SUEWS Manual: Version 2016a

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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.

1 Introduction

Surface **U**rban **E**nergy and **W**ater Balance **S**cheme (SUEWS) (Järvi et al. 2011) 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), 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 is allowed. The user can specify the model timestep, but 5 min is strongly recommended. The main output file is provided at a resolution of 60 min by default. Timestamps refer to the end of the averaging period. The model provides the radiation and energy balance components, surface and soil wetness, surface and soil runoff and the drainage for each surface (see section 5).

The following sub-models are used within SUEWS:

1. NARP (*Net All-wave Radiation Parameterization,* Offerle et al. 2003, Loridan et al. 2010) radiation scheme.
2. OHM (O*bjective Hysteresis Model,* Grimmond et al. 1991, Grimmond & Oke 1999a, 2002) for the storage heat flux.
3. LUMPS (*Local-scale Urban Meteorological Parameterization Scheme,* Grimmond & Oke 2002) does the initial turbulent sensible and latent heat fluxes calculation for stability (Appendix 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).
5. A simple urban water-use model (Grimmond and Oke 1991).
6. A convective boundary layer (CBL) slab model (Cleugh and Grimmond 2001) calculates the CBL height, temperature and humidity during daytime (Onomura et al. 2015)
7. A snowmelt model (Järvi et al. 2014).
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:

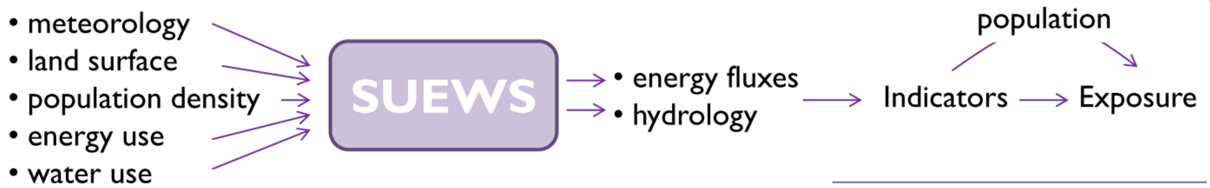
1) for an individual area
2) for multiple areas that are contiguous

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).

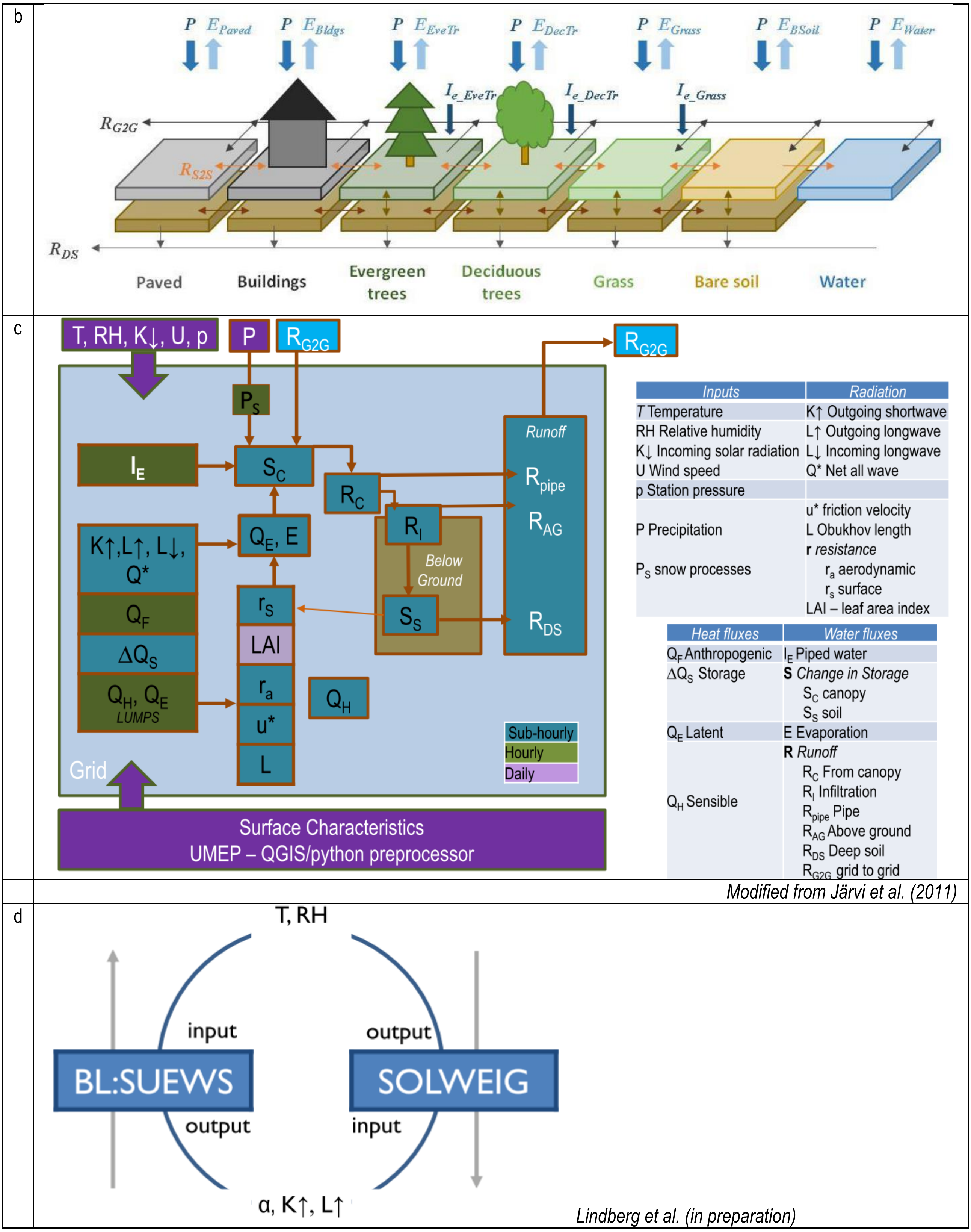
Figure 1: SUEWS (a) main components of the SUEWS model (b) surfaces considered (c) processes within the model (d) relation between the boundary layer (BL)/SUEWS and SOLWEIG (e,f) relation between SUEWS and the BL.

a

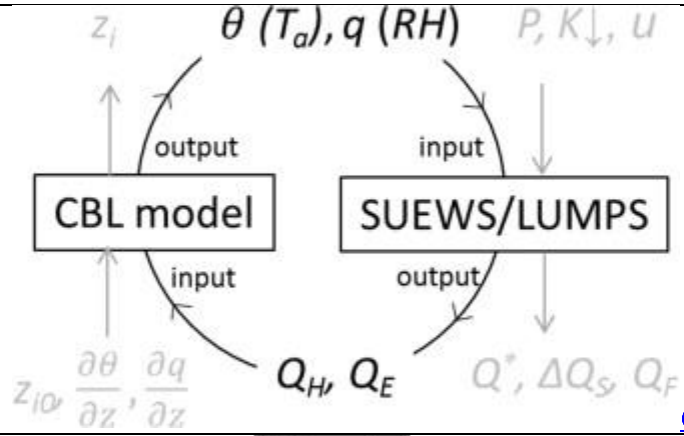


Heat fluxes	
Q^*	Net all-wave radiation
Q_F	Anthropogenic heat flux
Q_H	Sensible heat flux
Q_E	Latent heat flux (evaporation)
ΔQ_S	Storage heat flux

Water fluxes	
I_e	Irrigation
R_{S2S}	Runoff between surfaces
R_{G2G}	Runoff between grids
R_{DS}	Runoff to deep soil
Dr	Drainage
E	Evaporation
ΔC	Change in surface state

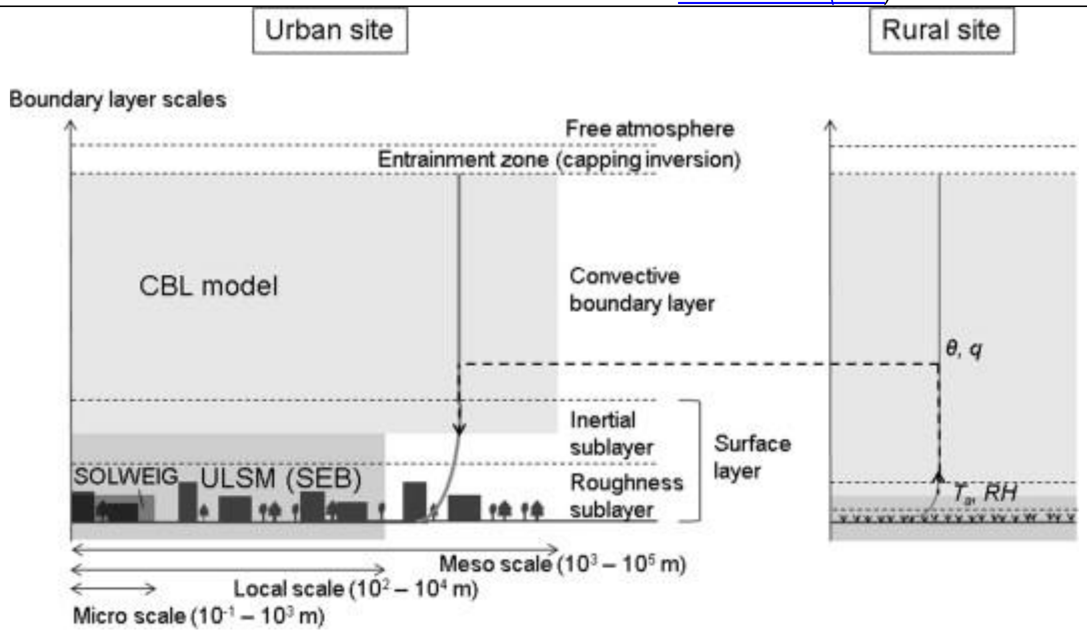

b
P E_{Paved}
P E_{Bldgs}
P E_{EveTr}
P E_{DecTr}
P E_{Grass}
P E_{BSoil}
P E_{Water}
I_{e_EveTr}
I_{e_DecTr}
I_{e_Grass}
R_{G2G}
R_{S2S}
R_{DS}
Paved
Buildings
Evergreen trees
Deciduous trees
Grass
Bare soil
Water
c
T, RH, K↓, U, p
P
R_{G2G}
P_S
I_E
S_C
R_C
R_I
Below Ground
S_S
Runoff
R_{pipe}
R_{AG}
R_{DS}
K↑, L↑, L↓, Q*
Q_F
ΔQ_S
Q_H, Q_E
LUMPS
Q_E, E
r_S
LAI
r_a
u*
L
Q_H
Sub-hourly
Hourly
Daily
Grid
Surface Characteristics
UMEP – QGIS/python preprocessor
Inputs | Radiation
T Temperature | K↑ Outgoing shortwave
RH Relative humidity | L↑ Outgoing longwave
K↓ Incoming solar radiation | L↓ Incoming longwave
U Wind speed | Q* Net all wave
p Station pressure
P Precipitation | u* friction velocity
L Obukhov length
r resistance
P_S snow processes | r_a aerodynamic
r_s surface
LAI – leaf area index
Heat fluxes | Water fluxes
Q_F Anthropogenic | I_E Piped water
ΔQ_S Storage | S Change in Storage
S_C canopy
S_S soil
Q_E Latent | E Evaporation
R Runoff
R_C From canopy
R_I Infiltration
Q_H Sensible | R_{pipe} Pipe
R_{AG} Above ground
R_{DS} Deep soil
R_{G2G} grid to grid
Modified from Järvi et al. (2011)
d
T, RH
input
output
BL:SUEWS
SOLWEIG
output
input
α, K↑, L↑
Lindberg et al. (in preparation)

e



[Onomura et al. (2015)]

f



[Onomura et al. (2015)]

New in SUEWS Version 2015a (released 15 October 2015)

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 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. 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.
7) SUEWS hasve been incorporated into UMEP (http://www.met.reading.ac.uk/umep)

Previous version changes: see Appendix B. Please let us know if you find problems or have suggestions for the manual.

2 Notation (in alphabetical order)

italics	variables names in the tables
bold	input/output filenames
λ_F	frontal area index
ΔQ_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
$L\downarrow$	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, Loridan et al. 2010)
OHM	Objective Hysteresis Model (Grimmond et al. 1991, Grimmond & Oke 1999a, 2002)
PAV	paved surface
Q^*	net all-wave radiation
Q_E	latent heat flux
Q_F	anthropogenic heat flux
Q_H	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
z_i	Convective boundary layer height
z_{0m}	roughness length for momentum

Contact Information

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3 Preparing to run the model

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

	Read the relevant papers and the manual. Decide what type of model run you are interested in.

	Things to consider	Available in this release
LUMPS		Yes – 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 likely to 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** **There is also a version linked to QGIS → UMEP** If you are not using the Windows setup release **– see Appendix F**
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. 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.

Example Inputs/Outputs are provided for:

Site Code	*Location*	*What special aspects this data set*	*Orginal reference for the data*	*Modelling details provided*
He	Helsinki	Snow performance	Järvi et al. (2008)	Järvi et al. 2015
Sc	Sacarmento	Boundary layer height	Cleugh and Grimmond (2000)	Onomura et al. (2015)
Kc	London	UMEP	Kotthaus and Grimmond (2014) Ward et al. (2015)	Lindberg et al. (in prep) Ward et al. (in prep)

In the following **SS** – is the site code, **tt** time interval. See Table above for the actual sites where data examples are provided for.

Filename	**Description**	**Input/Output**	**Part of model**
SS1_2010_data_tt.txt	Meteorological input file	Input	SUEWS single grid

InitialConditionsSm1_2010_2010.nml[1]	Initial conditions	Input	SUEWS single grid
SS_Filechoices.txt	Run options	Output	
SS_2011_5min.txt	(Optional) 5-min resolution	Output	
SS_2011_60.txt	60-min output file	Output	
SS_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
SS1_YYYY_BL.txt	CBL model output file	Output	BL

(*) filename is set in CBLinput.nml.

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 (in the directory where the programme is located type the model name) or just double click the executable file. Please see Troubleshooting if you have problems running the model.

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 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*
	Paved area	*SUEWS_NonVeg.txt*
	Bare soil	*SUEWS_NonVeg.txt*
Vegetated	*Evergreen trees and shrubs*	*SUEWS_Veg.txt*
	Deciduous trees and shrubs	*SUEWS_Veg.txt*
	Grass	*SUEWS_Veg.txt*
Water	*Water*	*SUEWS_Water.txt*
Snow	*Snow*	*SUEWS_Snow.txt*

The surface cover fractions are critical. Make certain that the different surface cover fractions are appropriate for your site.

How to obtain appropriate values?

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.

[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.

<table>
<tr><td></td><td>UMEP version – allows for a direct link to a GIS environment – using QGIS</td></tr>
<tr><td>Anthropogenic heat flux</td><td>The population density is needed as an input for LUMPS and SUEWS to calculate Q_F. If you have no information about the population of the site we recommend that you use the LUCY model to get a first estimate of Q_F. 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
• The program can be downloaded from here: http://www.met.reading.ac.uk/micromet/</td></tr>
<tr><td>Enter the data into the spreadsheet and run the macro, or edit the text (txt) files</td><td>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 files 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:
6)
Sub SaveAllSheets()
For Each Sheet In ActiveWorkbook.Sheets
  Sheet.Select
  ActiveWorkbook.SaveAs Filename:=" C:\InputDataForSUEWS\" & Sheet.Name & ".txt", FileFormat:=xlText
Next Sheet
End Sub

7) Save this
8) Close
9) 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] 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 <u>should not be altered</u> 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
• See example help

In addition to these text files, the following files are also needed to run the model.</td></tr>
<tr><td>Prepare the RunControl.nml file</td><td>In the RunControl.nml file the site name (SS_) and file paths for the model input as well as output are given.
This means <u>before running</u> 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) 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.</td></tr>
</table>

[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.

<table>
<tr><td></td><td colspan="2">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.</td></tr>
<tr><td>Prepare the meteorological forcing data</td><td colspan="2">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 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.</td></tr>
<tr><td>Prepare the Initial Conditions file</td><td colspan="2">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.</td></tr>
<tr><td>Run the model</td><td colspan="2">To run the model you can use Command Prompt (in the directory where the programme is located type the model name) or just double click the executable file. Please see Troubleshooting if you have problems running the model.

Suews_Wrapper_V2015a.exe

Or you can double click the file and it will run Suews_Wrapper_V2015a.exe</td></tr>
<tr><td rowspan="2">Analyse the output</td><td>Albedo</td><td>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?</td></tr>
<tr><td>LAI</td><td>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</td></tr>
</table>

3.1 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 – currently not recommended/UNTESTED 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 to record the availability of input data and aid completion of the input files needed for the model. See Section 3.2 for details about files.

3.2 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

File Name	Description	When Needed [Used]
Input (see section 4)		
RunControl.nml	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	*** **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	Namelist file paths, run options and input parameters for CBL model	1/run [B]
CBL_initial_data.txt	Initial data for CBL model	1/day [B]
Output (see section 5)		
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]

4 Input files

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 <u>examples</u> of recommended values
Values given are <u>example</u> values and need to be changed for your site/model domain.

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

<table>
<tr><th>Name</th><th>VI</th><th>Description</th></tr>
<tr><td colspan="3">Model run options</td></tr>
<tr><td>AnthropHeatChoice</td><td>F</td><td>Determines if Q_F and how is calculated
<table>
<tr><th>Value</th><th>Comments</th></tr>
<tr><td>0</td><td>• 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 Q_F or supply values, then the values in the meteorological input file should be zero.</td></tr>
<tr><td>1</td><td>• 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 <u>modelled values</u> will be used.</td></tr>
<tr><td>2</td><td>• 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 <u>modelled values</u> will be used.</td></tr>
</table></td></tr>
<tr><td>CBLuse</td><td></td><td>Determines if a CBL slab model is used to calculate temperature and humidity.
<table>
<tr><th>Value</th><th>Comments</th></tr>
<tr><td>0</td><td>• CBL model is NOT used.
• SUEWS and LUMPS use temperature and humidity provided in Meteorological input file.</td></tr>
<tr><td>1</td><td>• CBL model is used.
• SUEWS and LUMPS use the modelled temperature and humidity.</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>NetRadiationChoice</td><td>R</td><td>Determines if radiation is observed or modelled (NARP) (Offerle et al. 2003, Loridan et al. 2010)
$L\downarrow$ downwelling longwave radiation
Q* net all wave radiation
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>Observed values of Q* used</td></tr>
<tr><td>1</td><td>• Modelled, but $L\downarrow$ observations supplied in forcing data
• Albedo zenith angle not accounted for</td></tr>
<tr><td>2</td><td>• Modelled with $L\downarrow$ modelled using cloud cover fraction supplied in forcing data file (see Loridan et al. 2010)
• Albedo zenith angle not accounted for</td></tr>
<tr><td>3</td><td>• Modelled with $L\downarrow$ modelled using air temperature and relative humidity data (see Loridan et al. 2010)
• Albedo zenith angle not accounted for</td></tr>
<tr><td colspan="2">The following are not recommended in this release</td></tr>
<tr><td>100</td><td>• Modelled but $L\downarrow$ observations supplied in forcing data
• Albedo zenith angle modelled
• SSss_YYYY_NARPOut.txt file</td></tr>
<tr><td>200</td><td>• Modelled with $L\downarrow$ modelled using cloud cover fraction supplied in forcing data file
• Albedo zenith angle accounted for
• SSss_YYYY_NARPOut.txt file</td></tr>
<tr><td>300</td><td>• Modelled with $L\downarrow$ modelled using air temperature and relative humidity data (see Loridan et al. 2010)
• Albedo zenith angle accounted for
• SSss_YYYY_NARPOut.txt file</td></tr>
</table></td></tr>
<tr><td>gsChoice</td><td>W,M</td><td>Surface conductance choice
<table>
<tr><td>Value</td><td></td><td>CondCode in SUEWS_SiteSelect.txt.*</td></tr>
<tr><td>1</td><td>surface conductance equation in Jarvi et al. (2011)</td><td>100</td></tr>
<tr><td>2</td><td>new formulation (Ward et al. at ICUC9, July 2015)</td><td>200</td></tr>
<tr><td colspan="3">*Note can also add own coefficients for either form (i.e.CondCode in SUEWS_SiteSelect.txt and SUEWS_Conductance.txt
*Coefficients in SUEWS_Conductance.txt selected using CondCode in SUEWS_SiteSelect.txt must be compatible with gsChoice.</td></tr>
</table></td></tr>
<tr><td>QSChoice</td><td>S</td><td>Selects which method is used to determine storage heat flux ΔQ_S
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Modelled using the objective hysteresis model (OHM)) (Grimmond et al. 1991, Grimmond & Oke 1999a, 2002)
The model is based on surface types</td></tr>
<tr><td>2</td><td>Observed ΔQ_s values are used from the meteorological input file</td></tr>
</table></td></tr>
<tr><td>OHMIncQF</td><td>S</td><td>Specifies whether the storage heat flux calculation uses Q* (0) or Q* + QF (1, recommended)</td></tr>
<tr><td>RoughLen_heat</td><td>M</td><td>Method to calculate roughness length for heat to be used
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>as $0.1z_{0m}$</td></tr>
<tr><td>2</td><td>according to Kawai et al. (2009) (recommended)</td></tr>
<tr><td>3</td><td>according to Voogt and Grimmond (2000)</td></tr>
<tr><td>4</td><td>according to Kanda et al. (2007)</td></tr>
</table></td></tr>
<tr><td>smd_choice</td><td>W</td><td>Soil moisture deficit
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>Modelled – need to provide values for SoilDepth, SoilStoreCap and SatHydraulicConduct in SUEWS_Soil.txt. (Recommended in current release).</td></tr>
<tr><td>1</td><td>Measured Volumetric data supplied in meteorological data file – need values for SoilDepthMeas, SoilRocks and smCap in SUEWS_soil.txt
Observed SM options need checking</td></tr>
<tr><td>2</td><td>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</td></tr>
</table></td></tr>
<tr><td>SnowFractionChoice</td><td>M</td><td>Defines the method to calculate snow plan area fraction (set to 2). Used only if SnowUse=1.</td></tr>
</table>

<table>
<tr><td>SnowUse</td><td>M</td><td>1 = snow calculations are done, 0 = no snow calculations are done</td></tr>
<tr><td>SOLWEIGuse</td><td>N</td><td><table>
<tr><td colspan="2">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.</td></tr>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Grid of mean radiant temperature (Tmrt) are calculated and saved based on high resolution digital surface models.</td></tr>
<tr><td>0</td><td>No Tmrt is calculated</td></tr>
</table></td></tr>
<tr><td>StabilityMethod</td><td>M</td><td>Defines which atmospheric stability functions are used<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0-1</td><td>Not used</td></tr>
<tr><td>2</td><td>Recommended!
Momentum: Unstable: Dyer (1974), modified by Högstrom (1988)
Stable: Van Ulden & Holtslag (1985)
Heat: Dyer (1974), modified by Högstrom (1988)</td></tr>
<tr><td>3</td><td>Momentum: Campbell & Norman eqn 7.27 p 97
Heat: Unstable: Campbell & Norman
Stable: Dyer (1974) modifed by Högstrom (1988)</td></tr>
<tr><td>4</td><td>Momentum Businger et al. (1971) modifed by Högstrom (1988)
Heat: Businger et al. (1971) modifed by Högstrom (1988)</td></tr>
</table></td></tr>
<tr><td>WU_choice</td><td>W</td><td>External water use<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>Modelled using options set in SUEWS_Irrigation.txt</td></tr>
<tr><td>1</td><td>Observations are used</td></tr>
</table></td></tr>
<tr><td>z0_method</td><td>A</td><td>Determines how aerodynamic roughness length (z_{0m}) and zero displacement height (z_d) are obtained<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Values in SUEWS_SiteSelect.txt file are used
(z_{0m} and z_d are adjusted with time to account for seasonal variation in porosity of deciduous trees) not currently</td></tr>
<tr><td>2</td><td>Calculated from mean building and tree heights with “Rule of Thumb” (Grimmond and Oke 1999)
Heights must be given in SUEWS_SiteSelect.txt</td></tr>
<tr><td>3</td><td>Calculated using heights, plan area fraction and frontal areal index based on the MacDonald et al. (1998) method
Heights and Frontal area Index must be given in SUEWS_SiteSelect.txt</td></tr>
</table></td></tr>
<tr><td colspan="3">File related</td></tr>
<tr><td>FileCode</td><td>A</td><td>Total site identification code (e.g. SSss)</td></tr>
<tr><td>FileInputPath</td><td>A</td><td>File path with the required input files.</td></tr>
<tr><td>FileOutputPath</td><td>A</td><td>File path where the output files are created.</td></tr>
<tr><td>SkipHeaderSiteInfo</td><td>A</td><td>Number of header lines to skip in SiteSelect input file (2 by default)</td></tr>
<tr><td>SkipHeaderMet</td><td>A</td><td>Number of header lines to skip in meteorological input file (1 by default)</td></tr>
<tr><td>MultipleMetFiles</td><td>A</td><td>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).</td></tr>
<tr><td>KeepTstepFilesIn</td><td></td><td>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.</td></tr>
<tr><td>KeepTstepFilesOut</td><td></td><td>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.</td></tr>
<tr><td>WriteSurfsFile</td><td></td><td>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.</td></tr>
<tr><td colspan="3">Time related</td></tr>
<tr><td>TIMEZONE</td><td>R</td><td>Time zone relative to UTC (Note: east is positive) [Units: h]</td></tr>
<tr><td>Tstep</td><td>A</td><td>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]</td></tr>
<tr><td colspan="3">Height</td></tr>
</table>

z	M	Height of the meteorological forcing data – the most important height is that of the **wind** speed measurement [Units: m]

4.2 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
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
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] Not used in current version of the model.
31	O	PopDensNight	10.2	Night-time population density (i.e. residents) [people ha-1] Required if AnthropHeatChoice = 2 in **4.1 RunControl**.nml.
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.

4.2.1 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
```

4.2.2 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.

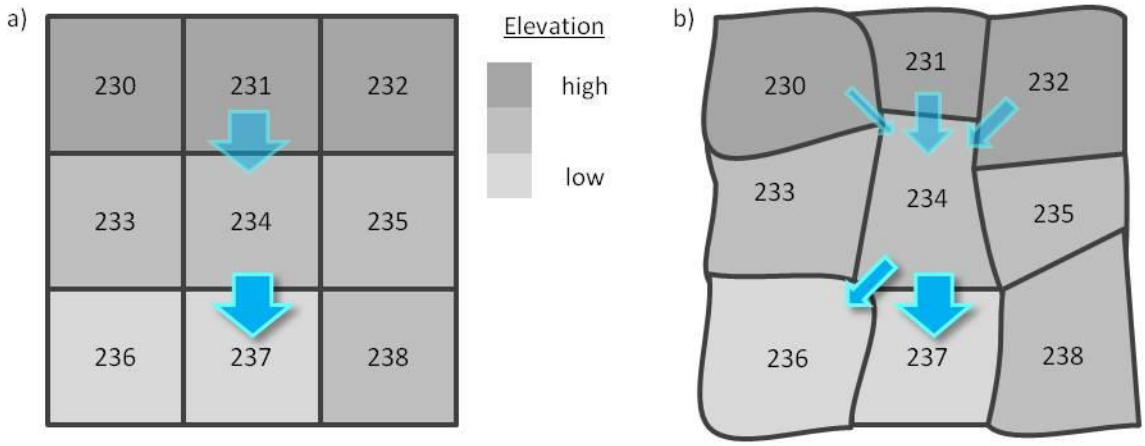

Figure 1 Example grid connections showing water flow between grids. Arrows indicate the water flow in to and out of grid 234, but note that only only water flowing out of each grid is entered in SUEWS_SiteSelect.txt.

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

1	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Grid	GridConnection 1of8	Fraction1of8	GridConnection 2of8	Fraction2of8	GridConnection 3of8	Fraction3of8	GridConnection 4of8	Fraction4of8	GridConnection 5of8	Fraction5of8	GridConnection 6of8	Fraction6of8	GridConnection 7of8	Fraction7of8	GridConnection 8of8	Fraction8of8
230	233	0.90	234	0.10	0	0	0	0	0	0	0	0	0	0	0	0
231	234	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
232	234	0.20	235	0.80	0	0	0	0	0	0	0	0	0	0	0	0
233	236	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234	236	0.10	237	0.90	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238	237	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4.2.3 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	AlbedoMin	0-1	Minumum (wintertime, not including snow) albedo of this surface [-] Effective surface albedo (middle of the day value). View factors should be taken into account. Not currently used – set the same as AlbedoMax. 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		AlbedoMax	0-1	Maximum (wintertime, not including snow) albedo of this surface [-] Effective surface albedo (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)
4	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)
5	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)
6	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)
7	MD	WetThreshold		Threshold for a completely wet surface (i.e. a depth in mm), which determines whether evaporation occurs from a partially wet or completely wet surface. 0.6 !Paved 0.6 !Bldgs
8	MD	StateLimit		Upper limit to the surface state [mm] **Currently only used for the water suface**
9	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)
10	MD	DrainageCoef1		Coefficient for drainage equation [units vary according to equation] 10 !Paved, coefficient D_0, Grimmond and Oke (1991) 10 !Bldgs, coefficient D_0, Grimmond and Oke (1991) 0.013 !BSoil, Grimmond and Oke (1991) [mm h-1]
11	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]
12	L	SoilTypeCode		Code for soil characteristics below this surface Provides the link to column 1 of SUEWS_Soil.txt, which contains the attributes describing sub-surface soil for this surface type. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Soil.txt.

13	O	SnowLimPatch	Maximum SWE [mm] Limit of snow water equivalent when the surface is fully covered with snow. 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.
14	O	SnowLimRemove	SWE when snow is removed from this surface [mm] Limit of snow water equivalent when snow is removed from paved surfaces and buildings **Currently not implemented for BSoil surface** 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.
15	L	OHMCode_SummerWet	Code for OHM coefficients to use for this surface during wet conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
16	L	OHMCode_SummerDry	Code for OHM coefficients to use for this surface during dry conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
17	L	OHMCode_WinterWet	Code for OHM coefficients to use for this surface during wet conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
18	L	OHMCode_WinterDry	Code for OHM coefficients to use for this surface during dry conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

4.2.4 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	AlbedoMin	0-1	Minimum albedo of this surface [-] Effective surface albedo (leaf-off, middle of the day value). View factors should be taken into account. 0.10 !EveTr 0.12 !DecTr 0.18 !Grass
3	MU	AlbedoMax	0-1	Maxium 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)

4	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)
5	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)
6	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)
7	MD	WetThreshold		Threshold for a completely wet surface (i.e. a depth in mm), which determines whether evaporation occurs from a partially wet or completely wet surface. 1.8 !EveTr 1.0 !DecTr 2.0 !Grass
8	MD	StateLimit		Upper limit to the surface state [mm] **Currently only used for the water suface**
9	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)
10	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 D_0, Grimmond and Oke (1991)
11	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 D_0, Grimmond and Oke (1991)
12	L	SoilTypeCode		Code for soil characteristics below this surface Provides the link to column 1 of SUEWS_Soil.txt, which contains the attributes describing sub-surface soil for this surface type. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_Soil.txt.
13	O	SnowLimPatch		Maximum SWE [mm] Limit of snow water equivalent when the surface 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.
14	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)

15	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)
16	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)
17	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)
18	MD	LAIMin		Minimum leaf area index [m^2 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)
19	MD	LAIMax		Maximum leaf area index [m^2 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)
20	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)
21	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.
22	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
23	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
24	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
25	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
26	L	OHMCode_SummerWet		Code for OHM coefficients to use for this surface during wet conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
27	L	OHMCode_SummerDry		Code for OHM coefficients to use for this surface during dry conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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

4.2.5 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	AlbedoMin	0-1	Minimum albedo of this surface [-] View factors should be taken into account. Not currently used. 0.1 !Water, Oke (1987)
3	MU	AlbedoMax	0-1	Albedo of this surface [-] View factors should be taken into account. 0.1 !Water, Oke (1987)
4	MU	Emissivity	0-1	Emissivity of this surface [-] Effective surface emissivity. View factors should be taken into account 0.95 !Water, Oke (1987)
5	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
6	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
7	MD	WetThreshold		Threshold for a completely wet surface (i.e. a depth in mm), which determines whether evaporation occurs from a partially wet or completely wet surface. 0.5 !Water
8	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
9	MD	DrainageEq	-999	Drainage equation to use for this surface. Coefficients specified in the following two columns. **Not currently used for water suface**
10	MD	DrainageCoef1	-999	Coefficient for drainage equation [units vary according to equation] **Not currently used for water suface**
11	MD	DrainageCoef2	-999	Coefficient for drainage equation [units vary according to equation] **Not currently used for water suface**
12	L	OHMCode_SummerWet		Code for OHM coefficients to use for this surface during wet conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
13	L	OHMCode_SummerDry		Code for OHM coefficients to use for this surface during dry conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

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

4.2.6 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	Emissivity	0-1	Emissivity of this surface [-] Effective surface emissivity. View factors should be taken into account 0.99 !Snow, Järvi et al. (2014)
7	MD	tau_a		Time constant for snow albedo aging in cold snow [-] 0.018 !Järvi et al. (2014)
8	MD	tau_f		Time constant for snow albedo aging in melting snow [-] 0.11 !Järvi et al. (2014)
9	MD	PrecipiLimAlb	2	Limit for hourly precipitation when the ground is fully covered with snow. Then snow albedo is reset to AlbedoMax [mm]
10	MD	*snowDensMin*	100	Fresh snow density [kg m^{-3}]
11	MD	*snowDensMax*	400	Maximum snow density [kg m^{-3}]
12	MD	tau_r		Time constant for snow density ageing [-] 0.043 !Järvi et al. (2014)
13	MD	CRWMin		Minimum water holding capacity of snow [mm] 0.05 !Järvi et al. (2014)
14	MD	CRWMax		Maximum water holding capacity of snow [mm] 0.20 !Järvi et al. (2014)
15	MD	PrecipLimSnow	2.2	Temperature limit when precipitation falls as snow [°C] !Auer 1974
16	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.
17	L	OHMCode_SummerDry		Code for OHM coefficients to use for this surface during dry conditions in summer. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
18	L	OHMCode_WinterWet		Code for OHM coefficients to use for this surface during wet conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.
19	L	OHMCode_WinterDry		Code for OHM coefficients to use for this surface during dry conditions in winter. Links to SUEWS_OHMCoefficients.txt. Value of integer is arbitrary but must match code specified in column 1 of SUEWS_OHMCoefficients.txt.

4.2.7 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 [m^3 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**

4.2.8 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)) and should be used with gsChoice=1 in RunControl.nml. An alternative formulation (gsChoice=2) uses slightly different functional forms and different coefficients.

No.	USE	Column name	Example	Description
1	L	Code		Code linking to the CondCode column in SUEWS_SiteSelect.txt. Value of integer is arbitrary but must match code specified in SUEWS_SiteSelect.txt.
2	MD	G1	16.4764	Related to maximum surface conductance [mm s-1]
3	MD	G2	566.0923	Related to Kdown dependence [W m^{-2}]
4	MD	G3	0.2163	Related to VPD dependence [Units depend on gsChoice in RunControl.nml]
5	MD	G4	3.3649	Related to VPD dependence [Units depend on gsChoice in RunControl.nml]
6	MD	G5	11.0764	Related to temperature dependence [°C]
7	MD	G6	0.0176	Related to soil moisture dependence [mm^{-1}]

8	MD	TH	40	Upper air temperature limit [°C]
9	MD	TL	0	Lower air temperature limit [°C]
10	MD	S1	0.45	Related to soil moisture dependence [-] **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}]

4.2.9 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)

4.2.10 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}
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]

4.2.11 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.

4.2.12 SUEWS_WithinGridWaterDist.txt

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

Each row corresponds to a surface type (linked by the Code in column 1 to the SiteSelect.txt 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

4.2.13 SUEWS_OHMCoefficients.txt

OHM, the Objective Hysteresis Model (Grimmond et al. 1991), is used to calculate the storage heat flux. For each surface, OHM requires three model coefficients (a_1, a_2, a_3). 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) In the model run, canyons are excluded.

Surface type		Author	a_1	a_2	a_3
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

4.5 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	°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	m^2 m^{-2}	Initial LAI for evergreen trees
LAIinitialDecTr	W	m^2 m^{-2}	Initial LAI for deciduous trees
LAIinitialGrass	W	m^2 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			
albEveTr0	R	-	Albedo of evergreen trees on day 0 of run
albDec0	R	-	Albedo of deciduous trees on day 0 of run

albGrass0	R	-	Albedo of Grass 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

4.6 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 [m^3]
20	O	xsmd	Observed soil moisture [m^3 m^{-3} or kg kg^{-1}]
21	O	lai	Observed leaf area index [m^2 m^{-2}]
22	O	kdiff	Diffuse radiation [W m^{-2}] Recommended if SOLWEIGUse = 1
23	O	kdir	Direct radiation [W m^{-2}] Recommended if SOLWEIGUse = 1
24	O	wdir	Wind direction [°]Currently not implemented

Note: The meteorological input file should match the information given in SUEWS_SiteSelect.txt. If a partial year is used that specific year must be given in SUEWS_SiteSelect.txt. If multiple years are used, all years should be included in SUEWS_SiteSelect.txt If a whole year (e.g. 2011) is intended to be modelled using and hourly resolution dataset, the number of lines in the metdata-file should be 8760 and begin and end with:

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

4.7 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) and Cleugh and Grimmond (2000).*

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

<table>
<tr><th>Name</th><th>Units</th><th>Explanation/Details/ Description</th></tr>
<tr><td>EntrainmentType</td><td>-</td><td>Determines an entrainment scheme (see Cleugh and Grimmond 2000) for discusson
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Tennekes and Driedonks (1981) Recommended</td></tr>
<tr><td>2</td><td>McNaughton and Springs (1986)</td></tr>
<tr><td>3</td><td>Rayner and Watson (1991)</td></tr>
<tr><td>4</td><td>Tennekes (1973)</td></tr>
</table></td></tr>
<tr><td>QH_choice</td><td>-</td><td>Determines Q_H used for CBL model.
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>1</td><td>Q_H values modelled by SUEWS</td></tr>
<tr><td>2</td><td>Q_H values modelled by LUMPS</td></tr>
<tr><td>3</td><td>Observed Q_H values are used from the meteorological input file</td></tr>
</table></td></tr>
<tr><td>Wsb</td><td>m s^{-1}</td><td>Subsidence velocity in eq. 1 and 2 of Onomura et al. (2015)
<table>
<tr><td>Subsidence velocity</td></tr>
<tr><td>-0.01 Recommended</td></tr>
</table></td></tr>
<tr><td>CBLday(id)</td><td>-</td><td>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</td></tr>
<tr><td>CO2_included</td><td>-</td><td>In the current version, it should be set to zero.</td></tr>
<tr><td>InitialData_use</td><td>-</td><td>Determines initial values (z_{i0}, gamt_Km, gamq_gkgm, Theta+_K, q+_gkg, Theta_K and q_gkg) (see CBL_Initial_data.txt).
<table>
<tr><td>Value</td><td>Comments</td></tr>
<tr><td>0</td><td>All initial values are calculated. This is NOT available yet in this version.</td></tr>
<tr><td>1</td><td>Take z_{i0}, gamt_Km and gamq_gkgm from input data file. Theta+_K, q+_gkg, Theta_K and q_gkg are calculated using Temp_C, avrh and Pres_kPa in meteorological input file.</td></tr>
<tr><td>2</td><td>Take all initial values from input data file (see CBL_Initial_data.txt).</td></tr>
</table></td></tr>
<tr><td>InitialData_FileName</td><td>-</td><td>If InitialData_use ≥ 1, write the file name including the path from site directory</td></tr>
</table>

		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)]) 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.

4.7.1 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.nml.

Definitions and example file of initial values prepared for Sacramento

zi_0	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	z_{i0}	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
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

4.8 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 gridl output
Lup2d_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl output
Ldown2d_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl output
Kup2d_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl output
Kdown2d_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl output
GVF_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl output
GVF_out	-	Value: Comments 1: Write grid to file (saves as ERSI Ascii grid) 0: No gridl 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**.

5 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 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 [m^2 m^{-2}]
59	z0m	Roughness lengt for momentum [m]
60	zdm	Displacemt height [m]
61	qn1_sf	Net all-wave radiation for snow-free area [W m^{-2}]
62	qn1_s	Net all-wave radiation for snow surface [W m^{-2}]
63	Qm	Snow related heat exchange [W m^{-2}]
64	QmFreez	Internal energy change [W m^{-2}]
65	QmRain	Heat release by rain on snow [W m^{-2}]
66	SWE	Snow water equivalent [mm]
67	Mw	Meltwater [mm]
68	Mwstore	Meltwater store [mm]
69	SnowRem_Paved	Snow removal from paved surfaces [mm]
70	SnowRem_Bldgs	Snow removal from buildings [mm]
71	ChSnow/i	Change in snowpack [mm]
72	albSnow	Snow albedo [-]

5.3 SSss_YYYY_SnowOut.txt

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

File format of ***SSss*_YYYY_Snow_60.txt**

Col	Header	Name	Units
1	*iy*	Year	
2	*id*	Day of year	
3	*it*	Hour	-
4	*imin*	Minute	-
5	*dectime*	Decimal Time	-
6	*SWE_Paved*	Snow water equivalent – paved surface	mm
7	*SWE_Bldgs*	Snow water equivalent – building surface	mm
8	*SWE_EveTr*	Snow water equivalent – evergreen surface	mm
9	*SWE_DecTr*	Snow water equivalent – deciduous surface	mm
10	*SWE_Grass*	Snow water equivalent – grass surface	mm
11	*SWE_BSoil*	Snow water equivalent – bare soil surface	mm
12	*SWE_Water*	Snow water equivalent – water surface	mm
13	*Mw_Paved*	Meltwater – paved surface	mm h^{-1}
14	*Mw_Bldgs*	Meltwater – building surface	mm h^{-1}
15	*Mw_EveTr*	Meltwater – evergreen surface	mm h^{-1}
16	*Mw_DecTr*	Meltwater – deciduous surface	mm h^{-1}
17	*Mw_Grass*	Meltwater – grass surface	mm h^{-1}
18	*Mw_BSoil*	Meltwater – bare soil surface	mm h^{-1}
19	*Mw_Water*	Meltwater – water surface	mm h^{-1}
20	*Qm_Paved*	Snowmelt related heat – paved surface	W m^{-2}
21	*Qm_Bldgs*	Snowmelt related heat – building surface	W m^{-2}
22	*Qm_EveTr*	Snowmelt related heat – evergreen surface	W m^{-2}
23	*Qm_DecTr*	Snowmelt related heat – deciduous surface	W m^{-2}
24	*Qm_Grass*	Snowmelt related heat – grass surface	W m^{-2}
25	*Qm_BSoil*	Snowmelt related heat – bare soil surface	W m^{-2}
26	*Qm_Water*	Snowmelt related heat – water surface	W m^{-2}
27	*Qa_Paved*	Advective heat – paved surface	W m^{-2}
28	*Qa_Bldgs*	Advective heat – building surface	W m^{-2}
29	*Qa_EveTr*	Advective heat – evergreen surface	W m^{-2}

30	*Qa_DecTr*	Advective heat – deciduous surface	W m^{-2}
31	*Qa_Grass*	Advective heat – grass surface	W m^{-2}
32	*Qa_BSoil*	Advective heat – bare soil surface	W m^{-2}
33	*Qa_Water*	Advective heat – water surface	W m^{-2}
34	*QmFr_Paved*	Heat related to freezing of surface store – paved surface	W m^{-2}
35	*QmFr_Bldgs*	Heat related to freezing of surface store – building surface	W m^{-2}
36	*QmFr_EveTr*	Heat related to freezing of surface store – evergreen surface	W m^{-2}
37	*QmFr_DecTr*	Heat related to freezing of surface store – deciduous surface	W m^{-2}
38	*QmFr_Grass*	Heat related to freezing of surface store – grass surface	W m^{-2}
39	*QmFr_BSoil*	Heat related to freezing of surface store – bare soil surface	W m^{-2}
40	*QmFr_Water*	Heat related to freezing of surface store – water	W m^{-2}
41	*fr_Paved*	Fraction of snow – paved surface	-
42	*fr_Bldgs*	Fraction of snow – building surface	-
43	*fr_EveTr*	Fraction of snow – evergreen surface	-
44	*fr_DecTr*	Fraction of snow – deciduous surface	-
45	*fr_Gass*	Fraction of snow – grass surface	-
46	*Fr_BSoil*	Fraction of snow – bare soil surface	-
47	*RainSn_Paved*	Rain on snow – paved surface	mm
48	*RainSn_Bdgs*	Rain on snow – building surface	mm
49	*RainSn_EveTr*	Rain on snow – evergreen surface	mm
50	*RainSn_DecTr*	Rain on snow – deciduous surface	mm
51	*RainSn_Grass*	Rain on snow – grass surface	mm
52	*RainSn_BSoil*	Rain on snow – bare soil surface	mm
53	*RainSn_Water*	Rain on snow – water surface	mm
54	*qn_PavedSnow*	Net all-wave radiation – paved surface	W m^{-2}
55	*qn_BldgsSnow*	Net all-wave radiation – building surface	W m^{-2}
56	*qn_EveTrSnow*	Net all-wave radiation – evergreen surface	W m^{-2}
57	*qn_DecTrSnow*	Net all-wave radiation – deciduous surface	W m^{-2}
58	*qn_GrassSnow*	Net all-wave radiation – grass surface	W m^{-2}
59	*qn_BSoilSnow*	Net all-wave radiation – bare soil surface	W m^{-2}
60	*qn_WaterSnow*	Net all-wave radiation – water surface	W m^{-2}
61	*kup_PavedSnow*	Reflected shortwave radiation – paved surface	W m^{-2}
62	*kup_BldgsSnow*	Reflected shortwave radiation – building surface	W m^{-2}
63	*kup_EveTrSnow*	Reflected shortwave radiation – evergreen surface	W m^{-2}
64	*kup_DecTrSnow*	Reflected shortwave radiation – deciduous surface	W m^{-2}
65	*kup_GrassSnow*	Reflected shortwave radiation – grass surface	W m^{-2}
66	*kup_BSoilSnow*	Reflected shortwave radiation – bare soil surface	W m^{-2}
67	*kup_WaterSnow*	Reflected shortwave radiation – water surface	W m^{-2}
68	*frMelt_Paved*	Amount of freezing melt water – paved surface	mm
69	*frMelt_Bldgs*	Amount of freezing melt water – building surface	mm
70	*frMelt_EveTr*	Amount of freezing melt water – evergreen surface	mm
71	*frMelt_DecTr*	Amount of freezing melt water – deciduous surface	mm
72	*frMelt_Grass*	Amount of freezing melt water – grass surface	mm
73	*frMelt_BSoil*	Amount of freezing melt water – bare soil surface	mm
74	*frMelt_Water*	Amount of freezing melt water – water surface	mm
75	*MwStore_Paved*	Melt water store – paved surface	mm
76	*MwStore_Bldgs*	Melt water store – building surface	mm
77	*MwStore_EveTt*	Melt water store – evergreen surface	mm
78	*MwStore_DecTr*	Melt water store – deciduous surface	mm
79	*MwStore_Grass*	Melt water store – grass surface	mm
80	*MwStore_BSoil*	Melt water store – bare soil surface	mm
81	*MwStore_Water*	Melt water store – water surface	mm
82	*DensSnow_Paved*	Snow density – paved surface	kg m^{-3}
83	*DensSnow_Bldgs*	Snow density – building surface	kg m^{-3}
84	*DensSnow_EveTr*	Snow density – evergreen surface	kg m^{-3}
85	*DensSnow_DecTr*	Snow density – deciduous surface	kg m^{-3}
86	*DensSnow_Grass*	Snow density – grass surface	kg m^{-3}
87	*DensSnow_BSoil*	Snow density – bare soil surface	kg m^{-3}

88	*DensSnow_Water*	Snow density – water surface	kg m^{-3}
89	*Sd_Paved*	Snow depth – paved surface9	mm
90	*Sd_Bldgs*	Snow depth – building surface	mm
91	*Sd_EveTr*	Snow depth – evergreen surface	mm
92	*Sd_DecTr*	Snow depth – deciduous surface	mm
93	*Sd_Grass*	Snow depth – grass surface	mm
94	*Sd_BSoil*	Snow depth – bare soil surface	mm
95	*Sd_Water*	Snow depth – water surface	mm
96	*Tsnow_Paved*	Snow surface temperature – paved surface	°C
97	*Tsnow_Bldgs*	Snow surface temperature – building surface	°C
98	*Tsnow_EveTr*	Snow surface temperature – evergreen surface	°C
99	*Tsnow_DecTr*	Snow surface temperature – deciduous surface	°C
100	*Tsnow_Grass*	Snow surface temperature – grass surface	°C
101	*Tsnow_BSoil*	Snow surface temperature – bare soil surface	°C
102	*Tsnow_Water*	Snow surface temperature – water surface	°C

5.4 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 [m^2 m^{-2}]
15	LAI_DecTr	Leaf area index of deciduous trees [m^2 m^{-2}]
16	LAI_Grass	Leaf area index of grass [m^2 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

5.4 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	z_i	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}

5.5 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

6 Troubleshooting

1.	How to **create a directory** please search the web using this phrase if you do not know how to create a folder or directory	
2.	How **to unzip a file** - please search the web using this phrase if you do not know how to unzip a file	
3.	A **Text editor** is a program to edit plain text files. If you search on the web using the phrase 'text editor' you will find numerous programs. These include for example, NotePad, EditPad, Text Pad etc	
4.	**Command prompt**: From Start select run –type cmd – this will open a window. Change directory to the location of where you stored your files. The following website may be helpful if you do not know what a command prompt is: http://dosprompt.info/	
5.	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	
6.	Website: http://LondonClimate.info http://www.met.reading.ac.uk/micromet/	
7.	**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.	
8.	Check the **PROBLEMS.TXT** file (see section 5.1 and this section)	
9.	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.	
10	Check file options – in **RunControl.nml** (see section 4.1)	
11	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	
12	"*%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.
13	%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.
14	*"Reference to undefined variable, array element or function result"*	Parameter(s) missing from Input files. See also the error messages provided in **Problems.txt**

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Current contributors:

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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
    a. Names should be defined at least in one place in the code – ideally when defined
    b. Implicit None should be used in all subroutines
    c. 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:

a. New input of <u>three</u> additional columns in the Meteorological input file (diffusive and direct solar radiation, and wind direction)
b. Change of input variables in InitialConditions.nml file. Note we now refer to CT as ET (ie. Evergreen trees rather than coniferous trees)
c. In GridConnectionsYYYY.txt, the site names should now be without the underscore (e.g "Sm" and not "Sm_")

Other issues:

d. Number of grid areas that can be modelled (for one grid, one year 120; for one grid two years 80)
e. Comment about Time interval of input data
f. Bug fix: Column headers corrected in 5 min file
g. Bug fix: Surface state 60 min file - corrected to give the last 5 min of the hour (rather than cumulating through the hour)
h. Bug fix: units in the Horizontal soil water transfer
i. ErrorHints: More have been added to the problems.txt file.
j. Manual: new section on running the model appropriately
k. Manual: notation table updated
l. **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)

a) Please see the large number of changes made in the 2014a release in Appendix C
b) This is a minor change to address installing the software.
c) 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 <u>**Alt**</u> 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.
    a. This allows for clearer identification for users of the coefficients that are actually to be used
    b. 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
    a. time of year (summer, winter)
    b. surface wetness state
6) New files are written: DailyState.txt
    a. 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
    a. Clarification of surface types has been made. See GIS and OHM related files

New in SUEWS Version2011b

1) Storage heat flux (ΔQ_s) and anthropogenic heat flux (Q_F) 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
    a. *HydraulicConduct*
    b. *GrassFractionIrrigated*
    c. *PavedFractionIrrigated*
    d. *TreeFractionIrrigated*

    The lower three are now determined from the water use behaviour used in SUEWS
4) Following added to HeaderInput.nml
    a. *SatHydraulicConduct*
    b. *defaultQf*
    c. *defaultQs*
5) If ΔQ_s and Q_F are not calculated in the model but are given as an input, the missing data is replaced with the default values.
6) Added to SAHP input file
    a. 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 equation[5,6]. 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)	If option [1] is **NOT** used, put as many choices in the

	[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)	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
```

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 (ΔQ_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)[3]	Penman-Monteith equation[2]
Sensible heat flux (Q_H)	DeBruin and Holtslag (1982)	Residual from available energy minus Q_E
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] 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)

[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.

[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

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/) 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

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
Manual setup		Gfortran **SilverFrost**	*Create a Main site directory and locate SUEWS_V2015a.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**: cyggcc_s-seh-1.dll, cyggfortran-3.dll, cygquadmath-0.dll, cygwin1.dll **Windows SilverFrost**: 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.

Manual setup	*After you have* ***unzipped*** *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). 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 - 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	**InitialConditions*SSss_YYYY*.nml**[5]	
see table below (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)

[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.