

HOW TO...

MAKE A FLOW PATHWAY ANALYSIS

STEP-BY-STEP MANUALS AS PART OF T4.3.1 MODULE FOR
ASSESSMENT AND MAPPING OF HEAVY RAIN RISKS
(RAINMAN TOOL 1)

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T4.3.1 Module for assessment and mapping of heavy rain risks (RAINMAN Tool 1)

How to... make a flow pathway analysis

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1. Introduction

1.1. Short background on digital elevation models and flow pathways

What are digital elevation models?

Digital elevation models are approaches to describe the terrain surface in a way, that computers can display them and use them to calculate additional information, e.g. terrain slope, exposure, flow direction etc. They are also called digital terrain models (DTM). The surface might contain artificial elements such as buildings as well as vegetation.

What types of DEMs exist?

There are two main types of DEM representations: 1) Triangulated irregular networks (TIN) with elevation information at points and arcs connecting these points in a triangulated way. The terrain is approximated by the resulting triangle surfaces. 2) Regular rasters or matrices with elevation information at the centre of each of the raster cells. This type will be used in this manual.

What are sources of DEMs?

DEMs can be processed by digitizing of elevation lines from paper maps, terrestrial surveying, photogrammetric methods as well as remote sensing techniques based on RADAR or LIDAR (“Laser-Scanning”).

What are flow pathways?

Flow pathways are the routes that the water takes on its way downwards. A pathway is characterised by a concentration of the surface runoff that happens along a thalweg, i.e. the line of the lowest points along a valley or smaller linear depressions in the landscape. Flow pathways might also occur along linear elements such as field borders, field furrows, road embankments etc.

What is flow accumulation?

Flow accumulation is another term to describe the process of the concentration of surface runoff mainly by the convergence of runoff from different areas in the landscape. It is often used to describe the potential catchment area of a certain point in the landscape. Flow accumulation analysis is synonymously used for flow pathway or catchment area analysis.

What are flow directions?

Flow directions are the orientations (typically in compass directions) that show the steepest slope from a certain point to its lower neighbour and that is assumed to be the main direction of the surface runoff.

What is catchment area?

Catchment area is the sum of the surfaces that drain to a certain point. The higher the catchment area value, the more water can be expected at this point in case of a heavy rain event.

1.2. Methods for flow pathway analysis

The following example for a flow pathway analysis is based on the D8 method (based on 8 deterministic flow directions). Fig. 1a shows the 8 potential directions the water can take. The method looks for the steepest gradient between the current cell in the centre and its 8 neighbours and sets this direction as the direction where all the water is routed to. Fig. 1b shows an example raster with elevation values and Fig. 1c the result of the flow direction analysis. In a final step shown in Fig. 1d the number of cells that are



connected to each other via a kind of inflow cascade is calculated. In a simple form each cell has a value of one, in a more precise form the values that are summed up are the cell areas. The sum of the areas of cells that drain to a certain cell are the hydrologic surface catchment area of this cell. The higher this value, the more water is to be expected to flow at this point. Typically high values are associated with “downstream” positions along linear depressions such as ditches, gullies or valleys and often a threshold can be found, where in reality permanent streams appear. In case of heavy rain events, the network of these high catchment area cells representing the flow pathways give hints where water might accumulate and substantial water levels and flow velocities might be observed (the latter also depending on slope distribution/steepness of the catchment area). This process of surface water accumulating by confluence is called runoff concentration and this analysis method is therefore also named catchment or flow accumulation analysis.

Besides the D8 methods that assumes that all the water is solely routed to the steepest neighbour, alternative methods exist that try to come closer to reality where a flow of water can also be observed to other areas (=cells in the model) that are relatively lower to the position or cell under consideration.

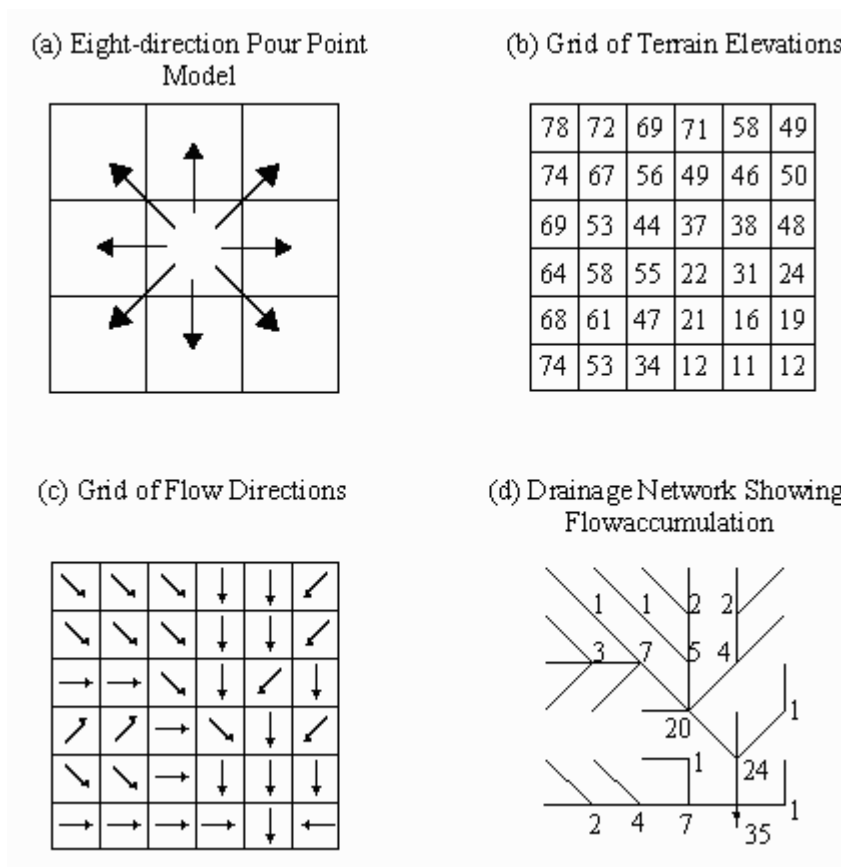


Fig. 1 Examples for the different processing steps of a flow pathway analysis¹

¹ <http://www.ce.utexas.edu/prof/maidment/gishydro/seann/texas/f51.gif>

2. Step-by-step manual

2.1. Prerequisites

To carry out the following steps you need:

- a digital elevation model of your area of interest (or alternatively for testing purposes the sample data provided here) without sinks (e.g. the result of the manual “How to... prepare a depressionless digital elevation model”).
- SAGA-GIS [<https://sourceforge.net/projects/saga-gis/files/>] or QGIS with SAGA-GIS module [<https://www.qgis.org/en/site/forusers/download.html>].

2.2. Processing steps

Start SAGA-GIS

Go to File|Open and navigate to your DEM dataset to load it.

After SAGA-GIS has read the dataset you see it listed in the left window under the “data” tab. Raster data in SAGA-GIS is called “Grids”. In the tree list of the grids you get some short meta-information about your grids called the “grid system”. The first number shows the raster or cell width, the next two numbers give the columns and rows, and the last two number the origin of the grid in map coordinates related to the lower left corner.

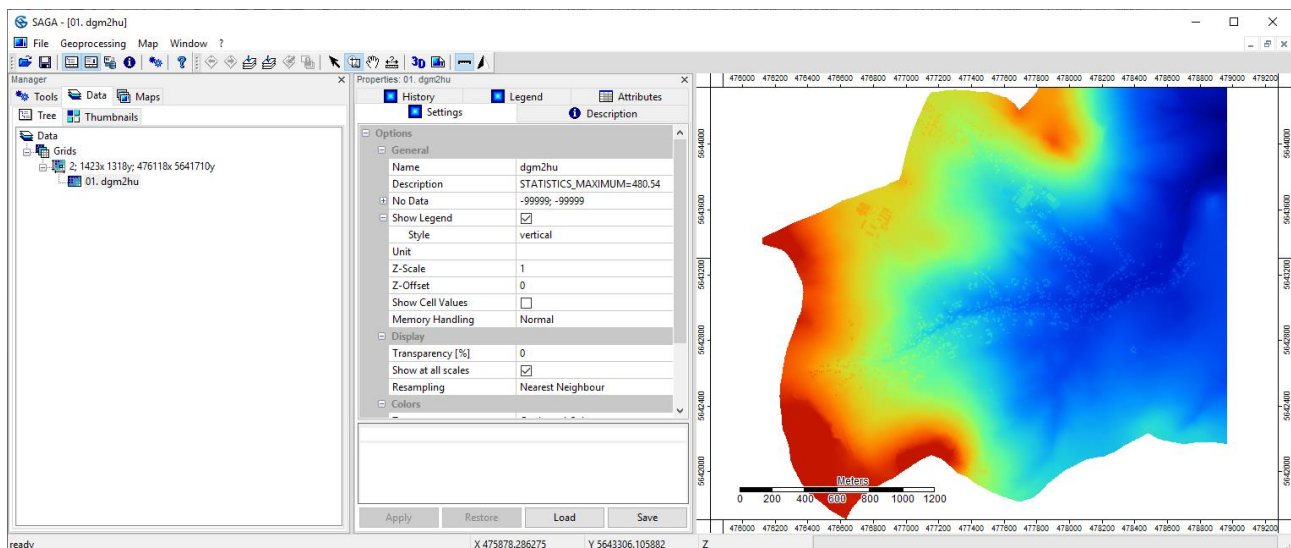


Fig. 2 SAGA-GIS program window with visualisation of DEM

Go to the “Tools” tab, move in the “Tool Libraries” tree to Terrain Analysis|Hydrology and open tool “Flow Accumulation (Recursive)” via double click.

In the tools window that appears select under the “Grids” heading your grid system first, than the filled/depressionless DEM grid and set the “<<Flow accumulation” field to “<create>” and leave all other fields to “<not set>”. Under the “Options” heading set the “Step” value to 1, “Flow Accumulation Unit” to

“cell area” (because than all result values van be interpreted as catchment areas) and select “Method” as “Deterministic 8”. Click “Apply” and “Execute”.

Repeat these steps for the three alternative methods “Rho 8”, “Deterministic Infinity” and “Multiple m-flow Direction” and rename after each run the result grids in the “Properties” tab to MyDGMMName_d8, MyDGMMName_r8, MyDGMMName_di and MyDGMMName_mf (or you will end with four grids all named “Flow Accumulation”). To save typing, you can copy the names of your grid via double-click on the text in the “Name” field and using “Ctrl-C” and “Ctrl-V”.

When running the tool again, make sure to set “<<Flow accumulation” to “<create>”, otherwise your prior result will be overwritten!

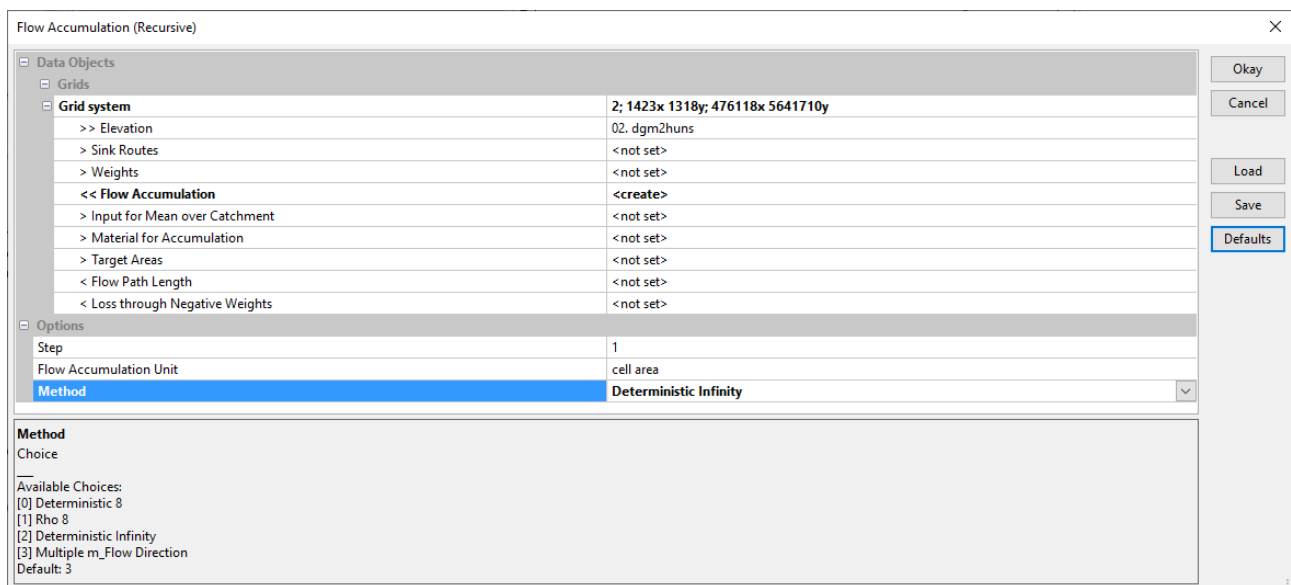


Fig. 3 Tool window “Flow Accumulation (Recursive)”

After carrying out the above steps, you should have five grids in your data tab: the depressionsless DEM as input and the four different flow accumulation grids.

Let’s have a look at the different results and create some maps. But wait, before doing this we will create a so called “shaded relief map”, i.e. a map of the terrain with brighter areas and shadowed areas as if the sun was shining on the terrain. To do this, got to the tools tab and select “Terrain Analysis|Lightning, Visibility” and there the tool “Analytical Hillshading”. As with the tools before, select grid system and elevation grid (e.g. your depressionsless DEM). Under “Options|Shading Method” select “Combined Shading” and set “Exaggeration” to 10. Double-klick on the new grid named “Analytical Hillshading” to view it in a new map. In the window that appears (see Fig. 5) select “New”.

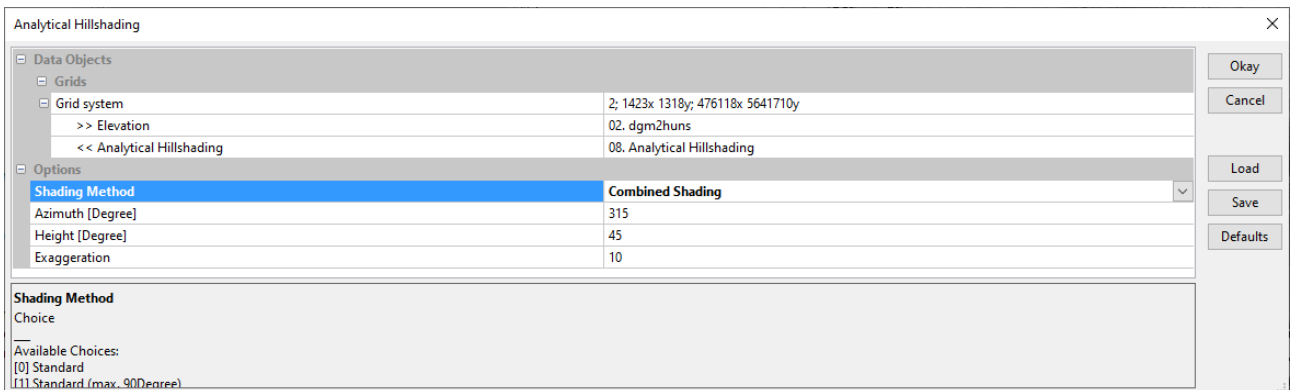


Fig. 4 Tool window “Analytical Hillshading”

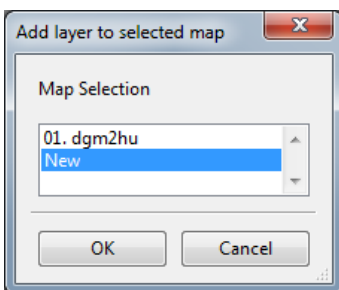


Fig. 5 Layer to map selection window

Choose the “Settings” tab from the “Properties” window in the middle. Got to the last row with the field “Mode” and change from “Linear” to “Logarithmic (up)”, click “Apply” and see what happens. You can now change the value in the field “Logarithmic Stretch Factor” until the maps gives you a good visual impression of your terrain.

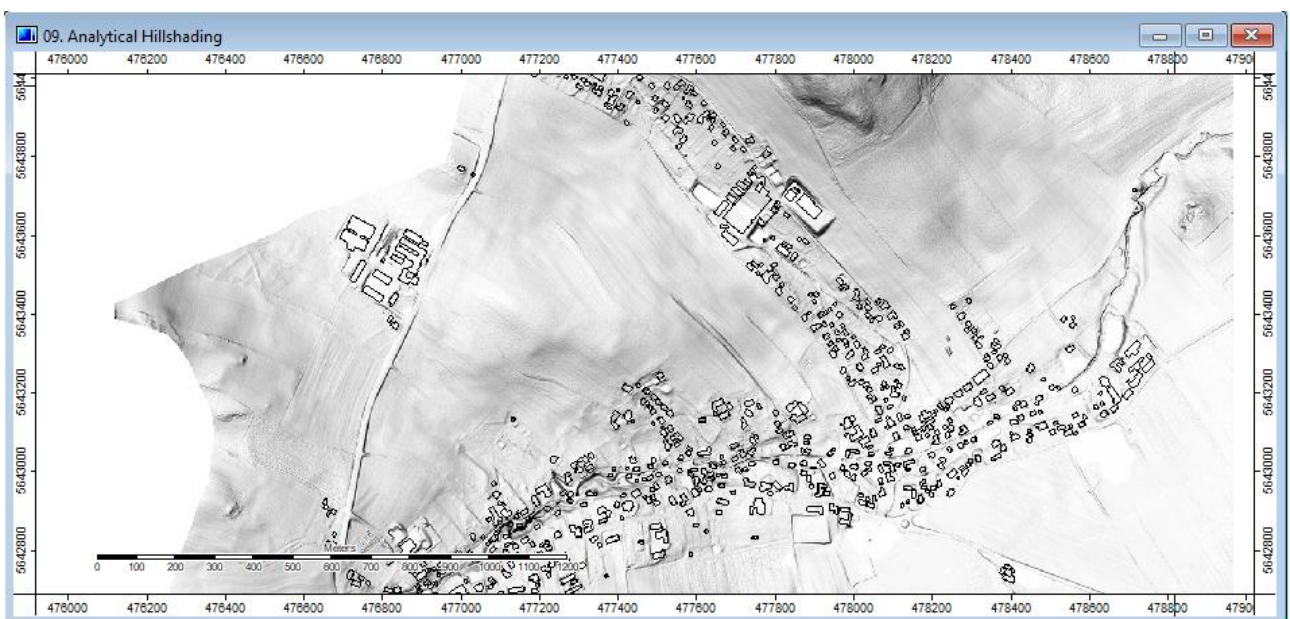


Fig. 6 “Logarithmic Stretch Factor” 1



Fig. 7 “Logarithmic Stretch Factor” 20

Now go to the “Maps” tab in the manager window on the left side and select the map you just created. It should have the same name as the grid that you used for creating the map, e.g. “Analytical hillshading”. In the “Properties” window in the middle select “Settings” tab and change “Name” to “Flow Accumulation D8”. Go back to “Data” tab and double-click on the grid MyDEM_d8. The following window should appear:

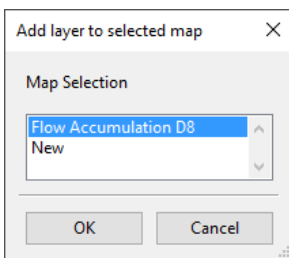
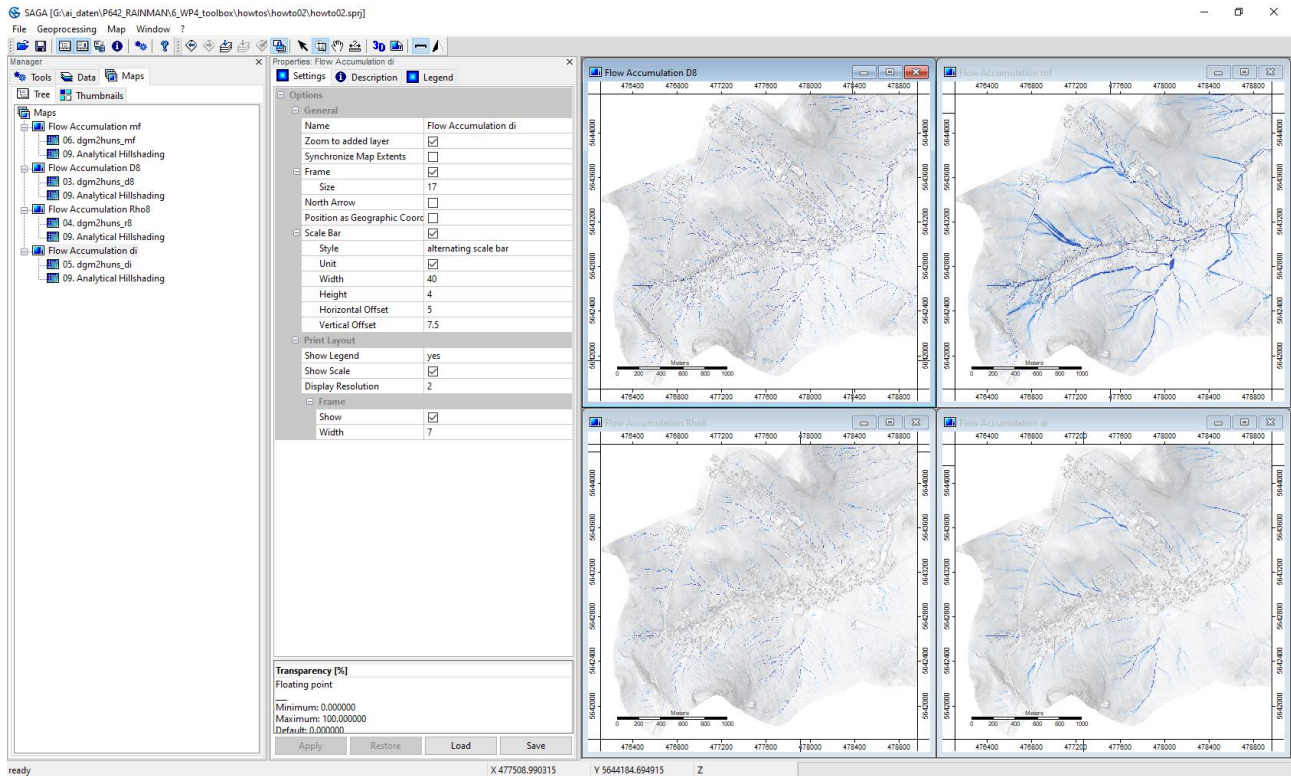


Fig. 8 Layer to map selection window with adding layer to an existing map

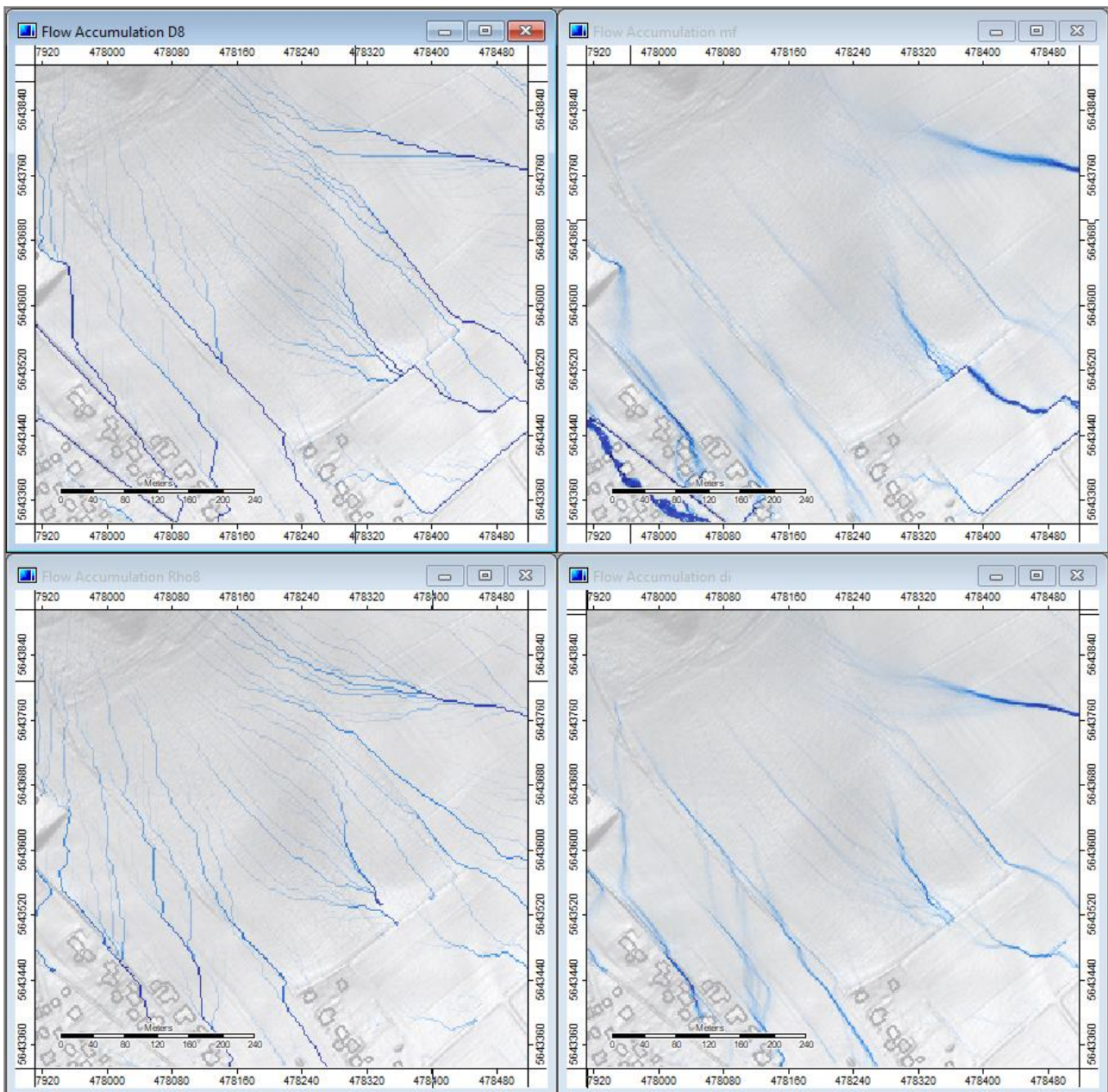
This time select your existing map “Flow Accumulation D8” and click OK. The flow accumulation grid will now be placed over the hillshade grid (see order in “Maps” tab). In the first view it seems as if the hillshade has disappeared. Click the “MyDEM_d8” grid and in the “Properties|Settings” tab go to “Display|Transparency” and change the value, click “Apply” and see what happens.

You can now create a map for each result. Double-click on the “Analytical Hillshading” grid and select “New” for a new map. Go to the “Maps” tab and rename the map e.g. with the name of the method. In the “Data” tab, double-click the result grid of a method and select the according map name to add the layer. Under “Settings” adjust the “Transparency [%]” value that looks best for you.

You should now have four different map windows. To compare the results, go to the main menu and select “Window | Tile horizontally”.



Now to zoom in to compare at a more detailed level, activate a map by clicking its frame and click the “Synchronise Map Extents” icon (lock symbol, left to the arrow icon). Do this for each map. Select the “Zoom” icon (magnifying glass, right to the arrow icon). Your zoom and pan actions will now be synchronised between all map windows so that you see the same area in all windows. If you want to keep the zoom level and change the location, activate the “Pan icon” (white hand).



As you might experience, the flow pathways are quite different. If you have knowledge about observed flow pathways, you can compare them with these results to choose the method that comes closest to the real world situation.

RAINMAN Key Facts

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ERDF funding: 2,488,510 €

RAINMAN website &
newsletter registration: www.interreg-central.eu/rainman



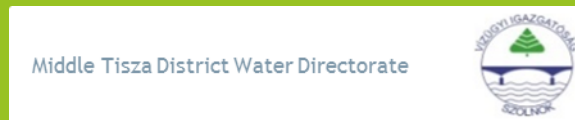
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