# Topobathy Lidar and VDatum in the Coastal Mapping Program

**Stephen White**

**NOAA**

**National Geodetic Survey/Remote Sensing Division**

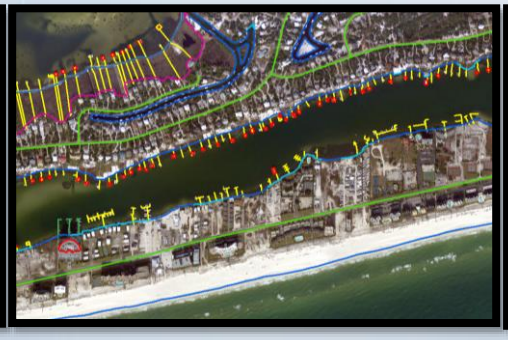
National Oceanic and Atmospheric Administration

# National Geodetic Survey

**Mission:** Define, maintain and provide access to the National Spatial Reference System.

**RSD Primary Programs:**

**Aeronautical Survey Program**



**Coastal Mapping Program**

**Emergency Response**

National Oceanic and Atmospheric Administration

# The Issue: Delineating a Consistent Shoreline

**The Coastal Environment: a margin of continuous change.**

- **Shorelines vary due to:**
  - **-wave energy**
  - **-tidal cycles**
  - **-atmospheric conditions**
  - **-anthropogenic influences**

- **Shoreline change can vary dramatically or negligibly and in no uniform pattern, at temporal scales of daily, seasonally, and decadal.**

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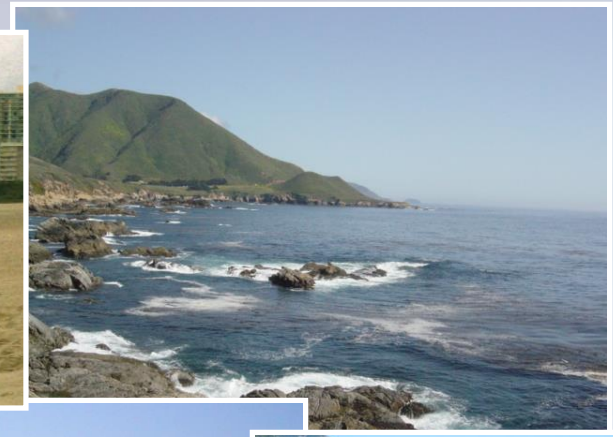
# The Issue: Delineating a Consistent Shoreline:

## There are numerous proxies utilized to establish the shoreline





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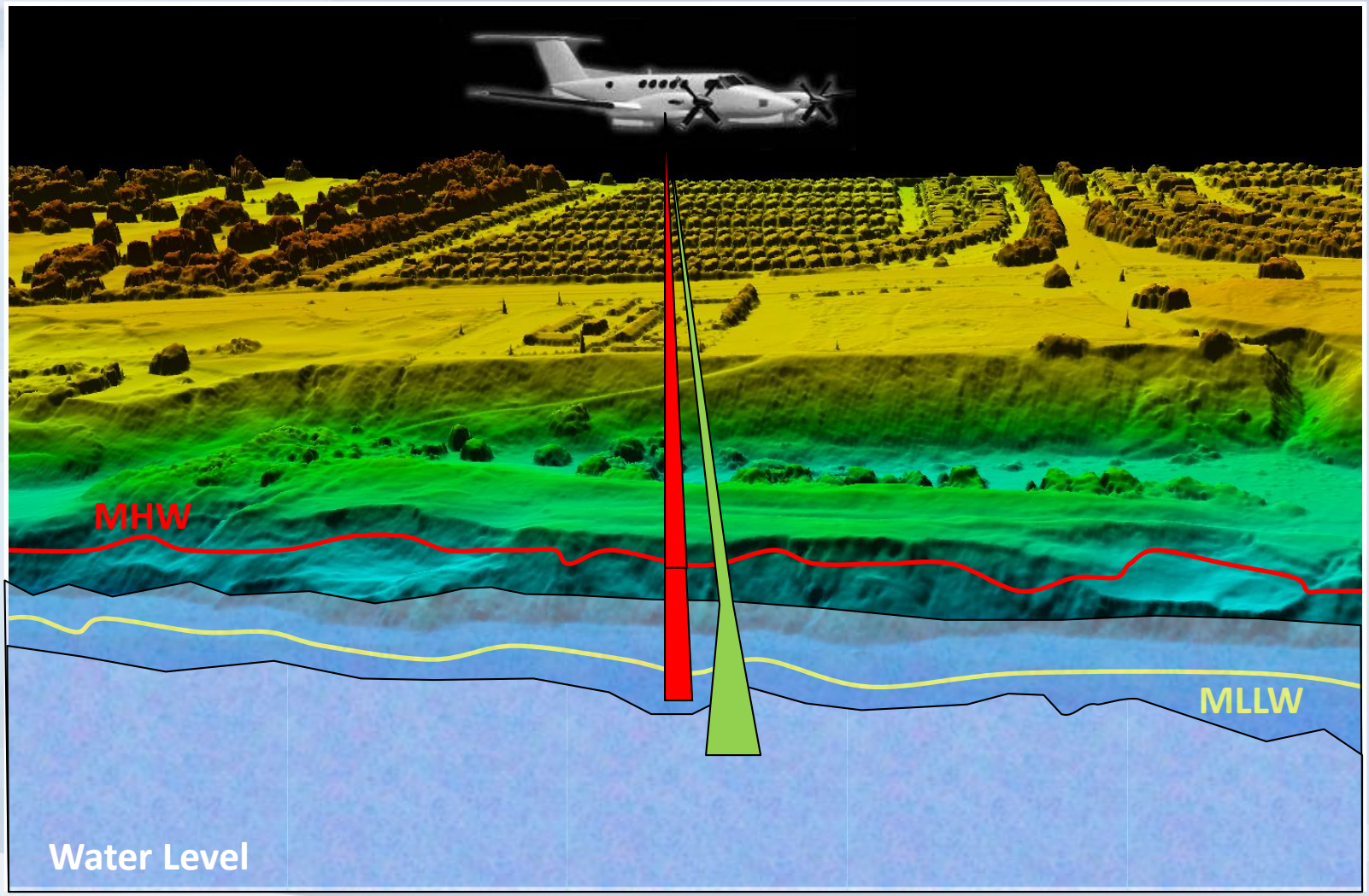
# The Issue: Extracting multiple tidal datum based shorelines from one lidar dataset

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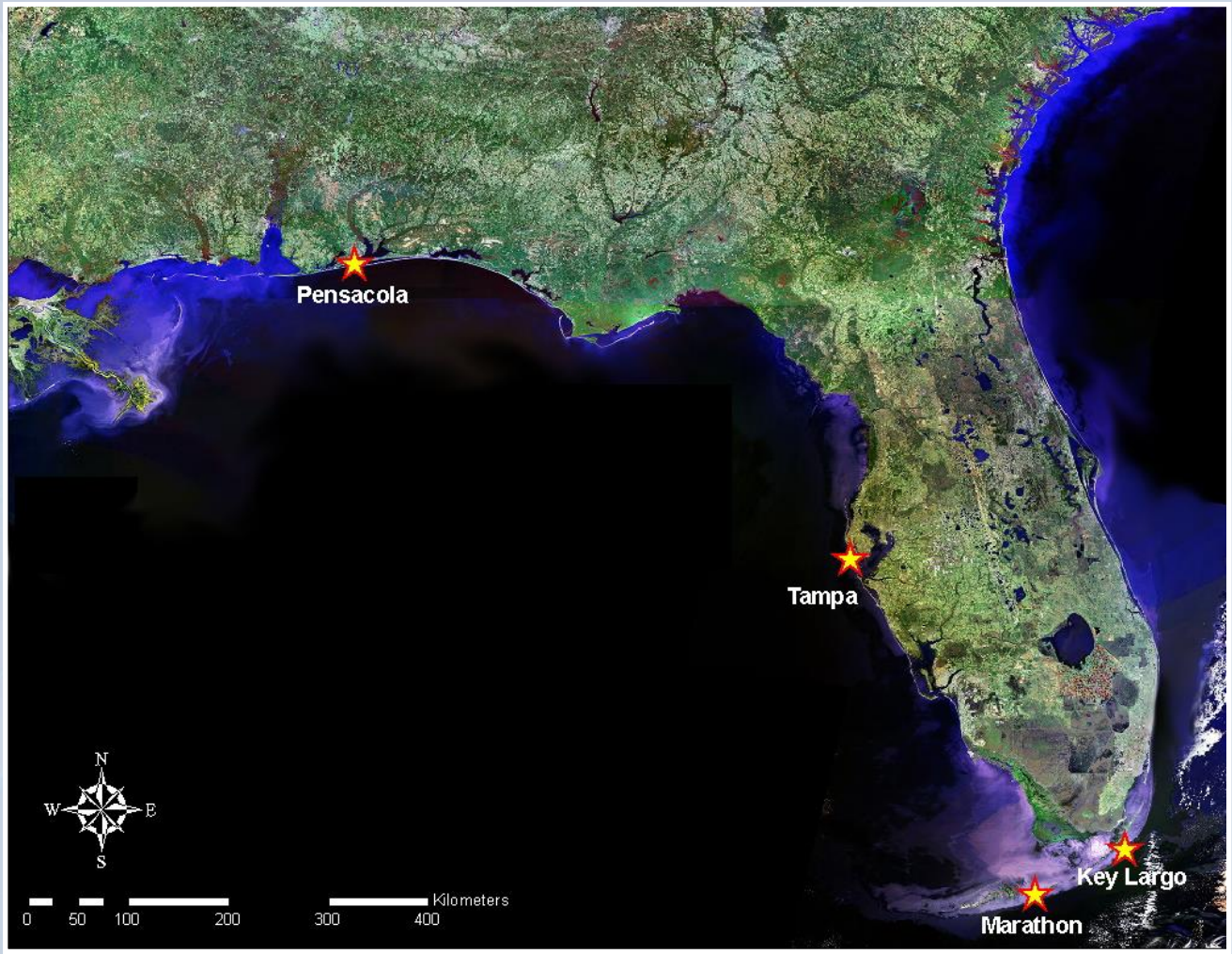
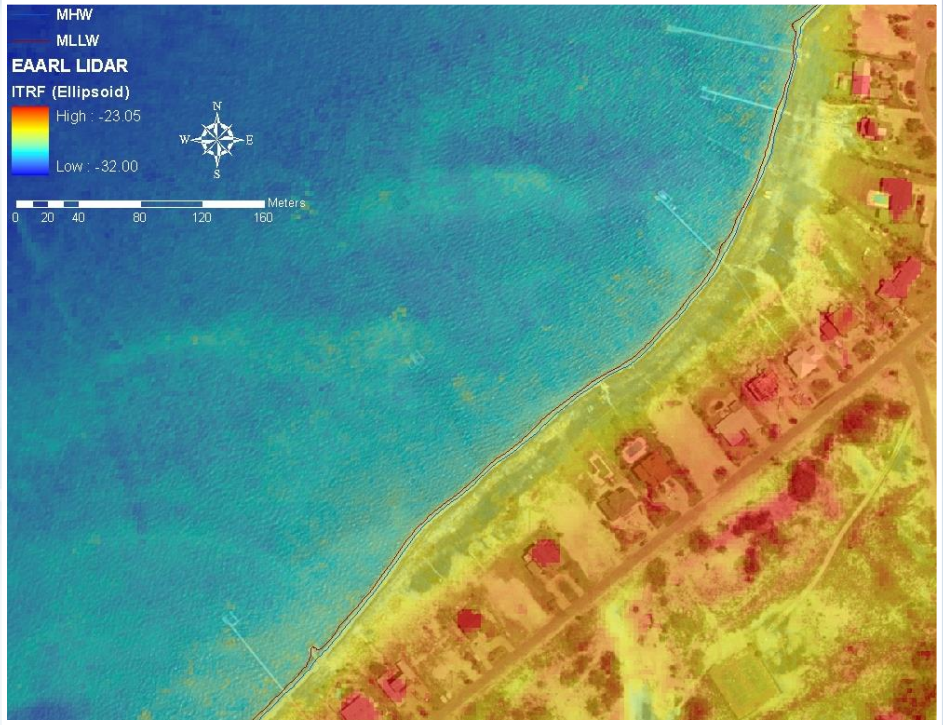
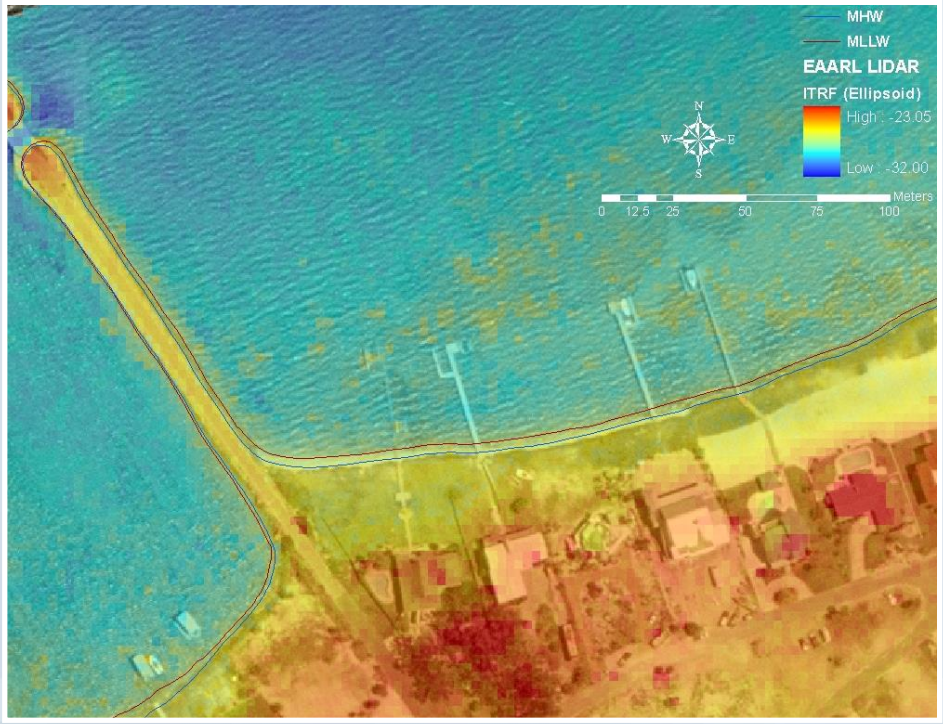
# Experimental Advance Airborne Research Lidar (EAARL): 2006



# The EAARL Project: Shoreline Extraction (Pensacola)

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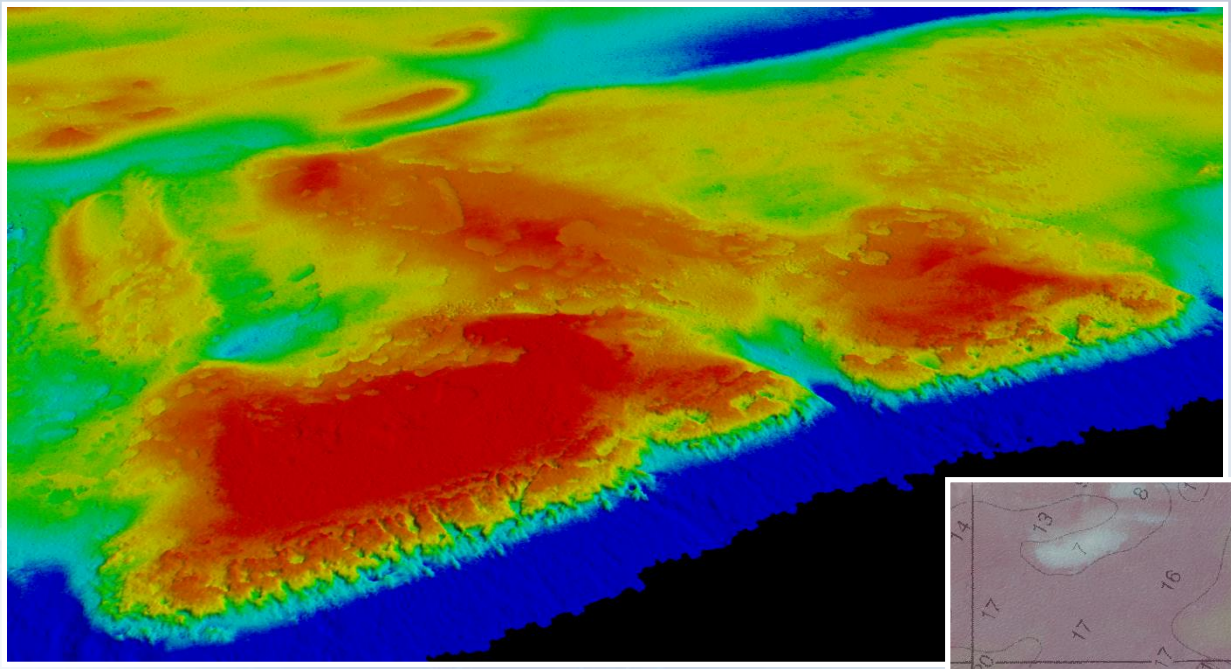
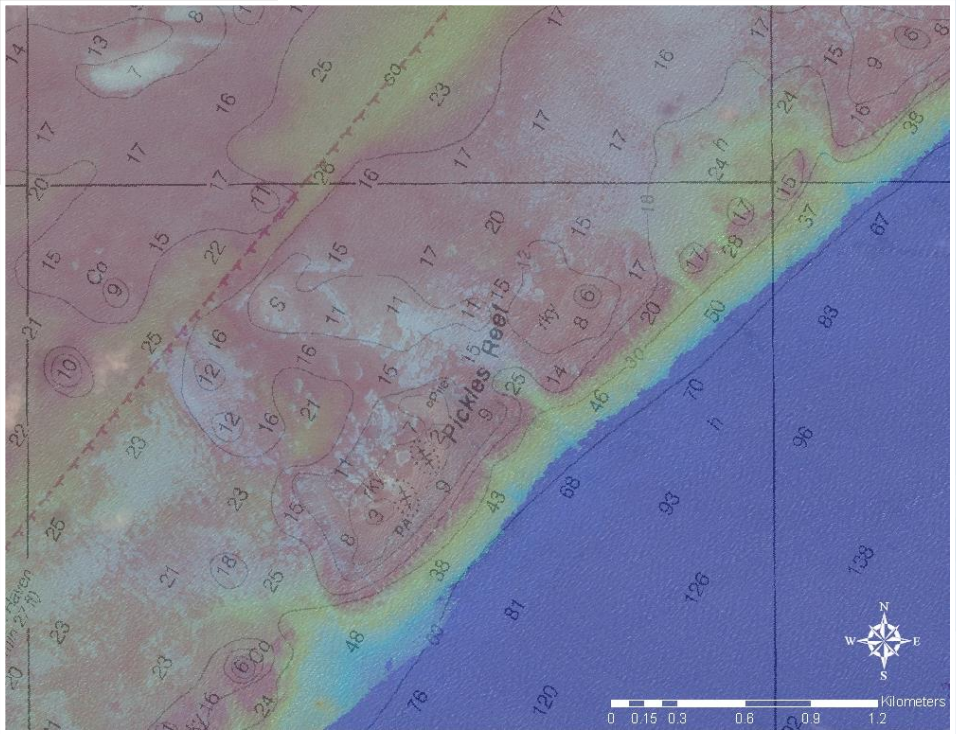
# The EAARL Project: Florida Keys



- Nautical Charting
- Rugosity Measurements

Habitat Structure and Cover

Ecosystem Management

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# Acquisition: Aerial Platform

National Oceanic and Atmospheric Administration

# Topobathy Lidar

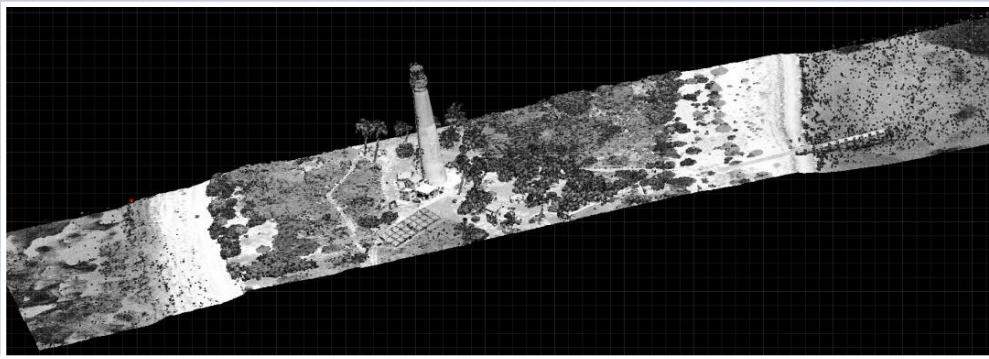
**Occupies middle ground between conventional topographic and bathymetric systems:**

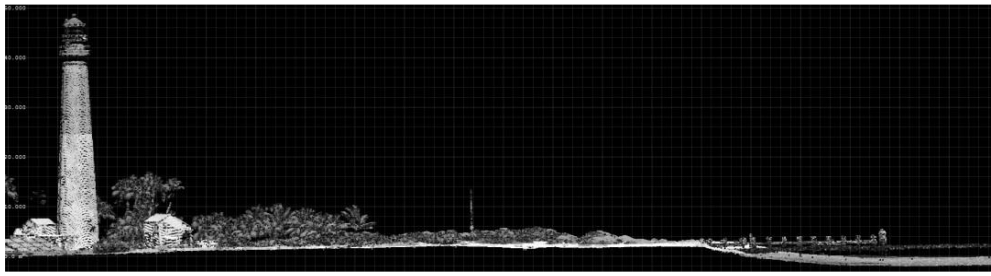
- Narrow Beam,
- Low Power,
- Small FOV,
- Very High Sampling Rates

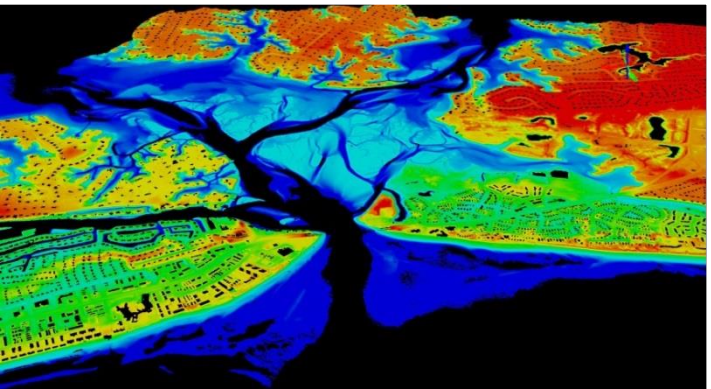
- Focus is on shallow water and environmental applications

- **Uniquely suited for shoreline mapping**
  Seamless, high-resolution data across backshore, intertidal, and nearshore marine zones

- **Fill in shallow water gap**
  (shoreward of NALL line)

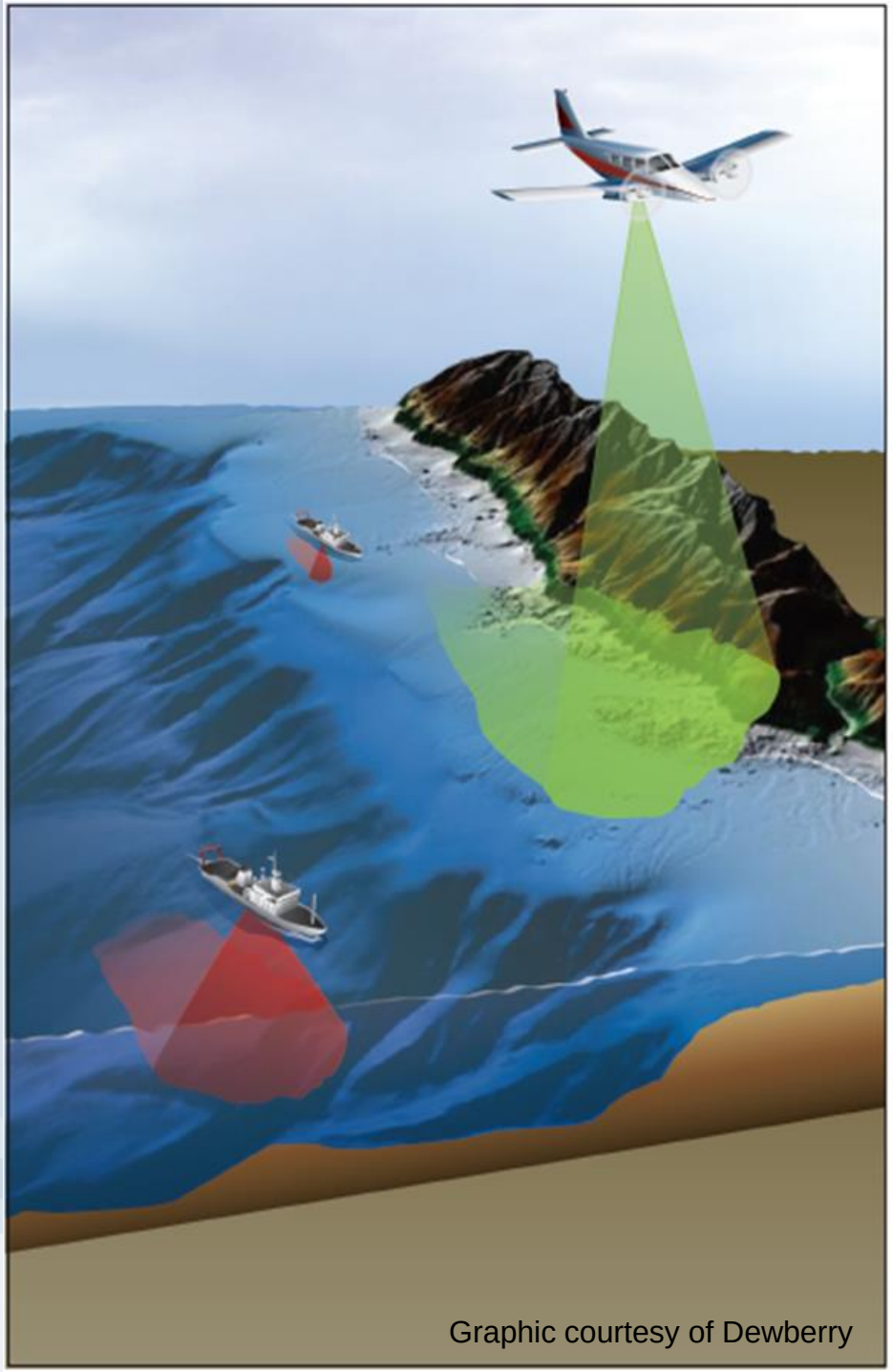






# Support of Hydrographic Surveys

- RSD collects nearshore topobathy lidar to the 4m NALL in the year prior to ship ops
- RSD will provide both shoreline and nearshore bathymetry
- Hydro operations will use this data to plan operations and overall situational awareness
- Increases efficiency and safety of launch and ship operations



Graphic courtesy of Dewberry

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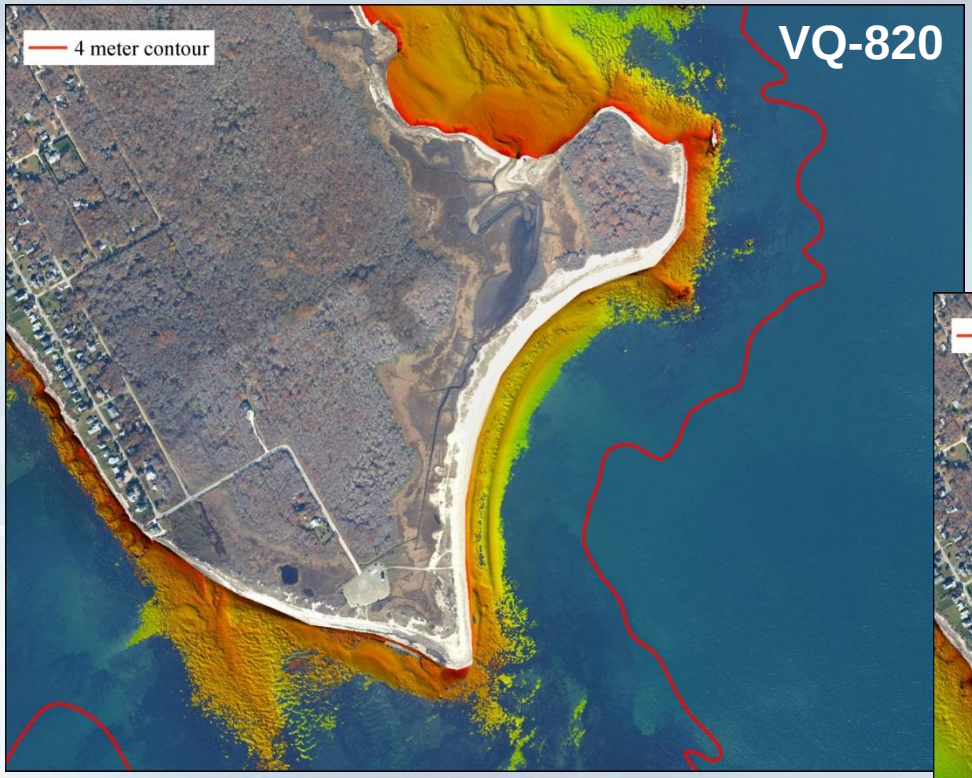
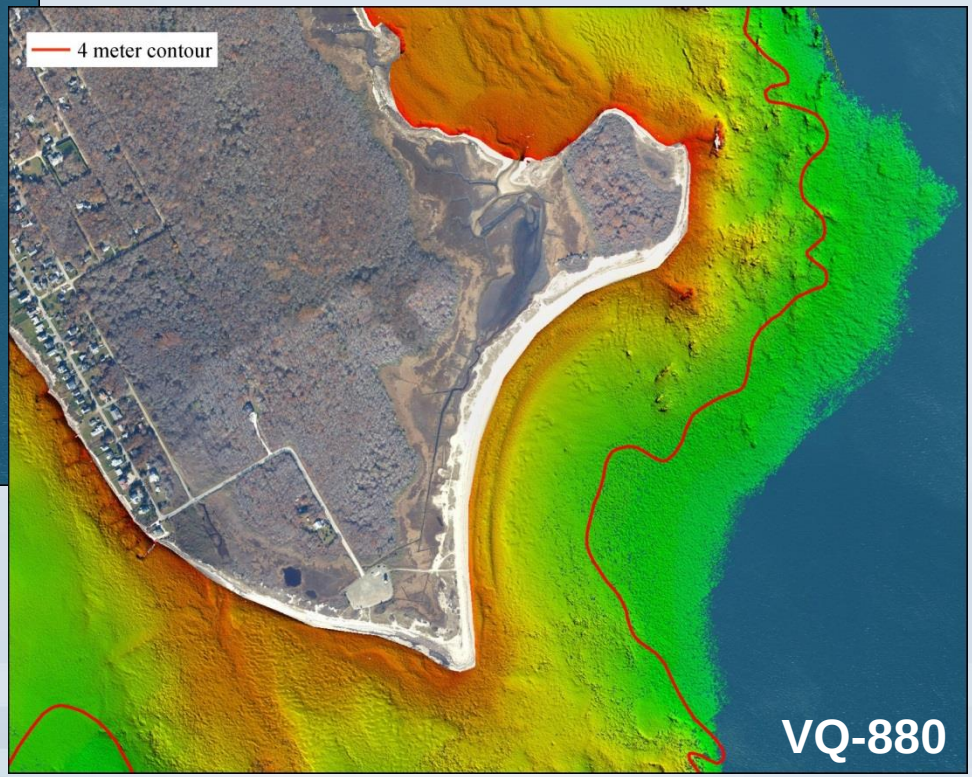
# Buzzards Bay

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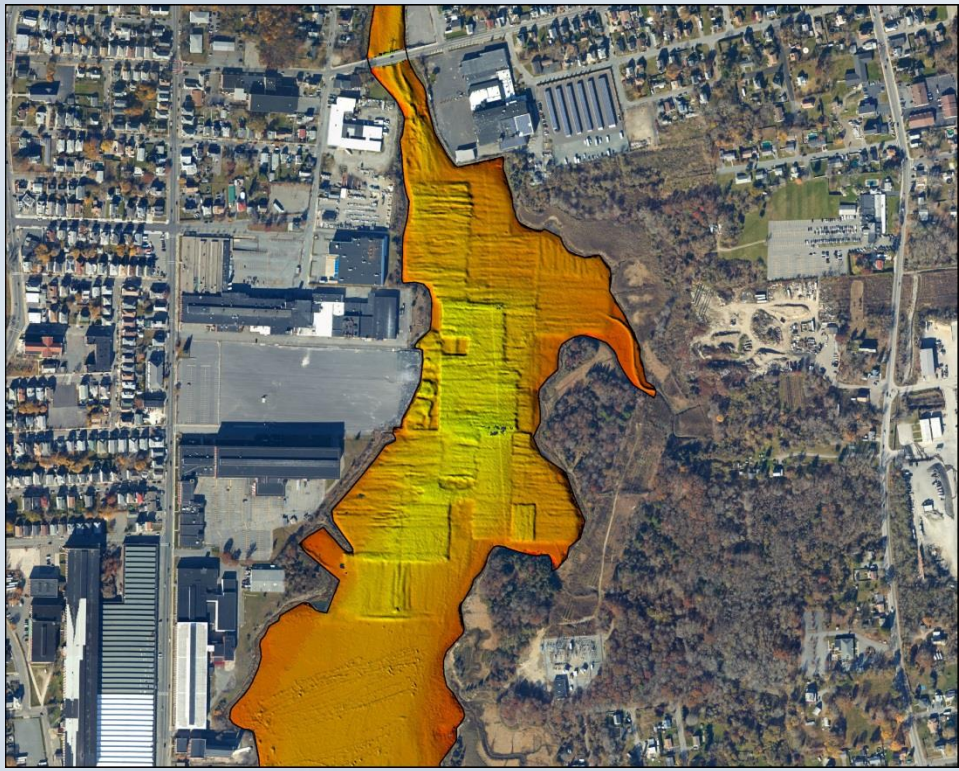
# Buzzards Bay: New Bedford Harbor

## VQ-820

## VQ-880



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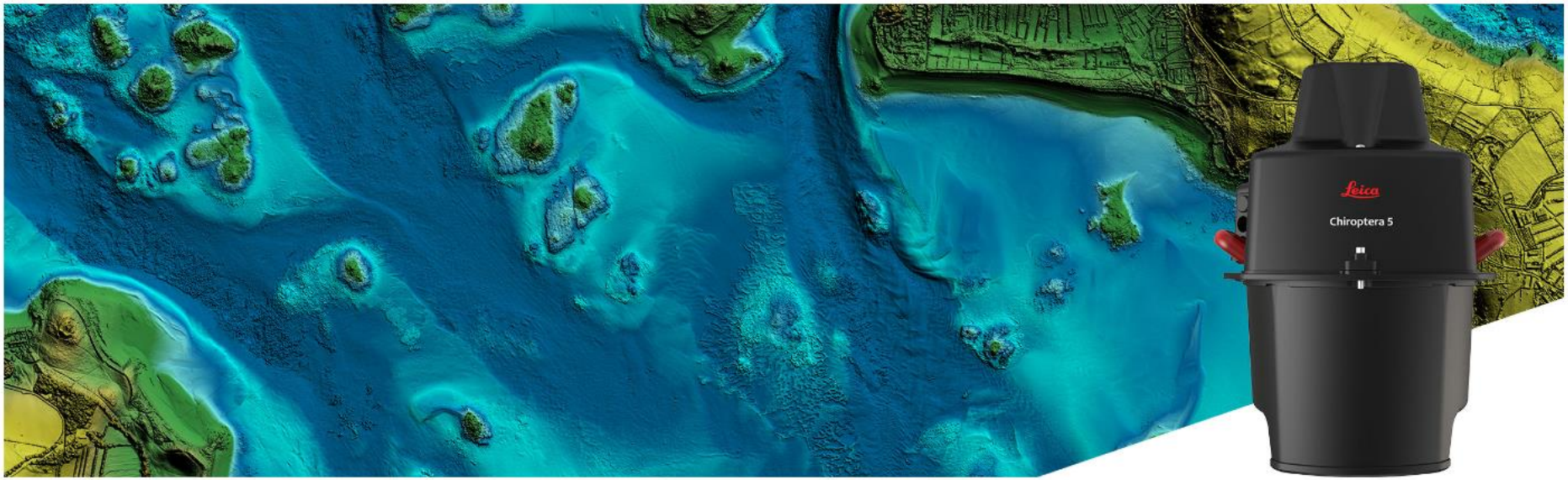
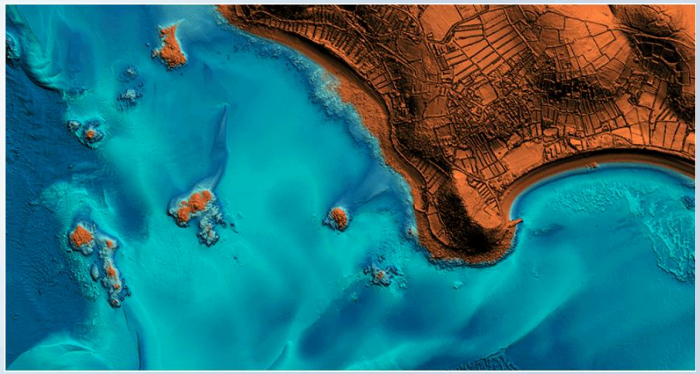
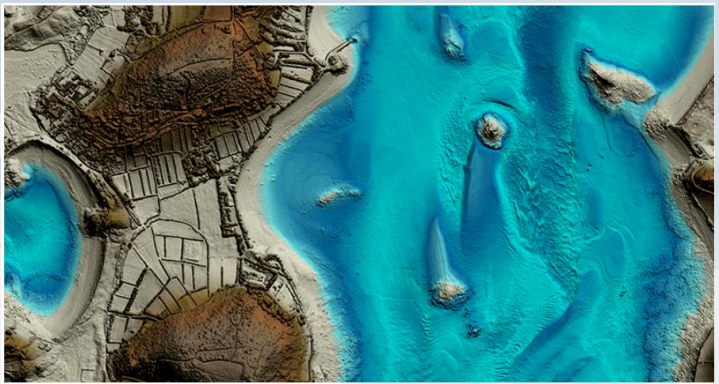
# Leica Chiroptera-5 Bathymetric & Topographic LiDAR

Superior point density and depth penetration for coastal and inland water surveys



Leica Chiroptera-5, the high-performance airborne sensor, combines topographic and bathymetric LiDAR channels with a 4-band camera to deliver seamless data from water to land. The system provides 40% higher point density, a 20% increase in water depth penetration and improved topographic sensitivity compared to previous generations. The sensor delivers detailed LiDAR data of submerged terrain and objects and supports numerous applications such as nautical charting, erosion risk assessment, environmental monitoring and seabed classification.



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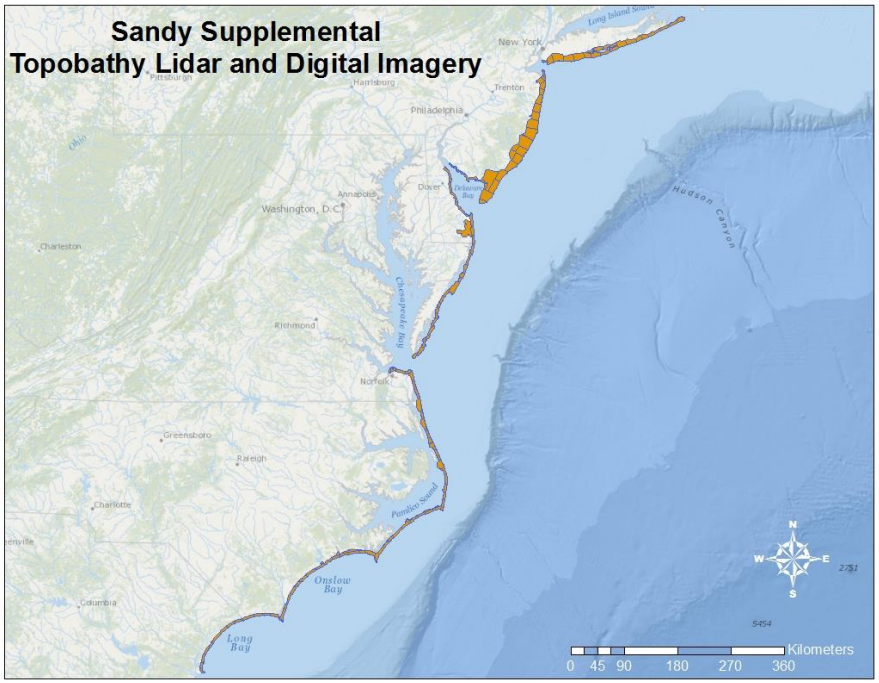
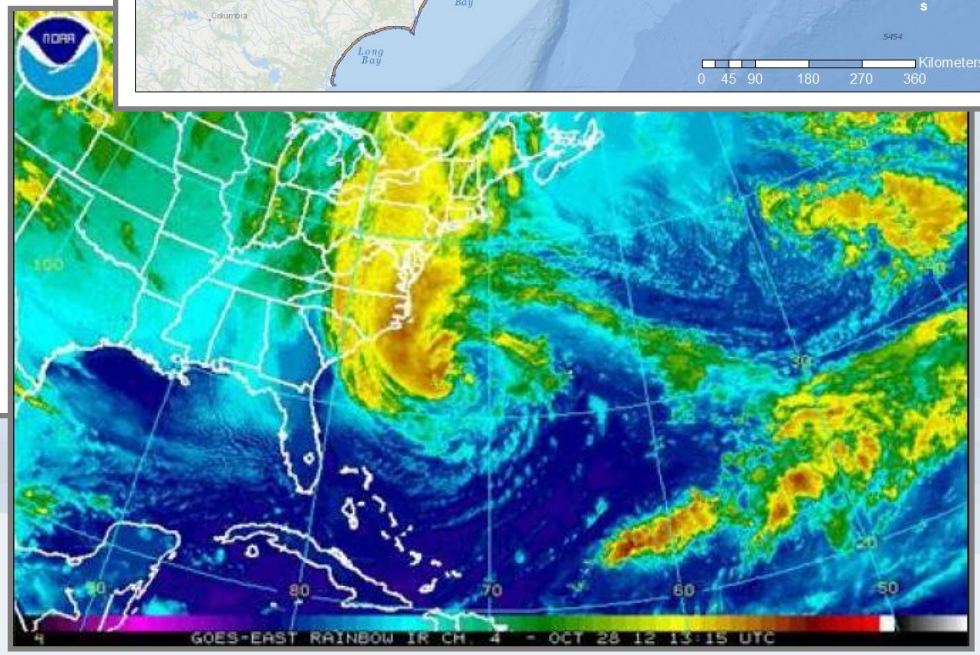
# Sandy Supplemental Topobathy Lidar

**Light Detection and Ranging (LIDAR) and Digital Camera Imagery Requirements**

**SCOPE OF WORK FOR SHORELINE MAPPING**
**IN SUPPORT OF**
**Public Law No: 113-002,**
**Disaster Relief Appropriations Act 2013**

REMOTE SENSING DIVISION
NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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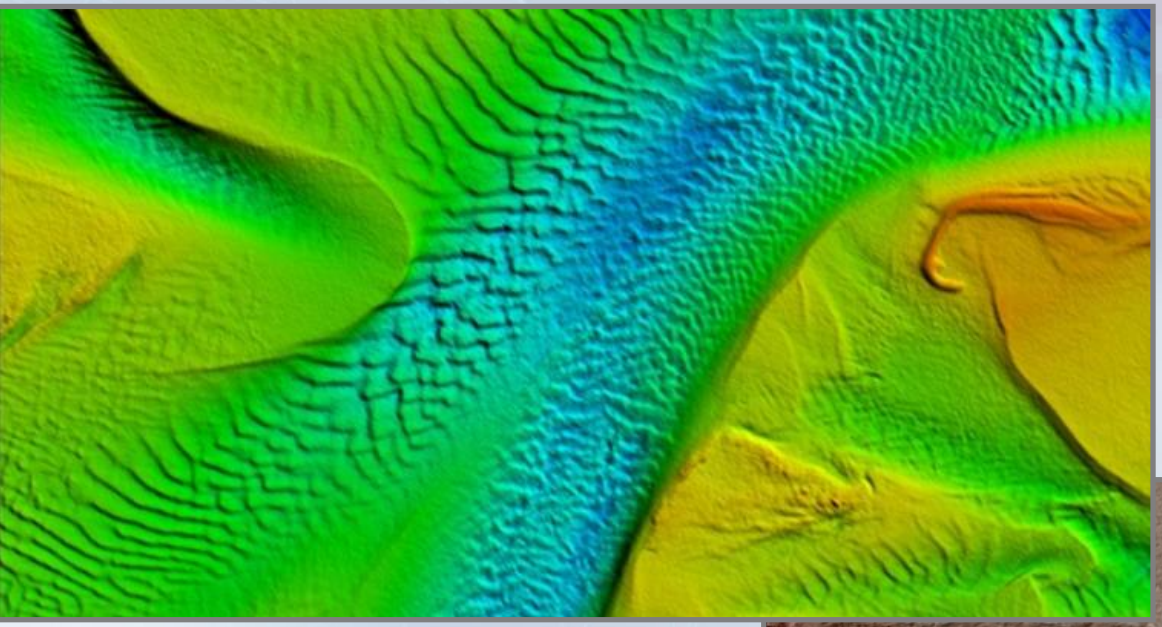
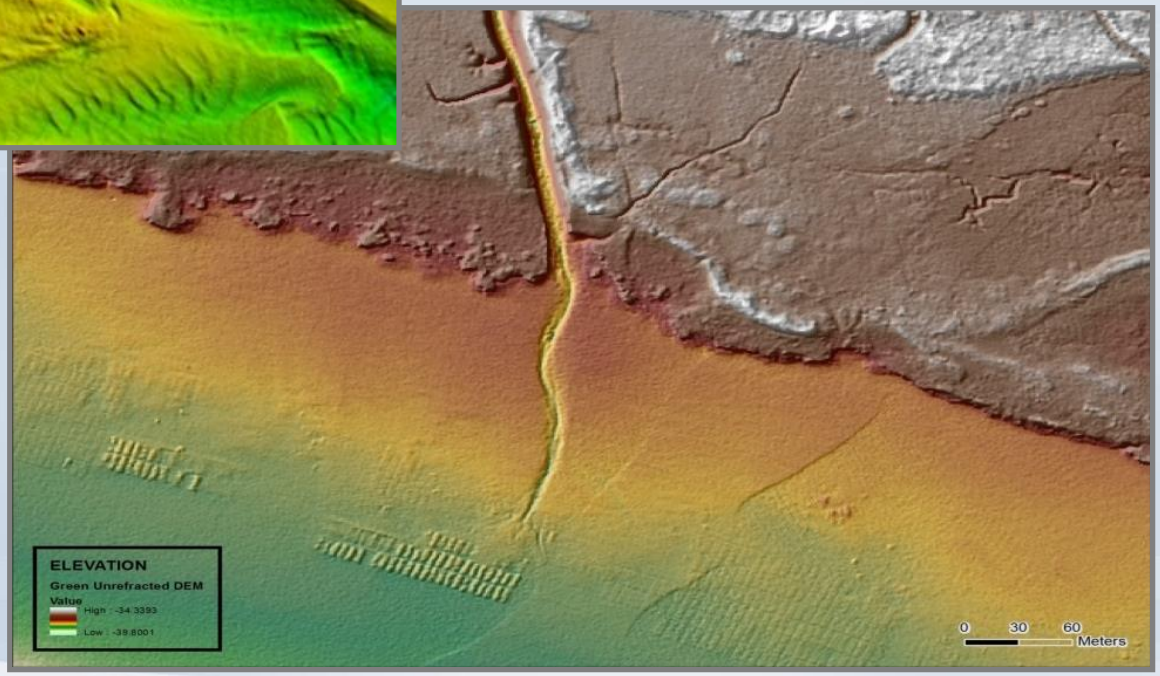
# Sandy Supplemental Topobathy Lidar



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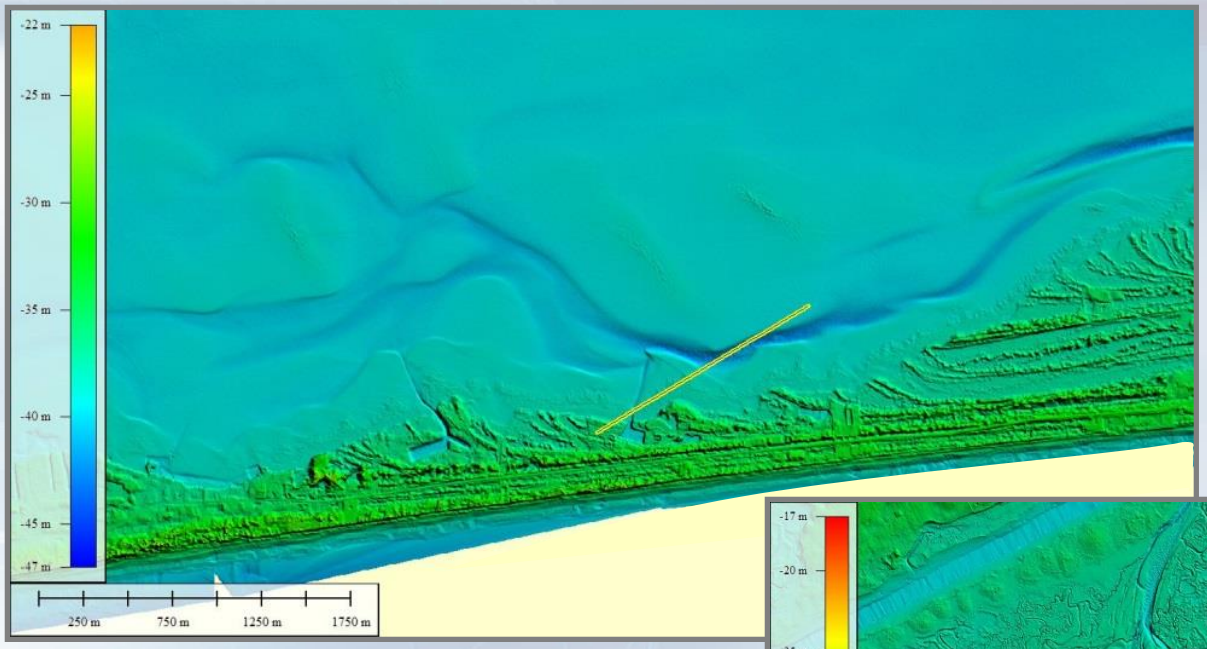
Courtesy of Dewberry/Quantum Spatial

# Sandy Supplemental Topobathy Lidar





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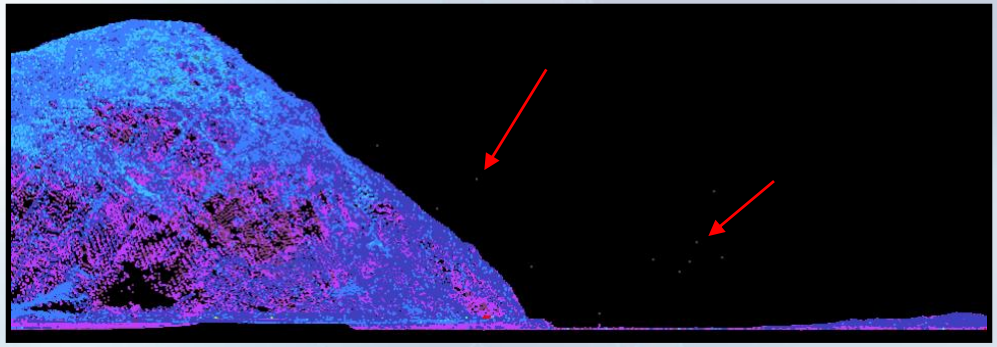
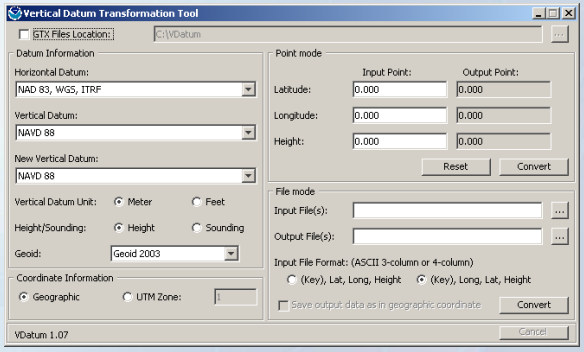
Courtesy of Dewberry/Quantum Spatial

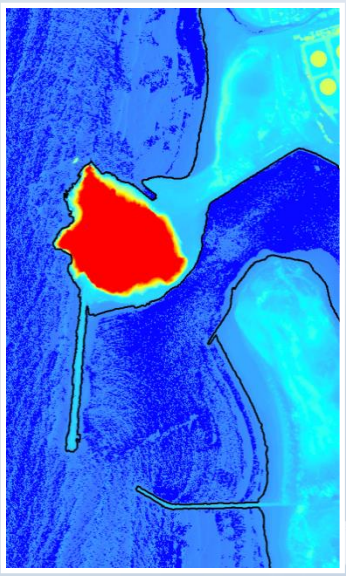
# Lidar Shoreline Extraction

## Edit Lidar Point Cloud

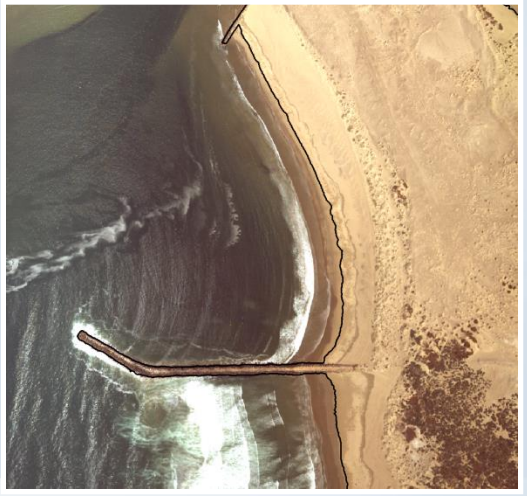





VDatum



Contour Shoreline from DEM



Quality Control &
Feature Attribution

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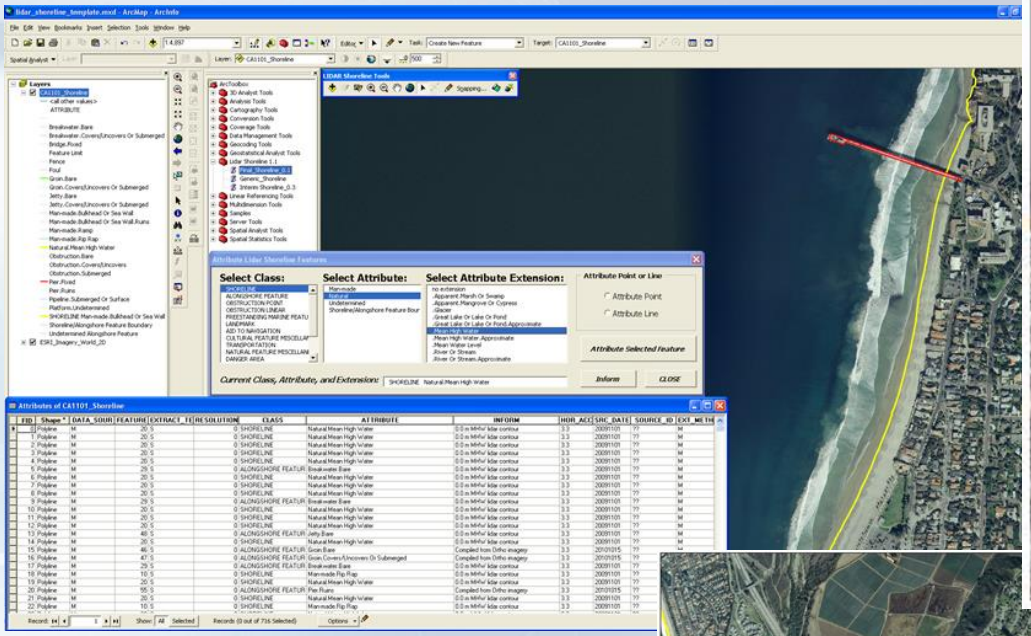
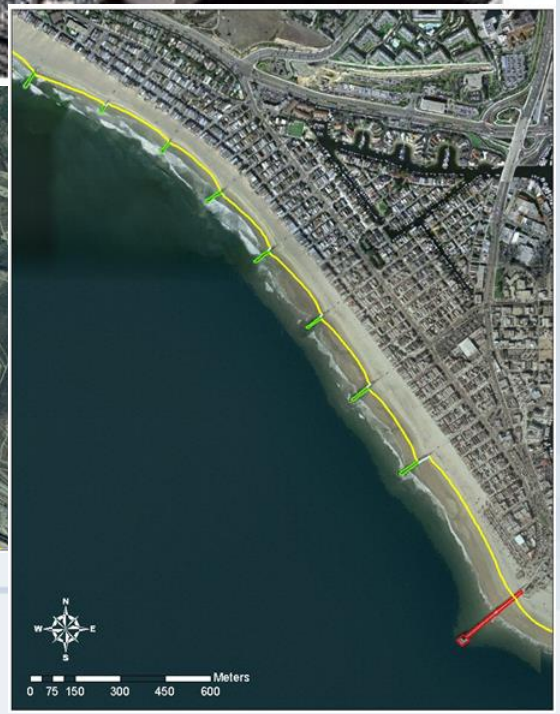
# Imagery





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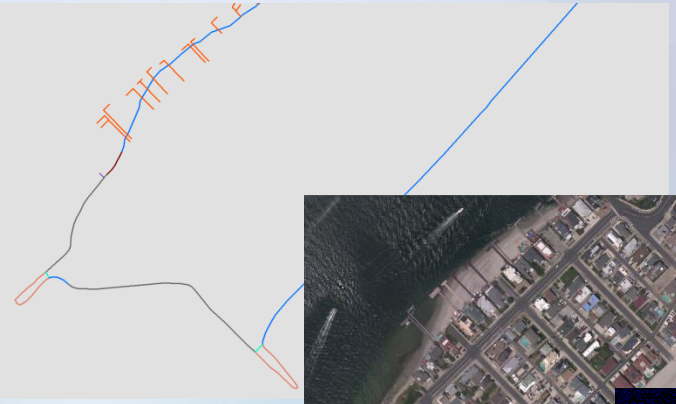
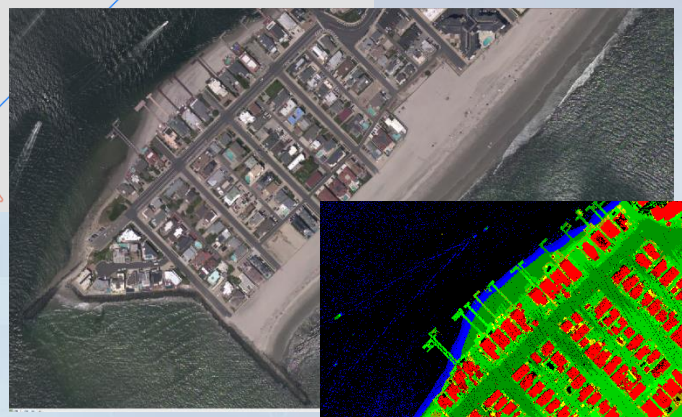
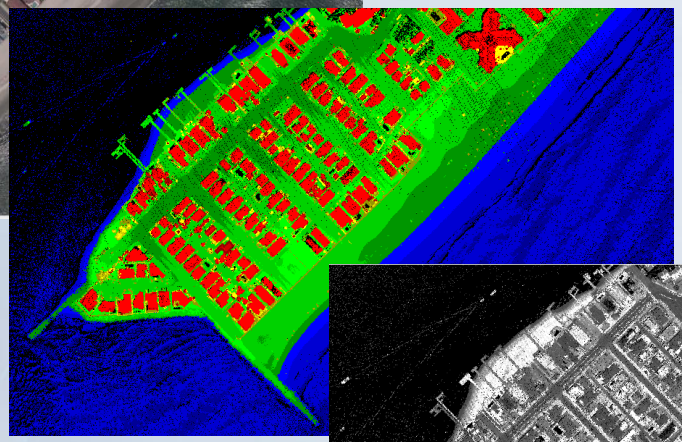
# IOCM Products/Deliverables



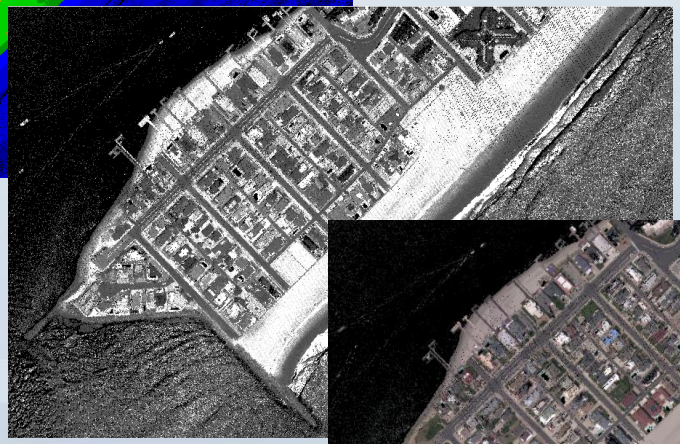
Shoreline



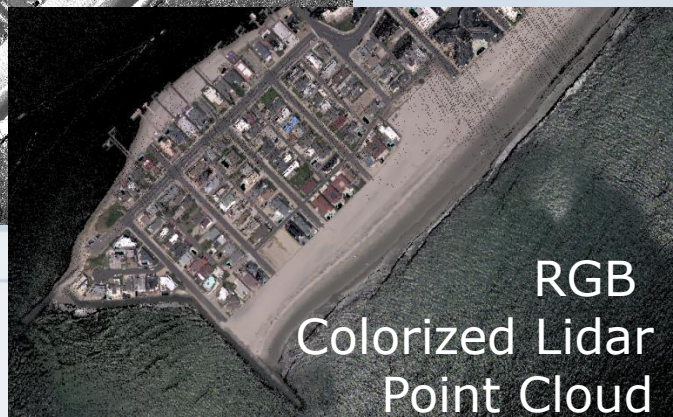
Ortho Mosaic Imagery



Lidar Point Cloud (elevation)



Lidar Point Cloud (intensity)



RGB Colorized Lidar Point Cloud

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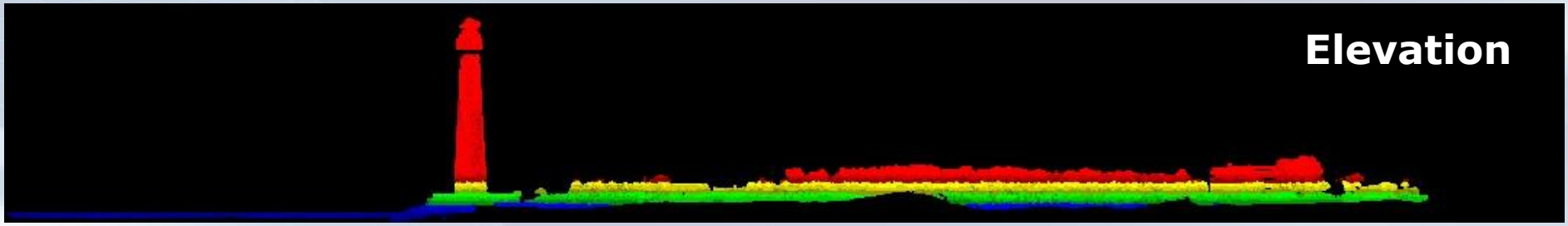



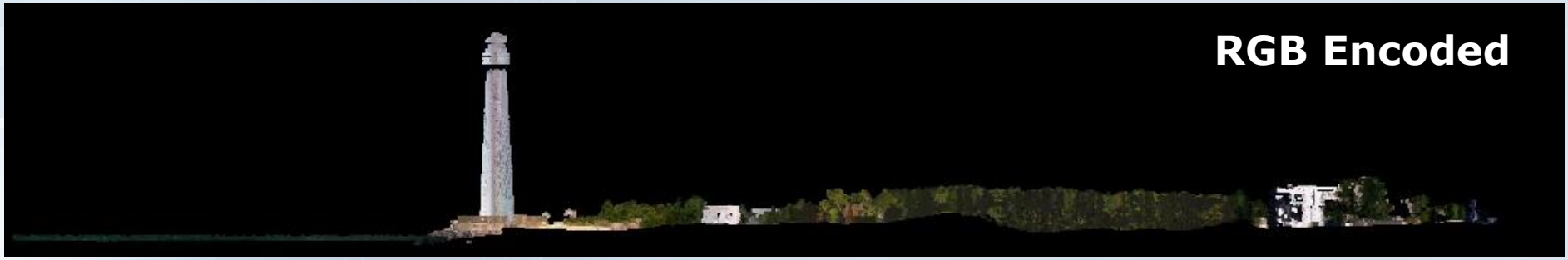


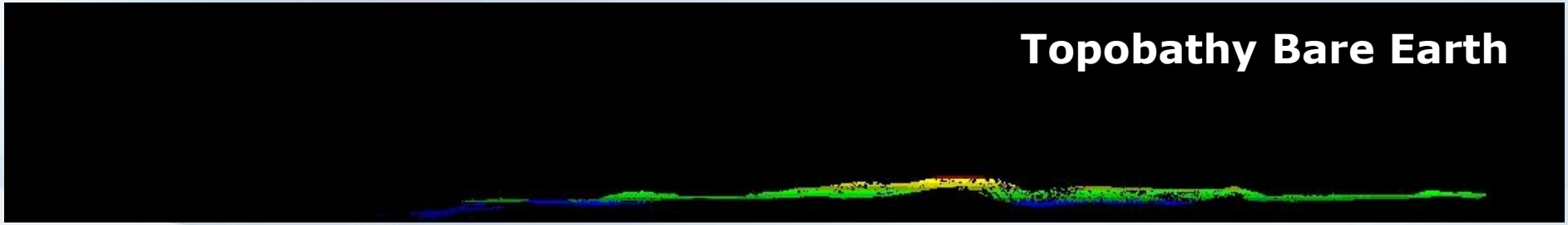


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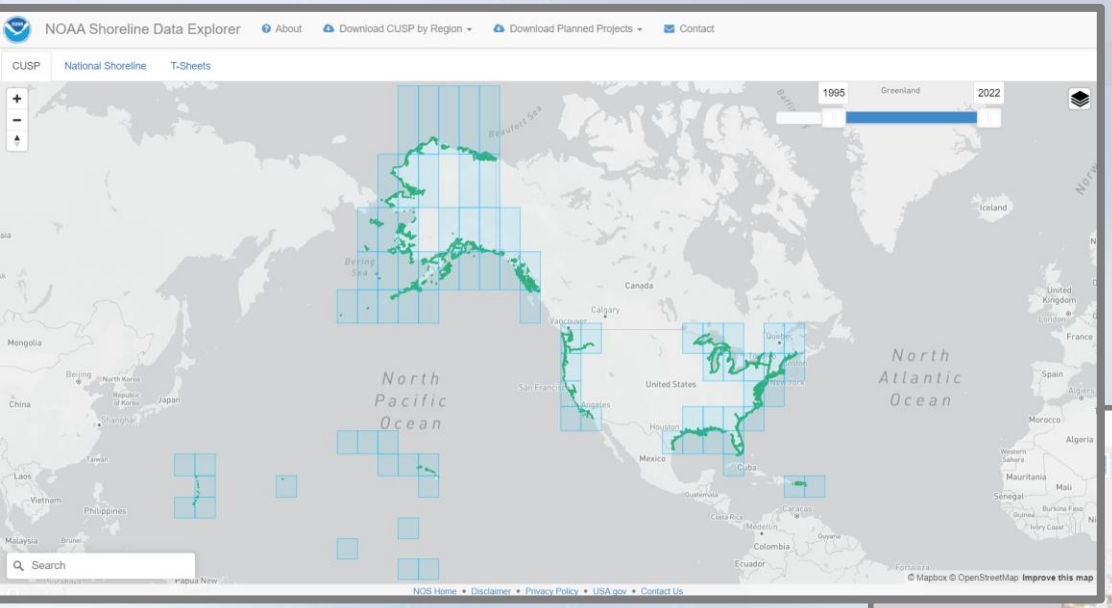
# Distribution of Data




## Shoreline:

https://nsde.ngs.noaa.gov/

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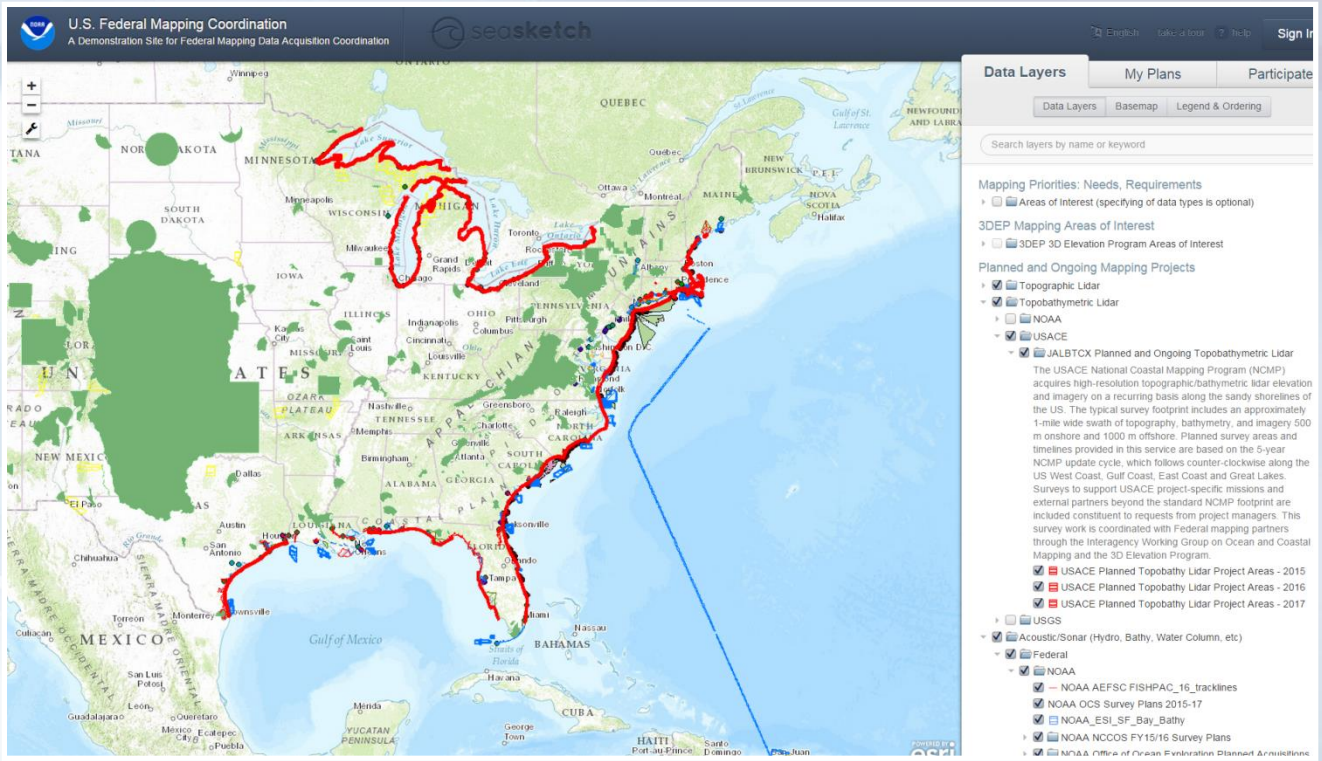
## Lidar and Imagery:

https://www.coast.noaa.gov/digitalcoast/

# U.S. Federal Mapping Coordination Site




- IWG-OCM and 3DEP agencies are using Seasketch tool to share info on acquisition plans, data needs, coordination
- Additional tools available for use – forums, sketching

**http://www.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4**

- Identifies mapped areas
- Improves planning
- Enables cross-agency collaboration

- Avoid costly duplication of effort
- Maximize survey time
- Meet science & mission requirements

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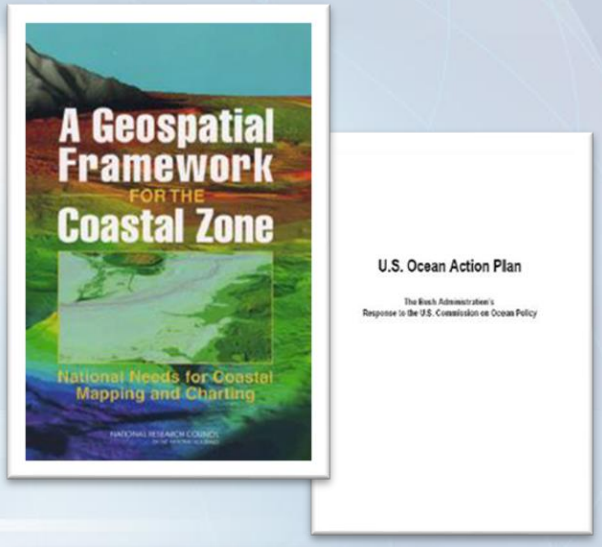
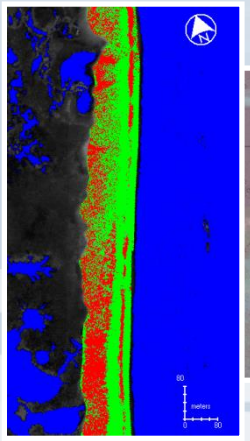
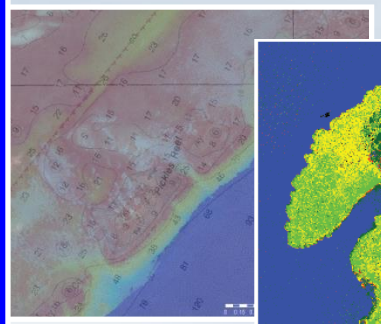
# Integrated Ocean and Coastal Mapping (IOCM)

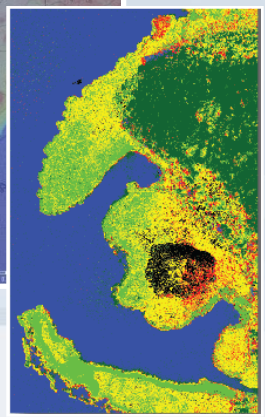



**The practice of acquiring, managing, integrating and disseminating ocean and coastal geospatial mapping data in such a manner that permits these data and their derivative products to be easily accessed and used by and for the greatest range of users and purposes.**

**IOCM requires intra- and inter-agency coordination with a focus on streamlining operations, reducing redundancies, improving efficiencies, developing common standards, and stimulating innovation and technological development.**







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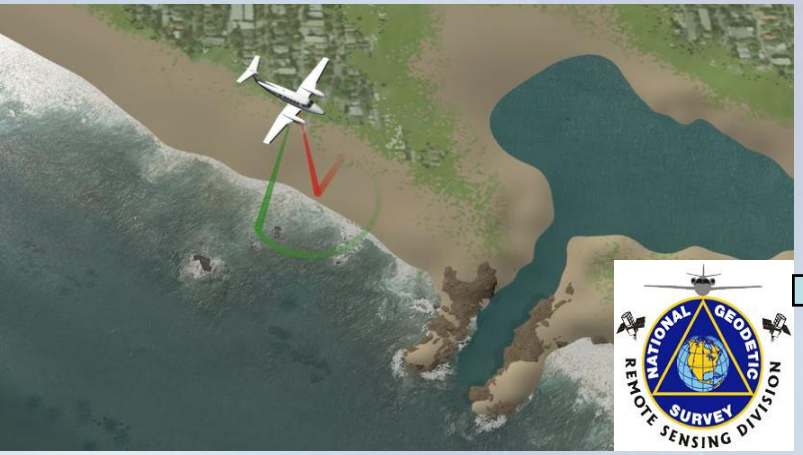
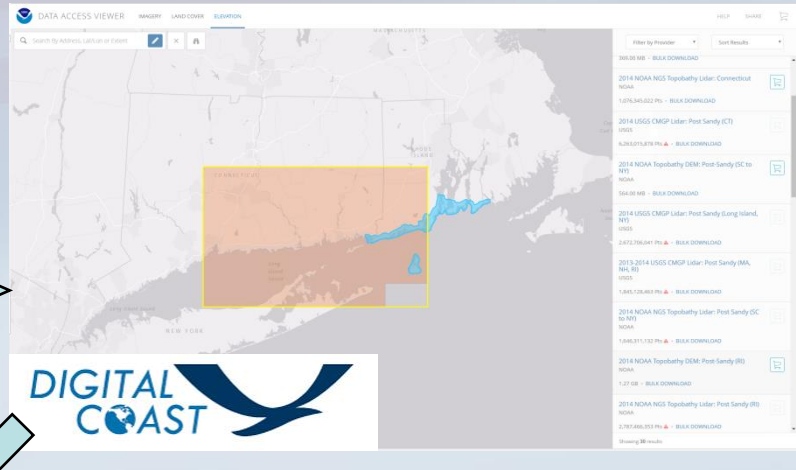
# National Centers for Environmental Information (NCEI):



Acquisition & Processing

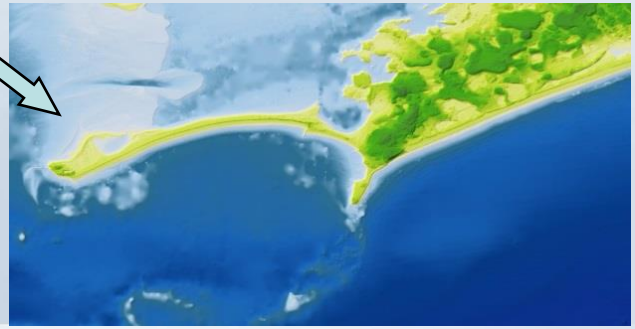



Discovery & Dissemination

NCEI

NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION

Long Term Archiving & Stewardship



Topo-Bathy DEM Development

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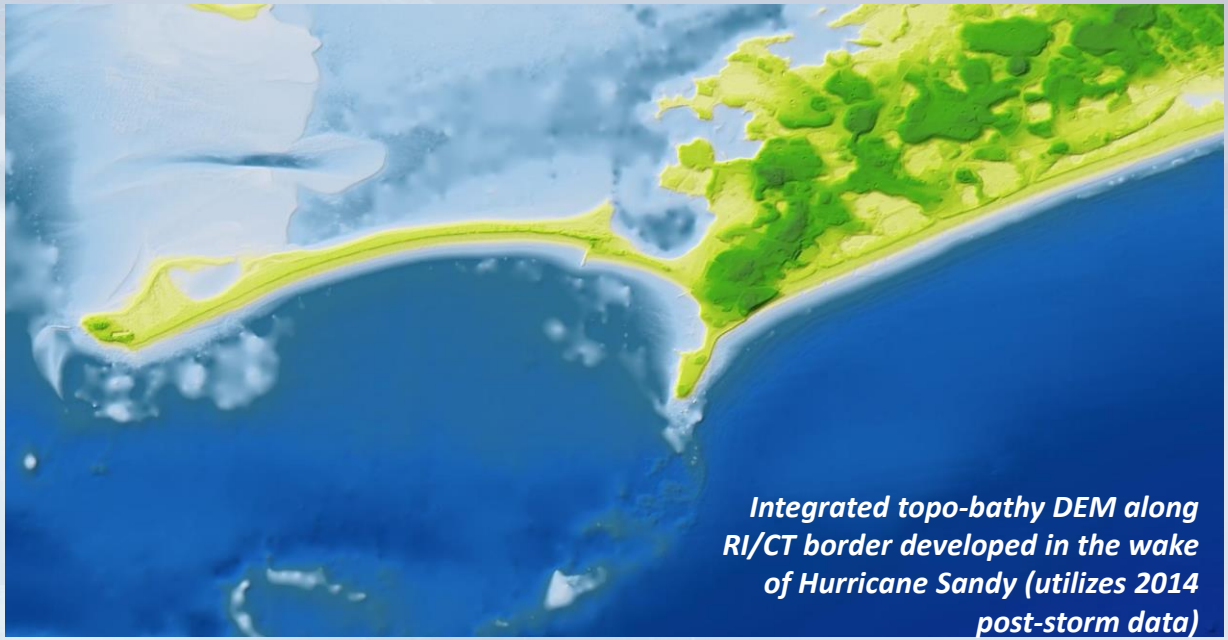
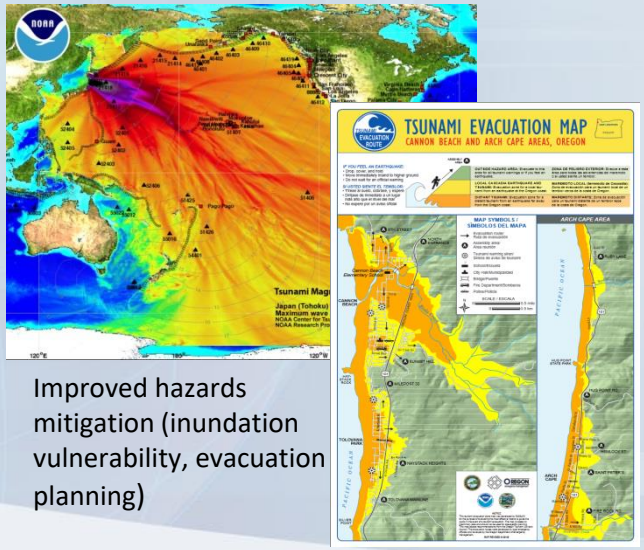


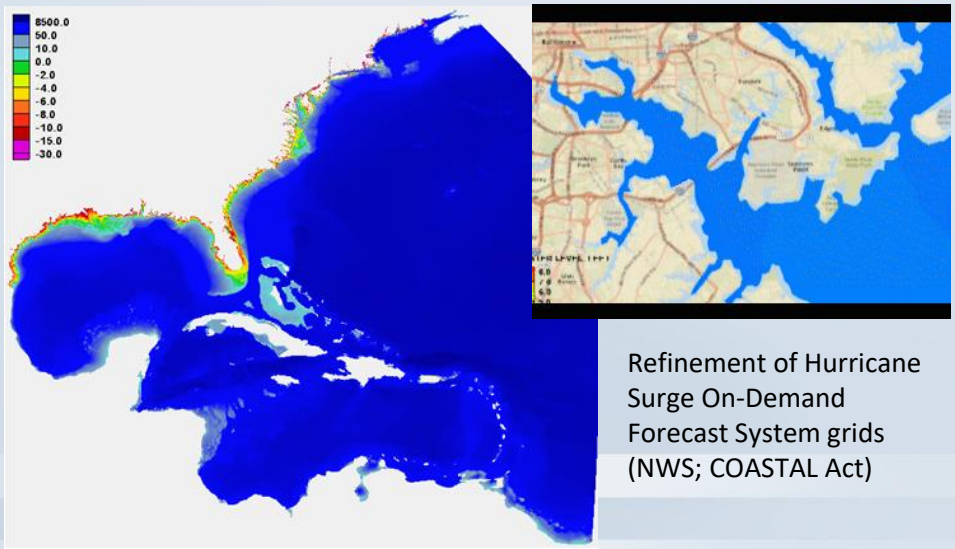
*Integrated topo-bathy DEM along RI/CT border developed in the wake of Hurricane Sandy (utilizes 2014 post-storm data)*

# National Centers for Environmental Information-Boulder (NCEI): DEMs developed at the NOAA support improved tsunami and storm surge inundation modeling and mapping

Modeling tsunami generation, propagation, and inundation (NOAA Tsunami Program And National Tsunami Hazard Mitigation Program)




Improved hazards mitigation (inundation vulnerability, evacuation planning)




Refinement of Hurricane Surge On-Demand Forecast System grids (NWS; COASTAL Act)

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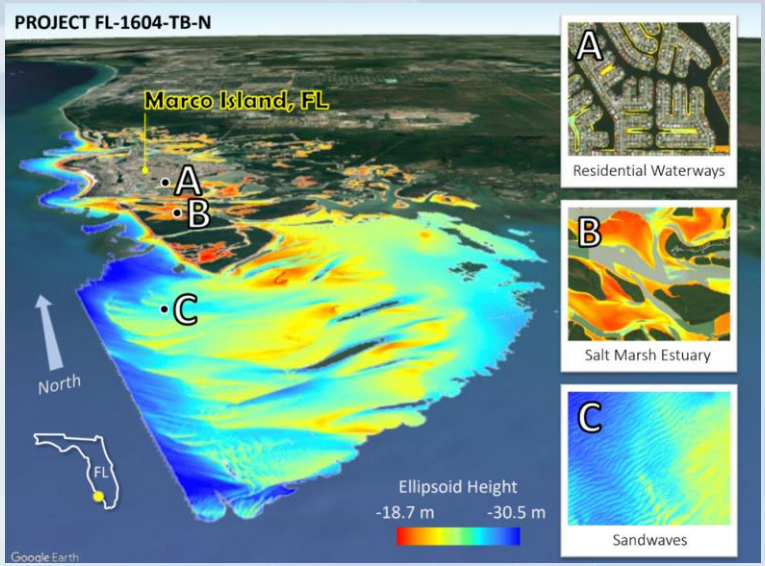
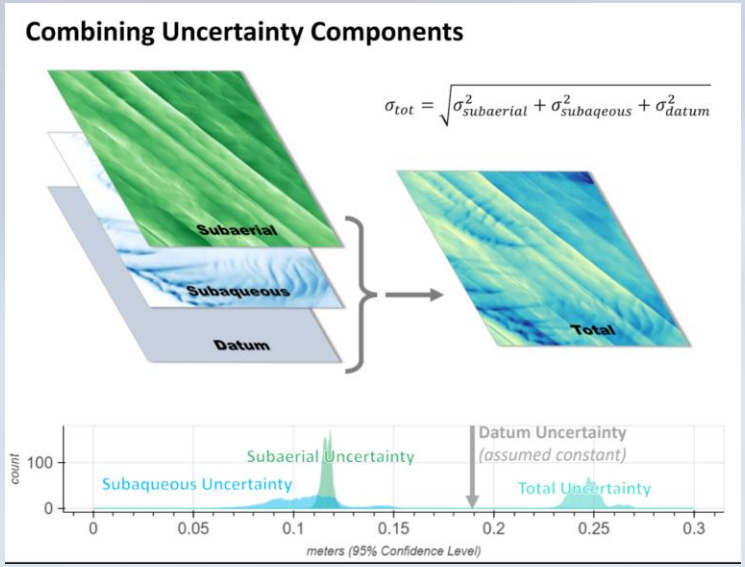
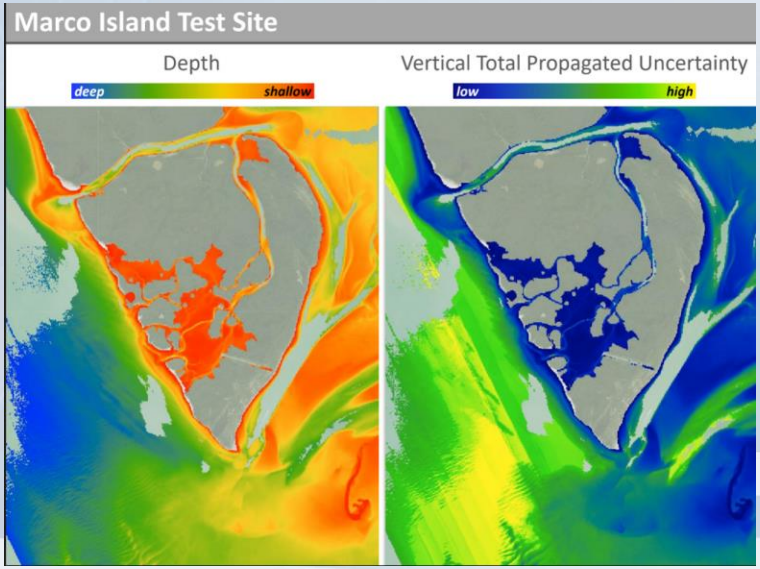
# Total Propagated Uncertainty for Topobathy Lidar



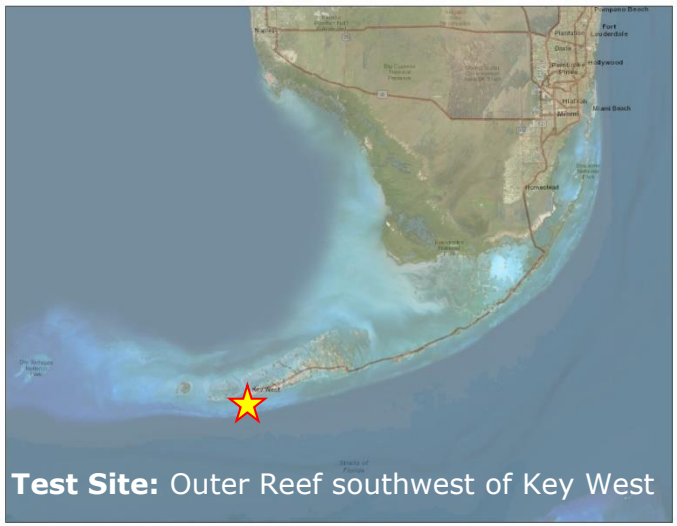



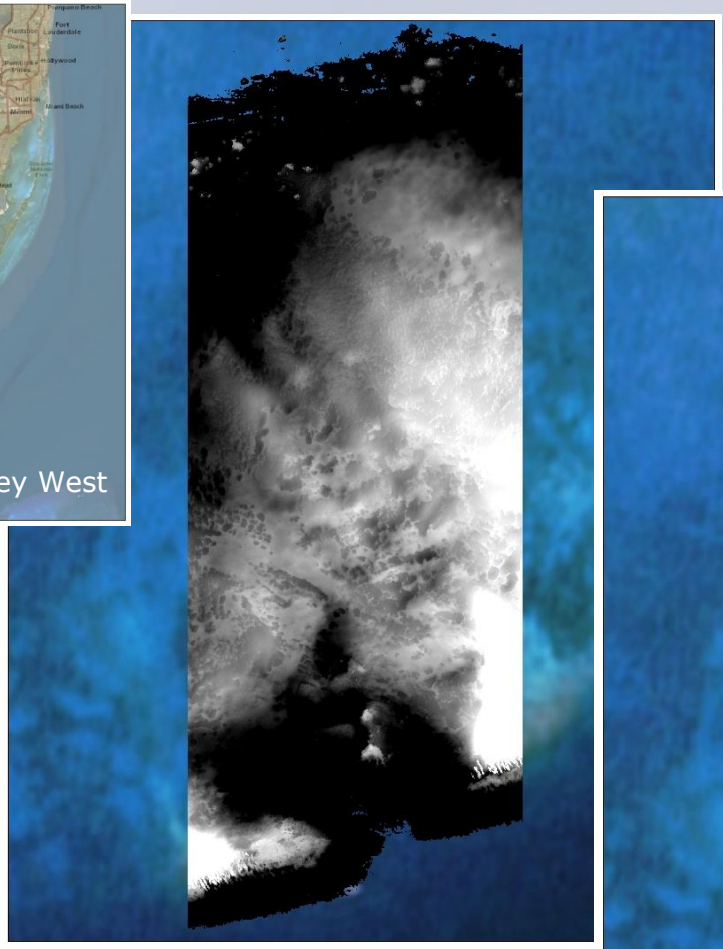




National Oceanic and Atmospheric Administration

cBLUE Comprehensive Bathymetric Lidar Uncertainty Estimator

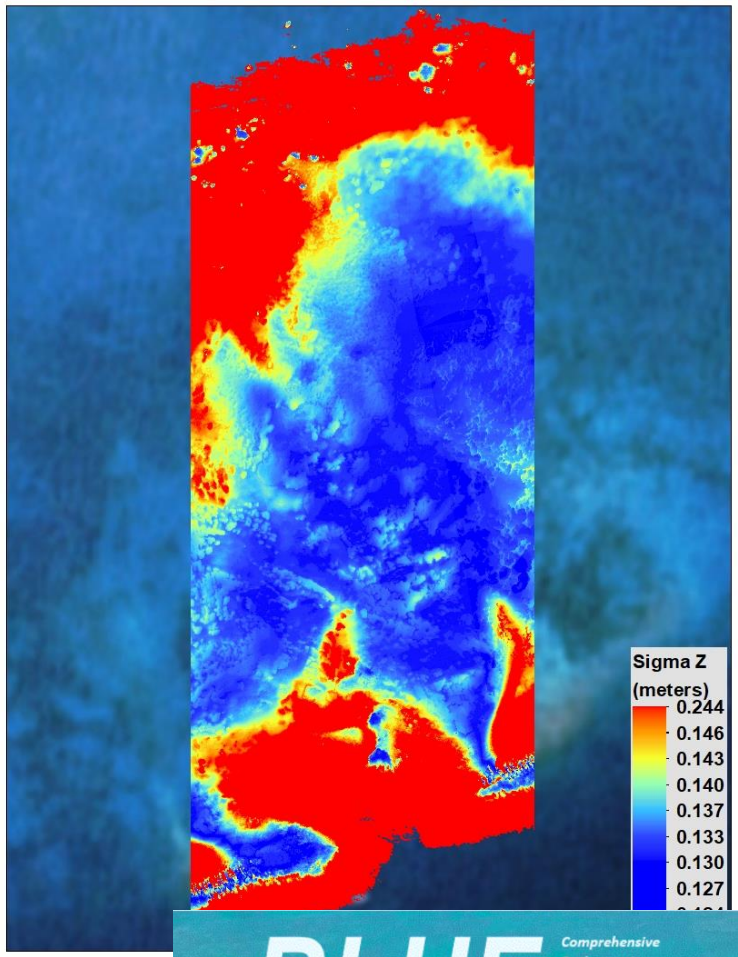
# Total Propagated Uncertainty for Topobathy Lidar



Digital Elevation Model

TPU Result

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cBLUE Comprehensive Bathymetric Lidar Uncertainty Estimator

# Submerged Object – Outer Reef, Florida

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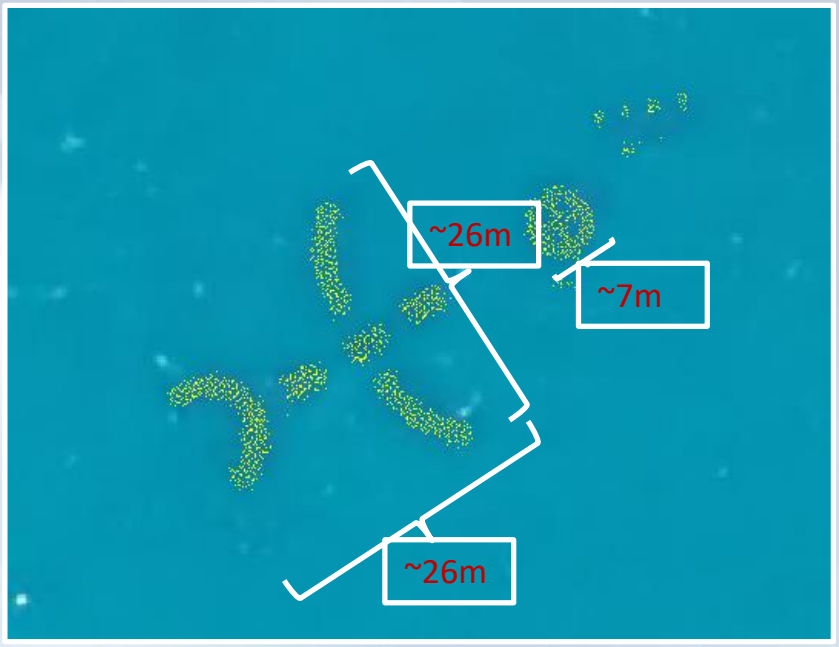
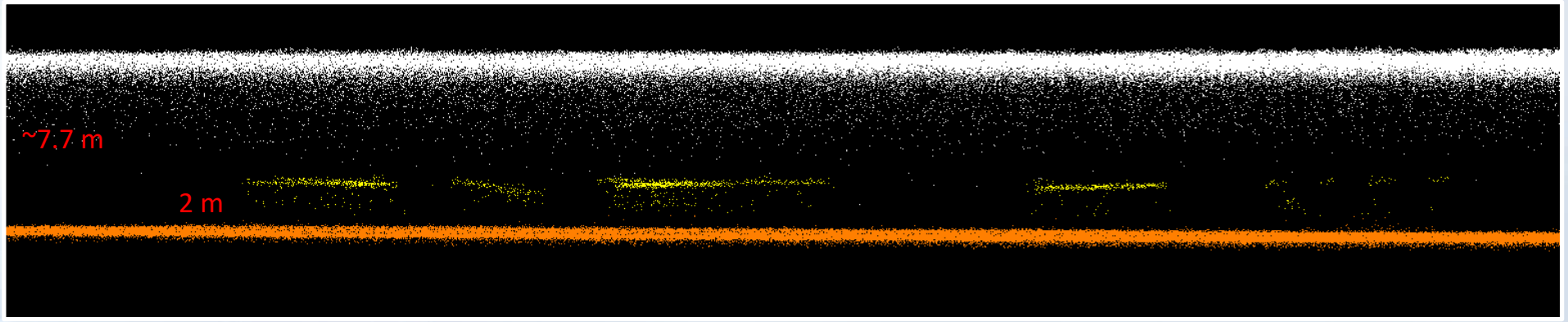



- Point density of the object ranged from ~12 to 13 pts per $m^2$
- Water depth: ~7.7m
- Object height: 2m

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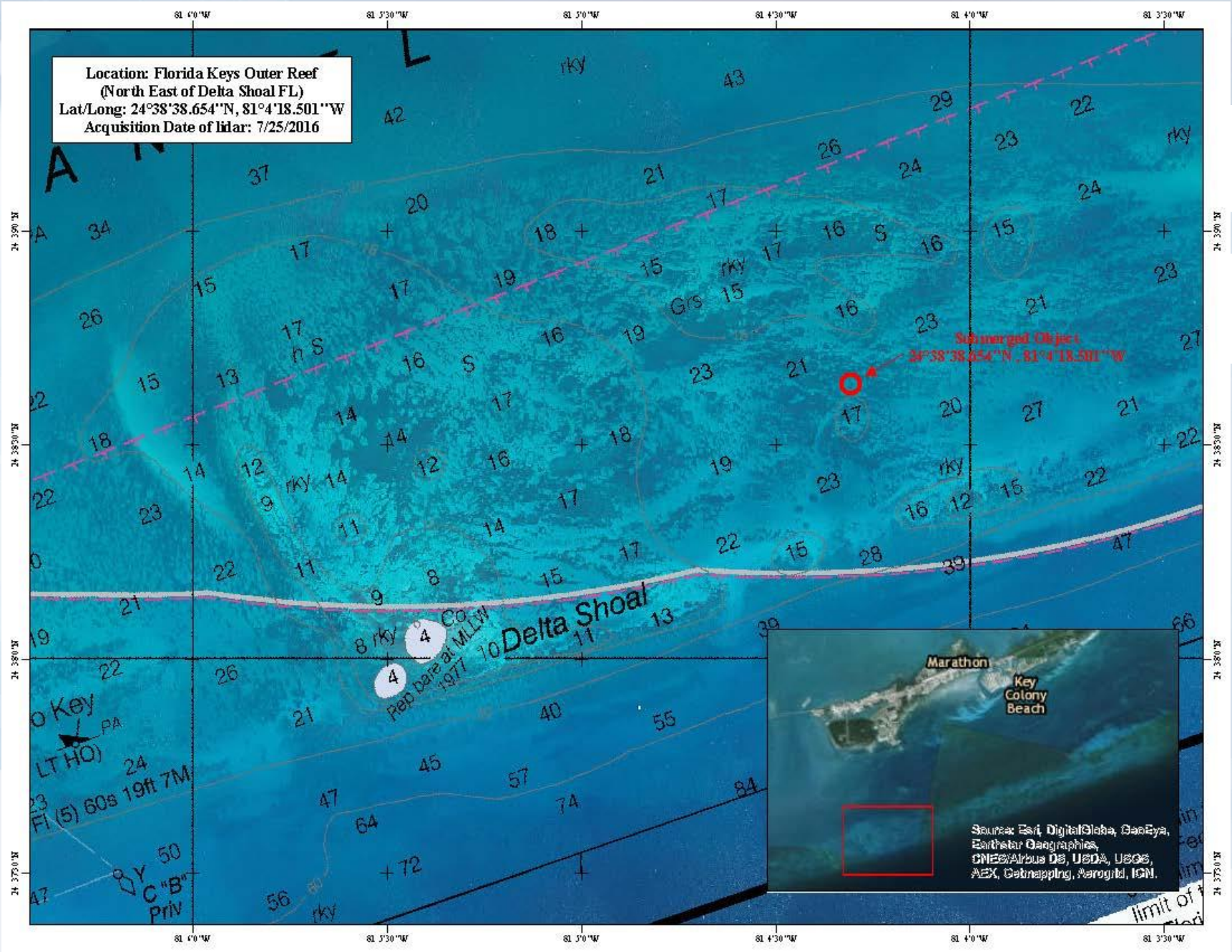
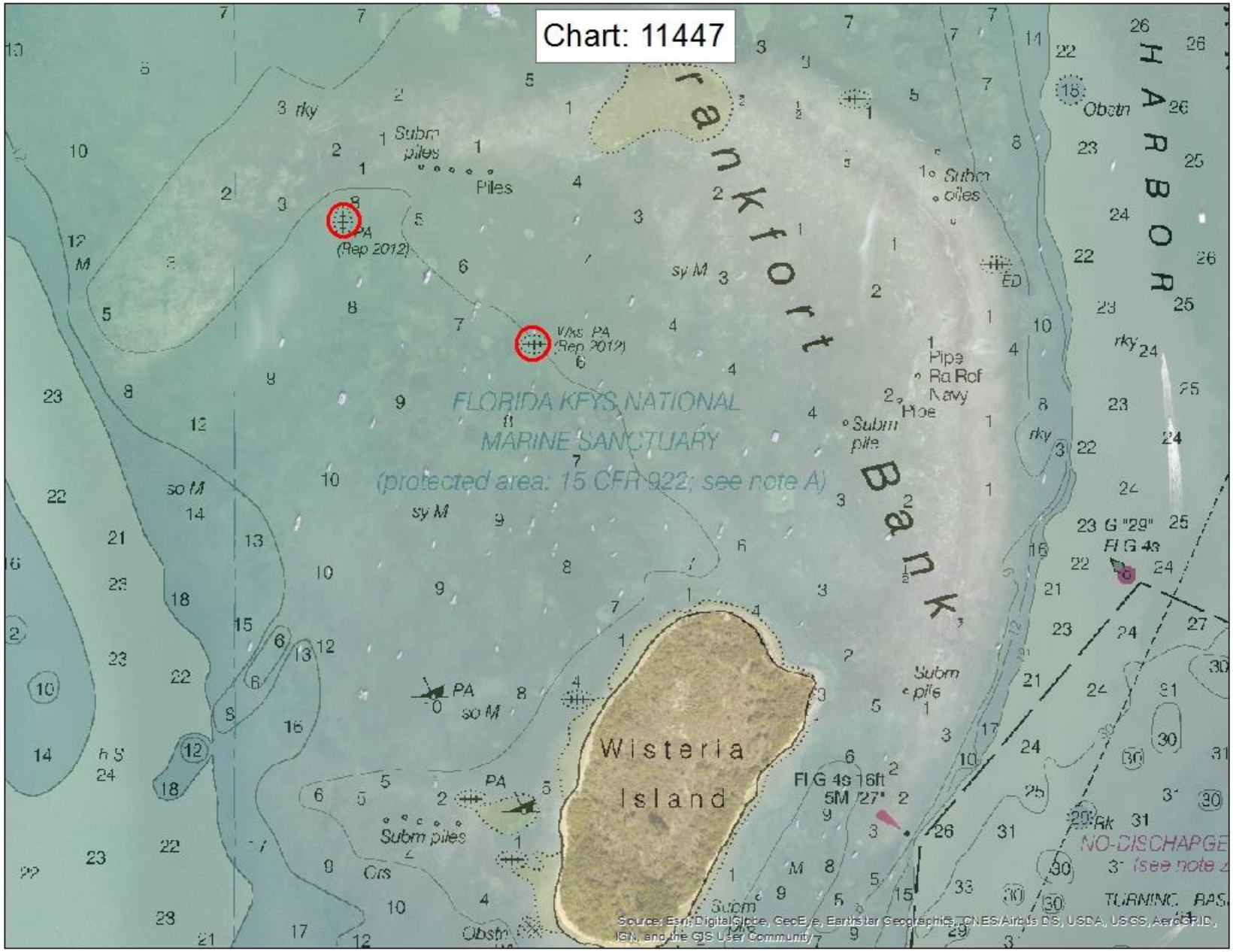
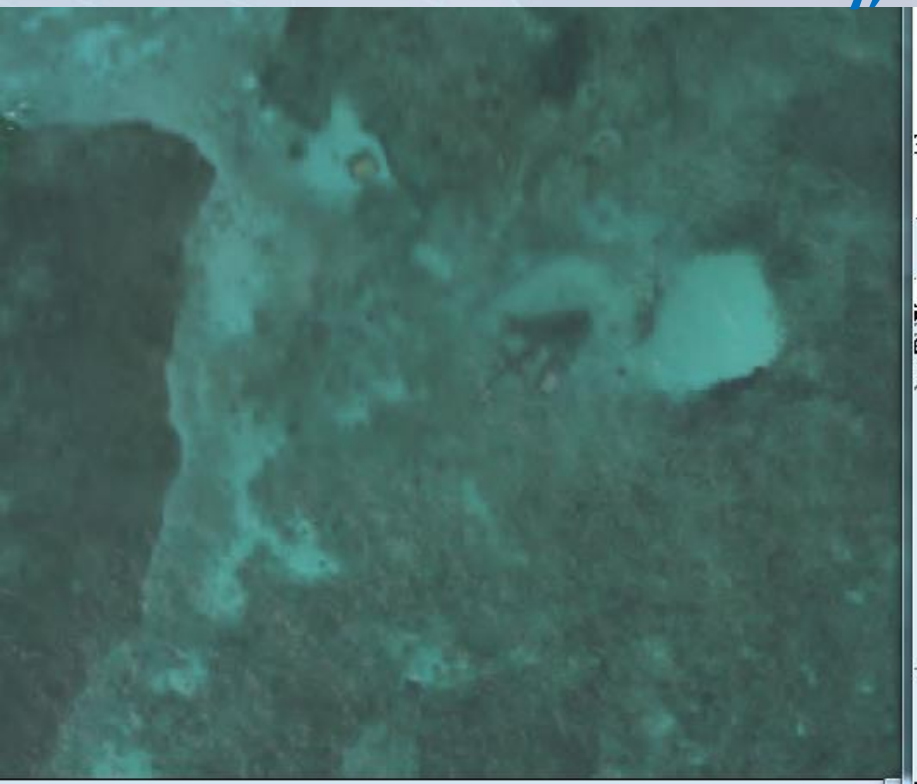
# Detection of Unknown Submerged Objects

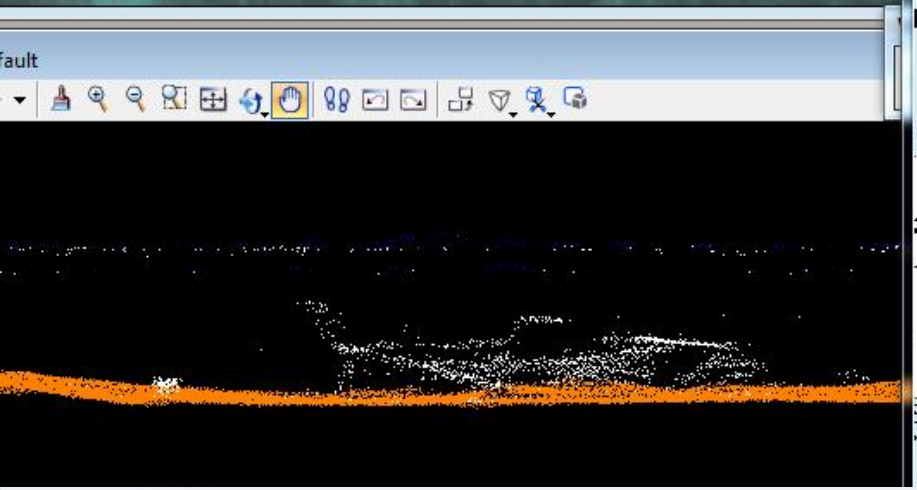


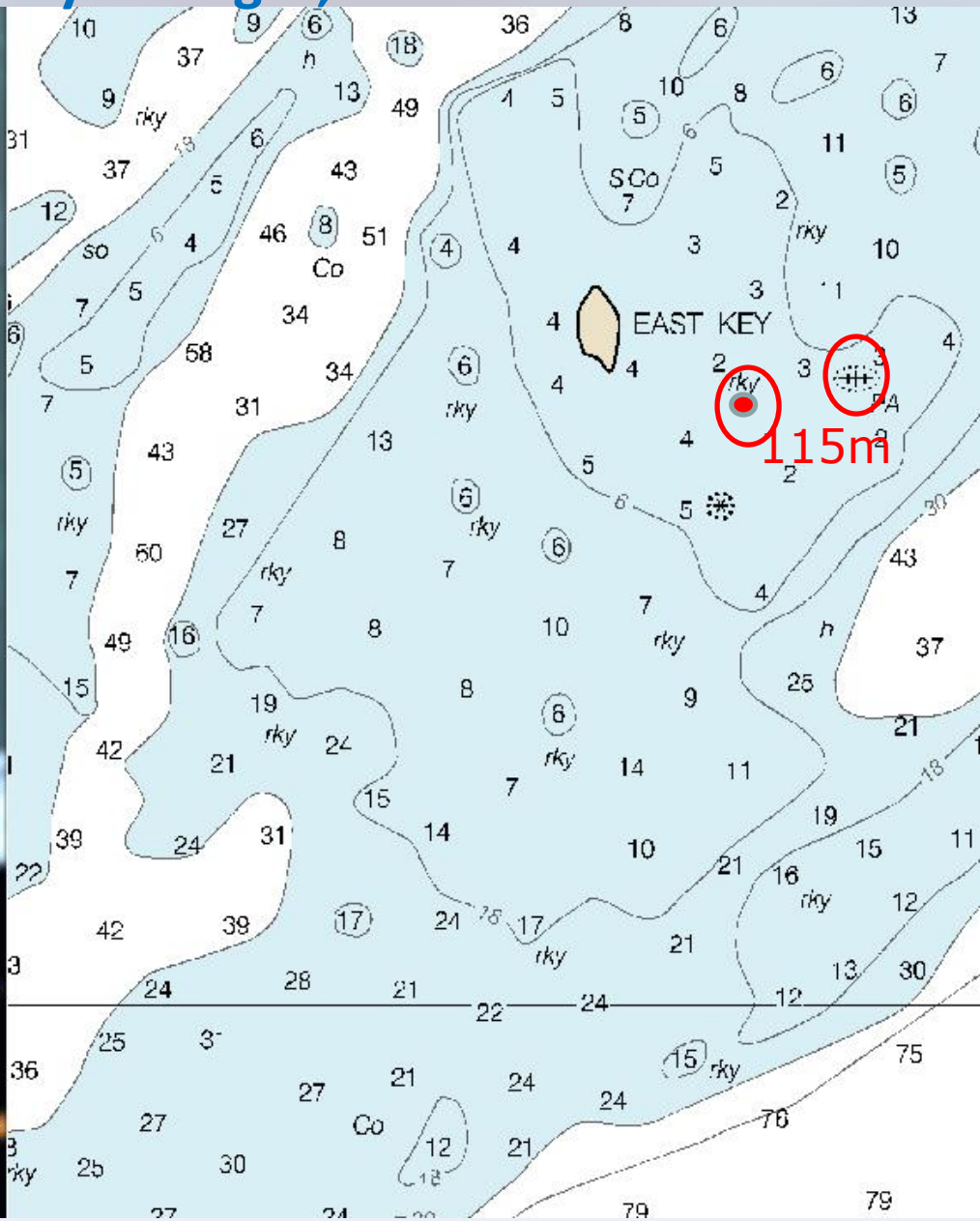
# Confirmation of Submerged Objects



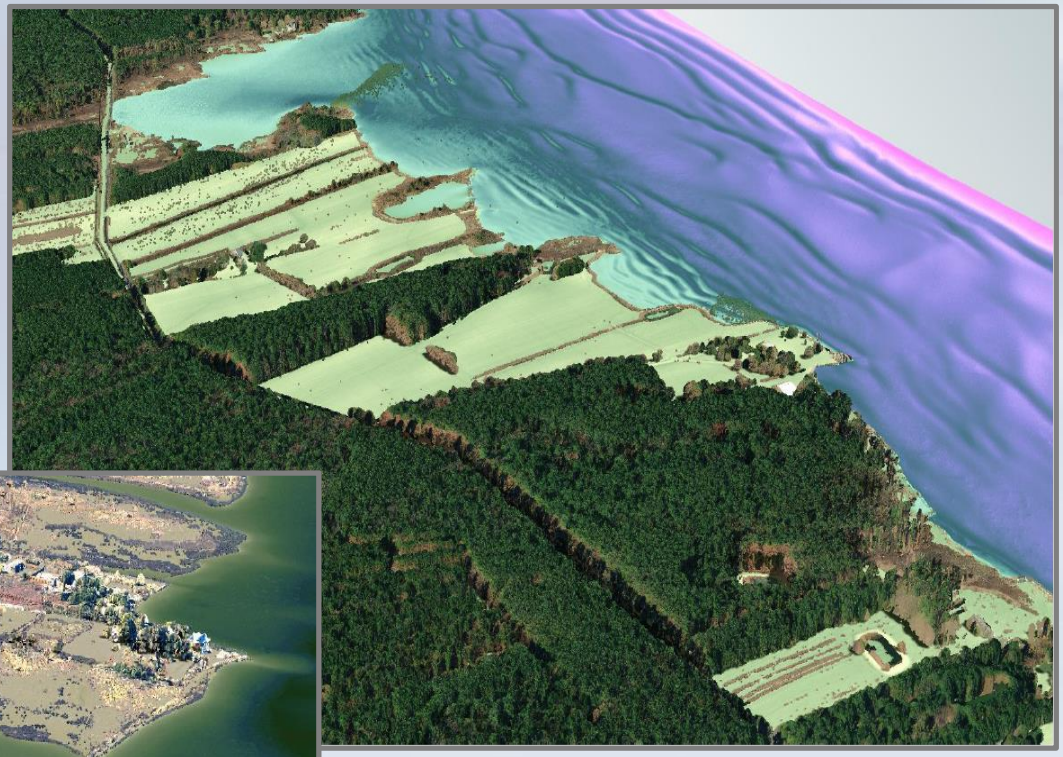
# Wreck with Position Approximate (PA) updated near East Key, Dry Tortugas, FL







# Chesapeake Bay



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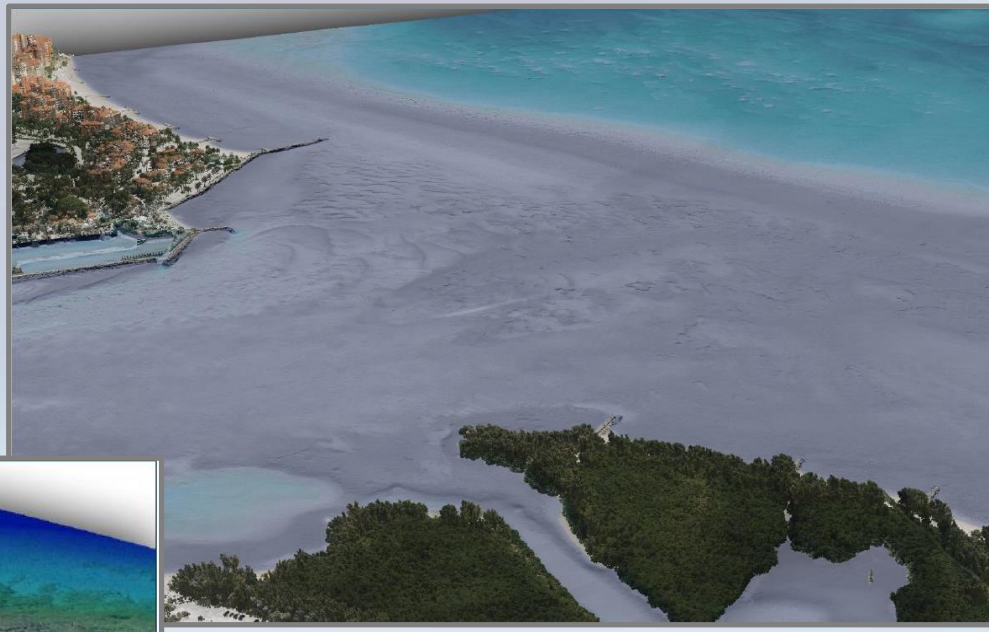
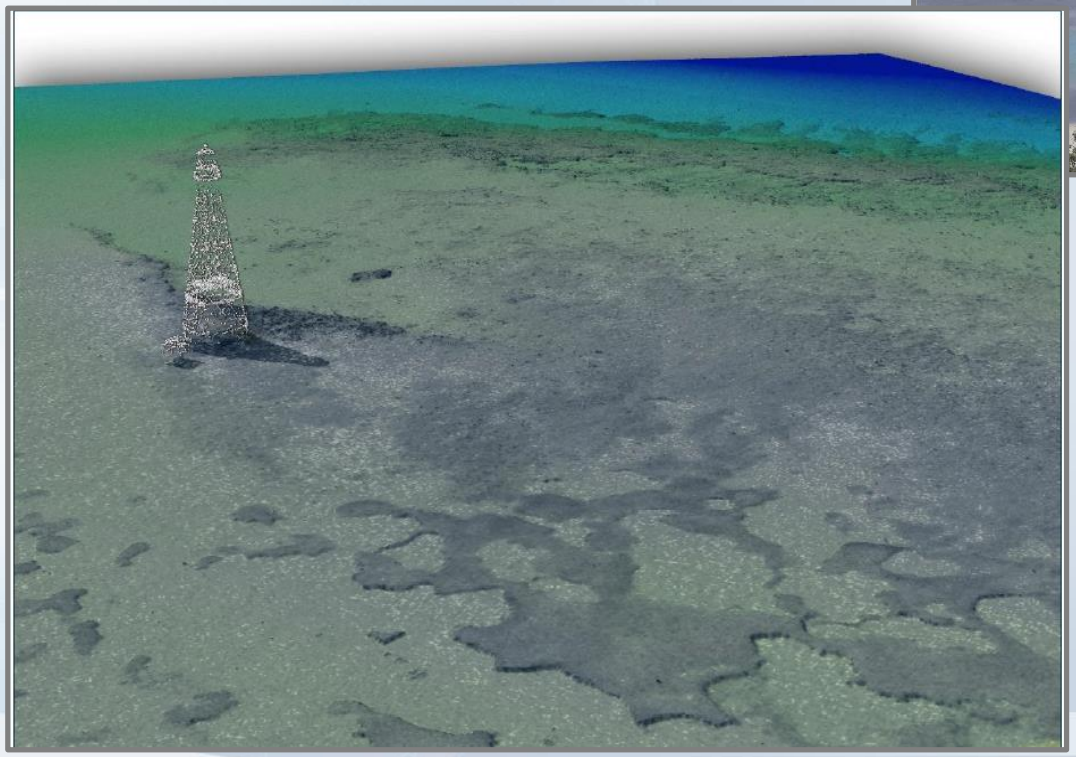
# Florida Keys





*(Courtesy of NV5)*

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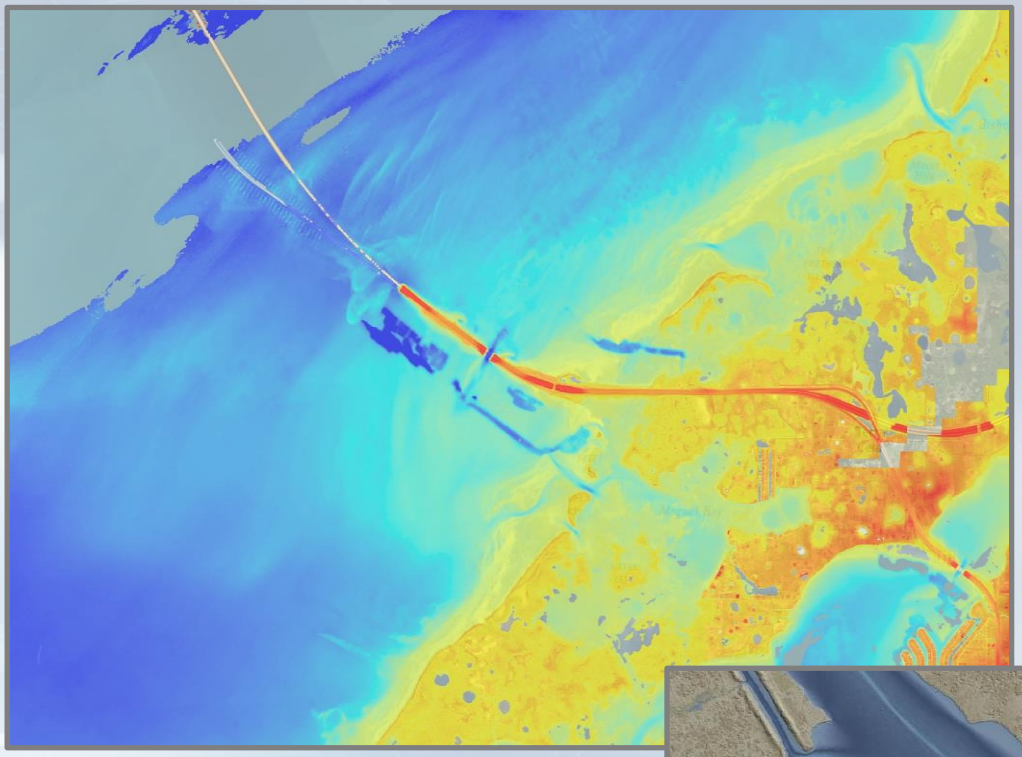
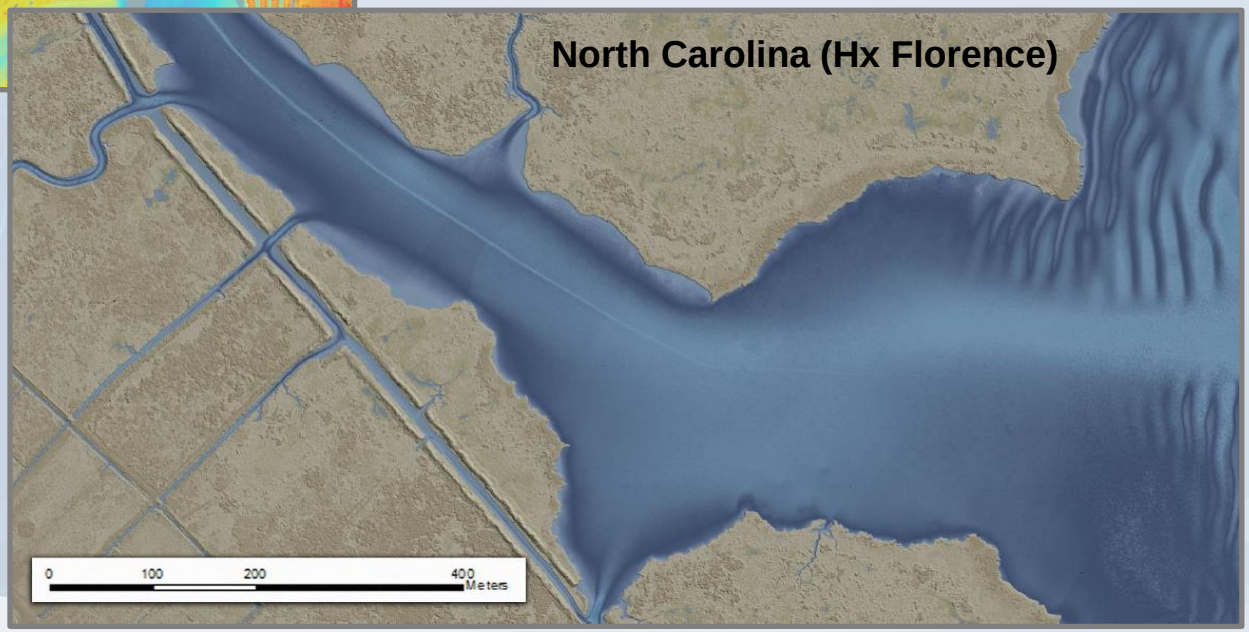


**South Tampa Bay**
***(Sunshine Skyway Bridge)***

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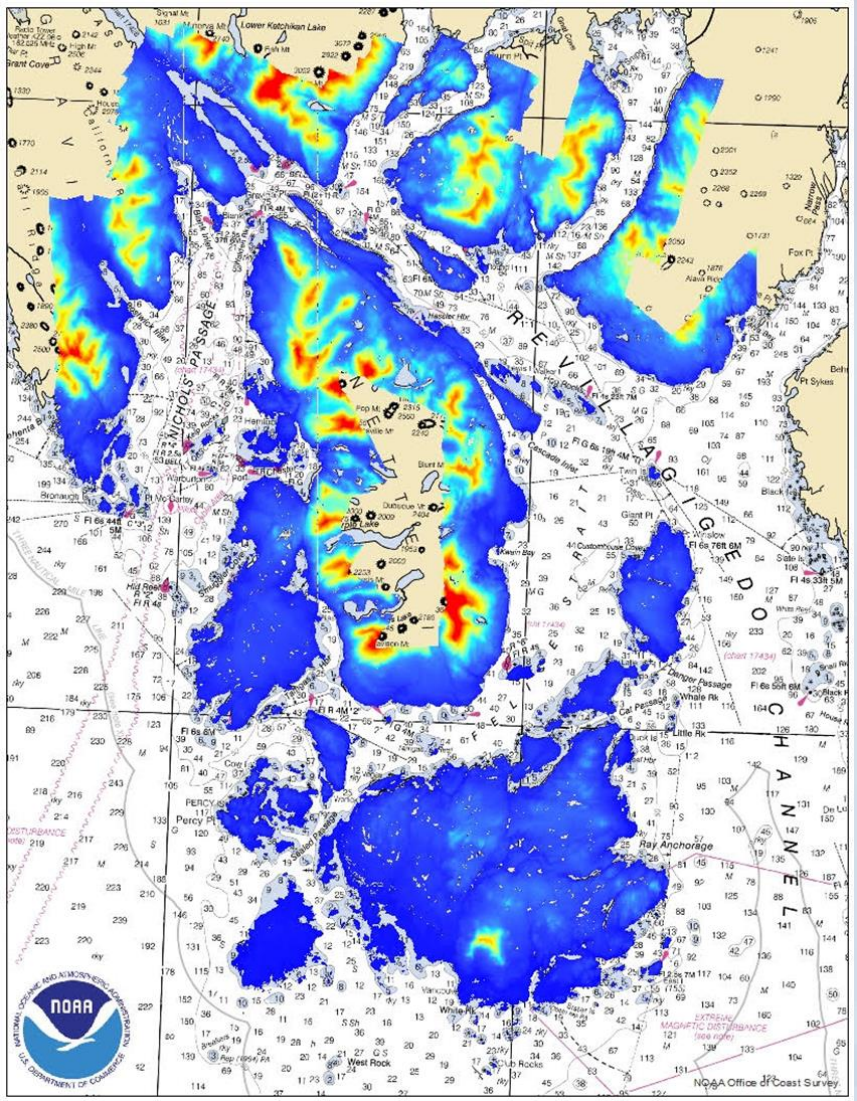
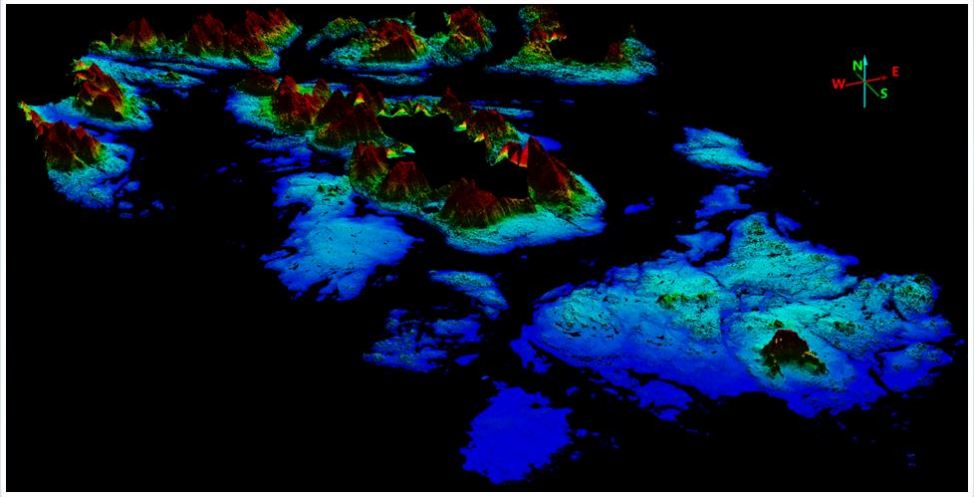
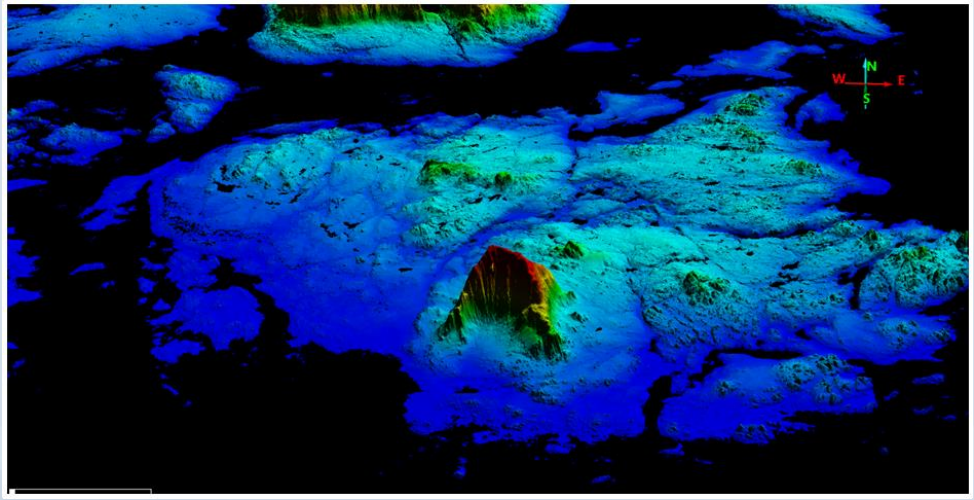
# Revillagigedo, SE AK

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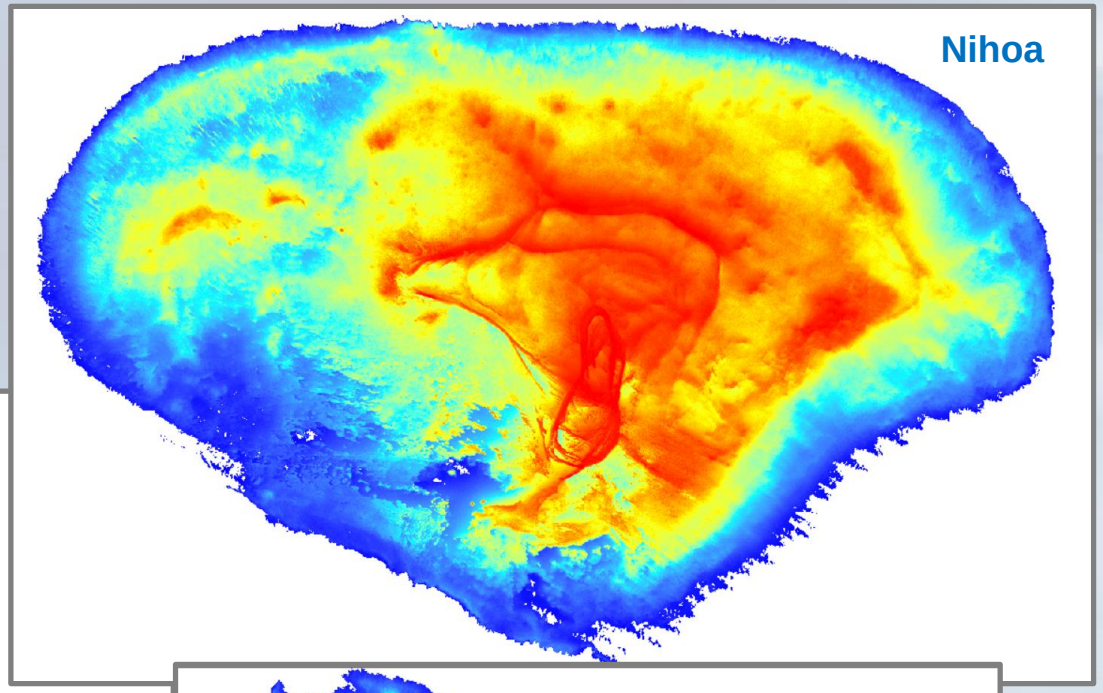
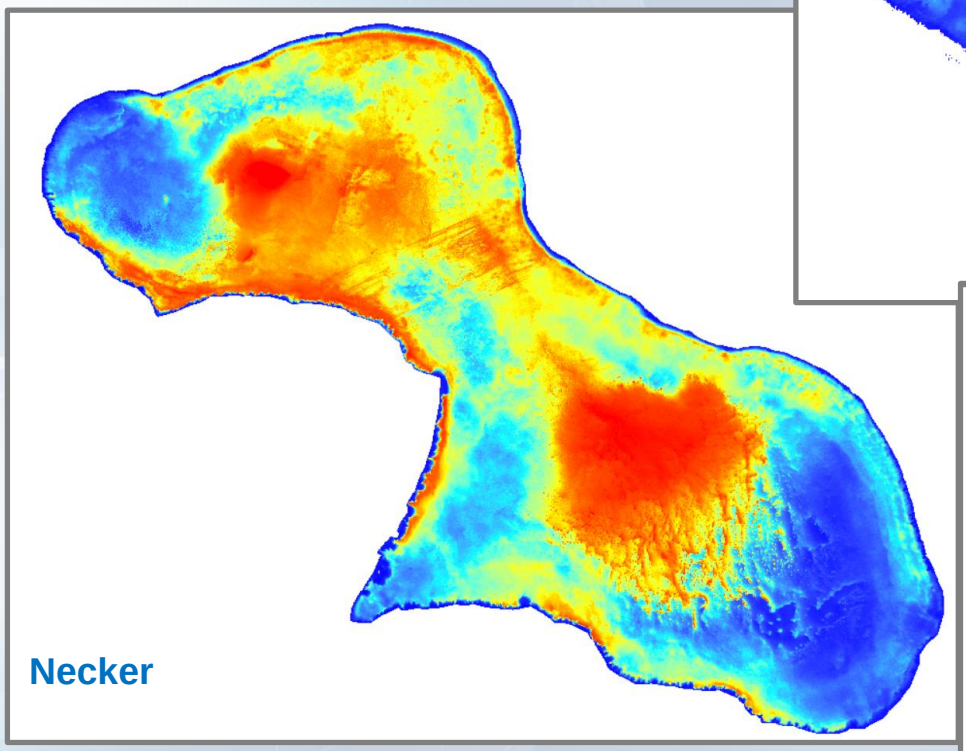
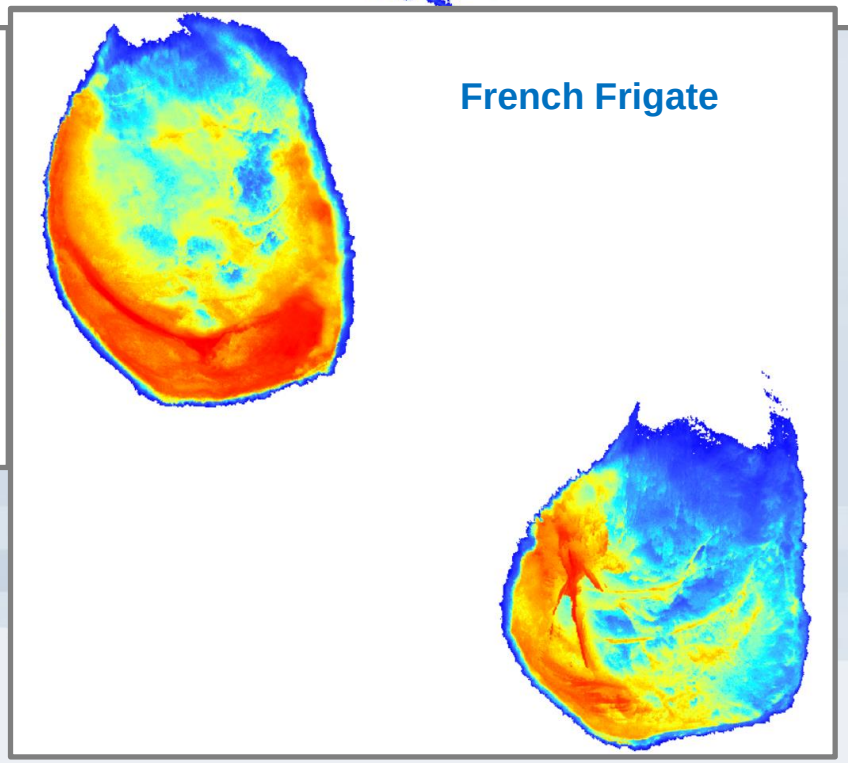
## Eastern Northwestern Hawaiian Islands

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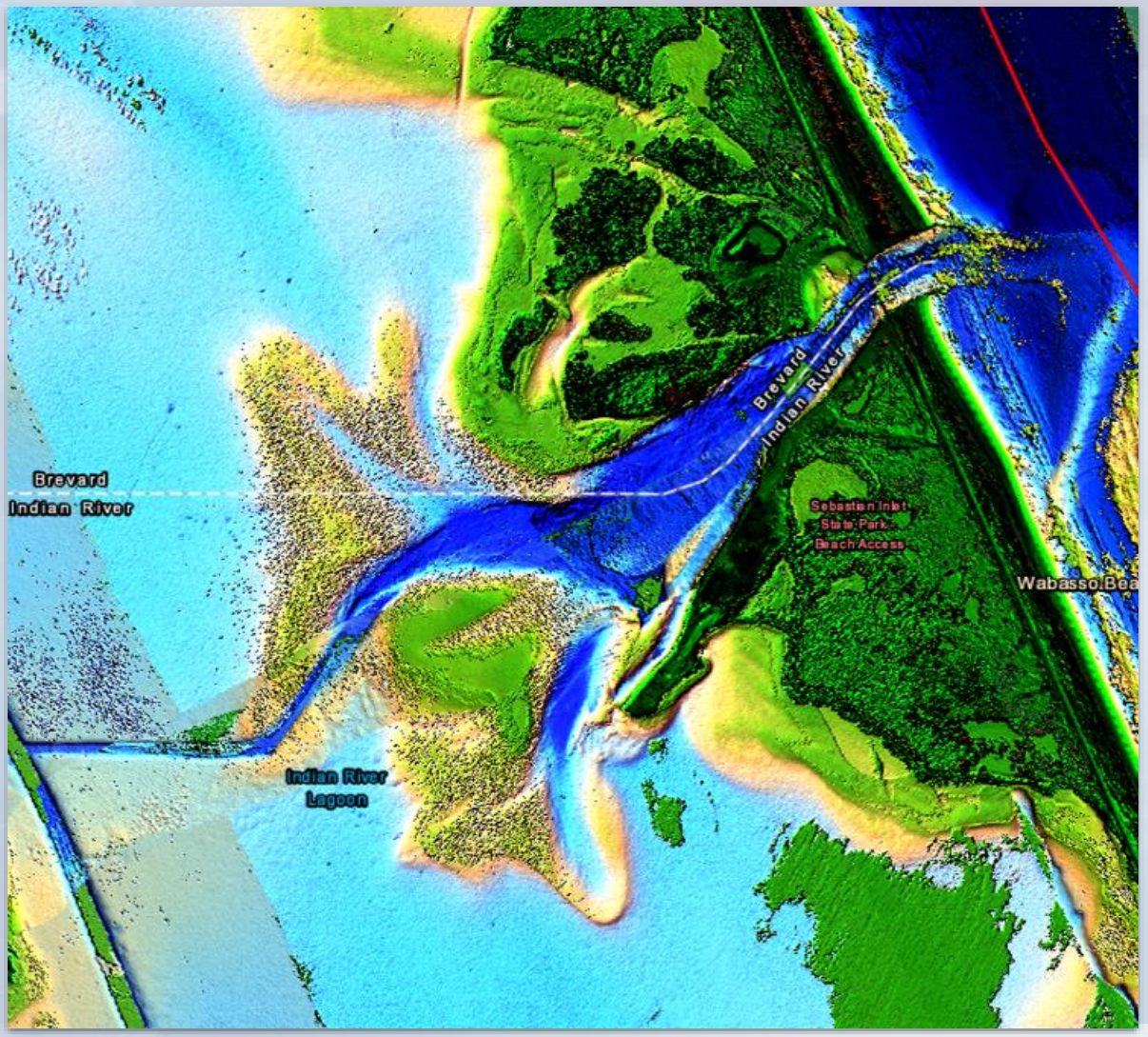


**Indian River Lagoon:**
**Sebastian Inlet**
***(Courtesy of Dewberry)***

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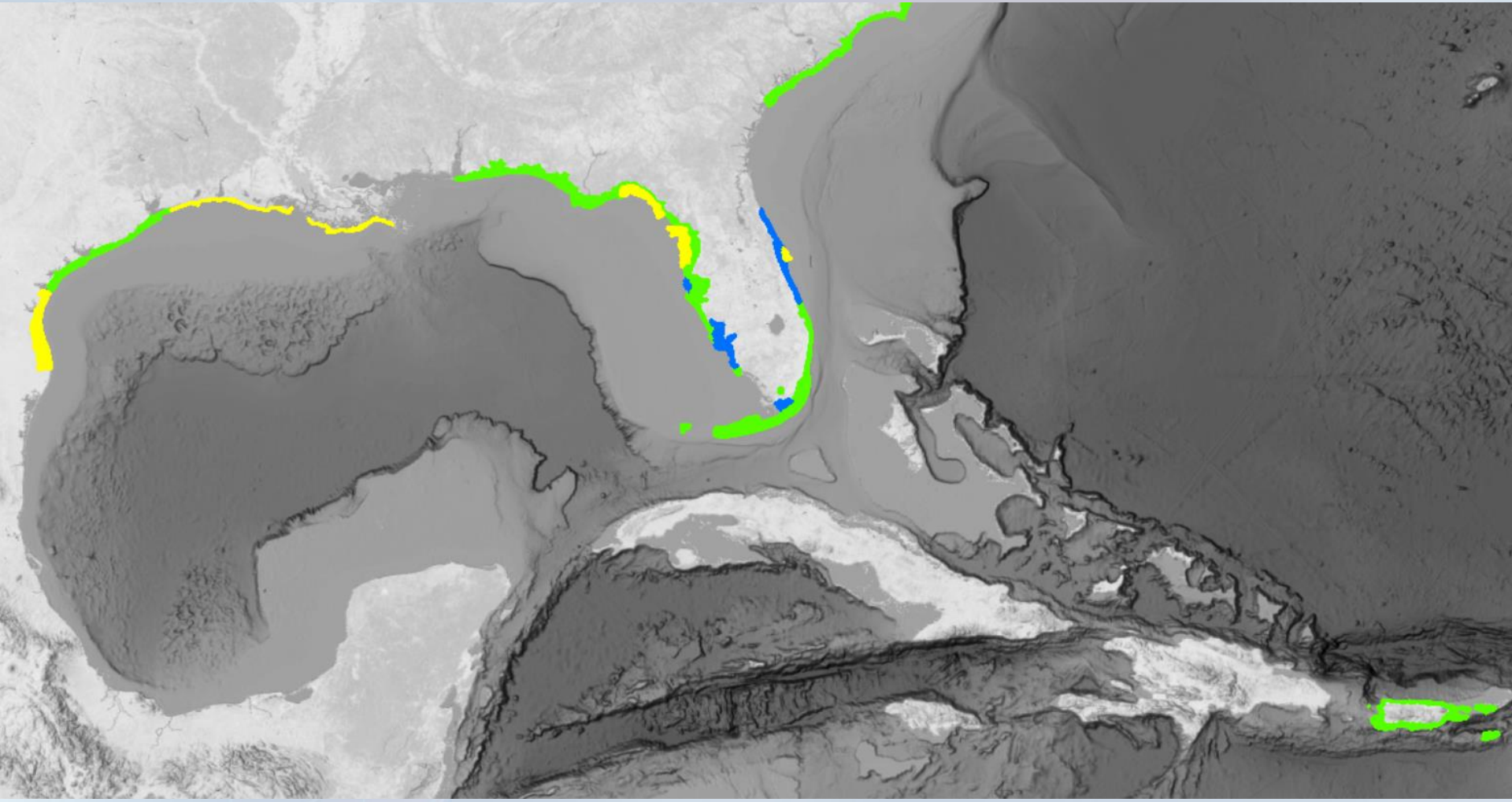

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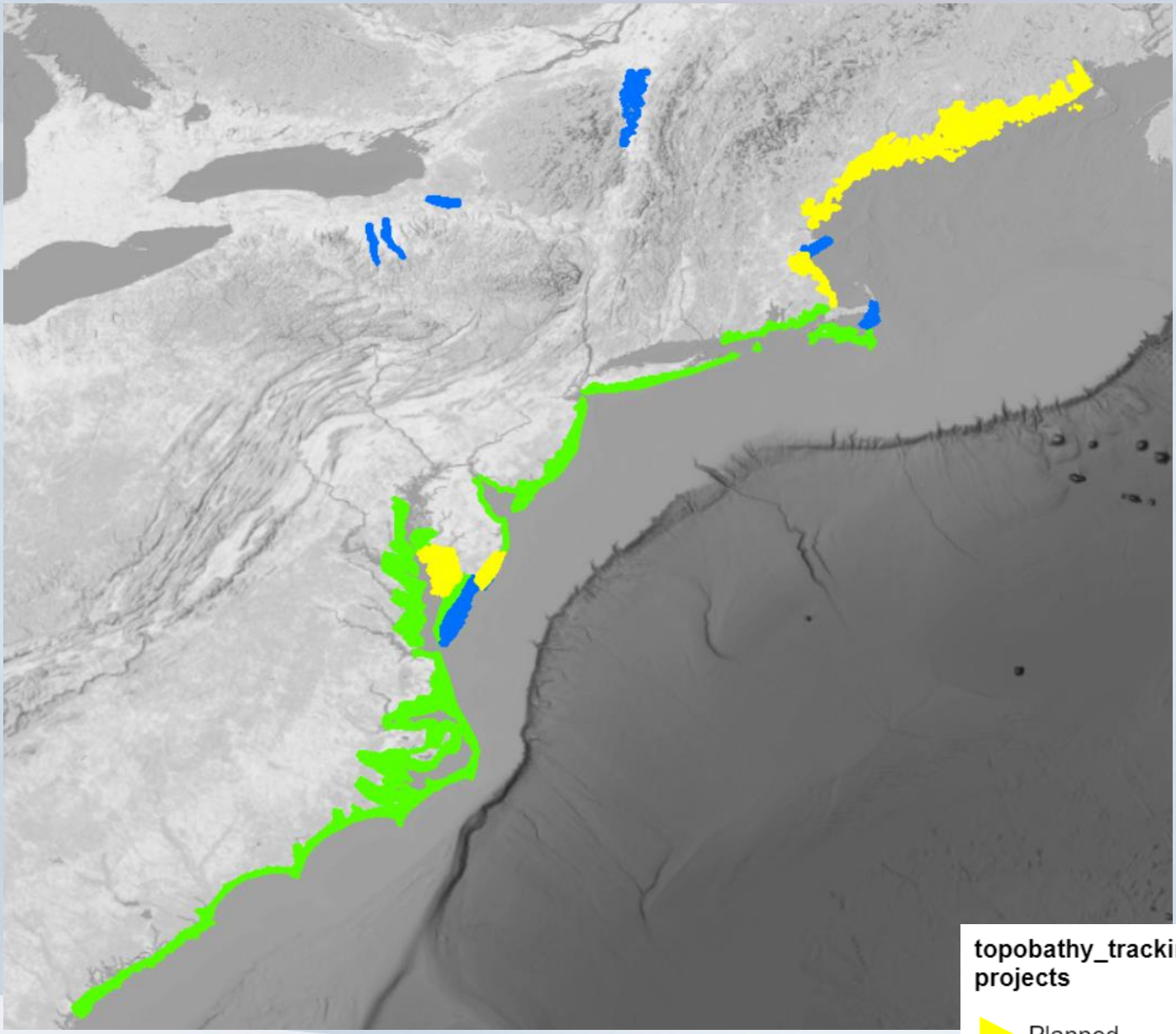
**topobathy_tracking_inhouse projects**

- Planned
- Acquired
- Completed

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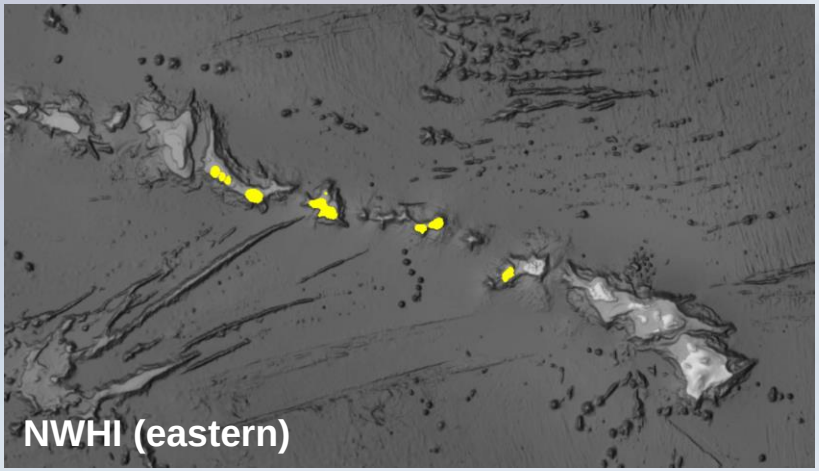
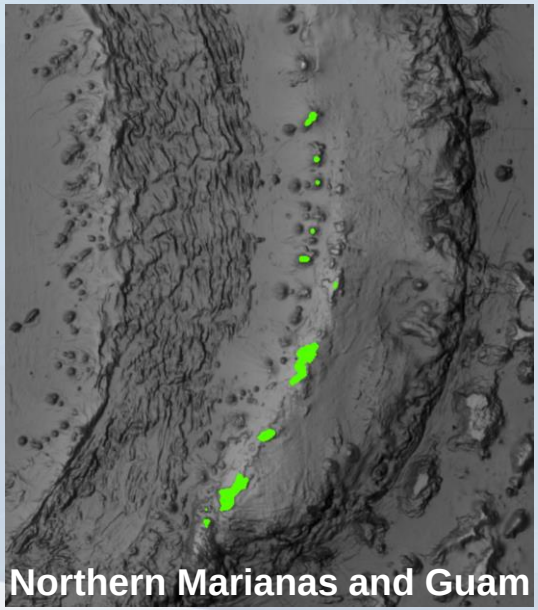
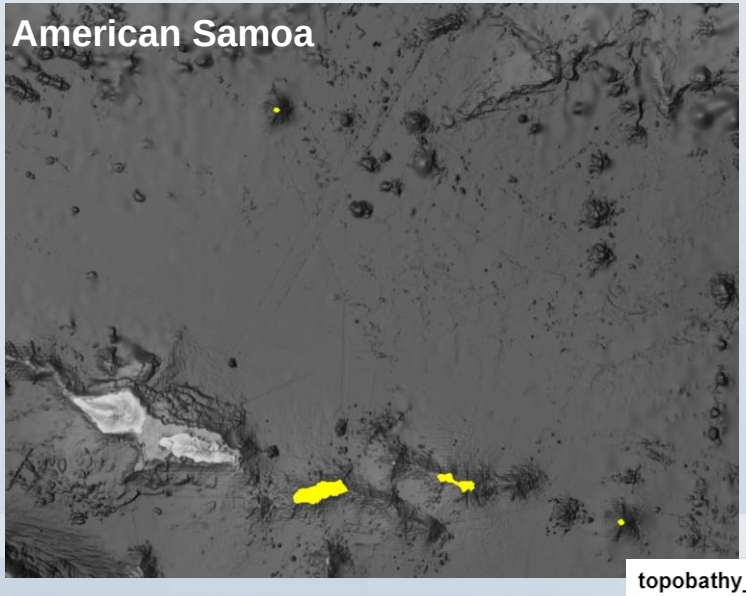



National Oceanic and Atmospheric Administration

topobathy_tracking_inhouse projects

Planned

Acquired

Completed

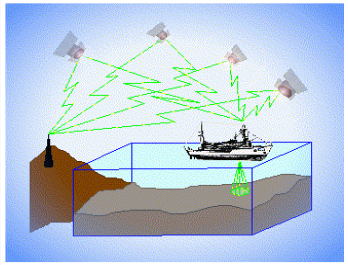
# VDatum

## Vertical Datum Transformation Tool

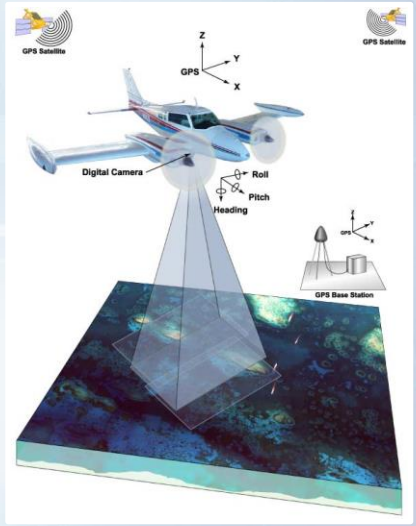
National Oceanic and Atmospheric Administration

# What Vertical Datum is My Data in?

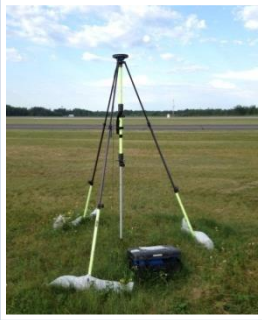
## Ellipsoidal Datums



*RTK-GPS vertical referencing Hydrographic Surveys*

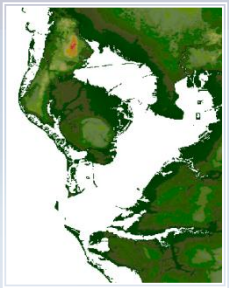



*Lidar*

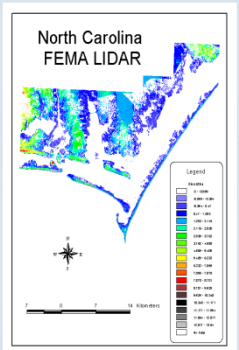


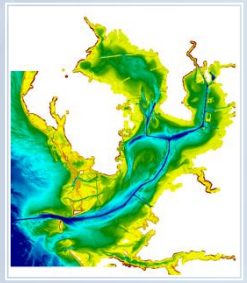
*GPS*

## Orthometric Datums

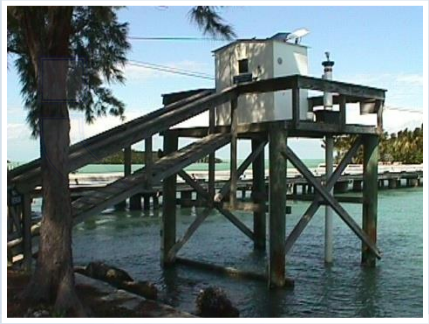


*USGS Topography*

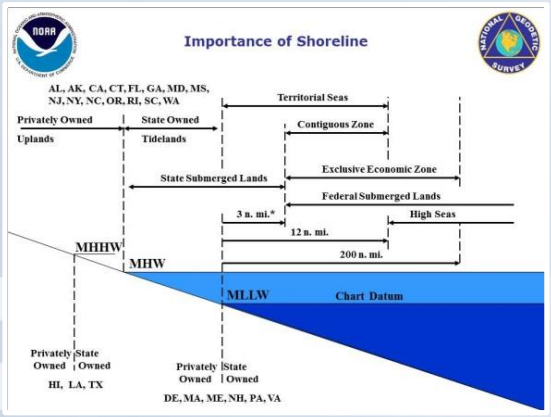



*NOAA Bathymetry (MLLW)*



## Tidal Datums

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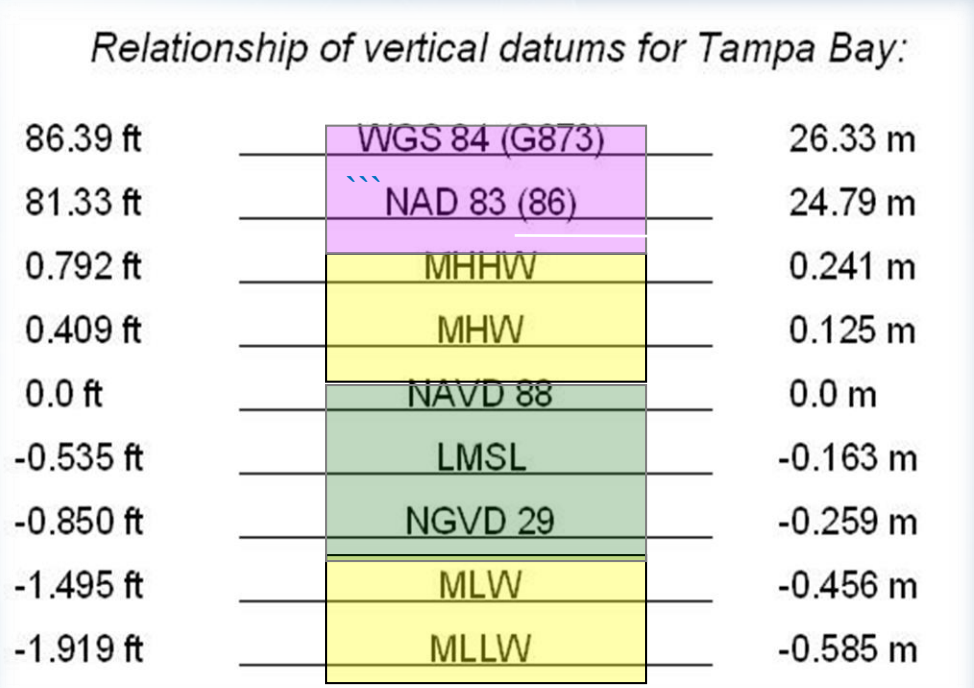
# All elevation data is referenced to a vertical datum.

***BUT** there are a many different vertical datums in use around the nation*




***For elevation data sets to be blended together they must be referenced to <u>same</u> vertical datum.***

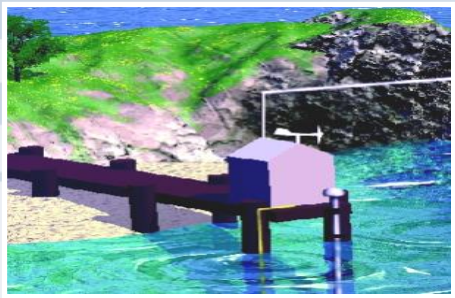
**Ellipsoid Datums**

***ITRF, WGS 84, NAD 83** (NSRS)*

**Orthometric Datums**


***NAVD 88, NGVD 29***

**Tidal Datums**



***MHHW, MHW, MTL, DTL, LMSL, MLW, MLLW***

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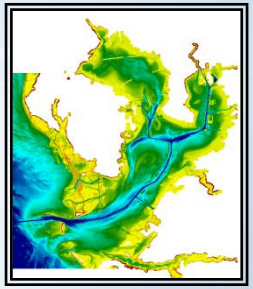
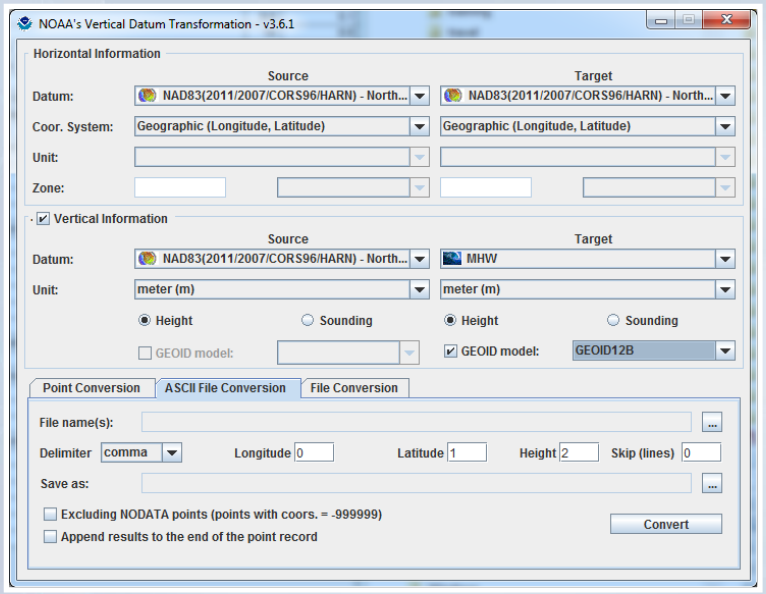
# Development and Use of VDatum

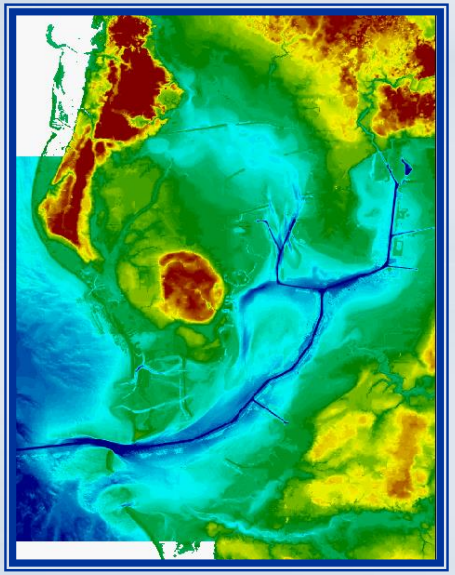
***Mapping the Land-Sea Interface:*** VDatum converts elevation data (heights and soundings) among different vertical datums

USGS Topography



NOAA Bathymetry



***VDatum is a Java application developed jointly by :***

- **National Geodetic Survey (NGS)**
- **Office of Coast Survey (OCS)**
- **Center for Operational Oceanographic Products & Services (CO-OPS)**

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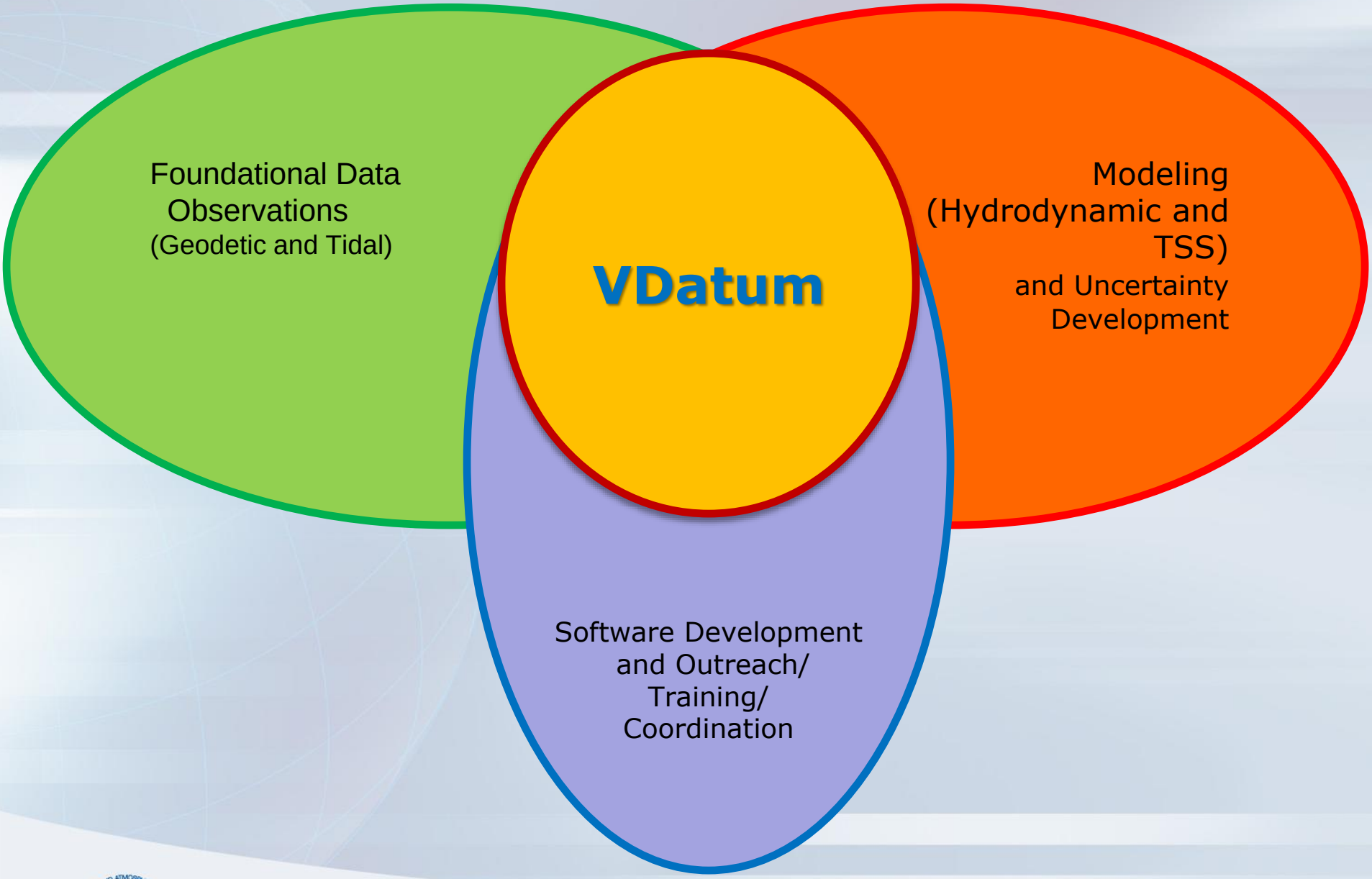


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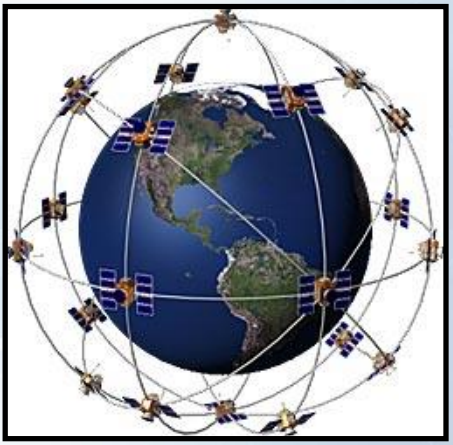
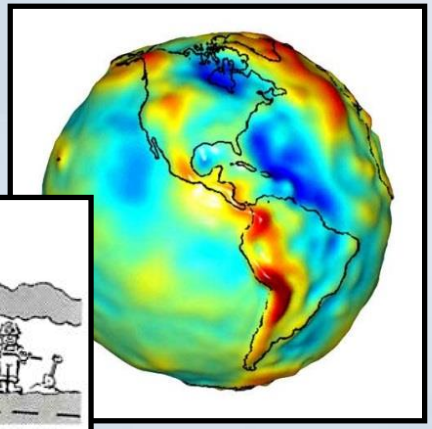
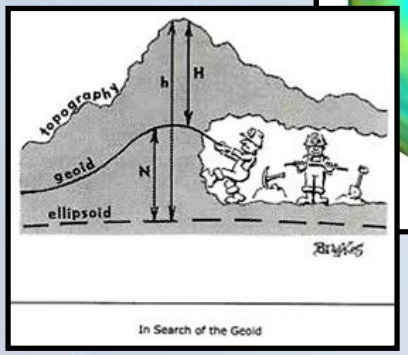
# 3 Categories of Vertical Datums:

**3D/Ellipsoid**
realized through space-based systems, such as GPS

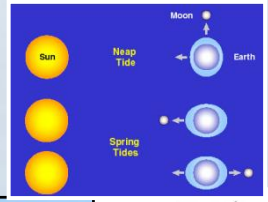


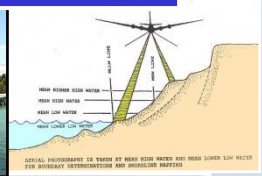
**Orthometric (GEOID)**
based on a form of global mean sea level



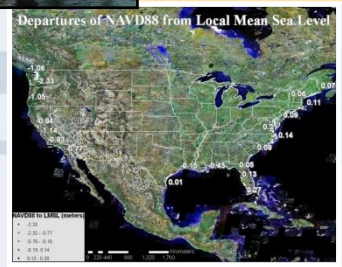



**Tidal Datums**
based on tidally-derived surfaces such as high or low water



National Water Level Observation Network (NWLON)

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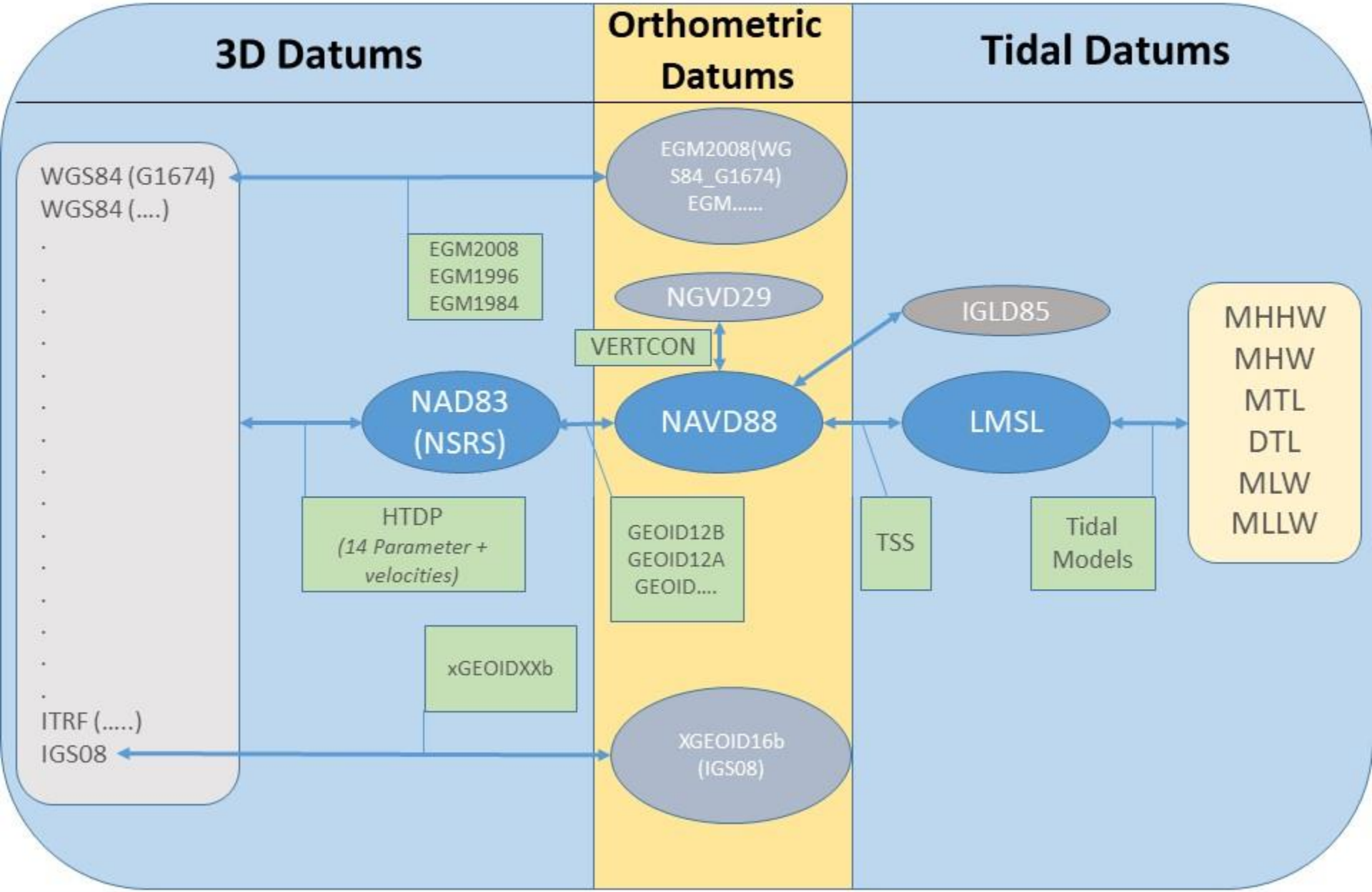
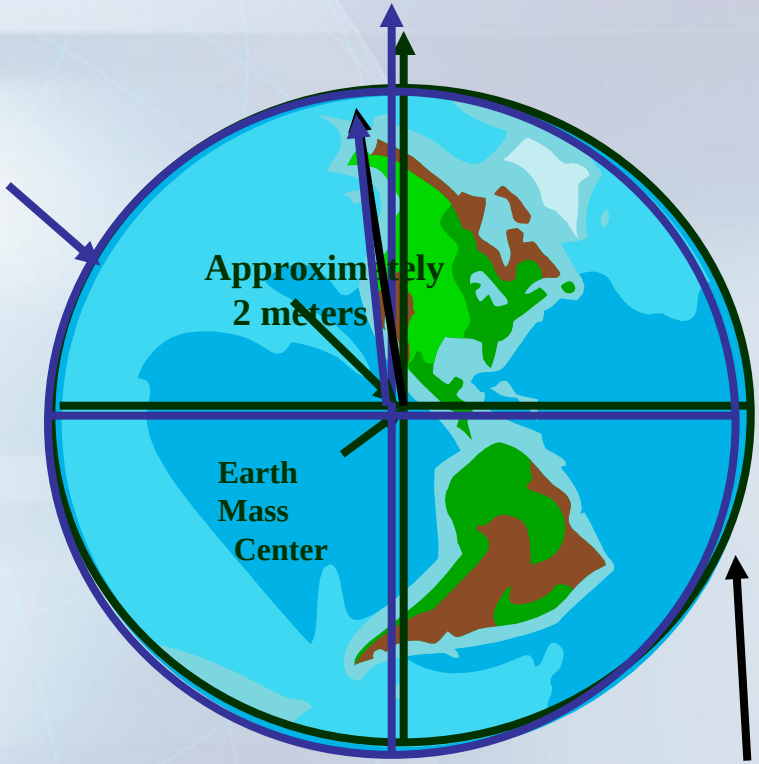
# Vertical Datum Transformation "Roadmap"



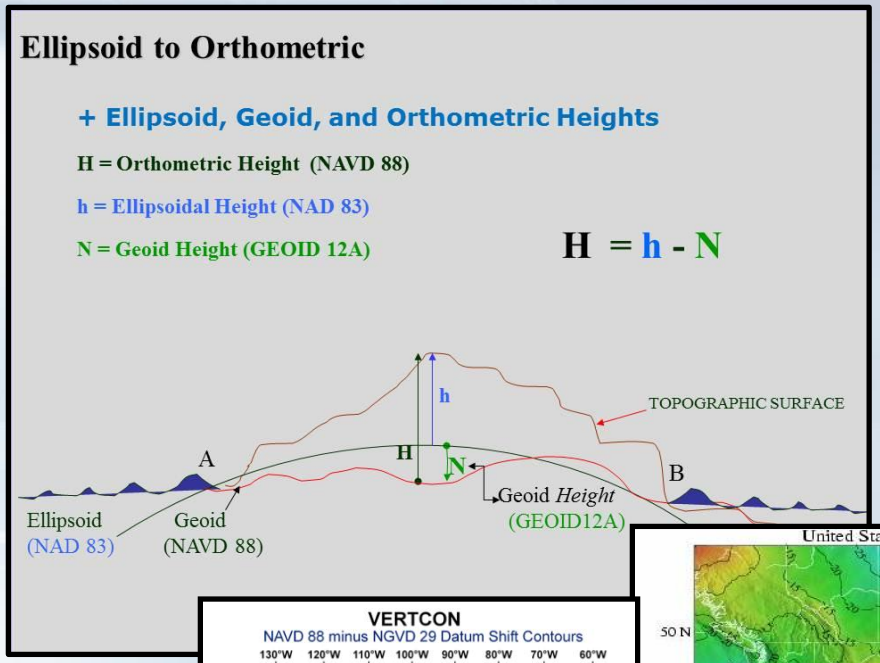
# 3D/Ellipsoid Datums



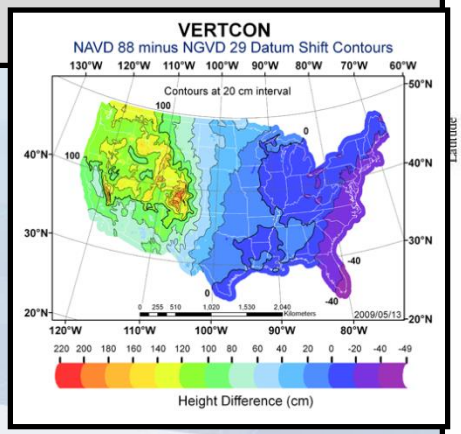

- Calculation of geographic position on this irregular surface is very complex. A simpler model is needed.
- This simplified mathematical surface is the *ellipsoid*.
- An ellipsoid approximates the shape of the earth, a datum defines the position of the ellipsoid relative to the center of the earth. A datum provides a frame of reference for measuring locations on the surface of the earth.

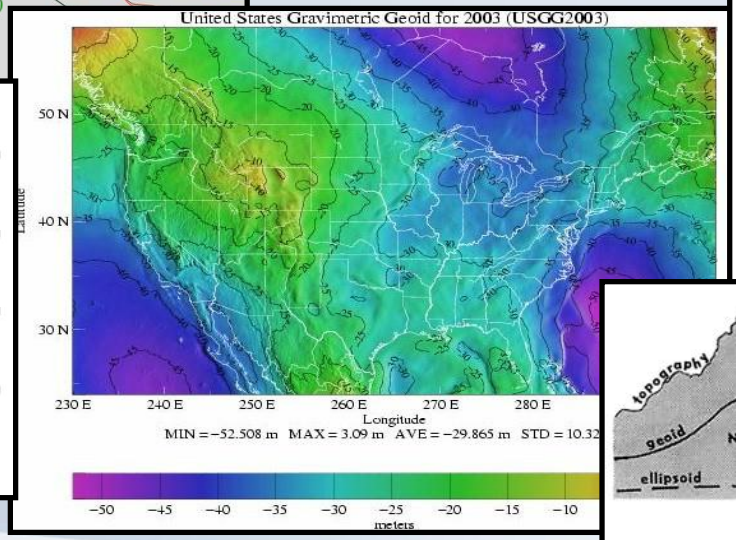
**The GRS80 ellipsoid's origin is approximately 2m from WGS84 ellipsoid's. The Clarke 1866 ellipsoid's origin is approximately 236 m from WGS84 ellipsoid's**

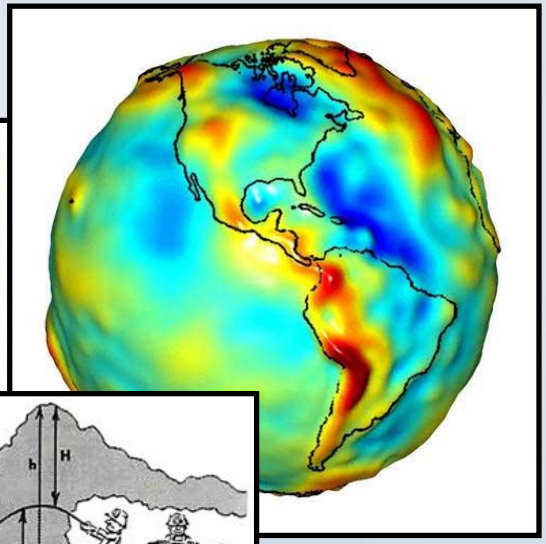
# Orthometric Datums and the GEOID

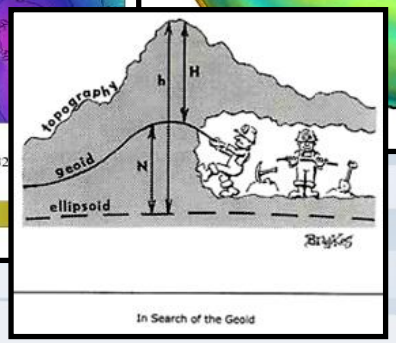



- NAVD88 is based on an adopted elevation at Point Rimouski (Father's Point). It uses Helmert orthometric heights as an approximation to true orthometric heights.
- GEOID: "The *equipotential surface* of the Earth's gravity field which best fits, in the least squares sense, (global) mean sea level."
- Can't see the surface or measure it directly.
- Can be modeled from gravity data as they are mathematically related.





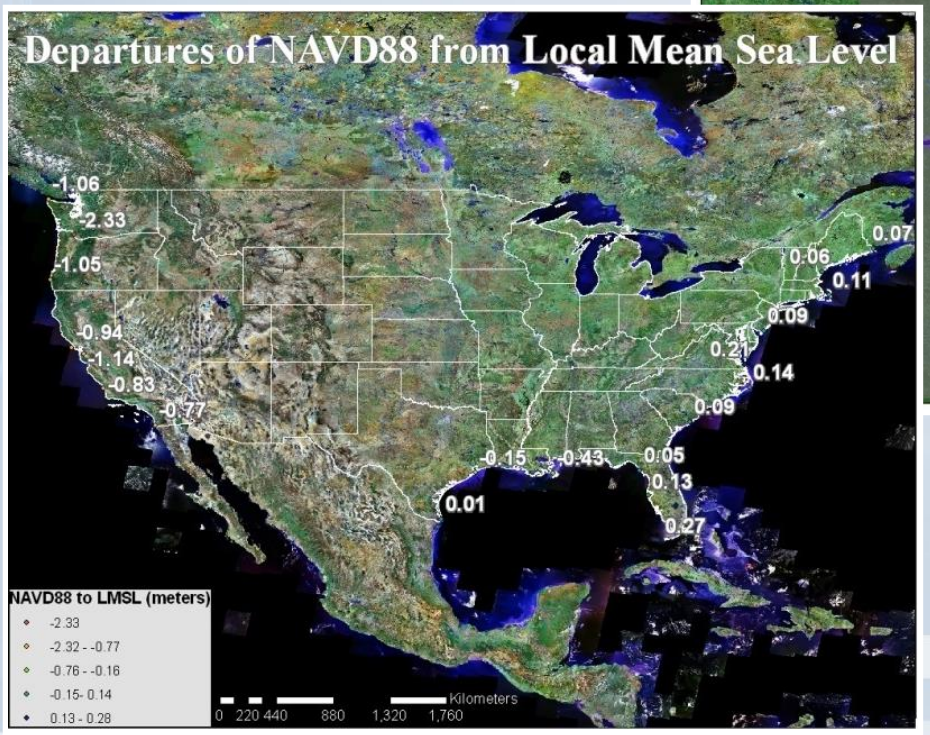

National Oceanic and Atmospheric Administration

***biquadratic interpolation***

# Topography of the Sea Surface

**The Topography of the Sea Surface (TSS)** is defined as the elevation of the North American Vertical Datum of 1988 (NAVD88) relative to local mean sea level (LMSL).

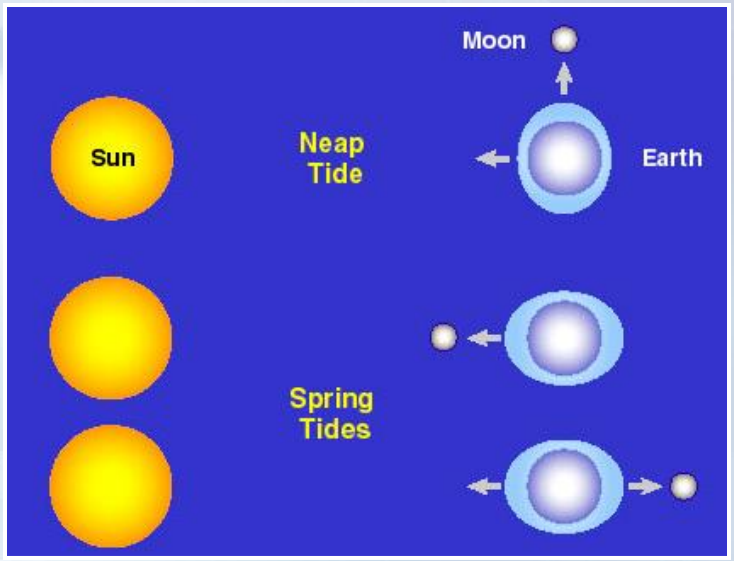

- This grid provides compensation for the local variations between a mean sea level surface and the NAVD88 geopotential surface.
- A positive value specifies that the NAVD88 reference value is further from the center of the Earth than the local mean sea level surface.



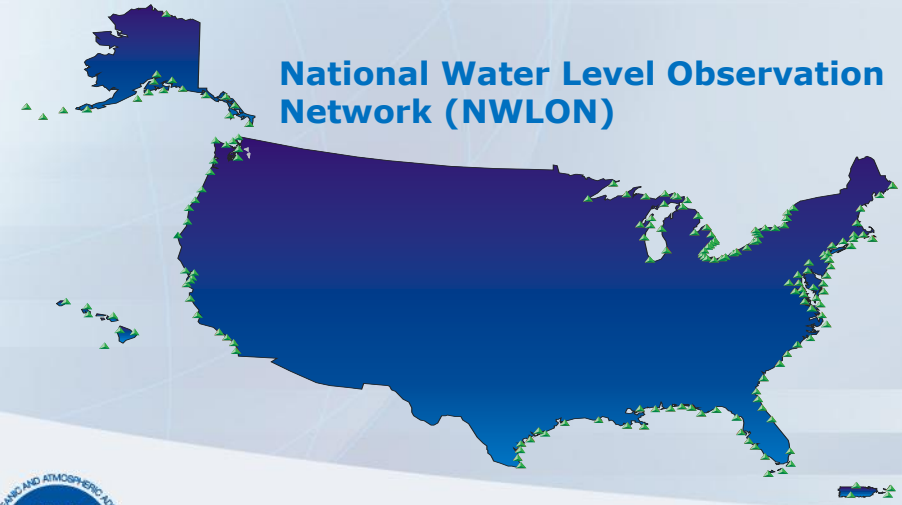

National Oceanic and Atmospheric Administration

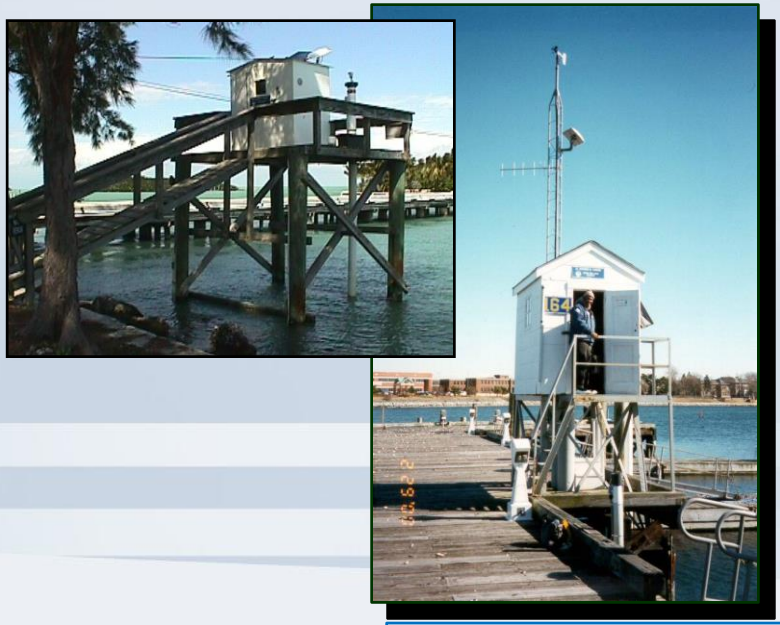
**bilinear interpolation**

# Tidal Datums




- A vertical datum is called a tidal datum when it is defined by a certain phase of the tide.
- National Tidal Datum Epoch (NTDE): is a specific 19-year period that spans the longest periodic tidal variations resulting from astronomical tide-producing forces.
- The fundamental base from which most coastal and marine boundaries are determined.
- Also important for referencing soundings and depicting shorelines on nautical charts.



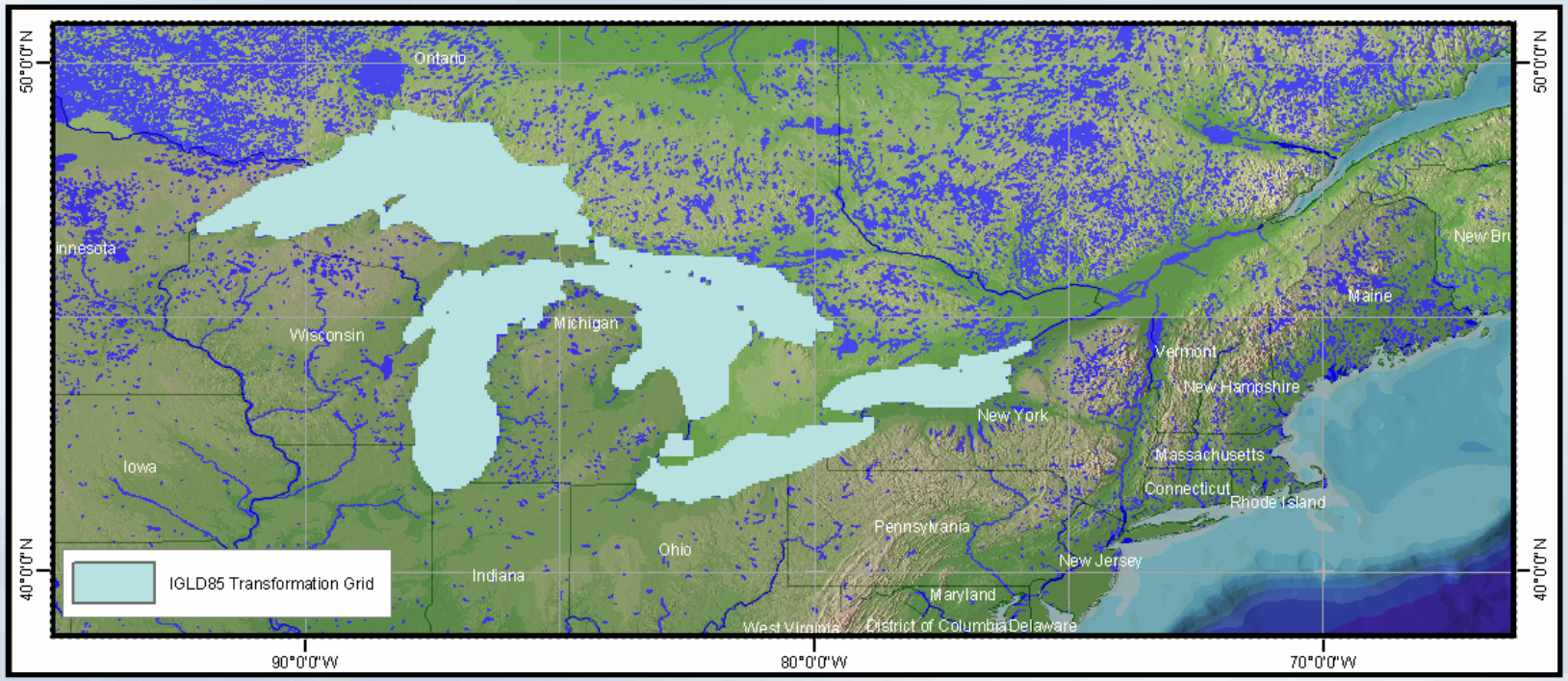



National Oceanic and Atmospheric Administration

bilinear interpolation

# VDatum: IGLD85

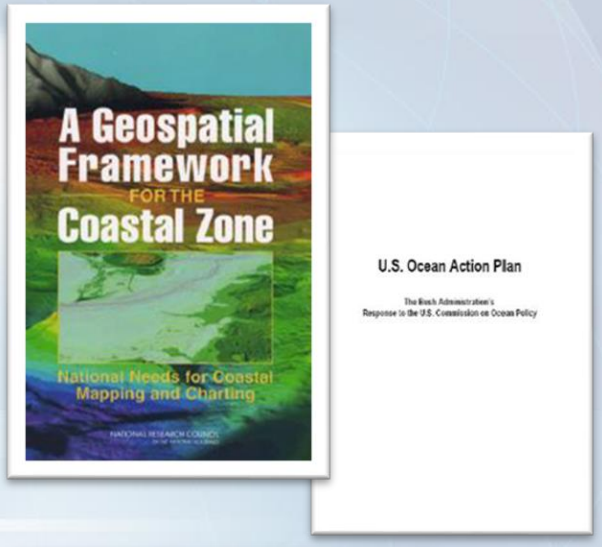
- Conversions between IGLD 85 and NAVD 88 are provided based on the NAVD 88 gravity model (http://www.ngs.noaa.gov/TOOLS/Navdgrav/navdgrav.html) and the hydraulic corrector model.




National Oceanic and Atmospheric Administration

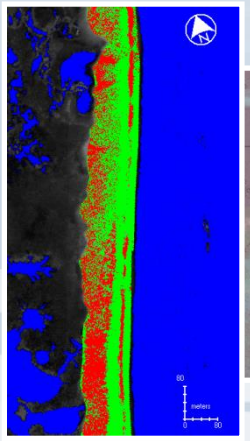
# VDatum Applications

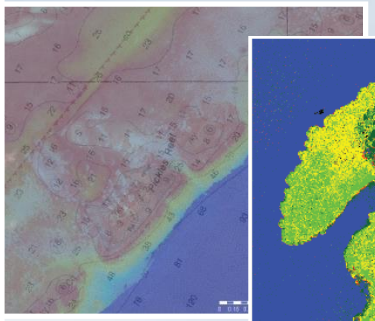
# Integrated Ocean and Coastal Mapping (IOCM)

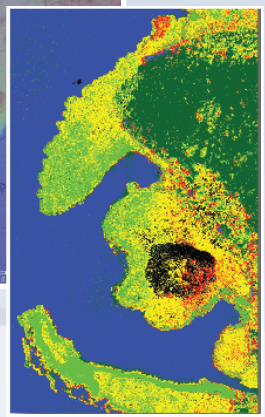



**The practice of acquiring, managing, integrating and disseminating ocean and coastal geospatial mapping data in such a manner that permits these data and their derivative products to be easily accessed and used by and for the greatest range of users and purposes.**

**IOCM requires intra- and inter-agency coordination with a focus on streamlining operations, reducing redundancies, improving efficiencies, developing common standards, and stimulating innovation and technological development.**

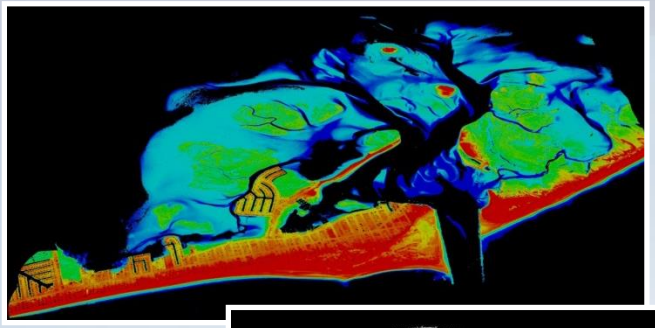


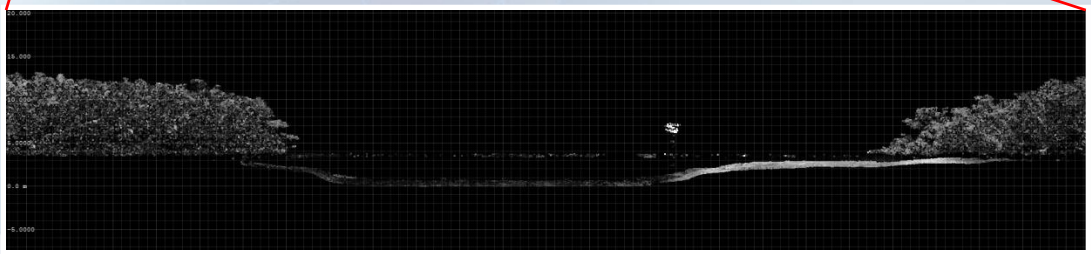


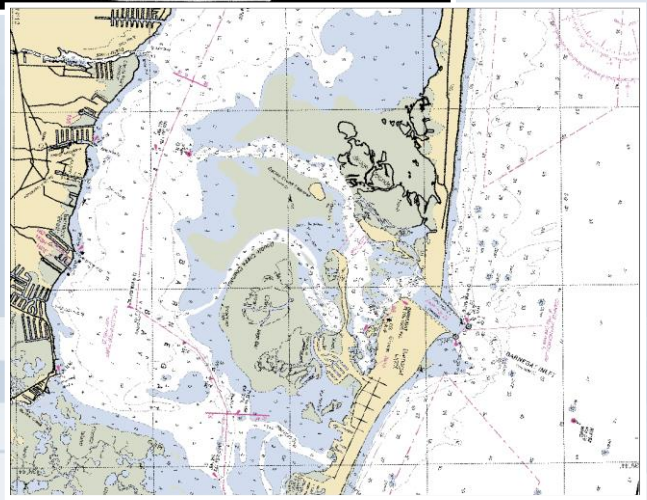


National Oceanic and Atmospheric Administration

# TopoBathy Lidar

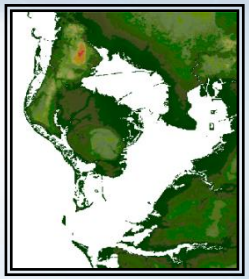




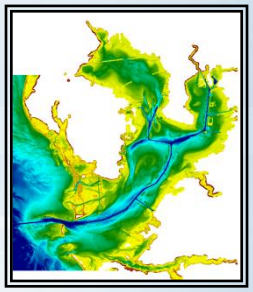


National Oceanic and Atmospheric Administration

# VDatum: Used to Create Digital Elevation Models

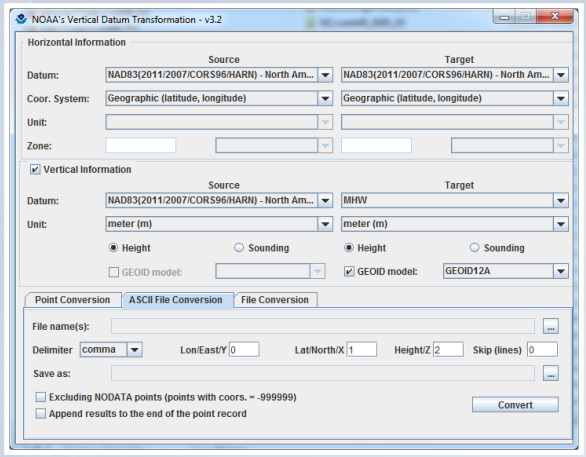


Topography

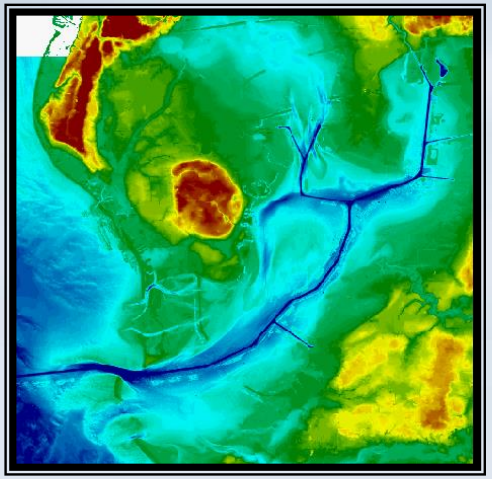


Bathymetry

VDatum




Topo/ Bathy
Digital Elevation Model



## Applications for Seamless Bathy/Topo Datasets:

- Inundation modeling from storm surge, tsunamis, and sea level rise.
- Erosion, accretion, renourishment
- Analyzing storm impacts
- Determining setback lines
- Determining local, state, and national boundaries
- Navigation products and services
- Habitat restoration
- Shoreline Change Analysis
- Analyzing environmental and natural resources
- Permitting

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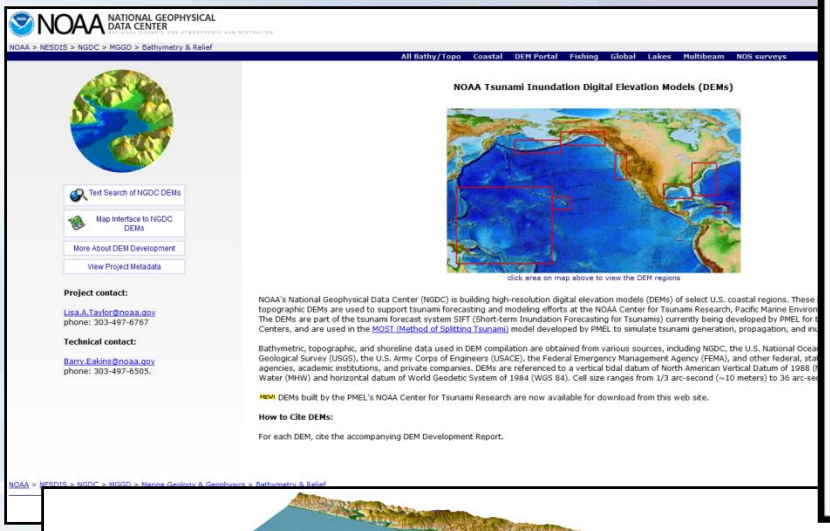
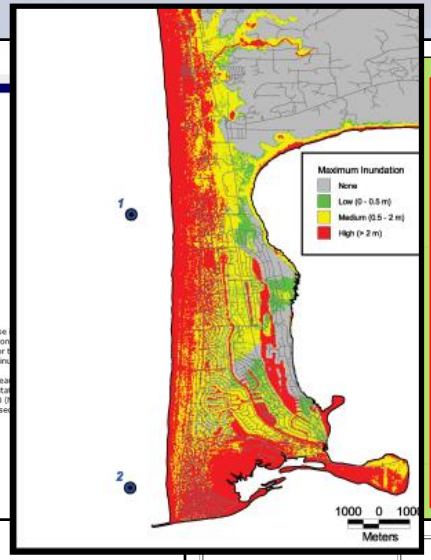
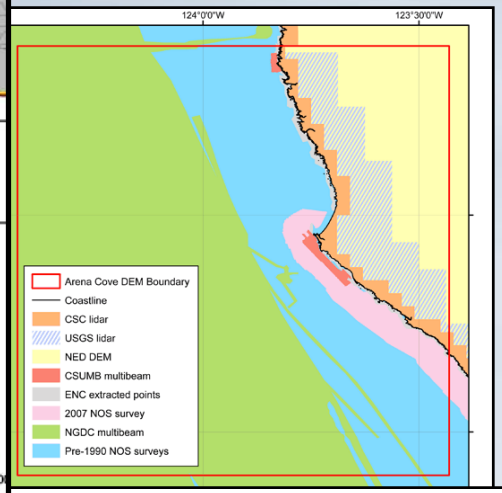
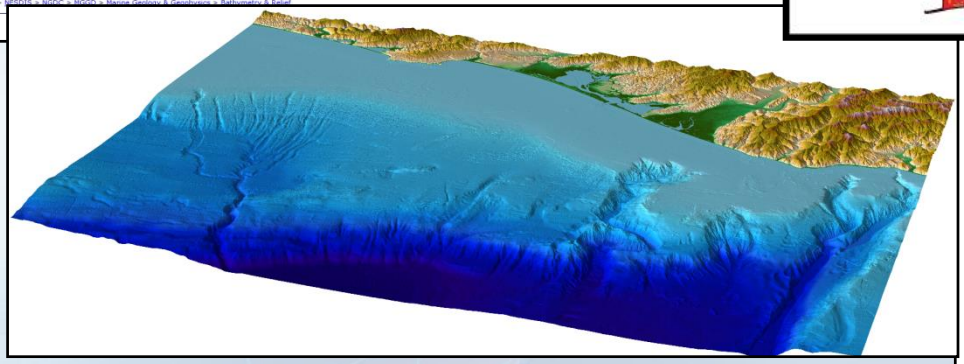
# Utilizing VDatum for Digital Elevation Model Creation: Tsunami Inundation



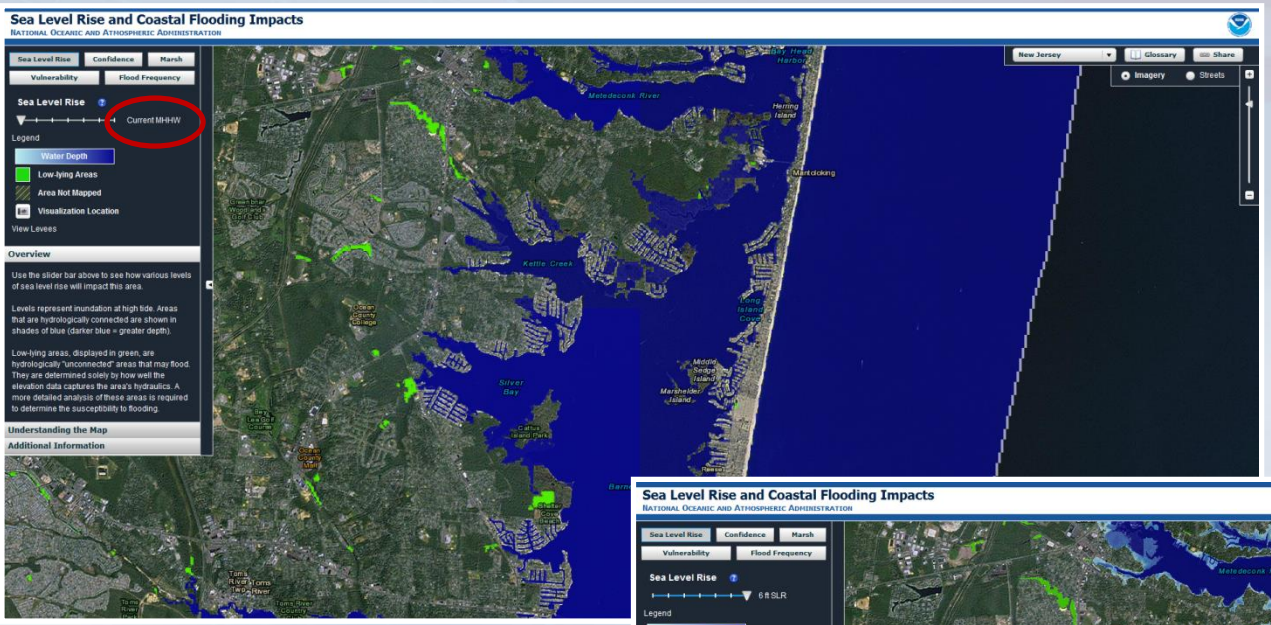



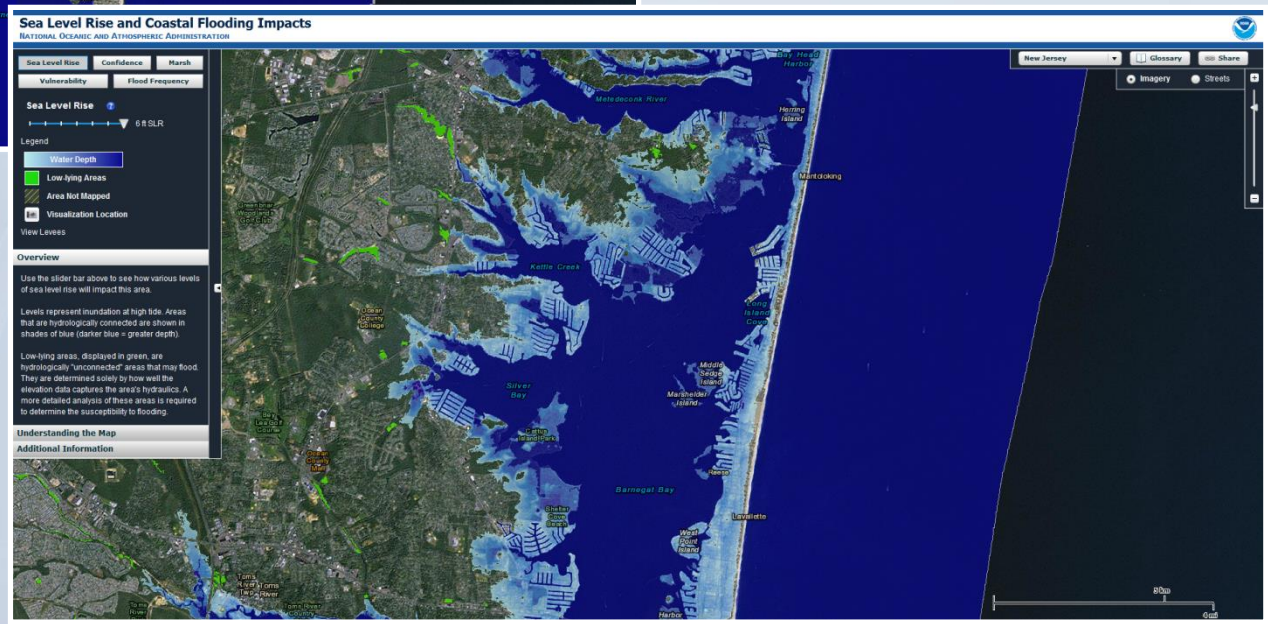



| Source | Year | Data Type | Spatial Resolution | Original Horizontal Datum/Coordinate System | Original Vertical Datum |
|---|---|---|---|---|---|
| NGDC | 1921 to 2008 | NOS hydrographic survey soundings | Ranges from less than 10 m to 600 m (varies with scale of survey, depth, traffic, and probability of obstructions) | NAD 83 geographic | MLLW |
| NGDC | 1984 to 2006 | Multibeam swath sonar | gridded to 1 arc-second | WGS 84 geographic | Assumed Mean Sea Level |
| University of New Hampshire, Center for Coastal and Ocean Mapping, Joint Hydrographic Center | 2009 | Multibeam swath sonar | 40 meter grid | WGS 84 geographic | Inferred Mean Sea Level |
| U.S. Army Corps of Engineers | 2009 | Hydrographic survey | Not Available | NAD 83 California State Plane I (feet) | MLLW |
| California State University Seafloor Mapping Laboratory | 2005 | Multibeam swath sonar | 1 meter grid | WGS 84 UTM 10 North | NAVD 88 |
| NOAA Office of Coast Survey | 1992 to 2008 | ENC extracted soundings | Not Available | WGS 84 geographic | MLLW |

National Oceanic and Atmospheric Administration

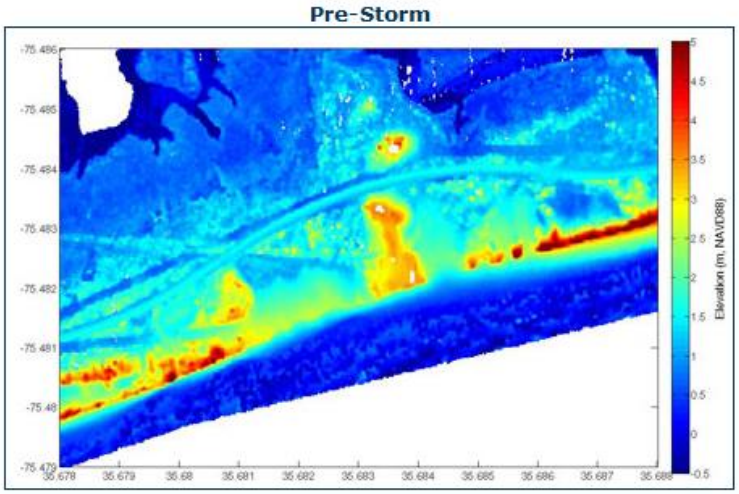
# Sea Level Rise/Coastal Flooding

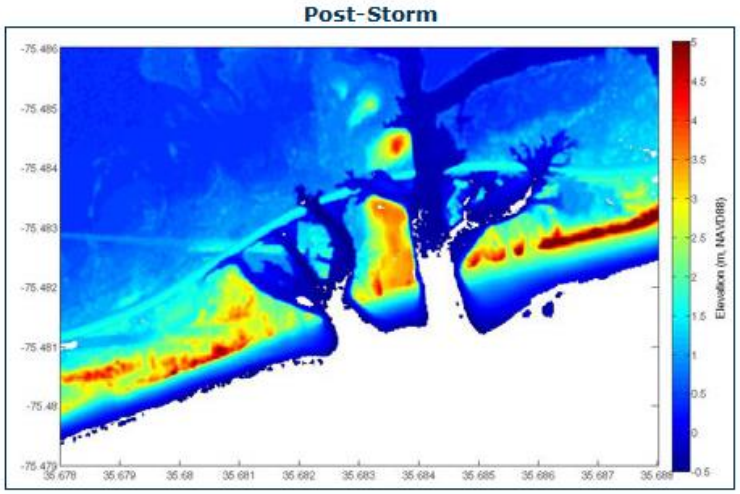


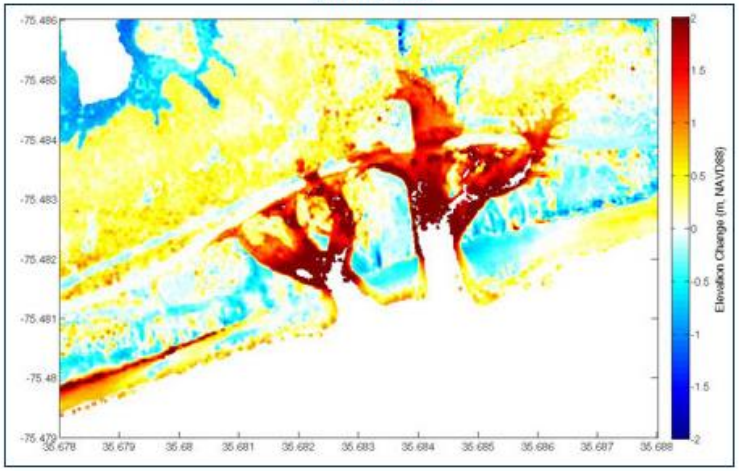




National Oceanic and Atmospheric Administration

# Emergency Response




**Location 5: Lidar topography from November 27-December 1, 2009 (Pre-Storm) and August 28-29, 2011 (Post-Storm) and topographic change (Difference) for a portion of the Outer Banks in the Pea Island National Wildlife Refuge, NC.** In the pre-storm image, note the two particularly low elevation areas between a relative high. During the storm, surge and waves were funneled through the lower areas, carving two breaches (post-storm image). The difference image shows the intricate pattern of erosion associated with the formation of the breaches. See pre- and post-storm photo comparisons for additional discussion.

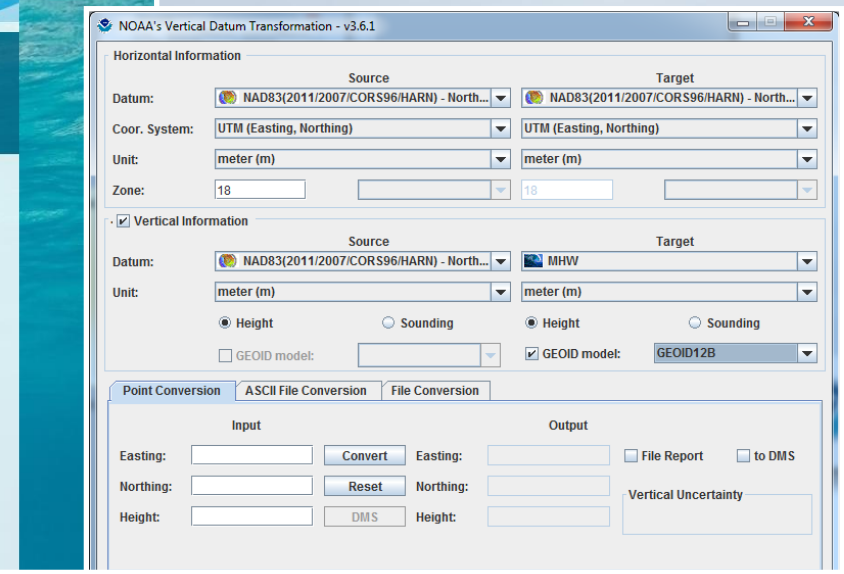
Courtesy of USGS

# Additional Applications

- Coastal Inundation/Sea Level Rise/Tsunami Modeling
- Erosion/Accretion/Shoreline Change
- Habitat/Wetland Restoration
- Dredging and Infrastructure Engineering (levees, jetties)
- Floodplain Mapping
- Topobathy DEM Creation
- Civil and Water Works Projects
- Easement and Setback Planning
- Marine Construction
- Coastal Engineering
- Coral Reef Mapping
- Analyzing Storm Impacts
- Real Estate Mapping
- Evacuation Route Mapping
- Site Management
- Insurance Studies
- Hazardous Waste Site Studies
- Groundwater mapping and modeling
- Feasibility Studies and Planning,
- Determining Local, State and National Boundaries
- Permitting
- Analyzing Environmental and Natural Resources
- Emergency Response
- ??? What Can You Imagine ???

# VDatum Website: vdatum.noaa.gov

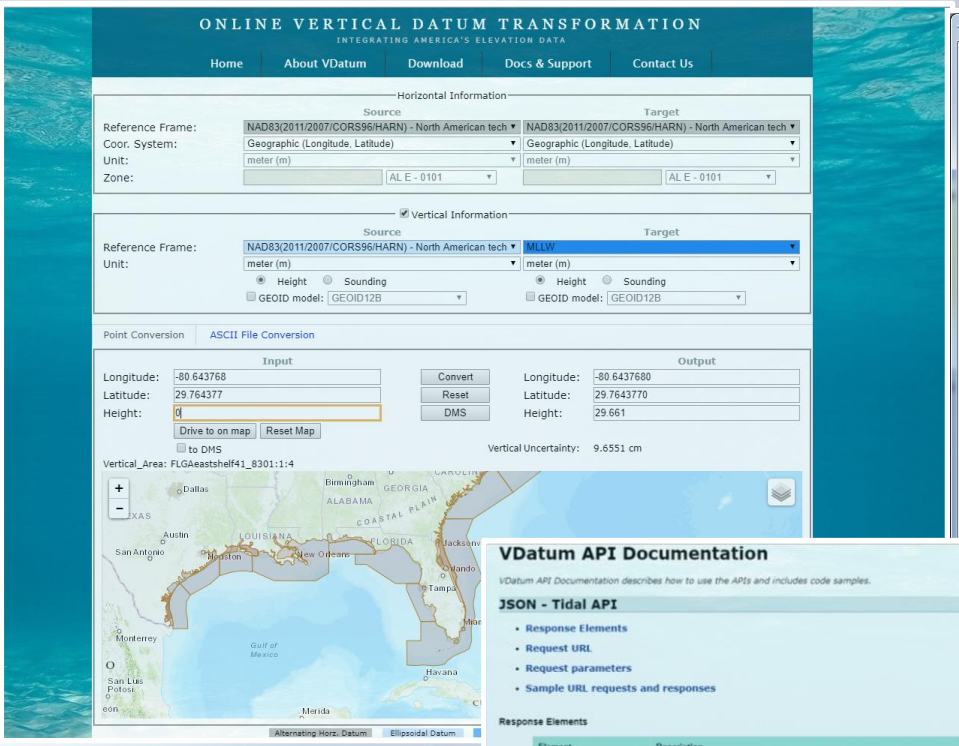
## (Version 4.4.2 Released, May 13, 2022)

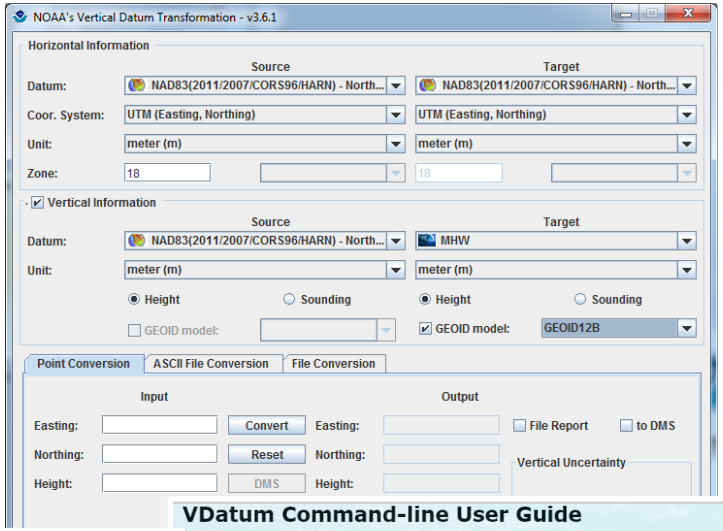



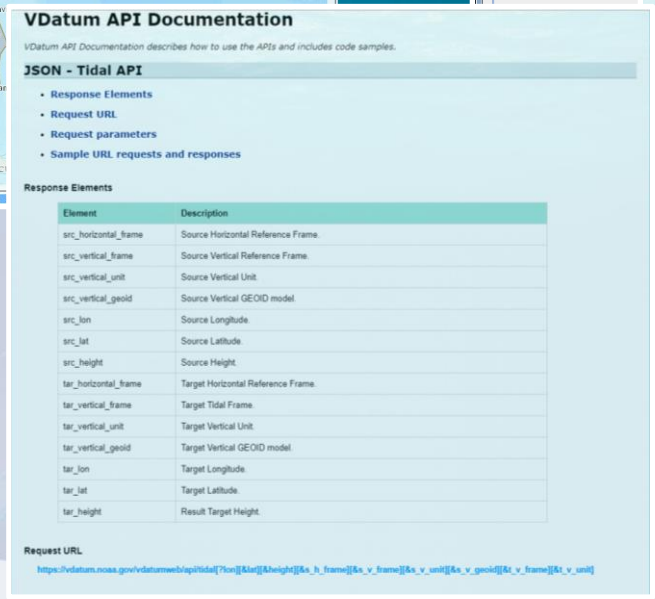


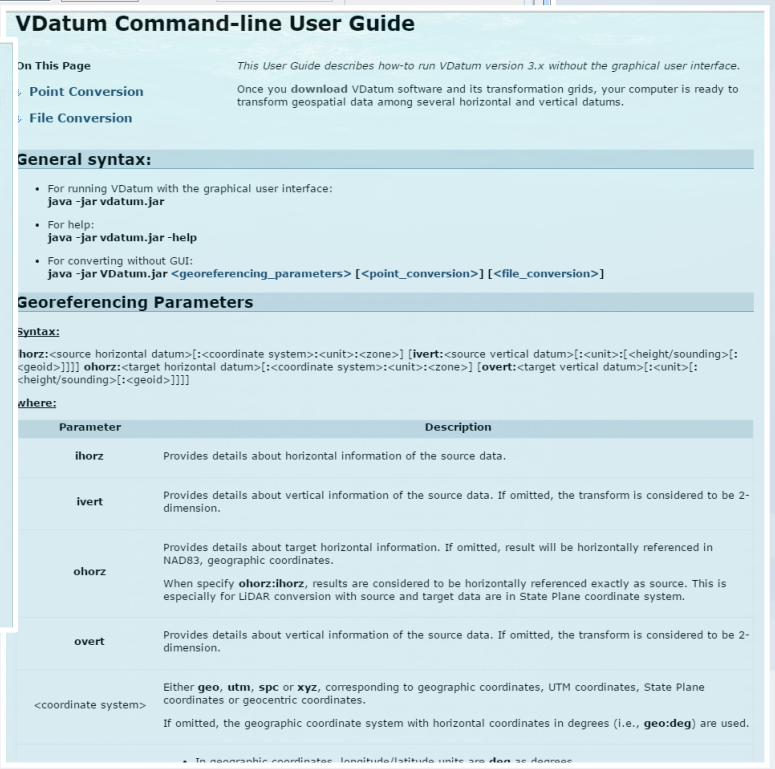
National Oceanic and Atmospheric Administration

# VDatum: Interfaces




National Oceanic and Atmospheric Administration

# VDatum: Documentation and Support

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

VERTICAL DATUM TRANSFORMATION
INTERGRATING AMERICA'S ELEVATION DATA

Home | About VDatum | Download | Docs & Support | Contact Us

- Est. of VDatum Uncertainties
- User FAQs
- User Guide
- Command-line Guide
- Datum Tutorial
- Manual, Presentations & Publications
- Transformation Grid Format

## Welcome to VDatum!

VDatum is a free software tool being developed jointly by NOAA's National (NGS), Office of Coast Survey (OCS), and Center for Operational Oceanogra Services (CO-OPS). VDatum is designed to vertically transform geospatial d of tidal, orthometric and ellipsoidal vertical datums - allowing users to conv different horizontal/vertical references into a common system and enabling geospatial data in desired reference levels.

Download

ad the newest VDatum 6) and its datasets.

imated tutorial!

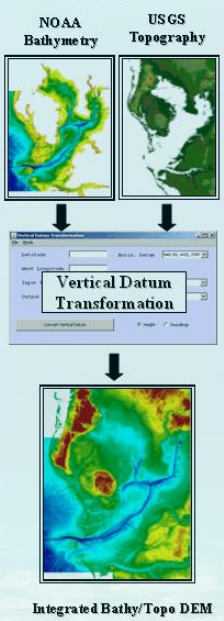
Datum Demonstration ject in Tampa Bay, Florida

## Features

VDatum software is written in Java, so it runs on Mac OS X, Unix, VMP, and Windows.

Where available and uncertainties are established, VDatum supports the conversions among following:

- **Coordinate Systems:** Geographic, UTM, State Plane Coordinates (SPC), and geocentric (ECEF)
- **Horizontal Datums:** NAD27, NAD83(1986), and NAD83(HARN); and ellipsoidal datums such as of ITRF, WGS84, and NAD83 serializations
- **Vertical Datums:**
  - **Ellipsoidal Datums:** NAD83, WGS84, ITRF88, ITRF89, ITRF90, NEOS 90, PNEOS 90, ITRF91, ITRF92, SIO/MIT 92, ITRF93, ITRF94, ITRF96, ITRF97, IGS97, ITRF2000, IGS00, IGb00, ITRF2005, IGS05, ITRF2008, IGS08, WGS84(transit), WGS84(G730), WGS84(G873), WGS84(G1150), WGS84(G1674), NAD83(PACP00), NAD83(MARP00)
  - **Orthometric Datums:** NAVD88, NGVD29, PRVD02, VIVD09, ASVD02, GUVD04, NMVD03, HAWAII EGM2008, EGM1996, and EGM1984
  - **Tidal Datums:** MLLW, MLW, LMSL, DTL, MTL, MHW, LWD, and MHHW
  - IGLD85
- **GEOID models:** GEOID12B, GEOID12A, GEOID09, GEOID06 (Alaska only), GEOID03, GEOID99, and GEOID96
- **EGM models:** EGM2008, EGM1996, and EGM1984
- **Supported file format:** text(ASCII), LiDAR(.LAS) version 1.0 to 1.2, ESRI ASCII Raster(.ASC), and ESRI 3D shapefile




## Manual, Presentations and Publications

### Manual

- VDatum Manual for Development and Support of NOAA's Vertical Datum Transformation Tool, VDatum. Version 1. 01, June 2012.

### Presentations

- White, S. A. (2013). VDatum: Vertical Datum Transforamtion Tool. Presented to the Hydrographic Services Review Panel.

Publications On This Page:

2013 | 2012 | 2011
2010 | 2009 | 2008
2007 | 2006 | 2005
2004 | 2003 | 2002
2001 | 2000 and earlier

### Publications

#### 2013

- Wang, J., E. Myers, I. Jeong, S. White (2013). VDatum for the Coastal Waters of Puerto Rico and the U. S. Virgin Islands:Tidal Datums, Marine Grid, and Sea Surface Topography. NOAA Technical Memorandum NOS CS 33.
- Yang, Z., E. Myers, I. Jeong, S. White (2013). VDatum for the Gulf of Maine:Tidal Datums and Topography of the Sea Surface. NOAA Technical Memorandum NOS CS 31.
- Hess, K., I. Jeong, S. White (2013). Revised VDatum For Eastern Florida. NOAA Technical Memorandum NOS CS 30.
- Xu, J., E. Myers, I. Jeong, S. White (2013). VDatum For Coastal Waters of Texas and Western Louisiana: Tidal Datums and Topography of the Sea Surface. NOAA Technical Memorandum NOS CS 29.

#### 2012

- Yang, Z., E. Myers, I. Jeong, S. White (2012). VDatum For Coastal Waters From The Florida Shelf to the South Atlantic Bight: Tidal Datums, Marine Grids, And Sea Surface Topography. NOAA Technical Memorandum NOS CS 27.

#### 2011

#### 2010

- Yang, Z., E. Myers, S. White (2010). VDatum For Eastern Louisiana And Mississippi Coastal Waters: Tidal Datums, Marine Grids, And Sea Surface Topography. NOAA Technical Memorandum NOS CS 19.
- Yang, Z., E. Myers, S. White (2010). VDatum for Great South Bay, New York Bight And New York Harbor: Tidal Datums, Marine Grids, and Sea Surface Topography. NOAA Technical Memorandum NOS CS 21.
- Xu, J., E. Myers, S. White (2010). VDatum for the Coastal Waters of North/Central California, Oregon and Western Washington: Tidal Datums and Sea Surface Topography. NOAA Technical Memorandum NOS CS 22.

#### 2009

## Frequently Asked Questions

- **Which OS does VDatum run on?**
- **I have the latest Java, however when I double click vdatum.bat, the command prompt window flashes for a split second and the application does not launch.**
- **Running "java -jar vdatum.jar" at the command prompt window gives me "java is not recognized as an internal or external command, operable program or batch file".**
- **I can't select any tidal datum, or NAD 27, NAD83(1986), NGVD29, IGLD85!**
- **I recieved a result of -999999.0. What does that mean?**

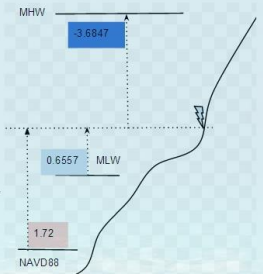
  The -999999.0 is the no-data-value in our program. It occurs in areas where the transformations are invalid. In the tidal transformations, this -999999.0 value could mean that your elevation data are either out of the boundaries of our tidal transformation grids, or in the masked-out areas, i.e. inland or where are not covered by the tidal models.
- **Why doesn't VDatum provide tidal datums inland?**
- **What are the VDatum bounding polygons and why are they utilized?**
- **While trying to convert from NAVD88 to MLLW, MLW, MHW, etc.. I got results showing that the MLLW and MLW are higher than MHW and MHHW. Could it be program bug or something mixed up?**

  No, it isn't a program bug, nor a mix up.

  Let's consider the diagram on the right, assuming a point (at the lightning bolt) has following elevation values (height values):

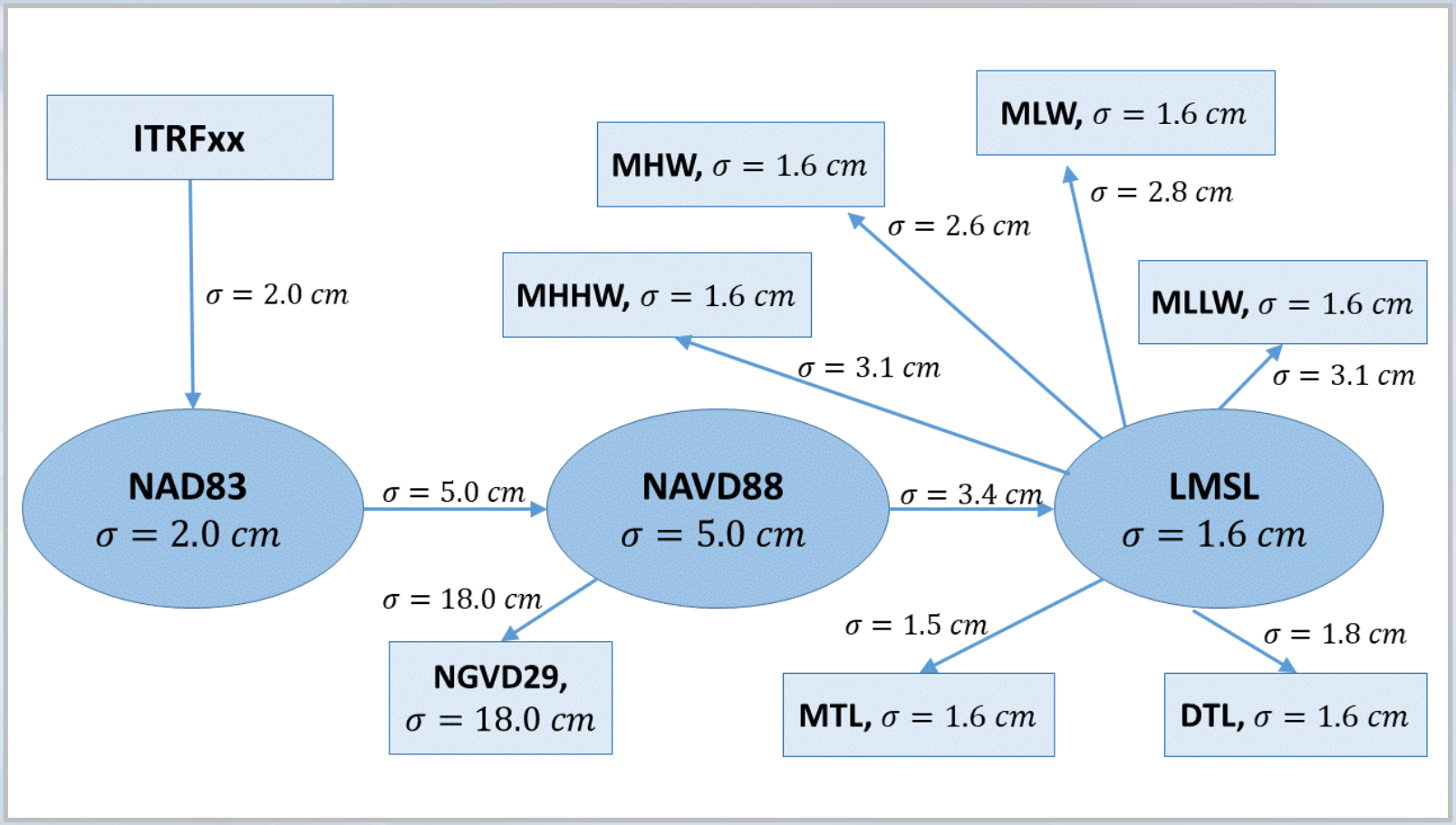
  - NAVD88: 1.72m
  - MLW: 0.6557m
  - MHW: -3.6847m

  where the original elevation value is relative to NAVD88 (1.72m). Using VDatum to get elevation values referenced in MLW (0.6557m), and in MHW is (-3.6847m). Since the origin of MHW is above the origin of MLW, the elevation result of MHW will be less than that of MLW.




National Oceanic and Atmospheric Administration

# VDatum Uncertainty Modeling




See: vdatum.noaa.gov/docs/est_uncertainties.html

# Operational: Vertical Datum Transformation Uncertainty

20090721_47122H2102-works.las.log

```
2016/06/01 13:10:30
NOAA's Vertical Datum Transformation v3.6

                        INPUT                   OUTPUT
Coordinate System:      State Plane             State Plane
Horizontal Datum:       NAD83                   NAD83
Horizontal Unit:        m                       m
Zone:                   4601
Vertical Datum:         NAD83                   NAVD88
Vertical Unit:          m                       m
Height/Sounding:        height                  height
GEOID model:                                    geoid12b
Vertical Area:          geoid12b
Vertical Uncertainty:   7.3485cm

From: C:\temp\las_files\las_files\20090721_47122H2102-works.las
To: C:\temp\las_files\las_files\result\20090721_47122H2102-works.las
Number of processed Points: 333773
Number of valid-transform Points: 333773
Number of points in this output file (NODATA points were excluded): 3
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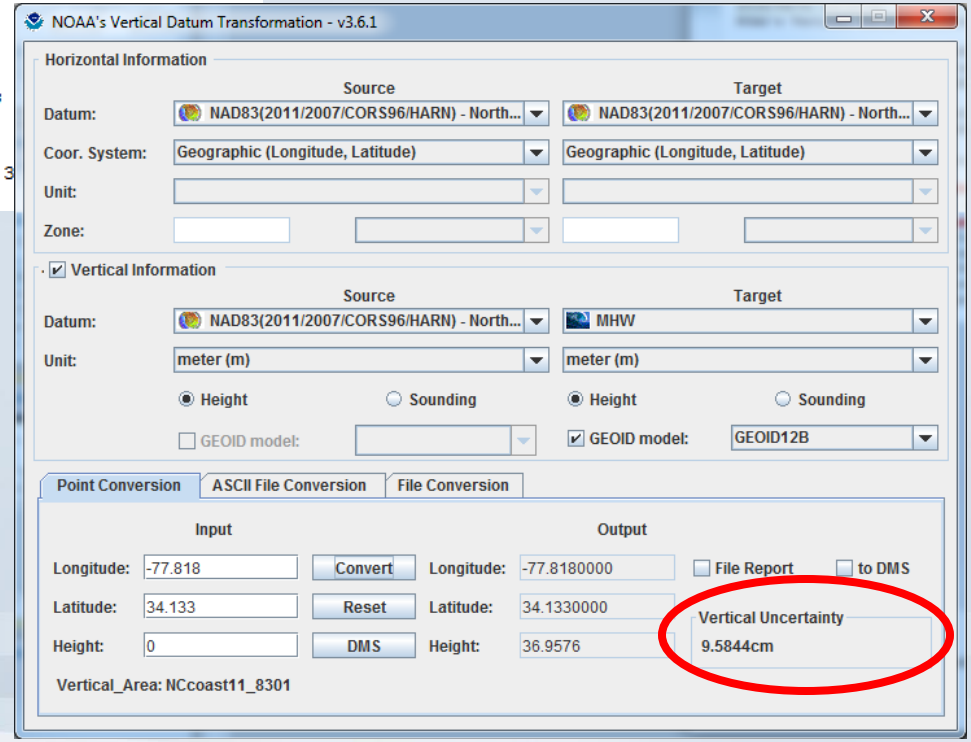


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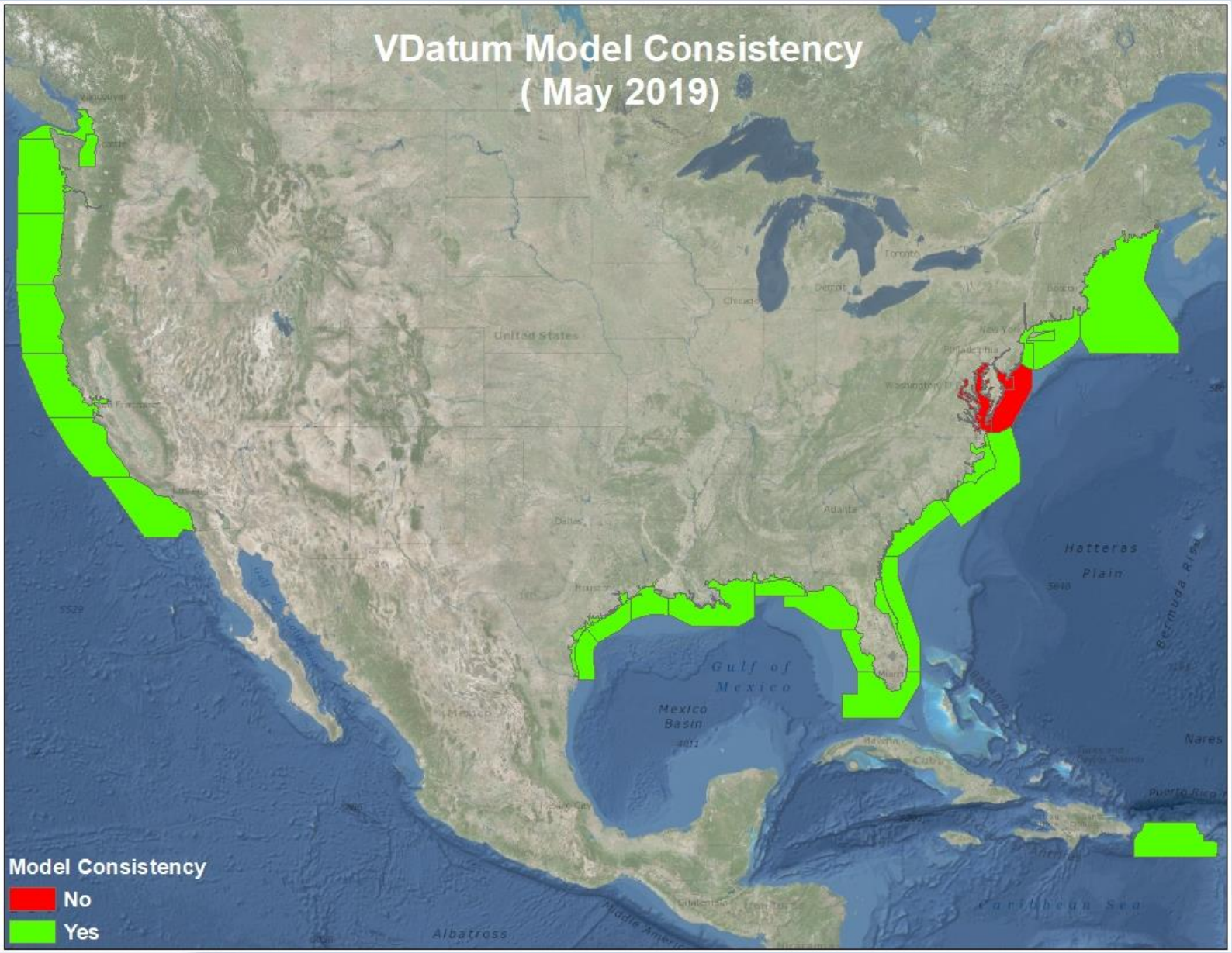
# What's Next: *Strategic Priorities*

- Create Consistency between Regional Models
- Reducing Regional Model Uncertainty to <10cm
- Increasing Coverage
- Next Generation TSS Model (utilizing gravimetric GEOID transformation roadmap) – ***GPS on Tidal Benchmarks***
- Spatially Varying Uncertainty
- Software Development
- Communication and Outreach

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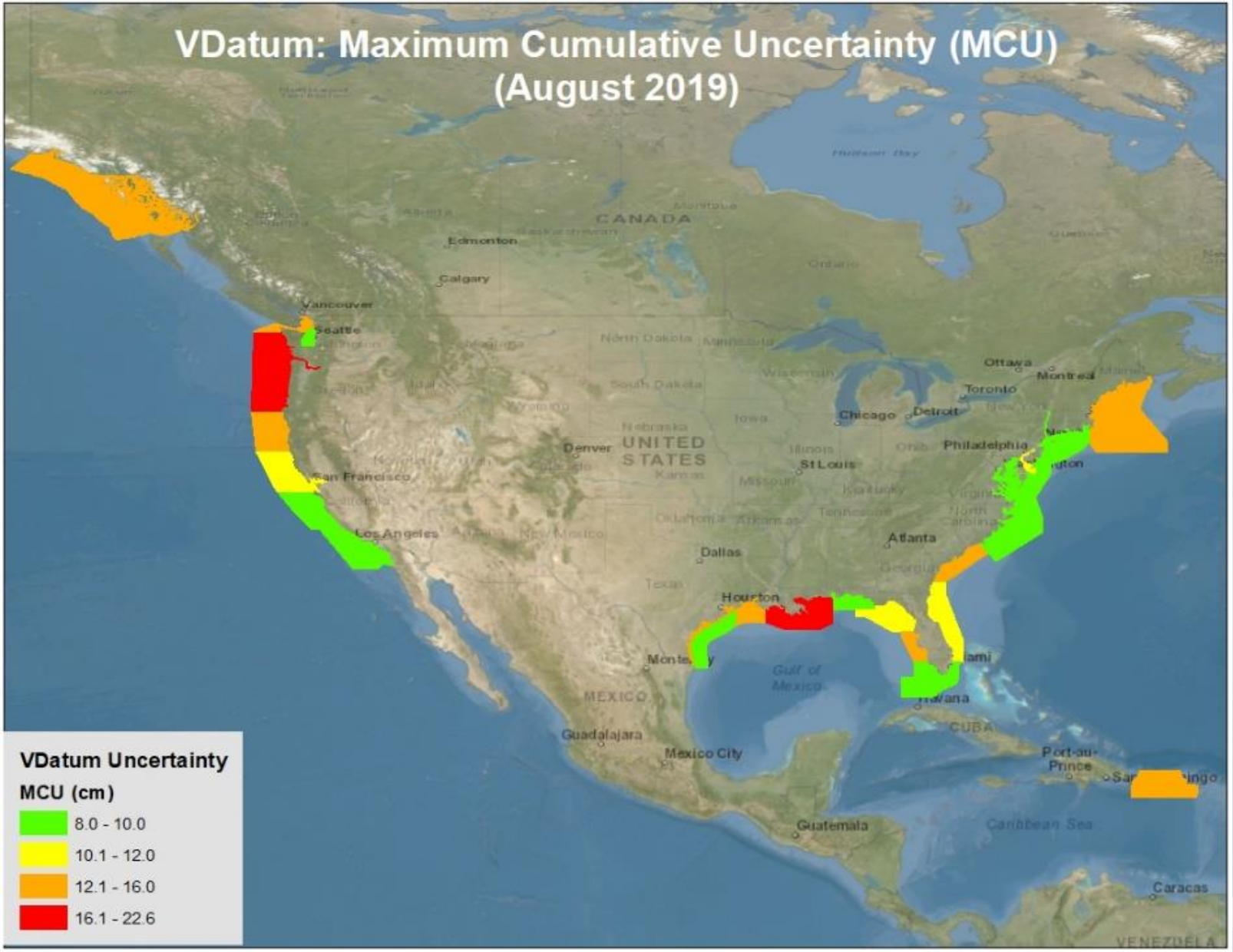


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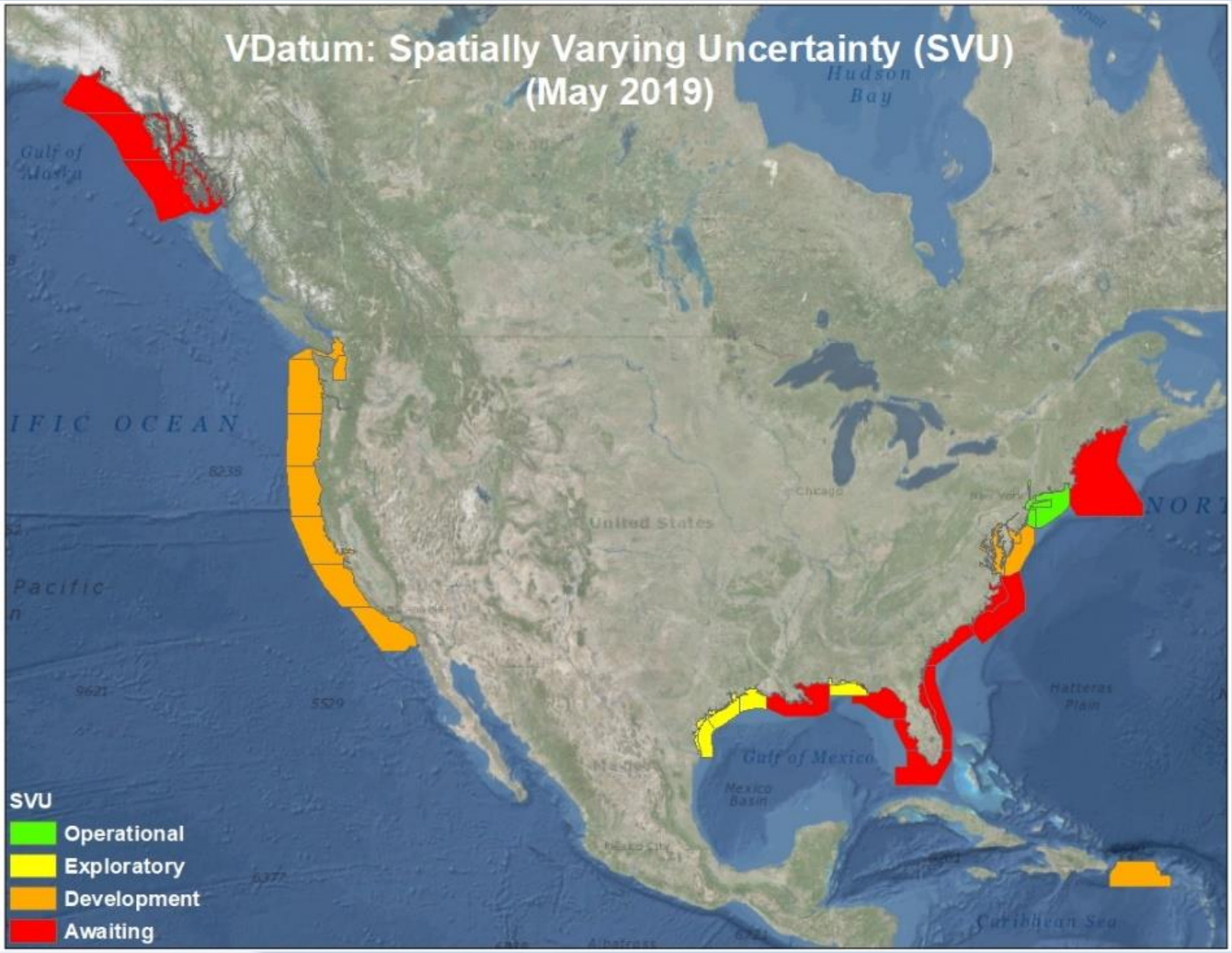


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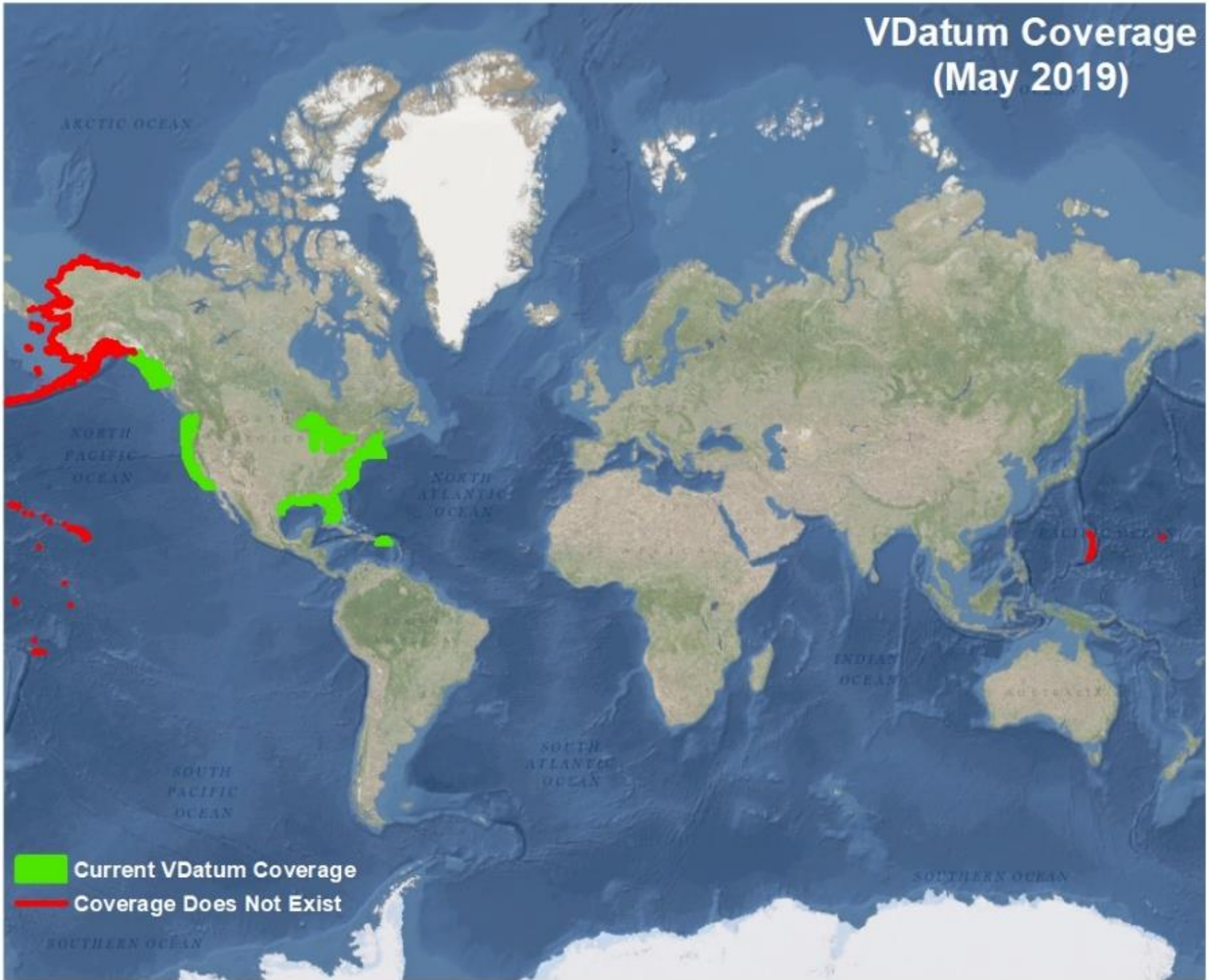
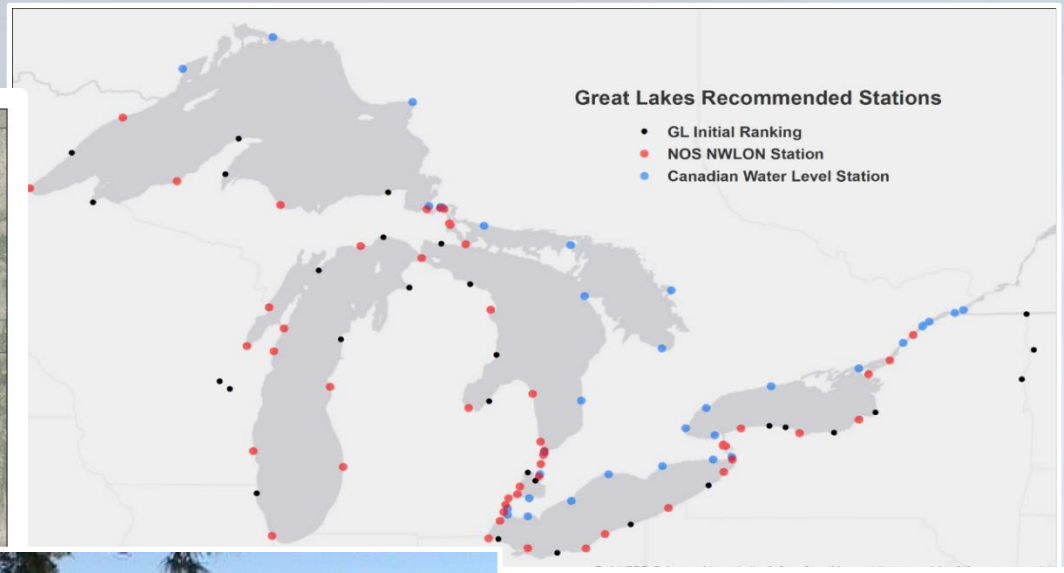
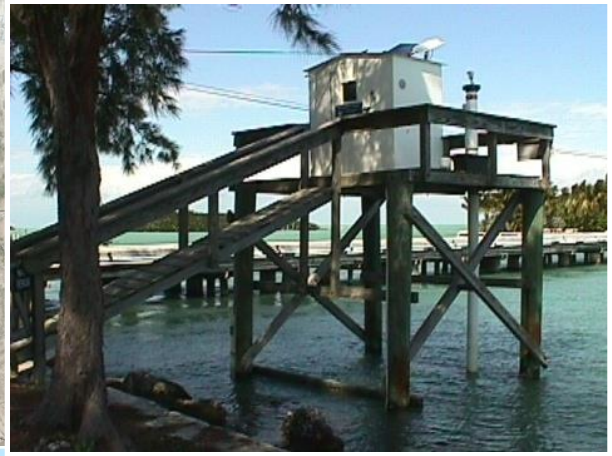

VDatum Coverage
(May 2019)
ARCTIC OCEAN
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
SOUTHERN OCEAN
Current VDatum Coverage
Coverage Does Not Exist

# Foundational Data: Tidal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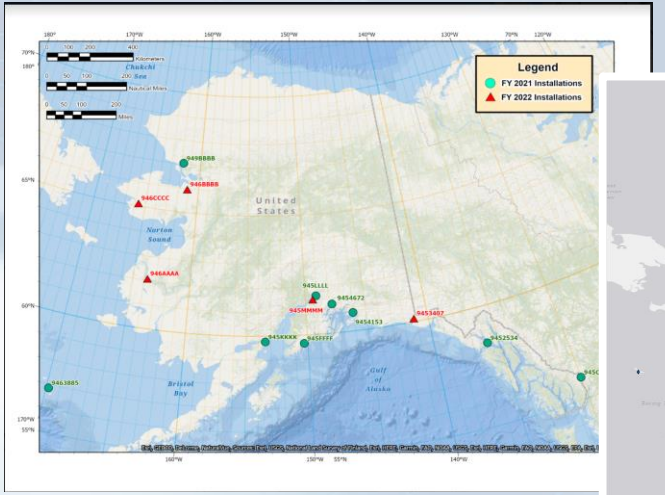
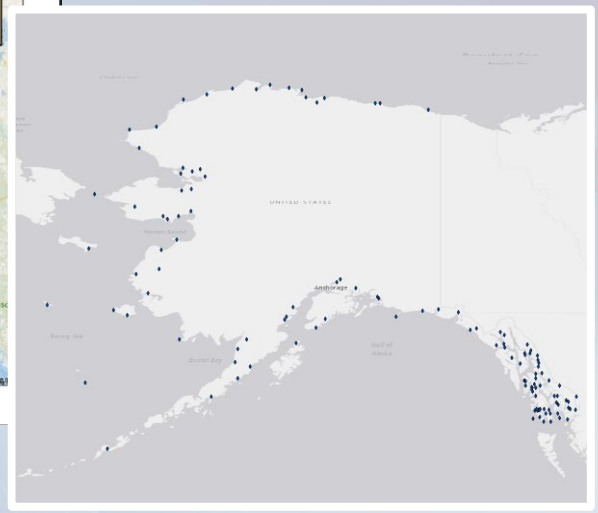
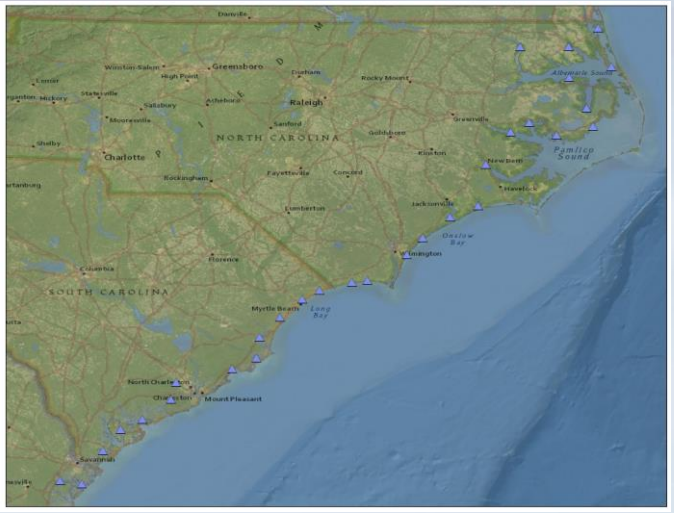
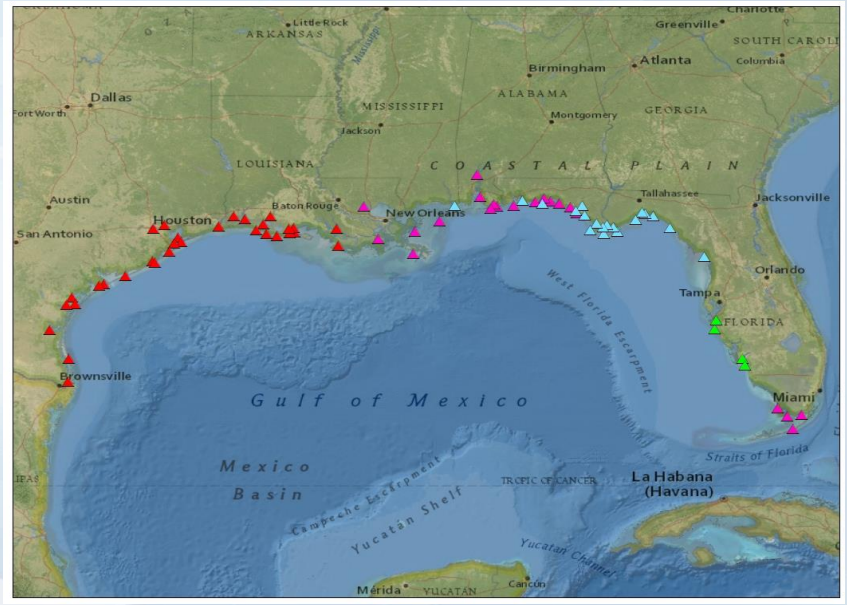
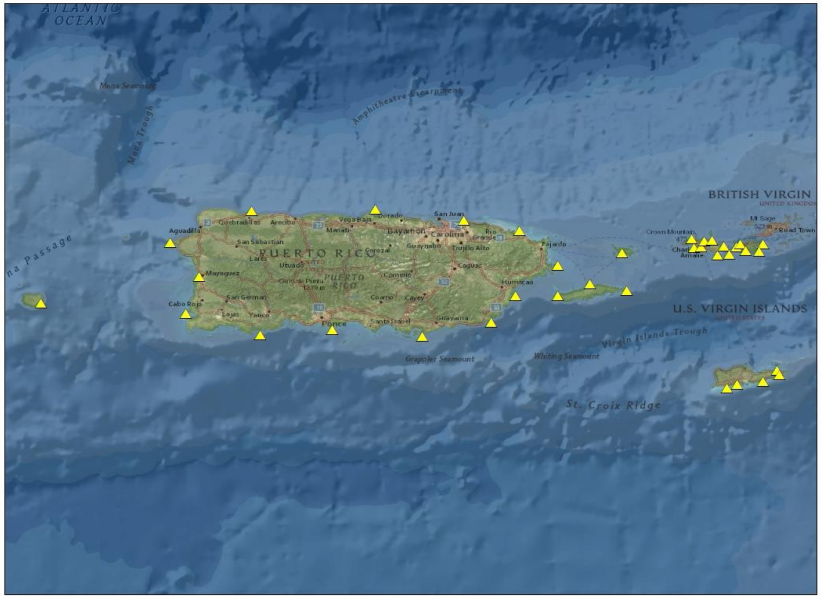
# Foundational Data: Tidal

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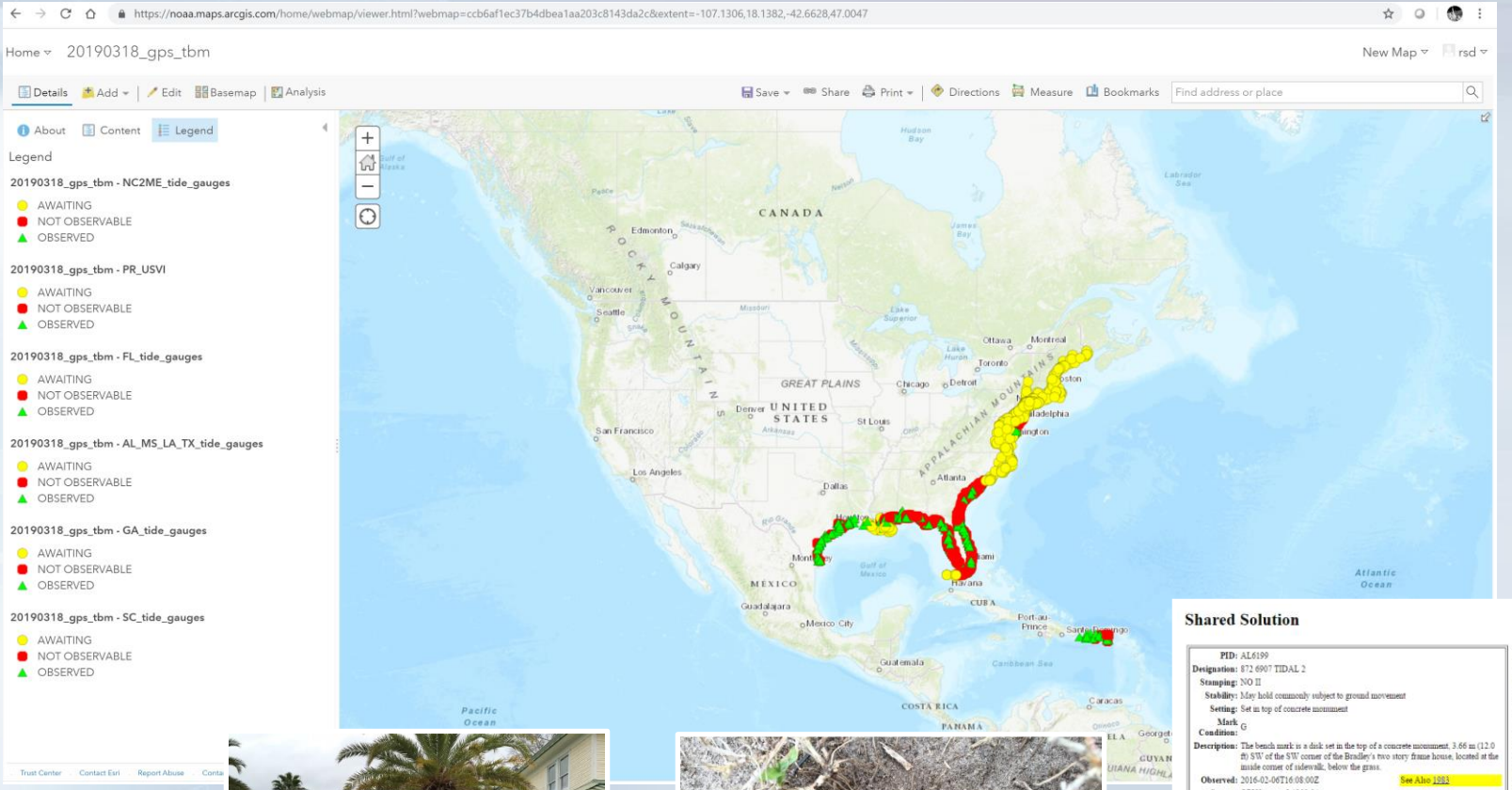
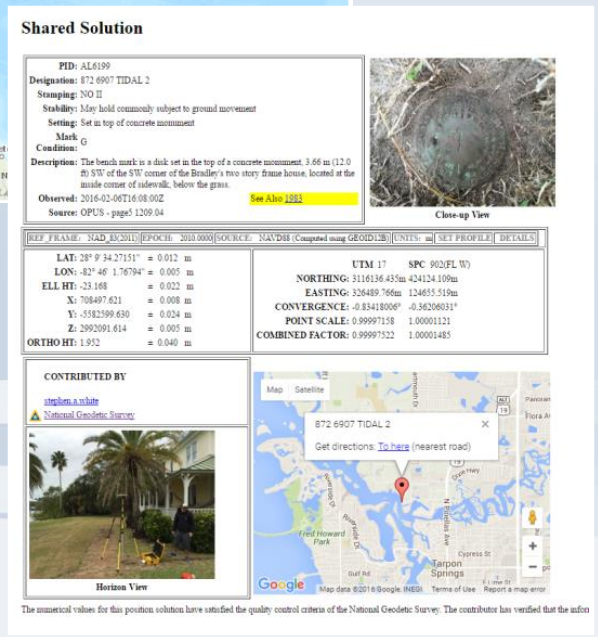
# Foundational Data: Geodetic

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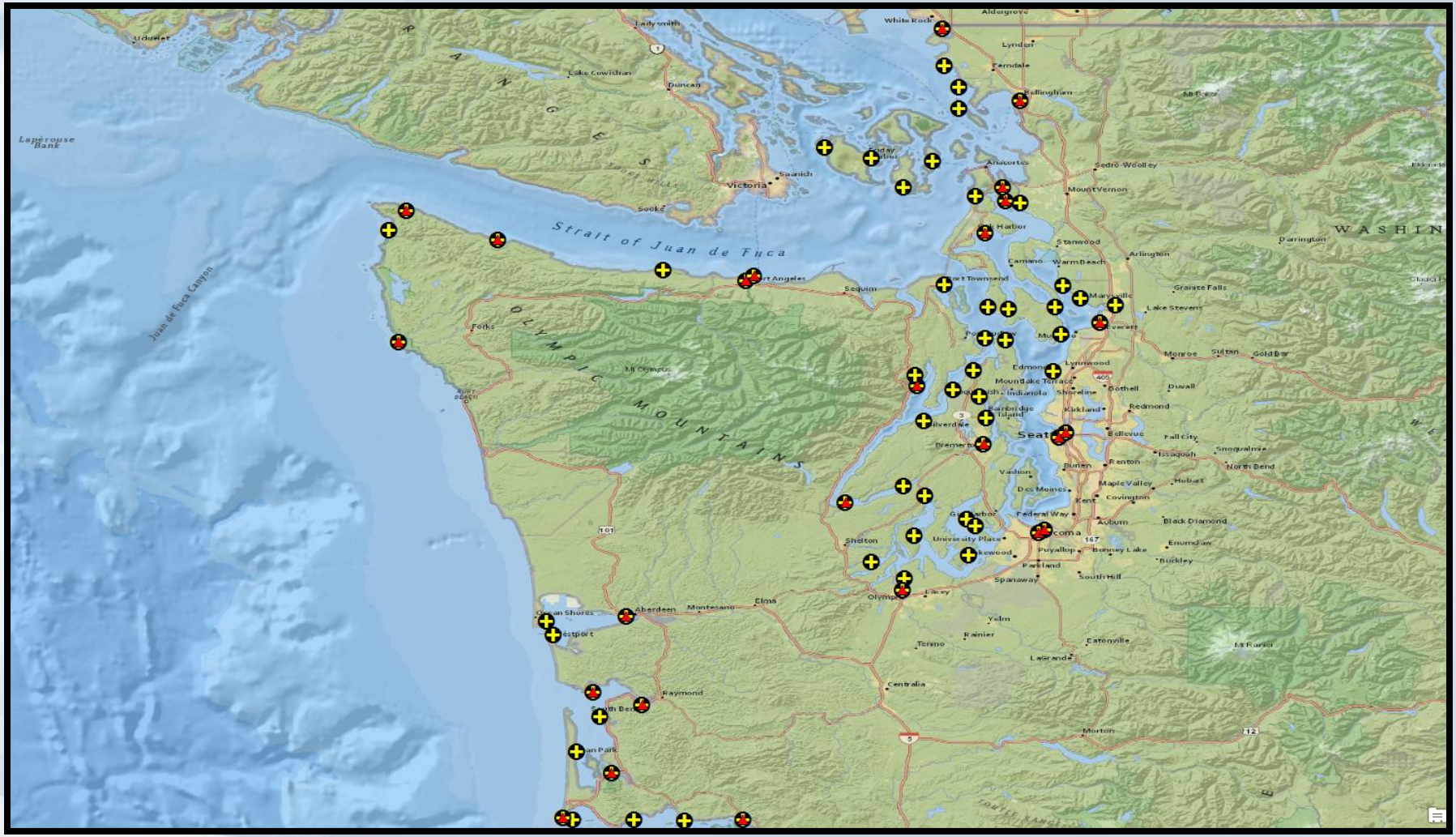
# Hydrodynamic vs. TSS Modeling

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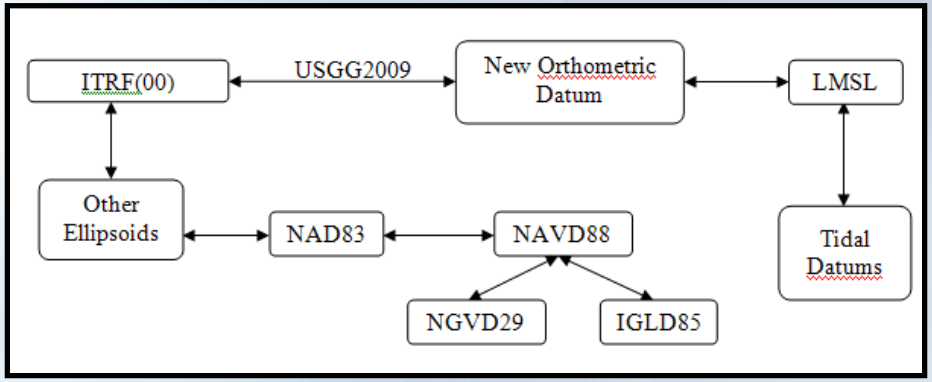
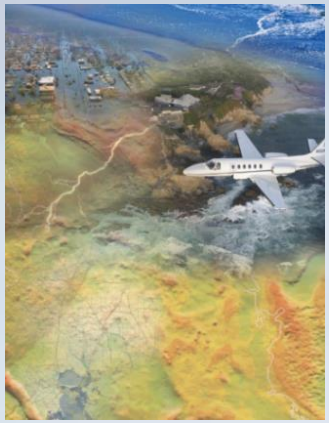
# Future Enhancements: Next Generation TSS Development

## New Proposed Transformation Roadmap based on a purely Gravimetric GEOID

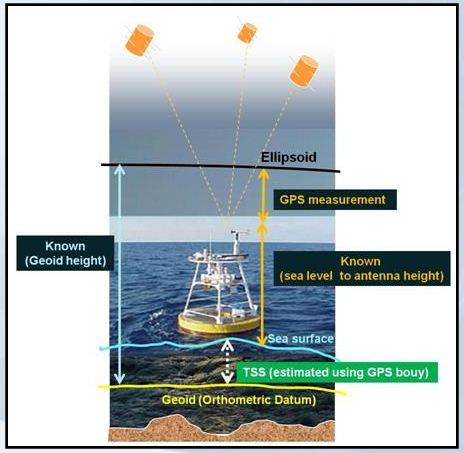


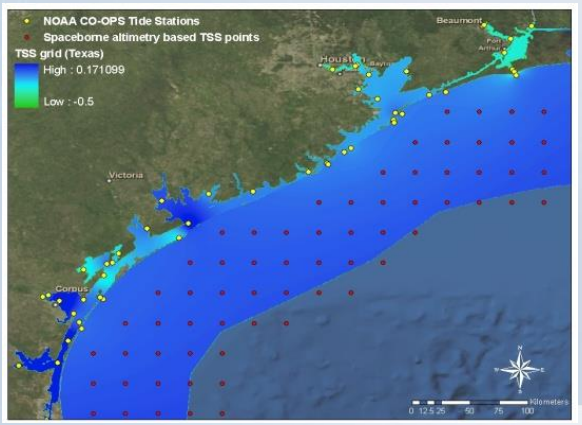

**New GEOID**: Coastal gravity field improvement



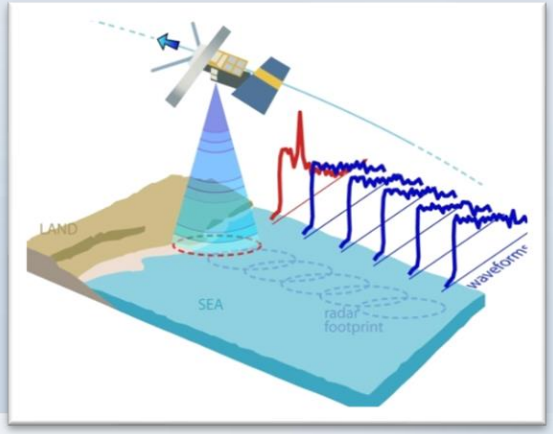
**A Must:** GPS Campaign on bench marks to determine new relationships


**Wish List:** GPS tide buoys to be utilized for data input and validation




Satellite Altimetry/Derived Products to better understand offshore TSS




Re-tracked coastal altimetry data to capture nearshore sea surface height signal

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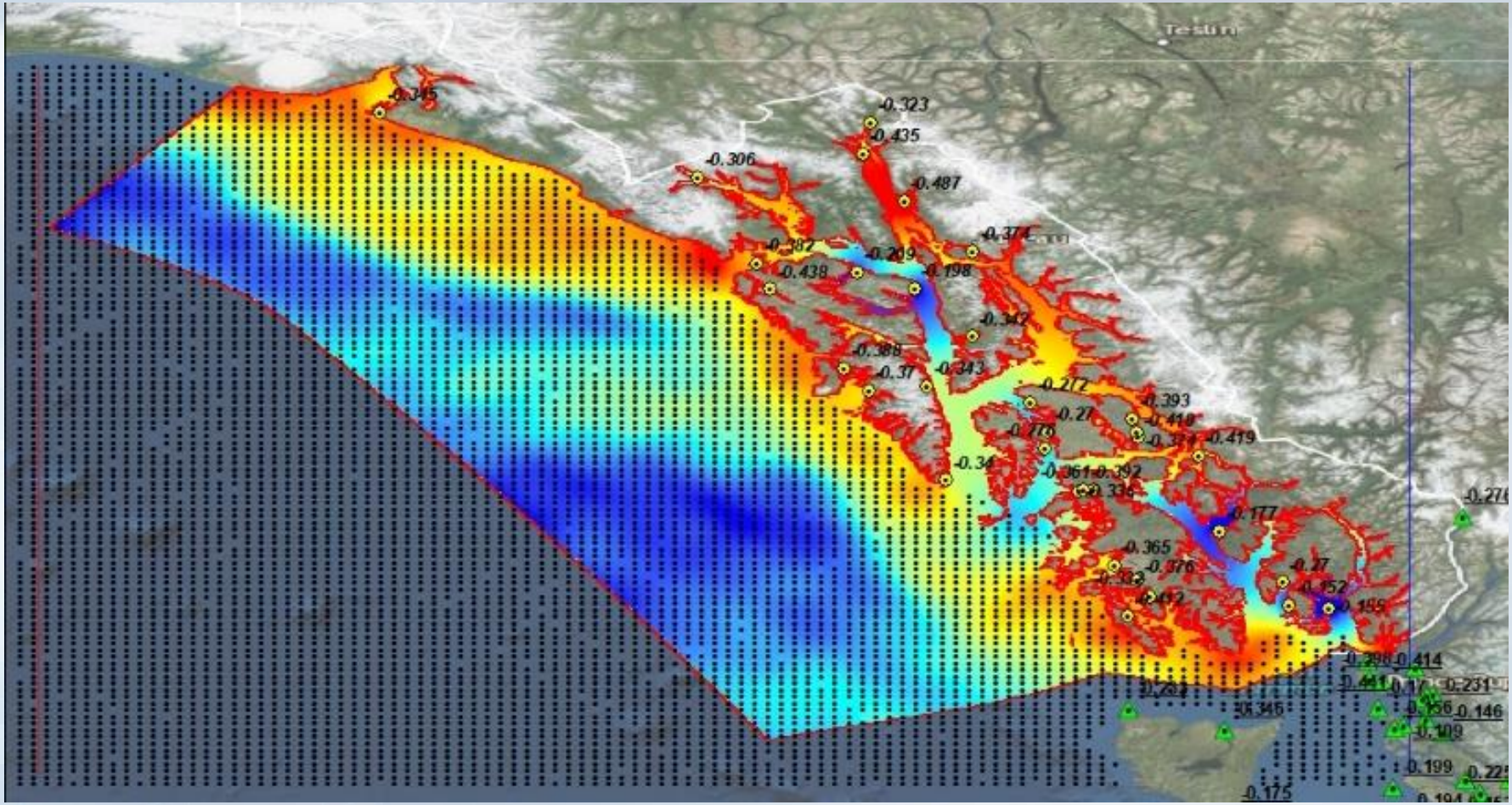
# Southeast Alaska (Released 2019)

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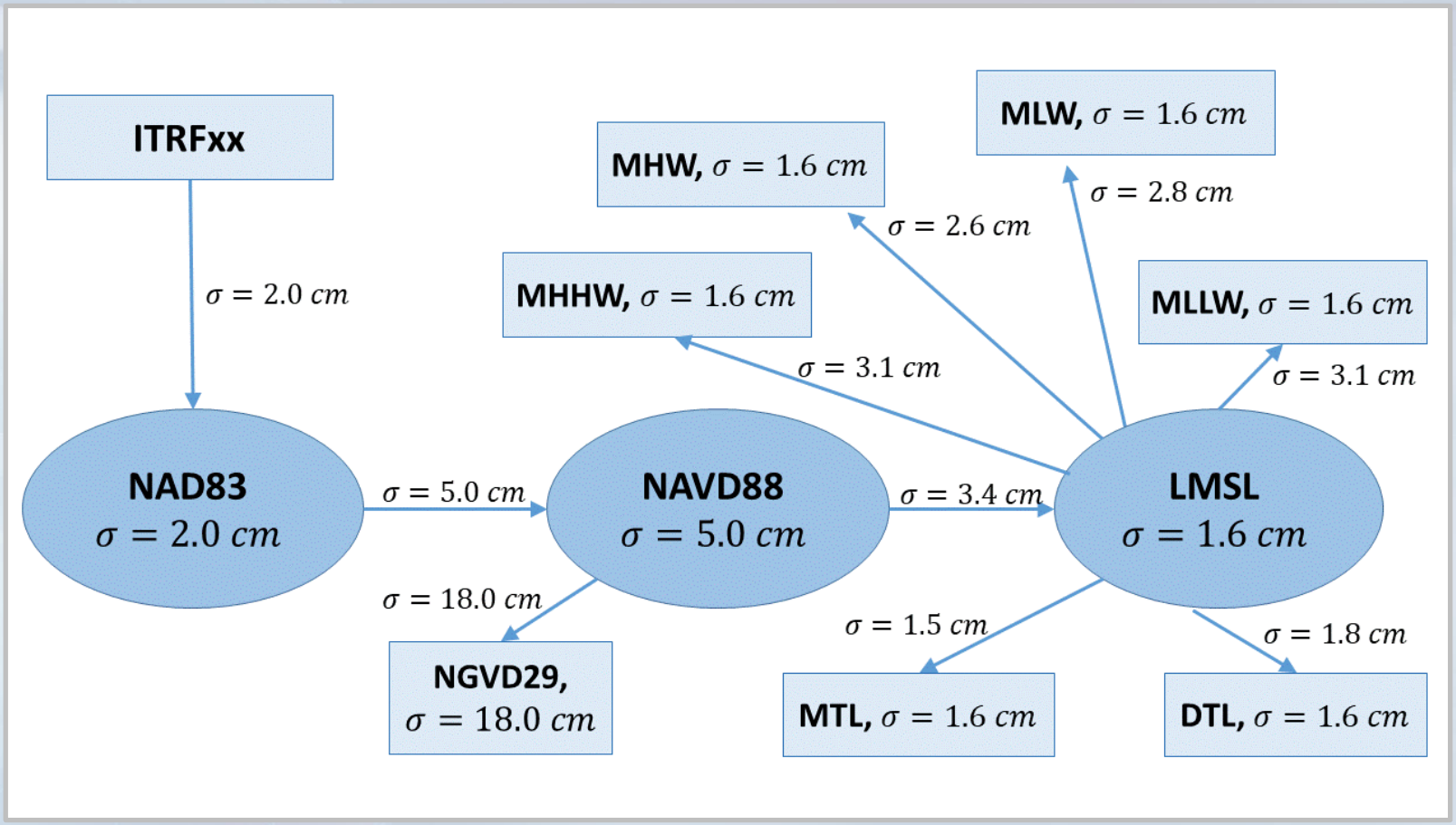
# VDatum Uncertainty Modeling




See: vdatum.noaa.gov/docs/est_uncertainties.html

# Spatially Varying Uncertainty
## (Phase 2: Transition to Operations)

**Table 2.** The regression equations and parameters for estimating uncertainties in tidal datums for Mean Low Water (from Bodnar, 1981)

S1M = 0.0068 ADLWI + 0.0053 SRGDIST + 0.0302 MNR + 0.029

S3M = 0.0043 ADLWI + 0.0036 SRGDIST + 0.0255 MNR + 0.029

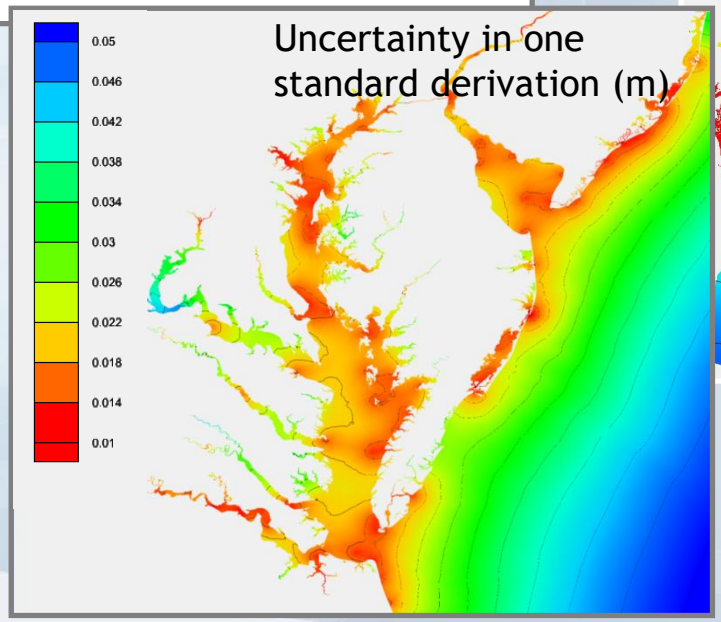
S6M = 0.0019 ADLWI + 0.0023 SRGDIST + 0.0207 MNR + 0.030

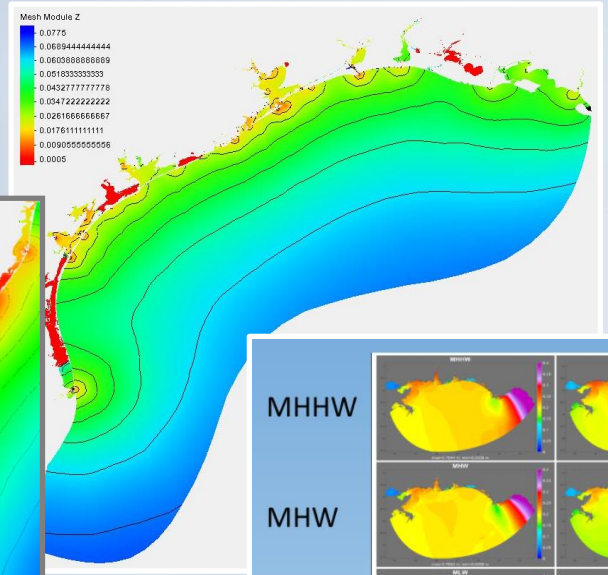
S12M = 0.0045 SRSMN + 0.128 MNR + 0.025

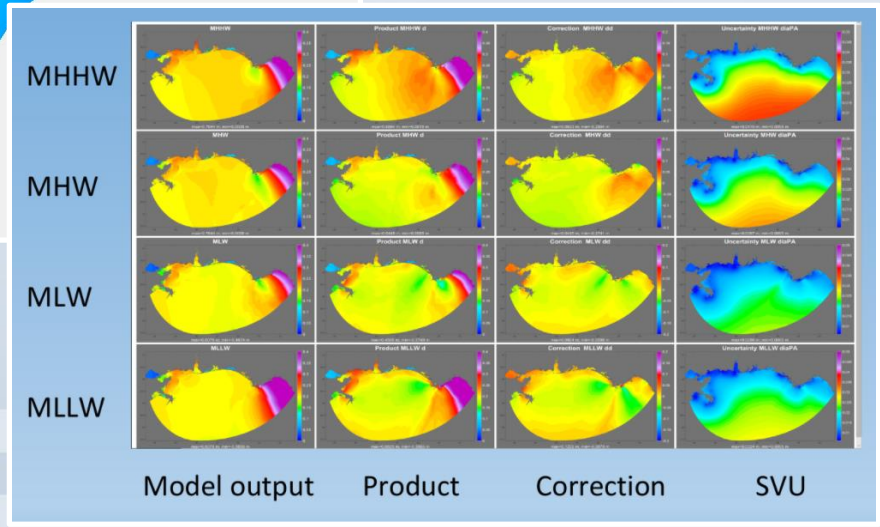
Where:

S is the standard deviation (in feet),
M is the number of months of subordinate station observation,
ADLWI is the absolute time difference of the Low Water Intervals between control and subordinate stations (in hours),
SRGDIST is the square root of the geographic distance between control and subordinate stations (in nautical miles),
MNR is a mean range ratio that is defined as the absolute value of the difference in mean range between control and subordinate stations divided by the mean range of tide at the control station (using range values in feet), and
SRSMN is the square root of the sum of the mean ranges at the control and subordinate stations (in feet).

- Statistical data assimilation is used to blend model results and data, also providing the associated uncertainty.

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# VDatum Version Updates: vdatum.noaa.gov

(Version **4.4.2** Released, May **13**, 2022) Notable updates since COVID

## 3.9:

- Availability of Low Water Datum transformation for the Great Lakes

## 4.0:

- Integration of NADCON 5.0 release 20160901
- xGEOID18B incorporation
- Southeast Alaska Regional Model Release
- New York Bight/Long Island Sound Regional Model Update
- Ordinary High Water Mark (OHWM) relative to IGLD 1985

## 4.1:

- Integration of VERTCON 3.0 release 20190601
- Support for ITRF 2014
- GEOID18 incorporation
- xGEOID19b incorporation
- Spatially Varying Uncertainty (SVU) implementation for NY/LIS regional models

## 4.2:

- New support for xGEOID20b (BETA)
- New support for GEOID18 Spatially Varying Uncertainty
- New support for varying uncertainty associated with individual hybrid GEOIDs
- Opened up NGVD29 to NAVD88 conversions in Alaska, Local Tide “LT” conversion with PRVD02, VIVD09, ASVD02, NMVD03, and the GUVD63 conversion to GUVD04 associated with the VERTCON 3.0 release 20190601.
- Full VDatum API (BETA) Release

## 4.3:

- Updated Chesapeake and Delaware Bay Regional Model, that includes Spatially Varying Uncertainty
- Added Spatially Varying Uncertainty Availability layer into the online map

## 4.4:

- Updated Continental United States West Coast Regional Model, that includes Spatially Varying Uncertainty (SVU)
- Updated website to include information on Interpolation usage
- Partial Implementation of new HTDP version 3.4.0 (the following regions have been implemented, with additional to be incorporated in the near future)

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# VDatum: Moving Forward

## Version 4.5:

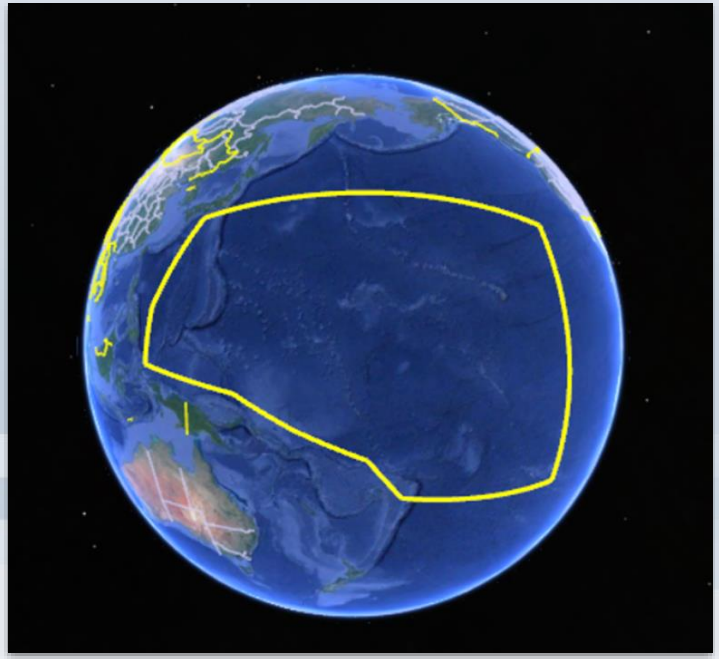
- CRD implementation
- Additional HTDP 3.4.0 regions
- NCAT (NADCON5), changes NGS is making

## Regional Model Development and Updates Schedule:

- PR/USVI (FY24)
- TX/Western LA (FY24)
- Statewide AK Model (FY24) - *High Uncertainties may be present due to known data gaps*
- HI and Pacific Model (2027)
- Regional Model, Gulf of Mexico, Caribbean, East Coast (2027)

## Moving towards Regional Modeling Approach:

- **4 Regional Models**
  - West Coast CONUS
  - Gulf of Mexico/Caribbean/East Coast
  - Alaska
  - Pacific Islands
- **Allows us to be agile in updating more frequently, ingesting new data, and fixing any issues**



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# What's Being Replaced with the Modernization of Reference Frames

## Horizontal

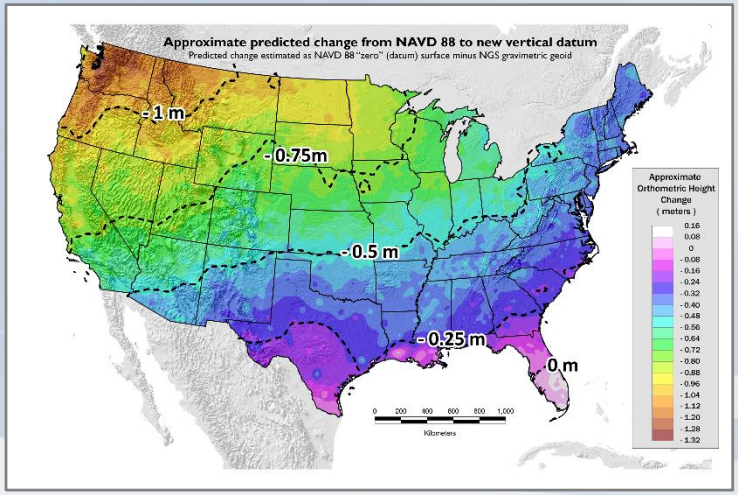
- NAD 83(2011)
- NAD 83(PA11)
- NAD 83(MA11)

Latitude
Longitude
Ellipsoid Height
State Plane Coordinates

## Vertical

- NAVD 88
- PRVD 02
- VIVD09
- ASVD02
- NMVD03
- GUVD04
- IGLD 85

Heights




- **Approximate level of geoid mismatch known to exist in the NAVD 88 zero surface.**
- **Does not include local subsidence issues**

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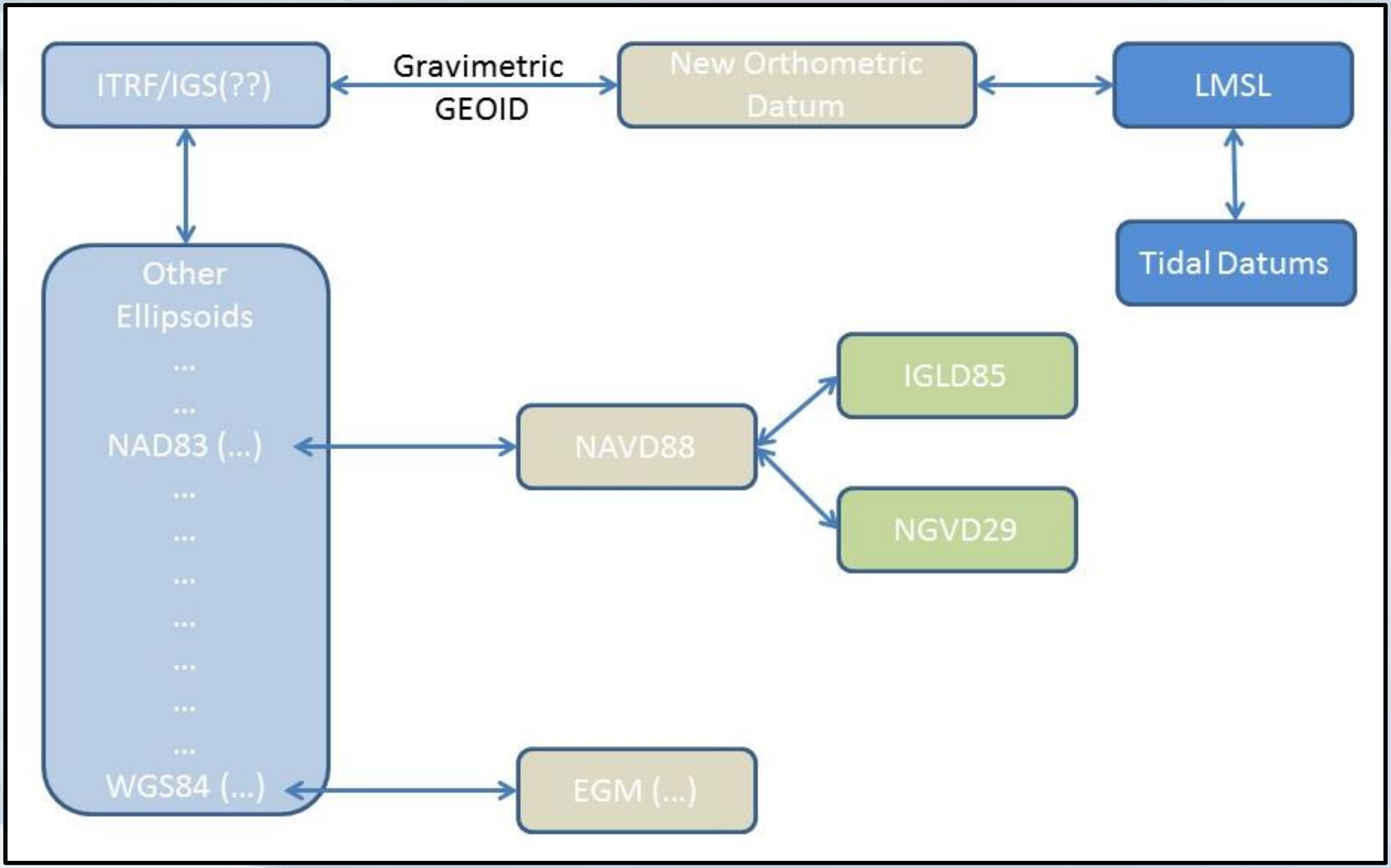
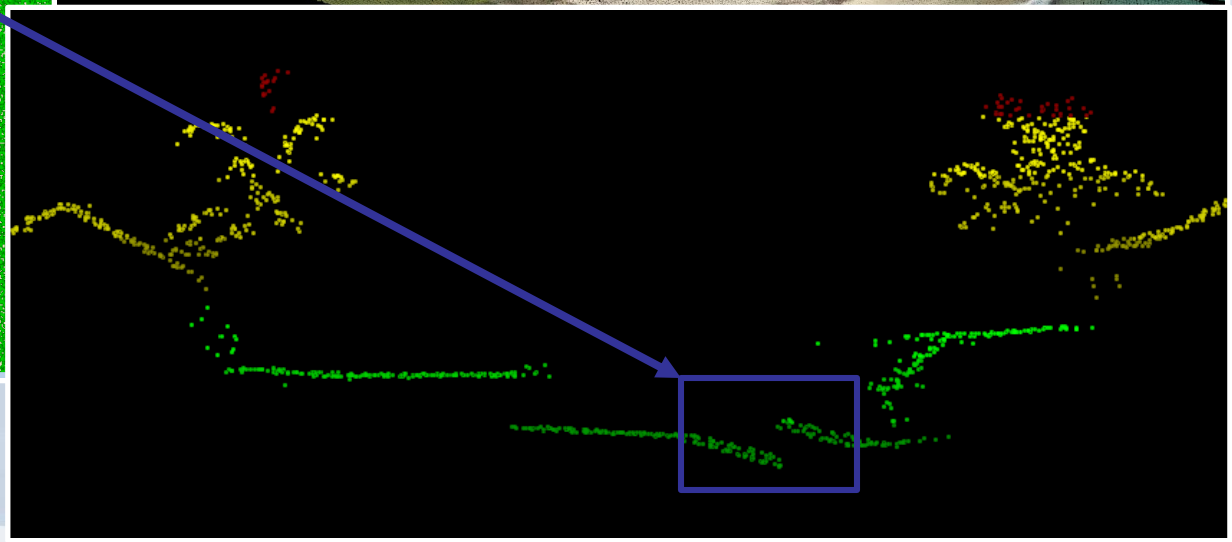
# VDatum: *Updated NSRS*



# Point Cloud Discrepancies



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There should not be a crack in the bottom of pool !!

# Applying the new GEOID incorrectly

4-6 Degree sloping beach

https://geodesy.noaa.gov/datums/newdatums/index.shtml

# National Geodetic Survey

Positioning America for the Future



**New Datums**
Home
Delayed Release Message
Background
What to Expect
Get Prepared
Blueprint Documents
Track our Progress
Naming Convention
Watch Videos
Related Projects
New Datums FAQ
Contact Us

**Subscribe for email notifications**

**Events**
Industry Engagement
2021 Summit
2019 Summit
2017 Summit
2015 Summit
2010 Summit

## New Datums: Replacing NAVD 88 and NAD 83

To improve the National Spatial Reference System (NSRS), NGS will replace all three North American Datum of 1983 (NAD 83) frames and all vertical datums, including the North American Vertical Datum of 1988 (NAVD 88), with four new terrestrial reference frames and a geopotential datum.

The new reference frames will rely primarily on Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS), as well as on a gravimetric geoid model resulting from our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project.

These new reference frames will be easier to access and to maintain than the current NSRS, which relies on physical survey marks that deteriorate over time.

Delayed Release Message

Background | What to Expect | Get Prepared

Blueprint Documents | Track our Progress | Naming Convention

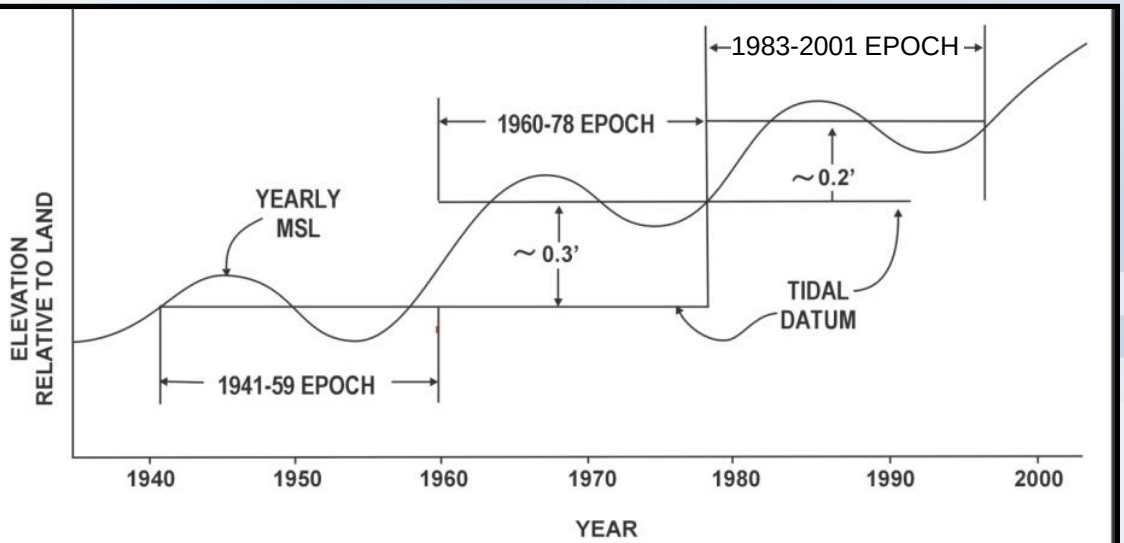
FAQs | Watch Videos | Related Projects

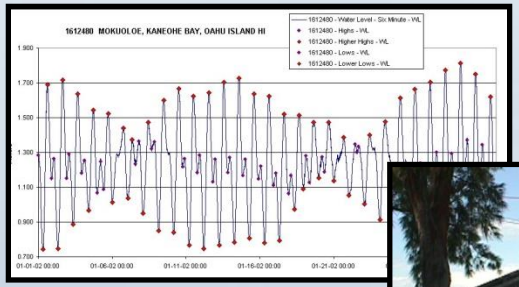

# National Tidal Datum Epoch (NTDE)

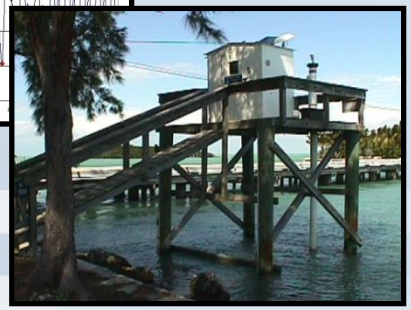
## Anticipated release 2025 time frame

***Next NTDE will be computed on period of (2002-2020)***

- Official time period of tidal observations that are used for primary datum calculations
  - Time it takes the Earth, Moon, & Sun to complete an epoch tidal cycle
  - 19 year time period (Current NTDE is 1983-2001)
  - Considered for revision every ~20-25yrs
  - Includes the longest period tidal variations *(18.6 year node cycle)*
  - Averages out seasonal fluctuations
  - Provides a nationally consistent tidal datum network by accounting for seasonal and apparent environmental trends in sea level that affect the accuracy of tidal datums



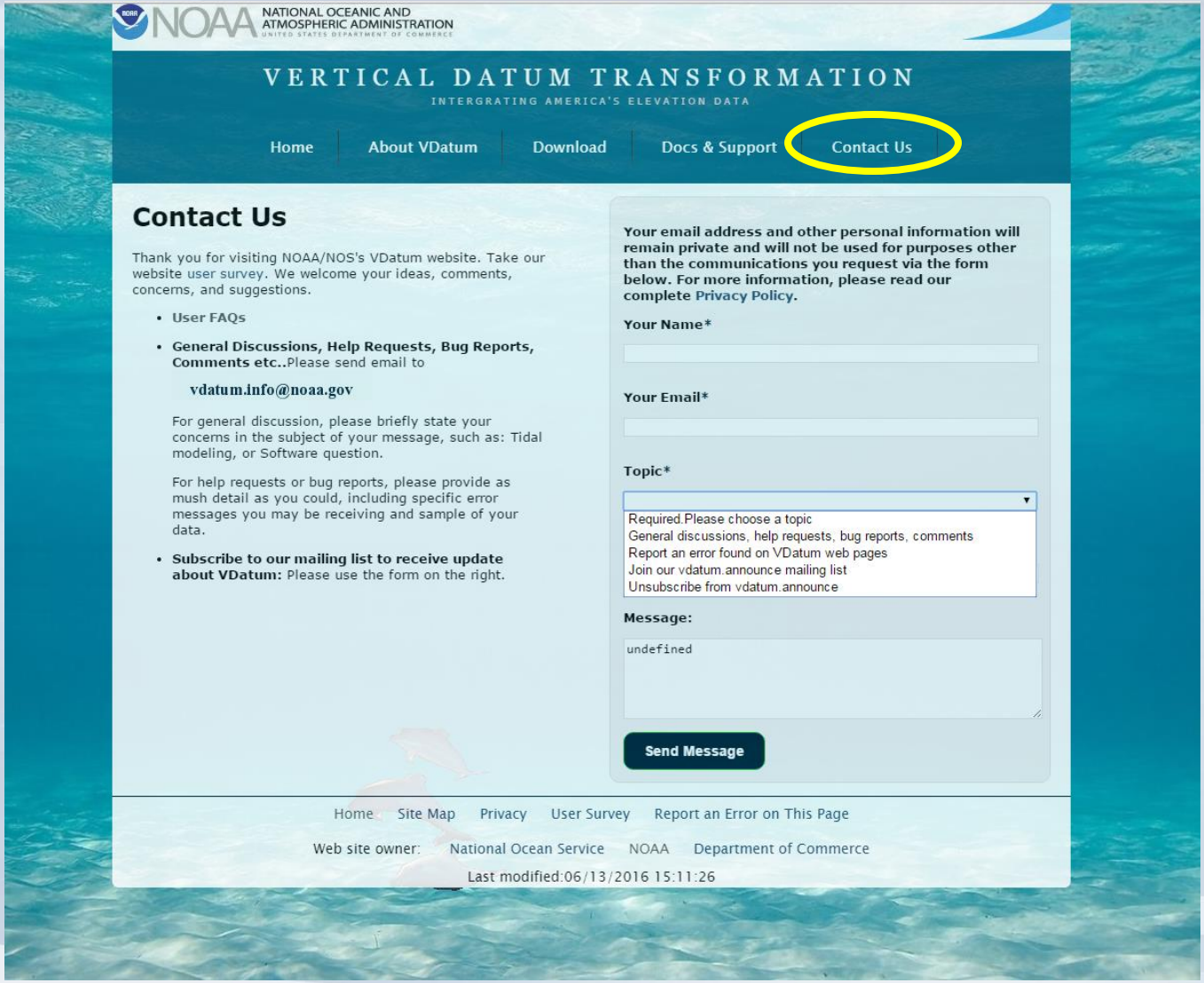



# Summary

**The VDatum transformations tool from NOAA allows us to transform vertical datasets between ellipsoidal, orthometric and tidal datums...**

- Assuring data is transformed correctly
- Enabling multiple uses for datasets across applications (Coastal Resilience, Intelligence, and place-based)
- Permitting merging of disparate data sets to a common reference
- And providing transformation uncertainty estimates for intelligent decision-making and analysis.

# VDatum: Contact Us

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# Thank You!

## Contact Information:

***Stephen White***

Email: stephen.a.white@noaa.gov