

Processing UAV and lidar point clouds in GRASS GIS

XXIII ISPRS Congress, Prague 2016

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July, 2016



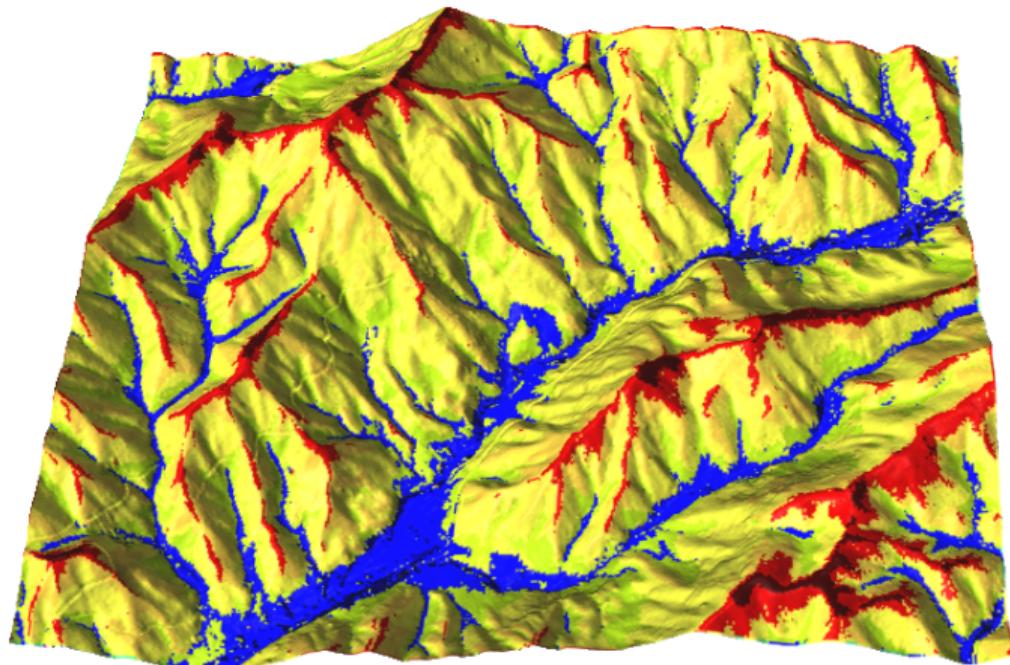
available at

wenzeslaus.github.io/grass-lidar-talks

Providing algorithms to the community

- ▶ new landform recognition approach – geomorphons
- ▶ by Jasiewicz and Stepinski from AMU, Poland and University of Cincinnati, USA
- ▶ not just a paper Geomorphology, 2013
- ▶ not just public code
- ▶ *r.geomorphon*

module in GRASS GIS addons repository



Free, libre and open source

Scripts and code I'm writing

- ▶ review
- ▶ re-usable
 - ▶ by other people
 - ▶ by future myself

Software I'm using

- ▶ driven by needs of users
- ▶ longevity
 - ▶ learn now, use forever
 - ▶ GRASS GIS: over 30 years of development



Open Science Logo, Greg Emmerich,
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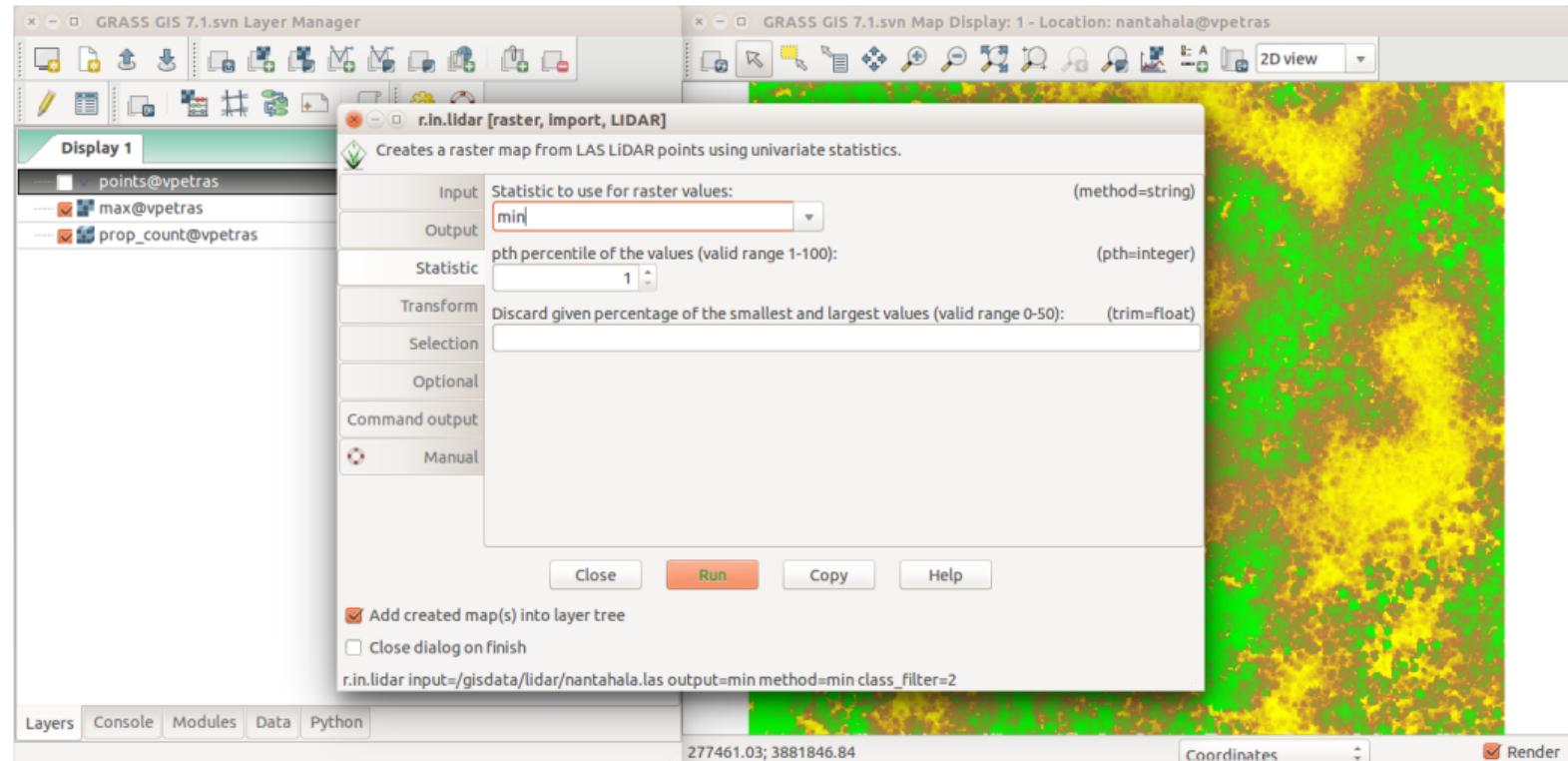
- ▶ all in one
 - ▶ hydrology modeling, image segmentation, point clustering, ...
- ▶ from small laptops to supercomputers
 - ▶ Raspberry Pi, Windows, Mac, GNU/Linux, FreeBSD, IBM AIX
- ▶ learn now, use forever
 - ▶ over 30 years of development and interface refinement
- ▶ used by
 - ▶ US Oak Ridge National Laboratory, Edmund Mach Foundation, JRC, ...



GRASS GIS

latest release 7.0.4 Sunday

GUI



Python and command line interfaces

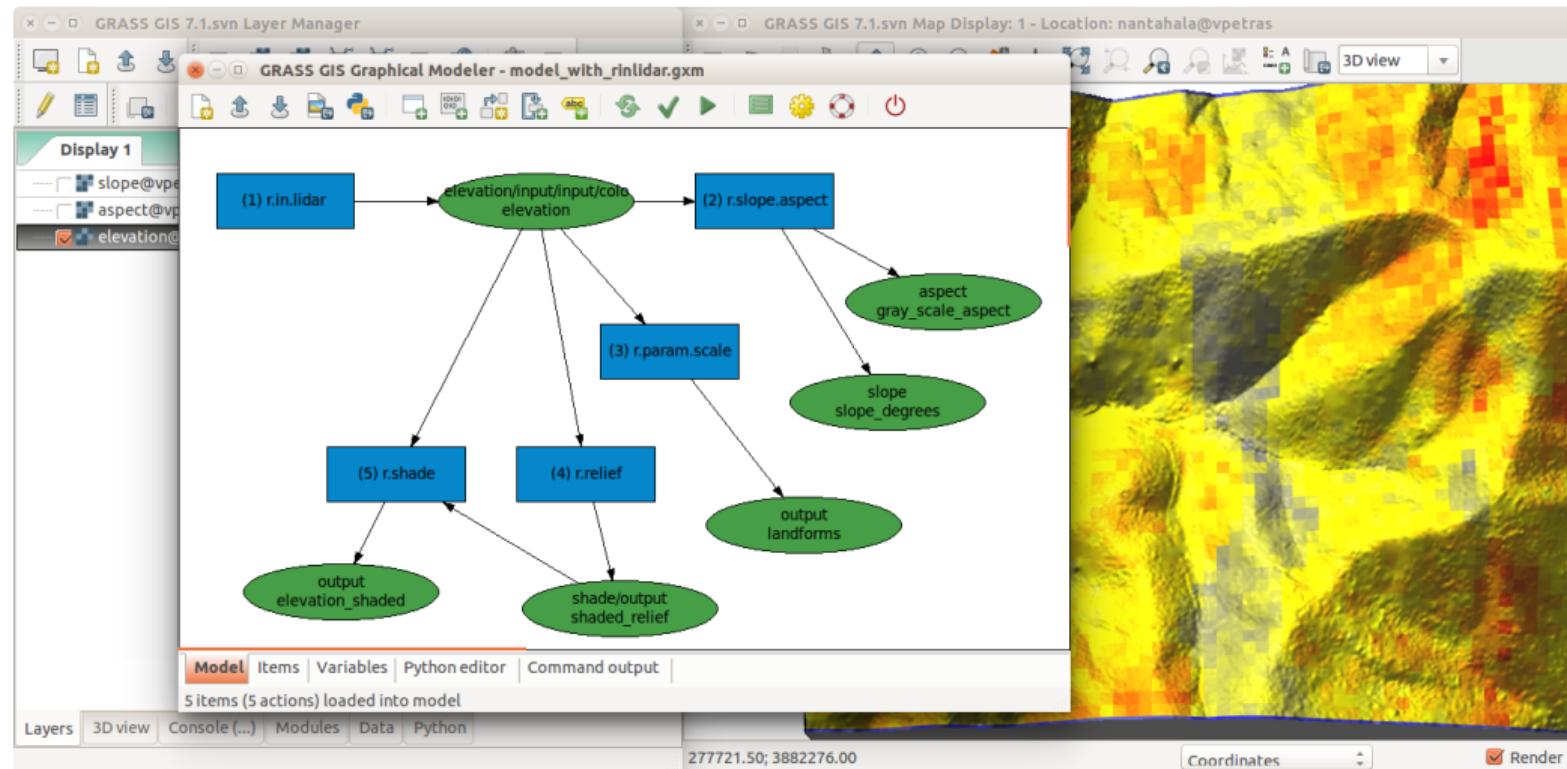
Documentation, Command Line (Shell, Bash, cmd.exe):

```
r.in.lidar input=points.las \
    output=elevation -e
```

Python:

```
from grass.script import run_command
run_command('r.in.lidar',
            input="points.las",
            output="elevation",
            flags='e')
```

Graphical Modeler



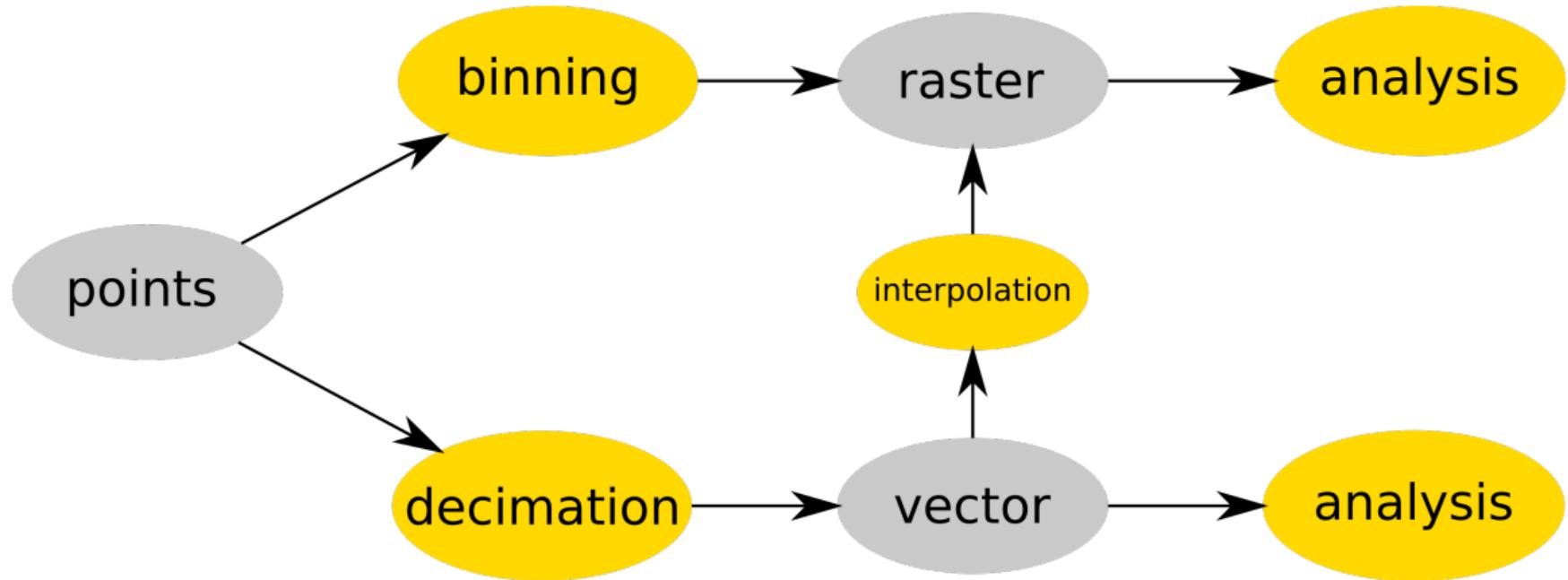
Points

- ▶ collected by lidar
- ▶ generated by Structure from Motion (SfM) from UAV imagery



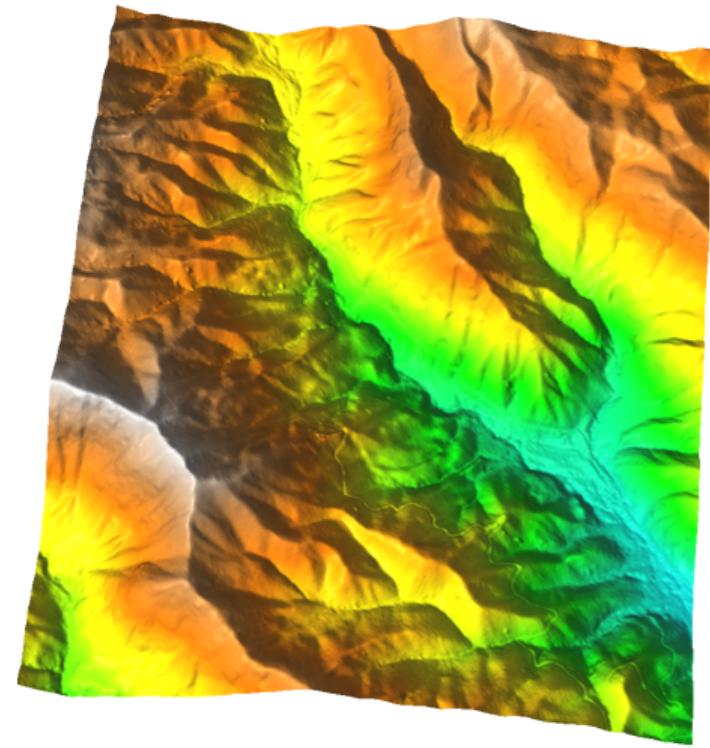
surface interpolated from points and visualized in GRASS GIS

Workflow overview



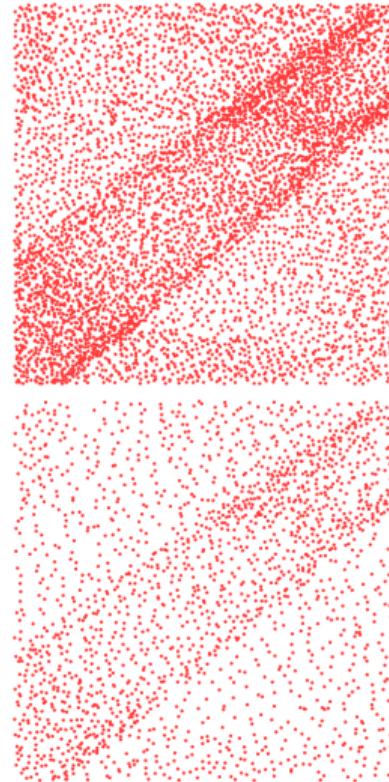
Surface interpolation

- ▶ *v.surf.idw*
 - ▶ Inverse Distance squared Weighting
- ▶ *v.surf.bspline*
 - ▶ Bicubic or bilinear Spline interpolation with Tykhonov regularization
- ▶ *v.surf.rst*
 - ▶ Regularized Spline with Tension
 - ▶ *v.surf.rst.mp* (experimental)
 - ▶ 2 millions of points in 11 minutes



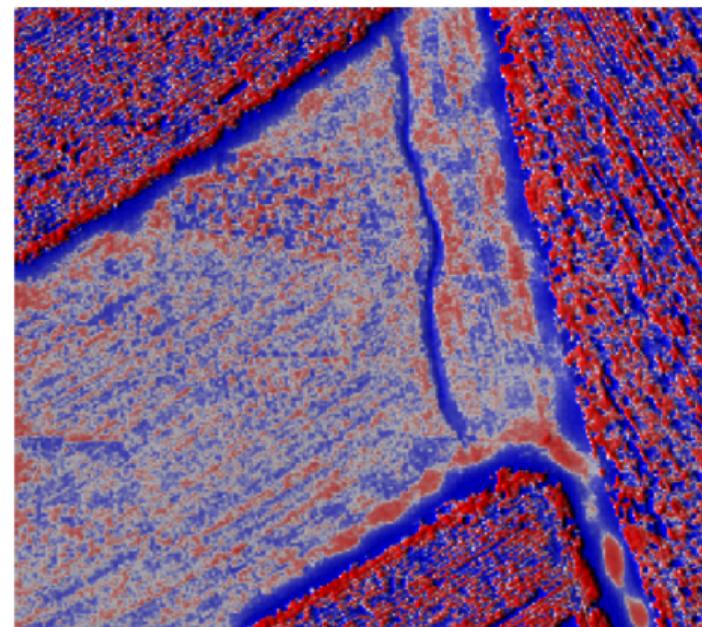
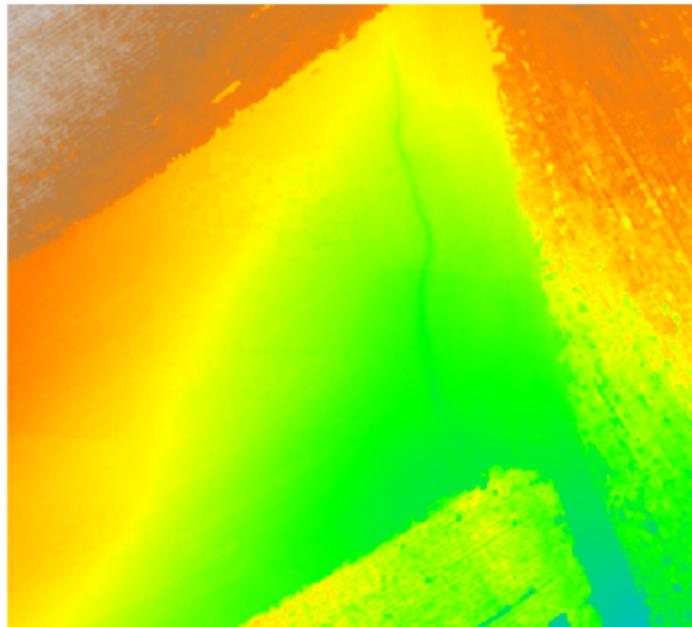
Import and decimation

- ▶ *v.in.lidar*
 - ▶ libLAS
 - ▶ LAS/LAZ to GRASS GIS native vector
 - ▶ data stored in GRASS GIS database
- ▶ interpolation, clustering, ... are costly
- ▶ often more points than we need
- ▶ decimation \approx thinning \approx sampling
 - ▶ count-based decimation (skips points)
 - ▶ grid-based experimental, others needed?
 - ▶ fast count-based as good as more advanced decimations



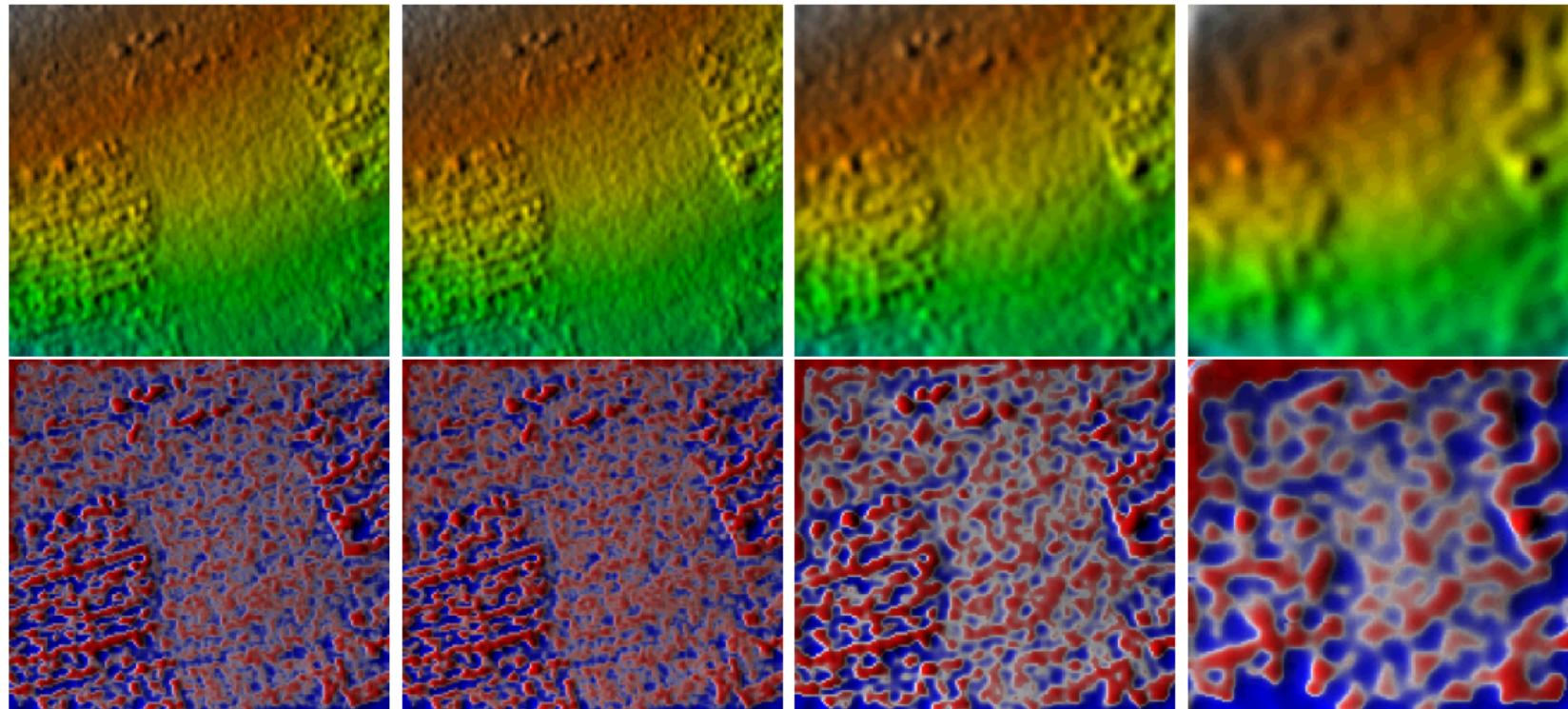
Local relief model (LRM)

- ▶ `r.local.relief` (micro-topography, features other than trend)



30-60cm wide, 30cm deep, 60m long gully (resolution 30cm)

Count-based decimation influence on interpolated elevation



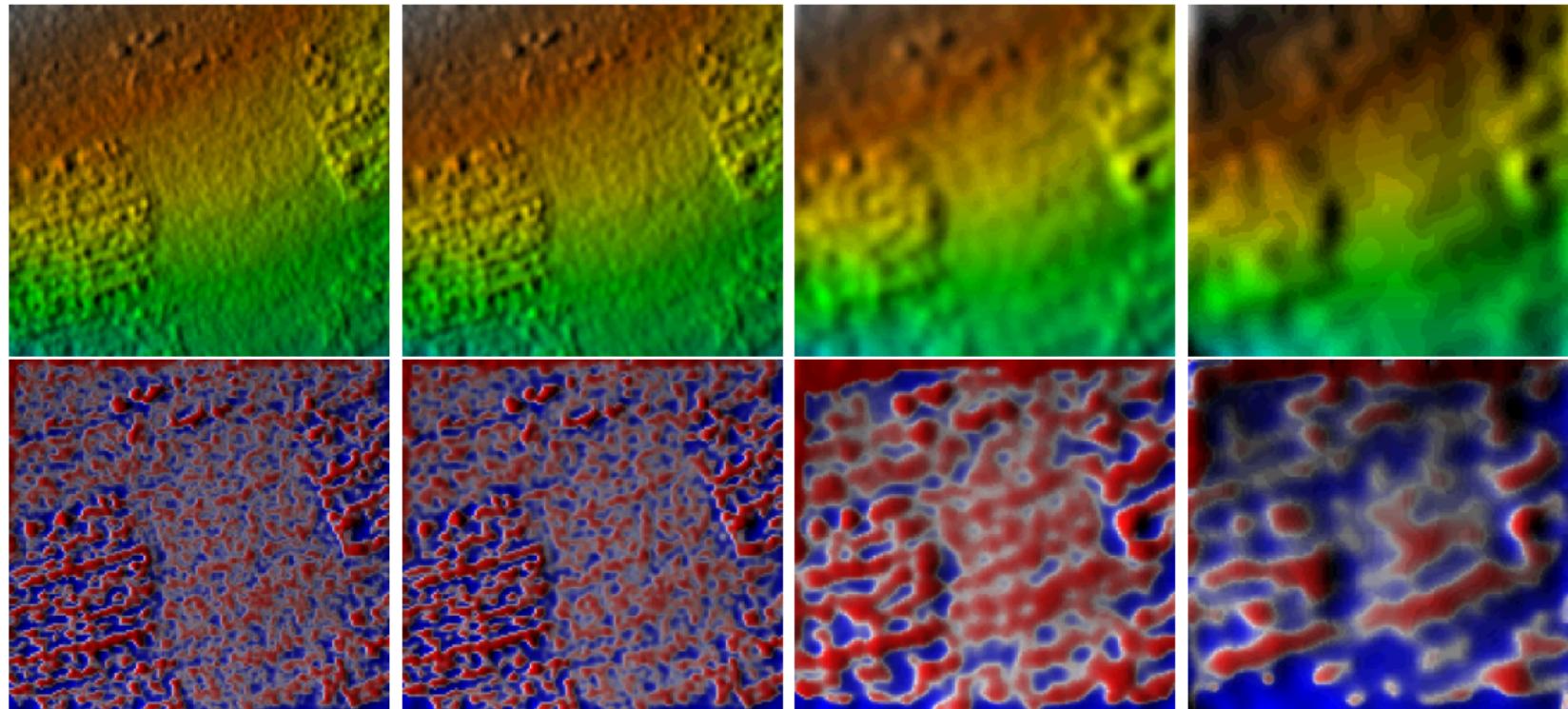
keep all
0 %

skip every 5
20 %

keep every 20
90 %

keep every 100
99 %

Influence of grid-based decimation resolution



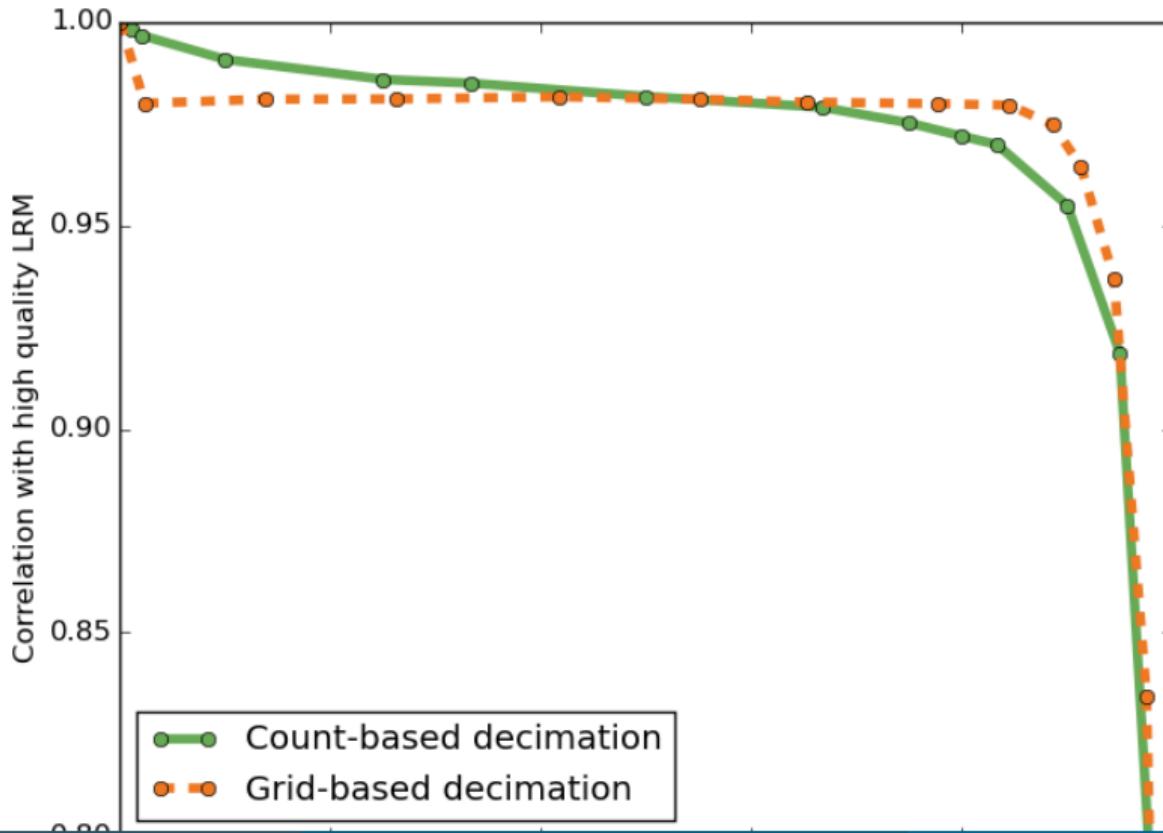
grid size 0.1 m
0 %

grid size 0.3 m
81 %

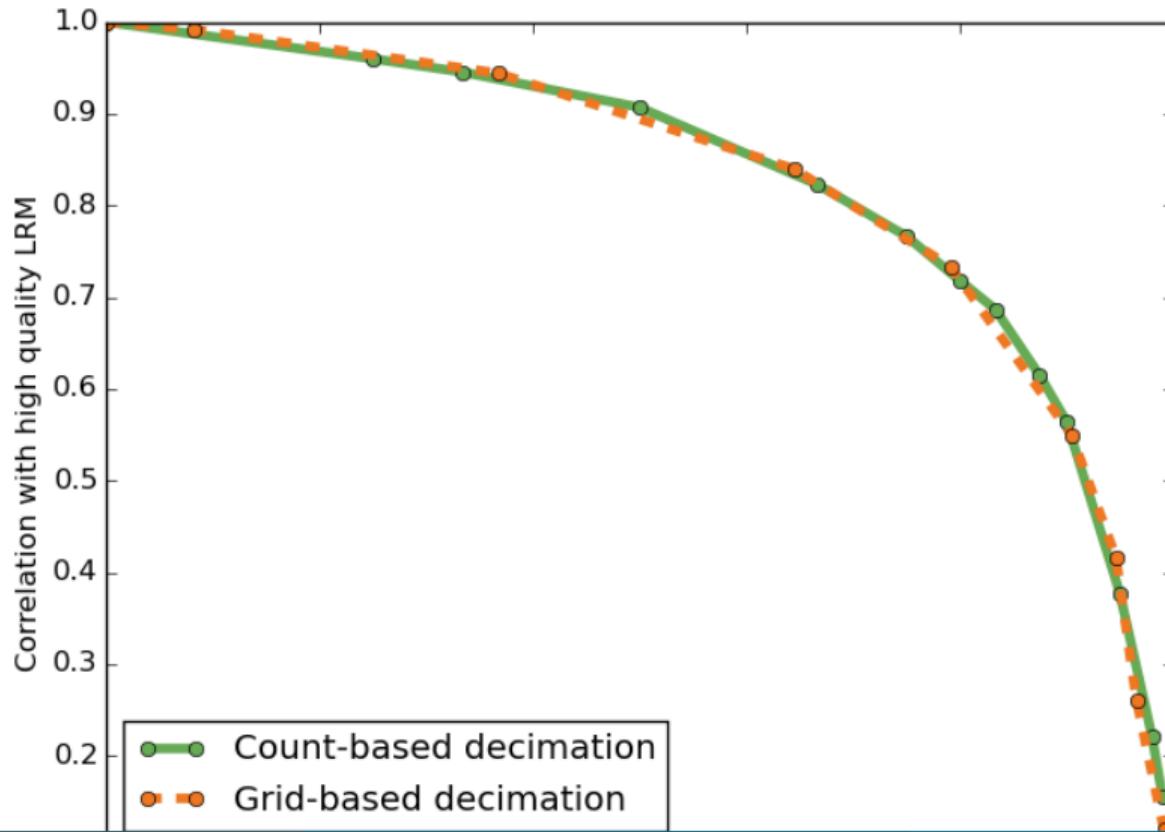
grid size 0.9 m
98 %

grid size 1.5 m
99 %

Decimating UAV/SfM point cloud

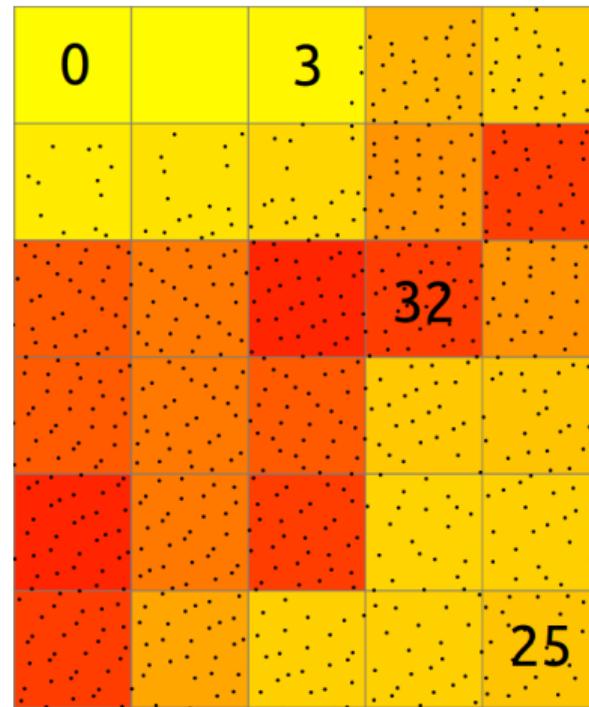


Decimating lidar point cloud



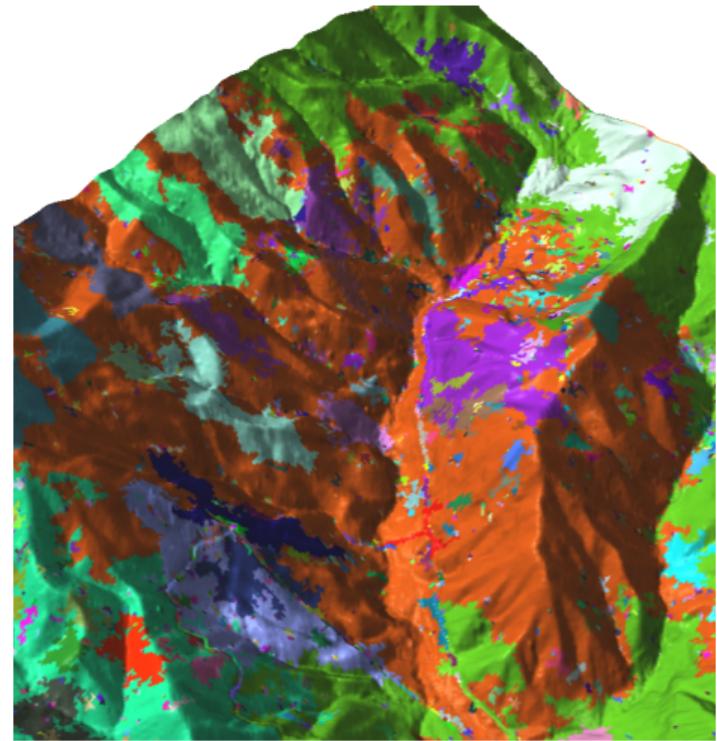
Binning points to raster

- ▶ *r.in.lidar*
- ▶ import and analysis
- ▶ statistics of point counts, height and intensity
 - ▶ n, min, max, sum
 - ▶ mean, range, skewness, ...



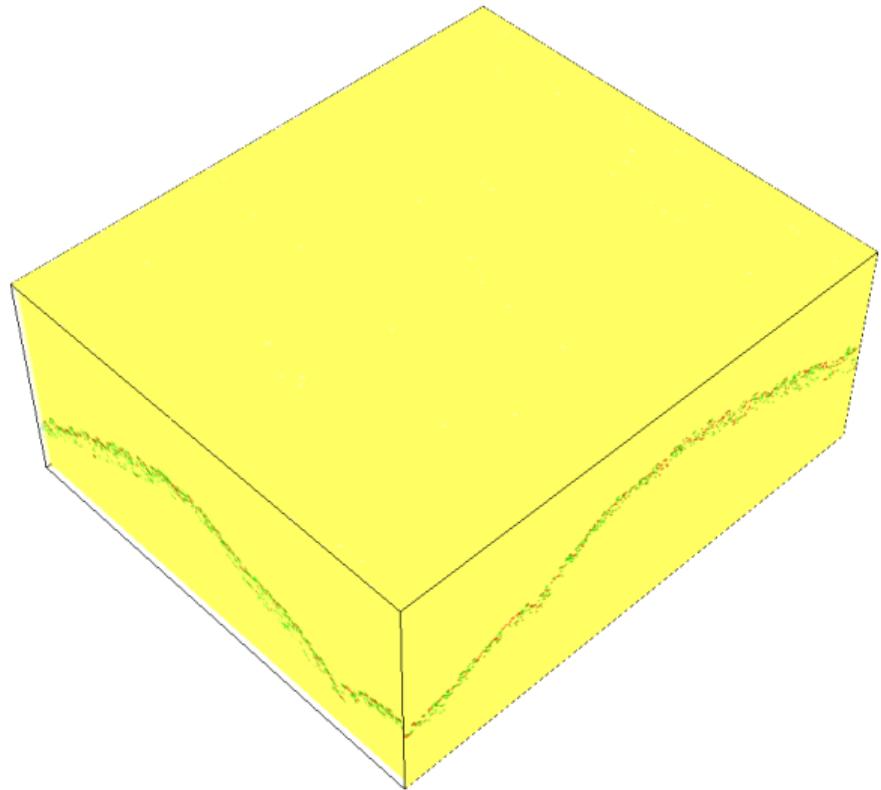
Raster processing

- ▶ many algorithms are raster-based
 - ▶ 163 raster modules
 - ▶ 45 imagery modules
 - ▶ 20 spatio-temporal raster modules
- ▶ example:
 1. count of ground points
 2. count of non-ground points
 3. used as image bands
 4. segmentation using *i.segment*



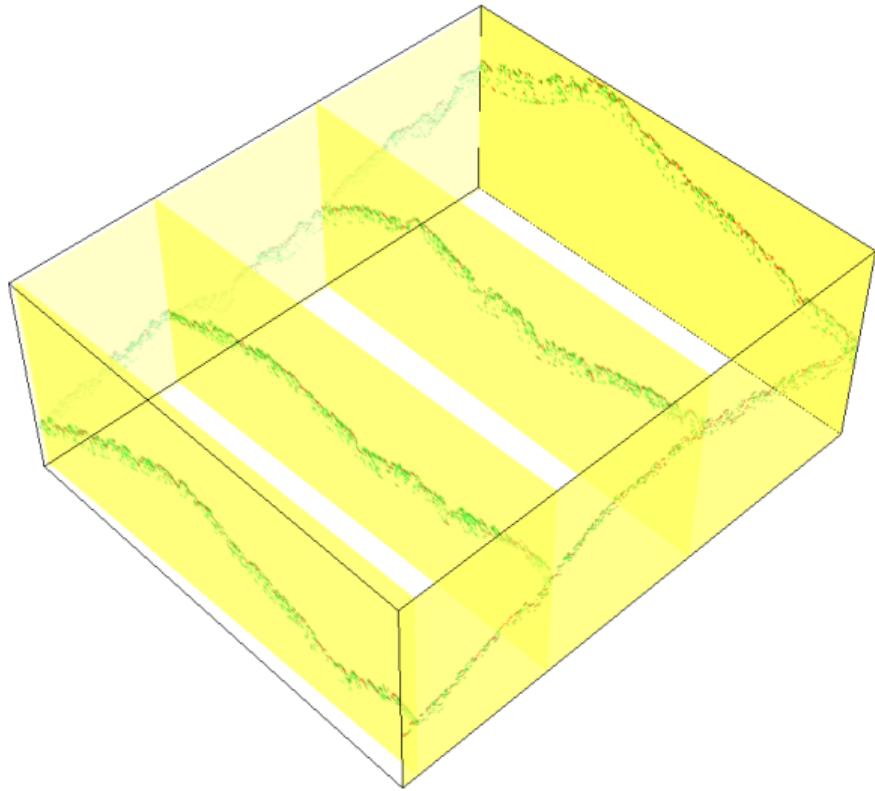
3D raster

- ▶ stacked 2D rasters
- ▶ challenging to visualize
- ▶ same principles as in 2D
 - ▶ e.g. 3D raster map algebra



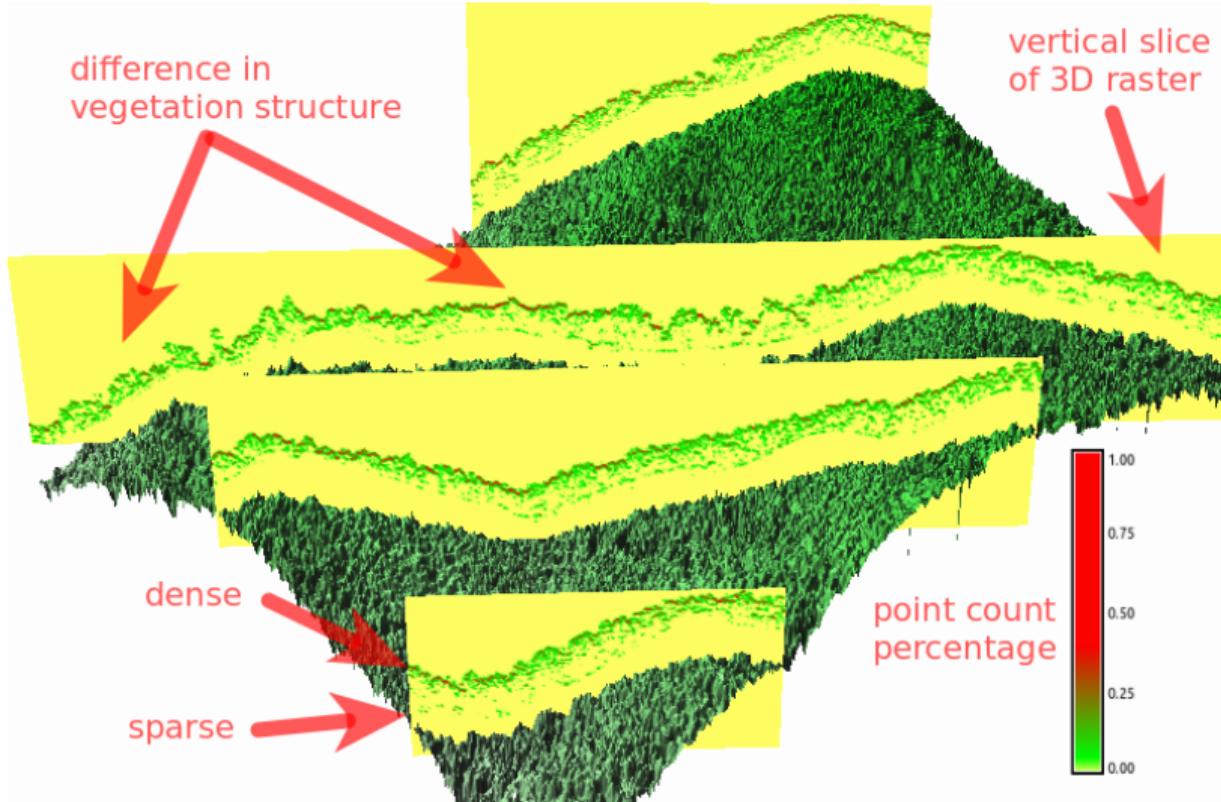
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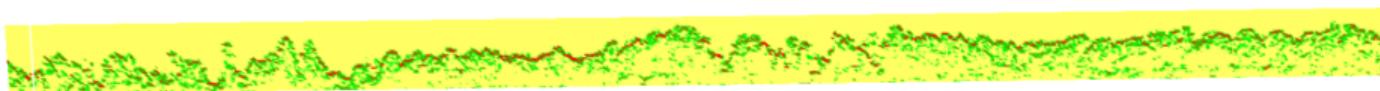
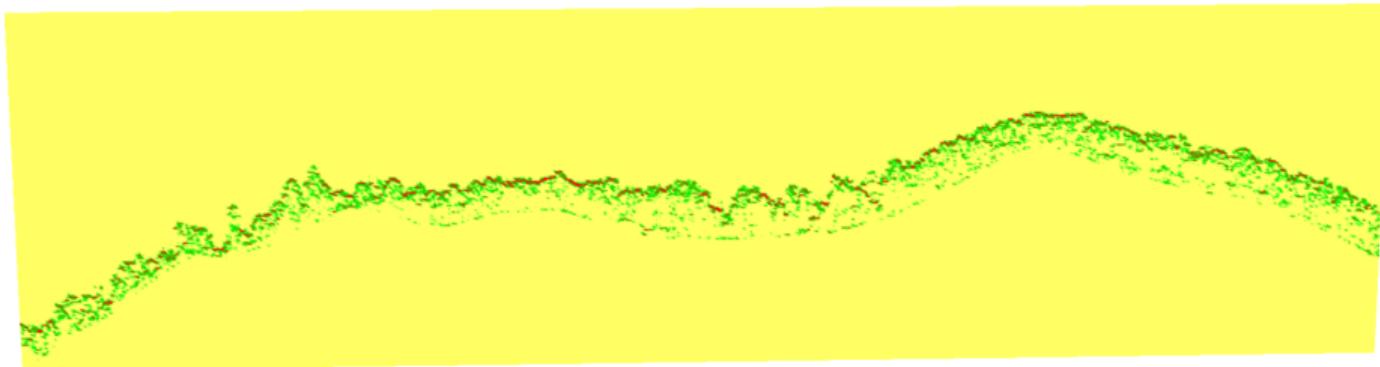


Binning points to 3D raster

- ▶ *r3.in.lidar*
- ▶ proportional count
 - ▶ count per 3D cell relative to the count per vertical column
- ▶ intensity can be used instead of count



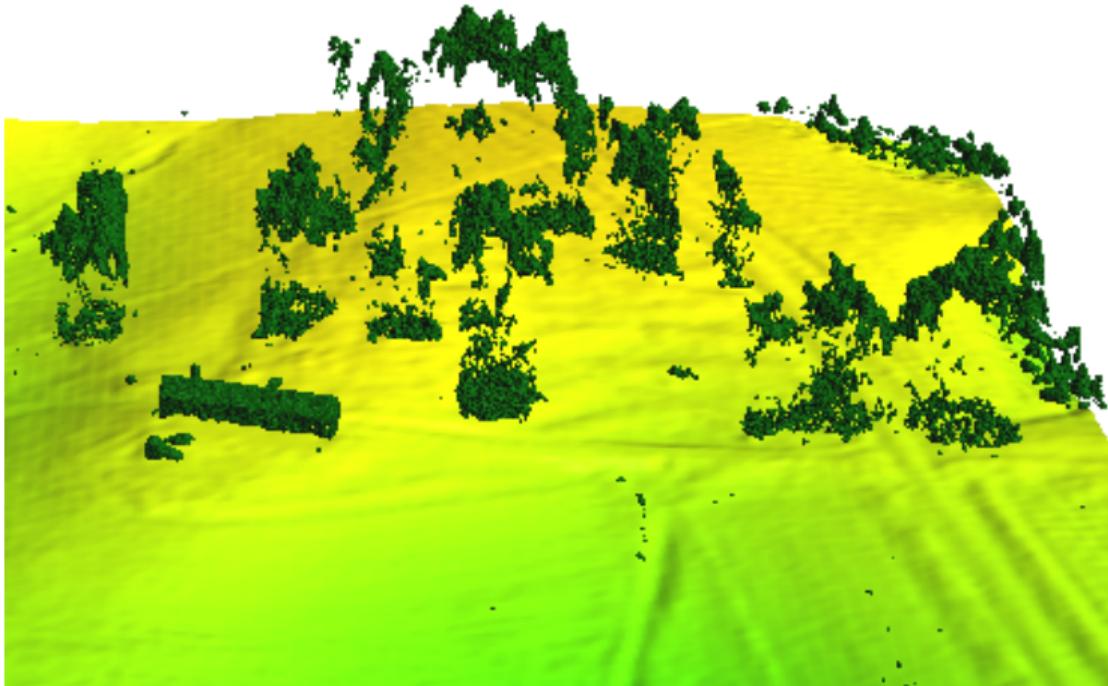
Point heights reduced to surface



- ▶ `r3.in.lidar`, option `base_raster`
- ▶ height reduced by 2D raster values
- ▶ similarly also for 2D binning: height above a surface, top of the canopy, ...

Ground detection

- ▶ *v.lidar.edgedetection*,
v.lidar.growing,
v.lidar.correction
 - ▶ by Brovelli, Cannata, Antolin & Moreno
- ▶ *v.lidar.mcc*
 - ▶ multiscale curvature based classification algorithm
 - ▶ by Blumentrath, according to Evans & Hudak
- ▶ PDAL filters.ground
 - ▶ currently in v.in.pdal
 - ▶ progressive morphological filter by Zhang
 - ▶ provided by PCL



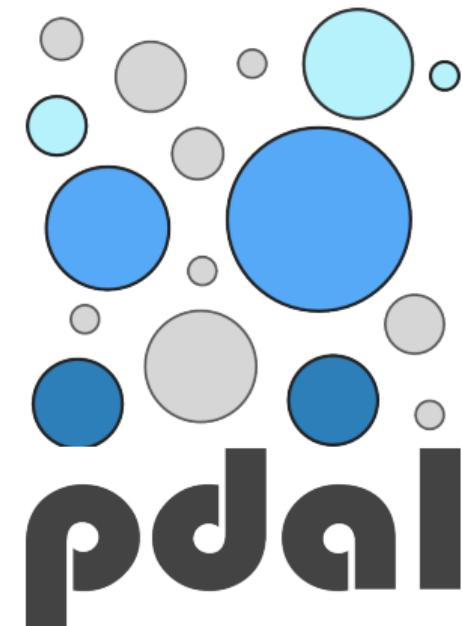
Current state of integration with PDAL

PDAL

- ▶ Point Data Abstraction Library
- ▶ format conversions
- ▶ processing, filtering

Experimental integration

- ▶ *v.in.pdal*
 - ▶ next: *r.in.pdal*, *r3.in.pdal*
- ▶ runs PDAL filters during import
 - ▶ filters are followed by GRASS processing

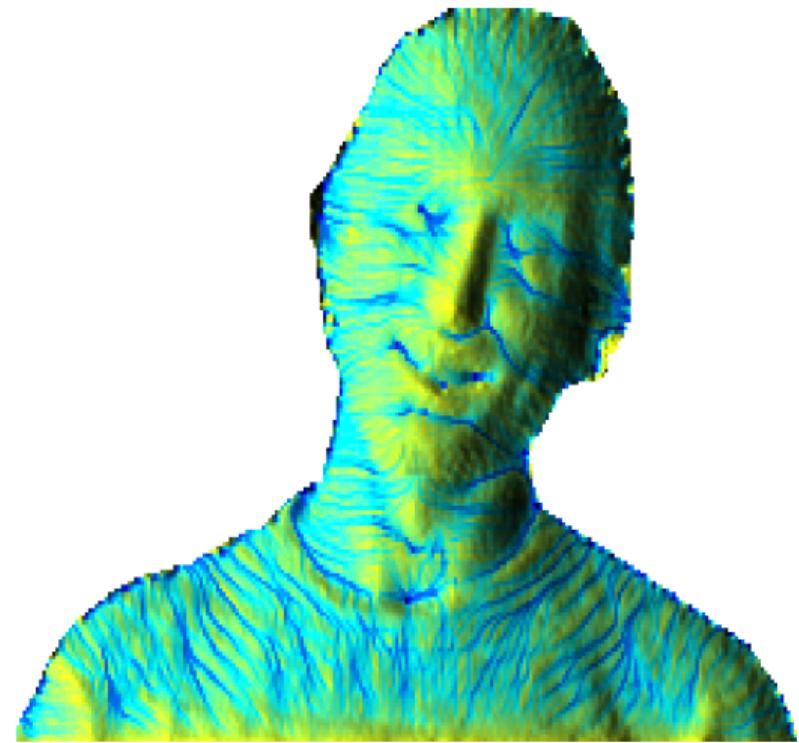


Using other open source projects

r.in.kinect

- ▶ scans using Kinect
- ▶ OpenKinect libfreenect2
- ▶ Point Cloud Library (PCL)
- ▶ GRASS GIS libraries
 - ▶ C API
 - ▶ raster processing
 - ▶ regularized spline with tension interpolation

used in Tangible Landscape



Summary

- ▶ rasterize early
- ▶ GRASS modules can work with large data
 - ▶ sometimes a special flag is needed
 - ▶ if not, report a bug
- ▶ 3D rasters, PDAL integration



Get GRASS GIS 7.3 development version at
grass.osgeo.org/download

GRASS user mailing list
lists.osgeo.org/listinfo/grass-user

Paper and slides available at
wenzeslaus.github.io/grass-lidar-talks



Acknowledgements

Software

Presented functionality is work done by Vaclav Petras, Markus Metz, and the GRASS development team.

Thanks to users for feedback and testing, especially to Doug Newcomb, Markus Neteler, Laura Belica, and William Hargrove.

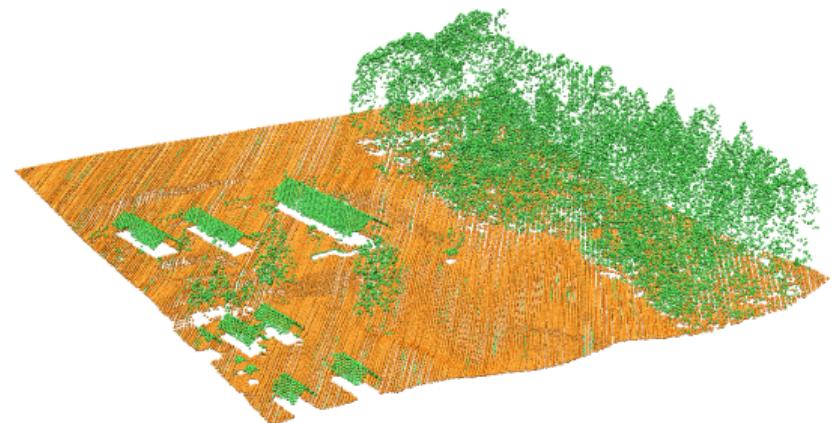


Acknowledgements

Datasets

Lidar and UAV Structure from Motion (SfM) data for
GIS595/MEA792: UAV/lidar Data Analytics course

Nantahala NF, NC: Forest Leaf Structure, Terrain and
Hydrophysiology. Obtained from OpenTopography.
<http://dx.doi.org/10.5069/G9HT2M76>



Acknowledgements

Presentation software

Slides were created in L^AT_EX using the BEAMER *class*.