
The Hydrological Modelling System PREVAH

Part III – User Manual

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Joachim Gurtz,
and Massimiliano Zappa**

This document contains the user manual for the hydrological modelling system PREVAH. It is Part III of the extensive model documentation by Viviroli, Gurtz and Zappa (2007) and is complemented by Part I, which gives an overview of PREVAH, and Part II, the physical model description. Part IV is a sample project containing selected components of the modelling system. For more information and updates, visit <http://www.hydrologie.unibe.ch/PREVAH>.

<i>Publication Part</i>	Part I	Part II	Part III	Part IV
<i>Contents</i>	Overview and selected applications	Physical model description	User manual	Sample project and selected executables
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The PREVAH modelling system is available for academic and research purposes exclusively. It must not be used commercially. Please read the "Terms of use" on page 3 of Part III or contact the authors for further inquiries: PREVAH@giub.unibe.ch.

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Terms of use

The tools presented in this manual have been jointly developed by Daniel Viviroli (Institute of Geography, University of Berne) and Massimiliano Zappa (Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf) as an extension to the PREVAH model. Together with the model core, which was originally developed by Joachim Gurtz (Institute for Atmospheric and Climate Science, ETH Zürich), they represent a complete modelling system with various pre- and postprocessing tools (referred to as "Software" below).

The Software was developed in the Compaq Visual Fortran Environment, partly using freeware ActiveX components provided by the Compaq Array Viewer (both © 2001 Compaq Computer Corporation).

This Software is property of the authors. It is provided upon request to academics employed by educational institutions and for academic and research purposes exclusively. The authors do not make any warranty of any kind with respect to the suitability of the software for any particular use or its suitability for use under any specific conditions; and will not be liable for any claims, damages or liabilities which arise directly or indirectly from the use of the software, including claims for loss of profit. You must not use this Software commercially. This includes use of the software or any derivative of it for research with the final aim of developing products for sale or license to a third party.

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Installation

Prior to the first use of several components of the hydrological modelling system PREVAH (i.e. WINGRID, WINHRU and HYDROGRAPH), the Array Viewer components (© 2001, Compaq Computer Corporation) have to be installed. The free, fully functional viewer component (declared "demo version") can be downloaded as installer package from Intel¹. Make sure your system supports the required OpenGL and ActiveX standards.

Alternatively, the batch program "install_viewer.bat" may be used; it is distributed with complete versions of the modelling system such as the release coming along with this publication. It comes with the necessary program libraries (AVIEW160.DLL, AVIS2D.OCX, AVISGRID.OCX and DFDLG100.DLL) which are registered after execution of the batch program.

A complete sample project, including selected components of the PREVAH modelling system described here, is available on-line at <http://www.hydrologie.unibe.ch/PREVAH> as Part IV of the extensive PREVAH model documentation.

¹ current hyperlink: <http://www.intel.com/cd/software/products/asmo-na/eng/compilers/226288.htm>

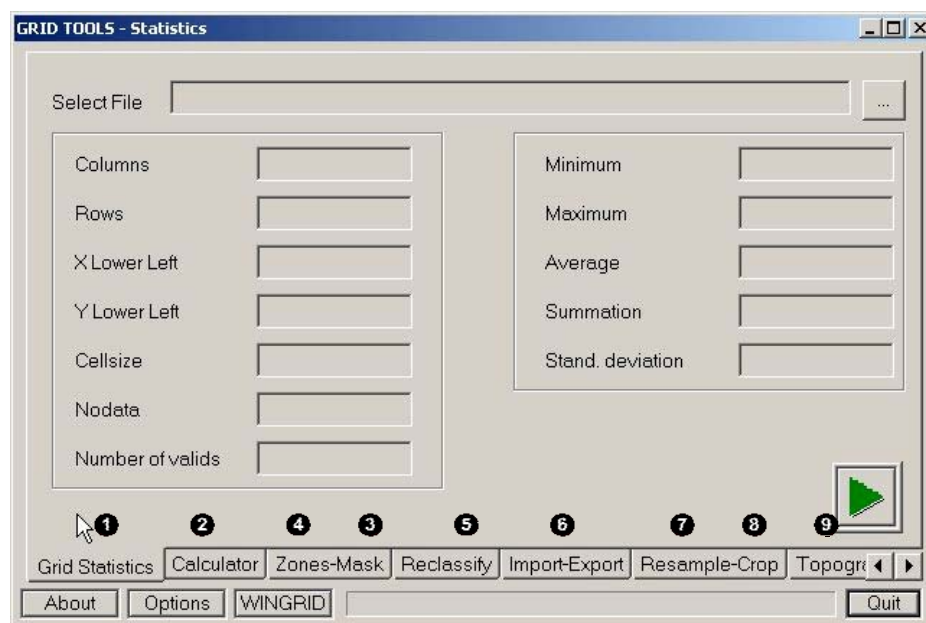
A GRIDMATH: Management of PREVAH-formatted binary grids

A.1 Introduction

The management of digital representations of spatially distributed physiogeographical information is an important requirement for the development, parameterisation and initialisation of GIS-based spatially distributed hydrological models. GRIDMATH is a tool allowing the management of spatial data stored in the grid format required for using the hydrological modelling system PREVAH.

The GRIDMATH tool allows different operations:

- ❶ Computation of statistical values of a grid
- ❷ Simple calculations between two grids or between a grid and a number
- ❸ Overlaying a grid mask to a grid
- ❹ Zonal statistics between two grids
- ❺ Reclassifying the content of a grid
- ❻ Importing grid from and exporting grid to other grid formats
- ❼ Reducing the resolution of a grid (resample) by different methods
- ❽ Reducing the size of a grid by cropping the borders
- ❾ Making the topographic analysis of a digital elevation model grid



Main dialog of GRIDMATH

A.2 Binary format

In the PREVAH modelling system, a binary grid format is used. In order to exchange grids between different computer platforms and with other software, e.g. with ESRI ArcInfo, an ASCII-format is required:

Rows 1 to 6: grid header (number of columns and rows, co-ordinates of the lower left corner, cell size, No-Data value)

The following rows represent the grid data from top left to bottom right:

ncols	7					
nrows	12					
xllcorner	680500					
yllcorner	222200					
cellsize	2000					
NoData_value	-9999					
-9999	-9999	-9999	-9999	-9999	-9999	-9999
-9999	-9999	-9999	-9999	-9999	-9999	-9999
-9999	-9999	586	559	595	601	585
584 -9999	-9999	-9999	-9999	-9999	-9999	
-9999	449	-9999	-9999	454	511	551
-9999	561	529	509	498	487	499
521 523	523	534	-9999	-9999	-9999	
-9999	-9999	-9999	-9999	-9999	-9999	-9999
-9999	-9999	-9999	-9999	-9999	345	234
567 453	456	478	789	576	482	
123 -9999	1252	1211	876	564	825	
-9999	-9999	234	1246	-9999	-9999	-9999

The PREVAH binary format is structured similarly to the ASCII-format. All values are stored in single precision (4 bytes in most computer systems, 6 to 7 digits precision). Records 1 to 6 correspond to the data of the ASCII-Format. Then 6 additional records describing the grid statistics follow:

Records 1 to 6: as in the ASCII-format

Records 7 to 12:

- Count of valid cells (without NoData-values)
- Minimum value of all valid grid cells
- Maximum value of all valid grid cells
- Sum of all valid grid cells
- Mean value of all valid grid cells
- Standard deviation of all valid grid cells

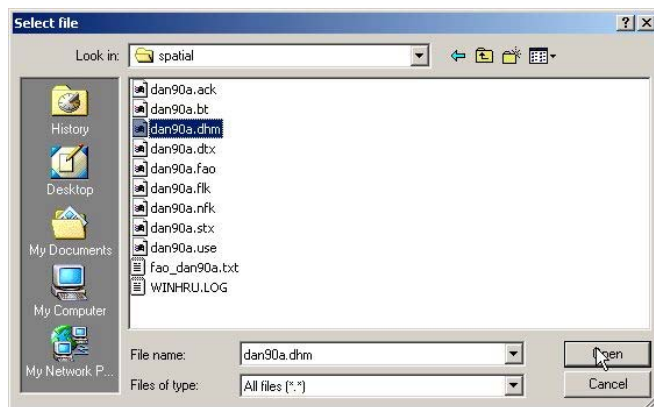
After this header, all cells of the grid are following in the same order as in the ASCII-format, i.e. from the top left cell to the lower right cell in a row by row order. GRIDMATH is able to convert the formats from one into another. ASCII-formats can be exchanged between different systems using e.g. ftp-programs with an automatic conversion of carriage returns/line feeds. To exchange binary data, they first have to be converted into ASCII-data, subsequently the exchange can be achieved and thereafter a re-converting on the target platform should be completed.

A.3 Usage

Basic commands:



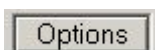
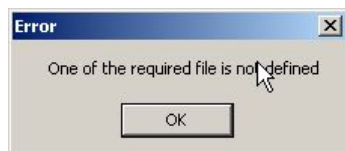
All the available operations require that files and directories are selected. This button launches the following dialog:



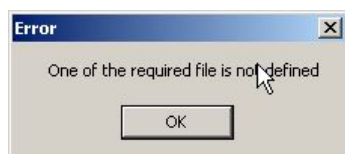
This dialog allows for the determination of the working directory, selection of the file to be analysed or typing of the name of an output file. It is also possible to use this dialog to create a directory, change the name of a file and delete a file.



This button starts the selected process (statistics, crop, resample, etc.). If a required file is not selected, an error box is displayed.



This button enables a dialog for the definition of the directory, where plug-ins are stored:



gridmath.exe requires two plug-ins: tanalys.exe (see Chapter 3.1.1., Part II of the PREVAH documentation) and wingrid.exe (see Chapter H). The initialisation file gridmath.ini stores this option. gridmath.ini is created in the same directory where gridmath.exe is stored.



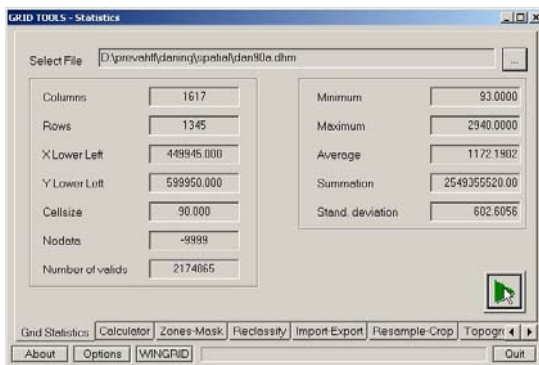
This button starts wingrid.exe (see separate documentation).

A.4 Operations

The name of the active operation, for example [GRID TOOLS – Masking and zonal statistics], is displayed in the title bar of the dialog. To change operation, select the appropriate tab at the bottom of the window.



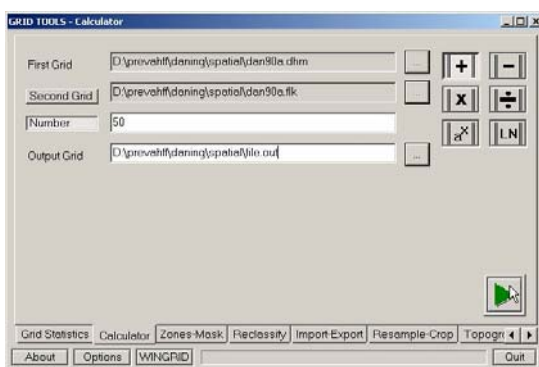
A.4.1 Grid Statistics



Usage: 1). Select grid. 2). Start process.

This operation displays the 12 headers of the selected binary file. This operation is very useful to determine if two files have the same dimensions (same number of columns and rows, co-ordinates, cell spacing and NoData value) and co-ordinate system.

A.4.2 Grid calculator

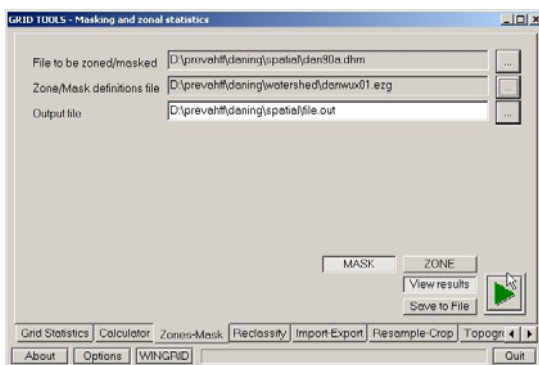


This operation allows for the completion of simple mathematical operations between two grids or between a grid and a number.

Usage: 1). Select first grid. 2). Select if you want to make a grid to grid (click [Second Grid]) or a grid to number (click [Number]) operation. 3). Select a mathematical operation. 4). Define an output grid. 5). Start process.

Notes: NoData cells are skipped. Division by '0' set values to NoData.

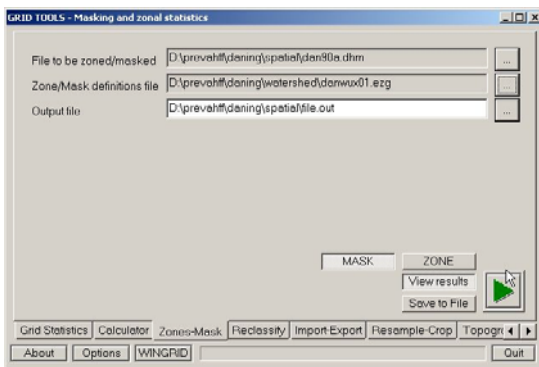
A.4.3 Changing the domain of a grid through a mask



This operation enables the change of the extent of the domain of a grid by selecting a second grid. All NoData values in the second grid are set as NoData in the first grid. This operation is very useful for cutting the perimeter of a watershed from full-extent grids.

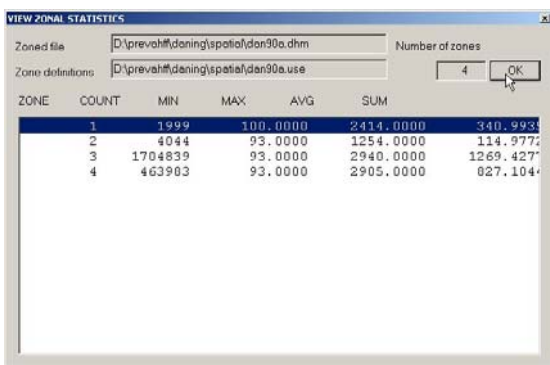
Usage: 1). Select first grid. 2). Select the mask grid. 3). Select the option [MASK]. 4). Define the name of an output grid. 5). Start process.

A.4.4 Zonal Statistics



This operation allows for the computation of zonal statistics between two grids

Usage: 1). Select first grid, whose statistics are required for each zone. 2). Select the grid containing the zones (which can be the same grid as the first grid). 3). Select the option [ZONE] and specify whether the results should be displayed in a dialog window (select or deselect [View results] button); if you wish to write the results to a file, click [Save to File]. 4). Define the name of a zonal statistics output file. 5). Start process.



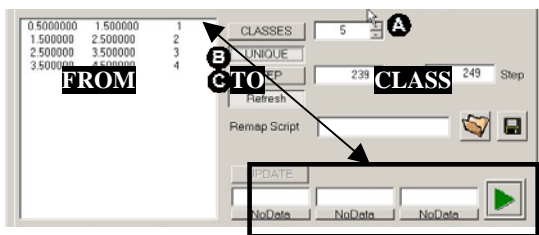
Both on the displayed dialog (here left) and in the output file (sample follows in the grey box) following statistical parameters are listed for each zone: Zone ID, Number of cells (COUNT); Minimum value (MIN); Maximum value (MAX); Average value (AVG); Summation (SUM).

Zonal statistics for D:\spatialch\CH\arhin\arhin.dhm

Zone definitions D:\spatialch\CH\arhin\arhin.pus

1	57	530.4000	2402.3601	1626.2500	92696.2500
2	59	523.3200	1575.9200	842.0817	49682.8203
3	2078	1400.1600	2127.1599	1656.5428	3442296.0000
4	284	510.2000	796.4400	701.7695	199302.5469
5	1656	800.2400	1400.0000	1130.2294	1871659.8750
6	1	649.8400	649.8400	649.8400	649.8400
7	1591	503.5600	2138.6799	1149.6309	1829062.7500
8	787	567.8800	2335.2400	1874.3894	1475144.5000
14	278	2343.0000	3225.6399	2771.7542	770547.6250
15	3818	686.1600	3458.2400	2510.2693	9584208.0000
19	4	525.0800	577.0400	552.9200	2211.6799
22	2	998.7200	2050.4800	1524.6000	3049.2000
24	4744	829.2800	2750.8000	2107.9688	10000204.0000
25	623	1036.5200	2471.3999	1794.6443	1118063.3750
26	853	565.1200	2808.3201	2261.6719	1929206.1250
29	9	548.7600	611.6800	571.2000	5140.7998

A.4.5 Reclassify a grid



This operation allows for the reclassification of a grid. Different options are available.

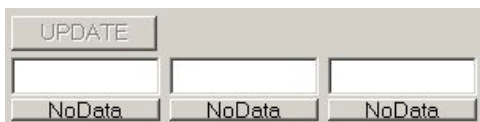
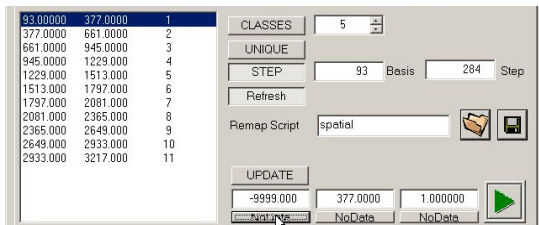
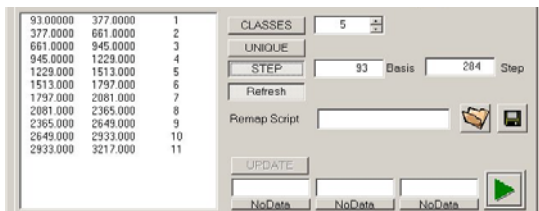
Basic Usage: 1). Select a grid. 2). Click [LOAD]. 3). Select the method ([CLASSES], [UNIQUE] or [STEP]). 4). Define the name of an output grid. 5). Start process.


Options:


A: Method CLASSES: Increase or decrease the number of classes (default 5 classes, equal interval) or type a number in the field to the right of the [CLASSES] button. After typing a number in the field click the [Refresh] button.

B: Method UNIQUE: No options. A class is defined for each integer number in the grid.

C: Method STEP: Change the basis of the step classification (default: Minimum in the selected grid) and dimension of the step (default: $\frac{1}{11}$ of the difference between maximum and minimum in the selected grid). After every change, click the [Refresh] button.

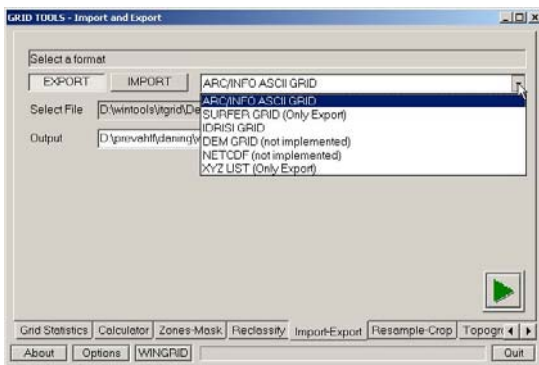


Save a Reclassify Script: A reclassify table can be saved into a script which can be used again later for similar tasks. Click  and provide a name for the script. The extension '.rms' will be added automatically to the script name.

Load a Reclassify Script: After loading the selected grid (see above), a saved reclassify table can be loaded. Click  and select the desired script (with the extension '.rms'). The script will be loaded into the list box of the dialog.

Change the range of the classes: 1). Mark one of the classes. 2). The range of the selected class is loaded in the three fields at the bottom part of the dialog. Type the new FROM/TO range and/or the new CLASS in the respective fields. If you want to set FROM/TO or CLASS to NoData, then click the corresponding button below the three fields. Click [UPDATE] to refresh the list box of the dialog.

A.4.6 Import-export tool



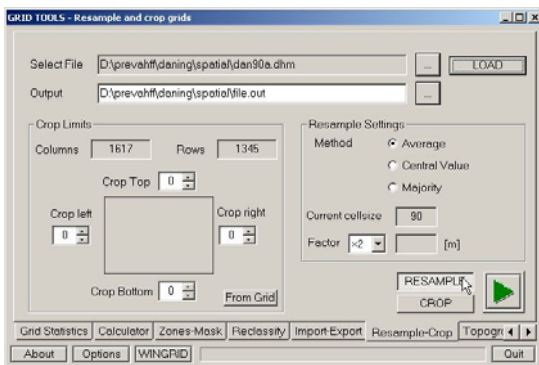
This operation allows the assimilation from and conversion to other grid formats.

Usage: 1). Select whether you want to [EXPORT] from or [IMPORT] to the PREVAH binary grid format. 2). Select non-PREVAH format. 3). Select source grid. 4). Define an output grid. 5). Start process.

Notes: Some of the declared formats are still not fully implemented.

To import from a grid with other formats is the first and most crucial step in using the PREVAH modelling system.

A.4.7 Resample tool



This operation allows for the reduction of the resolution of a grid after 3 methods.

Basic Usage: 1). Select the [RESAMPLE] operation. 2). Select a grid and click [LOAD]. 3). Define the name of an output grid. 4). Select the method (Average, Central Value or Majority). 5). Select a resample factor. 6). Start process.

After loading a grid the current cell size is displayed. The new cell size after resampling with the currently chosen factor is displayed in a second box.

Available methods (options):

Average: All the grid cells in the sample are averaged (best for physical values like elevation).

Central Value: The central cell of the cells sample is taken as representative random value for the full sample (suitable for spatially very variable categorical data like land cover classes).

Majority: The most frequent class in the sample is taken as a representative for the full sample (suitable for homogeneous categorical data like soil classes).

In the example shown, a grid with 9 columns and 9 rows is sampled by a factor of 3 (red lines in upper left grid) with the average method (upper right grid), the central value method (lower left grid, green box) and the majority method (lower right grid, red box). Some parameters controlling the analysis have to be specified (threshold values, constants, file names).

Original Grid

1	1	2	4	4	4	5	5	5
1	1	2	4	4	5	5	5	5
1	3	2	2	4	5	5	5	5
2	2	3	3	2	5	5	6	5
1	1	3	3	2	3	6	6	6
2	2	3	3	3	6	6	9	9
2	2	2	2	6	3	8	9	9
2	2	7	7	6	8	8	8	9
2	1	7	6	6	6	8	8	8

3x, Average

14/9	36/9	44/9
19/9	30/9	58/9
27/9	50/9	75/9

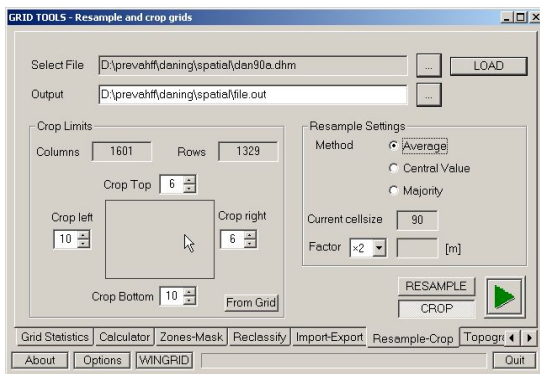
3x, Central Value

1	4	5
1	2	6
2	6	8

3x, Majority

1	4	5
2	3	6
2	6	8

A.4.8 Crop tool



This operation enables the reduction of the domain of a grid.

Basic Usage: 1). Select the [CROP] operation. 2). Select a grid and click [LOAD]. 3). Define the name of an output grid. 4). Select the portion you want to crop. 5). Start process.

To cut undesired portions from a grid, you may specify the extent (in rows or columns) of the domain portion you would like to crop from left, top, right and bottom. Example:

Original Dimension of the Picture: 1617 columns \times 1345 rows. Cropping 6 rows from top, 10 rows from bottom, 10 columns from left, and 6 columns from right. The final domain has only 1601 columns (1617-16) and 1329 rows (1345-16).

A.4.9 Topographical analysis



This operation makes a partial topographical analysis of a digital elevation model.

Basic Usage: 1). Select a digital elevation model (DEM) file. 2). Select the output options. 3). Start process.

GRIDMATH starts tanalys.exe and makes a partial topographical analysis. This operation is required to determine flow direction and flow accumulation.

Additional information on the topographical analysis is presented in Chapter 3.1.1, Part II of the PREVAH documentation. A list of the produced files with explanation of the extensions is provided in the Appendix.

B **FAO-Soil: Processing soil grids from the FAO digital soil map of the world**

B.1 **Introduction**

FAO-Soil is a tool allowing the parameterisation of soil properties grids from available information on the spatial distribution of FAO classes within the investigated domain. The FAO soil classes can be generated from the Digital Soil Map of the World (<http://www.fao.org/ag/agl/agll/dsmw.htm>), which is based on the FAO/UNESCO Soil Map of the World, original scale 1:5'000'000. The digital soil map of the world consists of the following map sheets: Africa, North America, Central America, Europe, Central and Northeast Asia, Far East, Southeast Asia, and Oceania. A set of ESRI ArcInfo (<http://www.esri.com>) coverages covering all the continental surfaces is provided upon request.

B.2 **Data requirements**

For the use of FAOSoil, the following binary grids are required:

- Digital Elevation Model (*.dhm)
- Land Use Map (*.use or *.pus)
- Grid with information on the FAO-Classes (*.fao)

The FAO soil classes grid can be generated by using the provided ESRI ArcInfo coverages and commercial GIS and/or remote sensing software. To obtain the binary format required in the PREVAH modelling system the tool GRIDMATH has to be used (see separate documentation). It is imperative that all grids are in the same format (same number of columns and rows, same co-ordinates, cell spacing and NoData value).

Additionally, the following tables must be in the directory where FAOSoil is running:

- 'faoworld.dat'. Contains the Texture Identifier and portion of dominant and associate soils for all FAO soil classes
- 'faodepth.dat'. For each FAO soil a portion (in percent) for each of the five soil depth classes is given.
- 'faosmax.dat'. For each FAO soil a portion (in percent) for each of the seven soil moisture storage capacity classes is given.

These tables shouldn't be modified.

B.3 Usage

- ❶ Load an available grid with spatial distribution of FAO soil classes.
- ❷ Load an available grid of the digital elevation model (DEM).
- ❸ Load an available grid of the land use classes.
- ❹ Declare the ID of the land use classes Rock, Water, Glacier and Buildings in the land use grid.
- ❺ Click [GO!] and then look at the results in the right half of the dialog (compare with documentation and report file!). Exit.

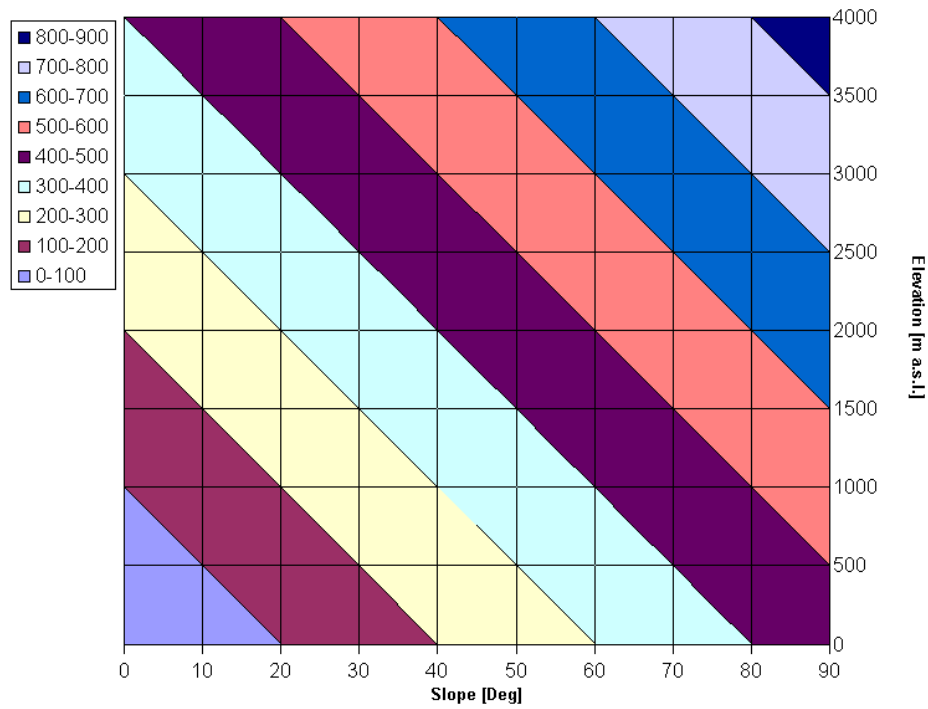
The resulting grids can then be evaluated with GRIDMATH and visualised with WINGRID.

B.4 Algorithm

For the spatial disaggregation of the soil properties according to the different portions of soil depth and available field capacity classes in the different FAO soil units, a simple index based on slope elevation and land use is adopted. The index is computed for each (x,y) grid cell in the investigated domain. It is assumed that the deepest soils and the soils with highest plant available field capacity are located in the lower altitudes and in the flat part of the domain. The disaggregation index is defined as:

$$SOIL_{(x,j)} = \frac{DHM_{(x,j)}}{10} + SLP_{(x,j)} \cdot 5 \quad (B1)$$

SOIL is the computed disaggregation index for a (x,y) grid cell. DHM is the elevation and SLP the slope for a (x,y) grid cell.



The above Figure shows the SOIL disaggregation index as a function of Elevation and Slope after Equation B1.

The disaggregation index is then normalised:

$$SOIL_{(x,j)}^{NORM} = 1 - \frac{(SOIL_{(x,j)}^{NORM} - SOIL_{MIN}^{NORM})}{(SOIL_{MAX}^{NORM} - SOIL_{MIN}^{NORM})} \quad (B2)$$

From Equation B2, it results that the (x,y) grid cells with a normalised soil disaggregation index close to 1 have the highest chance to show deep soils and high plant available field capacity.

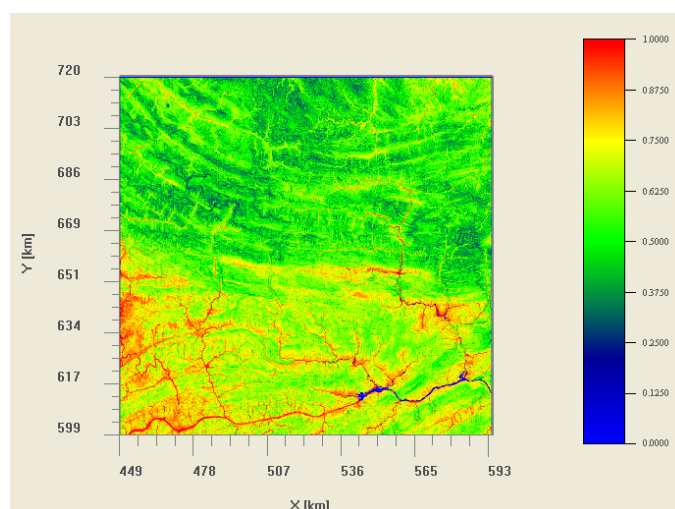
There are additional restrictions, which depend on the land use. Shallow soil should first be assigned to grid cells covered by water bodies, rocky areas, urban areas and glaciers. In case of the plant available field capacity the index for the land use "water bodies" is set per default to 1.

Default normalised disaggregation index for special land use categories

	Water bodies	Rocky areas	Urban Areas	Glaciers
Soil Depth	0.0	0.0	0.0	0.0
Field capacity	1.0	0.0	0.0	0.0

B.5 Results

- Grid of effective soil depth classes (*.bt).
- Grid of soil moisture storage capacity classes (*.nfk).
- Report file (fao*.txt).
- Grids of the two indices used for the downscaling of the soil classes (*.dtx and *.stx).



Normalised disaggregation index for the soil depth in the Daning catchment (China).

B.5.1 Effective soil depth derived from the soil map of the world

Soil depth is the vertical distance between the surface and parent material of a soil. Soil depth indicates the state of pedogenesis; its changes can indicate degradation and other transformation processes. Soil depth usually remains the same over very long periods of time. Sudden changes will most likely be the result of a change of the soil itself (erosion, soil removal or allocation).

To estimate effective soil depth, the following rules based on the soil unit's classification name, the soil phase(s) indicated for the dominant unit and the slope class. It takes into account the full composition of each mapping unit as given in the mapping unit composition file ('faoworld.dat'). Estimates for the % occurrence of each depth class are derived from a file called 'faodepth.dat'.

The following table indicates recommended parameterisation for soil depth in meters in the case of categorical data from the FAO "Digital Soil Map of the world" (FAO-UNESCO, 1988).

Classification of soil depth from the FAO soil map (FAO-UNESCO, 1988)

Category	Soil depth	Parameterisation [m]	Recommended [m]
5	Very Deep	1.5-3.0	2.00
4	Deep	1.00–1.5	1.25
3	Norm	0.5–1.0	0.75
2	Shallow	0.1–0.5	0.35
1	Very shallow	<0.10	0.10

B.5.2 Soil moisture storage capacity derived from the soil map of the world

Soil moisture storage capacity (also referred to as field capacity) is the water content of a soil at a defined time after its complete wetting and free drainage has become negligible. Soil moisture storage capacity is an important soil characteristic for two reasons: Firstly, together with the permanent wilting point, it defines the ability of a soil to satisfy the vegetation's water needs during periods without precipitation. Thus the plant-available filed capacity is defined as the amount of soil water that can be extracted by the plant, as the difference in soil moisture content between the field capacity and wilting point. It is expressed as millimetres of plant-available water within the root zone. Secondly, it describes a soil's effectiveness as a buffer in the vertical transfer of water after precipitation, thus determining a soil's water retention and purification properties.

In the context of defining ranges and values for important properties and qualities derived from the Soil Map of the World (FAO-UNESCO, 1988), this text describes a methodology to determine values for the soil moisture storage capacity to a depth of 100 cm or to an impermeable layer, which ever is shallower (SMAX).

It is recognised that the prediction of Smax is only a part of the solution to the more general problem of soil water available to plants (SWAP). Indeed, SMAX is determined in isolation of the prevailing climate and is, to a large extent, ignoring specific rooting habits of crops. Furthermore, some researchers have rejected the concept of the soil water availability as a static capacity in favour of a continuous variable in relation to atmospheric demand, root extension, water-table depth, rate of water movement to root surfaces etc.

SMAX classes proposed for the interpretation of the Soil Map of the World.

Symbol	EAV range	Smax_range	Class_name
1	Not_applicable	Not_applicable	W(wetlands)
2	> 120 mm	> 200 mm	A
3	100–120 mm	150–200 mm	B
4	60–100 mm	100–150 mm	C
5	40–60 mm	60–100 mm	D
6	20–40 mm	20–60 mm	E
7	< 20 mm	< 20 mm	F

C WINHRU: Gather and process spatial information

C.1 Introduction

Spatial information is an indispensable basis for distributed hydrological modelling. WINHRU serves to produce the necessary raster-based grids and handles the creation of hydrological response units (HRUs). The spatial information gathered with WINHRU may also be of use for various other hydrological and geographical applications. The resulting grids may be interpreted visually (e.g. with WINGRID) or be analysed statistically in a standard GIS system after conversion into a suitable exchange format (use e.g. GRIDMATH).

C.2 Basic features of WINHRU

WINHRU has been developed to easily create all the spatial information needed for running PREVAH in a single step. Some features may be specifically adjusted for application within Switzerland. However, this does not restrict the use of WINHRU for any other geographic domain. WINHRU is able to:

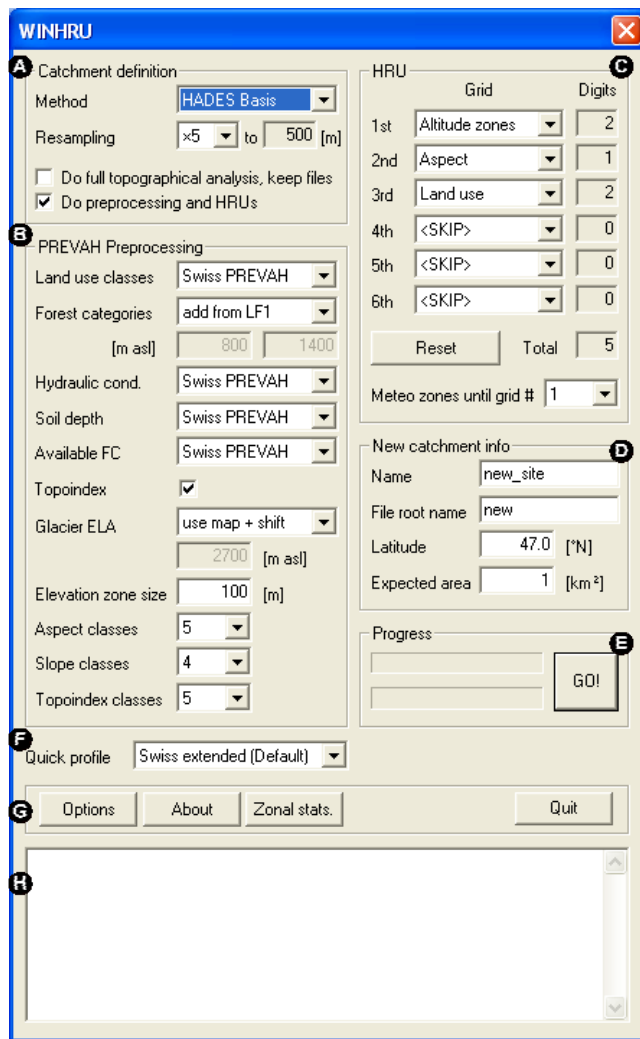
- Define hydrological catchments in various ways, e.g. based on a digital elevation model
- Perform a detailed topographical analysis
- Derive hydrological response units based on user-specified criteria
- Create tables and input files suitable for the PREVAH modelling system

Together with WINMET, all the tables necessary for running PREVAH can be created.

If you are not using the standard WINHRU paths and filenames, you will have to adjust these settings in the Options dialog (see page 27).

C.3 Start-up

Start winhru.exe by double-clicking the icon linked to the winhru.exe executable or by clicking the appropriate button in LAUNCHER.

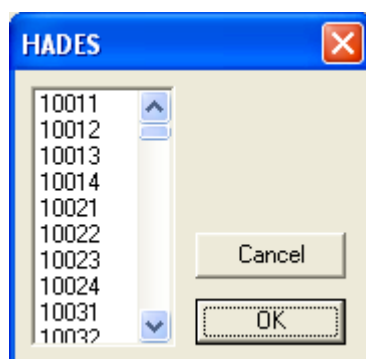
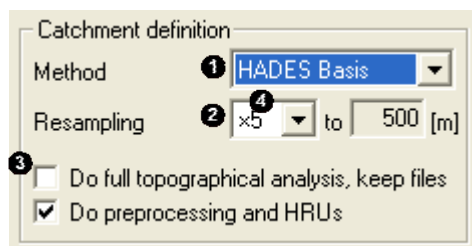


After start-up, the main dialog window of WINHRU is displayed. It consists of the following sections:

- A Catchment definition settings
- B PREVAH preprocessing settings
- C HRU definition settings
- D PREVAH project settings
- E Progress bar and launch button
- F Quick profile selector
- G Program runtime buttons
- H Console output

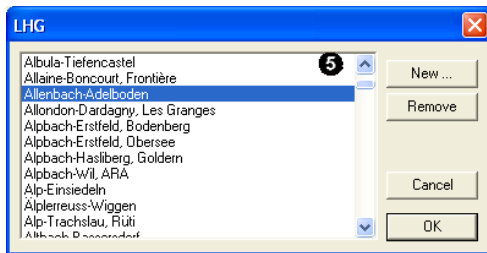
A detailed description of these components follows below. Note that changes in the dialog serve to configure the behaviour of WINHRU and take effect only after launching the program with the [GO!] button (Progress section, E).

C.3.1 Catchment definition settings (A)

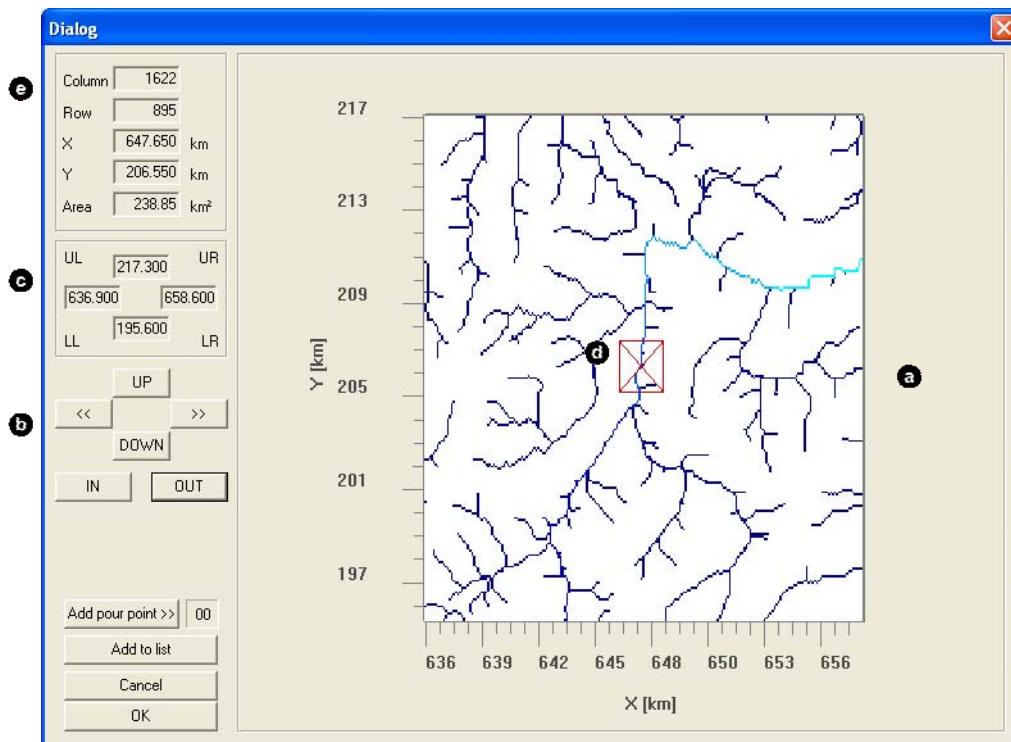
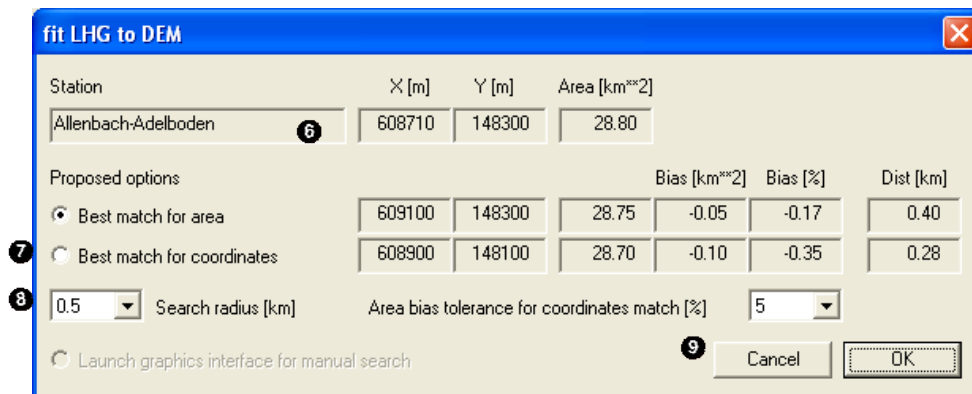


[Method] allows the selection of the manner of catchment definition (1). For the resulting catchment, a set of windowed grids is created from the source grids. Available methods are:

- HADES Basis: Definition based on small catchments as defined in the Hydrological Atlas of Switzerland ("Basisgebiete", see Breinlinger et al., 1992). After launching WINHRU, a dialog appears (4) where the desired catchments may be selected according to their 5-digit ID. Use <Ctrl> and <Shift> to select multiple basins. This option is applicable for Swiss catchments only.
- HADES Balance: Similar to HADES Basis, but applying to a 4-digit HADES water balance basins ID. This option is applicable for Swiss catchments only.
- LHG gauge site: Allows the selection of a specific gauge site. When WINHRU is launched, a dialog showing the available locations appears (5). [New...] and [Remove] may be used to add or delete stations from the record (see Options, page 27, for further details on file structure). Select the desired station and click [OK] to proceed. WINHRU derives the upstream



area of the selected location and subsequently displays a dialog showing location and basin area of the actual gauging station (6) as well as suggestions for defining the catchment based on the underlying digital elevation model (DEM) (7). Consider co-ordinates (X, Y), Area, Bias (km^2 and %) and distance (Dist) to decide upon a selection. Specify search radius (8) and tolerance for catchment area bias (9) to alter the suggestions. [OK] proceeds with the catchment definition; [Cancel] stops the catchment definition and returns to the main WINHRU dialog.



- Free pour point: Calls a dialog where the user may specify a basin outlet with the help of a graphical interface (a). Similarly to WINGRID, use the navigation buttons (b) to move and zoom the currently displayed domain; the limits are displayed in Swiss co-ordinates [km] (c). Click on the map or use the cursor keys to place the marker (d) on a point of choice in the flow accumulation map. Co-ordinates and basin area of the currently selected point are displayed in e. To launch the basin definition based on the selected pour point simply click [OK]. You may also add the currently selected point as an additional pour point for defining sub-catchments [Add pour point >>] or add it to the gauge site list [Add to list] for easier access in a subsequent catchment definition process (see Method, LHG gauge site, above). [Cancel] returns the user to the main WINHRU dialog without completing changes.

Due to the inaccuracies contained in any digital elevation model (DEM), flow accumulation and flow direction may not correspond with reality; this may lead to the determination of unsuitable basin areas and basin limits, especially in flat areas. There are two simple ways to avoid this problem: Either, use a different topographical analysis algorithm from a GIS-package to derive a new flow accumulation and flow direction grids; or edit the DEM directly (e.g. with WINGRID) and thereby correct obvious errors. The former option may be more suitable for some areas but fail to work in others. A more sophisticated approach is to apply a DEM Surface Reconditioning System such as AGREE (available at www.ce.utexas.edu/prof/maidment/GISHYDRO/ferdi/research/agree/agree.html).

- From grid file: A dialog opens where the user can load a PREVAH-formatted grid file which defines the catchment (values of 1 for grid cells inside of the catchment, NoData or 0 for all remaining cells); note that extent and resolution of this grid file must match these of the basic grid maps used (such as e.g. the digital elevation model). If necessary, use GRIDMATH (see Section A) to convert standard GIS formatted files (e.g. ASCII-type from ArcInfo) into the PREVAH format.

[Resampling] (2 in the WINRHU main dialog window) specifies the resampling factor which should be applied to the source grids (see Options in Section C.3.4). Factors 1, 2, 3, 4, 5, 10, 20 and 50 are available. The resulting grid resolution is displayed on the right-hand side of the list box. Simply select 1 as factor if no resampling is desired.

When [Do full topographical analysis and keep files] is checked (3), WINRHU derives a number of additional topographical maps which are not used by PREVAH but may be very useful for other hydrological interpretations. When unchecked, only the necessary topographical analysis is completed. The grids that are always created include aspect (*.exp), slope (*.slp), flow direction (*.fld), flow accumulation (*.acc) and basin area (*.ezg). Additional grids in full analysis are e.g. river network (*.lin) with associated river order (*.ord) and nomenclature (*.num), flow duration (*.fzt), flow depths (*.dep), flow widths (*.wit), sub-basins (*.e01, *.e02, ...) with associated pour points (*.m01, *.m02, ...) and flow time sums (*.zs1, *.zs2, ...) as well as a corrected digital elevation model (*.dhk) with sinks (*.sin) removed and associated corrected grids of flow direction (*.flk), flow accumulation (*.ack), river network order (*.ork) and river network nomenclature (*.nuk). The extended topographical analysis uses components from Schulla and Jasper (2000), which are partly described in Section 4.4.2, Part II of the PREVAH documentation.

C.3.2 PREVAH preprocessing (9)

In this dialog section, options for processing the windowed and resampled grids (see A in Section C.3.1) into PREVAH-suitable grids are specified.

1 [Land use classes]: Define the aggregation of land use information. Options are [keep actual classes] (this means that the PREVAH classes have already been assigned during a previous phase of the preprocessing of the land use grids), [Swiss PREVAH] (for application of PREVAH in Switzerland), [user defined] (to use previously stored default settings), [interactive] (a dialog is prompted to assign physically based values to categorical information) and [<Skip>] (do nothing).

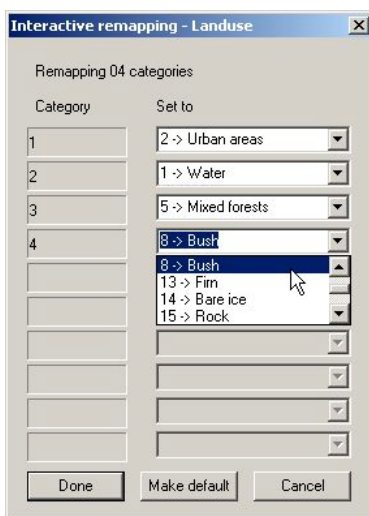
2 [Forest categories]: Define how the category "forest" from the land use map is split into deciduous and coniferous trees. [Add from LF1] uses the Swiss national forest statistics (WSL, 1988) to update the forest categories. [Define mixing zone] allows the specification of an altitude zone (edit boxes below) in which deciduous and coniferous trees are each assumed to represent a 50% share. Higher altitudes are assumed to be purely coniferous, lower altitudes are purely deciduous forest. This option assumes that all the

forested areas have been defined as mixed forest in the previous phase of the preprocessing of the land use grid or during the interactive reclassification of land use data. [Keep actual values] completes no updating. This means that the PREVAH classes for deciduous, mixed and coniferous forests have already been assigned during a previous phase of the preprocessing of the land use grid.

[Hydraulic conductivity] ③, [Soil depth] ④ and [Available field capacity] ⑤ specify the respective grid aggregation similarly to Land use classes.

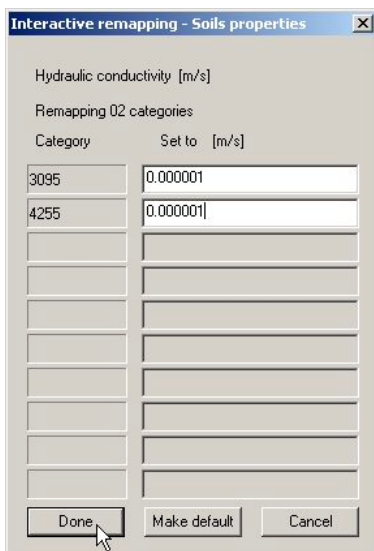
Interactive classification:

If you decide to interactively assign land use classes and/or physical parameterisations to the soil categories then, during the processing of WINHRU, the following dialogs are prompted:



1). Interactive remapping of land use into PREVAH land use categories. A full list can be found in Part II of the PREVAH documentation.

Activate [Make default] before clicking [Done] to set your choice as the default option. The file 'defpus.rm' is stored in the [Tools path] which may be defined through the Options dialog (see Section C.3.4).



2). Interactive remapping of hydraulic conductivity into physical values [m/s]. A list of recommended values from Swiss soil maps is provided in Part II of the PREVAH documentation. If you have no idea on the hydraulic conductivity, use the dummy value 0.000001.

Activate [Make default] before clicking [Done] to set your choice as the default option. The file 'defkms.rm' is stored in the [Tools path] which may be defined through the Options dialog (see Section C.3.4).

3). Interactive remapping of soil depth into physical values [m]. A list of recommended values from Swiss and FAO soil maps is provided in Part II of the PREVAH documentation.

Activate [Make default] before clicking [Done] to set your choice as the default option. The file 'defbtk.rm' is stored in the [Tools path] which may be defined through the Options dialog (see Section C.3.4).

4). Interactive remapping of available field capacity into physical values [Vol%]. A list of recommended values from Swiss and FAO soil maps is provided in Part II of the PREVAH documentation.

Activate [Make default] before clicking [Done] to set your choice as the default option. The file 'defpfc.rm' is stored in the [Tools path] which may be defined through the Options dialog (see Section C.3.4).

If you saved your own defaults, you may choose the [user defined] option the next time you want to classify land use and soil properties.

⑥ [Topindex]: Defines whether topographic indices should be calculated. The definition of the topographic index is reported in Part II of the PREVAH documentation.

⑦ [Glacier ELA]: Allows the user to select a method for splitting glaciated areas into accumulation and ablation zones. [Use map] refers to the equilibrium line altitudes (ELAs) calculated for Switzerland by Maisch et al. 1999, which are then corrected for the individual site-specific expositions (see Viviroli, 2007). [Use map + shift] uses the same map, but with a shift of 25 m upwards in the ELAs (recommended). This is used in order to account for the glacier retreat since 1973, which is the reference year for the underlying glacier inventory. [User defined] allows using a specific ELA (entered in the edit box below). This is recommended if detailed regional knowledge on the area in scope is available.

Classification into elevation zones:

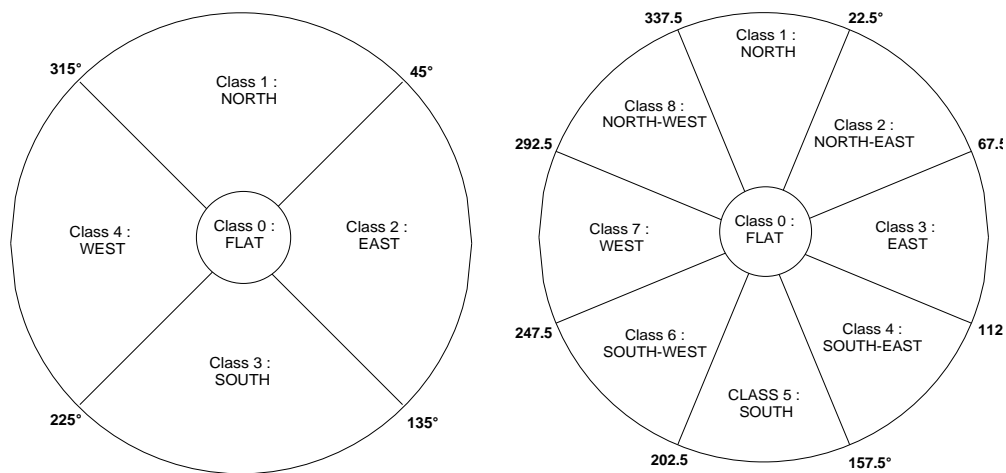
⑧ [Elevation zone size]: Defines the extent of an elevation zone. These zones are commonly used for aggregation of meteorological input data and definition of hydrological response units (HRUs). The value should be selected with respect to the intended spatial model resolution and quality of the meteorological data available. The value of 100 meters is recommended for most applications.

⑨ [Aspect classes], [Slope classes] and [Topoindex classes]: Define the aggregation of the respective grids to classed value grids. Several numbers of classes are available, although it is recommended to use the default values.

Classification of different topographic parameters into categories using WINHRU

Source feature	Source grid	Categories	Target grid
Digital elevation model	[*.DHM]	Defined by size of the elevation zone	[*.PHK]
Aspect	[*.EXP]	Defined into 5, 9 or more categories	[*.EXK]
Slope	[*.SLP]	Defined into 3 to 8 default categories	[*.SLK]
Soil-Top-Index	[*.ABB]	Split into categories between	[*.ABK]
Area-Top-Index	[*.ATB]	minimum and maximum	[*.ATK]

Classification of aspect:



Classification of aspect into 5 (left) and 9 (right) exposition classes. The classification into 5 classes is recommended

Classification of aspect into 3, 4, 6 or 8 categories (the classification into 4 classes is recommended)

Category	3 Classes	4 Classes	6 Classes	8 Classes
1	< 3°	< 10°	< 3°	< 3°
2	3° – 15°	10° – 22°	3° – 9°	3° – 9°
3	> 15°	22° – 36°	9° – 17°	9° – 15°
4		> 36°	17° – 27°	15° – 22°
5			27° – 36°	22° – 30°
6			> 36°	30° – 38°
7				38° – 45°
8				> 45°

C.3.3 HRU definition (㉓)

	Grid ①	Digits ②
1st	Altitude zones	2
2nd	Aspect	1
3rd	Land use	2
4th	<SKIP>	0
5th	<SKIP>	0
6th	<SKIP>	0

⑤ Reset Total 5③

Meteo zones until grid # 1④

For defining hydrological response units (HRUs), WINHRU offers several criteria for possible selection. The grids for HRU determination may be selected in their appropriate order through the grid dropdown boxes (①) and include Watersheds, Altitude zones, Aspect, Slope, Land use, Soil, Soil-Topographic index, Area-topographic index, Geology, Glaciers, Meteo zones and Soil variance. The reference of these generic grids to actual grid file extension may be specified and altered in the WINHRU Options dialog (see Section C.3.4). Select [<SKIP>] to exclude a grid from the HRU definition process. A grid must not appear more than once.

In the Digits column (②), WINHRU displays the number of digits that are used by a grid in the HRU code as well as the total number of digits used (③). It is suggested to use a limited number of grids for HRU definition since the advantage of the HRU approach is that it evades the time-consuming, cell-by-cell processing in model runs. If the HRUs are too small, this advantage is abandoned. Therefore, an upper limit of 8 to 9 digits is recommended.

Finally, the number of grids serving as meteo zones [Meteo zones until grid #] (④) may be changed. Usually, only the first grid (altitude zones by default) is used for specification of meteo zones. There is no need to make changes to this default setting for standard model runs in small watersheds. For larger catchments, it is recommended to include the watersheds grid (second or third order watersheds) at the top of the list of criterion for the generation of HRUs followed by the criterion altitude zones. In this case, the [Meteo zones until grid #] option must be set equal to 2. Push the [Reset] button (⑤) if you want to begin again.

C.3.4 PREVAH project settings (㉔)

New catchment info

Name new_site

File root name new

Latitude 47.0 [*N]

Expected area 1 [km²]

In this part of the main dialog window, some settings for the PREVAH project generated by WINHRU may be entered. [Name] is the catchment name for the new project. [File root name] is the file stem which will be used to denote the grids and tables created by WINHRU. Enter the mean northern latitude of your new catchment in [Latitude]. Finally, specify the official area provided for the basin in scope in [Expected area]; this is updated automatically if LHG gauge site has been selected as the catchment definition method (see Catchment definition settings, ㉒, Section C.3.1 above).

C.3.5 Progress bar and launch button (㉕)

Progress

GO!

The two progress bars show the state of the currently running WINHRU components when WINHRU has been started with the [GO!] button.

C.3.6 Quick profile selector (㉖)

Quick profile Swiss extended (Default)

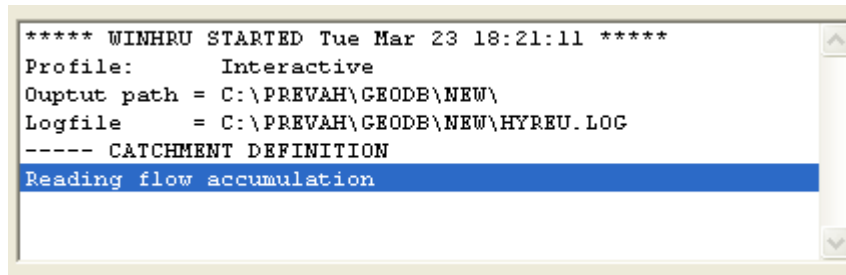
Use this selector to conveniently switch between different settings of the dialog elements in WINHRU.

C.3.7 Program runtime buttons (ⓐ)



[Options] opens the options dialog window (see Section C.3.4). [About] shows program credits and version. [Zonal stats.] launches a dialog which allows the easy computation of zonal statistics. [Quit] terminates the present WINHRU session.

C.3.8 Console output (ⓑ)



This section of the main dialog window provides information on the operations currently in progress when WINHRU has been started with the [GO!] button (see Progress bar and launch button, ⓐ, Section C.3.5 above). Use this output to find errors if any WINHRU process should fail or not deliver the desired results.

C.4 Options

Options

1 Paths and files

Input grid path: C:\PREVAH\GEODB\CH\ ...

Output grid path: C:\PREVAH\GEODB\NEW\ ...

Tools path: C:\PREVAH\WASIM\ ...

Flow dir. file: C:\PREVAH\GEODB\CH\FLDR.BIN ...

Flow acc. file: C:\PREVAH\GEODB\CH\FLAC.BIN ...

Gauges DB file: C:\PREVAH\LHG.TXT ...

2 Source grid processing

	File name	out ext.
<input checked="" type="checkbox"/> Elevation	HOEH.BIN	.DHM
<input checked="" type="checkbox"/> Land use	AS85.BIN	.USE
<input checked="" type="checkbox"/> Filled capacity	NFK.BIN	.NFK
<input checked="" type="checkbox"/> k-values	K.BIN	.K
<input checked="" type="checkbox"/> Soil type	BTYP.BIN	.ART
<input checked="" type="checkbox"/> Soil depth	BTIF.BIN	.BT
<input checked="" type="checkbox"/> Soil structure	SKEL.BIN	.SKE
<input checked="" type="checkbox"/> Geology	GEOL.BIN	.GEO
<input checked="" type="checkbox"/> Forest categories	WMG.BIN	.WMG
<input checked="" type="checkbox"/> Glacier ELA	GWL.BIN	.GWL
<input type="checkbox"/> Hydrogeology	HGEO.BIN	.HGL
<input checked="" type="checkbox"/> Catchment		.EZG

3 HRU Grid definitions

Item	Grid ext.	Digits
Watersheds	.ezg	1
Altitude zones	.phk	2
Aspect	.exk	1
Slope	.slk	1
Land use	.pus	2
Soil	.pat	2
TI-soil	.abk	1
TI-area	.atk	1
Geology	.geo	1
Glaciers	.glm	1
Meteo zones	.mez	2
Soil variance	.baw	2

4 Source grid dimensions

Extent: 3600 [c] 2400 [r]

Cellsize: 100 [m]

Fringe: 25 [cells] ...

5 Misc

☐ Archive

☐ Debug

6

Load options Save options Cancel OK

This dialog is launched with the [Options] button in the main WINHRU dialog (see Program runtime buttons, ③, Section C.3.7 above). It serves to adjust a number of settings that affect the main WINHRU program.

Use [Paths and files] (①) to adjust WINHRU to the file system of your computer. Match these settings if you are not using default paths and filenames.

- [Input grid path] specifies the location where the source grids are stored, i.e. the grids containing information on the entire geographic domain from which the windowed and resampled maps are extracted (see also [Source grid processing], ②, below)
- [Output grid path] is where the new grids created by WINHRU are written. Since these tables and grids are path-independent, they may conveniently be moved from this directory to a final target directory after completion of WINHRU. However, the final target directory may also be indicated directly as the output grid path.
- [Tools path] is a path where a set of additional, necessary files are stored. These files are: tanalys.exe, tanpur.dat, sample.inp.

- [Flow direction file] and [Flow accumulation file] indicate the grids used for determination of upstream areas when WINHRU operates in the gauge site or free pour point mode (see Catchment definition settings, **A**, Section C.3.1). These two files have to be generated by topographical analysis prior to the first use of WINHRU in a particular region. To generate alternative versions of the two files you can use common GIS commercial software with support of hydrological analysis or the tool GRIDMATH (see Chapter A).
- [Gauges database file] is the ASCII-formatted text file containing name, location and catchment area of gauging stations available for the gauge site mode of WINHRU (see Catchment definition settings, **A**, Section C.3.1). A sample of a gauge database file is given below. It consists of one header column, followed by the actual records; each column lists a station name (59 characters), area in square kilometres (5 characters) as well as station northing (12 characters) and easting (12 characters) in meters, each separated by one blank character. You may edit this file preserving the given format rules. To add or remove stations you may also use the respective buttons in the gauge site or free pour point dialogs (see Catchment definition settings, **A**, Section C.3.1)

GAUGING STATION	AREA_KM^2	EASTING_M	NORTHING_M
Rhône-Porte du Scex	5220	557660	133280
Rhône-Sion	3349	593770	118630
Ticino-Bellinzona	1515	721245	117025
Vispa-Visp	778	634150	124850
Drance-Martigny, La Bâtiaz	678	571280	105680
Fiescherbach-Fiesch	81.0	653450	139350
Inn (En)-Scanfs	615	794560	165230
Engelberger Aa-Stans, Wil	226	672310	201340
Birs-Münchenstein, Hofmatt	911	613570	263080

[Source grid processing] (**2**) lists all available source grids which are available for processing in WINHRU. Check or uncheck the grids according to whether you want WINHRU to process them. The filename of the source grid may be entered in the File name column. The output extension column specifies the extensions of the grids that are later created by WINHRU through windowing and resampling. Note that the following grids must be present:

- Digital elevation model for the source grid [Elevation]
- Land use map for the source grid [Land use]
- Soil map for the source grids [Field capacity], [k-values], [Soil type] and [Soil Depth]

[HRU grid definitions] (**3**) enables identifying the grid types which are used for defining the hydrological response units (HRUs). Enter the desired grid type extension for an item in the grid extension column; the number of digits used for a grid in the HRU code may be specified in the Digits column.

In [Source grid dimensions] (**4**), the maximum grid extent that will be processed has to be entered (extent in [c]olumns and [r]ows), along with the resolution of the source grids (Cellsize, in [m]eters). These settings may be conveniently gathered from an existing source grid file using the ["..."] button. Fringe is a buffer zone that will be added when windowing the source grids according to the extent of the catchment area.

[Misc] (**5**) contains checkboxes to enable or disable Archiving and Debugging mode (turned off by default).

Use the [Save options] button (**6**) to save the current dialog settings to a default settings file which will be loaded at each program start of WINHRU. Press [Load options] to reload these settings. To reset WINHRU options to default, simply delete the "winhru.ini" file located in the folder from which you start WINHRU.

C.5 Outputs

Gridded output:

WINHRU produces several grids for the full domain in the neighbourhood of your selected catchment, stored as files FULL_ File-root-name.*.

For your specific catchment, WINHRU produces a series of grids for the full catchment and stores them as File-root-name.*.

If you selected to use sub-catchments for the definition of the HRUs and the meteorological zones, a series of grids is saved for each of the sub-catchments. The basic name of such files is File-root-name##.*, with ## equal to the ID of the sub-catchment.

A list of file extensions (.) is provided in the Appendix.

Tabular Output:

The main result of WINHRU is the table which PREVAH needs to assimilate the HRU-based spatial information on the investigated catchment. Such information is written in the so-called control file for spatial information which is stored as tabFile-root-name.gkw for the full catchment and tabFile-root-name.g## for the sub-catchments, with ## equal to the ID of the sub-catchment. The file is structured as follows (divided into two parts for display reasons):

PREVAH control file for spatial information (Columns 1–14):

HYDROTOPCODE	NR	AETF	COUN	HOEHE	LN	EXP	ASP	SLO	NFC	BTIE	KWT	BA	BT	TOPI
1041084		0.6075	3	325	8	1	329	19	17.5	1.25	3.60E+00	0	0	28.2
1042044		0.2025	1	280	4	2	53	7	17.5	1.25	3.60E+00	0	0	29.1
1042084		1.62	8	303	8	2	101	14	17.5	1.25	3.60E+00	0	0	28.4
1043084		1.215	6	302	8	3	158	14	17.5	1.25	3.60E+00	0	0	28.4
1044084		1.215	6	306	8	4	280	13	17.5	1.25	3.60E+00	0	0	28.5
1051044		0.2025	1	356	4	1	315	26	17.5	1.25	3.60E+00	0	0	27.7
1051084		1.0125	5	397	8	1	18	15	17.5	1.25	3.60E+00	0	0	24.7
1052081		0.405	2	426	8	2	122	36	2	0.1	3.60E+00	0	0	20.5
...	

PREVAH control file for spatial information (Columns 1 and 15–27):

HYDROTOPCODE	NR	BTOP	GEO	GLE	MEZ	PHK	SKE	FREE1	FREE2	FREE3	FREE4	EZGNR	EZGID	ID
1041084		35.1	0	0	104	4	0	-9.9	-9.9	-9.9	-9.9	1	1	1
1042044		36	0	0	104	4	0	-9.9	-9.9	-9.9	-9.9	1	2	2
1042084		35.3	0	0	104	4	0	-9.9	-9.9	-9.9	-9.9	1	3	3
1043084		35.3	0	0	104	4	0	-9.9	-9.9	-9.9	-9.9	1	4	4
1044084		35.4	0	0	104	4	0	-9.9	-9.9	-9.9	-9.9	1	5	5
1051044		34.6	0	0	105	5	0	-9.9	-9.9	-9.9	-9.9	1	6	6
1051084		31.6	0	0	105	5	0	-9.9	-9.9	-9.9	-9.9	1	7	7
1052081		27.4	0	0	105	5	0	-9.9	-9.9	-9.9	-9.9	1	8	8
...	

The definition of the 27 columns of the control file for spatial information generated by WINHRU and assimilated by PREVAH at model initialisation follows in the next table:

Column	Header	Description	Source grid(s)	Unit	Status
1	CODE NR.	Code of the HRU	[* .HRU]	-	category
2	AETF	Area of the HRU	[* .IDH]	km ²	summation
3	COUN	Count of cells for this HRU	[* .IDH]	-	summation
4	HOEHE	Elevation	[* .DHM]	m a.s.l.	average
5	LN	Land use	[* .PUS]	-	category
6	EXP	Aspect class	[* .EXK]	-	class
7	ASP	Aspect	[* .EXP, * .AZM]	Degree	average
8	SLO	Slope	[* .SLP]	Degree	average
9	NFC	Available field capacity	[* .PFC]	Vol%	average
10	BTIE	Soil depth	[* .BTK]	m	average
11	KWT	Hydraulic conductivity	[* .KWT]	mm h ⁻¹	average
12	BA	Soil type	[* .PAT]	-	category
13	BT	Soil structure	NO-DATA	-	no data
14	TOPI	Area-TopIndex	[* .ATB]	[-]	average
15	BTOP	Soil-TopIndex	[* .ABB]	[-]	average
16	GEO	Geology	[* .GEO];[* .HGL]	-	category
17	GLE	Glacier morphology	[* .GLM]	-	category
18	MEZ	Meteorological zones	[* .MEZ]	-	category
19	PHK	Elevation Zones	[* .PHK]	-	category
20	SKE	Stones content	[* .SKE]	-	category
21–24	FREE1–4	Free columns	NO-DATA	-	no data
25	EZGNR	Sub-catchment	[* .EZG]	-	category
26	EZGID	ID in sub-catchment	[* .EZG]	-	category
27	ID	ID of the HRU	[* .IDH];[* .I##]	-	category

Source grid is the extension of the grid(s) needed to generate a particular column. Status declares whether the source grid consists of physical information (averages and summations) or categorical data. NoData represents columns which are currently not assigned, but are available for future extensions of PREVAH.

Default Control File for WINPREVAH:

A standard control file for WINPREVAH is produced by WINHRU. This file is stored as runFile-root-name.inp. This control file can be loaded and edited with WINPREVAH and used to initialise the model simulation. Further, the control file for spatial information and the grid with the HRU identifiers have to be linked to the control file with WINPREVAH. Further information is available in the WINPREVAH documentation.

Files for spatial interpolation of meteorological variables:

The digital elevation model grid (*.dhm), watershed limits grid (*.ezg) and grid of the meteorological zones (*.mez) have to be declared in the control files of the tools used for the spatial interpolation of meteorological variables (WINMET).

D DATAWIZARD: Assimilation of hydrometeorological ASCII data

D.1 Introduction

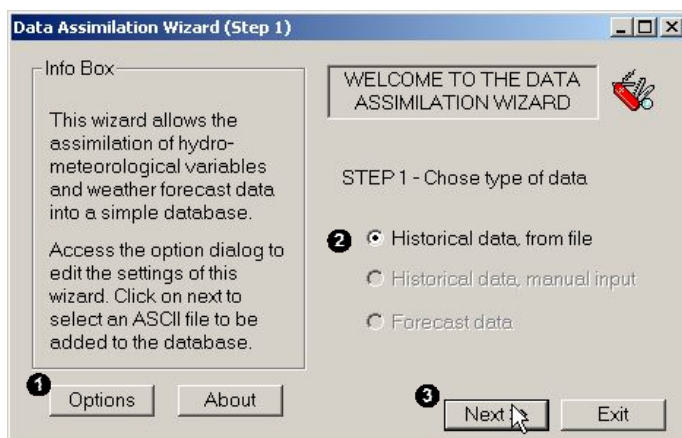
The assimilation and management of hydrometeorological data from a network of stations is crucial for the distributed application of hydrological models. DATAWIZARD is a tool allowing the assimilation and verification of hydrometeorological data and provides a link to WINMET, the spatial interpolation tool of the PREVAH modelling system (see Chapter E). DATAWIZARD has already been adopted for managing data in Switzerland, Austria, China, Germany, Italy, Kenya, Kyrgyzstan, Sweden, the United States and Uzbekistan.

D.2 Basic features of DATAWIZARD

DATAWIZARD has been developed to easily manage the hydrometeorological information needed for operating PREVAH.

- It is designed for the stepwise assimilation of raw meteorological information (precipitation, air temperature, wind speed, global radiation, relative humidity, water vapour pressure, sunshine duration, runoff and two user defined variables).
- It makes a simple plausibility/acceptability test of the data.
- It creates and edits a formatted station table, which includes all the attributes needed for running the interpolation of these hydrometeorological variables.
- It creates a simple database of hydrometeorological information.

D.3 Step 1: Welcome



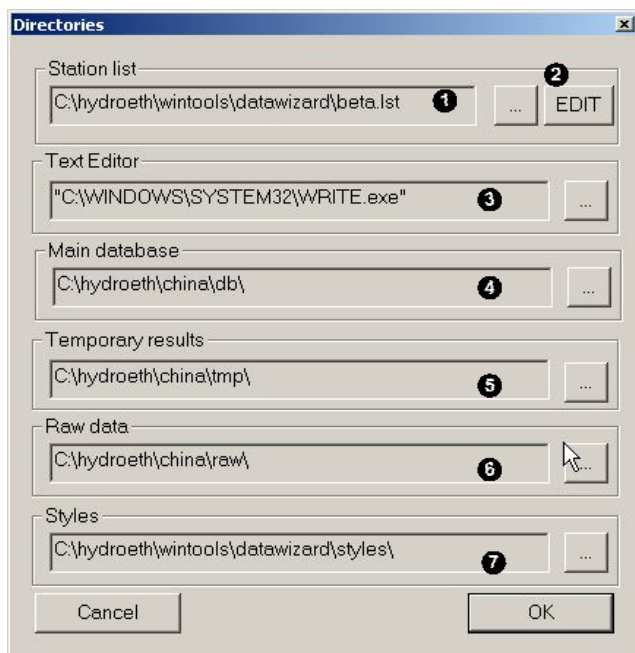
❶ Click the [Options] button to access the options dialog.

❷ Choose whether you desire to assimilate historical data from file, or manually (not yet implemented) or forecast data (not yet implemented).

❸ Click the [Next >>] button to launch step 2 of DATAWIZARD.

Launching the Wizard: Step 1 of DATAWIZARD.

D.3.1 Options Dialog



Setting the options of DATAWIZARD.

Through the options Dialog you have to link DATAWIZARD to a set of user defined files and directories. The following links have to be set:

❶ Link to the file containing the list and attributes of the stations available in the current database. By clicking the [EDIT] button (❷) you can access a dialog that allows you to update the attributes of each station. It is very important that you keep your attribute table as updated as possible and that you assign unique names and numbers to each station.

❸ Link to a default text editor (needed to view/edit the raw data and the station list files).

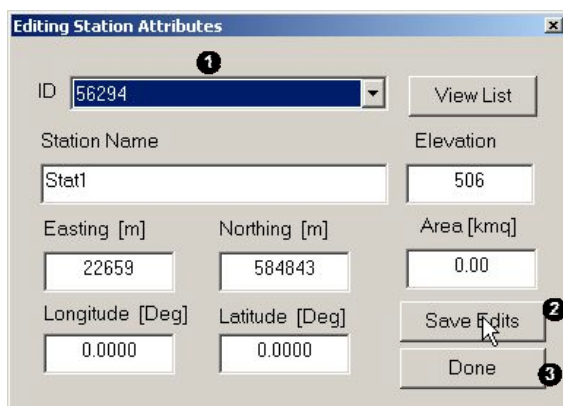
❹ Link to the directory where the database has to be stored.

❺ Link to the directory where the temporary files have to be stored.

❻ Link to the directory where you plan to transfer the raw data you want to assimilate with DATAWIZARD.

❼ Link to the directory where the format style macros have to be stored.

D.3.2 Edit the attributes of a station



This Dialog can be accessed through the OPTIONS Dialog (see above) by clicking the [EDIT] button. By clicking [View List] the station attribute table is opened with the selected Default Text Editor.

❶ Select the ID of a station to load its attributes in the dialog. Change the attributes accordingly:

- Name: As a CHARACTER
- Elevation, Northing, Easting: As an INTEGER in meters
- Area: As a FLOAT in km²
- Longitude and Latitude: As a FLOAT in degrees

❷ Click [Save Edits] to store the changes

❸ Click [Done] to leave the Dialog

D.3.3 Station attributes table

The station attributes table contains the following information:

Col	Definition	Position	Format	Notes	Sample
1	Station ID	Left	Chars 20 – 1X		56814
2	Station name	Left	Chars 30 – 1X		Sample_stat
3	Elevation [m a.s.l.]	Standard	Integer 6 – 1X		365
4	Area [km ²]	Standard	Float 12.2 – 1X	For runoff data	0.0
5	Easting [m]	Standard	Integer 12 – 1X		645233
6	Northing [m]	Standard	Integer 12 – 1X		187954
7	Latitude (Deg)	Standard	Float 10.3 – 1X		31.5
8	Longitude (Deg)	Standard	Float 10.3 – 1X		110.
9	DT-String-1	Standard	Chars 15 – 1X	Precipitation	NNNNNNNNNNNNNNNN
10	DT-String-2	Standard	Chars 15 – 1X	Air temperature	NNNNNNNNNNNNNNNN
11	DT-String-3	Standard	Chars 15 – 1X	Wind speed	NNNNNNNNNNNNNNNN
12	DT-String-4	Standard	Chars 15 – 1X	Global radiation	NNNNNNNNNNNNNNNN
13	DT-String-5	Standard	Chars 15 – 1X	Relative humidity	NNNNNNNNNNNNNNNN
14	DT-String-6	Standard	Chars 15 – 1X	Vapour pressure	NNNNNNNNNNNNNNNN
15	DT-String-7	Standard	Chars 15 – 1X	Sunshine duration	NNNNNNNNNNNNNNNN
16	DT-String-8	Standard	Chars 15 – 1X	Runoff	NNNNNNNNNNNNNNNN
17	DT-String-9	Standard	Chars 15 – 1X	Free variable 1	NNNNNNNNNNNNNNNN
18	DT-String-10	Standard	Chars 15 – 1X	Free variable 2	NNNNNNNNNNNNNNNN

A 15 character text string is assigned to each of the 10 variables that can be assimilated by DATAWIZARD. Each character of such strings indicates the availability of data at a particular time resolution in minutes (DT). If a variable time resolution (e.g. 60 minutes temperature) is available for a particular station, then DATAWIZARD will put an 'Y' in the appropriate position of the time resolution string (e.g. DT-string-2 = NNNNNYNNNNNNNNNN).

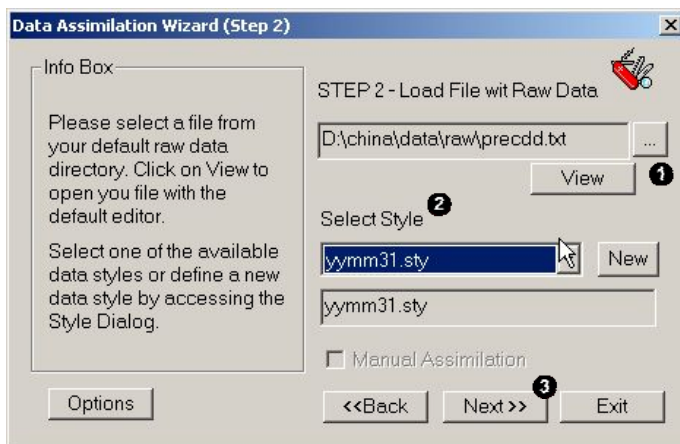
Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DT (MIN)	5	10	15	20	30	60	120	180	240	360	480	720	1440	From-To	Void
DT (HOURS)	-	-	-	-	-	1	2	3	4	6	8	12	24	-	-
Available	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Not available	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Example of stations attribute table:

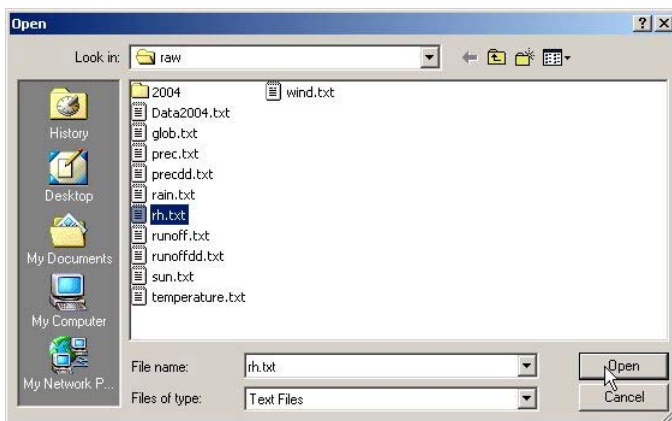
Station.ID Station Name Elev Area Easting Northing Lat Lon DT-Strings

Station.ID	Station Name	Elev	Area	Easting	Northing	Lat	Lon	DT-Strings
460	Davos	1590	0.00	783580	187480	0.000	0.000	NNNNNNNNNNNNNNNN
1030	St. Gallen	779	0.00	747940	254600	0.000	0.000	NNNNNNNNNNNNNNNN
2220	Saentis	2490	0.00	744180	234920	0.000	0.000	NNNNNNNNNNNNNNNN
3700	Zuerich_SMA	556	0.00	685125	248090	0.000	0.000	NNNNNNNNNNNNNNNN
9400	Locarno-Mont	379	0.00	704220	114370	0.000	0.000	NNNNNNNNNNNNNNNN
9480	Lugano	273	0.00	717880	95870	0.000	0.000	NNNNNNNNNNNNNNNN
9850	Bever	1712	0.00	787840	158320	0.000	0.000	NNNNNNNNNNNNNNNN
1940	Basel-Binnin	316	0.00	610850	265620	0.000	0.000	NNNNNNNNNNNNNNNN
4140	Altdorf	451	0.00	691000	191750	0.000	0.000	NNNNNNNNNNNNNNNN
5520	Bern-Liebefe	570	0.00	598610	197470	0.000	0.000	NNNNNNNNNNNNNNNN
6340	Neuchatel	487	0.00	563110	205600	0.000	0.000	NNNNNNNNNNNNNNNN
7500	Sion	542	0.00	593850	120700	0.000	0.000	NNNNNNNNNNNNNNNN
7520	Sion-Aerodro	483	0.00	592130	118700	0.000	0.000	NNNNNNNNNNNNNNNN
8390	Geneve_Obser	405	0.00	500720	117300	0.000	0.000	NNNNNNNNNNNNNNNN
8440	Geneve-Cont	420	0.00	498580	122320	0.000	0.000	NNNNNNNNNNNNNNNN
40	Platta_(Mede	1375	0.00	708300	168400	0.000	0.000	NNNNNNNNNNNNNNNN
60	Disentis	1190	0.00	708230	173780	0.000	0.000	NNNNNNNNNNNNNNNN
280	Hinterrhein	1611	0.00	733900	153980	0.000	0.000	NNNNNNNNNNNNNNNN
289	Spluegen	1504	0.00	744380	157620	0.000	0.000	NNNNNNNNNNNNNNNN
380	Elvjo	1770	0.00	769800	148950	0.000	0.000	NNNNNNNNNNNNNNNN
440	Weissfluhjoc	2690	0.00	780600	189630	0.000	0.000	NNNNNNNNNNNNNNNN
510	Alvaneu-Dorf	1178	0.00	768880	172060	0.000	0.000	NNNNNNNNNNNNNNNN
600	Arosa	1840	0.00	770730	183320	0.000	0.000	NNNNNNNNNNNNNNNN

D.4 Step 2: Loading raw data



Step 2 of DATAWIZARD: Loading a file with raw data and selecting the format.



❶ Click the button [...] to access a dialog (here on the right) for selecting a file with raw data from the defined raw data default directory. By clicking [View] the selected file is opened with the Default Text Editor. You can use this to identify the format of the file you are going to process with DATAWIZARD and integrate in the database.

❷ Select a Style macro from the list of the available macros. Style macros govern the assimilation of raw data. New Style macros can be created by clicking the [New] button.

❸ Click the button [Next >>] to launch step 3 of the DATAWIZARD.

D.4.1 The file format dialog

For the assimilation of the hydrometeorological information from files containing raw data, the format of the file has to be defined through the [File Format Wizard] Dialog, which can be accessed by clicking the [New Style] button during the second step of the data assimilation procedure. Every defined style is then stored as a macro in the assigned directory. Style macros (*.sty) are formatted as follows:

```
[Style file for data formats]
ID YY MM DD Ed Ed Ed Ed Ed      ! Nine IDs to define the content of the format columns
Headers = 0001                  ! Number of headers/rows to be skipped in the file
Columns = 0001                  ! Column after the format where data have to be read from
1st Hour = 0000                 ! Begin hour (only for time steps smaller than 1 day)
```

This means that your raw data file may have up to nine columns to define the date format. The content of each column can be defined through a key. The previous example of style macro defines raw data available in the following format:

				Global Radiation	Temperature
57516	1990	1	1	422	25.2
57516	1990	1	2	573	26.7
57516	1990	1	3	116	24.2
57516	1990	1	4	151	23.9
57516	1990	1	5	364	25.5
57516	1990	1	6	40	26.1
.....

The first row is a header and therefore skipped. Only non-numeric information is allowed in the headers! The first column in this raw data file represents the Station ID, the second the year (YY), the third the month (MM) and the fourth the day (DD). Only four columns are needed here for a complete definition of the date format. The other five possible format columns are not needed, thus they maintain the initial setting of "Edit" (Ed). The data are stored in the first and second column after the columns required to define the date, in this case the fifth column. In the given example of style macro the first column after the format columns will be assimilated in the database, in this case the global radiation. To assimilate the temperature (second column) you have to define a new style macro, where you assign the 2nd column after the format to be read from.

```
[Style file for data formats]
ID YY MM DD Ed Ed Ed Ed Ed      ! Nine IDs to define the content of the format columns
Headers = 0001                  ! Number of headers/rows to be skipped in the file
Columns = 0002                  ! Column after the format where data have to be read from
1st Hour = 0000                 ! Begin hour (only for time steps smaller than 1 day)
```

Special case:

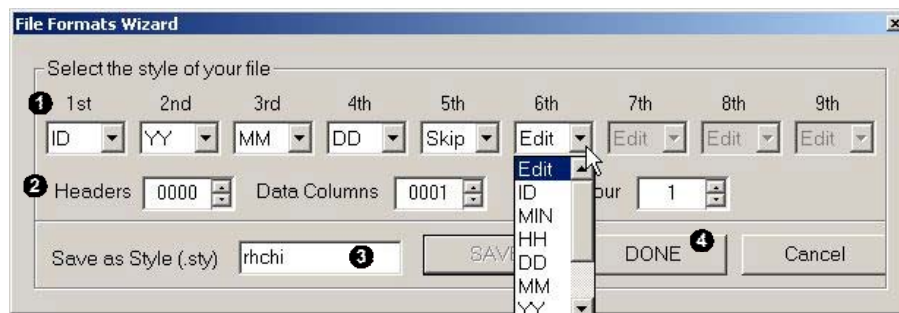
Station ID	Year	Month	Day1	Day2	Day3	Day4
60535600	1988	1	0	0	0	...
60535600	1988	2	0	0	0	...
60535600	1988	3	0	0	0	...
60535600	1988	4	0	0	0	...
60535600	1988	5	0	0	0	...
60535600	1988	6	0	0	0	...
60535600	1988	7	0	40.1	12	...
60535600	1988	8	0	0	0	...
60535600	1988	9	0	21	0	...
60535600	1988	10	0	0	0	...
60535600	1988	11	0	0	0	...
60535600	1988	12	0	0	0	...
...	1989	1	...	...	...	...

To assimilate daily data in the following format, such a style macro has to be defined:

```
[Style file for data formats]
ID YY MM Ed Ed Ed Ed Ed Ed      ! Nine IDs to define the content of the format columns
Headers = 0000                  ! Number of headers/rows to be skipped in the file
Columns = 0031                  ! Column after the format where data have to be read from
1st Hour = 0000                 ! Begin hour (only for time steps smaller than 1 day)
```

In this case the assimilation tool will search for raw data according to the current month and current year in up to 31 columns.

Style macros can be either edited manually and stored with the extension "*.sty" in the defined style macros directory (see above) or created through the implemented [File Format Wizard] dialog, which can be accessed by clicking the [New Style] button during the second step of the data assimilation procedure with DATAWIZARD.



File format wizard of DATAWIZARD: Defines the format of raw data.

❶ With this [File Format Wizard] Dialog you can define the format of your raw data files interactively by assigning a key to each column. These are the recognised keys:

Key	Full name	Definition
Ed	Edit	Initial settings for each column.
ID	Station ID	Assign ID to the column in your raw data file that defines the station identifier (as an INTEGER). If no column with station identifier is available, the station identifier has to be provided later interactively.
MI	Minutes	Assign MI to the column in your raw data file that defines the minutes (required only if the time step is smaller than 1 hour)
HH	Hours	Assign HH to the column in your raw data file that defines the hours (required only if the time step is smaller than 1 day)
DD	Days	Assign DD to the column in your raw data file that defines the hours (recommended, required only if the time step is smaller than 1 day)
MM	Month	Assign MM to the column in your raw data file that defines the month (always required)
YY	Year	Assign YY to the column in your raw data file that defines the year (always required)
Sk	Skip	Assign Sk if you desire to skip a certain column
FR	From	Not yet implemented
TO	To	Not yet implemented

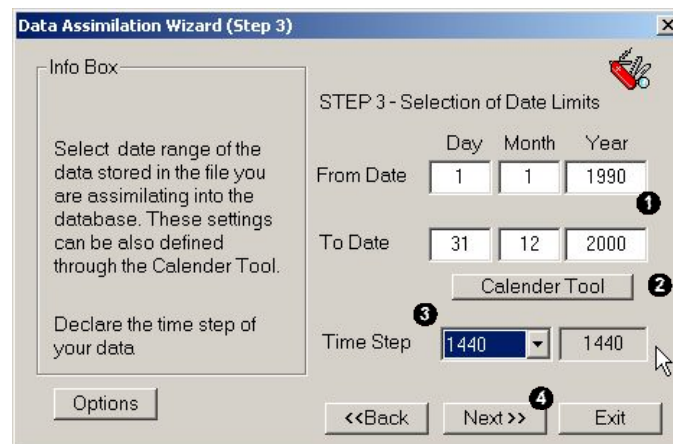
❷ Additionally you have to declare how many headers have to be skipped and in which column after the format the data have to be read. If you assimilate data with a time resolution smaller than one day (1440 minutes) a start hour can be assigned. If you sample six-hourly data (360 minutes) at 2:00, 8:00, 14:00 and 20:00, then you should assign "begin hour"=2 and time resolution 360.

❸ You can save the settings of the [File Format Wizard] dialog as a Style macro in the defined style macros directory. Thus, give a name to the macro and save it by clicking the button [Save].

❹ Leave the dialog by clicking the button [Done].

The assimilation algorithm will then process the different columns of the selected file with raw data according to the keys assigned in the style macro.

D.5 Step 3: Selection of date range and time step



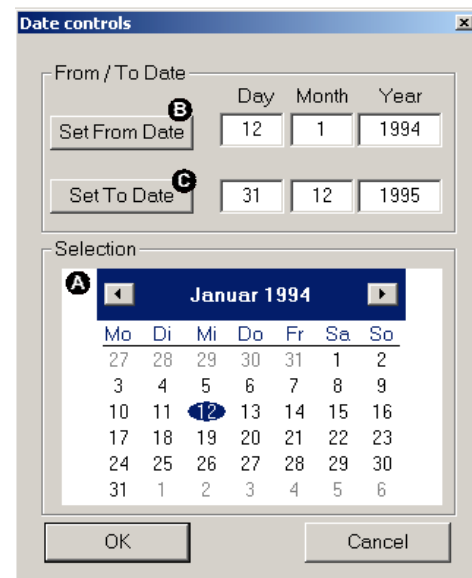
Step 3 of DATAWIZARD: Allows the selection of the start and end date for the data import and declaration of the raw data time step.

❶ Declare the start and end date for the available raw data. Attention: Do not be too generous with the selection of the start and end date. If data begins on April 15 1995 do not set as [From Date] January 1 1995. Otherwise the assimilation process could last much longer than due.

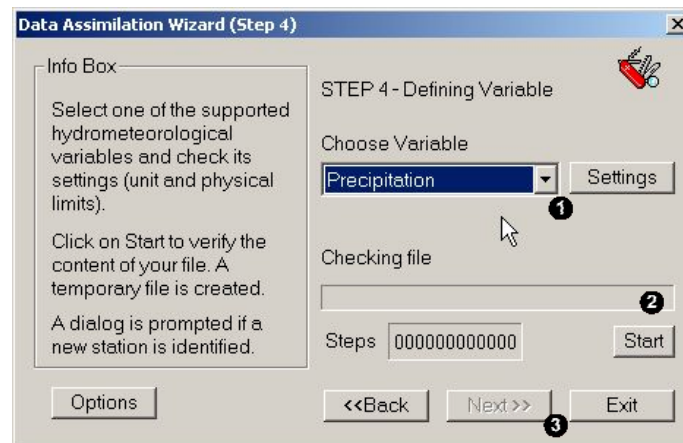
❷ By clicking the [Calendar Tool] button, you can access a [Date controls] dialog that allows you to set the date limits interactively. To change the 'From Date', select the envisaged start date in the Wizard (❹) and click the [Set From Date] (❷) button. To change the 'To Date', select the desired end date in the Wizard and click the [Set To Date] (❸) button.

❸ Select the time step. To date, DATAWIZARD has been successfully tested for a time resolution of 60, 360, 480 and 1440 minutes.

❹ Click the button [Next >>] to launch step 4 of the DATAWIZARD.



D.6 Step 4: Variable definition and quality check



Step 4 of DATAWIZARD: The variable to be assimilated is defined here.

❶ Select the variable to assimilate. Many settings have to be carefully assigned to each of the hydrometeorological variables processed by DATAWIZARD. To set and edit such information click the [Settings] button to access the [Physical Limits] dialog. In this dialog you can then:

❶ Choose the variable

❷ Click [Start editing]

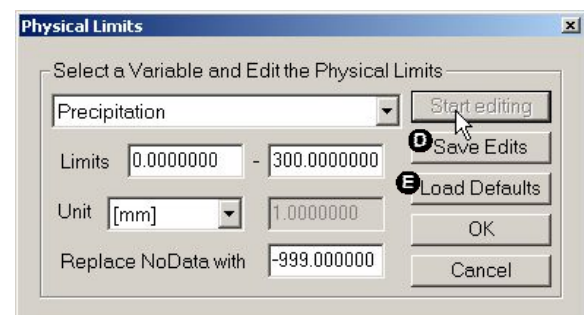
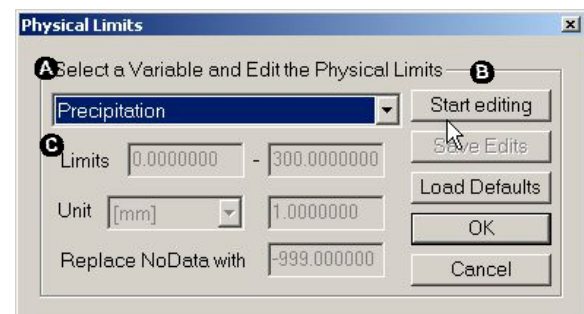
❸ Edit the physical limits, choose the input unit, select the NoData value

❹ Click [Save Edits]

❺ Defaults for daily time resolution (see the following table) can be loaded by clicking the [Load Defaults] button.

❻ Start the verification of the data you are assimilating with DATAWIZARD.

❼ Click the button [Next >>] to launch step 5 of DATAWIZARD.



Recommended NoData value, physical unit and minimal x_{\min}^{phys} and maximal x_{\max}^{phys} physical limits for daily hydrometeorological variables assimilated and controlled by DATAWIZARD.

Variable	NoData	Unit	x_{\min}^{phys}	x_{\max}^{phys}
Precipitation	-998	[mm day ⁻¹]	0	500
Air Temperature	-998	[°C]	-50	50
Wind Speed	-998	[m s ⁻¹]	0	70
Global Radiation	-9998	[W m ⁻²]	0	1360
Relative Humidity	-998	[-]	0	1
Water Vapour Pressure	-998	[hPa]	0	123
Sunshine Duration	-998	[-]	0	1
Runoff	-9998	[m ³ s ⁻¹]	0	user
Free1	-9998	[-]	user	user
Free2	-9998	[-]	user	user

D.7 Data verification

During the fourth step of the data assimilation procedure, the following phases (a to e) are completed:

- a) Identification of the station from where data were obtained. If the Style macro (and the raw data) contains a column with the ID of the station that provided the data, then this ID is compared to all IDs of the stations included in the stations attribute table. If no STATION-ID is provided, then a small dialog is prompted and you have to declare a STATION-ID. If the STATION-ID is already available, the data verification goes to phase b). If the STATION-ID is not yet included in the stations attribute table, then a dialog is prompted:

- ❶ Give the stations attributes accordingly:
Name: As a CHARACTER
Elevation, Northing, Easting: As an INTEGER in meters
Area: As a FLOAT in km²
Longitude and Latitude: As a FLOAT in degrees
- ❷ Click [Add...] to include the new station into the stations attribute table.
- ❸ Click [Cancel] to leave the Dialog without adding the station to the stations attribute table.

Do take enough time to maintain the station attribute table. The name of the station should be unique and allow you to have a clear idea on the location of the station.

- b) Once the STATION-ID is known, all the raw data records are checked for quality. The absolute value of each x_i record must be smaller than the absolute value of the defined NoData value. If this condition is not satisfied (Equation D1), DATAWIZARD sets the value to NoData for this record and switches to the next record.

$$\begin{cases} |x_i| < |\text{NoData}| & \text{then Data are available} \\ |x_i| \geq |\text{NoData}| & \text{then Data are missing, } |x_i| = |\text{NoData}| \end{cases} \quad (\text{D1})$$

- c) If the condition set by Equation D1 is fulfilled, the raw data records are ready for a second test. Prior to the second test an internal unit adjustment is completed. If the processed raw data records are not available in the required physical unit, they are transformed into this unit according to the coefficients given by the settings of the [Physical Limits] dialog (see above).

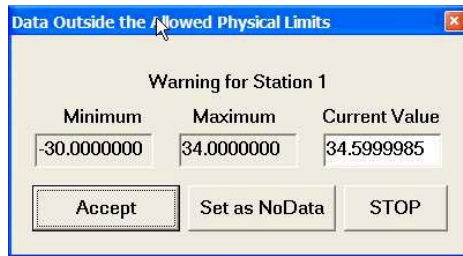
Units conversion table as supported by DATAWIZARD. The default units are marked in yellow.

Variable	Option	Unit	Adjustment factor
Precipitation	1	[mm]	1.0
	2	[¹ / ₁₀ mm]	0.1
Air temperature	1	[°C]	1.0
	2	[¹ / ₁₀ °C]	0.1
	3	[K]	-273.15
	4	[°F]	(x _i -32)·5/9
Wind speed	1	[m s ⁻¹]	1.0
	2	[¹ / ₁₀ m s ⁻¹]	0.1
Global radiation	1	[W m ⁻²]	1.0
	2	[J cm ⁻²]	8.64 ⁻¹

Variable	Option	Unit	Adjustment factor
Relative humidity	1	[-]	1.0
	2	[%]	0.01
	3	[‰]	0.001
Water vapour Pressure	1	[hPa]	1.0
	2	[¹ / ₁₀ hPa]	0.1
Sunshine duration	1	[min]	60 ⁻¹
	2	[h]	24 ⁻¹
	3	[¹ / ₁₀ h]	240 ⁻¹
	4	[-]	1.0
Runoff	1	[mm]	1.0
	2	[l s ⁻¹]	1.0
	3	[m ³ s ⁻¹]	1.0

- d) The main task of the data quality check is the test of plausibility against user defined minimal x_{\min}^{phys} and maximal physical limits x_{\max}^{phys} (see the Table above).

$$\left\{ \begin{array}{ll} x_{\min}^{\text{phys}} < x_i < x_{\max}^{\text{phys}} & \text{then Data are accepted} \\ x_i \leq x_{\min}^{\text{phys}} \quad \text{or} \quad x_i \geq x_{\max}^{\text{phys}} & \text{then Warning Dialog} \end{array} \right. \quad (\text{D2})$$



If the conditions set by Equation D2 are not fulfilled, a warning dialog is prompted. The current record x_i and the defined physical limits x_{\min}^{phys} and x_{\max}^{phys} are shown. You can decide here if you [Accept] the current value. You can also modify the value before accepting it or discard the value and [set as NoData].

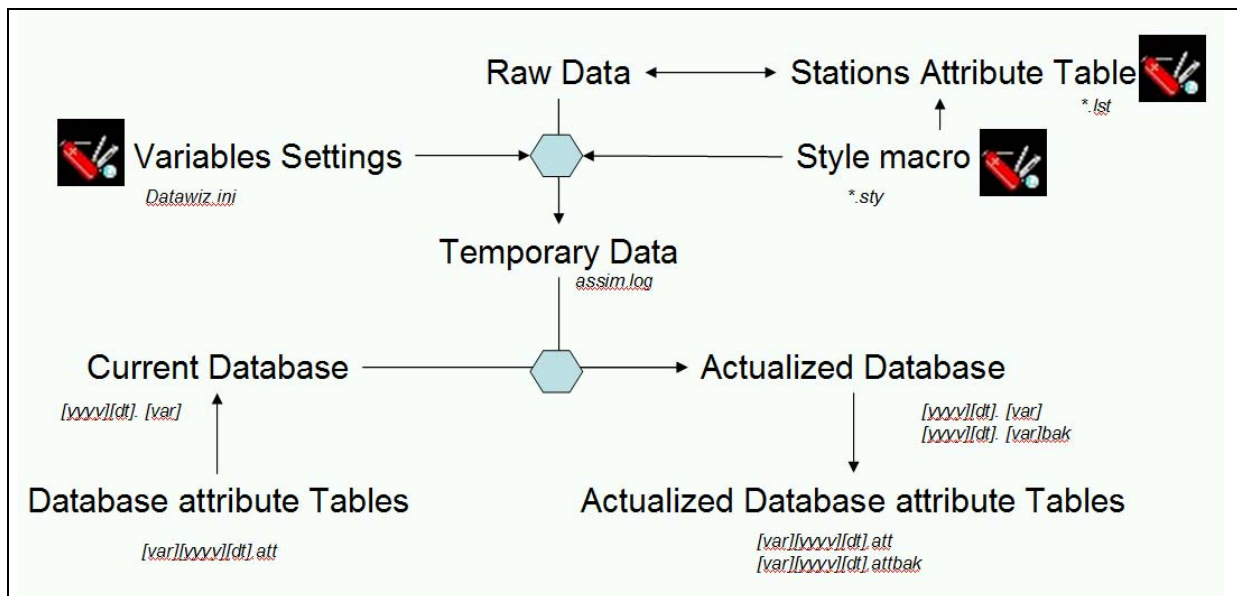
You can also [Stop] the data verification if you feel that you have set the physical limits too restrictively.

For a more sophisticated data plausibility test, we suggest a detailed data pre-processing (homogenisation, cross correlations, plausibility tests ...) before assimilating the data with DATAWIZARD.

- e) The results of the data verification are written in the default temporary directory. A file per station is stored. The file name is defined by the STATION-ID, the file extension is defined by the variable that is currently being assimilated (see later in this document). A log-file (assim.log) is written to control the transfer of the verified data into the simple database.

D.7.1 Structure of the database

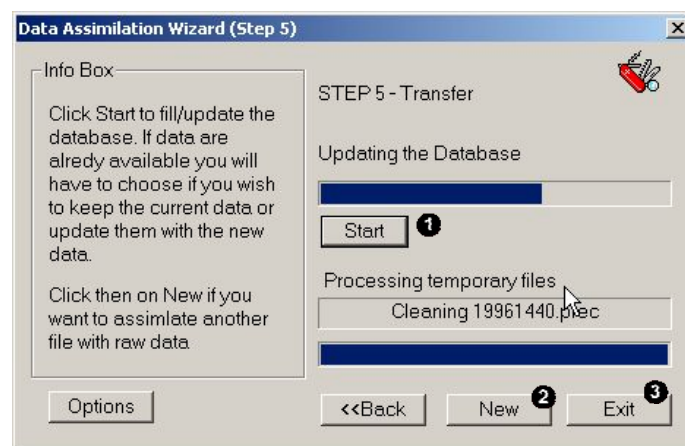
The simple database created by DATAWIZARD works as depicted in the following scheme:



Database records consist of two files per year for each variable and time resolution: A data table and attribute table. The following table exemplifies how file names are built:

Variable [var]	Time resolution [dt]	Year [yyyy]	Data Table [yyyy][dt].[var]	Attribute Table [var][yyyy][dt].att
Air Temperature	60 Minutes	2000	200060.tair	tair200060.att
Precipitation	1 Day	1988	19881440.prec	prec19881440.att
Runoff	6 hours	1995	1995360.runo	runo1995360.att

D.8 Step 5: Transfer of data into the database



Step 5 of DATAWIZARD: Data are transferred into the database.

- ❶ The data transfer can be initialised by clicking the [Start] button.
- ❷ After successful assimilation you can either begin with a new assimilation job.....
- ❸ or leave DATAWIZARD.

D.8.1 Database attribute table

For each year [yyyy], time resolution [dt] and variable [var] assimilated by DATAWIZARD an attribute table is maintained. The name of the attribute table is composed as follows:

The accepted variables are labelled as follows [var]

Variable	[var]
Precipitation	prec
Air Temperature	tair
Wind Speed	wspd
Global Radiation	radg
Relative Humidity	rhum
Water Vapour Pressure	vapo
Sunshine Duration	sund
Runoff	runo
Free1	fre1
Free2	fre2

[dt] accepts the following values

DT (MIN)	5	10	15	20	30	60	120	180	240	360	480	720	1440
----------	---	----	----	----	----	----	-----	-----	-----	-----	-----	-----	------

Database attribute tables are formatted as follows:

Attribute Table 2000	Air temperature	! Header
00001	57516	! 1 st Station-ID
00002	57461	! 2 nd Station-ID
00003	57237	! 3 rd Station-ID
00004	57411	!
00005	57355	!

The database attribute tables basically contain a link between the Stations attribute table and the columns in the Database data table. The example given above shows that, for the year 2000, there are 5 stations providing data. The first column after the DATE-ID in the Database data table will include data from station '57516', the second from station '57461' ...and so on.

Thus, DATAWIZARD can, at every time step, check which station is providing data for a certain year and hydrometeorological variable. This also allows for updating the data of a certain station without having to reload previously processed data.

D.8.2 Database data table

For each year [yyyy], time resolution [dt] and variable [var] assimilated by DATAWIZARD a data table is maintained. The name of each data table is composed as follows:

[yyyy][dt].[var] backup copies as [yyyy][dt].[var]bak

Database data tables are formatted as follows:

YYYYMMDDhhmmbeigiendd	57516	57461	57237	57411	57355
20000101240000000000	5.2000	7.2000	5.6000	4.4000	9.8000
20000102240000000000	6.8000	8.2000	2.5000	5.6000	7.6000
20000103240000000000	7.4000	8.4000	6.0000	6.3000	8.2000
20000104240000000000	8.2000	8.3000	7.0000	7.4000	9.2000
20000105240000000000	9.9000	5.8000	7.6000	8.3000	8.2000
20000106240000000000	10.2000	6.9000	7.7000	8.6000	7.8000
20000107240000000000	10.1000	4.4000	5.9000	8.5000	4.7000
20000108240000000000	9.8000	3.3000	5.6000	8.4000	5.8000
20000109240000000000	9.0000	4.6000	6.3000	6.4000	7.4000
20000110240000000000	10.0000	5.0000	7.2000	8.6000	7.5000
20000111240000000000	11.7000	4.6000	5.1000	9.8000	6.6000
20000112240000000000	10.1000	4.7000	5.3000	7.4000	6.3000
20000113240000000000	10.7000	5.6000	2.2000	7.8000	6.6000

The header of the Database data tables contains the information on the STATIONS-ID. This allows a link with the Database attribute tables and Stations attribute table. Every file contains a full year at the given time resolution, even if only portions of the year are available. The first column is the DATE-ID. The DATE-ID is composed as follows:

[YYYY][MM][DD][hh][mm][begi][endd]

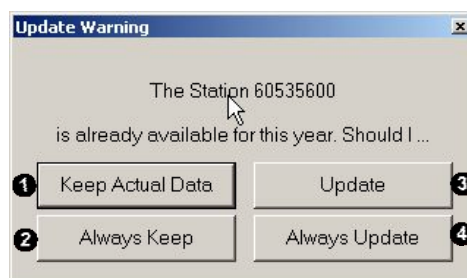
with

[YYYY]	Year	[MM]	Month
[DD]	Day	[hh]	Hour
[mm]	Minutes	[begi]	Start Time (hhmm) – not implemented
		[endd]	End Time (hhmm) – not implemented

The DATE-ID is computed internally for each of the year time steps. The columns of the raw data file that build the date are used to compute a second DATE-ID. A loop is made to compare the DATE-ID from the raw data to the internal DATE-ID. If both DATE-IDs match, the data for this time step are loaded into the database file. Thus, it is possible to assimilate only parts of the data. Gaps in the raw data are automatically filtered when an internal DATE-ID does not match any DATE-ID from the raw data file.

DATAWIZARD recognises if data from a station are already loaded into the corresponding database data table. In such cases a warning dialog is prompted at the beginning of each year. The user can then decide to:

- ❶ Keep the actual records for that station and year, and update only where NoData are stored.
- ❷ Keep the actual records for all years and that station. Update only where NoData are stored.
- ❸ Update the records for that year and that station. Keep only where raw data show NoData.
- ❹ Update the records for all years and that station. Keep only where NoData are stored.



E WINMET: Spatial interpolation of hydrometeorological variables

E.1 Introduction

WINMET has been developed to easily interpolate meteorological information required by PREVAH. Currently, WINMET integrates two versions in one. The first version (Swiss version) is specifically designed for applications based on the hydrometeorological data provided by MeteoSwiss. The second version (international version) is designed to interact with DATAWIZARD, another tool of the PREVAH modelling system (see preceding Chapter). This documentation will focus on the second, international version.

E.2 Start-up and welcome

After launching WINMET, a dialog is prompted for choosing the Swiss or international version. When using the command line, the version choice for WINMET may be skipped using the following arguments:



`winmet /s` for the Swiss version
`winmet /i` for the international version

E.2.1 Basic features of WINMET international

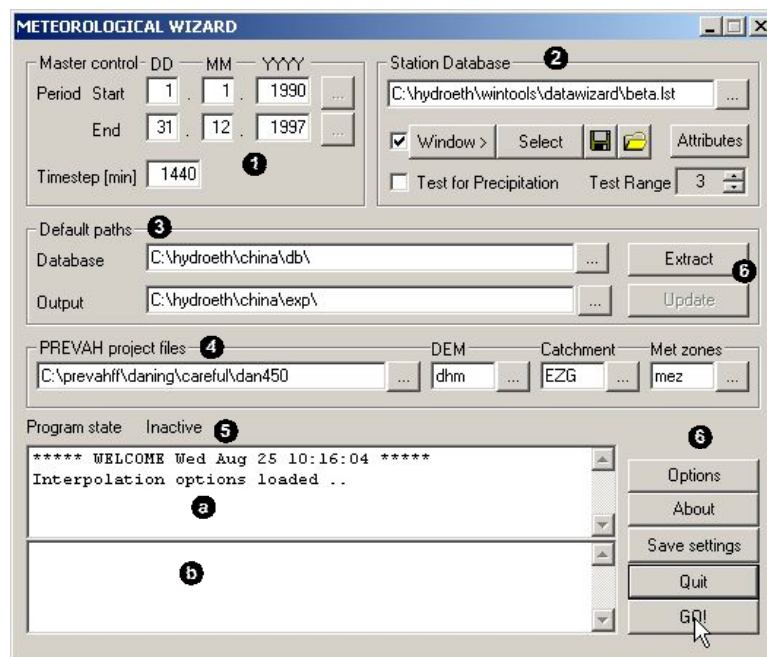
- Extracts meteorological information from a simple database created by DATAWIZARD.
- Different methods for a user friendly selection of hydrometeorological stations.
- Creates elevation dependent regressions of the analysed variables.
- Implements different approaches for the spatial interpolation of hydrometeorological information.
- Checks whether the interpolated values are reasonable.
- Creates tables of hydrometeorological information required to operate PREVAH.

E.2.2 Plug-ins

The `regr.exe` and `regrasci.exe` programs have to be copied in the directory where the simple database of hydrometeorological information created by DATAWIZARD is stored. `regr.exe` determines elevation dependent gradients for input data of any time step. The regression is completed for two separate altitudinal ranges which can be specified by the user. The profile may consist of up to three sections (see Chapter 3.4.2 in Part II of the PREVAH documentation). `regrasci.exe` converts a binary regression as generated by `regr.exe` into an ASCII-regression file. This may be desired for file transfer between different systems (e.g. DOS/WINDOWS or UNIX) or for looking into the file for data checking. The specifications of both formats are described later in this documentation.

The station attribute table [`*.lst`] created and maintained by DATAWIZARD has to be available.

E.2.3 Main dialog of WINMET international



International version: Main dialog of WINMET

The main dialog of the WINMET international version is divided into sectors:

❶ In the [Master control] sector, you have to specify the time range of the interpolation job. The start and end dates both have to be given as day (DD), month (MM) and year (YYYY). You also have to indicate the time step of the data you intend to process with WINMET.

❷ The [Station Database] sector is where you can access Station selection tools and the station attribute table. In this block, you may also activate an acceptability test for precipitation data.

❸ The [Default Paths] sector allows the setting of links to the directory where the database maintained by DATAWIZARD is stored and where WINMET outputs have to be transferred. In the output directories, four sub-directories will be created:

- *Database_Path/Stations/*: Data extracted from the database.
- *Database_Path/Input/*: Results of elevation dependent analysis.
- *Database_Path/Tables/*: Tabular interpolation results.
- *Database_Path/Grids/*: Gridded interpolation results.

If such directories contain data from previous interpolation jobs, WINMET will ask if you desire to delete their content before running the current interpolation job.

❹ The [PREVAH Project Files] sector links WINMET with spatial data of the investigated catchment. The file extensions for the digital elevation model [DEM], watershed limits [Catchment] and meteorological zones [Met zones] have to be indicated. The DEM grid is required for elevation dependent interpolation approaches. The watershed limits grid is required to define the domain of interest for the spatial interpolation. The grid of the meteorological zones is needed to generate separate output for different sub-units within the domain of interest.

❺ The [Message] window displays information on the current processes: Station availability (❶); files availability (❷); and progress of the interpolation procedure.

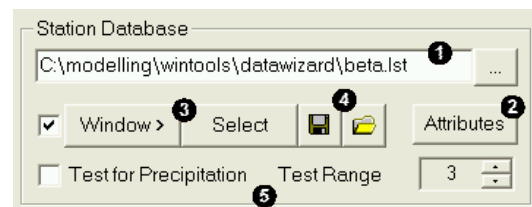
⑥ The [Commands] sector contains the main controls for WINMET. By clicking the appropriate button you can:

- Extract station data from the database and save them as a formatted table in the *Database_Path/Stations/* directory.
- Access the options dialog.
- Save the current settings.
- Start the interpolation job [GO!].
- Leave WINMET.

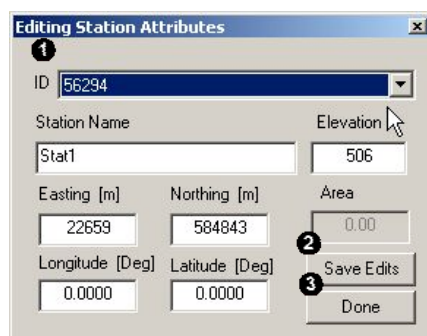
E.2.4 Station database

The Station Database sector of WINMET's main dialog serves for setting a link between WINMET and the Station attribute table generated by DATAWIZARD. The format specifications of this table are provided in the documentation of DATAWIZARD.

- ① Link to the Station attribute table file of the current database.
- ② By clicking the [Attributes] button you can access a dialog that allows you to update the attributes of each station.
- ③ By clicking the [Window] button you can access a dialog that allows you to select the domain where available stations are sought. The [Select] button prompts a window with a list of all available stations. You can then mark or unmark stations and save the final configuration of stations.
- ④ The current selection of stations can be saved to [] and loaded [] from a file.
- ⑤ The acceptability of precipitation records can be tested. Click the check box to activate the test during the extraction of data from the database. The test range may vary between 1 (very rigorous test) and 5 (very weak test).



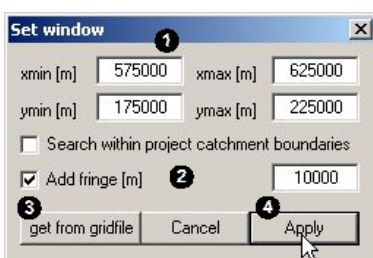
E.2.5 Edit the attributes of a station



This dialog can be accessed through the Station database sector of WINMET's main dialog by clicking the [Attributes] button.

- ① Select the ID of a station to load its attributes. Change the attributes accordingly: Name: As a CHARACTER; Elevation, Northing, Easting: As an INTEGER in meters; Area: As a FLOAT in km²; Longitude and Latitude: As a FLOAT in degrees
- ② Click [Save Edits] to store the changes
- ③ Click [Done] to leave the dialog

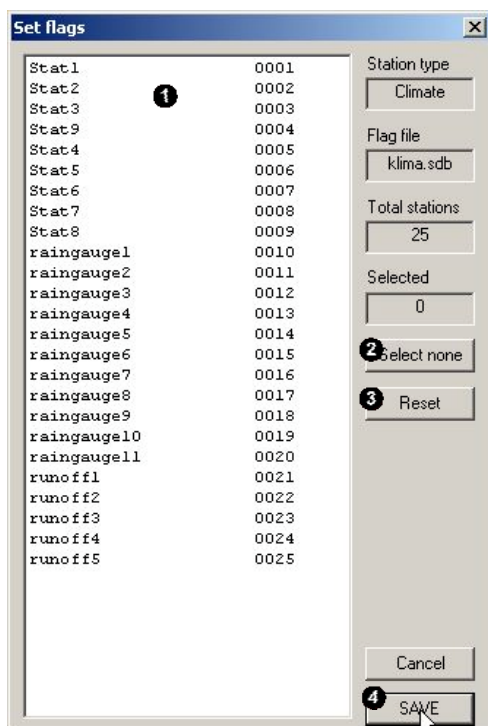
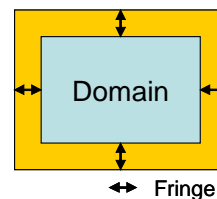
E.2.6 Selection of stations



By clicking the [Window] button, the [Set Window] dialog is prompted. Two methods for selecting the station to be extracted from the database and used for spatial interpolation are available.

When selecting the appropriate station for interpolation, you can define the co-ordinates of a window (❶ xmin, xmax, ymin, ymax) where stations have to be located. A so-called fringe area (❷) can be defined to extend the search area. To reduce the search area to the area of the investigated basin, activate the checkbox [Search within project catchment boundaries].

To simplify the selection of the window, set the co-ordinates of the window of interest equal to the domain of a catchment. Thus click the [get from gridfile] button (❸) and select a grid of the domain you are interested in. In this case, the xmin, xmax, ymin, ymax settings (❶) are set automatically, according to the co-ordinates of the loaded grid. Further, you can add a fringe to expand the area of the domain of interest. Stations located in the defined window (\pm fringe) will then be selected, after clicking [Apply] (❹).



A second dialog will be prompted to confirm the selection.

Stations can also be selected through the [Set Flags] dialog. This is prompted automatically after the [Set Window] dialog and can also be accessed by clicking the [Select] button in the Station Database sector of the main WINMET.

All stations included in the Station attribute table are listed in a selection field (❶). You can select the stations of interest by clicking on their name. For multiple selection press "SHIFT" or "CTRL" while you are clicking. To cancel all selections, click [Select none] (❷). To discard the changes click [Reset] (❸). Once you have made the right selection, click [SAVE] to store a station flag file (❹).

The Station flag file is needed for the extraction of data from the available database. It is a reduced copy of the station attribute table and is formatted as follows:

Flag No.	W	Name	H	Easting	Northing	
1	1	2.0	Stat1	506	22659	584843
0	2	2.0	Stat2	1892	-138483	-36689
1	3	2.0	Stat3	133	720284	579827
1	4	2.0	Stat9	23	991990	579941
0	5	2.0	Stat4	259	254925	456134
1	6	2.0	Stat5	674	408446	729820
1	7	2.0	Stat6	303	22245	590031
--	--	---	-----	-----	-----	-----

The Flag indicates whether a station was selected or not. "No." is an internal incremental number assigned by WINMET to each station in the Station attribute table. Name is the name of the station. H is the elevation of the station. Easting and Northing are the x,y co-ordinates, respectively, of the station in the co-ordinate system defined by the digital elevation model of the investigated area. This information is assimilated from the Station attribute table provided by DATAWIZARD. Previous to using both WINMET and DATAWIZARD, the user has to transform the co-ordinates of the stations intended for modelling into the same co-ordinate

system of the spatial data available for the investigated area – co-ordinates must be in meters, and using UTM co-ordinates is recommended.

E.3 WINMET options

The screenshot shows the 'Interpolation details' dialog box in WINMET. It is divided into four numbered sectors:

- Sector 1: Interpolation variables**
 - Method: IDW
 - IN: Table: prec\$\$\$\$.tab
 - IN: Regressions: prec\$\$\$\$.out
 - OUT: prec
 - Nodata: 998
 - Unit adjustment: 1.000
 - Physical limits: 0.0 to 570.2
 - Decimals: 2
 - Output:
 - ☐ DT IDW/KRIG
 - ☐ REG
 - ☐ IDW/KRIG (RES)
 - ☒ PREVAH
 - ☐ PIPE
 - Grid output:
 - Hourly: Off
 - Daily: None
 - Monthly: None
 - Yearly: Sum
- Sector 2: Regression variables**
 - Do regression: ☐
 - Infile 1: prec
 - Infile 2: -
 - Infile for precip: -
 - Outfile: prec
 - Error if above: 998
 - Lower limit: 500
 - Upper limit: 1000
 - Dynamic range: 200
 - Spread at least: 100
 - # of stations: 99
 - Usage of stations: 11111111111111111111
- Sector 3: Kriging control**
 - Access: [button]
- Sector 4: General controls**
 - Grid Stack Output: None
 - Threshold for accepting regression [-1 .. 1]: 0.300
 - ☐ Create ASCII regressions
 - ☐ Edit scripts prior to execution
 - ☒ Keep scripts and input after execution

Buttons at the bottom: Save, Cancel, OK.

Options dialog of WINMET

The Options dialog of WINMET is also divided into sectors:

❶ In the Interpolation variables sector, you may for each variable:

- Define the method used for interpolating each variable
- Assign a name to the input and output files
- Indicate the NoData value which indicates missing data to be skipped
- Edit a factor for transforming the interpolation results into the physical unit required by the model
- Set the physical limits for accepting the interpolation results. If such limits are exceeded, the value of the limit is assumed as an interpolated value
- Activate or deactivate optional gridded and tabular output

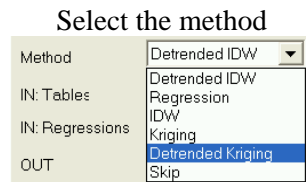
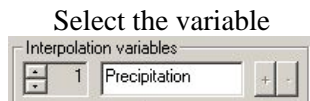
Further details on the Interpolation variables sector follow in the next section.

❷ The Regression variables sector sets the options controlling 'regr.exe', the plug-in that determines the coefficients of the elevation dependent regression.

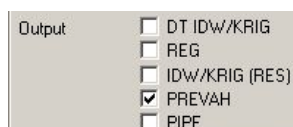
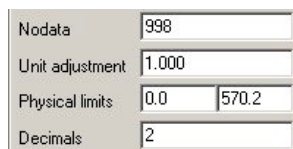
❸ The Kriging and IDW sectors allow the modification of basic options of the two interpolation approaches. The maximum distance for IDW interpolation can be modified. The constant temperature trend for the "Lapse Rate" interpolation method can be modified. By checking a box you can obtain grids of the IDW-weights for each station. Such grids are saved in the Database_Path/Grids/ directory with the extension [*.wid]. The Kriging settings can be modified within a separated dialog, which is opened by clicking the [Access] button.


❹ The General controls sector provides access to miscellaneous features of WINMET.

E.3.1 Defining the interpolation variables



Assign the names for input/output



The Interpolation Variables sector allows editing of the interpolation option of up to six hydrometeorological variables. You can edit the name of the variable (e.g. change from water vapour pressure to relative humidity). Use  to change from one variable to the next or previous.

Each variable can be interpolated using a user defined approach:

The following methods are implemented in WINMET:

- Detrended IDW (DTIDW)
- Simple Elevation Dependent Regression (EDR)
- Simple Inverse Distance Weighting (IDW)
- 2D Kriging (KRI)
- Detrended Kriging (DTKRI)
- IDW Lapse Rate
- Kriging Lapse Rate

Select 'Skip', if you do not want to interpolate a particular variable. Recommendations follow at the end of this chapter.

The root name of the input file needs to be specified.

- Tables: The year format has to be declared either as \$\$ (if two digits) or as \$\$\$\$ (if four digits).
- Regressions: As for Tables.
- OUT: The basic name for the output files regarding a specific variable has to be set.

The default names for Tables and Regressions files are optimised for using WINMET together with DATAWIZARD. Only advanced users should change these settings. The OUT name may be chosen freely, although the default names are strongly recommended for first time users.

Data in the input tables may be erroneous or missing. DATAWIZARD substitutes such data with a NoData value. WINMET skips these data if the NoData value is declared correctly. A value can be provided to transform the interpolated value into another physical unit. After the unit adjustment, the interpolated data shall not under-run or exceed given physical limits (left is minimum, right is maximum). If such limits are exceeded, then the value of the limit is assumed as the interpolated value. Further, the precision (in digits of 0–5) of the tabular output may be specified. Recommendations follow at the end of this chapter.

WINMET is designed to generate gridded and tabular results of the spatial interpolation of hydrometeorological variables. File formats are specified in the Appendix.

The following outputs can be optionally saved at each time step:

- DT IDW/KRIG: GRID interpolated by DTIDW/DTKRI Name **[Out]MMDDHH.d\$\$\$\$**. A grid is written for each time step.
- REG: GRID interpolated by EDR / Name **[Out]MMDDHH.r\$\$\$\$**
- IDW/KRIG(RES): GRID interpolated by IDW/KRI (the residuals in case of method DTIDW/DTKRI) / Name **[Out]MMDDHH.i\$\$\$\$**
- PREVAH: Meteorological table for PREVAH, a value per time step and meteorological zone, formatted as an ASCII file / Name **[Out][GRID].s\$\$\$\$**
- PIPE: Not yet implemented.

Grid output	Daily	None
	Monthly	Sum
	Yearly	Sum

The user can decide whether additional grids are saved in the Database_Path/Grids/ directory. Grids can be written at the end of each day [DD], month [MM] and year [YYYY]. You can choose to save either the sum [Sum] or the average [Avg] of the data. The following rules apply for naming the grids.

DAILY GRID: Database_Path/Grids/ [OUT]YYYYMM.[S/A]DD

MONTHLY GRID: Database_Path/Grids/ [OUT]YYYY.[S/A]MM

YEARLY GRID: Database_Path/Grids/ [OUT]YYYY.[S/A]yy

[OUT] is the general character string for the outputs of a certain hydrometeorological variable.


Save

After each change in the Interpolation Variables block, the save button is activated. Click to save your edits. If you forget to save a warning will be prompted.

E.3.2 Defining the elevation dependent regression

Select the variable

Regression variables	
1	precipitation
<input checked="" type="checkbox"/> Do regression	

The Regression Variables sector allows the editing of the interpolation option of up to seven hydrometeorological variables. Click  1 to change from one variable to the next or previous. For disabling the estimation of regression for a certain variable you have to deactivate the corresponding checkbox [Do regression].

Assign the names for input/output

Infile 1	sund
Infile 2	-
Infile for precip.	
Outfile	ssd_

The basic name of the input files where station data are stored is required. The default names are optimised for using WINMET international together with DATAWIZARD. Only advanced users should change these settings.

Error if above	998
Lower limit	500
Upper limit	1000
Dynamic range	200
Spread at least	100

The elevation dependent regressions of meteorological variables are controlled by changing some basic settings:

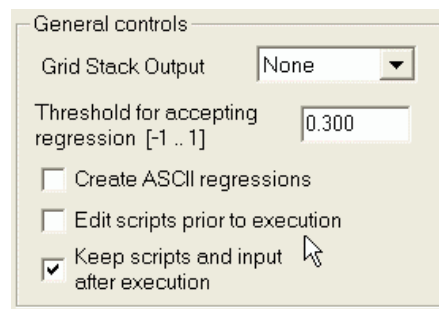
- Error if above: This value is used to skip NoData from the tables created by DATAWIZARD. To skip data an algorithm is used.
- Lower limit is required to define the elevation in meters above sea level where a first inversion has to be identified.
- Upper limit is required to define the elevation in meters above sea level, where a second (higher) inversion has to be identified.
- Dynamic range is a tolerance interval in meters, above or below one of the two given elevations, where the inversion has to be searched.
- Spread range is the minimum elevation difference between two inversions, in meters.

Again, the default values are optimised for using WINMET international together with DATAWIZARD. Only advanced users should change these settings.

Save

After each change in the Interpolation Variables block, the save button is activated – click to save your edits.

E.3.3 Managing general controls



Grid Stacks: Stacks may be activated either as ASCII or binary elements. Stacked output writes a file per time step where gridded data of all variables are saved. Contact the developers if you think you need this feature. Set tolerance for accepting regressions of precipitation

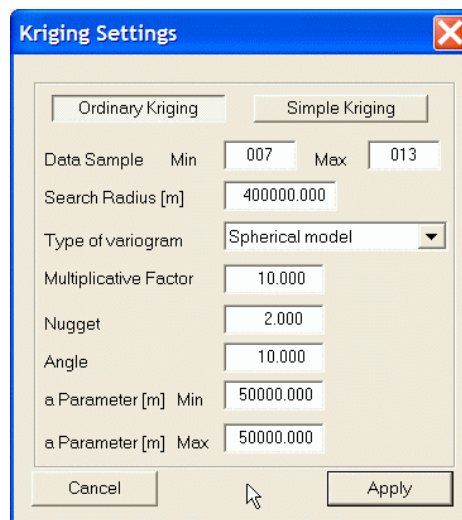
A threshold can be assigned to avoid accepting regressions of precipitation that are not well correlated with the observations and would cause artefacts. A correlation value between [-1 to 1] has to be declared. If you declare "-1", then all regressions are accepted. A noncommittal threshold of "0.3" is recommended for accepting regressions of precipitation.

Creation of ASCII Regression Files: Regression files are stored either in binary or ASCII format. To generate the ASCII format, activate the corresponding check box [Create ASCII regressions].

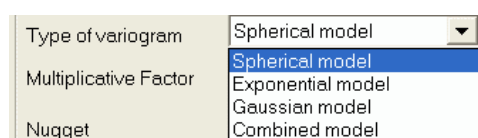
Viewing the Interpolation Script: To make changes by hand to the interpolation scripts (not recommended), activate the corresponding check box [Edit scripts prior to execution]

Management of scripts: By activating (default) the corresponding checkbox [Keep scripts and input after execution], the content of the Output_Path/Input/ directory is kept.

E.3.4 Managing Kriging options



Four variogram models are available (View section):



- The Spherical model is perhaps the most commonly used variogram model. It has a linear behaviour at small separation distances near the origin but flattens at larger distances. If the nugget variance is impor-

tant but not too large, and there is a clear range and sill, the spherical model usually fits observed variograms well.

- The Exponential model is another commonly used transition model. This model reaches its sill asymptotically, but it is linear at very short distances from the origin as in the spherical model. However, it rises more steeply and then flattens more gradually. It is usually a good option if there is a clear nugget and sill, but only a gradual approach to the range.
- The Gaussian model is a transition model often used to model extremely continuous phenomena. Like the exponential model, it is reaching the sill asymptotically. The Gaussian model is indicative of very continuous phenomena, so this estimation procedure makes much more use of the closest samples.
- The Combination model is the fourth model. It is a weighted combination of the spherical, exponential and Gaussian model. Weights for the three models are all equalised in WINMET. Near the origin, the combination model is almost equal to the spherical model, but it flattens earlier than this model.

Increasing the nugget effect makes the distribution of weights more equal, which in turn causes the estimated value to be somewhat higher and the estimation procedure to become more like a simple averaging of the available data. A pure nugget effect model entails a complete lack of spatial correlation. The graph of a pure nugget effect model would be a horizontal line.

Changing the range has a relatively minor effect on the Kriging weights and estimates. If the range is becoming very small, all sample points appear to be equally far away from the point being estimated and from each other. This gives a result similar to that of the pure nugget effect. If the range is set very large, all sample points are included for the interpolation of all grid cells, but they are weighted in succession to their lag distance and chosen variogram model. For irregularly gridded data, the search neighbourhood should be slightly larger than the average spacing between the sample data. As a final condition, at least four samples should be within the range, but in practice, one typically tries to have at least 12 samples.

Ordinary Kriging is often associated with the acronym BLUE for "best linear unbiased estimator": The estimates of Ordinary Kriging are weighted linear combinations of the available data, thus it is "linear"; it is "unbiased" since it tries to have the mean residual or error equal to 0; and it is the "best" because it aims to minimise the variance of errors, which distinguishes Ordinary Kriging from most other interpolation methods.

Simple Kriging is based on three assumptions:

- Observations are a partial realisation of a random function
- The realisation is second order stationary
- The mean is known.

These are the same conditions as for Ordinary Kriging, except that the third condition is more restrictive. In Ordinary Kriging, the mean only has to be stationary.

E.4 Recommendations

Variable	Name	ASCII Tables	Binary regression	Recommended Unit
Precipitation	<i>precYYYY</i>	*.txt	*.out	[mm day ⁻¹]
Air temperature	<i>tempYYYY</i>	*.txt	*.out	[°C]
Global radiation	<i>globYYYY</i>	*.txt	*.out	[W m ⁻²]
Wind speed	<i>windYYYY</i>	*.txt	*.out	[m s ⁻¹]
Sunshine duration	<i>ssd_YYYY</i>	*.txt	*.out	[-]
Water vapour pressure	<i>vapoYYYY</i>	*.txt	*.out	[hPa]
Relative humidity	<i>hum_YYYY</i>	*.txt	*.out	[-]

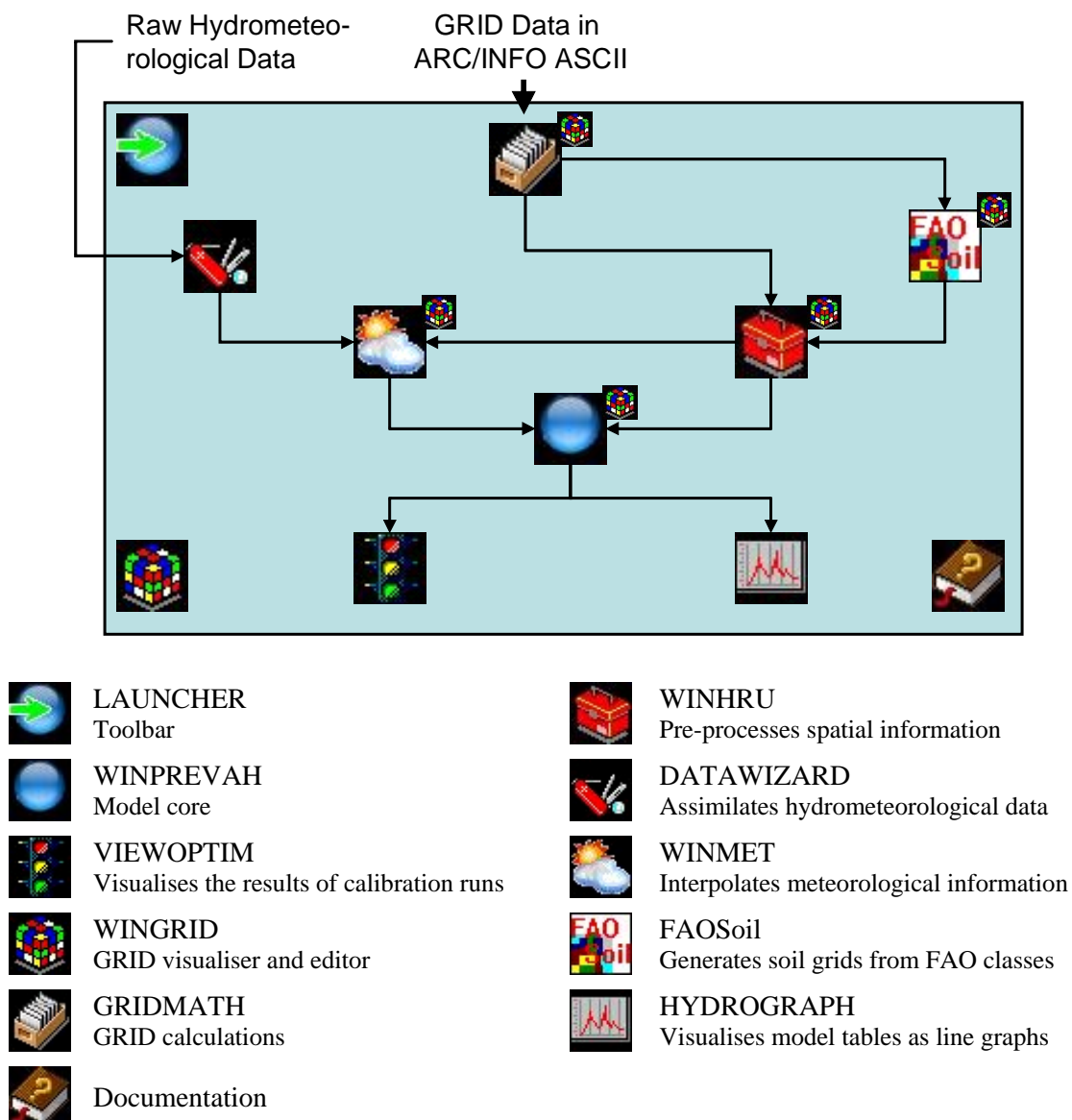
Variable	DTIDW	EDR	IDW	KRI	DKRI	LIDW	LKRI
Precipitation							
Air temperature							
Global radiation							
Wind speed							
Sunshine duration							
Water vapour pressure							
Relative humidity							

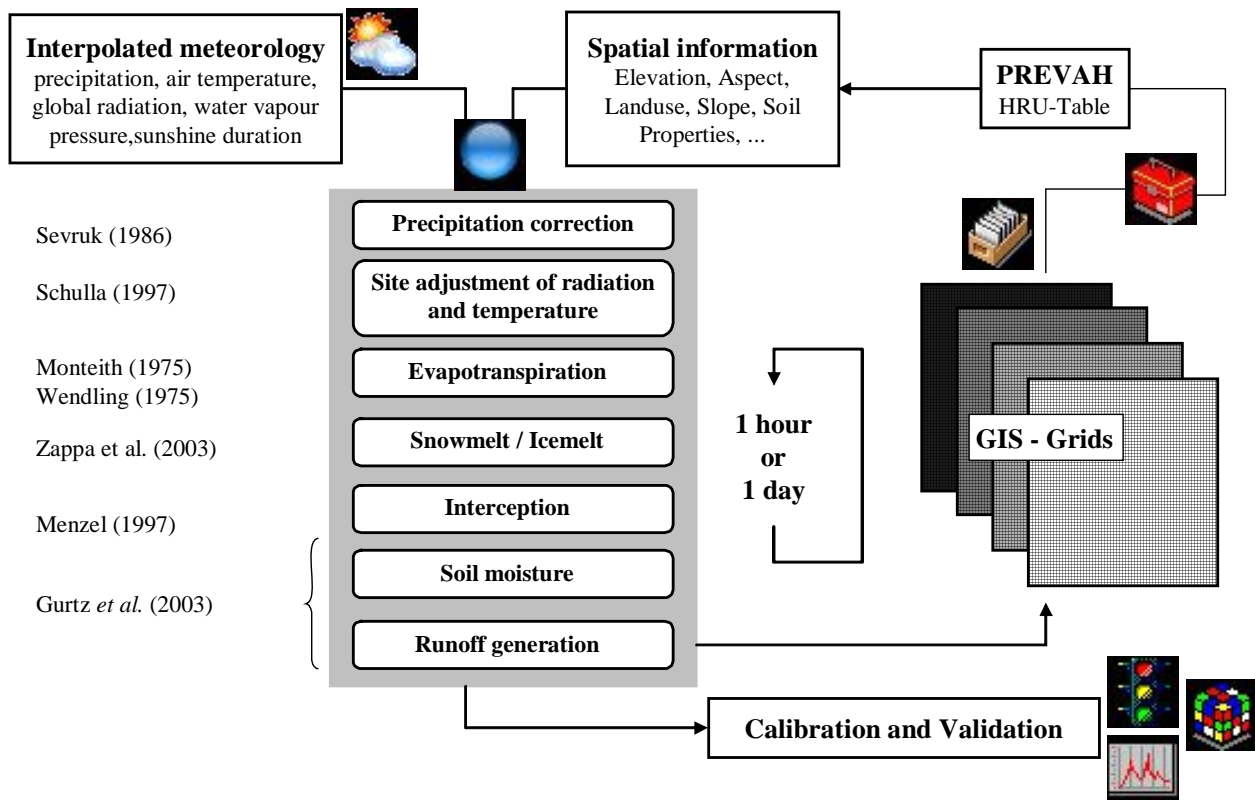
<i>Recommended</i>
<i>Avoid if possible</i>
<i>Do not use</i>

F WINPREVAH: Running and controlling the PREVAH model core

F.1 Introduction

The spatially distributed hydrological model PREVAH (Precipitation-Runoff-EVApotranspiration-Hydrotope model) was originally developed by Joachim Gurtz of the Institute for Atmospheric and Climate Sciences, ETH Zürich, for the simulation of influences of climate change on hydrological processes in mountainous catchments (Gurtz et al., 1997). Since then, PREVAH has developed into a complete system for the spatially distributed simulation of the hydrological cycle at different spatial scales and with different kinds of meteorological input (Zappa, 2002). WINPREVAH was subsequently developed as a plug-in to the PREVAH modelling system in order to facilitate application (Viviroli, 2007).





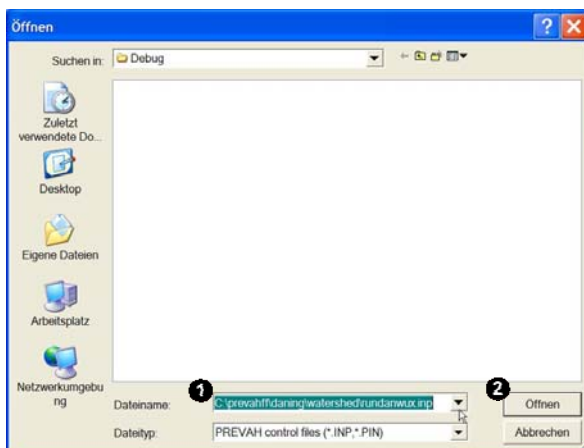
The flow chart of the PREVAH modules including the assimilation of physiographic and meteorological information and the gridded or table-oriented model outputs

F.2 Installation and start-up

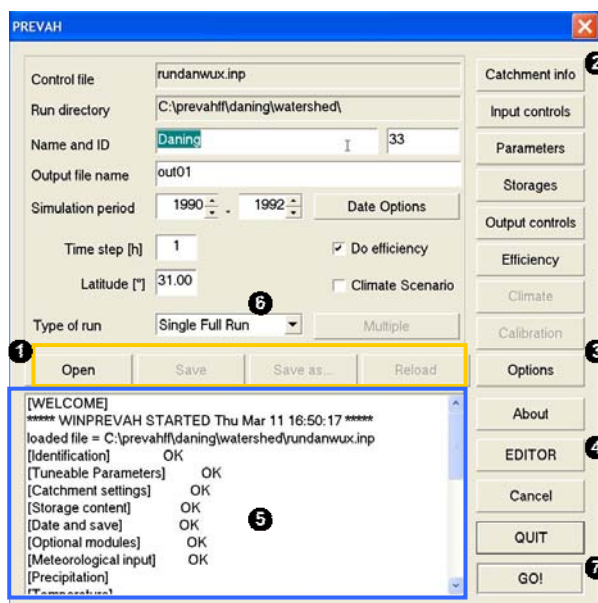
Several preprocessing steps are needed prior to the start of PREVAH / WINPREVAH:

- Creation of a project directory
- Assimilation and full analysis of the spatial data with WINHRU
- Assimilation and interpolation of meteorological information with WINMET
- Generation of tables with observed runoff data for the investigated catchment
- Setting the WINPREVAH options
- Editing the PREVAH control file either with a text editor and/or WINPREVAH

F.3 The main dialog

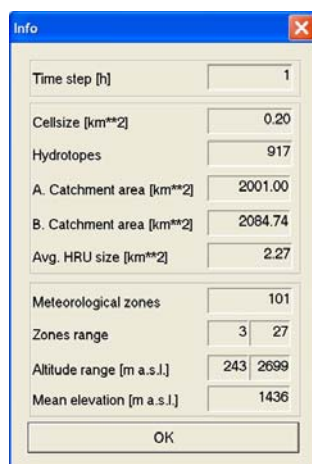


After launching winprevah.exe, a file open dialog is automatically prompted. Choose a PREVAH control file (❶) and click [Open] (❷). After this, the main dialog of WINPREVAH is prompted.



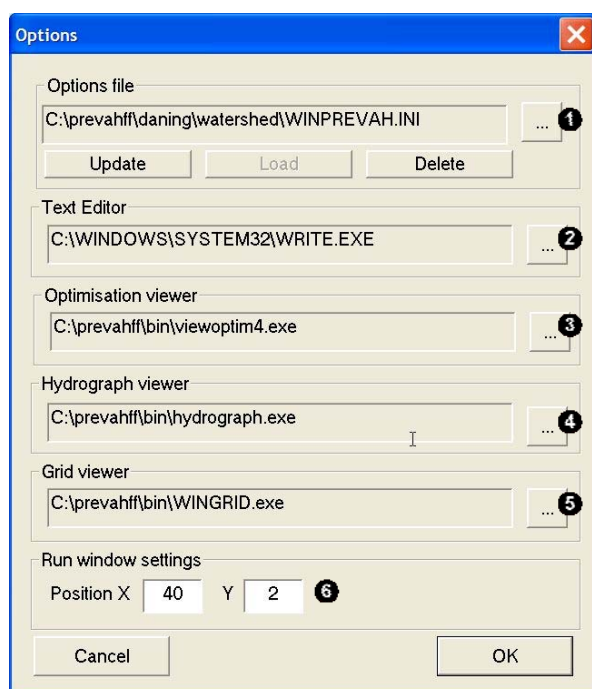
Basic operations in the main dialog of WINPREVAH are:

- ❶ Management of the Control File [Open], [Save], [Save As..], [Reload].
- ❷ Prompt the visualisation of basic [Catchment info].
- ❸ Prompt the [Options] settings.
- ❹ Visualise and edit the control file with a text [EDITOR].
- ❺ Follow the editing process in the LOG-Box. The content of the LOG-Box is also written in a log-file, which is automatically created in the same directory where the active PREVAH control file is stored.
- ❻ Select the type of model run (see Section C).
- ❼ Launch the simulation [GO!].



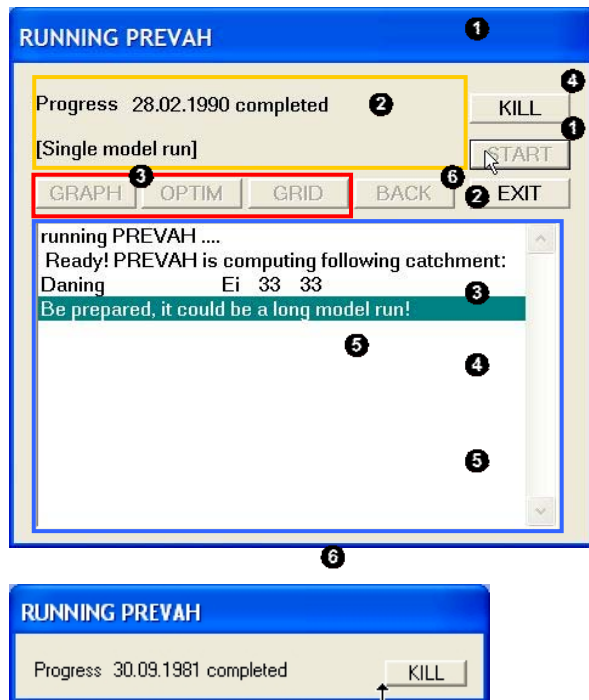
The [Catchment info] dialog displays basic characteristics of the catchment, derived from a control file of the spatial information created by WINHRU.

[Cellsize] is the area of each grid point in the basic grids used to run WINHRU and WINPREVAH. [Hydrotopes] is the number of HRUs as found in the control file for spatial information. The [A. Catchment area] is the true area of the investigated catchment in km^2 . The [B. Catchment area] is the area of the catchment as derived by topographical analysis of the digital elevation model. The [Avg HRU size] is the average area in km^2 of each HRU, being equal to the catchment area divided by the number of hydrotopes. Additional information on average altitude and altitude ranges is also displayed.



The [Options] dialog allows the linking of WINPREVAH with other tools of the PREVAH modelling system:

- ❶ [LOAD] and [UPDATE] the options file.
 - ❷ Link PREVAH to a text editor. This allows the loading of the control file into a text editor (e.g. WRITE.EXE) and manual modification (click the [EDITOR] button in the main dialog of WINPREVAH).
 - ❸ Link to the VIEWOPTIM tool which visualises the results of calibration runs.
 - ❹ Link to the HYDROGRAPH tool which visualises model tables as line graphs.
 - ❺ Link to the WINGRID tool which visualises gridded data stored in the binary format of the PREVAH modelling system.
 - ❻ Select the starting position of the [RUNNING PREVAH] window; this window is displayed subsequently to launching the simulation with the [GO!] button in the main dialog of WINPREVAH
- Options are stored automatically after every change (see Section F.6).



The [RUNNING PREVAH] window is prompted to manage the model run as soon as the [GO!] button is clicked in the main dialog of WINPREVAH.

Here you may:

- ① [START] the simulation.
 - ② View the progress of the simulation (updated at the end of each month).
- Before or at the end of the simulation you may:
- ③ Launch HYDROGRAPH, VIEWOPTIM and/or WINGRID.

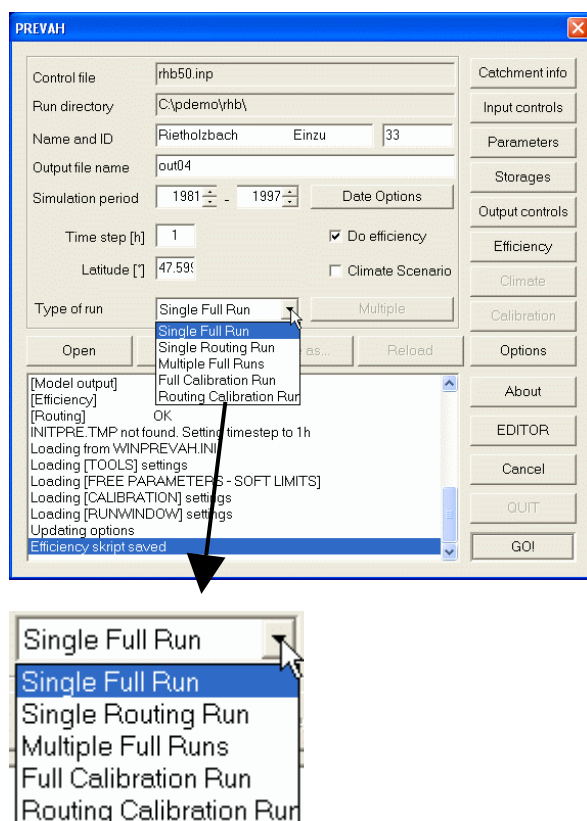
During the simulation you may:

- ④ [KILL] the current job. After clicking this button, the simulation may be stopped at the end of the next month.
- ⑤ Follow the progress of the model run through the LOG-BOX.

After the simulation you can:

- ⑥ Go [BACK] to the main dialog or leave WINPREVAH.

F.3.1 Selection of the type of model run



PREVAH supports several types of model runs:

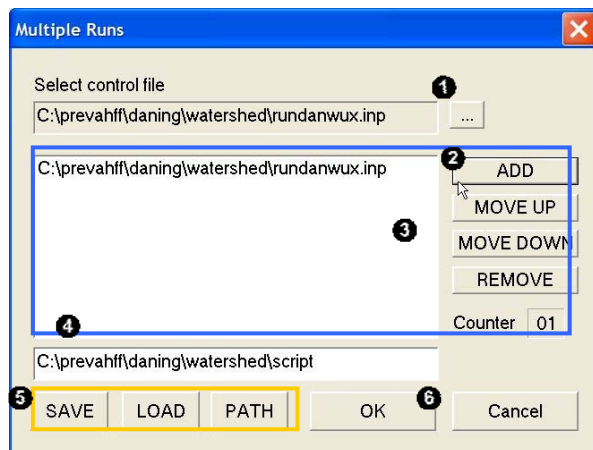
a. Typically, PREVAH is run in [Single Full Run] configuration. This type runs a simulation for the selected catchment between the given start and end dates.

b. The type [Single Routing Run] allows the routing of model results from two sub-catchments without the need of making a full model run (recommended only for experienced PREVAH users).

c. Selecting [Multiple Full Runs], you may prompt a dialog (click [Multiple]) for selecting several control files and run them automatically consecutively (recommended only for experienced PREVAH users).

d. Another important option is to start an automatic calibration of PREVAH. Select [Full Calibration Run] to configure the model for automatic calibration. The calibration options can be set by accessing the Calibration dialog (use the corresponding button in the main dialog of WINPREVAH). For further information on calibration, see Section F.5 in this part of the documentation and Chapter 8 in Part II of the documentation.

e. The type [Routing Calibration Run] allows the calibration of the routing options (recommended only for experienced PREVAH users).



The [Multiple Full Runs] dialog:

- ❶ Select PREVAH control files from your file system.
- ❷ Select whether you want to [ADD] the selected control file to the job-queue (❸).
- ❸ If you select a job in the queue you may then either [REMOVE] it from the queue, or set this job earlier [MOVE UP] or later [MOVE DOWN] in the queue. A counter displays how many jobs are currently in the queue.
- ❹ Provide a name for the job-list and...
- ❺ [SAVE] it in a script file. You may also [LOAD] a previously stored job-list and modify it or change the [PATH] of the directory where job-list scripts are stored.
- ❻ Leave the dialog.

F.4 The control file of PREVAH and WINPREVAH

Both the DOS and WINDOWS version of PREVAH are initialised with a control file which is ASCII-text formatted. The structure of this file consists of different modules:

[Identification]	[Tuneable Parameters]
[Catchment settings]	[Storage content]
[Date and save]	[Optional modules]
[Meteorological input]	[Climate scenario]
[Model output]	[Efficiency]
[Routing]	

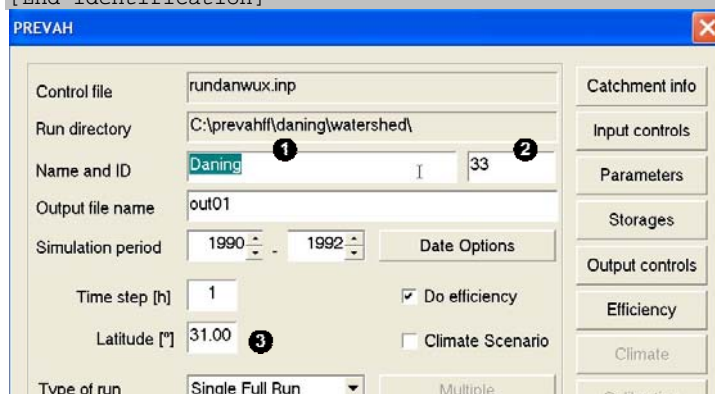
A default control file is generated during the preprocessing of spatial information with WINHRU. This default control file may be either edited in the dialog-based WINPREVAH or with any common text editor.

The following sections will explain the functions of the different settings modules, how they are edited with WINPREVAH and which options should be considered if the file is edited with a text editor.

F.4.1 [Identification] settings:

Syntax:

```
[Identification]
33      ! Watershed ID
Thur    ! Watershed Name
47.000  ! Latitude
493.00  ! Official area [km²]
0.25    ! Cell size
[End Identification]
```



This settings module is automatically written by WINHRU. Cell size in [km²] is equal to the square of the grid resolution in [km].

Watershed-ID (❷), watershed name (❶), time step (in hours) and latitude (❸) may be edited with WINPREVAH.

Edits are saved by clicking [Save].

F.4.2 [Tuneable Parameters] settings:

Syntax:

```
[Tuneable Parameters]
1          ! CREDV, Def=1
-4.8       ! Precipitation correction, Def=0.0
16.4       ! Snow correction, Def=0.0
-0.56      ! Threshold temperature snowfall, Def=0.0
0.33       ! Transition temperature snow-rain, Def=0.75
0.00       ! Threshold temperature snowmelt, Def=0.0
2.69       ! Maximal temperature-index melting factor, Def=2.0
0.42       ! Minimal temperature-index melting factor, Def=1.0
0.00       ! Melting factor by wind 1, Def=0.0
0.00       ! Melting factor by wind 2, Def=0.0
0.10       ! Retention factor for melting snow, Def=0.1
0.50       ! Exponent for retention of melting snow, Def=0.5
0.10       ! Coefficient for re-freezing, Def=0.1
1.5        ! Constant temperature melt factor for snow Def=1.5
0.000100   ! Constant radiation melt factor for snow, Def=0.0001
2.4        ! Non linearity parameter for infiltration module, Def=3.0
0.70       ! Threshold (0...1) for reduction ETP, Def=0.7
0.00       ! 0...1 maximal percentage of runoff generated by surface runoff, Def=0.0
28.0       ! Threshold coefficient for surface runoff, Def=30.0
28.0       ! Storage coefficient in hours for surface runoff, Def=10.0
130.2      ! Storage coefficient in hours for interflow, Def=75.0
3604.9     ! Storage coefficient in hours for base flow, Def=2500.0
440.7      ! Storage coefficient in hours for quick base flow, Def=750.0
37.3       ! Maximal content of the quick base flow storages, Def=150.0
0.184      ! Percolation rate in mm per hour, Def=0.1
0          ! Equilibrium line altitude of a glacier, Def=0
2.00       ! Constant temperature melt factor for ice, Def=2.0
0.000200   ! Constant radiation melt factor for ice, Def=0.00002
15.0       ! Coefficient for runoff generation from ice storage in hours, Def=15.0
30.0       ! Coefficient for runoff generation from snow storage in hours, Def=30.0
0.0        ! Coefficient for runoff generation from firn storage in hours, Def=0.0
1          ! Translation time for icemelt, Def=1
2          ! Translation time for snowmelt, Def=2
0          ! Translation time for firnmelt, Def=0
0.0000     ! Critical precipitation intensity [mm/h], Def=1.5
0.0000     ! Albedo ageing for temperatures above 0°C, Def=0.1
0.0000     ! Albedo ageing for temperatures below 0°C, Def=0.05
0.0000     ! Addition factor for albedo, Def=0.5
[End Tuneable Parameters]
```

*Link of the tuneable variables to Equations in Chapter 3 and 4 of Part II of the PREVAH documentation.
The last column declares whether a parameter may be edited by WINPREVAH (Y) or only manually (N)*

Tuneable variable	Reference in script	Editable
CREDV	-	N
Precipitation correction [%]	Equation 3.5-1	Y
Snow correction [%]	Equation 3.5-1	Y
Threshold temperature snowfall [°C]	Equation 4.3-1	Y
Transition temperature snow-rain [°C]	Equation 4.3-1	Y
Threshold temperature snowmelt [°C]	Equation 4.3-2	Y
Maximal temperature-index melting factor	Equation 4.3-2	Y
Minimal temperature-index melting factor	Equation 4.3-2	Y
Melting factor by wind	Equation 4.3-3	Y
Retention factor for melting snow	-	Y
Exponent for retention of melting snow	-	Y
Coefficient for re-freezing	Equation 4.3-5	Y
Constant temperature melt factor for snow	Equation 4.3-7	Y
Constant radiation melt factor for snow	Equation 4.3-7	Y
Non linearity parameter for infiltration module	Equation 4.5-1	Y
Threshold for reduction of ETP	Equation 4.4-33	Y
Maximal percentage of runoff generated by surface runoff	-	N
Threshold coefficient for surface runoff	Equation 4.5-5	Y
Storage coefficient for surface runoff [h]	Equation 4.5-5	Y
Storage coefficient for interflow [h]	Equation 4.5-5	Y
Storage coefficient for base flow [h]	Equation 4.5-11	Y
Storage coefficient for quick base flow [h]	Equation 4.5-10	Y
Maximal content of the quick base flow storages	Equation 4.5-8	Y
Percolation rate [mm h ⁻¹]	Equation 4.5-3	Y
Equilibrium line altitude of a glacier	WINHRU	N
Constant temperature melt factor for ice	Equation 4.3-8	Y
Constant radiation melt factor for ice	Equation 4.3-8	Y
Coefficient for runoff generation from ice storage in hours	Equation 4.3-8	N
Coefficient for runoff generation from snow storage in hours	Equation 4.3-8	N
Coefficient for runoff generation from firn storage in hours	Equation 4.3-8	N
Translation time for ice melt [h]	Equation 4.3-8	N
Translation time for snowmelt [h]	Equation 4.3-8	N
Translation time for firn melt [h]	Equation 4.3-8	N
Critical precipitation intensity [mm h ⁻¹]	Strasser et al., 2002	Y
Albedo ageing for temperatures above 0°C	Strasser et al., 2002	Y
Albedo ageing for temperatures below 0°C	Strasser et al., 2002	Y
Addition factor for albedo	Strasser et al., 2002	Y

Most of the tuneable parameters used by PREVAH may be edited with WINPREVAH. The dialog [Modules and Tuneable Parameters] is displayed by clicking the [Parameters] button in the main dialog of WINPREVAH:

Modules and Tuneable Parameters

Precipitation - Correction and Separation Rain/Snow

- Rain correction [%]: -0.1
- Snow correction [%]: 13.8
- Threshold Temperature Rain-snow [°C]: -0.87
- Transition Temperature Rain-snow [°C]: 0.10

Runoff Generation Module

- Exponent for soil moisture recharge [-]: 4.40
- Threshold moisture saturation for ETR: 0.35
- Threshold storage for surface runoff [mm]: 17.4
- Storage coefficient for surface runoff [h]: 15.9
- Storage coefficient for interflow [h]: 101.9
- Percolation [mm/h]: 0.06
- Storage coefficient for fast baseflow [h]: 366.7
- Maximum storage for fast baseflow [mm]: 122.2
- Storage coefficient for delayed baseflow [h]: 2358

Routing Module

Discharge file: []

Operation: 1. Routing | Unit: mm/h | l/s | m3/s

Area [km2]: [] | Headers: 0

Translation time [h]: 0.0 | Use Column: 2

Storage time [h]: 0.0 | Count: 00

<< SAVE | >> DELETE | Enable

Snowmelt Module

ESCIMO - Strasser et al. (2002)

- Threshold Temperature snowmelt [°C]: 1.00
- Maximal degree day factor [mm/(d·K)]: 3.00
- Minimal degree day factor [mm/(d·K)]: 2.00
- Refreezing factor [mm/(d·K)]: 0.05
- Retention factor for melting snow: 0.05
- Exponent for retention of melting snow: 0.50
- Melting factor by wind 1: 0.00
- Melting factor by wind 2: 0.00
- Temperature melt factor for snow [mm/(d·K)]: 0.80
- Radiation melt factor for snow: 0.00050
- Critical precipitation intensity [mm/dt]: 1.41
- Albedo ageing > 0°C: 0.14
- Albedo ageing < 0°C: 0.095
- Addition factor for Albedo [-]: 0.53

Icemelt Module

- Temperature melt factor for ice [mm/(d·K)]: 2.50
- Radiation melt factor for ice: 0.00600


Additional Modules

- Snow Evaporation module: Daily - PENMAN (recommended)
- Evapotranspiration module: Actual evapotranspiration - Penman-Monteith (recommended)
- Longwave Parameterization: Penman 1948 (requires sunshine duration) (recommended)
- Shortwave Parameterization: Observed global radiation (recommended)
- Aerodynamic Term: Penman 1948 (recommended)

Export | Cancel | OK

The tuneable parameters are subdivided into 4 "families"; the chapter indication refers to Part II of the PREVAH documentation:

- ❶ Precipitation module (Chapter 3.5)
- ❷ Snowmelt module (Chapter 4.3.2)
- ❸ Runoff generation module (Chapter 4.3.3)
- ❹ Icemelt module (Chapter 3.5)

The value of each parameter may be edited by moving the corresponding slider () to the left or right. The minimal and maximal limits of the slider correspond to the soft limits defined for a specific variable. The edit field also accepts manual input of values larger than the soft limits, but within the defined hard limits.

Some parameters of the snowmelt module are editable only if a specific method for the determination of snowmelt is selected. For instance, if the method ESCIMO (Strasser et al., 2002) is selected, only the following parameters may be edited: Critical precipitation intensity, Albedo ageing for temperatures above 0°C, Albedo ageing for temperatures below 0°C and the addition factor for Albedo. Recommended initial values for each of the tuneable parameters are declared in the following table.

Assigned Hard and Soft Limits for the tuneable parameters used in PREVAH. The default value is recommended as initial the value for model calibration.

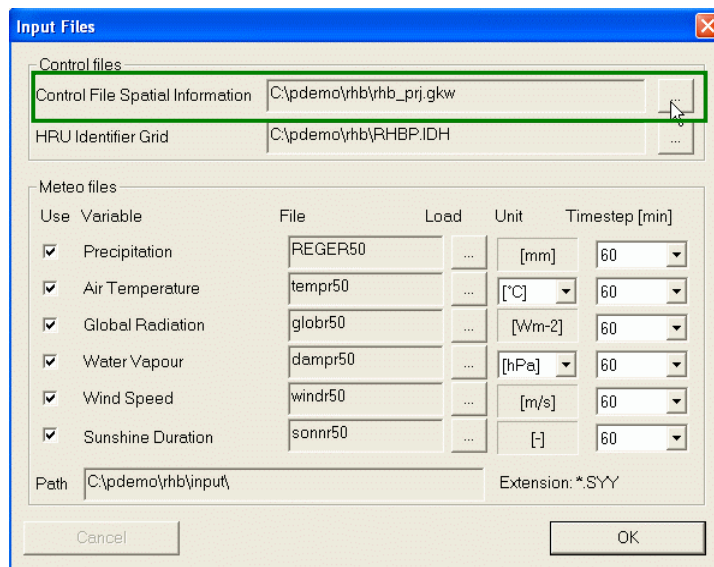
Tuneable Variable	Hard limit MIN	Soft limit MIN	Default	Soft limit MAX	Hard limit MAX
CREDV	0	0	1	1	1
Precipitation correction	-100	-30	0	30	200
Snow correction	-100	-30	0	50	200
Threshold temperature snowfall	-5	-1	0	1	5
Transition temperature snow-rain	0	0	0.75	1.5	5
Threshold temperature snowmelt	-5	-1	0	1	5
Maximal temperature-index melting factor	1	2	2	4	10
Minimal temperature-index melting factor	0.1	0.25	1	2	5
Melting factor by wind 1	0	0	0	1	2
Melting factor by wind 2	0	0	0	1	2
Retention factor for melting snow	0	0	0.1	0.25	0.5
Exponent for retention of melting snow	0.01	0.1	0.5	2	5
Coefficient for re-freezing	0	0	0.1	1.5	5
Constant temperature melt factor for snow	0.1	0.1	1.5	3	7
Constant radiation melt factor for snow	0.00001	0.00005	0.0001	0.0003	0.001
Non linearity parameter for infiltration module	0.1	1.5	3	6	10
Threshold for reduction ETP	0.1	0.4	0.7	0.9	1
Maximal percentage of runoff generated by surface runoff	-	-	0	-	-
Threshold coefficient for surface runoff	1	10	30	50	500
Storage coefficient in hours for surface runoff	1	10	10	30	500
Storage coefficient in hours for interflow	1	50	75	150	750
Storage coefficient in hours for base flow	1	1000	2500	4000	10000
Storage coefficient in hours for quick base flow	1	200	750	1000	2500
Maximal content of the quick base flow storages	1	25	150	250	500
Percolation rate in mm per hour	0.01	0.04	0.1	0.2	0.5
Equilibrium line altitude of a glacier	-	-	0	-	-
Constant temperature melt factor for ice	0.1	0.5	2	3	10
Constant radiation melt factor for ice	0.00001	0.00001	0.00002	0.0003	0.001
Coefficient for runoff generation from ice storage in hours	-	-	15	-	-
Coefficient for runoff generation from snow storage in hours	-	-	30	-	-
Coefficient for runoff generation from firn storage in hours	-	-	0	-	-
Translation time for icemelt	-	-	1	-	-
Translation time for snowmelt	-	-	2	-	-
Translation time for firmelt	-	-	0	-	-
Critical precipitation intensity [mm/h]	0.2	0.5	1.5	3	5
Albedo ageing for temperatures above 0°C	0.03	0.05	0.1	0.15	0.25
Albedo ageing for temperatures below 0°C	0.01	0.02	0.05	0.1	0.2
Addition factor for albedo	0.2	0.3	0.5	0.55	0.6

F.4.3 [Catchment settings] settings:

Syntax:

```
[Catchment settings]
c:\prevahff\daning\watershed\tabdanwux.gkw ! Control file of the Spatial Information
000917 ! Number of hydrological response units (HRUs)
Y ! Differentiation into meteorological zones [Y,N]
000101 ! Number of meteorological zones
      {# of HRUS per meteorological zone}
0005 ! 00001 HRUS pro meteorological zone
0009 ! 00002 HRUS pro meteorological zone
0012 ! 00003 HRUS pro meteorological zone
.....
0001 ! 00100 HRUS pro meteorological zone
0001 ! 00101 HRUS pro meteorological zone
[End Catchment settings]
```

Most of the content of this module is generated automatically by WINHRU; it defines how PREVAH assimilates the spatial information for the catchment under investigation. The number of meteorological zones is declared, and the number of HRUs in each of the meteorological zones is also indicated. Only the full path of the control file for spatial information (*.gkw, *.g##) has to be edited. This path may be loaded with WINPREVAH. The dialog [Input Files] is displayed if the button [Input Controls] is clicked in the main dialog of WINPREVAH.



To load the control file for spatial information (*.gkw, *.g##), click the corresponding [...] button (green box) and select the correct file from your system.

The control file for spatial information is stored in the output path of the current WINHRU project by default.

F.4.4 [Storage content] settings:

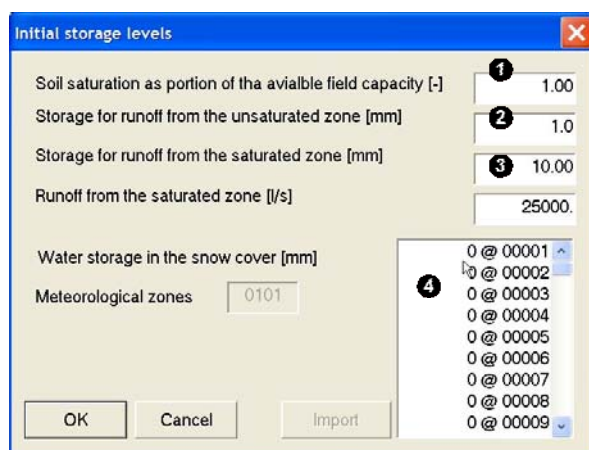
Syntax:

```
[Storage content]
{Snow water equivalent per meteorological zone}
00000          ! 00001 Snow cover per meteorological zone
00000          ! 00002 Snow cover per meteorological zone
.....
00000          ! 00100 Snow cover per meteorological zone
00000          ! 00101 Snow cover per meteorological zone
               {Soil moisture and runoff generation storages}
1.00           ! Initial saturation of soil moisture, Default=1.0
 1.0           ! Initial storage in unsaturated zone
-10.00         ! Initial storage in saturated zone
-25000.0       ! Initial baseflow
               [End Storage content]
```

Initial conditions may be very important for the model results, especially when applying the model to a short time period, to arid or semiarid regions or regions with high snow accumulation during winter. Therefore, PREVAH is able to read initial storage or reservoir content values. Because this information may also be written at the end of a model run, it may be used to initialise the following model runs. If no initialisation files are available, the internal states are initialised using constant values taken from the control file. The minimal information for sound model initialisation without information from previous model runs consists of:

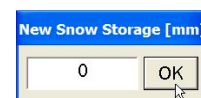
- ❶ Soil moisture saturation as a percentage of the available field capacity.
- ❷ The initial storage content of the unsaturated soil zone in millimetres.
- ❸ The initial base flow, as runoff in litre per second from the unsaturated zone.
- ❹ Snow water equivalent in each of the meteorological zones in millimetres.

The dialog [Initial storage levels] is displayed if the button [Storages] is clicked in the main dialog of WINPREVAH. This dialog allows the editing of the initial conditions at model initialisation.



❶, ❷ and ❸ and can be edited directly.

To edit the initial snow water equivalent in each of the meteorological zones (❹), you have to double-click the value you want to edit. This small dialog is prompted:



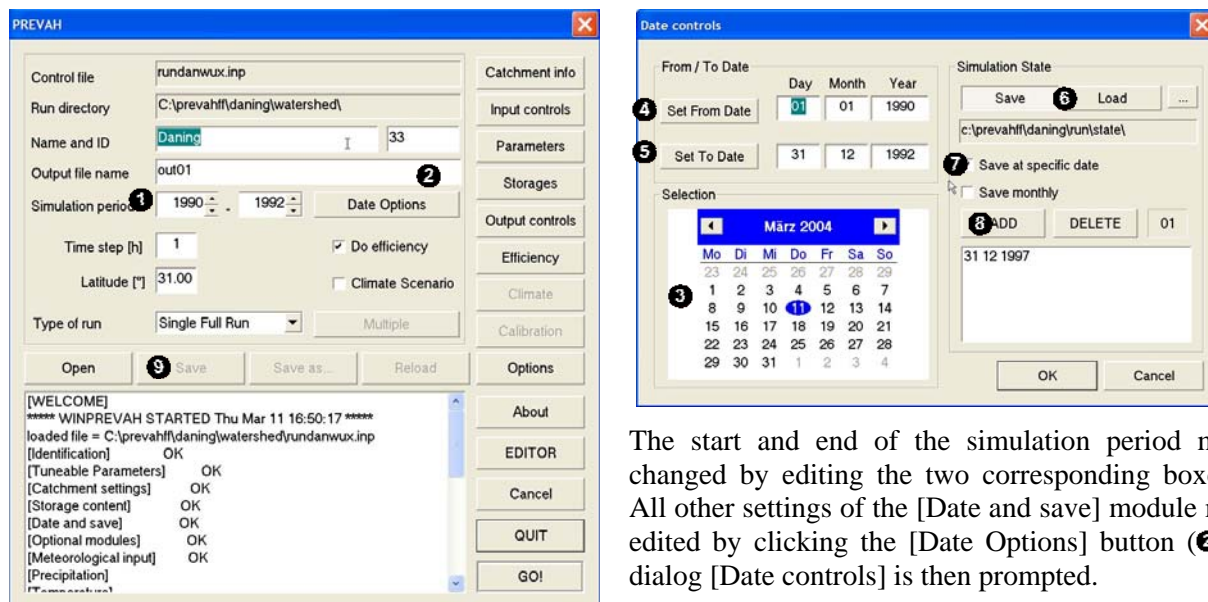
You may write the new value of the snow water equivalent for the selected meteorological zone and store it by clicking [OK]. You may also edit these values by loading the control file into a text editor.

F.4.5 [Date and save] settings:

Syntax:

```
[Date and save]
01 01 1990          ! Start date of simulation DD MM YYYY
N                  ! Load initial conditions from previous run (Y,N)
c:\prevahff\daning\run\state\ ! Directory where state-files of previous runs are stored
31 12 1998          ! Date of simulation end DD MM YYYY
Y                  ! Save model conditions for later run (Y,N)
N                  ! Save model conditions at the end of each month (Y,N)
Y                  ! Save model conditions at the end of a defined day (Y,N)
01                 ! How many other dates
31 12 1997         ! Declare the date: DD MM YYYY
[End Date and save]
```

The range of the simulation period and settings for saving or loading the state of the model at a specific time may be controlled through this module. To change only the years of the simulation period, the main dialog of WINPREVAH (❶) is used:



The start and end of the simulation period may be changed by editing the two corresponding boxes (❶). All other settings of the [Date and save] module may be edited by clicking the [Date Options] button (❷). The dialog [Date controls] is then prompted.

Here, the extent of the simulation period is defined, either by editing the boxes or using the Date Wizard (❸). To change the start or end date, select the date in the Wizard and click [Set From Date] (❹) / [Set To Date] (❺).

To activate the saving of model conditions, click [Save], to allow loading the state from a previous simulation, click [Load] (❻). The directory where the model state is stored/loaded is set by clicking [...]. To save the model state at a specific date, activate the corresponding checkbox (❼), and to select or deselect dates, use the wizard and click [ADD] / [DELETE] (❽).

To save the model state at the end of each month, the corresponding check box has to be activated (❼). Edits are saved by pushing the button [Save] in the main dialog (❾).

F.4.6 [Optional modules] settings:

Syntax (parameters highlighted in yellow can only be edited manually):

```
[Optional modules]
1          ! Method for snow evaporation
0          ! Do shadowing correction (0=No, 1= Yes). Please use 0!!
0          ! Method for computing snowmelt
2          ! Method for computing evapotranspiration
5          ! Method for estimating incoming short-wave radiation
1          ! Method for estimating the long-wave radiation budget
1          ! Method for estimating the aerodynamic term of Penman's equation
0          ! Activate Debugging output (0=No, 1= Yes).

[End Optional modules]
```

To change the [Optional modules] settings, the Modules and Tuneable Parameters dialog has to be accessed by clicking the button [Parameters] in the main dialog of WINPREVAH.

Modules and Tuneable Parameters

Precipitation - Correction and Separation Rain/Snow

Rain correction [%]	-0.1
Snow correction [%]	13.8
Threshold Temperature Rain-snow [°C]	-0.87
Transition Temperature Rain-snow [°C]	0.10

Runoff Generation Module

Exponent for soil moisture recharge [-]	4.40
Threshold moisture saturation for ETR	0.35
Threshold storage for surface runoff [mm]	17.4
Storage coefficient for surface runoff [h]	15.9
Storage coefficient for interflow [h]	101.9
Percolation [mm/h]	0.06
Storage coefficient for fast baseflow [h]	366.7
Maximum storage for fast baseflow [mm]	122.2
Storage coefficient for delayed baseflow [h]	2358

Routing Module

Discharge file: []

Operation: 1. Routing Unit: mm/h (selected) | l/s | m3/s

Area [km2]: [] Headers: 0

Translation time [h]: 0.0 Use Column: 2

Storage time [h]: 0.0 Count: 00

<< SAVE >> DELETE Enable

1 Snowmelt Module

ESCI-MO - Strasser et al. (2002)

Threshold Temperature snowmelt [°C]	1.00
Maximal degree day factor [mm/(d·K)]	3.00
Minimal degree day factor [mm/(d·K)]	2.00
Refreezing factor [mm/(d·K)]	0.05
Retention factor for melting snow	0.05
Exponent for retention of melting snow	0.50
Melting factor by wind 1	0.00
Melting factor by wind 2	0.00
Temperature melt factor for snow [mm/(d·K)]	0.80
Radiation melt factor for snow	0.00050
Critical precipitation intensity [mm/dt]	1.41
Albedo ageing > 0°C	0.14
Albedo ageing < 0°C	0.095
Addition factor for Albedo [-]	0.53

Icemelt Module

Temperature melt factor for ice [mm/(d·K)]	2.50
Radiation melt factor for ice	0.00600

2 Additional Modules

3 Snow Evaporation module	Daily - PENMAN (recommended)
4 Evapotranspiration module	Actual evapotranspiration - Penman-Monteith (recommended)
5 Longwave Parameterization	Penman 1948 (requires sunshine duration) (recommended)
6 Shortwave Parameterization	Observed global radiation (recommended)
7 Aerodynamic Term	Penman 1948 (recommended)

Export Cancel OK

Six drop-down boxes may be modified to select the processes simulation methods of PREVAH:

- ❶ Method for computing snowmelt (see also Zappa et al., 2003 and Chapter 4.3.2 in Part II of the PREVAH documentation):

0. Positive degree day index (PDDI) or Combination Method (COMB): PDDI is used if both the melting factors by wind are set to a value below or equal 0.0; COMB is used if at least one of the melting factors by wind are set to a value above 0.0.
1. PDDI or COMB, but EMA (Hock, 1998) on glaciated areas with constant melt factor;
2. PDDI or COMB, but EMA (Hock, 1998) on glaciated areas with varying melt factor;
3. EMA, with constant melt factor;
4. EMA, with varying melt factor (recommended);
5. PDDI or COMB, but EMA with constant melt factor, if no precipitation;
6. PDDI or COMB, but EMA with varying melt factor, if no precipitation;
10. ESCIMO (Strasser et al., 2002).

Sensitivity of the tuneable parameters and meteorological requirements for the different snowmelt modelling approaches implemented in PREVAH.

Approach for snowmelt computation	PDDI	COMB	EMA	ESCIMO
Tuneable Variable Used in methods	0,1,2,5,6	0,1,2,5,6	1,2,3,4,5,6	10
Threshold temperature snowmelt				
Maximum temperature-index melting factor			2,4,6	
Minimum temperature-index melting factor			2,4,6	
Melting factor by wind 1	≤ 0.0	> 0.0		
Melting factor by wind 2				
Retention factor for melting snow				
Exponent for retention of melting snow				
Coefficient for re-freezing				
Constant temperature melt factor for snow			1,3,5	
Constant radiation melt factor for snow				
Critical precipitation intensity [mm/h]				
Albedo ageing for temperatures above 0°C				
Albedo ageing for temperatures below 0°C				
Addition factor for Albedo				

Meteorological requirements

Precipitation	required	required	required	required
Air temperature	required	required	required	required
Global radiation				required
Wind Speed		required		required
Water vapour pressure / relative humidity		required		required
Sunshine duration				required

② Method for computing snow evaporation:

0. None (not available in the user interface)
1. Daily – Penman [including ageing of snow albedo] (recommended);
2. Daily – Penman-Monteith [including ageing of snow albedo];
3. Hourly – Penman [including ageing of snow albedo];
4. Hourly – Penman Monteith [including ageing of snow albedo];
5. Routine sublimation/condensation after Kuzmin (1960)
[function of air temperature and wind speed];
6. Routine sublimation/condensation after Anderson (1973)
[function of wind speed and saturation deficit].

- ③ Method for computing evapotranspiration (see also Chapter 4.4 in Part II of the PREVAH documentation; for details on the approaches, refer to DVWK, 1996 and Schroedter, 1985):

0. Potential evapotranspiration – Penman;
1. Potential evapotranspiration – Penman-Monteith;
2. Actual evapotranspiration – Penman-Monteith (recommended);
3. Potential evapotranspiration – Hamon (1961);
4. Potential evapotranspiration – Turc (1961);
5. Potential evapotranspiration – Wendling (1975).

Meteorological requirements for the different evapotranspiration approaches implemented in PREVAH

Variables	Methods	Penman-Monteith 0,1,2	Hamon 3	Turc 4	Wendling 5
Precipitation		required	required	required	required
Air temperature		required	required	required	required
Global radiation		required		required	required
Wind Speed		required			
Water vapour pressure / relative humidity		required			
Sunshine duration		required			

- ④ Method for estimating the long-wave radiation budget (see also the Appendix to Part II; for details on the approaches, refer to DVWK, 1996 and Schroedter, 1985):

0. Penman (1948) – requires sunshine duration (recommended);
1. Penman (1954) – requires sunshine duration;
2. Angstroem (1923) – requires sunshine duration;
3. Angstroem (1923) requires cloudiness;
4. Feussner – requires sunshine duration;
5. Feussner – requires cloudiness;
6. Kasten und Czeplak (1980) – requires sunshine duration;
7. Kasten und Czeplak (1980) – requires cloudiness;
8. Brutsaert (1975) – requires sunshine duration;
9. Schulla (1997) – requires sunshine duration.

- ⑤ Method for estimating incoming short-wave radiation (see also the Appendix to Part II; for details on the approaches, refer to DVWK, 1996 and Schroedter, 1985):

0. Penman (1948) – requires sunshine duration;
1. Penman (1954) – requires sunshine duration;
2. Golchert (1981) – requires sunshine duration;
3. Karsten und Czelpak (1980) – requires cloudiness;
4. Morecs (1981) – requires sunshine duration;
5. Observed global radiation (recommended);
6. Schulla (1997) – requires sunshine duration.

- ⑥ Method for estimating the aerodynamic term of Penman's equation:

0. Penman (1948) (recommended); See Equation 4.4-8 in Chapter 4, Part II;
1. Penman (1954);
2. Petznik (1988).

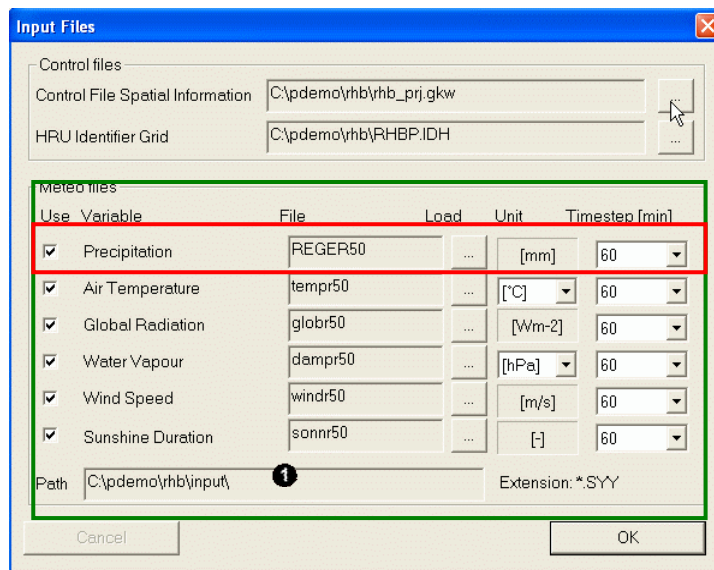
F.4.7 [Meteorological Input] settings:

Syntax (parameters highlighted in yellow may only be edited manually):

```
[Meteorological input]
c:\prevahff\daning\hydrometeo\modeloutput\      ! Path of meteorological tables
0003      ! Headers of meteorological tables
0001      ! Start columns of meteorological tables
4          ! Digits of year in extension 4=*.syyyy,
          2=*.syy
[Precipitation]
Y          ! Read (Y/N)
1440      ! Time step in minutes
precdanwux ! Name of precipitation file
[Temperature]
Y          ! Read (Y/N)
1440      ! Time step in minutes
tairdanwux ! Name of temperature file
0001      ! Unit (see Documentation)
[Global Radiation]
Y          ! Read (Y/N)
1440      ! Time step in minutes
rad_danwux ! Name of global radiation file
[Vapour Pressure / Humidity]
Y          ! Read (Y/N)
1440      ! Time step in minutes
hum_danwux ! Name of vapour/RH file
0002      ! Unit (see Documentation)
[Wind speed]
Y          ! Read (Y/N)
1440      ! Time step in minutes
winddanwux ! Name of wind speed file
[Relative sunshine duration]
Y          ! Read (Y/N)
1440      ! Time step in minutes
ssd_danwux ! Name of sunshine duration file
[End Meteorological input]
```

To edit the [Meteorological input] settings with WINPREVAH, the [Input files] dialog has to be accessed by clicking the button [Input Controls] in the main dialog of WINPREVAH.

The interpolation program WINMET always writes files with three headers. Thus, the number of headers in the meteorological tables is set by default equal to 3 lines. You may only edit this value manually. The start column of the meteorological tables is set, by default, to 1. Only advanced PREVAH users should modify these values for particular model applications. The number of digits for the declaration of the year in the meteorological values is set automatically by WINPREVAH and should not be modified. All other elements of the [Meteorological input] settings are edited with the [Input files] dialog.



The results of spatial interpolation with WINMET are used to force PREVAH and WINPREVAH. The files stored in the output path of the dtdw.exe (1) run for the investigated catchment may be linked to PREVAH by loading a file for each variable. The path of the precipitation file corresponds to the location of all meteorological files needed to force PREVAH.

For each required (and available) meteorological variable, the following settings have to be defined:

<input checked="" type="checkbox"/>	Precipitation	precdanwux	...	[mm]	1440
READ (Y/N)		Name of Used File	Select File	Required Unit	Time Step in minutes

We recommend using air temperature values in [°C] and water vapour data as vapour pressure in [hPa] or as relative humidity. Other units are also accepted:

Temperature: [°C], [K] and [°F]

Water vapour: Water vapour pressure [hPa], relative humidity RH [-] (between 0 and 1), and dew point temperature in [°C], [°K] or [°F].

Meteorological files are automatically identified by WINPREVAH if named following the table below:

Variable	Recognised file names				
Precipitation	pre*.s*	rai*.s*	reg*.s*		
Air temperature	tem*.s*	tai*.s*			
Global radiation	rad*.s*	rg*.s*	gl*.s*		
Wind speed	win*.s*	wsp*.s*			
Water vapour pressure / relative humidity	vap*.s*	dam*.s*	rh*.s*	fe*.s*	hu*.s*
sunshine duration	sun*.s*	ssd*.s*			

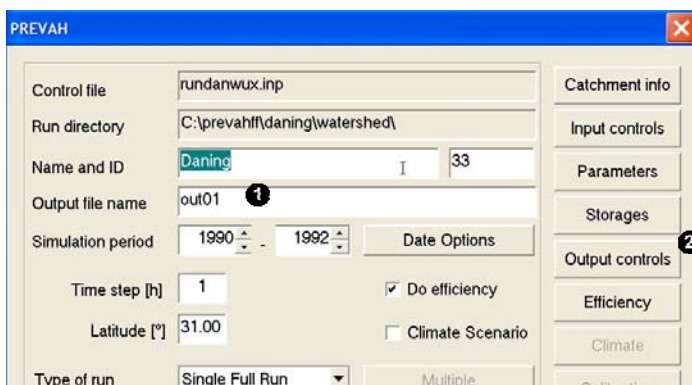
Accepted time steps to force PREVAH with meteorological information. For all variables, using the same time step and possibly hourly or daily time step is recommended

minutes	5	10	15	20	30	60	120	180	240	360	480	720	1440
hours	0.083	0.167	0.25	0.333	0.5	1	2	3	4	6	8	12	24

F.4.8 [Model Output] settings:

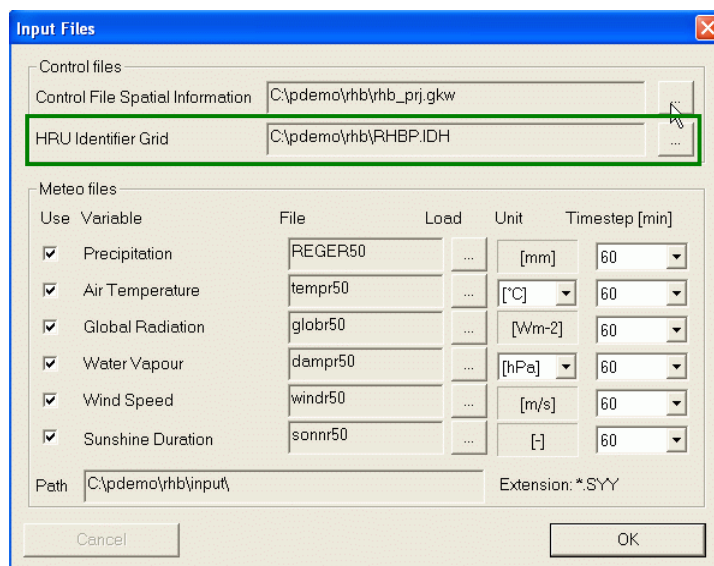
Syntax:

```
[Model output]
c:\prevahff\daning\run\          ! Directory for output
out01                            ! Basic name for output files
N-N-Y-Y-N-N-N-N                 ! Output Tables (see later in the documentation)
N                                ! Do GRIDDED Output (Y/N)
c:\prevahff\daning\watershed\danwux.idh ! Basic GRID for GRIDDED Output (Full path!)
N-N-Y-N                          ! P:      DD-MM-YY-##      [Y/N] (see later in the Documentation)
N-N-N-N                          ! ETP:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-Y-N                          ! ETR:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! EI:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! EB:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-Y-N                          ! RGS:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! R0:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! R1:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! R2:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! GL0:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! GL1:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-Y-N                          ! SWA:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! GWN:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SSO:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SI:      DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SSM:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SUZ:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SLZ:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SL1:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SL2:     DD-MM-YY-##      [Y/N] (see Documentation)
N-N-N-N                          ! SL3:     DD-MM-YY-##      [Y/N] (see Documentation)
[End Model output]
```



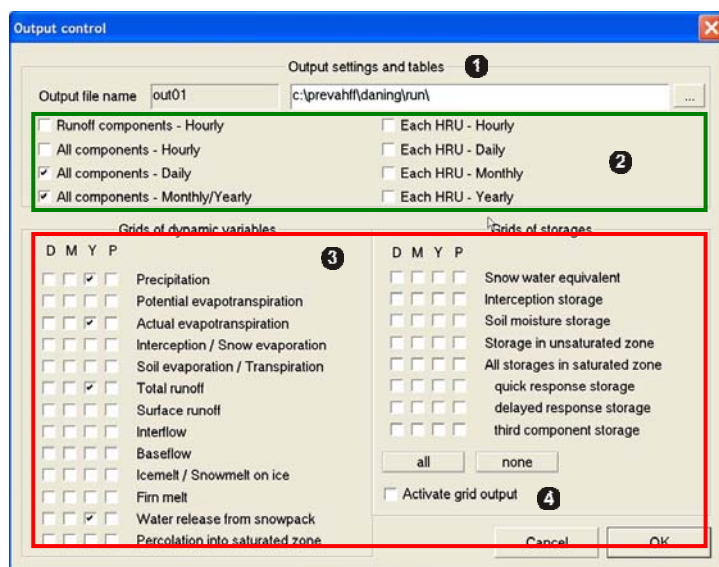
The basic name for output files may be changed by editing the corresponding box (❶) in the main dialog of WINPREVAH. To define the basic grid for gridded output, the [Input files] dialog is accessed by clicking the button [Input controls].

All other settings of the Model Output module are edited clicking the [Output controls] button (❷).



To load the basic grid for gridded output ([HRU Identifier grid], *.idh, *.i##), click the corresponding [...] button (green box) and select the correct file from your system.

This basic grid is stored by default in the output path of the WINHRU project you started for the catchment under investigation (see also the WINHRU documentation).



In the Output control dialog you can:

- ❶ Define the Directory for output
- ❷ Select the Output Tables that PREVAH should write during the simulation
- ❸ Select the output grids that PREVAH should write during the simulation
- ❹ Activate or deactivate the gridded output

❷ Output Tables:

Up to eight tables are written by PREVAH during the model simulation; output is activated either manually (SET **Y** or **N** at the corresponding position in the control file!) or automatically through the [Output control] dialog:

File Description	Extension	Active	Not Active
1. Runoff components – hourly	*.q	Y	N
2. All components – hourly	*.std	.. Y.....	..N
3. All components – daily	*.mit	... Y.....	...N
4. All components – monthly/yearly	*.pri	....Y.....	....N
5. Each HRU – hourly	*.hou	.....Y...	.....N ...
6. Each HRU – daily	*.tag	.....Y...	.....N ...
7. Each HRU – monthly	*.mon	.....Y...	.....N ...
8. Each HRU – yearly	*.tmp	.....Y...	.....N ...

The different output tables of PREVAH are organised as follows (extension in the table header):

Column	*.q	*.std	*.mit	*.pri	*.hou	*.tag	*.mon	*.tmp
1	YYYY	YYYY	YYYY	BASINID	YYYY	YYYY	YYYY	YYYY
2	MM	MM	MM	YYYY	MM	MM	MM	HRU-ID
3	DD	DD	DD	MM	DD	DD	HRU-ID	ADJ-P
4	HH	HH	P	BASINID	HH	HRU-ID	BASINID	SWA
5	RTOT	ZERO	ADJ-P	P	HRU-ID	P	P	ETP
6	RTOT (l s ⁻¹)	P	SWA	ADJ-P	P	ADJ-P	ADJ-P	ETR
7	R0	ADJ-P	ETP	SWA	ADJ-P	SWA	SWA	EI
8	R1	SWA	ETR	ETP	SWA	ETP	ETP	EB
9	R2	ETP	EI	ETR	ETP	ETR	ETR	RTOT
10	RG1	ETR	EB	EI	ETR	EI	EI	SSO
11	RG2	EI	R0	EB	EI	EB	EB	SI
12	RG3	EB	R1	R0	EB	R0	R0	SSM
13		R0	R2	R1	R0	R1	R1	BASINID
14		R1	RTOT	R2	R1	R2	R2	
15		R2	SSO	RTOT	R2	RTOT	RTOT	
16		RTOT	SI	SSO	RTOT	SSO	SSO	
17		SSO	SSM	SI	SSO	SI	SI	
18		SI	SUZ	SSM	SI	SSM	SSM	
19		SSM	SLZ	SUZ	SSM	SUZ	SUZ	
20		SUZ	BIL	SLZ	SUZ	SLZ	SLZ	
21		SLZ	ICEM	ICEM	SLZ	BIL		
22			RG1			ICEM		
23			RG2					
24			RG3					
25			DIFGA					

The next four sub-sections describe in more detail the structure of the four output files related to the entire catchment (*.q, *.mit, *.std, *.pri)

Output files for the hourly runoff components (.q):*

Description of the data file:

year	month	day	hour	variable1	variable2	...
1981	1	1	1	0.03235 ...		
1981	1	1	2	0.03181 ...		
1981	1	1	3	0.03128 ...		
...		
1981	1	1	23	0.02842 ...		
1981	1	1	24	0.02902 ...		
1981	1	2	1	0.02851 ...		
1981	1	2	2	0.02825 ...		
1981	1	2	3	0.02804 ...		
...		
1981	12	31	24	0.02851 ...		
1982	1	1	1	0.02825 ...		
...		

There is no header in this data file. The data are written out continuously in hourly steps. The length of the file varies depending on the occurrence of leap years. In a leap year, there are 8784, in all the other years, there are 8760 data points. The following variables are written to this output file from left to right:

1. YYYY Year
2. MM Month
3. DD Day
4. HH Hour
5. RTOT Total runoff
6. RTOT (l s⁻¹) Total runoff in l s⁻¹

- 7. R0 Surface runoff
- 8. R1 Interflow
- 9. R2 Total baseflow
- 10. RG1 Fast response baseflow
- 11. RG2 Delayed baseflow
- 12. RG3 Third component baseflow

The values are dimensioned in [mm] and correspond to the selected time-step. RTOT is additionally provided in [l s^{-1}].

Output files for all hourly components (.std):*

Scheme of the data file:

day	month	year	hour	var1	var2	...
1	1	1981	1	0	...	
1	1	1981	2	0	...	
1	1	1981	3	0	...	
...	
1	1	1981	24	0	...	
2	1	1981	1	0	...	
...	
31	12	1981	24	0	...	
1	1	1982	1	0	...	
...	

There is no header in this data file. The data is written out continuously in hourly steps. The length of the file varies depending on the occurrence of a leap year (see above). The following variables are written to this output file from left to right:

- 1. DD Day
- 2. MM Month
- 3. YYYY Year
- 4. HH Hour
- 5. ZERO Dummy variable
- 6. P Interpolated precipitation [mm h^{-1}]
- 7. ADJ-P Adjusted interpolated precipitation² [mm h^{-1}]
- 8. SWA Snow melt [mm h^{-1}]
- 9. ETP Potential evapotranspiration [mm h^{-1}]
- 10. ETR Actual evapotranspiration [mm h^{-1}]
- 11. EI Interception evaporation / snow evaporation [mm h^{-1}]
- 12. EB Transpiration / soil evaporation [mm h^{-1}]
- 13. R0 Surface runoff [mm h^{-1}]
- 14. R1 Interflow [mm h^{-1}]
- 15. R2 Total baseflow [mm h^{-1}]
- 16. RTOT Total runoff [mm h^{-1}]
- 17. SSO Snow water equivalent [mm]
- 18. SI Interception storage [mm]
- 19. SSM Plant available soil moisture storage [mm]
- 20. SUZ Runoff generation storage (unsaturated zone) [mm]
- 21. SLZ Runoff generation storage (saturated zone) [mm]

² Adjusted with water balance correction factors (PKOR, SNOKOR)

The output files for all daily components (.mit)*

Description of the data file:

year	month	day	variable1	variable2	...
------	-------	-----	-----------	-----------	-----

Rietholz bach			3.310		
---------------	--	--	-------	--	--

YYYY	MM	DD	P-uk	P-kor
------	----	----	------	-------

1981	1	1	2.558	...
------	---	---	-------	-----

1981	1	2	8.632	...
------	---	---	-------	-----

1981	1	3	13.161	...
------	---	---	--------	-----

...
-----	-----	-----	-----	-----

1981	1	31	0.000	...
------	---	----	-------	-----

1981	2	1	0.000	...
------	---	---	-------	-----

...
-----	-----	-----	-----	-----

1981	12	21	8.632	...
------	----	----	-------	-----

1982	1	1	0.000	...
------	---	---	-------	-----

...
-----	-----	-----	-----	-----

This file contains a header. The first line lists the name and size of the concerned catchment area. In the second line, the name of each variable is declared. The actual data follow on the subsequent lines, written out continuously in daily steps. The values are dimensioned in [mm d⁻¹], storage values have the dimension [mm]. The following variables are written to this output file from left to right:

1. YYYY Year
2. MM Month
3. DD Day
4. P-UK Interpolated precipitation [mm d⁻¹]
5. P-KOR Adjusted interpolated precipitation³ [mm d⁻¹]
6. P-SME Snowmelt [mm d⁻¹]
7. EPOT Potential evapotranspiration [mm d⁻¹]
8. EREA Actual evapotranspiration [mm d⁻¹]
9. EI Interception evaporation / snow evaporation [mm d⁻¹]
10. EB Transpiration / soil evaporation [mm d⁻¹]
11. R0 Surface runoff [mm d⁻¹]
12. R1 Interflow [mm d⁻¹]
13. R2 Total baseflow [mm d⁻¹]
14. RGES Total runoff [mm d⁻¹]
15. S-SNO Snow water equivalent [mm]
16. SI Interception storage [mm]
17. SSM Plant available soil moisture storage [mm]
18. SUZ Runoff generation storage (unsaturated zone) [mm]
19. SLZ Runoff generation storage (saturated zone) [mm]
20. BIL Balance from previous time step [mm d⁻¹]
21. GLAC Ice melt [mm d⁻¹]
22. RG1 Fast response baseflow [mm d⁻¹]
23. RG2 Slow response baseflow [mm d⁻¹]
24. RG3 Third component baseflow [mm d⁻¹]
25. DIFGA Input to DIFGA [mm d⁻¹]

³ Adjusted with water balance correction factors (PKOR, SNOKOR)

Output files for all monthly/yearly components (*.pri)

Description of the data file:

basinID	year	month	basinID	var1	var2	...
33	1981	1	33	145.6	...	
33	1981	2	33	61.4	...	
33	1981	3	33	140.1	...	
...	
33	1981	12	33	290.3	...	
33	1981	0	33	1820	...	
33	1982	1	33	226.3	...	
...	
33	0	0	33	1675	...	
33	1	-1	1	0.0	...	
33	2	-2	2	1.8	...	
33	3	-3	3	1.4	...	
33	4	-4	4	0.0	...	

There is no header in this data file. The data is written out in monthly steps. After each year, an additional line follows, containing the values for the whole year. This is recognised by the '0' in the month-column. At the end of the file, more lines are added: The first shows the variable values of the entire period (0 in year- and month-column), the following ones show the data of the different meteo zones (meteo zone ID in year-, month- and second basinID-column), also for the whole period. The following variables are written to this output file from left to right:

1. BASINID Basin ID
2. YYYY Year / zero / meteo zone ID
3. MM (MM-0) Month / zero / neg. meteo zone ID
4. BASINID Basin id / meteo zone ID
5. P Interpolated precipitation [mm month⁻¹] or [mm year⁻¹]
6. ADJ-P Adjusted-interpolated precipitation [mm month⁻¹] or [mm year⁻¹]
7. SWA Snow melt [mm month⁻¹] or [mm year⁻¹]
8. ETP Potential evapotranspiration [mm month⁻¹] or [mm year⁻¹]
9. ETR Actual evapotranspiration [mm month⁻¹] or [mm year⁻¹]
10. EI Interception evaporation / snow evaporation [mm month⁻¹] or [mm year⁻¹]
11. EB Transpiration / snow evaporation [mm month⁻¹] or [mm year⁻¹]
12. R0 Surface runoff [mm month⁻¹] or [mm year⁻¹]
13. R1 Interflow [mm month⁻¹] or [mm year⁻¹]
14. R2 Total baseflow [mm month⁻¹] or [mm year⁻¹]
15. RTOT Total runoff [mm month⁻¹] or [mm year⁻¹]
16. SSO Snow water equivalent [mm]
17. SI Interception storage [mm]
18. SSM Plant available soil moisture storage [mm]
19. SUZ Runoff generation storage (unsaturated zone) [mm]
20. SLZ Runoff generation storage (saturated zone) [mm]
21. ICEM Ice melt [mm]

3 Output grids

PREVAH is able to generate output in form of grids for 13 dynamic variables and 8 state variables (storages). In the [Output control dialog you may activate the gridded output for their variables and select how often you desire to write a grid: Every day; at the end of every month; at the end of every year or; as a yearly average for all the years in the simulation period. The grids are stored in the binary format of the PREVAH modelling system.

List of the 22 variables for which PREVAH is able to generate grid output. Dynamic variables are highlighted yellow, static variables blue.

Written grid	Extension
Adjusted Interpolated Precipitation	P
Potential evapotranspiration	ETP
Actual evapotranspiration	ETR
Interception evaporation / snow evaporation	EI
Transpiration / soil evaporation	EB
Total runoff	RGS
Surface runoff	R0
Interflow	R1
Total baseflow	R2
Icemelt / snowmelt on ice	GL0
Firn melt	GL1
Water release from snowpack	SWA
Percolation into saturated zone	GWN
Snow water equivalent	SSO
Interception storage	SI
Plant available soil moisture storage	SSM
Runoff generation storage (unsaturated zone)	SUZ
Runoff generation storage (saturated zone)	SLZ
Runoff generation storage (fast baseflow)	SL1
Runoff generation storage (delayed baseflow)	SL2
Runoff generation storage (third component baseflow)	SL3

Structure of the file names in the grids generated by PREVAH

Time step for gridded output	Unit	Filename	Active	Not Active
Daily	mm day ⁻¹	gdDDMMYY.EXT	Y-...-..	N-...-..
Monthly	mm month ⁻¹	[Grid]MMYY.EXT	..Y-...-	..N-...-
Yearly	mm year ⁻¹	[Grid]YYYY.EXT	...-Y-	...-N-
Period average	mm year ⁻¹	[Grid]_AVG.EXT	...-...Y	...-...N

Notes: [Grid] = Name of basic grid for gridded output (without extension)

DD = Day

MM = Month

YY = Year (two digits)

YYYY = Year (four digits)

EXT = Extension of desired dynamic or static variables (see previous table).

F.4.9 [Efficiency] settings

Syntax:

```
[Efficiency]
Y                      ! Compute Model Efficiency
01                    ! Number of Efficiency scripts
C:\prevahff\daning\watershed\danc.effs ! Name of the first efficiency script
[End Efficiency]
```

To evaluate the model performance, you have to link your PREVAH control file with a file where the observed runoff values are stored. The link occurs through a script file which is generated through the Efficiency calculation dialog of WINPREVAH. If a new efficiency script (*.effs) is created, or an available script is deleted, WINPREVAH updates the [Efficiency] settings automatically.

The efficiency script

Syntax:

```
[Begin]
1990                      ! Start year
1992                      ! End year
Y                          ! Do flood statistics (Y/N)
out01.MIT                ! Simulated file (filled automatically)
02 14 14                 ! Headers/Columns/Take Column
C:\prevahff\daning\hydrometeo\tables\rundaning.day      ! File with Observed runoff [mm]!
01 02 02                 ! Headers/Columns (After Date)/Take Column
DD                        ! Time resolution DD=Daily data; HH=Hourly data
cdan                      ! Basic name for Output
Y                          ! Consider special season (Y/N)
06                        ! Number of months in this season
04 05 06 07 08 09        ! Declaration of months in this season (e.g. April-September)
N                          ! Skip years (Y/N)
0                          ! How many years should be skipped?
1900                      ! Which years have to be skipped? (=1900 if no year is skipped)
[End]

[FLOOD EFFICIENCY CONTROL FILE] ! Optional ....

HEADRS = 00              ! Headers
OBSCOL = 4               ! Column with observed data (output file from efficiency computation)

SIMCOL = 5               ! Column with simulated data (idem)
TIMEST = D               ! Time resolution D=Daily data; H=Hourly data
WAEEXP = 0.00            ! Exponent for WAE computation (See later in the Documentation)
POTNUM = 9903            ! Options for POTNUM computation (See Documentation)
POTSEP = 0               ! Options for POTSEP computation (See Documentation)
[End]
```


In the Efficiency calculation dialog you have to:

- ❶ Define the period for the computation of the model efficiency (e.g. the calibration period)
- ❷ Decide whether some years should be skipped from the calibration (mark them in the list).
- ❸ Decide whether a separate output for a particular season (e.g., summer) is desired (select the beginning and end of this season in the box).
- ❹ Load the file where the observed runoff values are stored.
- ❺ This file may be opened with the standard editor linked to WINPREVAH to be sure that you have the correct formats, to look for the number of headers and the number of columns after the date (the date columns do not count), and which column number contains the observed runoff data. Do keep in mind that these data have to be given in mm per time step.
- ❻ The number of headers, the number of columns after the date and the column where the model should read observed runoff data have to be declared, together with whether daily or hourly data is used for the computation of the efficiency.
- ❼ The contents of this box are edited automatically by the model.
- ❽ Provide a name for the efficiency script and ...
- ❾ ... a 4-character string to assign a name to the outputs of the efficiency script.
- ❿ To save an efficiency script, click [CREATE>>]; you may also add a script saved earlier by clicking [LOAD]; the stack of efficiency scripts to be executed is displayed in a list box (⓫). To remove an efficiency script from the stack, mark it in the list box and click [REMOVE<<].

12 In order to specifically analyse runoff peaks (e. g. when calibrating PREVAH for flood estimation purposes), the peak-specific efficiency component FLOODSTAT has been implemented. It has the following options:

- a Headers applies to the number of header columns to be skipped in the runoff record file used (0 by default, no adjustment necessary)
- b Time-steps between two peaks specifies the number of time steps (as declared in the WINPREVAH main dialog window, e.g. 1 h) that has to occur between two peaks in order for them to be regarded as independent events. If two peaks occur within the specified interval, (3 time steps by default) only the larger of the two is used for computing the flood statistics.
- c Exponent for SAE declares the exponent for computing the SAE score (1.5 by default)
- d The radio buttons allow the specification of how the peak record is being derived from the complete runoff record:
 - Number of peaks extracts exactly the specified amount of peak values
 - Average of peaks per year (recommended, with value 3) derives an average of n peaks per efficiency-year (with n the number of peaks and efficiency-years the modelled years included in the common efficiency computation). A total of $n \times$ efficiency-years peaks are derived.
 - Peaks over threshold extracts only peaks that are larger than the value entered (in [mm], remember that this unit corresponds with the modelling time-step as declared in the WINPREVAH main dialog window).
 - Annual peaks derives exactly one peak per year (only recommended for large records)

FLOODSTAT provides a variety of data which may be interpreted by the user or may serve to calibrate the model on peak runoff. FLOODSTAT writes an ASCII-formatted text file with the ending "_FLS.dat" which may be viewed with any text editor.

Objective functions for flood peaks							
ID	TYPE	NSE	WAE	P-QT	P-SAE	SPM_R	SPM_P
91	9999	0.7811	31822	4.859	27.12	0.58	0.946
G							
<ANNUAL>		A	B	C	D	E	F
	OBS_HQA	DATE	SIM_HQA	DATE			
	49.6918	1982-01-06	40.9100	1982-01-06			
	28.6384	1981-12-16	34.0200	1981-09-29			
	23.9764	1983-11-28	21.0100	1983-11-28			
H							
<P-REC:N>		12					
	OBS_HQ	DATE	SIM_HQ	DATE			
	49.6918	1982-01-06	40.9100	1982-01-06			
	37.9200	1982-01-09	34.0200	1981-09-29			
	28.6384	1981-12-16	28.5500	1981-12-16			
	23.9764	1983-11-28	27.3700	1981-07-19			
	22.3372	1981-10-15	26.3500	1982-01-30			
	21.6033	1981-09-29	25.3600	1981-10-15			
	20.3786	1981-10-11	21.0100	1983-11-28			
	20.0309	1981-07-19	20.3800	1981-10-30			
	19.2324	1981-12-01	18.5600	1983-04-06			
	18.8043	1982-01-12	18.1500	1981-03-13			
	18.3409	1983-04-07	17.8900	1981-01-04			
	17.8013	1982-01-30	17.3700	1982-07-27			

The third line lists the FLOODSTAT scores obtained for the peak record as it has been defined in FLOODSTAT OPTIONS (see above). The corresponding legends are found in line two. The following figures are provided:

A NSE: Nash-Sutcliffe efficiency score for the entire runoff record (same as in standard efficiency output, see Chapter 6 in Part II of the PREVAH documentation).

- Ⓔ WAE: Sum of weighted absolute errors in peak flow record.
- Ⓕ P-QT: Sum of time- and size-weighted peak errors.
- Ⓖ P-SAE: Sum of absolute errors in peak flow record
- Ⓗ SPM_R: Spearman rank-correlation coefficient for peak records
- Ⓙ SPM_P: Significance level of SPM_R (assuming normal distribution)

The following text block headed by <ANNUAL> (Ⓒ) lists the magnitude and occurrence date of annual maximum peaks in the observed (OBS_HQA) and simulated (SIM_HQA) flow record. If the chosen modeling time-step is smaller than 24 hours (see WINPREVAH main dialog), DATE also provides the hour of the peak occurrence.

In the last text block, Ⓢ reveals the peak flow record used for computation of the FLOODSTAT scores (observed, OBS_HQN and simulated, SIM_HQA peaks, DATE same as above) in descending order. If the user has specified a number of peaks to be extracted (total or average per year, see FLOODSTAT OPTIONS), the block header is <P-REC:N>, followed by the number of peaks in the record (12 in the example above). If the user has provided a threshold value for peak extraction, the last text block will be headed by <P-REC:T> (Ⓣ, see below) and the specified threshold value in [mm] (20 in the example). If annual peaks have been chosen as the basis of the scores (not recommended for small samples), the last text block will be headed <P-REC:A>, followed by the number of considered years (3 in the example far below, Ⓤ).

```
<P-REC:T> 20.0000 Ⓣ
OBS_HQ      DATE      SIM_HQ      DATE
I  49.6918    1982-01-06    40.9100    1982-01-06
   37.9200    1982-01-09    34.0200    1981-09-29
   28.6384    1981-12-16    28.5500    1981-12-16
   23.9764    1983-11-28    27.3700    1981-07-19
   22.3372    1981-10-15    26.3500    1982-01-30
   21.6033    1981-09-29    25.3600    1981-10-15
   20.3786    1981-10-11    21.0100    1983-11-28
   20.0309    1981-07-19    20.3800    1981-10-30
```

```
<P-REC:A> 3 Ⓤ
OBS_HQ      DATE      SIM_HQ      DATE
II 49.6918    1982-01-06    40.9100    1982-01-06
   37.9200    1982-01-09    34.0200    1981-09-29
   28.6384    1981-12-16    28.5500    1981-12-16
```

The efficiency script generates 6 ASCII-formatted text files which may be opened with any text editor. [...] refers to the output ID name given in the Efficiency calculation dialog.

Name	Definition
[...]_ost.dat	Statistics for observed runoff
[...]_sst.dat	Statistics for simulated runoff
[...]_dst.dat	Difference between simulated and observed runoff
[...]_eli.dat	Linear efficiency score
[...]_eln.dat	Logarithmic efficiency score
[...]_fls.dat	Flood statistics file (see Part II, Section 4.9.2)

Statistics for observed and simulated runoff (\$\$\$\$_ost.dat / \$\$\$\$_sst.dat)

Statistics for Observed Runoff									
ID	TYPE	Maximum	Minimum	Average	Summation	Variance	St.Dev	AV-STD	AV+STD
1	9999	49.6918	0.1206	2.6356	4812.61	14.8831	3.8579	-1.2223	6.4935
1	1981	28.6384	0.2464	3.1515	1150.28	16.9880	4.1217	-0.9702	7.2731
1	1982	49.6918	0.1971	2.9254	1067.78	20.5377	4.5319	-1.6064	7.4573
...
1	1985	19.5804	0.1325	2.2181	809.62	9.5519	3.0906	-0.8725	5.3087
1	1	49.6918	0.5481	4.4765	693.86	41.3962	6.4340	-1.9575	10.9105
1	2	33.8152	0.6468	3.6382	512.99	21.4918	4.6359	-0.9977	8.2742
1	3	15.6878	0.5814	3.3864	524.88	7.2267	2.6883	0.6981	6.0746
...
1	12	28.6384	0.4437	3.6112	559.74	19.7687	4.4462	-0.8350	8.0574
1	8888	23.4069	0.1206	2.0801	1903.28	9.6414	3.1051	-1.0250	5.1851

The output of the statistical function is divided into three different files. They all contain a header which describes whether the observed ('_ost') or simulated ('_sst') statistic is calculated. Most of the variable names are self-explanatory. The second column TYPE contains different markers. The line with 9999 represents the entire period. This is followed by the statistics for the mentioned years (1991–1985 in this example) by twelve lines which represent one month for the entire period each. In this example, all Januarys from 1981 to 1985 are used to build monthly statistics. The last line with the 8888 identifier shows the statistical values of an individually chosen season. The last three columns have the following meaning:

- St.Dev Standard deviation
- AV-STD Average – standard deviation
- AV+STD Average + standard deviation

Statistics on differences between observed and simulated runoff (\$\$\$\$_dst.dat)

The third file is set up similarly. It contains the differences ('_dst') of the statistics between the observed and simulated values, and therefore is a combination of the two files \$\$\$\$_ost.dat and \$\$\$\$_sst.dat.

Efficiency for linear and logarithmic data (\$\$\$\$_eli.dat / \$\$\$\$_eln.dat)

Efficiency for linear data							
ID	TYPE	E0.25	E0.50	E1.00	E2.00	E4.00	
2	9999	0.2990	0.4732	0.6477	0.7960	0.9449	
2	1981	0.2954	0.4711	0.6495	0.7851	0.9231	
2	1982	0.2546	0.4012	0.5577	0.7586	0.9446	
...	
2	1985	0.2977	0.4761	0.6590	0.8092	0.9366	
2	1	0.3139	0.4916	0.6572	0.7895	0.9375	
2	2	0.2859	0.4282	0.5378	0.6558	0.9235	
2	3	0.0923	0.1737	0.3248	0.6344	0.9414	
...	
2	12	0.3064	0.4750	0.6264	0.7462	0.9133	
2	8888	0.2852	0.4628	0.6576	0.8154	0.9269	

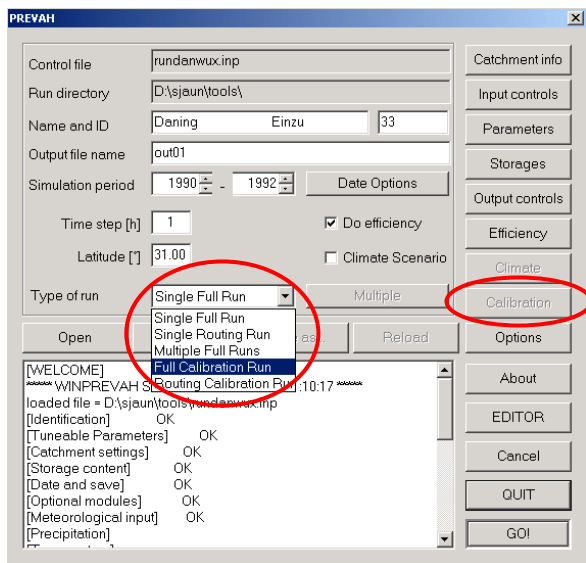
The efficiency score for the model is calculated and written in a linear (\$\$\$\$_eli.dat) and logarithmic (\$\$\$\$_eln.dat) version. More information on the efficiency score can be found in Chapter 6, Part II of the PREVAH documentation. The files in the same format as the statistics files, except for the different variables. E2.00 corresponds to the original Nash-Sutcliffe equation, whereas the others are based on a more generalised version of this equation (Legates and McCabe, 1999; Equation F1). The exponent j of the generalised Nash-Sutcliffe equation corresponds to the second part of the variable name.

$$E_j = 1 - \frac{\sum_{i=1}^n |o_i - s_i|^j}{\sum_{i=1}^n \left| o_i - \left[\frac{1}{n} \sum_{i=1}^n o_i \right] \right|^j} \quad (\text{F1})$$

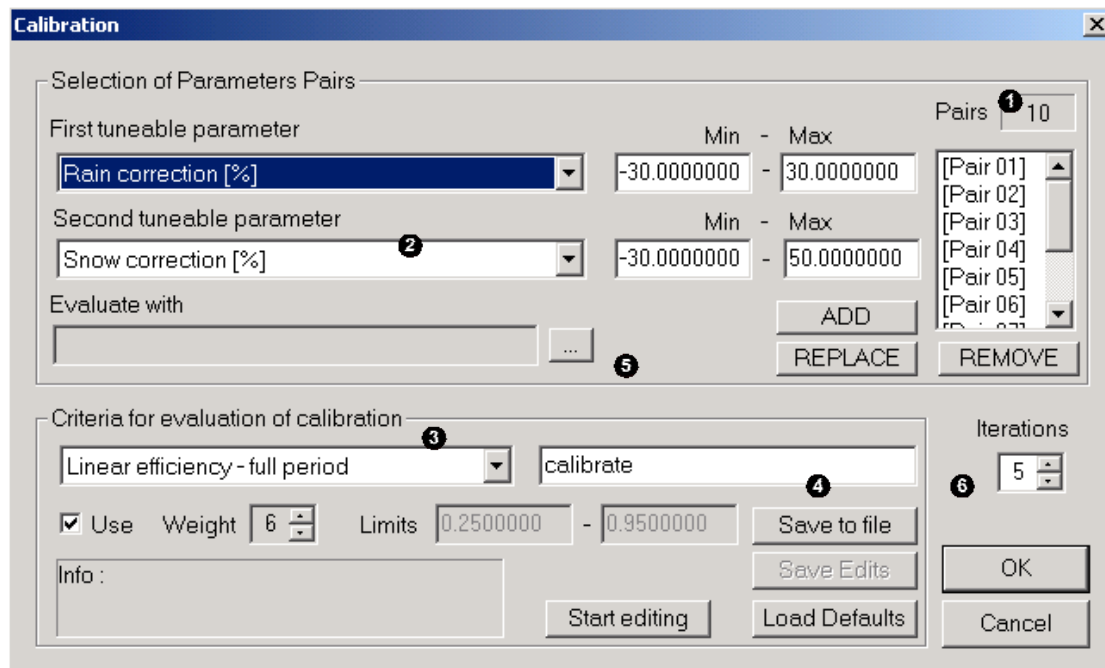
The efficiency module also provides two files needed to load the results of the model simulation in the tool HYDROGRAPH.

F.5 The calibration dialog

F.5.1 Dialog settings



To run the calibration, choose "Full Calibration Run" from the type of run. With this, the button [Calibration] (on the right side) is activated. Pressing it opens the calibration dialog.



In this dialog, the options for the automatic calibration of PREVAH are set.

Selection of Parameter Pairs:

❶ On the upper right side, the number of parameter pairs used is provided, the parameter pairs to be edited are found below. Parameter pairs may be added, removed or replaced using the drop-down menu (❷). The minimum and maximum values for calibration of each parameter is assigned in the corresponding edit boxes.

Criteria for evaluation of calibration:

❸ Different evaluation methods may be chosen from the dropdown menu. All available methods (efficiency scores and volume errors) are calculated for a model run if the checkbox [Use] is activated. To edit and adjust limits and weight of the respective score, press the [Start editing] button. Save your changes with the [Save Edits] button, and then proceed with the next method. After you adjusted the calibration criteria, press the [Save to file] button and your changes are saved under the name defined in box ❹ with extension .eopt. To undo your changes, press the [Load Defaults] button. To use the changed evaluation criteria with a parameter pair, they have to be linked to it. Click the [...] button (❺) to select the respective setting file and then click the button [REPLACE]. With this, different evaluation criteria may be assigned to every parameter pair.

❻ On the right side, the number of iterations is assigned. The [OK] button writes your calibration settings to the options file of WINPREVAH (see Section F).

The following four tables indicate the recommended settings for the CALIBRATION DIALOG.

Recommended settings for the nine objective functions used for the calibration of PREVAH

#	Description	SCORE	WEIGHT	LIMIT _{MIN}	LIMIT _{MAX}	Function
1	Linear efficiency – full period	ALIN _{PERIOD}	6	0.25	0.95	E_2^{lin}
2	Linear efficiency – year-by-year	ALIN _{YY}	4	0.1	0.01	STDEV(E_2^{lin})
3	Linear efficiency – month-by-month	ALIN _{MM}	2	0.5	0.02	STDEV(E_2^{lin})
4	Logarithmic efficiency – full period	ALOG _{PERIOD}	3	0.25	0.95	E_2^{log}
5	Logarithmic efficiency – year-by-year	ALOG _{YY}	2	0.1	0.01	STDEV(E_2^{log})
6	Logarithmic efficiency – month-by-month	ALOG _{MM}	1	0.5	0.02	STDEV(E_2^{log})
7	Volume error – full period	AVOL _{PERIOD}	10	0.1	0.01	DV
8	Volume error – year-by-year	AVOL _{YY}	4	0.15	0.02	STDEV(DV)
9	Volume error – month-by-month	AVOL _{MM}	3	0.10	0.02	STDEV(DV)

The column SCORE declares in which score the different functions are integrated (see equations 6.3-1 to 6.3-16 in the Part II of the PREVAH documentation). WEIGHT indicates the recommended (and default) weight of each function for building the corresponding score and overall score.

Default parameter pairs for automatic calibration of PREVAH for Swiss glaciated catchments. These default settings assume that the recommended snowmelt module "4. EMA with varying melt factor" (see Section 4.3, Part II of the PREVAH documentation) is used

PAIR	Parameter 1	Parameter 2
1	Rain correction [%]	Snow correction [%]
2	Threshold Temperature Rain-snow [°C]	Transition Temperature Rain-snow [°C]
3	Maximal degree day factor [mm (d·K) ⁻¹]	Minimal degree day factor [mm (d·K) ⁻¹]
4	Threshold Temperature Rain-snow [°C]	Threshold Temperature snowmelt [°C]
5	Exponent for soil moisture recharge [-]	Percolation [mm h ⁻¹]
6	Refreezing factor [mm (d·K) ⁻¹]	Radiation melt factor for snow
7	Threshold storage for surface runoff [mm]	Storage coefficient for surface runoff [h]
8	Storage coefficient for interflow [h]	Percolation [mm h ⁻¹]
9	Storage coefficient for fast baseflow [h]	Maximum storage for fast baseflow [mm]
10	Storage coefficient for delayed baseflow [h]	Percolation [mm h ⁻¹]
11	Temperature melt factor for ice [mm (d·K) ⁻¹]	Radiation melt factor for ice

Recommended parameter pairs for automatic calibration of PREVAH for large catchments with no glaciers and daily meteorological input. These default settings assume that the snowmelt module "0. Positive degree day index (PDDI)" (see Section 4.3, Part II of the PREVAH documentation) is used.

PAIR	Parameter 1	Parameter 2
1	Rain correction [%]	Snow correction [%]
2	Threshold Temperature Rain-snow [°C]	Transition Temperature Rain-snow [°C]
3	Maximal degree day factor [mm (d·K) ⁻¹]	Minimal degree day factor [mm (d·K) ⁻¹]
4	Refreezing factor [mm (d·K) ⁻¹]	Threshold Temperature snowmelt [°C]
5	Exponent for soil moisture recharge [-]	Percolation [mm h ⁻¹]
6	Threshold storage for surface runoff [mm]	Storage coefficient for surface runoff [h]
7	Storage coefficient for interflow [h]	Percolation [mm h ⁻¹]
8	Storage coefficient for fast baseflow [h]	Maximum storage for fast baseflow [mm]
9	Storage coefficient for delayed baseflow [h]	Percolation [mm h ⁻¹]

Recommendations for building tuneable parameter pairs for the full calibration of PREVAH. The description corresponds to the text reported in the CALIBRATION dialog of WINPREVAH. MODEL ID declares the name of these variables in the source code of PREVAH and WINPREVAH.

	Description	MODEL ID	Link To
1	Rain correction	PKORF	SNOKOR
2	Snow correction	SNOKOR	PKORF
3	Threshold Temperature Rain-snow	TGR	TTRANS or T0
4	Transition Temperature Rain-snow	TTRANS	TGR or T0
5	Threshold Temperature snowmelt	T0	TGR, TTRANS, CRFR, CRMFMIN, CRFRMAX
6	Exponent for soil moisture recharge	CBETA	CPERC, SGRLUTZ or K1H
7	Maximal degree day factor	CRMFMAX	CRMFMIN or T0
8	Minimal degree day factor	CRMFMIN	CRMFMAX or T0
9	Refreezing factor	CRFR	CWH, CEXLIQ or T0
10	Radiation melt factor for snow	RMFSNOW	CRMFMIN or CRMFMAX or TSFSSNOW
11	Threshold storage for surface runoff	SGRLUZ	K0H, K1H or CBETA
12	Storage coefficient for surface runoff	K0H	SGRLUZ or K1H
13	Storage coefficient for interflow	K1H	CBETA, CPERC, SGRLUZ or K0H
14	Percolation	CPERC	CBETA, SGRLUZ, K1H, K2H
15	Storage coefficient for fast baseflow	CG1H	SLZ1MAX, K2H
16	Maximum storage for fast baseflow	SLZ1MAX	CG1H, K2H
17	Storage coefficient for delayed baseflow	K2H	SLZ1MAX, CPERC or CG1H
18	Temperature melt factor for ice	CICEMF	CAICE or T0
19	Radiation melt factor for ice	CAICE	CICEMF or T0
20	Critical precipitation intensity	A0	AADD
21	Albedo ageing > 0°C	APOS	ANEG
22	Albedo ageing < 0°C	ANEG	APOS
23	Retention factor for melting snow	CWH	CRFR, CEXLIQ or T0
24	Melting factor by wind 1	CWU1	CWH2
25	Melting factor by wind 2	CWA2	CWU1
26	Exponent for retention of melting snow	CEXLIQ	CRFR, CWH or T0
27	Temperature melt factor for snow	TSFSSNOW	RMFSNOW or T0
28	Routing: Translation time [h]	TROUT	SROUT
29	Routing: Storage time [h]	SROUT	TROUT
30	Threshold moisture saturation for ETR	CRAFC	CBETA
31	Addition parameter for maximal Albedo	AADD	A0

F.5.2 Control file for the calibration *.eopt

The *.eopt files are resulting from the changes made in the calibration program module under "Criteria for evaluation of calibration". When you save a calibration control file, this kind of text file is written in the same directory as the control file of WINPREVAH:

Syntax

```
[Begin]
D:\sjaun\china\tools\rundanwux.inp      ! PATH of the PREVAH control file
C:\prevahff\daning\watershed\danc.effs    ! PATH of the model efficiency control file
9                                          ! Number of pairs
D:\sjaun\china\tools\runsts.cali          ! Name and location of the logfile of calibration.
[Linear efficiency - full period]          ! Name of the 1st efficiency score
1                                          ! Use this score
06                                         ! Weight
      0.1111111      0.9500000           ! Limits for fuzzy function
[Linear efficiency - year-by-year]         ! Name of the 2nd efficiency score
1                                          ! .....
04                                         ! .....
      0.1000000      0.0100000
[Linear efficiency - month-by-month]
...
[Logarithmic efficiency - full period]
...
[Logarithmic efficiency - year-by-year]
...
[Logarithmic efficiency - month-by-month]
...
[Volume error - full period]
...
[Volume error - year-by-year]
...
[Volume error - month-by-month]
...
[End]
```

This file is linked to the desired parameter pair and updates the default settings, storing them in the winprevah.ini file (see next section). Every available score (see previous section) is listed separately; its definition consists of three lines. The first line, either a 1 or a 0, specifies whether the score is used for calibration (1) or ignored (0). This entry corresponds to the checkbox "Use". The second line shows the weight, the third the selected limits for the fuzzy function (defined to reduce this score to a range between 0 and 1).

F.6 The options file of WINPREVAH

```
[TOOLS]
C:\WINDOWS\SYSTEM32\WRITE.EXE
C:\prevahff\bin\viewoptim4.exe
C:\prevahff\bin\hydrograph.exe
C:\prevahff\bin\WINGRID.exe
[END TOOLS]

[FREE PARAMETERS - SOFT LIMITS]
      -4.800000      -30.00000      30.00000
.....
.....
      0.000000E+00      0.3000000      0.5500000
[END FREE PARAMETERS - SOFT LIMITS]

[CALIBRATION]
      10
      1          2
default.eopt
      3          4
default.eopt
      7          8
default.eopt
      6         14
default.eopt
      9         10
default.eopt
     11         12
default.eopt
     13         14
default.eopt
     15         16
default.eopt
     17         14
default.eopt
     18         19
default.eopt
      0.2500000      0.9500000      6.0000000      T
      0.1000000      0.0100000      4.0000000      T
      0.5000000      0.0200000      2.0000000      T
      0.2500000      0.9500000      3.0000000      T
      0.1000000      0.0100000      2.0000000      T
      0.5000000      0.0200000      1.0000000      T
      0.1000000      0.0100000     10.0000000      T
      0.1500000      0.0200000      4.0000000      T
      0.1000000      0.0200000      3.0000000      T
[END CALIBRATION]

[RUNWINDOW]
      40          2
[END RUNWINDOW]
```

The winprevah.ini file is used to store the options of the WINPREVAH program. It is separated into different sections, which are discussed below:

In the [TOOLS] section, the paths to the text editor, optimisation viewer, hydrograph viewer and grid viewer are set. Section A of this manual provides further information.

[FREE PARAMETERS – SOFT LIMITS]: The second and third column show the lower and upper soft limit of the corresponding parameter. The first column contains the last value that has been stored for the parameter. Changes are made in the parameters program which is described in Section F.4.2

[CALIBRATION]: This section controls the calibration program module. The first line of this section shows the number of parameter pairs used for calibration. The following lines first show the number of the two parameters which form a parameter pair, and the name of the file which contains the chosen limits and weight of the used efficiency scores and volume errors. More information on this file is found in Chapter 6 of Part II of the PREVAH documentation. If no changes were made to the initial settings, default.eopt is assumed as a placeholder. The default values for the limits and weights are assigned after the last parameter

pair. The first two columns show the lower and upper limit, the third column shows the weight. The fourth column either contains a T (true) or F (false) to decide whether the respective efficiency score or volume error is used for calibration.

[RUNWINDOW]: These specifications are used to place the WINPREVAH model run window (displayed after clicking the [GO!] button in the main dialog window). The first number and second number refer to on-screen x and y co-ordinates, respectively, with origin in the upper left corner, positive x-axis running down, and positive y-axis running right. This setting may also be updated in the program module "Options" under the "Run window settings".

G HYDROGRAPH: Quick visualisation of hydrological simulations

G.1 Introduction

Visualisation of results from hydrological models requires the availability of commercial software. During calibration, the visualisation of simulation results is often a time-consuming task. To avoid this, the HYDROGRAPH tool was developed to allow for a quick visualisation of the main results of PREVAH.

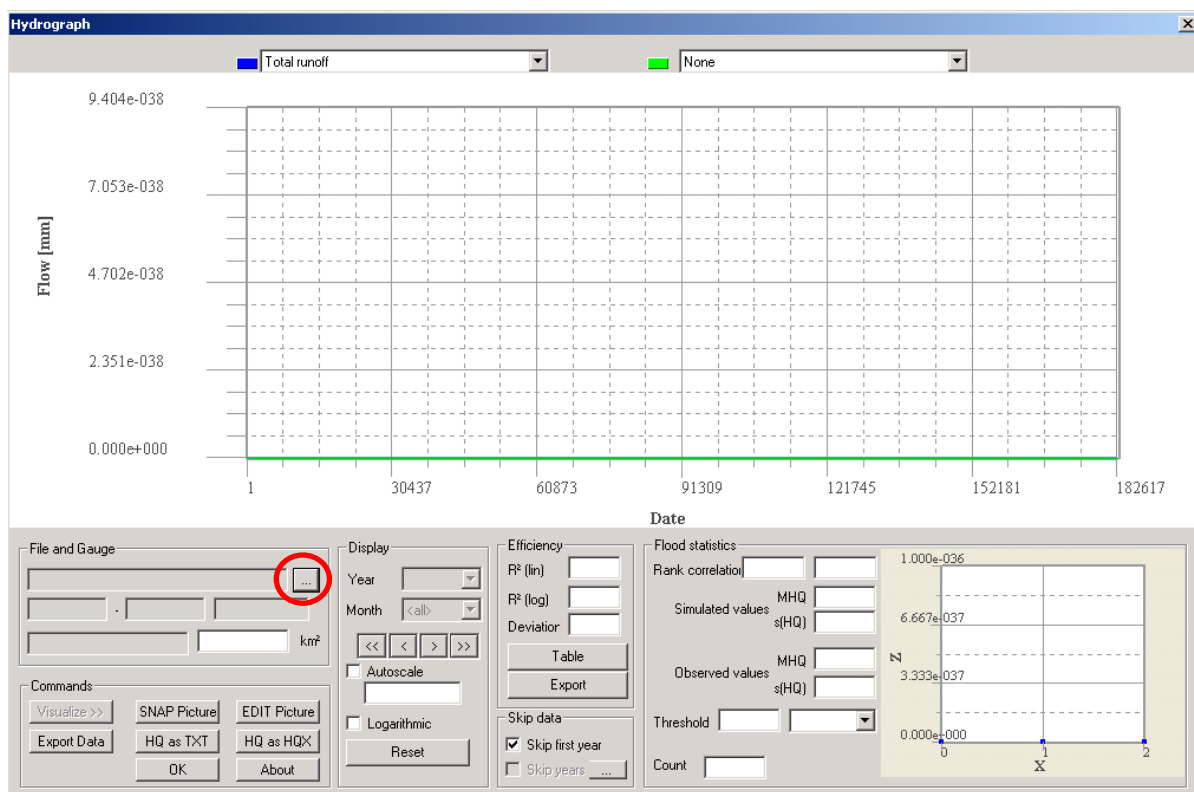
G.2 Program description

Two types of files may be plotted with this program:

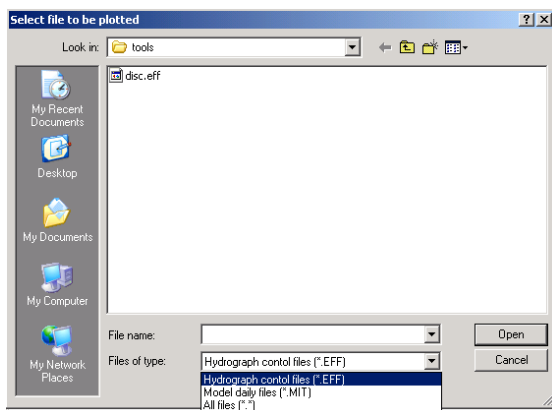
- xxxx.eff (modelled and observed runoff) (*.eff, *.ddd/*.hhh): Such files are an optional model output. The results of the model run may be compared to observed runoff values. Different time frames may be chosen and the efficiency score of the model is calculated. Various possibilities to export data and create screenshots are available.
- xxxx.mit (various parameters from model output): These files only contain model data. Therefore, the functions related to the efficiency score and display of observations are not available. Various model parameters may be chosen and plotted against each other. The format of this model output is described in the WINPREVAH manual.

G.3 Main dialog window

The following main dialog window is displayed after start-up:

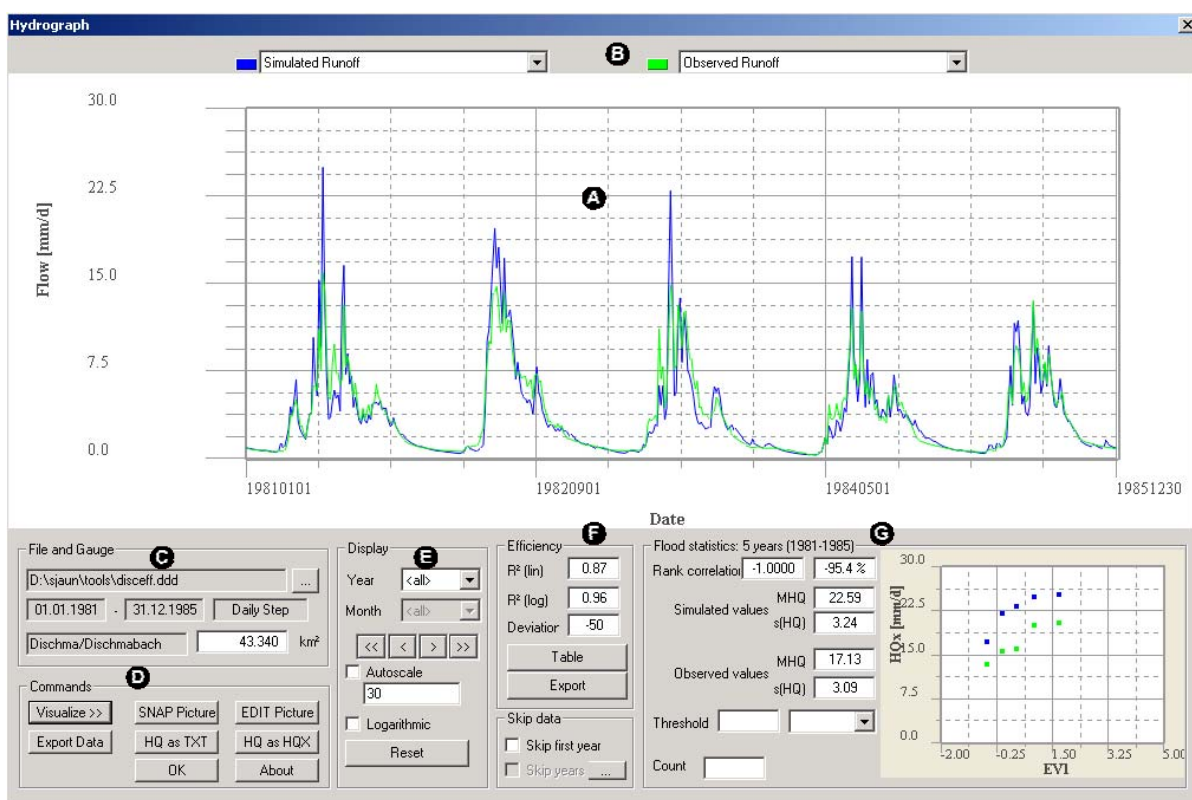


To select a file, press the [...] button (see red circle above). The file selection dialog opens:



Select your data directory. Two types of files may be plotted with this program:

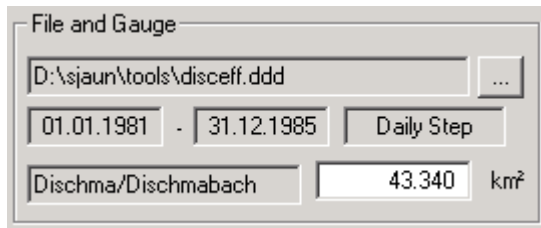
- xxxx.eff (link to the file containing the modelled and observed runoff values)
- xxxx.mit (file containing daily model output).



Legend:

A Plotting area	B Select line to be plotted
C File selection	D Commands
E Selecting a time frame	F Model efficiency
G Flood statistics	

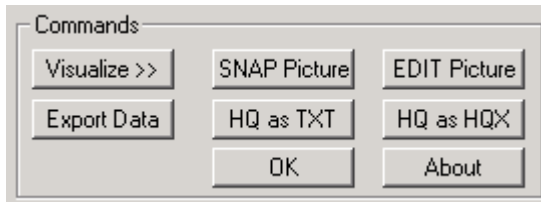
G.4 Display control



The first field shows the path to the selected data file. To select a different one, click the [...] button.

The second line shows the temporal range and time step of the data.

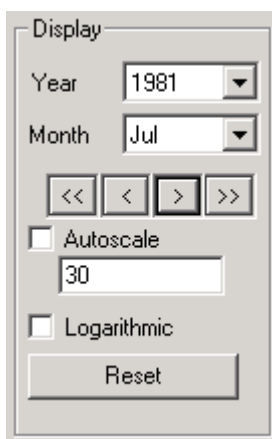
The third line shows the name of the observed/simulated catchment with its catchment size.



Every time a new data file is selected, the [Visualize>>] button has to be clicked in order to plot the data. With the [SNAP Picture] button, a screen shot of the main dialog is pasted to the clipboard. To edit the content of the clipboard, click the [EDIT picture] button. A new dialog is prompted.

The [HQ as TXT] and [HQ as HQX] buttons serve to export peak flow, as ASCII-formatted text file or HQ-EX-formatted exchange file (WASY, 1997).

The [OK] button closes the window and quits the program.



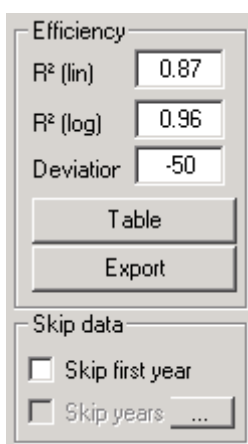
Initially, all discharge data of the file are plotted. To display only a part of the data set, the desired year and month can be selected. If no month is selected, the full year is plotted.

The arrow buttons are used to switch between the months [<] [>] and years [<<] [>>]. If a month is selected, [>>] shows the same month of the next year.

If [Autoscale] is checked, the y-axis of the plot is adjusted automatically to the data range.

To make a logarithmic plot of the data, activate the [Logarithmic] checkbox.

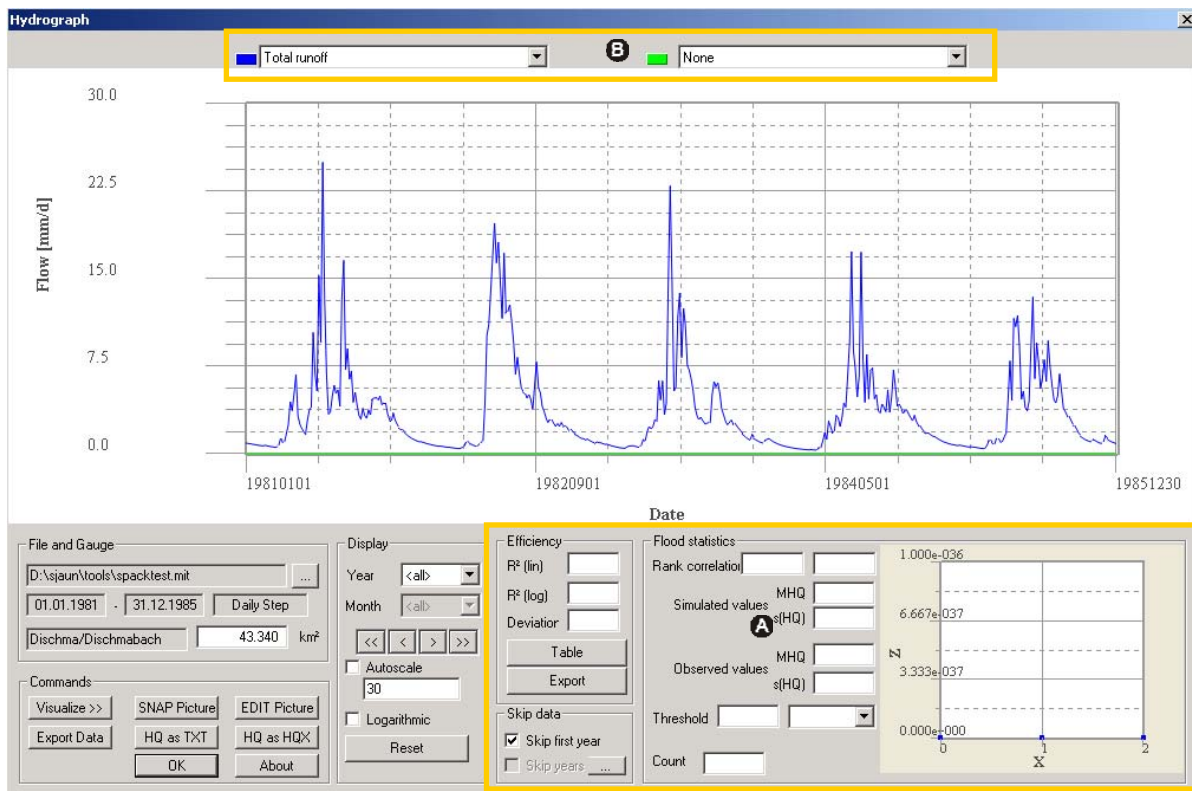
The [Reset] button restores the initial state.



The linear and logarithmic efficiency scores of the whole data range are showed. Additionally, the deviation (volume error) in [mm] between simulated and observed runoff is displayed. To see detailed yearly and monthly values, click the [Table] button. These values can also be exported and saved to a text file by pressing the [Export] button.

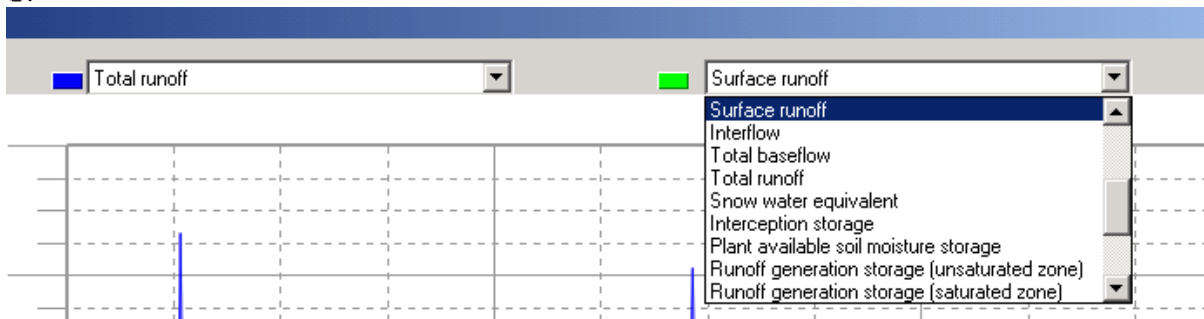
If the first year is used to initialise the model, it may be skipped and will not be considered by the efficiency calculation ([Skip first year] check box).

Differences when using the xxxx.mit files:



A If an xxxx.mit file is plotted, the marked area is not used and remains empty.

B:



The drop-down menus on the top allow the selection of different parameters from the model output. Two parameters may be chosen to be plotted in blue and green. The following parameters are available:

- P-UK: Interpolated precipitation [mm d^{-1}]
- P-KOR: Adjusted - Interpolated Precipitation [mm d^{-1}]
- P-SME: Snowmelt [mm d^{-1}]
- EPOT: Potential evapotranspiration [mm d^{-1}]
- EREA: Actual evapotranspiration [mm d^{-1}]
- EI: Interception evaporation / Snow evaporation [mm d^{-1}]
- EB: Transpiration / Soil evaporation [mm d^{-1}]
- R0: Surface runoff [mm d^{-1}]
- R1: Interflow [mm d^{-1}]
- R2: Total baseflow [mm d^{-1}]
- RGES: Total runoff [mm d^{-1}]

- SSNO: Snow water equivalent [mm]
- SI: Interception storage [mm]
- SSM: Plant available soil moisture storage [mm]
- SUZ: Runoff generation storage (unsaturated zone) [mm]
- SLZ: Runoff generation storage (saturated zone) [mm]
- BIL: Balance from previous time step [mm d⁻¹] [mm]
- GLAC: Icemelt [mm d⁻¹]
- RG1: Fast response baseflow [mm d⁻¹]
- RG2: Slow response baseflow [mm d⁻¹]
- RG3: Third component baseflow [mm d⁻¹]
- DIFGA: Input to DIFGA [mm d⁻¹]

*.mit file: Header and columns 1–14

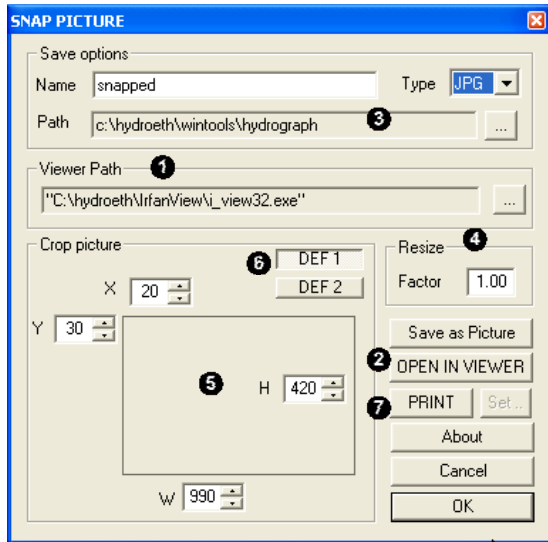
YYYY	MM	DD	P-uk	P-kor	P-SME	EPOT	EREA	EI	EB	RO	R1	R2	RGES
1983	1	1	0	0	0	0.259	0.085	0	0.085	0	0.05	12.6	12.65
1983	1	2	1.593	1.916	0	0.55	0.235	0.114	0.121	0	0	12.48	12.48
1983	1	3	5.714	6.484	1.641	0.003	0.003	0.002	0.001	0	0.1	12.37	12.47
1983	1	4	4.678	5.847	0.844	0.033	0.033	0.029	0.004	0	0.21	12.28	12.49
1983	1	5	17.804	21.259	7.491	0.147	0.147	0.142	0.004	0.06	1.62	12.19	13.87
1983	1	6	0	0	4.561	0.217	0.164	0.128	0.035	0	2.72	12.13	14.85
1983	1	7	4.324	5.088	0.517	0.234	0.227	0.214	0.013	0	2.34	12.07	14.42
1983	1	8	0.791	0.97	0	0.044	0.044	0.044	0	0	1.14	12.01	13.15
1983	1	9	0	0	0.001	0	0	0	0	0	0.39	11.94	12.33

*.mit file: Columns 15–25

S-SNO	SI	SSM	SUZ	SLZ	BIL	GLAC	RG1	RG2	RG3	DIFGA
0	0	6.83	0.17	1304.99	0	0	0.02	12.58	0	0
1.34	0.37	6.71	0.17	1292.51	0.08	0	0.02	12.46	0	0.53
5.95	0.42	6.79	1.12	1280.7	0.11	0	0.03	12.34	0	1.76
10.37	0.42	6.82	1.32	1269.39	0.01	0	0.06	12.22	0	1.42
20.9	0.5	6.87	8.41	1258.56	0.32	0	0.09	12.11	0	10.35
16.34	0.37	6.85	8.03	1248.36	0.27	0	0.14	11.99	0	4.84
20.52	0.42	6.85	4.6	1238.24	-0.22	0	0.2	11.88	0	0.72
21.49	0.42	6.85	2.01	1227.85	-0.23	0	0.25	11.76	0	0.01
21.5	0.42	6.85	0.47	1217.15	-0.09	0	0.29	11.65	0	0

G.5 Capturing and saving images

In connection with the freeware picture viewer Irfanview (<http://www.irfanview.com/>), HYDROGRAPH allows the capturing, viewing and printing of screenshots for the displayed hydrograph. To load a screenshot of the main dialog in the clipboard, click the [Snap picture] button. To subsequently edit the content of the clipboard, click the [Edit picture] button. A new dialog is prompted.



Usage:

At first use, link the SNAP PICTURE plug-in with Irfanview [Viewer Path] (1).

To export the content of the clipboard to Irfanview, click [OPEN IN VIEWER] (2).

To save the content of the clipboard as a file, select a path where the pictures will be stored and provide a name for the picture (3). Select then the type of the picture you want to save (choose between JPG, GIF, BMP, PCX, PNG, TIFF formatting). Then click the [Save as Picture] button (4).

To print the content of the clipboard to the default printer, click [PRINT] (7).

Editing options:

You may resize the picture stored in the clipboard by changing the resize factor field (4). Factors between 0.1 and 5 are recommended.

To cut undesired portions from the screenshot stored in the clipboard, you may specify the extent (in pixels) of the picture portion you would like to view in Irfanview or save as a picture (5). Select the X and Y pixels where the cropping of the picture has to start (e.g. X=20 pixels, Y=30 pixels) and the width (W) and height (H) of the portion of the picture you want to crop.

Example: Original Dimension of the Picture: 1014x680 pixels.

Start crop from X=20 and Y=30 pixels, for a width of 990 and height of 420 pixels.

The final picture will contain the pixel range X=[20, 1010] and Y=[30, 450].

The current settings of the crop option (5) are stored automatically in an initialisation file. Two different settings may be saved. The first default setting is loaded and updated when the [DEF 1] button is activated. The second default setting is loaded and updated when the [DEF 2] button is activated (6).

H WINGRID: Visualisation of grid raster files

H.1 Introduction

The management of digital representations of spatially distributed physiogeographical information is an important requirement for the development, parameterisation and initialisation of spatially distributed hydrological models such as PREVAH. The grid raster files involved in modelling and preprocessing are stored in a specific format (see below). While it may also be processed with commercial GIS software after conversion to a suitable import format, WINGRID is intended for quick display and rudimentary editing of PREVAH raster data.

H.2 Binary format

The PREVAH modelling system uses a straight-forward binary grid format. It is structured similarly to the widespread ASCII-format (see below). All values are stored in single precision (4 bytes in most computer systems, 6...7 digits precision). Records 1 to 6 correspond to the data of the ASCII format, followed by 6 additional records describing the grid statistics:

Records 1...6:

- Grid header with number of columns and rows
- Co-ordinates of the lower left corner
- Cell size
- NoData value

Records 7...12:

- Count of valid cells (without NoData-values)
- Minimum value of all valid grid cells
- Maximum value of all valid grid cells
- Sum of all valid grid cells
- Mean value of all valid grid cells
- Standard deviation of all valid grid cells

Following this header, all cells of the grid are listed from the top left cell to the lower right cell in a row by row order.

In order to exchange grids between different computer platforms and transfer grids to other software, e.g. with ArcInfo, an ASCII-format is required. The tool GRIDMATH (see particular documentation) is available for converting the various formats. ASCII-formats can be exchanged between different systems using e.g. ftp-programs with an automatic conversion of carriage returns/line feeds. To exchange binary data, they first have to be converted into ASCII-data, subsequently the exchange can be completed and then a re-converting on the target platform should be performed.

An ASCII-formatted file will look as follows when opened in a text editor:

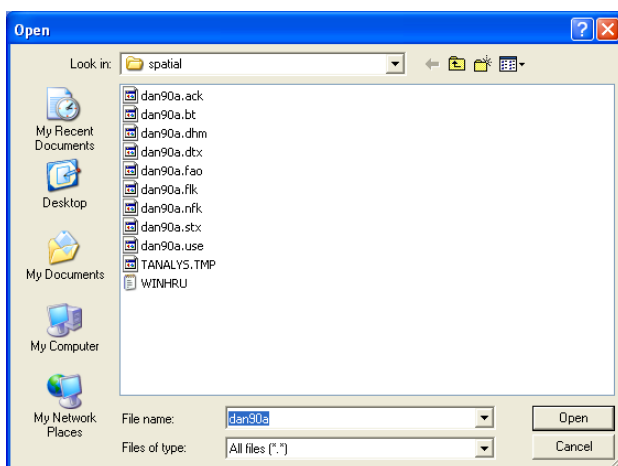
```
ncols      7
nrows     12
xllcorner 680500
yllcorner 222200
cellsize  2000
NoData_value -9999
-9999 -9999 -9999 -9999 -9999 -9999
-9999 -9999 -9999 -9999 -9999 -9999
-9999 -9999 586 559 595 601 585
584 -9999 -9999 -9999 -9999 -9999 -9999
-9999 449 -9999 -9999 454 511 551
-9999 561 529 509 498 487 499
521 523 523 534 -9999 -9999 -9999
-9999 -9999 -9999 -9999 -9999 -9999 -9999
-9999 -9999 -9999 -9999 -9999 345 234
567 453 456 478 789 576 482
123 -9999 1252 1211 876 564 825
-9999 -9999 234 1246 -9999 -9999 -9999
```

H.3 Basic features

WINGRID is used for:

- Displaying grids in the binary format used by the PREVAH modelling system and ASCII grid format defined above.
- 2D and 3D visualisation.
- Editing grid cell values.
- Exporting binary grids to a standard ArcInfo ASCII grid format.
- Exporting binary grids to IDRISI raster format.
- Capturing and managing screenshots with the freeware picture viewer Irfanview.

H.4 Start-up



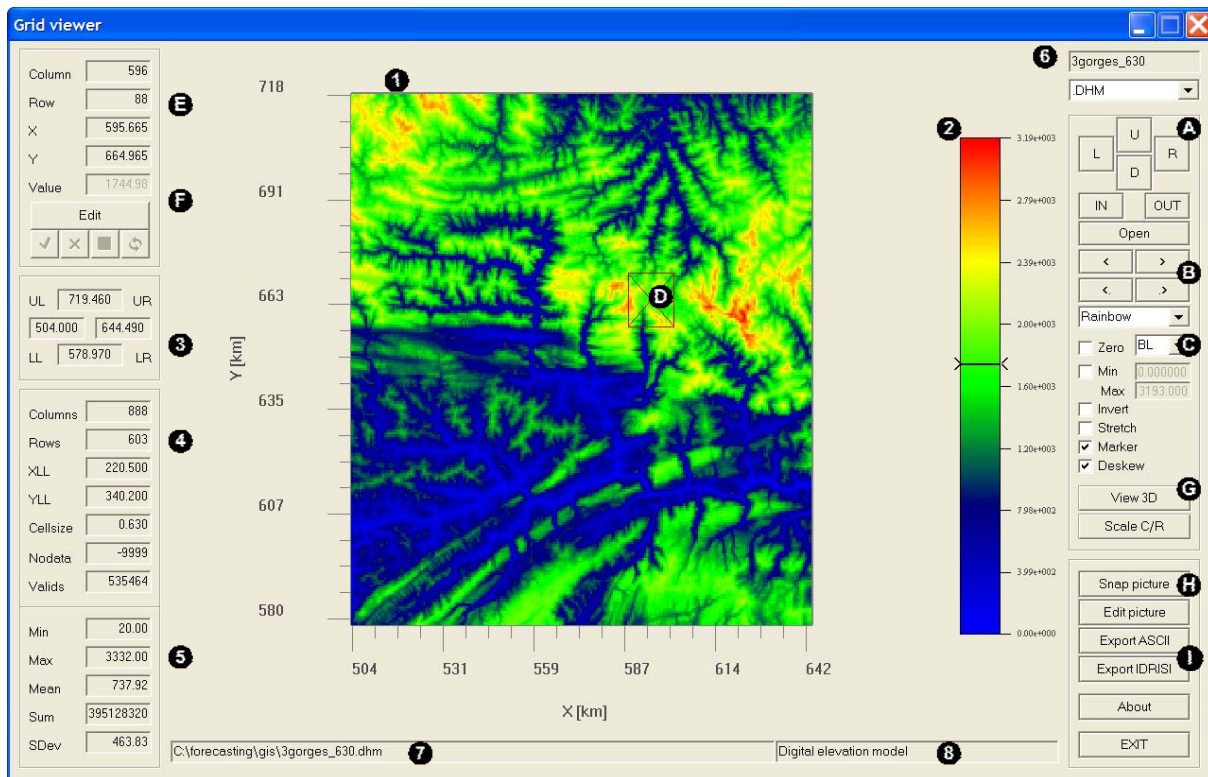
After launching WINGRID, a file open dialog is prompted automatically. Choose a grid to display and click [Open]. If the selected file does not meet the format requirements, a warning shows the particular file error, e.g.:



A void grid is displayed. By clicking [Open], the file open dialog is displayed again and you may choose another file.

H.5 Main dialog

The following screenshot shows the main dialog of WINGRID.



- Legend:**
- 1 Plotting area
 - 2 Palette / legend
 - 3 Grid domain, co-ordinates in kilometres
 - 4 Grid properties
 - 5 Basic grid statistics
 - 6 File name and list box of recognised grids with same file root name
 - 7 Path of the current file
 - 8 Description of the current file (only for recognised grid extensions)
 - A Navigation buttons
 - B File-change buttons
 - C Visualisation options
 - D Point selection marker
 - E Location and value of the marked grid cell
 - F Grid editor
 - G View options
 - H Capture screenshot
 - I Export grid

H.6 Grid info and standard visualisation options

UL 720.910 UR
449.945 595.385
LL 599.950 LR

Columns 1617
Rows 1345
XLL 449.945
YLL 599.950
Cellsize 0.090
Nodata -9999
Valid 2174865

Min 93.00
Max 2940.00
Mean 1172.71
Sum 25504952
SDev 599.77

In the left part of the main dialog, information on the displayed grid is shown.

③ The grid domain is defined by the lowest y co-ordinate (in the example 599.950 km), highest y co-ordinate (720.910 km), leftmost x co-ordinate (449.945 km) and rightmost x co-ordinate (595.385 km). These co-ordinates are obtained from the grid settings.

④ Grid settings include: Number of rows, number of columns, lower left corner x co-ordinate (449.945 km), lower left corner y co-ordinate (599.950 km), cell size (0.090 km), NoData value (voids, -9999) and the number of valid grid cells (i.e. all cells excluding NoData cells). For combining grids with PREVAH-tools (such as GRIDMATH), it is imperative that all grids are stored in the same format, resolution and extent (same number of columns and rows, co-ordinates, cell spacing and No-Data value).

⑤ For all valid grid elements in the displayed domain, basic grid statistics are shown: Minimum (Min), maximum (Max), average (Mean), summation (Sum) and standard deviation (SDev).

dan90a

.DHM

.ACK
.BT
.DHM
.FLK
.NFK
.USE

In the upper right part of the main dialog, the name and extension of the current file are displayed (⑥). The path (⑦) and description (⑧) of the current file are shown in the bar located in the lowermost part of the dialog (see main dialog window). In the dropdown list box, a list of other recognised extensions may be available. These are grid types that have the same file root name as the currently displayed file (in the example dan90a) located in the current directory (⑦). The example shows that besides the file dan90a.dhm, WINGRID also recognised the files dan90a.ack, dan90a.btm, dan90a.flk, dan90a.nfk and dan90a.use. Extensions which are not recognised are not listed in this box; a list of recognised grid extensions with their corresponding description is provided in the Appendix.

L U R
D
IN OUT

To navigate within the displayed grid, the following options are provided (⑨).

To zoom in, simply click the [IN] button. To focus the zoom on a particular area of the grid you may first move the marker (⑩, see further below) by double-clicking on the part of the grid you want to zoom in. After zooming in, it is possible to move the focus left click [L], right [R], up [U] or down [D]. To zoom out, click the [OUT] button.

Open

< >

<. >.

Several options are available to change to another grid file:

- Click [Open] and select a grid from your file system.
- Select an extension from the list-box ⑥.
- Switch to the previous [<.] or next [>.] grid with same file root name, but different extension.
- Switch to the previous [<] or next [>] grid with same extension, but different file root name.



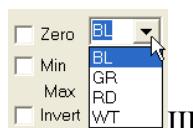
C

Some visualisation options are controlled by the main dialog (C):

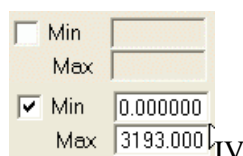
1. Change the colours of the palette (CII). Six standard colour ramps are implemented (CII): Blue-Cyan, Blue-White, Greyscale, Rainbow (Default), Red-Green and Red-White. The orientation of the ramp may be inverted by activating the [Invert] check-box.
2. Stretch the data to full palette scale by activating the [Stretch] check-box. Data minimum and maximum values are then used for palette minimum and maximum.
3. Change the background colour of NoData values (CIII). First activate the [Zero] check-box, then choose a colour. Select BL for black, GR for green, RD for red and WT for white.
4. If you want to assign a specific minimum and maximum to the palette, activate the [Min/Max] option (CIV) and enter the desired values for the minimum and maximum. All values outside the specified range will be displayed with the minimum (below range) or maximum (above range) colour, respectively.
5. Deskew the grid visualisation. If the option deskew is checked (default), the aspect-ratio of the grid is preserved and the scaling is fitted so that the resolution of the horizontal axis is identical with the vertical axis. If deskew is not checked, the grid is fitted to the full Plotting Area and the aspect-ratio is broken (different resolution in x and y directions)



II

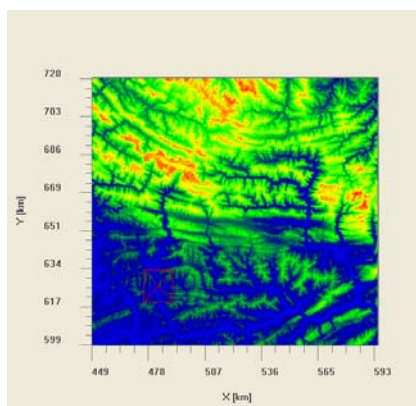


III

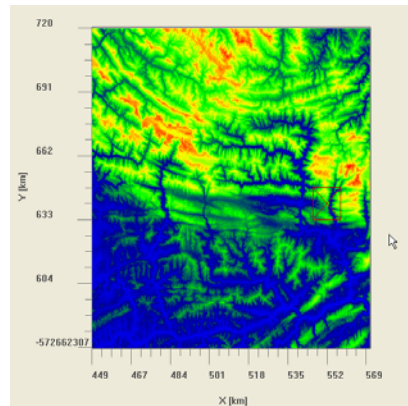


IV

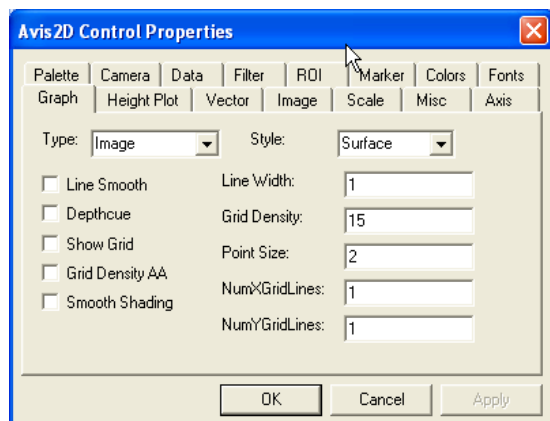
Deskew checked



Deskew unchecked



H.7 Additional visualisation options

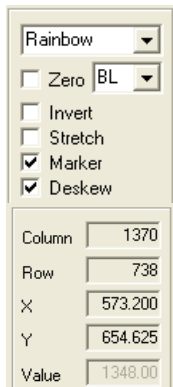


With a right-button click on the Plotting Area, the Array Visualiser Properties Dialog is accessed.



This allows the controlling of several additional plotting options. The consultation of the Compaq Array Visualiser documentation is advisable for understanding the meaning of all the available features. You may also take some time to try all the options to understand how they work.

H.8 Grid cell options

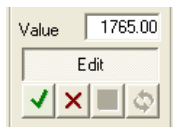


Ⓔ

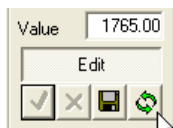
A red marker, Ⓔ on the main Grid Viewer dialog above, is activated by default. To move the marker, simply double-click a cell within the displayed domain. The selected cell may be used to control the zoom-in operation (see above). Uncheck the marker box to deactivate the marker.

In the upper left area, the attributes of the selected grid cell are displayed (Ⓔ). The attributes consist of the column, row, x co-ordinate (in km), y co-ordinate (in km) and value of the selected grid cell.

The value of the grid cell may be edited by activating the edit mode (click [Edit], Ⓔ) and entering the new value for the grid cell in the value field. To accept the changes applied, click the OK button [✓]. To discard them, click the cancel button [✗].

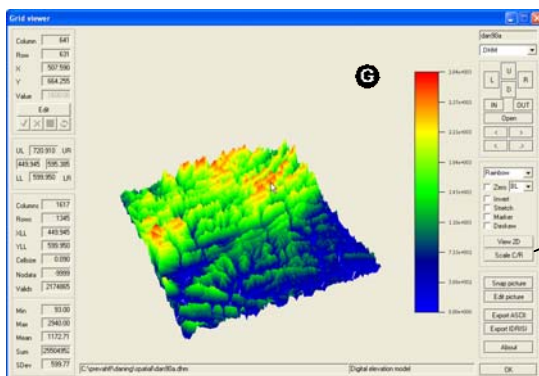


After accepting changes, you may still choose whether to store the changed grid (click the save button [💾]) or to restore the original grid (click the reload button, [🔄]).



This edit operation may prove very useful to amend a digital elevation model when the digitally derived river network differs considerably from reality. Such errors are common in flat parts of a landscape and if the resolution is too low.

H.9 3D-Visualisation



The grids may also be displayed as 3-dimensional surfaces. To switch to 3D-view, click the [View 3D] button.



To adjust the scale of the z-axis, access the Array Visualiser Properties Dialog and edit the option [Scale]. To return to the 2D visualisation click the same button.

H.10 Axis Co-ordinates

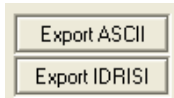
The x and y axis labels may be displayed in kilometric co-ordinates (default) or column and row numbers, respectively. To switch to column/row labels click the button [Scale C/R]. To change back to kilometric co-ordinates click the same button again (now named [Scale [km]]), see below).



H.11 Capturing and saving images

In connection with the freeware picture viewer Irfanview, WINGRID allows capturing, viewing and printing of screenshots of the displayed grid. This has already been described in Section G.5.

H.12 Export grids to other GIS formats



WINGRID allows the conversion of binary grids into two standard GIS formats:

- ArcInfo ASCII grid format
- IDRISI raster format

To export the grids, click the appropriate button and provide a filename in the appearing file save dialog.

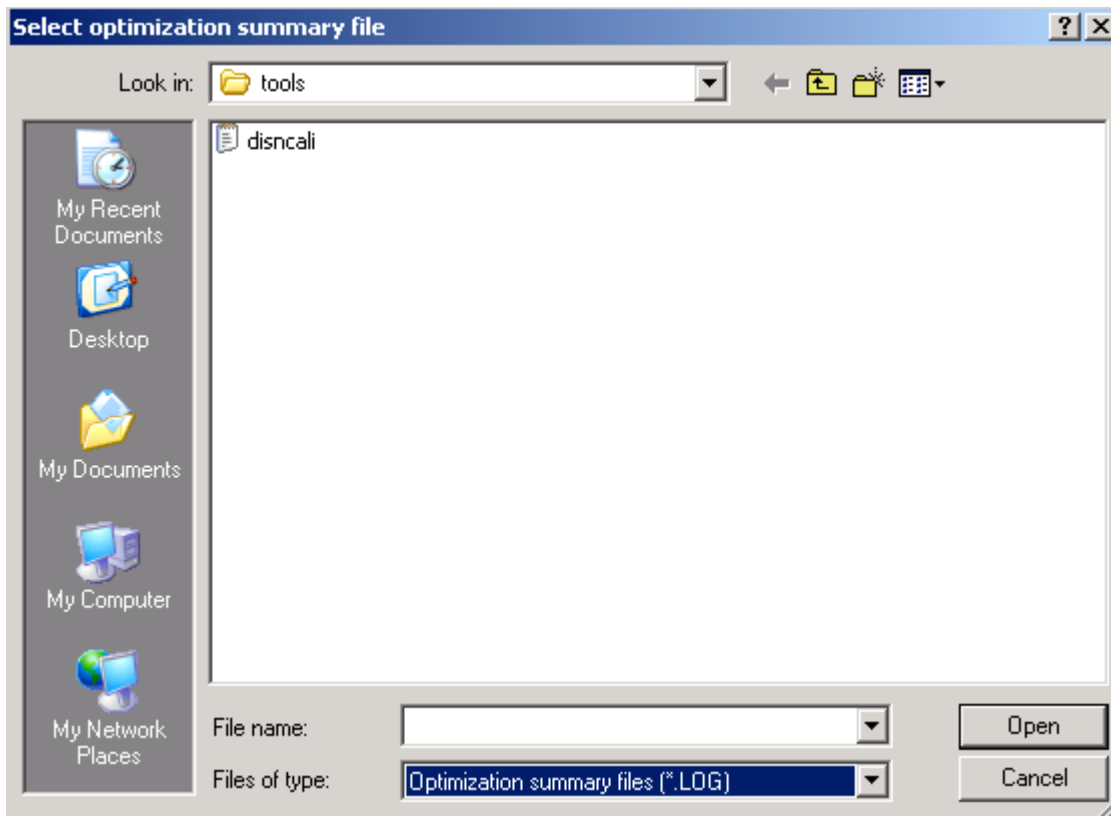
I VIEWOPTIM

I.1 Program description

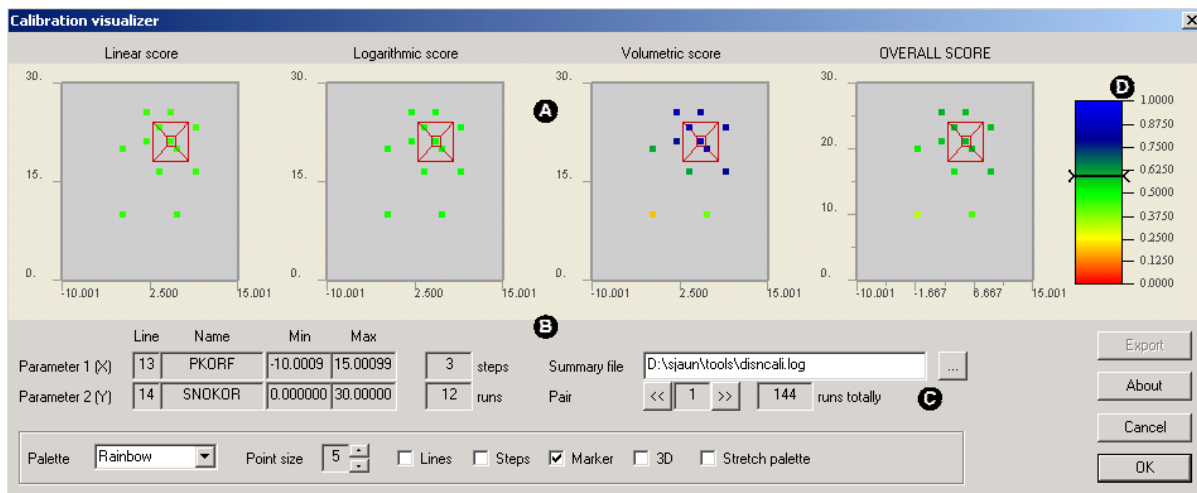
During an automatic calibration of WINPREVAH, the intermediate results are written to a summary file. This output may be visualised with the program VIEWOPTIM. It shows the gradual pair-wise optimisation process of the parameters and offers different settings to adjust the plotting to specific needs.

I.2 Start-up

VIEWOPTIM is started by double-clicking the corresponding icon in the program launcher or the file viewoptim.exe. The following file-open dialog will be displayed:



Select a data directory and choose the summary file to display.



Legend:

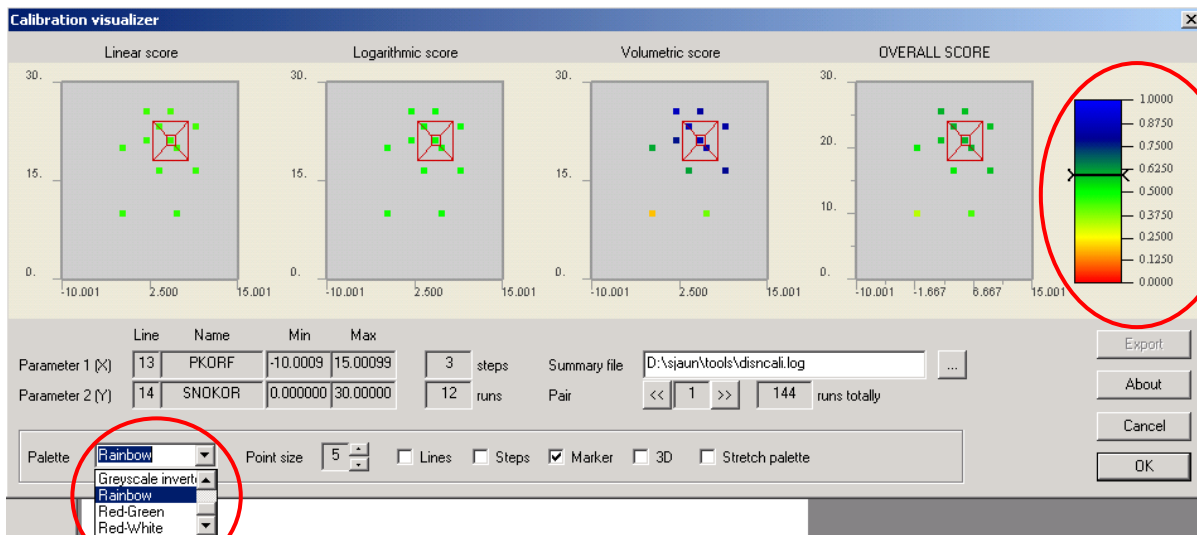
- A** Plotting area
- B** File and parameter display
- C** View options
- D** Colour palette

Plotting area

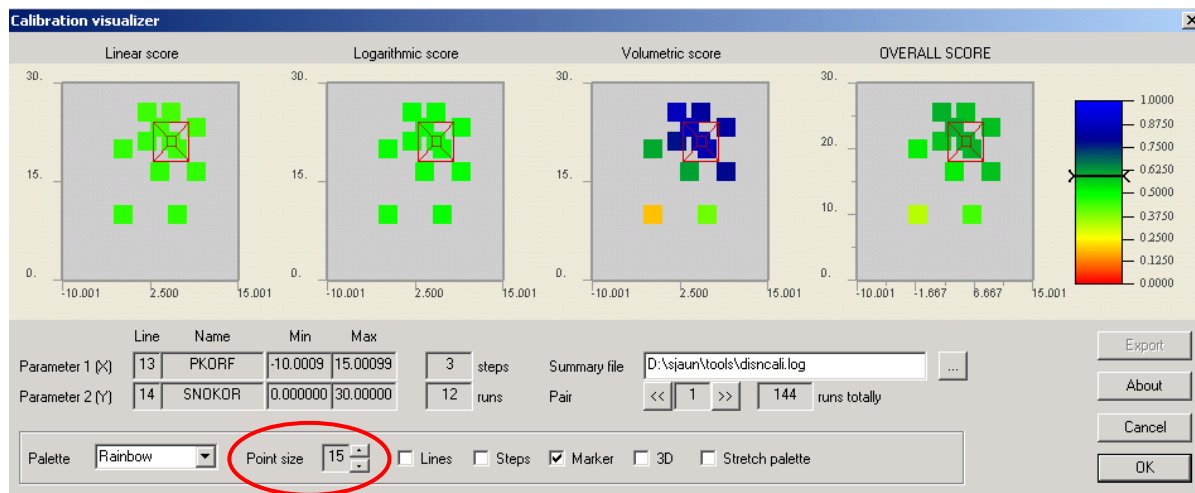
The plotting area is divided into 4 sections which show the course of different scores during calibration. The scores are from left to right: Linear score, logarithmic score, volumetric score, and the overall score, which combines the three preceding scores.

View options

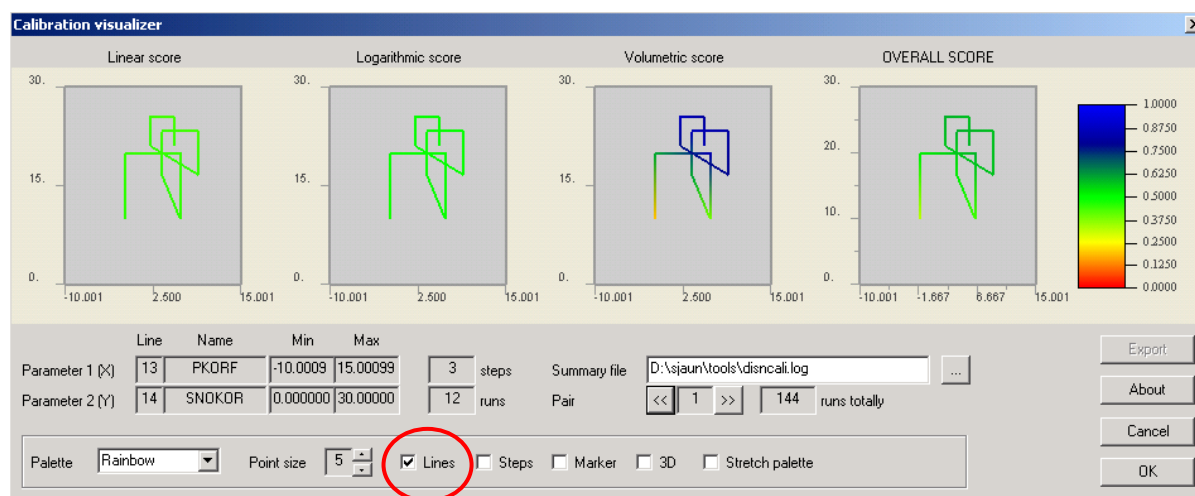
As an initial setting, the data marker is placed at the end-point of the calibration process.



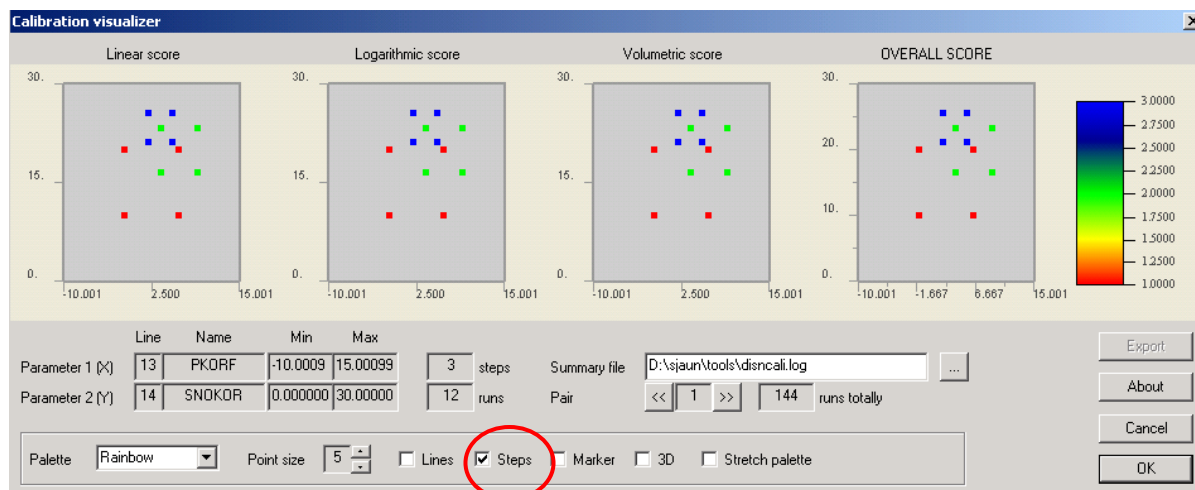
Different types of colour palettes may be chosen. On the right side of the main window, the corresponding colour palette is shown with the assigned values.



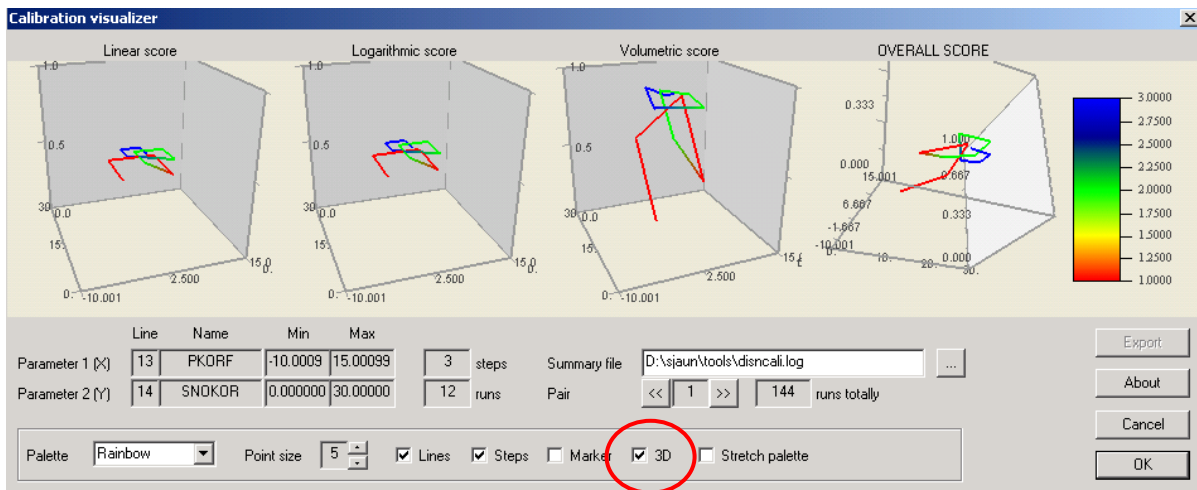
The point size may be varied from 1 to 20, the initial value is 5.



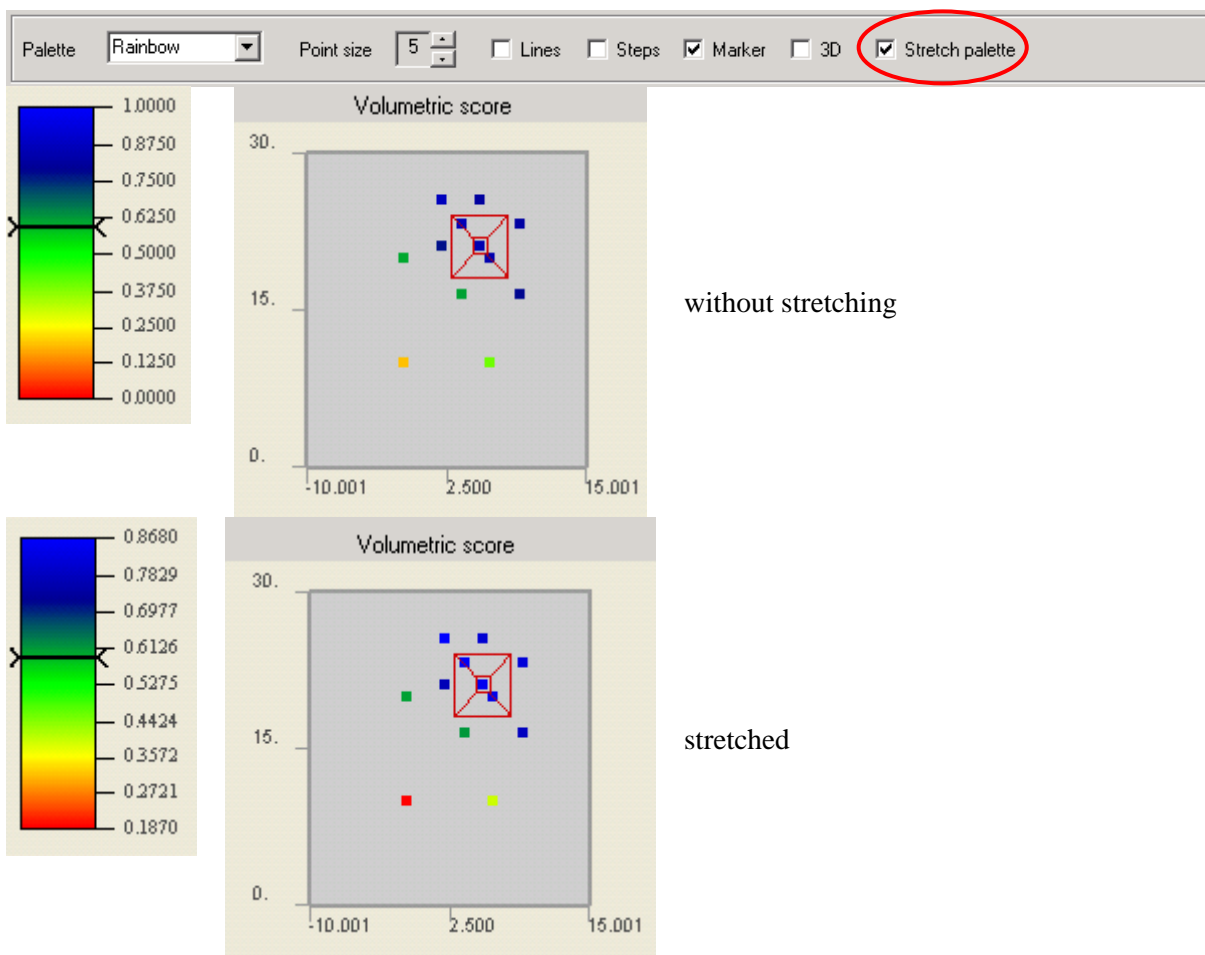
It is possible to connect the optimisation steps (points) with a line, which gives a better impression of the optimisation process.



The steps may be coloured individually in a separate colour.



The 3D-plot is especially useful in combination with other settings like step colouring or lines; the 3D-plots may be turned with help of the mouse to change the perspective.



The Stretch palette option adjusts the colour palette to the actual data range.

Parameter pairs

The parameter optimisation is always completed for two parameters simultaneously. The display of parameter pairs in VIEWOPTIM depends on the respective settings that were used during the calibration with PREVAH.

	Line	Name	Min	Max		steps	Summary file	
Parameter 1 (X)	13	PKORF	-10.0009	15.00099	3		D:\winmodtools\disncali.log	...
Parameter 2 (Y)	14	SNOKOR	0.000000	30.00000	12	runs	Pair	<< 1 >> 144 runs totally

Use the arrow buttons ([<<] / [>>]) to switch between the different parameter pairs.

Values which PREVAH protocols during calibration

The automatic calibration of WINPREVAH generates an optimisation summary file which shows the pair-wise optimisation process of the parameters. This output can be visualised using VIEWOPTIM as described above.

Log file of a calibration as interpreted by VIEWOPTIM

ITER	STEP	RUN	LINE1	LINE2	PAR1	PAR2	ALIN	ALOG	ADST	ATOT
1	1	1	13	14	-.1667E+01	0.1000E+02	0.452	0.475	0.187	0.322
1	1	2	13	14	-.1667E+01	0.2000E+02	0.449	0.482	0.603	0.516
1	1	3	13	14	0.6667E+01	0.1000E+02	0.452	0.481	0.393	0.436
1	1	4	13	14	0.6667E+01	0.2000E+02	0.444	0.486	0.841	0.589
1	2	1	13	14	0.3889E+01	0.1667E+02	0.450	0.484	0.611	0.520
1	2	2	13	14	0.3889E+01	0.2333E+02	0.441	0.486	0.859	0.593
1	2	3	13	14	0.9444E+01	0.1667E+02	0.446	0.486	0.781	0.573
1	2	4	13	14	0.9444E+01	0.2333E+02	0.434	0.488	0.814	0.578
1	3	1	13	14	0.2037E+01	0.2111E+02	0.446	0.485	0.769	0.569
1	3	2	13	14	0.2037E+01	0.2556E+02	0.438	0.486	0.868	0.594
1	3	3	13	14	0.5741E+01	0.2111E+02	0.443	0.486	0.847	0.590
1	3	4	13	14	0.5741E+01	0.2556E+02	0.433	0.487	0.807	0.576
2	1	1	15	16	-.3333E+00	0.5000E+00	0.443	0.488	0.861	0.595
2	1	2	15	16	-.3333E+00	0.1000E+01	0.444	0.489	0.879	0.601
2	1	3	15	16	0.3333E+00	0.5000E+00	0.436	0.484	0.843	0.586
...
10	1	4	38	39	0.2833E+01	0.2167E-03	0.442	0.495	0.983	0.630
10	2	1	38	39	0.2444E+01	0.1889E-03	0.442	0.495	0.977	0.628
10	2	2	38	39	0.2444E+01	0.2444E-03	0.442	0.495	0.981	0.629
10	2	3	38	39	0.3222E+01	0.1889E-03	0.442	0.496	0.985	0.630
10	2	4	38	39	0.3222E+01	0.2444E-03	0.443	0.496	0.987	0.631

In more detail, a log file (*.log), written by the automatic calibration routine, serves as input for VIEWOPTIM. The file's contents are as follows: The first column shows the iteration number. For every parameter pair, an iteration takes place. Each iteration consists of several steps (second column), the number of steps may differ between each iteration completed. The steps again consist of several model runs (third column). The number of runs may vary from iteration to iteration, but not between the steps and iteration. Columns four and five identify the two parameters that constitute the parameter pair through their respective line number in the PREVAH control file. PAR1 and PAR2 show the actual parameter values for every run. ALIN represents the linear, ALOG the logarithmic efficiency score, ADST is the volume score and ATOT the combined overall score.

A short version of this file (*.best) logs only the best run (i.e. the one with the highest total score, see Chapter 6.3.2 in Part II of the PREVAH documentation) of each step within an iteration.

Table: Best file (*.best), as a summary to the optimisation logging file (*.log)

Syntax

ITER	STEP	RUN	LINE1	LINE2	PAR1	PAR2	ALIN	ALOG	ADST	ATOT
1	1	4	13	14	0.6667E+01	0.2000E+02	0.444	0.486	0.841	0.589
1	2	2	13	14	0.3889E+01	0.2333E+02	0.441	0.486	0.859	0.593
1	3	2	13	14	0.2037E+01	0.2556E+02	0.438	0.486	0.868	0.594
2	1	2	15	16	-.3333E+00	0.1000E+01	0.444	0.489	0.879	0.601
...
10	1	4	38	39	0.2833E+01	0.2167E-03	0.442	0.495	0.983	0.630
10	2	4	38	39	0.3222E+01	0.2444E-03	0.443	0.496	0.987	0.631

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Appendix

Topographical analysis output.

Box to be Checked	Extension	Explanation
[Curvature]	.cur	Curvature
[Flow Correction]	.ack	Corrected flow accumulation
[Flow Correction]	.dhk	Corrected elevation model
[Flow Correction]	.flk	Corrected flow direction
[Flow Correction]	.nuk	Corrected river order
[Flow Correction]	.ork	Corrected river number
[Flow Correction]	.sin	Sinks
[Flow Separation]	.m##	Mouths of ## order
[Flow Times]	.dep	Stream depth
[Flow Times]	.fzt	Flow times
[Flow Times]	.wit	Stream width
[Horizont]	.hor	Horizon
[Plancurvature]	.plc	Plancurvature
[Profilcurvature]	.prc	Profilcurvature
[River Network]	.lin	Stream network
[River Order]	.num	River number
[River Order]	.ord	River order
Default	.acc	Flow accumulation
Default	.dhm	Digital elevation model
Default	.exp	Aspect
Default	.fld	Flow direction
Default	.slp	Slope

Recognised grid extensions.

ABB	Soil-topographic index	LN5	5th order streams
ABK	Soil-topographic index, classified	LNK	Routing network
ACC	Flow accumulation	M01	1st order stream pour point
ACK	Flow accumulation, corrected	M02	2nd order stream pour point
ART	Soil type	M03	3rd order stream pour point
ATB	Hydraulic-topographic index	M04	4th order stream pour point
ATK	H.-topographic index, classified	M05	5th order stream pour point
AZM	Help grid for aspect averaging	MEZ	Meteo zones
BIN	Binary grid (generic)	NAS	Nutrients content
BOS	Soil moisture storage	NFK	Soil water storage, classified
BT	Soil depth, classified	NUK	Stream numbering, corrected
BTK	Soil depth [m]	NUM	Stream numbering
DEP	Stream depth	ORD	Stream order
DHK	DEM with filled sinks	ORK	Stream order, corrected
DHM	Digital elevation model	PAT	Soil type, classified
E01	1st order catchments	PFC	Soil water storage capacity [%]
E02	2nd order catchments	PHK	Altitude, classified
E03	3rd order catchments	PRC	Precipitation
E04	4th order catchments	PUR	Pour points
E05	5th order catchments	PUS	Land use, classified
ETP	Potential evapotranspiration	RGS	Total runoff
ETR	Actual evapotranspiration	SCS	Snow storage
EXK	Aspect, classified	SID	Cell IDs
EXP	Aspect [°]	SIN	Sinks
EZG	Catchment	SKE	Portion of stones, classified
FLD	Flow direction	SLK	Slope, classified
FLK	Flow direction, corrected	SLP	Slope [°]
FZS	Flow time sums	SWA	Melt water runoff
FZT	Flow times	TRP	Transpiration
GEO	Geotopes	USE	Land use
GLM	Glacier morphology	WIT	Stream width
GWL	Glacier equilibrium line altitude	ZS1	1 st order streams flow time sums
HGL	Hydrogeology	ZS2	2 nd order streams flow time sums
HRU	HRU codes	ZS3	3 rd order streams flow time sums
IDH	Identifier of the HRUs	ZS4	4 th order streams flow time sums
INS	Interception storage	ZS5	5 th order streams flow time sums
K	Hydraulic conductivity, classified		
KMS	Hydraulic conductivity [m s ⁻¹]		
KWT	Hydraulic conductivity [mm h ⁻¹]		
LIN	Stream network		
LN1	1 st order streams		
LN2	2 nd order streams		
LN3	3 rd order streams		
LN4	4 th order streams		



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