

# Using Free and Open Source Solutions in Geospatial Science Education

Tools and ideas for better geospatial science education

Vaclav Petras (Vashek)<sup>1</sup>

Anna Petrasova<sup>1</sup>, Keren Cepero Perez<sup>1</sup>, Markus Neteler<sup>2</sup>,

Luca Delucchi<sup>2</sup>, Martin Landa<sup>3</sup>, Helena Mitasova<sup>1</sup>

<sup>1</sup>North Carolina State University

<sup>2</sup>Fondazione Edmund Mach

<sup>3</sup>Czech Technical University in Prague and GISMentors

July 15, 2015  
FOSS4G Europe



# Free and open source software

*Open Source Software Is Now a Norm in Businesses*

Katherine Noyes, PCWorld, May 18, 2011

*Open Source has Become Mainstream but Still Drives Innovation*

Talend Yves de Montcheuil, ZDNet, May 2, 2012

*10 of Europe's 15 largest banks are now running [...] Postgres*

Sandor Klein said for ZDNet (Toby Wolpe), November 19, 2013

*Redmond top man Satya Nadella: 'Microsoft loves Linux'*

Neil McAllister, The Register, October 20, 2014

*Survey indicates four out of five developers now use open source*

Steven J. Vaughan-Nichols, ZDNet, October 29, 2014

*64% of internet exchange points are now using [...] an open source solution*

Gijs Hillenius, Joinup Open source observatory, June 8, 2015

*Open Sourcing Is No Longer Optional, Not Even for Apple*

Clint Finley, WIRED, June 9, 2015

# Free and open source software

*Software [...] developed as part of novel methods is as important for the method's implementation [...] Such software [...] must be made available to readers upon publication.*

Nature Methods 4, 189, 2007

*The opposite of 'open' isn't closed. The opposite of open is 'broken.'*

Cable Green (quoting John Wilbanks) at Open Scotland Summit 2013

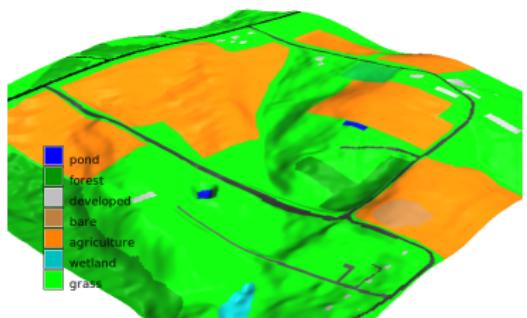


Image credit: Opensource.com

# Courses at North Carolina State University

## Geospatial Analysis and Modeling

- ▶ started in 2008
- ▶ on-campus and distance education
- ▶ every semester 30-60 students
- ▶ software:
  - ▶ GRASS GIS
  - ▶ ArcGIS
- ▶ workflow for software provided
- ▶ students write reports with general theory and methods

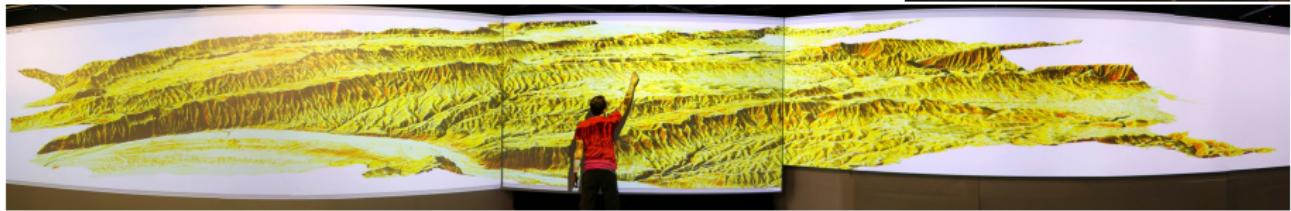
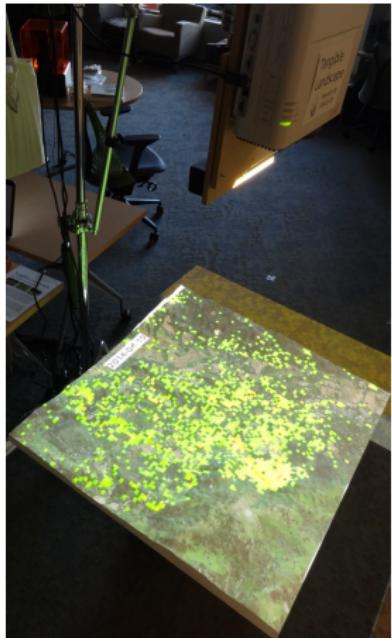


Listing only geospatial courses where presentation authors are involved.

# Courses at North Carolina State University

## Multidimensional Geospatial Modeling

- ▶ software:
  - ▶ GRASS GIS often with new features such as Temporal Framework (GRASS GIS 7)
  - ▶ + whatever the students need,  
e.g. XBeach, libLAS or LAStools
- ▶ curriculum depends on students projects
- ▶ new technologies: Tangible Landscape, NCSU Hunt Lib Teaching and Vis Lab, eye tracking



## GIS for Designers

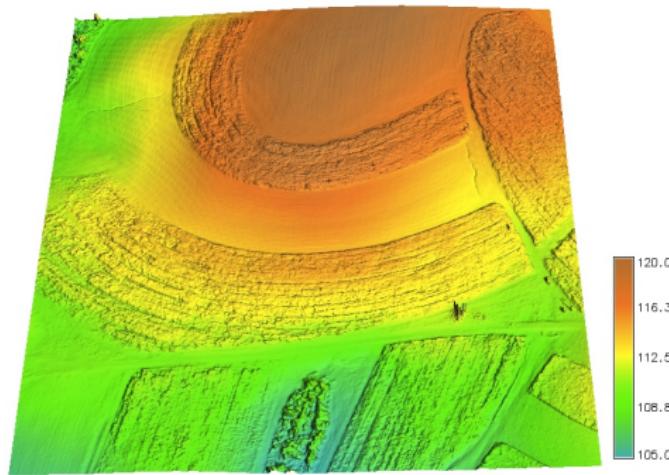
- ▶ software in class:
  - ▶ ArcGIS
  - ▶ GRASS GIS
  - ▶ Rhino (Rhinoceros)
- ▶ for projects architects and designers combine a lot of tools
  - ▶ Tangible Landscape (powered by GRASS GIS) was one of them



## UAV/lidar Data Analytics

- ▶ under development for this fall semester
- ▶ Agisoft PhotoScan in class, OpenDroneMap in projects

Related talk: Flow analysis using sUAS and lidar data (Helena Mitasova)



# The idea

- ▶ lectures:
  - ▶ theory, concepts
  - ▶ software-independent
- ▶ labs and assignments:
  - ▶ relate to given lecture
  - ▶ hands-on, practical
  - ▶ students use software

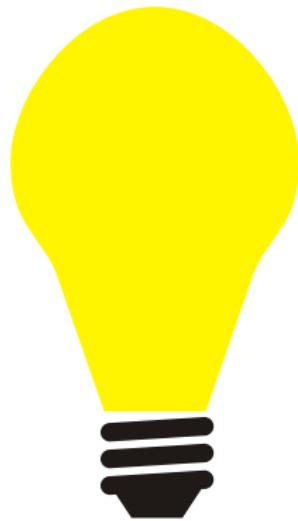


Image credit: Openclipart

# The problem

- ▶ students are becoming (only) software users instead of scientists
- ▶ students mix software details and general concepts
  - ▶ saying Shapefile or feature class instead of *vector* data...
- ▶ bonding with software limits flexibility
- ▶ software promotes software/vendor-specific formats/technologies
- ▶ single software choice limits explored algorithms

# The solution

- ▶ lectures:
  - ▶ theory, concepts
  - ▶ software-independent
- ▶ labs and assignments:
  - ▶ relate to given lecture
  - ▶ hands-on, practical
  - ▶ **students use two different software packages**, in our case:
    - ▶ GRASS GIS (free and open source)
    - ▶ ArcGIS (proprietary)
- ▶ similar task in both
- ▶ opportunity to see what is a general concept and what is specific to a particular software

# The solution

- ▶ lectures:
  - ▶ theory, concepts
  - ▶ software-independent
- ▶ labs and assignments:
  - ▶ relate to given lecture
  - ▶ hands-on, practical
  - ▶ students use two different software packages, in our case:
    - ▶ GRASS GIS (free and open source)
    - ▶ ArcGIS (proprietary)
- ▶ similar task in both
- ▶ opportunity to see what is a general concept and what is specific to a particular software

# The solution

- ▶ lectures:
  - ▶ theory, concepts
  - ▶ software-independent
- ▶ labs and assignments:
  - ▶ relate to given lecture
  - ▶ hands-on, practical
  - ▶ students use two different software packages, in our case:
    - ▶ GRASS GIS (free and open source)
    - ▶ ArcGIS (proprietary)
- ▶ similar task in both
- ▶ opportunity to see what is a general concept and what is specific to a particular software

# Teaching materials

- ▶ file format
  - ▶ originally HTML
  - ▶ selecting new one
    - ▶ Markdown, missing general standard
    - ▶ reStructuredText, hot candidate
  - ▶ result: HTML (same as delivery format)
  - ▶ presentation slides in HTML5 (Reveal.js)
- ▶ license: CC BY-SA
- ▶ Git (GitHub hosted) for revision control, collaboration and sharing source code
- ▶ registered in OSGeo Educational Content Inventory



[geospatial.ncsu.edu/  
osgeorel/courses.html](http://geospatial.ncsu.edu/osgeorel/courses.html)

The screenshot shows the homepage of the NCSU GIS/MEA582 course. The title "NCSU GIS/MEA582: Geospatial Modeling and Analysis" is displayed prominently at the top. Below the title, there are links for Syllabus, Schedule, Course logistics, Lectures, Assignments, and Projects. A banner below the title features a colorful elevation map of a region.

## Geospatial data models

### Resources:

- GRASS GIS overview and manual
- Recommendations and tutorial how to use wxGUI from the first assignment

For Windows users: When showing legend, make sure the numbers are displayed. If not, please go through the following steps:

1. In Layer Manager toolbar find Settings-> Map Display tab
2. Set font size to 10pt or greater font (e.g. sans)
3. Click on Save to save settings
4. Click on Render map (second button in Map Display toolbar) and legend numbers should appear.

## Resampling to higher resolution

Resample the given raster map to higher and lower resolution (30m->10m, 30m->100m) and compare resampling by nearest neighbor with bilinear and bicubic method.

First, set the region to 30m resolution and display the 30m resolution elevation raster.

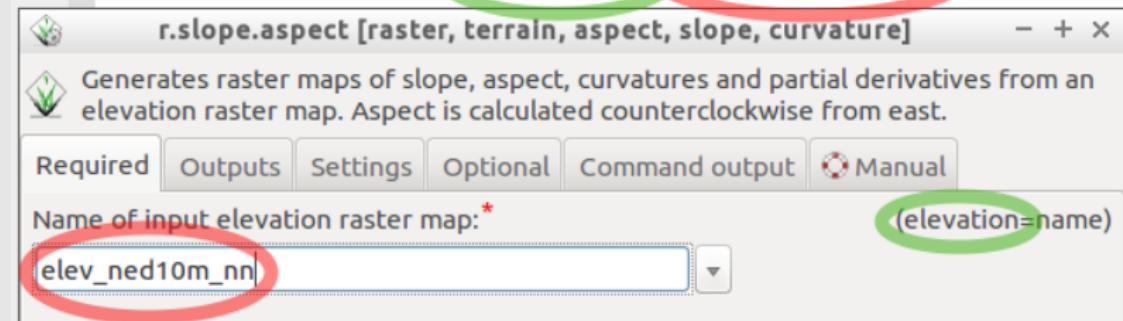
```
g.region swlake_30m -p  
d.rast elev_ned_30m
```

# GRASS GIS advantage for teaching materials maintenance

- ▶ GRASS GIS workflow recorded as commands.
  - ▶ Screenshots are hard to update while text is easy to update.
  - ▶ GUI dialog filled according to the command.
  - ▶ Commands can be automatically extracted and tested.

The elevation map "elev\_ned10m\_nn" looks the same as the original

`r.slope.aspect elevation=elev_ned10m_nn aspect=aspect_ned`



For ArcGIS we also use just text, but, unlike in GRASS GIS, the names in dialogs are not part of the API, so they change more often. (Course running since 2008.)

## *Integrating Free and Open Source Solutions into Geospatial Science Education*

Open Access

Vaclav Petras<sup>1, 4</sup>, Anna Petrasova<sup>1, 4</sup>, Brendan Harmon<sup>2, 4</sup>,  
Ross K. Meentemeyer<sup>3, 4</sup>, and Helena Mitasova<sup>1, 4</sup>

<sup>1</sup>Department of Marine, Earth, and Atmospheric Sciences

<sup>2</sup>Department of Landscape Architecture

<sup>3</sup>Department of Forestry and Environmental Resources

<sup>4</sup>Center for Geospatial Analytics and NCSU OSGeoREL – part of ICA-OSGeo-ISPRS Network (aka **Geo for All**)

North Carolina State University, Raleigh, USA

In: *ISPRS International Journal of Geo-Information*. 2015.



doi:10.3390/ijgi4020942



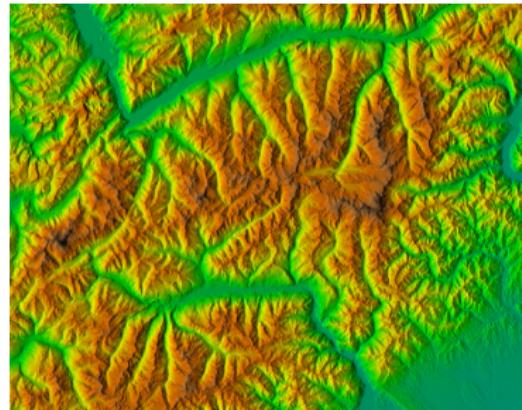
# Standardized Sample Datasets

- ▶ region specific datasets limit sharing of hands-on teaching material
- ▶ new version of North Carolina
  - ▶ commonly available data, frequently used in examples
  - ▶ standardized names such as *elevation*, *streets*, or *lakes*
    - ▶ rather than *srtm*, *dem\_10m*, *streets\_como*
- ▶ different datasets should use the same standardized names
- ▶ challenges:
  - ▶ attributes, coordinates, values, extents, resolutions

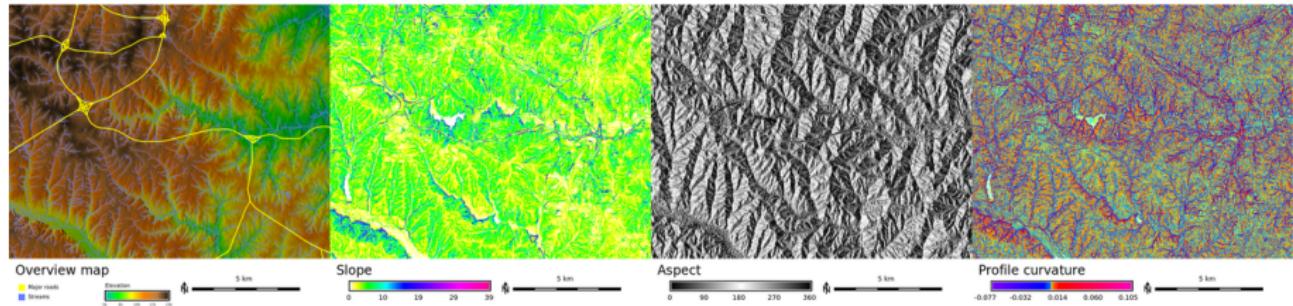
```
g.region raster=elevation  
r.relief input=elevation output=shade
```

```
d.shade shade=shade color=elevation
```

- ▶ wiki page



# Standardized Sample Dataset: North Carolina, USA

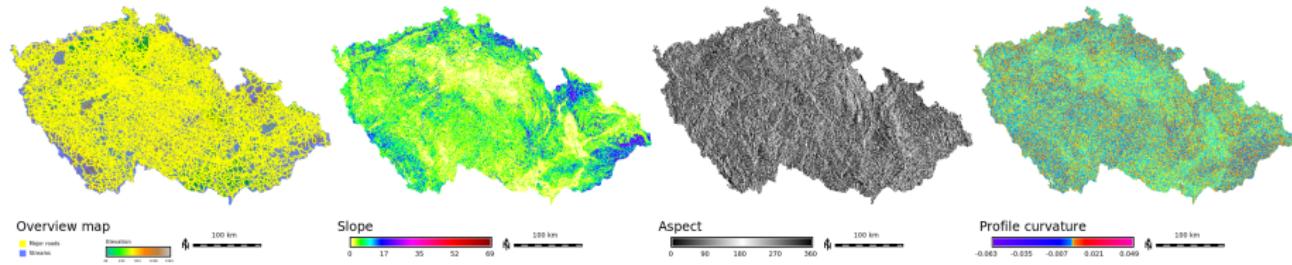


Helena Mitasova<sup>1</sup> and Markus Neteler<sup>2</sup>, authors of  
*Open Source GIS: A GRASS GIS Approach* (fourth edition in preparation)

<sup>1</sup>Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, USA

<sup>2</sup>Research and Innovation Centre, Fondazione Edmund Mach, Italy

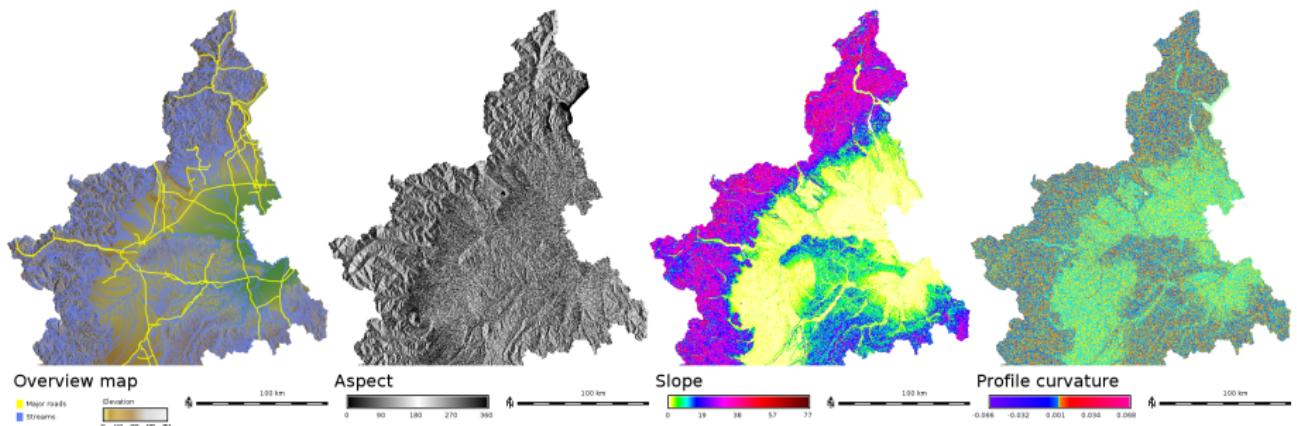
# Standardized Sample Dataset: Czech Republic



Martin Landa\* and Jachym Cepicky from GISMentors

\*OSGeoREL at Czech Technical University in Prague, Faculty of Civil Engineering

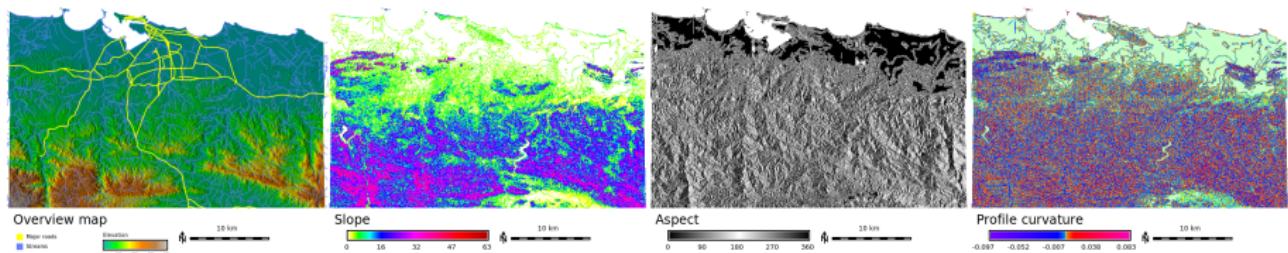
# Standardized Sample Dataset: Piedmont, Italy



Luca Delucchi and Markus Neteler

Research and Innovation Centre, Fondazione Edmund Mach, Italy

# Standardized Sample Dataset: Puerto Rico



Keren Cepero Perez

Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, USA

# Future directions: IPython Notebook

Used in workshop *How to write a Python GRASS GIS 7 addon*

- ▶ <https://github.com/wenzeslaus/python-grass-addon>

## Solution

- ▶ Docker + GRASS GIS + IPython Notebook
- ▶ Dockerfile:
  - ▶ <https://github.com/wenzeslaus/grass-gis-docker>

IP[y]: IPython  
Interactive Computing



# NCSU OSGeoREL workshops and tutorials

## Introduction to GRASS GIS

Delivered at NCSU

## Spatio-temporal data handling and visualization in GRASS GIS

FOSS4G 2014 (Portland) workshop, also delivered at NCSU

## Soil erosion and deposition modeling

Part of a broader project; workflows for GRASS GIS and ArcGIS

## How to write a Python GRASS GIS 7 addon

FOSS4G Europe 2015 (Como) workshop, also delivered at NCSU

Workshops are a way how to experiment with what to teach and how.

# Future directions: Tools for open science course

- ▶ Course dedicated to
  - ▶ exploring important role FOSS plays in science
  - ▶ overview of tools and methods common in FOSS and desperately needed in science
  - ▶ open access, open data, open standards, open...
  - ▶ reusability and reproducibility are standard in FOSS



Image credit: Opensource.com

# Future directions: Software, technologies and platforms

- ▶ OpenStreetMap, TeachOSM, LearnOSM
  - ▶ for introduction to geography or GIS
  - ▶ as an example of community-based project
  - ▶ as data source in advanced courses
- ▶ MapStory for student projects
- ▶ GIS.lab for easy lab setup
- ▶ IPython/Jupyter, JupyterHub, tmpnb
- ▶ desktop to browser: GTK+ Broadway, noVNC (to get something like rollApp)
- ▶ web-based tool to explore algorithm behavior in teaching materials
- ▶ link teaching materials, standard user manual and the source code

## Summary

- ▶ improve students' geospatial skills by teaching 2 software packages
- ▶ use available tools like Git and HTML to create teaching materials
- ▶ create a dataset with standardized names for your region



[github.com/wenzeslaus/foss-in-geospatial-science-education](https://github.com/wenzeslaus/foss-in-geospatial-science-education)