# GRASS GIS: A General-purpose Geospatial Research Tool

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## Why GRASS GIS as a Tool?

Multiple researchers for over three decades contributed code, wrote associated papers, implemented already published methods, and improved and built on each others work.

- Community-driven project
- Long-term releases, stable APIs, and emphasis on science
- Single environment for vector data analysis, 2D and 3D raster analysis, image processing, and spatio-temporal data
- Mature OSGeo Foundation project

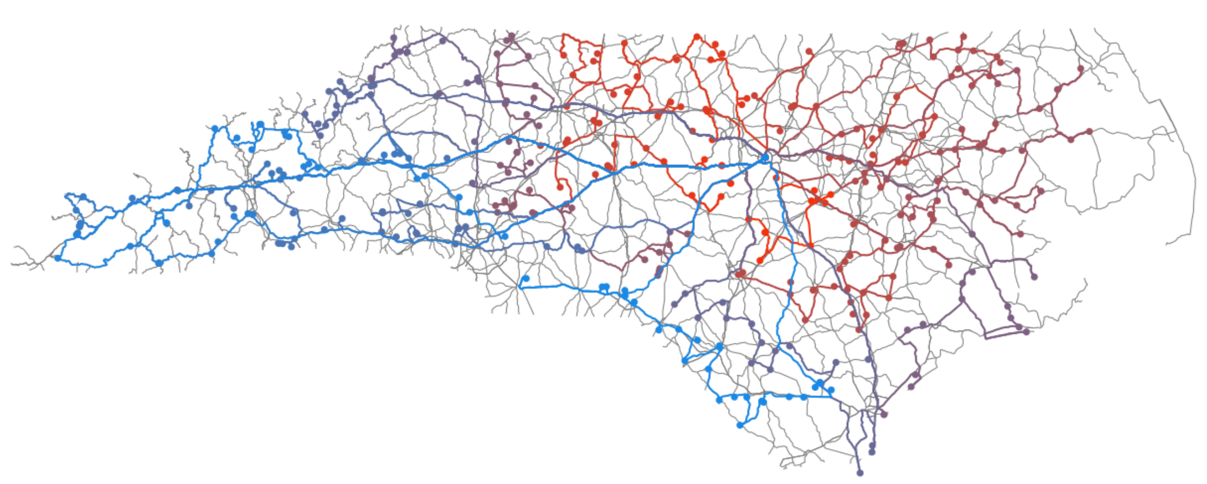
## Why GRASS GIS as a Platform?

Contributed code is maintained and extended by community and prevails even in cases when the original author cannot maintain the code anymore.

- New code typically contributed to Addons repository.
- Mature code is moved to the main code base.
- Structuring code into modules makes contributing easy.

## Example: Vector Network Analysis

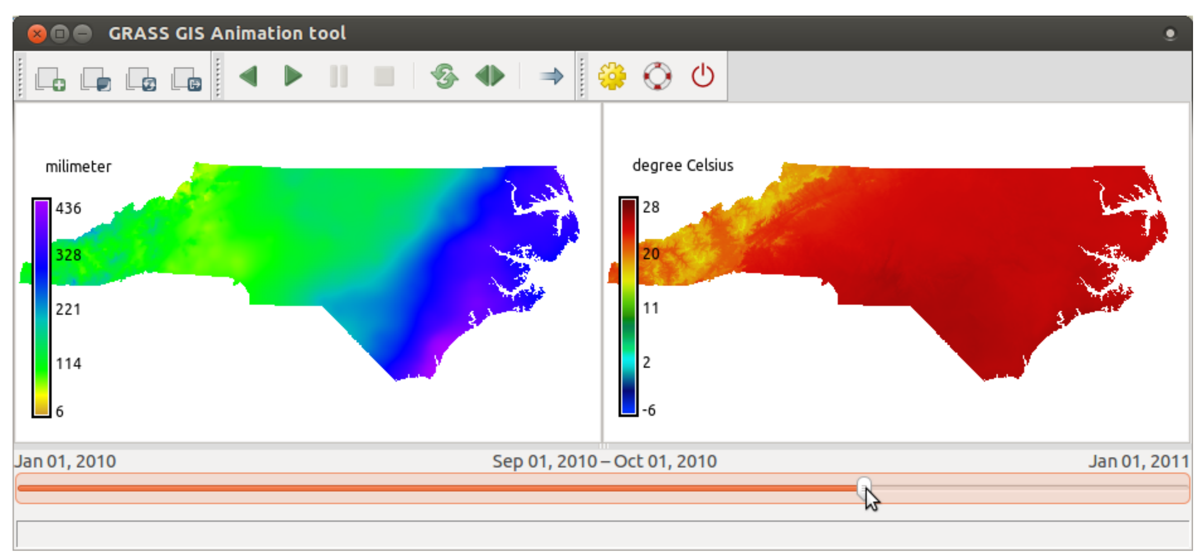
- Several modules for vector network analysis by Radim Blazek available since 2003 (e.g. *v.net.salesman*).
- The number of modules increased to almost 20.
- Turn support added by Stepan Turek in 2014.



Trips to collect samples across North Carolina, USA, as part of a water pollution testing project (PFAST).

## Example: Spatio-Temporal Data Analysis

- The time dimension was introduced in version 7.0 (Gebbert and Pebesma, 2014; Gebbert and Leppelt, 2015).
- Time series accessed as space time datasets and as individual vectors or rasters.
- More than 50 modules available to manage, analyze, process, and visualize space time datasets.
- More than 100,000 map layers can be now handled efficiently in GRASS GIS.
- Used for analysis of the European Climate Assessment & Dataset ECA&D (Haylock et al., 2008) and temperate climate zone identification (Gebbert and Pebesma, 2014).
- New temporal modules (e.g. *t.rast.aggregate*) work alongside well established *r.series* module and specialized modules such as *r.hants* implemented according to Roerink et al. (2000) or *r.seasons*.
- Raster and vector temporal algebra can be used for tasks such as computing hydrothermal coefficient for a time series of climate data using a mathematical formula (Leppelt and Gebbert, 2015).




Creating a synchronized animation of monthly total precipitation and mean temperature for NC, USA

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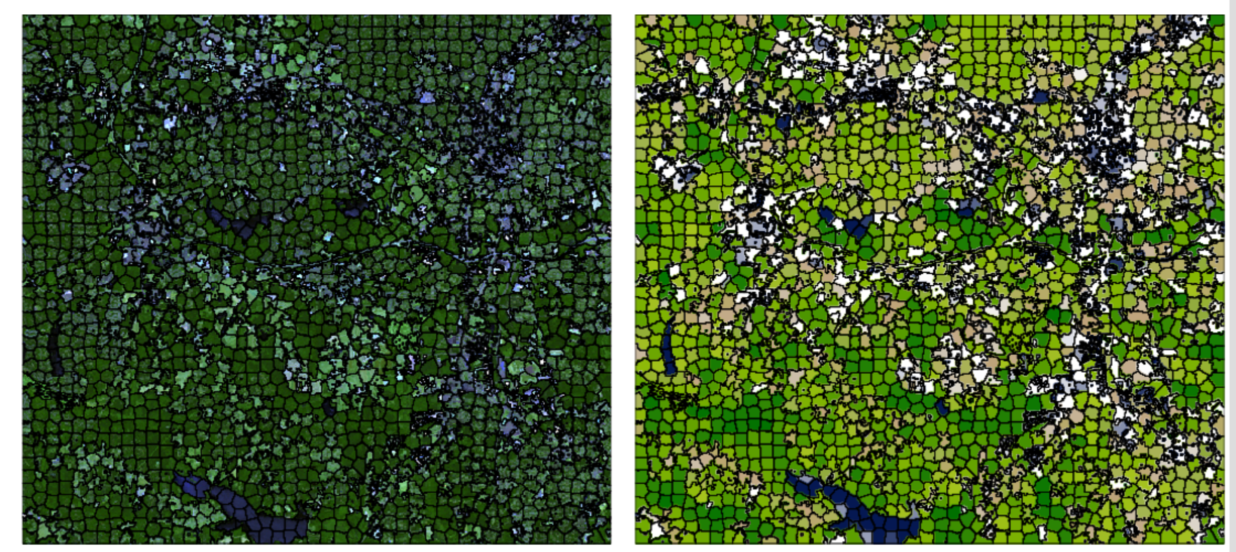
## Example: Image Segmentations

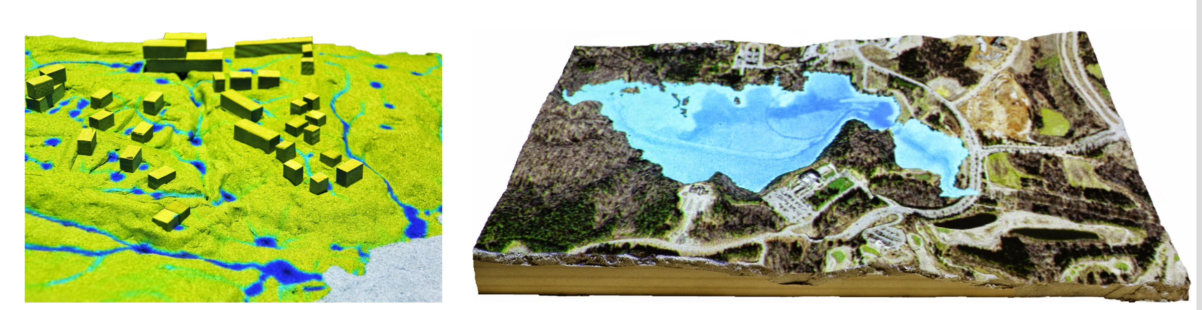
- *r.clump* for grouping pixels with the same integer values available since '80s. Now *r.clump* handles multiple image bands and floating point values.
- *r.smooth.seg* for noise reduction (Vitti, 2008, 2012)
- Region-growing image segmentation originally from Eric Momsen (2012) was improved by Markus Metz and included as *i.segment* into version 7.0.
- *i.segment.hierarchical* by Pietro Zambelli based on *i.segment* performs parallelized hierarchical segmentation.
- Rashad Kanavath and Markus Metz implemented SLIC Superpixels segmentation (Achanta, 2010; Achanta et al., 2012) in 2016 as *i.superpixels.slic*.



Superpixels (black outlines) with pseudo-color and NDVI images, central Wake county, NC, USA

## Example: Water, Floods, and Erosion

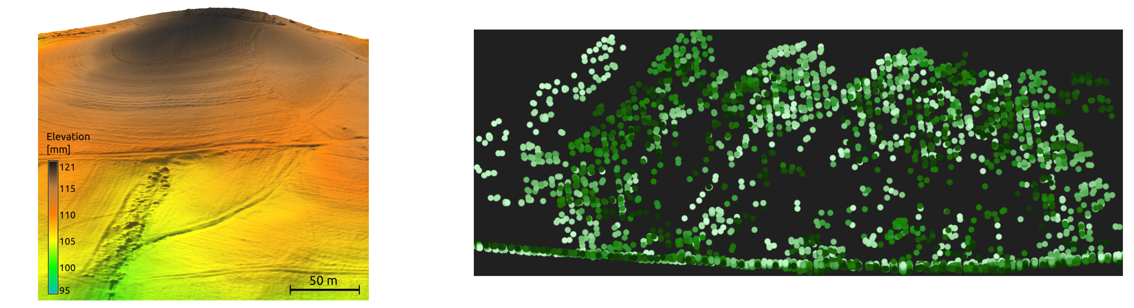
- *r.sim.water* (Mitas and Mitasova, 1998) overland flow simulation used for emergency routing (Raghavan et al., 2014).
- Least cost flow *r.watershed* from '89 updated for massive data in '11.
- Petrasova et al. (2014) used in *Tangible Landscape* dam break inundation *r.damflood* Cannata and Marzocchi (2012).



Flow used for landscape architecture design (left) and a dam breach on Lake Raleigh, NC, USA (right)

## Example: Lidar Data Processing

- Filtering of ground and non-ground points was included in the *v.lidar.edgedetection* group of modules.
- *v.outlier* module serves as a base for *v.lidar.mcc* implementing Multiscale Curvature Classification.
- *v.surf.rst* for spatial interpolation developed in '90s; improved several times and parallelized for version 7.4.
- Improved *r.in.lidar* statistically analyzes large point clouds.



DEM interpolated from lidar data shows tillage of a field in Raleigh, NC, USA (left) and a point cloud transect created with *v.profile.points* shows tree structure (right)

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