Fall 2013 NC State Rolls Out its “New” Logo
Some prefer NC as “Pirate Nation!”

Pirates 42  NCSU 28  Final
Climate Change and Coastal Resources

- Climate change amplified SLRise will reduce beaches
- Selected fishing access
- Uncertain impacts on fisheries and estuaries
- Ecosystem goods and services
- Potential future resource conflicts
Adaptation of Natural Hydrologic Regimes

• Adaptation/management strategy
• Installation of water control structures equipped with flashboard risers and tide gates at strategic locations.
• Preserving carbon reservoir in peatlands also forestalls additional climate change

Courtesy TNC
Coastal Agriculture and Forestry

• Hurricane frequency and intensity increase agricultural damage

• Timber damage will increase
  ~ $1B damage per storm event increase Cat 2 to 3

• Additional potential increases in drought, pathogens, and wildfire

<table>
<thead>
<tr>
<th>Storm Category</th>
<th>NC Statewide Totals (2004 $’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Storm</td>
<td>$53,695,368</td>
</tr>
<tr>
<td>Category 1</td>
<td>$32,878,317</td>
</tr>
<tr>
<td>Category 2</td>
<td>$208,558,508</td>
</tr>
<tr>
<td>Category 3</td>
<td>$837,822,329</td>
</tr>
</tbody>
</table>

1996-2006 Bin et al. (2008)
Coastal Energy Development

- Fossil fuels
- Wind farms
- Potential biofuels, tides, currents, & waves
- Value of carbon reservoirs and ecosystem services

ECU-AppState Wind Energy Recreation Survey
A FOCUS ON COASTAL HAZARDS

- Geomorphology and shoreline change
- Geovisualization of hurricane hazards
- Low-relief coastal terrain

- ...and the NC Coastal Atlas
Hatteras Island after Isabel 2003
Sea Level Rise
Analyzing Sea-Level Rise Morphodynamics Using 3D Geospatial Techniques
Cape Henry, Virginia

Tom Allen¹
George Oertel²

¹Department of Geography
East Carolina University
Greenville, NC
²Department of Ocean, Earth, and Atmospheric Sciences
Old Dominion University
Norfolk, VA
Virginia Beach Coastal Compartment

Antecedent headland and shoreface
184 ridges

CHESAPEAKE BAY

ATLANTIC OCEAN

DIAMOND SPRINGS SCARP

Mainland-associated ridges on terraces
Conceptual Model of Cuspate Foreland Transgressive Progradation

• Morphostatic vs. morphodynamic

• **Morphodynamic**- topography interacts with fluid dynamic processes including the transport of sediment
  • Shoreface, antecedent, ephemeral, modern
  • Nonlinear, +/- feedbacks, thresholds
Data

- LiDAR
  - NOAA IOCM LiDAR March 2008, NOAA NGS
  - City LiDAR and photogrammetric spot heights (2004, 2ft)
- Bathymetry
  - NOAA T-Sheets and Coastal Relief Model bathy
  - RTK GPS 2004-06 (swale depths)
  - USGS 1:24,000 DLG points and isobaths
- Datum transformations
  - VDATUM
  - WGS 1984, NGVD-NAVD 1988 orthometric heights
  - UTM coordinate system, NAD83, zone 18
  - ALDPAT LiDAR software

Spatial Analysis

- Surface elevation points to TINs
- Spatial interpolation
- Shoreface digitization and surface generation
  - Isobath and contour digitizing
  - Datum adjustment
  - Shoreface TIN
- Beach ridge, transect, and volumetric analysis
  - Cut and fill
  - Ridge and set volumes
  - Specific morphometry, circular statistics
- Rise and erosion rates
- Antecedent headland extrapolation
Surface Modeling
Shoreface and Subaerial Cape Topo

(a)

(b)

(c)

(d)
Spatial Dynamics and Sediment Transport

First-order volume of the eroded paleoshoreface

Headland width \( (w) = \frac{v}{l \times d} \)

\[ 493 \times 10^6 \text{m}^3 \times \frac{v}{(12 \text{km} \times l) \times 12 \text{m} \times d} = 6 \text{km} \]

Shoreface slope \( 0.005 \) (to -12m isobath)
LiDAR filtering across beach ridges, dune ridge, and swale topography (set E1)

- ALDPAT: Adv. LiDAR Data Processing Analysis Tool
Local Elevation Threshold-Filtered LiDAR Profile

ETEW ALDPAT 1.0 (Zhang and Whitman 2005)
Geovisualization

Can visualization of storm surges and hurricanes improve risk communication?

Collaboration with Kinesiology, English Technical Communications, and Geography
HAZUS Scenario

A HAZUS-MH 100-year coastal flood depth grid produced using an imported LIDAR DEM. The depth grid is underlain by Digital Orthophotos (DOQQ) of Kitty Hawk, NC. Uses NED.
Legacy SLOSH maps vs. Downscaled SLOSH and LiDAR DEMs

NC OneMap Contoured MOMs (ca. 1993)  
Downscaled NHC SLOSH model output

USGS 1:24k NED DEM  
5ft contour!

NC Floodplain Mapping LiDAR DEM  
10m pixels (+/-15cm) and 1km SLOSH grid
ADCIRC Interpolation

Convert ADCIRC nodes from MSL to NAVD88 (~10cm)*

ADCIRC Interpolation alternatives (IDW, Kriging, Splining)

Solution file joined to grid point file  IDW Surface Interpolation

*For tidal datum conversions we use VDATUM and NGS NC spheroid for the outer coast. Luettich, Blanton and others’ impressive examples ADCIRC, NC-CERA, etc.
SLOSH Downscale Process

* Identifies areas of potential inundation. E.g., SLOSH – DEM = -X = Inundated
SLOSH – DEM = +X = Non-Inundated

* Constrains inundation to *hydro-connected* areas. Water starts from the source and spreads in areas designated (SLOSH-DEM reclass value) of 0, else a penalty value is accumulated)

* 1 = Inundated; 2 = Non Inundated
Comparison

92.7% agreement
Dare County, NC

Legacy data
New downscaled
Agreement

8% disagreement
= errors of omission
4:1 in legacy data
LiDAR DEMs and Perspective Animations
Cape Hatteras Storm Surge Simulation (QT Modeler)
Photorealism influences salience and response? Gigapixel Imagery and CGI Wind Turbines

Jennette’s Pier Site, Nags Head

Tom Allen, Nick Lee, Laurynas Gedminas (ECU) and Eric Knisley (RENCI/UNC)
WELCOME to RENCI@ECU's Inundation Animation Portal! Located here are a variety of animations created by Faculty, Students, and Staff at RENCI@ECU that attempt to provide a greater understanding of the devastating effects of storm surges related to extrem coastal storms and hurricanes.

Featured Animations:

**Chicamacomico**

Category 1 Storm Surge

**Cape Hatteras Light House**

Category 4 Storm Surge

Select Animation by Location

- Kitty Hawk
- Nags Head
- Oregon Inlet
- Chicamacomico
- Cape Hatteras

Select Animation by Data Type

- Google Earth (KMZ)
- Animation (WMV)
- Online GIS

Select Animation by Storm Intensity

- Category 1
- Category 2
- Category 3
- Category 4
- Category 5
Prototype 3D Google Earth and Sketchup Visualizations
Scholarship of Engagement: 
*Talk to people!*
Focus Sketchup Models & GoogleEarth 3D on Landmarks

- Landmarks highlight place-based, local knowledge
- Capture attention
- 3D acquisition and placement enhanced by digital globes and GoogleEarth community

With advice from Sandy Sanderson (Dare Co. EM) and Nancy White (CSI)
Cape Hatteras Lighthouse and lightkeepers house
Sam & Omie’s Restaurant
Whalebone Junction, Nags Head
SLOSH MOM Cat3 Fast-moving
Visualization to Communicate Uncertainty

1. Monte carlo simulation of potential inundation and DEM error propagation
2. An alternative to the National Hurricane Center’s “Cone of Uncertainty”
Monte Carlo Simulation of Potential Flood Inundation Extents (Cat3 SLOSH MOM, slow-moving storm)

- Individual simulations as different colors, extensive isolated areas of the center being inundated under only a few cases... Identifying critical flowpath and uncertainty in the lower portion of the DEM.
- Possible extrapolation to fuzzy zones or epsilon bands
Monte carlo output using variable hue and transparency
RISK COMMUNICATION
PROJECT BIOVIZ
Cartography, Biometrics, and Hurricane Risk Perception

• Multidisciplinary research effort
  – Geography (GIS/Cartography)
  – Kinesiology (Visual motor research lab)
  – English (Risk communications)

• Cone of Uncertainty
• Alternative map design
• Storm surge visualizations
• Evacuation decision-making
• Eye-tracking and biometrics

2012 Geography thesis by Laurynas Gedminas
PROJECT BIOVIZ

- Eyetracking (fixations)
- Brain activity (EEG)
- Heart rate (ECG)
- Skin response (EDA)
- Facial movement (EMG)
- 34 subjects, split samples
- 30min session
- Post-session survey
"Cone of Uncertainty"
“Impact-based warning!”

TEST Alternative

“Cone of Uncertainty”
Biometrics

Increased Alpha Asymmetry

Left Frontal Dominance

Color Cone

$F(1, 496) = 3.724, p < .05$

Heat Map

NOAA TEST
Increases in Alpha represent decreases in the cortical activation. The red areas represent Alpha activity.* 
“Alpha power increases in right parietal cortex during focused internal attention.” (Benedek et al., 2014, Neuropsychologia.)

* Indicator of the depth or elaborateness of an ongoing mental process or imagination and indicator of a cognitive process.
Aggregate Fixation Density
Difference = TEST minus NOAA

Purples = more time in TEST than NOAA

Reds/yellows = more time in NOAA than TEST
What about stated preferences?

- Which map do you feel is easier to understand?
  TEST 70.5%
- Which map do you think is more attractive?
  TEST 85.2%
- Which map would you prefer to use?
  TEST 94.1%

Implications

- Clear preference and brain response for TEST graphic
- Plausible improvement and responsiveness, albeit small sample
- Cone fatigue
- Extensible to other warning graphics
Results

• Mixed bag of biometric results.
• Key difference was for brain activity showing left dominance and positive affect for TEST.
• No significant differences in risk communication, but TEST did not perform worse on survey questions.
• Clear preference for TEST over NOAA.
• Issue of small numbers
• Cone fatigue? Future storm surge work and extension to other warning graphics...
Low-Relief Coastal Terrain Analysis

Ultra low-relief landforms
Artificial ditches and canals

Global Average Temperature Vs. Number of Pirates

Aaargghhh!
Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System

Potential Inundation:
- Red: 0.4 meters (1.3 feet)
- Orange: 1.0 meters (3.3 feet)
- Yellow: 1.4 meters (4.6 feet)

Municipalities:
- Plymouth
- Manteo
- Washington
- New Bern
- Morehead City
- Ocracoke

Highways:
- US 158
- NC 17
- NC 63
- NC 70
- NC 45

Scale:
- 0 to 20 Miles
- 0 to 20 Kilometers
Salt Intrusion Via Extensive Ditch Networks

“Never let the salt of your tears be tasteless in grief.”
- Munia Khan

• Salt-poisoning of interior wetland vegetation.
• Rapid decomposition of peat soils by sulfate-reducing bacteria.
  • **Locally**: subsidence and increased inundation
  • **Globally**: release of previously sequestered carbon as carbon dioxide and methane.


Photos courtesy TNC
Hydro-conditioning Coastal LiDAR DEMs
LiDAR DEMs for Low Relief Coastal Applications

 Measurements
- Dedicated acquisition of airborne LiDAR for transportation corridors

 End-User Applications
- Improved runoff and flood inundation modeling
- Watershed and floodplain managers
- Environmental planners
- Stormwater engrs.

- Stormwater sub-basin delineations with ditches
- No ditches default
- agreement

Object feature extraction from LiDAR points and DOQs
Ditch depth vs. local relief

Original DEM | Ditches | Overlaid & Conditioned

Stormwater sub-basin delineations with ditches
No ditches default
agreement
GRASS r.flood simulation using 10m LiDAR DEM with and without hydro-conditioning

Moyock, NC
Multi-Hazard Risk Mapping & Symbology: Coastal Water Infrastructure Vulnerability to Storm Surges, Riverine Flooding, and Sea Level Rise
Multi-Hazard Coastal Vulnerability
C. Hatteras Natl. Seashore

- Shoreline change
- Storm surge inundation
- Sea level rise
- Focus on planning horizons for NPS landmarks
NC Coastal Atlas

www.nccoastalatlas.org

- A partnership created and led by ECU
- Atlas and data repository
- Thematic maps
- Decision support tools
- Coastal bibliography
Why a coastal web atlas for North Carolina?

- International Coastal Atlas Network
- ICAN has a long definition that says what a coastal web atlas should provide:

  “...collections of digital **maps** and **datasets** with supplementary tables, illustrations, and **information** that systematically **illustrate** the **coast**, oftentimes with cartographic and **decision support** tools, all of which are accessible via the **Internet**.”
What’s in the NC Coastal Atlas?

The Atlas can help with the following:

① Provide maps, data and information;
② In-depth on the coastal environment;
③ Visualization and analysis tools for decision-making and discovery;
④ Access and use maps in multiple ways (browser, GIS desktop, and mobile.)

But, a coastal web atlas is not the same thing to everybody!
The North Carolina Coastal Atlas

ArcGIS Server
- geoprocessing tools, WMS, KML/KMZ, data download.

Web Services
- geo-located bibliography, data catalog, social media integration, APIs.

Data Providers
- FEMA
- esri
- NC Division of Coastal Management
- Albemarle - Pamlico National Estuary Program
- ncOneMap
- and others

Scholarly Databases
- Mendeley

Citizen Science and Observation

East Carolina University
Joyner Library

Desktop GIS Managers, researchers, and GIS professionals

Mobile*
- on-the-go information access and submission

Visualizers
- property owners, educators and the interested public

Real-Time Information**
Thematic Maps

- Collection of GIS layers (data) that follow a certain theme or topic.

- Many existing thematic maps already on the Atlas.
  - Estuarine and Ocean Shorelines
  - Wetlands, Habitat and Threats
  - Flood Inundation Vulnerability
  - Dasymetric Population Mapping
  - Others

- Story maps can convey information by stepping the user through a sequential narrative.
Ocean & Estuarine Shorelines

Wetlands, Habitat and Threats

Flood Inundation Vulnerability

ECU Coastal Research
Dasymetric Population Mapping
Paddle Trails and Camping
Along the Roanoke River
Data Catalog

- Individual GIS layers that can be added to any map.

- The Data Catalog currently contains 100+ unique layers from 25+ different sources.

- Layers divided into 12 categories.
  - Historical (19)
  - Human Environment (16)
  - Imagery (16)
  - Environmental (12)
  - Plus 8 others

- New layers are being added on a weekly basis.

- Desktop GIS links are provided.
NC Division of Coastal Management
Estuarine Shoreline
Swipe Tool
Spotlight Tool
Address/POI Search
Distance Measurement
Place Name Searching

Search Results

1. Wright Brothers National Memorial
   Kill Devil Hills, North Carolina, USA

2. Wright Brothers National Memorial
   Kill Devil Hills, North Carolina, USA

3. Wright Brothers National Memorial Visitor Ce...
   Kill Devil Hills, North Carolina, USA
Flexible Map Output

- Export map contents to common file formats.
  - PDF
  - JPEG, PNG

- Settings for page size and orientation.

- Customize map title.

- Customize output resolution.

- Coastal planning and permitting.  
  *Do you see what I see?*  
  - Residents  
  - Contractors  
  - DCM and other officials

- Markup and review: ketch and annotation tools.

- Map sharing for accurate and efficient decisions.  
  - Coming this year!  
  - Share via social media or email.  
  - Per-map comments.
Geotagged Spatial Bibliography with curated list, spatial and topical searches, and full-text available*

* Some restrictions apply based on university affiliation
Socially Connected

Social media and local liaisons are key to attracting and maintaining contact between people, information, places.

- Atlas web visitors (since July 2014)
  - 4,200+ users (>900 returning)
  - 14,000 individual page views.
  - 500+ users per month (average)

- Twitter, Facebook (launched 10-15-2013)
  - Like us at facebook.com/NCCoastalAtlas
    ~200 likes (as of July, 2015)
  - Follow us @nccoastalatlas
    287 followers (as of July, 2015)
What’s Next?

We are working on a few features that should be available soon.

① Searchable online documentation and tutorial videos.

② Better support for tablets and smartphones including support for viewing and editing maps.

③ Save custom maps and continue working on them later, or collaborate with friends and colleagues.

④ Share maps by sending a link via email or social media.

⑤ Integration with ArcGIS Online to allow adding map layers from organizational accounts.
“Personas” from a user study guide redesign

- User experience (UX) expert Co-PI
- Guided tour based on user type.
- Walkthrough video/interactive help.
- Prioritization of UI elements based on most commonly used features.
**Aims:**
- Scientific and public access
- Sharing and curation
- Interactive and downloadable
Salinity Data in the Neuse River includes FerryMon
SalWise Database

- Collaboration between NC Coastal Atlas and UNC Institute of Marine Sciences.

- Compilation of water quality data from many state and federal sources.
  - Approx. 2M samples.
  - Salinity, temp. and other parameters.
  - Covers all of APES, entire NC coast.
  - New data constantly being added.

- Database will be available on NC Coastal Atlas as interactive, filterable map and clip-and-ship system.
Map will show SalWise data with filters for:
- Date and time
- Salinity, temperature values
- Collection program

Given high data density, easy option to cache prerendered tiles on the server, but that’s not user-centric.
- The map must also allow user-customizable symbologies.
- Too many permutations to cache them all!

ArcGIS Server is very slow with voluminous features, even with fast hardware!
- Perhaps not be the case in 10.4.
The solution was to create custom service based on tried-and-true open source technologies.
- NodeJS
- PostgreSQL, PostGIS

Vector tiles, MapBox style, not server-side rendered.

Instead of hard feature limit per tile, use occlusion culling based on location and user-specified sorting.
- Ensures even distribution in tiles with dense data.
- Location binning based on geohash tree; 9 chars. of precision, approx. ~5m cell size.

- One point selected from each bin to ensure high data density doesn’t exhaust feature limit.

- Selected point is from top of sorting stack.

- Method can also be used to aggregate points into clusters.
Questions? Feedback?

Please take a moment to ask any questions or provide any feedback that you may have.

Also, you may visit http://www.nccoastalatlas.org/contact-us to submit any comments, issues or feature requests.

Thank you!