summer) – Anandakumar (1999) | If option [1] is **NOT** used, put as many choices in the following rows as you want to take into account and add zero when finished |   The **Ln*3004\_2008*.ohm** file contained within the example dataset has the following structure.  % # Ln08.ohm  % 2 Canyons included: [1] Y [2] N  % 2 Vegetation as one [1] Y [2] Separate grass/trees&shrubs/water  % 3 Vegetation: [3] Short grass -- Doll *et al.* (1985)  % 4 [4] Bare soil -- Novak (1982)  % 0  % 1 Roof: [1] Mean of all  % 2 Impervious as one [1] Y [2] Concrete & asphalt separate  % 2 Impervious surface: [2] Concrete – Doll *et al.* (1985)  % 4 [4] Asphalt – Narita et al. (1984)  % 0 |

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| Appendix C: 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 (Δ*Q*S) | Input or from OHM | Input or from OHM | | Anthropogenic heat flux (*Q*F) | Input or calculated | Input or calculated | | Latent heat (*Q*E) | [DeBruin and Holtslag (1982](#DBH82))[[3]](#footnote-3) | Penman-Monteith equation2 | | Sensible heat flux (*Q*H) | [DeBruin and Holtslag (1982)](#DBH82) | Residual from available energy minus *QE* | | Water balance | No water balance included | Running water balance of canopy and water balance of soil | | Soil moisture | Not considered | Modelled | | Surface wetness | Simple water bucket model | Running water balance | | Irrigation | Only fraction of surface area that is irrigated | Input or calculated with a simple model | | Surface cover | buildings, paved, vegetation | buildings, paved, coniferous and deciduous trees/shrubs, irrigated and unirrigated grass | |
| **FRAISE Flux Ratio – Active Index Surface Exchange** |
| FRAISE provides an estimate of mean midday (±3 h around solar noon) energy partitioning from information on the surface characteristics and estimates of the mean midday incoming radiative energy and anthropogenic heat release. Please refer to Loridan and Grimmond (2012)[[4]](#footnote-4) for further details.   |  | | --- | | * Complexity:   + Simplest: FRAISE     - LUMPS   + More complex: SUEWS | | * Software provided:   + FRAISE: R code   + LUMPS: Windows exe (written in Fortran)   + SUEWS: Windows exe (written in Fortran) | | * Applicable period:   + FRAISE:Midday (within 3 h of solar noon)   + LUMPS:hourly   + SUEWS: 5min-hourly-annual | | * Unique features:   + FRAISE: calculates active surface – and fluxes   + LUMPS: radiation and energy balances   + SUEWS: radiation, energy and water balance (includes LUMPS) | |

# Appendix D: Past version of files

See previous manuals for details.

# Appendix E: Recommended details to record when gathering input data

The following table can be used to record the availability of input data and aid completion of the input files needed for the model. See Sections above for details about files.

As an example for London:

|  |  |  |  |
| --- | --- | --- | --- |
| Information required to run SUEWS | How is this information provided to SUEWS?  File | Column no. | Information source and details (time, spatial extent). Include potentially useful datasets if information is not available directly. | What must be assumed? Are there potential problems? Are there restrictions on the data use (e.g. licensing)? |
| Surface cover fractions (Paved, Built, EveTr, DecTr, Grass, BSoil, Water) | SiteSelect.txt | 12-18 | Data source: Neighbourhood Statistics ([www.neighbourhood.statistics.gov.uk/dissemination/](http://www.neighbourhood.statistics.gov.uk/dissemination/))  2011 Statistical Geography Hierarchy, based on Generalised Land Use Database 2005 (2001 also available). Data for each borough.  Area of Domestic Buildings, Non-domestic Buildings, Road, Path, Rail, Domestic Gardens, Greenspace, Water, Other Land Uses, Unclassified Land. (*LandUse2005\_Boroughs\_StatGeogHierarchy2011.csv*) | Surface cover categories provided are not the same as those required for SUEWS, so other information or assumptions are required.  20% land cover in London is trees (GLA, Connecting Londoners with Trees and Woodlands, *LondonTrees\_ltwf\_highlights.pdf*).  Surface cover within gardens (GLA, London: Garden City? *LondonGardenCity.pdf*)  Assume 1/5 trees are evergreen; 4/5 are deciduous (no real basis for this assumption). |

# Appendix F: Information if you are not using the Windows Setup file

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| --- | --- | --- | --- |
| **Operating System** | **Version** | **Compiled with** | **Comments** |
| Windows 8  Windows 7 | 64 bit | gfortran | *A Setup file is provided that will put the manual in a third sub-directory. When you initiate the setup you can select what directory the program is installed into. The setup process also add shortcuts to the manual etc. to the start-menu.* |
| Apple | 10.8.5 | gfortran | *This will require some dll files. Please contact us. The manual does not at this stage provide the simple instructions that are relevant for iOS. If you intend to use this and need initial help (e.g. with creating directories etc.) let us know and we will update the manual with these details. The models specific information otherwise applies.* |
| Linux |  |  | [Please contact us](#_Contact_Information) |
| Manual setup |  | Gfortran  **SilverFrost** | *Create a Main site* [*directory*](#_Troubleshooting) *and locate SUEWS\_V2015a*[*.exe*](#exe) *in that directory*  *Create two subdirectories: a) Input and b) Output*  Dynamic link library (dll) files  Depending on the version selected the following are required to run the executable (library files need to be in a path that can be found by the programme).Note that the current window release version you should not need to worry about this as it is included in the install.   |  |  | | --- | --- | | **Windows 7 gFortran** | **Windows SilverFrost** | | cyggcc\_s-seh-1.dll  cyggfortran-3.dll  cygquadmath-0.dll  cygwin1.dll | salflibc.dll  OR you need to install SilverFrost  If you have installed SilverFrost – it will find the **salflibc.dll** file. You do not need to worry where you locate it or copy it each time to the directories you are using. | |

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| --- | --- |
| Manual setup | *After you have* [***unzipped***](#_Troubleshooting) *the SUEWS file you should save the files in the same locations as indicated* |
| Required files | ***Example files*** are provided with the compiled version of the SUEWS (available for download from the [website](#website)London Climate Urban Micromet Webpage). The zip file has the required input data files and example output files (Section 5). Additionally this manual is available for download (**SUEWS\_Manual.pdf)**   |  |  |  |  | | --- | --- | --- | --- | |  | Site | Year | Use | | Sm\_2011 | Helsinki | 2011 | General SUEWS or LUMPS runs, new snow module | | Sc91 | Sacramento | 1991 | [BLUEWS](#Bluews)  - CBL runs *(not this release*) |   The files provided should be in three directories Assuming the site name *SSss*\_ and year *YYYY*, and one area only.   |  |  |  | | --- | --- | --- | | Site Directory | Input | Output | | RunControl.nml | ***SSss*\_*YYYY*\_data\_tt.txt(\*)** | Needs to be created - will be empty to begin with | | SUEWS\_V2015a.[exe](#exe) | **InitialConditions*SSss*\_*YYYY*.nml[[5]](#footnote-5)** |  | | [see table below (dll)](#dll) |  |  | | Input (directory) | SUEWS\_AnthropogenicHeat.txt |  | |  | SUEWS\_Conductance.txt |  | |  | SUEWS\_NonVeg.txt |  | |  | SUEWS\_Irrigation.txt |  | |  | SUEWS\_OHMCoefficients.txt |  | |  | SUEWS\_Veg.txt |  | |  | SUEWS\_Profiles.txt |  | |  | SUEWS\_SiteSelect.txt |  | |  | SUEWS\_Snow.txt |  | |  | SUEWS\_Soil.txt |  | |  | SUEWS\_Water.txt |  | |  | SUEWS\_WithinGridWaterDist.txt |  | |  |  |  | | Output (directory) |  |  | |  | (CBLInput.nml) |  | |  | (CBLinputfiles (directory)) |  |   (\*) – One file for each year and grid  Underscore – specified (or not) |

1. There is a second file **InitialConditions*SSss*\_*YYYY\_end*.nml** or **InitialConditions*SSss*\_*YYYY+1*.nml** in the input directory. At the end of the run, and at the end of each year of the run, the state is written out so that this information could be used to initialize further model runs. [↑](#footnote-ref-1)
2. 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. [↑](#footnote-ref-2)
3. de Bruin H.A.R. & Holtslag A.A.M. (1982). A simple parameterization of surface ﬂuxes of sensible and latent heat during daytime compared with the Penman–Monteith concept. *J. Appl. Meteor.*, 21, 1610–1621. [↑](#footnote-ref-3)
4. **Loridan T** & **CSB Grimmond** (2012) Characterization of energy flux partitioning in urban environments: links with surface seasonal properties Journal of Applied Meteorology and Climatology 51, 219-241 doi: 10.1175/JAMC-D-11-038.1 [↑](#footnote-ref-4)
5. There is a second file **InitialConditions*SSss*\_*YYYY\_end*.nml** or **InitialConditions*SSss*\_*YYYY+1*.nml** in the input directory. At the end of the run, and at the end of each year of the run, the state is written out so that this information could be used to initialize further model runs. [↑](#footnote-ref-5)