

GRASS GIS loves lidar

FOSS4G NA 2016

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available at

wenzeslaus.github.io/grass-lidar-talks

GRASS GIS

- ▶ all in one
 - ▶ hydrology modeling, image segmentation, point clustering, ...
- ▶ from small laptops to supercomputers
 - ▶ Raspberry Pi, Windows, Mac, GNU/Linux, GNU/Hurd, FreeBSD, IBM AIX
- ▶ learn now, use forever
 - ▶ over 30 years of development and interface refinement
- ▶ probably used more than you think
 - ▶ similarly to C/C++ is often not mentioned but is somewhere in there



GRASS GIS

latest release 7.0.4

Sunday, May 1, 2016



```
Welcome to GRASS GIS 7.1.svn (r68305M)
```

```
GRASS GIS homepage:
```

```
http://grass.osgeo.org
```

```
This version running through:
```

```
Bash Shell (/bin/bash)
```

```
Help is available with the command:
```

```
g.manual -i
```

```
See the licence terms with:
```

```
g.version -c
```

```
Start the GUI with:
```

```
g.gui wxpython
```

```
When ready to quit enter:
```

```
exit
```

```
To run a command as administrator (user "root"), use "sudo <command>".
```

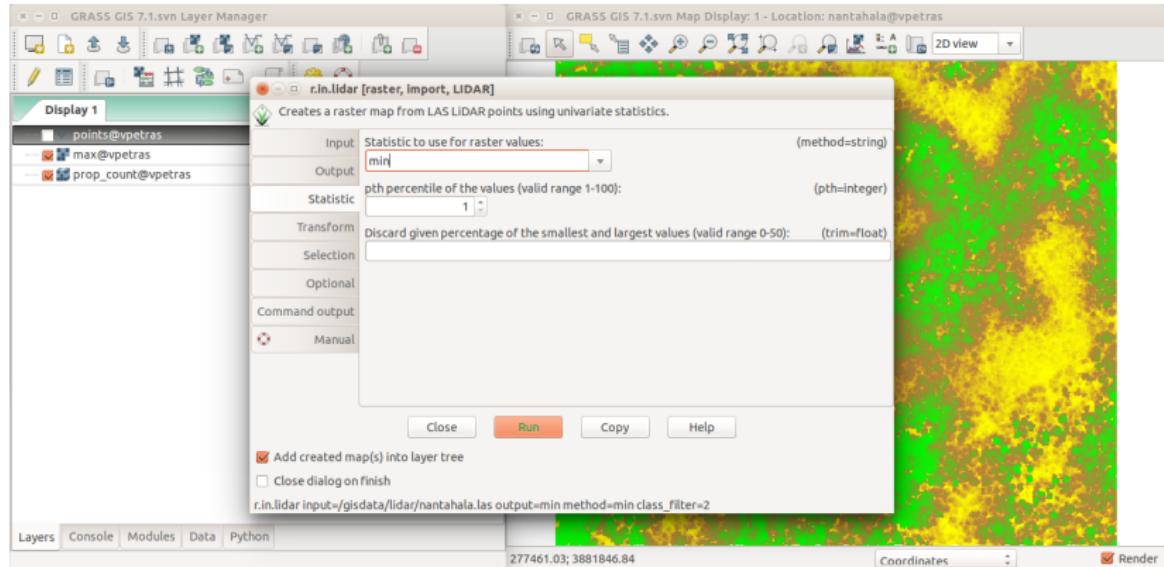
```
See "man sudo_root" for details.
```

```
GRASS 7.1.svn (nantahala):~/dev/grass/gcc_trunk > g.region vector=points
```

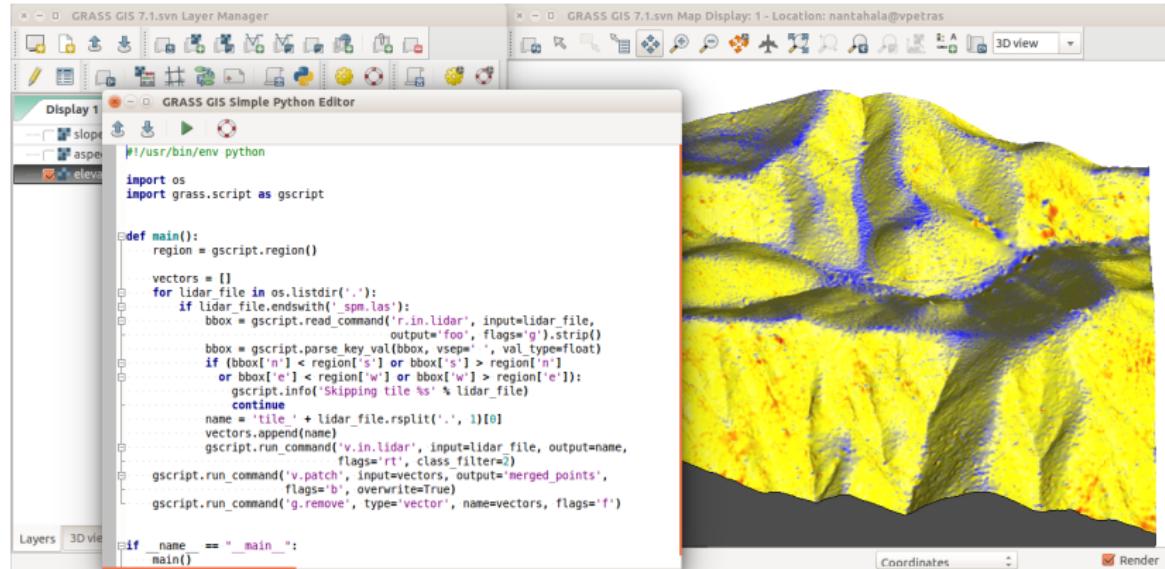
```
GRASS 7.1.svn (nantahala):~/dev/grass/gcc_trunk > g.region res=5
```

```
GRASS 7.1.svn (nantahala):~/dev/grass/gcc_trunk > r.in.lidar input=/gisdata/lidar/points.las output=mean
```

GUI



Python



```
#!/usr/bin/env python

import os
import grass.script as gscript

def main():
    region = gscript.region()

    vectors = []
    for lidar_file in os.listdir('.'):
        if lidar_file.endswith('_smpl.las'):
            bbox = gscript.read_command('r.in.lidar', input=lidar_file,
                                         output='foo', flags='g').strip()
            bbox = gscript.parse_key_val(bbox, vsep=' ', val_type=float)
            if (bbox['n'] < region['s'] or bbox['s'] > region['n']
                or bbox['e'] < region['w'] or bbox['w'] > region['e']):
                gscript.info("Skipping tile %s" % lidar_file)
                continue
            name = 'tile' + lidar_file.rsplit('.', 1)[0]
            vectors.append(name)
            gscript.run_command('v.in.lidar', input=lidar_file, output=name,
                                flags='rt', class_filter=2)
    gscript.run_command('v.patch', input=vectors, output='merged_points',
                        flags='b', overwrite=True)
    gscript.run_command('g.remove', type='vector', name=vectors, flags='f')

if __name__ == "__main__":
    main()
```

Python versus CLI

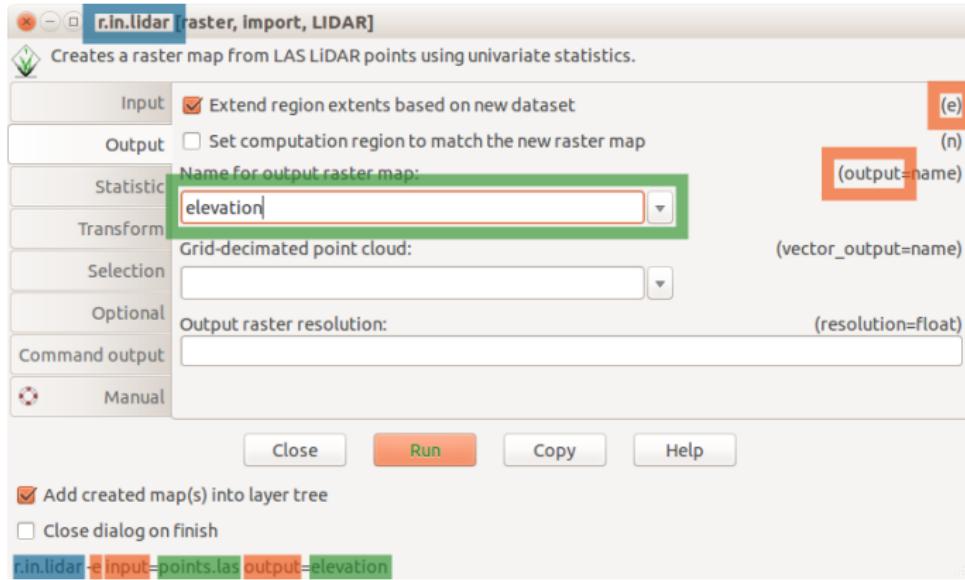
Documentation, Command Line (Shell, Bash, cmd.exe):

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

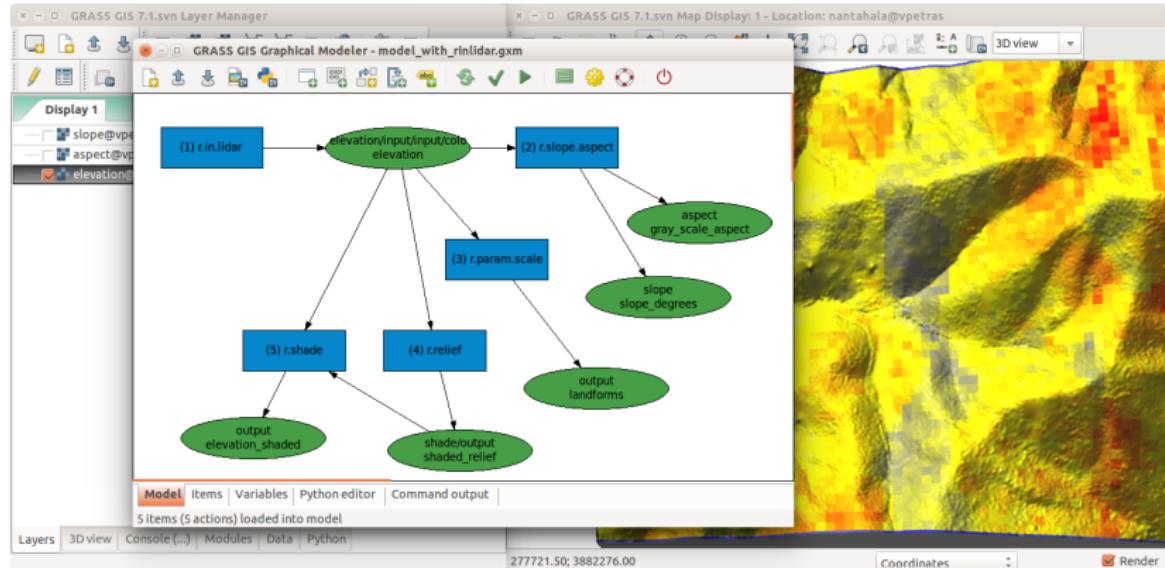
Python:

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

Module GUI



Graphical Modeler



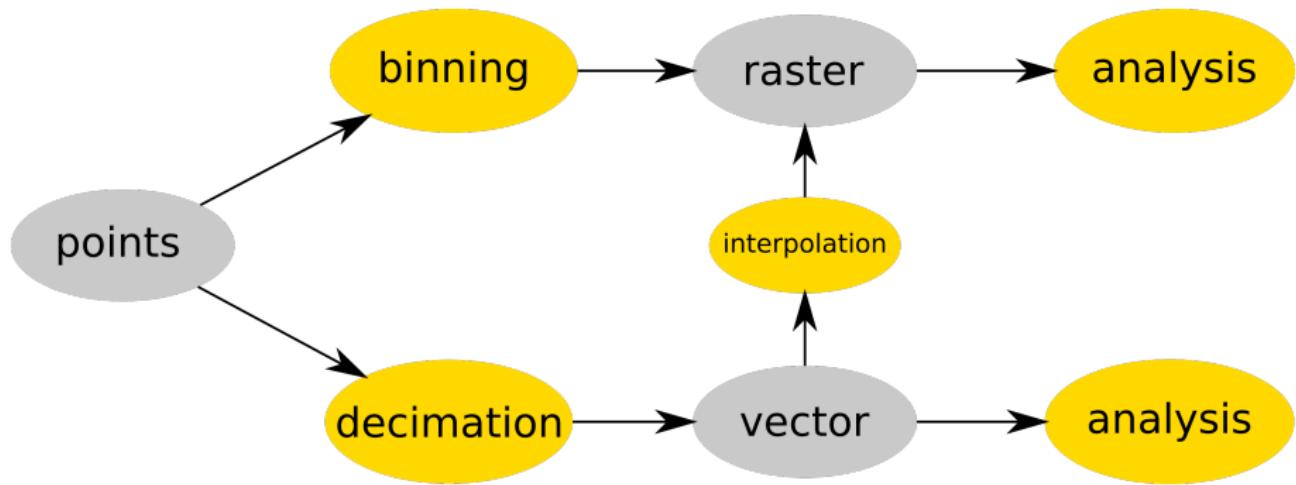
Points

- ▶ collected by lidar
- ▶ generated by Structure from Motion (SfM) from UAV imagery
- ▶ a lot of points



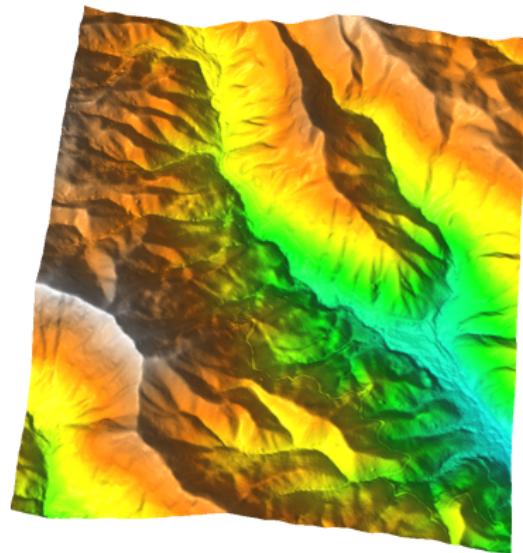
surface interpolated from points and visualized in GRASS GIS

Workflow overview



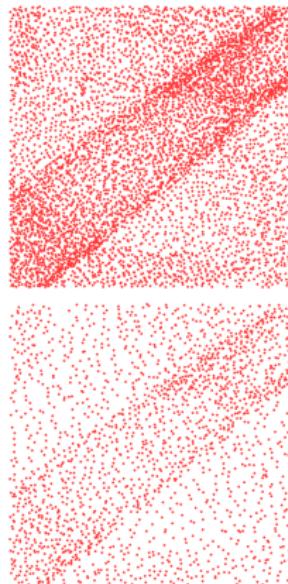
Surface interpolation

- ▶ *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



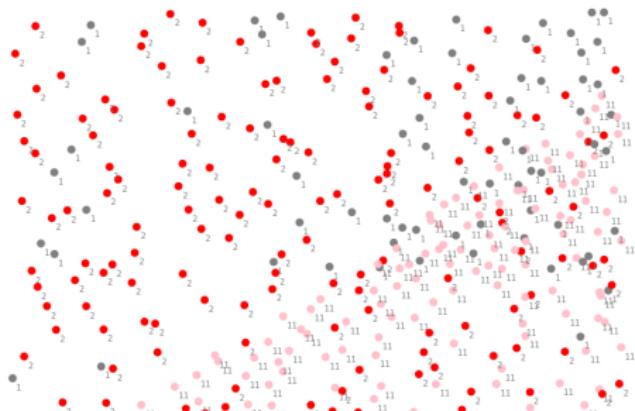
Import and decimation

- ▶ *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



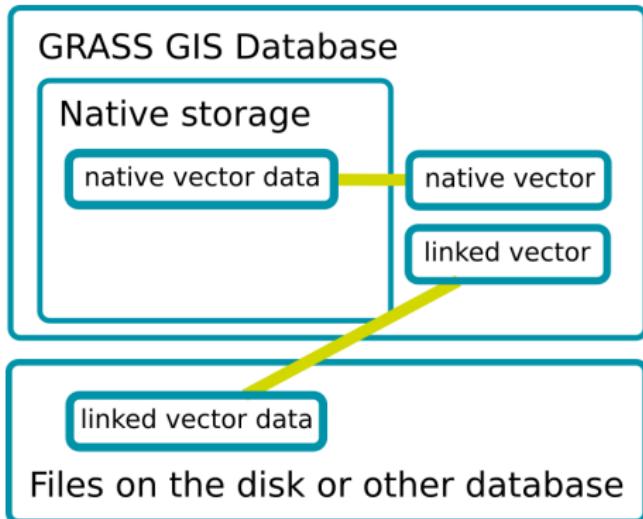
GRASS vector model and format

- ▶ topology and index
 - ▶ can be disabled (`-b` flag)
- ▶ attributes in a database
 - ▶ SQLite, PostgreSQL, ...
 - ▶ can be disabled (`-t` flag)
- ▶ each feature can have any number of categories/classes
 - ▶ without attribute table



Linked external data

- ▶ *r.external*
 - ▶ raster data (GDAL)
 - ▶ *r.external.out* for newly created data
- ▶ *v.external*
 - ▶ vector data
 - ▶ GDAL/OGR
 - ▶ PostGIS including topology
 - ▶ *v.external.out* for newly created data
 - ▶ alternative: @OGR
`v.info map=.../directory@OGR
layer=file`
- ▶ missing: libLAS/PDAL backend
 - ▶ intermediate C API needed in PDAL or GRASS GIS



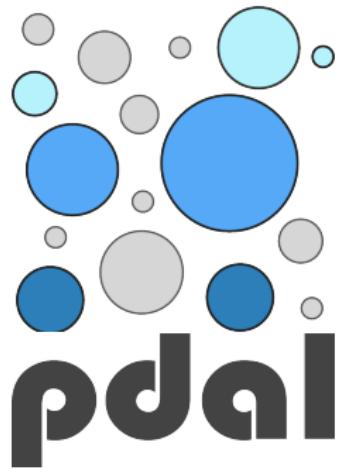
Current state of integration with PDAL

PDAL

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

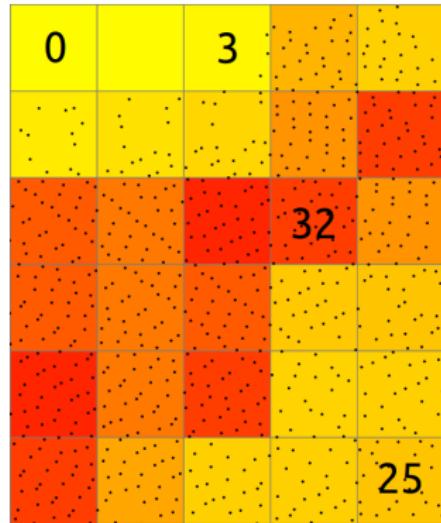
Experimental integration

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



Binning points to raster

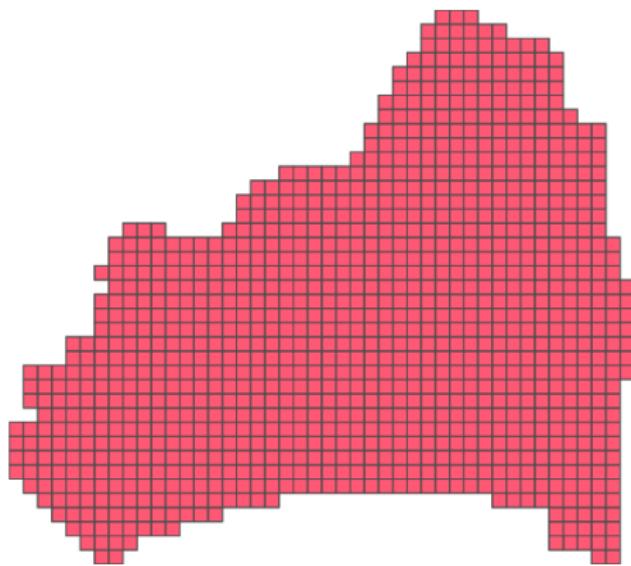
- ▶ *r.in.lidar*
- ▶ import and analysis
- ▶ statistics of point counts, height and intensity
 - ▶ n, min, max, sum
 - ▶ mean, range, skewness, ...



Read multiple tiles as one

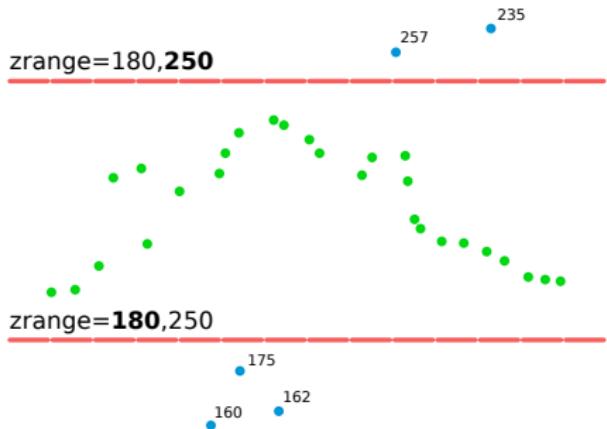
- ▶ `r.in.lidar`, option `file`
 - ▶ read multiple tiles as one
 - ▶ no merging

0.5 billion points in 90 files in minutes



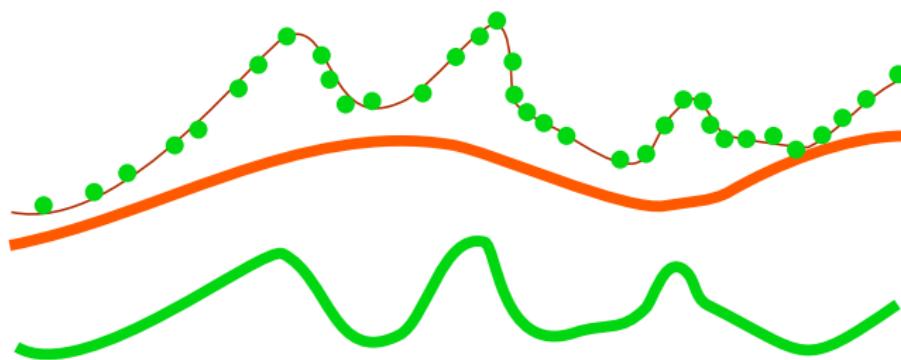
Filtering points

- ▶ filter points by
 - ▶ range of Z
 - ▶ return
 - ▶ class
 - ▶ ...
- ▶ at the time of binning with
r.in.lidar
 - ▶ minimal additional cost



Height above a surface

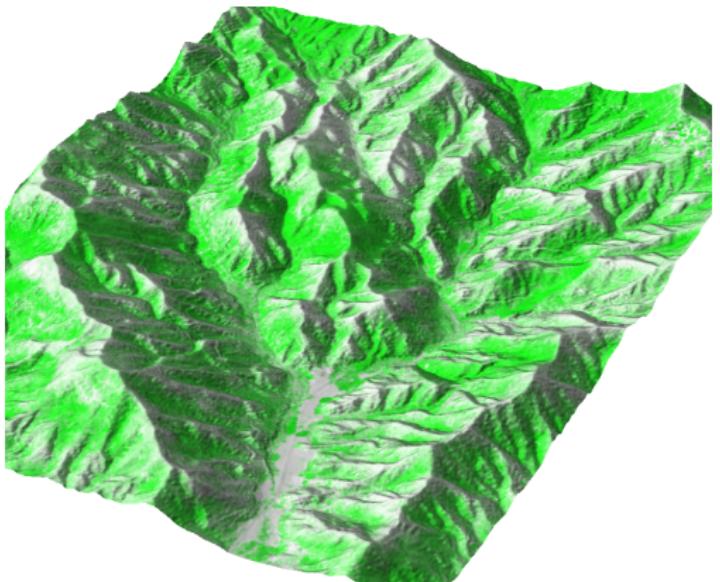
- ▶ `r.in.lidar`, option `base_raster`
- ▶ given surface + points cloud → height of features



- ▶ low additional memory requirements

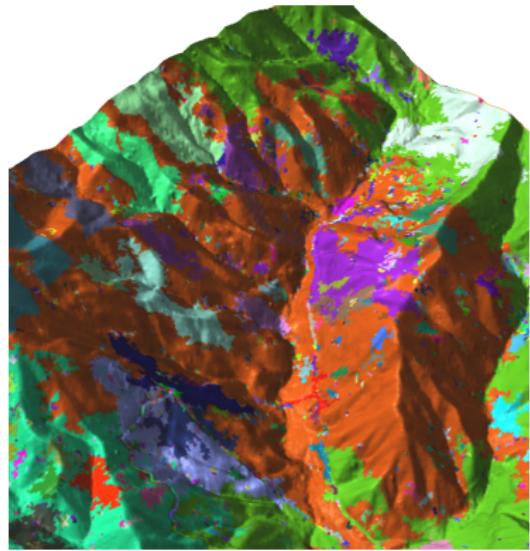
Height above a surface

- ▶ different resolutions
 - ▶ 1m ground surface
 - ▶ 30m height above ground
- ▶ different statistics
- ▶ different combinations
 - ▶ surface can be e.g. top of the canopy
 - ▶ combine with zrange
 - ▶ combine with intensity



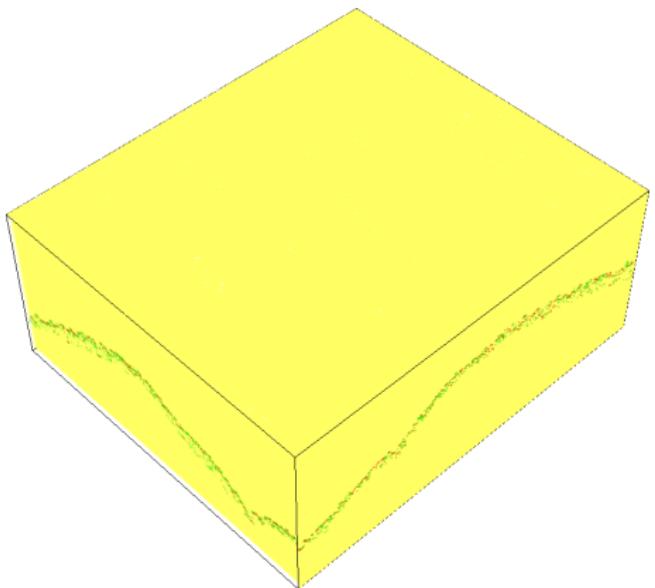
Rastersize early

- ▶ 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*



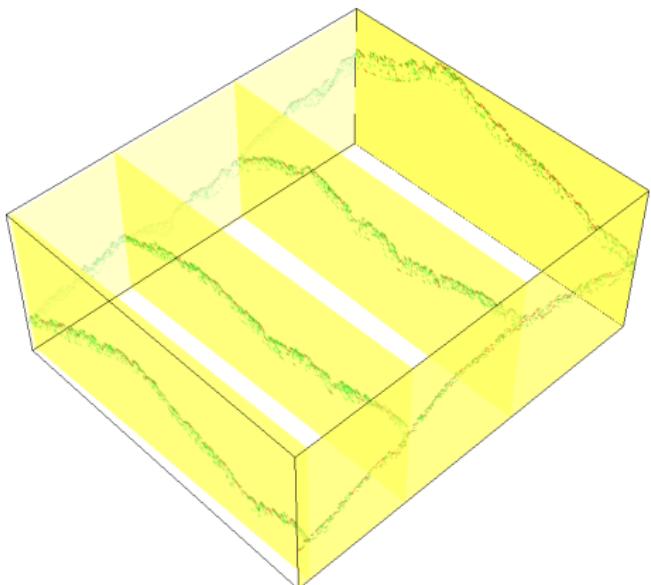
3D raster

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



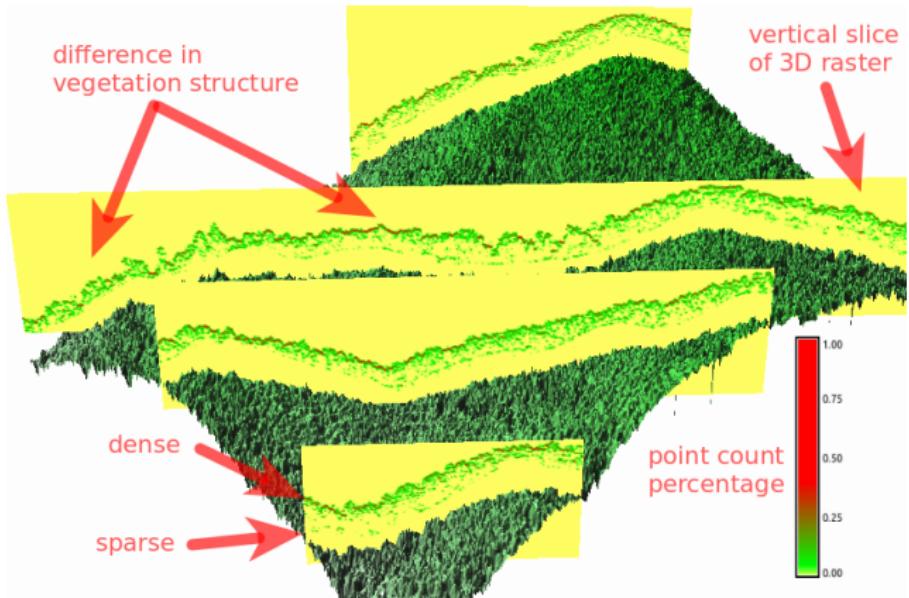
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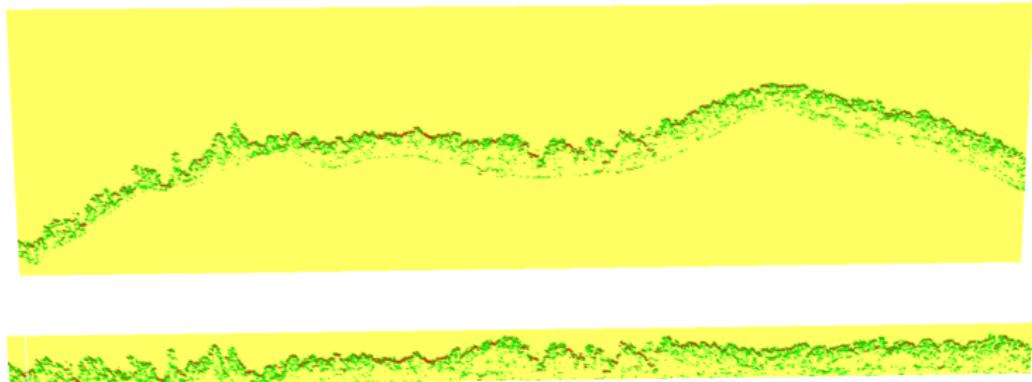


Binning points to 3D raster

- ▶ *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

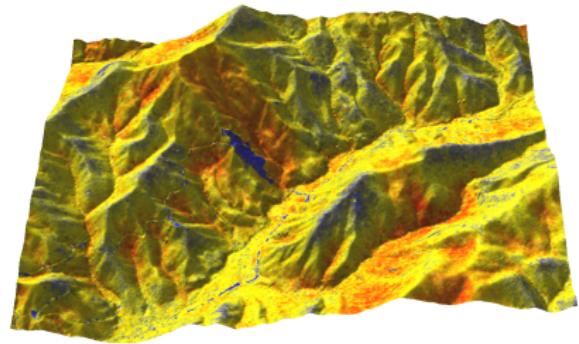


- ▶ *r3.in.lidar*, option *base_raster*
- ▶ height reduced by raster values

Trade-offs

Raster processing

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



visualization: range from binning on interpolated surface

Vector processing

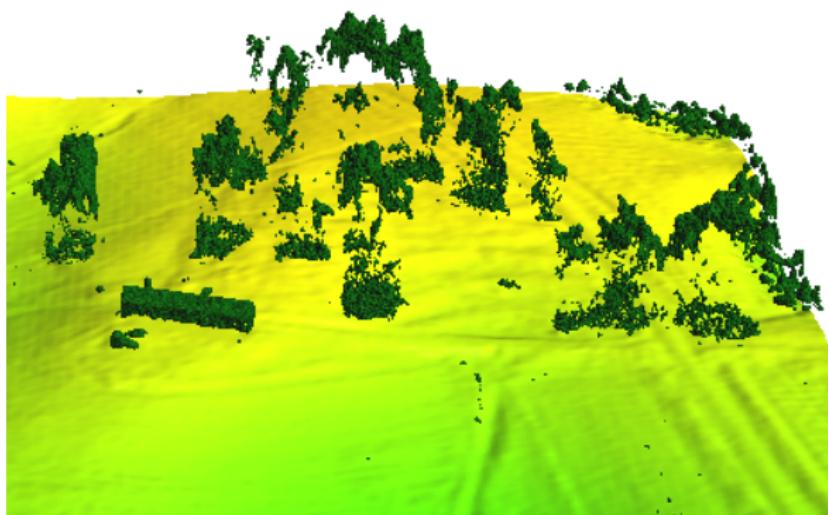
- ▶ slower than raster
 - ▶ e.g., interpolation much slowed than binning
- ▶ hard to make general statements

example: binning with base elevation subtraction:
 ≈ 1000 files, > 9 billion points

≈ 3 hours, ≈ 10 GB of memory (in-memory mode)

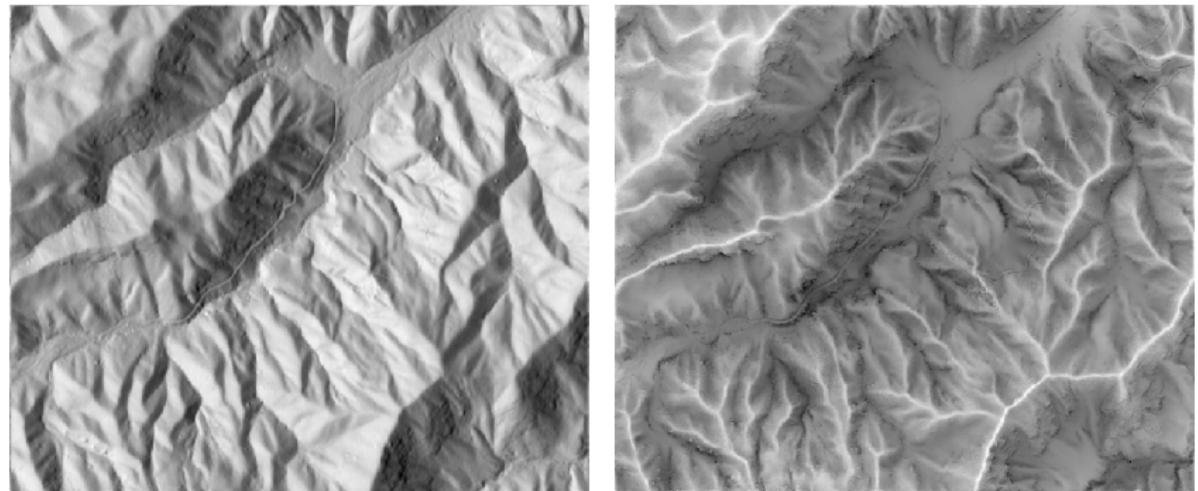
Ground detection

- ▶ *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
 - ▶ now in *v.in.pdal*
 - ▶ progressive morphological filter by Zhang
 - ▶ provided by PCL



Sky-view factor

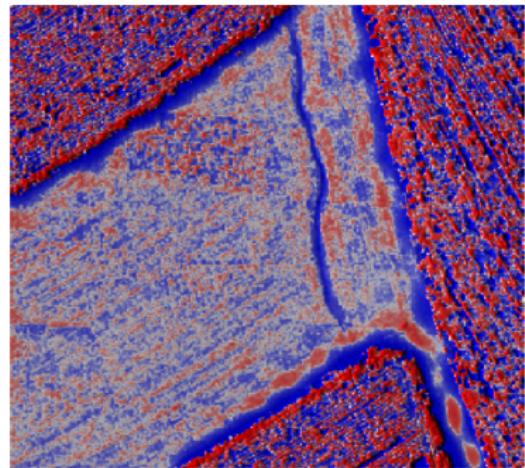
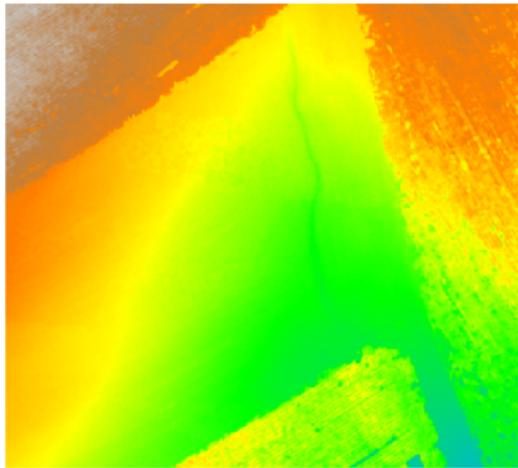
- ▶ *r.skyview* (percentage of visible sky)



comparison of shaded relief and sky-view factor

Local relief model (LRM)

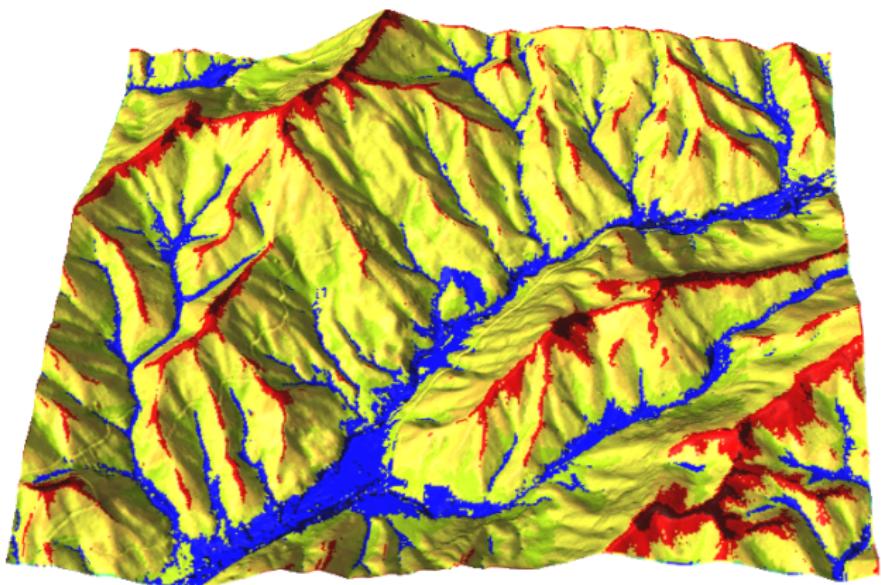
- ▶ `r.local.relief` (micro-topography, features other than trend)



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

Landforms

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

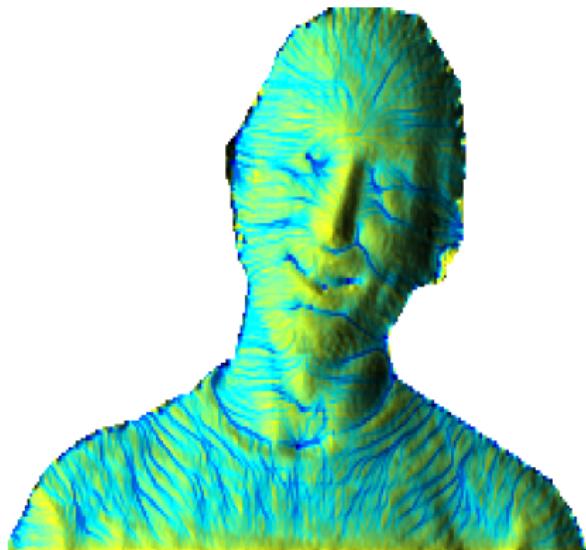


libfreenect2 + PCL + GRASS GIS = *r.in.kinect*

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
- ▶ make use of existing methods for raster and vector processing
- ▶ 3D rasters, PDAL integration



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

Slides and paper available at
wenzeslaus.github.io/grass-lidar-talks

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



Acknowledgements

Software

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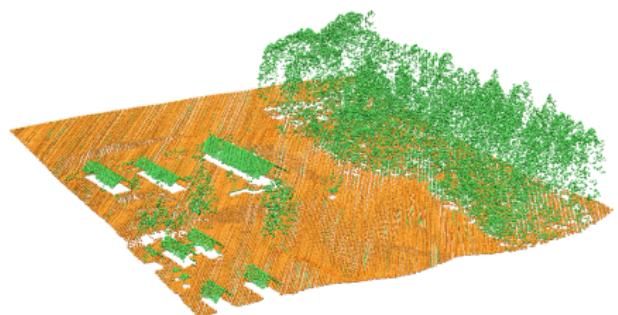
Acknowledgements

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>



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Presentation software

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