

Processing UAV and lidar point clouds in GRASS GIS

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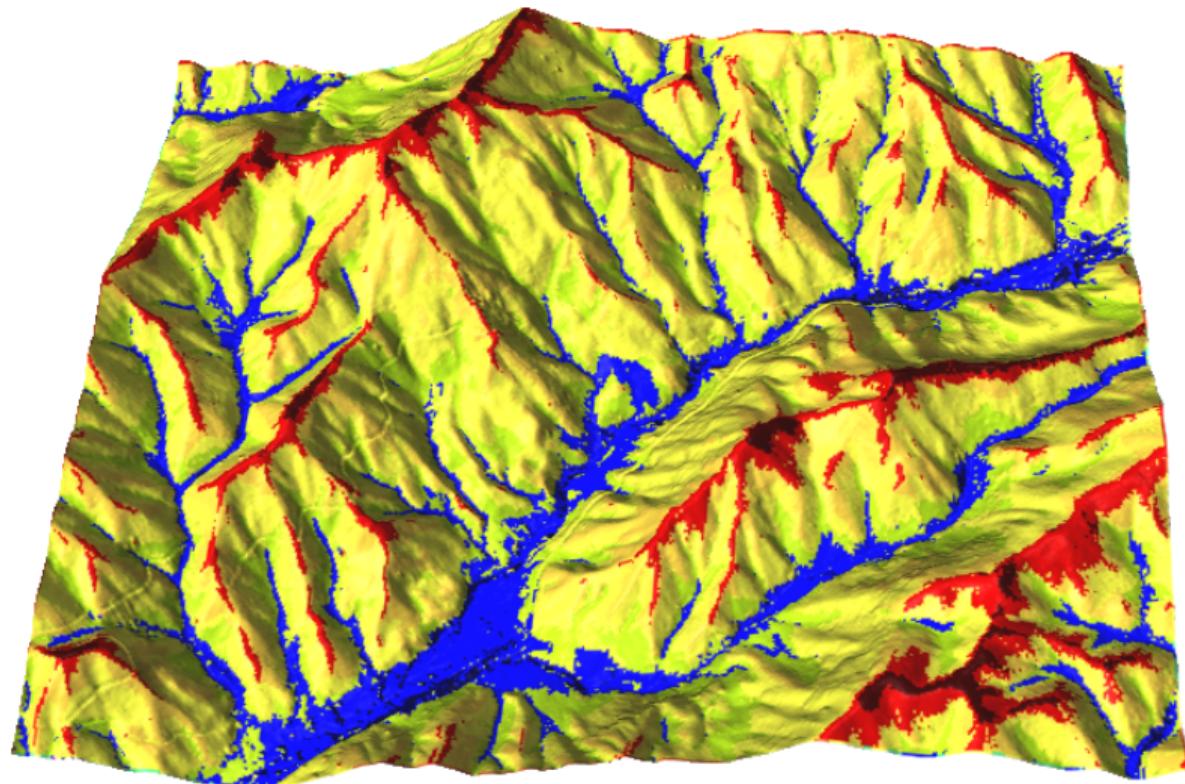


available at

wenzeslaus.github.io/grass-lidar-talks

Landforms

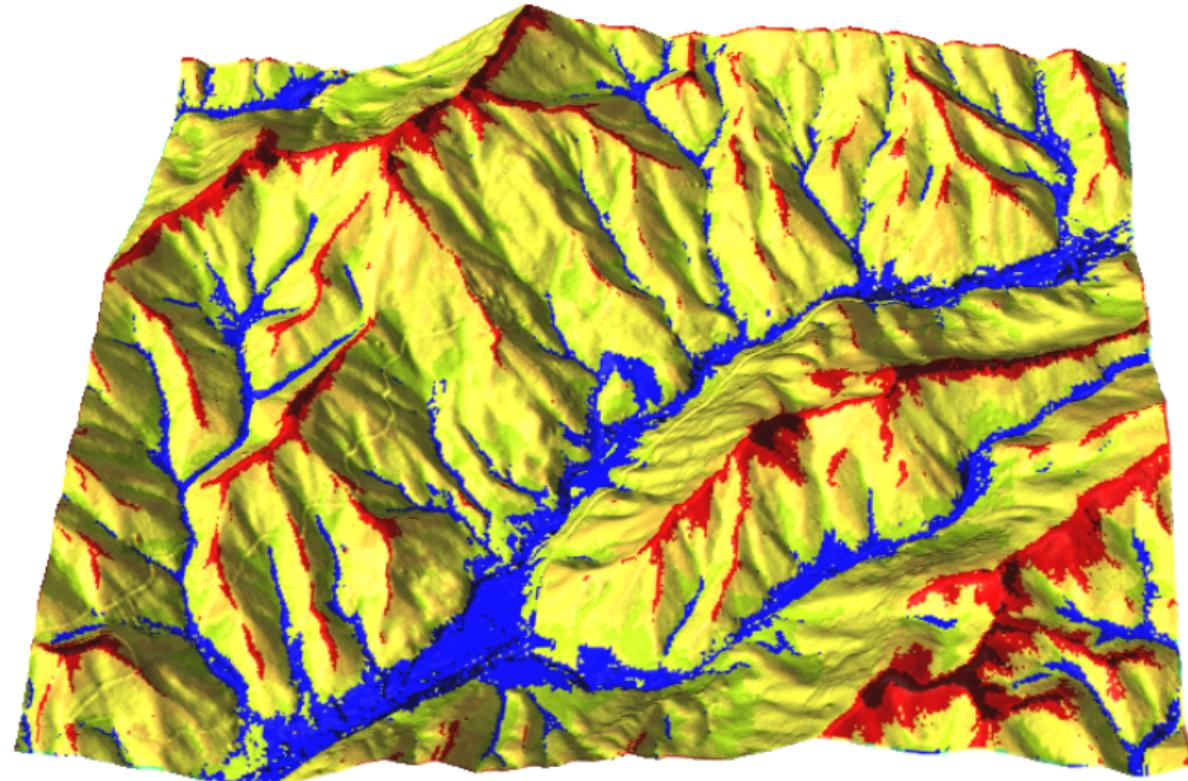
- ▶ *r.geomorphon*
 - ▶ new landform classification approach
 - ▶ by Jasiewicz & Stepinski



Landforms

- ▶ *r.geomorphon*
- ▶ geomorphons - a new approach to classification of landform¹

¹ Jasiewicz, J., Stepinski, T., 2013, Geomorphons - a pattern recognition approach to classification and mapping of landforms, *Geomorphology*



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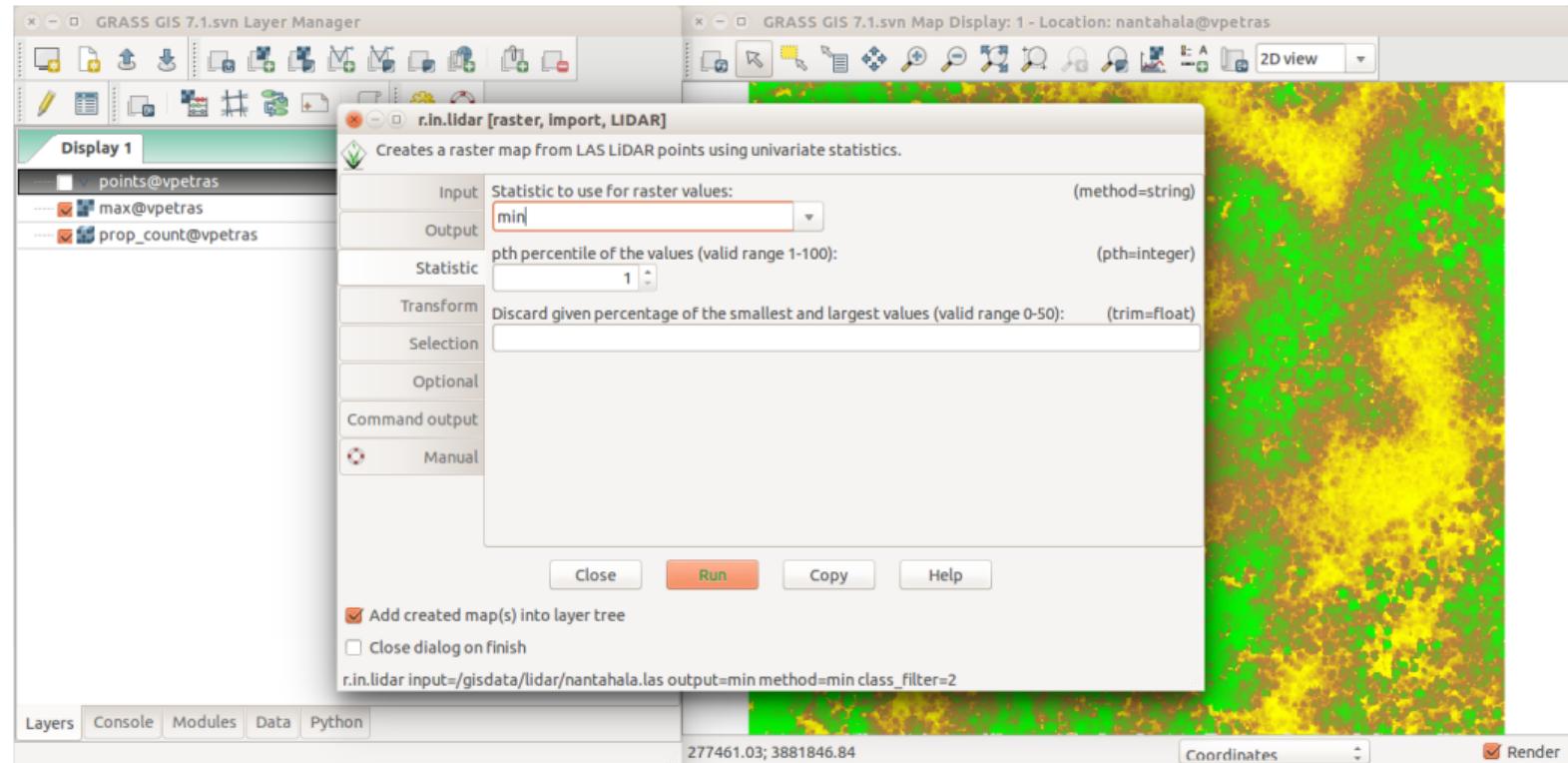
- ▶ all in one
 - ▶ hydrology modeling, image segmentation, point clustering, ...
- ▶ from small laptops to supercomputers
 - ▶ Raspberry Pi, Windows, Mac, GNU/Linux, FreeBSD, IBM AIX
- ▶ learn now, use forever
 - ▶ over 30 years of development and interface refinement
- ▶ used by
 - ▶ US Oak Ridge National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



GRASS GIS

latest release 7.0.4 Sunday

GUI



Python and command line interfaces

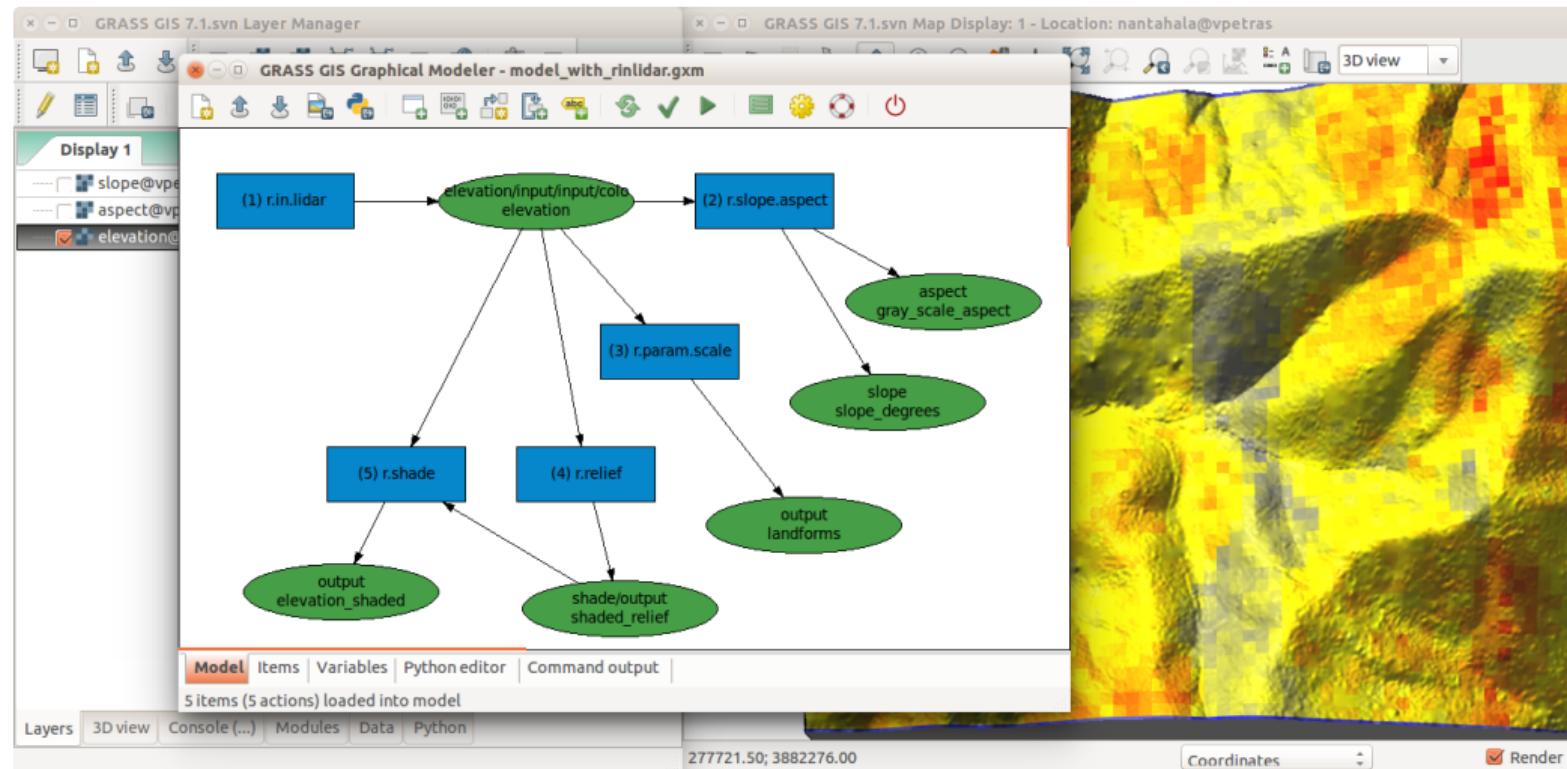
Documentation, Command Line (Shell, Bash, cmd.exe):

```
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



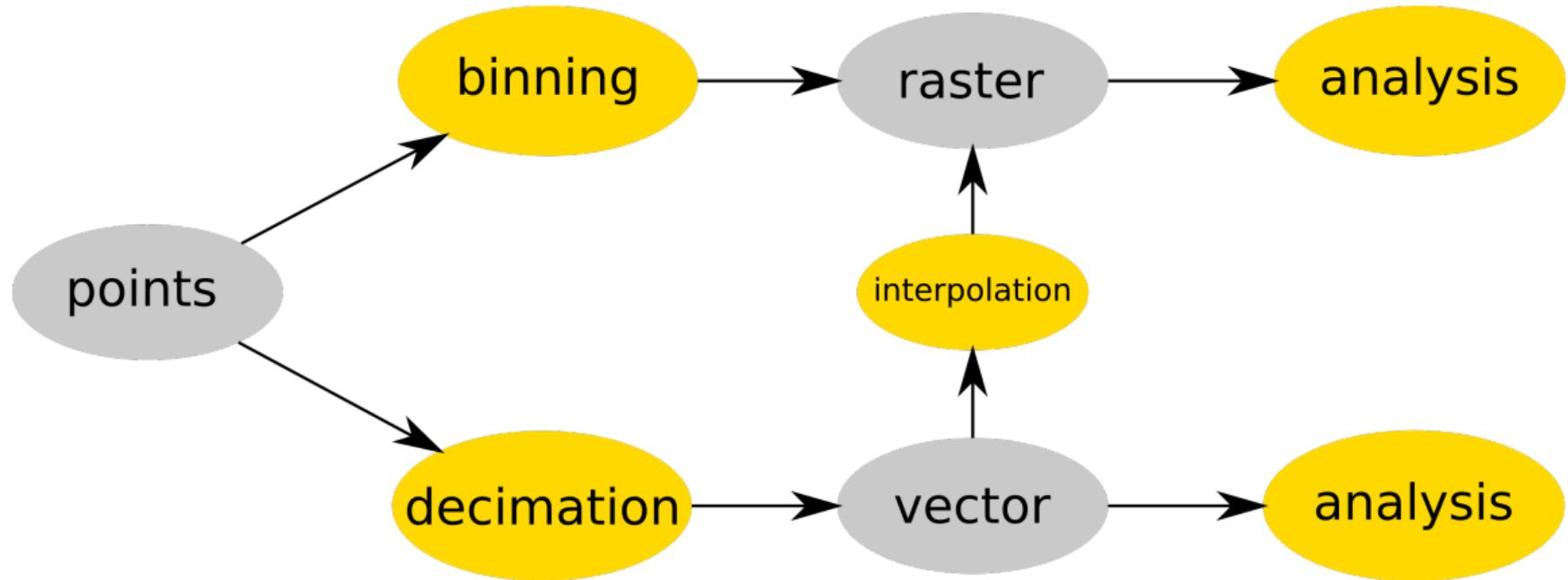
Points

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



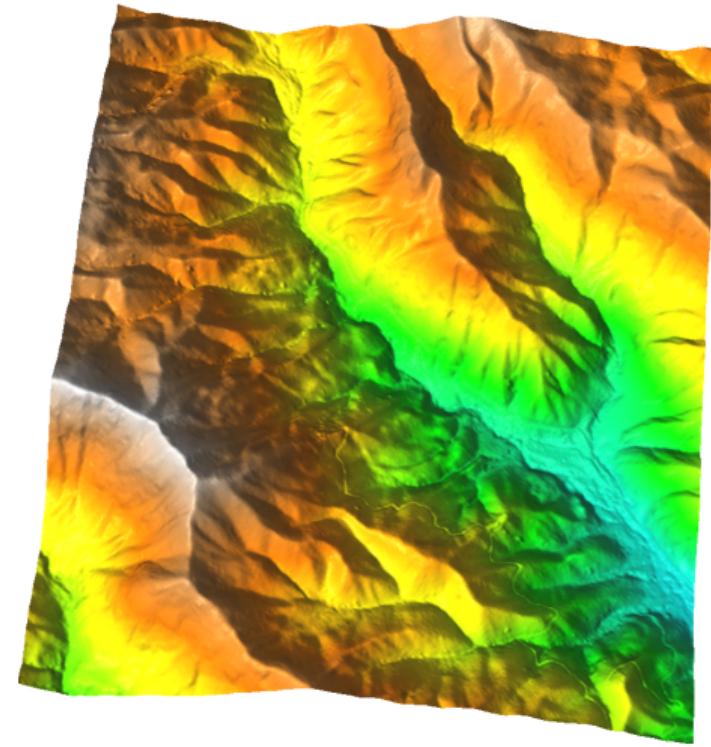
surface interpolated from points and visualized in GRASS GIS

Workflow overview



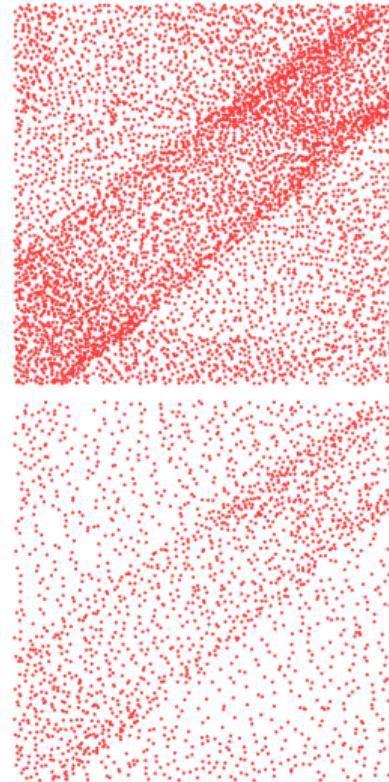
Surface interpolation

- ▶ *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



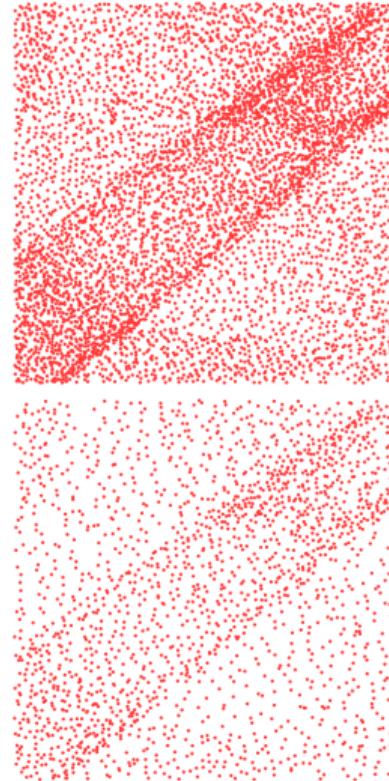
Import and decimation

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



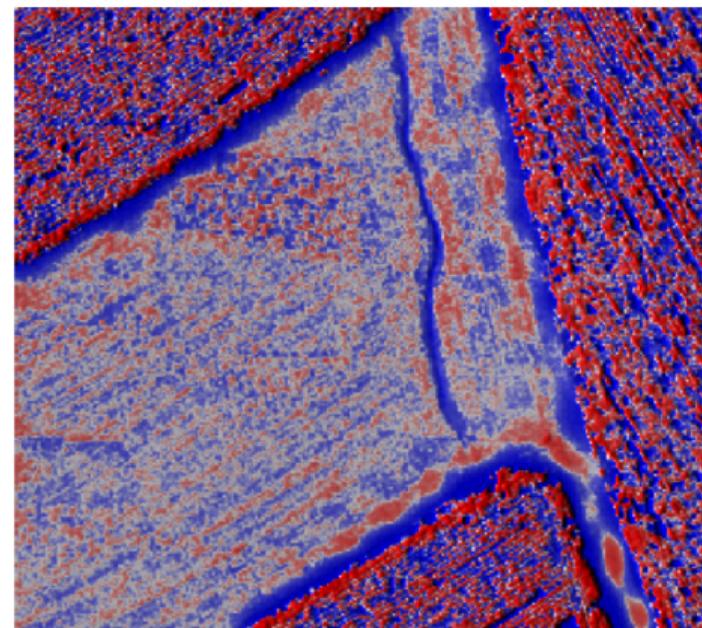
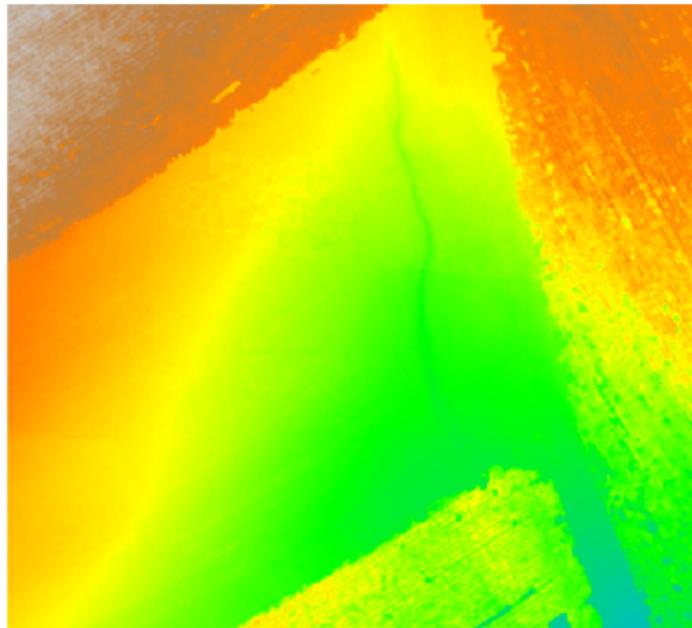
Decimation

- ▶ *v.in.lidar*
 - ▶ filtering same as in *r.in.lidar*
- ▶ often more points than we need
(research shows, Singh et al. 2015, Petras et al. 2016)
- ▶ interpolation, clustering, ... are costly
- ▶ decimation \approx sampling
 - ▶ fast count-based as effective as more advanced decimation



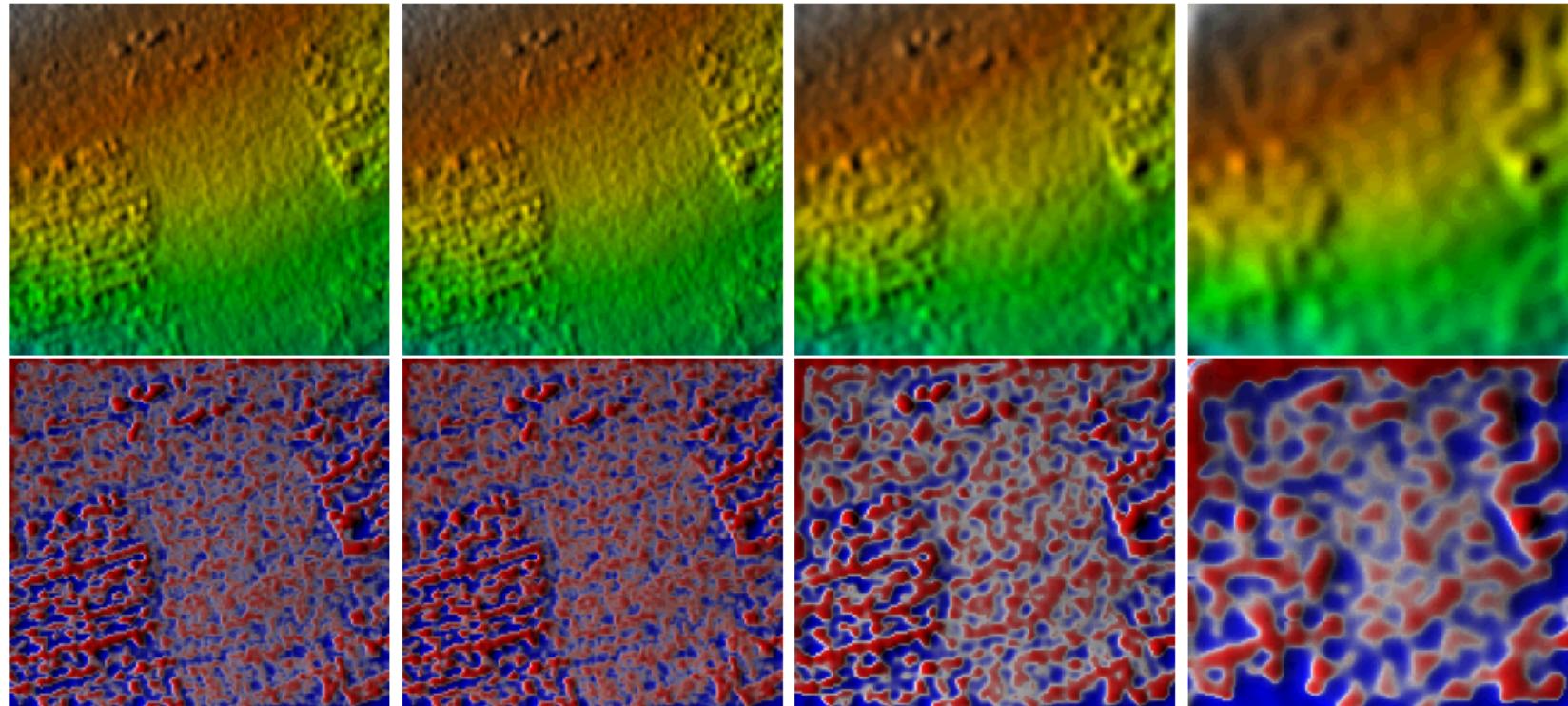
Local relief model (LRM)

- ▶ `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



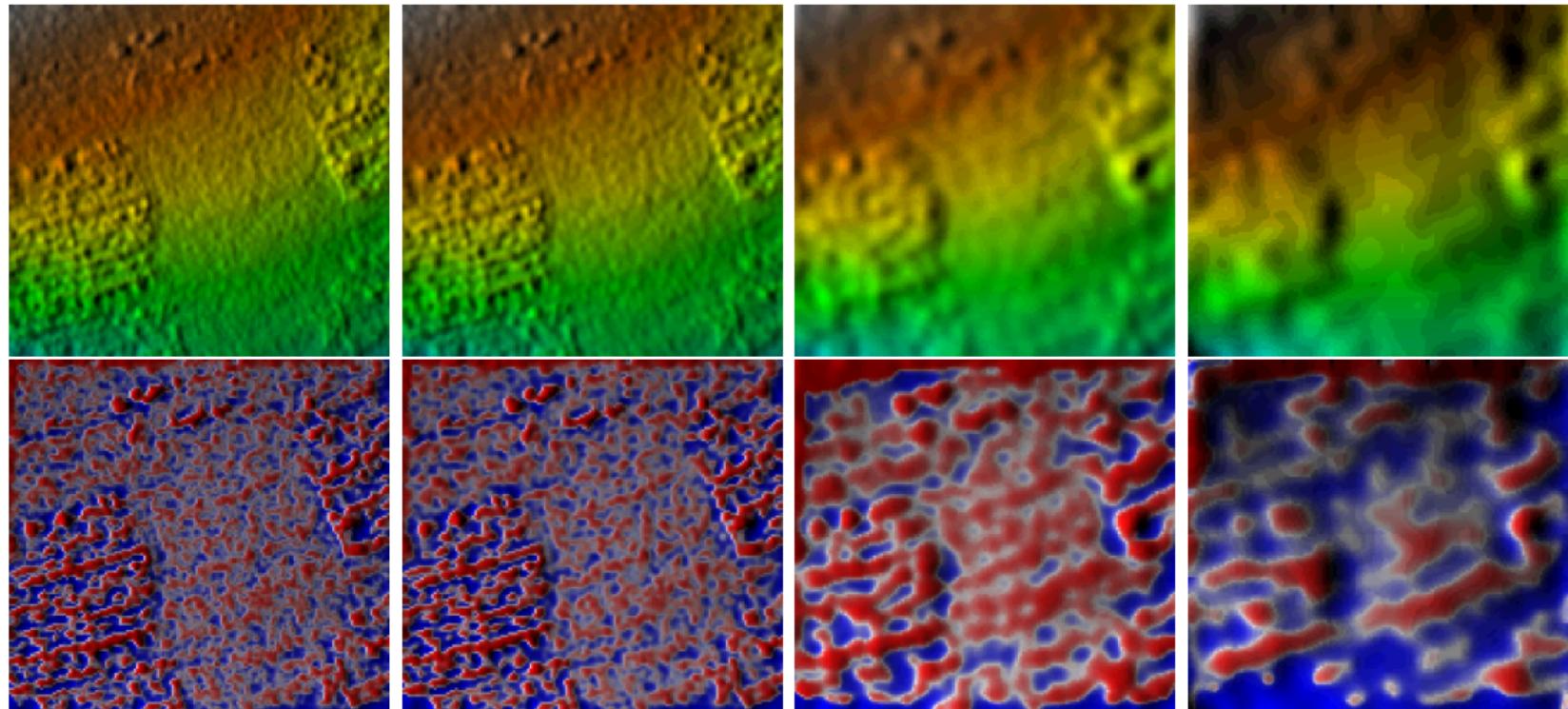
keep all
0 %

skip every 5
20 %

keep every 20
90 %

keep every 100
99 %

Influence of grid-based decimation resolution



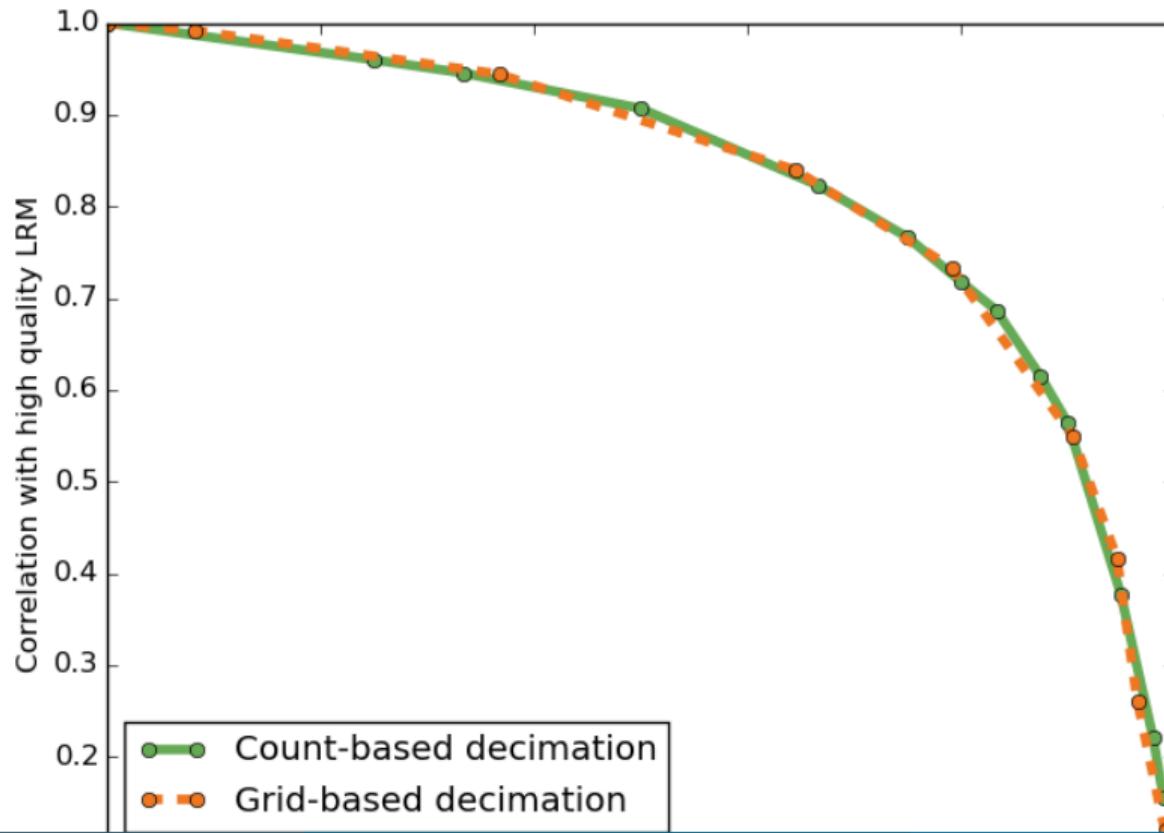
grid size 0.1 m
0 %

grid size 0.3 m
81 %

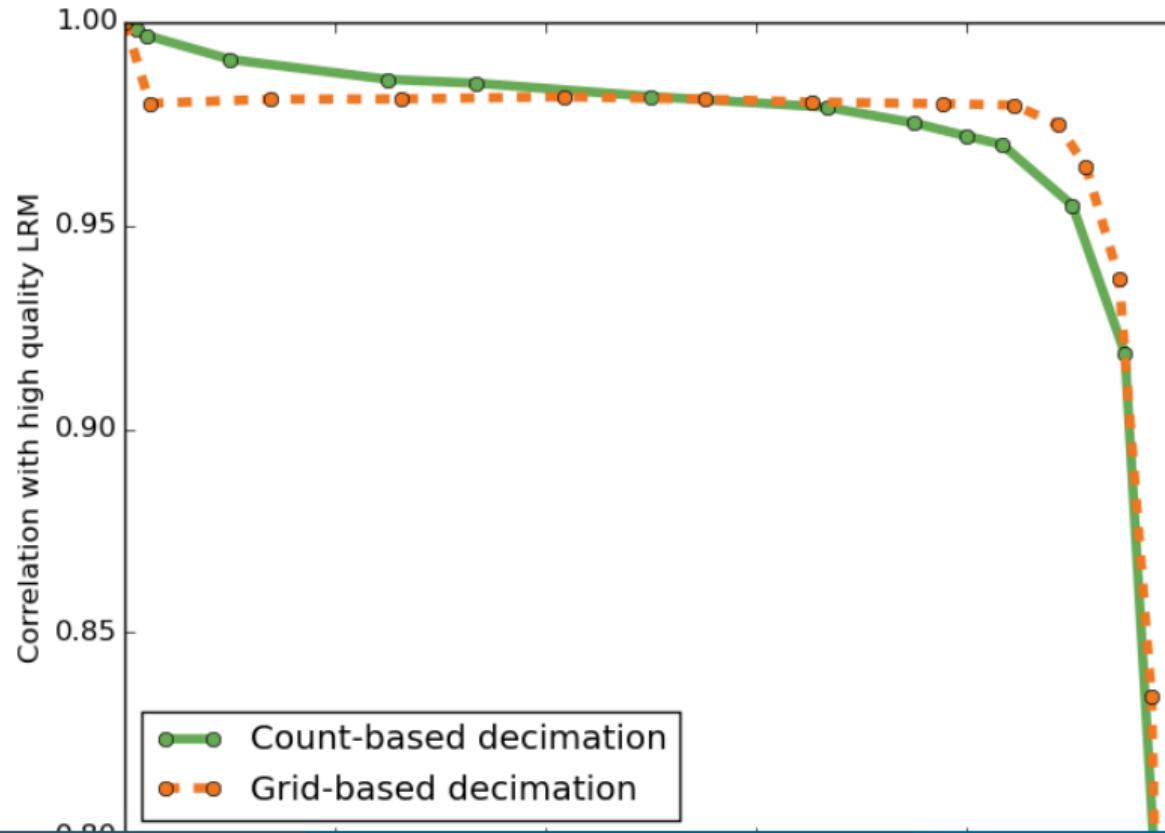
grid size 0.9 m
98 %

grid size 1.5 m
99 %

Decimation

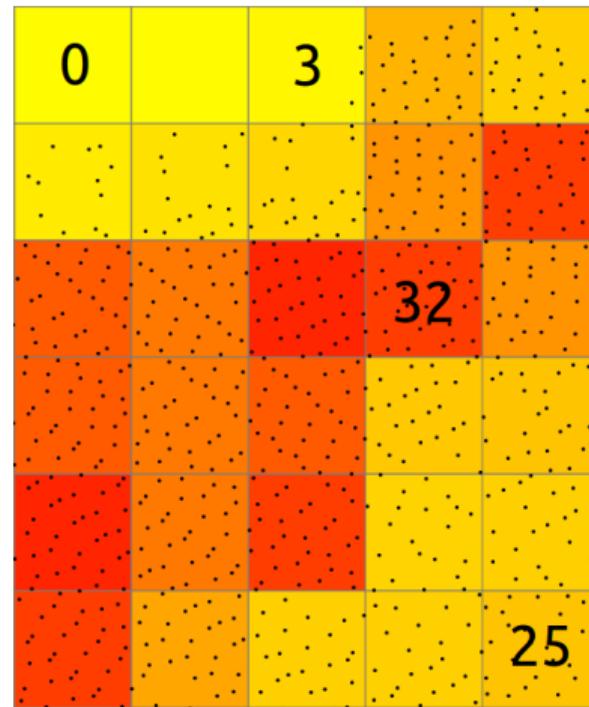


Decimation



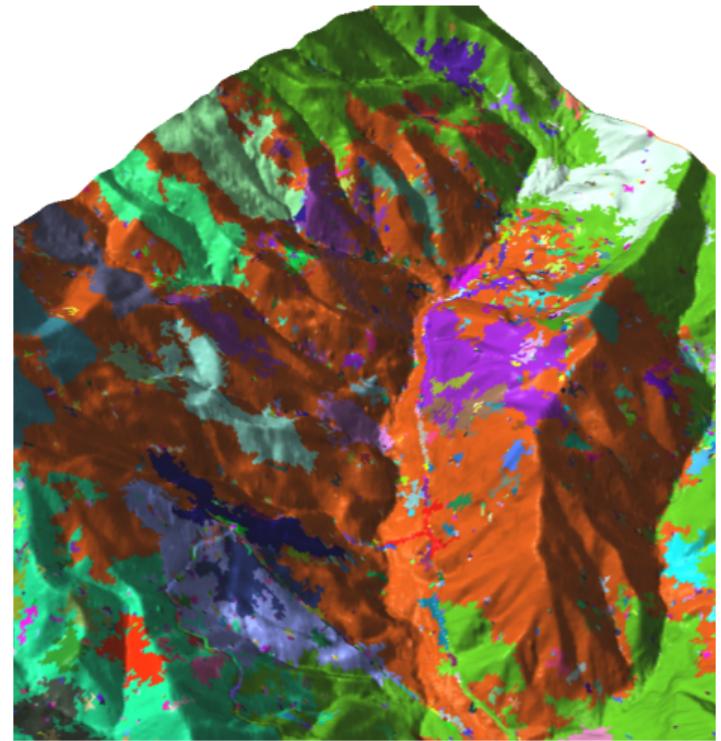
Binning points to raster

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



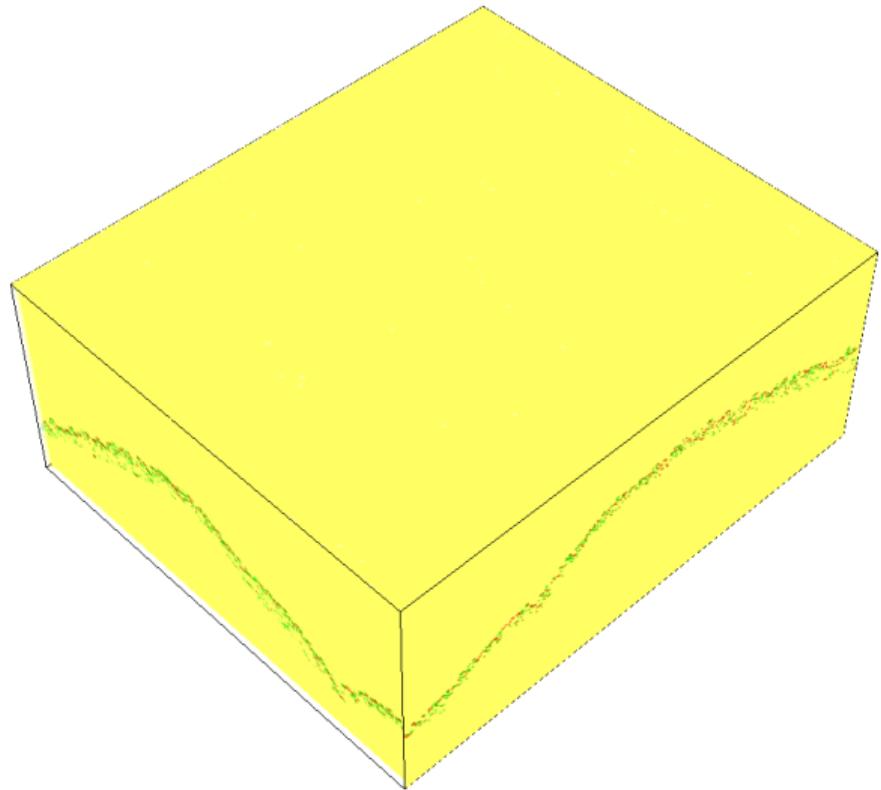
Rastersize early

- ▶ many algorithms are raster-based
 - ▶ a lot of data with continuous nature
 - ▶ natural spatial index
- ▶ example:
 1. count of ground points
 2. count of non-ground points
 3. used as image bands
 4. segmentation using *i.segment*



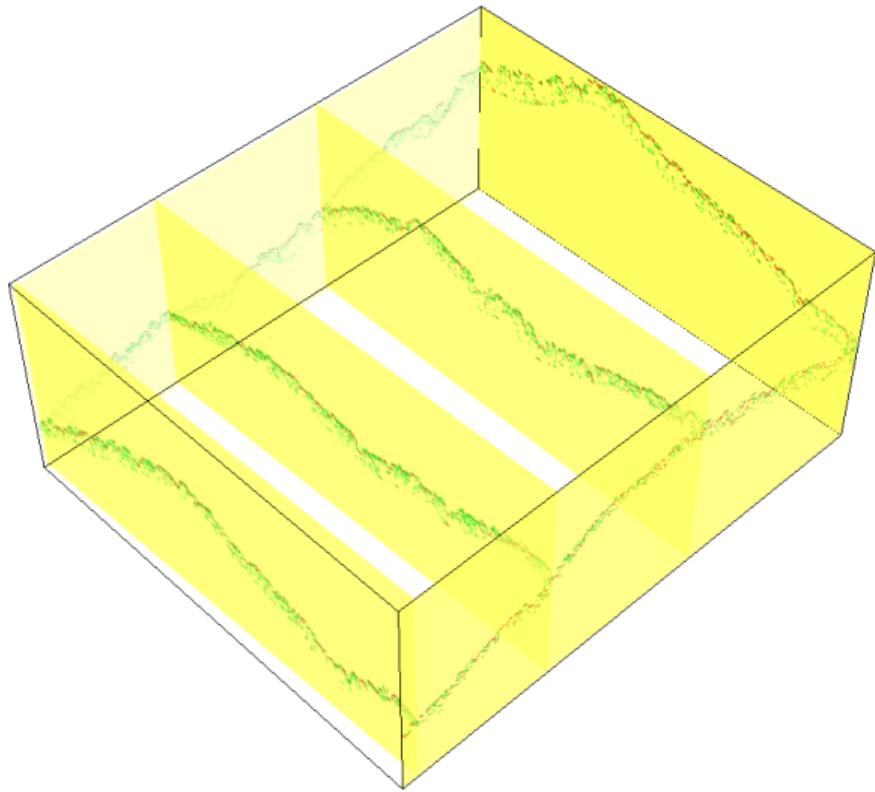
3D raster

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



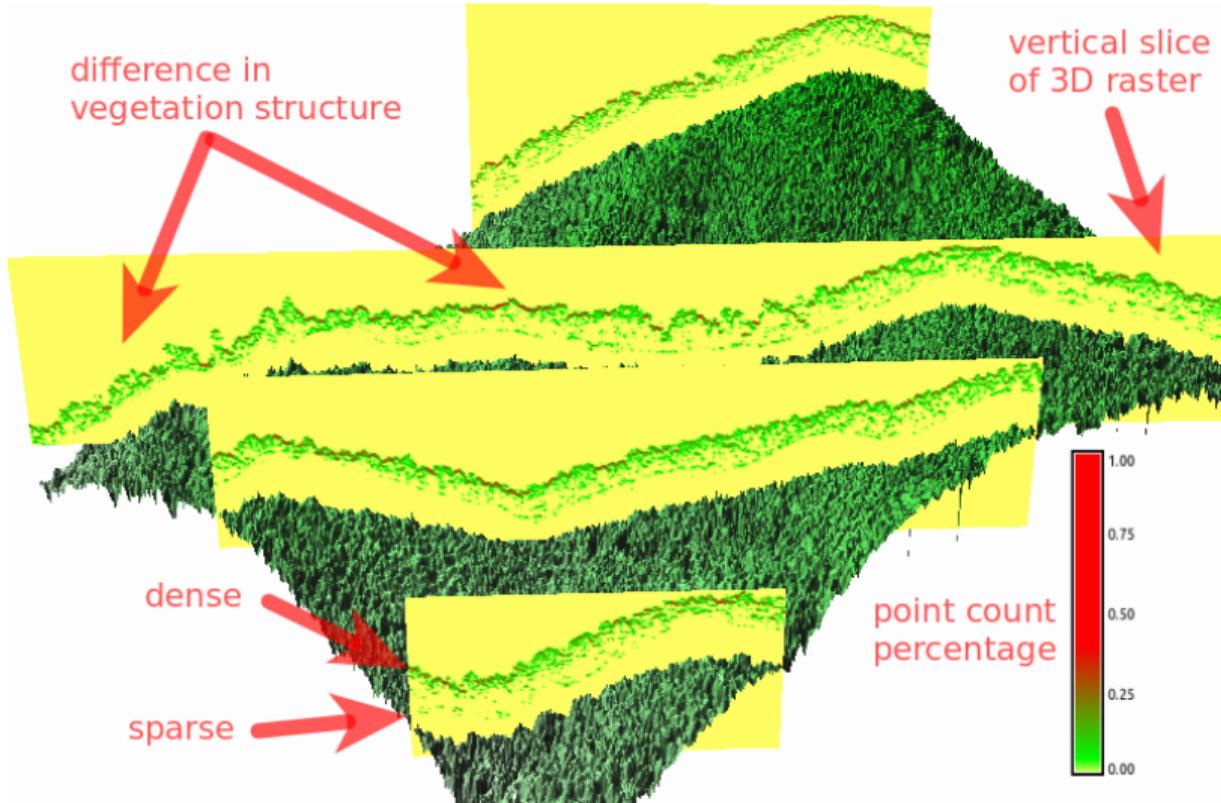
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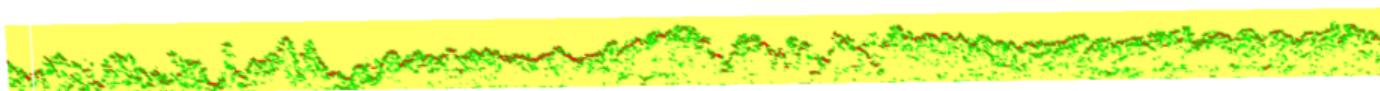
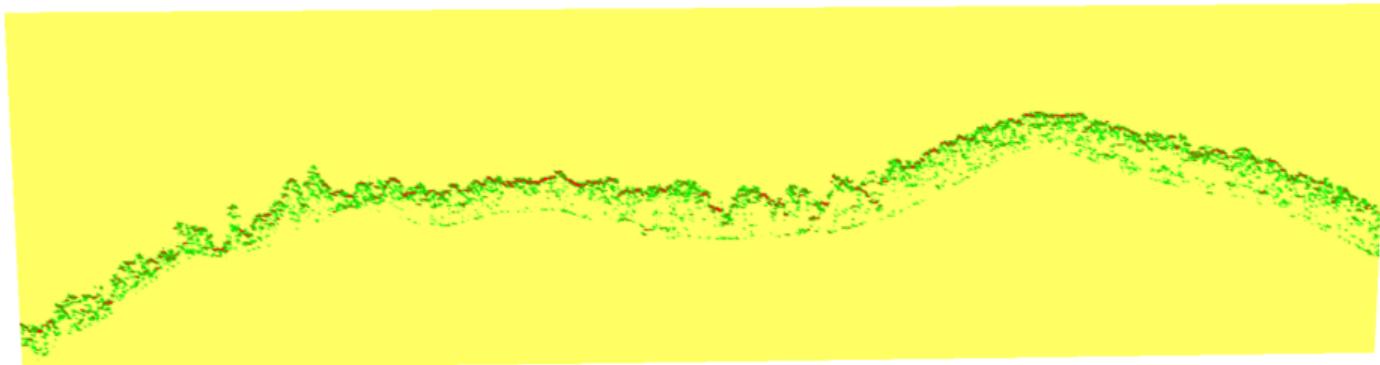


Binning points to 3D raster

- ▶ *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, ...

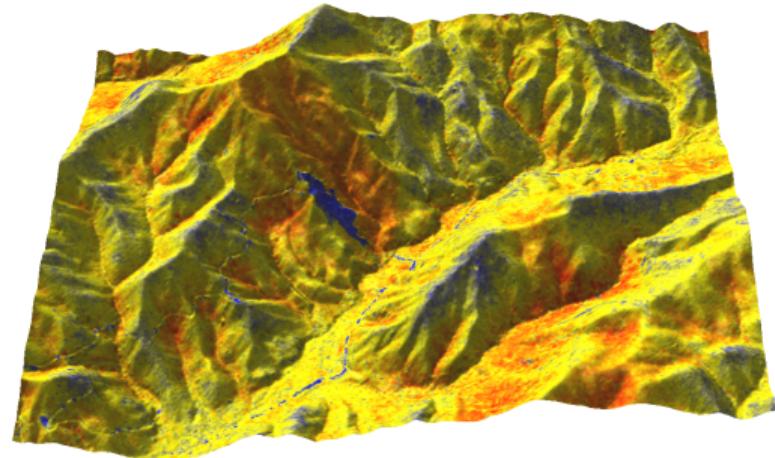
Trade-offs

Raster processing

- ▶ high memory (RAM) usage – fast
- ▶ low memory usage (high I/O) – slow

Vector processing

- ▶ slower than raster
 - ▶ e.g., interpolation much slowed than binning
- ▶ hard to make general statements

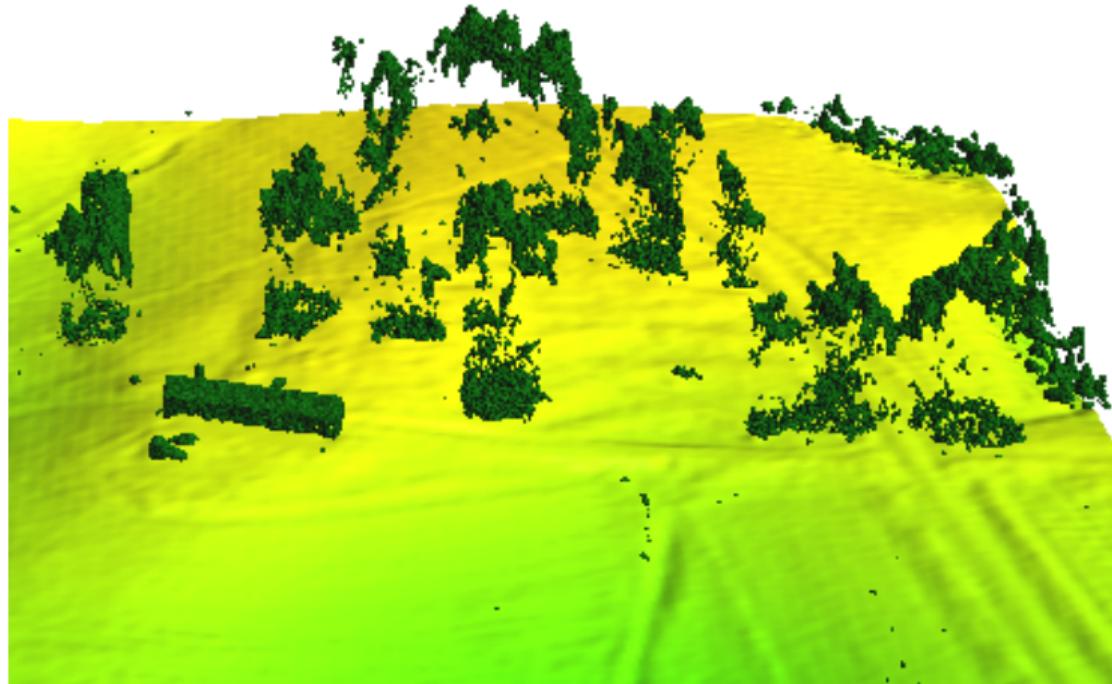


visualization: range from binning on interpolated surface

example: binning with base elevation subtraction:
 ≈ 1000 files, > 9 billion points
 ≈ 3 hours, ≈ 10 GB of memory (in-memory mode)

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



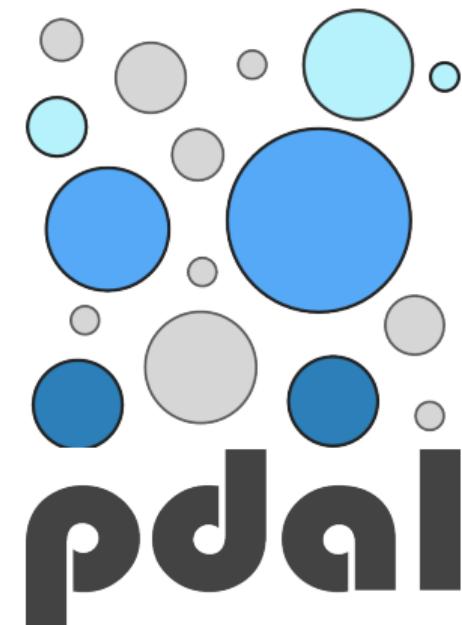
Current state of integration with PDAL

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

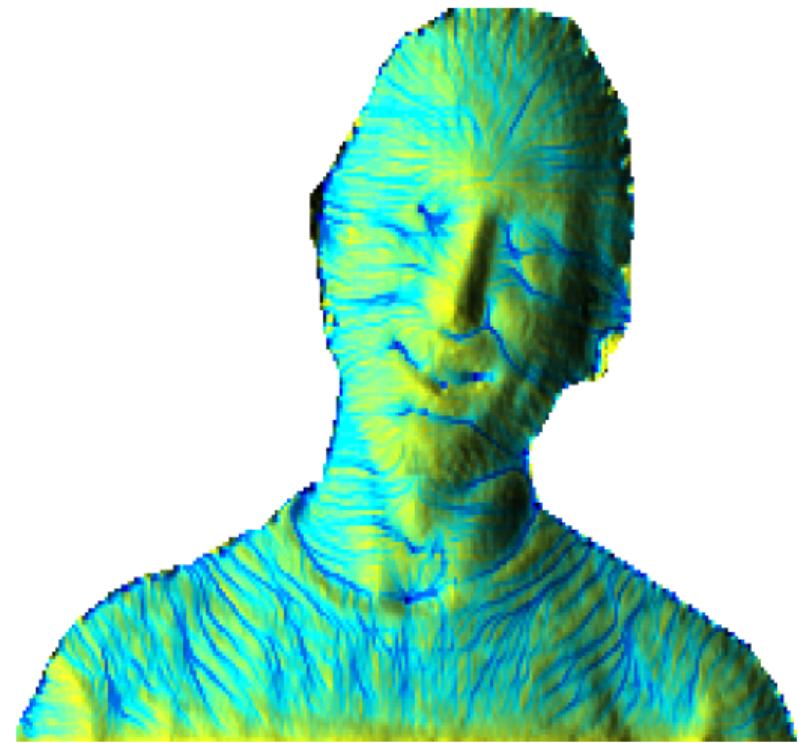


Using other open source projects

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.

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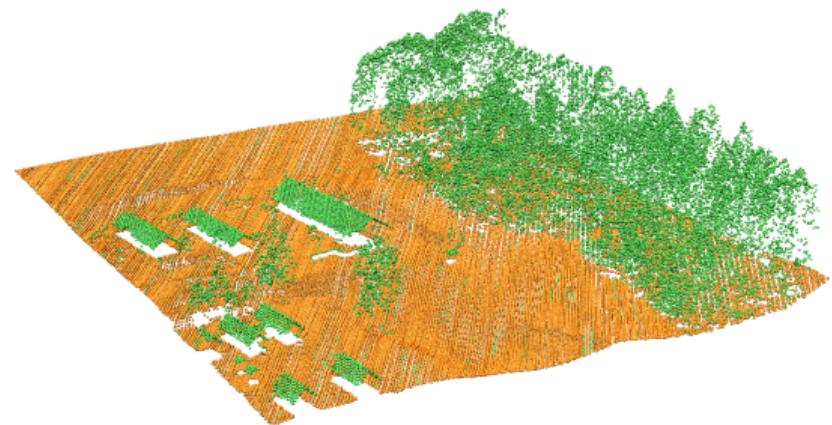
GRASS GIS

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*.