IRSSS 2026 Practical Exercise Handout

Surface runoff simulation using *r.sim.water* in GRASS GIS 8.4
Comparison of Copernicus DEM and ZBGIS LiDAR DEM

Scenario

A short-duration strong rainfall event is simulated using identical hydrological model parameters but different Digital Elevation Models (Copernicus DEM 30 m and ZBGIS LiDAR DTM 1 m). The objective is to evaluate how DEM resolution and land cover representation influence simulated overland flow patterns.

Learning objectives

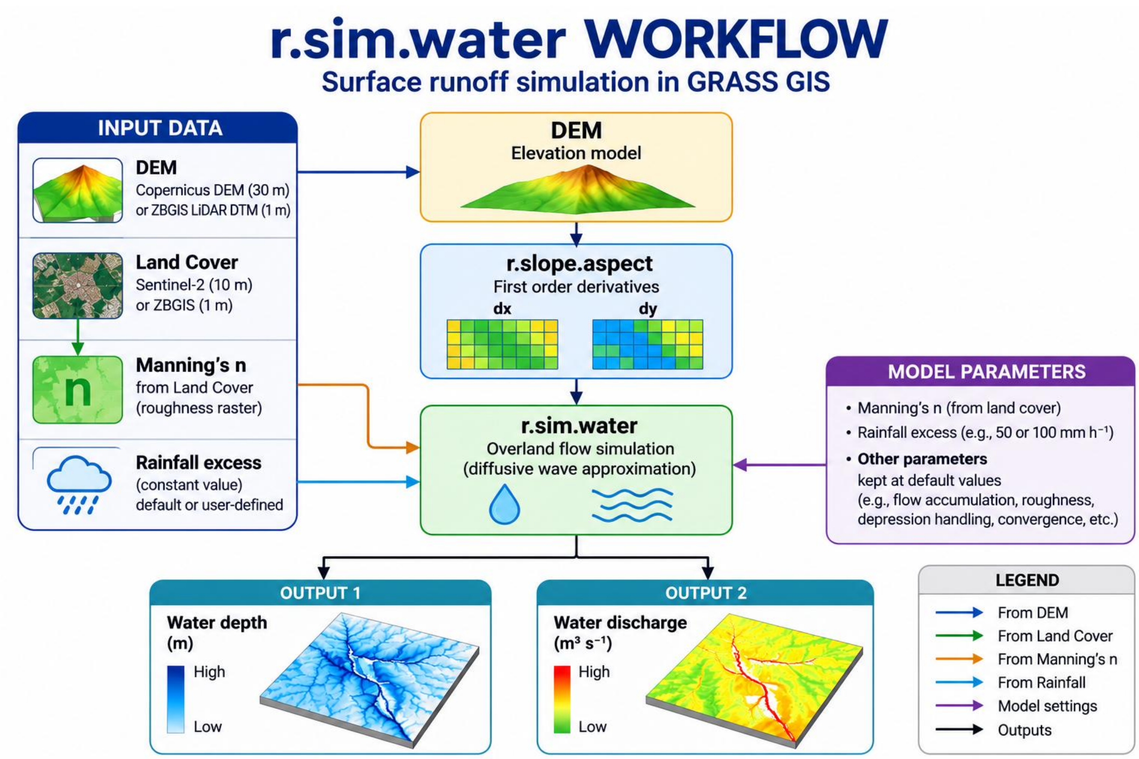
- Learn basic operations in GRASS GIS.
- Derive input data for r.sim.water hydrological model from provided data.
- Run r.sim.water using prepared input datasets.
- Interpret water depth, water discharge velocity and runoff patterns.
- Compare simulations based on Copernicus DEM and ZBGIS LiDAR DEM.
- Understand the influence of DEM, its resolution and Land Cover on hydrological modelling.

Input datasets

Dataset	**Description**	**Name**
Copernicus DEM	30 m DEM raster	DEM_Copernicus
ZBGIS LiDAR DEM	1 m DEM raster	DEM_ZBGIS
Orthophoto from ZBGIS	Reference 20 cm imagery	Orthophoto_ZBGIS
RGB from Sentinel2	Reference 10 m imagery	Sentinel2_RGB
Manning’s n from Sentinel 2	Prepared roughness raster S2 Land Cover 10m Tree cover – 0.12 Low vegetation (shrubs and grass) – 0.06 Bare ground - 0.03 Built-up area – 0.08 Water – 0.03 Note: Higher Manning's n values represent higher surface roughness and therefore lower runoff velocity.	Manning_S2
Manning’s n from ZBGIS	Prepared roughness raster from ZBGIS Orthophoto Land Cover, 20cm, Tree cover – 0.15 Low vegetation (shrubs and grass) – 0.08 Bare ground – 0.03 Roads – 0.015	Manning_ZBGIS

	Buildings – 0.3 Gravel and rocks – 0.04 Note: Higher Manning's n values represent higher surface roughness and therefore lower runoff velocity.	
Land Cover ZBGIS	Vector	Land_Cover_ZBGIS
Land Cover ZBGIS	Raster, 1 m, ZBGIS, 5 categories	Land_Cover_ZBGIS
Land Cover Sentinel2	raster 10 m	Land_Cover_S2
AOI Boundary	vector	AOI_boundary

Procedure

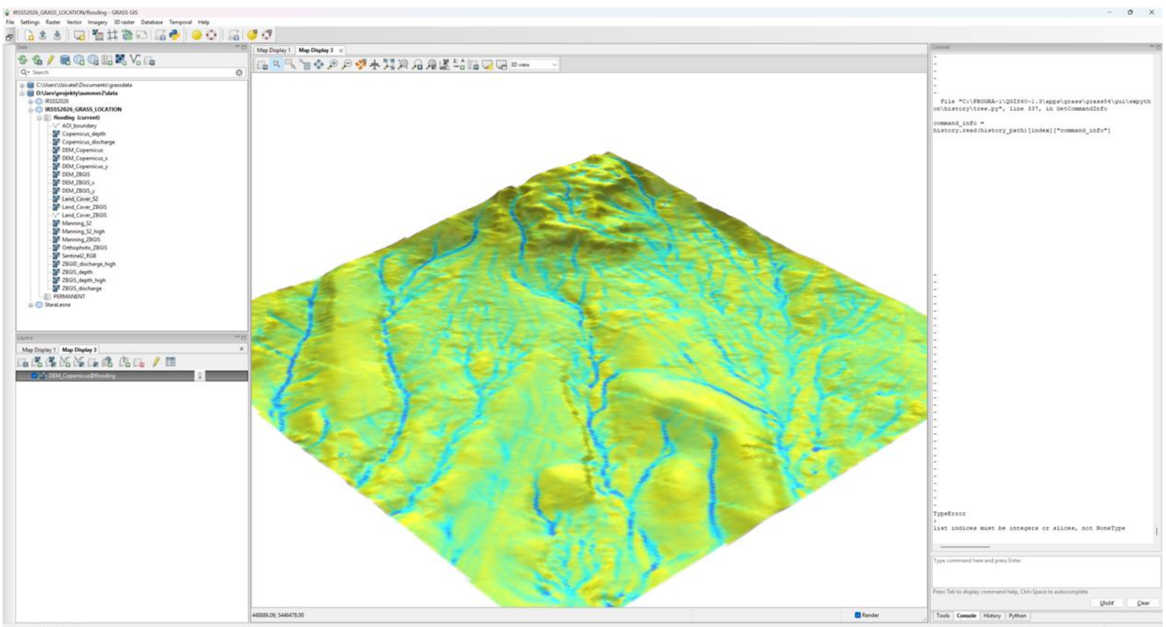


Manual page:

https://grass.osgeo.org/grass-stable/manuals/r.sim.water.html

Part 1 – Simulation using Copernicus DEM

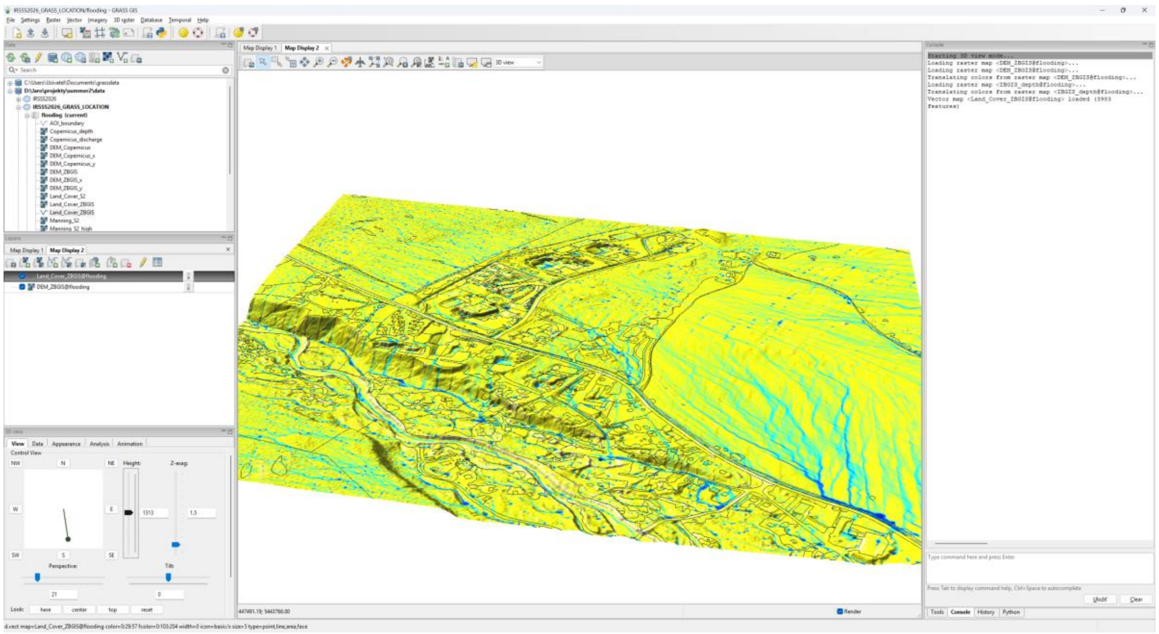
1. Open the prepared GRASS GIS project IRSSS2026_GRASS_LOCATION, mapset flooding.
2. Display the Copernicus DEM, Sentinel_RGB imagery, derived Land_Cover_S2 and Manning_S2 layers.
3. Set the computational region to DEM_Copernicus.
4. Run r.slope.aspect to derive first order derivatives dx and dy.
5. Run r.sim.water using Copernicus DEM, computed dx, dy, Manning_S2. Keep all remaining parameters at their default values. Name water depth and water discharge outputs.
6. Display water depth and water discharge maps.
7. Open new Map Display 2, display Copernicus DEM.
8. Open 3D View, set the right view (View) and light (Appearance) settings and then identify main terrain features. In "Data" choose water depth layer as color (water depth layer will be draped over the terrain). Identify water flow concentrations.
9. Make a screenshot of the map or save the display to a file on disk for later comparisons.



Part 2 – Simulation using ZBGIS LiDAR DTM

1. Return to Map Display 1.
2. Display ZBGIS_DEM, Orthophoto_ZBGIS, Land_Cover_ZBGIS (raster), Land_Cover_ZBGIS (vector) and Manning_ZBGIS.
3. Set the computational region using g.region to ZBGIS_DEM.
4. Run r.slope.aspect to derive first order derivatives dx and dy.
5. Run r.sim.water using ZBGIS_DEM, its first order derivatives and ZBGIS Manning and calculate water depth and water discharge with different names. Keep rainfall excess, and

other parameters unchanged. To speed up the calculation you can use a parallel processing and select a number of threads if your computer allows it (e.g., 4).
6. Display water depth and water discharge 2D and 3D view. You can overlay vector Land Cover to analyse the effect of land cover features represented by Manning's n on overland flow.
7. Compare all simulations side by side. If similations are done in different region settings, it is better to make screenshots or save displays to files on disk.



Comparison

- How the change in spatial resolution affected the simulation result?
- Can you identify topographic features such as roads affecting overland flow?
- Which simulation better represents roads and urban drainage?
- Can you identify major overland flow concentrations/areas with a great contribution to runoff?
- Can you identify possible DEM artifacts (e.g., striping) influencing runoff patterns?

Sensitivity experiment

Repeat the water flow simulation while changing one parameter:

- Rainfall intensity: 50 → 100 mm h^{-1}
- Manning roughness: low → high

Predict the expected changes before running the model. Discuss how the outputs change.

Final discussion

Complete the summary table during the exercise (use +, ++, +++ to indicate suitability):

Criterion	Copernicus DEM	ZBGIS LiDAR DEM
River channel representation		
Microtopography (roads, buildings)		
Flow concentrations		
Water accumulation with possible flood risk		
Computation time		
Overall suitability		

Take-home message

The quality of hydrological simulations depends not only on the numerical model itself, but also on the spatial resolution and quality of the input data. High-resolution LiDAR DEMs better represent terrain morphology and microtopographic features controlling overland flow, while coarser DEMs remain valuable for regional-scale analyses and rapid assessments.

References

MITAS, L., MITASOVA, H. (1998). Distributed soil erosion simulation for effective erosion prevention. Water Resources Research, 34(3):505–516.

NETELER, M., MITASOVA, H. (2008). Open-SOURCE GIS: A GRASS GIS approach (3rd ed.). New York: Springer.

TOKARČÍK, O., HOFIERKA, J. (2024). Designing flash flood control measures for urban areas using the Monte Carlo water flow simulation. Geomatics, Natural Hazards and Risk, 15, 1, 2361806.