Modeling Dynamic Landscapes in Open Source GIS

Helena Mitasova,

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Geographic Information Science & Technology
North Carolina State University

GRASS GIS

OSGeo
Your Open Source Compass

Free and Open Source Software

Software that is free to **run, study, modify and distribute**
Free means **freedom:** free is a matter of **liberty not price**

It can be **commercial** (Red Hat Linux) but **not proprietary**

OSGeo foundation supports the development of open source geospatial software and promotes its widespread use since 2006. Founded with AutoDESK support.

FOSS4G: GRASS GIS – GPL**, GDAL** – LGPL

General Public Licenses (simplified):

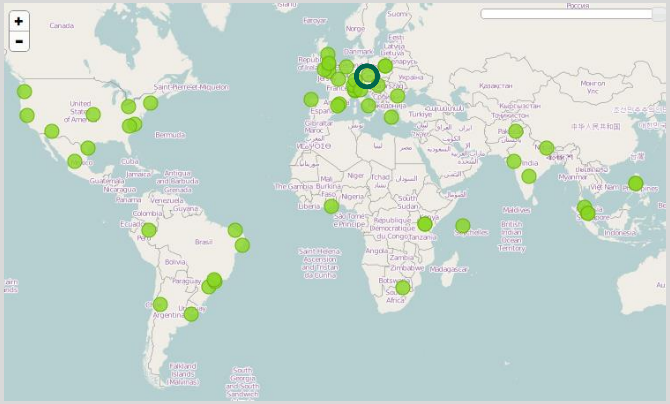
GPL - cannot be combined with closed software binary

LGPL - allows combined binary, but the GPL part must remain free

http://www.gnu.org/licenses/license-list.html#SoftwareLicenses

New Initiative: OSGeo REL network

Global network of Open Source Geospatial Research and Education Laboratories:



- ICA-OSGeo MOU: build teaching and research infrastructure worldwide
- open network
- 6 founding laboratories, including NCSU
- growing fast: currently **56 labs** globally

http://www.geoforall.org/

http://www.geoforall.org/

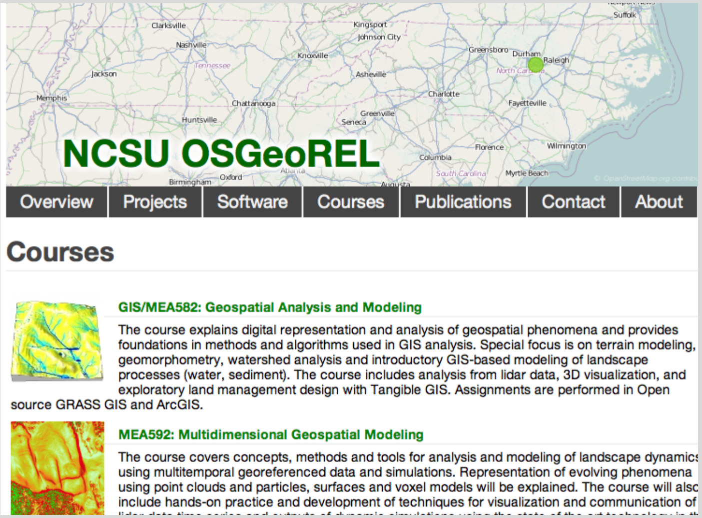
thanks to Suchith Anand, Nottingham University

Open Source Geospatial at NCSU

NCSU Open Source Initiative

supported by **RedHat:** the largest open source software company

http://gis.ncsu.edu/osgeorel/



MS program in GIST

- interdisciplinary: no geography dept.
- FOSS4G **integrated** into courses along with proprietary software

Discipline PhD with GIST focus

Course: Geospatial Modeling

Lectures:

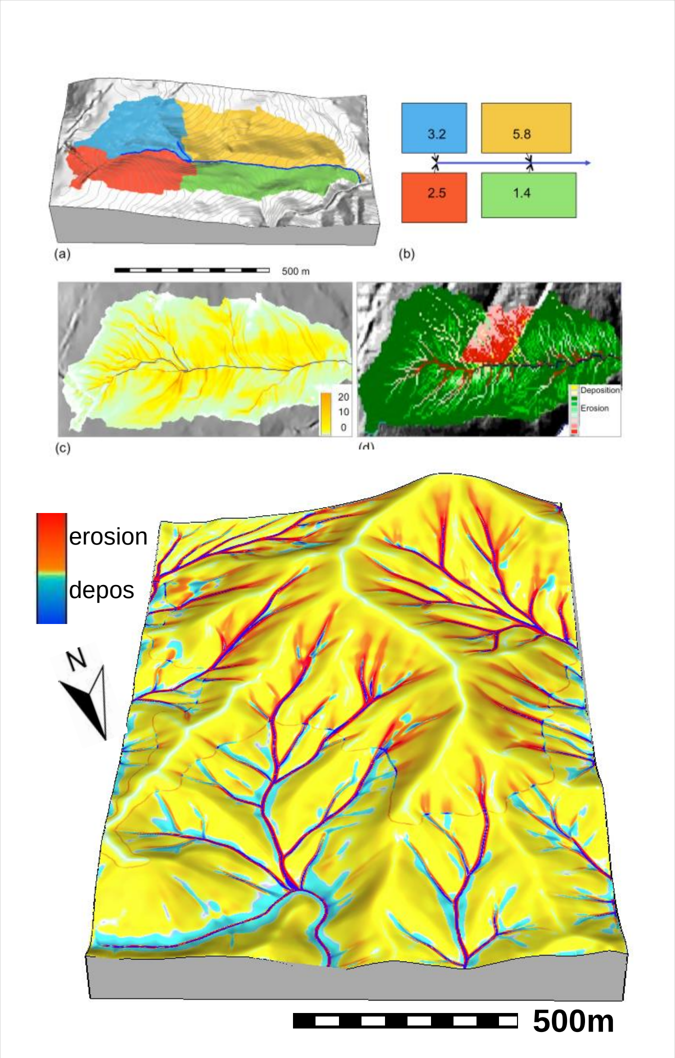
- fundamentals and methods
- software independent

Weekly Assignments:

- GRASS GIS + ArcGIS
- “flipped approach”: given workflow, explain methods and results

Independent project:

- thesis-based or selected topic
- students chose software
- combining is encouraged



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On-line section

Screen capture with audio:

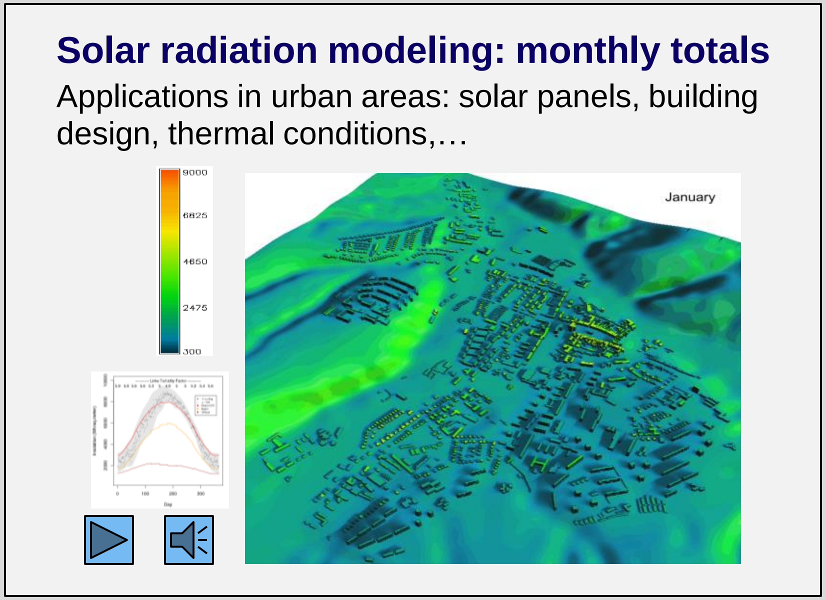
- lectures
- interactive tools such as visualization

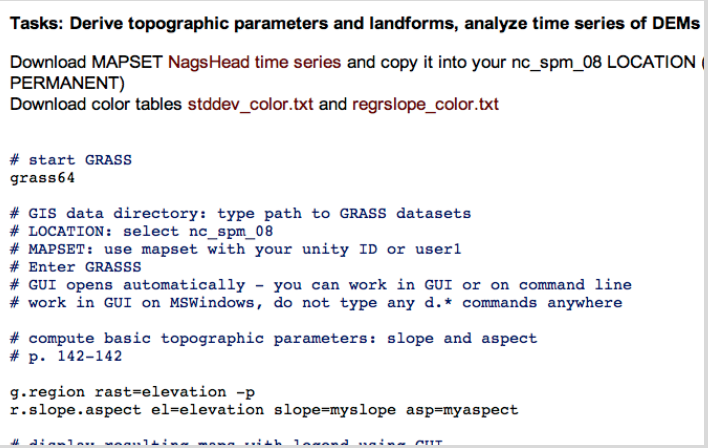
Assignments for GRASS, ArcGIS:

in plain html for easy updates

Course is free online

- message board discussion, help
- Google sites: post HW, get feedback
- register to get credit





Tasks: Derive topographic parameters and landforms, analyze time series of DEMs

Download MAPSET NagsHead time series and copy it into your nc_spm_08 LOCATION (
PERMANENT)
Download color tables stddev_color.txt and regrslope_color.txt

```
# start GRASS
grass64

# GIS data directory: type path to GRASS datasets
# LOCATION: select nc_spm_08
# MAPSET: use mapset with your unity ID or user1
# Enter GRASSS
# GUI opens automatically - you can work in GUI or on command line
# work in GUI on MSWindows, do not type any d.* commands anywhere

# compute basic topographic parameters: slope and aspect
# p. 142-142

g.region rast=elevation -p
r.slope.aspect el=elevation slope=myslope asp=myaspect
```

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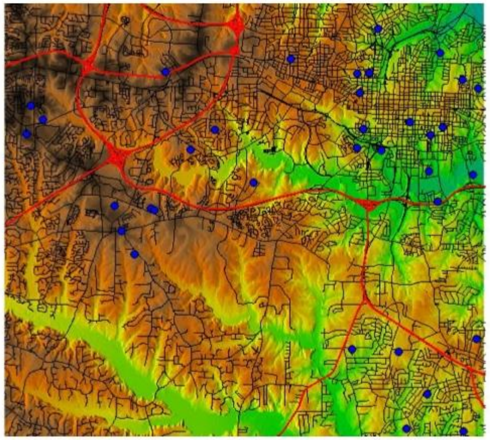
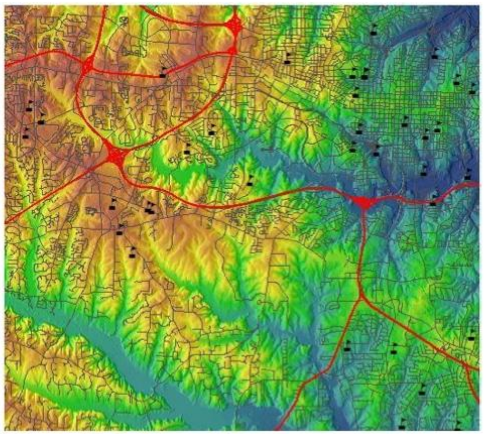
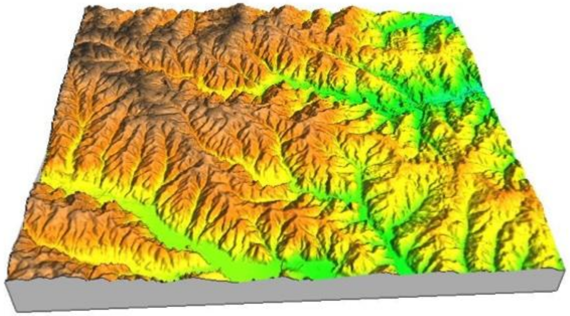
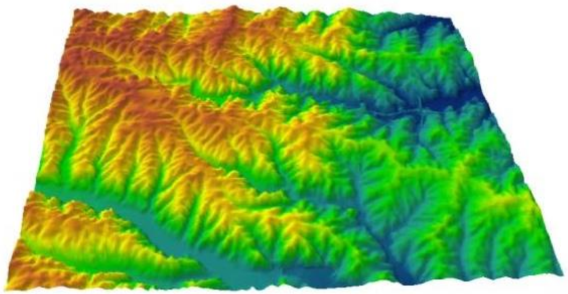
Assignment: Getting started

Display provided Wake county data in 2D and 3D

Makiko Shukunobe, spring 2012

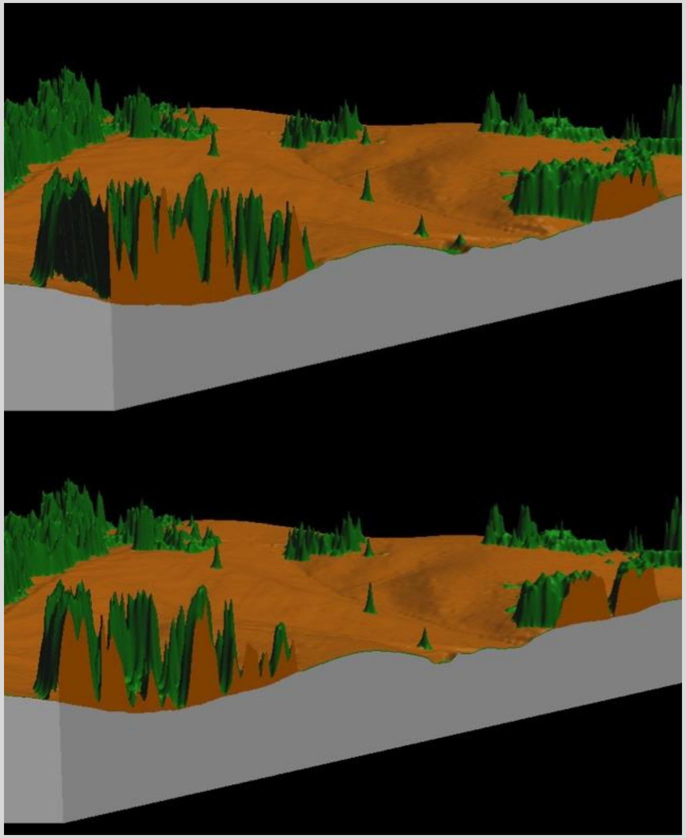
GRASS	ArcGIS
 Figure 1-1 Streets, major streets and school data overlay on elevation data using GRASS	 Figure 1-2 Streets, major streets and school data overlay on elevation data using ArcGIS 10
 Figure 2-1 3D elevation using NVIZ function in GRASS (z-value exegration: 10)	 Figure 2-2 3D elevation using ArcScene (z-value exegration: 10)

Assignment: Lidar

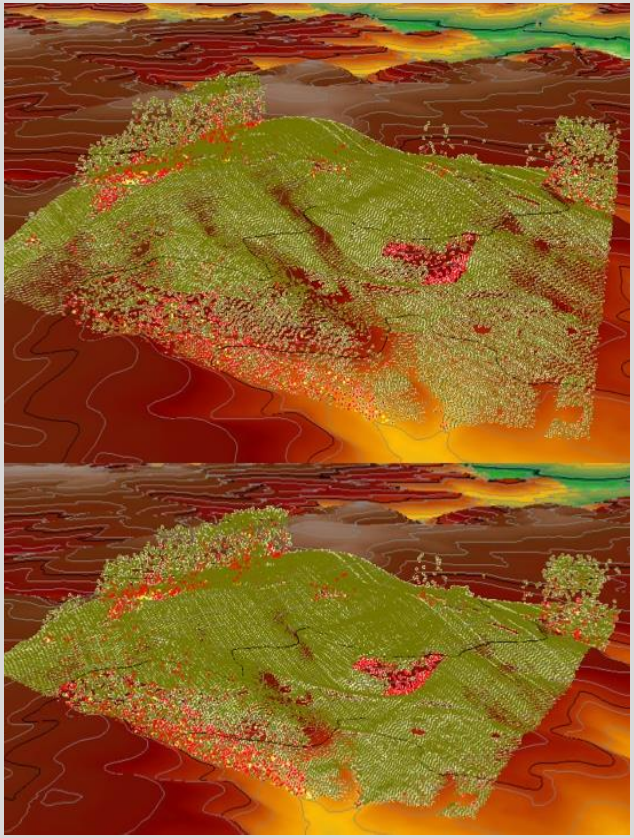
Compare
DEM and DSM
cutting planes,
analyze lidar point
cloud properties

Mathew J Pare,
fall 2012

GRASS



ArcGIS



Midterm exam

Find least cost path between two off-road locations using GRASS *or* ArcGIS.

Granzow, Shortley,

Terblanche, Shukunobe,

GRASS

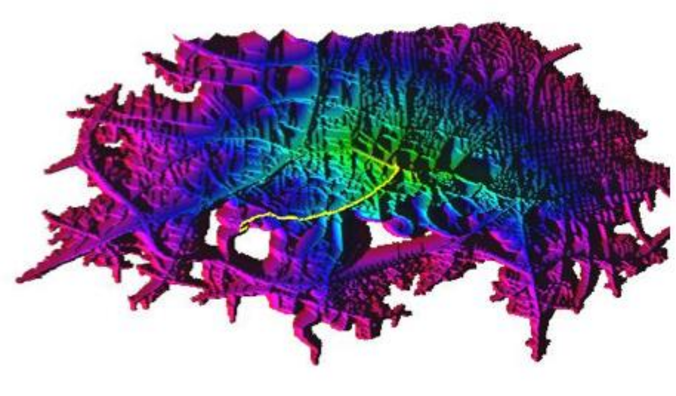
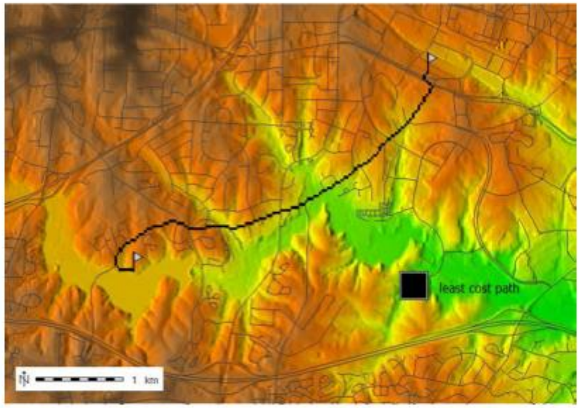
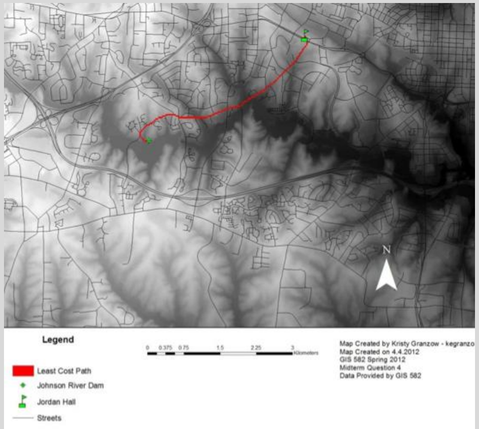


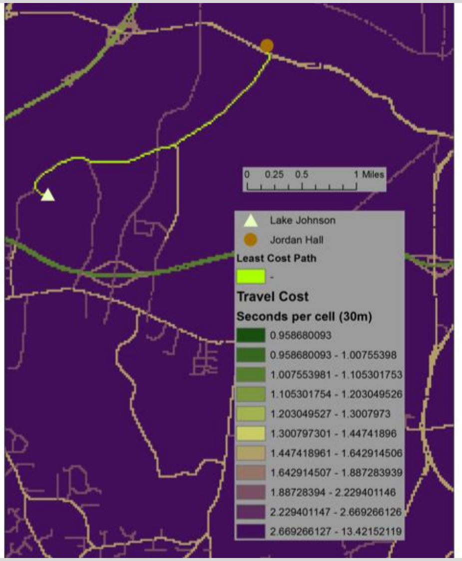
Figure 6: Least Cost Path in NVIZ.

Figure 2. The least cost path between Jordan Hall and Johnson Lake



ARCGIS





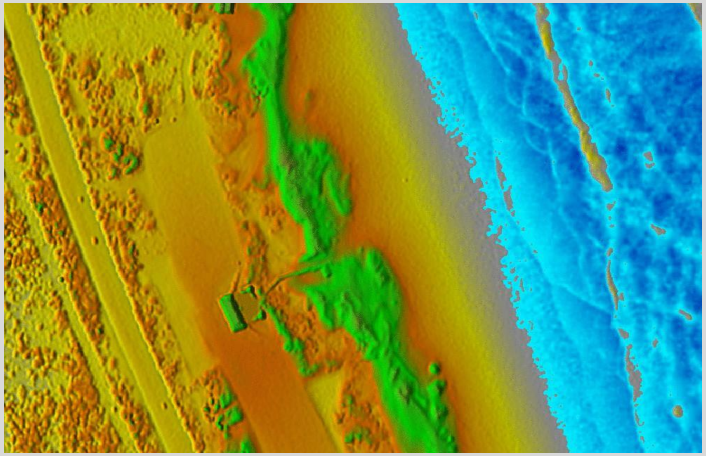
Independent Projects

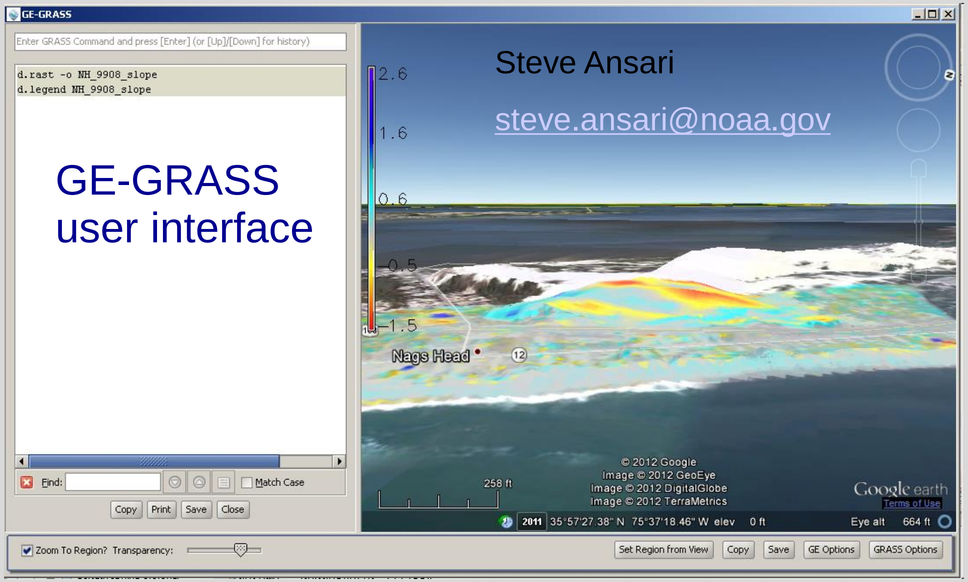
Example topics:

- Solar energy potential
- Coastal hazards
- Watershed analysis
- Trail and greenway design
- Lidar data processing

Most students use ArcGIS but number of students who use GRASS for at least part of their project is increasing every semester

coastal flooding





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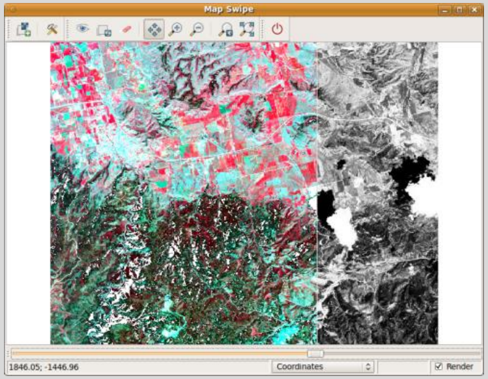
Working with OSGeo REL CTU Prague

Google summer of code 2008, 2010, 2011

GRASS GIS Development,
Visualization tools for 3D time series:
wxnviz, map swipe, 2D/3D animations



CTU: development of visualization tools
Martin Landa, Anna Kratochvilova, Vaclav Petras

NCSU: data collection, processing, applications, Eric Hardin, Katie Weaver, Emily Russ, Nathan Lyons, Keren Cepero

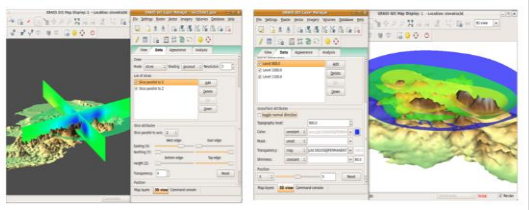


Figure 4. GUI for 3D visualization developed as GSoC project

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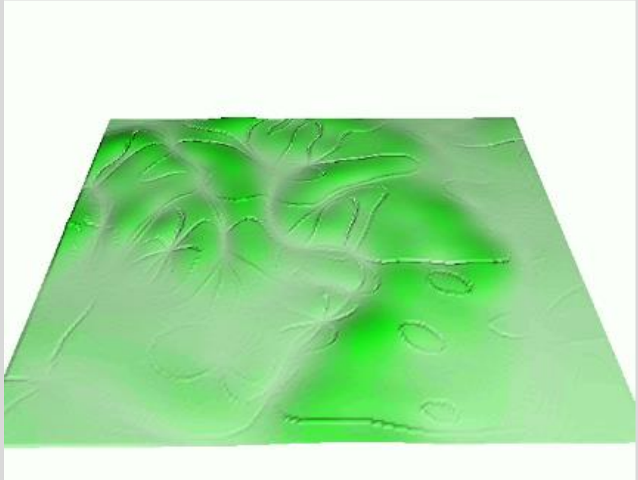
GRASS GIS for dynamic landscapes

First open source GIS with dynamic landscape support:

hydrologic and erosion modeling

1983 GRASS born at USACERL – 30 years



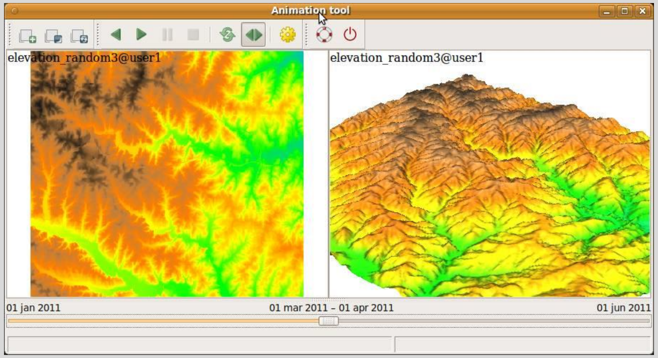
sediment transport capacity

Visualization

1993 Dynamic Surfaces: GRASS4.1 SG3d

20th anniversary:

2013 – **GRASS7**: new generation of tools for dynamic landscapes



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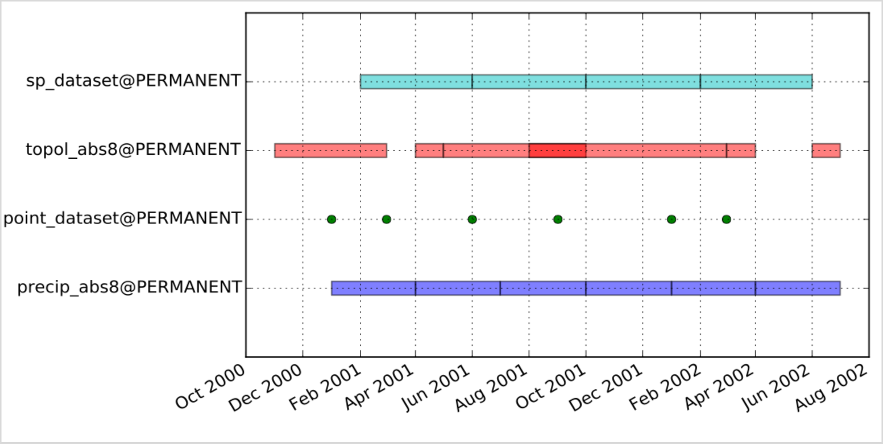
Managing time series in GRASS7

Raster and vector temporal data management and analysis:

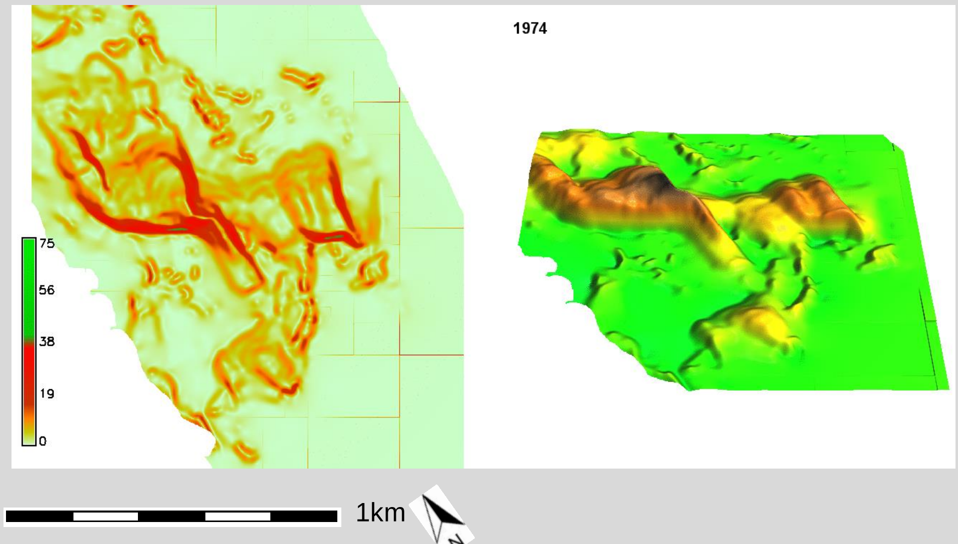
t.* modules

Developed by Soeren Gebbert (vTI)
Intro by Anna Petrasova (NCSU)
http://courses.ncsu.edu/mea592/common/Assign_GISmdmodel/a_temporal.html



New visualization tools:

- simultaneous 2D/3D animation
- voxel-based visualization



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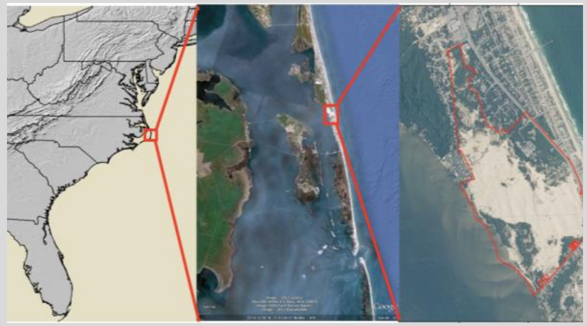
Application: Coastal terrain evolution

Barrier islands
Outer Banks

Dynamic landscape:
sand redistributed
by wind, waves, storm
surge

Vulnerable:
coastal erosion,
sea level rise, breach

Lidar mapping
1996 – 2011:
14 snapshots
Road mapping in
2012



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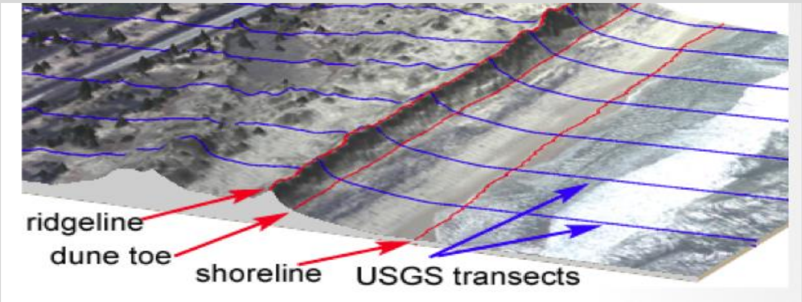
MultiD topographic change analysis

Lines

Line feature extraction, transect-based analysis:

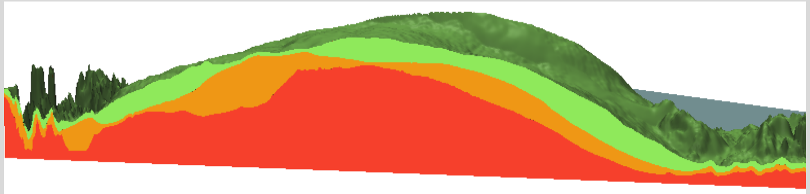
shoreline, dune ridge migration



Surfaces

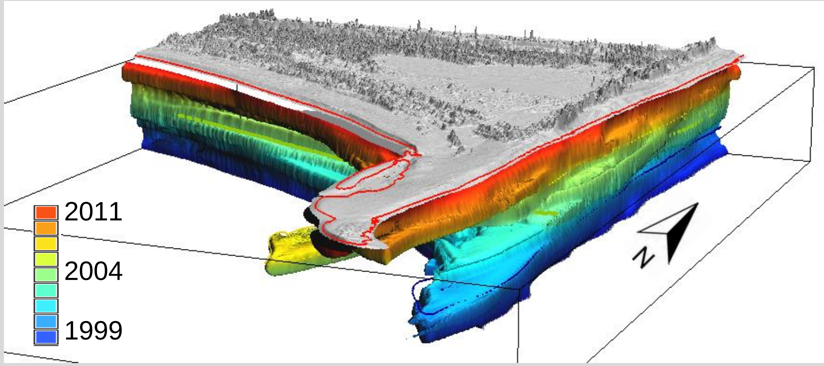
Raster-based analysis:

DEM differencing, per-cell statistics: core, envelope, rate of change



Volumes

Space-Time voxel model



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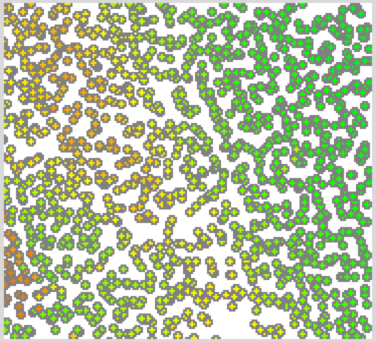
DEM processing

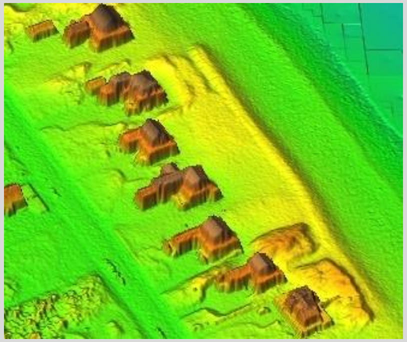
Series of point clouds interpolated to 0.3m-1m DEMs

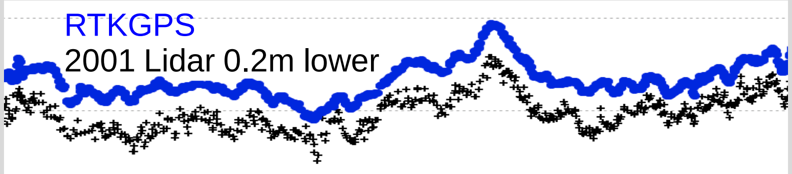
Systematic errors identified and corrected

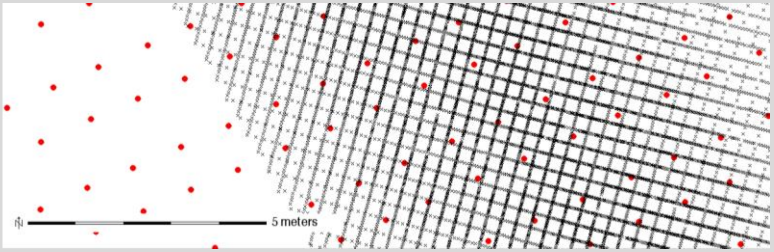
New mobile terrestrial lidar road survey for all NC coastal counties

- scan lines: 15-20cm
- masked 10cm resolution DEMs

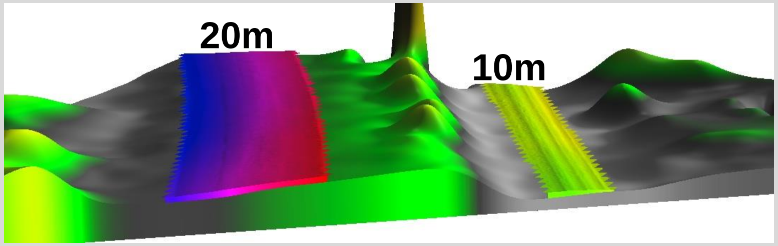




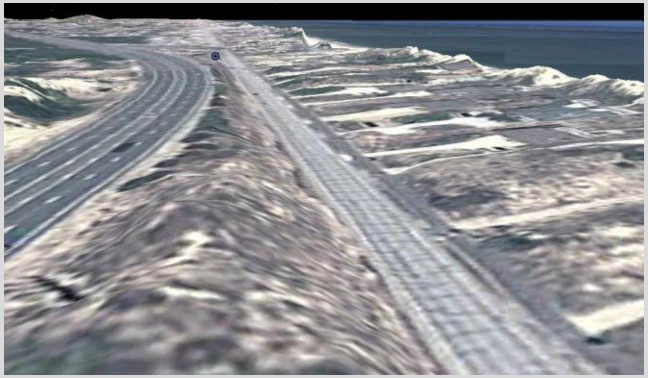




● airborne + terrestrial



2001 **1m** res. DEM, 2012 **0.1m** res. road DEM



Thanks to Doug Newcomb and Hope Morgan for sharing the data

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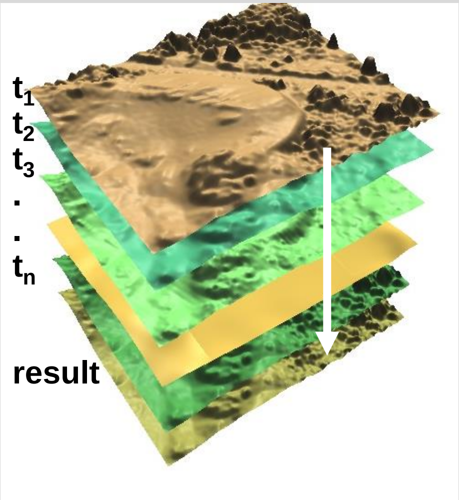
Raster-based analysis

Core surface z-min for each cell
Envelope surface z-max for each cell
Shoreline band: defined by shoreline from core and envelope, bounds shoreline dynamics for given period



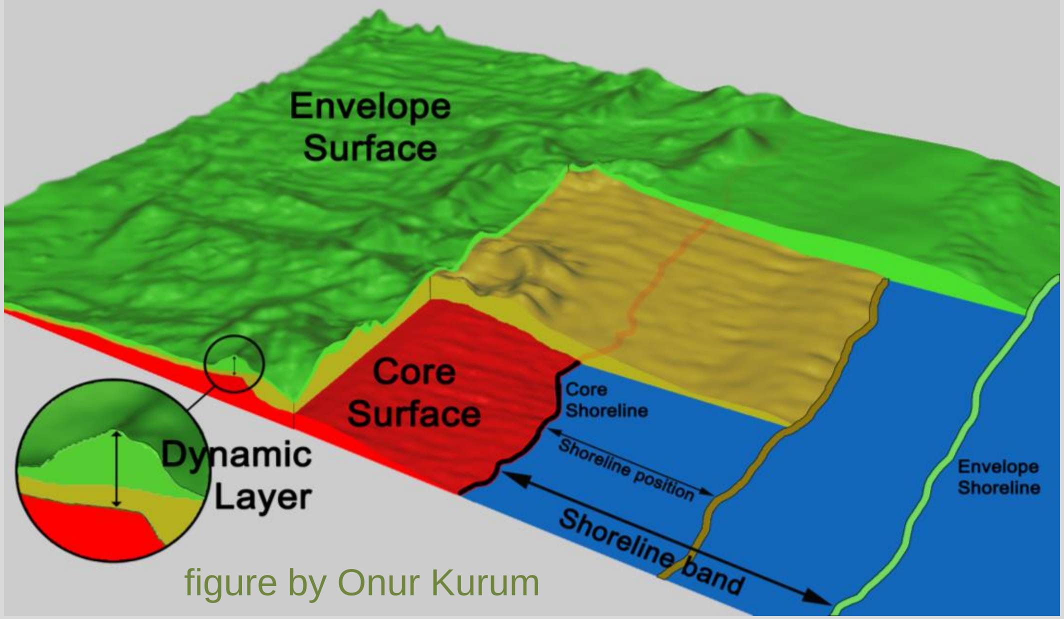
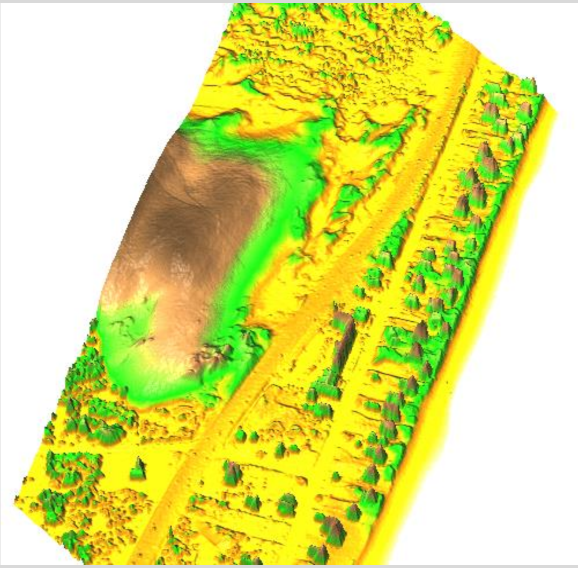


figure by Onur Kurum



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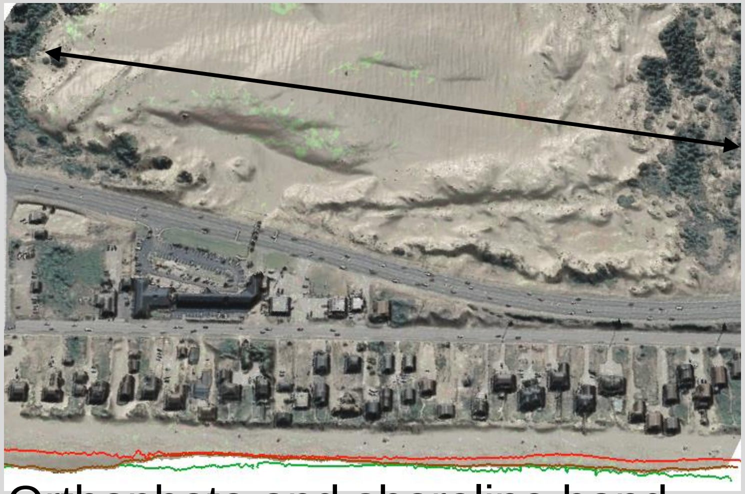
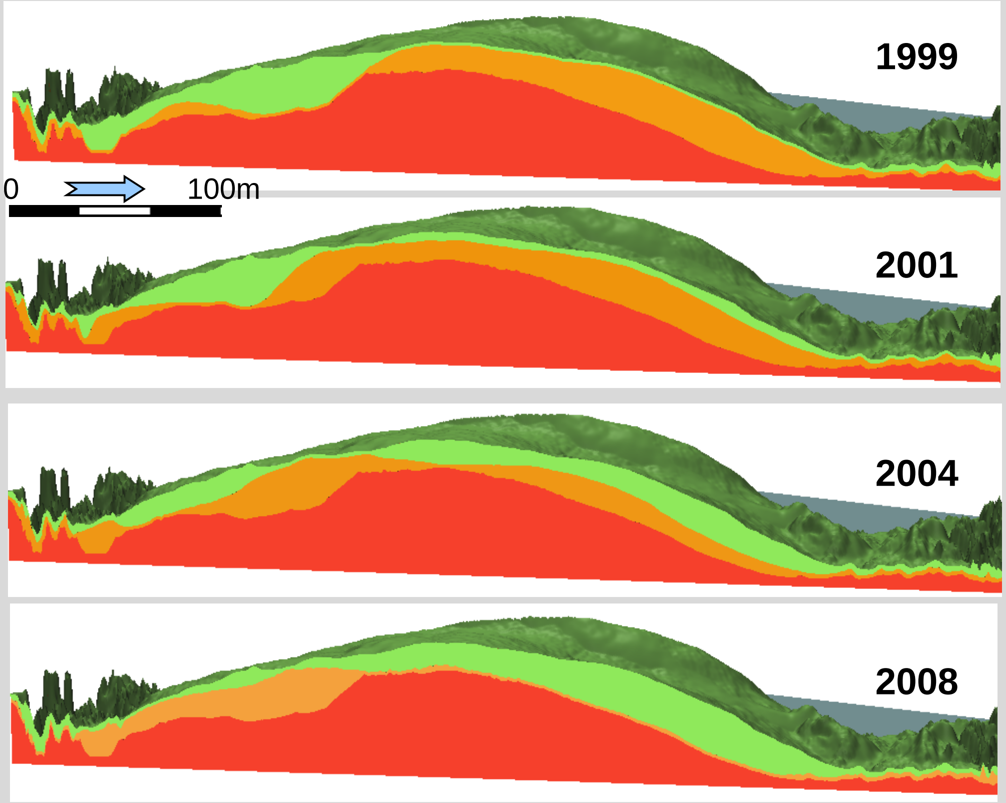
Raster-based analysis: dune

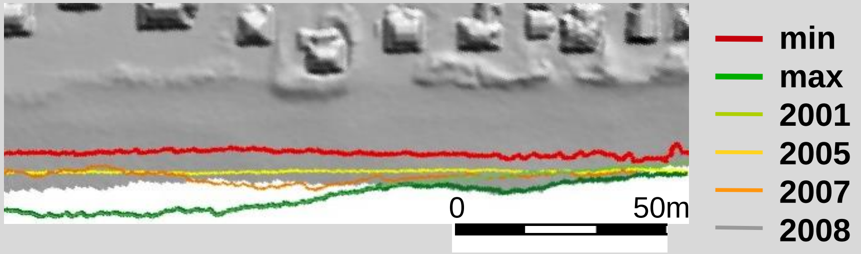


Orthophoto and shoreline band

Time of maximum

core, envelope, DEM





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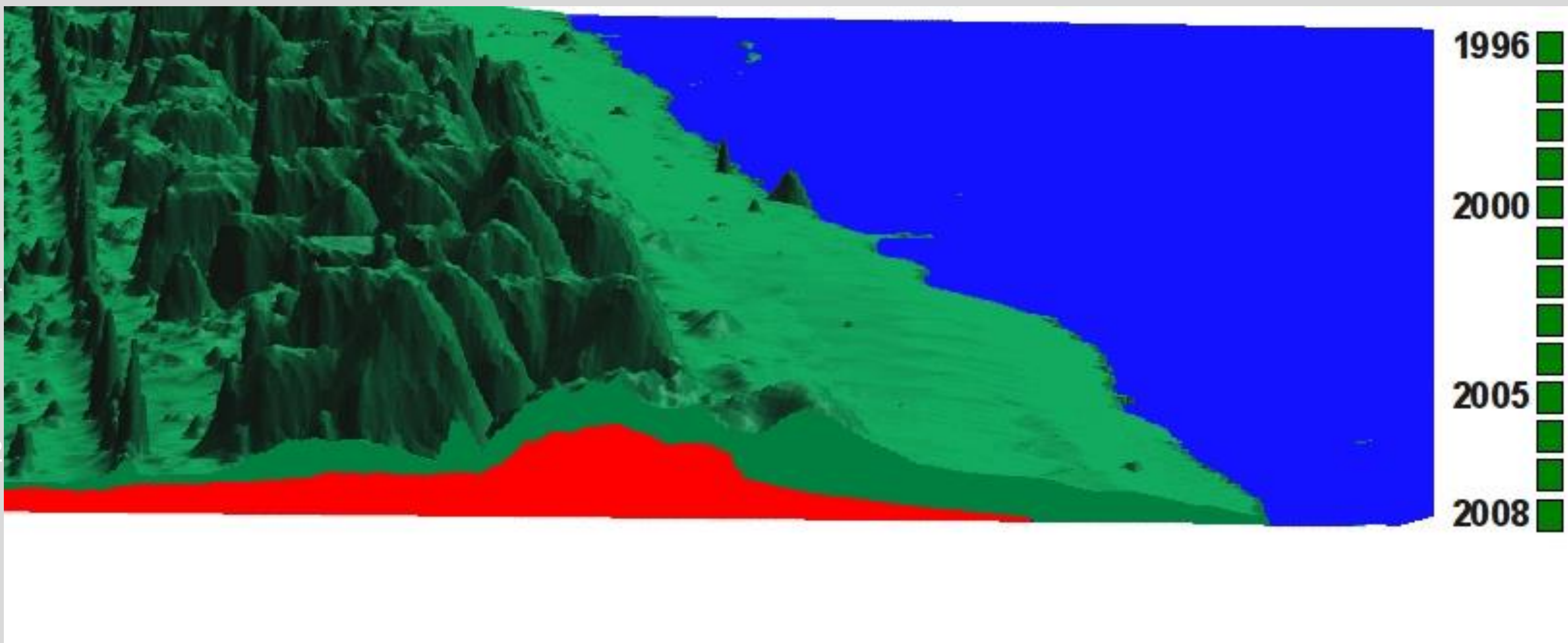
Raster-based analysis: beach

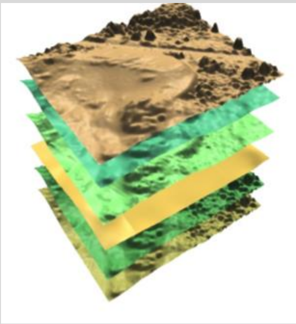
Core surface z-min for each cell
Envelope surface z-max for each cell
Dynamic layer: bounds terrain evolution



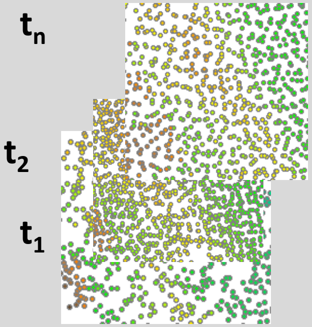
animation by Eric Hardin

Terrain evolution in space-time cube

How did terrain evolve at a given elevation?
How does evolution pattern change with elevation?



stack 2D rasters

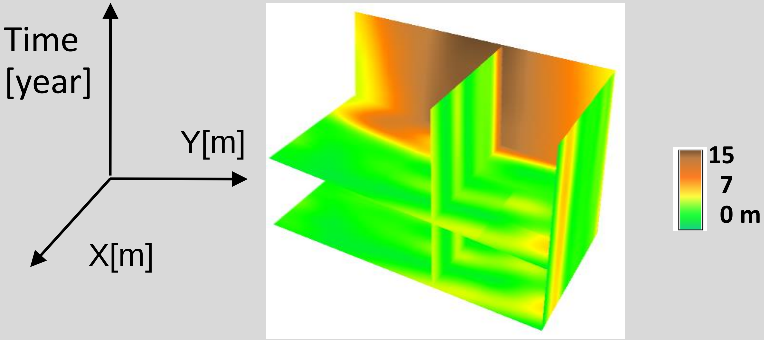


interpolate point clouds

Create space-time voxel model

$z=f(x,y,t)$

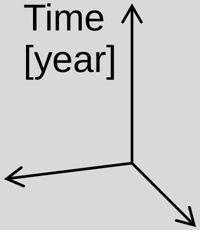
- stack time series of DEMs
- interpolate time series of (x,y,z) point clouds using trivariate spline

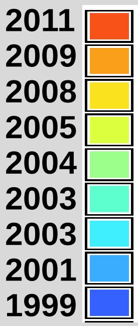


Shoreline evolution at Rodanthe

New representation as isosurface using Space-Time Cube concept

z=0.5m, colored by year





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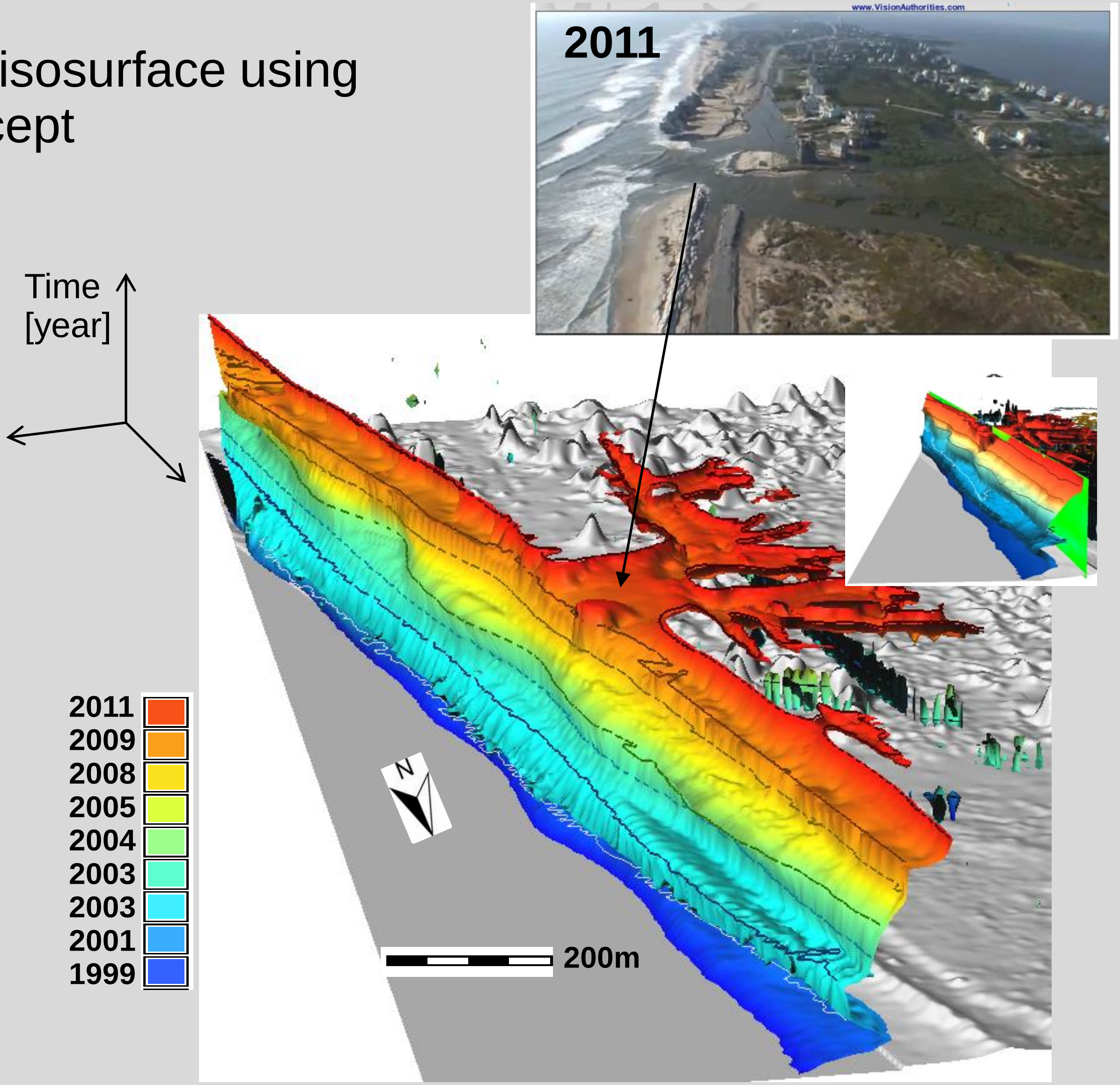

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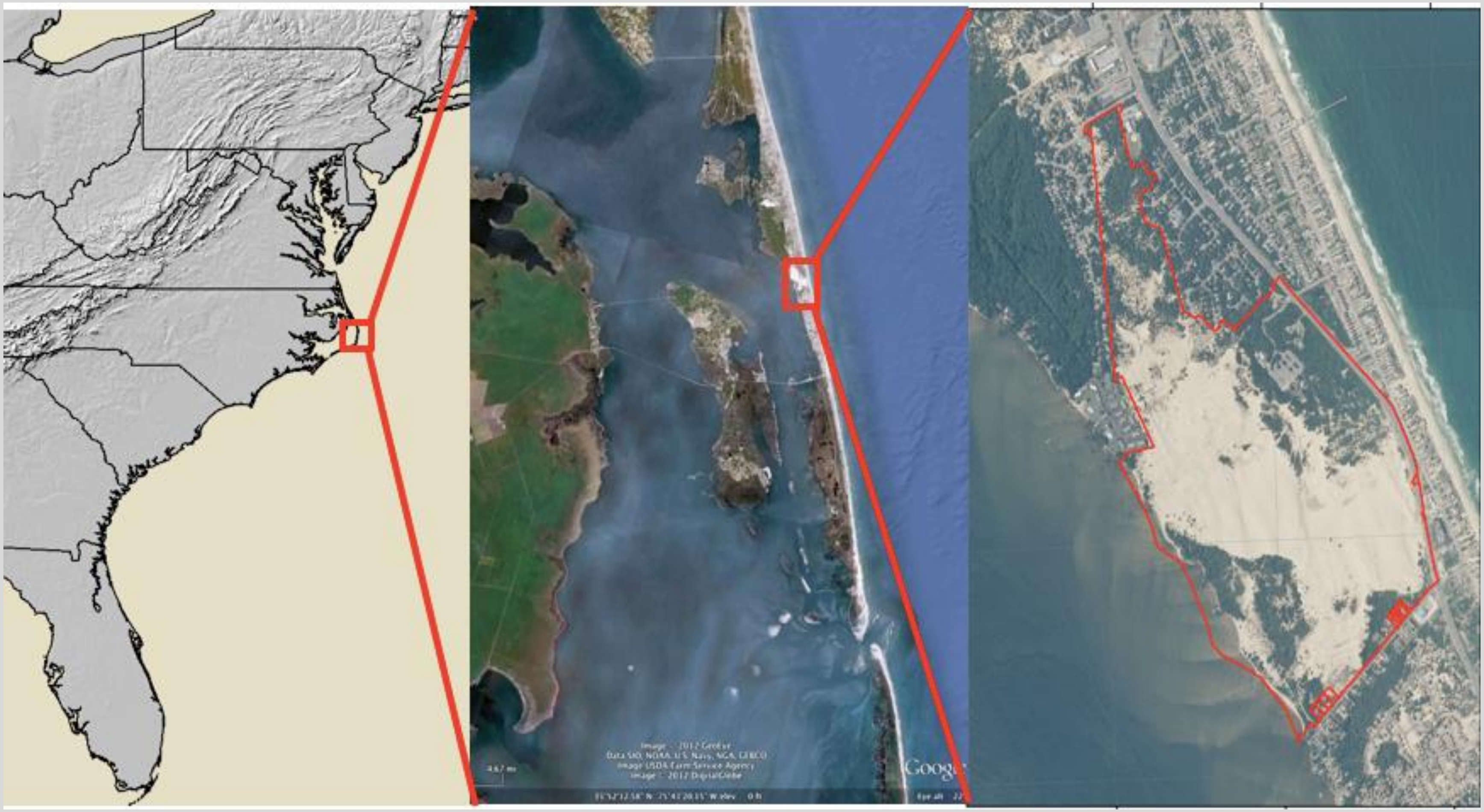
Jockey's Ridge state park



largest active sand dune field on the east coast

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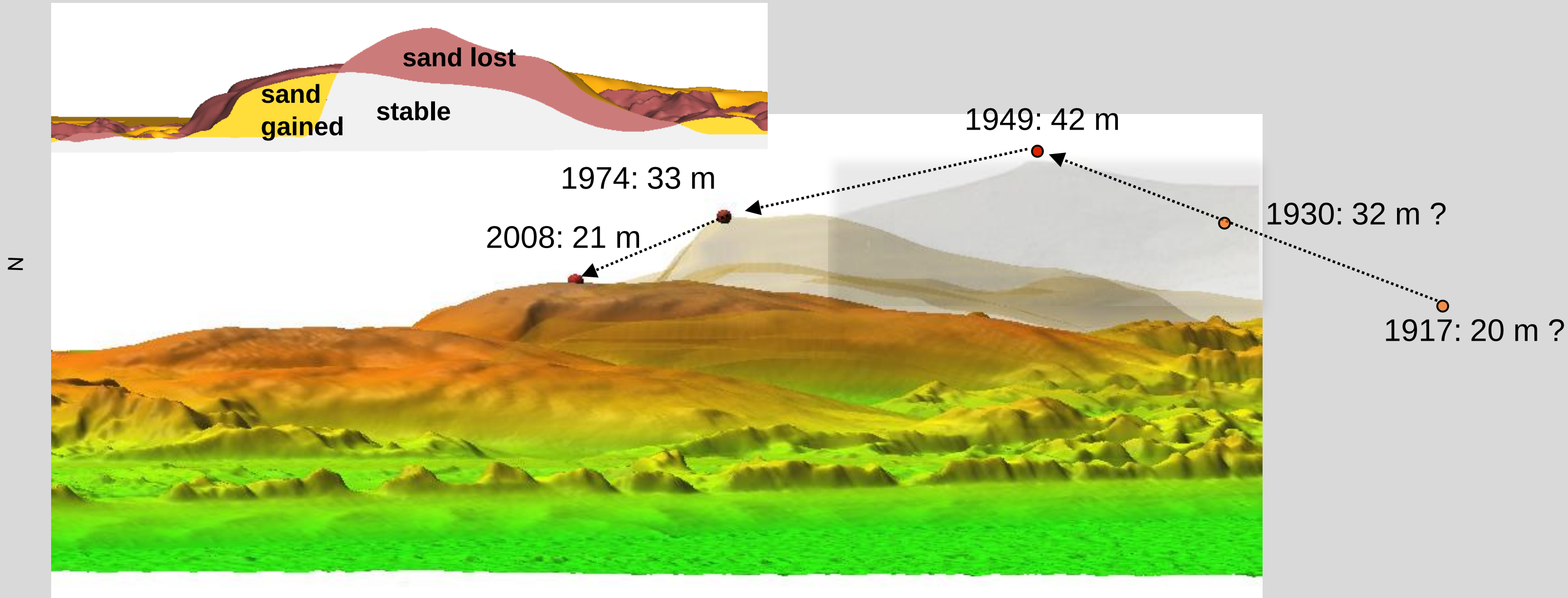
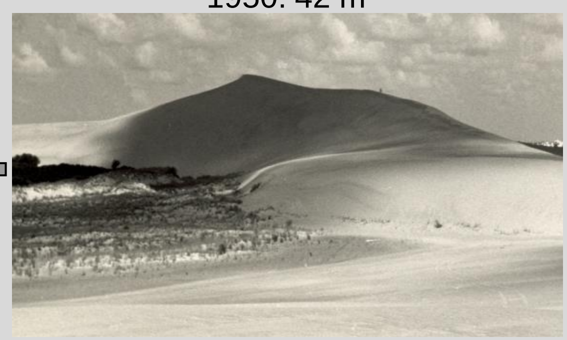
Jockey's Ridge dune evolution

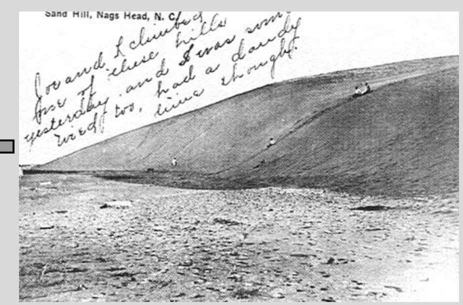


2008: 21 m

1950: 42 m



1917 20 m ?



High active dune: result of bad land management?

Landscape going back to its more stable form

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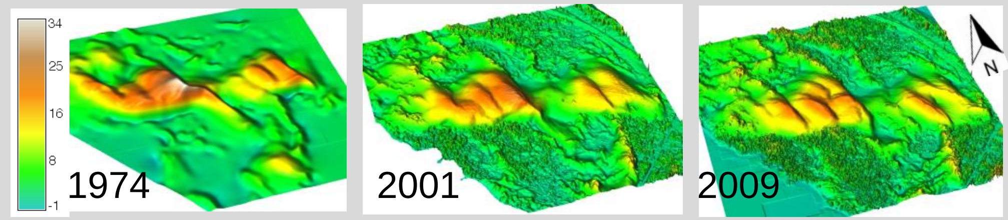
Space-Time terrain voxel model

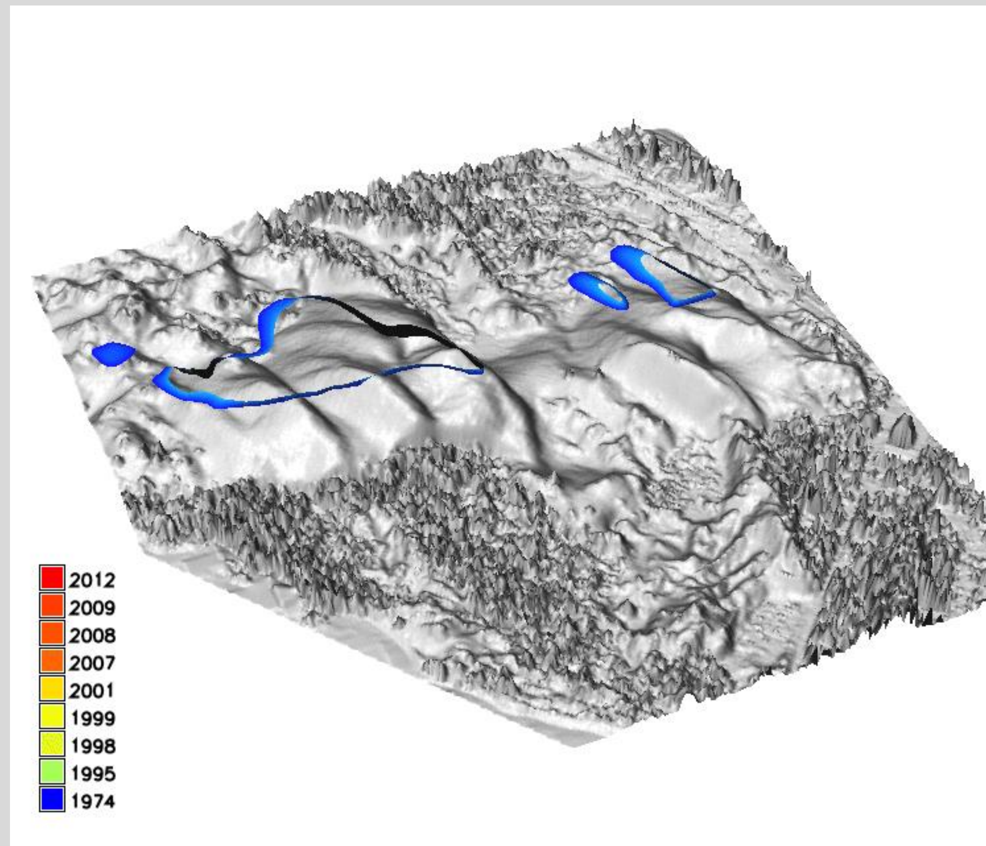
Stacked time series of DEMs or interpolated time series of point clouds

Evolution along a contour: represented by isosurface

When, where and at what elevation landform transformation occurred?

Jockey's Ridge
18m contour 1974-2012: splitting of coalescent crescentic dunes into parabolic dunes around 1998-99





500m

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Space-Time terrain voxel model

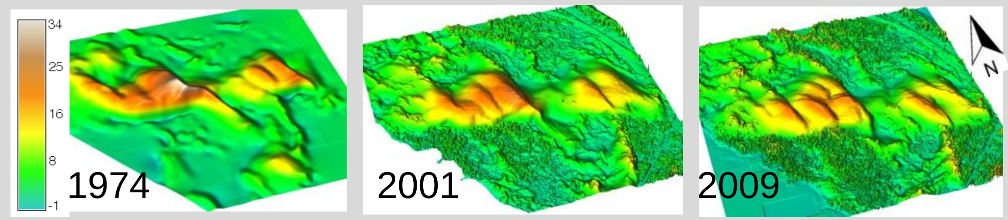
Stacked time series of DEMs or interpolated time series of point clouds

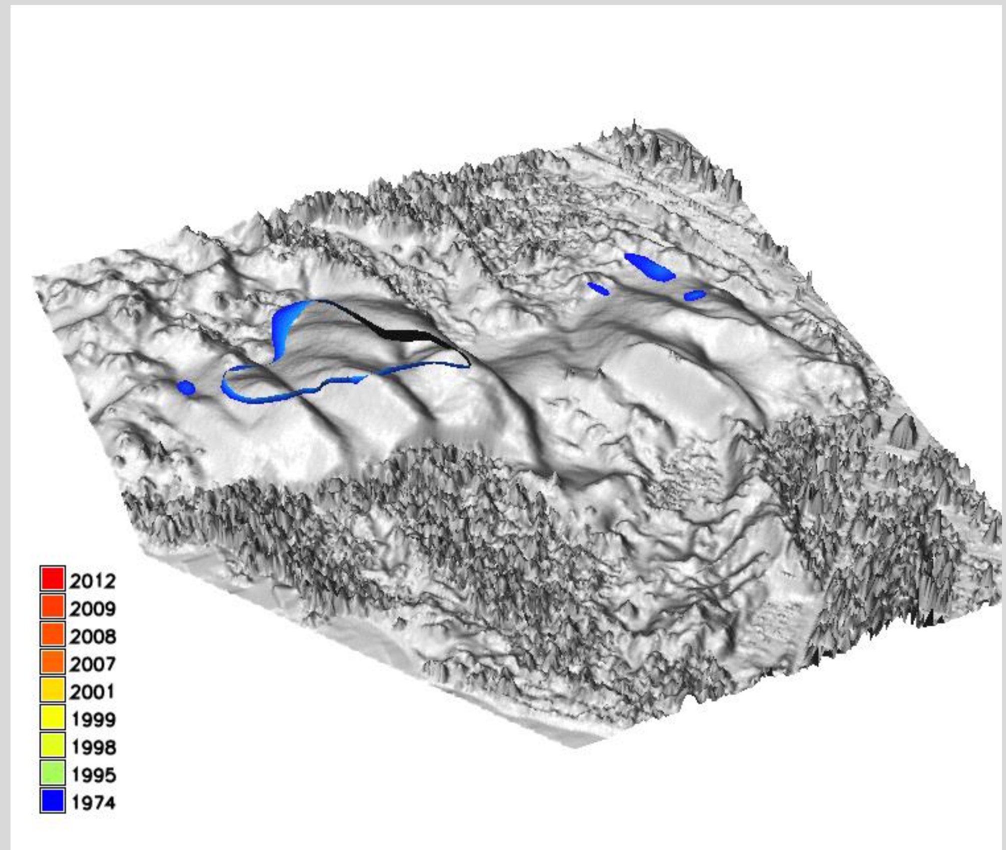
Evolution along a contour: represented by isosurface

When, where and at what elevation landform transformation occurred?

Jockey's Ridge
20 m contour 1974-2012:

loss and gain of elevation





500m

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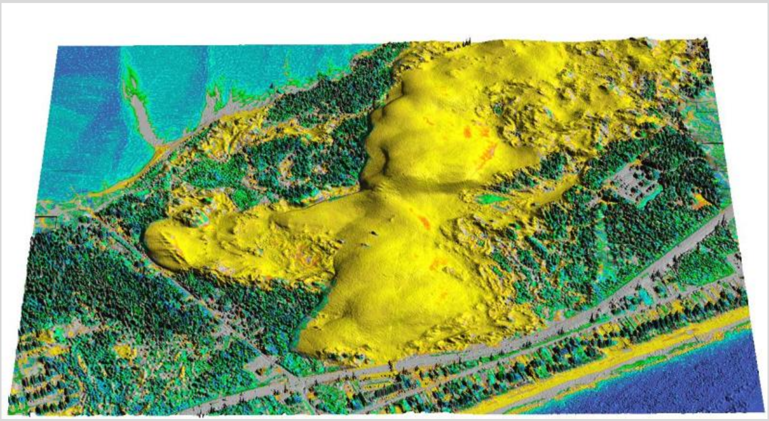
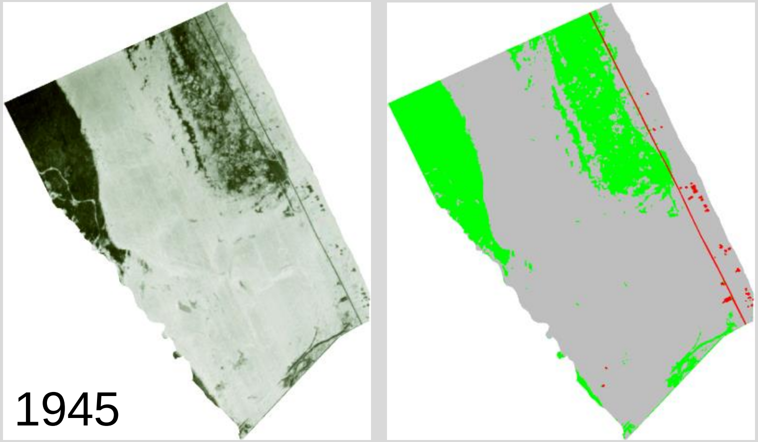
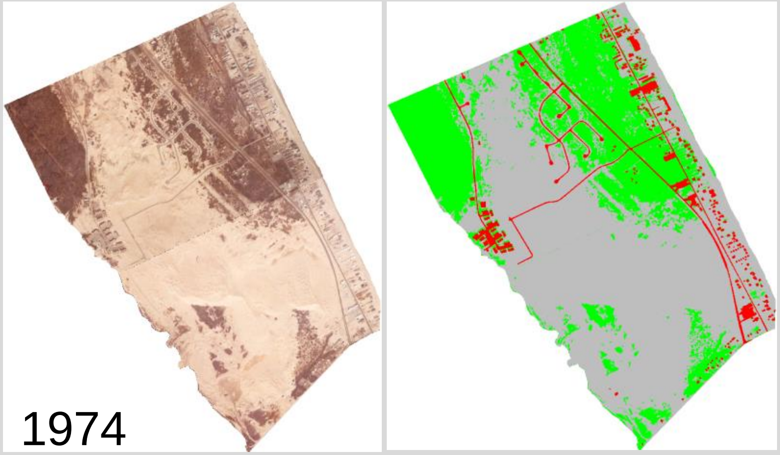
Nags Head change in land cover



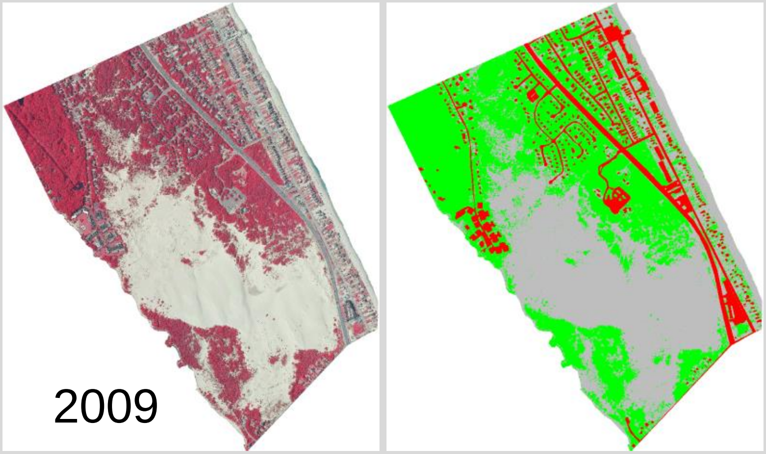
1999



74% sand 25% vegetated 1% developed



64% sand 31% vegetated 5% developed



46% sand 42% vegetated 11% developed

Analysis and figures: Katie Weaver

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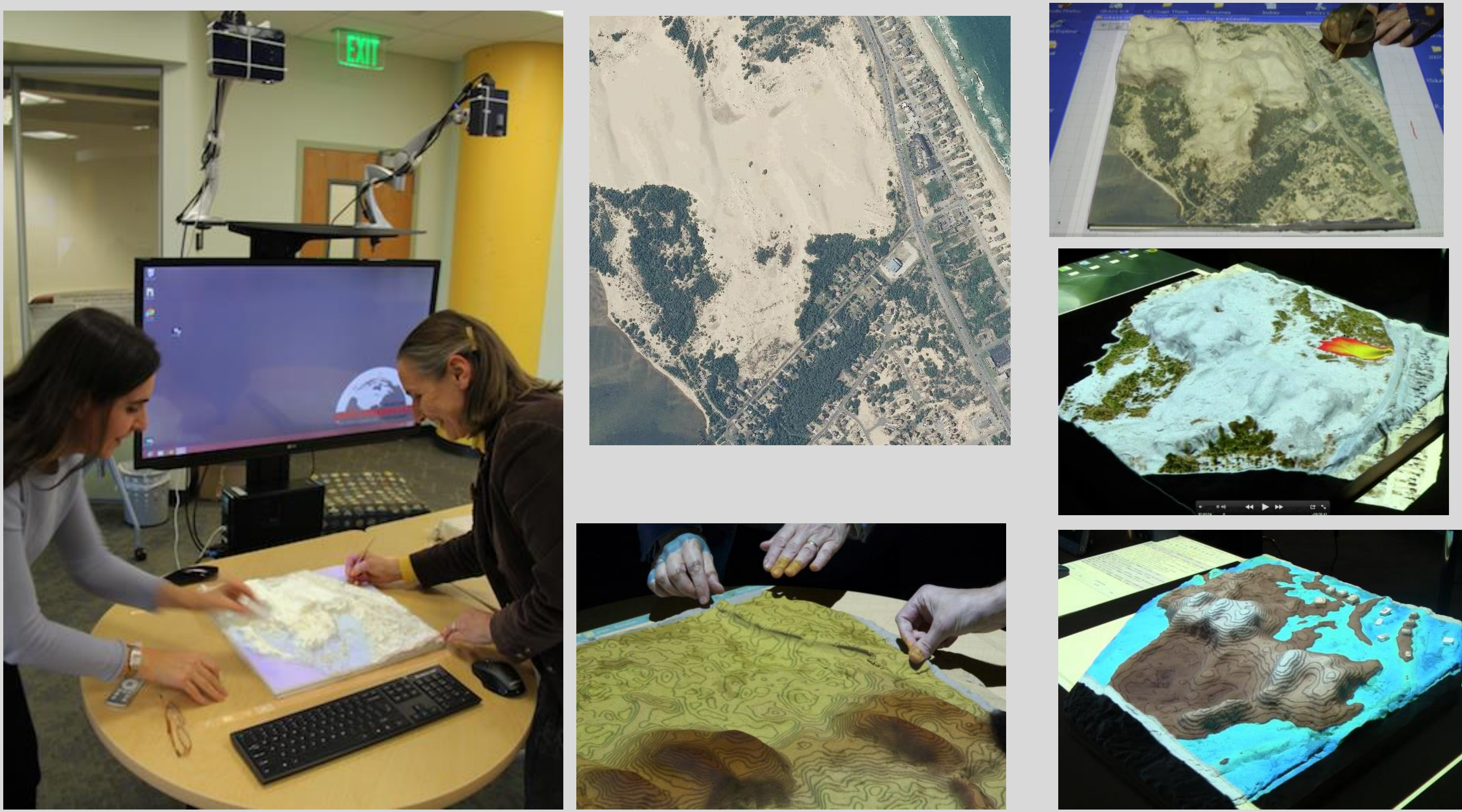
Tangible Geospatial Modeling System



Snapshots from dynamic simulations of inundation and fire spread

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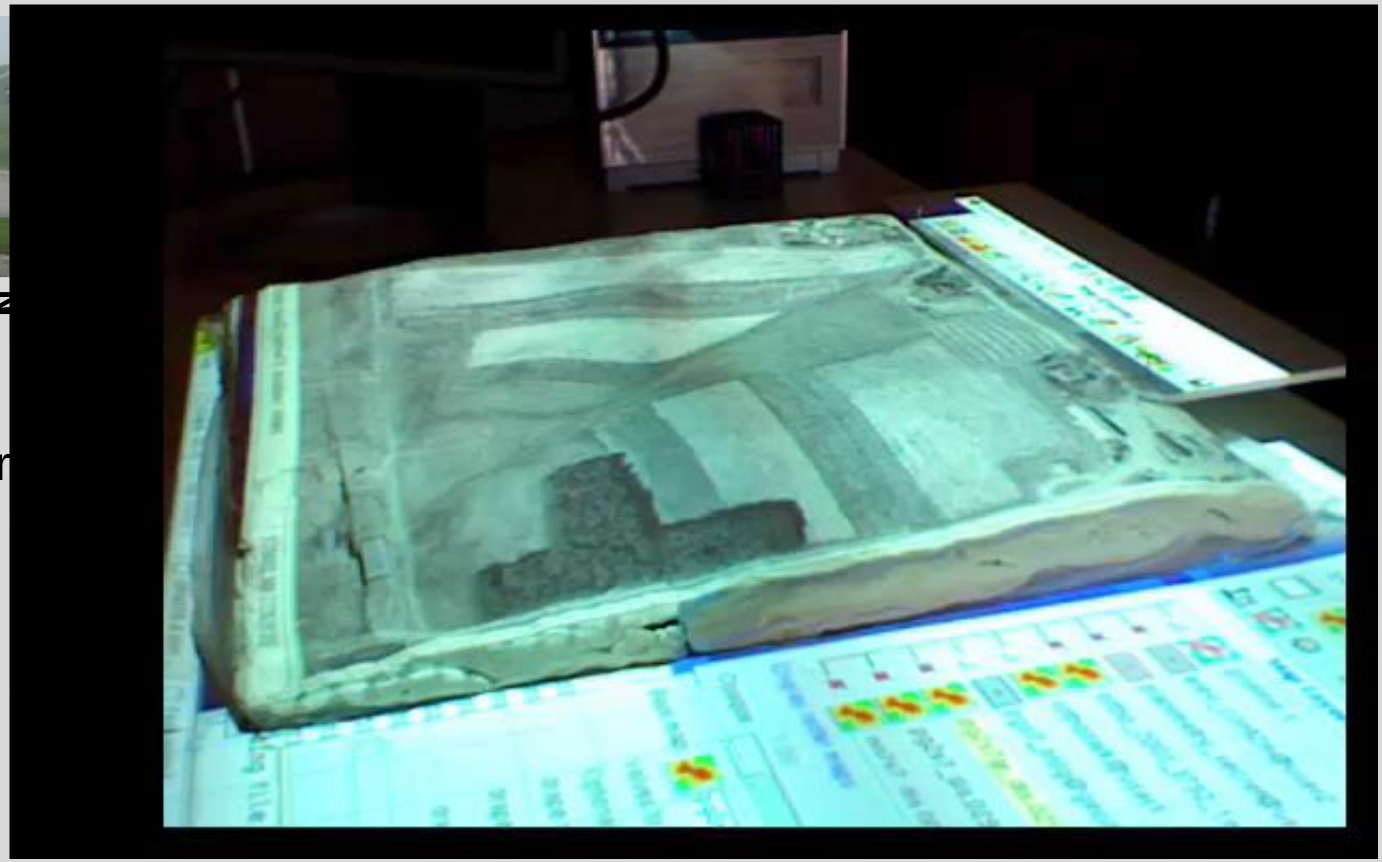
Tangible Geospatial Modeling System

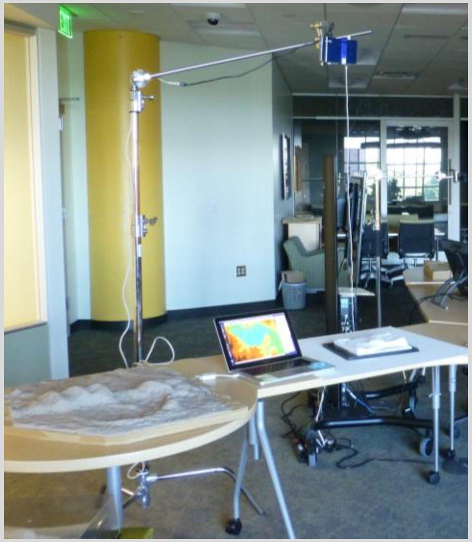
http://skagit.meas.ncsu.edu/~helena/wrriwork/tangis/tg1bak2_ed4_1min640.mov

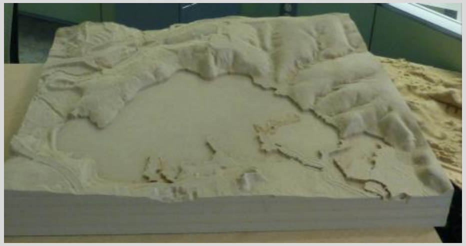


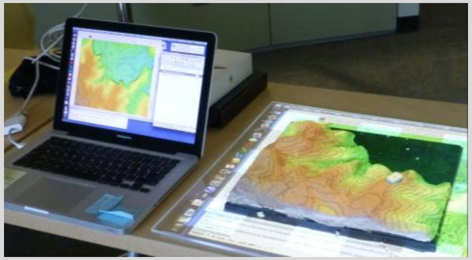
2009 version
with laser scanner

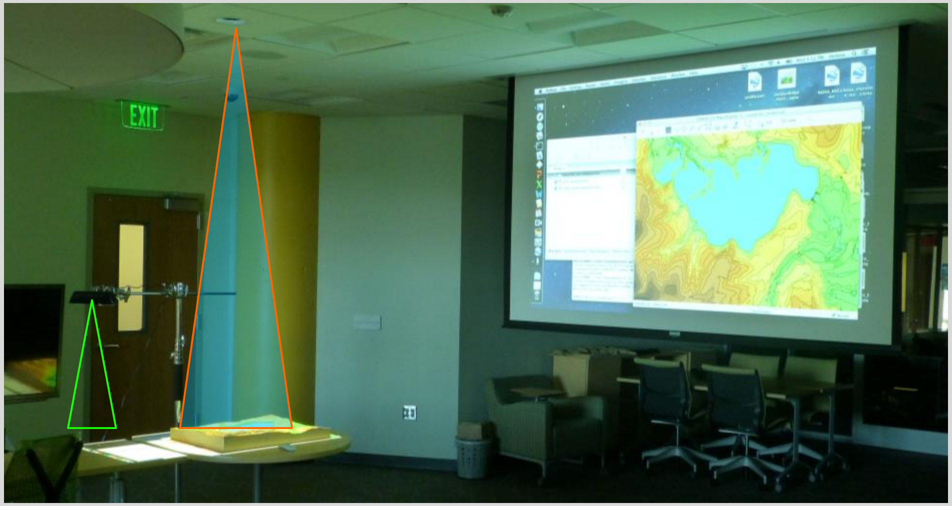
TanGeoMS current set up

- $40,000 heavy laser scanner replaced by light $150 Kinect
- projector(s)
- printed, carved, sand molded models
- smaller, more flexible, MUCH cheaper
- personal and group set-up
- coupled with GRASS GIS









Conclusions

Education

- continue integrating open source approach into courses,
- provide all material free on-line, keep it up to date

Research

- new time series modules in GRASS7 support analysis and visualization of 3D monitoring data and dynamic simulations
- multidimensional framework provides comprehensive metrics for quantification and visualization of 3D landscape change
- new scanners and 3D printers offer cheaper, more flexible and portable TanGeoMS solution for investigation and communication of topographic change impacts on landscape processes

Conclusions: ideas for future

OSGeo educator wiki page: pool of faculty who could serve on student BS, MS, PhD committees or as advisors - similar to OSGeo advocate wiki: http://wiki.osgeo.org/wiki/OSGeo_Advocate

OSGeo graduate student wiki: student exchange, Research Assistant positions

Community sprints: participate, organize, send students (CTU Prague GRASS code sprints)

Google Summer of Code: 10th year, co-mentor students

OSGeo REL network: expand in NA

Funding for FOSS4G academic infrastructure

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The presented research was performed at the NCSU OSGeo Research and Education Laboratory

http://gis.ncsu.edu/osgeorel/

the lead North American node of worldwide OSGeo network

http://www.geoforall.org/

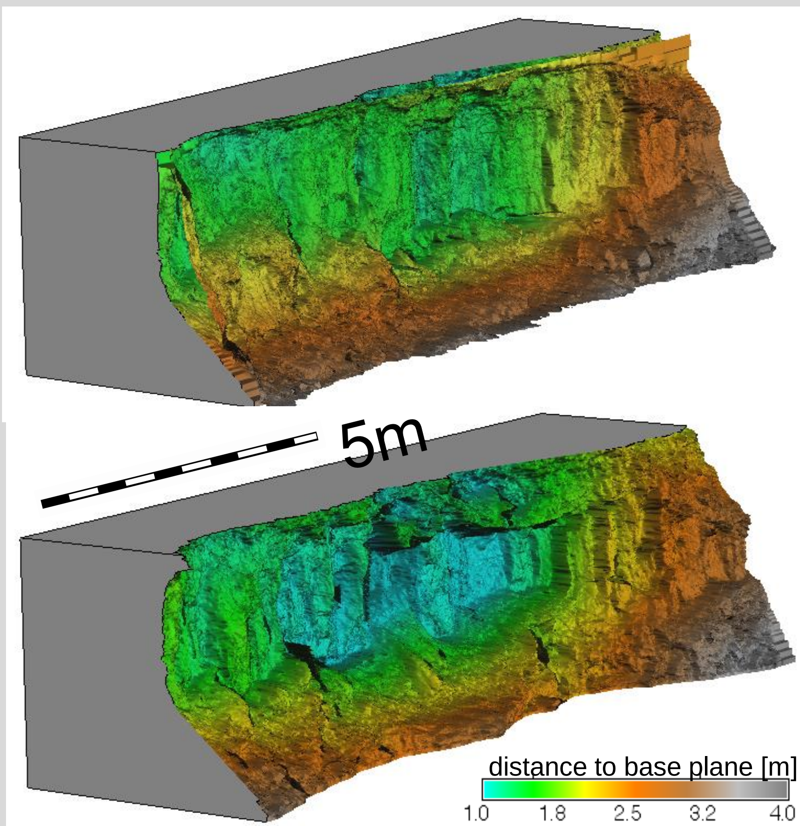
GRASS GIS

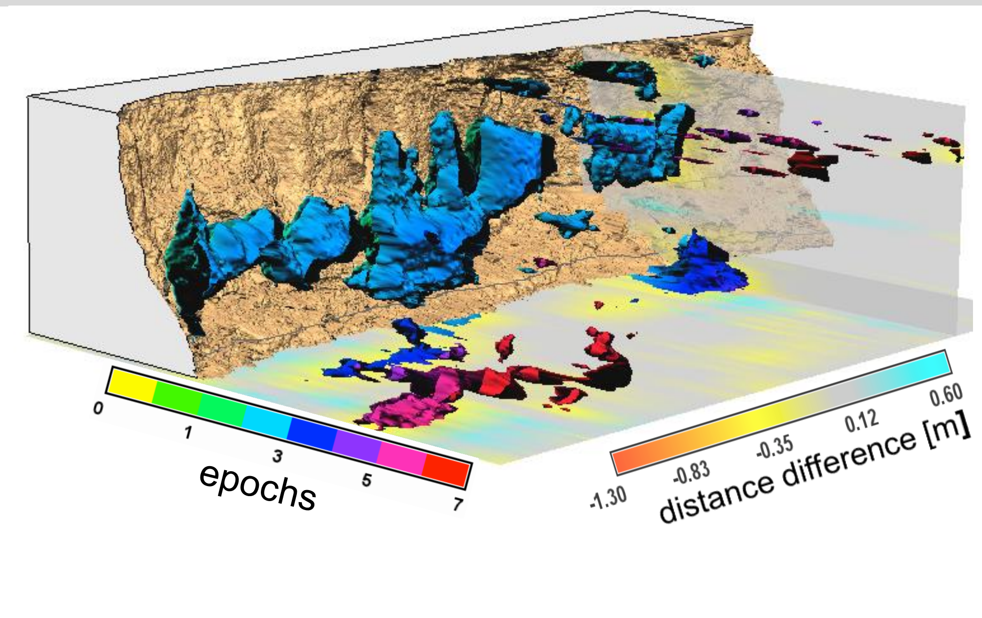
Monitoring eroding stream bank

Where and when was the change between two surveys greater than 0.5m and what was its pattern?

Isosurfaces of change > 0.5 m

First and last scan of 9 total





Dr. M. Starek, N. Lyons, K. Cepero, Dr. Wegmann
legacy sediment from old millpond, in farmland turned to state park
monitoring by Leica Scan terrestrial scanner – 8 epochs 2010 – 2012, 1cm res DEM

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