

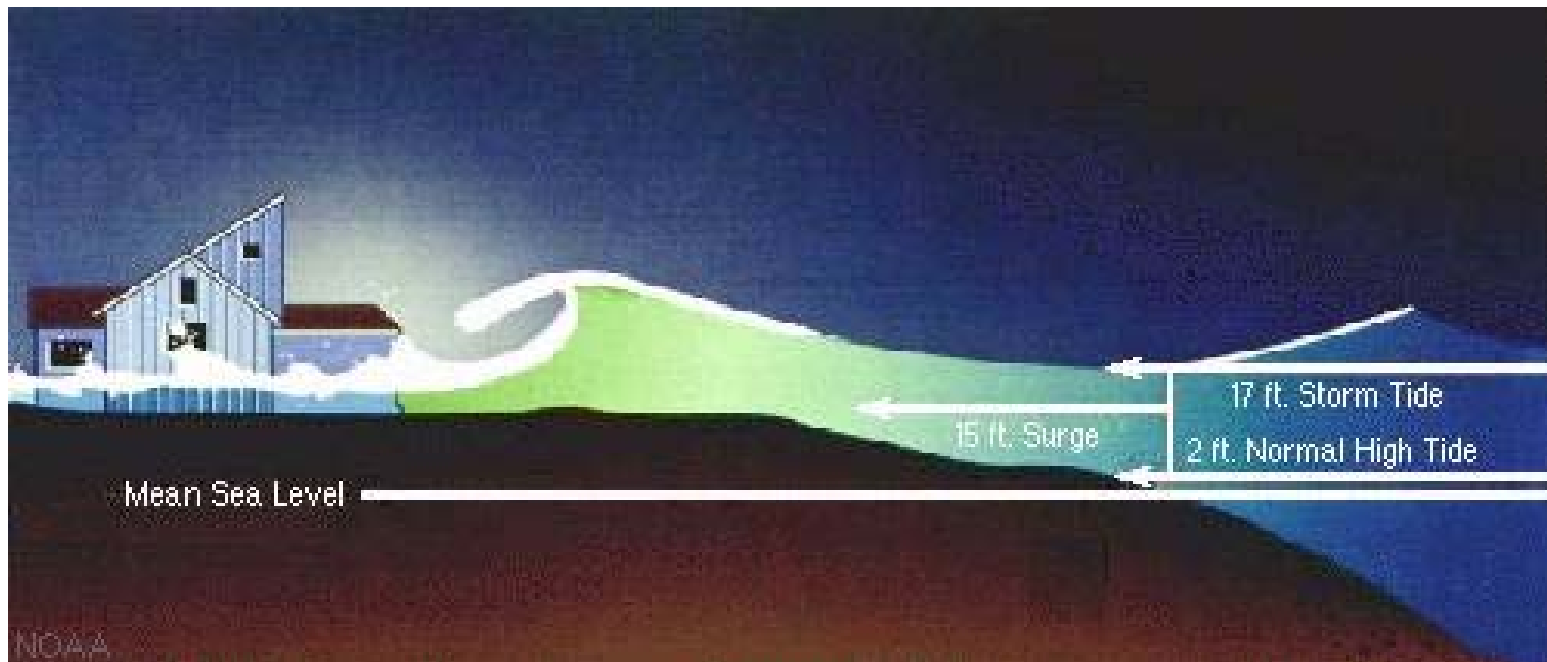
Improving Storm Surge Risk Awareness with Geovisualization



Thomas R. Allen
Department of Geography and
RENCI @ East Carolina University

Storm Surge

“An abnormal rise of water generated by a storm, over and above the predicted astronomical tide. For a hurricane the surge typically has a duration of several hours and affects about 100 miles of coastline”
Jelesnianski *et al.* (1992)



Source: National Hurricane Center – Hurricane Preparedness
http://www.nhc.noaa.gov/HAW2/english/storm_surge.shtml

Purpose

- Exploit advances in GIS and visualization for the communication of storm surge model forecasts.
- 3D, animated, and interactive visualization.
- Prototype products e.g.,
 - Online surge viz library
 - GoogleEarth 3D interactive maps
 - Products for hurricane exercises, education, and awareness

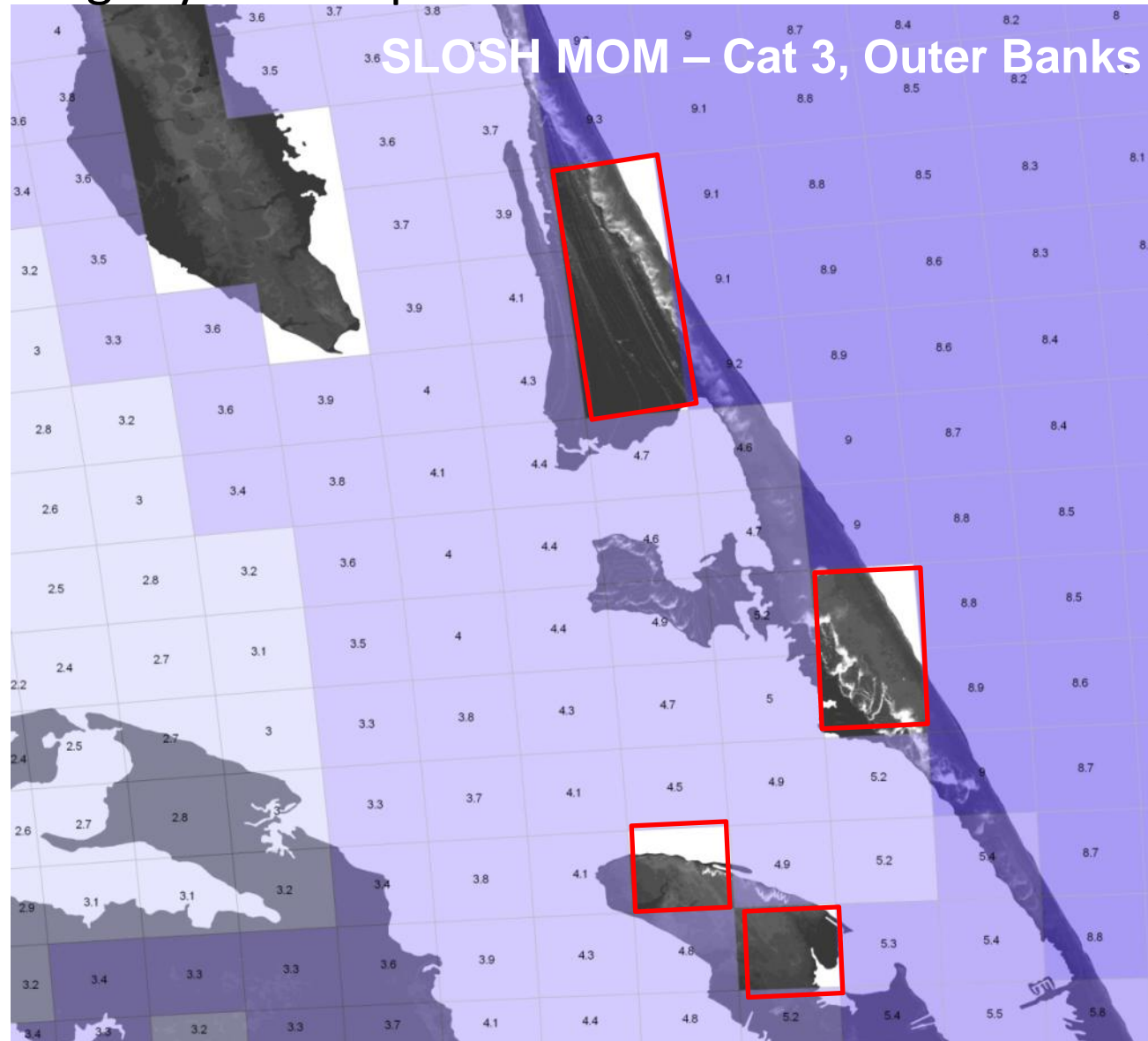
Pushing the Button...



- It is possible to downscale hydrodynamic models (e.g., SLOSH or ADCIRC) to finer spatial resolution.
 - + Coarse numerical grid scale can be improved by “careful” GIS post-processing
 - GIS enables powerful maps but also potentially cascading errors and miscommunication
- 3D, animated, and interactive cartography could improve analytic risk assessment and risk communication (vs. static maps.)
 - Engage map readers
 - Characterize dynamics and use multi-modal senses
 - Increase cognitive arousal
 - Meet user preferences for graphics

Why downscale? Location, location,

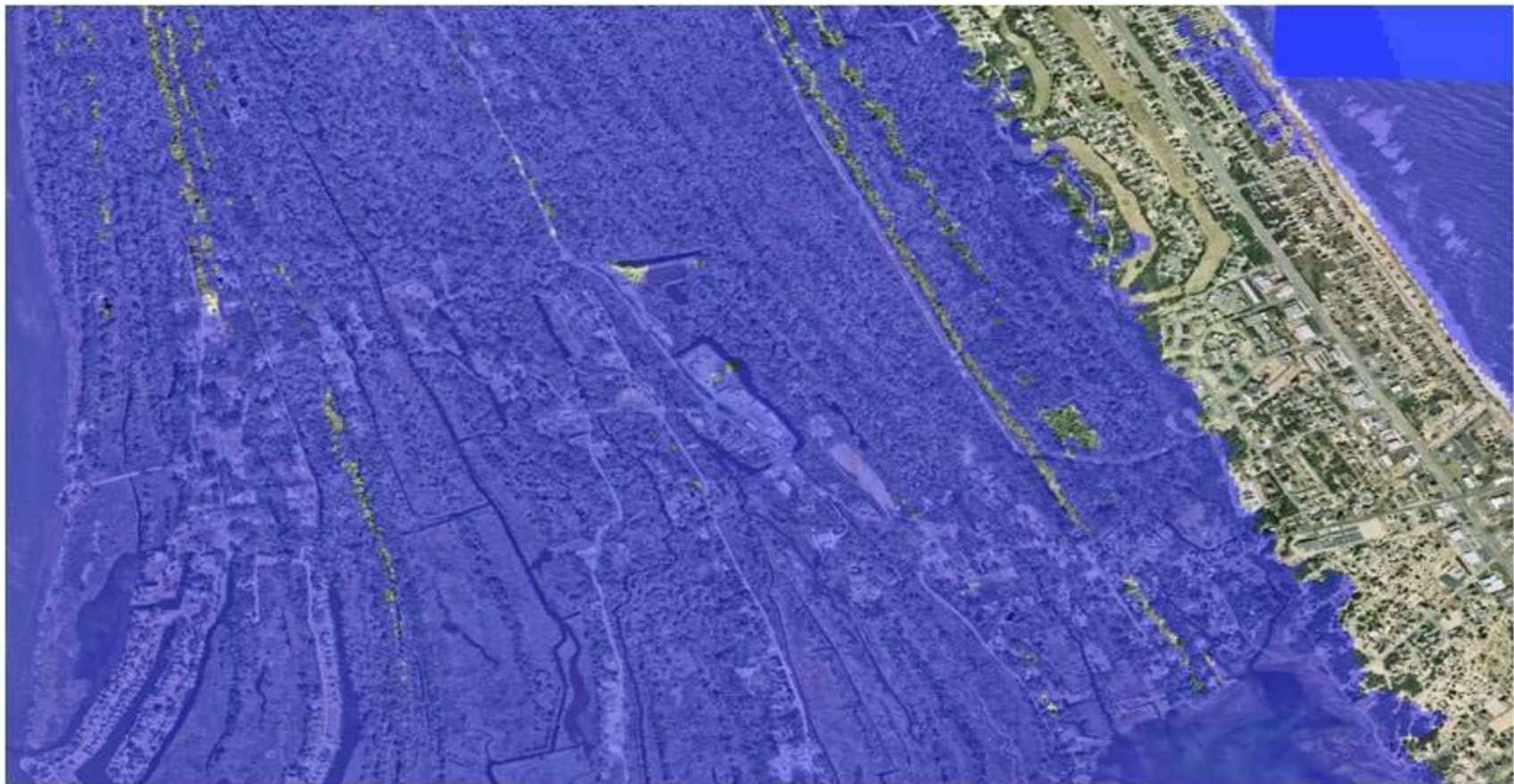
Inundation Ambiguity on Complex Shores- Raster and Vector GIS Worlds



HAZUS Simulation



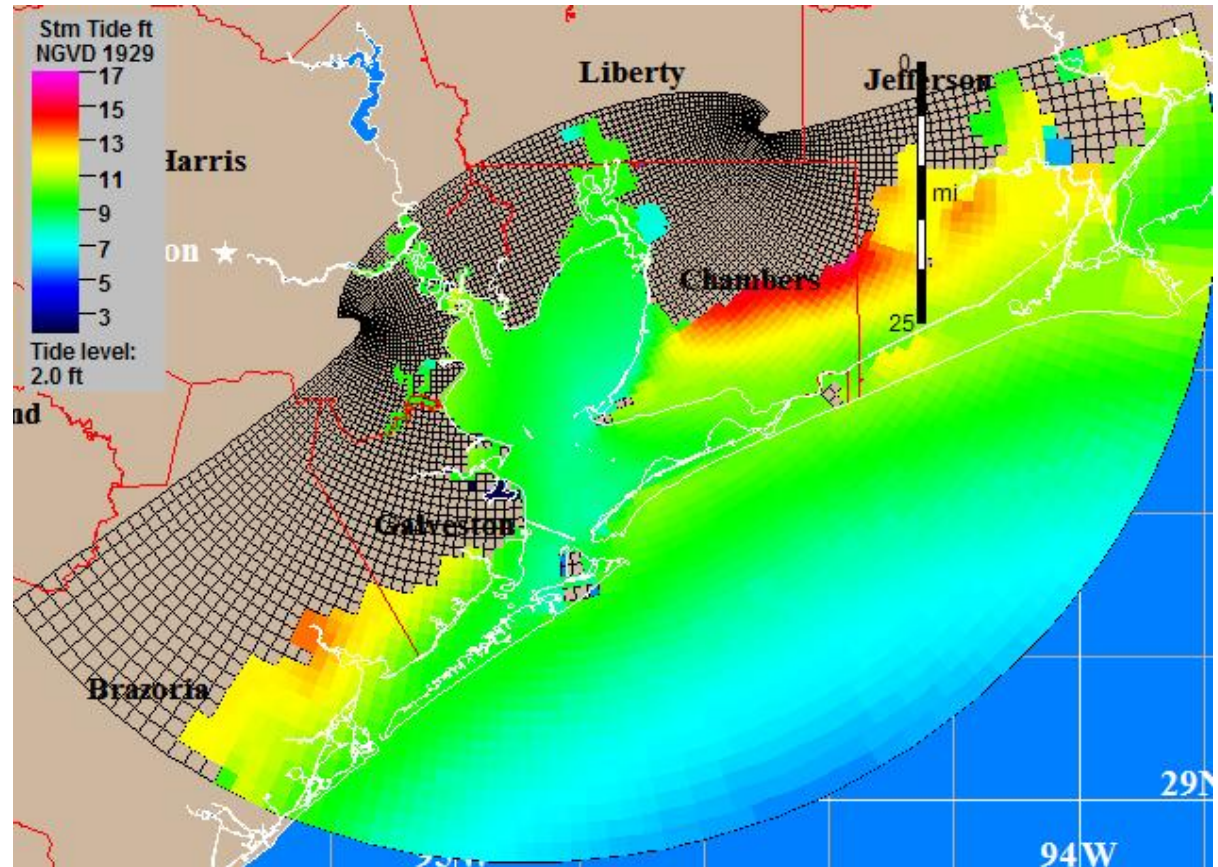
A HAZUS-MH 100-year coastal flood depth grid underlain by Digital Orthophotos (DOQQ) of Kitty Hawk, NC... LiDAR makes it better.



NC COHAZ team

SLOSH Model Maximum of Maximums (MOM) Cat 2

- Maximum Envelopes of Water (MEOW) files
- Difficulty of interpretation of probabilistic surge forecasts
- Maximum of MEOWs (MOMs)
- Common misnomer of direct surge association with Safir-Simpson scale

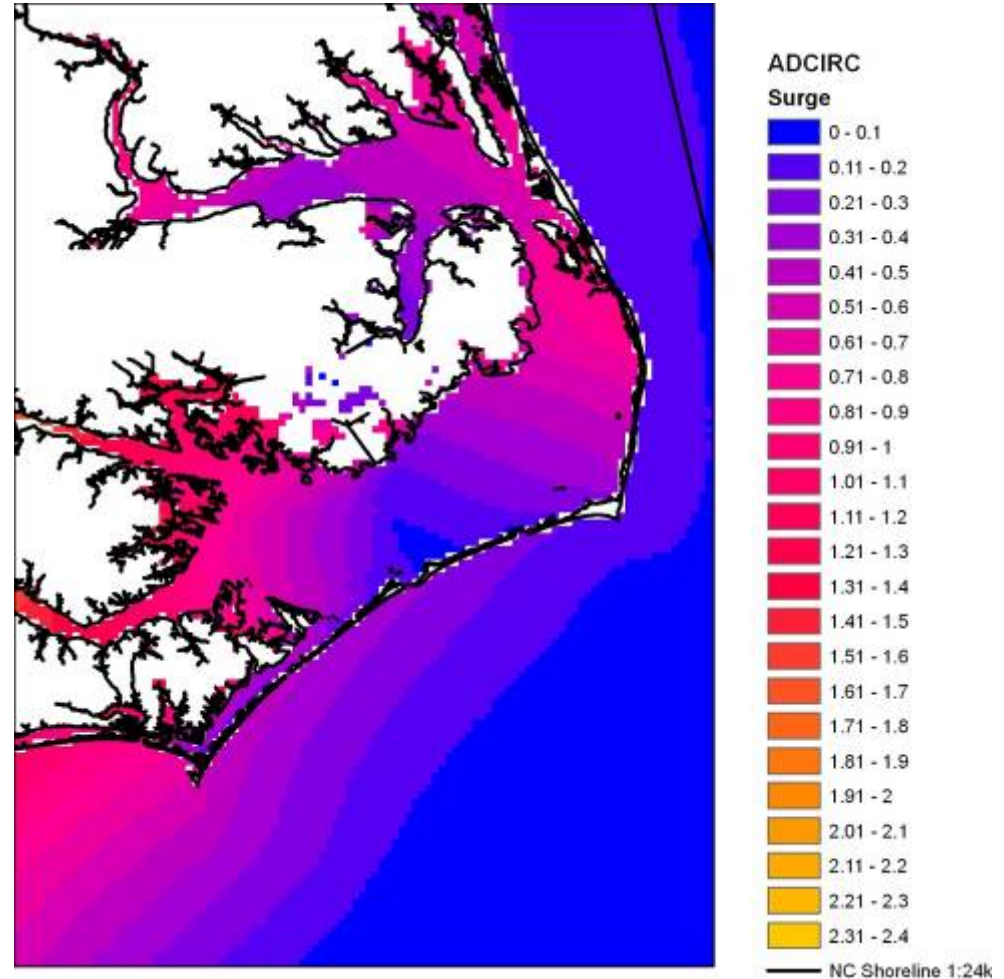


ADCIRC Inundation Model

- Pre-Hanna model run
- Post-Hanna



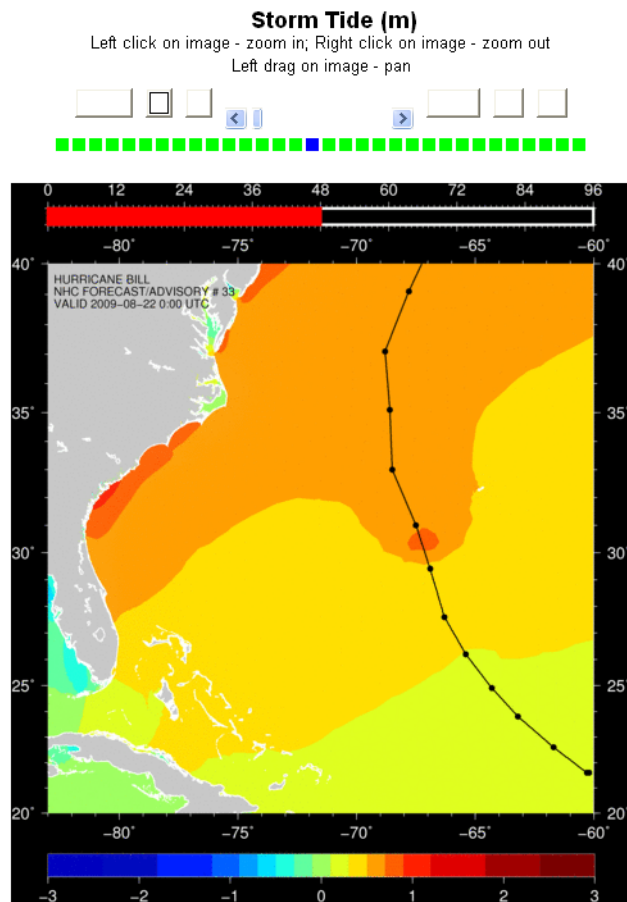
Goose Creek



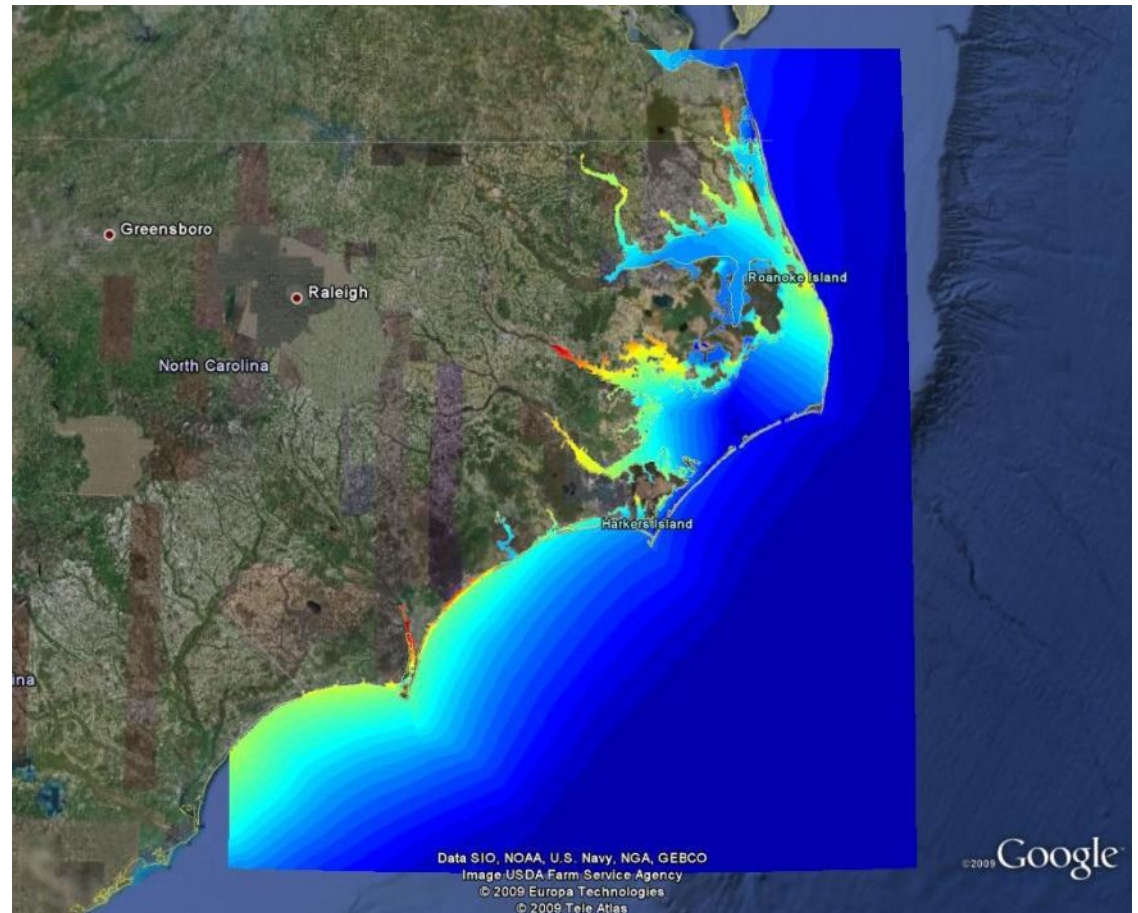
Brian Blanton, RENCi

Further Examples: ADCIRC

North Carolina Forecast System
UNC-CH Inst. Marine Science



ADCIRC output for Hanna –
Renaissance Computing Institute UNC



Industry Example: Ike Storm Surge Forecast

**American Proxix
Solutions Insurance
Underwriting**



First American

Image © 2008 DigitalGlobe
Image Houston-Galveston Area Council
© 2008 Tele Atlas
© 2008 Sanborn

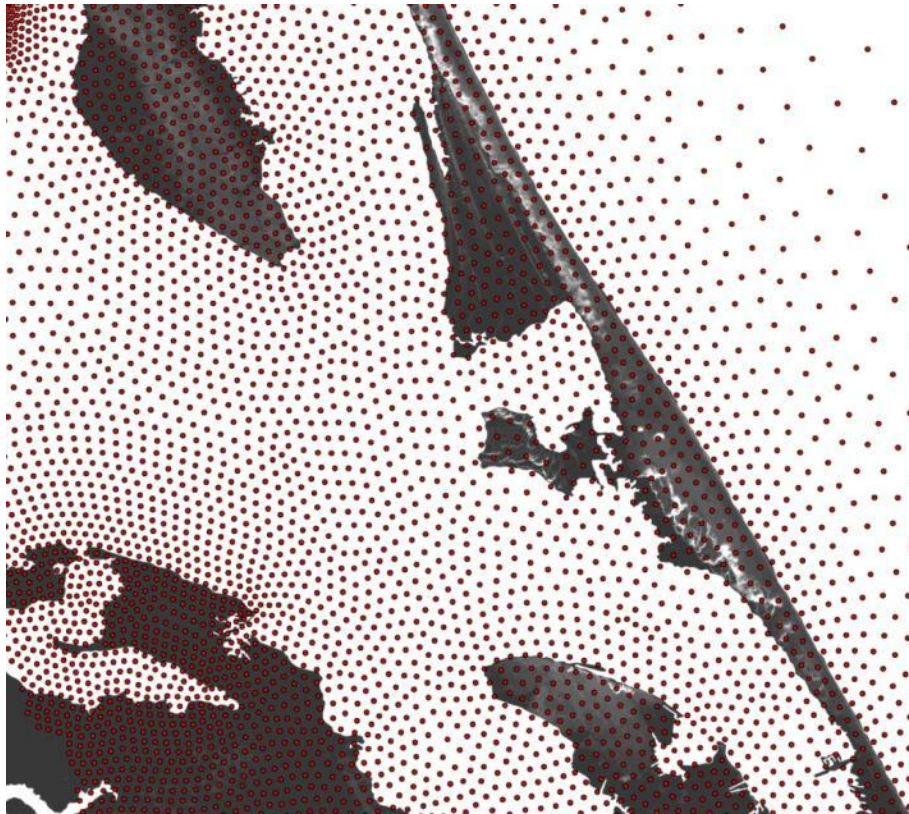
© 2007 Google™

ADCIRC Visualizations

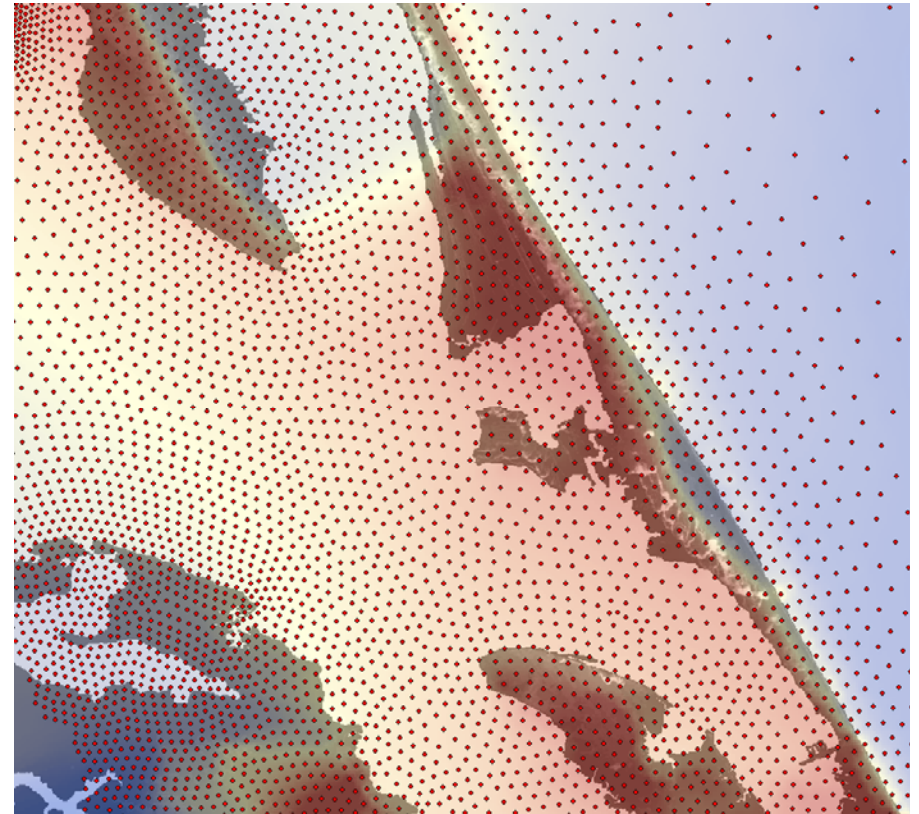
Convert ADCIRC nodes to MSL and back to NAVD88 (~10cm)

ADCIRC Interpolation alternatives (IDW, Kriging, Splining)

Solution file joined to grid point file

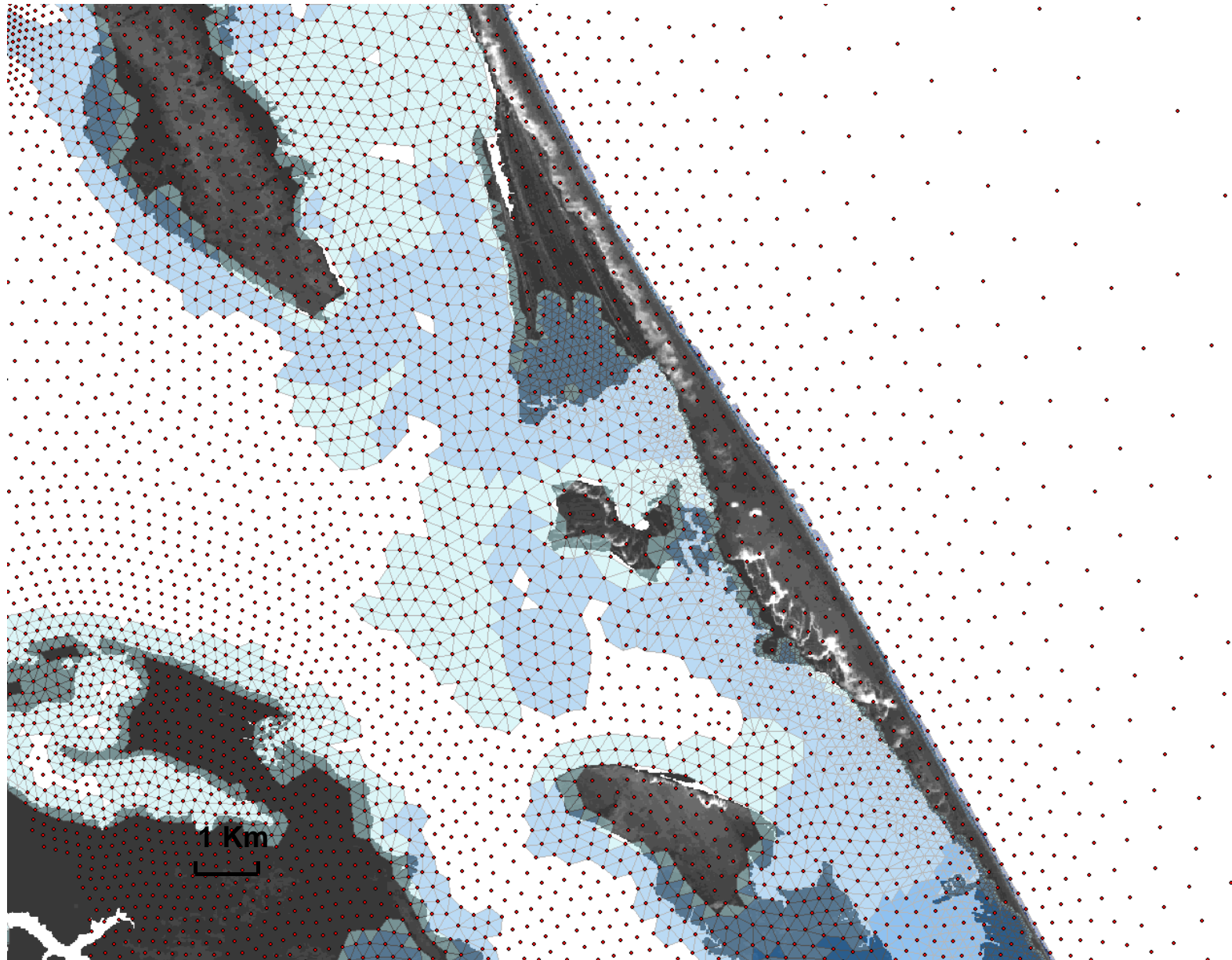


IDW Surface Interpolation



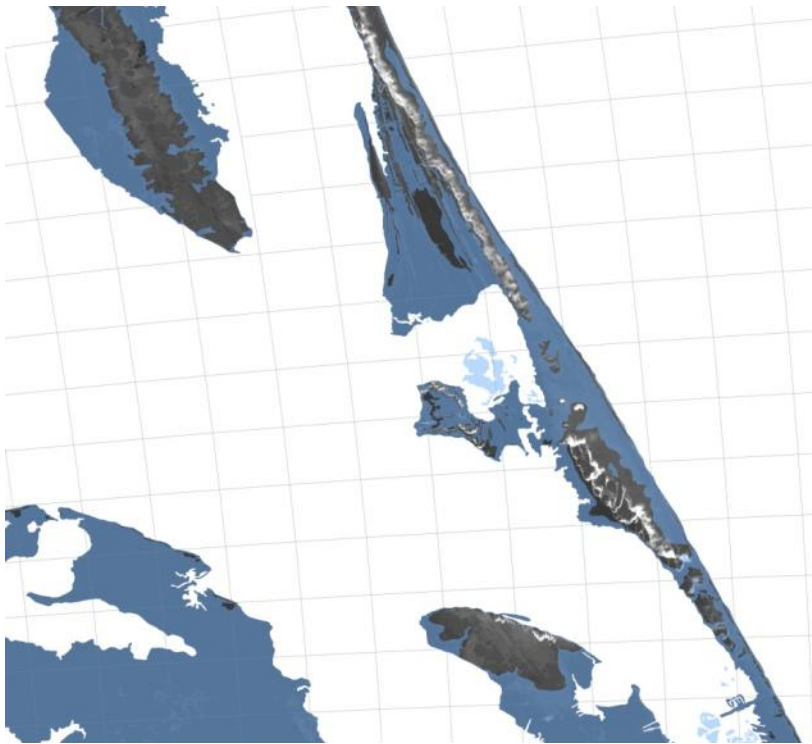
ADCIRC Inundation Polygons in ArcMap

Topography finer than the grid resolution is not represented (i.e., flooding potential)



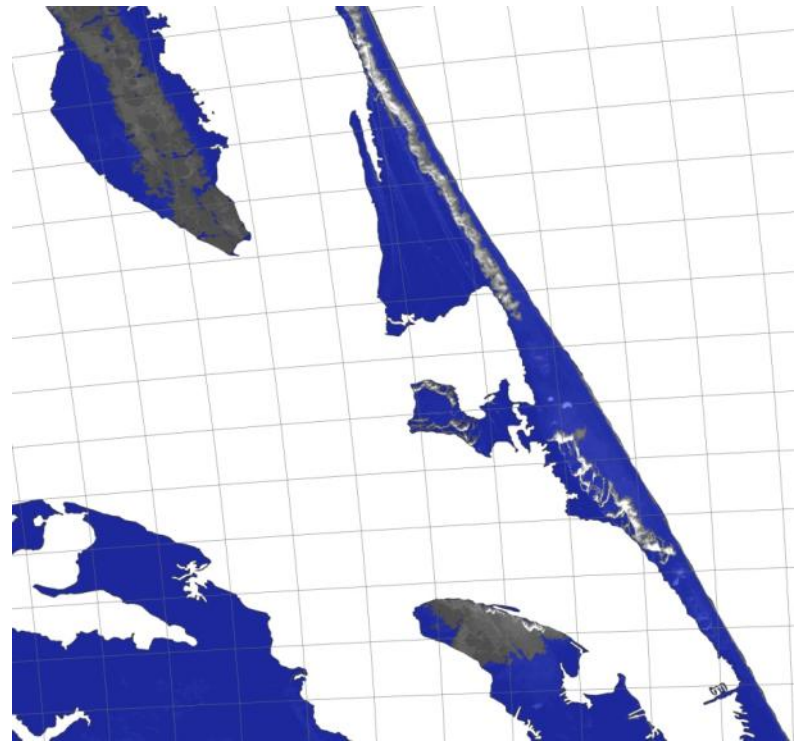
Comparing Legacy Elevation vs. Downscaled SLOSH and LiDAR DEMs

NCCGIA Contoured MOMs



USGS 1:24k NED DEM
5ft contour

Fine scale inundation model output



NC Floodplain Mapping Program
15cm LiDAR DEM, 10m pixel

Comparison

92.7% agreement

Dare County, NC

Downscaled Model

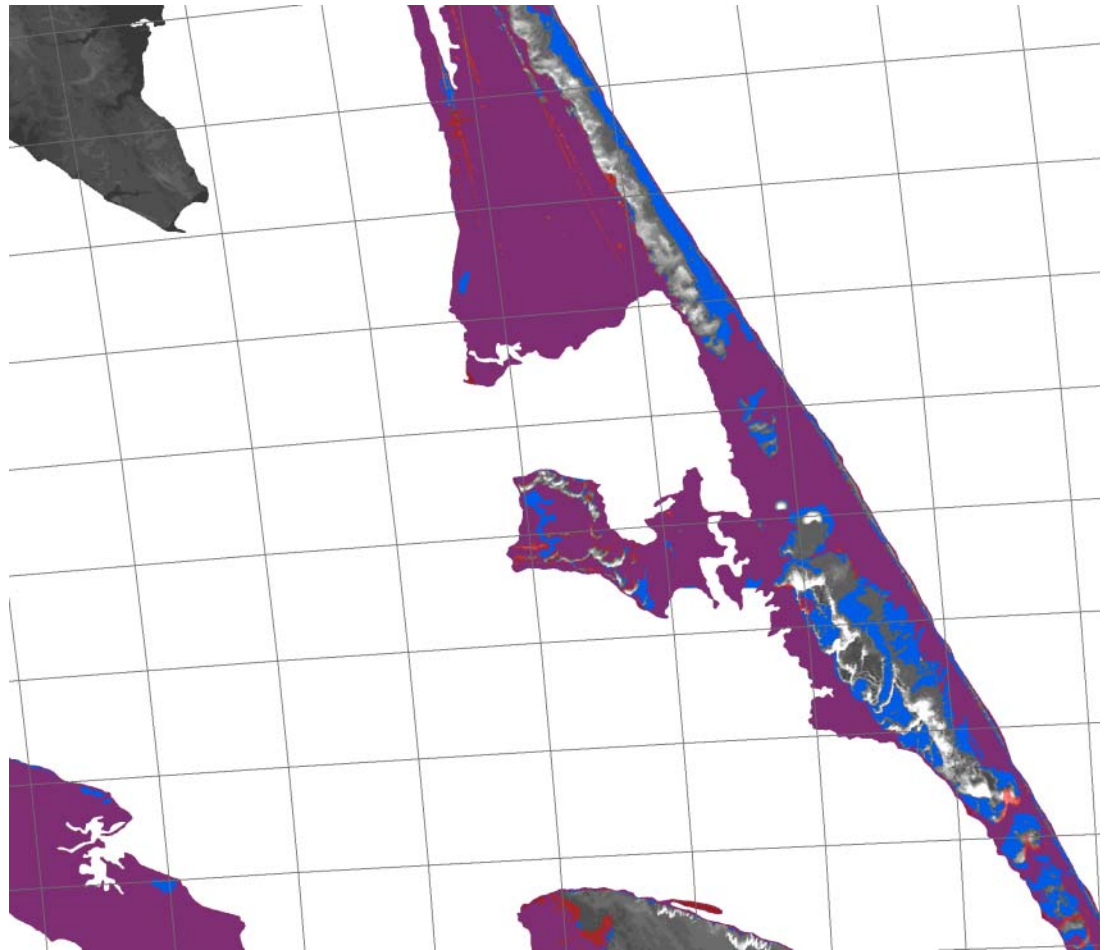
Output = Blue 919.1km²

Legacy elevation only = Red

Agreement = Purple

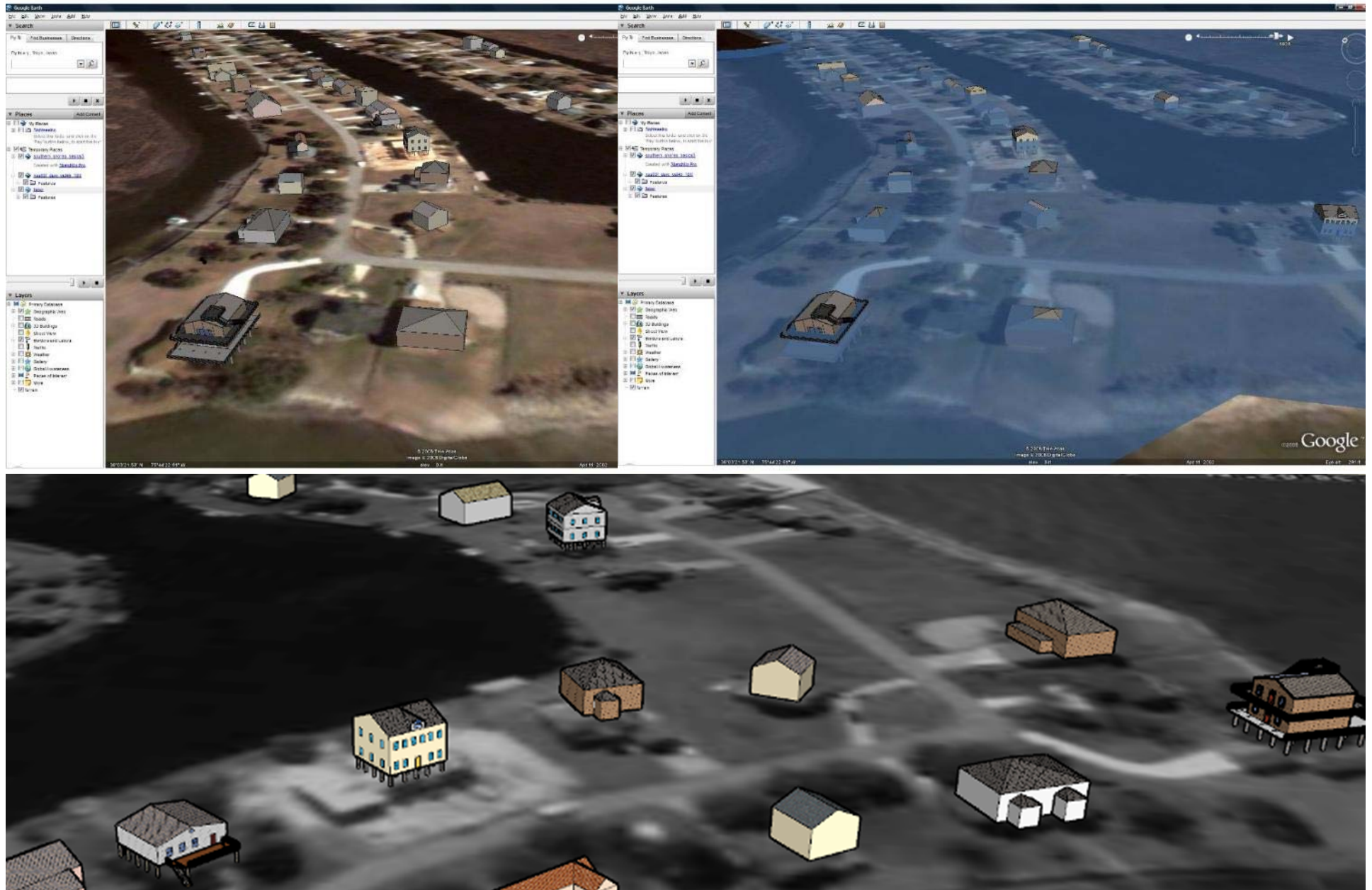
**Nonetheless, 8%
disagreement**

**4:1 omission error
without LiDAR and
downscaling**

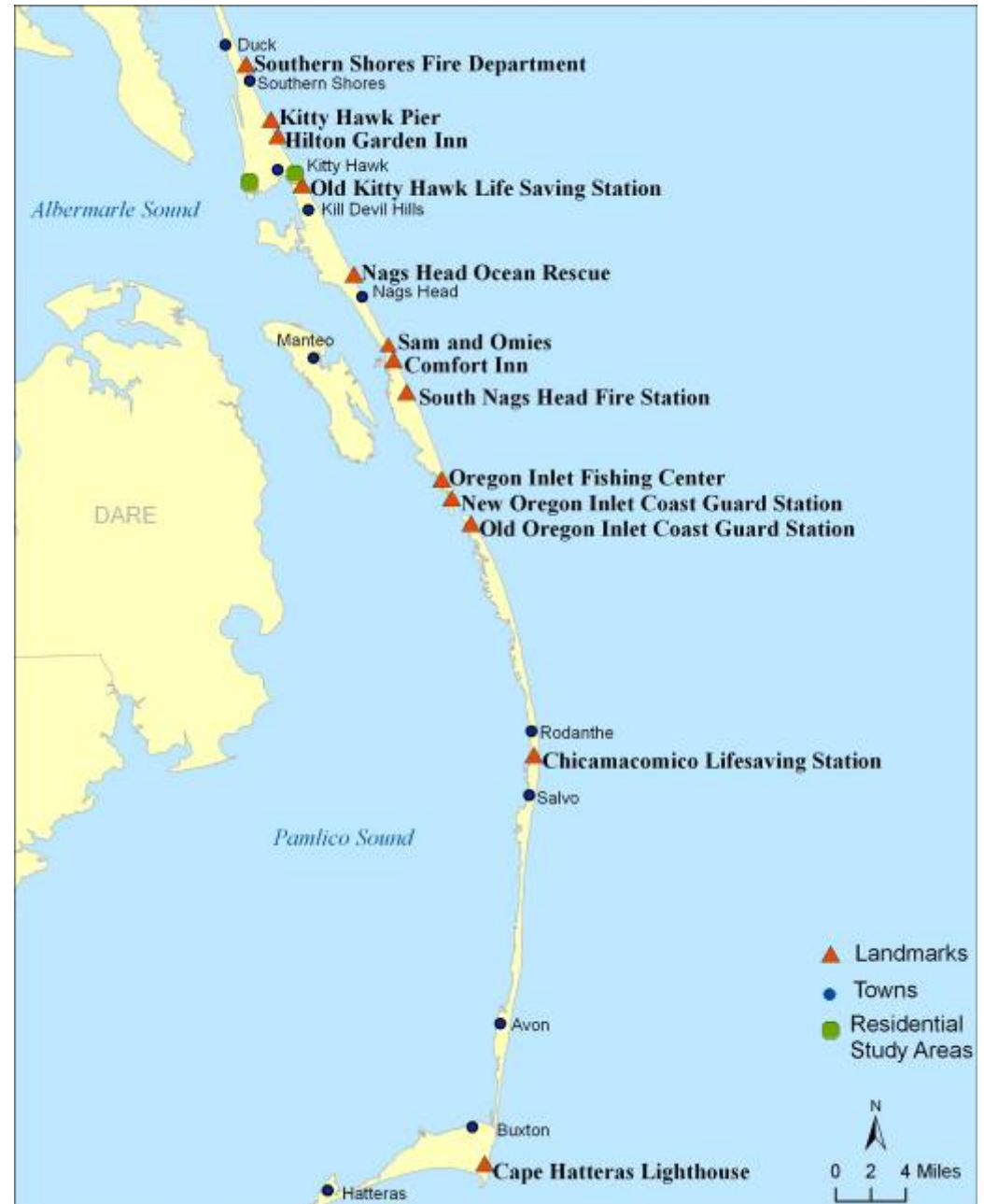


COMMUNICATION: Initial 3D Google Earth Visualizations

Garrett Nelson and Suzanne McArdle

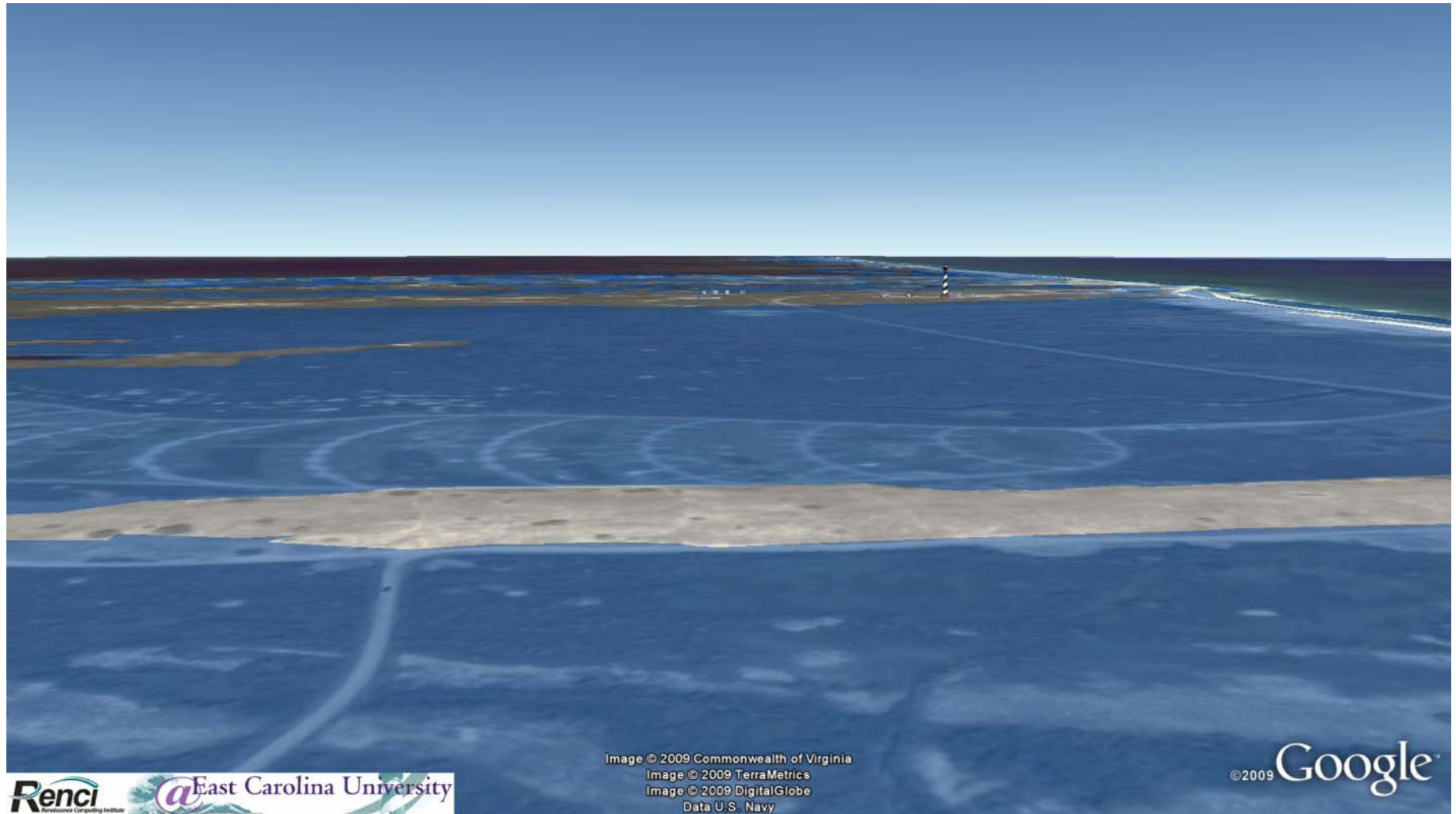


SLOSH MOMs, Sketchup Models, & GoogleEarth: A 3D Warehouse Initiative



With advice from Sandy Sanderson (Dare Co. EM) and Nancy White (UNC CSI)

Prototype for 3D Models in GoogleEarth

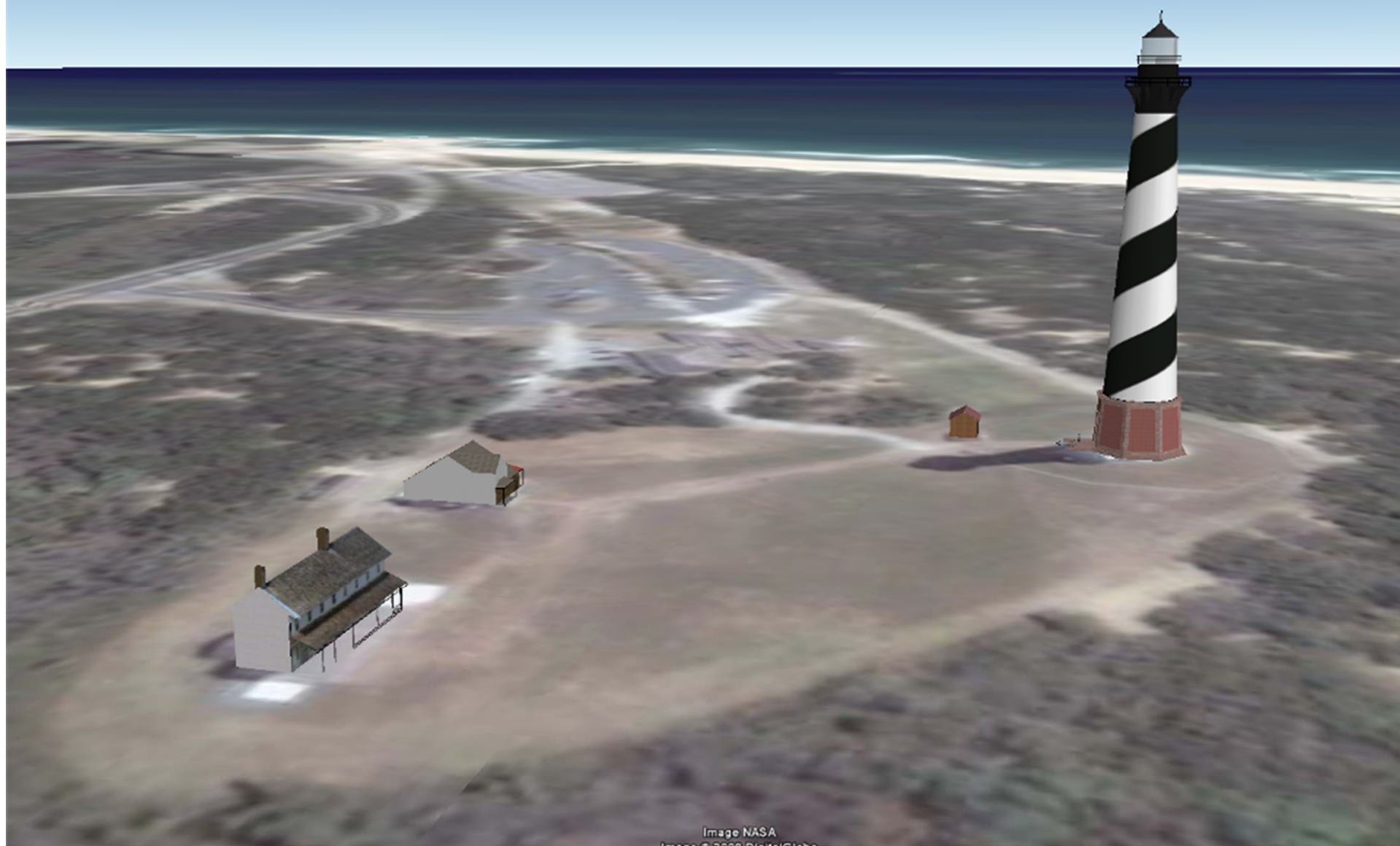


S. Nags Head Fire and Rescue

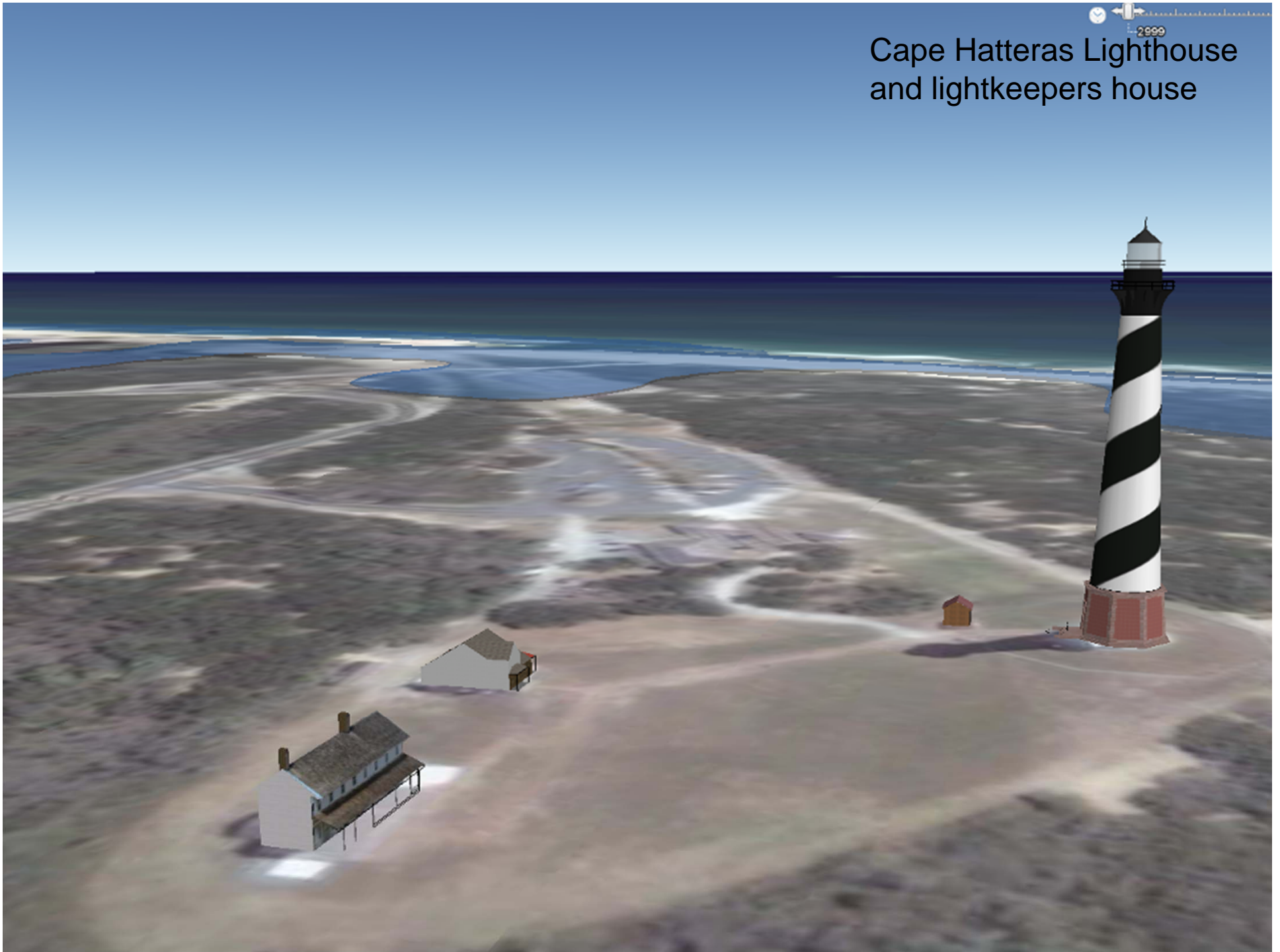


S. Nags Head Fire and Rescue

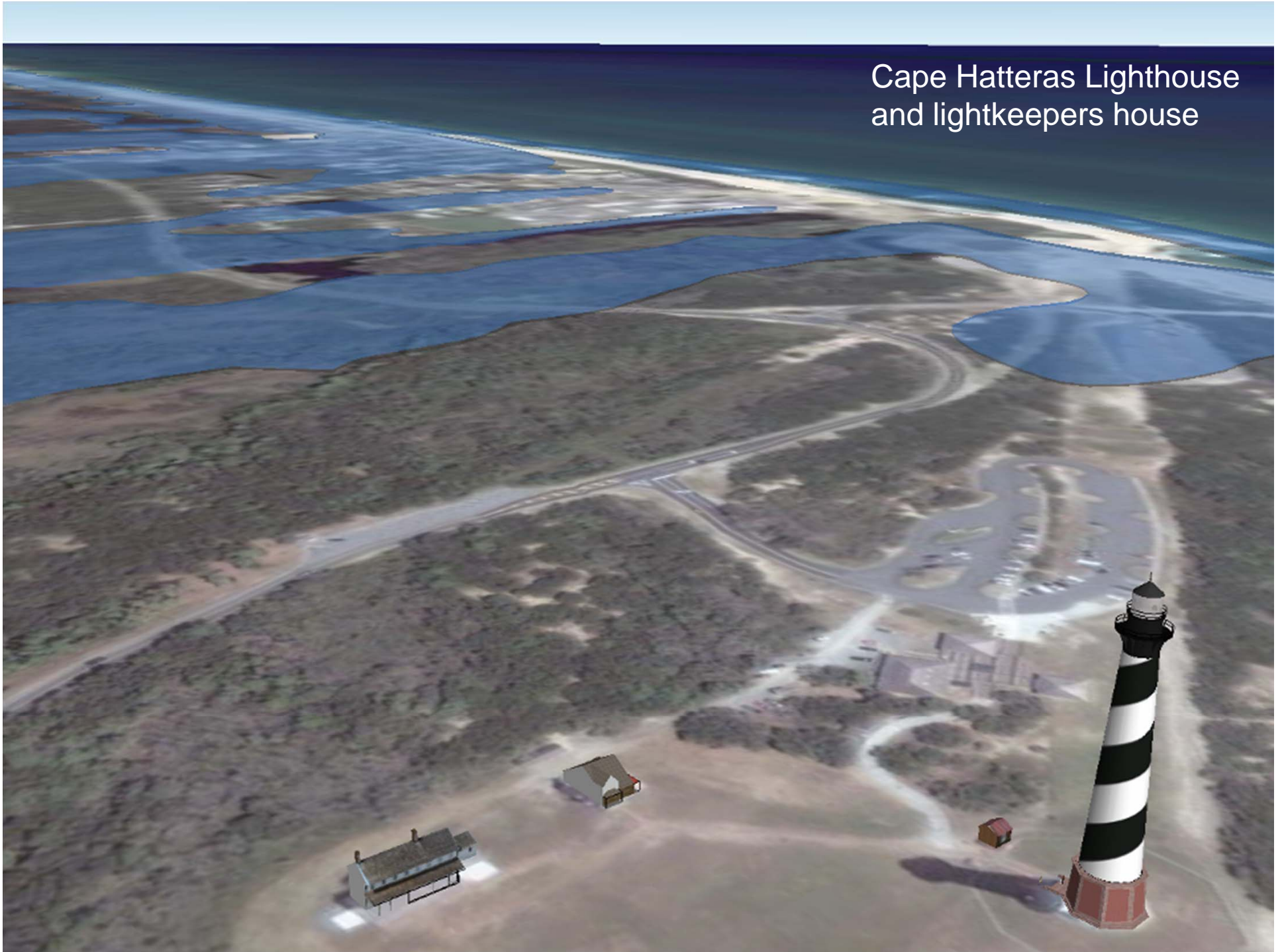
Cape Hatteras Lighthouse and lightkeepers house



Cape Hatteras Lighthouse
and lightkeepers house



Cape Hatteras Lighthouse
and lightkeepers house



Chicamacomico Lifesaving Station



Image ©2008 DigitalGlobe
©2008 Inria
Image NASA

©2008 Google

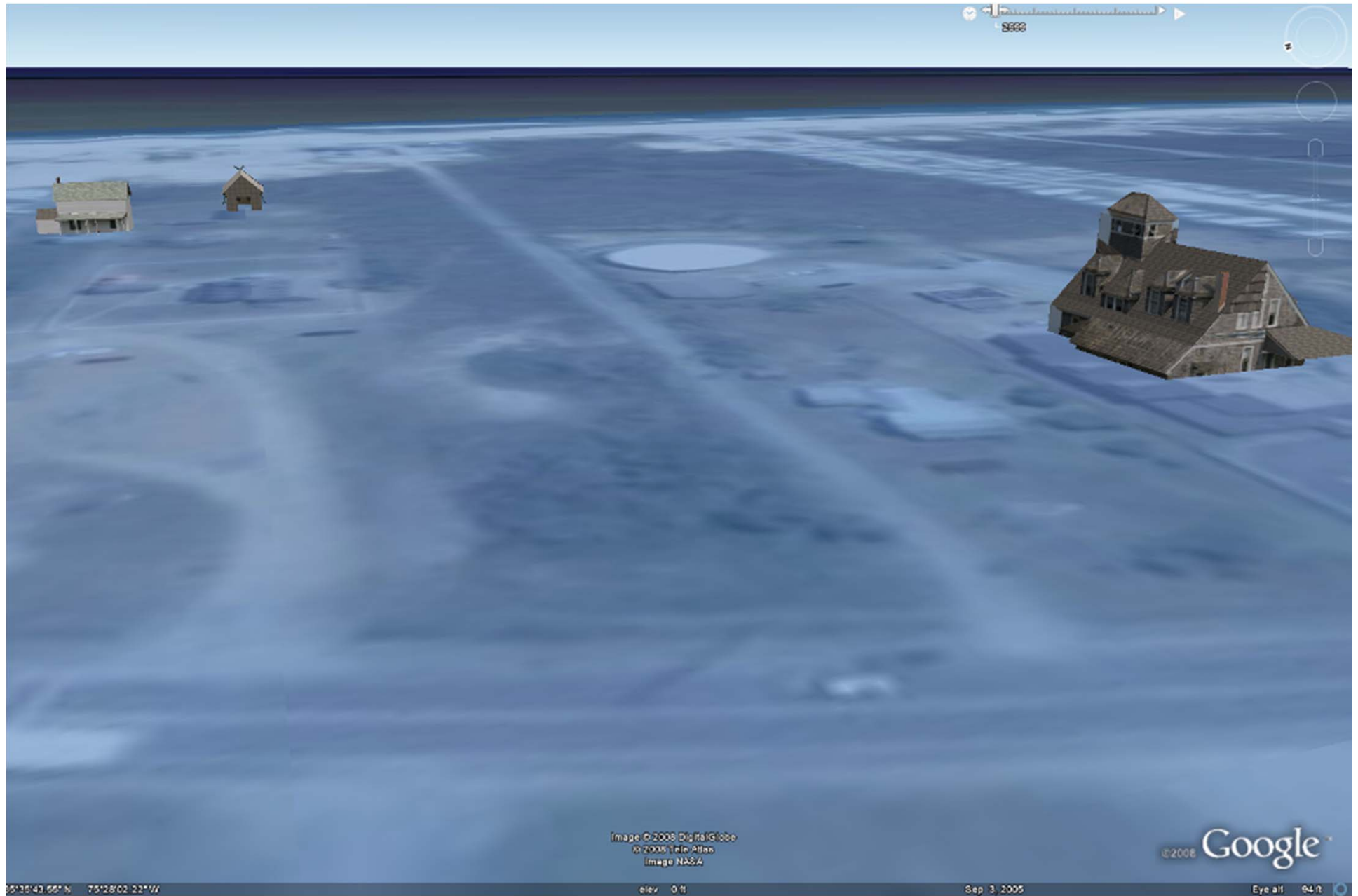
35°35'41.50"N 75°27'26.94"W

elev 3 ft

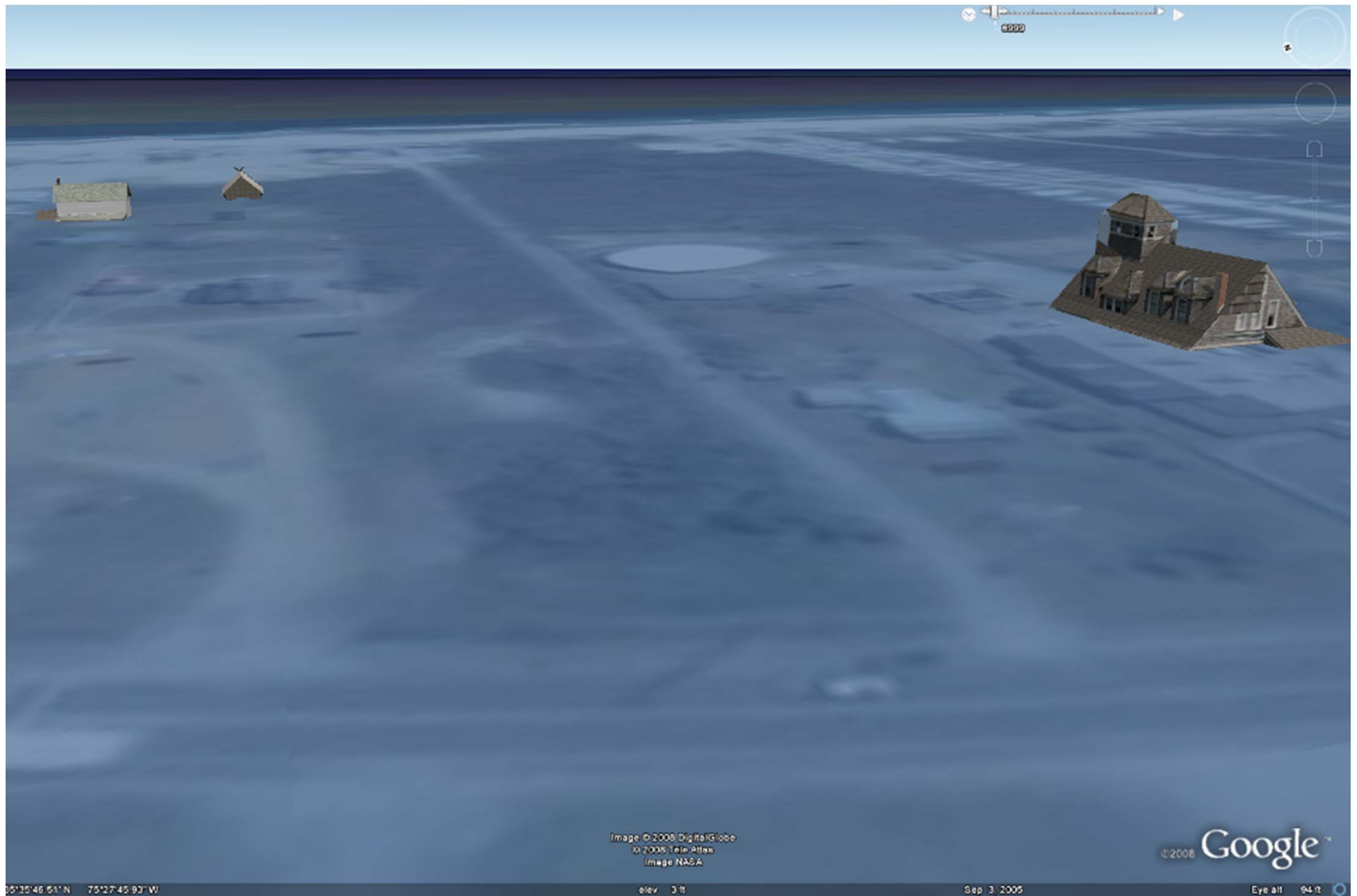
Sep 3, 2005

Eye alt 94 ft

Chicamacomico Lifesaving Station

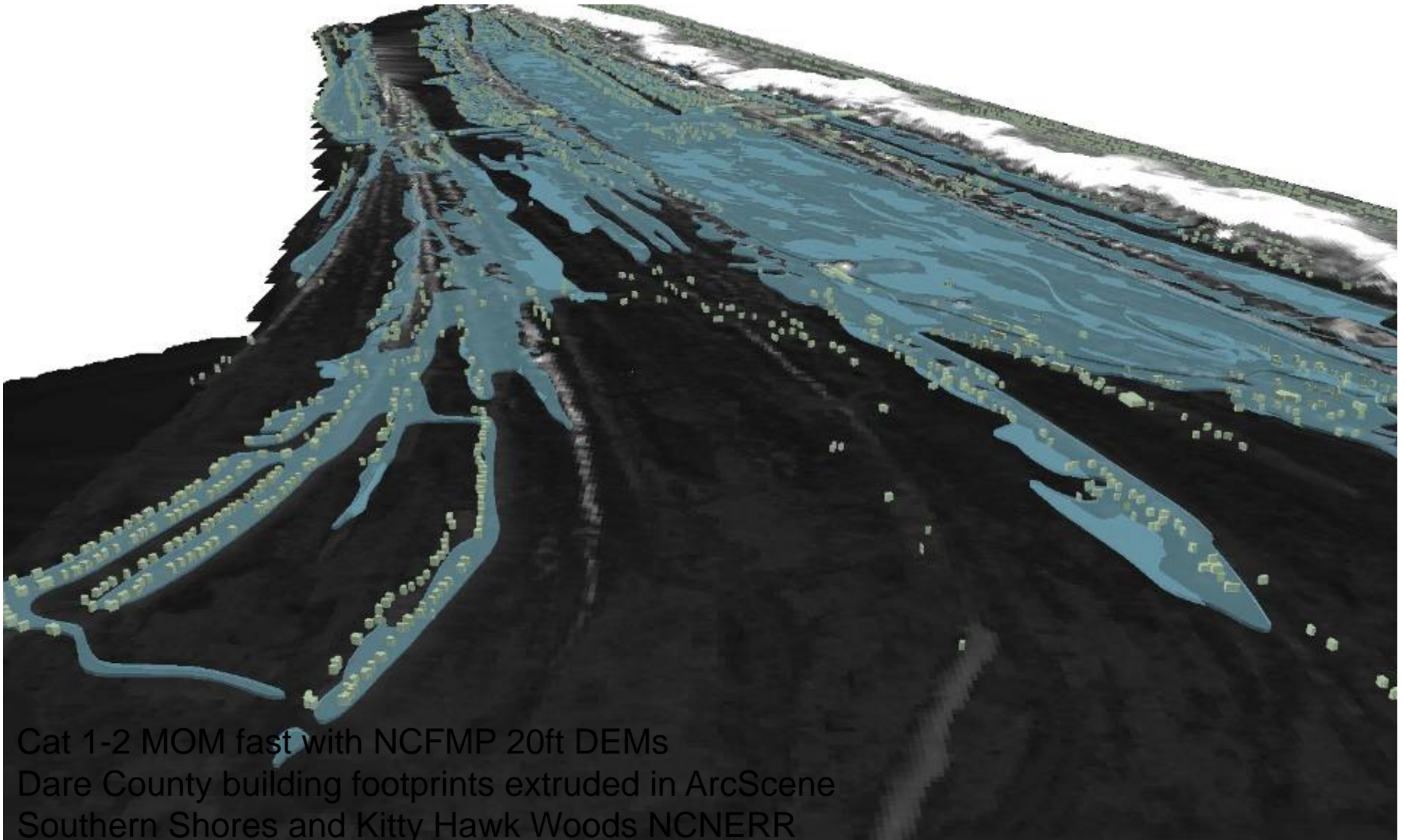


Chicamacomico Lifesaving Station



ArcScene

Building footprints, SLOSH, and LiDAR DEMs



Cat 1-2 MOM fast with NCFMP 20ft DEMs

Dare County building footprints extruded in ArcScene

Southern Shores and Kitty Hawk Woods NCNERR

Visualizing Storm Surges
SLOSH MOM Cat3 Fast-moving
Whalebone Junction, Nags Head, NC

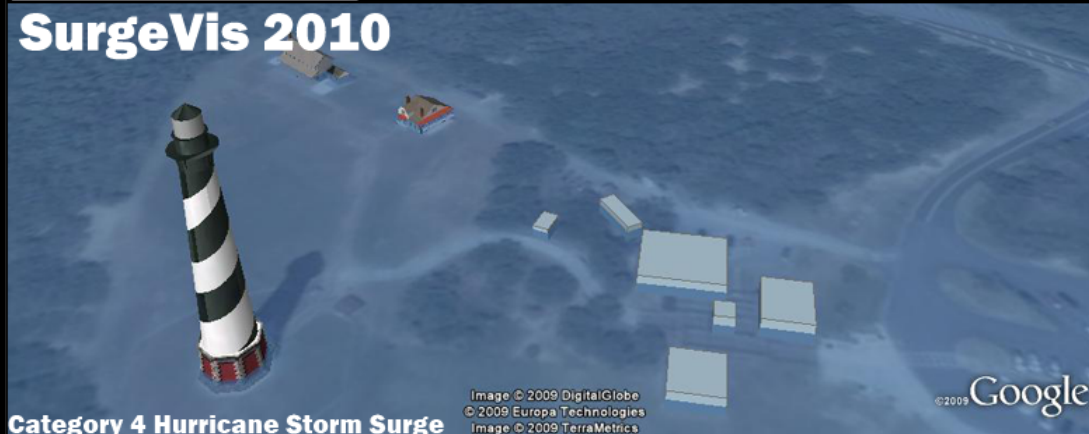
Sam & Omie's?

©2008 Europa Technologies
©2008 Terra Atlas
Image NASA
Image ©2008 DigitalGlobe
elev. 3 ft

35°54'37.81"N 75°35'55.53"W

Aug 17, 2004

SurgeVis 2010



Category 4 Hurricane Storm Surge

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 extreme 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



Application...

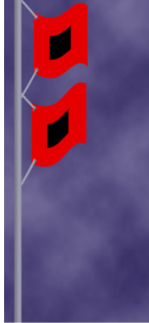


HURRICANE FELIX

Dare County Exercise



Latest Felix Information



Advisory Time: 8 AM EDT August 15, 2010

Position: 32.4 North 67.5 West, about 420 miles SE of Cape Hatteras

Intensity: Sustained winds near 130 mph (Category 4) with gusts to 155 mph

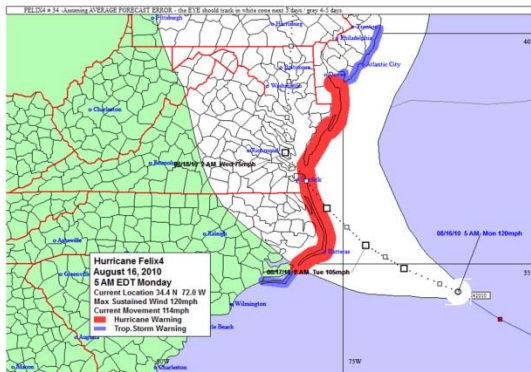
Movement: Moving toward the NW near 10 mph

Minimum Pressure: 944 mb or 27.88 inches

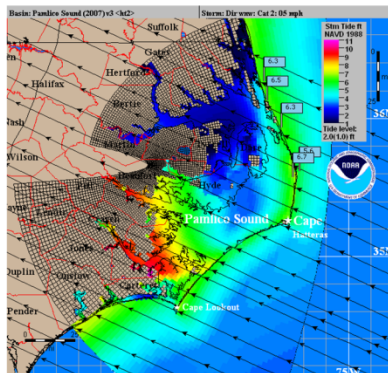
Watches/Warnings: Tropical Storm Watch from Cape Lookout to Cape Hatteras, Hurricane Watch from Cape Hatteras to Cape May, NJ.

Follows updated NHC Advisory 30

NHC 5 Day Forecast



Potential Surge Threat



- For Planning Purposes the image to the left is a SLOSH surge map for a Category 2 Hurricane on a WNW track moving at 5 mph making landfall at high tide. The image is a consolidation of various landfall locations impacting the outer banks.
- 5 to 7 feet of storm surge would be possible in this scenario.
- Based on latest track most surge would be Sound-side on the backside of the storm. If the track were to shift further left, there would be more impact on the Northern Outer Banks.

Hurricane Felix Exercise

Dare County EM Control Board,

NC and VA Emergency Mgt.

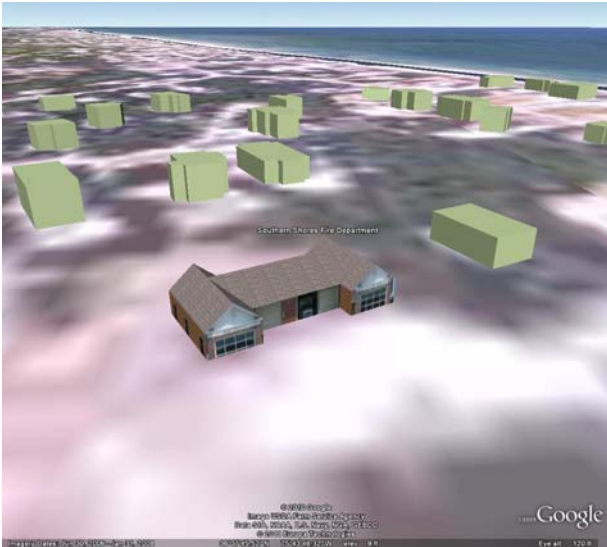
NC and VA State Police

US Coast Guard

National Park Service, Fish and Wildlife Svc.



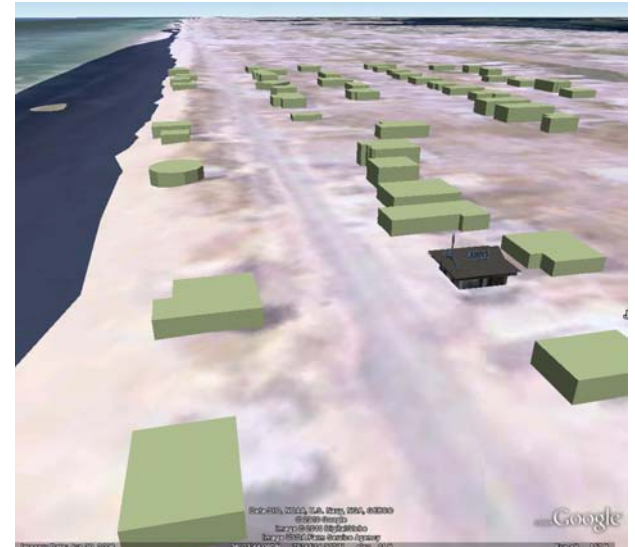
Geovisualization: Slosh MOM Category 2 Surge



Southern Shores Fire Department



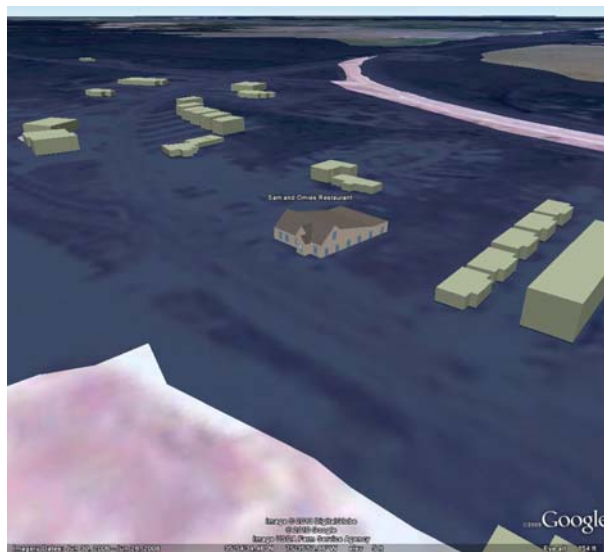
Kitty Hawk Hilton Garden Inn



John's Drive-In



Nags Head Ocean Rescue

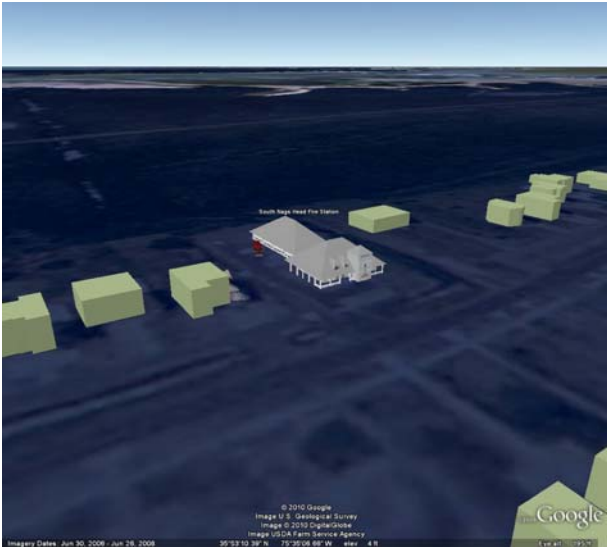


Sam and Omies Restaurant



Nags Head Comfort Inn

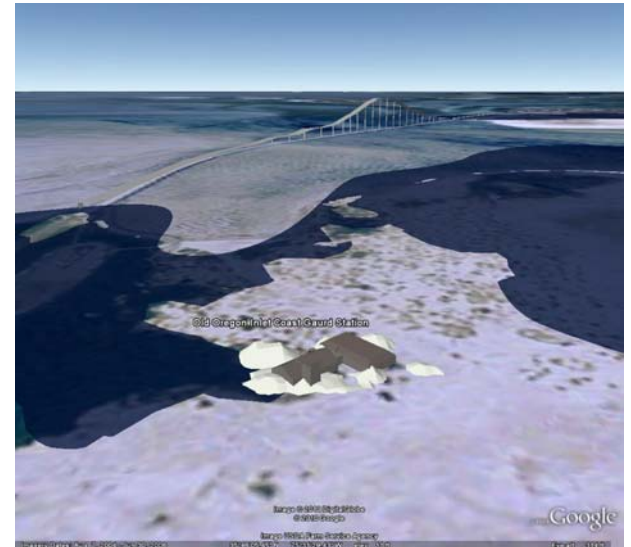
Slosh MOM Category 2 Surge



South Nags Head Fire Station



Oregon Inlet Coast Guard Station



Old Oregon Inlet Coast Guard Station

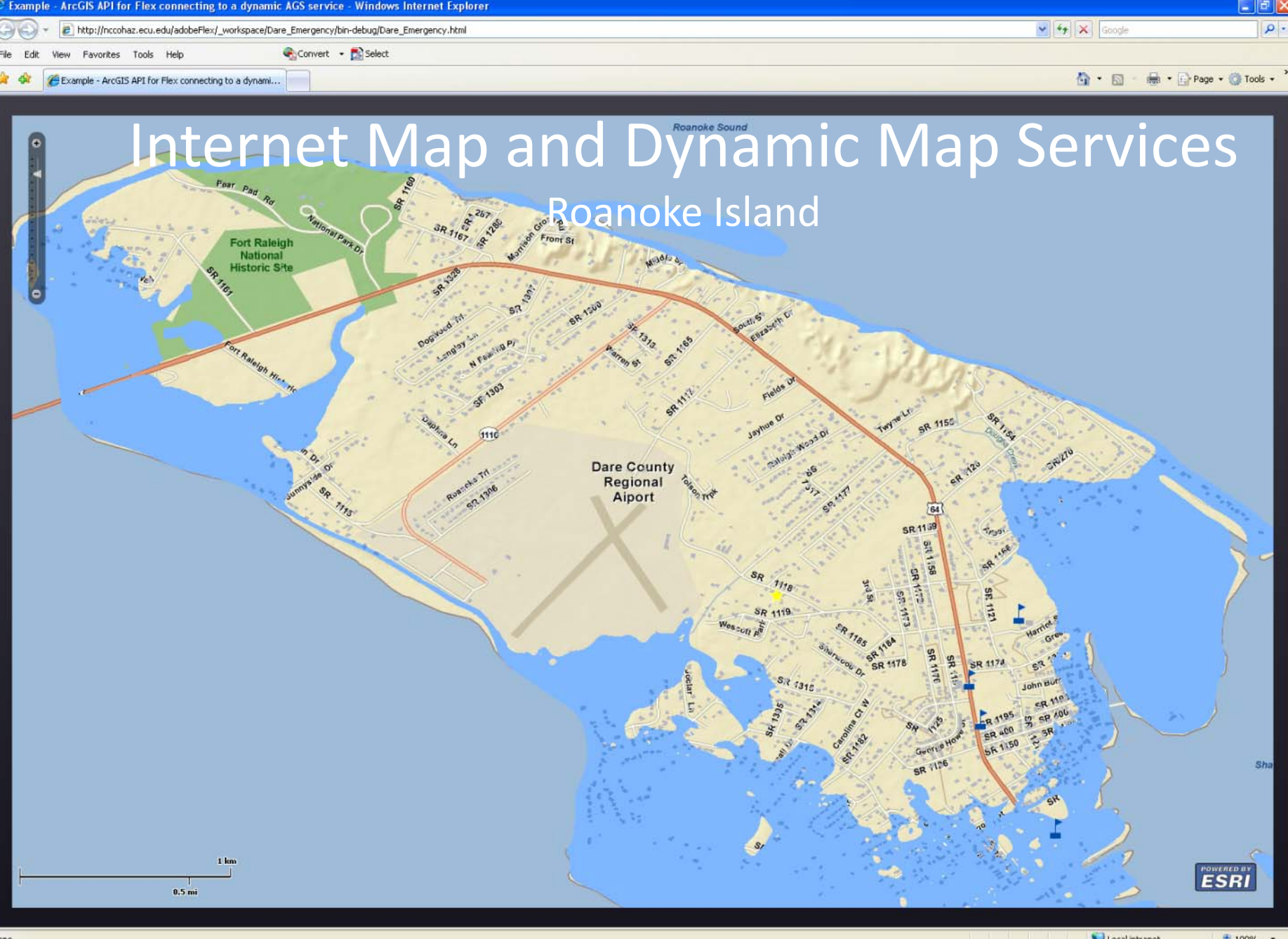


Chicamacomico Life Saving Station



Cape Hatteras Lighthouse

Internet Map and Dynamic Map Services

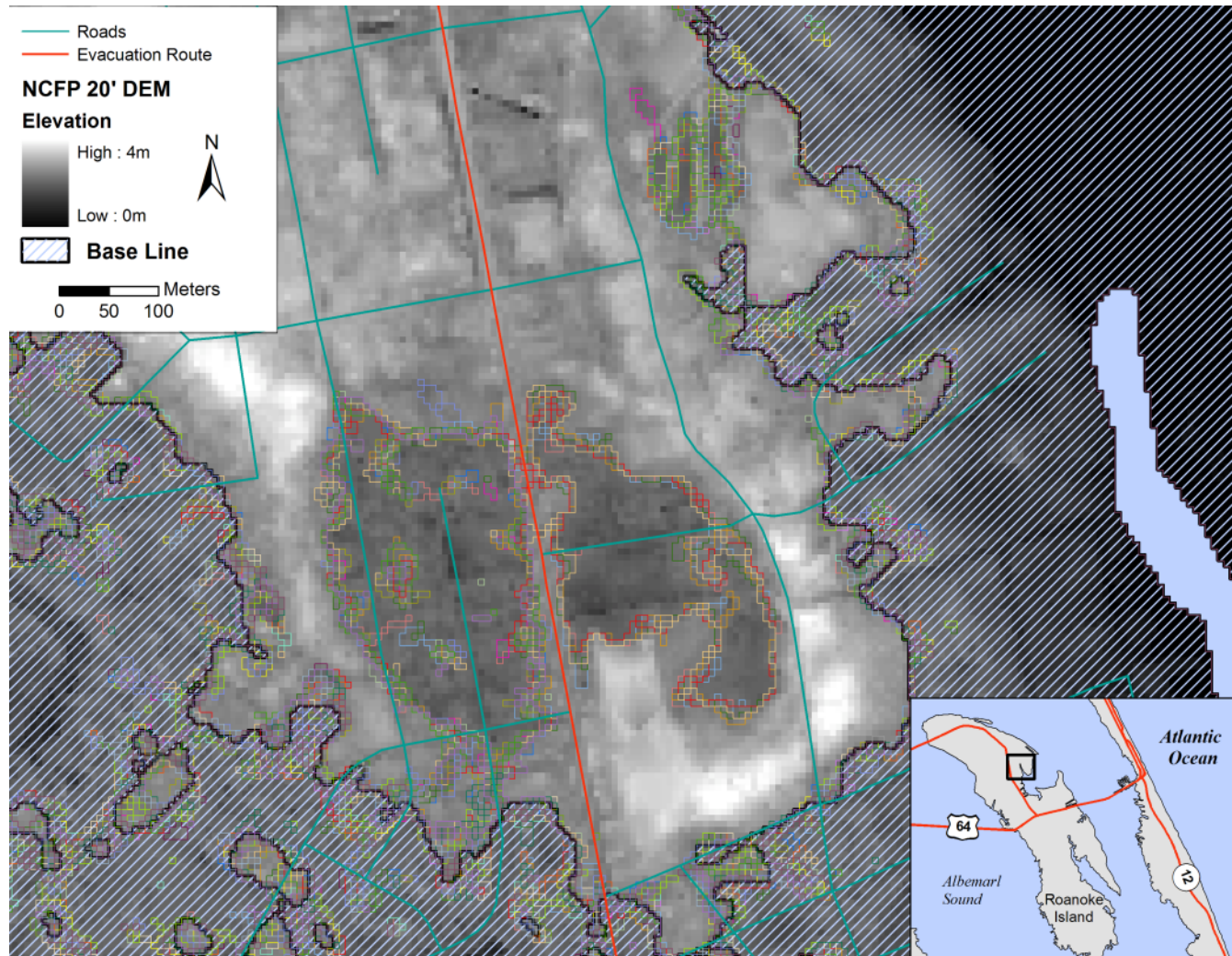


The screenshot shows a web browser window with the title "Example - ArcGIS API for Flex connecting to a dynamic AGS service - Windows Explorer". The address bar displays the URL "http://nccohaz.ecu.edu/adobeFlex/_workspace/Dare_Emergency/bin-debug/Dare_Emergency.html". The browser's menu bar includes "File", "Edit", "View", "Favorites", "Tools", and "Help". A search bar is located in the top right corner. The main content area displays a map of Roanoke Island, North Carolina. The map is titled "Roanoke Island" and shows the island's coastline, major roads, and the Dare County Regional Airport. A large white text overlay reads "Internet Map and Dynamic Map Services" and "Roanoke Island". The map includes a scale bar indicating 1 km and 0.5 mi. The browser's status bar at the bottom shows "Done", "Local intranet", and "100%".

Uncertainty

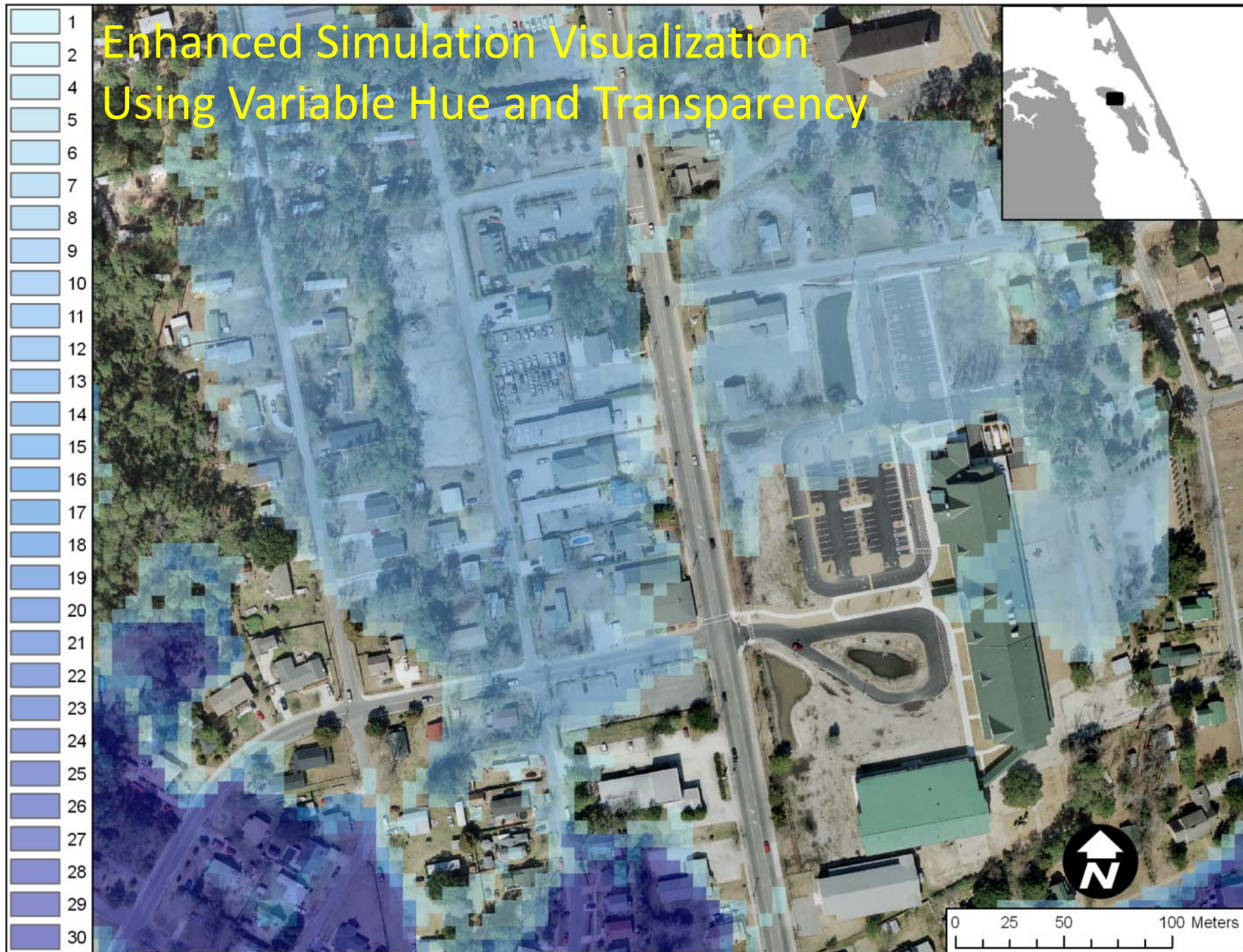
- GIScience has a strong research agenda to understanding spatial uncertainty and representing it cartographically (analytical and communicative)
- Unsaavy users may ignore uncertainty and propagate error
- How does error concern us- omission or commission?

Monte Carlo Simulation of DEM Error Propagation on Inundation Extents (Cat3 SLOSH MOM slow-moving storm)

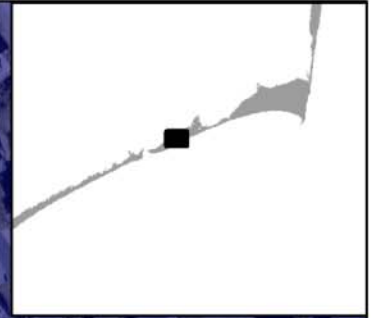


- Individual simulations are shown as different colors, with isolated extensive areas of the center being inundated under only a few cases, arising from uncertainty in the lower portion of the DEM.

Enhanced Simulation Visualization Using Variable Hue and Transparency



Hatteras Village

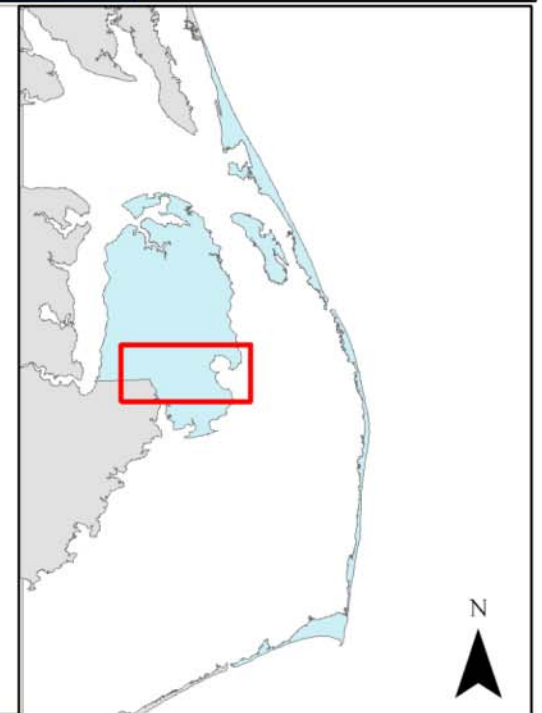
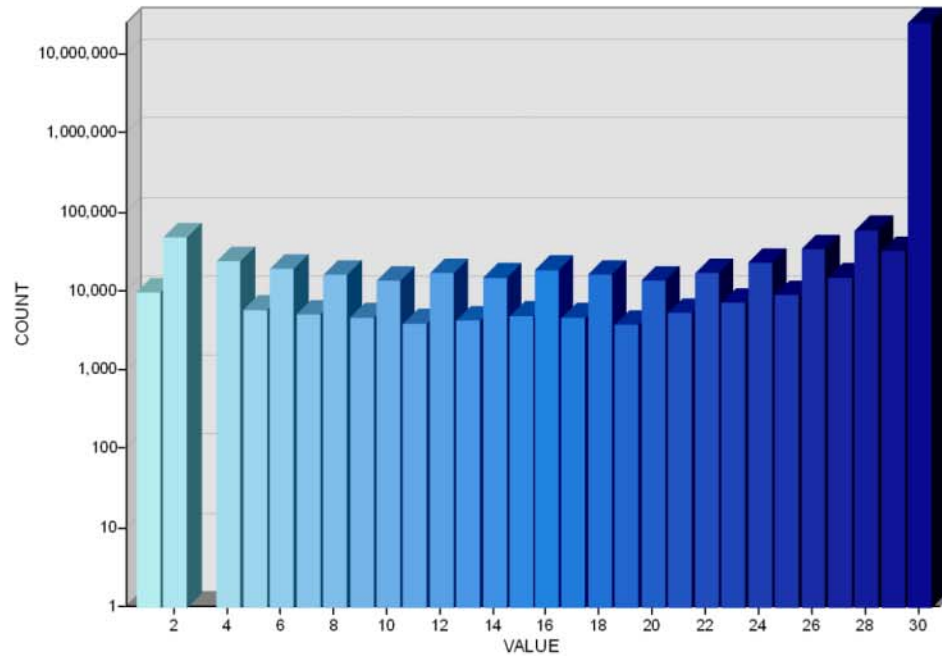
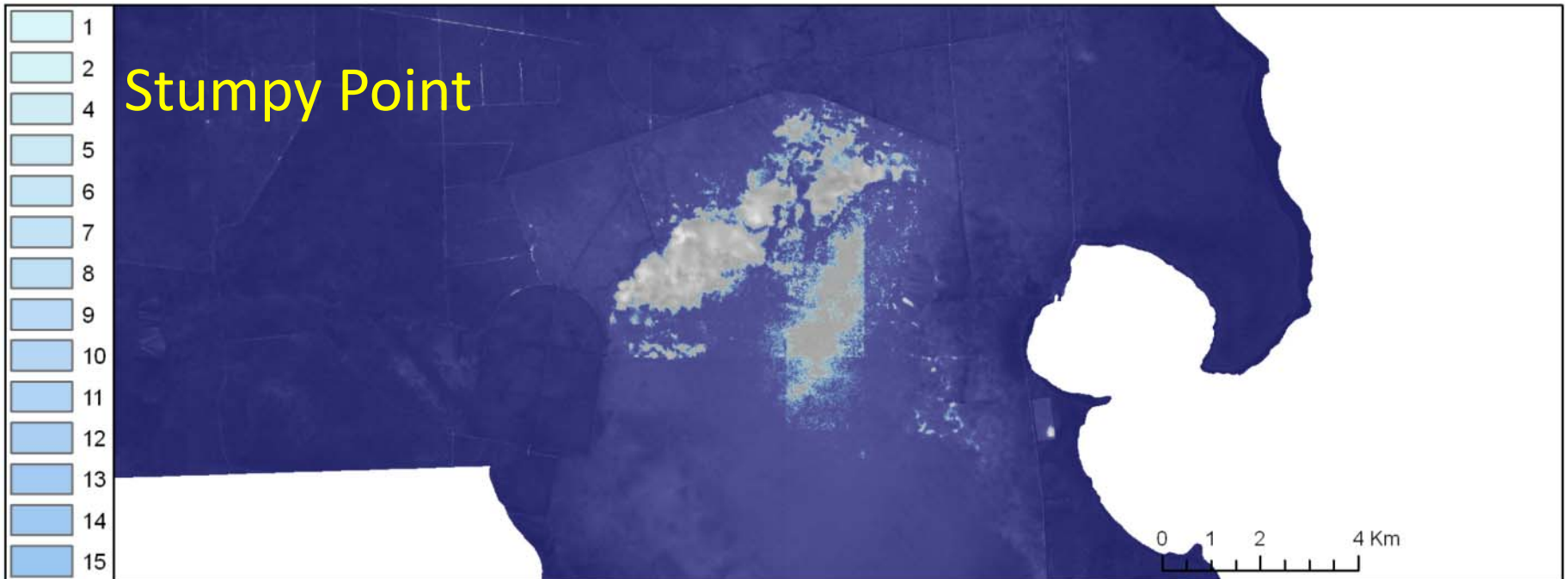


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0 25 50 100 Meters

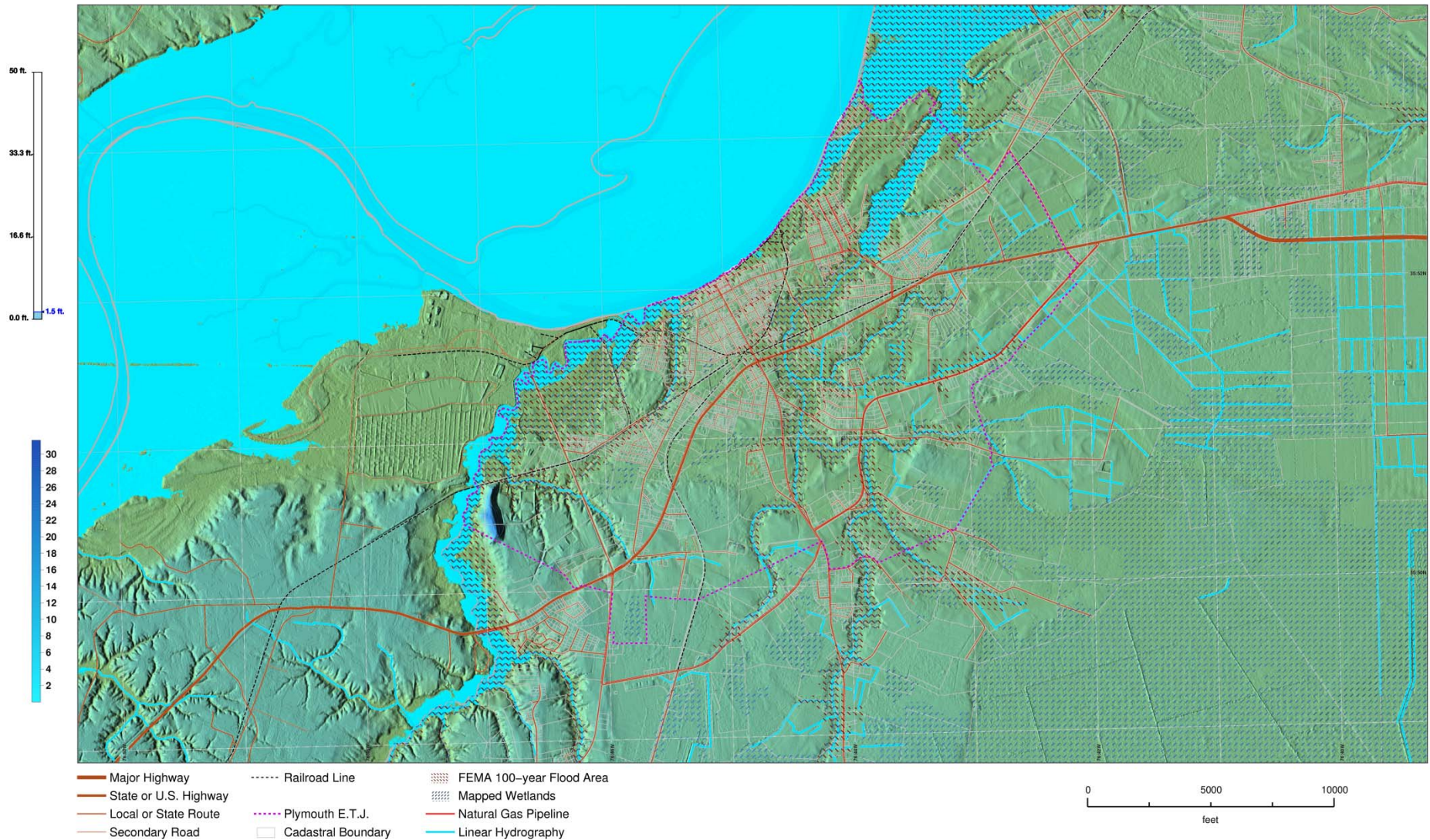
Stumpy Point



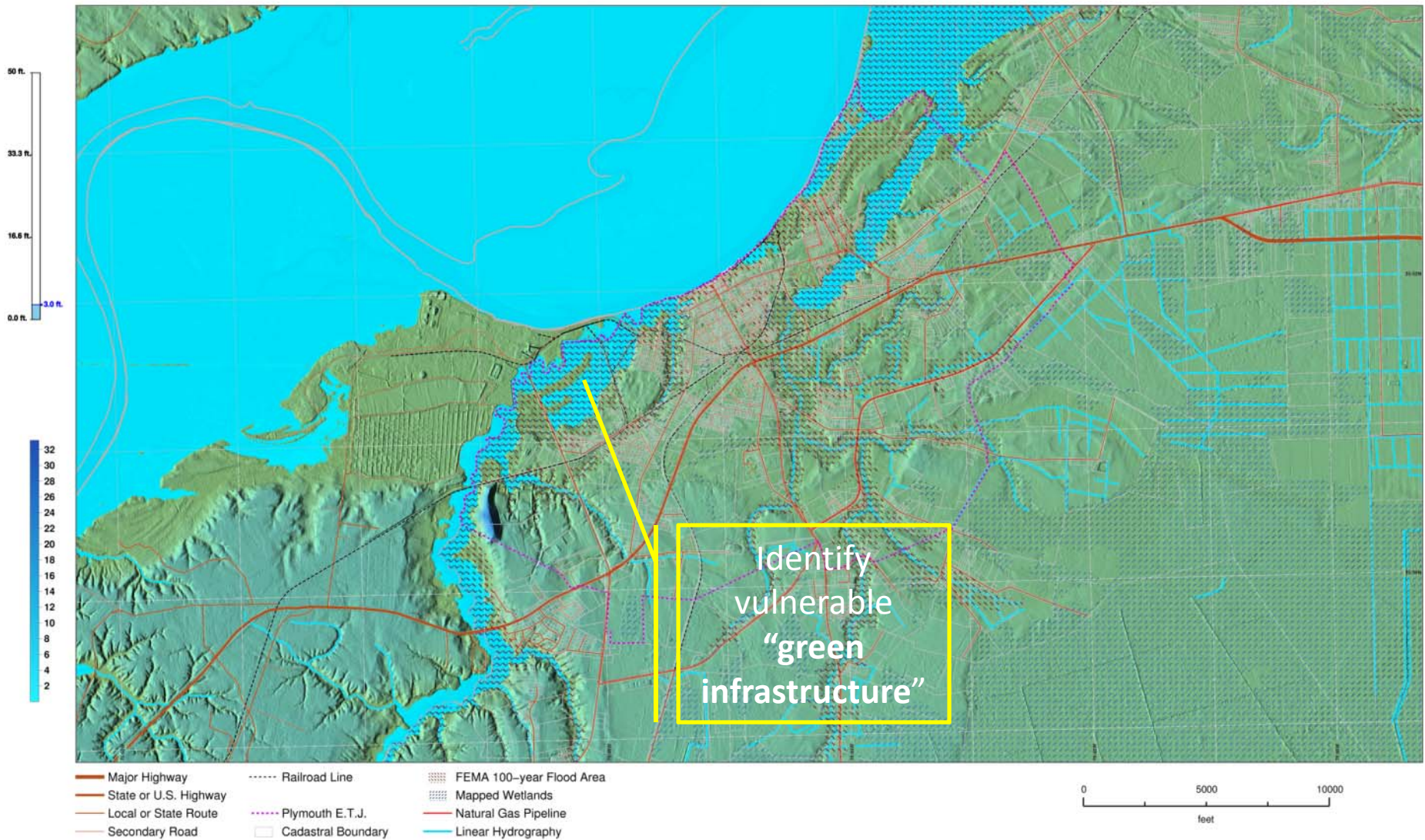
Communicating Abstract Spatial Information

Flooding past and present, routine flood inundation

e.g., 1.5ft wind tide/riverine flood, Town of Plymouth, NC



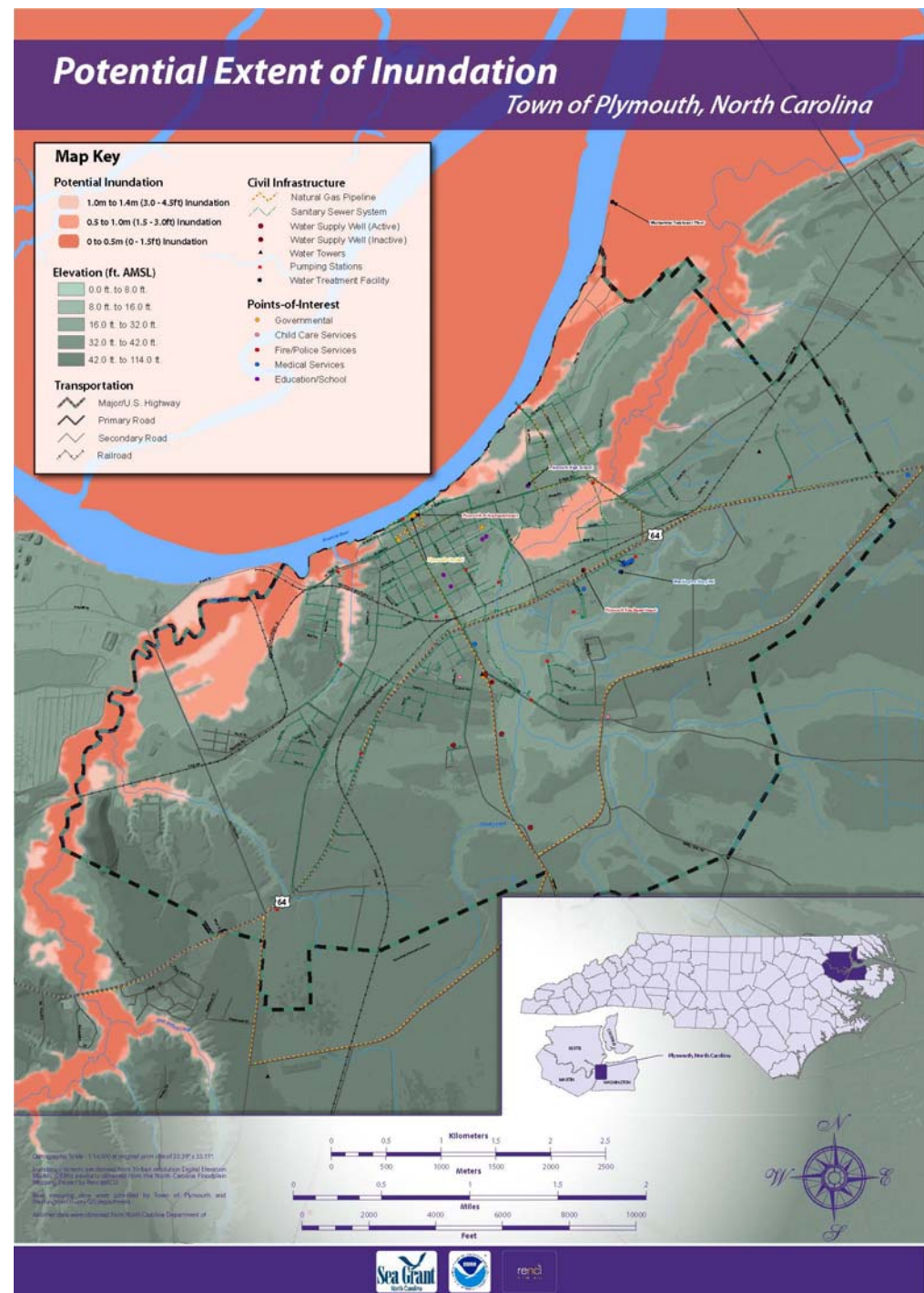
1m Sea-Level Rise similar to a major storm tide or riverine flood,
only permanent (e.g., +3.0 ft, Hurricane Isabel 2003)



Town of Plymouth, NC

- Problem:
 - How can local communities prepare for SLRise?
- Approach:
 - High resolution, large scale maps
 - Build capacity
 - Sensitivity to cultural and political reality

With NOAA NC Sea Grant SARP
Thigpen, Putnam, Whitehead, & Covi



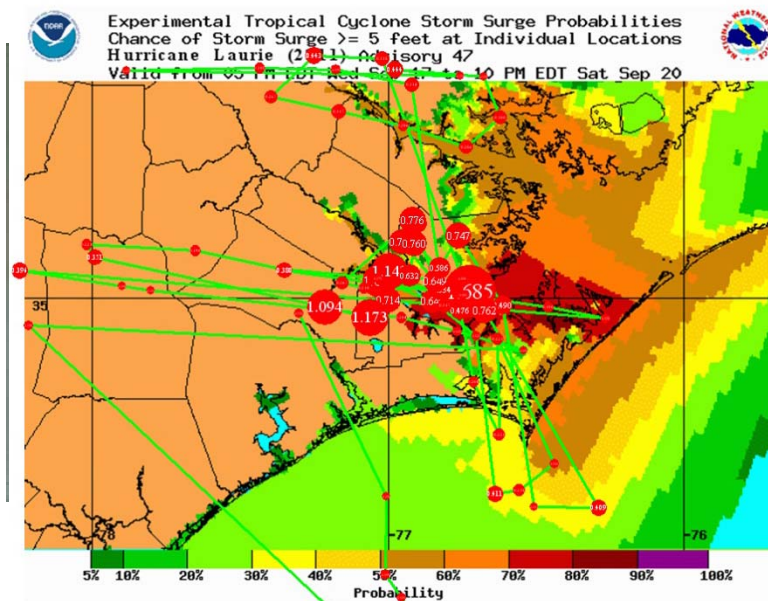
Future Work

- Understanding the influence visualization and maps have on risk perception and decision-making.
 - Expressed vs. observed risk perception
 - Biometrics, GIS, and social science methods
- Cone of Uncertainty
- Probabilistic forecasts, graphics, and impacts

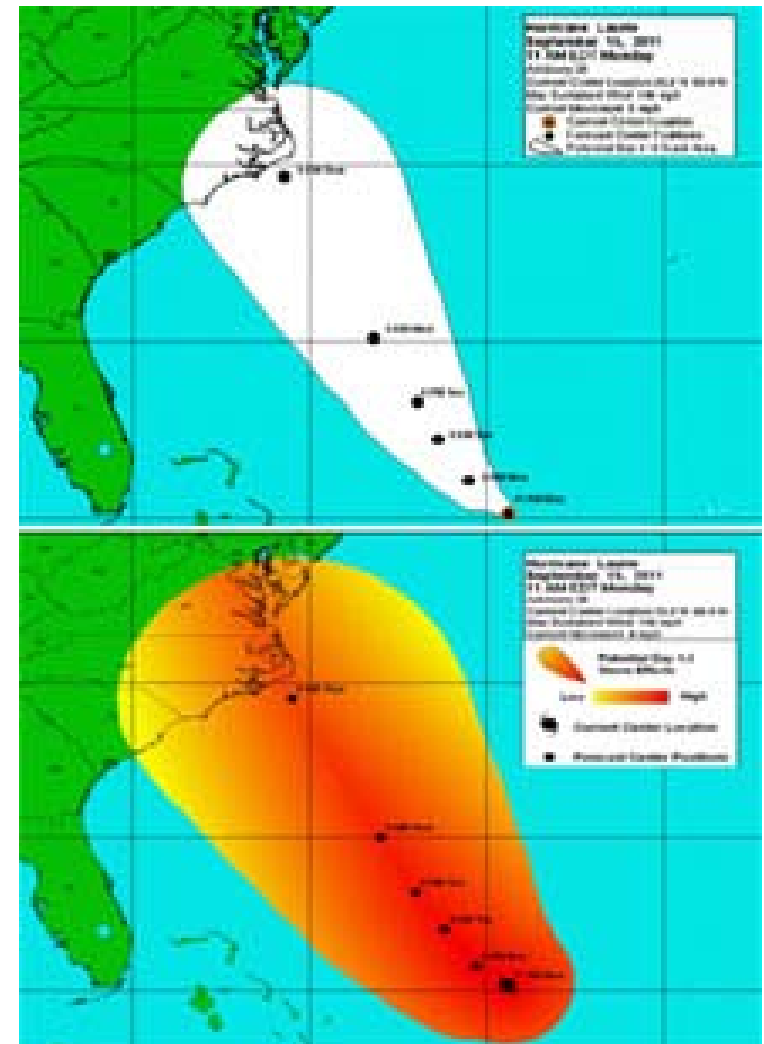
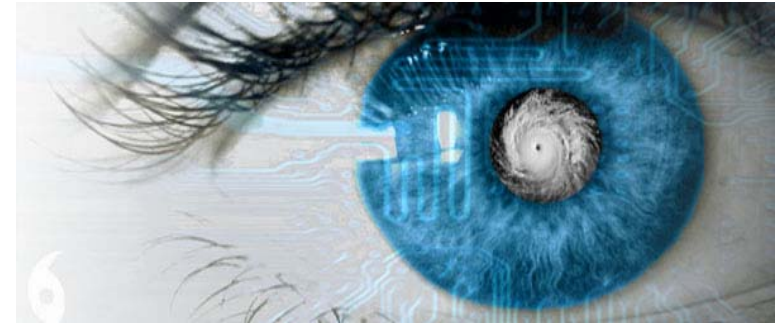
Project BioViz:

Geovisualization for Hurricane Risk Communication

- Geography
- Kinesiology
- Technical communications
- Economics



Allen, Crawford, Murray, Kain, and Gedminas



Invitation: 3rd Annual NC Hurricane Workshop

- May 23, 2012
- ECU, Greenville, NC
- 150+ EM professionals
- NWS, NGOs, media, medical, and institutional
- Focus on Hurricane Irene, risk communication
- <http://www.ecu.edu/renci/>
- <http://www.ecu.edu/hazards/>

