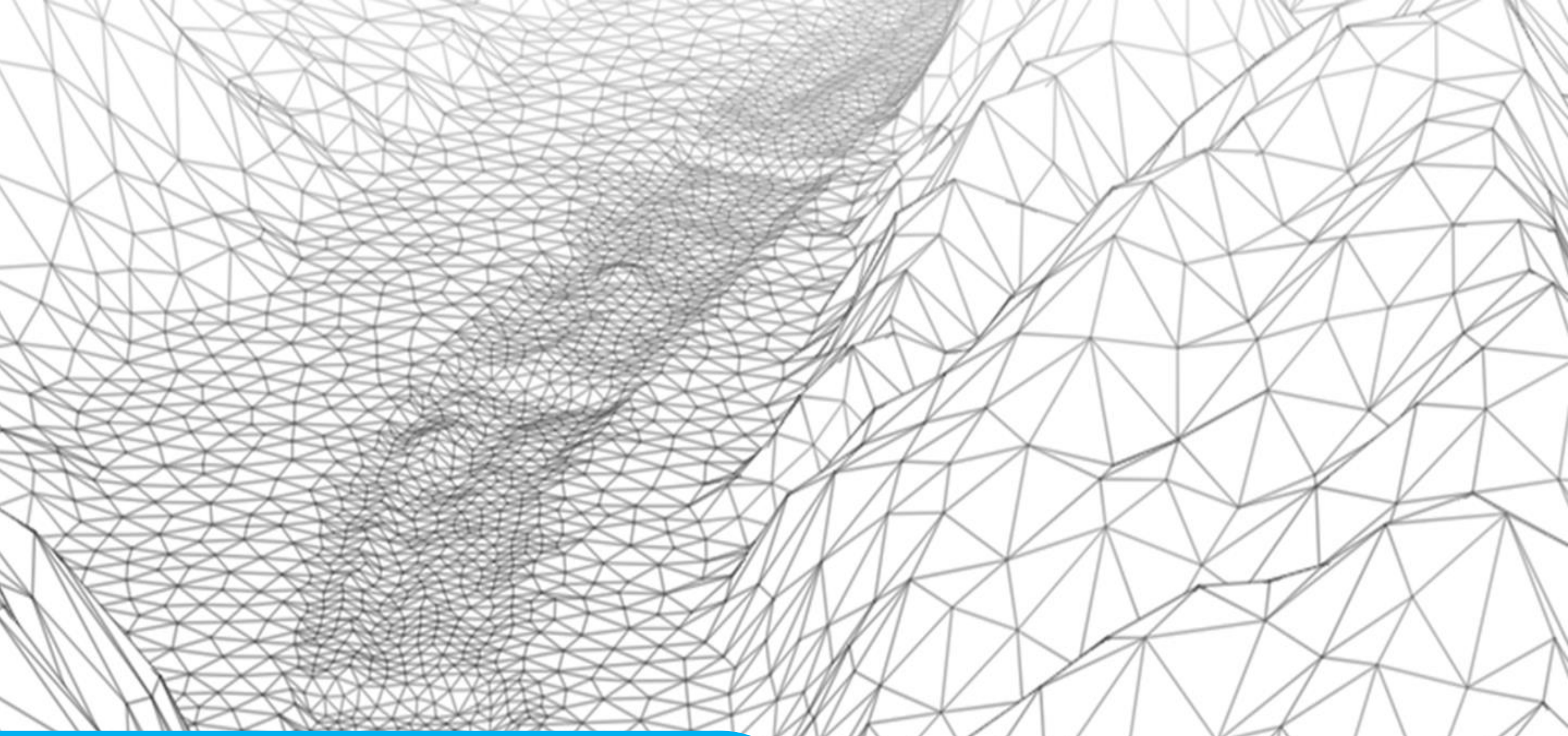


Integrated Project

Erasmus+ Programme Cooperation Partnerships
2022-1-FR01-KA220-HED-000089658
HydroEurope

Uncertainty in Advanced Hydrological and Hydraulic Modelling

Case Study Tervuren Catchment (Belgium)

Uncertainty Analysis and Data Preprocessing: 2D Flood Model – LISFLOOD-FP

Nahad Helmi, Vrije Universiteit Brussel
Version 2.19 Feb - 1 Mar 2025

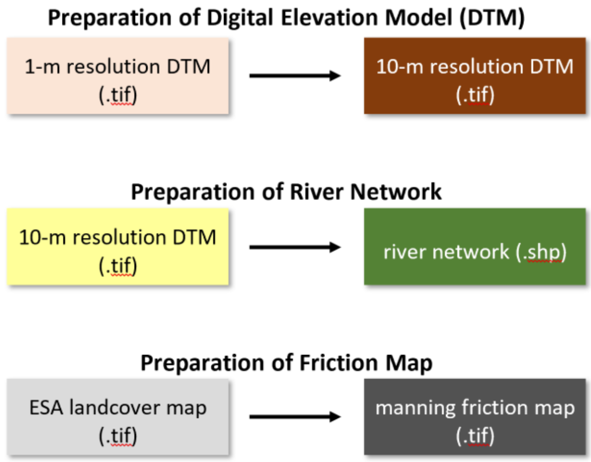
Co-funded by the European Union
Universitat Politècnica de Catalunya BarcelonaTech
Vrije Universiteit Brussel
Warsaw University of Technology
Newcastle University
Brandenburgische Technische Universität Cottbus - Senftenberg
Université Côte d'Azur

1 Introduction

Uncertainty analysis is a method used to assess the degree of confidence in a model's predictions. In hydrological modeling, uncertainty analysis helps evaluate how variations in input parameters or environmental conditions can affect model outcomes. The quality, range, and variability of input data directly impact the reliability of the model's uncertainty analysis

Accurately assessing uncertainty analysis requires specific input data with appropriate resolution and quality.

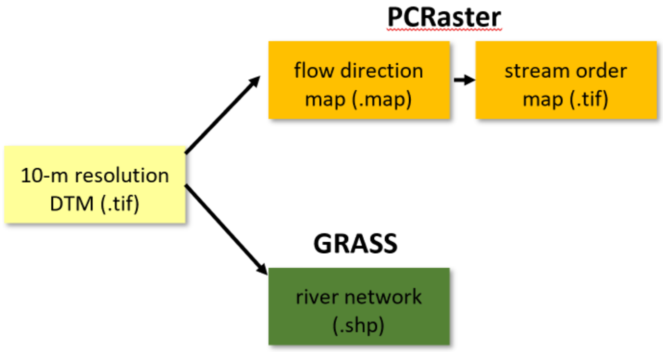
1.1 Digital Elevation Model



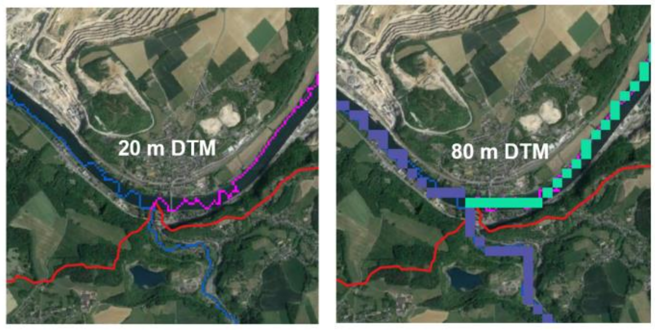
Using a 1-m resolution DTM will provide high-resolution elevation data, by capturing detailed topographic features, and contributing to refine parameter estimation like slope, flow direction, and accumulation.

1.2 River Network Delineation

The river network delineation will improve uncertainty analysis by defining flow paths and connectivity, representing in a better way the water movement and runoff patterns.



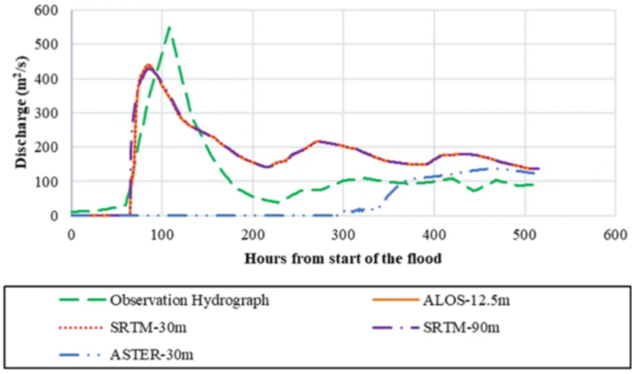
Converting the 1-m DEM to a 10-m DEM for river network calculation will help balance detail and efficiency. The 10-DEM will capture the primary stream networks while reducing data volume.



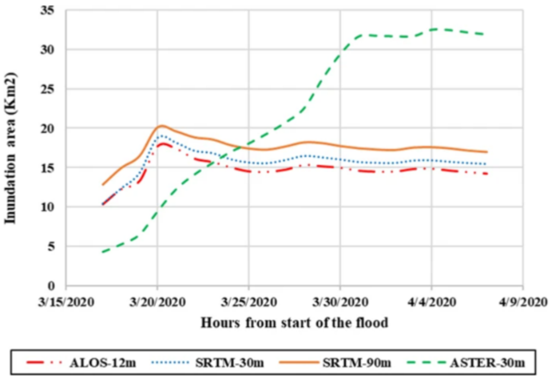
Implementing lower resolution DTM capture the meanders of Meuse River in a better way

1.3 The impact of data resolution

In uncertainty analysis, high resolution DEMs reduce uncertainty by capturing finer terrain details, resulting in more accurate predictions of flood peaks, timing and inundation areas.

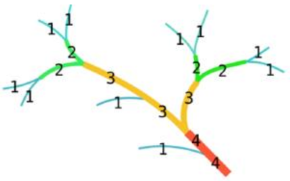


Observed and simulated hydrographs obtained by considering different DEMs in the hydraulic model in Voshmgir dam hydrometric station (Khojeh et al., 2022)

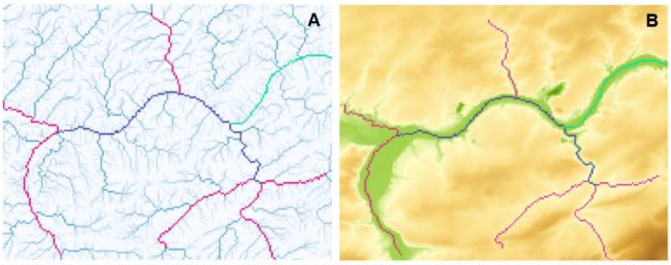


Time evolution of flood inundation area simulated by 2D hydraulic model based on different DEMs

1.4 Strahler Order



Strahler Order is a way of classifying the **hierarchy of streams** or rivers based on their branching patterns and the characteristics of its tributaries.



Strahler order (a) Not filtered: 1 to 9 stream orders, (b) Filtered: 6 to 9 stream orders overlayed on DTM (6 – pink, 7 – blue, 8 – green, 9).

The Strahler order helps to identify higher order streams representing main rivers, which are more stable and less sensitive to minor variations in terrain or parameter changes. The parameter adjustments near this higher Strahler order will have a more significant impact on flow.

Co-funded by the European Union
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
VRIJE UNIVERSITEIT BRUSSEL
WARSAW UNIVERSITY OF TECHNOLOGY
Newcastle University
Brandenburgische Technische Universität Cottbus - Senftenberg
UNIVERSITÉ CÔTE D'AZUR

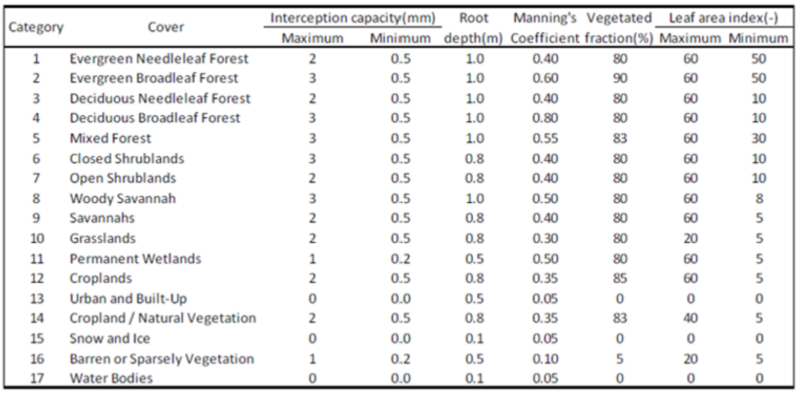
1.5 Land cover map – Manning Coefficient

The Manning's roughness coefficient is a dimensionless value used to describe the **resistance of a surface to the flow of water**

$$Q_x^{t+\Delta t} = \frac{\overbrace{Q^t}^{local\ acceleration\ term} - \overbrace{gh^t\Delta t\frac{\partial(h_t+z)}{\partial x}}^{water\ slope\ term}}{1 + \underbrace{g\Delta t\boxed{n^2}\left|Q_{flow}^t\right|/\left[{h_{flow}^t}^{7/3}\right]}_{friction\ term}}$$

2D Acceleration Solver

Table 3.2. Default parameters characterizing land use classes



Category	Cover	Interception capacity(mm)		Root	Manning's	Vegetated	Leaf area index(-)	
		Maximum	Minimum	depth(m)	Coefficient	fraction(%)	Maximum	Minimum
1	Evergreen Needleleaf Forest	2	0.5	1.0	0.40	80	60	50
2	Evergreen Broadleaf Forest	3	0.5	1.0	0.60	90	60	50
3	Deciduous Needleleaf Forest	2	0.5	1.0	0.40	80	60	10
4	Deciduous Broadleaf Forest	3	0.5	1.0	0.80	80	60	10
5	Mixed Forest	3	0.5	1.0	0.55	83	60	30
6	Closed Shrublands	3	0.5	0.8	0.40	80	60	10
7	Open Shrublands	2	0.5	0.8	0.40	80	60	10
8	Woody Savannah	3	0.5	1.0	0.50	80	60	8
9	Savannahs	2	0.5	0.8	0.40	80	60	5
10	Grasslands	2	0.5	0.8	0.30	80	20	5
11	Permanent Wetlands	1	0.2	0.5	0.50	80	60	5
12	Croplands	2	0.5	0.8	0.35	85	60	5
13	Urban and Built-Up	0	0.0	0.5	0.05	0	0	0
14	Cropland / Natural Vegetation	2	0.5	0.8	0.35	83	40	5
15	Snow and Ice	0	0.0	0.1	0.05	0	0	0
16	Barren or Sparsely Vegetation	1	0.2	0.5	0.10	5	20	5
17	Water Bodies	0	0.0	0.1	0.05	0	0	0

Obtained and Adapted from Dickinson et al. (1993), Lull (1964), Zinke (1967), Rowe (1983), Chow (1964), Haan (1982), Yen (1992) and Ferguson (1998).

A 10-m resolution land cover map will improve flood simulation by accurately representing surface roughness and land cover spatial variability across the terrain. A detailed land cover map allows a sensitivity testing on manning's values across specific land cover types, identifying which areas most influence model outcomes.

1.6 Soil/ Infiltration Map

Preparation of Floodplain Infiltration Map

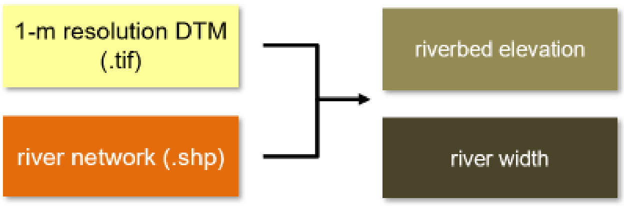
soil map (.shp) → spatially distributed floodplain infiltration map (.tif)

The soil map provides detailed information on soil properties, which influence infiltration, runoff, and storage characteristics, capturing variability in areas with diverse soil types across the catchment. Accurate soil data reduces uncertainty in flow and peak discharge calculations.

Co-funded by the European Union

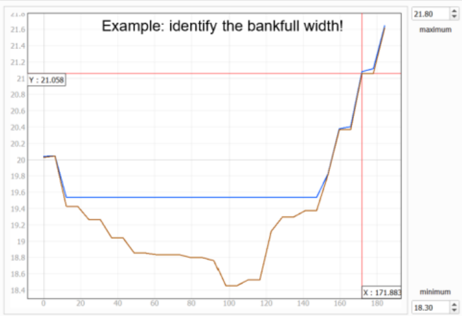
1.7 River Geometry

Preparation of River Geometry Map



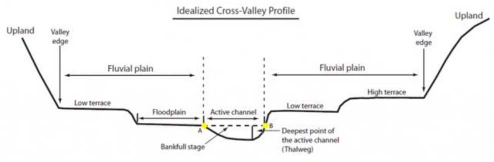
River geometry provides detailed information on river cross-sections, channel width, depth, and slope, which directly impact flow capacity and flood behaviour.

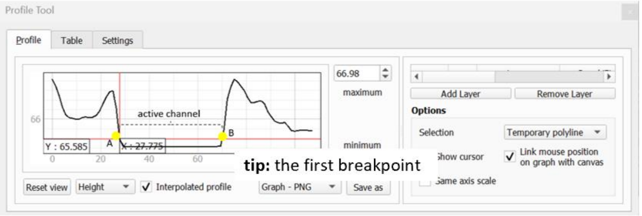
Bankfull stage : maximum amount of water that can be accommodated within its channel without causing flooding



Bank full stage acts as a threshold for potential flooding, helping calibrate the model to accurately predict when overbank flows may occur, it reduces uncertainty in flood extent and timing predictions.

Calculate river width at bankfull stage by identifying the location of river 's (active channel) boundary based on river cross section



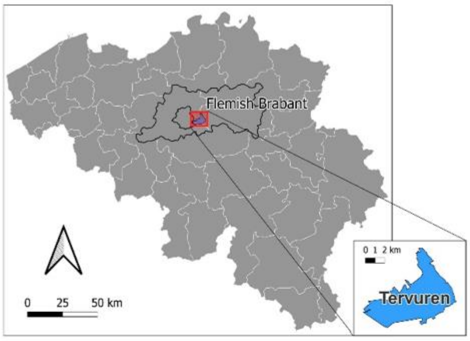


tip: the first breakpoint

An accurate width calculation defines floodplain interactions, leading to better predictions of inundation areas and flood extent. It also impacts sediment movement and channel stability.

Co-funded by the European Union

2 Case Study: Tervuren Catchment



Study Area of Tervuren, Belgium

- The study area of this project is Tervuren Municipality, Belgium
- A large area in Tervuren is at risk of urban fluvial and pluvial floods (HNL, 2023; Flemish Government, 2023)
- Climate change is expected to increase precipitation extreme which potentially exacerbate urban pluvial flooding in Tervuren

3 Step by step tutorial

Simulate flood inundation in Tervuren with LISFLOOD require several data input and information. The input data required by LISFLOOD are as follows:

1. Digital elevation model file (.dem.asc)
2. Floodplain friction coefficient file (.n.asc)
3. Infiltration (set in parameter file (.par))
4. Spatially variable river bed elevation(.bed.asc)
5. Spatially variable river width (.width.asc)
6. Boundary condition file (.bci)
7. Time-varying boundary file (.bdy)
8. Rainfall (.rain)
9. Parameter file (.par)

This exercise is the first part of a series of exercises on preparing LISFLOOD input data. We will start the preprocessing with preparing digital elevation model file (.dem.asc), delineate stream network, and preparing floodplain friction coefficient file (.n.asc). The result of stream network delineation process will be used to define spatially variable river bed elevation(.bed.asc), spatially variable river width (.width.asc), as well as, the points on boundary condition file (.bci). Additionally, we will prepare spatially distributed floodplain infiltration and river geometry maps. Based on floodplain infiltration (hydraulic conductivity) map, average infiltration rate will be defined and set in parameter file (.par). Meanwhile, river bed elevation (.bed.asc) and river width (.width.asc), which are the river geometry parameters required by LISFLOOD, will be estimated based on finer resolution (1m) elevation model.

Prior to the preprocessing, PCRaster Tools and Profile Tool plugin need to be installed in QGIS. The installation of PCRaster Tools is explained in the following link: https://www.youtube.com/watch?v=2pEr5RoGAXc

3.1 Digital Elevation Model (DEM)

The first step of pre-processing is preparing the elevation model, which will be use as both model input, further step of river network delineation and river geometry estimation. To obtained 10 m resolution digital elevation data (.dem.asc) for the study case, the following steps should be followed:

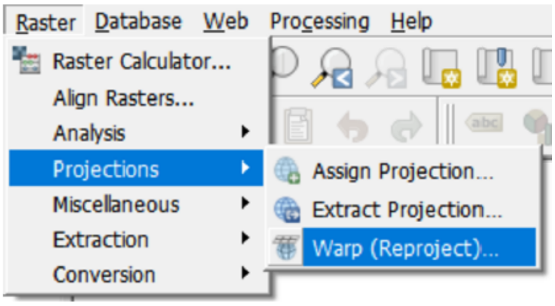
Step 1: Load DTM and catchment boundary shapefile

First, load the high-resolution DTM (dem_1m.tif) and shapefile of catchment's boundary (tervuren_boundary.shp) that compose the basin area should be loaded.

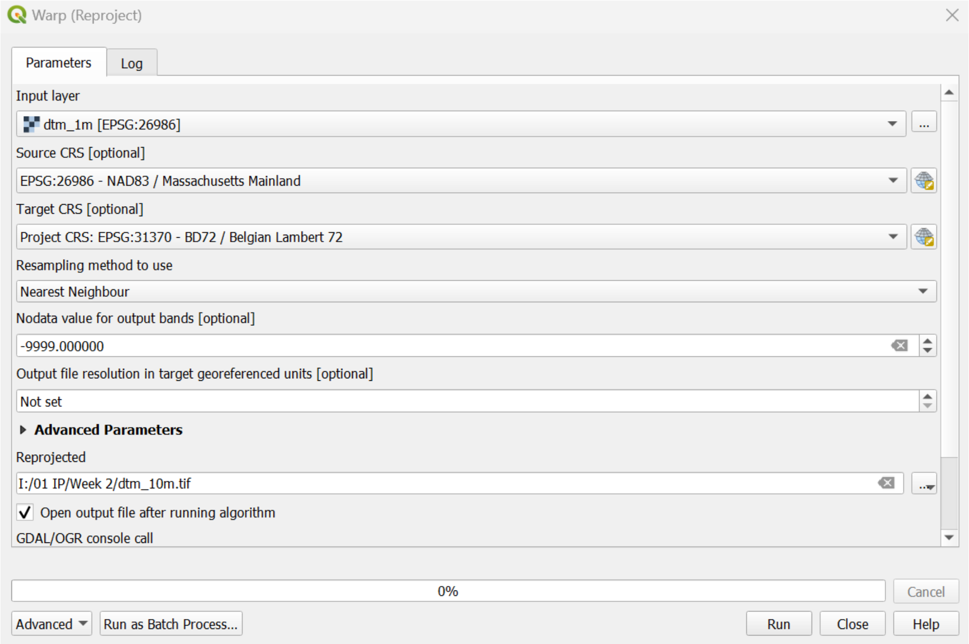
Step 2: Reprojection

The next step is the reprojection of the merged DTM. Generally, the elevation model is available in a Geographic Reference System (GRS), and it must be reprojected using the **Warp function** to a Projected Reference System, EPSG: 31370 – BD72 / Belgian Lambert

Co-funded by the European Union · UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH · VUB VRIJE UNIVERSITEIT BRUSSEL · WARSAW UNIVERSITY OF TECHNOLOGY · Newcastle University · b-tu Brandenburgische Technische Universität Cottbus - Senftenberg · UNIVERSITÉ CÔTE D'AZUR



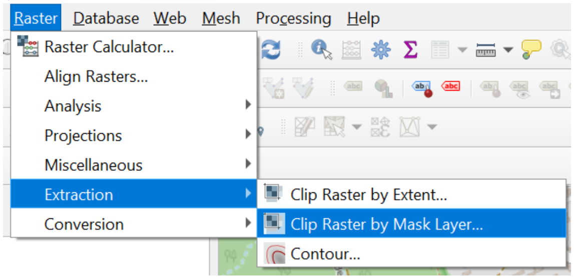
Complete the dialogue as follow and run the algorithm:



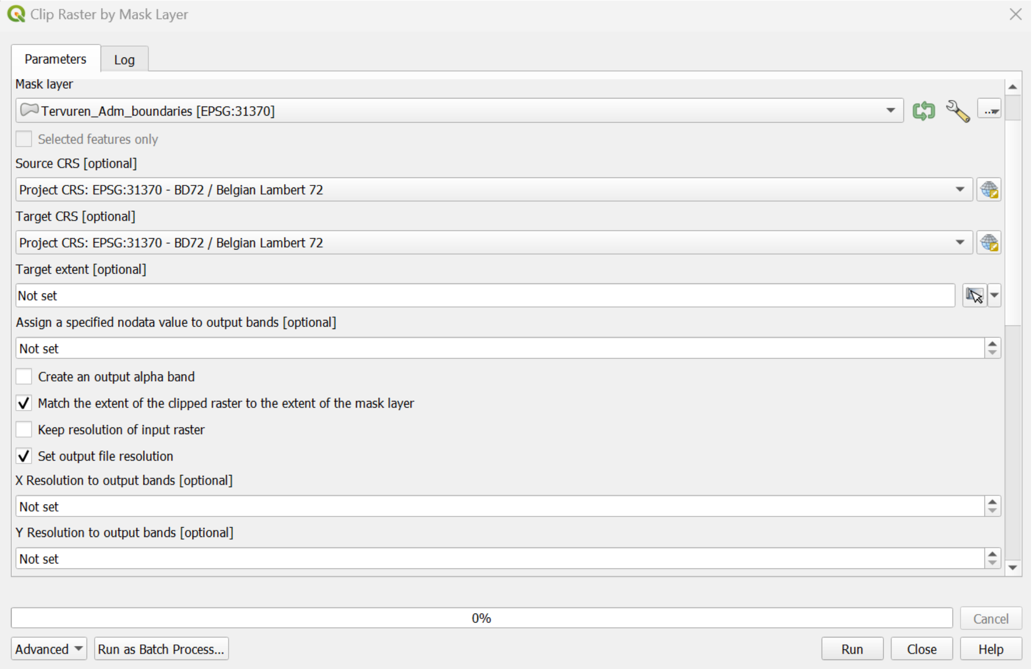
Input layer
dtm_1m [EPSG:26986]
Source CRS [optional]
EPSG:26986 - NAD83 / Massachusetts Mainland
Target CRS [optional]
Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72
Resampling method to use
Nearest Neighbour
Nodata value for output bands [optional]
-9999.000000
Output file resolution in target georeferenced units [optional]
Not set
Reprojected
I:/01 IP/Week 2/dtm_10m.tif
☑ Open output file after running algorithm
GDAL/OGR console call

Step 3: Clipping and Aggregation

The next step is to use **Clip Raster by Mask Layer** to clip the DTM file into desire area. The DTM extension must be extracted using the Clip Raster by Extent function (implementing the extension of the catchments shapefile).



In addition, it is also needed to aggregate the raster data from 1 to 10 m resolution by setting horizontal and vertical layer resolution to the desired resolution. Complete the dialogue as follow and run the algorithm:


Clip Raster by Mask Layer

Mask layer: Tervuren_Adm_boundaries [EPSG:31370]

☐ Selected features only

Source CRS [optional]: Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72

Target CRS [optional]: Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72

Target extent [optional]: Not set

Assign a specified nodata value to output bands [optional]: Not set

☐ Create an output alpha band

☑ Match the extent of the clipped raster to the extent of the mask layer

☐ Keep resolution of input raster

☑ Set output file resolution

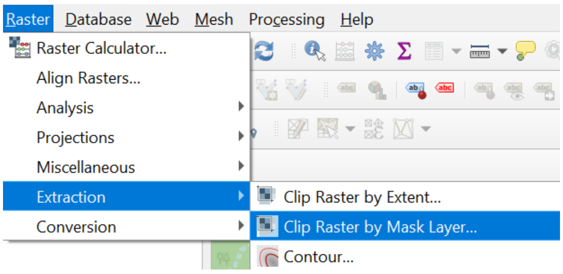
X Resolution to output bands [optional]: Not set

Y Resolution to output bands [optional]: Not set

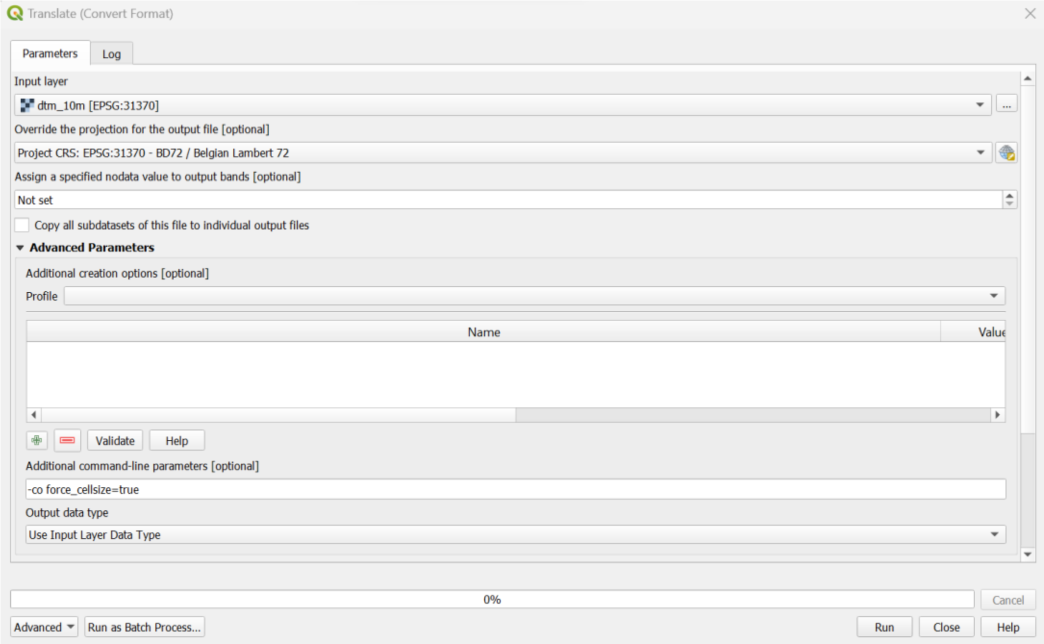
Save file as *tervuren_10m.tif*. The result of this step will be used in the further steps of river network delineation.

Step 4: Convert/Translate

The final step is to Convert / Translate the DTM layer (.tif) into .ASC format (ideal format to be used in the flood model). In the **additional command-line parameter** put the following text: **-co force_cellsize=true**



Complete the dialogue as follow and run the algorithm:



Input layer: dtm_10m [EPSG:31370]

Override the projection for the output file [optional]: Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72

Assign a specified nodata value to output bands [optional]: Not set

☐ Copy all subdatasets of this file to individual output files

Additional command-line parameters [optional]: -co force_cellsize=true

Output data type: Use Input Layer Data Type

Save file as *tervuren_10m.dem*.asc

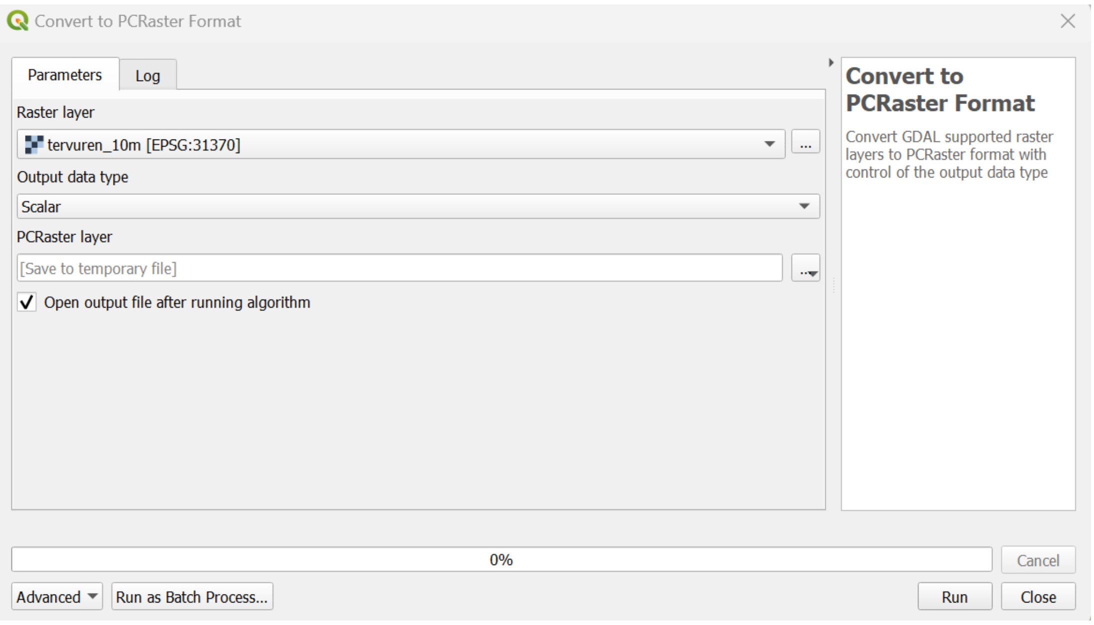
3.2 River Network Delineation

To delineate the stream/ river network of each basin we will implement the DTM extent (.tif) obtained from the previous procedure. We use two different methodology for this procedure which are PCRaster Tool Puglin (GIS tool) and GRASS. The final product from PCRaster Tool is stream order (.tif), meanwhile, GRASS will produce the stream network (.shp).

Part I : PCRaster tool

Step 1: Convert

Once PCRaster is installed, use **Convert to PCRaster Format** and set the **Output data type: Scalar** to convert *tervuren_10m.tif* to *tervuren_10m.map*. Complete the dialogue and run the algorithm:



Raster layer: tervuren_10m [EPSG:31370]

Output data type: Scalar

PCRaster layer: [Save to temporary file]

☑ Open output file after running algorithm

Convert to PCRaster Format

Convert GDAL supported raster layers to PCRaster format with control of the output data type

Co-funded by the European Union
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
VUB VRIJE UNIVERSITEIT BRUSSEL
WARSAW UNIVERSITY OF TECHNOLOGY
Newcastle University
b-tu Brandenburgische Technische Universität Cottbus - Senftenberg
UNIVERSITÉ CÔTE D'AZUR

Step 2: Flow direction calculation

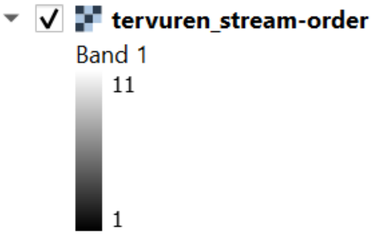
Next step is to calculate the Flow direction map, using the **Lddcreate** tool (Local drain direction map) – Use default settings.

Step 3: Derive Strahler Order

Once flow direction map (.map) is generated, use the **streamorder** tool to derive the streams Strahler order from the flow direction map generated from the previous step.

Step 4: Filter Strahler Order

Filter the lower-order streams from the previously generated strahler order map (.map) by keeping the last 3 river order and get the final river network *final_stream_order.tif* (.tif) file. This can be done by **Raster Calculator** and assigning 3 to maximum river order, 2 to "maximum river order – 1", and 1 to "maximum river order – 2". For instance, in this case, the strahler order is ranging from 1 to 11, therefore, only order 9, 10, 11 will be kept on the final map.



Command:

```
("name of the streamorder map" = 11) * 3 + ( "name of the streamorder map= 10) * 2 + (
"name of the streamorder map" = 9) * 1
```

Step 5: Reproject Strahler Order

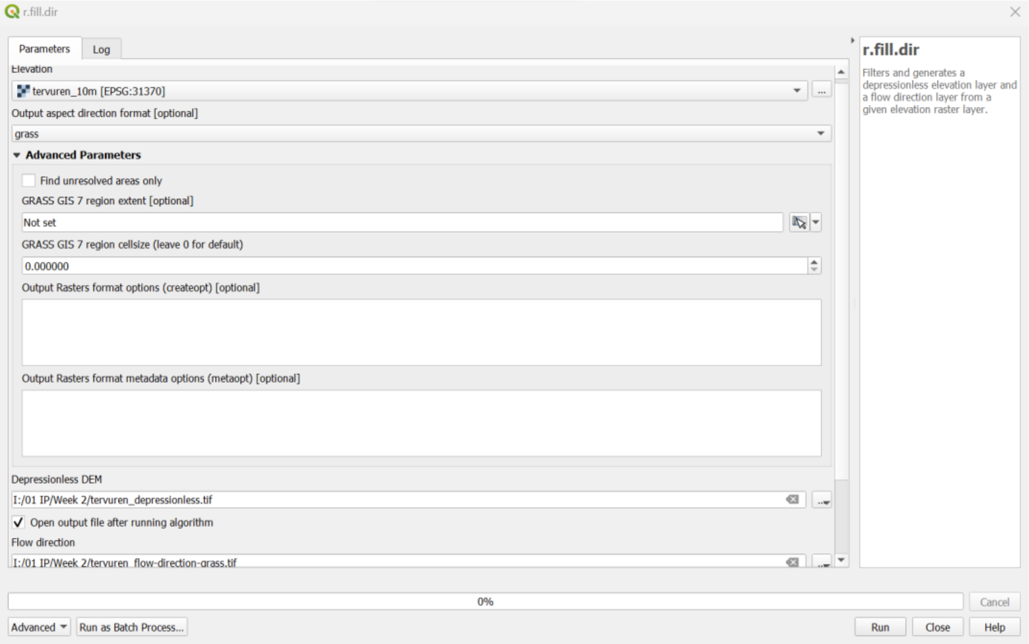
Finally, reproject *final_stream_order.tif* generated from the previous map, using the **Warp function** to a Projected Reference System, EPSG: 31370 – BD72 / Belgian Lambert. The result of PCRaster processes will be used to analyze delineated river in the further steps.

Part II : GRASS

Step 1: Depression-less Elevation and Flow Direction

To filter and generate depression-less elevation map and flow direction from *tervuren_10m.tif,* use **r.fill.dir.** Define **grass** for the **output aspect direction format,** complete the dialogue as follow and run the algorithm:

Co-funded by the European Union
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
VUB VRIJE UNIVERSITEIT BRUSSEL
WARSAW UNIVERSITY OF TECHNOLOGY
Newcastle University
b-tu Brandenburgische Technische Universität Cottbus - Senftenberg
UNIVERSITÉ CÔTE D'AZUR


r.fill.dir

Elevation: tervuren_10m [EPSG:31370]

Output aspect direction format [optional]: grass

Advanced Parameters

☐ Find unresolved areas only

GRASS GIS 7 region extent [optional]: Not set

GRASS GIS 7 region cellsize (leave 0 for default): 0.000000

Output Rasters format options (createopt) [optional]

Output Rasters format metadata options (metaopt) [optional]

Depressionless DEM: I:/01 IP/Week 2/tervuren_depressionless.tif

☑ Open output file after running algorithm

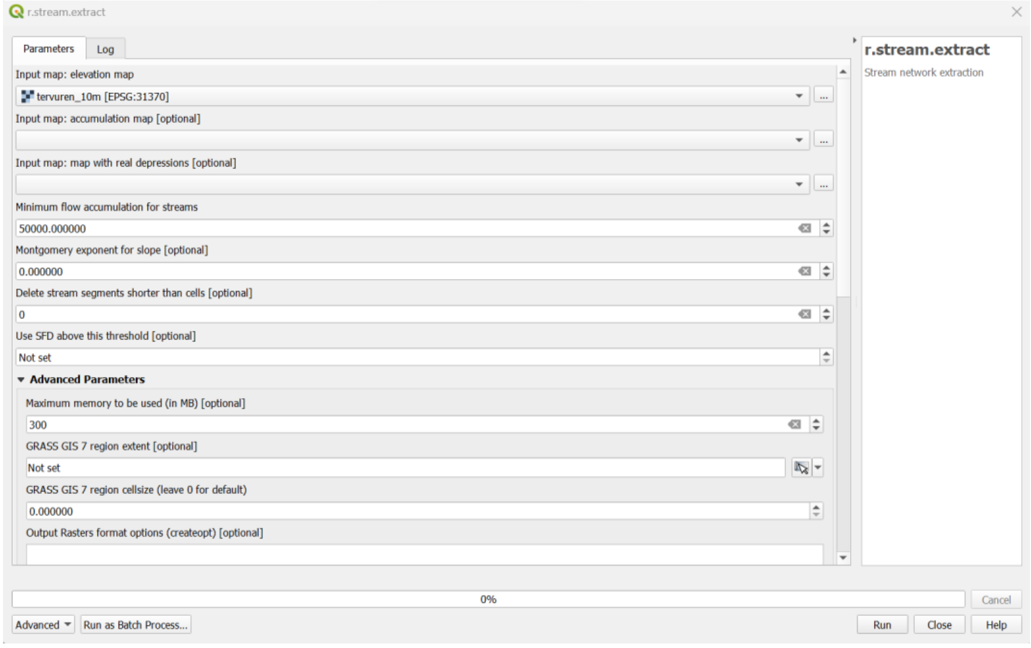
Flow direction: I:/01 IP/Week 2/tervuren_flow-direction-grass.tif

r.fill.dir

Filters and generates a depressionless elevation layer and a flow direction layer from a given elevation raster layer.

Step 2: Stream Extraction

To extract river network use *tervuren_10m.tif,* use **r.stream.extract.** The **minimum flow accumulation for stream** should be considered **50000**. The **v.out.ogr** output type should be considered as **line.** Complete the dialogue as follow and run the algorithm:


r.stream.extract

Input map: elevation map: tervuren_10m [EPSG:31370]

Input map: accumulation map [optional]

Input map: map with real depressions [optional]

Minimum flow accumulation for streams: 50000.000000

Montgomery exponent for slope [optional]: 0.000000

Delete stream segments shorter than cells [optional]: 0

Use SFD above this threshold [optional]: Not set

Advanced Parameters

Maximum memory to be used (in MB) [optional]: 300

GRASS GIS 7 region extent [optional]: Not set

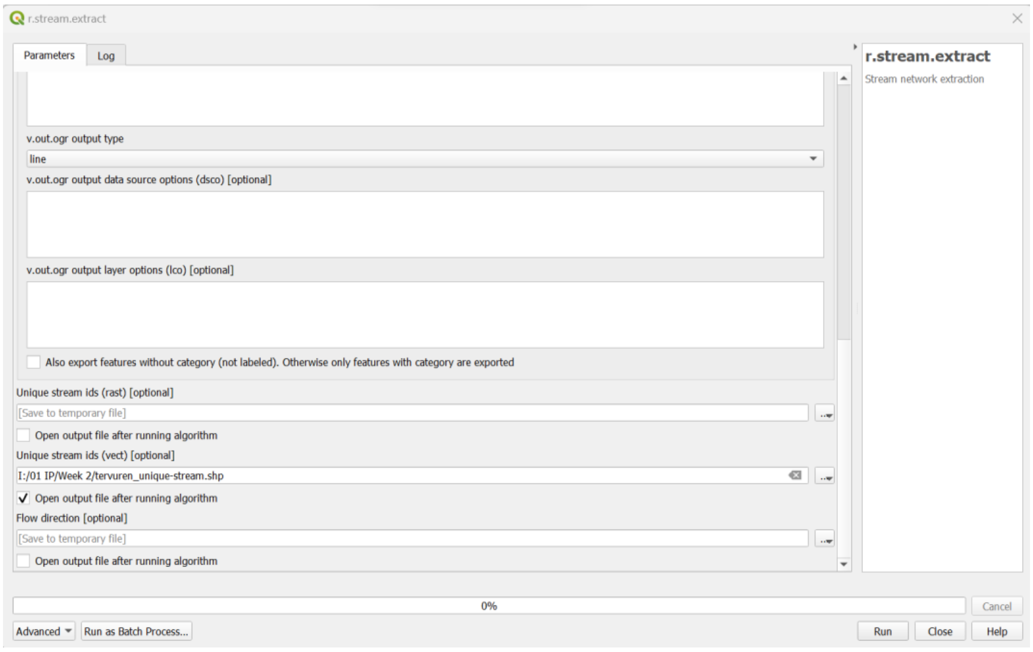
GRASS GIS 7 region cellsize (leave 0 for default): 0.000000

Output Rasters format options (createopt) [optional]

r.stream.extract

Stream network extraction

Co-funded by the European Union



v.out.ogr output type: line

v.out.ogr output data source options (dsco) [optional]

v.out.ogr output layer options (lco) [optional]

☐ Also export features without category (not labeled). Otherwise only features with category are exported

Unique stream ids (rast) [optional]: [Save to temporary file]

☐ Open output file after running algorithm

Unique stream ids (vect) [optional]: I:/01 IP/Week 2/tervuren_unique-stream.shp

☑ Open output file after running algorithm

Flow direction [optional]: [Save to temporary file]

☐ Open output file after running algorithm

The value of **minimum flow accumulation for stream** needs to be calibrated with the initial value used is 50000. Stream order map resulted from PCRaster method can be use in this calibration process. The resulted *tervuren_unique-stream.shp* will be use in defining river geometry and inflow points (boundary conditions).

3.3 Friction Map

To generate a distributed friction map (.tif) from a landuse map (.tif) the following steps must be carried out:

Step 1: Reclassify Land Use Map

Import the landuse map (tervuren_landcover_reprojected.tif) of the study-area and reclassify the landuse code map according to the International Geosphere-Biosphere Programme (IGBP) classification system using **Raster Calculator**.

Conversion of ESA WORLD LAND COVER CLASSES → to IGBP CODE

10 - Tree cover → 5

20 – Shrubland → 7

30 – Grassland → 10

40 – Cropland → 12

50 - Built-up → 13

60 - Bare / sparse vegetation → 16

70 - Snow and ice → 15

80 - Permanent water bodies → 17

90 - Herbaceous wetland → 11

95 - Mangroves → 11

Co-funded by the European Union
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
VUB VRIJE UNIVERSITEIT BRUSSEL
WARSAW UNIVERSITY OF TECHNOLOGY
Newcastle University
b-tu Brandenburgische Technische Universität Cottbus - Senftenberg
UNIVERSITÉ CÔTE D'AZUR

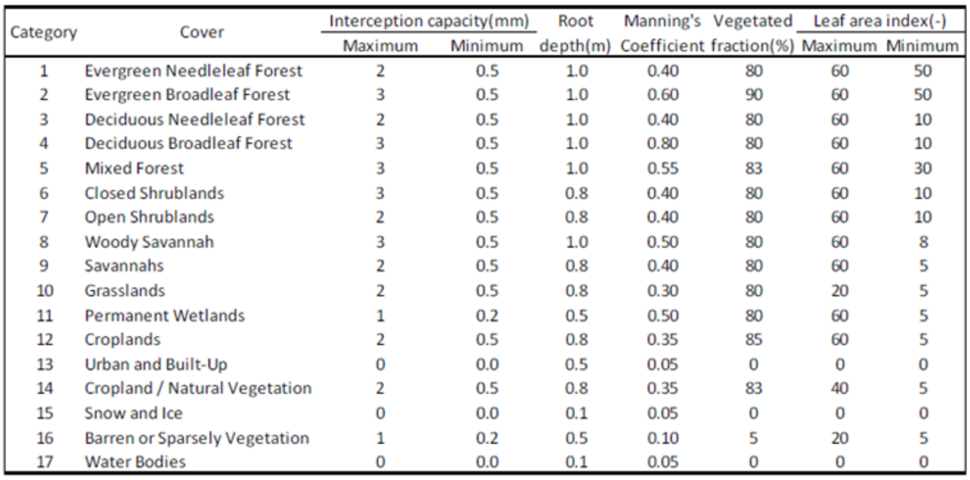
Command:

```
( "ESA_Landcover_Reprojected@1" = 10) * 5 + ( "ESA_Landcover_Reprojected@1" = 20) * 7 + (
"ESA_Landcover_Reprojected@1" = 30) * 10 + ( "ESA_Landcover_Reprojected@1" = 40) * 12 + (
"ESA_Landcover_Reprojected@1" = 50) * 13 + ( "ESA_Landcover_Reprojected@1" = 60) * 16 + (
"ESA_Landcover_Reprojected@1" = 70) * 15 + ( "ESA_Landcover_Reprojected@1" = 80) * 17 + (
"ESA_Landcover_Reprojected@1" = 90) * 11 + ( "ESA_Landcover_Reprojected@1" = 95) * 11
```

Step 2: Distributed Friction Map

Use **Raster Calculator** to generate a distributed friction map from reclassified land cover map generated from previous step. The calculation is carried out by assign Manning's roughness coefficient to each IGBP landuse class according table below:

Table 3.2. Default parameters characterizing land use classes



Category	Cover	Interception capacity(mm) Maximum	Interception capacity(mm) Minimum	Root depth(m)	Manning's Coefficient	Vegetated fraction(%)	Leaf area index(-) Maximum	Leaf area index(-) Minimum
1	Evergreen Needleleaf Forest	2	0.5	1.0	0.40	80	60	50
2	Evergreen Broadleaf Forest	3	0.5	1.0	0.60	90	60	50
3	Deciduous Needleleaf Forest	2	0.5	1.0	0.40	80	60	10
4	Deciduous Broadleaf Forest	3	0.5	1.0	0.80	80	60	10
5	Mixed Forest	3	0.5	1.0	0.55	83	60	30
6	Closed Shrublands	3	0.5	0.8	0.40	80	60	10
7	Open Shrublands	2	0.5	0.8	0.40	80	60	10
8	Woody Savannah	3	0.5	1.0	0.50	80	60	8
9	Savannahs	2	0.5	0.8	0.40	80	60	5
10	Grasslands	2	0.5	0.8	0.30	80	20	5
11	Permanent Wetlands	1	0.2	0.5	0.50	80	60	5
12	Croplands	2	0.5	0.8	0.35	85	60	5
13	Urban and Built-Up	0	0.0	0.5	0.05	0	0	0
14	Cropland / Natural Vegetation	2	0.5	0.8	0.35	83	40	5
15	Snow and Ice	0	0.0	0.1	0.05	0	0	0
16	Barren or Sparsely Vegetation	1	0.2	0.5	0.10	5	20	5
17	Water Bodies	0	0.0	0.1	0.05	0	0	0

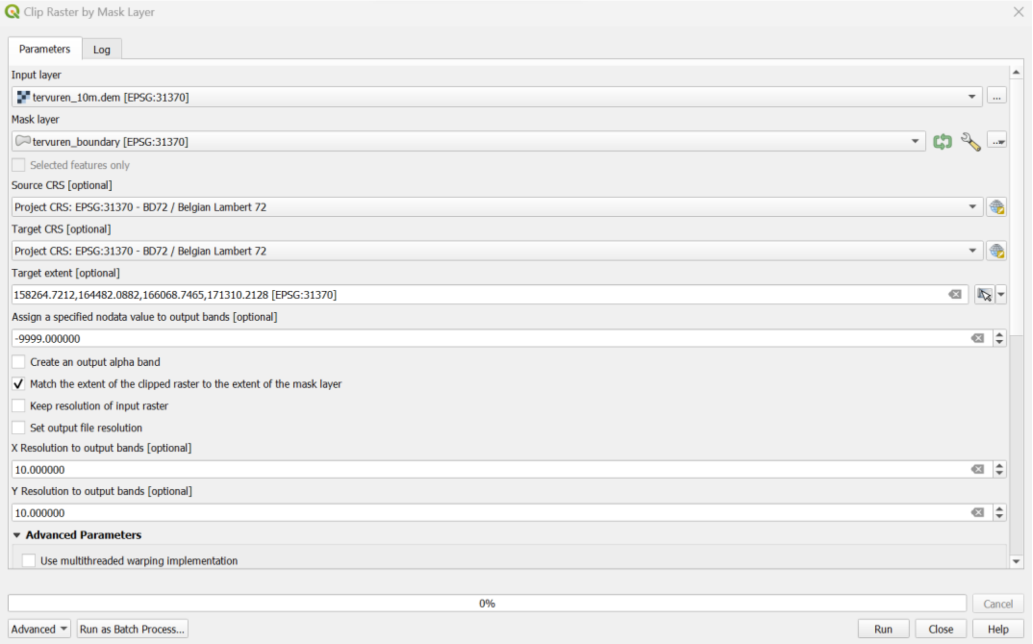
Obtained and Adapted from Dickinson et al. (1993), Lull (1964), Zinke (1967), Rowe (1983), Chow (1964), Haan (1982), Yen (1992) and Ferguson (1998).

Command :

```
 ( "name of the reclassified map" = 5) * 0.55 + ( "name of the reclassified map" = 7) *
0.4 + ( "name of the reclassified map" = 10) * 0.3 + ( "name of the reclassified map" =
11) * 0.5 + ( "name of the reclassified map" = 12) * 0.35 + ( "name of the reclassified
map" = 13) * 0.05 + ( "name of the reclassified map" = 15) * 0.05 + ( "name of the
reclassified map" = 16) * 0.1 + ( "name of the reclassified map" = 17) * 0.05
```

Step 3: Clipping and Aggregation

As all input raster maps need to have the same resolution and dimension, clipping and downscaling (aggregate) should be carried out using **Clip Raster by Mask Layer.** Set target extend based on *tervuren_10m.dem.asc*, then set x resolution and y resolution to 10m. Complete the dialogue as follow and run the algorithm:



Input layer: tervuren_10m.dem [EPSG:31370]

Mask layer: tervuren_boundary [EPSG:31370]

☐ Selected features only

Source CRS [optional]: Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72

Target CRS [optional]: Project CRS: EPSG:31370 - BD72 / Belgian Lambert 72

Target extent [optional]: 158264.7212,164482.0882,166068.7465,171310.2128 [EPSG:31370]

Assign a specified nodata value to output bands [optional]: -9999.000000

☐ Create an output alpha band

☑ Match the extent of the clipped raster to the extent of the mask layer

☐ Keep resolution of input raster

☐ Set output file resolution

X Resolution to output bands [optional]: 10.000000

Y Resolution to output bands [optional]: 10.000000

Advanced Parameters

☐ Use multithreaded warping implementation

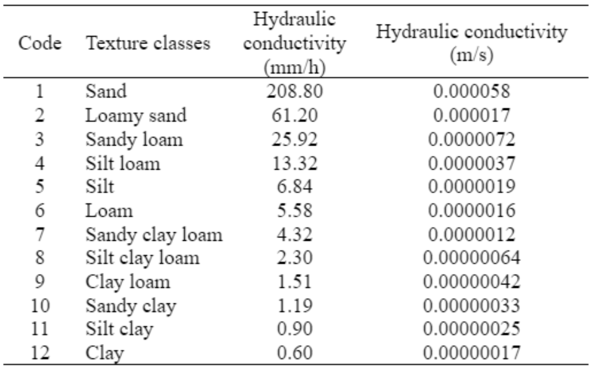
Step 4: Convert/Translate

The final step is to Convert / Translate the tervuren_n layer (.tif) into .ASC format (ideal format to be used in the flood model). In the **additional command-line parameter** put the following text: **-co force_cellsize=true.** Save as tervuren.n.asc

3.4 Floodplain Infiltration

Calculated hydraulic conductivity by use of the value provided for each soil class (tervuren_soil.tif) in the hydraulic conductivity column [m/s] in the table below:

Table B.2: Default parameters characterizing soil textural classes.



Code	Texture classes	Hydraulic conductivity (mm/h)	Hydraulic conductivity (m/s)
1	Sand	208.80	0.000058
2	Loamy sand	61.20	0.000017
3	Sandy loam	25.92	0.0000072
4	Silt loam	13.32	0.0000037
5	Silt	6.84	0.0000019
6	Loam	5.58	0.0000016
7	Sandy clay loam	4.32	0.0000012
8	Silt clay loam	2.30	0.00000064
9	Clay loam	1.51	0.00000042
10	Sandy clay	1.19	0.00000033
11	Silt clay	0.90	0.00000025
12	Clay	0.60	0.00000017

Source: Liu, 2004

Generate spatially distributed hydraulic conductivity (floodplain infiltration) map using **raster calculator.**

Command:

```
( "Rasterized@1" = 1)*0.000058+ ( "Rasterized@1" = 3)*0.0000072+ ( "Rasterized@1"
= 6)*0.000000155 + ( "Rasterized@1" = 12)*0.0000017
```

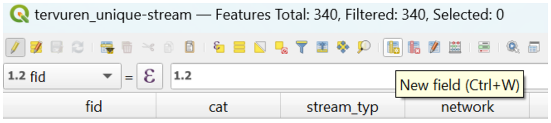
Adjust the command based on the available code number, then check STATISTICAL_MEAN of the generated raster file (check properties) and use it as infiltrationvalue in parameter file (.par).

3.5 River Geometry

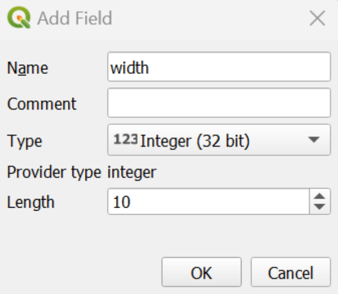
a. River Width

Step 1: Prepare Data Input

Load tervuren_1m.tif, tervuren_unique-stream.shp and tervuren_boundary.shp from previous week exercise, as well as, tervuren_zero.tif. Open the attribute table of tervuren_unique-stream.shp file and click on “edit“, “new field” then add a name “width” and type “integer”.



tervuren_unique-stream — Features Total: 340, Filtered: 340, Selected: 0



Add Field

Name: width

Comment:

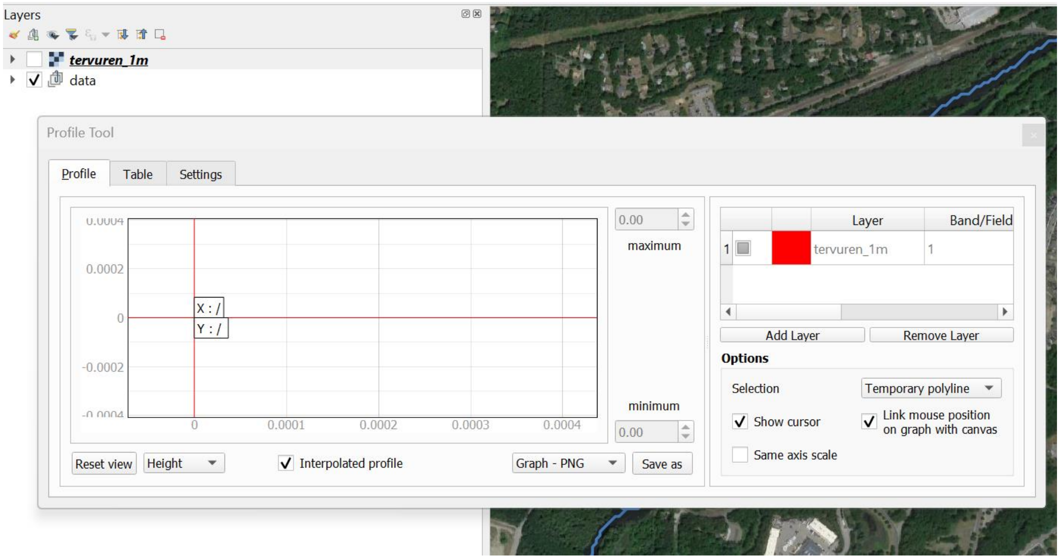
Type: 123 Integer (32 bit)

Provider type integer

Length: 10

Step 2: Plot Terrain Profile

River width will be calculated based on the terrain profile (elevation map) using **profile tool.** To begin with, click “terrain profile” in the vector toolbar then add tervuren_1m.tif layer (click tervuren_1m.tif on layer then click add layer in profile tool).



Layers

☐ tervuren_1m

☑ data

Profile Tool

		Layer	Band/Field
1	☐	tervuren_1m	1

Options

Selection: Temporary polyline

☑ Show cursor

☑ Link mouse position on graph with canvas

☐ Same axis scale

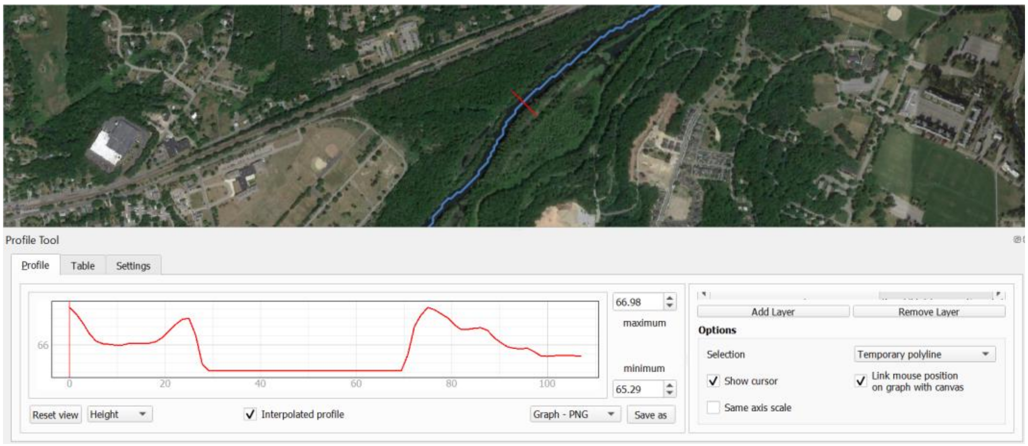
Height

☑ Interpolated profile

Graph - PNG

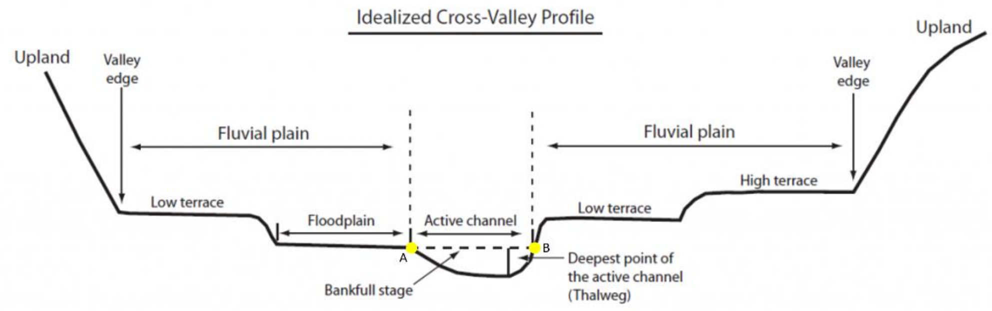
Plot terrain profile of river cross section by drawing a line perpendicular to the river (tervuren_unique-stream.shp), as depicted below:

Co-funded by the European Union
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
VRIJE UNIVERSITEIT BRUSSEL
WARSAW UNIVERSITY OF TECHNOLOGY
Newcastle University
Brandenburgische Technische Universität Cottbus - Senftenberg
UNIVERSITÉ CÔTE D'AZUR

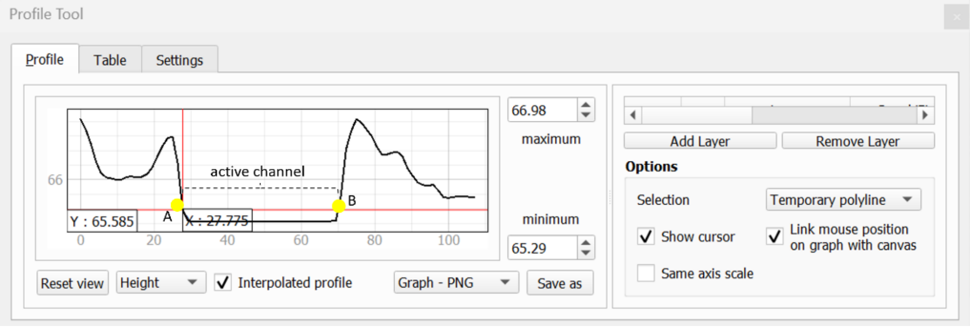


Step 3: Calculate River Width

Based on the terrain profile of river cross section, calculate river width at bankfull stage by identifying the location of river ‘s (active channel) boundary (point A and B for example) as depicted in the figures below:



(source: Barr, 2023)



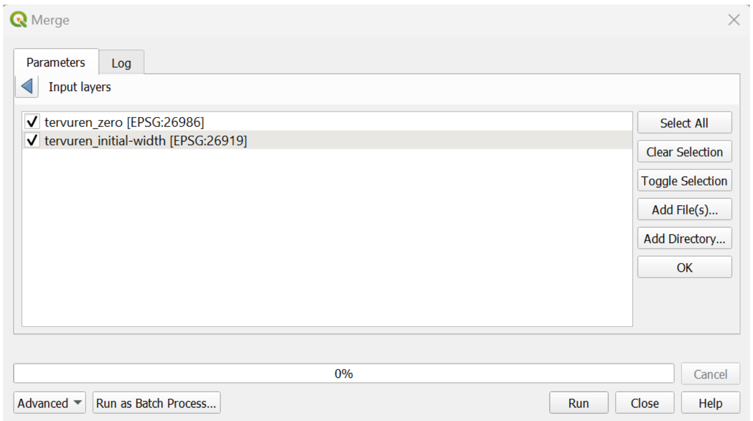
Use Google Satellite as additional information to define the boundary of the river. Carried out this calculation at adequate number of samples for each river segment. The final river width of each segment should be the average river width from the samples.

Step 4: Rasterize River Width

Rasterize tervuren_unique-stream.shp using **rasterize**. Set field to use for burn-in value as “width”, the vertical and horizontal resolution as 10 m, output extend based on previously generated raster input map and no data value as -9999.

Step 5: River Width Map Revision

As LISFLOOD require specific format of its input maps, previously generated river width map (.tif) need to be revised by merging the map with tervuren-zero.tif (raster map contains of 0 inside the model boundary and NULL outside model boundary) using **merge.** Pay attention to the order of input layers; tervuren-zero.tif need to be above the tervuren_initial-width.tif as follow:



☑ tervuren_zero [EPSG:26986]
☑ tervuren_initial-width [EPSG:26919]

Complete the dialogue with default option and run the algorithm. Once the merging process finish, clip the resulted layer using the **Clip Raster by Extent** function. Use tervuren_boundary.shp as mask layer and assign no data value as -9999.

Step 6: Convert/Translate

The final step is to Convert / Translate the river width map from previous step (.tif) into .ASC format (ideal format to be used in the flood model). In the **additional command-line parameter** put the following text: **-co force_cellsize=true.** Save as tervuren.width.asc.

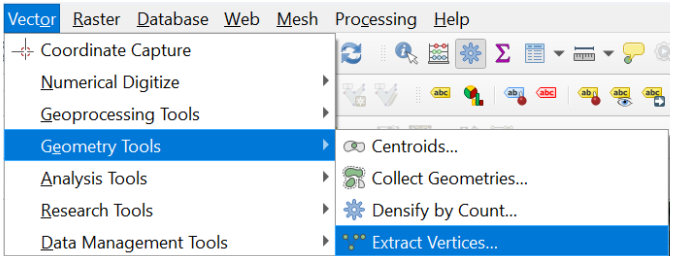
b. Riverbed Elevation

Step 1: Prepare Data Input

In addition to tervuren_1m.tif and tervuren_unique-stream.shp, prepare initial riverbed elevation raster map by duplicating previously generated initial river width (.tif) and rename as tervuren_bed.tif.

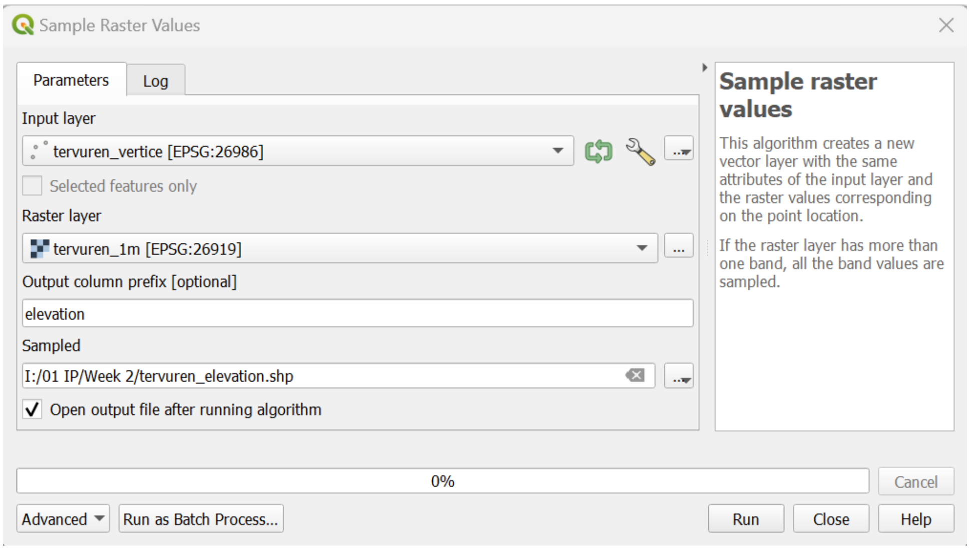
Step 2: Extract Vertice

Extract points (vertices) based on tervuren_unique-stream.shp using **extract vertices** function.



Step 3: Sample Bed Elevation

Use **sample raster values** function for calculating the elevation of each point with the 1-m DTM (tervuren_1m.tif) and the point map (tervuren_vertices.shp) generated in the previous step should be used as an input. Complete the dialogue as follow and run the algorithm:



Sample Raster Values

Input layer: tervuren_vertice [EPSG:26986]

☐ Selected features only

Raster layer: tervuren_1m [EPSG:26919]

Output column prefix [optional]: elevation

Sampled: I:/01 IP/Week 2/tervuren_elevation.shp

☑ Open output file after running algorithm

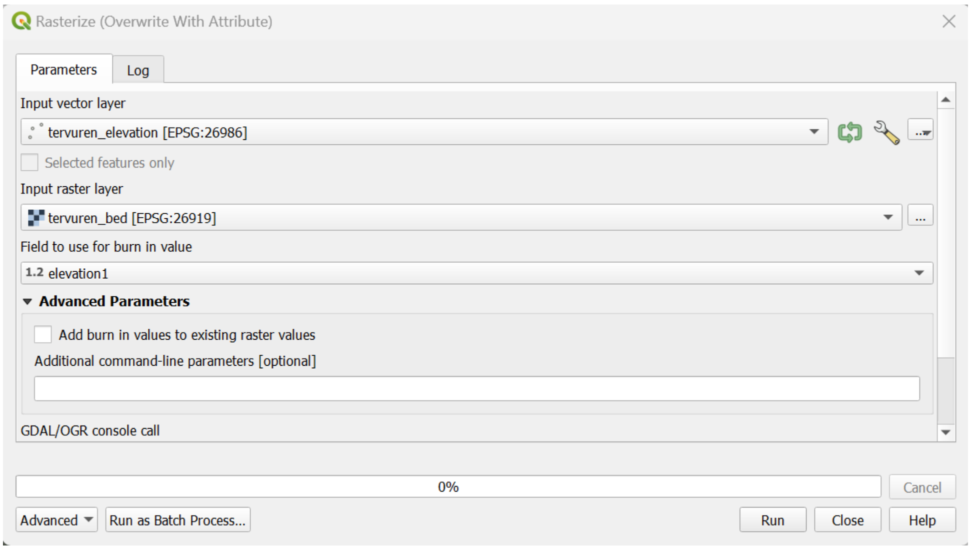
Sample raster values

This algorithm creates a new vector layer with the same attributes of the input layer and the raster values corresponding on the point location.

If the raster layer has more than one band, all the band values are sampled.

Step 4: Rasterize Bed Elevation

Rasterize riverbed elevation using **Rasterize (overwrite with attribute)** with sampled bed elevation (tervuren_elevation.shp) and initial riverbed (tervuren_bed.tif) as input vector and raster layers. Complete the dialogue as follow and run the algorithm:



Rasterize (Overwrite With Attribute)

Input vector layer: tervuren_elevation [EPSG:26986]

☐ Selected features only

Input raster layer: tervuren_bed [EPSG:26919]

Field to use for burn in value: 1.2 elevation1

Advanced Parameters

☐ Add burn in values to existing raster values

Additional command-line parameters [optional]

GDAL/OGR console call

Step 5: Convert/Translate

The final step is to Convert / Translate the riverbed elevation map from previous step (.tif) into .ASC format (ideal format to be used in the flood model). In the **additional command-line parameter** put the following text: **-co force_cellsize=true.** Save as tervuren.bed.asc.