

New lidar processing functionality in GRASS GIS 7.1

webinar for U.S. Fish and Wildlife Service Remote Sensing Technical Group

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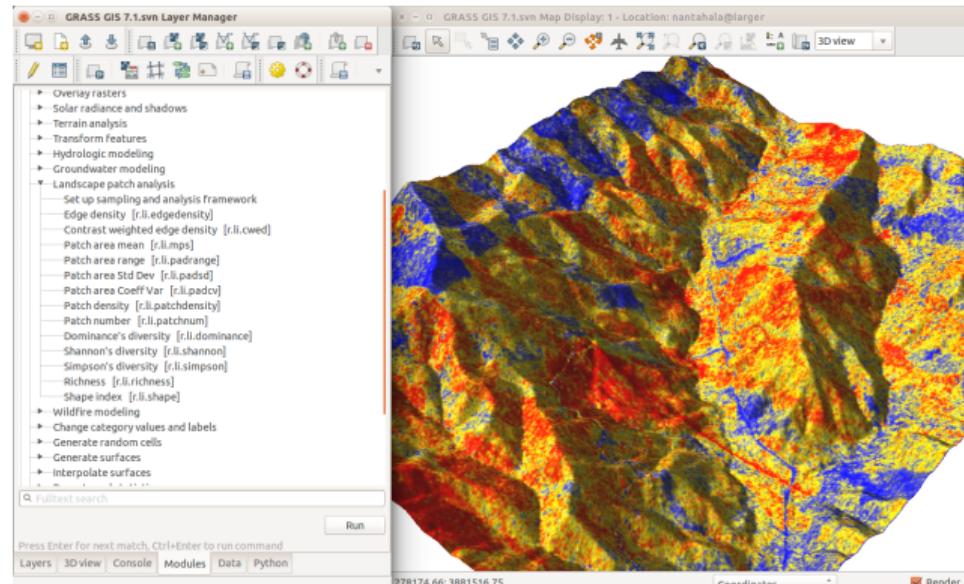


available at

wenzeslaus.github.io/grass-lidar-talks

GRASS GIS

- ▶ all in one
- ▶ functionality split to modules
- ▶ unified access to all modules from GUI, command line, Python and R
- ▶ GUI independent but integrated



Typical lidar workflow

Explore the data with *r.in.lidar*

- ▶ import extent based on input data
(-e flag)
- ▶ resolution set to high number (coarse,
`resolution=10`)
- ▶ count number of points per cell
(`method=n`)
- ▶ try different class and return filters
(`class_filter`, `return_filter`)
- ▶ decide on computational region extent
and resolution (`g.region`)



r.in.lidar, 578 million points in 90 files to 1882 × 1651 cells using 50MiB in 2 min

Typical lidar workflow

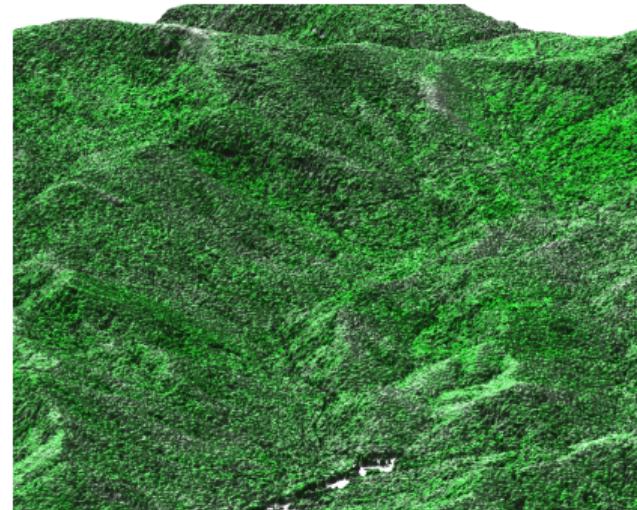
Analyze with *r.in.lidar*

- ▶ statistics of point counts, height and intensity
- ▶ using different resolutions

Create surface with *v.in.lidar* and interpolation

- ▶ few/sparse points, smaller extent
- ▶ interpolate smooth surface without NULLs

Continue analysis using standard GRASS GIS tools



r.in.lidar and *r.neighbors*, range smoothed maximum surface, 551 million points from 90 files to 8076 x 7223 cells using 480MiB in 4 min

Openly accessible study materials by NCSU OSGeoREL

- ▶ GRASS GIS, Python and more
- ▶ Geospatial Modeling and Analysis ncsu-osgeorel.github.io/geospatial-modeling-course
- ▶ UAV/lidar Data Analytics course ncsu-osgeorel.github.io/uav-lidar-analytics-course



r.in.lidar

- ▶ one file or multiple files as input
- ▶ produces raster from points
 - ▶ n, min, max, sum
 - ▶ mean, range, skewness, ...
- ▶ limits import by
 - ▶ range of Z
 - ▶ return, class
- ▶ subsequent raster-based processing
- ▶ use intensity instead of the Z
- ▶ base raster

i.segment on count of ground points and count of non-ground points



r.in.lidar: compute height above a given raster during binning

r.in.lidar – compute height above given surface (base_raster)



The resolutions of binning and ground raster can differ.

r.in.lidar: base_raster workflow

`r.in.lidar method=mean class=2`

□← 29 million points from 90 files
□→ ground with NULLs (8×8km, 1m)

`r.neighbors size=25`

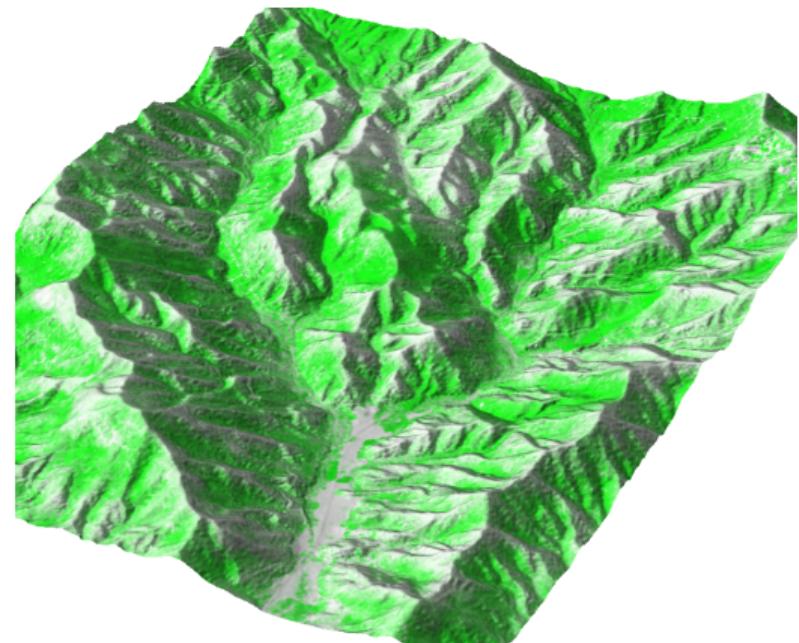
□← ground with NULLs
□→ continuous ground

`r.in.lidar method=max`

`resolution=10 class_filter=1`
□← 522 million points from 90 files
□← continuous ground
□→ max veg height per 10m cell

9 min, 480 MiB, Ubuntu, 2.7 GHz, SSD

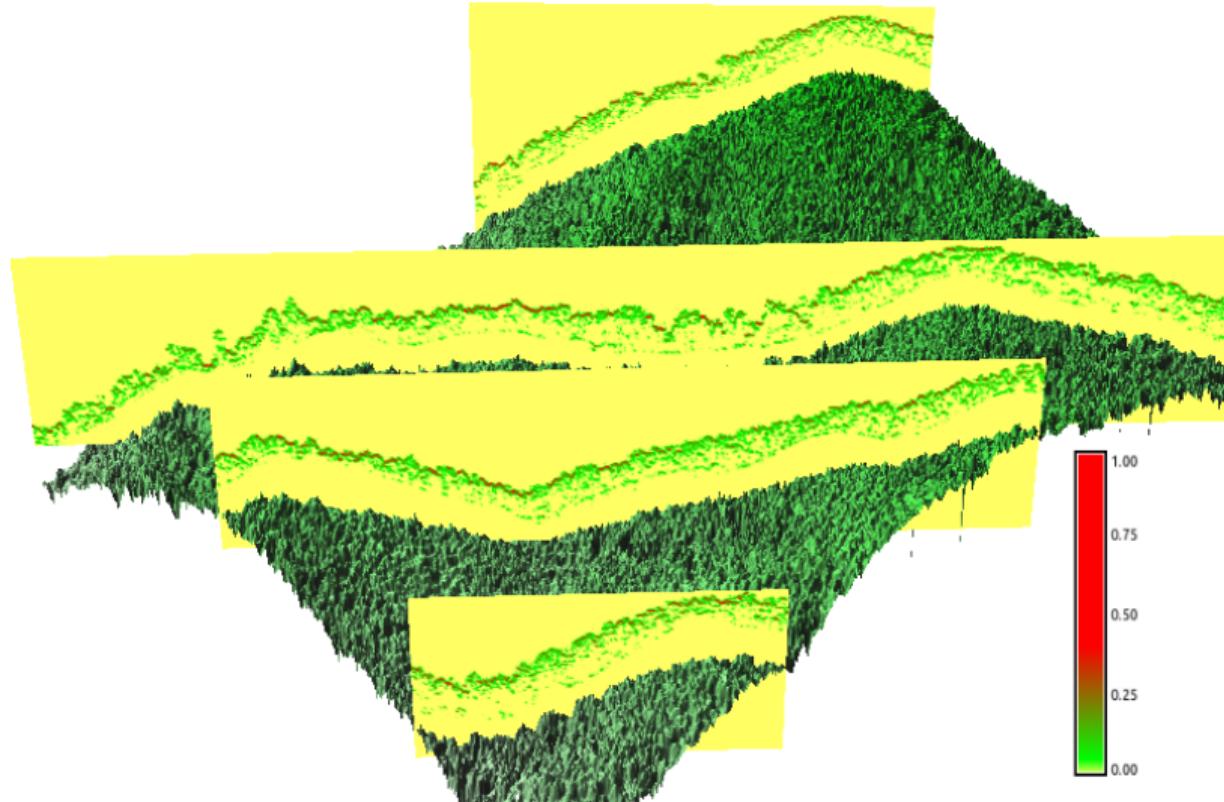
578 million points in 90 files



r3.in.lidar

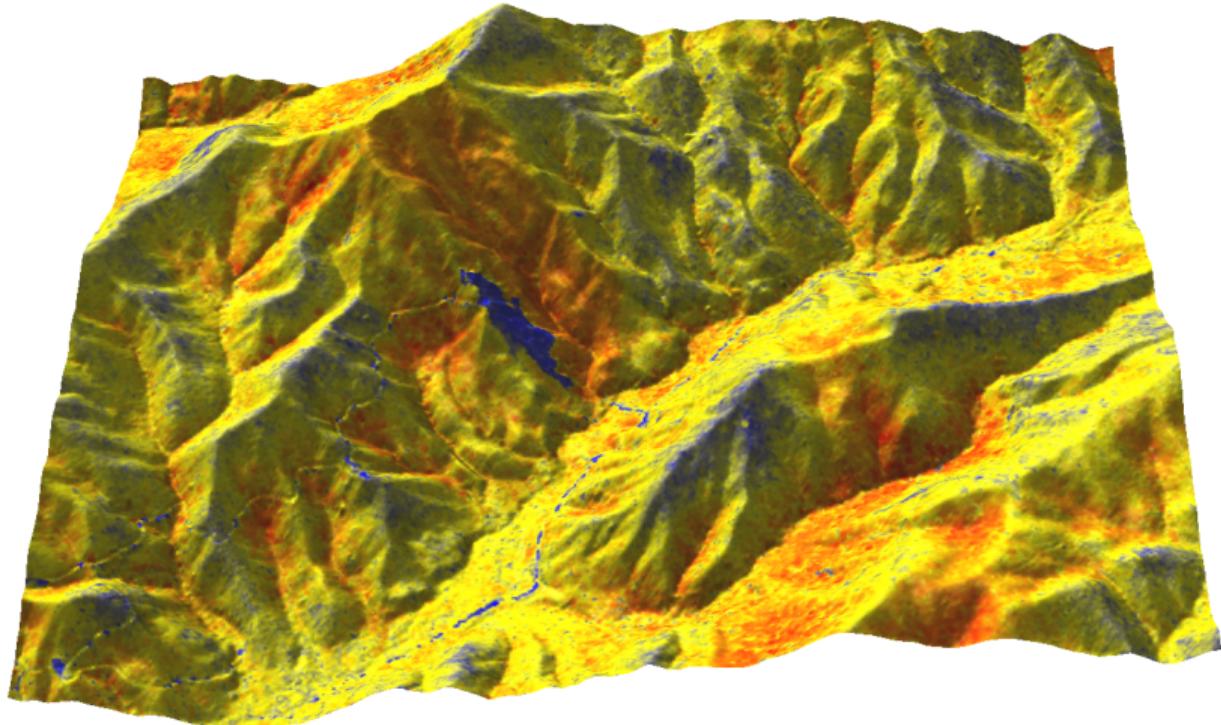
- ▶ generally similar to *r.in.lidar*
- ▶ 3D raster
- ▶ proportional count
 - ▶ count per 3D cell relative to the count per vertical column
- ▶ intensity can be used instead of count

under development



v.in.lidar

- ▶ filtering same as in *r.in.lidar*
- ▶ 3D vector
- ▶ used together with
 - ▶ *r.in.lidar*
 - ▶ interpolation modules (*v.surf.rst*, *v.surf.bspline*, *v.surf.idw*)
- ▶ decimation
- ▶ polygons as a mask



range from *r.in.lidar* on ground obtained from *v.in.lidar* followed by *v.surf.rst*

Comparison of count-based and grid-based decimation



Crop the point cloud by polygon

v.in.lidar – limit the import to selected areas (2D)



Speed optimization

r.in.lidar

- ▶ choose computation region extent and resolution ahead
- ▶ have enough memory to avoid using percent option

v.in.lidar

- ▶ **-r** limit import to computation region extent
- ▶ **-t** do not create attribute table
- ▶ **-b** do not build topology (applicable to other modules as well)
- ▶ **-c** store only coordinates, no categories or IDs

Memory requirements

r.in.lidar

- ▶ depend on the size of output and type of analysis
- ▶ can be reduced by percent option
- ▶ ERROR: G_malloc: unable to allocate ... bytes of memory
- ▶ on Linux available memory for process is RAM + SWAP partition

v.in.lidar

- ▶ low when not building topology
- ▶ export GRASS_VECTOR_LOWMEM=1

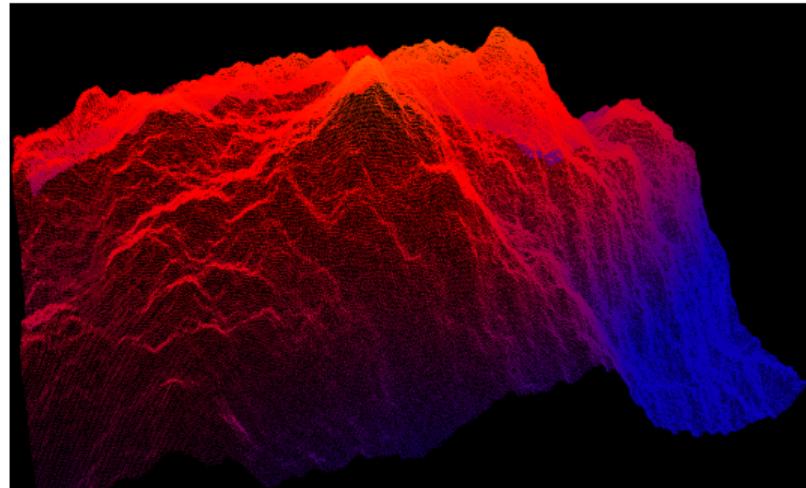
Limits

- ▶ vector features with topology: count limit is about 2 billion features per vector map
- ▶ points without topology: count theoretically limited only by the 64bit architecture (may be 16 exabytes per file but depends on the file system)
- ▶ more limits for 32bit versions for operations which require memory
- ▶ number of open files limitation (system limit)
 - ▶ often 1024, change using *ulimit* on Linux
- ▶ *r.watershed* 90,000 × 100,000 (9 billion cells) in 77.2 hours (2.93GHz)
- ▶ *v.surf.rst*: minutes = $1.5e-11 * \text{points}^2$ (test: 13 min for 1 million points and 201880 cells)
- ▶ read the documentation
- ▶ write to grass-user mailing list or GRASS GIS Tracker in case you hit limits

v.out.lidar

exports points in a vector map as lidar points

- ▶ visualization (plas.io, CloudCompare)
- ▶ further processing (PDAL, libLAS, CloudCompare, ...)
- ▶ testing workflows with generated data

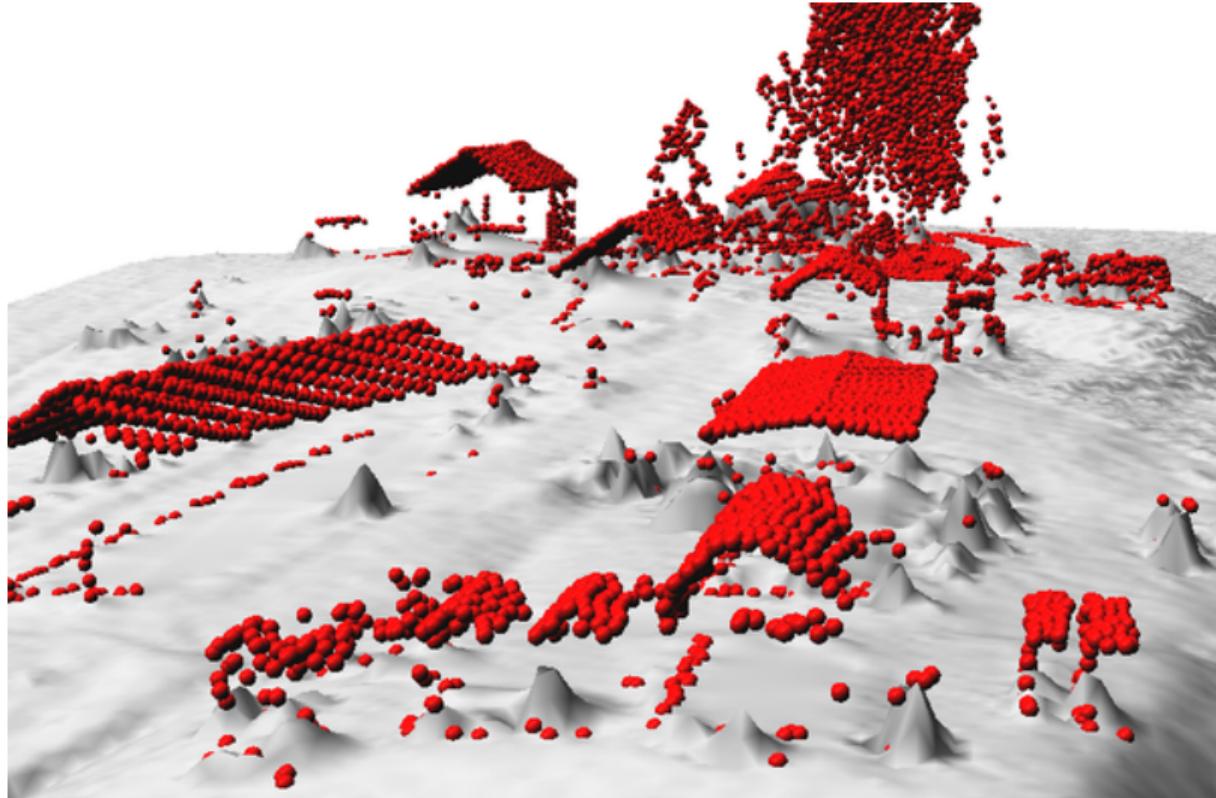


r.surf.fractal output in plas.io

More smaller tools under development.

v.lidar.edgedetection suite

- ▶ *v.lidar.edgedetection*
- ▶ *v.lidar.growing*
- ▶ *v.lidar.correction*
- ▶ uses return information



- ▶ ground and non-ground
- ▶ multiscale curvature based classification algorithm



- ▶ sky-view factor



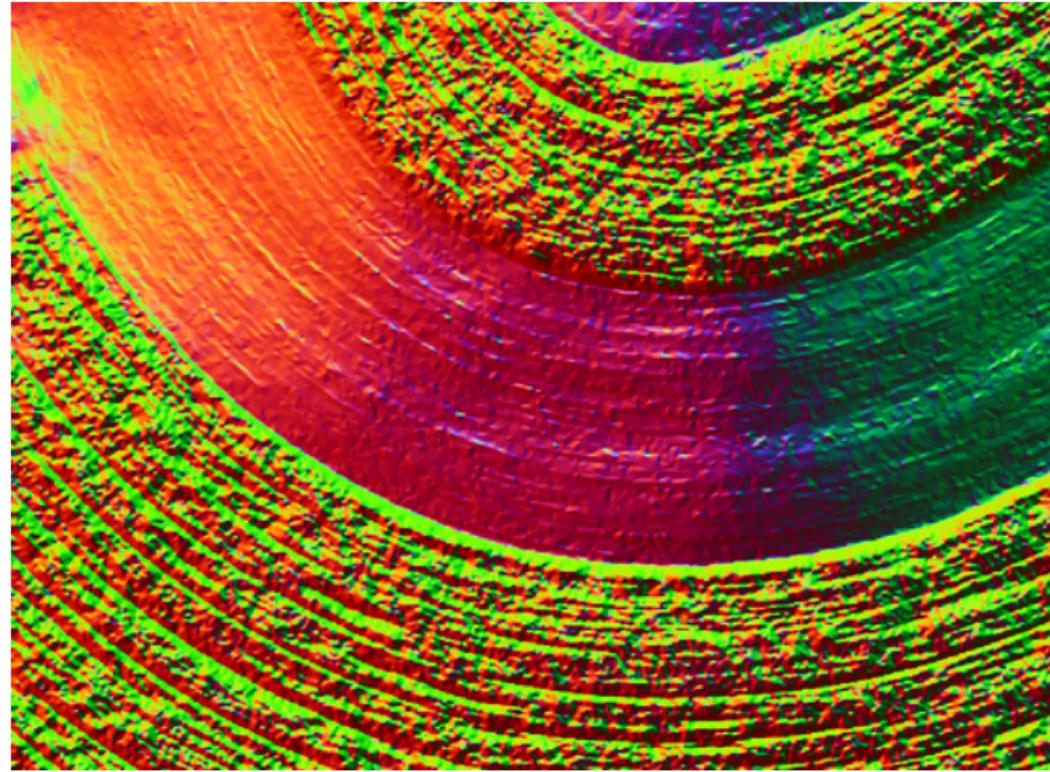
r.local.relief

- ▶ local relief model



r.shaded.pca

- ▶ relief shades from various directions
- ▶ combined into RGB composition



Integration with PDAL

experimental

- ▶ *v.in.pdal*
- ▶ reprojection during import
- ▶ ground filter (alternative to *v.lidar.edgedetection* or *v.lidar.mcc*)
- ▶ compute height as a difference from ground

planned

- ▶ *r.in.pdal*, *r3.in.pdal*, *v.out.pdal*, *r.out.pdal*, ...
- ▶ more PDAL filters

GRASS GIS lidar tools roadmap

- ▶ now: basic tools available in GRASS GIS 7.0
 - ▶ 7.0.3 released this January with 64bit support for MS Windows
- ▶ now: presented functionality available for testing in development version of GRASS GIS
 - ▶ daily build for MS Windows and Ubuntu
 - ▶ self-compiled version (simple for Fedora, CentOS, ... possible on Mac OS)
- ▶ summer: 3D raster, PDAL, 2D display, smooth reprojections
- ▶ fall/winter: backport of stable functionality to 7.0 or release of 7.1

Acknowledgements

Software: GRASS GIS

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Dataset: Nantahala NF, NC: Forest Leaf Structure, Terrain and Hydrophysiology

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<http://dx.doi.org/10.5069/G9HT2M76>

Summary

- ▶ rasterize early
- ▶ make use of existing methods for raster and vector processing
- ▶ 3D rasters, PDAL integration
- ▶ the plan for next 30 years driven by users – grass-user mailing list

Get GRASS GIS 7.1 development version at
grass.osgeo.org/download

