

## Assignment: Cellular Automata – hydrological run-off model

In this assignment, you will model water run-off in a digital elevation model. Water run-off is a process that extends continuously over space. This makes it a perfect process to be modelled with a Cellular Automaton. While we stay with the application area of hydrology, this diffusion process can also be applied to many other domains, like urban sprawl, the spread of a disease, or the expansion of invasive species.

The assignment directly builds on the exercise of Lesson 6. Therefore, I strongly recommend to work through the exercise, before you start with the assignment. In case you are not much experienced with programming in general, I also recommend to first work through the first section of the chapter Coding 101: Part I: Good practice in coding.

### Your task

You will model the water of a spring as it flows down along the valleys of a mountain landscape. Visualise the simulation with a map and a chart.

- The map shows the DEM. Only cells that are currently covered with water shall be blue.
- The chart shows the lowest elevation, which the water has reached over time.

### Instructions

#### 1. Create a new GAMA model

Create a new model in your “UNIGIS models” GAMA project.

#### 2. Prepare your own raster data

Download a DEM Digital Elevation Model of a mountainous region close to you. A platform that offers void-filled DEMs with a global coverage is here:

<http://www.viewfinderpanoramas.org/dem3.html>. Of course, you can also use other data sources.

Note the following constraints:

- GAMA can work either with ESRI .asc grid files, or with .tif (geo)tiff files that have pixels of an 8bit data type ( $2^8 = 255$  integer values).
- the data are void-filled (especially SRTM sometimes has so much backscatter that there are some void pixels with missing data).
- The data are most probably in a Geographic Coordinate system. To work with it, you thus need to reproject. To avoid unwanted artefacts in the DEM, use a smoothing interpolation method for the resampling. In QGIS, look for the “Warp (reproject)” tool and select e.g. cubic spline as resampling method.

Finally, clip the raster to an extent of about 200 by 200 pixels (anything between 25,000 and 75,000 pixels is fine). In QGIS, you can do this by zooming into the area of interest, right mouse-click on the layer → export → save as → and select the map canvas extent as the extent of your new data.

### 3. *Implement the model*

Load the raster data into your new model, place your mountain spring somewhere in the upper parts of your mountains and start coding the water run-off. In the implementation, consider two properties of water: first, water always only can run downwards, and second the water column increases, if it cannot run downwards. Eventually, sinks are filled with ponds or lakes. This means, water only propagates into a neighbouring cell, if its elevation plus its water column is higher than the elevation plus the water column of the neighbour.

When you think about an adequate height for water spilling over into a neighbouring cell, consider that you are working with geographic data. The default unit of spatial data in GAMA is meter. A water column of 5 thus corresponds to 5m, and 0.1 corresponds to 10cm.

Besides the map, also provide a chart that tracks the lowest elevation the water has reached at each time step.

You will be able to re-use quite a bit of the code we have discussed in the exercise.

## Submit

1. A report with screenshots of your results, i.e. the map after the water has worked its way down; and a chart that shows the lowest elevation the water has reached over time. Briefly document your study area and the model outcomes. Interpret your results:
  - Does the model behave as you have expected?
  - Which features or patterns do you see in the map and the chart?
2. The model as part of a .zip file of the 'UNIGIS models' project that you create at the end of this module and that includes all assignment models.