

ACCUM PLUS 1.0

for ArcGIS 9.x and ArcView 3.x

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1. Introduction

AccumPlus is a software which calculates flow accumulation by considering dams/sinks and their specific operation time. Two different flow routing algorithms are implemented: the well-known D8 single flow algorithm (standard algorithm in ArcView, ArcGIS, Idrisi, GRASS, etc.) and the newly developed D8t single flow algorithm (Sch€uble et al., 2008). AccumPlus is available for ArcView GIS 3.x (Spatial Analyst Extension and Dialog Designer needed) and ArcGIS 9.x (Spatial Analyst Extension needed). AccumPlus is free of charge for all purposes (private and commercial use as well). AccumPlus is limited to grid sizes up to 10000*10000 pixels. Larger grid sizes are supported by AccumPlus Professional for ArcGIS 9.x which can be purchased upon request from www.terracs.com. This manual gives a short introduction in the use of AccumPlus. A more detailed description about the principles is given in Sch€uble et al. (2008). Any comments or suggestions for improvement will be appreciated.

2. Installation of ACCUM PLUS

Installation of the specific version for ArcView GIS 3.x

The extension 'AccumPlus3x' comes along with the dynamic link library `accum3x.dll` and the extension file `accumplus3x.avx`. To make the extension run it is necessary to copy both libraries on your computer. Make sure to copy the file '`accum3x.dll`' to the ArcView Bin32 folder. The extension file '`accumplus3x.avx`' should be copied in the ArcView Ext32 folder. Please note that the Spatial Analyst and Dialog Designer extension are required for AccumPlus. Then perform the following steps to start:

- Launch ArcView GIS 3.x
- Go to the Extensions menu (File – Extensions...) and select the AccumPlus 1.0 extension (Fig. 1)
- AccumPlus program can be started by opening a new view and then clicking the button  from the menu section (Fig. 2).

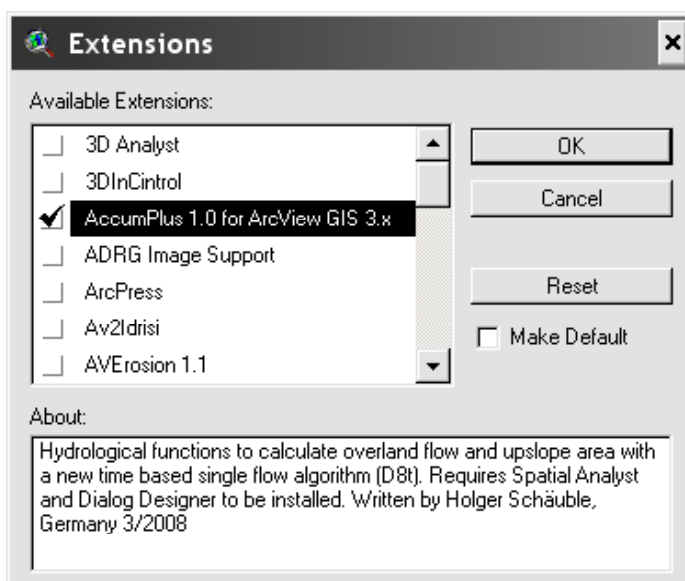


Figure 1: Launching of AccumPlus from ArcView 3.x Extension menu

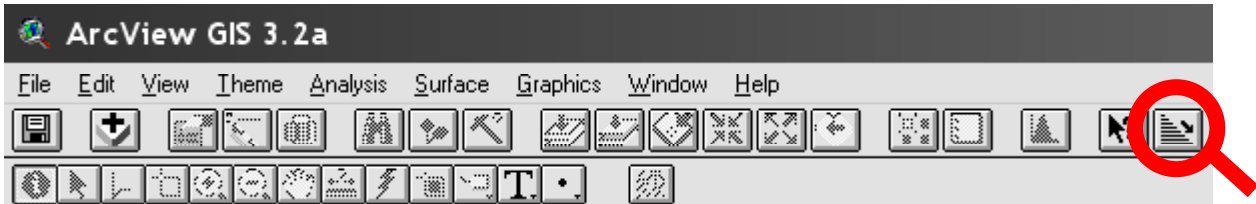
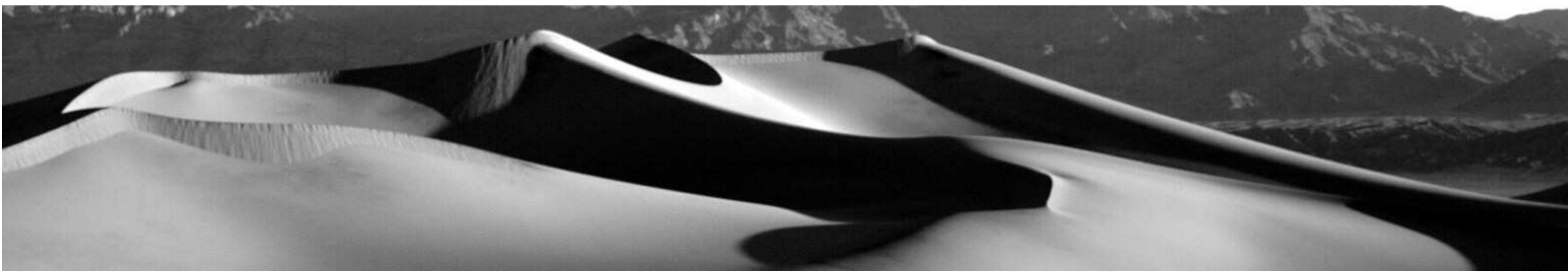




Figure 2: Start button of AccumPlus in the button section of ArcView 3.x

Installation of the specific version for ArcGIS 9.x

The extension 'AccumPlus9x' comes along with the dynamic link library `accum9x.dll` and the extension file `accumplus9x.dll`. To make the extension run it is necessary to copy both libraries on your computer. Make sure to copy the file '`accum9x.dll`' to the ArcGIS Bin folder. The extension file '`accumplus9x.avx`' can be copied elsewhere (recommended: also ArcGIS 'Bin' folder). Please note that the Spatial Analyst extension is required for AccumPlus. Then perform the following steps to start:

- Launch Arc GIS 9.x
- Go to the Tools menu, choose Customize and push the 'Add from file' button (red circle at the bottom of Fig. 3)
- Browse for the extension '`accumplus9x.dll`'. Choose the extension and close the dialog.
- Go to the 'Commands' tab. In the 'Categories' list box choose 'Developer Samples'. Select the new command  ' AccumPlus' that has to be added to the 'Commands' list box and put it on the menu section by by drag-and-drop (red circle at the top of Fig. 3).
- AccumPlus can be started by clicking the  button from the menu section (Fig. 4).

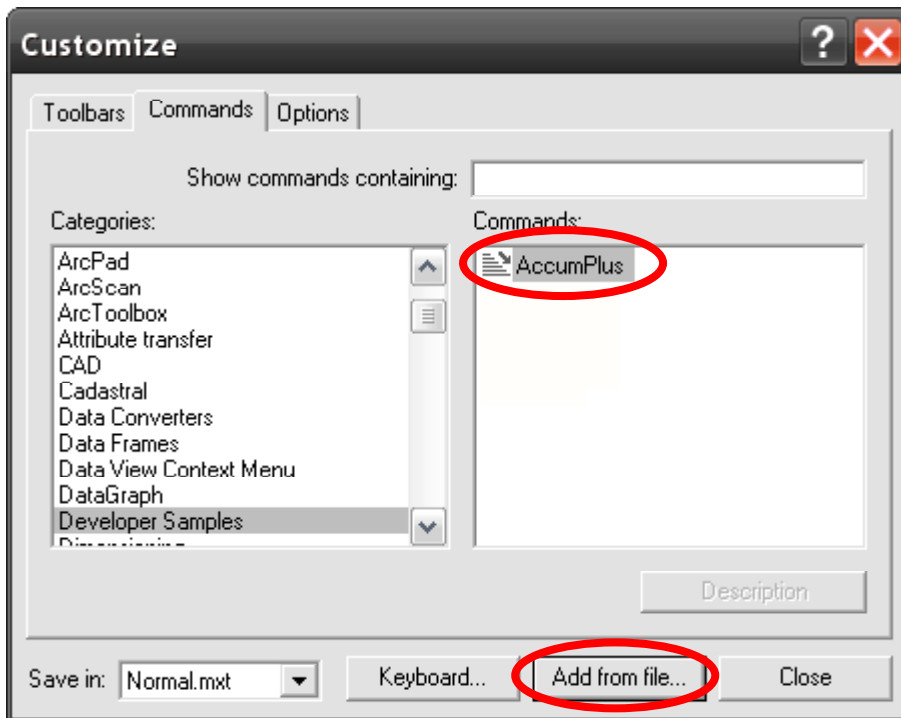
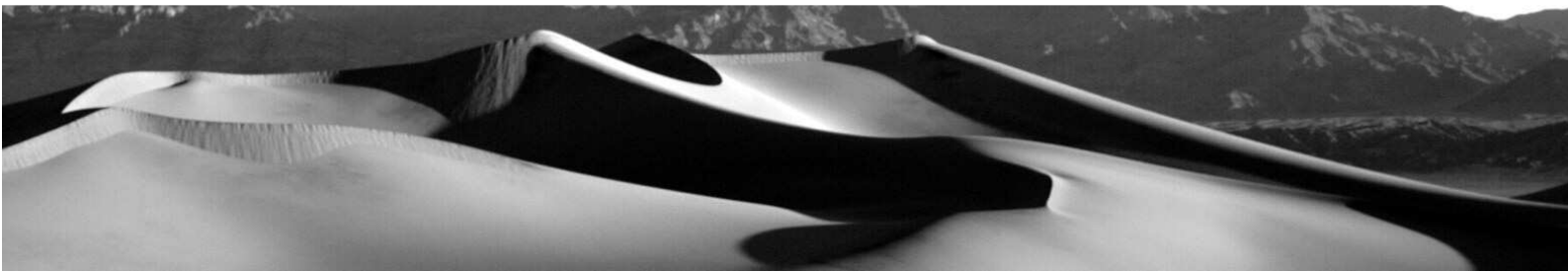


Figure 3: Installation of AccumPlus for ArcGIS 9.x through the Customize window

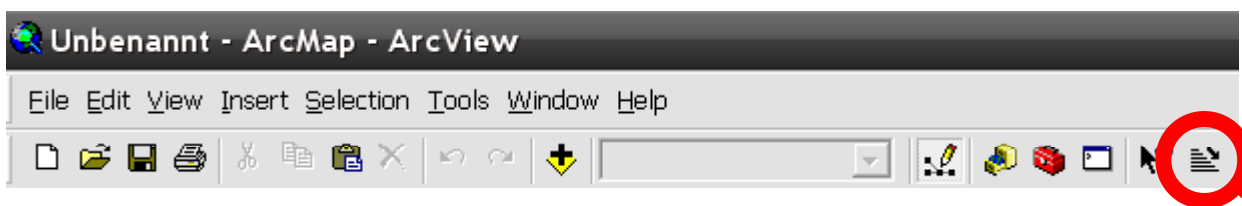



Figure 4: AccumPlus for ArcGIS 9.x after the installation procedure.

3. Using AccumPlus for ArcGIS 9.x and ArcView 3.x

Main program interface window of AccumPlus

AccumPlus is launched by pressing the  button which is located in the menu section in ArcView GIS 3.x and ArcGIS 9.x. (Fig. 5 and 6). Both versions are identical and have the same look and feel. The following functions are available:

- **Filling sinks:** Creation of a depressionless digital elevation model (DEM) by filling dischargeless sinks (for detailed information have a look at Sch.uble, 2004)
- **Flow direction:** Calculation of a flow direction grid from a digital elevation model (which has been corrected by the Filling Sinks function above, for detailed information have a look at Sch.uble, 2004 or ESRI, 2005)
- **Accumulation (D8):** Calculation of flow accumulation with the well-known D8 single flow algorithm
- **Accumulation (D8t):** Calculation of flow accumulation by considering sinks/dams and their specific operation time with the new D8t single flow algorithm.

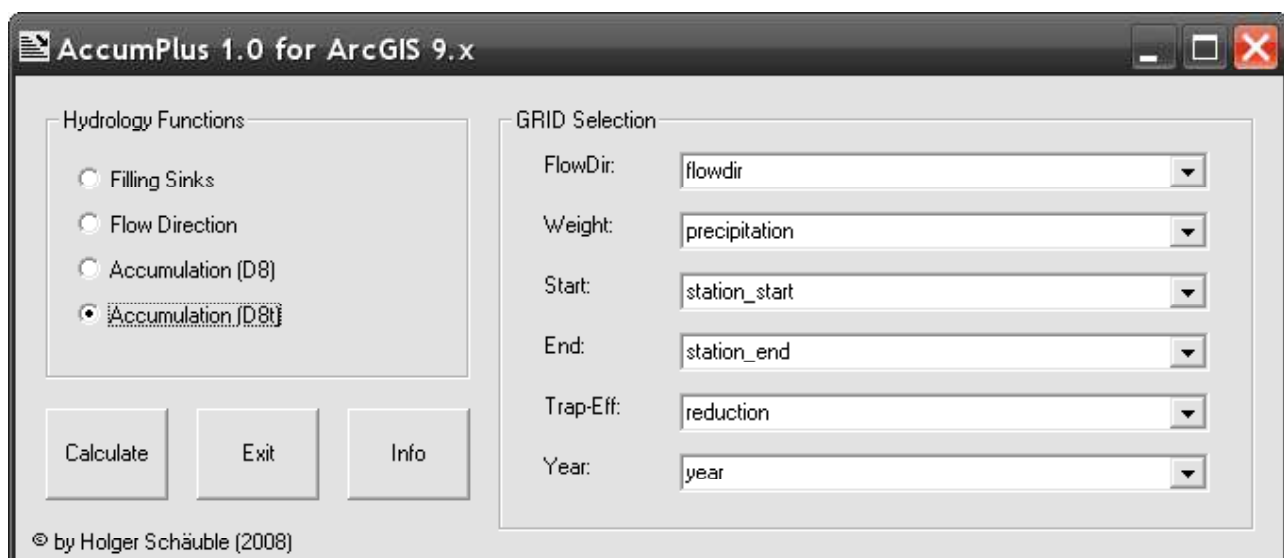


Figure 5: Main program window of AccumPlus for ArcView GIS 3.x or ArcGIS 9.x

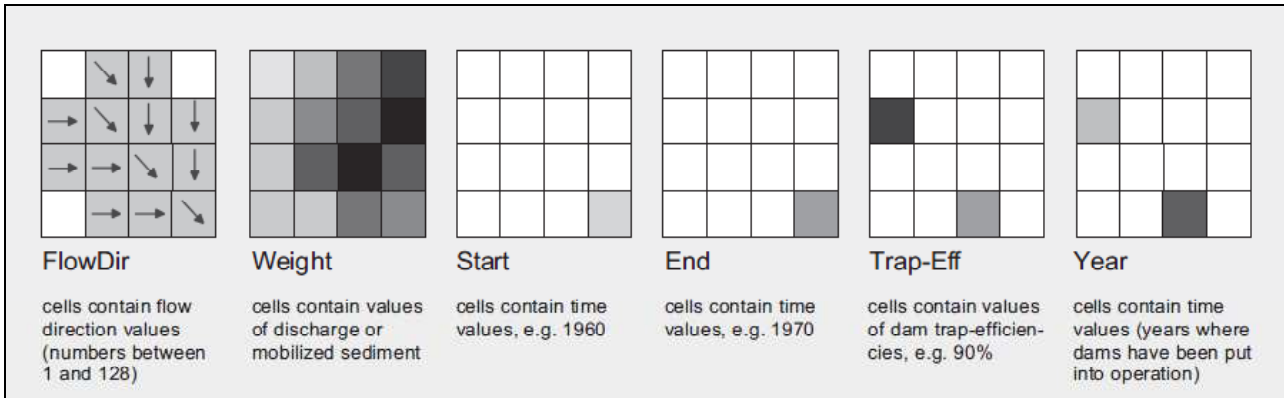
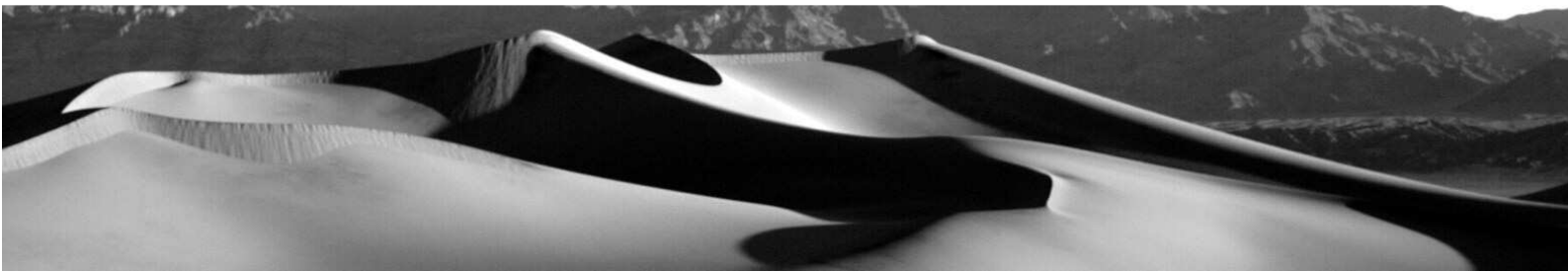
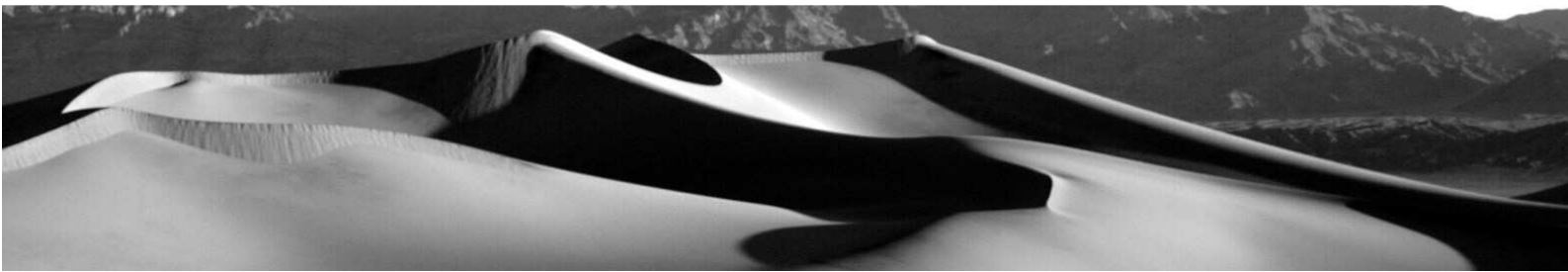


Figure 6: Samples of grids that are needed. White color = No data values.

Sample datasets of AccumPlus

For a straightforward and fast introduction AccumPlus comes with several additional sample datasets that will be used in the following explanations (Fig. 7).

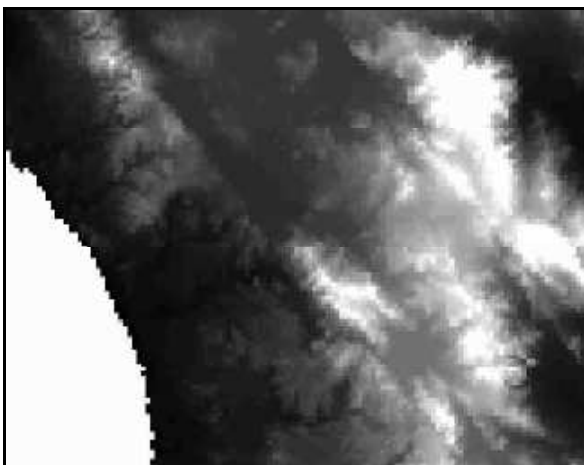
- A digital elevation model “**dem**” with elevation values in meters
- A flow direction dataset „**flowdir**“ with flow direction values from 1 to 128 according to ESRI notation (created from the “dem” dataset)
- An optional weight dataset “**precipitation**” that shows the precipitation of the sample area in mm/year (not explicitly used in this manual)
- Three datasets that show a sample measurement station at the outlet of a river catchment:
 - 1) an overall vector shapefile “**station**” that shows the location and gives informations about the beginning and the end of the measurement period and
 - 2) two raster datasets “**station_start**” (year of the beginning of the measurement) and “**station_end**” (year of the end of the measurement).



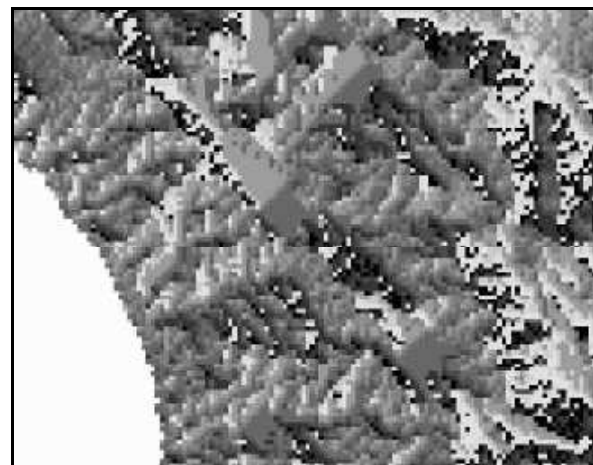
- Three datasets that show two dams which are located in the catchment of the measurement station above:
 - 1) an overall vector shapefile **“dams”** that shows the location and gives informations about the trap-efficiency of the dams in % and their year of commissioning (= year of construction) and
 - 2) two raster datasets **“trap-efficiency”** (trap-efficiency in %, see Sch.uble et al., 2008) and **“year”** (year of construction).

- Three **datasets for checking purposes** which show the results of the calculations:
 - a) **“AccumD8-simple”**: Simple D8 flow accumulation with Accumulation (D8) without any weight grid and the **“flowdir”** dataset (= unweighted D8 accumulation),
 - b) **“AccumD8-adv”**: Advanced single D8 flow accumulation with Accumulation (D8) and the usage of the optional **“trap-efficiency”** dataset (= D8 accumulation by considering trap-efficiency of dams),
 - c) **“AccumD8t-adv”**: Advanced D8t flow accumulation with Accumulation (D8t) and the usage of all available grids **“flowdir”**, **“station_start”**, **“station_end”**, **“trap-efficiency”** and **“year”**.

Figure 7: Sample datasets for AccumPlus 1.0 – raster data and vector shapefiles



7.1. „dem“: Digital elevation model (ESRI Grid)



7.2. „flowdir“: Flow direction dataset (ESRI Grid)

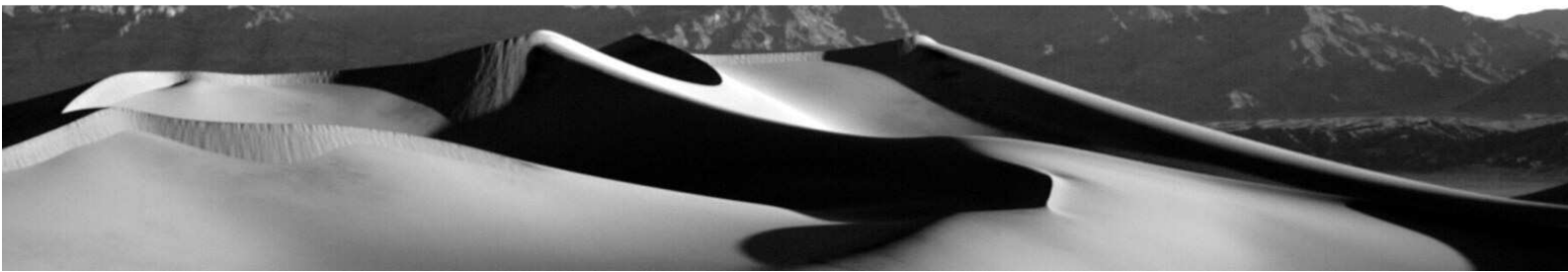
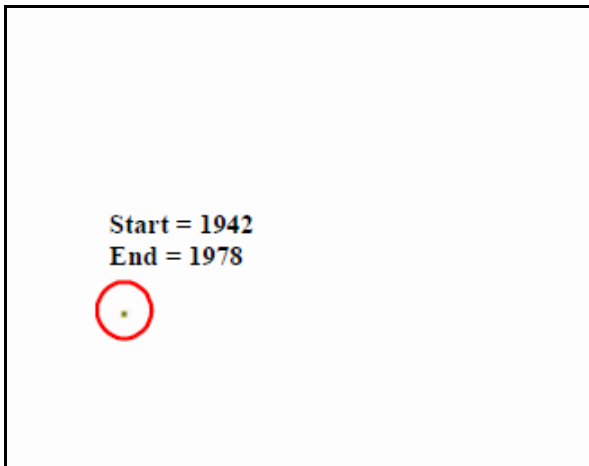
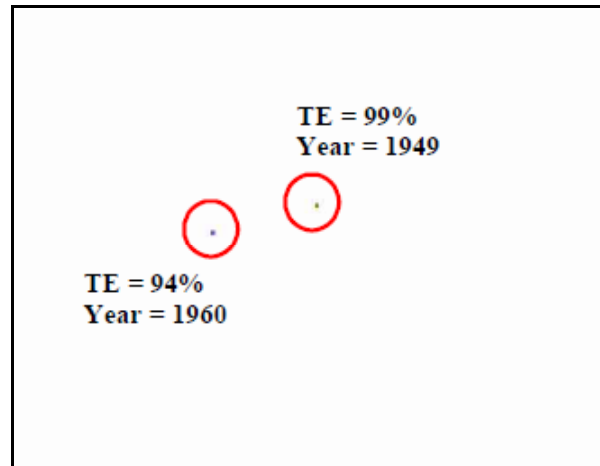


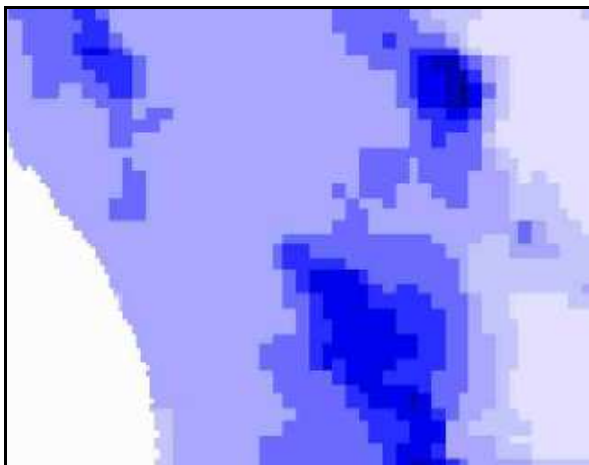
Figure 7 (continued): Sample datasets for AccumPlus 1.0 – raster data and vector shapefiles



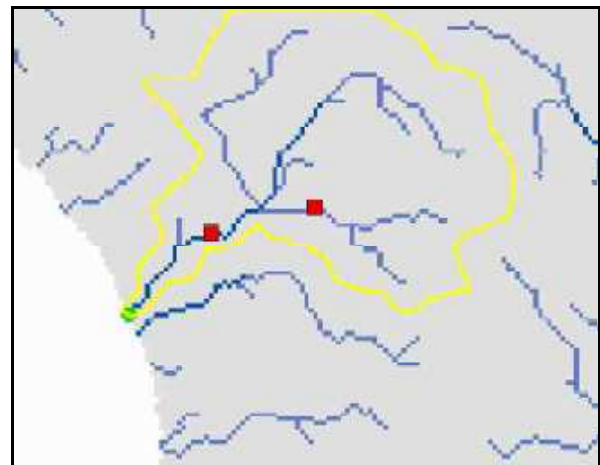
7.3. „station_start“ and „station_end“ (ESRI Grids): one station pixel (surrounded by a red circle line)



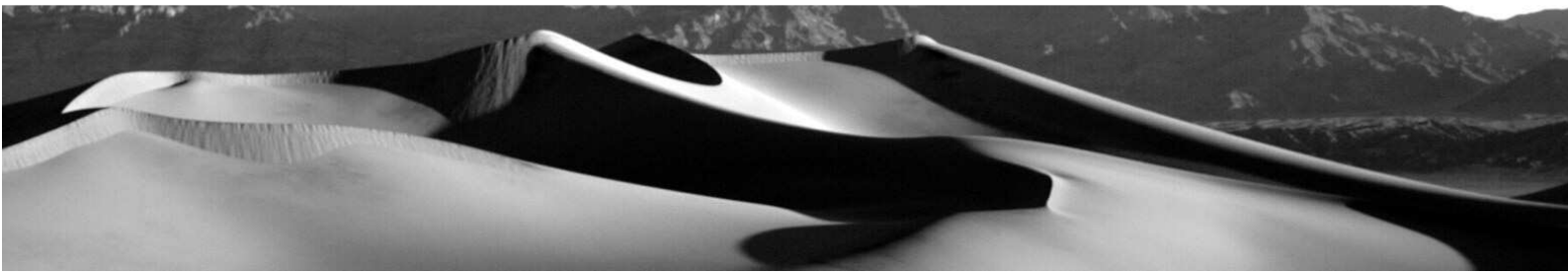
7.4. „year“ and „trap-efficiency“ (ESRI Grids): two dam pixels (surrounded by a red circle line)



7.5. „precipitation“: weighting grid (ESRI grid)

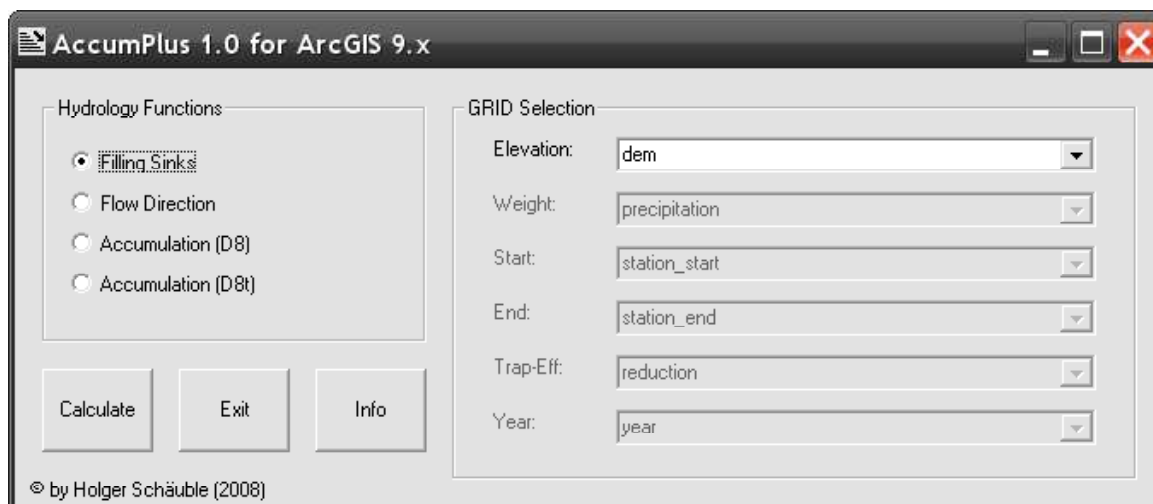


7.6. Sample datasets overview: Sampling station (green circle), dams/sinks (red squares), catchment (yellow borders) and rivers (blue pixels = rivers)



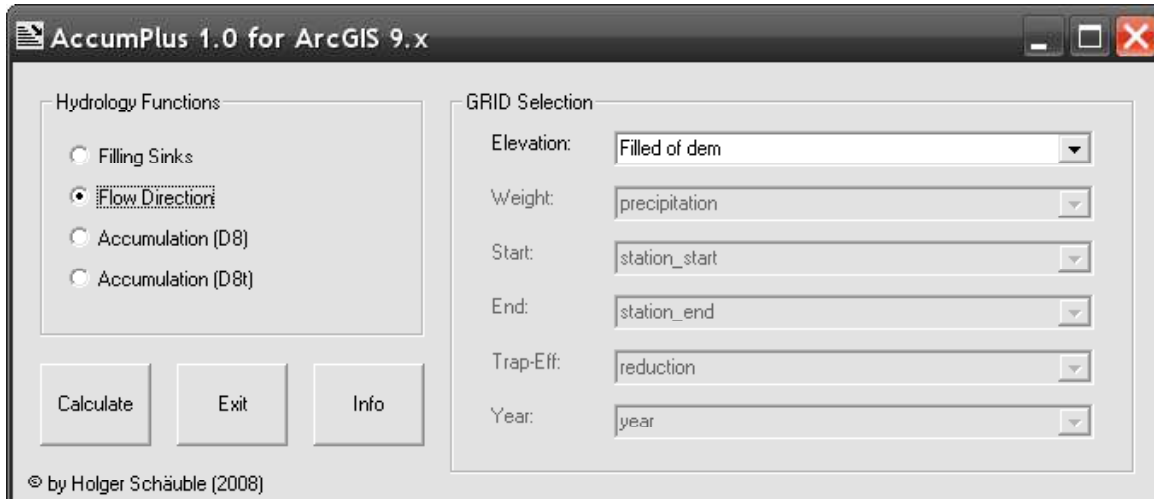
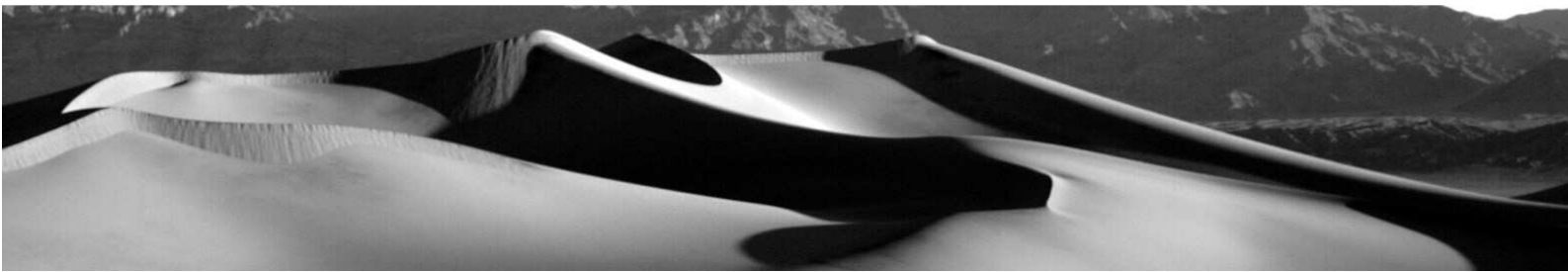
Filling Sinks function

Function to correct a digital elevation model by filling dischargeless sinks. Just one grid necessary: digital elevation model that needs to be corrected, other options and combo boxes are greyed out. For more information (see Schäuble, 2004). Genuine ESRI function of the Spatial Analyst extension.



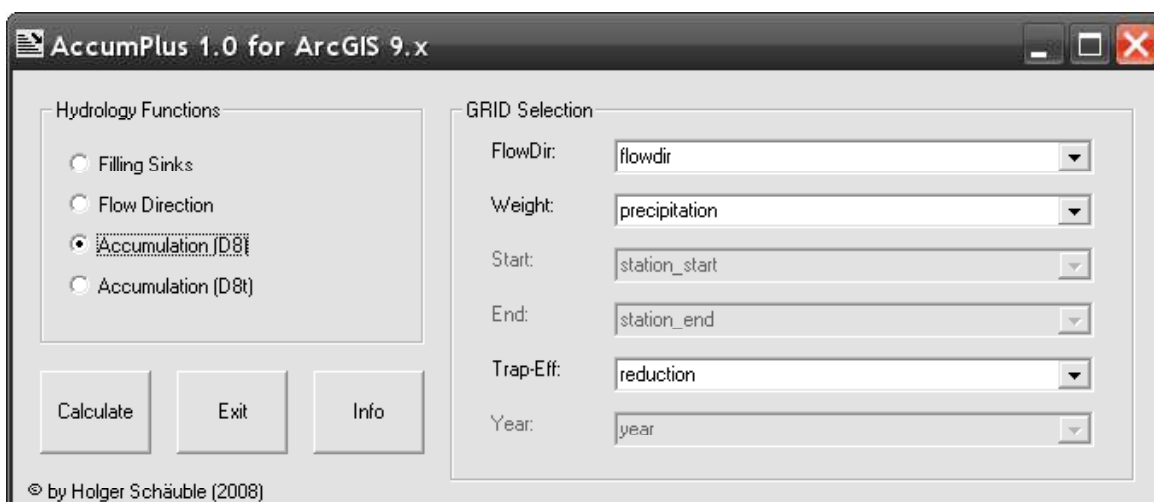
Flow Direction function

Function to calculate the flow direction from a corrected digital elevation model. Just one grid necessary: digital elevation model that needs to be corrected, other options and combo boxes are greyed out. The derived flow direction grid acts as input for the next two functions "Accumulation (D8)" and "Accumulation (D8t)". For more information have a look at ESRI online help, ESRI (2005) or Burrough & McDonnell (1998). Genuine ESRI function of the Spatial Analyst extension.



Accumulation (D8) function

Function to calculate the flow accumulation from a flow direction grid. The derived result will look like in Fig.7 (5), the calculation principles are show in Fig. 8. The user has the option to select additional weight and trap-efficiency grids (upper screenshot), other options are greyed out. In general just a flow direction grid is needed. If no weight or trap-efficiency grid is selected (<None> in the Weight and Trap-Eff combo box, lower screenshot), all pixels will have the same weight (value of 1) and no flow reduction will happen (trap-efficiency of all pixels = 0%).



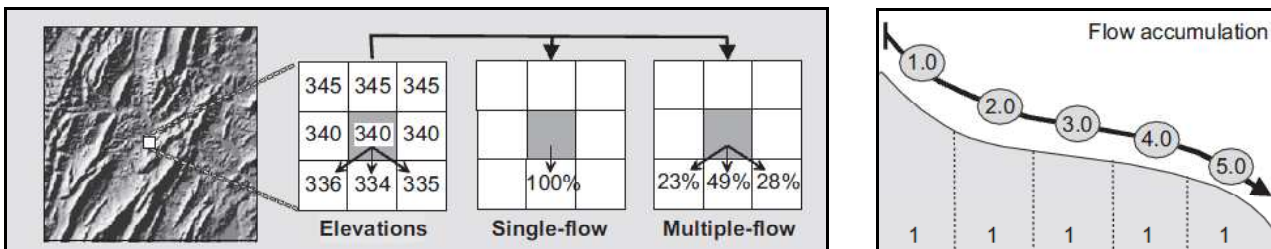
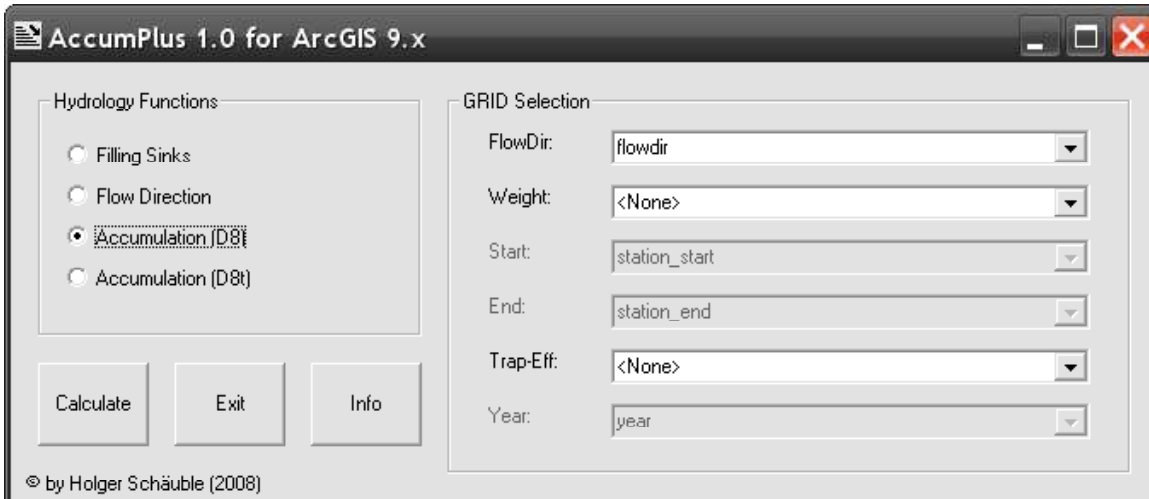
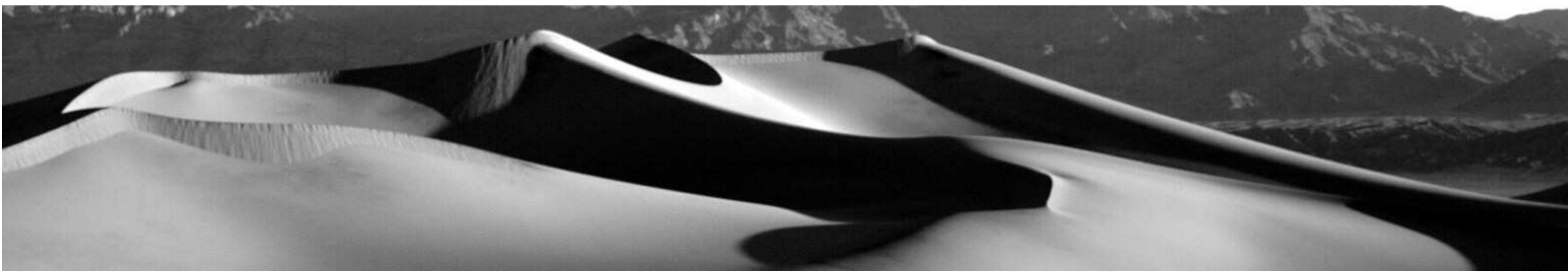
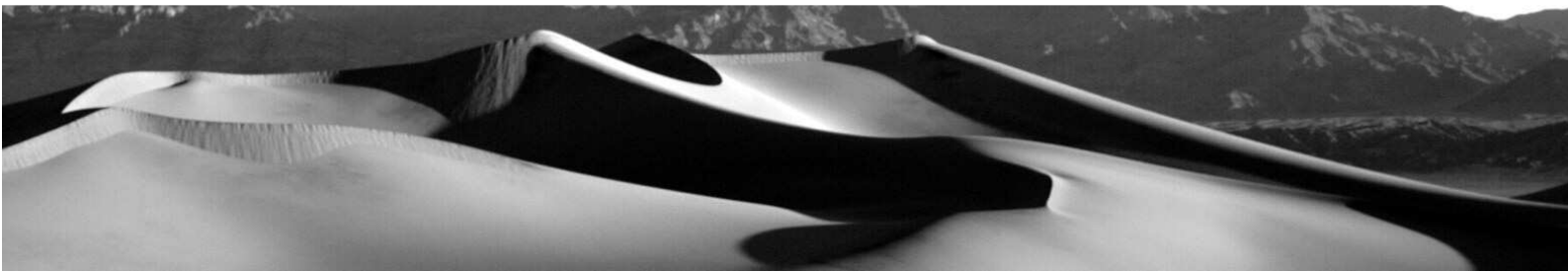


Figure 8: Basics of flow accumulation. Left: Different algorithms. Right: Unweighted flow accumulation along a hillslope (weight of each pixel = 1) (from Schäuble et al., 2008).

Accumulation (D8t) function

Function to calculate flow accumulation with the new D8t algorithm from a flow direction grid by considering the trap-efficiency of dams/sinks and their specific operation time. A short overview can be viewed in Fig. 9, a detailed description is given in Schäuble et al. (2008). 5 grids are obligatory in any case: a flow direction grid (FlowDir combo box), two grids that give information about the beginning (year first measurement in the Start combo box) and end of a sampling period (year of last measurement in the End combo box) and two grids that give information about the dams/sinks in the watershed or catchment: a grid with information about the trap-efficiency of sinks, i.e. the reduction of flow in % (from 0 to 100%) and grid with the year of the dams



construction or the beginning of the sink (Year combo box). The user has the option to select an additional weight grid (i.e. a precipitation grid). If no one is selected (denoted by <None> in the Weight combo box), all cells are treated equally with a value of 1.

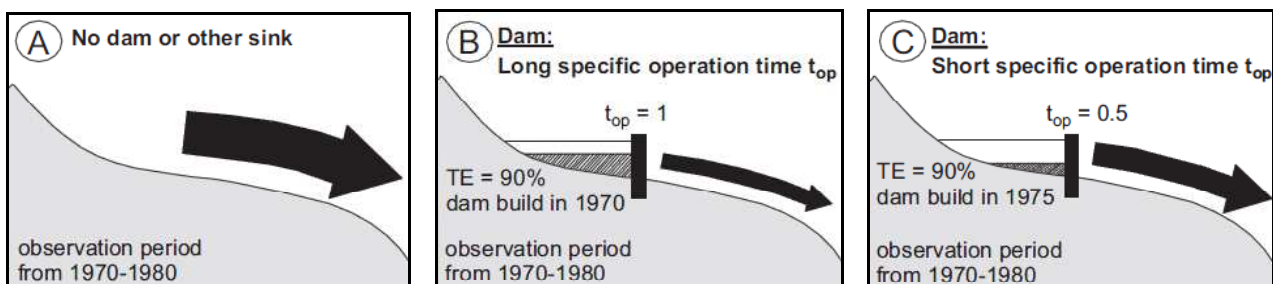
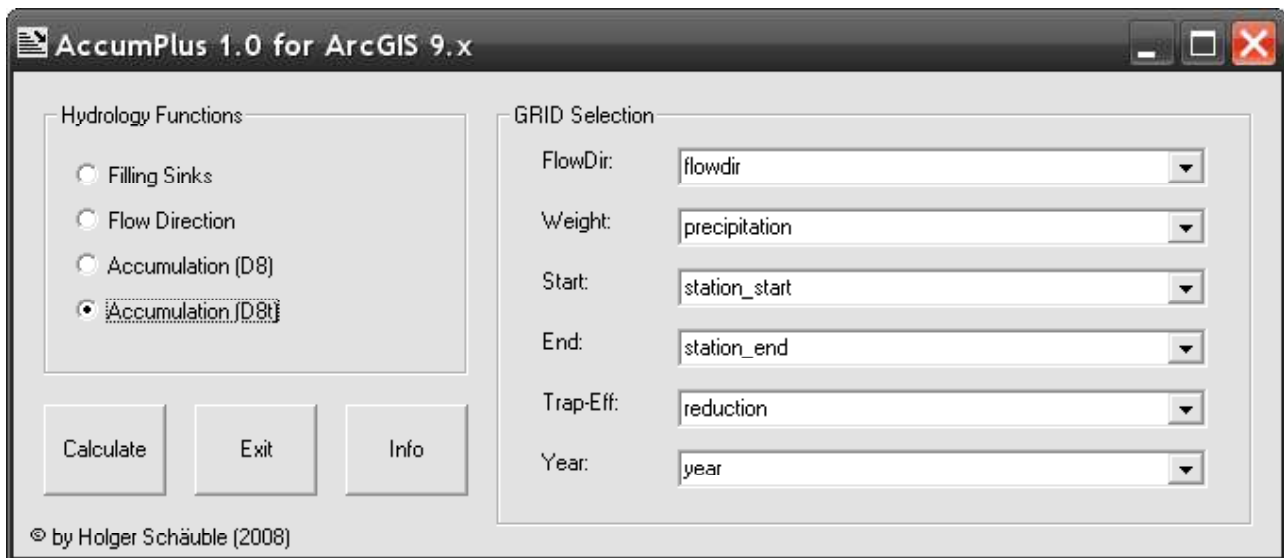
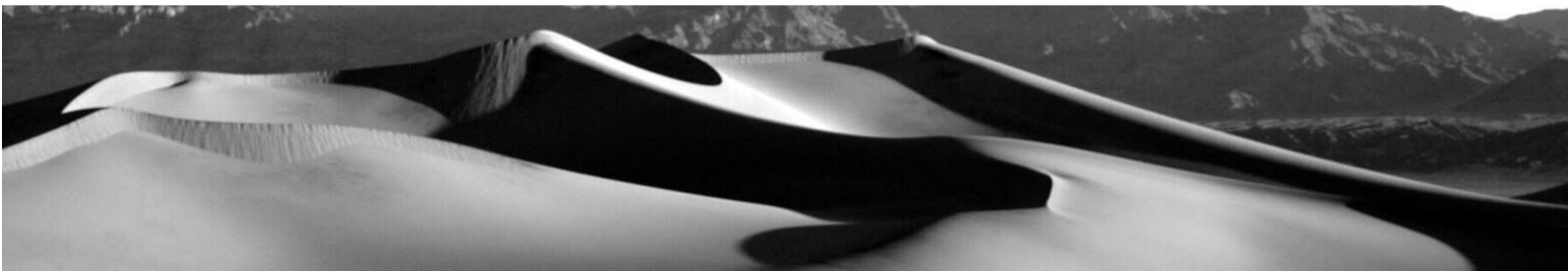


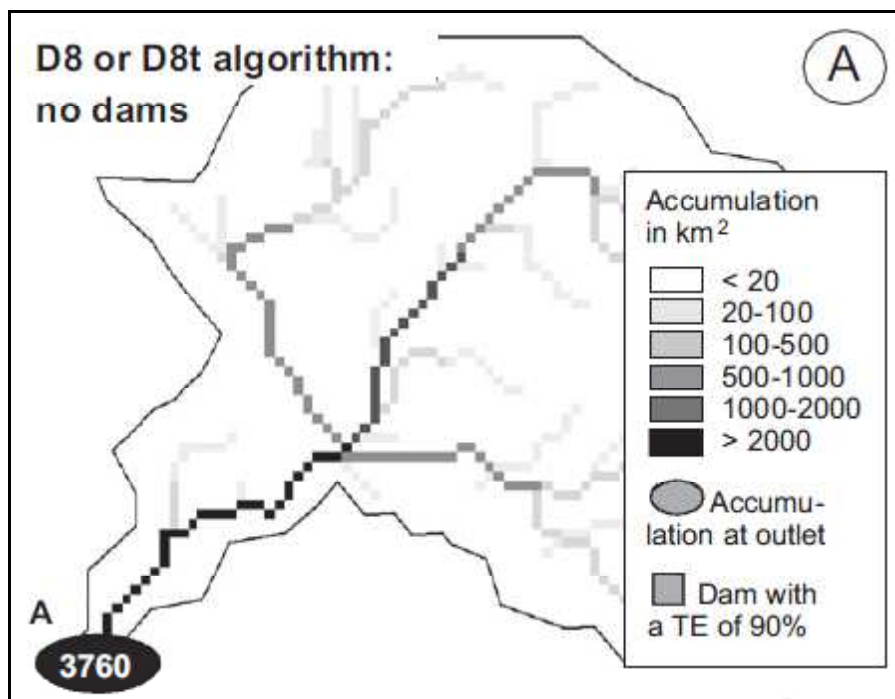
Figure 9: Basic principles of calculations with the D8t algorithm. TE = trap-efficiency in %. A: No sink or dam: all flow is transferred downslope with no reduction. B: Permanent sink or dam that exists during the entire observation period: all flow is reduced by 90% from the sink. C: Temporary active sink or dam (5 years during the sampling period from 1970-1980): all flow is reduced less compared to case B because of the reduced specific operation time (from Schäuble et al., 2008).

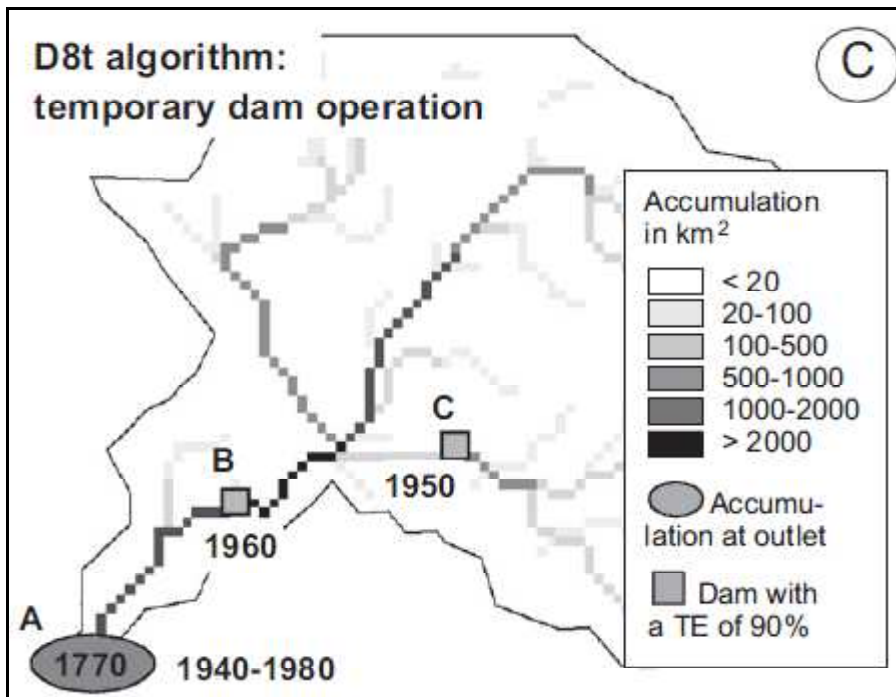
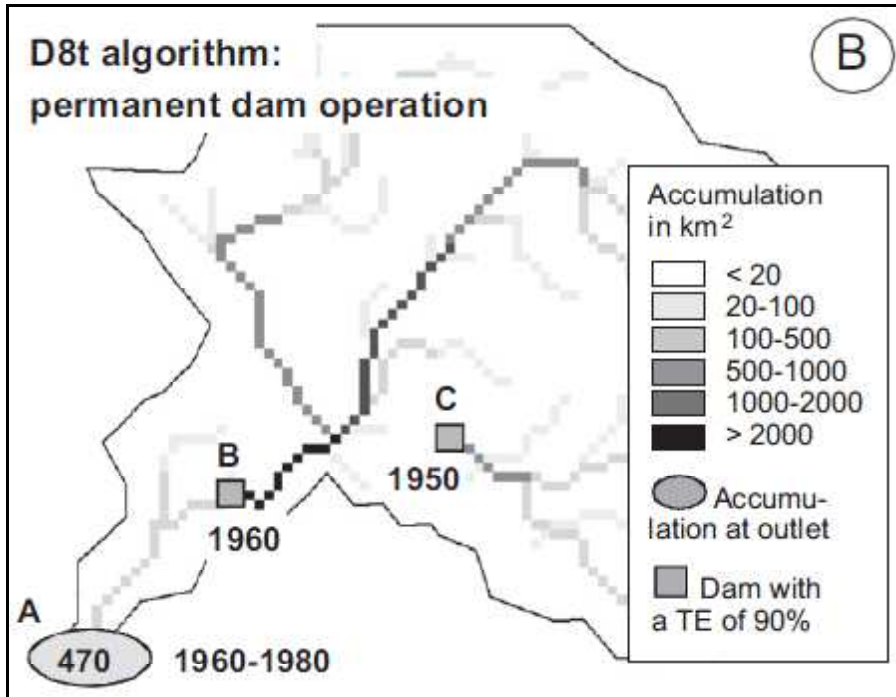
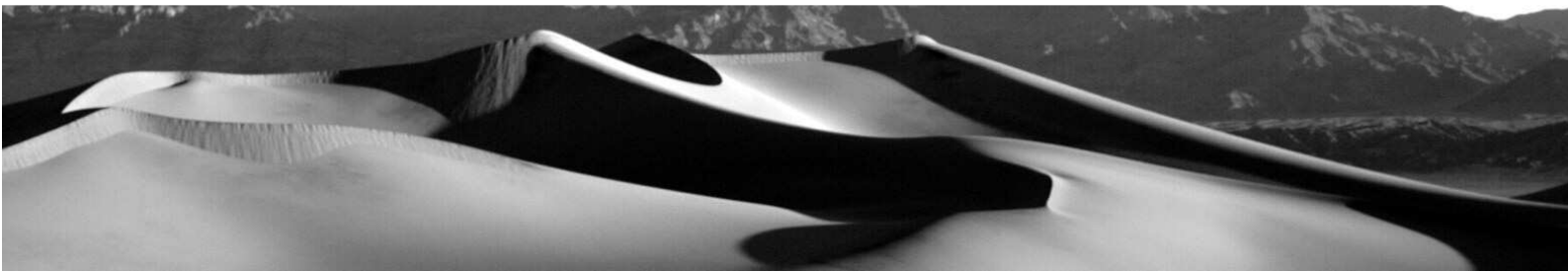


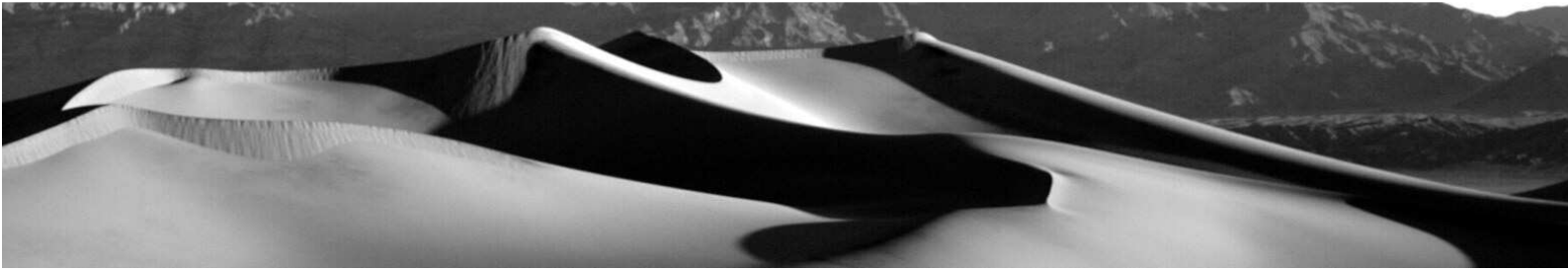
4. Sample calculations in Computers & Geosciences

For better imagination on how AccumPlus works several sample calculations have been made for Computers & Geosciences. These show the differences between an ordinary D8 accumulation with no weighting grid and no sinks/dams (Fig. 10, A), an advanced D8 accumulation with no weighting grid but permanent sinks/dams (Fig. 10, B) and a sophisticated D8t simulation by considering sinks/dams and their variable influence in time (Fig. 10, C). Because of the different flow reduction the accumulation values in the catchment and at the outlet are quite different: 3760 (A, no reduction), 470 (B, permanent and large reduction) and 1770 (C, temporary and thus less larger reduction). A detailed description is given in Schäuble et al., 2008.

Figure 10 (this and next page): Accumulation with D8t algorithm. TE = trap-efficiency in %. A) No dams. B) Permanent dam operation. C) Temporary dam operation.

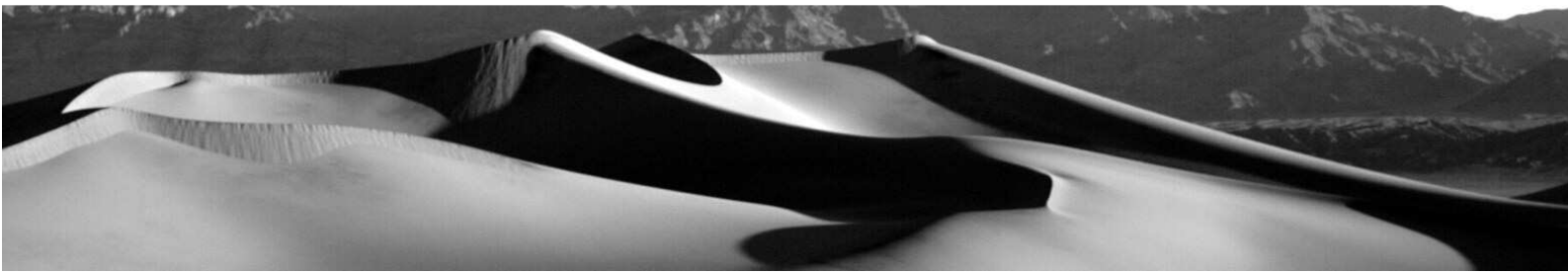






5. Important hints and troubleshooting

- AccumPlus works with all grid datasets that have a size of not more than 10000*10000 pixels. Grids with more than 10000*10000 pixels are supported by AccumPlus Professional which can be purchased from www.terracs.com on request.
- Only ESRI grids are supported, other raster datasets (like tif or Erdas img images) have to be converted to ERSI grids before doing the analysis.
- No environment checking is made. The user has to ensure that the cell sizes and the extents of all grids are identical. Check this by selecting the following menu items:
 - a) ArcGIS 9.x: Spatial Analyst – Options...or Layer Properties – Source....
 - b) ArcView 3.x: Analysis – Properties ...
- No data values are supported during the analysis. Grids in the Start, End, Year and Trap-Eff combo boxes: Pixels with values other than no data are treated as measurement stations (Start and End combo box) or sinks/dams (Trap-Eff and Year combo box), pixels with no data values are treated as areas with no measurement stations or sinks/dams respectively. In those cases no flow reduction is made during the analysis.
- Keep care that the pixels with values in the Start and End combo boxes or the Year and Trap-Eff combo boxes do share the same location (Fig.4). If a pixel at a dam location has trap-efficiency value but no associated year value (e.g. if the cell is misclassified as no data instead the construction year), the results of the analysis will not be correct. Similar problems will happen in case of the measurement stations.
- AccumPlus writes the new grids in the (last) active directory by default. Keep care that you have the authorization to write datasets in that directory (check with File – Add data...). If not just use the Add data button and navigate to a directory where writing operations are allowed.
- AccumPlus for ArcGIS 9.x uses the typical libraries of ArcGIS 9.x and will therefore not work with earlier versions (ArcGIS 8.0 – 8.3). It is not planned to create a separate version for ArcGIS 8.x.



References

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ArcGIS 9. Geoprocessing Commands Quick Reference Guide, ESRI Press, Redlands, 175 pp.
- Burrough, P.A.; McDonnell, R.A., 1998:
Principles of Geographic Information Systems. Oxford University Press. Oxford (UK). 342 p.
- Schäuble, H., 2004:
HYDRO TOOLS 1.0 for ArcView 3.x - Hydrological analysis of large and small watersheds, Software and Manual, TERRACS, Tübingen, Germany, <http://www.terracs.com>, 17 pp.
- Schäuble, H., Marinoni, O., Hinderer, M., 2008:
A GIS-based method to calculate flow accumulation by considering dams and their specific operation time. Computers & Geosciences. <http://dx.doi.org/10.1016/j.cageo.2007.05.023>