**UEB Parallel Input / Output Settings**

This document specifies the input files for the Parallel version of the Utah Energy Balance snow accumulation and melt model (UEB Parallel). It is an extension of the document “UEBGridInterfaceDesign.docx”. The contents here are intentionally limited to the actual input files. UEB Parallel uses a SIMD (Single Instruction Multiple Data) design with MPI (Message Passing Interface) specification. As the result, while the general design and much of the contents of the input files remain similar for the two versions, some of the input / output file configurations for UEB Parallel are different from the serial FORTRAN version which the document “UEBGridInterfaceDesign.docx” is intended for.

Much of (may be 90 %) of the contents of this document are very similar to that of the previous document (“UEBGridInterfaceDesign.docx”). If you have used the previous document you can see the changes in the document with the track changes.

Input variables are classified into four groups.

* Spatially constant and constant in time. (SCTC). These are essentially model parameters.
* Spatially variable but constant in time (SVCT). These are site variables like slope, aspect and vegetation, quantities that characterize each point where UEB is being applied
* Spatially constant but time varying (SCTV). Some of these may be quantities that vary in time, like precipitation, wind, humidity, but for which there is not information about spatial variability.
* Spatially variable and variable in time (SVTV)

Spatially variable inputs (and outputs) will be handled using spatial grid files. NetCDF has been selected as the file format to use for grid files for the following reasons.

1. It has been designed to accommodate multiple time steps
2. It has reasonable support for Fortran (at least the 3.6.1 version)

Model parameters are always SCTC. Site Variables may be SCTC or SVTC. The strategy for these is to have a text file that either gives the value for the variable if it is SCTC or the corresponding spatial grid (netCDF) file if it is SVTC. Input variables may be SCTV or SVTV. The strategy for these is to have a text file that either gives the value for the variable for each time step if it is SCTV, or the name of a grid file holding the value for each time step if it is SVTV. Output variables are grouped into grid output and aggregated outputs. Grid outputs are SVTV. The strategy is to have a text file that lists the grid output variables to be written. These will then be output as netCDF files. Similarly a text file will specify which aggregate variables to output and outputs will go into text files.

The first table below summarizes the function of the files used in the model. Figure 1 illustrates the files used. A specification of the format of each of the files then follows.

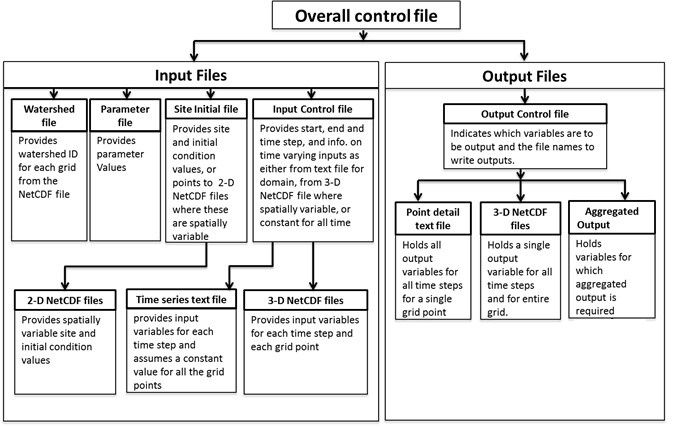


Figure 1. Input/Output Control Schematic

**Summary of UEBGrid snowmelt model input and output file**

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| File name | Description |
| control.dat | Model Driver: instantiates the model and controls run |
| param.dat | Model parameters file. |
| siteinitial.dat | Contain the site variable, values for each variable or name of grid file that contains the values |
| inputcontrol.dat | Control file that indicates for each variable whether it is SCTV or SVTV and the data or input file name for the data. |
| outputcontrol.dat | Control file that indicates which variables are to be outputs and their mode (point text file, detailed 3D netCDF or aggregated output). |
| watershed.nc | A 2D grid file that has integer values identifying each watershed (really an aggregation domain. It does not matter to the snow model whether they are watersheds or not. Aggregation domains are simply the set of grid cells aggregated together for output) |

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| **File Name** | **control.dat** | | |
| **File Function** | Provides control over the entire UEBGrid model | | |
| **FileFormat** | Files contains 15 lines | | |
| **Lines description** | **Line** | **Type** | **Description** |
| 1 | text | Descriptive text not used by the model but available to label and describe this file |
| 2 | text | Parameter file: Name of the file containing model SCTC parameters (including Bristow-Campbell parameters). Referred to in this document as param.dat |
| 3 | text | Site and initial conditions file: Name of the file containing site variables and initial conditions. Referred to in this document as siteinitial.dat. This file will specify the variable value in the case of SCTC variables or the name of the grid file containing SVTC information. |
| 4 | text | Forcing input control file: Name of file that specifies the reading of input variables. Input variables are either SCTV or SVTV. If the variable is SCTV, a text file of time series for that variable is named. If the variable is SVTV, then a file listing the NetCDF files that hold the input values for multiple time step is given |
| 5 | text | Output control file: Name of file that specifies gridded outputs, point time series outputs, and aggregated outputs |
| 6 | netCDF | Aggregate output file: Name of file where aggregated outputs will be written (e.g. aggout.nc) |
| 7 | text | Model domain (watershed) grid file: Name of a 2D netCDF file that contains integer values identifying each watershed |
| 8 | Text | Watershed variable name, and y and x axes names  Separated by space |
| 9 | integer | Model start data time in yyyy mm dd hh.h format separated by space |
| 10 | integer | Model end data time in yyyy mm dd hh.h format separated by space |
| 11 | float | Model time step (dt) |
| 12 | integer | UTC Offset. Use 0 for input times in UTC.  (e.g. -7 used when the Model start and end date times are in US Mountain time zone) |
| 13 | integer | Indicates whether model inputs are daily (1) or sub-daily (0). |
| 14 | integer | Time stride for detailed outputs, y step for debug outputs, x step for debug output.  For model with fine time steps, output time stride avoids writing dense outputs (so Time stride is ‘sampling step’ ), reducing file size. |
| 15 | integer | Output dimension ordering, aggregated output dimension ordering.  Dimension ordering refers to the indexing of netCDF output files. The following codes are used  0 = time, y, x  1 = y, x, time  2 = x, time, y  UEB output writing is fastest with the y, x, time ordering due to the way the model runs (model run in loops for each grid); however some CF based codes (e.g. GDAL) require time, y, x ordering. |
| **All time inputs for a specific model run should be with respect to the same UTC offset (time zone). This applies to both text and NetCDF files that contain time values.**  UTC offset is the number of hours that need to be subtracted from an input time value to get UTC time.  The handling of time in the code will be as follows  UTCtime = inputtime - UTCOffset (in hours)  modellocaltime = UTC time+longitude/15 (in hours)  e.g. if input time is 11:00 and UTC offset is -7 (as it would be for Utah) then the corresponding UTC time is 11 - (-7) = 18:00.  Now if the longitude is -104 (104 W) then modeltime = 18 -104/15=11.06 hr | | | |
| Example file | UEBGrid Model Driver File for TWDEF  param.dat  siteinitial.dat  inputcontrol.dat  outputcontrol.dat  aggout.nc  watershed.nc  watershed y x  2009 10 01 0.0  2010 05 31 0.0  1.0  1 15 16 1 1  -7.0  0  1 1 | | |

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| **File Name** | **param.dat** |
| **File Function** | Provides the parameter values for the model |
| **File Format** | First line is the header that is not parsed. The remaining lines are read in pairs. The first line in the pair starts with a parameter code that is a fixed string used to identify what parameter value comes on the next line. The code ends in a colon ":" The parameter description may be given following the colon and is not parsed. The next line contains one numeric value and is the parameter value in free format. |
| **File Example** | Model Parameters  irad: Radiation control flag (0=from ta, 1= input qsi, 2= input qsi,qli 3= input qnet)  0  ireadalb: Albedo reading control flag (0=albedo is computed internally, 1 albedo is read)  0  tr: Temperature above which all is rain (3 C)  3  ts: Temperature below which all is snow (-1 C)  -1  ems: Emissivity of snow (nominally 0.99)  0.99  cg: Ground heat capacity (nominally 2.09 KJ/kg/C)  2.09  z: Nominal meas. heights for air temp. and humidity (2m)  2  zo: Surface aerodynamic roughness (m)  0.010  rho: Snow Density (Nominally 450 kg/m^3)  337  rhog: Soil Density (nominally 1700 kg/m^3)  1700  lc: Liquid holding capacity of snow (0.05)  0.05  ks: Snow Saturated hydraulic conductivity (20 m/hr)  20  de: Thermally active depth of soil (0.1 m)  0.1  avo: Visual new snow albedo (0.95)  0.85  anir0: NIR new snow albedo (0.65)  0.65  lans: The thermal conductivity of fresh (dry) snow  1.0  lang: the thermal conductivity of soil  4.0  wlf: Low frequency fluctuation in deep snow/soil layer  0.0654  rd1: Amplitude correction coefficient of heat conduction (1)  1  dnews: The threshold depth of for new snow (0.001 m)  0.001  emc: Emissivity of canopy  0.98  alpha: Scattering coefficient for solar radiation  0.5  alphal: Scattering coefficient for long wave radiation  0.0  g: leaf orientation with respect to zenith angle  0.5  uc: Unloading rate coefficient (Per hour) (Hedstrom and Pomeroy, 1998)  .004626286  as: Fraction of extraterrestrial radiation on cloudy day, Shuttleworth (1993)  0.25  Bs: (as+bs):Fraction of extraterrestrial radiation on clear day, Shuttleworth  .5  lambda: Ratio of direct atm radiation to diffuse, worked out from Dingman  .857143  rimax: Maximum value of Richardson number for stability correction  0.16  wcoeff: Wind decay coefficient for the forest  0.5  a: A in Bristow-Campbell formula for atmospheric transmittance  0.8  c: C in Bristow-Campbell formula for atmospheric transmittance  2.4 |

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| **File Name** | **siteinitial.dat** |
| **File Function** | Provides site variables that may be SVTC or SCTC |
| **File Format** | First line of this file is a header that is not parsed. There are three lines for every variable. Each variable is either SCTC(constant spatially and temporally) or SVTC (variable spatially but constant temporally) as follows:  1. Variable code. Variable code is a fixed string used by UEB to identify a variable (see siteinitial variable code list below). The code ends in a colon ":" The variable description may be given following the colon and is not read by the program.  2. Variable flag .Variable flag is an integer numeric value, either 1 or 0. 0 indicates the variable is SCTC and only one value will be assigned to it. In this case, third line is the numeric value for that variable. 1 indicates the variable is SVTC and the third line would be details of the netCDF input file  3. Variable value for SCTC, or for SVTC, the file name of netCDF file and the name of the variable used inside the netCDF file separated by space  The y and x coordinates in the netCDF file must be the same as those in the watershed file.  An example is shown below:    hcan: Canopy height  0  12.0  lai: Leaf area index  1  LAI.nc LAI  Here the variable Canopy height is a single value of 12.0 m throughout the model domain while the Leaf area index is given by the netCDF file “LAI.nc” and the variable name inside the netCDF is LAI. “LAI.nc” |
| **File Example** | Site and Initial Condition Input Variables  USic: Energy content initial condition (kg m-3)  0  0.0  WSis: Snow water equivalent initial condition (m)  0  0.0  Tic: Snow surface dimensionless age initial condition  0  0.0  WCic: Snow water equivalent dimensionless age initial conditio(m)  0  0.0  df: Drift factor multiplier  0  1.0  apr: Average atmospheric pressure  0  74000.0  Aep: Albedo extinction coefficient  0  0.1  cc: Canopy coverage fraction  0  0.7  hcan: Canopy height  0  12.0  lai: Leaf area index  1  LAI.nc LAI  Sbar: Maximum snow load held per unit branch area  0  6.6  ycage: Forest age flag for wind speed profile parameterization  0  1.00  slope: A 2-D grid that contains the slope at each grid point  0  2.0  aspect: A 2-D grid that contains the aspect at each grid point  0  300.0  latitude: A 2-D grid that contains the latitude at each grid point  0  41.86  subalb: Albedo (fraction 0-1) of the substrate beneath the snow (ground, or glacier)  0  0.25  subtype: Type of beneath snow substrate encoded as (0 = Ground/Non Glacier, 1=Clean Ice/glacier, 2= Debris covered ice/glacier, 3= Glacier snow accumulation zone)  0  0.0  gsurf: The fraction of surface melt that runs off (e.g. from a glacier)  0  0.0  b01: Bristow-Campbell B for January (1)  0  6.743  b02: Bristow-Campbell B for February (2)  0  7.927  b03: Bristow-Campbell B for March(3)  0  8.055  b04: Bristow-Campbell B for April (4)  0  8.602  b05: Bristow-Campbell B for may (5)  0  8.43  b06: Bristow-Campbell B for June (6)  0  9.76  b07: Bristow-Campbell B for July (7)  0  0.0  b08: Bristow-Campbell B for August (8)  0  0.0  b09: Bristow-Campbell B for September (9)  0  0.0  b10: Bristow-Campbell B for October (10)  0  7.4  b11: Bristow-Campbell B for November (11)  0  9.14  b12: Bristow-Campbell B for December (12)  0  6.67  ts\_last: degree celsius  0  -9999  longitude: A 2-D grid that contains the latitude at each grid  0  -111.6 |

Table of site initial variable codes

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| **Code** | **Definition** |
| USic | Energy content initial condition (kg m-3) |
| WSic | Snow water equivalent initial condition (m) |
| Tic | Canopy Snow Water Equivalent (m) relative to T = 0 C solid phase |
| WCic | Dimensionless age of snow surface (or albedo - depending on iflag) |
| df | Drift factor multiplier |
| apr | Average atmospheric pressure |
| Aep | Albedo extinction coefficient |
| cc | Canopy coverage fraction |
| hcan | Canopy height |
| lai | Leaf area index |
| Sbar | Maximum snow load held per unit branch area |
| ycage | Forest age flag for wind speed profile parameterization |
| slope | A 2-D grid that contains the slope (in degrees) at each grid point |
| aspect | A 2-D grid that contains the aspect (in degrees clockwise from north) at each grid point |
| latitude | A 2-D grid that contains the latitude (in degrees) at each grid point |
| longitude | A 2-D grid that contains the longitude (in degrees) at each grid point |
| subalb | Albedo (fraction 0-1) of the substrate beneath the snow (ground, or glacier) |
| subtype | Type of beneath snow substrate encoded as (0 = Ground/Non Glacier, 1=Clean Ice/glacier, 2= Debris covered ice/glacier, 3= Glacier snow accumulation zone) |
| gsurf | The fraction of surface melt that runs off (e.g. from a glacier) |
| Ts\_last | Snow surface temperature one day prior to the model starting time |
| b01 | Bristow-Campbell B for January (1) |
| b02 | Bristow-Campbell B for February (2) |
| b03 | Bristow-Campbell B for March(3) |
| b04 | Bristow-Campbell B for April (4) |
| b05 | Bristow-Campbell B for may (5) |
| b06 | Bristow-Campbell B for June (6) |
| b07 | Bristow-Campbell B for July (7) |
| b08 | Bristow-Campbell B for August (8) |
| b09 | Bristow-Campbell B for September (9) |
| b10 | Bristow-Campbell B for October (10) |
| b11 | Bristow-Campbell B for November (11) |
| b12 | Bristow-Campbell B for December (12) |

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| **File Name** | **inputcontrol.dat** |
| **File Function** | Identifies time varying forcing input data. Input variables are either SCTV or SVTV (but with SCTC allowed). In the SCTV case the name of the file holding the time series data is specified. In the SVTV case, the name of the netCDF files giving the SVTV input, and the variable name in the netCDF file and the time dimension name are given. In the SCTC case a numeric value is given.  **All time inputs for a specific model run should be with respect to the same UTC offset (time zone). This applies to both text and NetCDF files that contain time values.** |
| **File Format** | First line of this file is a header that is not parsed. The remaining lines occur in groups of 3 for each variable as follows:  1. Variable code  2. Variable flag (0 for SCTV, 1 for SVTV, 2 for SCTC, and -1 to indicate the variable is computed internally by the model)  3. There are three scenarios depending on the value of the flag:   * Variable value for SCTC with flag = 2 or for flag = -1. When flag is -1 the constant value will serve as place holder until the actual value is computed.) * Name of time series file when flag = 0 (SCTV) * (In case of SVTV, flag = 1) Name of the netCDF file without the postfix “.nc”, the name of the variable name, the name of the time dimension, and the number of netCDF files.   In the last case (SVTV), for a typical UEB Parallel case there would be multiple netCDF files which are differentiated by a number starting with 0 before the file extension (i.e. “.nc”). See the example below.  Prec: Precipitation (always required)  0  prec precip time 2  In this example, there are two precipitation netCDF files prec0.nc and prec1.nc, where the variable name is “precip” and the time dimension name is “time”. The y and x coordinates are required to be the same as those in the watershed grid file.  Note that the inputs here also depend on whether daily or sub-daily values are used. When daily values are used, daily minimum and maximum temperature are required. In this case the sub-daily temperature values are interpolated with a diurnal cycle following a sinusoidal curve.  Warning: Generally it is better for the user to provide sub-daily values and use the sub-daily mode. The mode using a daily values is added for experimental purposes and follows a sine curve that has a daily maximum temperature values at 3 PM in the afternoon and minimum at 3 AM in the morning. You need to adjust this (in the source code) if it doesn’t fit your watershed.  The order of the variables in this file is important; thus the first variable is always precipitation, temperature is the second, and the last one (thirteenth) is snow albedo. |
| **File Example** | Input Control file for TWDEF  Prec: Precipitation (always required)  0  Prec.dat  Ta: Air temperature (always required)  0  Ta.dat  Tmin: Min Air temperature  0  Tamin.dat  Tmax: Max Air temperature  0  Tamax.dat  v: Wind speed (always required)  0  V.dat  RH: Relative Humidity (always required)  0  RH.dat  Vp: Air vapor pressure  2  0.5  AP: Air pressure (always required)  2  74000 //press Pressure Time 3  Qsi: Incoming shortwave(kJ/m2/hr) (only required if irad=1 or 2)  2  0  Qli: Long wave radiation(kJ/m2/hr) (only required if irad=2)  2  0  Qnet: Net radiation(kJ/m2/hr) (only required if irad=3)  2  0  Qg: Ground heat flux (kJ/m2/hr)  2  0  Snowalb: Snow albedo (0-1). (only required if ireadalb=1) The albedo of the snow surface to be used when the internal albedo calculations are to be overridden  2  0.6 |

Table of input variable codes

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| **Code** | **Definition** |
| Prec | Precipitation (m/hr) (always required) |
| Ta | Air temperature (0C) (Required when sub-daily inputs are given. Can be computed from daily minimum and maximum temperature values). |
| Tmin | Daily minimum temperature (0C). (Required when inputs are specified as daily values). |
| Tmax | Daily maximum temperature (0C). (Required when inputs are specified as daily values). |
| v | Wind speed (m/s) (always required). |
| RH | Relative Humidity (use flag -1 if it is computed from vapor pressure) |
| Vp | Air vapor pressure (Pa) (Required when the flag for RH is -1) |
| AP | Air pressure at the surface (Pa) (Always required). |
| Qsi | Incoming shortwave(kJ/m2/hr) (only required if irad=1 or 2) |
| Qli | Long wave radiation(kJ/m2/hr) (Only required if irad = 2) |
| Qnet | Net radiation(kJ/m2/hr) (only required if irad=3) |
| Qg | Ground heat flux (kJ/m2/hr) (Always required) |
| Snowalb | Snow albedo (0-1). (only required if ireadalb=1) The albedo of the snow surface to be used when the internal albedo calculations are to be overridden |

**Example time series input file format**

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| **File Name** | **LongwaveRadiationTimeseries.dat** | | |
| **File Function** | Provides values of longwave radiation time series which is spatially constant but time varying | | |
| **File Format** | File contains multiple lines. First line is header which contains the variable code, up to the colon. Information beyond the colon not read. Remaining lines contain five columns | | |
| **Lines description** | **Column** | **Type** | **Description** |
| 1-4 | numeric | Time step (format: YYYY MM DD HH.FFF) |
|  | 5 | numeric | Numeric Value of a variable at a particular time step |
| **Example file** | Qli: Incident longwave radiation  2011 11 26 03.00 34.01  2011 11 26 06.00 34.01  2011 11 26 09.00 32.40  2011 11 26 12.00 33.40  2011 11 26 15.00 31.40  2011 11 26 18.00 34.01  2011 11 26 21.00 32.96 | | |

**Note on time steps and synchronization**

Unlike in the FORTRAN version, missing values are not accounted for in the model. The input files have to provide data for each time step; hence missing values should be handled during input preparation.

**Output control file format**

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| **File Name** | **outputcontrol.txt** |
| **File Function** | Identifies the variables for which point detail, gridded output and aggregated outputs are to be produced |
| **File Format** | First line is the header and is not parsed  The remaining lines are in three groups.  The first group is set of specifications for point detail outputs. Point detail outputs provide all (about 66) variable inputs and outputs at a given grid point. The first line of this group specifies the number of point detail outputs (0 if no point detail wanted). The next lines specify for each grid point the y and x coordinate indexes and the output file name.  The second group of outputs is time-space netCDF outputs. The first line of the group specifies the number of netCDF outputs (0 if no netCDF output wanted). The remaining lines provide the variable symbol, the output netCDF file name and its unit separated by white space. The variable symbols are provided below. E.g. SWE represents Snow Water Equivalent.  The third group is a set of specifications for aggregated outputs. First line gives the number of aggregated output variables. The remaining lines each gives the symbol for variables that are to be in aggregated output, the unit and symbol for aggregation operation type. The variable symbol is as described above (e.g. SWE for Snow Water Equivalent) and is given at the end of this document. The aggregation operation type refers to Averaging (AVE), or total (SUM).  Different from the FORTRAN version, the aggregated output file is netCDF. |
| **File Example** | OUTPUT VARIABLES  2 // number of point details; put 0 if no point output needed  1 1 Point11.txt // y, x coordinates, output file name  3 5 Point35.txt  3 //number of netcdf outputs; put 0 if no netcdf output needed  SWE SWE.nc m //symbol, file name, variable unit (look up the dictionary "UEB\_Variables\_Symbols.dat" for the symbol)  SWIT SWIT.nc m  SWISM SWISM.nc m  3 //number of aggregated output variables  SWE m AVE //name/symbol unit Aggregation operation (look up the dictionary "UEB\_Variables\_Symbols.dat" for the symbol, Operation SUM or AVE)  SWIT m SUM  SWISM m SUM |

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| **File Name** | **pointdetail.dat** |
| **File Function** | Contains detailed output at a single point |
| **FileFormat** | Files contains free format numbers in groups of 66 per time step |
| **Data description** | The following data is output in free format for each time step at the specified point   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | Var\_Symbol | | | |  | Name | | | | | 1 | Year | | | |  | Year | | | | 2 | Month |  | | Month | | | | | 3 | Day | |  | | Day | | | 4 | dHour | |  | | Hour | | | 5 | atff | |  | | Atmospheric transmission factor | | | 6 | HRI | |  | | Radiation index | | | 7 | Eacl | |  | | Clear sky emissivity | | | 8 | Ema | |  | | Atmospheric emissivity | | | 9 | conZen | |  | | Cos of solar zenith angle (Zen) | | | 10 | Ta | |  | | Air temperature(C) | | | 11 | P | |  | | Precipitation (m/hr) | | | 12 | V | |  | | Wind speed (m/s) | | | 13 | RH | |  | | Relative humidity | | | 14 | Qsi | |  | | Incoming solar radiation (kJ/m2/hr) | | | 15 | Qli | |  | | Incoming longwave radiation (kJ/m2/hr) | | | 16 | Qnet | |  | | Input net radiation (kJ/m2/hr) | | | 17 | Us | |  | | Energy content (kJ/m2) | | | 18 | Ws | |  | | Surface snow water equivalent (m) | | | 19 | tausn | |  | | Dimensionless age of the snow surface | | | 20 | Pr | |  | | Precipitation in the form of rain (m/hr) | | | 21 | Ps | |  | | Precipitation in the form of snow (m/hr) | | | 22 | Alb | |  | | Snow surface albedo | | | 23 | QHs | |  | | Surface Sensible heat flux (kJ/m2/hr) | | | 24 | QEs | |  | | Surface Latent heat flux (kJ/m2/hr) | | | 25 | Es | |  | | Surface sublimation (m) | | | 26 | SWIT | |  | | Total outflow (m/hr). This combines rainfall (in the case of no snow/glacier) snow/glacier melt, and it the surface water input to the runoff generation process. | | | 27 | QMs | |  | | Surface melt energy (kJ/m2/hr) | | | 28 | Q | |  | | Net surface energy exchange (kJ/m2/hr) | | | 29 | FM | |  | | Net surface mass exchange (m/h) | | | 30 | Tave | |  | | Average snow temperature (C) | | | 31 | TSURFs | |  | | Surface snow temperature (C) | | | 32 | cump | |  | | Cumulative precipitation (m) | | | 33 | cumes | |  | | Cumulative surface sublimation (m) | | | 34 | cumMr | |  | | Cumulative surface melt (m) | | | 35 | NetRads | |  | | Modeled surface net radiation (kJ/m2/hr) | | | 36 | smelt | |  | | Melt generated at surface (m/hr). This is melt generated at the surface and modeled to infiltrate into the snow or glacier where it may refreeze. It is not base of the snow/glacier outflow. | | | 37 | refDepth | |  | | Depth of penetration of top refreezing (m) | | | 38 | totalRefDepth | |  | | Total depth of refreezing (m) | | | 39 | cf | |  | | Cloudiness fraction | | | 40 | Taufb | |  | | Direct solar radiation fraction | | | 41 | Taufd | |  | | Diffuse solar radiation fraction | | | 42 | Qsib | |  | | Direct solar radiation | | | 43 | Qsid | |  | | Diffuse solar radiation | | | 44 | Taub | |  | | Direct solar radiation canopy transmission fraction | | | 45 | Taud | |  | | Diffuse solar radiation canopy transmission fraction | | | 46 | Qsns | |  | | Solar radiation absorbed at surface (kJ/m2/hr) | | | 47 | Qsnc | |  | | Solar radiation absorbed in canopy (kJ/m2/hr) | | | 48 | Qlns | |  | | Longwave radiation absorbed a tsurface (kJ/m2/hr) | | | 49 | Qlnc | |  | | Longwave radiation absorbed in canopy (kJ/m2/hr) | | | 50 | Vz | |  | | Modeled wind beneath canopy (m/s) | | | 51 | Rkinsc | |  | | Was canopy aerodynamic resistance -not used presently | | | 52 | Rkinc | |  | | Aerodynamic resistance of surface (below canopy) | | | 53 | Inmax | |  | | Canopy snow interception capacity (m) | | | 54 | intc | |  | | Canopy snow interception (m/hr) | | | 55 | ieff | |  | | Fraction of precipitation intercepted (m/hr) | | | 56 | Ur | |  | | Canopy mass unloading (m/hr) | | | 57 | Wc | |  | | Canopy snow water equivalent (m) | | | 58 | Tc | |  | | Canopy temperature(C) | | | 59 | Tac | |  | | Air temperature within canopy (C) | | | 60 | QHc | |  | | Canopy sensible heat flux (kJ/m2/hr) | | | 61 | QEc | |  | | Canopy latent heat flux (kJ/m2/hr) | | | 62 | Ec | |  | | Canopy sublimation (m/hr) | | | 63 | Qpc | |  | | Precipitation energy advected to canopy (kJ/m2/hr) | | | 64 | Qmc | |  | | Canopy melt energy (kJ/m2/hr) | | | 65 | Mc | |  | | Melt from canopy (m/hr) | | | 66 | FMc | |  | | Net canopy energy exchange (m/hr) | | | 67 | SWIGM | |  | | Glacier melt outflow (m/hr). This is the part of total outflow that originates from glacier melting. | | | 68 | SWISM | |  | | Rainfall outflow (m/hr). This is the part of total outflow that is from rainfall in the case of no snow/glacier. | | | 69 | SWIR | |  | | Snow melt outflow (m/hr). This is the part of total outflow that originates from the melting of seasonal snow pack (as distinct from glacier ice) | | | 70 | errMB | |  | | Mass balance closure error (m) | | |
| **Example file** | 2009 10 1 0.000 0.569902 0.000000 0.737389 0.831980 0.000000 -8.930000 0.000000 4.405000 0.921000 0.000000 841.261780 0.000000 -398.796967 0.000000 0.002761 0.000000 0.000000 0.250000 -231.049316 -0.000000 0.000000 0.000000 0.000000 -398.796967 0.000000 -1.122423 -5.096191 0.000000 0.000000 0.000000 -167.747681 0.000000 0.000000 0.000000 0.360196 0.411303 0.158599 0.000000 0.000000 0.000000 0.687584 0.000000 0.000000 -167.747681 -22.772583 2.937449 54.906319 64.534798 0.003563 0.000000 0.000000 0.000000 0.000000 -8.880371 -8.749257 22.770226 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000  2009 10 1 1.000 0.417001 0.000000 0.742554 0.914013 0.000000 |

|  |  |  |  |
| --- | --- | --- | --- |
| **File Name** | **watershed.nc** | | |
| **File Function** | A 2D grid file that contain integer values identifying each watershed (really an aggregation domain - the snow model does not care whether they are watersheds or not, or even contiguous) | | |
| **File Format** | NetCDF  Attribute: Unit less  Variable: watershed Identification Number (integer) | | |
| **Fields description** | **Field** | **Type** | **Description** |
| watershed number | Numeric,  “\_Fill\_Value” gives the “no-data” grid | Each watershed will be numbered and each number within a grid will represent that particular watershed |
| **File Example** | 1 1 1 1 1 1 1 1 1 2  0 0 1 1 1 1 1 1 2 2  0 0 0 1 1 1 1 2 2 2  0 0 0 0 1 1 1 2 2 3  0 0 0 0 0 1 2 2 3 3  0 0 0 0 0 0 2 3 3 3 | | |

**NetCDF file requirements**

UEBGrid works with 2-D and 3-D netCDF files. 2-D netCDF files are used to store variables that are constant in time (Spatially variable and time constant SVTC), while 3-D netCDF files are used to store variables that change in time (Spatially variable and time variable SVTV).

The characteristics of a netCDF file required by UEBGrid are:

* The grid sizes have to be the same across all netCDF files used in any one UEBgrid run. There is no exception to this rule.
* 3-D netCDF files require a time dimension.
* A single forcing variable may be stored in multiple netCDF files. Dimension and variable names should be the same across all the netCDF files in which that variable is stored in. As described earlier multiple netCDF files of the same variable are number as

Filename0.nc

Filename1. nc

Filename2.nc

…etc.

UEB Parallel is not very strict regarding the netCDF metadata, however it is recommended that the CF Conventions be followed (In the future strict adherence to CF Conventions may be required for compatibility with other models, but at this moment we are still at experimental stage).

Metadata may be added as attributes inside a NetCDF file but will not be read by the model in most cases. However, metadata may help the users to understand various characteristics of the input data (such as units, data collectors, responsible organization, coordinate systems and projects etc.).

**Running UEB in point mode.**

To run UEB for a single point (lumped mode) use a watershed grid file of just one grid cell and provide forcing time series in text file.

**Codes for output variables**

|  |  |  |
| --- | --- | --- |
| Var\_Symbol | Symb\_in\_UEB Fortran | Name |
| Year | Year | Year |
| Month | Month | Month |
| Day | Day | Day |
| dHour | dHour | dHour |
| atff | ATF-BC | Atmospheric transmission factor |
| HRI | HRI | Radiation index |
| Eacl | Eacl | Clear sky emissivity |
| Ema | Ema | Atmospheric emissivity |
| conZen | Os | Cos of solar zenith angle (Zen) |
| Ta | Ta | Air temperature(C) |
| P | P | Precipitation (m/hr) |
| V | V | Wind speed (m/s) |
| RH | RH | Relative humidity |
| Qsi | Qsi | Incoming solar radiation (kJ/m2/hr) |
| Qli | Qli | Incoming longwave radiation (kJ/m2/hr) |
| Qnet | Qnet | Input net radiation (kJ/m2/hr) |
| Us | Ub | Energy content (kJ/m2) |
| Ws | SWE | Surface snow water equivalent (m) |
| tausn | tausn | Dimensionless age of the snow surface |
| Pr | Prain | Precipitation in the form of rain (m/hr) |
| Ps | Psnow | Precipitation in the form of snow (m/hr) |
| Alb | Alb | Snow surface albedo |
| QHs | Qh | Surface Sensible heat flux (kJ/m2/hr) |
| QEs | Qe | Surface Latent heat flux (kJ/m2/hr) |
| Es | E | Surface sublimation (m) |
| SWIT | SWIT | Total outflow (m/hr). This combines rainfall (in the case of no snow/glacier) snow/glacier melt, and it the surface water input to the runoff generation process. |
| QMs | Qm | Surface melt energy (kJ/m2/hr) |
| Q | Q | Net surface energy exchange (kJ/m2/hr) |
| FM | dMdt | Net surface mass exchange (m/h) |
| Tave | Tave | Average snow temperature (C) |
| TSURFs | Ts | Surface snow temperature (C) |
| cump | CumP | Cumulative precipitation (m) |
| cumes | CumE | Cumulative surface sublimation (m) |
| cumMr | CumMelt | Cumulative surface melt (m) |
| NetRads | NetRads | Modeled surface net radiation (kJ/m2/hr) |
| smelt | Smelt | Melt generated at surface (m/hr). This is melt generated at the surface and modeled to infiltrate into the snow or glacier where it may refreeze. It is not base of the snow/glacier outflow. |
| refDepth | refDep | Depth of penetration of top refreezing (m) |
| totalRefDepth | totRefDep | Total depth of refreezing (m) |
| cf | Cf | Cloudiness fraction |
| Taufb | Taufb | Direct solar radiation fraction |
| Taufd | Taufd | Diffuse solar radiation fraction |
| Qsib | Qsib | Direct solar radiation |
| Qsid | Qsid | Diffuse solar radiation |
| Taub | Taub | Direct solar radiation canopy transmission fraction |
| Taud | Taud | Diffuse solar radiation canopy transmission fraction |
| Qsns | Qsns | Solar radiation absorbed at surface (kJ/m2/hr) |
| Qsnc | Qsnc | Solar radiation absorbed in canopy (kJ/m2/hr) |
| Qlns | Qlns | Longwave radiation absorbed a tsurface (kJ/m2/hr) |
| Qlnc | Qlnc | Longwave radiation absorbed in canopy (kJ/m2/hr) |
| Vz | Vz | Modeled wind beneath canopy (m/s) |
| Rkinsc | Rkinsc | Was canopy aerodynamic resistance -not used presently |
| Rkinc | Rkinc | Aerodynamic resistance of surface (below canopy) |
| Inmax | Inmax | Canopy snow interception capacity (m) |
| intc | int | Canopy snow interception (m/hr) |
| ieff | ieff | Fraction of precipitation intercepted (m/hr) |
| Ur | Ur | Canopy mass unloading (m/hr) |
| Wc | SWEc | Canopy snow water equivalent (m) |
| Tc | Tc | Canopy temperature(C) |
| Tac | Tac | Air temperature within canopy (C) |
| QHc | QHc | Canopy sensible heat flux (kJ/m2/hr) |
| QEc | QEc | Canopy latent heat flux (kJ/m2/hr) |
| Ec | Ec | Canopy sublimation (m/hr) |
| Qpc | Qpc | Precipitation energy advected to canopy (kJ/m2/hr) |
| Qmc | Qmc | Canopy melt energy (kJ/m2/hr) |
| Mc | Mc | Melt from canopy (m/hr) |
| FMc | FMc | Net canopy energy exchange (m/hr) |
| SWIGM | SWIGM | Glacier melt outflow (m/hr). This is the part of total outflow that originates from glacier melting. |
| SWISM | SWIR | Rainfall outflow (m/hr). This is the part of total outflow that is from rainfall in the case of no snow/glacier. |
| SWIR | SWISM | Snow melt outflow (m/hr). This is the part of total outflow that originates from the melting of seasonal snow pack (as distinct from glacier ice) |
| errMB | MassError | Mass balance closure error (m) |