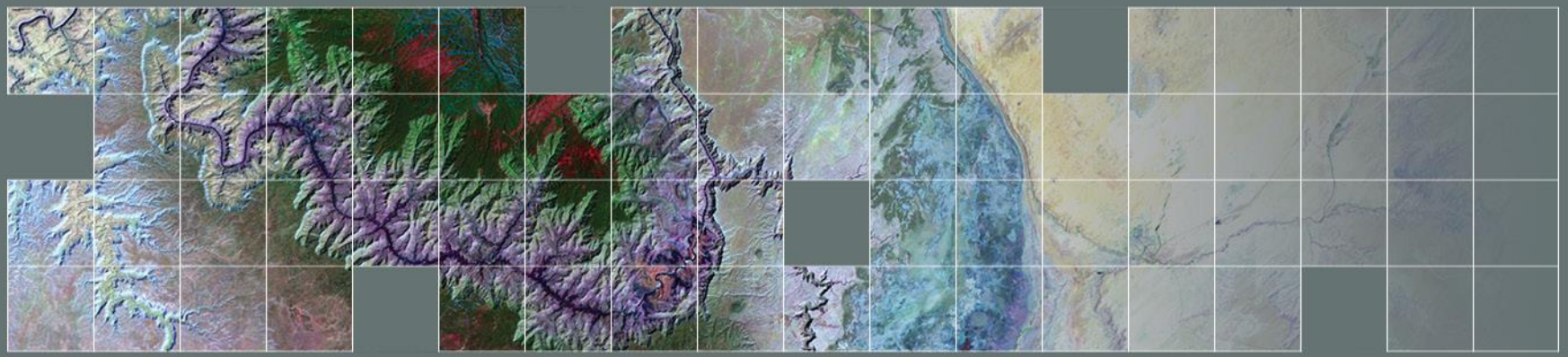
Climate and Land Use Change

Earth Resources Observation and Science (EROS) Center

The USGS Coastal National Elevation Database (CoNED): Integrated Topobathymetric Models for the US Coastal Zone



CZSS Planning Conference

Author: Jeffrey J. Danielson, CoNED Project Chief
daniels@usgs.gov

National Ocean Policy (NOP) – CoNED

Draft National Ocean Policy Implementation Plan

National Ocean Council

Vision of the National Ocean Policy:

"To achieve an America whose stewardship ensures that the ocean, our coasts, and the Great Lakes are healthy and resilient, safe and productive, and understood and treasured so as to promote the well-being, prosperity, and security of present and future generations."

- Executive Order 13547

Observations, Mapping, and Infrastructure

Strengthen and integrate Federal and non-Federal ocean observing systems, sensors, data collection platforms, data management, and mapping capabilities into a national system and integrate that system into international observation efforts.

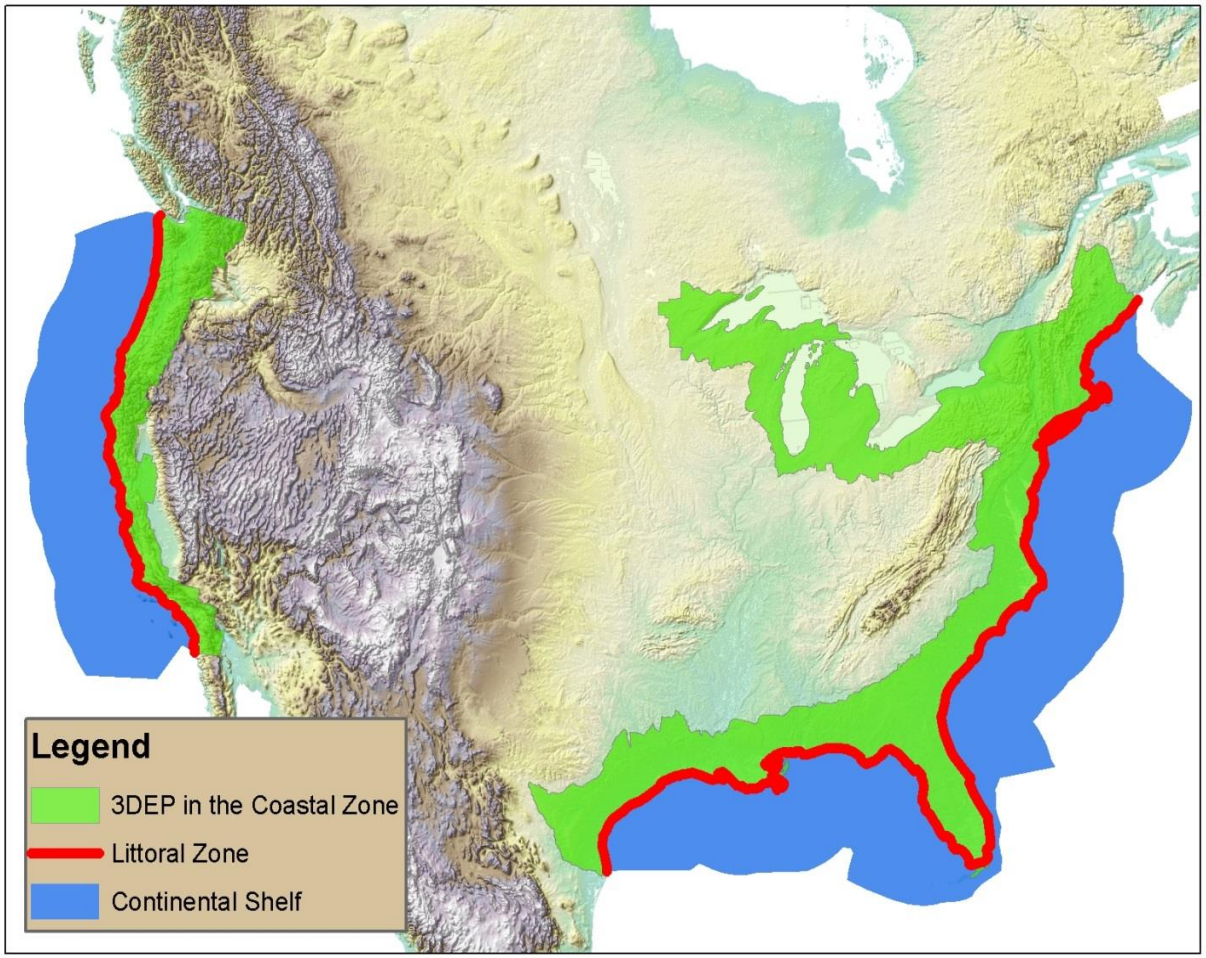
Action 6: Improve mapping capabilities and mapping products.

Milestones

- Improve and implement coastal change analysis products and a sustained and seamless description of coastal and marine elevation extending from on-shore coastal areas (Coastal National Elevation Dataset) through the U.S. Exclusive Economic Zone and extended continental shelf, including elevation models and derived map products, which meet the needs of decision-makers. (IC-OCM, USGS, USACE, NOAA; 2013)

USGS

Coastal National Elevation Database (CoNED) Project Integrated Topobathy Models for the Coastal Zone



- A USGS (CMGP, NGP) – NOAA (NGDC, NGS, OCS) – USACE (JALBTCX) collaboration.
- Geographic scope extends inland from the Fall Line offshore to the edge of the Continental Shelf.
- The CoNED Applications Project is:

1) Working with USGS NGP, NOAA, and USACE to help build 3D Nation in the coastal zone by assimilating the land surface topography with littoral zone and continental shelf bathymetry.
2) Constructing seamless topobathymetric elevation models for a sequence of US regions.
3) Conducting “algorithm point cloud (lidar / SfM) research” for land change science.

USGS

CoNED Applications Project Science Goals

1) Support coastal and marine spatial planning, by constructing the Coastal National Elevation Database (CoNED) at select focus regions thereby establishing a topobathymetric baseline product for scientific investigations and applications.

2) Populate the extended topobathymetric data structure and publish prototype CoNED Datasets for pilot focus regions at the Alaskan North Slope, San Francisco Bay, Northern Gulf of Mexico, Sandy Region, and the Pacific Northwest.

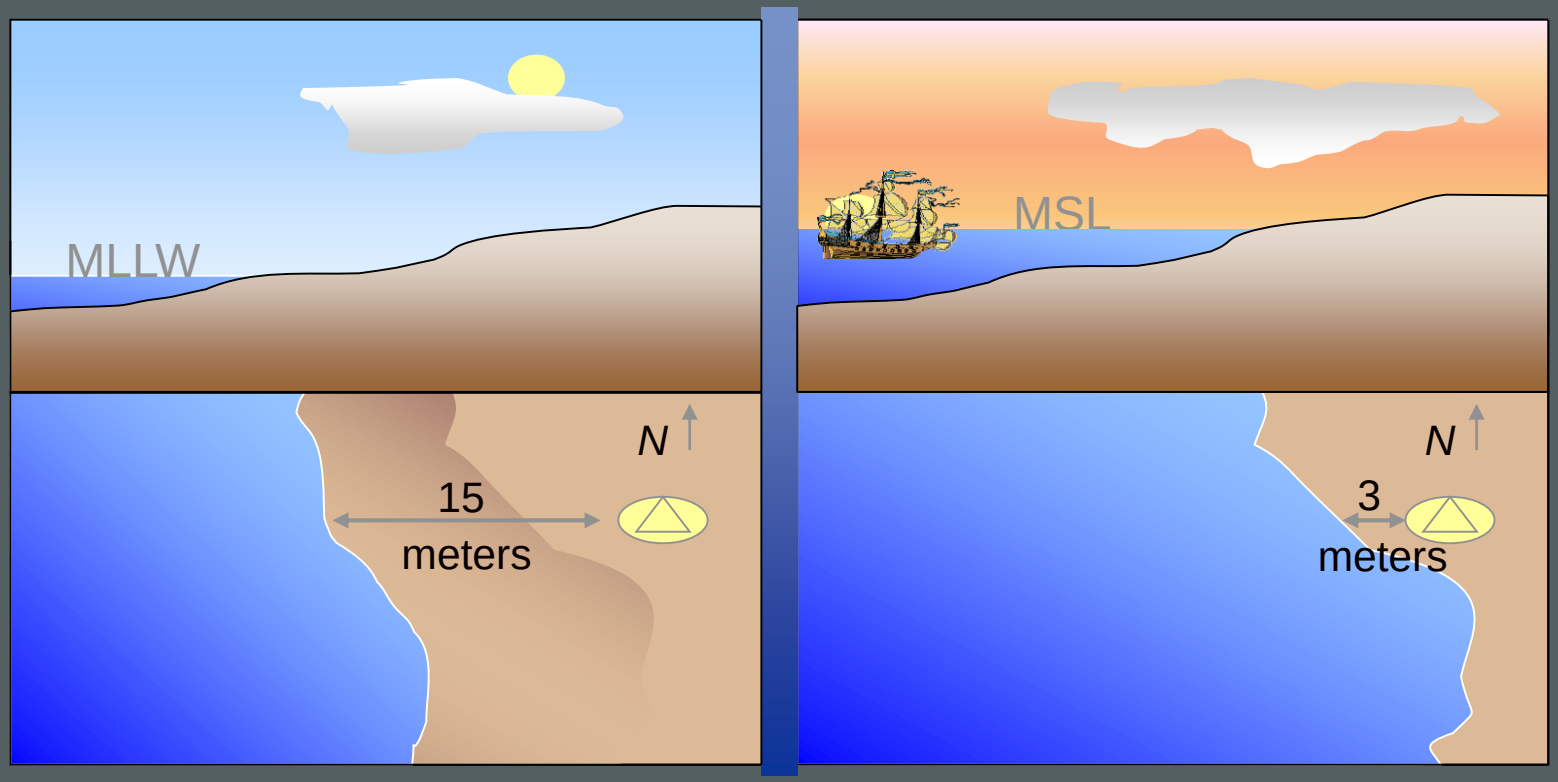
3) Conduct algorithm remote sensing (lidar) research to extend the data structure for topobathymetric elevation models and create methods for fostering land change science studies.

4) Work in partnership with USGS NGP to construct 3DEP in the ‘landside” coastal zone, while collaborating with the USACE and NOAA to assimilate littoral zone and continental shelf bathymetry.

USGS

Topobathy Application: “custom” Shoreline Delineation

- Intersecting a vertical reference surface through the seamless merge elevation model results in changes in the shape and location of the shoreline

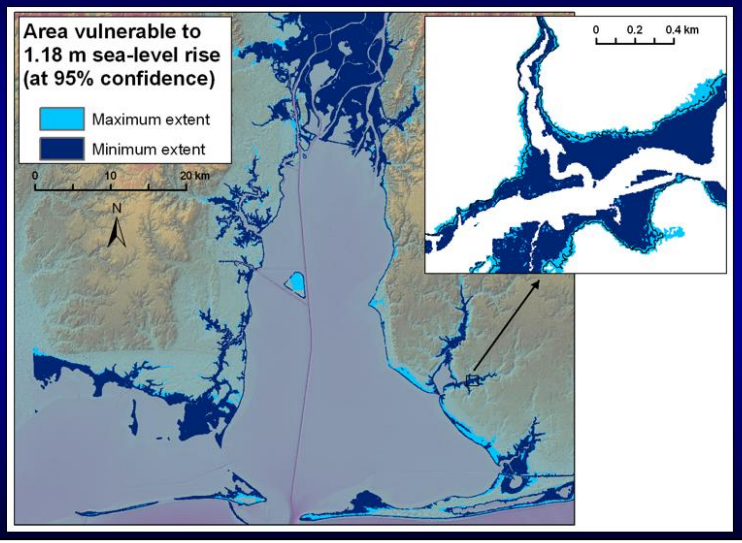


USGS

NOAA

Topobathy Application: Sea Level Rise (SLR) Vulnerability Modeling

Mobile Bay Sea-Level Rise Vulnerability



Journal of Coastal Research	SI	63	197–210	Coconut Creek, Florida	Spring 2013

Consideration of Vertical Uncertainty in Elevation-Based Sea-Level Rise Assessments: Mobile Bay, Alabama Case Study

Dean B. Gesch

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Earth Resources Observation and Science Center
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Sioux Falls, SD 57198, U.S.A.
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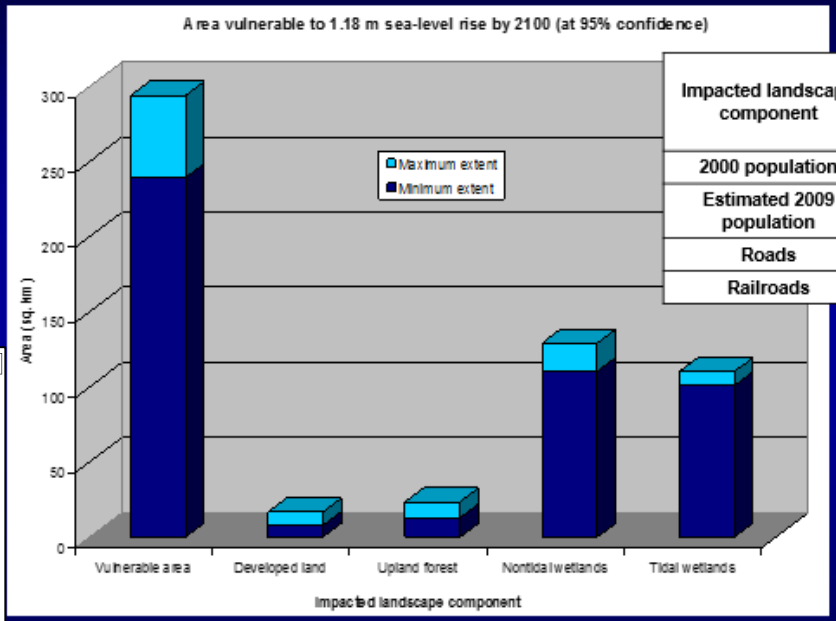
ABSTRACT

Gesch, D.B., 2013. Consideration of vertical uncertainty in elevation-based sea-level rise assessments: Mobile Bay, Alabama case study. *In:* Brock, J.C.; Barras, J.A., and Williams, S.J. (eds.), *Understanding and Predicting Change in the Coastal Ecosystems of the Northern Gulf of Mexico*, Journal of Coastal Research, Special Issue No. 63, pp. 197–210, Coconut Creek (Florida), ISSN 0749-0208.

The accuracy with which coastal topography has been mapped directly affects the reliability and usefulness of elevation-based sea-level rise vulnerability assessments. Recent research has shown that the qualities of the elevation data must be well understood to properly model potential impacts. The cumulative vertical uncertainty has contributions from elevation

Mobile Bay Sea-Level Rise Assessment

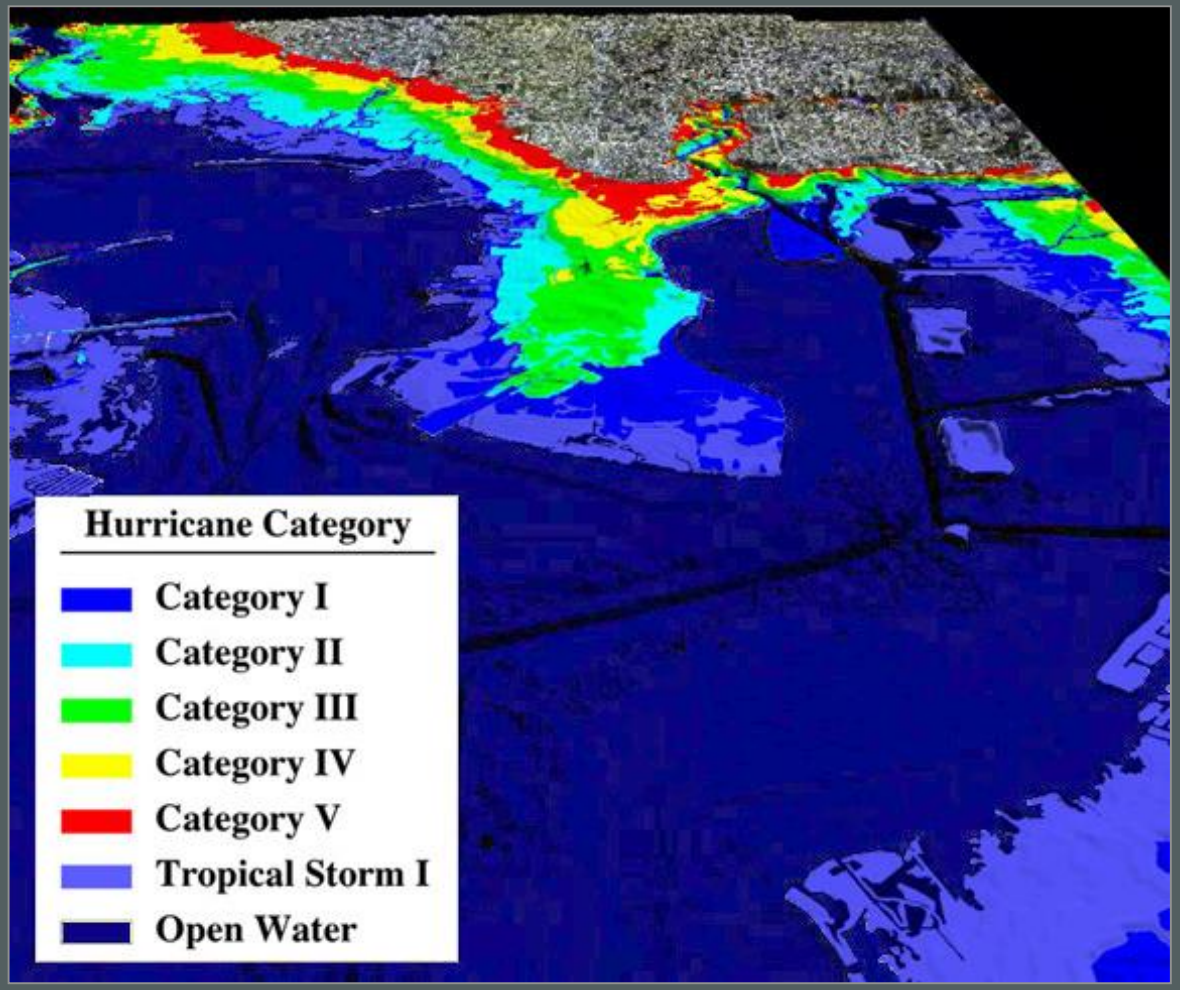


Impacted landscape component	Features vulnerable to 1.18 m sea-level rise by 2100 (at 95% confidence)
2000 population	8,760 – 13,482 people
Estimated 2009 population	10,496 – 16,569 people
Roads	120.47 – 303.22 km
Railroads	20.47 – 31.89 km

- Accounting for the vertical uncertainty in the coastal elevation (lidar) data facilitates reporting of the features and resources within the vulnerable zone at a specific confidence level

USGS

Topobathy Application: Coastal Storm Surge Modeling



USGS

Topobathy Application: Fluvial Geomorphology

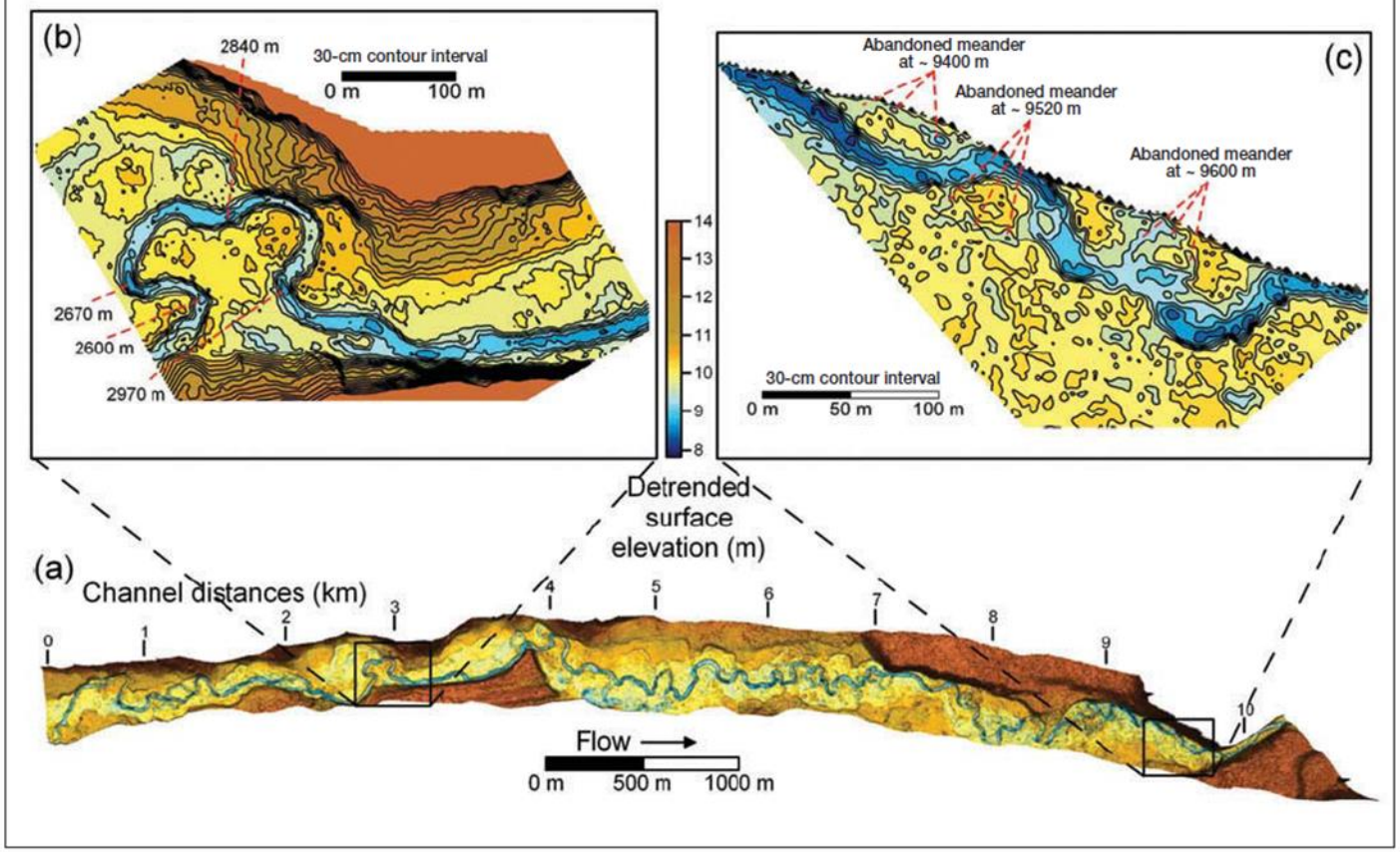
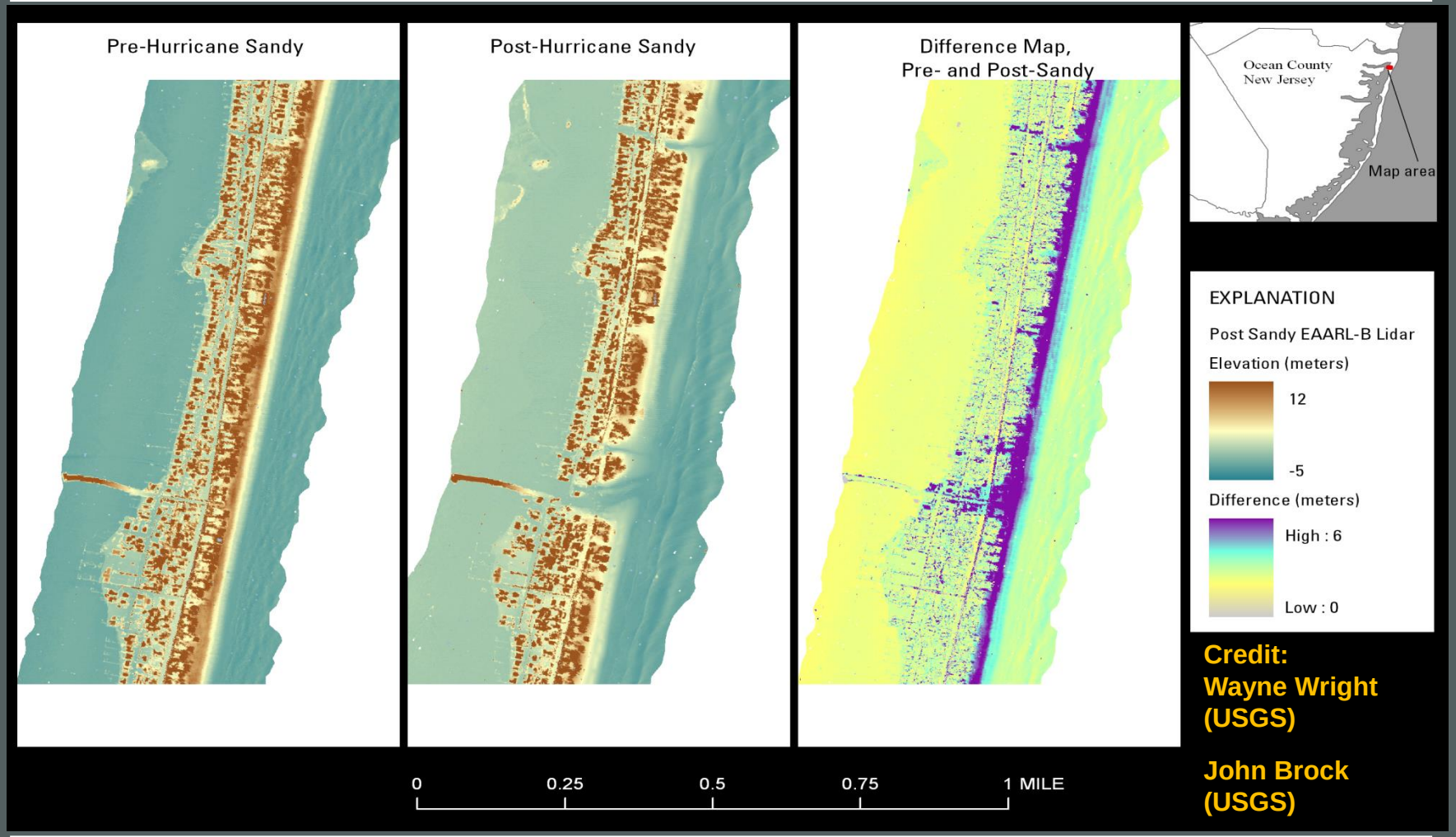


Figure 2. *(a) Channel, floodplain, and terrace topography after the valley gradient has been removed. (b and c) Contour maps of selected channel reaches, showing the ability of EAARL to simultaneously resolve floodplain, terrace, and channel topography. All digital topography produced from EAARL data gridded to a 3-m interval. For higher resolution, see WebFigure 4*

USGS

Topobathy Application: Change Detection

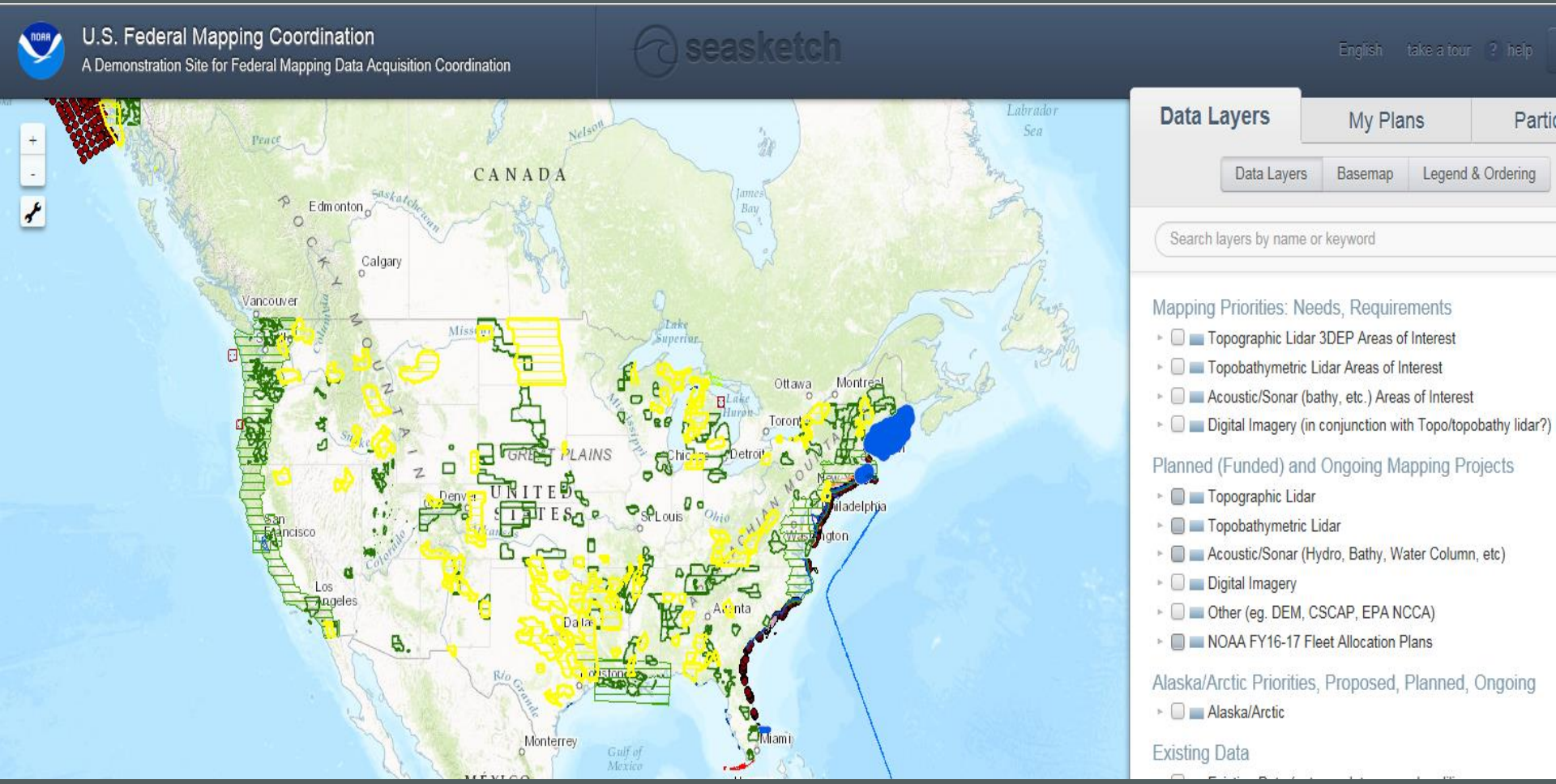


Credit:
Wayne Wright (USGS)

John Brock (USGS)

USGS

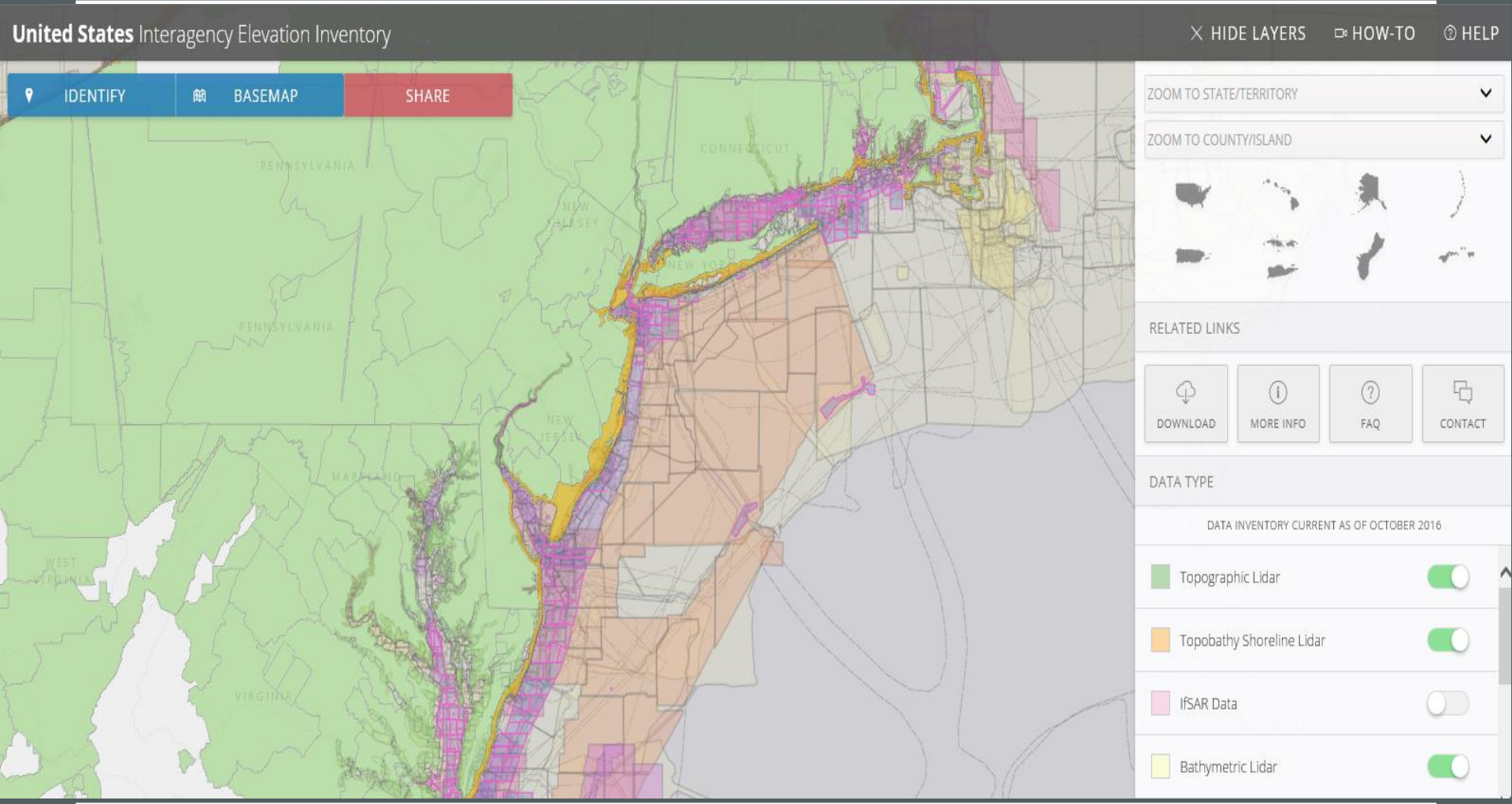
U.S Federal Mapping Coordination – Mapping Priorities and Planned and Ongoing Projects



USGS

Interagency Working Group On Ocean And Coastal Mapping

United States Interagency Elevation Inventory – Hurricane Sandy Topographic and Bathymetric Data



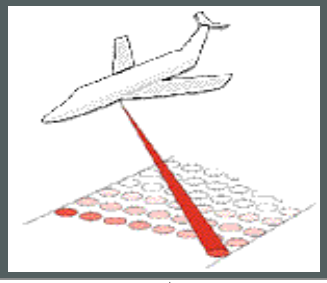
USGS

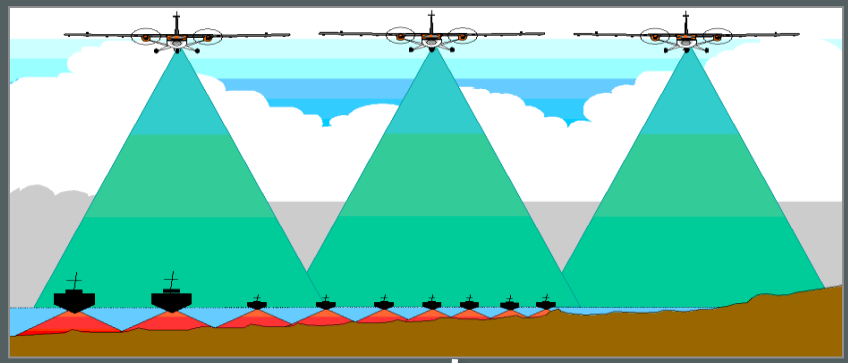
Interagency Working Group On Ocean And Coastal Mapping

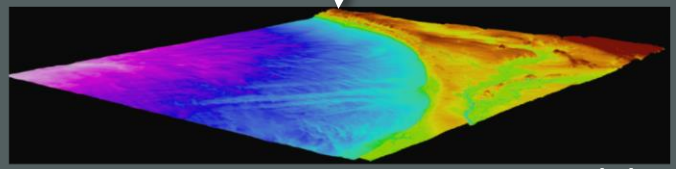
Topobathymetric Elevation Models - CoNED

- Topobathymetric elevation models are a merged rendering of both topography (land elevation) and bathymetry (water depth) to provide an integrated seamless elevation product

- Data sources
  - Light Detection and Ranging (Lidar)
    - Airborne (NIR-1064nm)
    - Terrestrial Ground-Based (NIR-1064nm)
    - Topobathymetric (CZMIL: Green-532nm)
  - Structure-from-Motion (SfM)
  - Bathymetric Sonar (Acoustic)
    - Multi-Beam
    - Single-Beam
    - Swath
    - Hydrographic Surveys



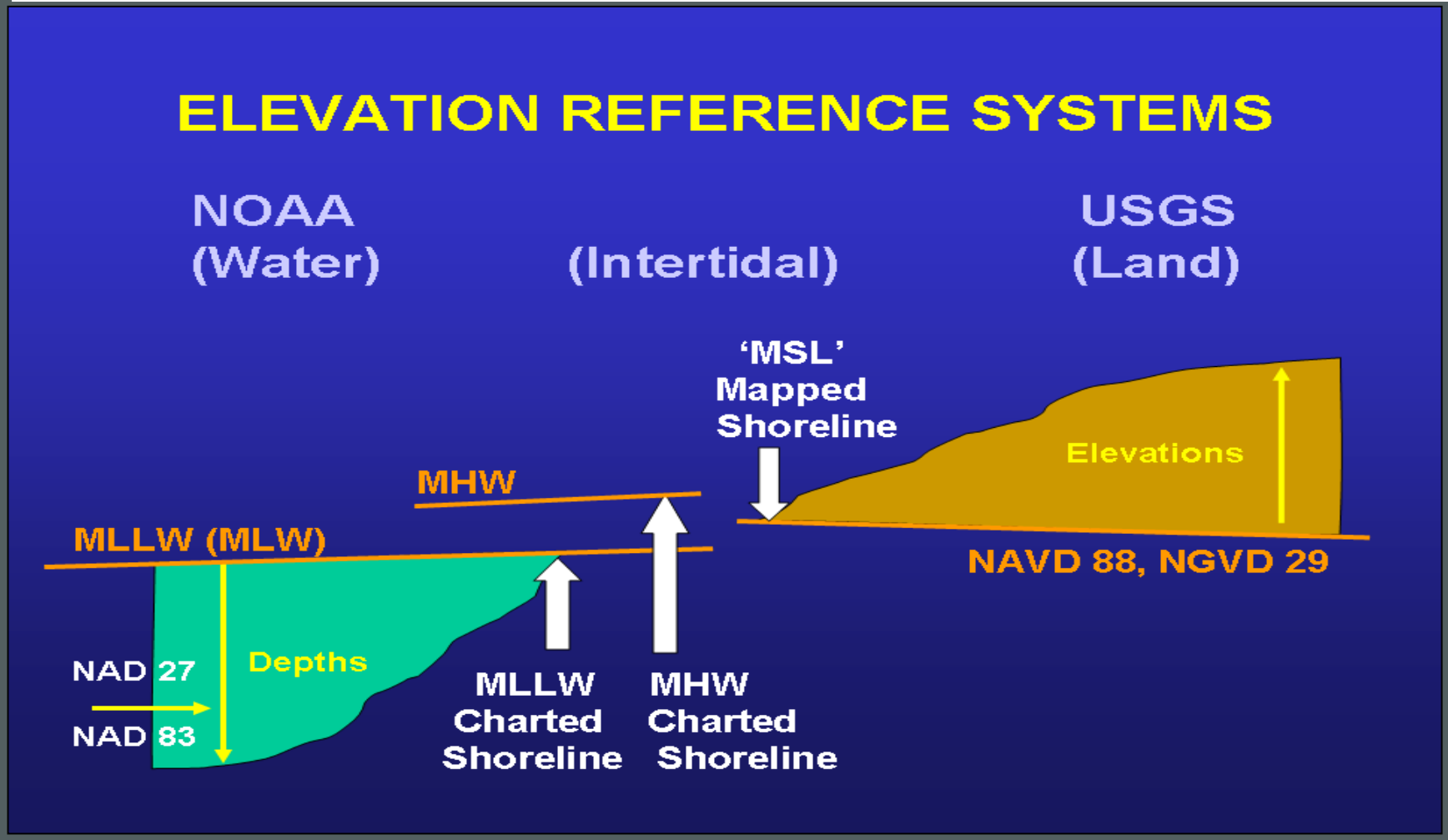




marine intertidal terrestrial

USGS

Elevation Reference Systems



USGS

Coastal National Elevation Database (CoNED) Topobathymetric Elevation Models – Great Lakes

Journal of Coastal Research	SI	76	75–89	Coconut Creek, Florida	2016

Topobathymetric Elevation Model Development using a New Methodology: Coastal National Elevation Database

Jeffrey J. Danielson[†*], Sandra K. Poppenga[†], John C. Brock[‡], Gayla A. Evans[†], Dean J. Tyler[†], Dean B. Gesch[†], Cindy A. Thatcher[§], and John A. Barras[**]

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www.JCRonline.org

ABSTRACT

Danielson, J.J.; Poppenga, S.K.; Brock, J.C.; Evans, G.A.; Tyler, D.J.; Gesch, D.B.; Thatcher, C.A., and Barras, J.A., 2016. Topobathymetric elevation model development using a new methodology: Coastal National Elevation Database. *In*: Brock, J.C.; Gesch, D.B.; Parrish, C.E.; Rogers, J.N., and Wright, C.W. (eds.), *Advances in Topobathymetric Mapping, Models, and Applications*. *Journal of Coastal Research*, Special Issue, No. 76, pp. 75–89. Coconut Creek (Florida), ISSN 0749-0208.

USGS

Enabling Science and Decision-Making: USGS Coastal Storm Modeling System (CoSMoS)

San Francisco Bay Region – 2m Topobathy Model (2012)

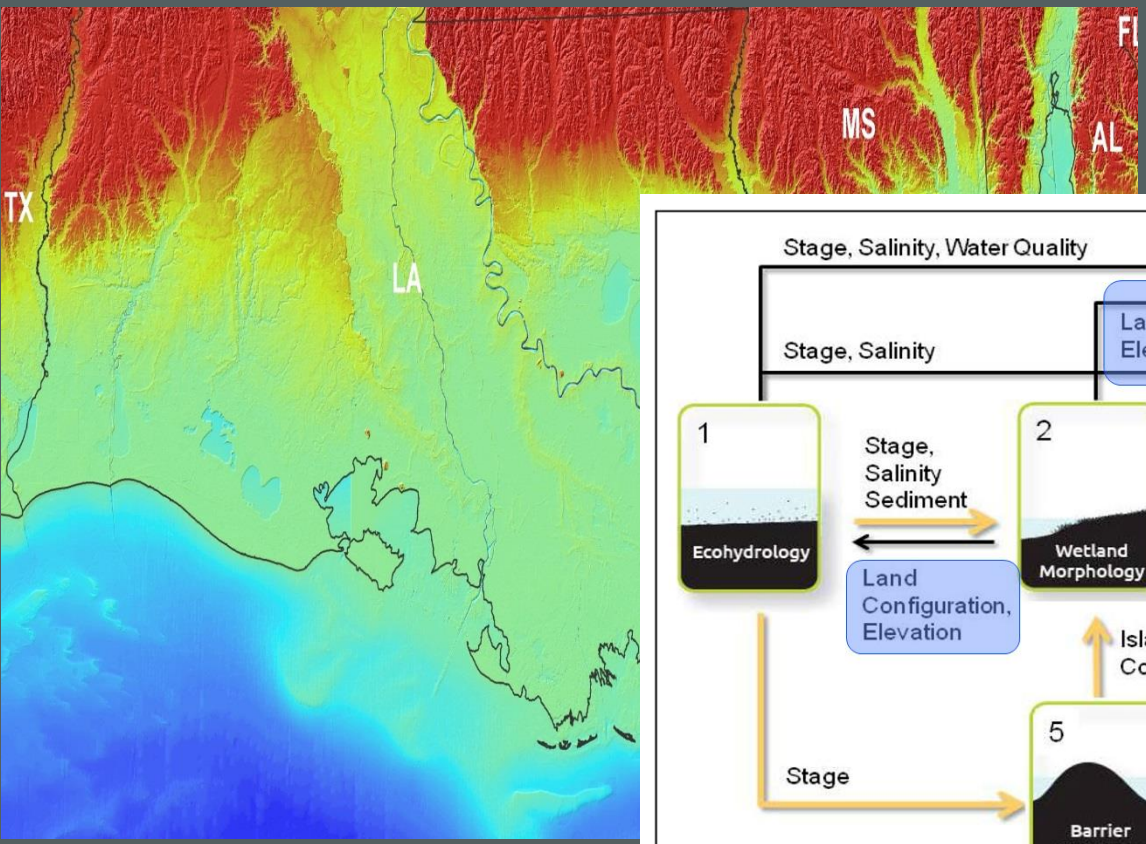
What is CoSMoS?
Coastal Storm Modeling System

- Physics-based numerical modeling system for assessing coastal hazards on West Coast
- Predicts coastal hazards for the full range of sea level rise and storm possibilities using the most sophisticated global climate and ocean modeling tools
- Developing coastal vulnerability tools with guidance from federal (e.g., NOAA, NPS), state (e.g., California State Parks), and city governments (City of San Diego, L.A., and San Francisco) to meet their planning and adaptation needs

USGS

USGS

Construction of the NGOM Region TBDEM Responds to the Needs of System Level Models that was Described in the LA CPRA 2012 State Master Plan



USGS CoNED – NGOM Integrated Topobathymetric Elevation Model

Modified from CPRA (2012)
http://www.lacpra.org/assets/docs/2012%20Master%20Plan/Final%20Plan/appendices/Appendix%20D-Decision%20Support%20Tools-ModelsFINAL_wTpg.pdf

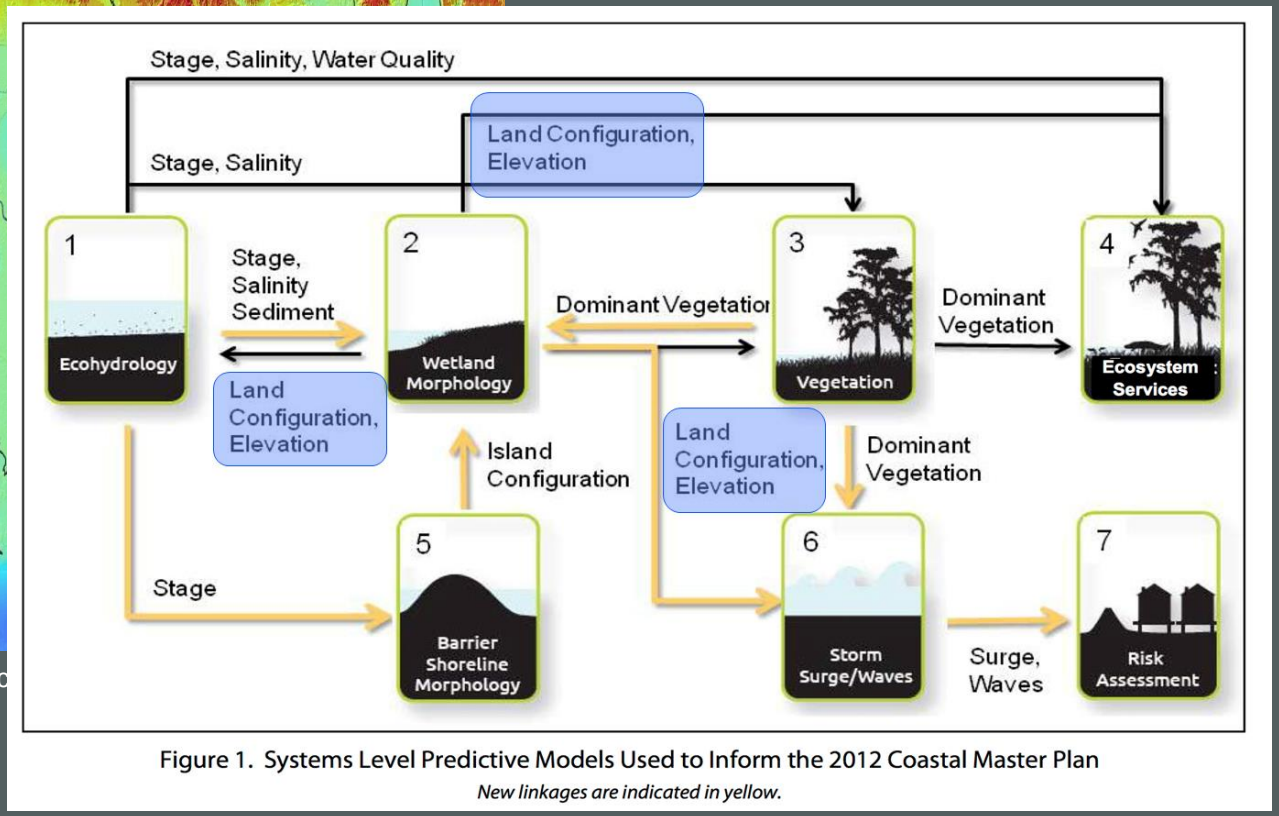
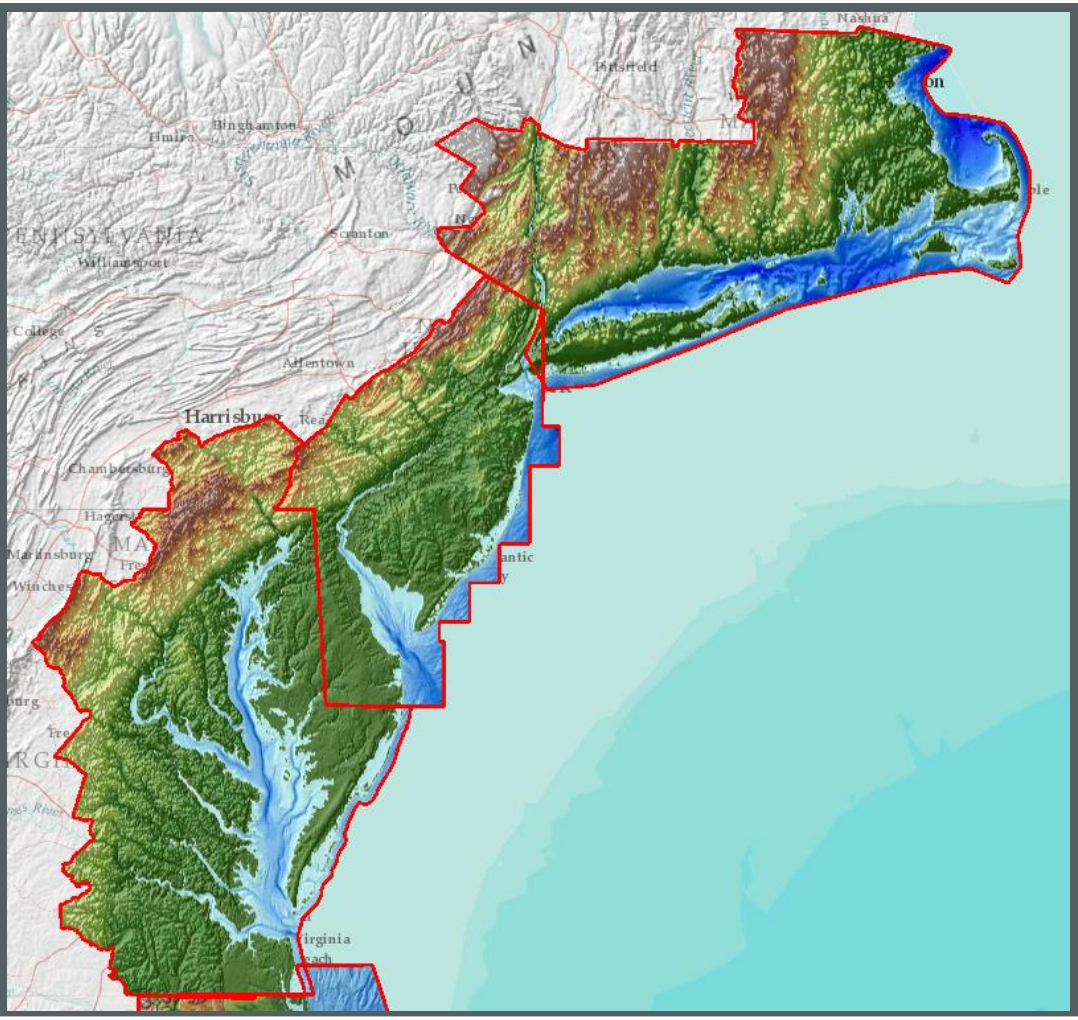


Figure 1. Systems Level Predictive Models Used to Inform the 2012 Coastal Master Plan

New linkages are indicated in yellow.

USGS

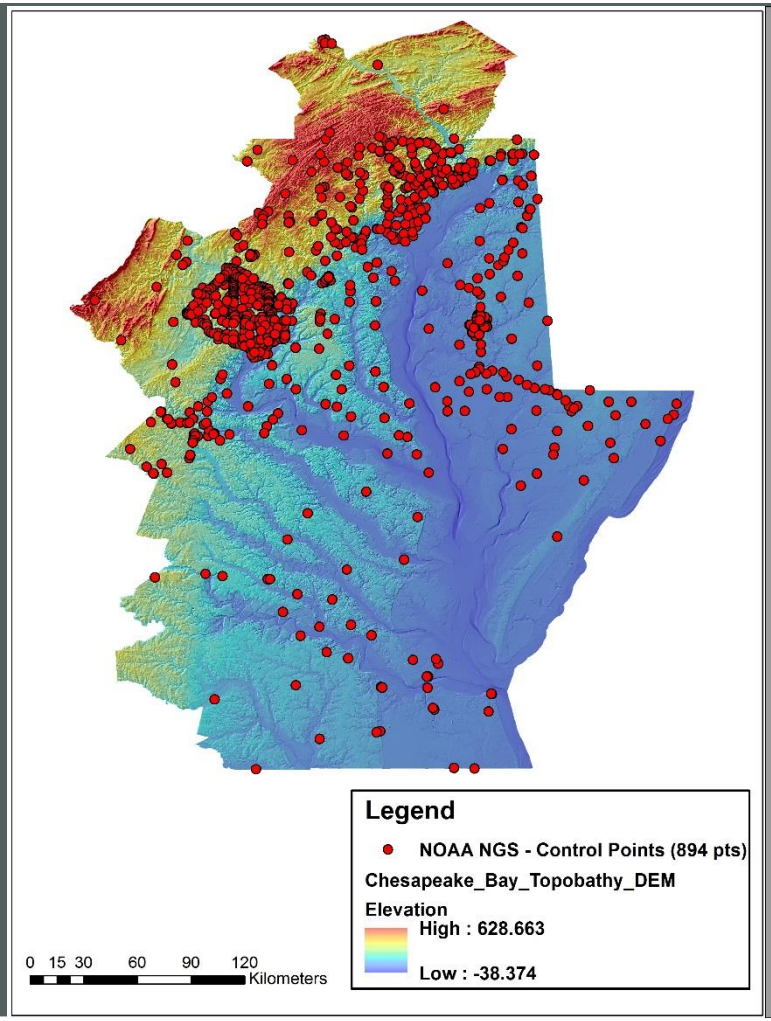
Hurricane Sandy Region – CoNED Integrated Topobathymetric Elevation Models

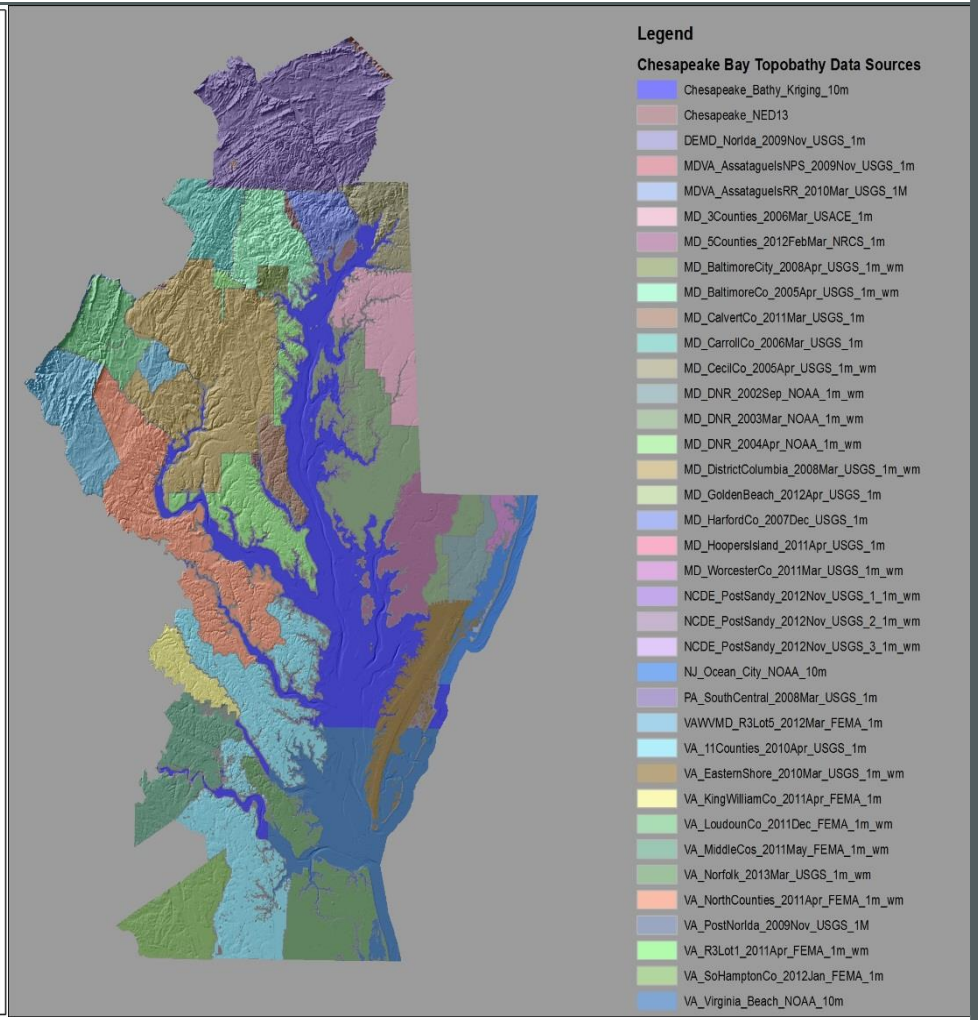


USGS

Chesapeake Topobathymetric Elevation Model

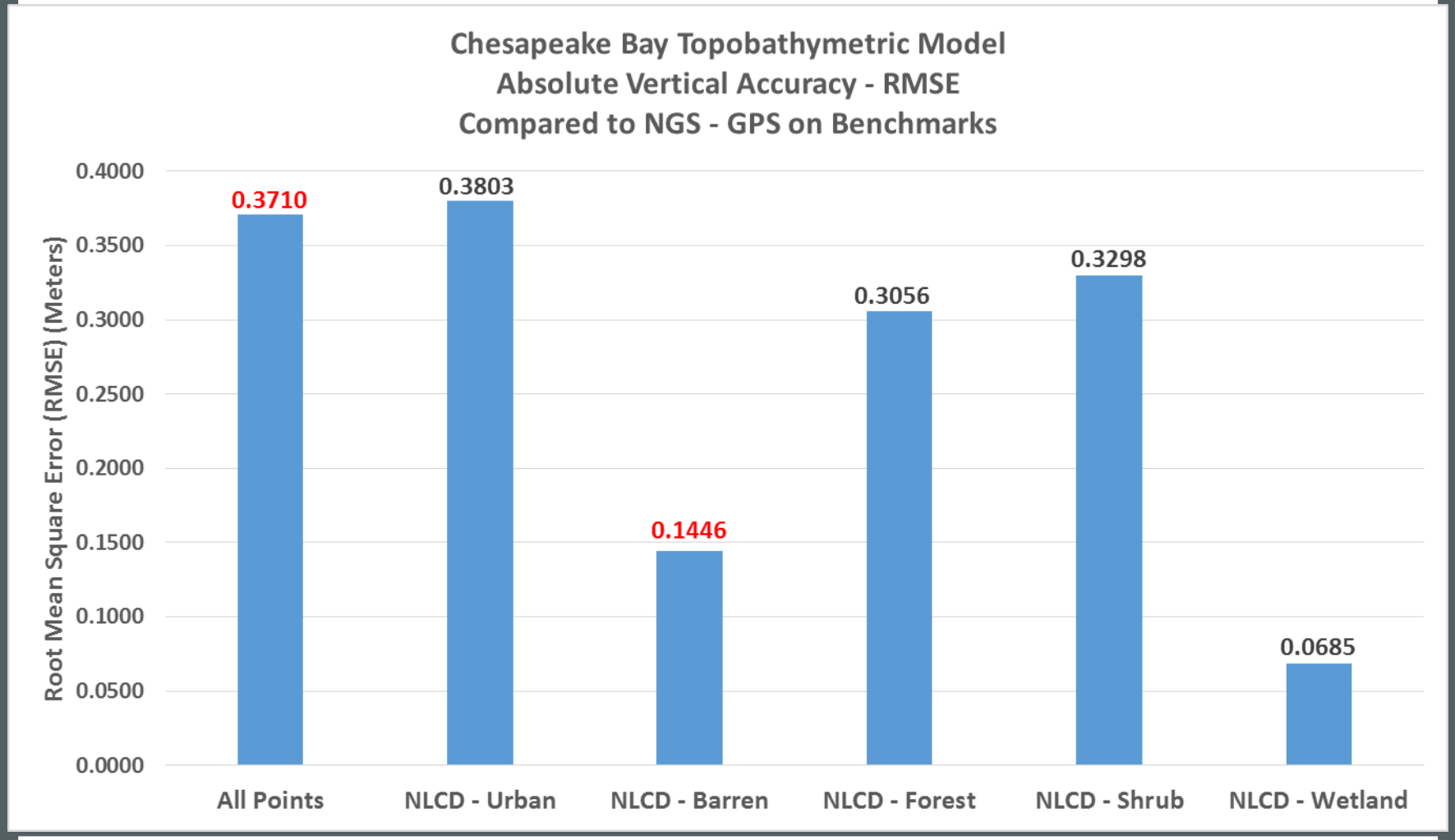
Absolute Vertical Accuracy Assessment





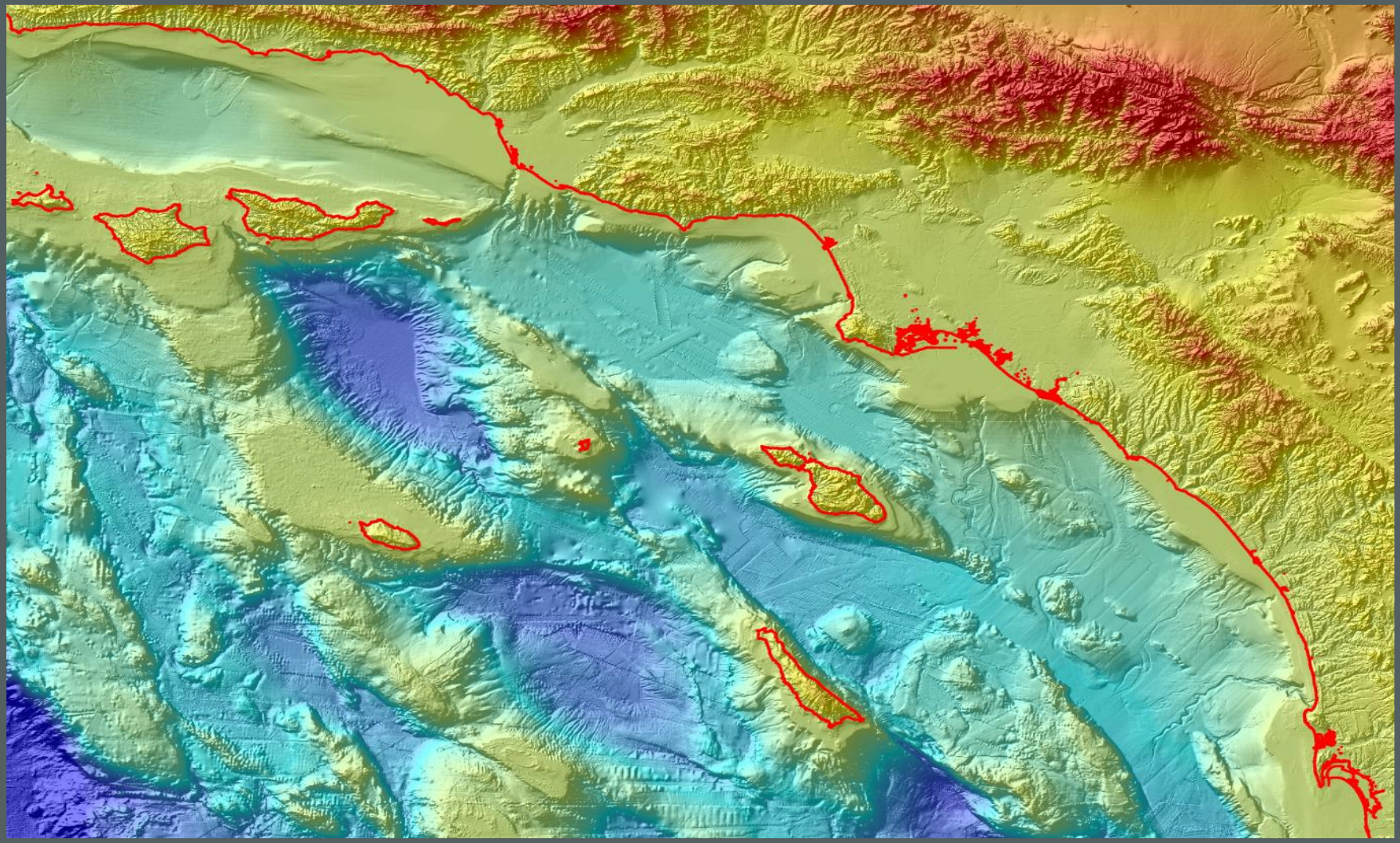
USGS

Chesapeake Topobathymetric Elevation Model Absolute Vertical Accuracy – RMSE by NLCD



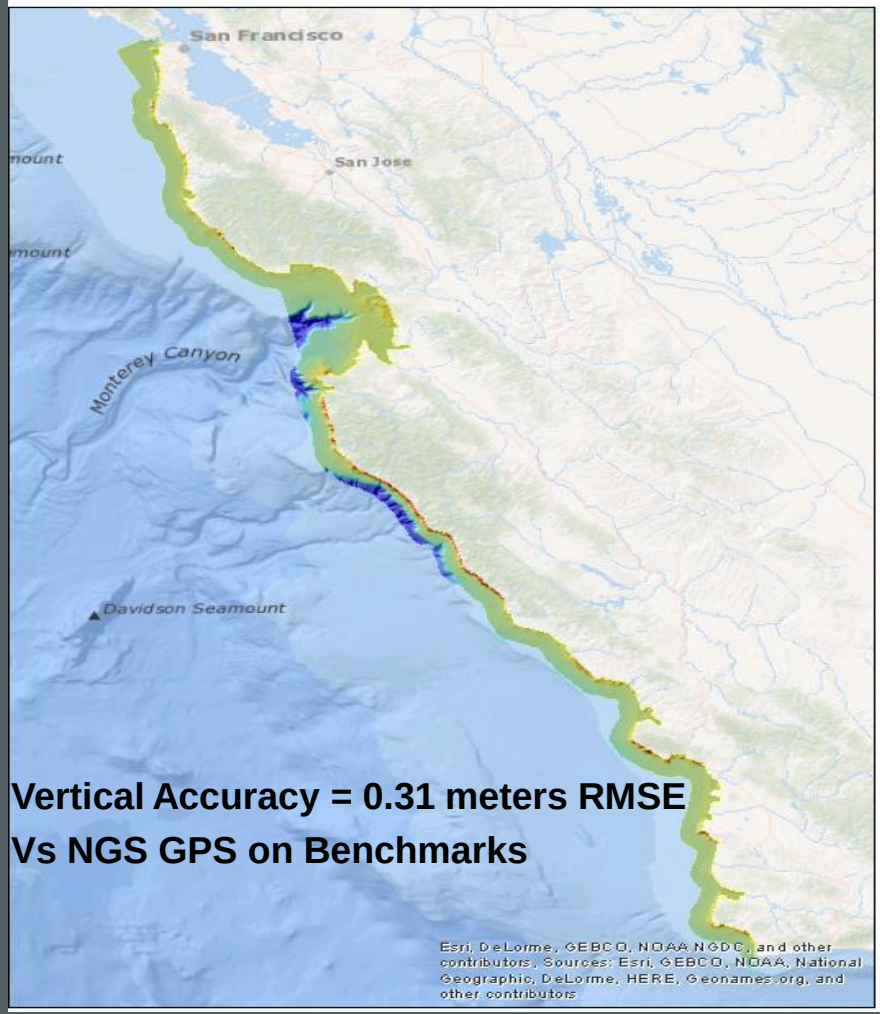
USGS

Integrated 1-Meter Topobathymetric Digital Elevation Model (TBDEM) – Southern California (USGS CoNED)

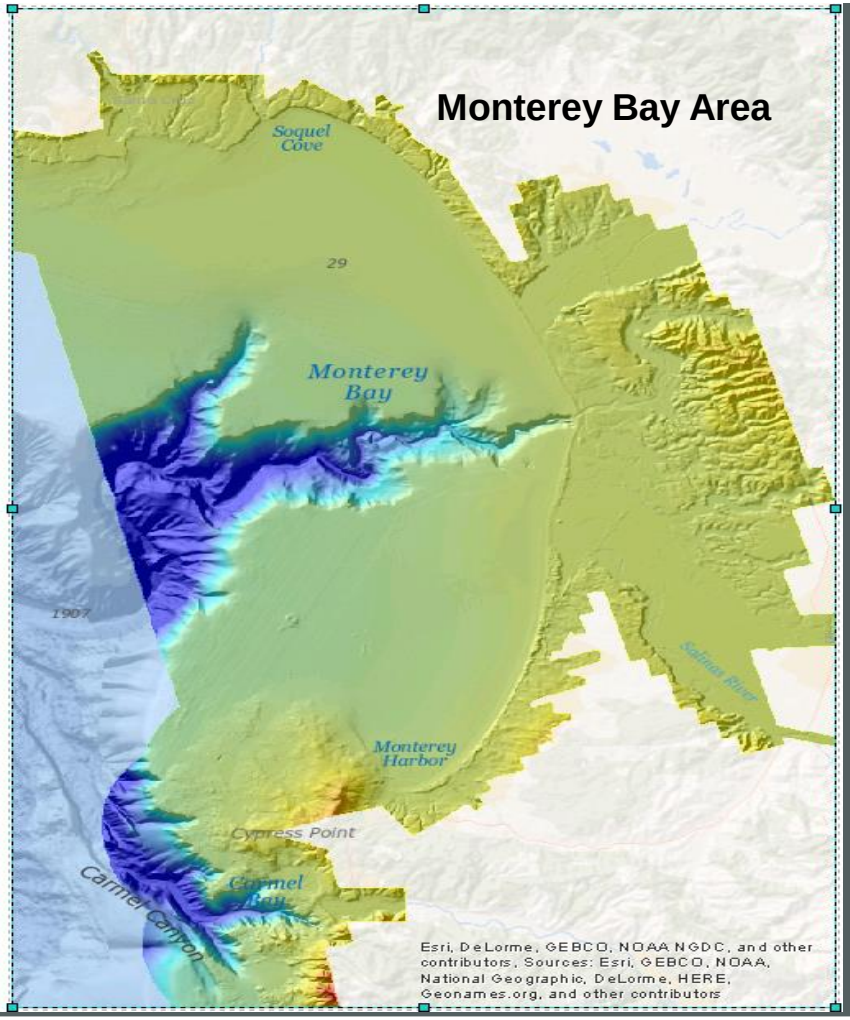


USGS

Integrated 1-Meter Topobathymetric Elevation Model (TBDEM) Central California (USGS CoNED)

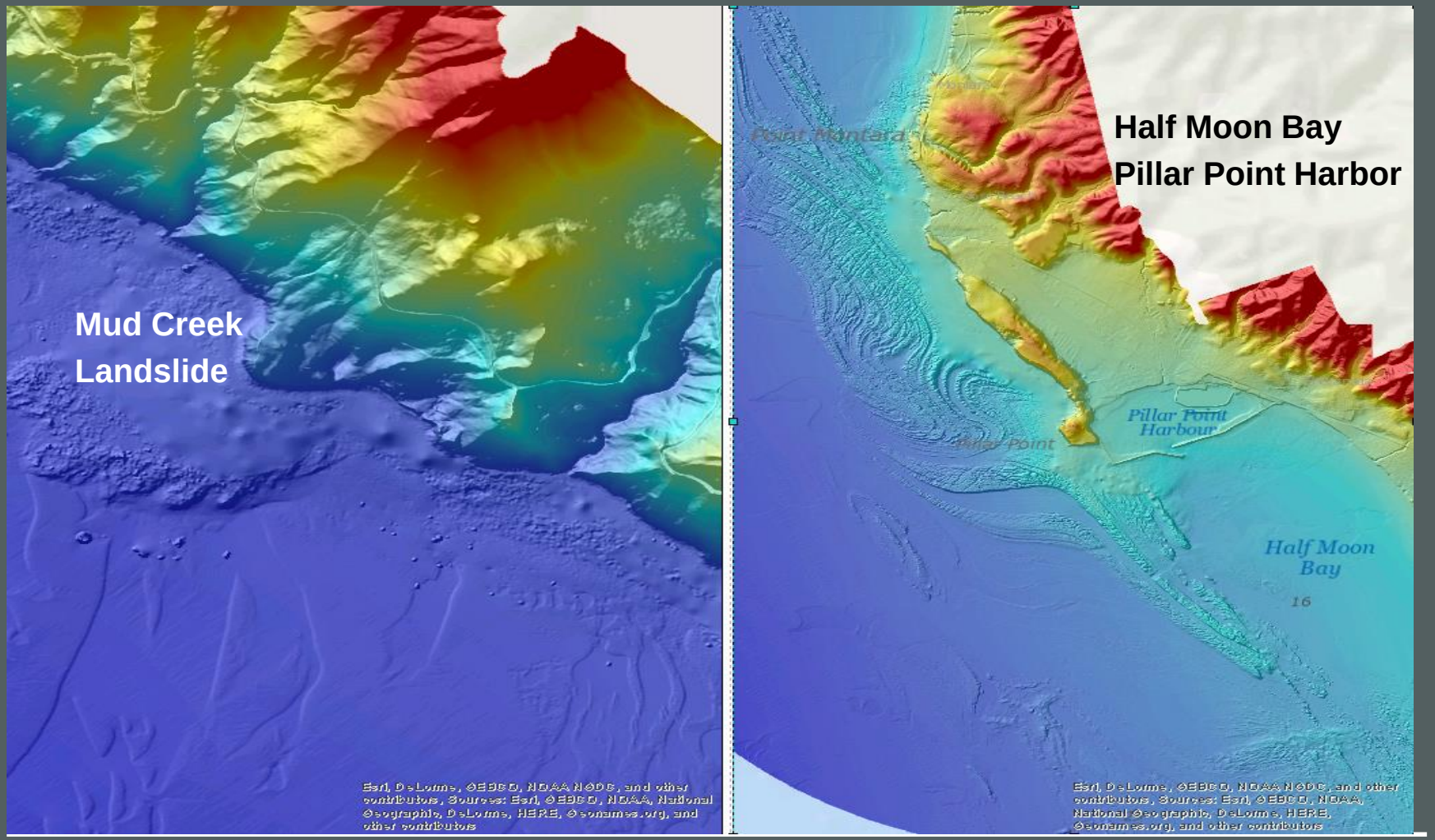


Vertical Accuracy = 0.31 meters RMSE Vs NGS GPS on Benchmarks



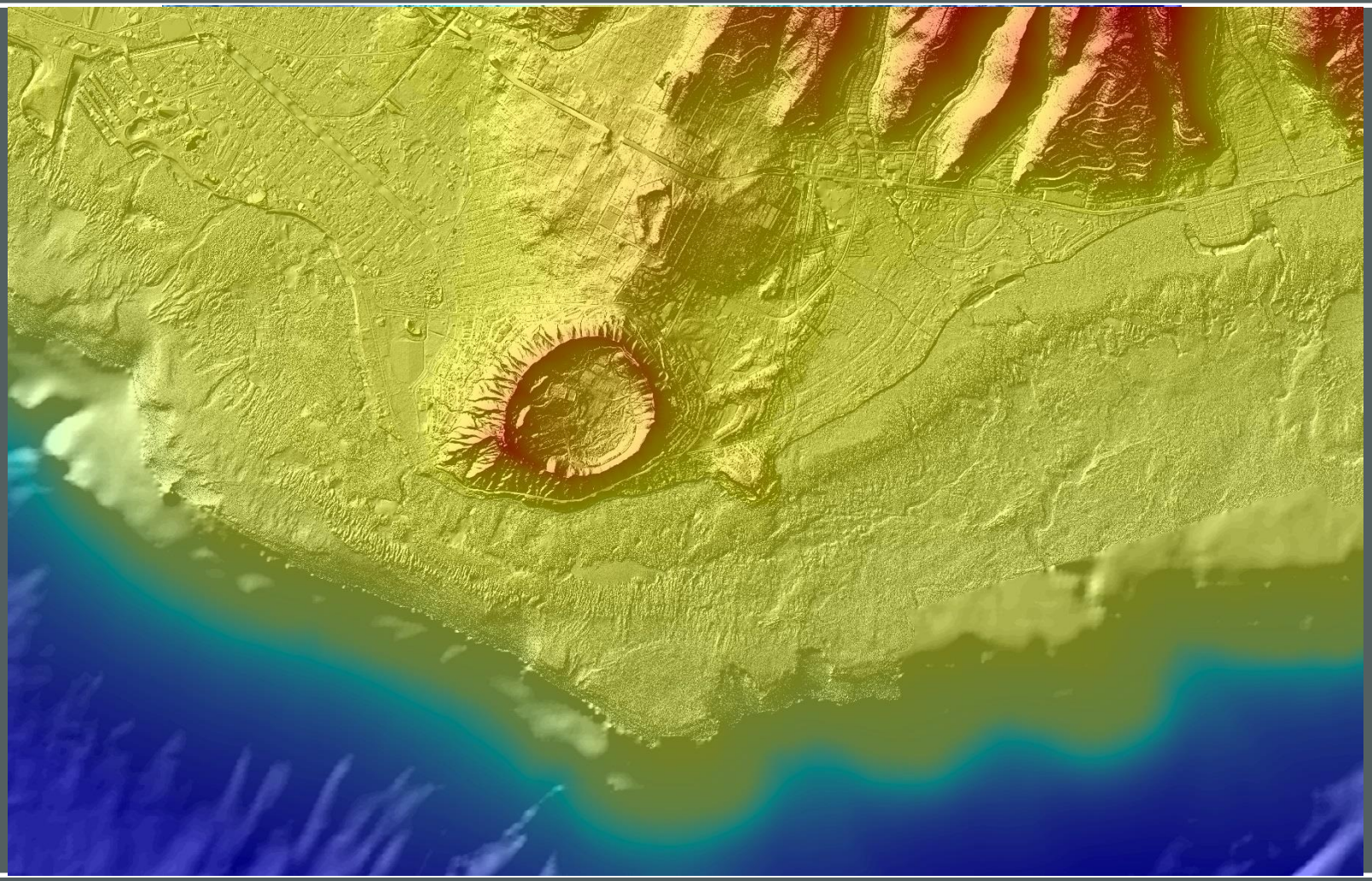
USGS

Integrated 1-Meter Topobathymetric Elevation Model (TBDEM) Central California (USGS CoNED)



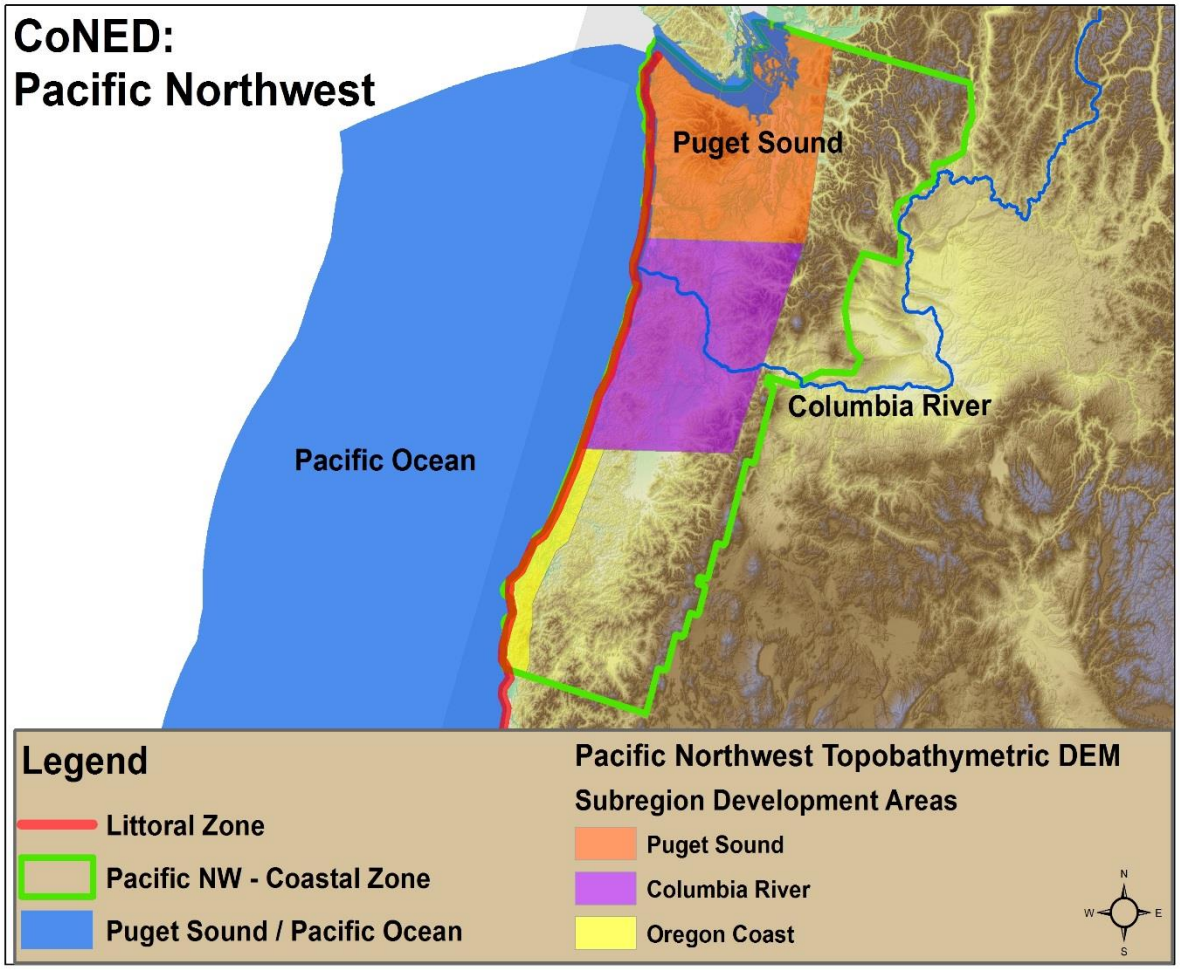
USGS

Integrated 1-Meter Topobathymetric Elevation Model (TBDEM) for Oahu, Hawaii (USGS CoNED)



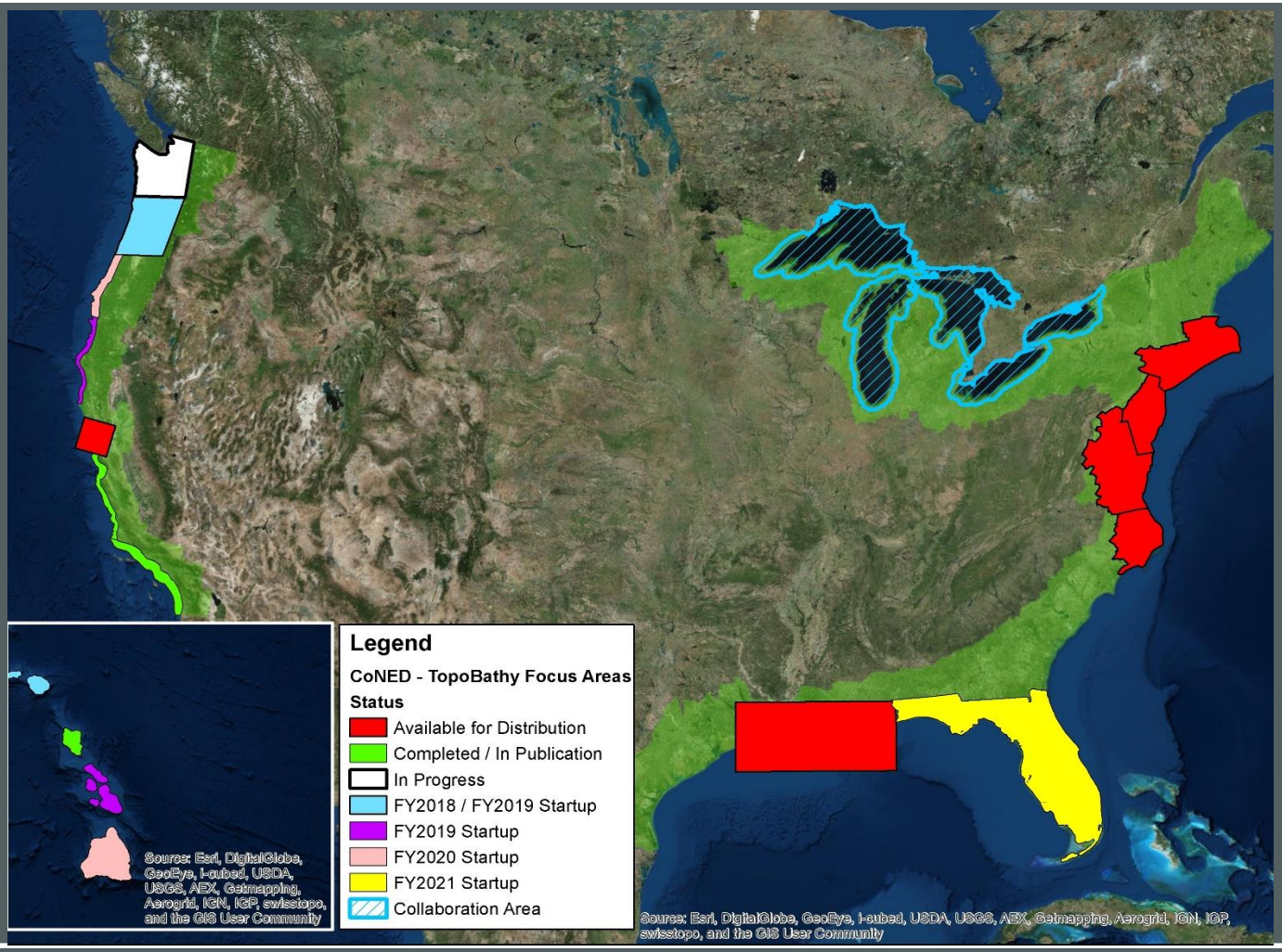
USGS

Pacific Northwest Topobathymetric DEM Subregion Development Areas - Plans



USGS

CoNED Applications Project – TBDEM Future Plans (FY18-FY21)



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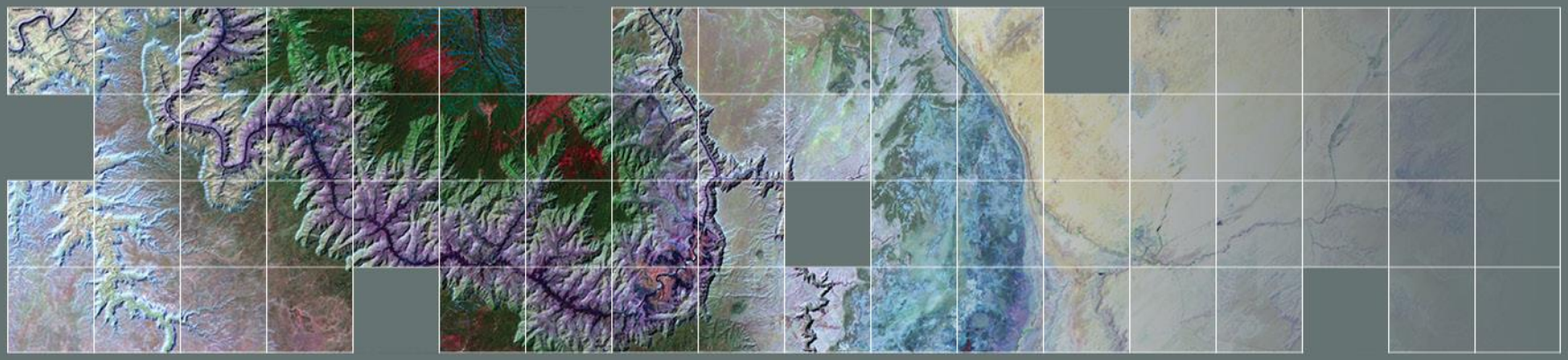
Climate and Land Use Change

Earth Resources Observation and Science (EROS) Center

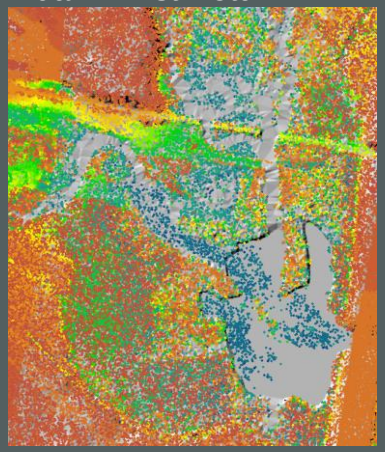
Additional Algorithm (Remote Sensing) Research – CoNED Project



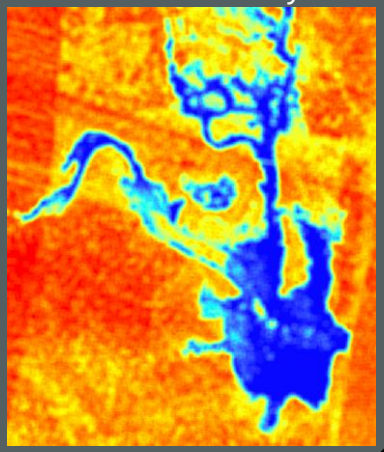
Wetland Extent Mapping & Landscape Position Research

Wetland Extent Mapping

Lidar – First Return

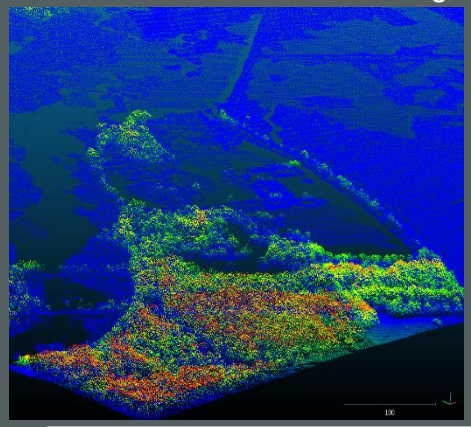


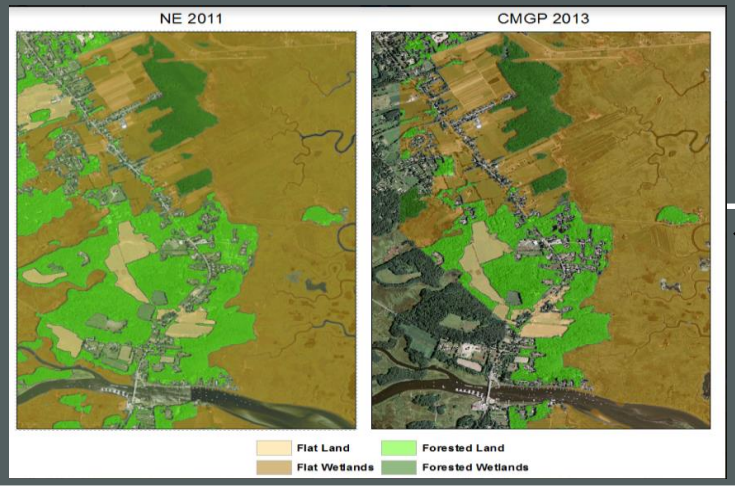
Lidar – Point Density



Wetland Extent Polygons

Coastal Forests: Habitat Change



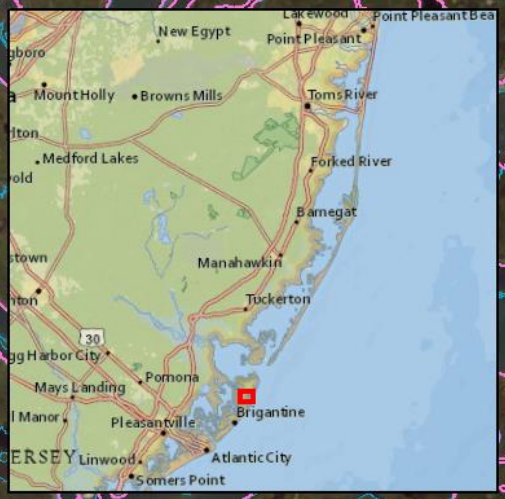


Wetland fragmentation: implications for valuable fisheries, threatened/endangered shorebirds, and water quality. Wetlands act as a natural barrier to storm surge.

Landscape Position Delineation: Emergent Marsh vs Upland Edge

USGS

Erosion



TRI 2010

TRI 2014

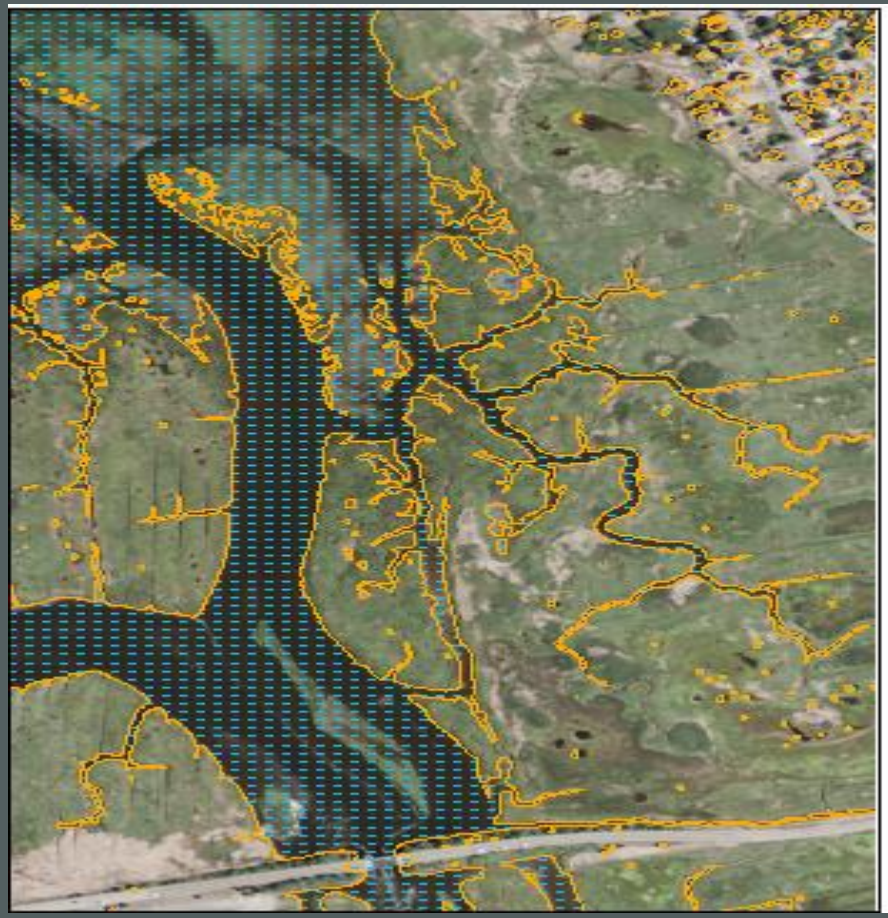
no change

erosion

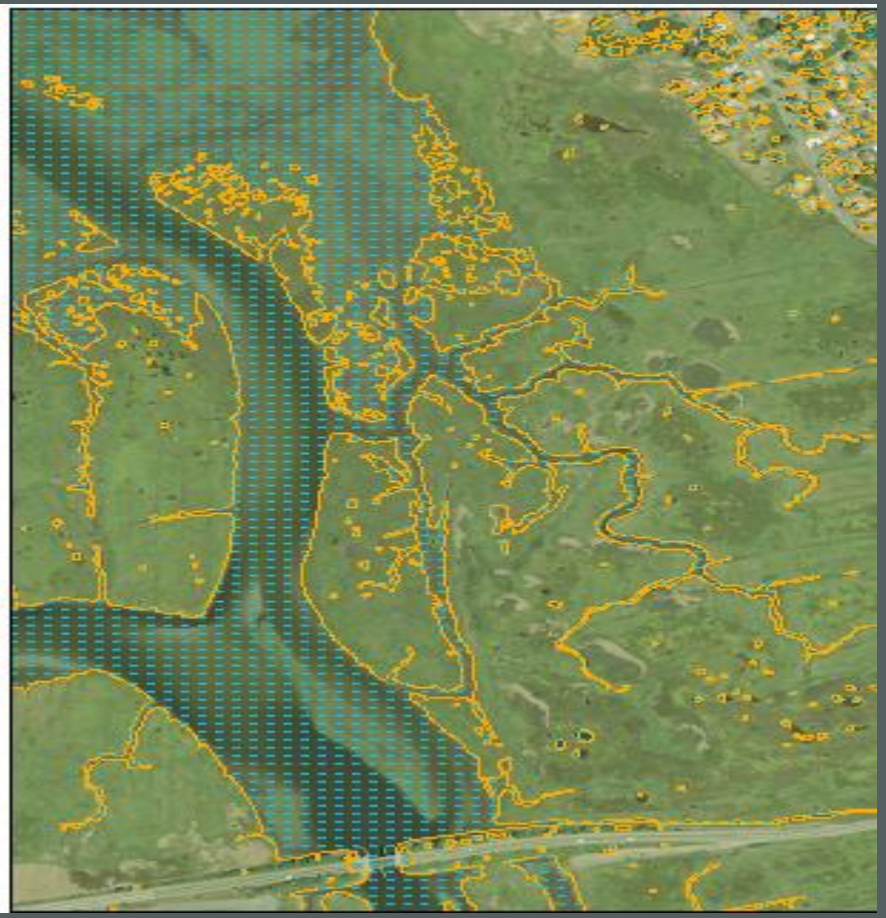
0 0.25 0.5 Kilometers

Parker River, National Wildlife Refuge, MA
CoNED – Wetland Extent Mapping Research

2014 Lidar – Parker River, NWR

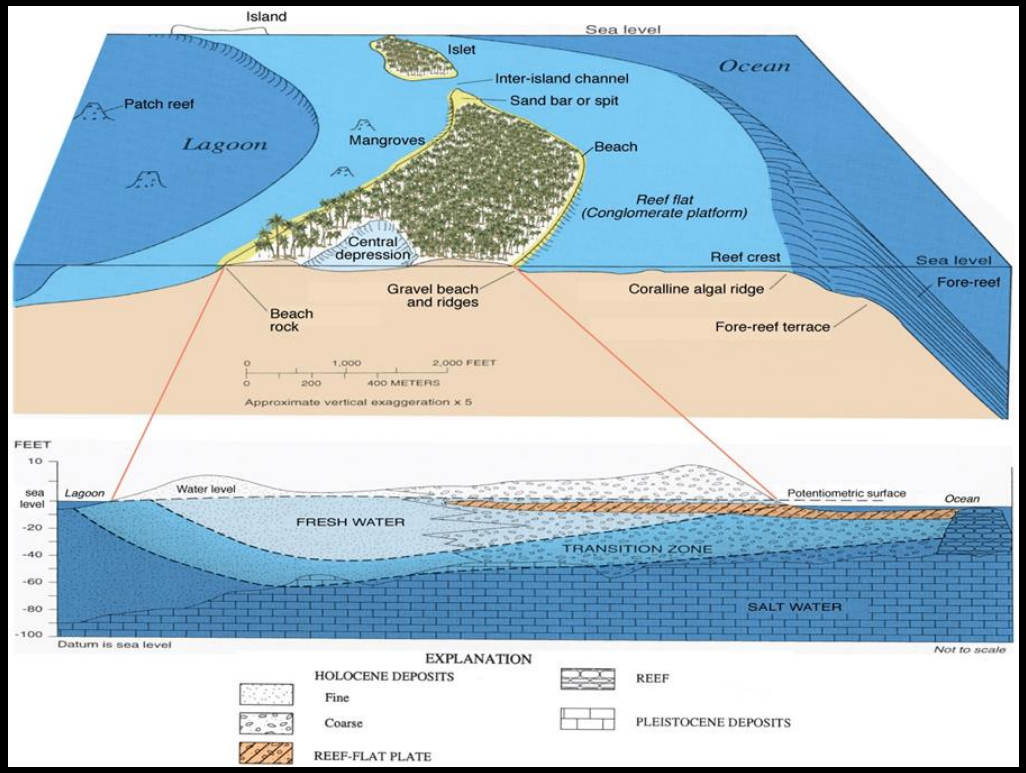


2011 Lidar – Parker River, NWR



USGS

Pacific Atolls are Endangered and Poorly Mapped

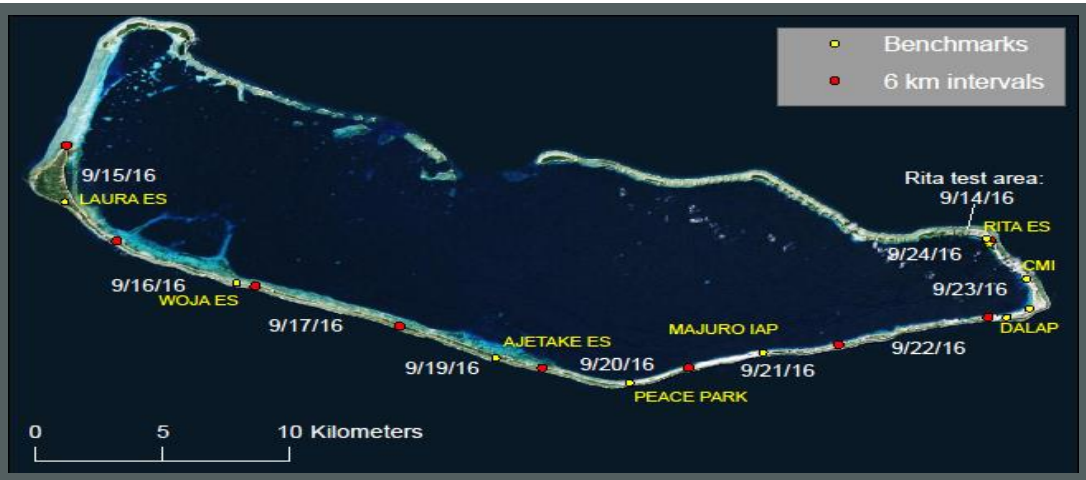


1) Very low and poorly known topography.
2) Very steep and poorly mapped bathymetry.
3) Available freshwater is limited to a shallow lens.
4) A mix of unconsolidated and consolidated carbonate sediments.
5) Changing coral reef status and biogeomorphology.

There are over 2000 islands in the Pacific that are extremely vulnerable to sea-level rise, tsunamis, storm surge, coastal flooding, and climate change that could impact the sustainability of their infrastructure, groundwater, and ecosystems.

USGS

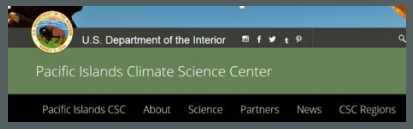
Majuro Atoll, RMI: 1–Meter DEM Project Improving Elevation Mapping in the Pacific



Primary Goal: To Generate a 1-Meter Digital Elevation Model (DEM) for the Majuro Atoll Derived from UAS-Based Structure-from-Motion (SfM) Point Clouds and GPS

Project Co-Sponsors:

USGS science for a changing world



Project Collaborators:

NOAA

USDA

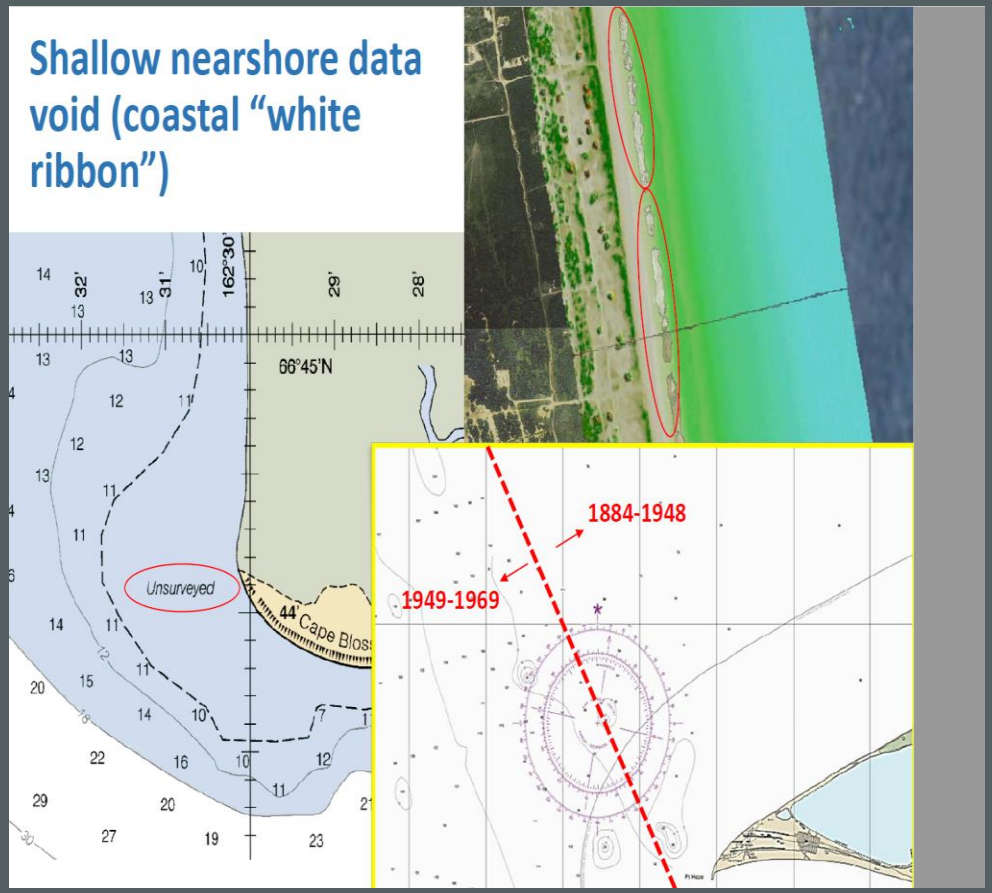
UNIVERSITY OF GUAM
UNIBETSEDÅT GUAHAN

UNIVERSITY OF HAWAI'I

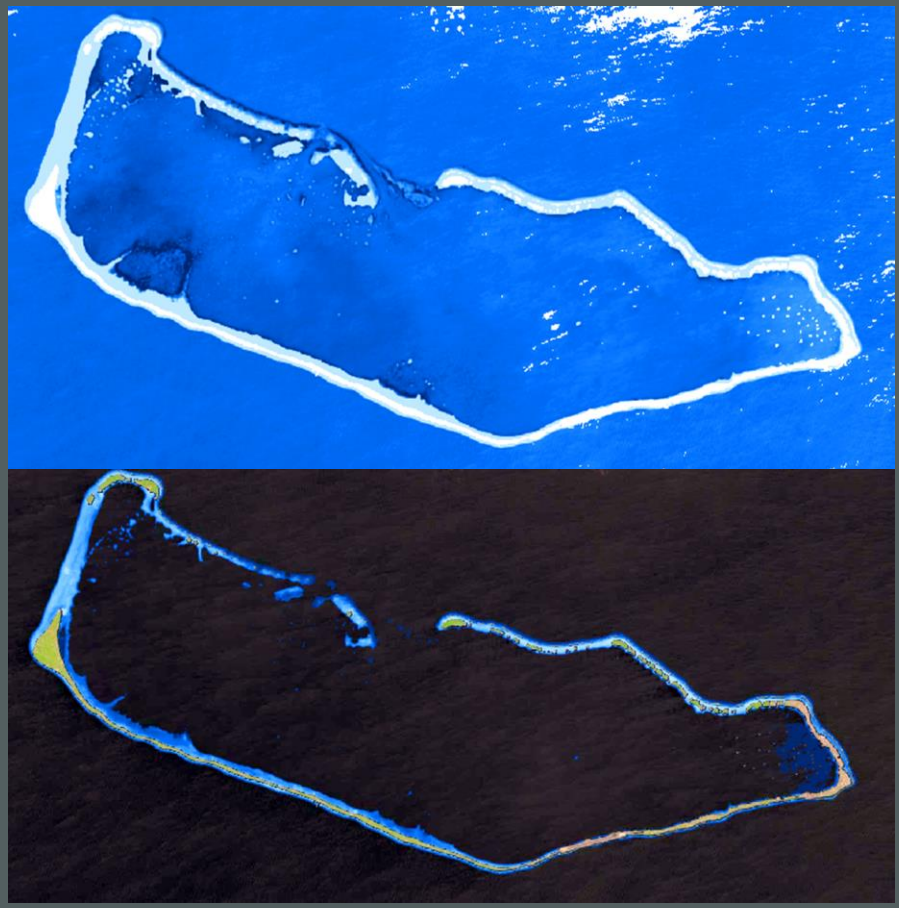
MICS
Marshall Islands Conservation Society

USGS

IWG-OCM Satellite-Derived Bathymetry (SDB) Mapping Task Team



Credit: C. Parrish, OSU



Credit: S. Poppenga, USGS CoNED, Landsat 8 SDB

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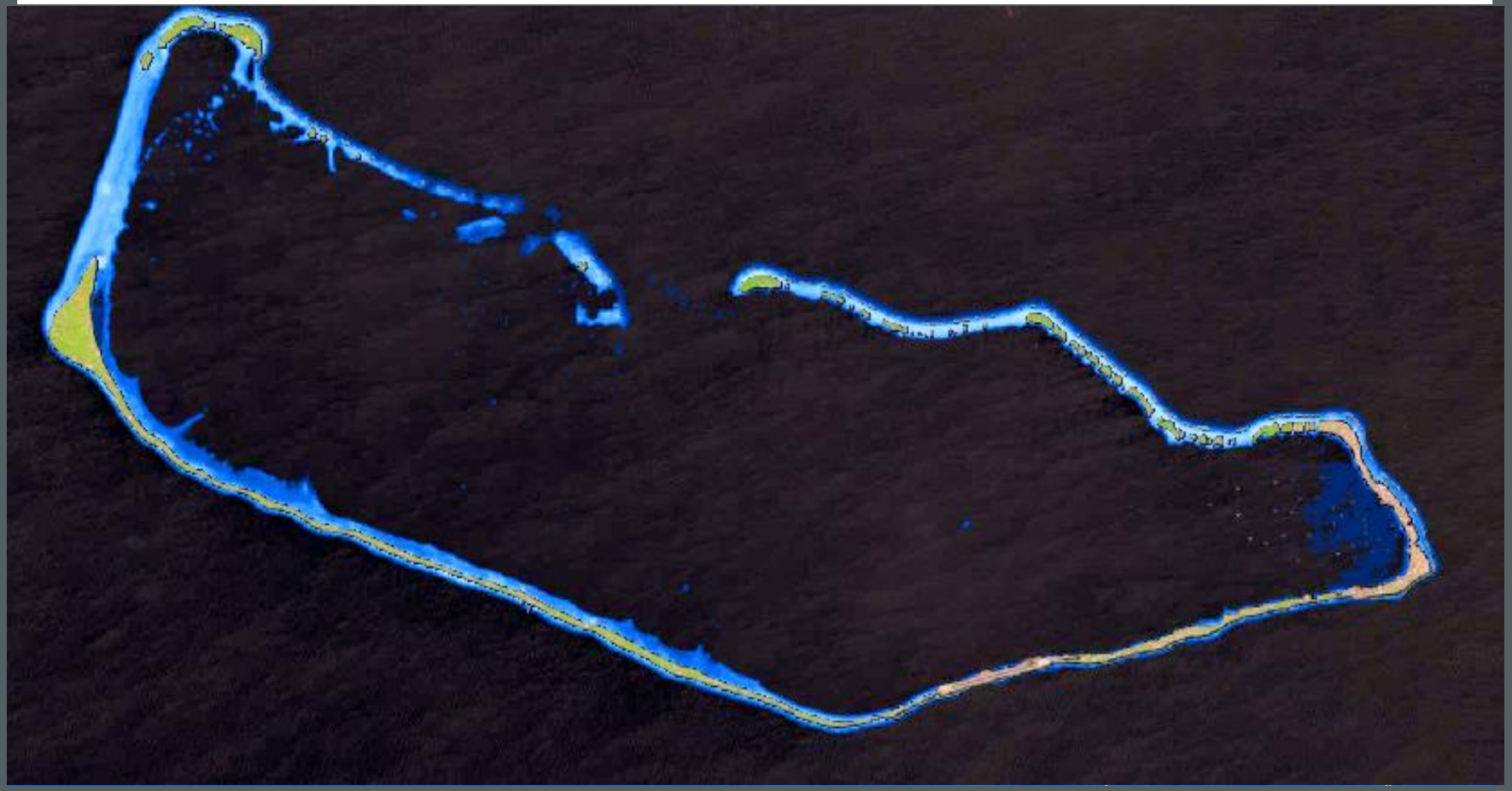
Interagency Working Group On Ocean And Coastal Mapping

Majuro Atoll – Satellite Derived Bathymetry (SDB)
Improving Elevation Mapping in the Pacific



Landsat 8 (August 8, 2014)

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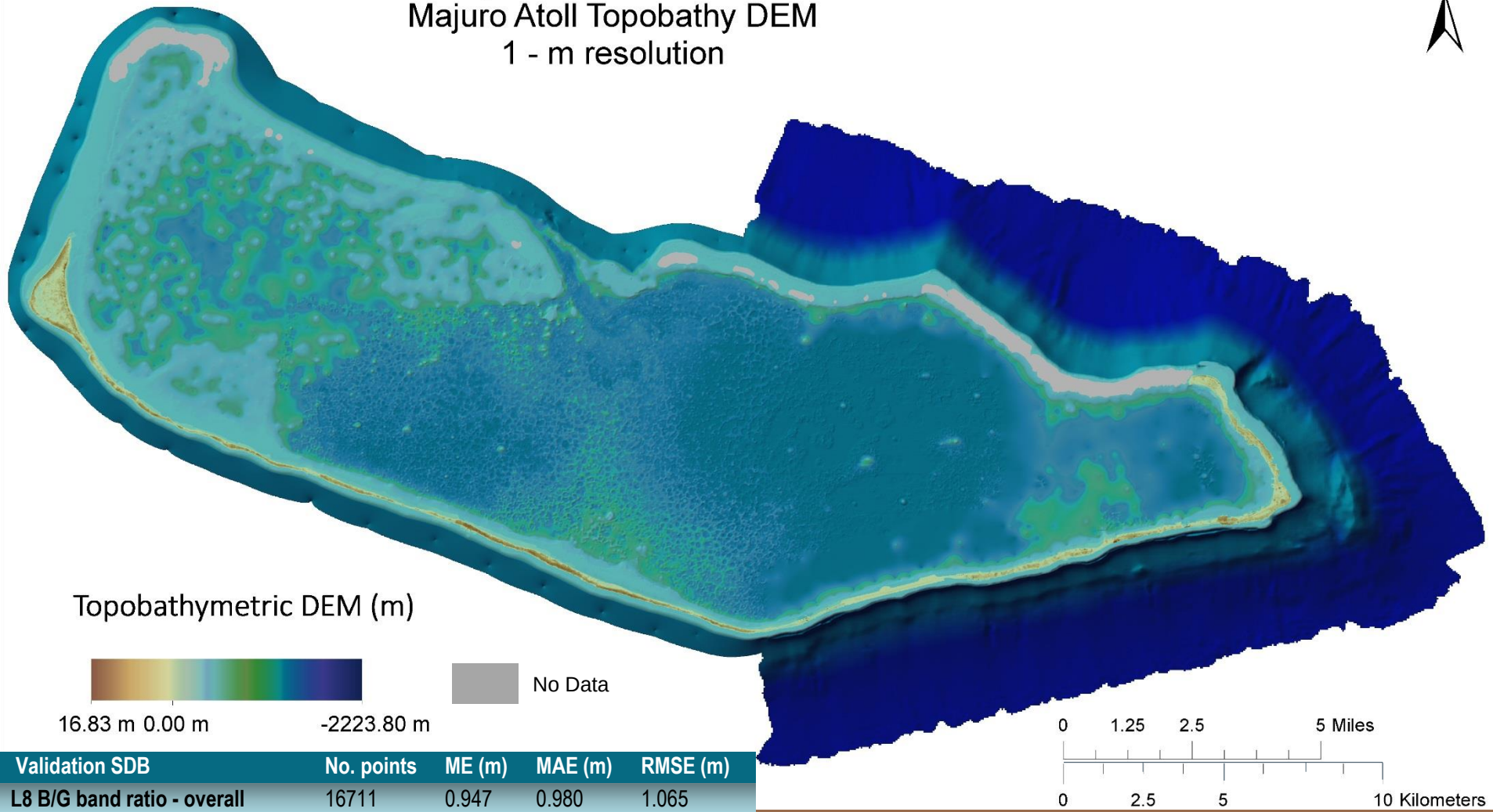
The Republic of Marshall Islands
Majuro Atoll Topobathy DEM
1 - m resolution



Validation SDB	No. points	ME (m)	MAE (m)	RMSE (m)
L8 B/G band ratio - overall	16711	0.947	0.980	1.065
L8 C/R band ratio - overall	3090	0.285	1.408	1.478
WV-3 B/G band ratio - overall	9632	0.866	0.919	1.112
L8 B/G band ratio; 0 to -4m	801	-0.199	0.479	0.608
L8 C/R band ratio; 0 to -4m	125	-0.913	1.038	1.478
WV-3 B/G band ratio; 0 to -4m	1239	1.253	1.327	1.640
L8 SDB B/G band ratio; < -4m	16140	0.336	1.005	1.082
L8 SDB C/R band ratio; < -4m	2965	0.285	1.423	1.488
WV-3 B/G band ratio; < -4m	8393	0.810	0.859	1.011

Validation SfM	No. points	ME (m)	MAE (m)	RMSE (m)
SfM 3-D point cloud P.E.	104	0.000	0.029	0.040
SfM 3-D point cloud	69,648	0.053	0.145	0.191
BE DEM (1 m resolution)	71,373	0.009	0.144	0.197

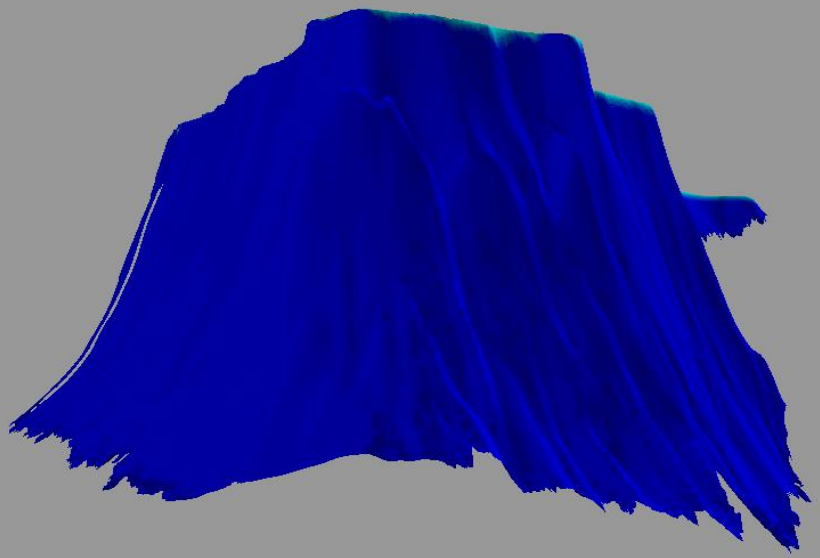
P.E. = Precision Error
WV-3 = WorldView 3
L8 = Landsat 8
SDB = Satellite Derived Bathymetry

B = Blue band
G = Green band
R = Red band
C = Coastal band

ME = Mean Error
MAE = Mean Absolute Error
RMSE = Root Mean Square Error

Majuro Topobathy Fly-by Video

https://doi.org/10.5066/F7416VXX



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CoNED Communications

USGS CoNED Applications Project – CMGP

- **CoNED Project -- https://topotools.cr.usgs.gov/coned/**

Coastal Changes and Impacts

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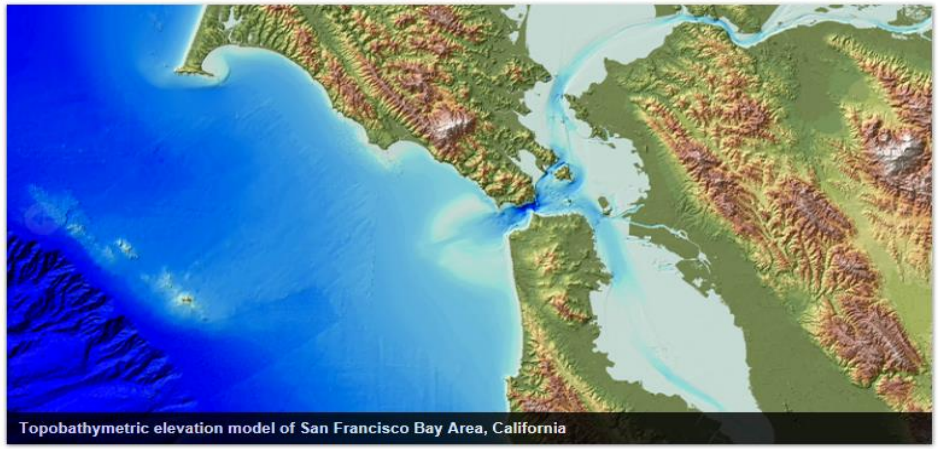
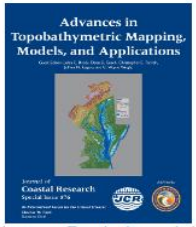
Coastal National Elevation Database (CoNED) Applications Project



Newly Released Topobathy Elevation Data



Special Issue on Topobathymetric Mapping

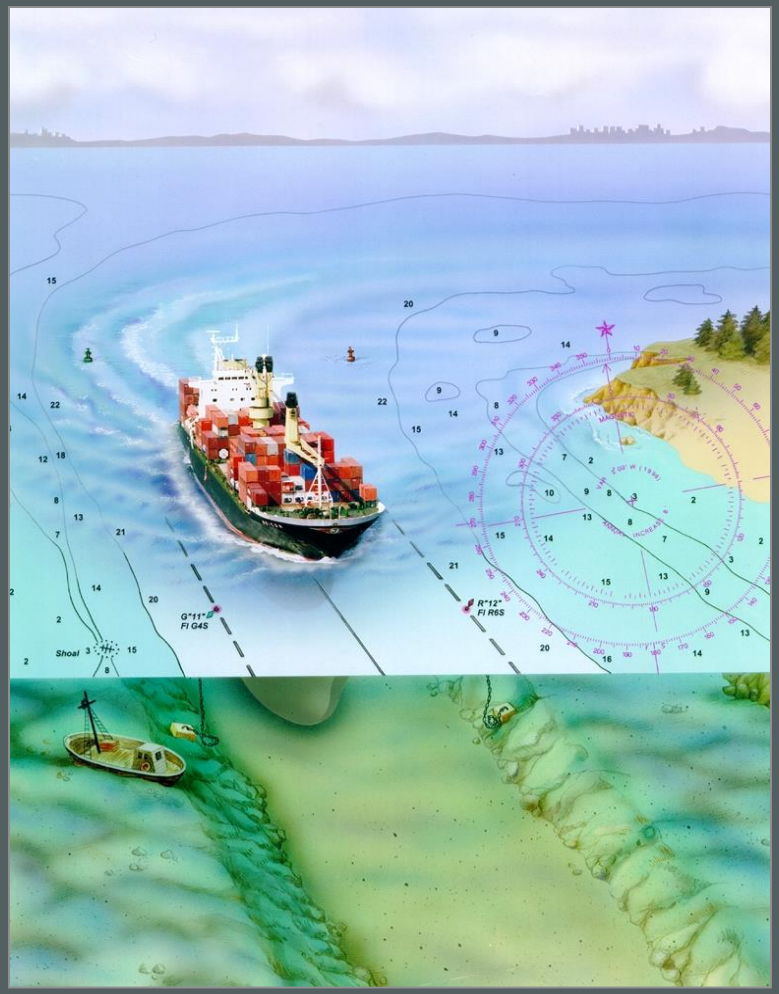
High-resolution coastal elevation data is required to identify flood, hurricane, and sea-level rise inundation hazard zones and other earth science applications, such as the development of sediment transport and storm surge models. Light detection and ranging (lidar) enables the rapid collection of very accurate elevation data over large areas, and during the last decade, airborne laser altimetry has been widely applied to map coastal geomorphology, leading to improved knowledge of coastal geomorphic processes. In addition, high-resolution elevation data from lidar has applications to coastal hazard prediction and mitigation, forest and wetland ecology, and benthic habitat structure and ecosystem function.

During the coming decades, coastlines will respond to widely predicted sea-level rise. Vulnerability maps that depict regions prone to flooding and sea-level rise are essential to planners and managers responsible for mitigating the associated risks and costs to both human communities and ecosystems. InSAR, subaerial lidar, terrestrial lidar, GPS point measurements, topobathymetric lidar, bathymetric lidar, and sonar are key sources of topographic and bathymetric data used to develop detailed, onshore-offshore, cross-ecosystem information on coastal elevation. By progressively constructing enhanced topobathymetric databases for an evolving set of U.S. coastal regions/ecosystems, the USGS Coastal National Elevation Database Applications Project is extending and improving the USGS National Elevation Dataset within coastal regions to enable the widespread creation of flood, hurricane, and sea-level rise inundation hazard maps.

USGS

Questions

daniels@usgs.gov



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CoNED Communications

CoNED Topobathymetric Elevation Model Availability

- Available in USGS Earth Explorer (EE) -- http://earthexplorer.usgs.gov/
- TBDEM Products Page -- https://lta.cr.usgs.gov/coned_tbdem

https://lta.cr.usgs.gov/coned_tbdem

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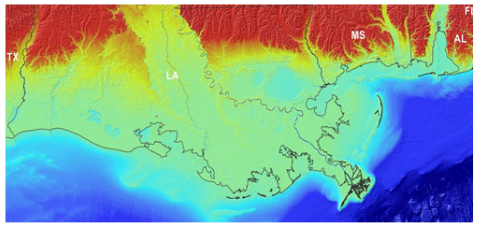
Coastal National Elevation Database (CoNED) Project - Topobathymetric Digital Elevation Model (TBDEM)



Northern Gulf of Mexico (NGOM) Topobathymetric Digital Elevation Model (2014)

Physical processes in the coastal environments are controlled by the geomorphology of both "over-the-land" topography and "underwater" bathymetry; therefore, many applications of geospatial data in coastal environments require detailed knowledge of near-shore topography and bathymetry (topobathymetry). The Coastal National Elevation Database (CoNED) Project is a collaboration between the U.S. Geological Survey (USGS) Coastal and Marine Geology Program (CMGP), the National Geospatial Program (NGP), and the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC). This coastal elevation database integrates disparate light detection and ranging (lidar) and bathymetric data sources into common databases aligned both vertically and horizontally to common reference systems. CoNED Project - topobathymetric digital elevation models (TBDEMs) provide a required seamless elevation product for science application studies such as shoreline delineation, coastal inundation mapping, sediment-transport, sea-level rise, storm surge models, tsunami impact assessment, and analysis of the impact of various climate change scenarios on coastal regions.

CoNED Project elevation model development is focused in select regions along the U.S. coast, such as in the Northern Gulf of Mexico (NGOM), the Hurricane Sandy region, San Francisco Bay, the Pacific Northwest, and the North Slope of Alaska. The models vary in spatial resolution from 1 to 3 meters. The temporal range of the input bathymetry and topography data varies for most CoNED Project TBDEMs from the mid- to late-1900s to the present. The raster topobathymetric elevation product, the Federal Geographic Data Committee (FGDC) metadata, and a spatial referenced ESRI shapefile are contained in the downloadable bundle.

CoNED Topobathymetric Digital Elevation Model Data Products

This collection of high-resolution coastal elevation data is available in a user-friendly Georeferenced Tagged Image File Format (GeoTIFF). The elevation model has floating point numeric values. Areas where data is incomplete due to lack of full image coverage or No Data are represented with the numeric value of -3.40282346639e+038.

CoNED topobathymetric elevation data are intended for scientific use within a Geographic Information System (GIS) or other special application software.

Product Specifications	
Projection	Geographic or UTM*
Horizontal Datum	NAD83 (North American Datum of 1983)
Vertical Datum	NAVD88 (North American Vertical Datum of 1988)
Vertical Units	Meters
Spatial Resolution	3 meter, 2 meter, or 1 meter*

*Projection and resolution will vary by region.

Product Info | Get Data | Policies | Help

CoNED Project Partners and Customers

- DOI Pacific Islands Climate Science Center – Improving Elevation Mapping in the Pacific
- USGS Land Remote Sensing (LRS) Program – Lidar Canopy and Vertical Land Transformations
- USGS Land Change Science (LCS) Program – Sea Level Rise Vulnerability
- USGS National Geospatial (NGP) Program – 3D Elevation Program (3DEP)
- USGS Ecosystems
  - National Wetlands Research Center (NWRC) – Topobathymetric data
  - Leetown Science Center – Inland Bathymetry & Lidar Vegetation
- USGS Water Science Centers – Groundwater and Hydrologic Modeling
  - New Jersey – Sandy Hook
  - New York – Jamaica Bay and Fire Island
- USGS PCMSC - Coastal Storm Modeling System: CoSMoS
- USGS WHCMSC – Wetland Synthesis
- NOAA National Centers for Environmental Information (NCEI) formally NGDC
- NOAA Office for Coastal Management (OCM) – Sea Level Rise Viewers
- USACE Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX)
- The Nature Conservancy (TNC) – Coastal Resiliency Viewers
- Coastal Protection and Restoration Authority (CPRA) – Wetland Restoration / Flood Prediction
- Virginia Institute of Marine Sciences (VIMS) – Wetland Extent Validation Research
- George Mason University – Frictional Surface Roughness Research & TBDEM Validation
- College of Staten Island – Storm Surge Workshop, Hydro-enforcement Research
- South Dakota State University – UAS Research

USGS