

Mapping and Visualizing SLR and Coastal Flooding Impacts

Doug Marcy

NOAA Coastal Services Center

Preparing for the Rising Tide:

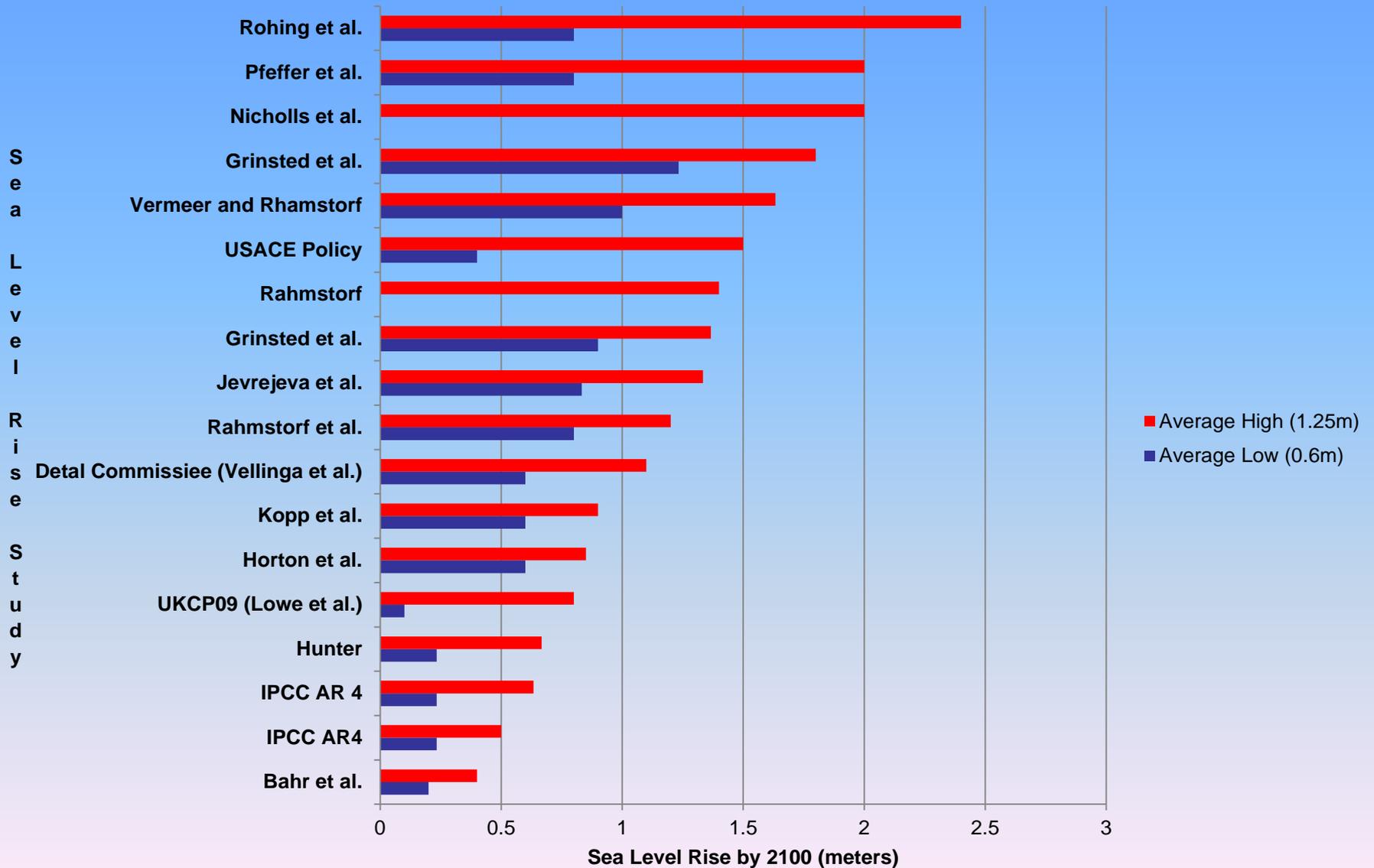
Adapting to Climate Change in the Mid-Atlantic

December 10 , 2012

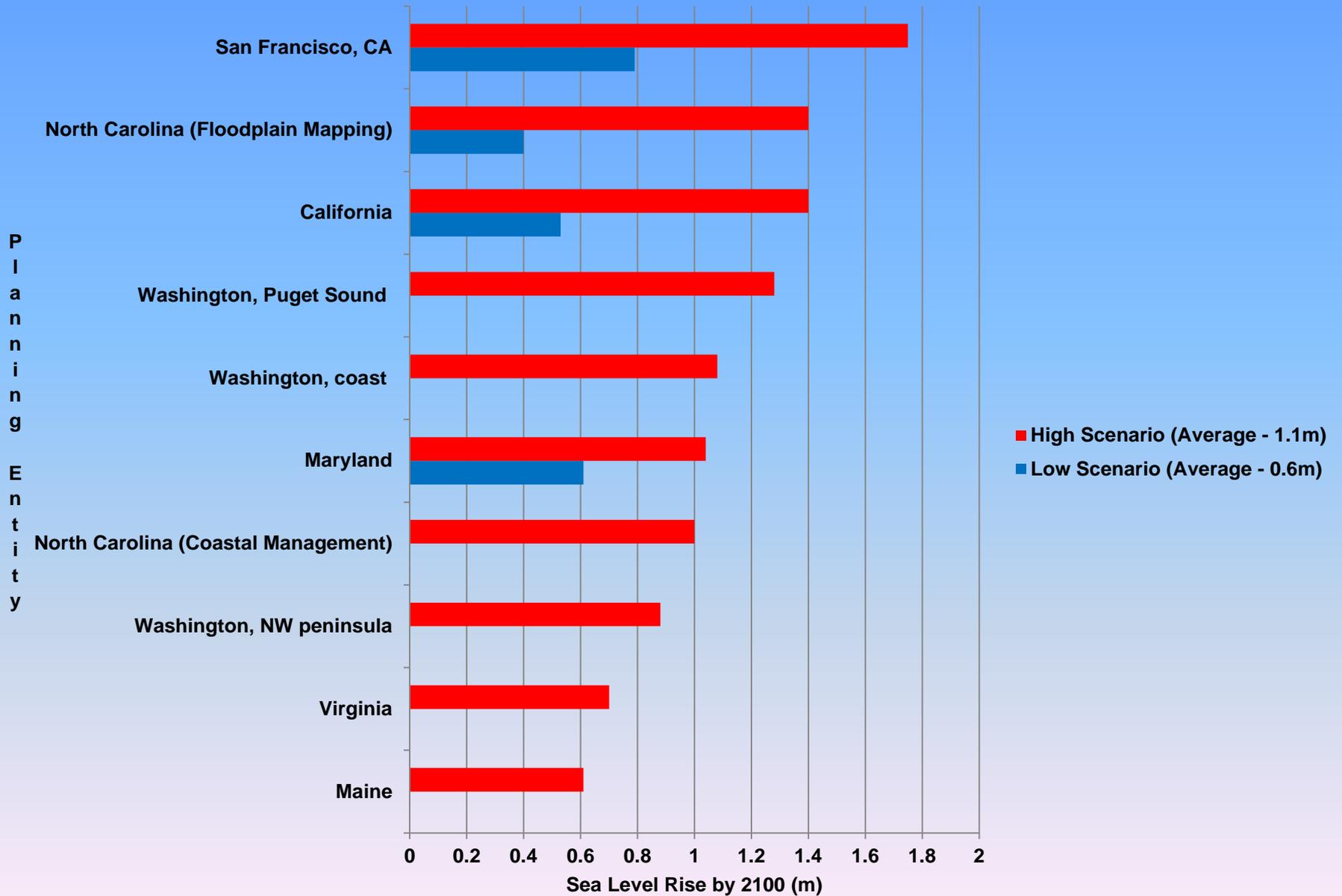


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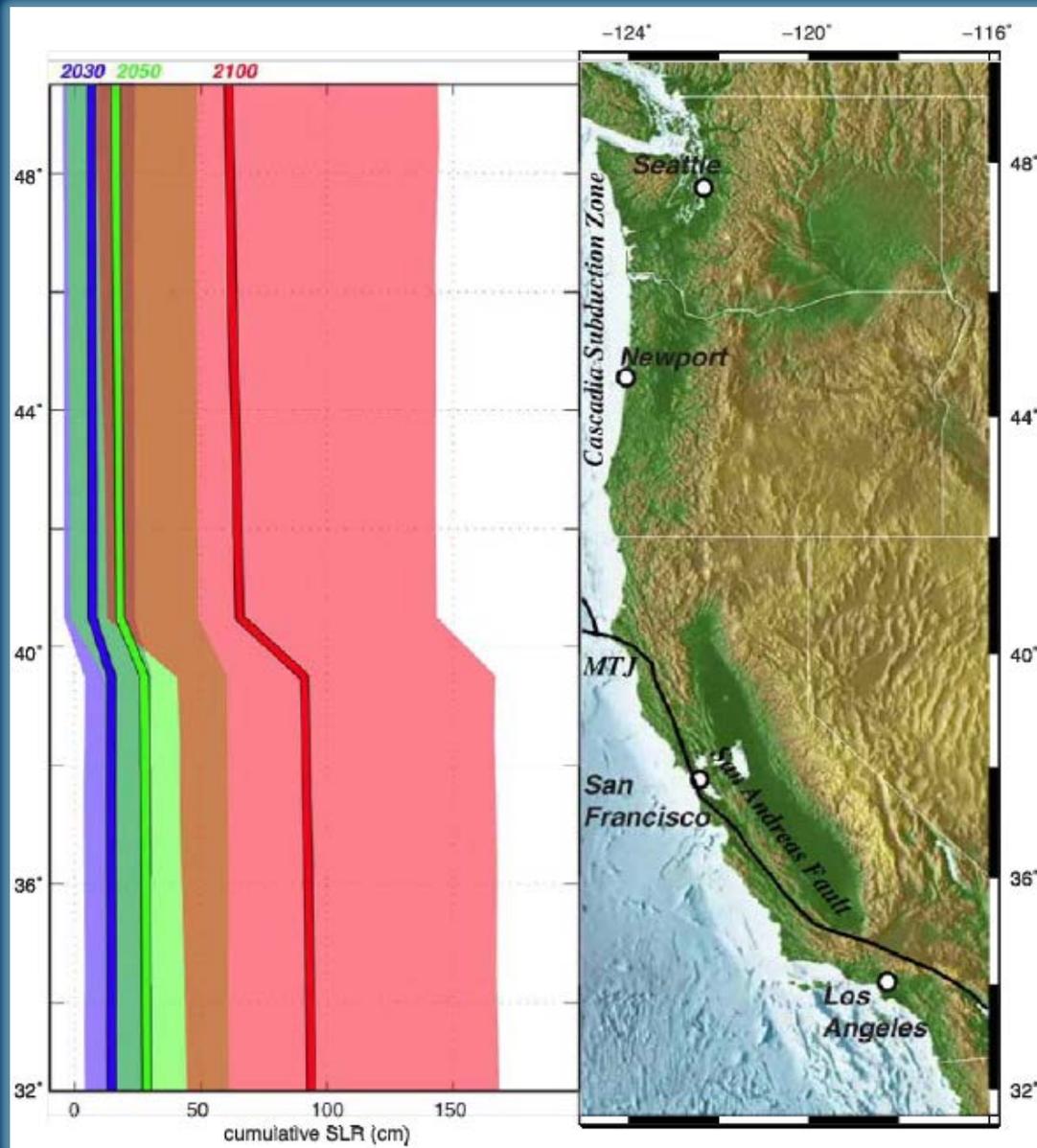
Sea Level Rise Projections (based on various climate scenarios)



Planning for Sea Level Rise



Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future – NRC, 2012



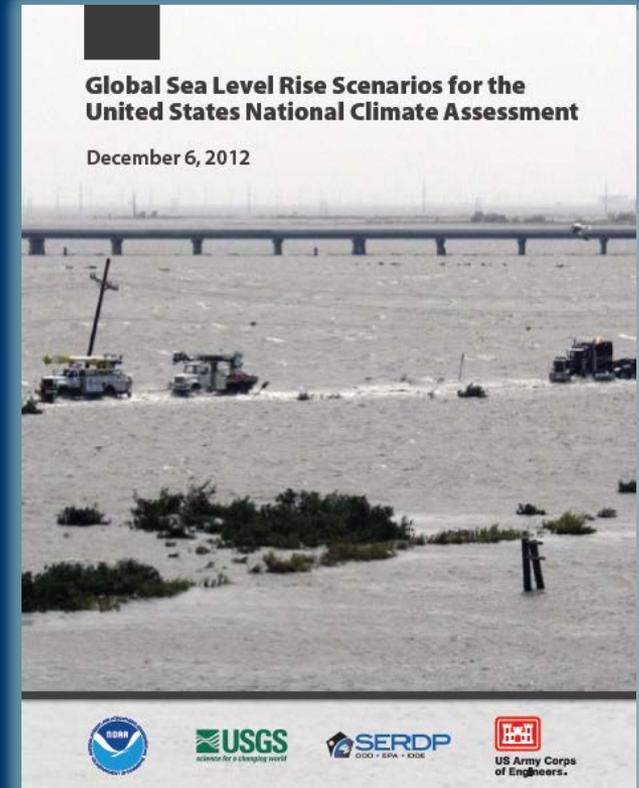
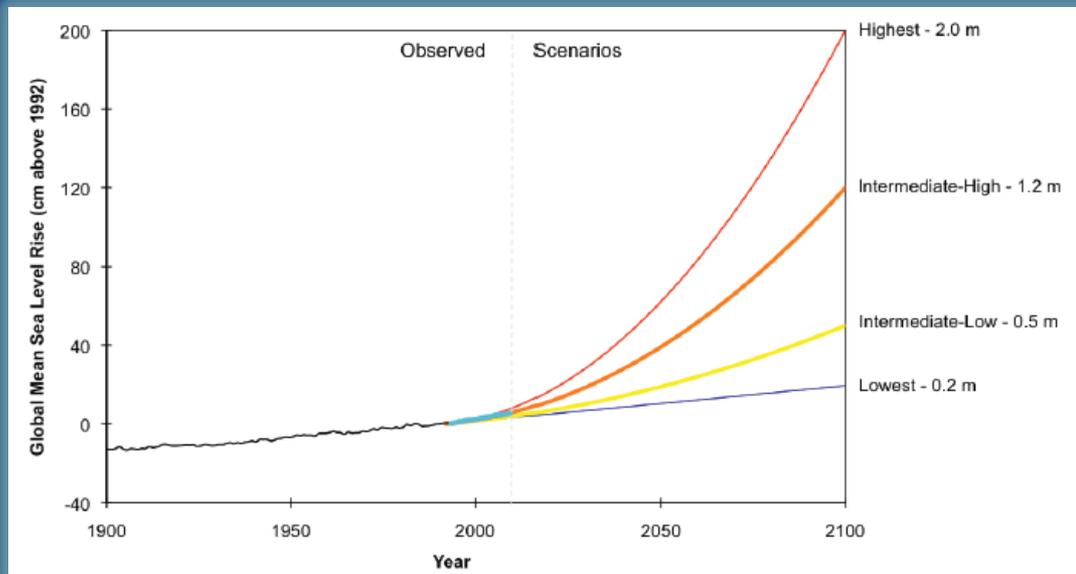
Earthquakes could cause an instantaneous rise of 1m



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Global Sea Level Rise Scenarios for the United States National Climate Assessment

<http://www.cpo.noaa.gov/reports/sealevel/>



Scenario	SLR by 2100 (m)*	SLR by 2100 (ft)*
Highest	2.0	6.6
Intermediate-High	1.2	3.9
Intermediate-Low	0.5	1.6
Lowest	0.2	0.7

* Using mean sea level in 1992 as a starting point.



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State, Regional, and County Needs

- Assistance with collection of consistent, standardized elevation data and avoidance of duplication
- Federal agency guidance and justification for flood, tide, and storm elevations for coastal areas to use for creating inundation models
- Methods and standards for mapping coastal inundation
- Simple sea level rise (SLR) visualization tools that show high-risk areas with possible future flooding problems so that land acquisition and adaptation planning can start now



When It Comes to Flood Mapping or Sea Level Rise Projection, Elevation Data Is the Key . . .

- 2009 National Research Council report “Mapping the zone: Improving Flood Map Accuracy”

Topographic/bathymetric data is the most important factor in determining the accuracy of flood maps

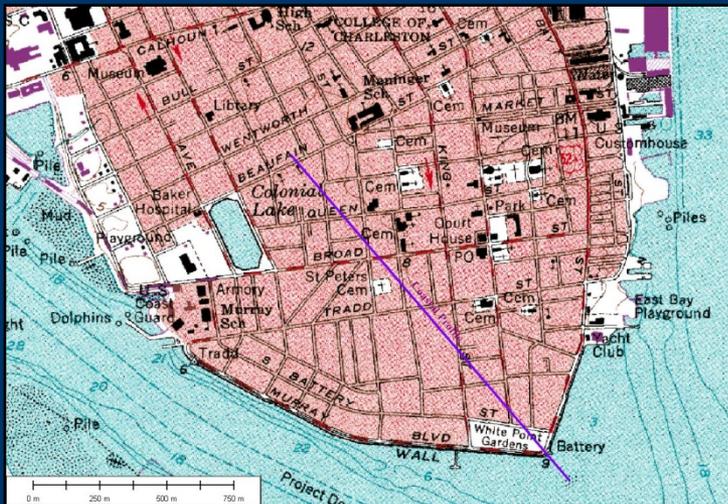
- Climate Change Science Program SAP 4.1, “Coastal Elevations and Sensitivity to Sea-Level Rise”

Sea level rise mapping requires high-resolution elevation data (Current national datasets {30m DEMs} are not adequate)

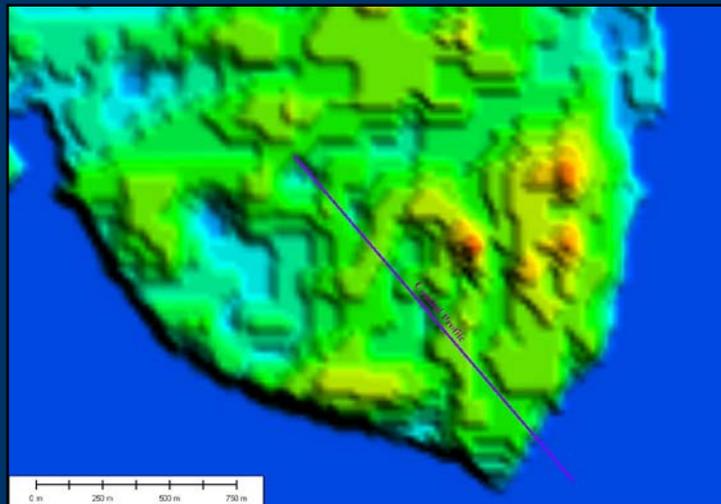


Importance of Elevation Data

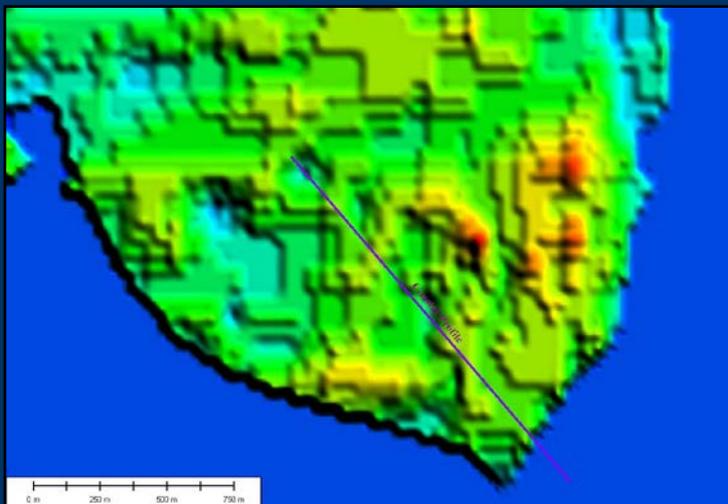
Profile in Charleston, South Carolina



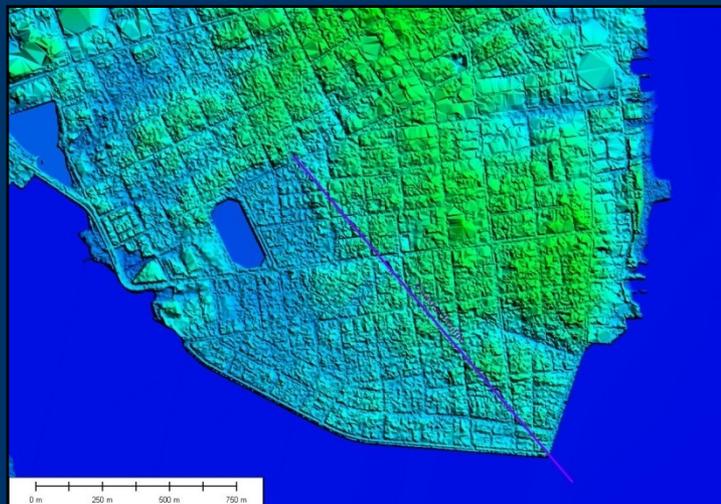
30-meter NED data (1 arc second)



10-meter NED data (1/3 arc second)

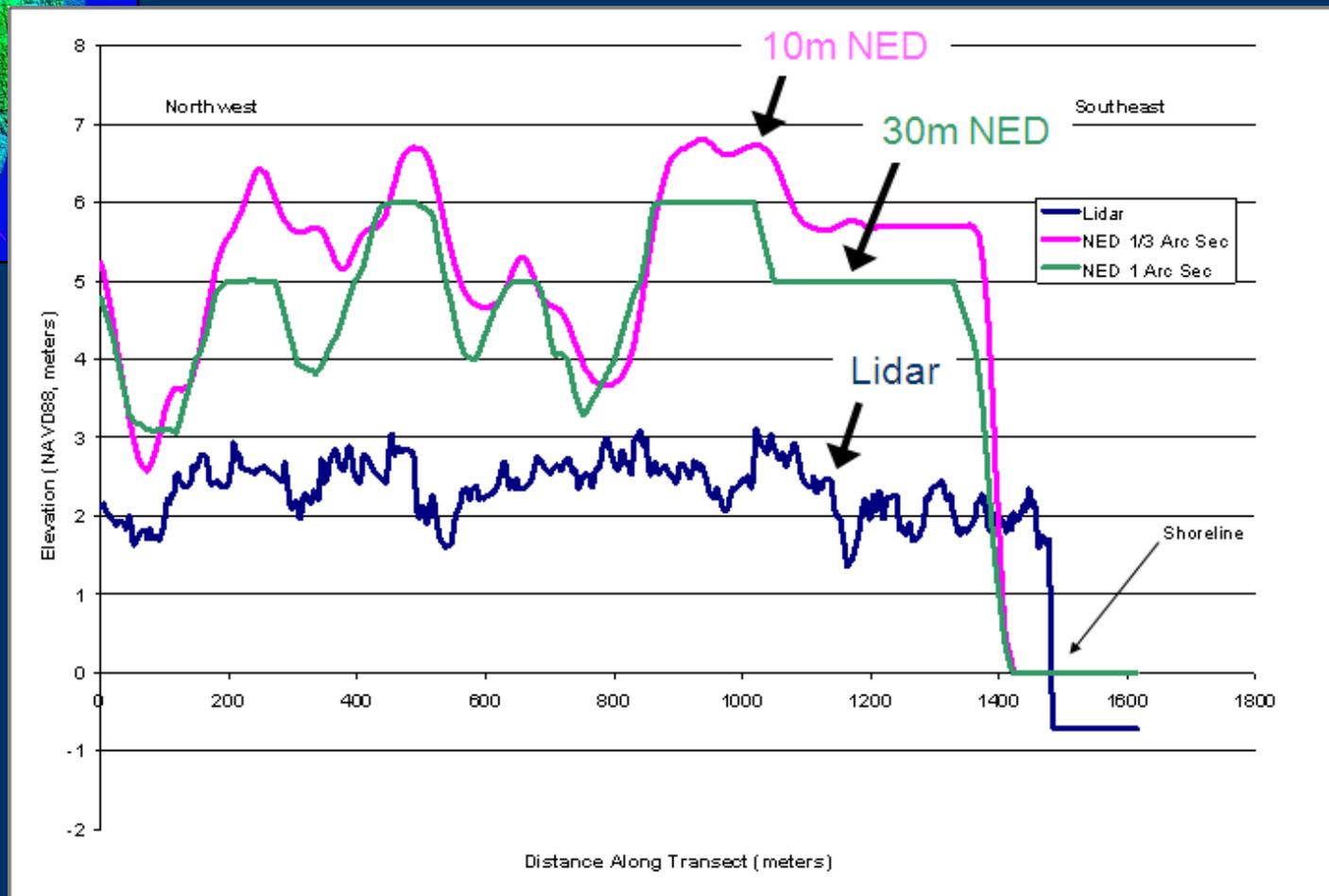
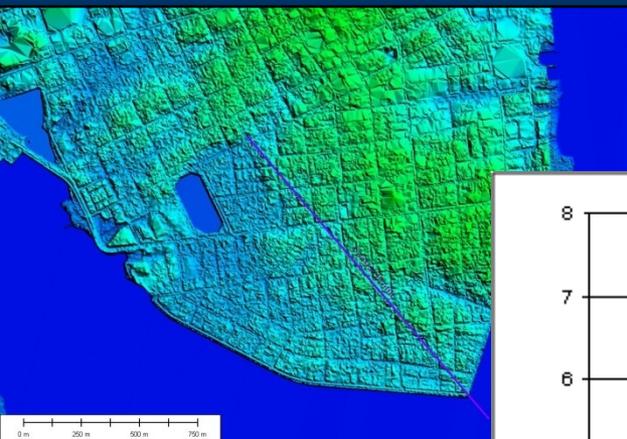


Lidar data



In Charleston, South Carolina Vulnerable Areas Are Lower Than We Thought

Up to 3 meters (10 feet) LOWER!!

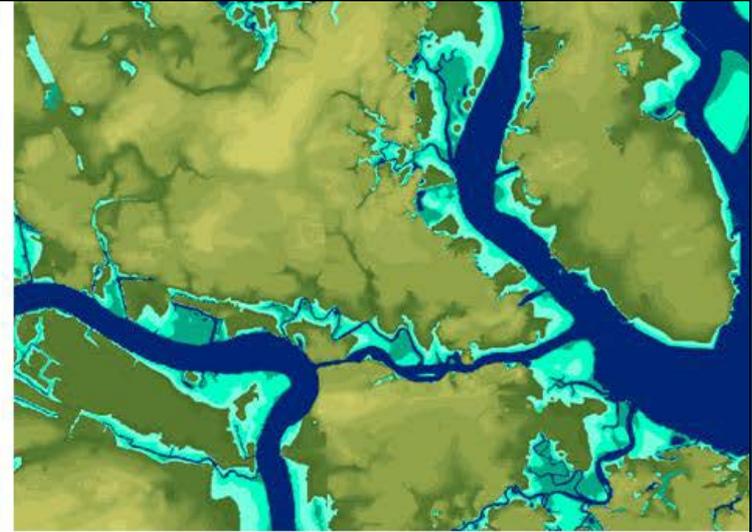
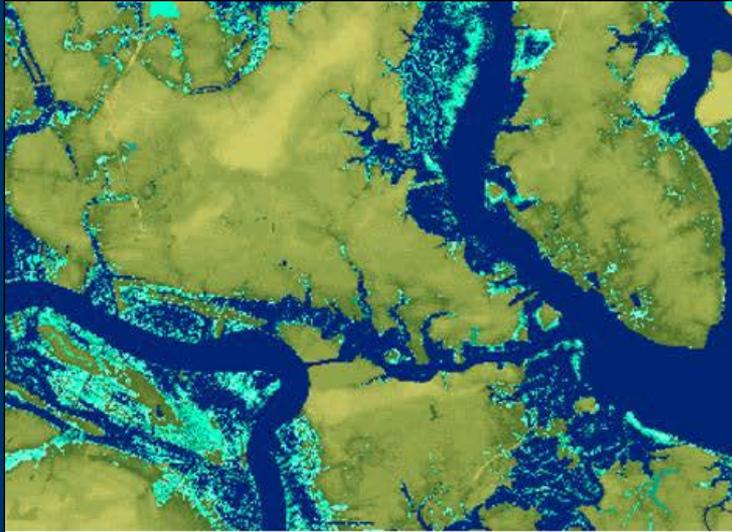


Digital Elevation Model (DEM) Accuracy and Mapping Results

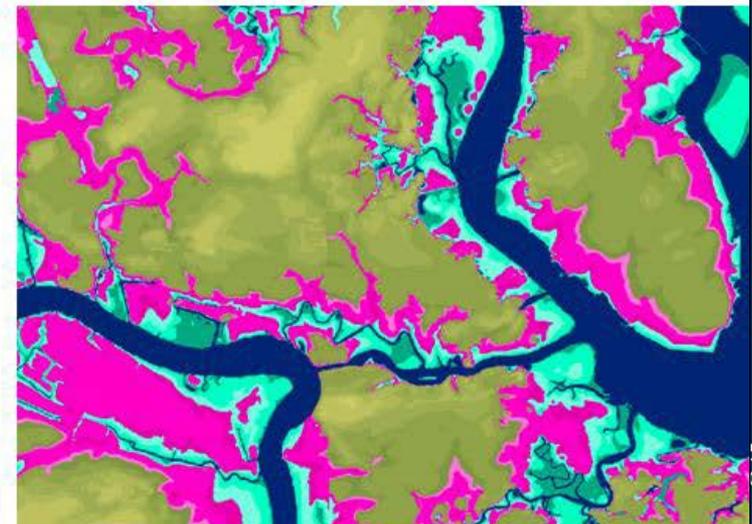
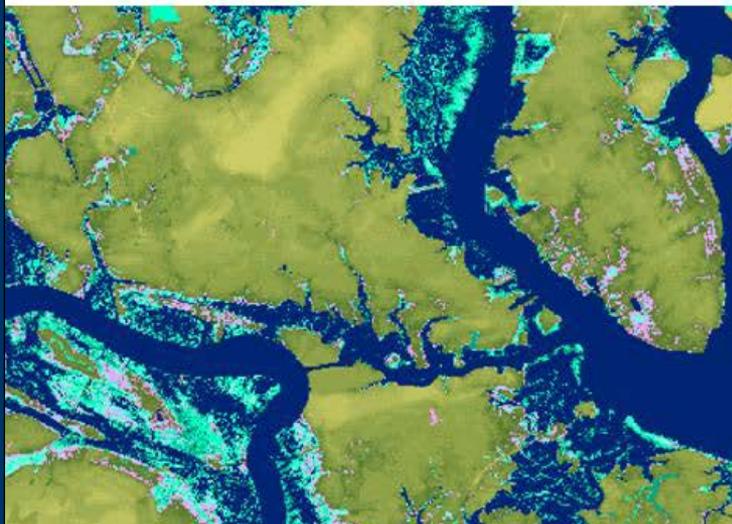
3-meter lidar DEM
VA = ~20 centimeters)

10-meter NED DEM
(VA = ~1 meter)

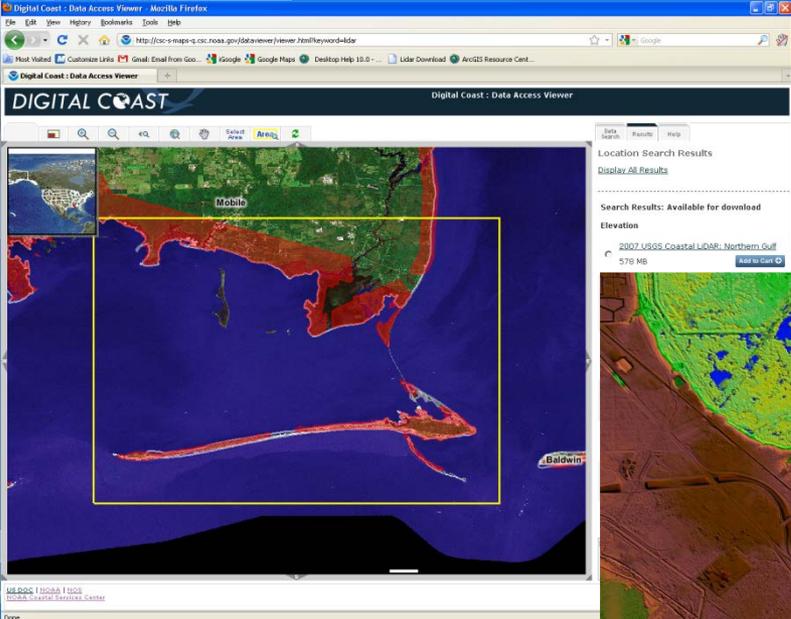
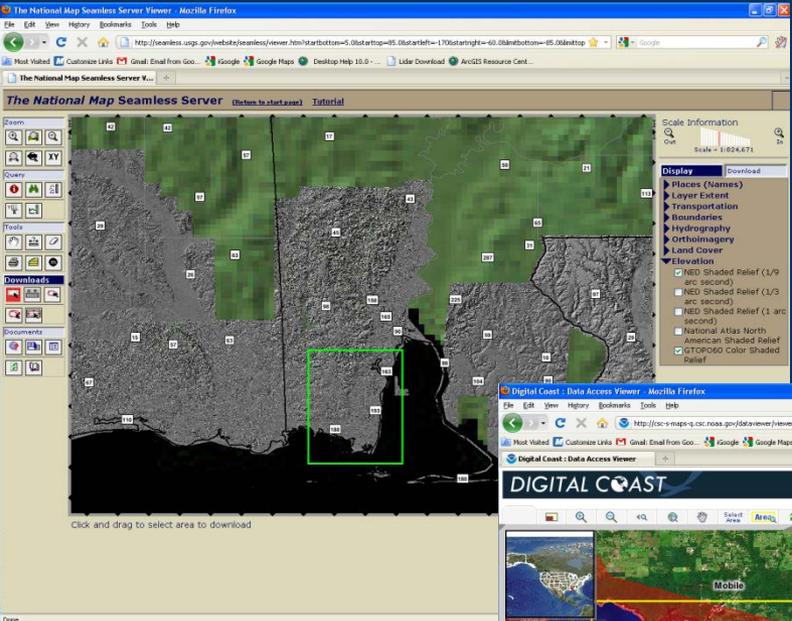
0.5-meter
SLR



0.5-meter SLR
+ 1 root mean
square error
(RMSE)

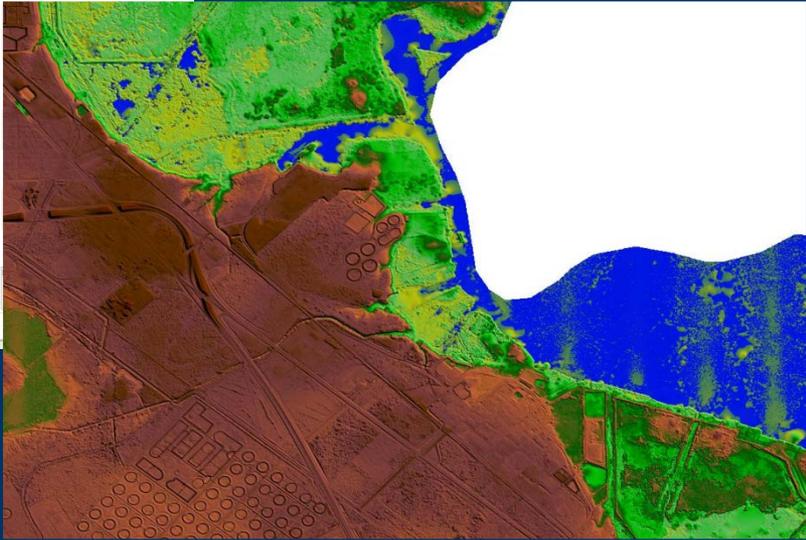


Build Best Terrain Available

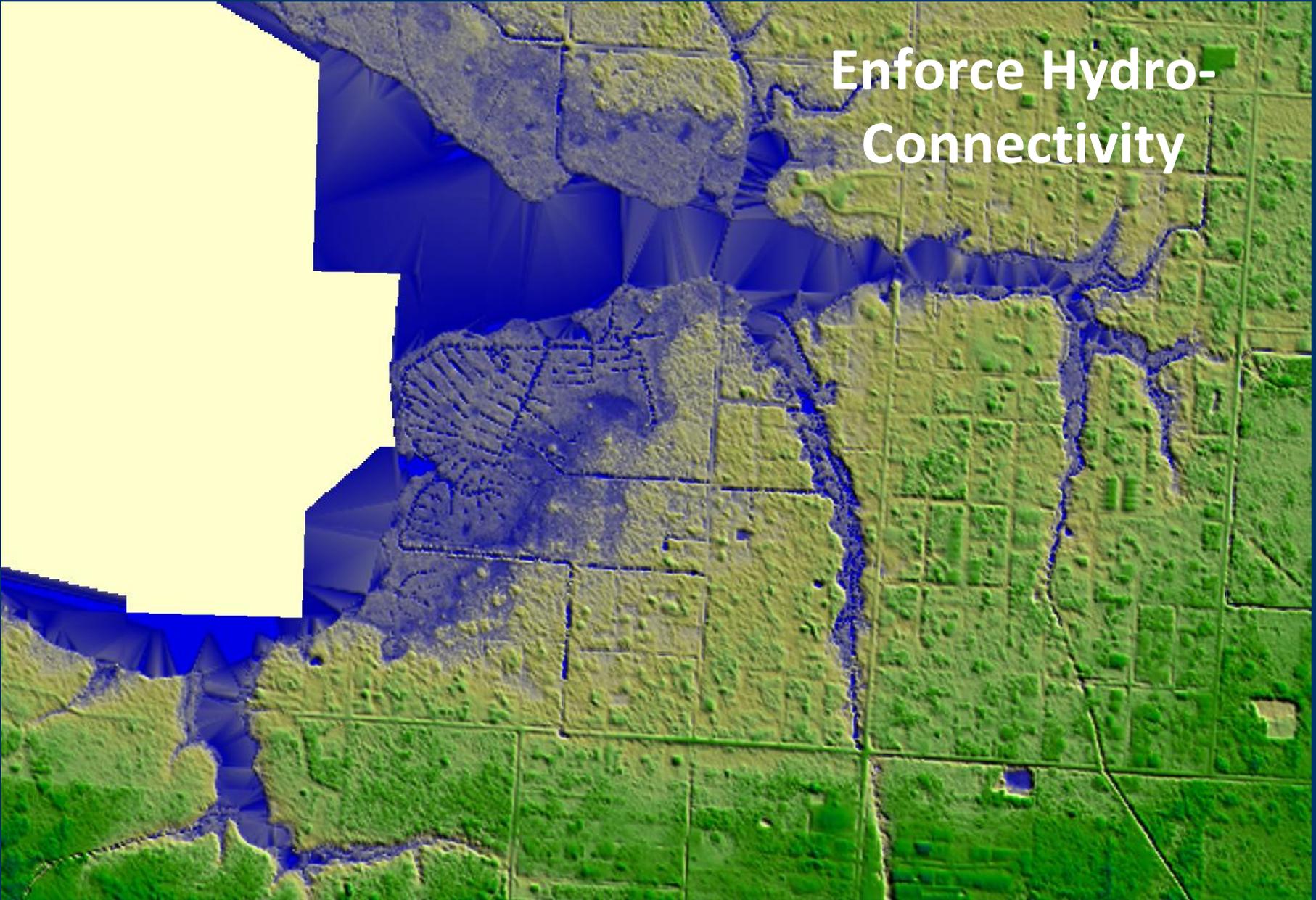


NED

Digital Coast - JABLTCX

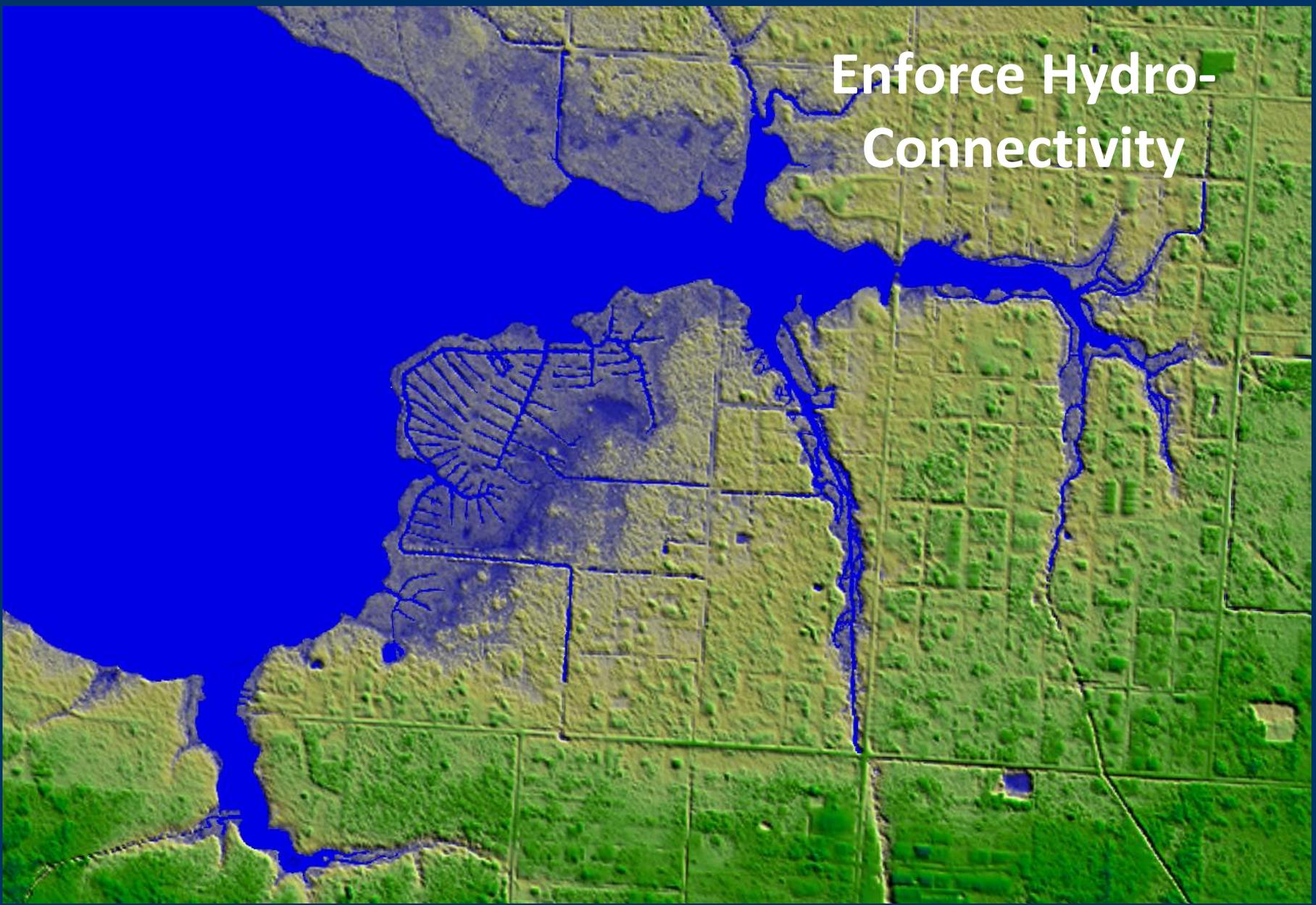


Enforce Hydro-Connectivity



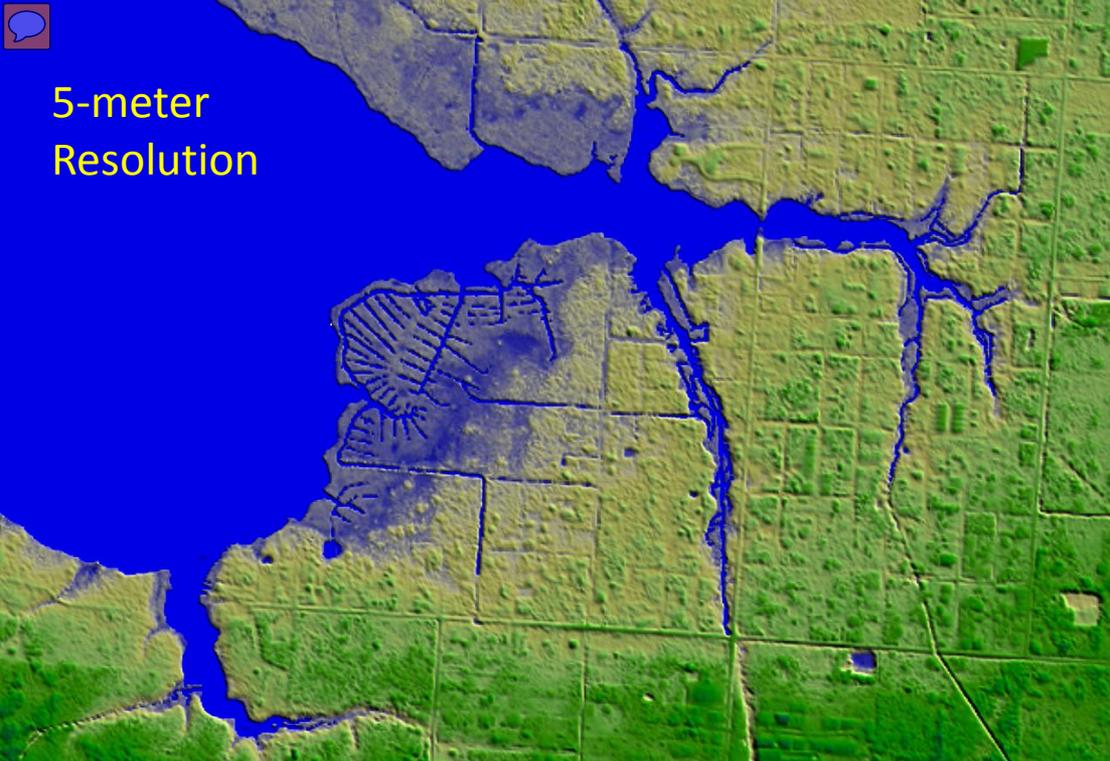


Enforce Hydro-Connectivity



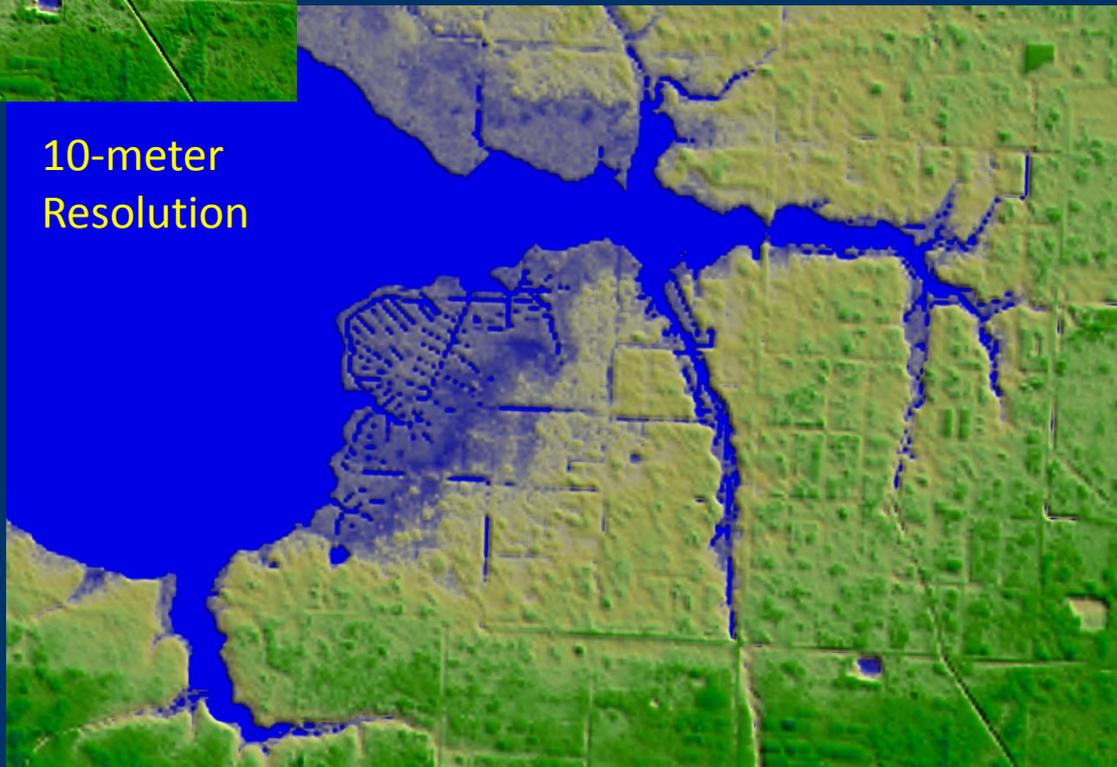


5-meter
Resolution

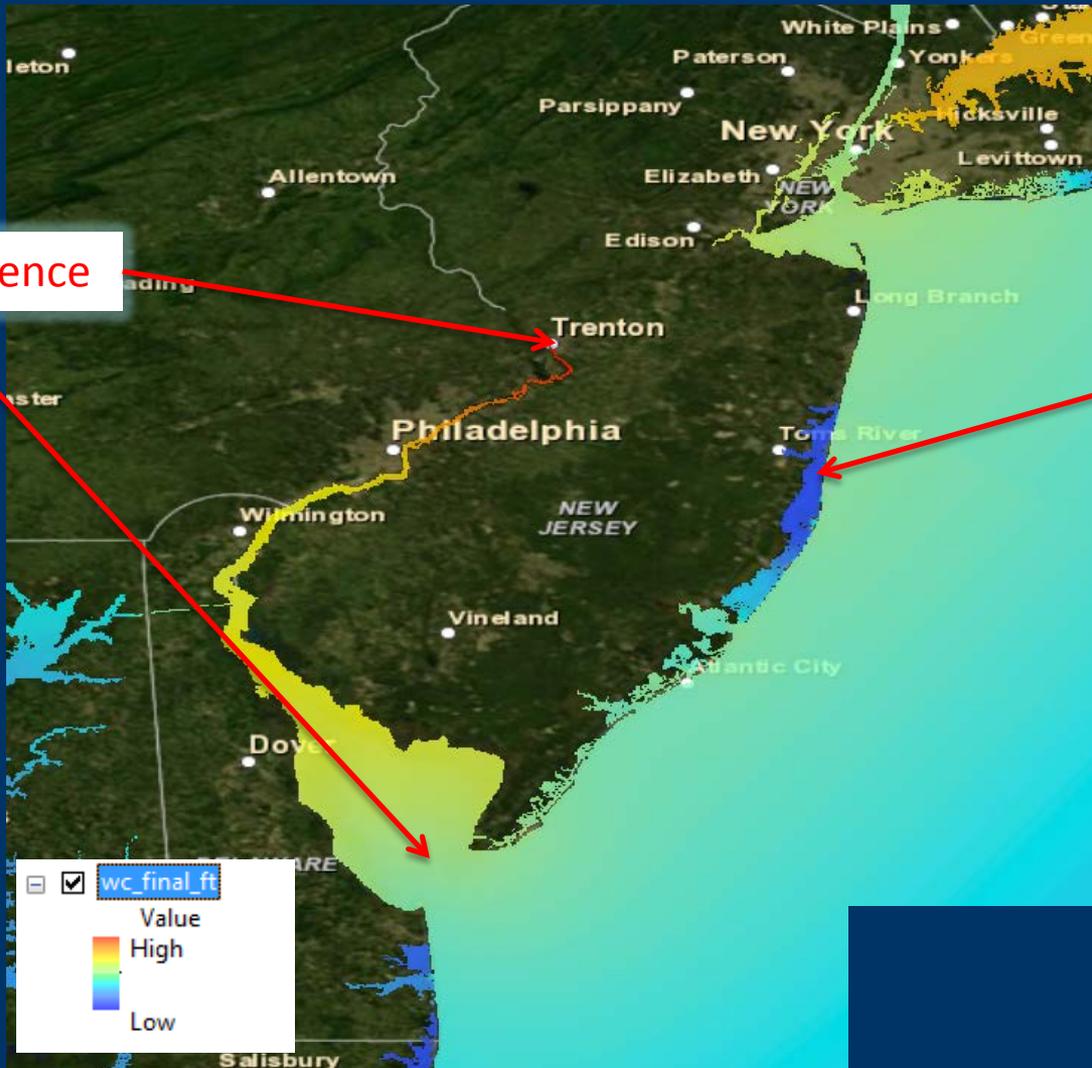


Resolution Requirements

10-meter
Resolution



The Ocean Is Not a Flat Surface (especially in bays and estuaries)



~3 foot difference

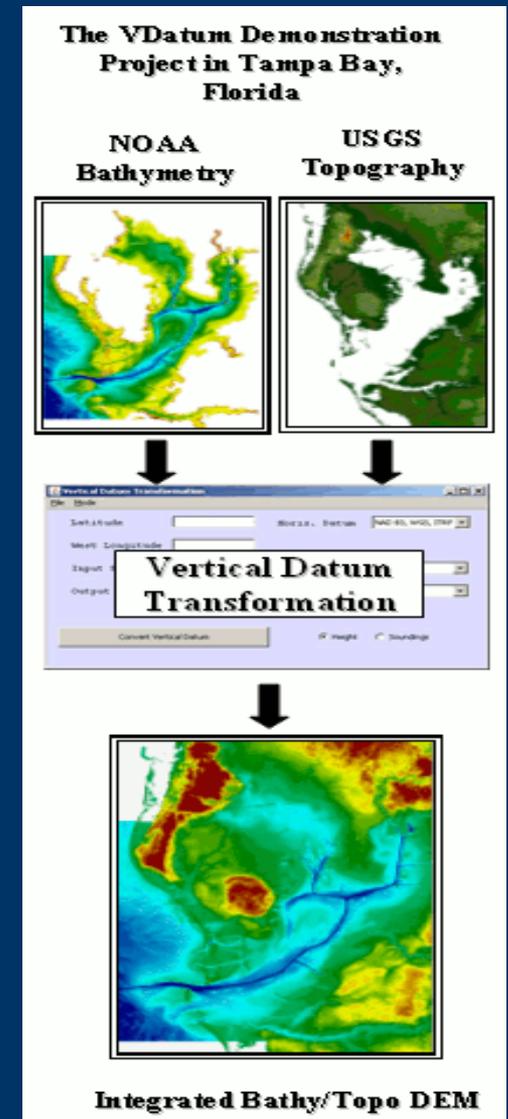
~2 foot difference

MHW
Tidal Surface

Vertical Transformation

Using VDatum to convert between tidal, orthometric, and ellipsoidal datums

- Vertical Datum Transformation Tool
- Developed jointly by NOAA's Office of Coast Survey and the National Geodetic Survey
- Provides a method to accurately combine topographic (orthometric) and bathymetric (tidal) elevation data
- Application is limited to the region it was developed for



State, Regional, and County Needs

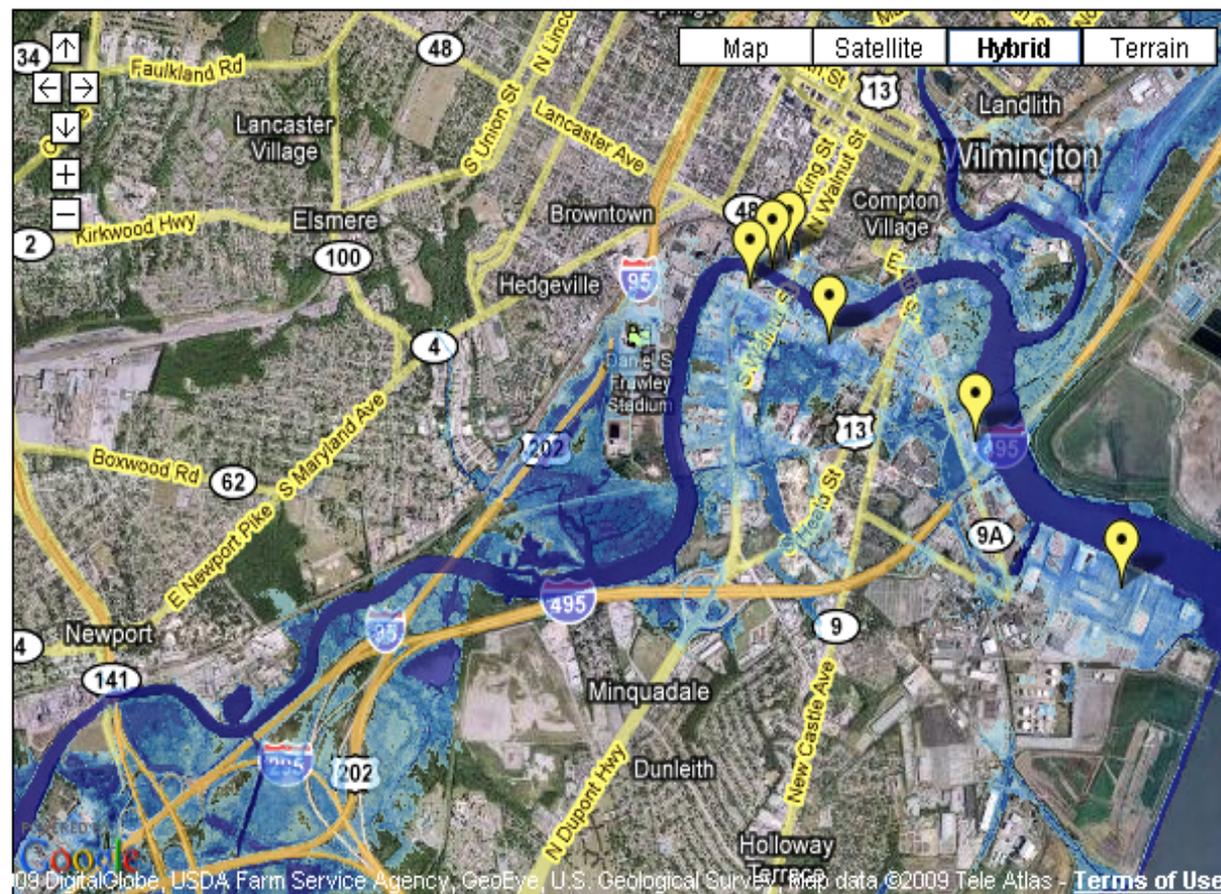
- Simple visualization tools
- Show potential impacts of SLR scenarios
- Show how everyday tidal flooding will become worse and more frequent

Building on local pilot studies and recommendations from communities of practice





SEA LEVEL RISE IMPACTS FOR WILMINGTON, DELAWARE



Sea Level Rise: 4 ft



This map shows potential flooding, or inundation, caused by sea level rise. Use the slider bar to view the extent.

The map illustrates the scale of potential flooding, not the exact location, and does not account for erosion, subsidence, or future construction. Water levels are shown as they would appear during an average high tide (mean high water). Rising sea levels will cause daily high tides to reach farther inland.

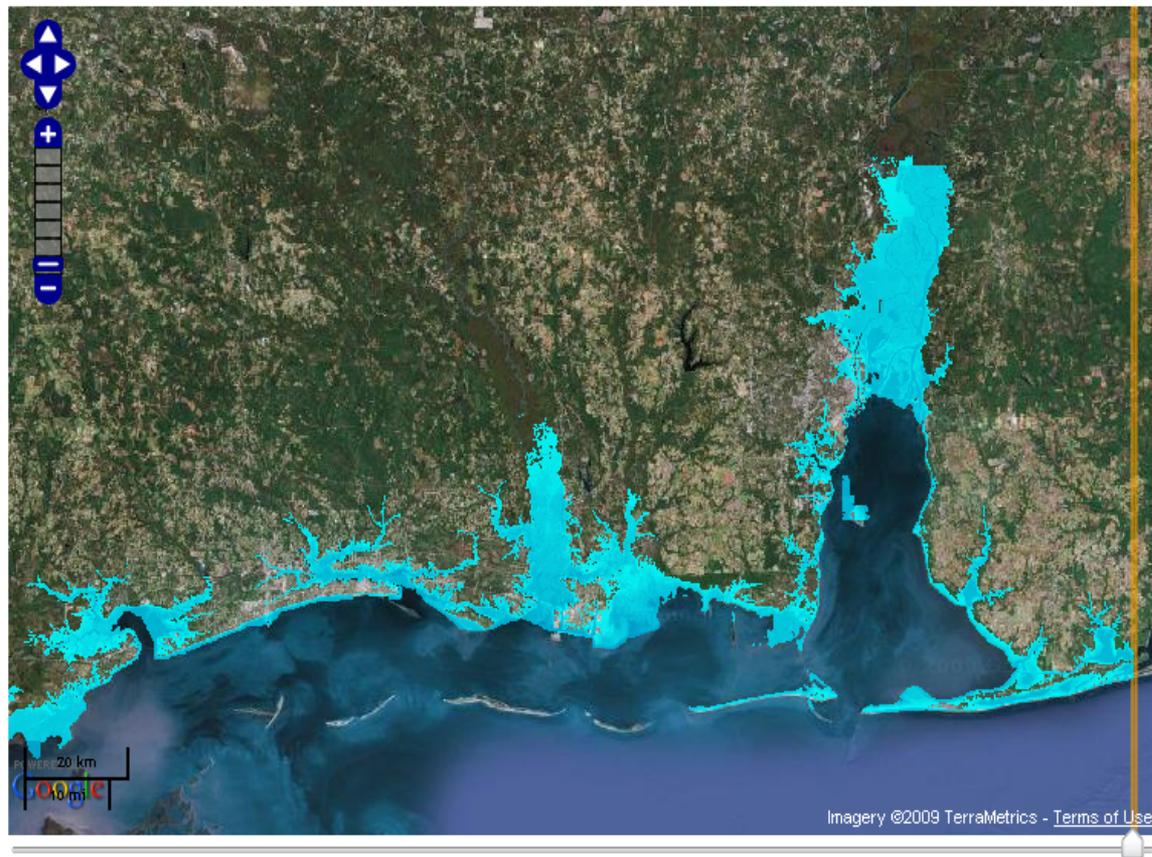
Places of interest vulnerable to sea level rise.

Note: Flood layers may take a moment to load.

View the [Flood Frequency Predictions](#)

This pilot project is a collaborative effort of NOAA, the U.S. Geological Survey, and the Delaware Department of Natural Resources.

SEA LEVEL RISE VISUALIZATION FOR ALABAMA AND MISSISSIPPI



Background Layer

- Maps
- Satellite
- Satellite+Labels
- Terrain

Overlay Layer

- Population

Population count in 2000

0  1000+

Transparency



Magnitude of Sea Level Rise

- 1ft
- 3ft
- 6ft

Water depth (ft)

0  25.194

Transparency



Select a scenario to view the extent of potential flooding, or inundation, caused by 1 foot, 3 foot, or 6 foot sea level rise on coastal Alabama and Mississippi.

Address Finder

Enter your address to locate it on the map.

The orange line marks the edge of the Sea Level Rise map. Move the slider to change the visible area.

Hold **Shift** and drag to zoom in to a particular area.

The map illustrates the scale of potential flooding, not the exact location, and does not account for erosion, subsidence, or future construction. Water levels are shown as they would appear during an average high tide. Rising sea levels will cause daily high tides to reach farther inland.

Addressing the Needs to Build a Better Tool

1. Sea Level Rise and Inundation Community Workshop “Executive Summary” (December 2009) www.csc.noaa.gov/publications/inundation-workshop.html
 - Defining needed data and tools for adaptation planning
2. *Technical Considerations for Use of Geospatial Data in Sea Level Change Mapping and Assessment* (September 2010)
www.csc.noaa.gov/publications/slc_tech.pdf
 - Technical guidance for sea level change monitoring and mapping
3. *Coastal Sea-Level Change Societal Challenge Needs Assessment Report* (October 2011) – www.floods.org/ace-files/documentlibrary/committees/Coastal/NOAA_Coastal_Sea_Level_Change_Societal_Challenge_Needs_Assessment_Report.pdf
 - Defining needed tools, education, and communication for decision-making



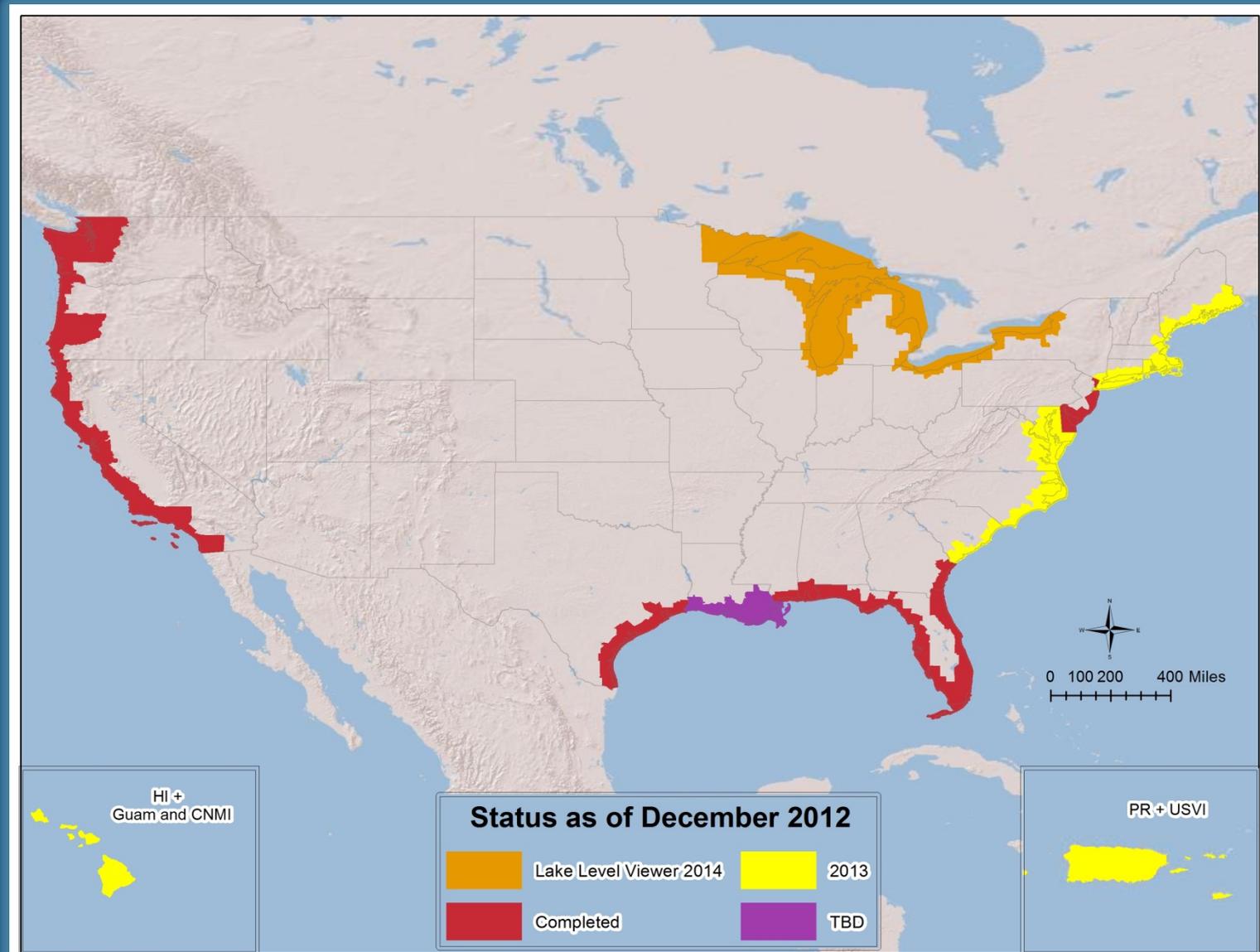
Sea Level Rise and Coastal Flooding Impacts Viewer

www.csc.noaa.gov/slr



* Working with U.S. Geological Survey, Sea Grant, Gulf Coast Services Center, Digital Coast Partners, National Ocean Service's Center for Operational Oceanographic Products and Services (CO-OPS), Dewberry, University of South Carolina, Bureau of Labor Statistics.

Current Geographies



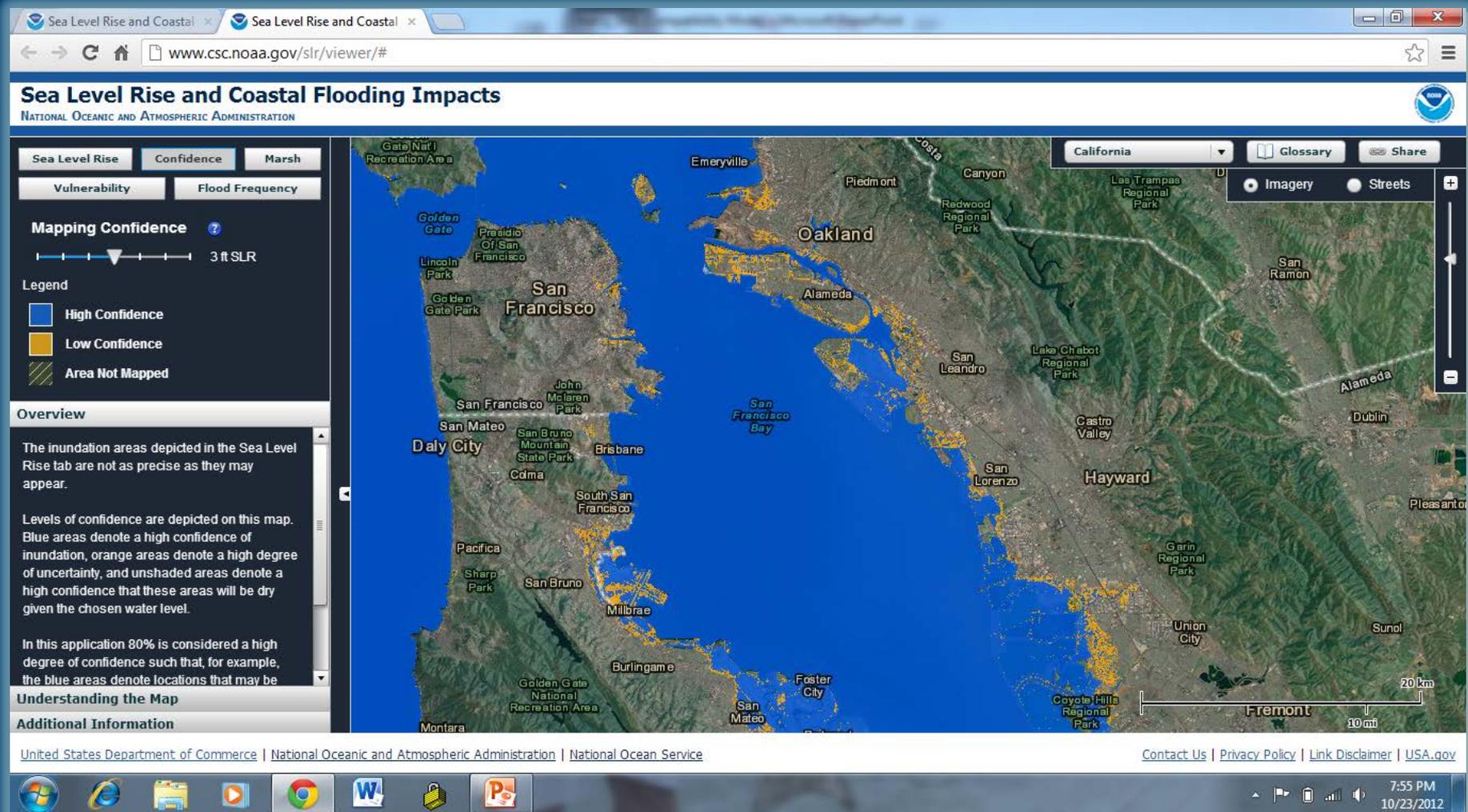
Impacts of Sea Level Rise

- Visualize impacts for mean higher high water (MHHW) 6-foot SLR scenarios overlaid on aerial imagery, street map, and terrain map. Photos of SLR on individual structures will illustrate site-specific impacts.

The screenshot displays the NOAA Sea Level Rise and Coastal Flooding Impacts viewer. The browser address bar shows the URL www.csc.noaa.gov/slr/viewer/#. The page title is "Sea Level Rise and Coastal Flooding Impacts" with the NOAA logo. The interface includes a left-hand navigation panel with tabs for "Sea Level Rise", "Confidence", and "Marsh". Under "Sea Level Rise", there are sub-tabs for "Vulnerability" and "Flood Frequency". A slider bar is set to "3 ft SLR". The legend identifies "Water Depth" (shades of blue), "Low-lying Areas" (green), and "Area Not Mapped" (hatched). The "Overview" section explains that blue shades represent inundation at high tide, with darker blue indicating greater depth, and green areas are hydrologically "unconnected" low-lying areas. The map shows the San Francisco Bay Area with various cities and parks labeled, such as San Francisco, Oakland, Alameda, San Mateo, and Daly City. A scale bar at the bottom right indicates 20 km and 20 miles. The footer contains links for "United States Department of Commerce", "National Oceanic and Atmospheric Administration", "National Ocean Service", "Contact Us", "Privacy Policy", "Link Disclaimer", and "USA.gov". The system tray at the bottom shows the date and time as 7:53 PM on 10/23/2012.

Communicate Mapping Confidence

- Visualize the mapping confidence of inundation area based on uncertainty of elevation data and MHHW tidal surface.



Visualize Marsh Impacts

- Visualize the impacts of SLR scenarios on marshes using Coastal Change Analysis Program (C-CAP) data.

The screenshot displays the NOAA Coastal Change Analysis Program (C-CAP) viewer interface. The browser address bar shows the URL www.csc.noaa.gov/slr/viewer/#. The page title is "Sea Level Rise and Coastal Flooding Impacts" from the National Oceanic and Atmospheric Administration.

The interface includes a left-hand navigation panel with the following sections:

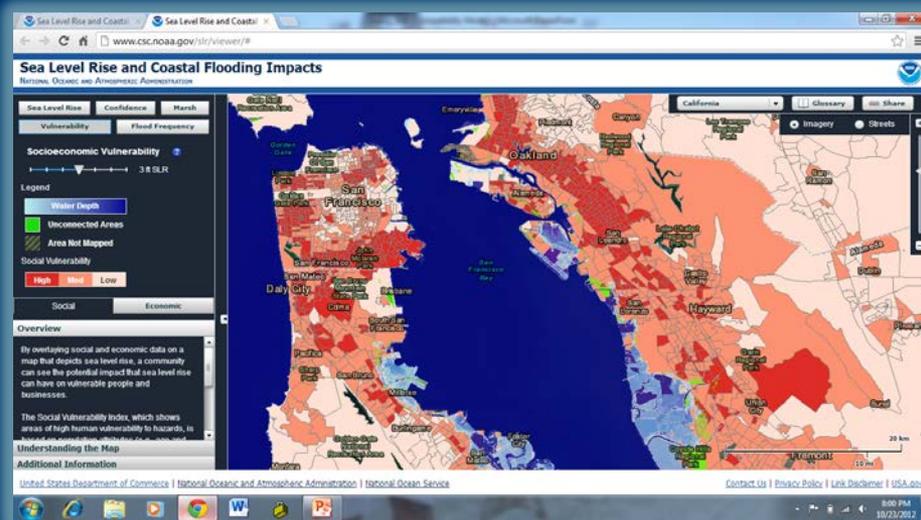
- Sea Level Rise**: Includes "Vulnerability" and "Flood Frequency" tabs.
- Marsh Impacts/Migration**: A slider set to "3 ft SLR".
- Advanced Options**: A dropdown menu.
- Legend**: A list of land use categories with corresponding color swatches:
 - High Intensity Developed (Dark Grey)
 - Medium Intensity Developed (Light Grey)
 - Low Intensity Developed (Medium Grey)
 - Developed Open Space (Light Green)
 - Upland (Light Brown)
 - Freshwater Forested Wetland (Dark Green)
 - Freshwater Shrub Wetland (Orange)
 - Freshwater Emergent Wetland (Pink)
 - Brackish/Transitional Marsh (Purple)
 - Saltwater Marsh (Light Purple)
 - Unconsolidated Shore (Cyan)
 - Water (Dark Blue)
- Overview**, **Understanding the Map**, and **Additional Information** sections.

The main map area shows the San Francisco Bay Area, including cities like San Francisco, Oakland, Alameda, San Mateo, and Hayward. The map is overlaid with various colors representing different land use and marsh impact scenarios. A legend on the left explains these colors. The map also includes a scale bar (0 to 20 km) and a "Share" button.

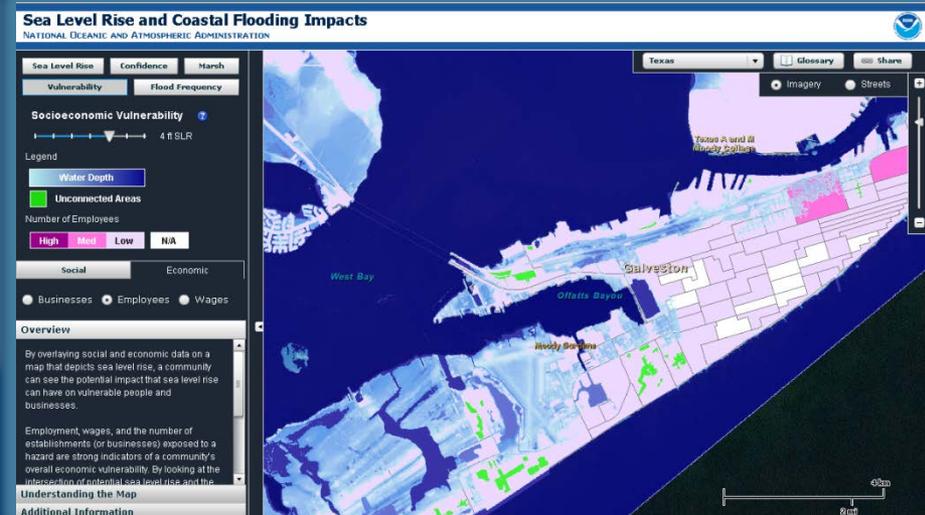
At the bottom of the browser window, the taskbar shows the Windows Start button, Internet Explorer, File Explorer, and other applications. The system tray displays the time as 7:56 PM on 10/23/2012.

Social and Economic Vulnerability

- Include Social Vulnerability Index (SOVI) from USC and data from Bureau of Labor Statistics (BLS) showing impacts on society and economy.



Social Vulnerability Index (Cutter)



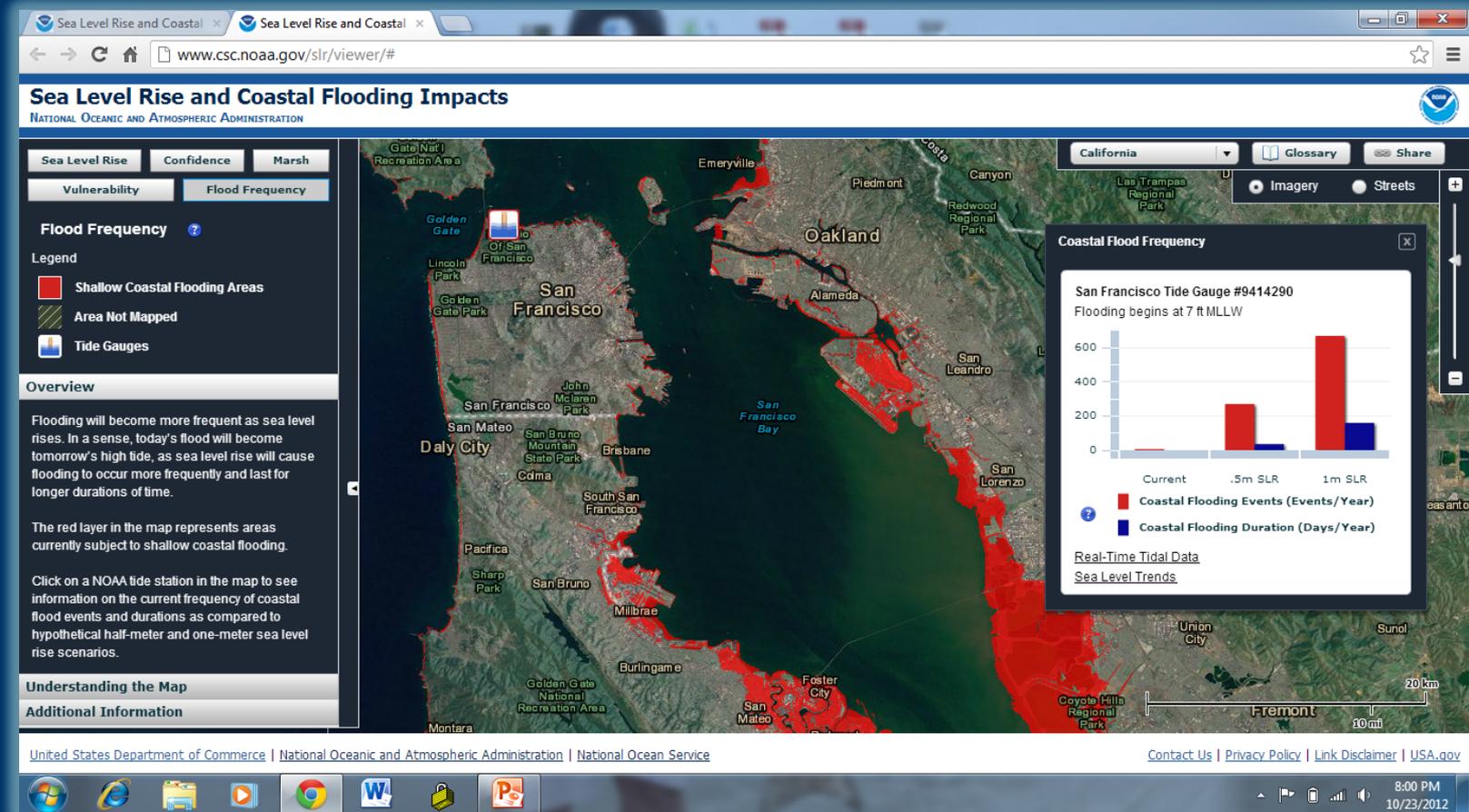
Bureau of Labor Statistics (Department of Labor)

- *Businesses*
- *Employees*
- *Wages*

Coastal Flood Frequency

- Communicate that today's flood is tomorrow's high tide. Use three years of observed water level data at National Ocean Service National Water Level Observation Network (NWLON) stations to show increased frequency of everyday flooding.

0.5m 270 times/30 days
1.0m 667 times/135 days



Future: Increase Geography and Regional Implementation

- Louisiana (on hold)
 - NY, MD, VA
 - Pacific
 - Northeast
 - Southeast
 - Caribbean
 - Great Lakes
- San Francisco Bay – Adapting to Rising Tides and OCOF
 - California Coastal Conservancy
 - **New Jersey – Rutgers**
 - **EPA Climate Ready Estuaries**
 - South Florida Climate Compact (Seven / 50)
 - TNC and U. of Southern MS Gulf of Mexico Coastal Resilience Project
 - EPA Point Source Outfalls
 - National Park Service Coastal Parks Assessment
 - U.S. Army Corps Projects Evaluation
 - HI Sea Grant and U. of Hawaii School of Ocean and Earth Sci. (NOAA Coastal Storms Program)
 - NCCOS N. Gulf Ecological Effects of SLR project



Data Distribution



Lots of Layers

- Conditioned DEMs
- SLR layers
- Marsh migration layers
- Uncertainty layers
- Shallow coastal flooding layer
- Social Vulnerability Index data
- Bureau of Labor Statistics data

Lots of Ways to Distribute

- Raster geodatabases via HTTP
- Representational State Transfer (REST) page
- Feature and Image services
- Enabling mash-up applications



Available via NOAA Digital Coast

www.csc.noaa.gov/digitalcoast/

DIGITAL COAST
NOAA Coastal Services Center

Home About Data Tools Training Approaches ▾ In Action

Tools

Sea Level Rise and Coastal Flooding Impacts Viewer

NOAA Coastal Services Center

Overview

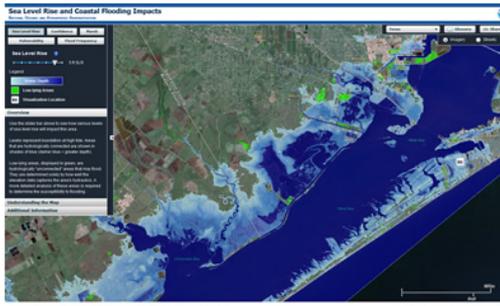
Support

Get It Now

Overview

Being able to visualize potential impacts from sea level rise is a powerful teaching and planning tool, and the Sea Level Rise Viewer brings this capability to coastal communities. A slider bar is used to show how various levels of sea level rise will impact coastal communities. The initial project areas include Mississippi, Alabama, and parts of Texas and Florida, with additional coastal counties to be added in the near future. Visuals and the accompanying data and information cover sea level rise inundation, uncertainty, flood frequency, marsh impacts, and socioeconomics.

Launch Now



Features

- Displays** potential future sea levels
- Provides** simulations of sea level rise at local landmarks
- Communicates** the spatial uncertainty of mapped sea levels
- Models** potential marsh migration due to sea level rise
- Overlays** social and economic data onto potential sea level rise
- Examines** how tidal flooding will become more frequent with sea level rise

Acknowledgements

The NOAA Coastal Services Center would like to acknowledge those organizations that provided direct content used in this tool or feedback, ideas, and reviews over the course of the tool's development. Specifically the Center would like to acknowledge the [following groups](#).



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Questions?

www.csc.noaa.gov/slr

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