

# HOW TO...

## PREPARE A DEPRESSIONLESS DIGITAL ELEVATION MODEL

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... prepare a depressionless digital elevation model*

Version 2            18.06.2020

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# 1. Introduction

## 1.1. Short background on digital elevation models and depressions

*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 depressions/sinks?*

Depressions that have no drainage, i.e. areas that are completely surrounded by higher points are also called sinks. They can be of natural origin or artefacts of the DEM processing, e.g. as a result of so called “filtering” where vegetation and buildings are removed from the model to get a “bare earth” surface.

## 1.2. Depressions and flow path analysis

In the manual “How to... make a flow pathway analysis” a short description of the theoretical background of flow path analysis methods is given. An important principle requirement of a sound flow accumulation analysis is a DEM without depressions. Fig. 1 shows what happens to a flow path that leads to a sink. In nature especially smaller sinks will fill up with water and the surface runoff will continue. In the flow path analysis the accumulation stops and a new path starts with a new accumulation cascade. In the result you get an underestimation of the flow accumulation process and the real catchment area of a point.

To bridge this gap and to come closer to reality, it is necessary to “fill” such sinks in your DEM to enable continuous flow pathways. This manual will show you one possible solution.



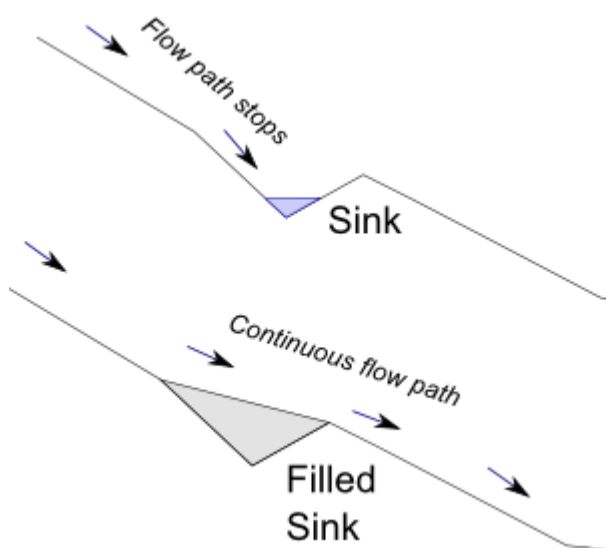


Fig. 1 Schematic representation of the sink filling procedure<sup>1</sup>

### 1.3. Depressions as a source of information about ponding areas

*How can the identification and quantification of depressions help in identifying areas prone to ponding?*

As a by-product of the sink filling procedure, you get a dataset of the filled sinks via a simple subtractive comparison of the filled DEM and the original DEM. The resulting map (see Fig. 8) gives information about areas that might fill up with water in reality during a heavy rain event. With the depth information resulting from the comparison and the cell area, it is possible to calculate storage volumes of such sinks. A depth classification can be used to identify major sinks or “hazardous” sinks.

## 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).
- 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

<sup>1</sup> <https://sagatutorials.files.wordpress.com/2016/11/image072.png>

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.

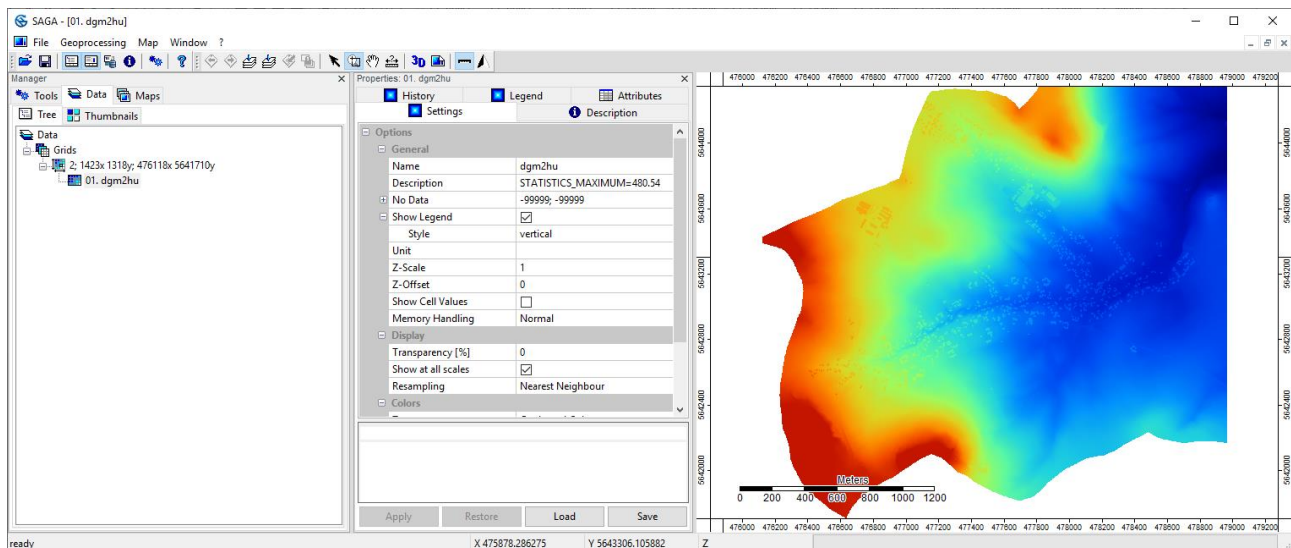


Fig. 2 SAGA-GIS program window with visualisation of DEM

Go to the “Tools” tab, move in the “Tool Libraries” tree to Terrain Analysis|Preprocessing and open tool “Fill Sinks (Planchon/Darboux, 2001)” via double click.

In the tools window select your grid system first, than the DEM grid and set the “Filled DEM” field to “<create>”. Set the “Minimum Slope [Degree]” value to 0.01.

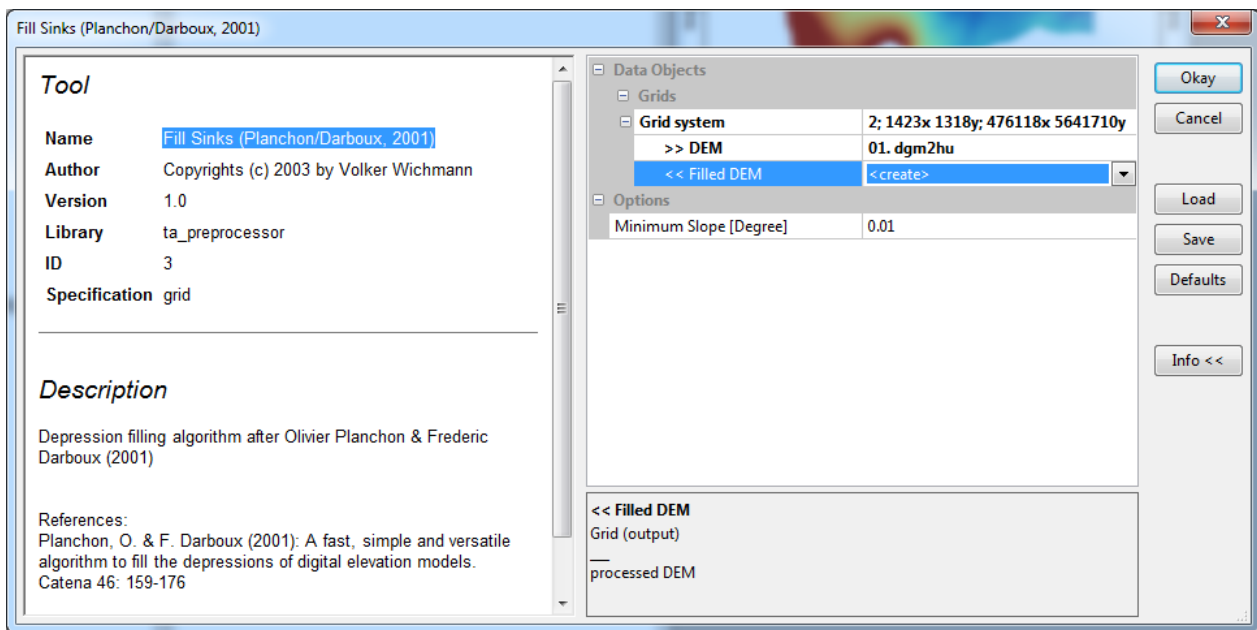


Fig. 3 Tool window “Fill Sinks (Planchon/Darboux, 2001)”

Click the “Okay” button and run the tool. Go to the data tab. A new dataset with identical grid system should be there named “My\_DEM\_Name [no sinks]”. If the “Properties” window (see Fig. 2 in the middle) is not visible, go to the text menu bar “Window” and click “Show object properties window”. Select there the “Settings” tab and double-click in the “Name” field to give the filled DEM a better name, e.g. MyDGM10ns (ns=no sinks). Press the return key and then the “Apply” button. The name in the “Data” tab should have changed now. To permanently save your calculation result, right-click on the grid in the “Data” tab and choose “Save as...” and select a location. The dataset is saved in the SAGA-GIS format - .sgrd that can be read by most GIS software. This dataset will be used in the manual “How to... make a flow pathway analysis”.

Double click to show it in a map window. In the window that appears (see below) select “New”.

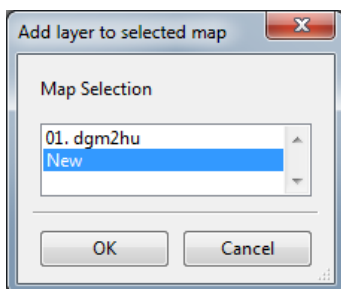


Fig. 4 Layer to map selection window

In the Tools tab move to Grid|Calculus and open the “Grid Calculator” tool. Select the grid system and both grids within the selection windows via Drag & Drop or by clicking the arrows in the middle.

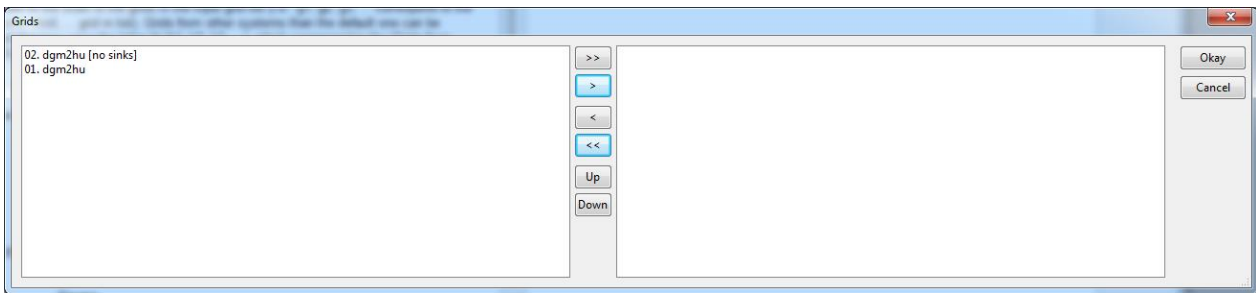


Fig. 5 Layer to map selection window

In the Formula field you can calculate with the grids and address them via a short name that consists of the letter “g” and the running number of the grid in the objects list. To calculate the difference between the grids with and without filling to see the filled areas, subtract the original DEM from the filled DEM with the formula “g1 - g2” and set Name to “sinks”. Press “Okay”.

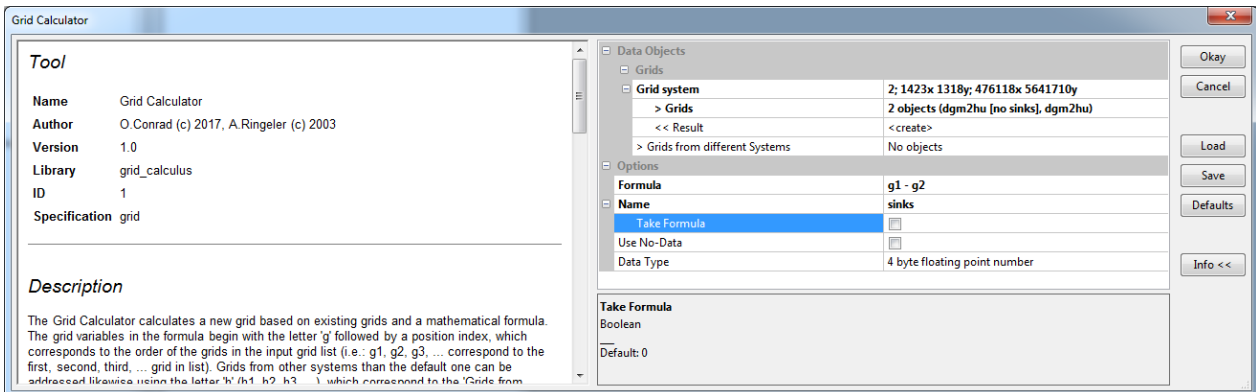


Fig. 6 “Grid calculator” tool window

The result is a grid with the difference value, i.e. the depth of the filled sinks.

Got to the Data tab and open a map window with the sinks grid via double clicking. In the “Settings” tab in the middle go to the “Colors” field and click the icon with the three points. In the “Colors” window click the “Presets button” and choose “white > blue” and press all Oks.



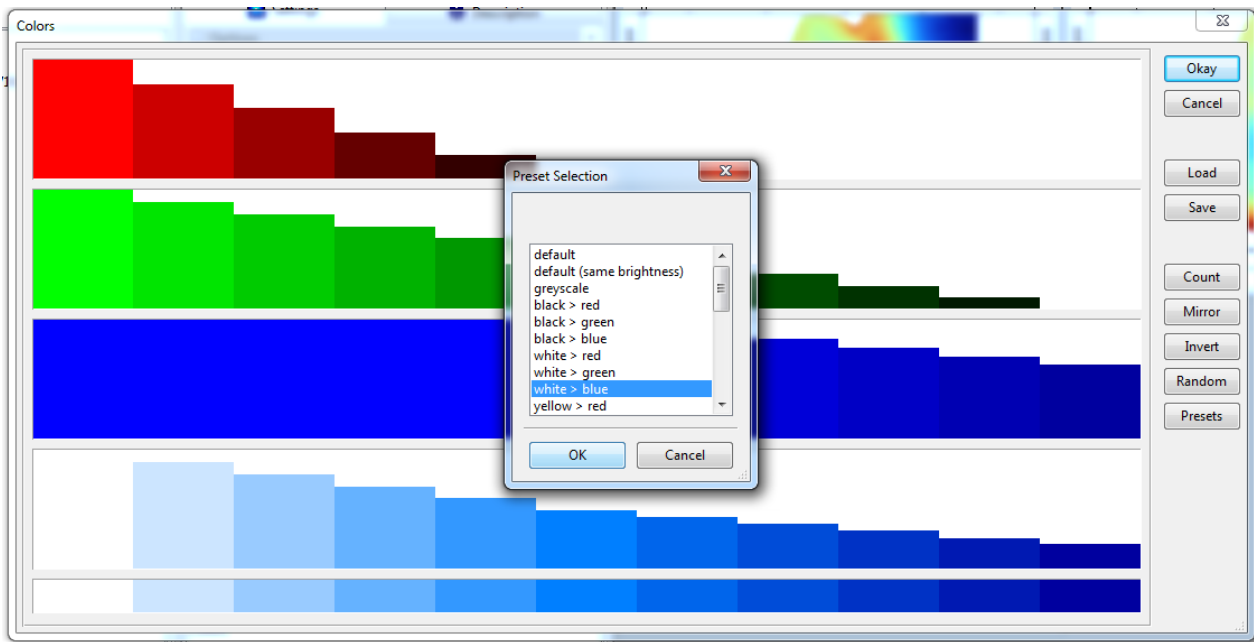


Fig. 7 Color selection window

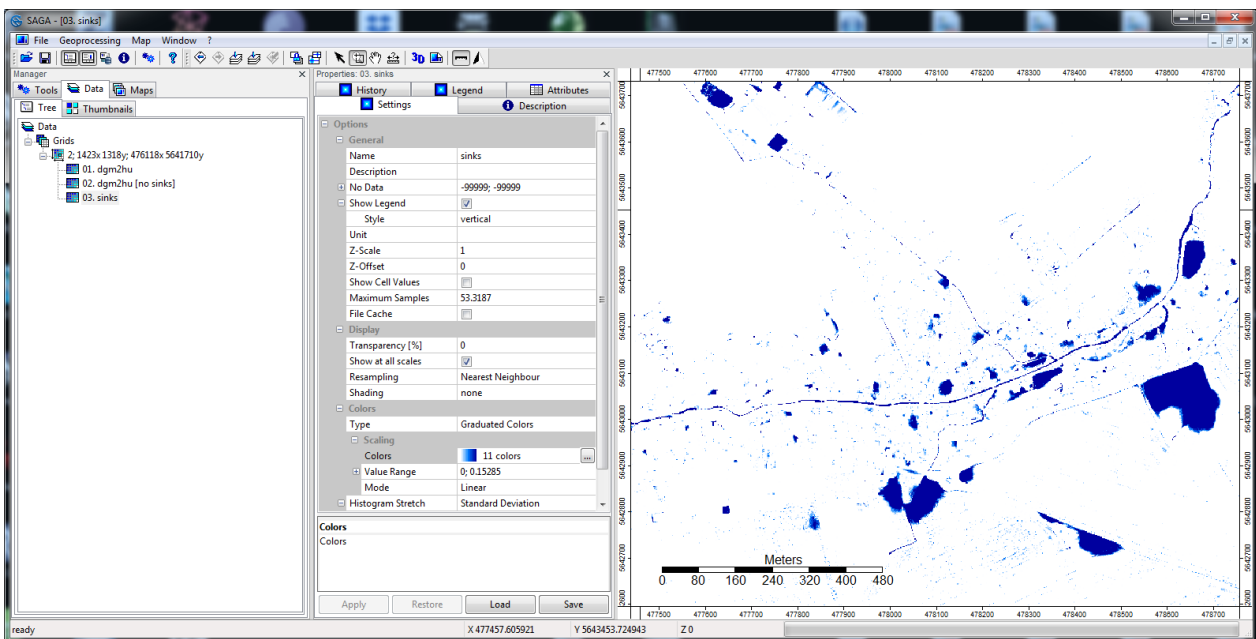


Fig. 8 Result map with depth of depressions

If you identify areas in this map that are sinks that you consider as “real”, e.g. an empty reservoir or rainwater pond, you need to manually “unfill” these areas back to the original elevations or mask these areas during the sink filling process.

# RAINMAN Key Facts

Project duration: 07.2017 – 06.2020  
Project budget: 3,045,287 €  
ERDF funding: 2,488,510 €

RAINMAN website &  
newsletter registration: [www.interreg-central.eu/rainman](http://www.interreg-central.eu/rainman)



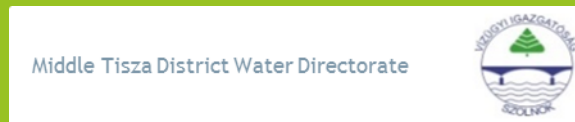
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