VDatum

Vertical Datum Transformation Tool

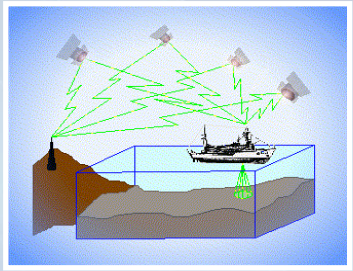
Stephen A. White
(Program Manager)

July 14, 2016

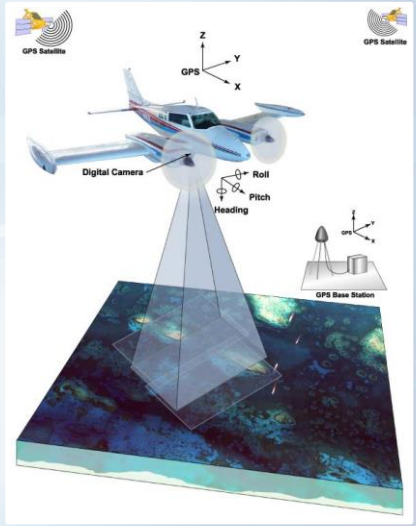
National Oceanic and Atmospheric Administration

What Vertical Datum is My Data in?

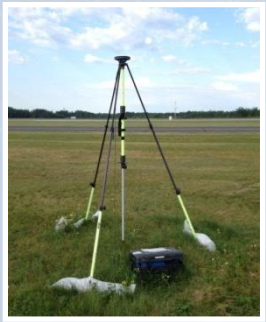
Ellipsoidal Datums



RTK-GPS vertical referencing Hydrographic Surveys



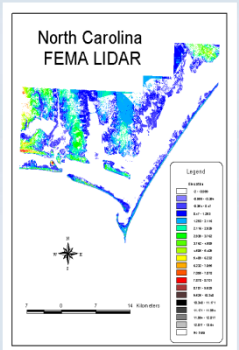
Lidar

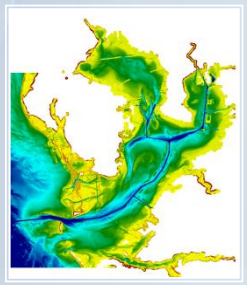


GPS

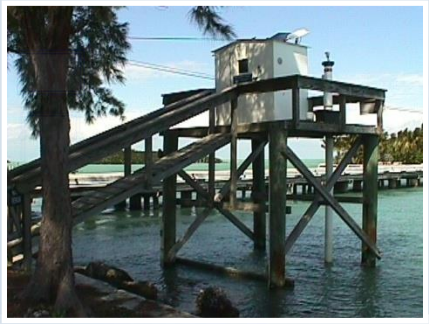
Orthometric Datums

USGS Topography

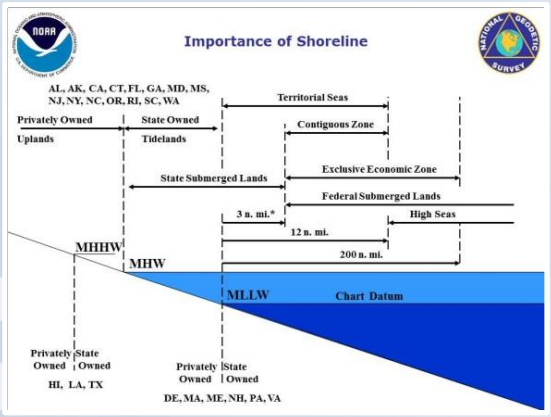




NOAA Bathymetry (MLLW)



Tidal Datums



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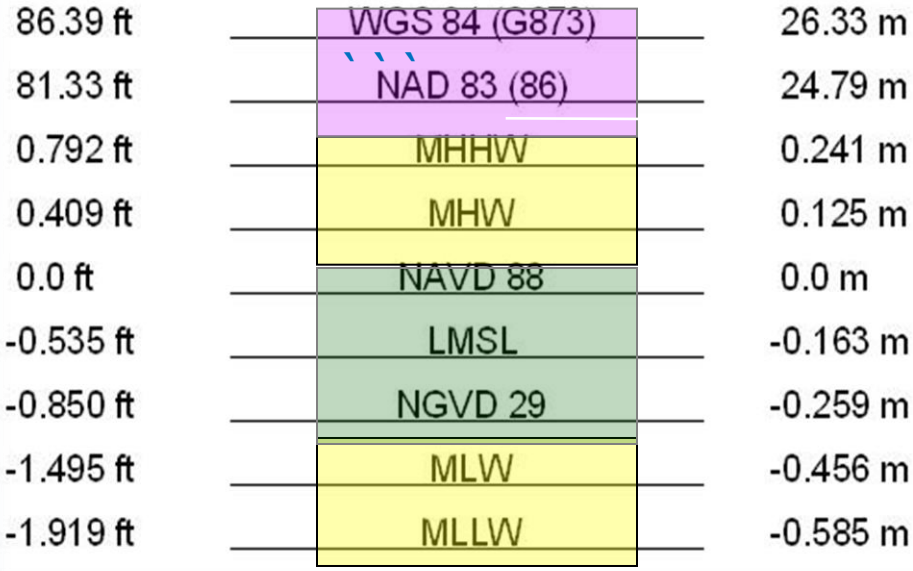
All elevation data is referenced to a vertical datum.

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

Relationship of vertical datums for Tampa Bay:



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

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Ellipsoid Datums

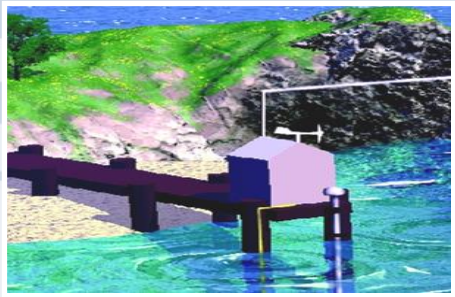
ITRF,
WGS 84,
***NAD 83** (NSRS)*

Orthometric Datums

NAVD 88,
NGVD 29

Tidal Datums

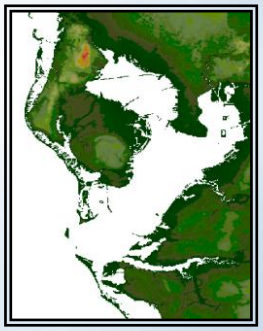
MHHW, MHW, MTL, DTL, LMSL, MLW, MLLW



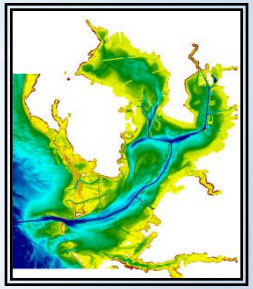
Development and Use of VDatum

Mapping the Land-Sea Interface:

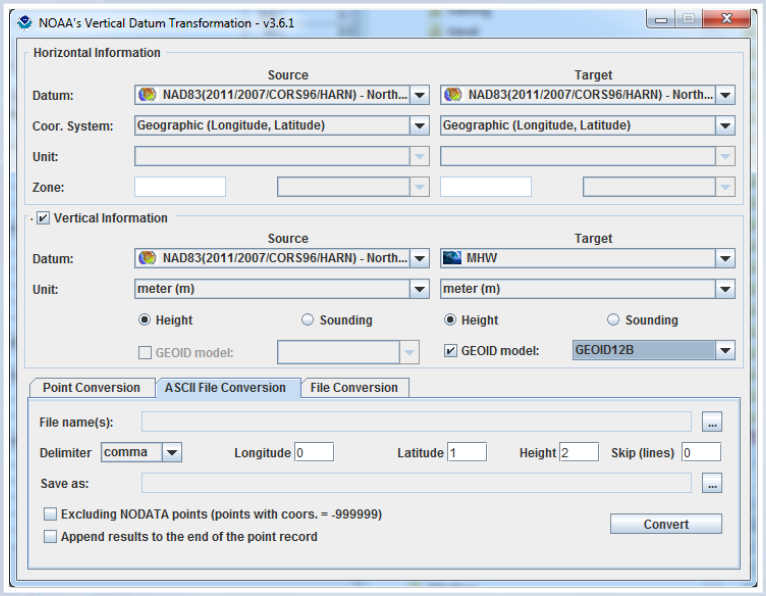
VDatum converts elevation data (heights and soundings) among different vertical datums

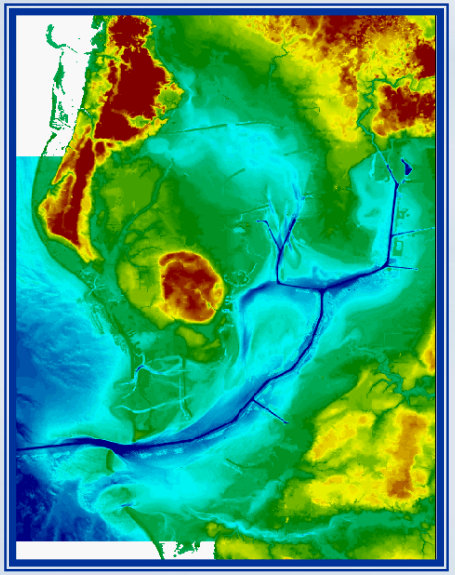


USGS Topography



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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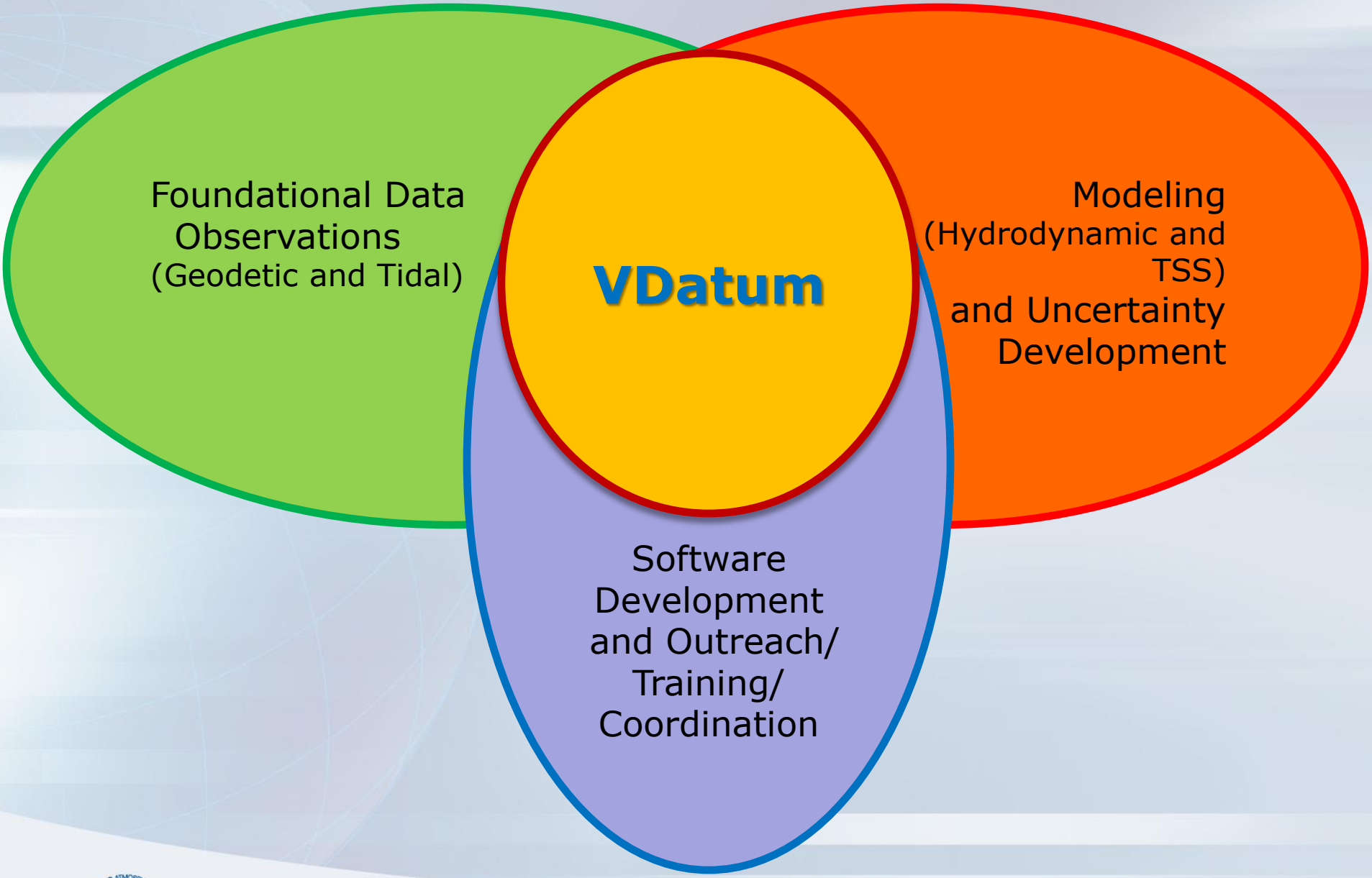

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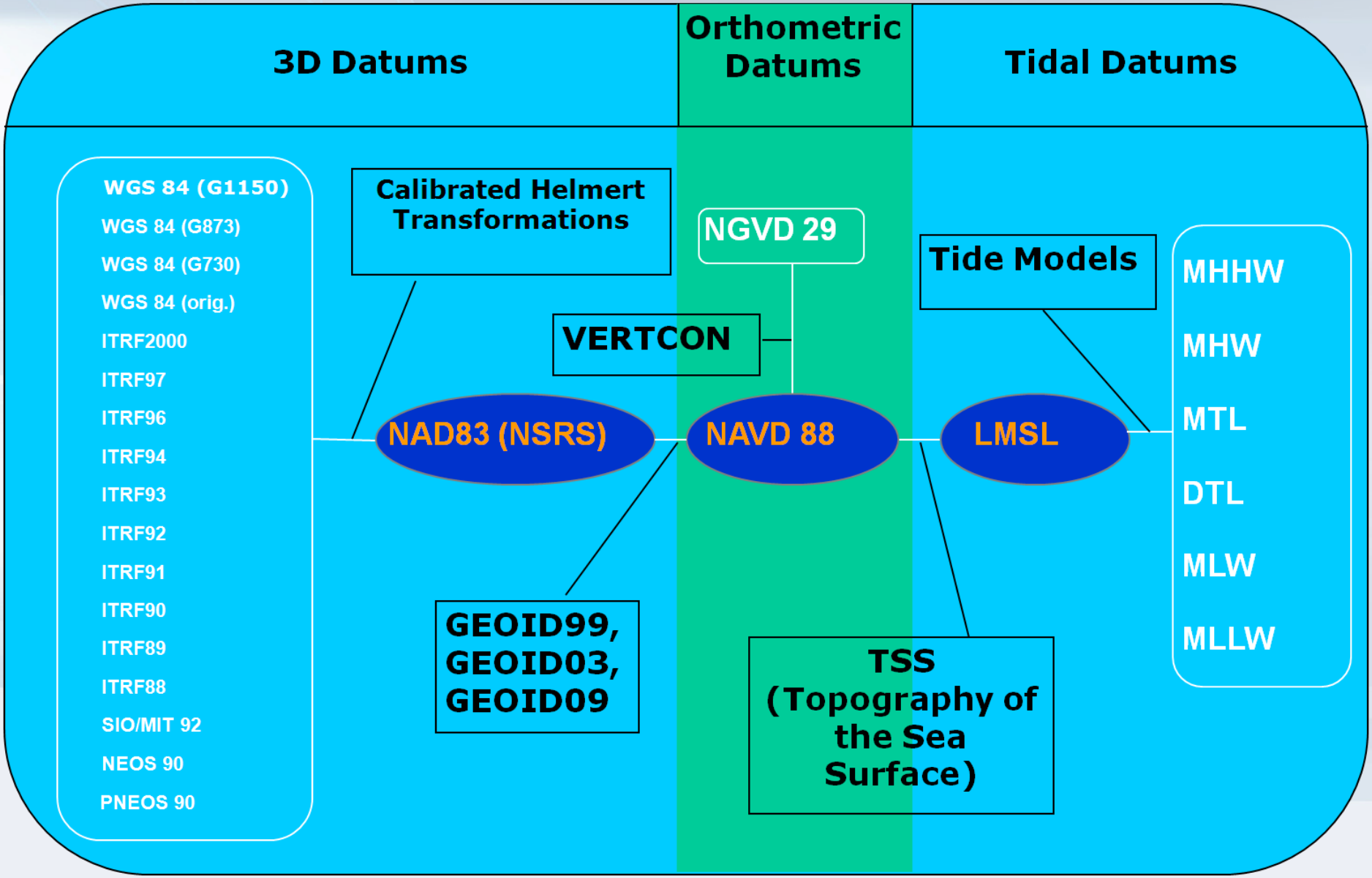
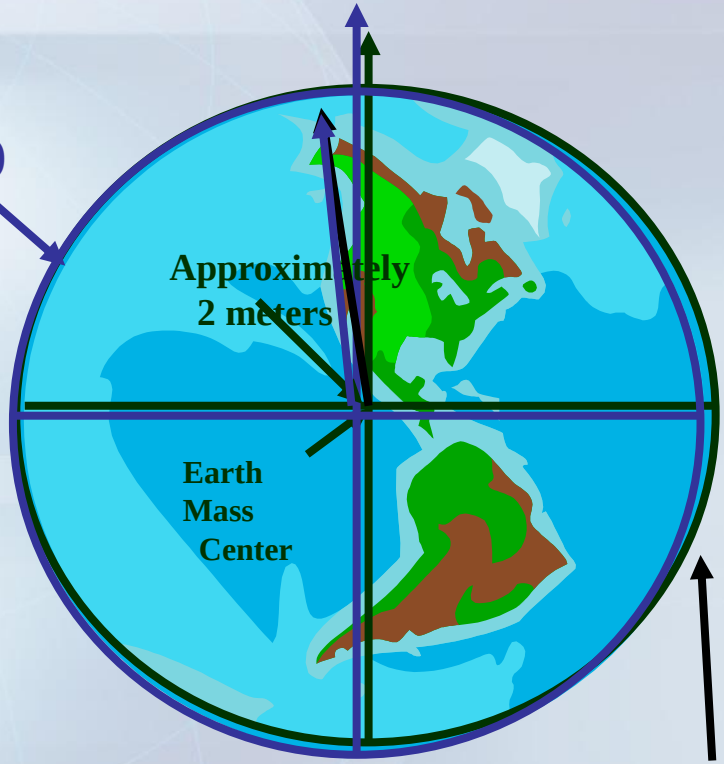
3 Categories of Vertical Datums:

- **3D/Ellipsoidal Datums:**
  - Realized through space-based systems, such as GPS
- **Orthometric Datums:**
  - Based on a form of mean sea level
- **Tidal Datums:**
  - a standard elevation defined from water level observations during a specific phase of the tide

Vertical Datum Transformation "Roadmap"



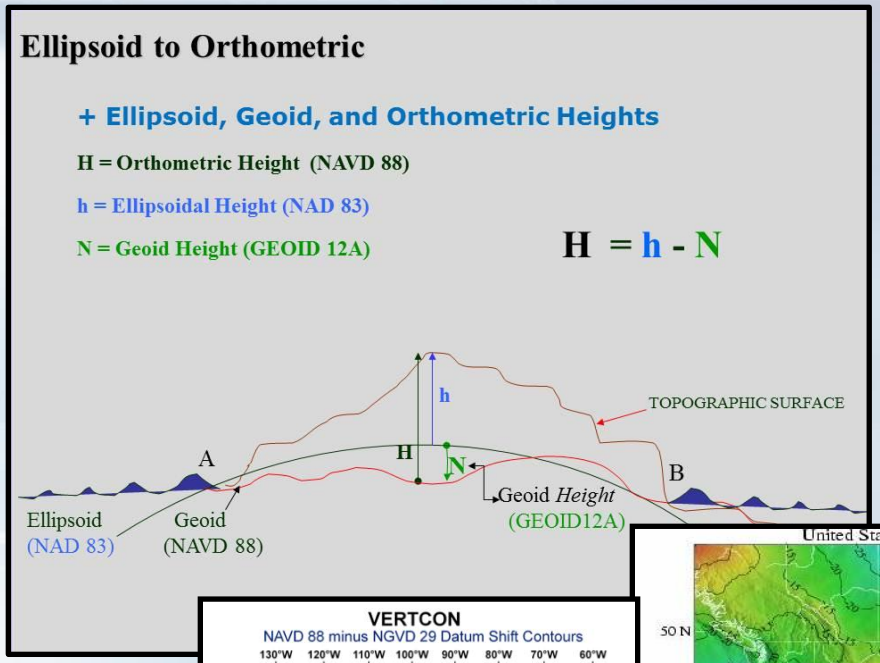
3D/Ellipsoid Datums



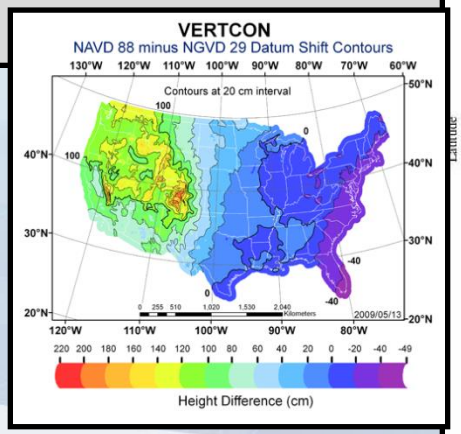
The GRS80 ellipsoid's origin is approximately 2m from WGS84 ellipsoid's. The Clarke 1866 ellipsoid's origin is approximately 236 m from WGS84 ellipsoid's

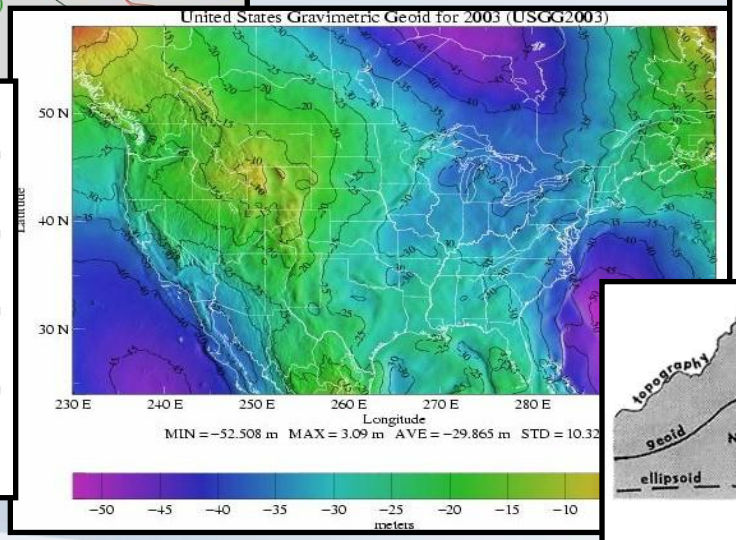
- Calculation of geographic position on this irregular surface is very complex. A simpler model is needed.
- This simplified mathematical surface is the *ellipsoid*.
- An ellipsoid approximates the shape of the earth, a datum defines the position of the ellipsoid relative to the center of the earth.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

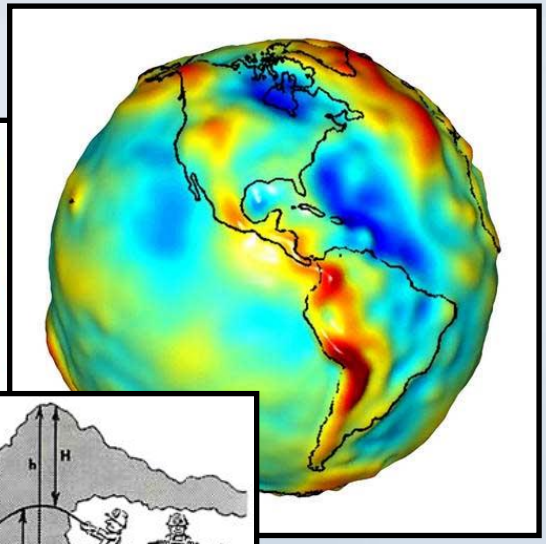
Orthometric Datums and the GEOID

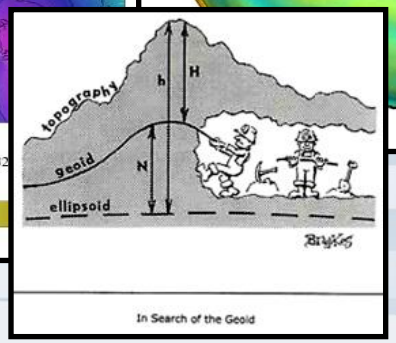


- NAVD88 is based on an adopted elevation at Point Rimouski (Father's Point). It uses Helmert orthometric heights as an approximation to true orthometric heights.
- GEOID: "The *equipotential surface* of the Earth's gravity field which best fits, in the least squares sense, (global) mean sea level."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









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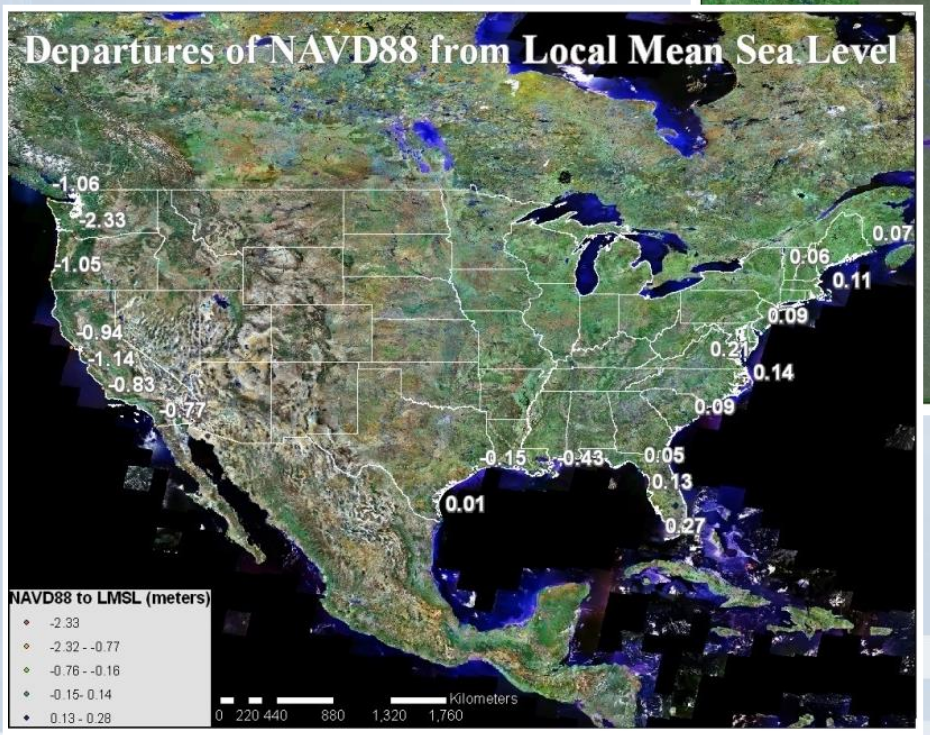
biquadratic interpolation

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.



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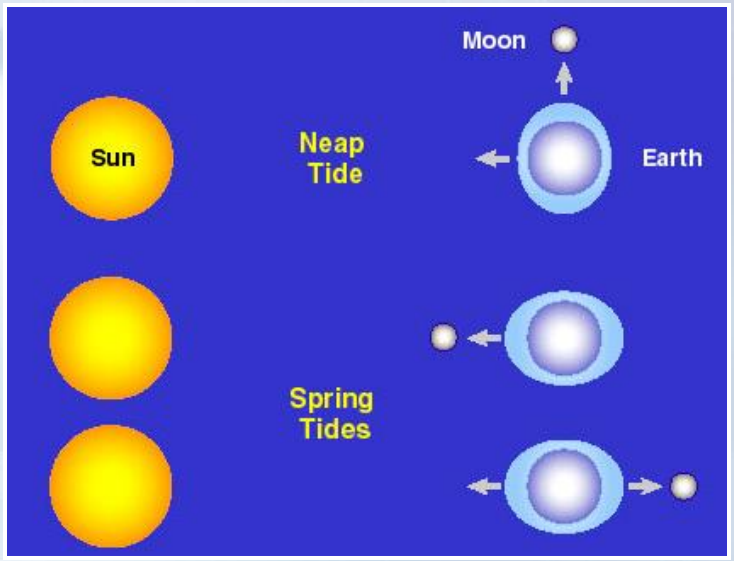
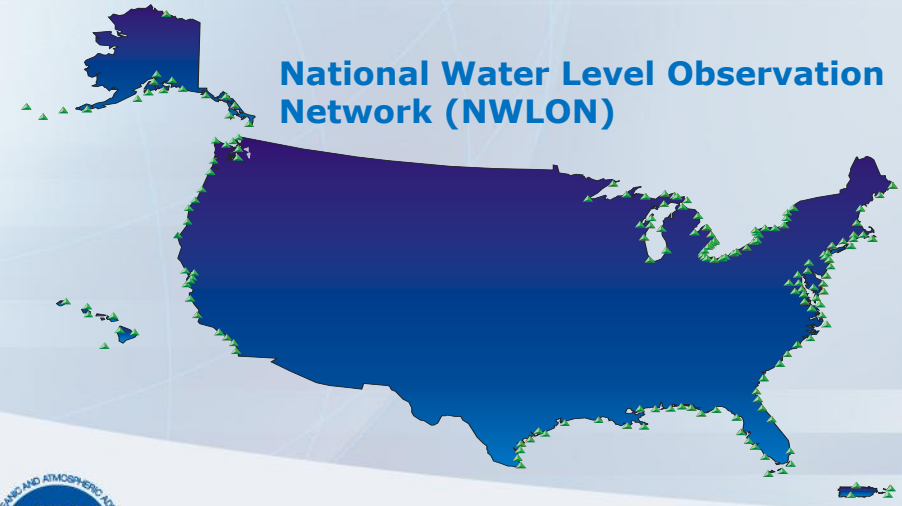
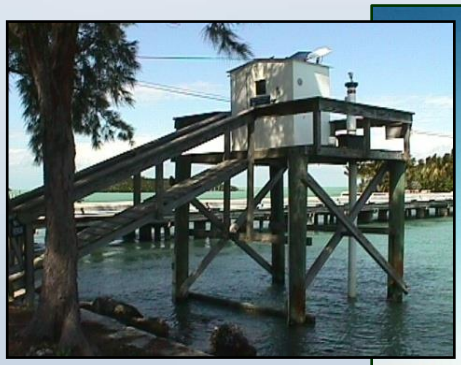
bilinear interpolation

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.





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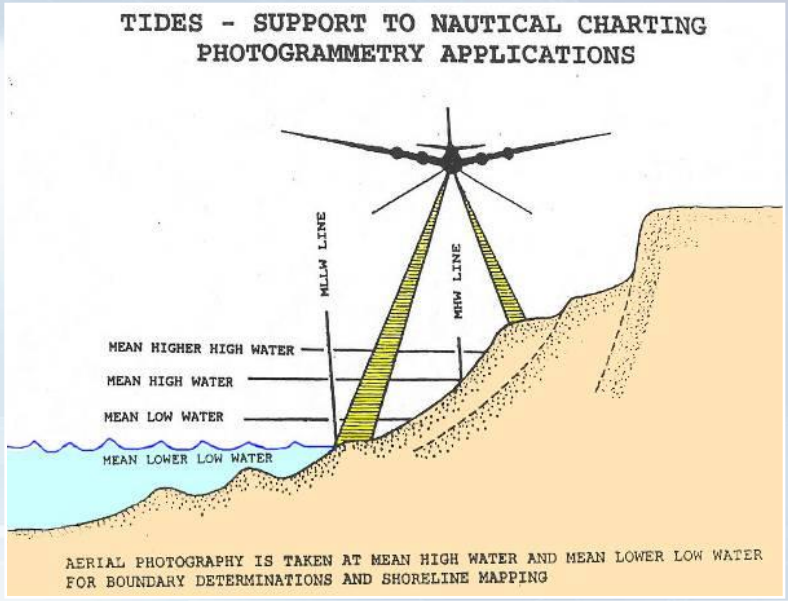
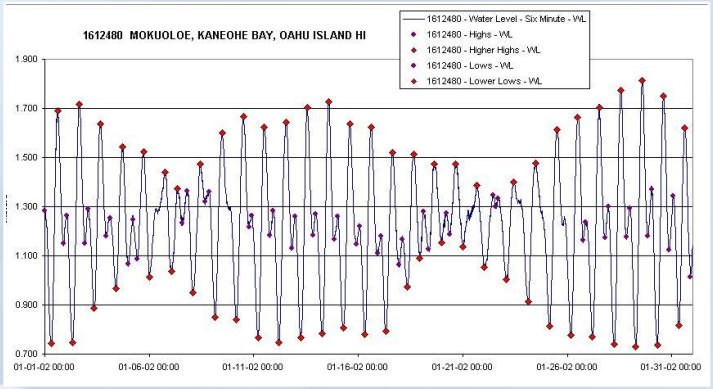
Tidal Datums





- Mean Higher High Water (MHHW): defined as the arithmetic mean of the higher high water heights of the tide over a specific 19-year Metonic cycle denoted as the NTDE.
- **Mean High Water (MHW):** defined as the arithmetic mean of the high water heights observed over a specific 19 year cycle.
- Mean Sea Level (MSL): defined as the arithmetic mean of hourly heights observed over a specific 19 year cycle.
- Mean Low Water (MLW): defined as the arithmetic mean of the low water heights observed over a specific 19 year cycle.
- **Mean Lower Low Water (MLLW):** defined as the arithmetic mean of the lower low water heights of the tide observed over a specific 19 year cycle.
- Mean Tide Level (MTL): a tidal datum which is the average of Mean High Water and Mean Low Water.
- Diurnal Tide Level (DTL): a tidal datum which is the average of Mean Higher High Water and Mean Lower Low Water.

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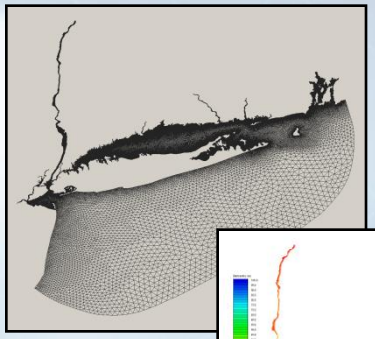
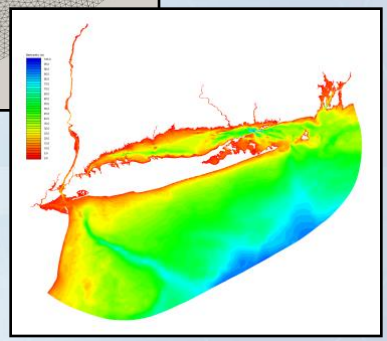
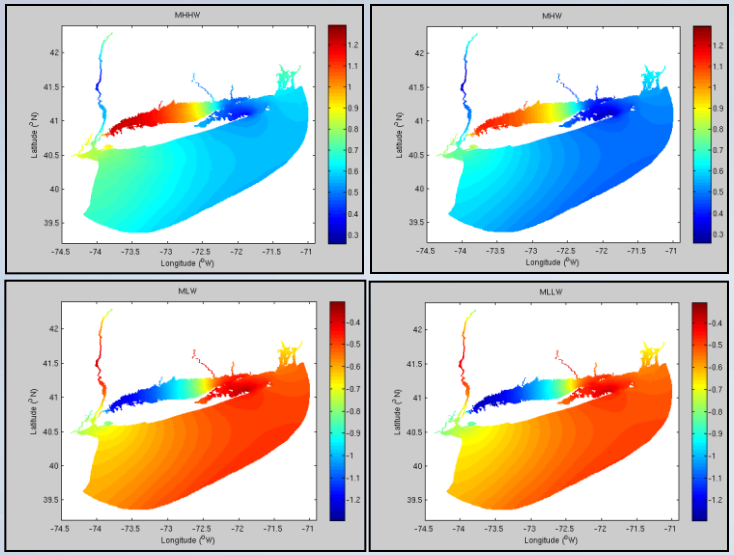
Tidal Datums and Hydrodynamic Modeling

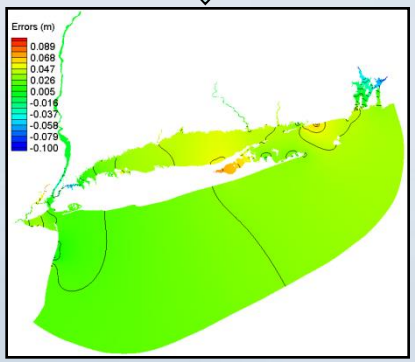


Finite Element grid is created and populated with bathymetry

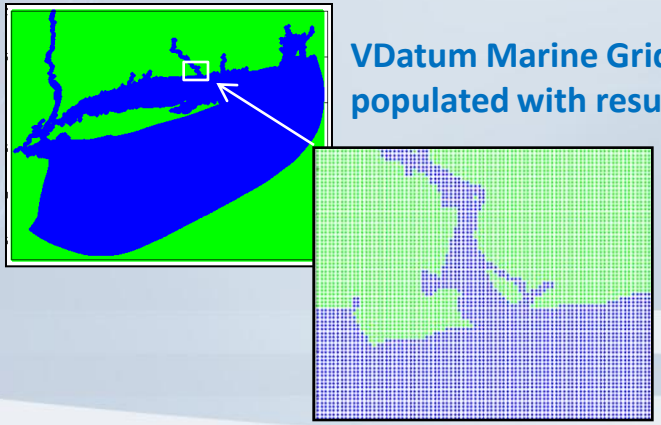




Tidal Datum fields are derived from ADCIRC (Advanced Circulation) Model, simulations are made on cluster computers at NOAA's Earth System Research Laboratory



Correct results by spatially interpolating errors with TCARI (Tidal Constituent and Residual Interpolation)



VDatum Marine Grid is populated with results

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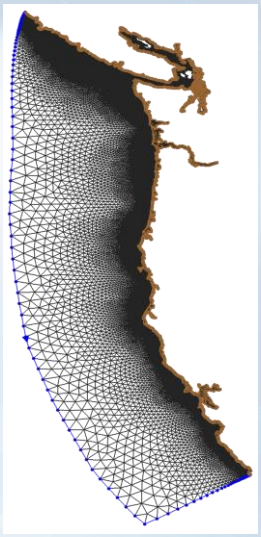
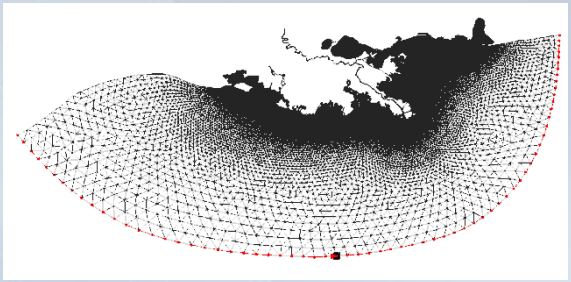
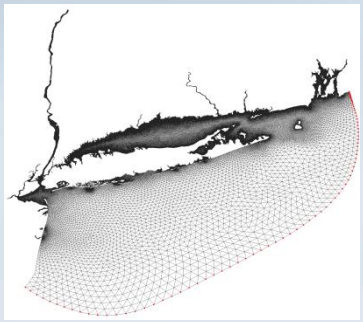
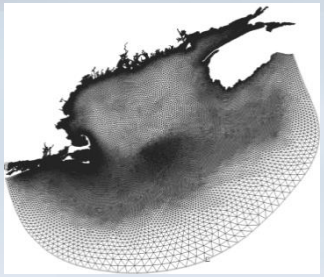
bilinear interpolation

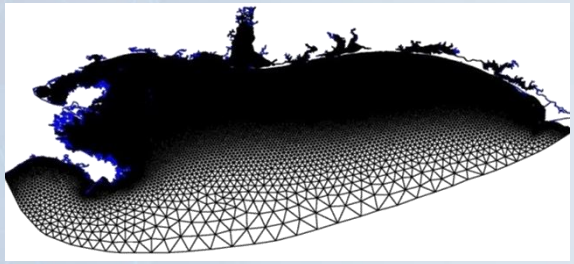
ADCIRC Modeling in Support of VDatum

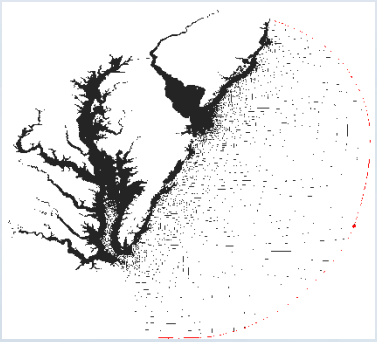


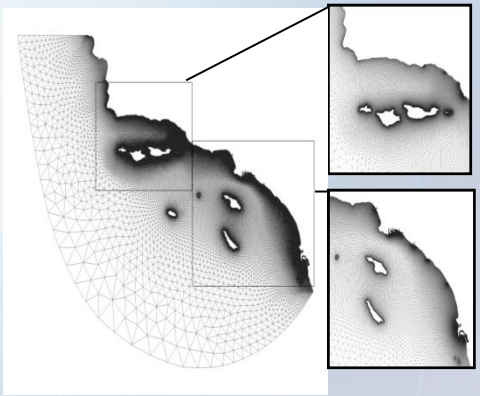


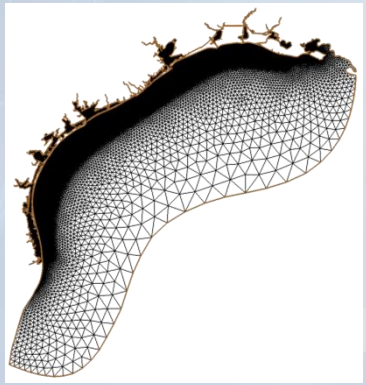


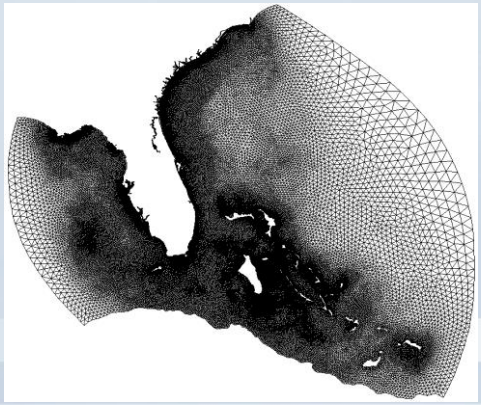


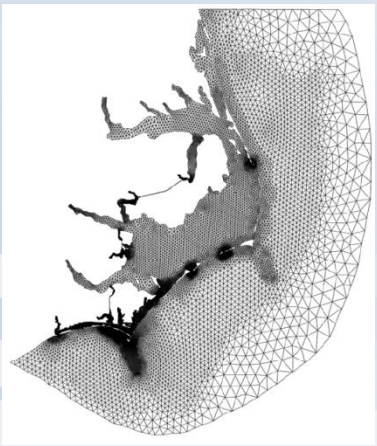












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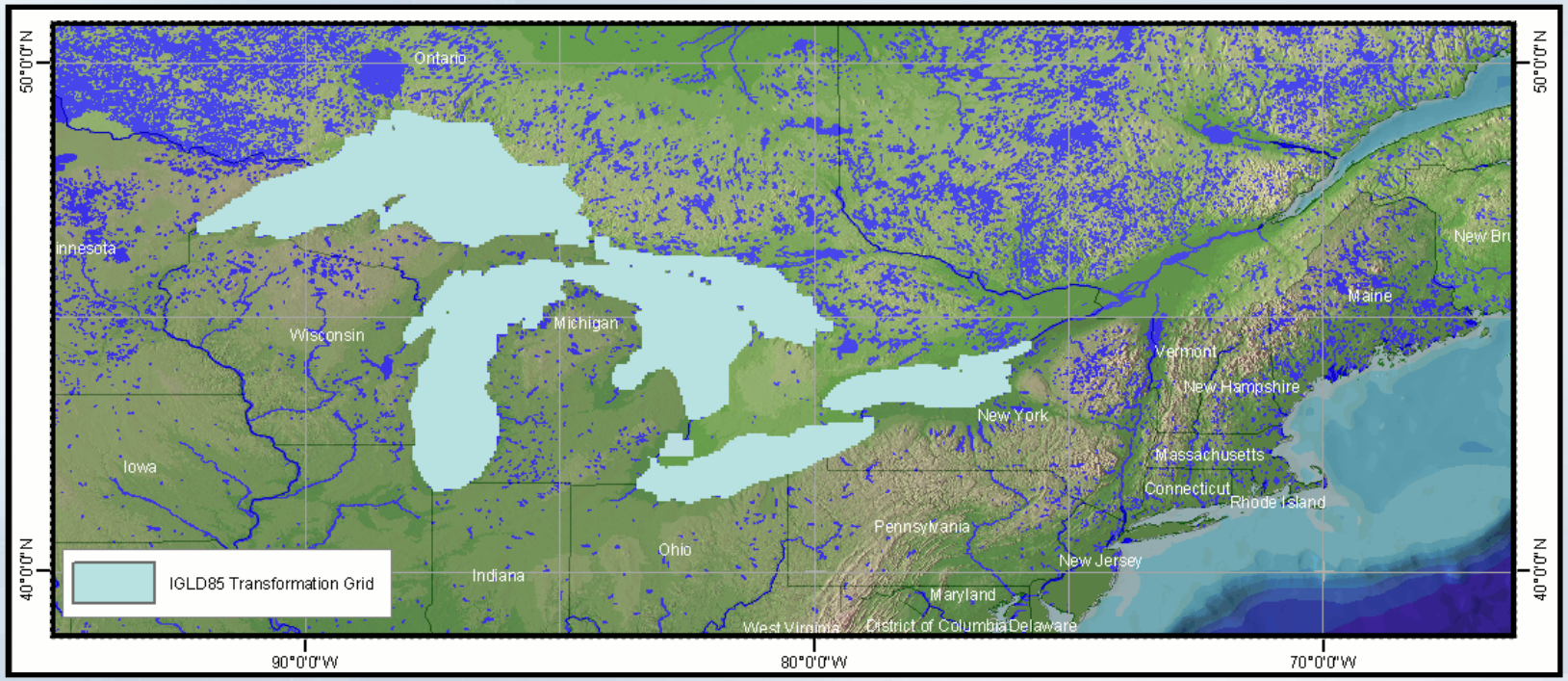
VDatum: IGLD85

- 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.



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VDatum Website: vdatum.noaa.gov

(Version 3.6 Released, May 13, 2016)

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

VERTICAL DATUM TRANSFORMATION

INTERGRATING AMERICA'S ELEVATION DATA

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Welcome to VDatum!

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

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

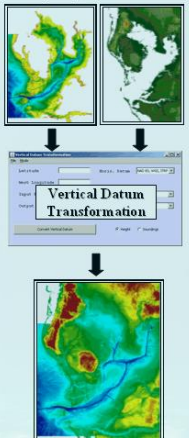
Download

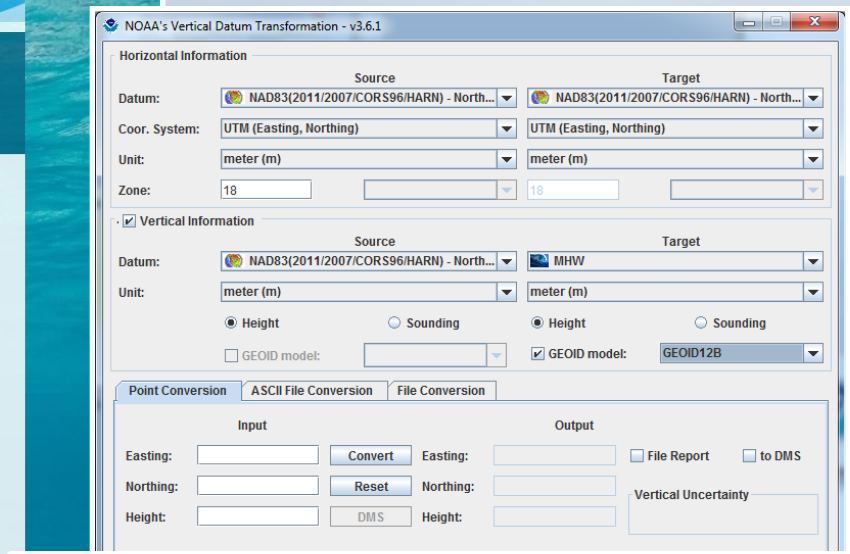
Download the newest VDatum (v3.6.1) and its datasets.

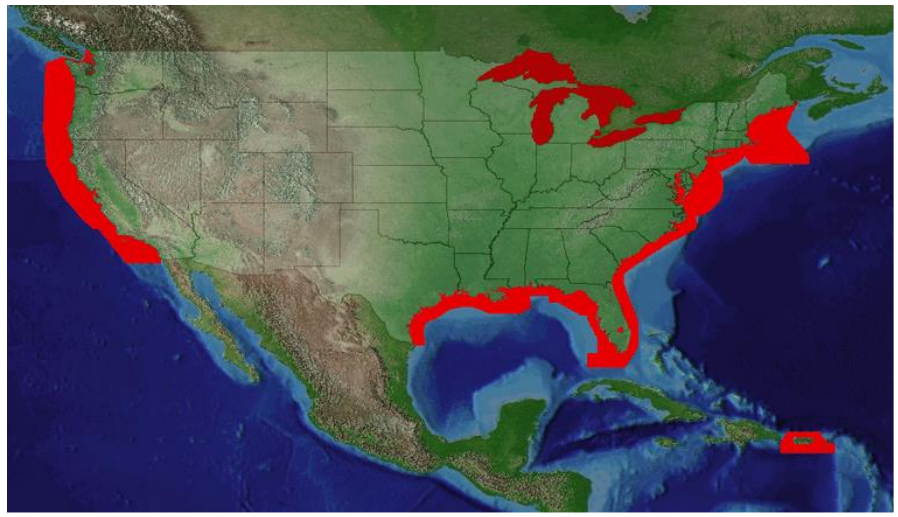
Animated tutorial!

The VDatum Demonstration Project in Tampa Bay, Florida

NOAA Bathymetry | USGS Topography







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!

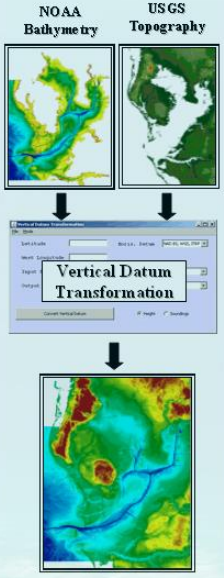
Features

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

Datum Demonstration ject in Tampa Bay, Florida



Manual, Presentations and Publications

Publications On This Page:
2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 and earlier

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

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?**

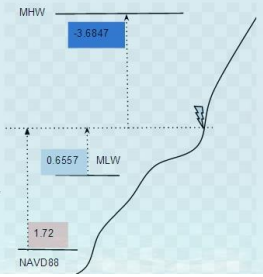
  The -999999.0 is the no-data-value in our program. It occurs in areas where the transformations are invalid. In the tidal transformations, this -999999.0 value could mean that your elevation data are either out of the boundaries of our tidal transformation grids, or in the masked-out areas, i.e. inland 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.



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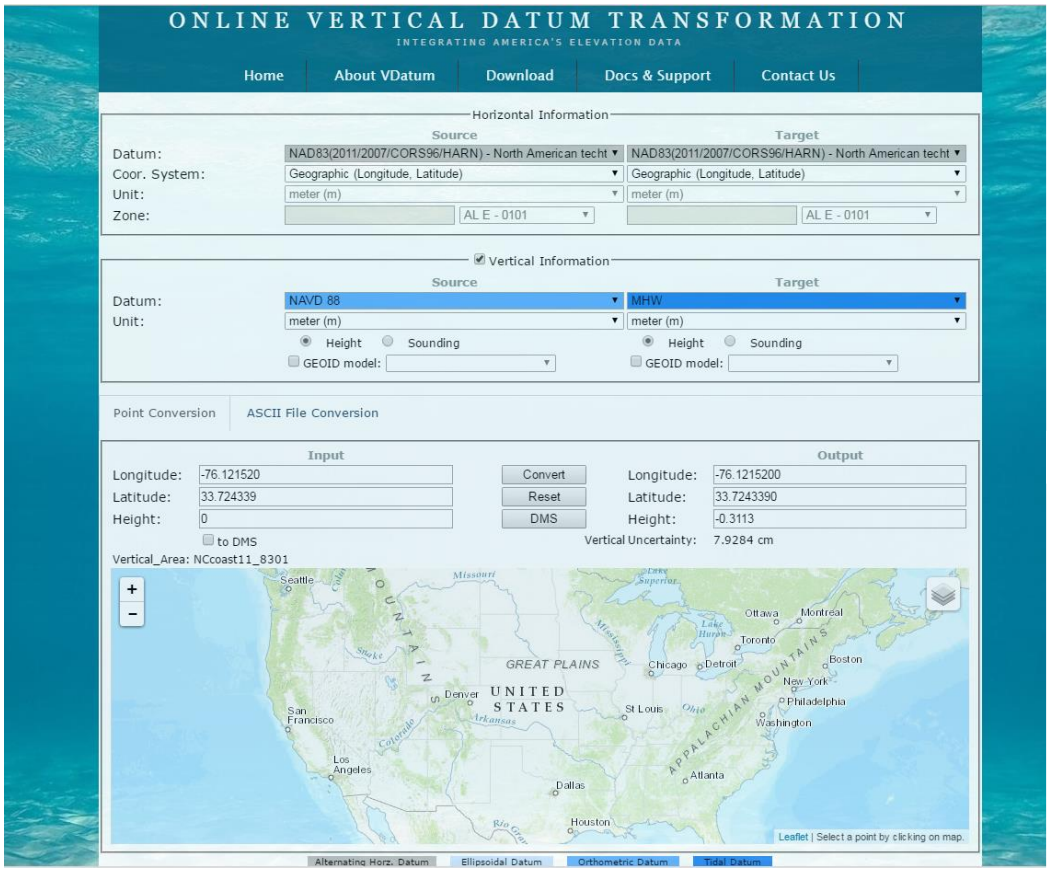
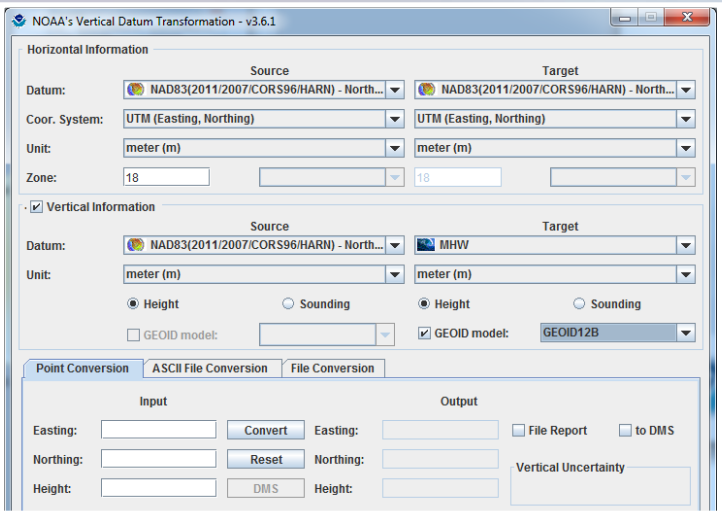
VDatum: Interfaces





VDatum Command-line User Guide

On This Page

- Point Conversion
- File Conversion

This User Guide describes how-to run VDatum version 3.x without the graphical user interface.

Once you **download** VDatum software and its transformation grids, your computer is ready to transform geospatial data among several horizontal and vertical datums.

General syntax:

- For running VDatum with the graphical user interface:
  java -jar vdatum.jar
- For help:
  java -jar vdatum.jar -help
- For converting without GUI:
  java -jar VDatum.jar <georeferencing_parameters> [<point_conversion>] [<file_conversion>]

Georeferencing Parameters

Syntax:

ihorz:<source horizontal datum>[:<coordinate system>:<unit>:<zone>] [**ivert:**<source vertical datum>[:<unit>:[<height/sounding>[:<geoid>]]]] **ohorz:**<target horizontal datum>[:<coordinate system>:<unit>:<zone>] [**overt:**<target vertical datum>[:<unit>[:<height/sounding>[:<geoid>]]]]

where:

Parameter	Description
ihorz	Provides details about horizontal information of the source data.
ivert	Provides details about vertical information of the source data. If omitted, the transform is considered to be 2-dimension.
ohorz	Provides details about target horizontal information. If omitted, result will be horizontally referenced in NAD83, geographic coordinates. When specify **ohorz:ihorz**, results are considered to be horizontally referenced exactly as source. This is especially for LiDAR conversion with source and target data are in State Plane coordinate system.
overt	Provides details about vertical information of the source data. If omitted, the transform is considered to be 2-dimension.
<coordinate system>	Either **geo**, **utm**, **spc** or **xyz**, corresponding to geographic coordinates, UTM coordinates, State Plane coordinates or geocentric coordinates. If omitted, the geographic coordinate system with horizontal coordinates in degrees (i.e., **geo:deg**) are used.

- In geographic coordinates, longitude/latitude units are **deg** as degrees

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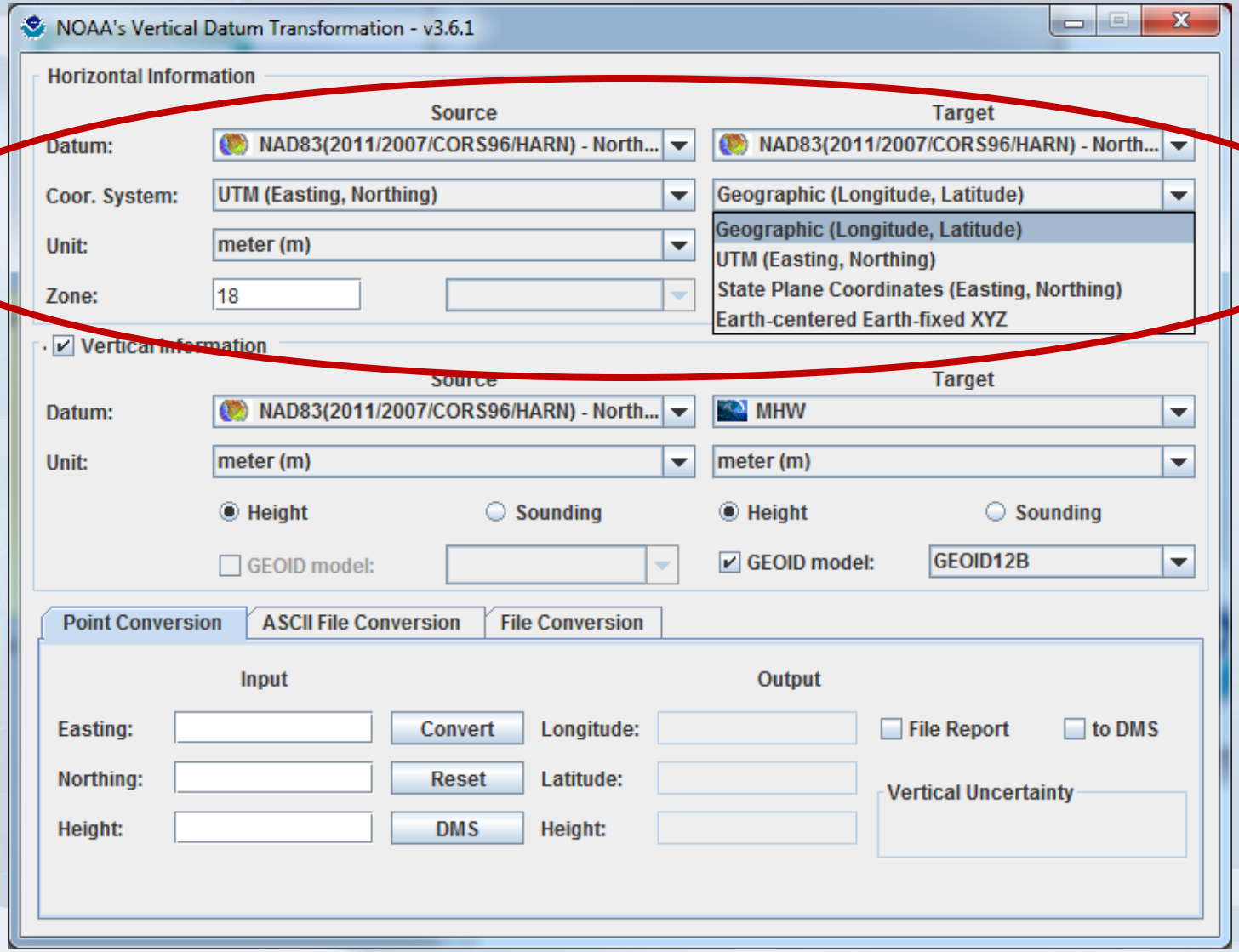
Utilizing VDatum: Horizontal



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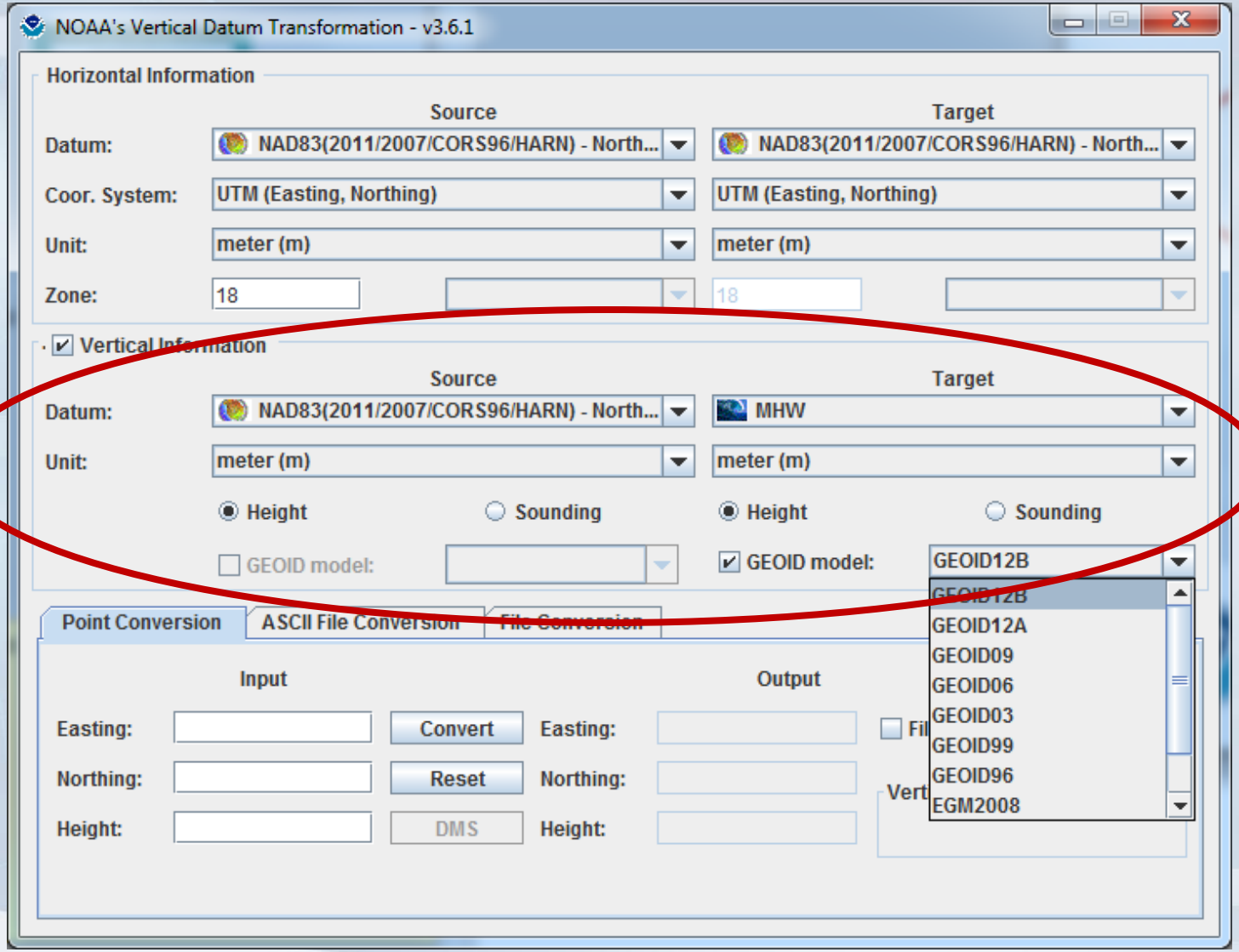
Utilizing VDatum: Vertical



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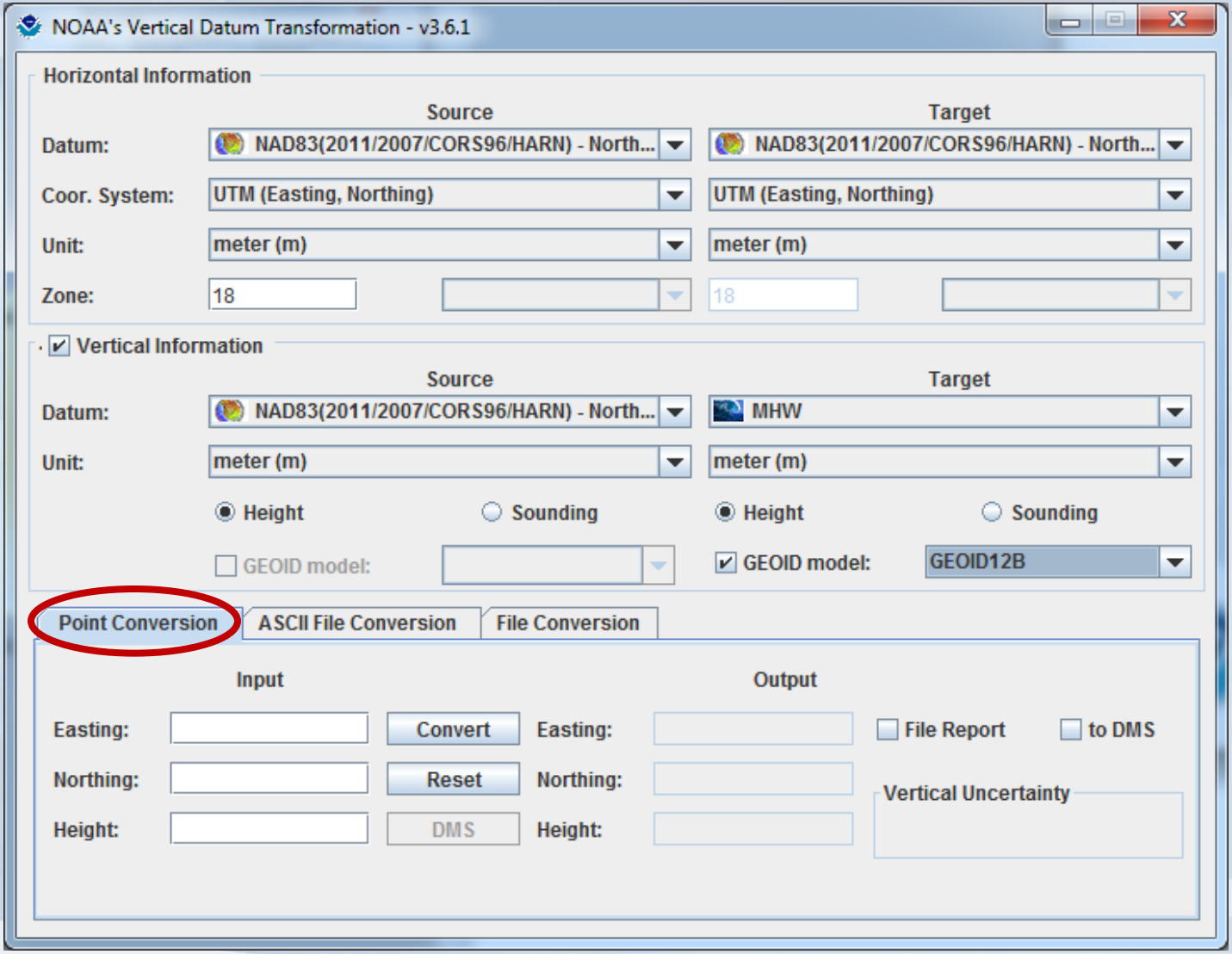
Utilizing VDatum: Input



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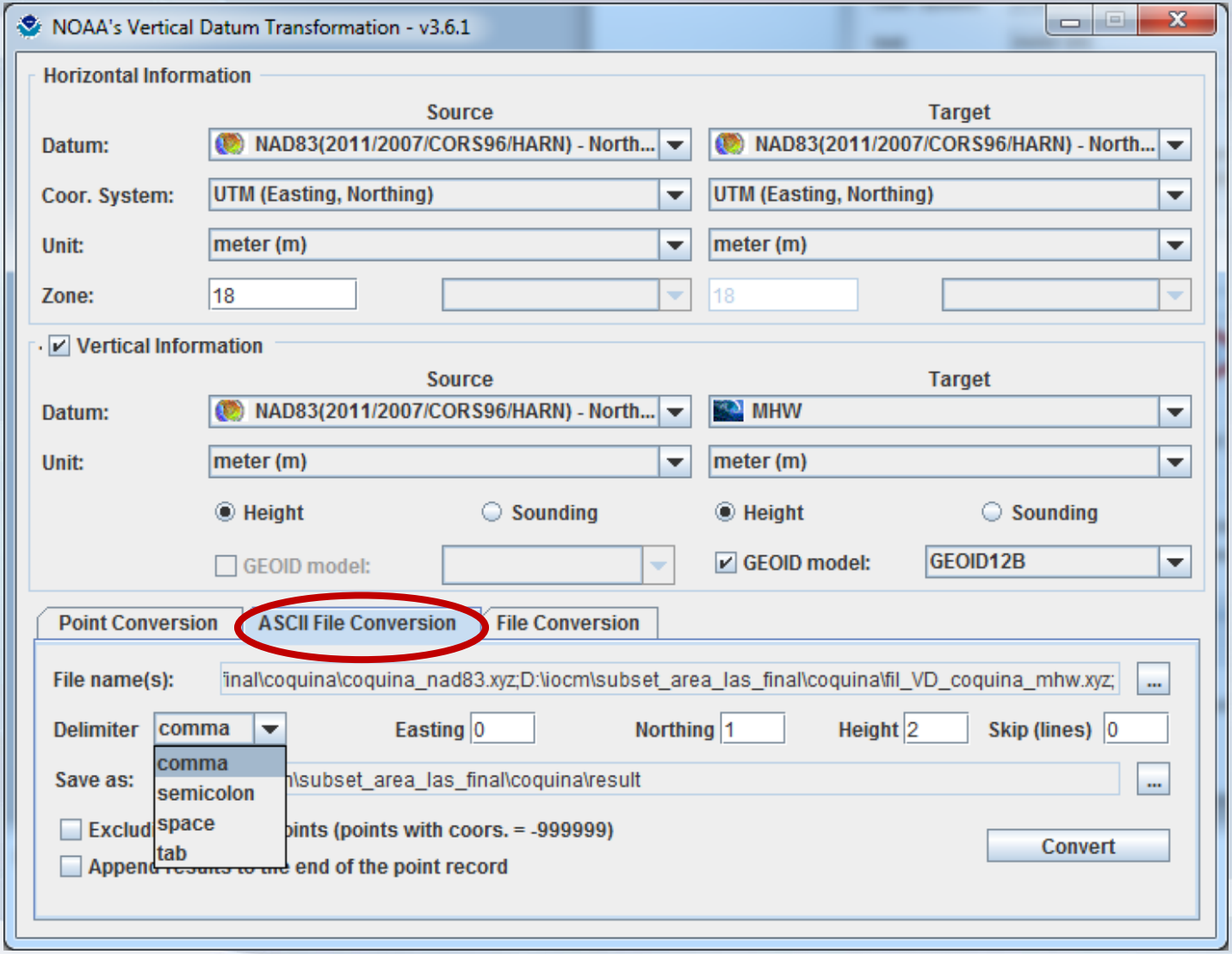
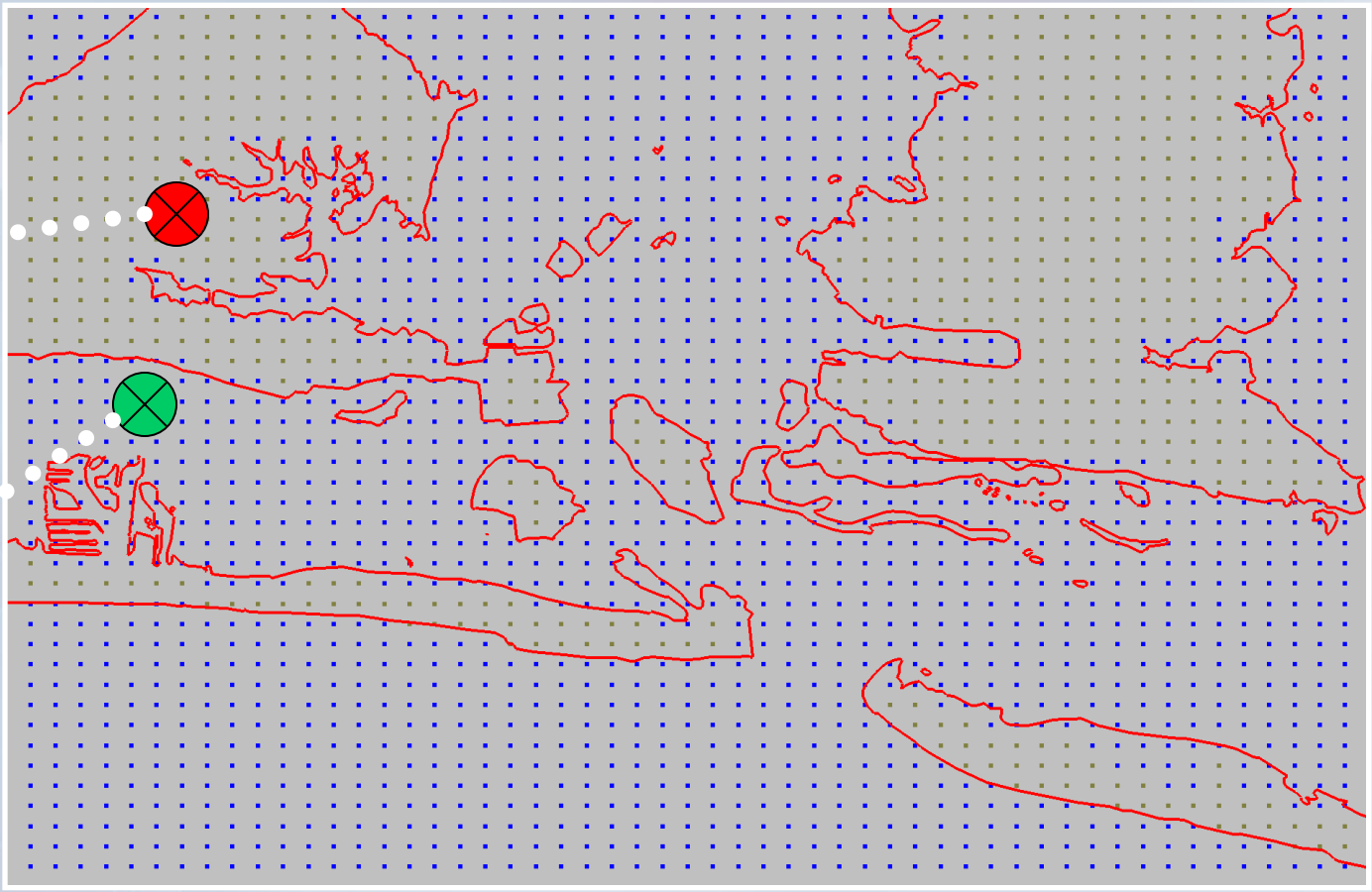
Utilizing VDatum: Input

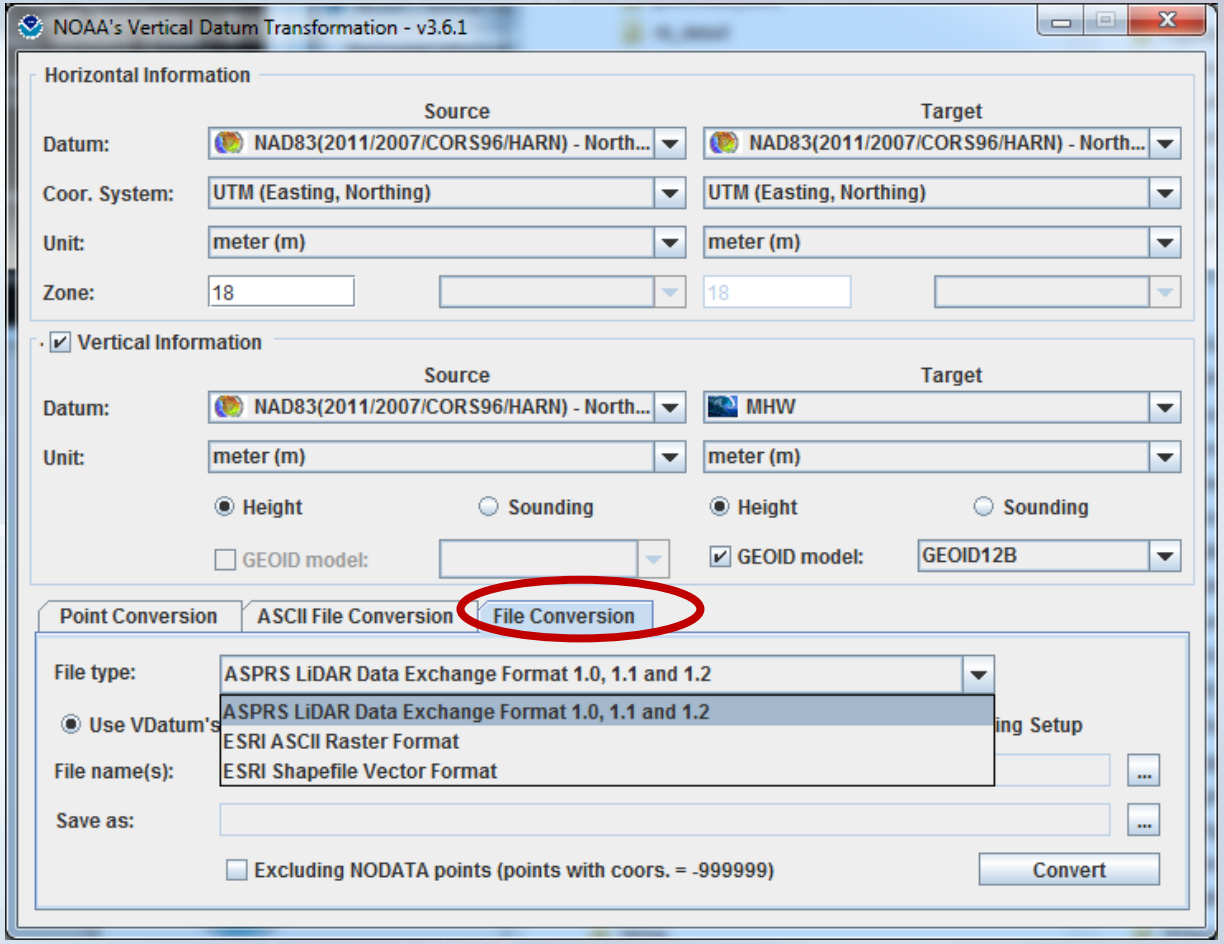


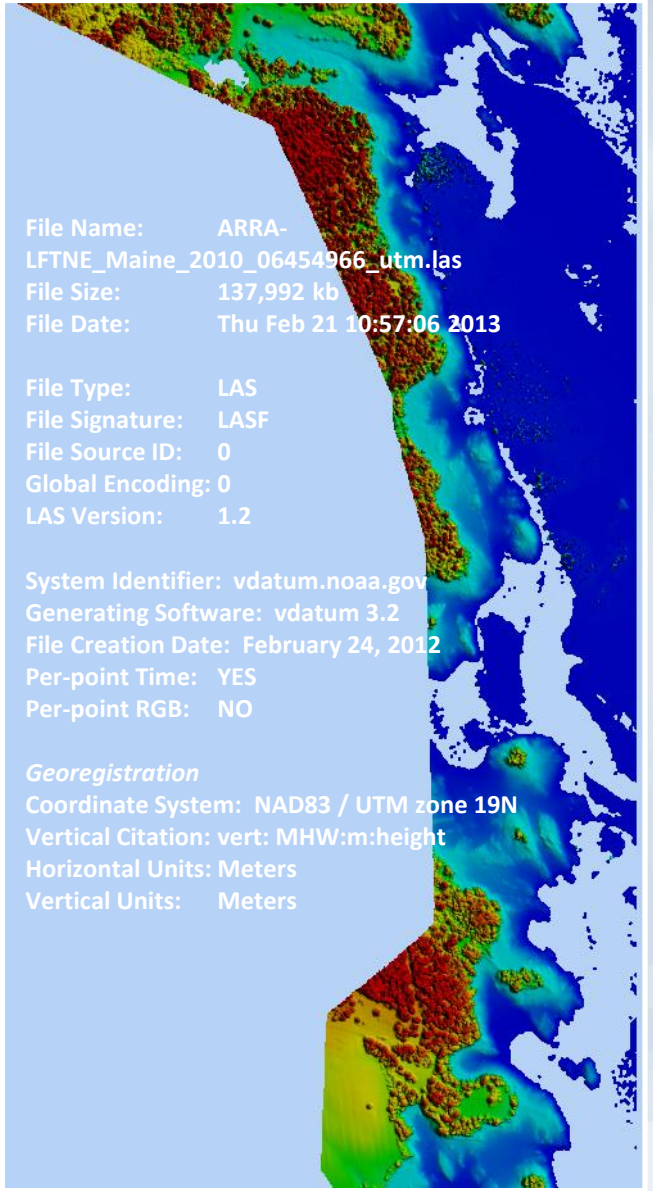
National Oceanic and Atmospheric Administration



- With exception of small buffer region near coastline, user-input points falling on “land” side of MHW shoreline are assigned a null value.
- Orthometric and ellipsoidal conversions may still be made at land points, as only conversions involving tidal datums will be invalid inland of the buffer zone along coastline.

Utilizing VDatum: Input





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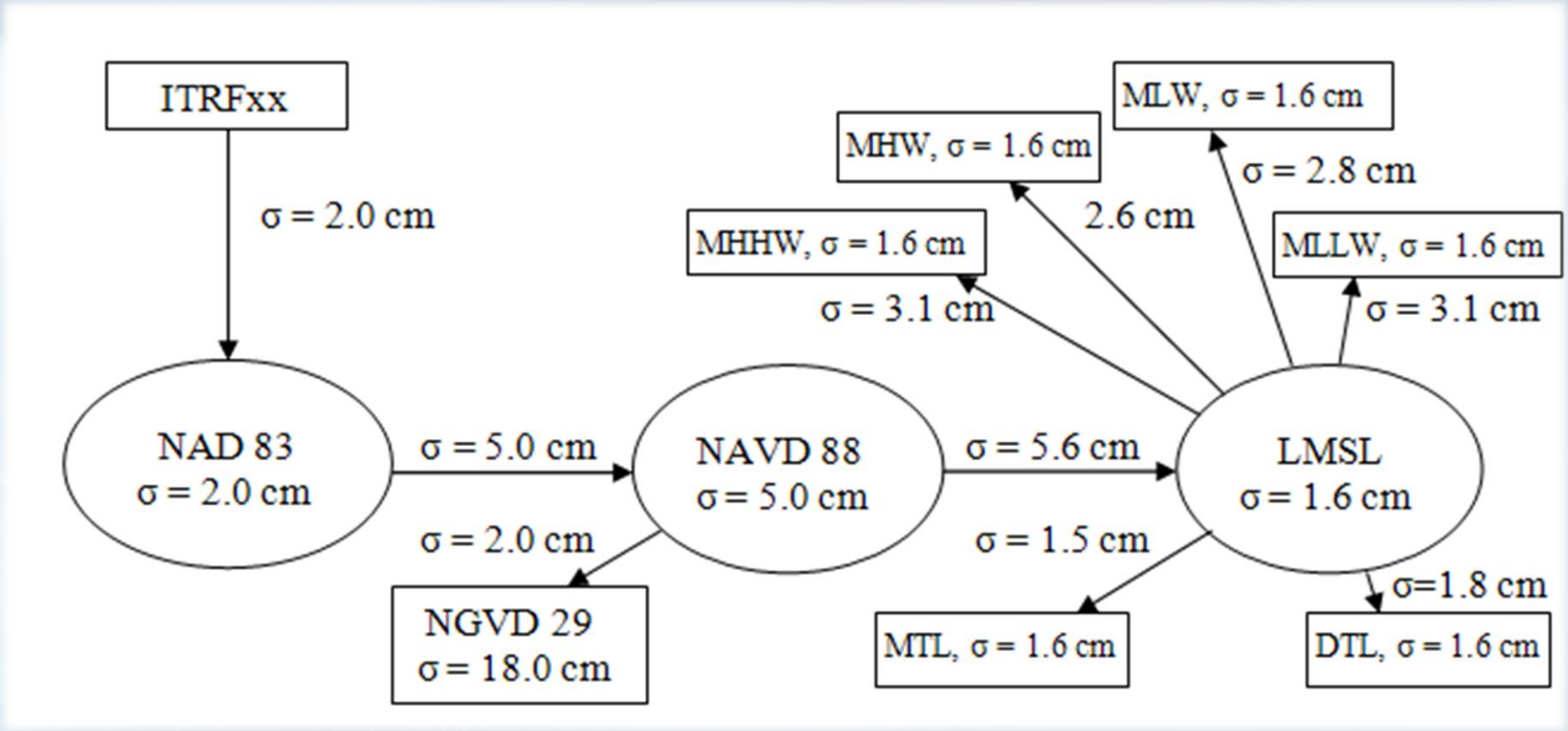
VDatum Uncertainty Modeling



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

VDatum Uncertainty Modeling (cm)

(ITRFxx to the tidal datum, the transformation with the greatest uncertainty)

VDATUM REGION	MAXIMUM CUMULATIVE UNCERTAINTY
California - Southern California from Morro Bay south to US/Mexico border	8.1
California - Monterey Bay to Morro Bay	8.0
California - San Francisco Bay Vicinity	9.8
Oregon/ California – Punta Gorda to Cape Blanco	13.1

Uncertainties that are constant for all VDatum regions of the U.S.

TRANSFORMATION			SOURCE DATA		
ITRFx to NAD83	NAD83 to NAVD88	NAVD88 to NGVD29	NAD83	NAVD88	NGVD29
2.0	5.0	2.0	2.0	5.0	18.0

REGION	TRANSFORMATION							SOURCE DATA	MCU
	NAVD88 to MSL	MSL to MHHW	MSL to MHW	MSL to MTL	MSL to DTL	MSL to MLW	MSL to MLLW	All Tidal Datums	
California - Southern California from Morro Bay south to US/Mexico border	1.6	1.4	0.9	0.1	0.4	0.8	0.9	1.3	8.1
California - Monterey Bay to Morro Bay	1.1	0.8	1	0.7	1	0.9	1.7	1.1	8
California - San Francisco Bay Vicinity	0.1	3.7	4.5	2	2.5	4.2	5.8	1.4	9.8
Oregon/ California – Punta Gorda to Cape Blanco	4.4	2	1.6	2.5	4.4	5.7	9.5	1.2	13.1

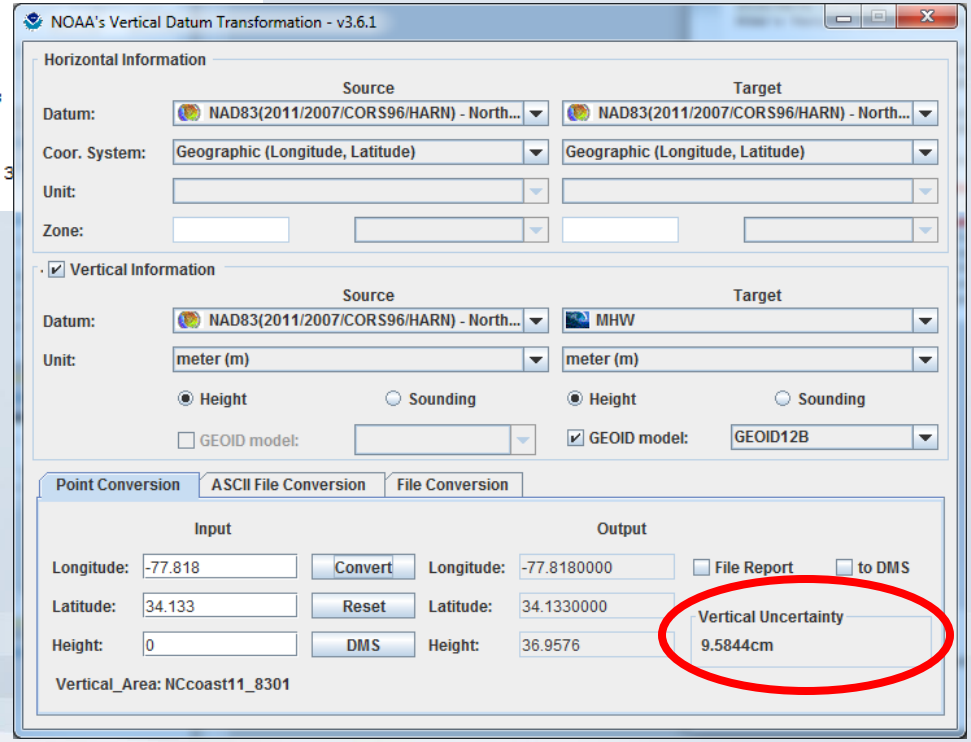
Operational: Vertical Datum Transformation Uncertainty

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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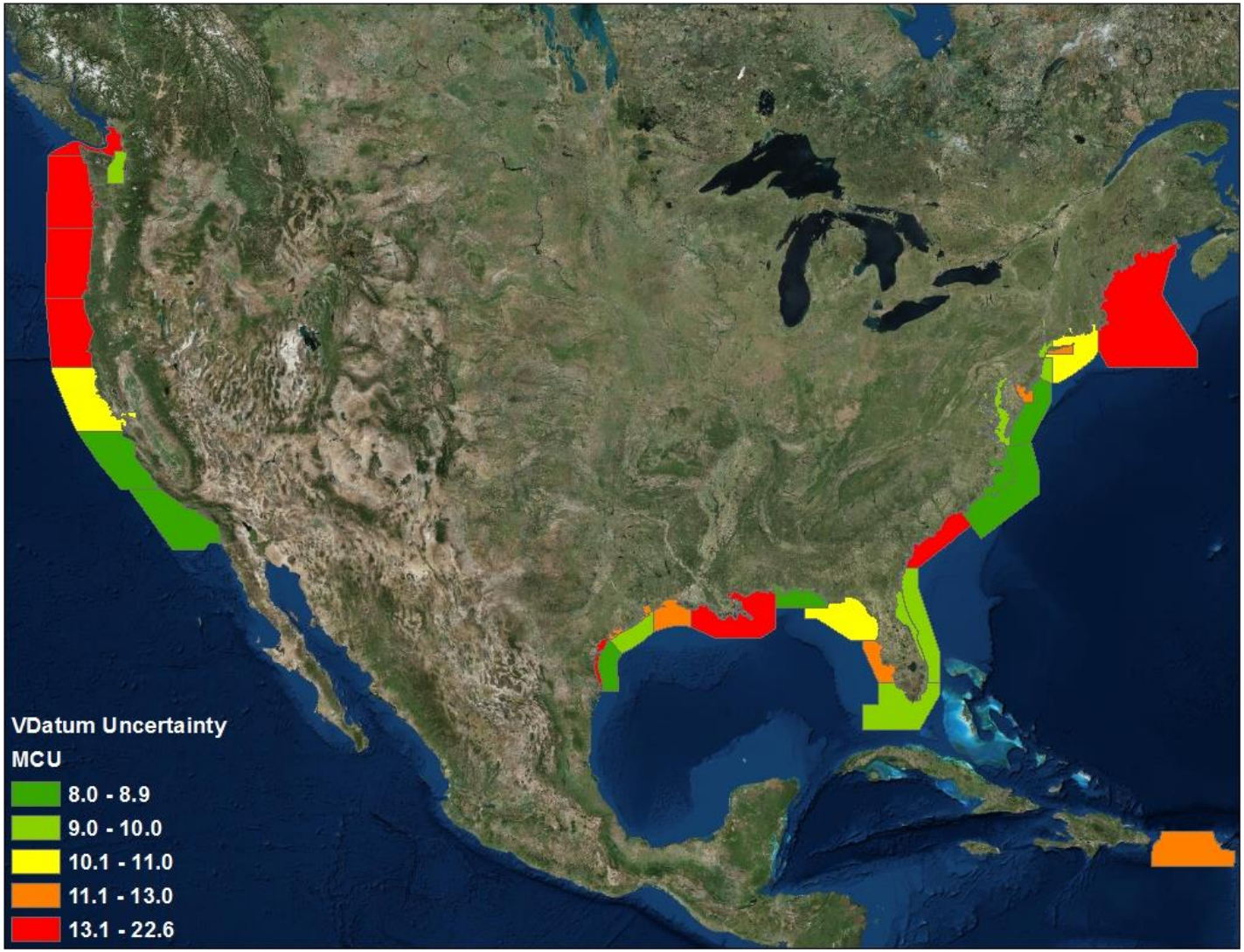
Vertical Datum Uncertainties By Region



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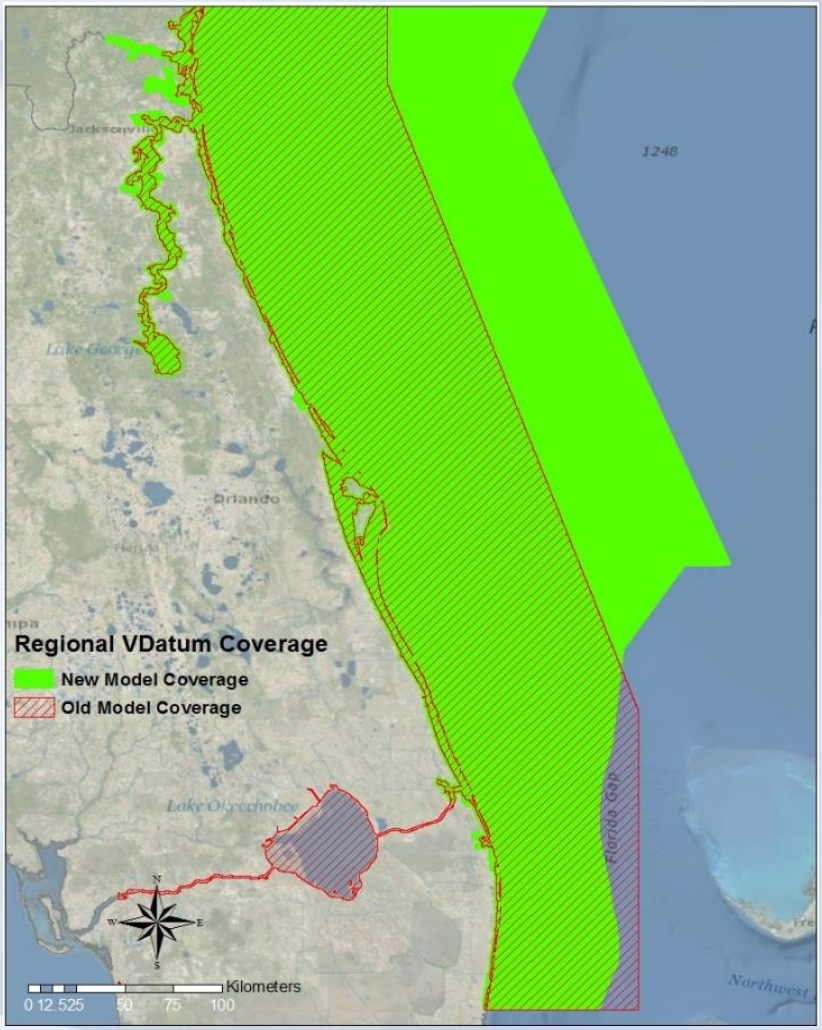
What's Next: *Strategic Priorities*

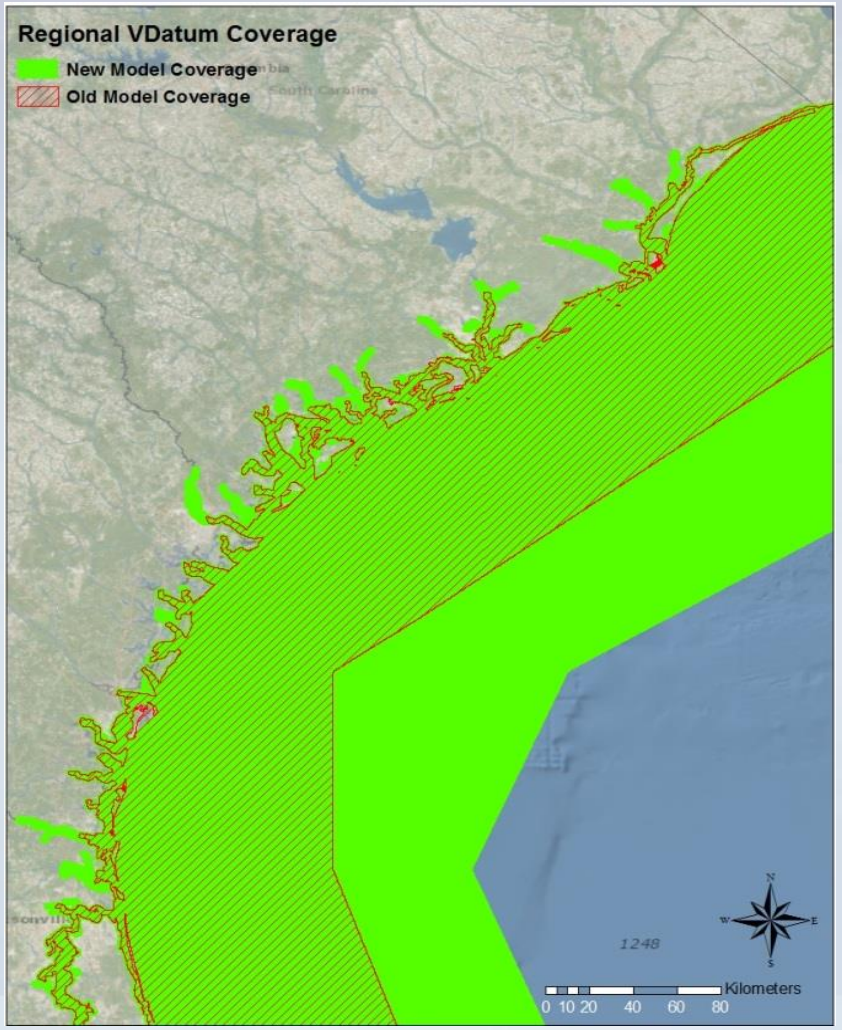
- Reducing Regional Model Uncertainty to <10cm
- Increasing Coverage
- Spatially Varying Uncertainty
- Next Generation TSS Model (utilizing gravimetric GEOID transformation roadmap)
- Software Development
- Communication and Outreach

Foundational Data: Tidal

National Oceanic and Atmospheric Administration

Increasing Spatial Coverage





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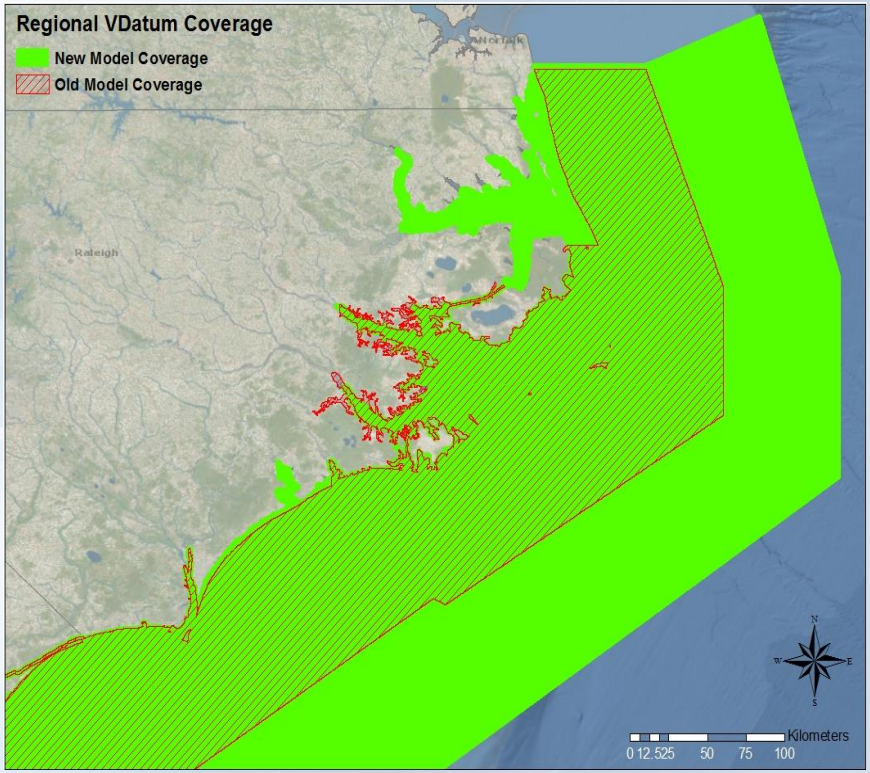
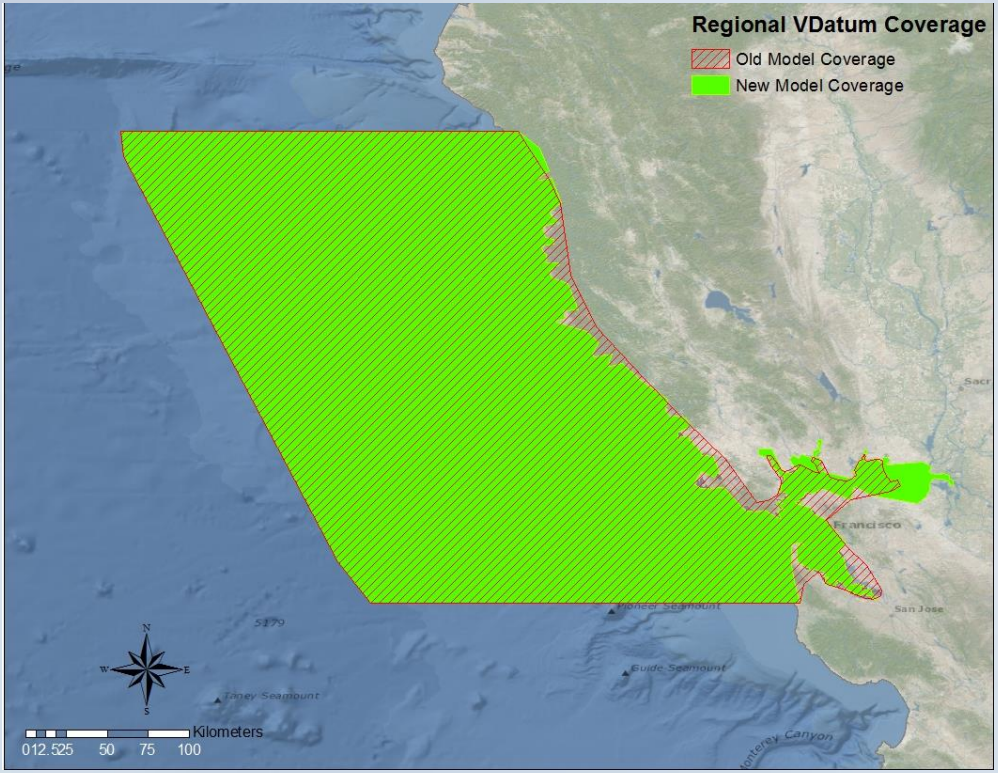
Increasing Spatial Coverage





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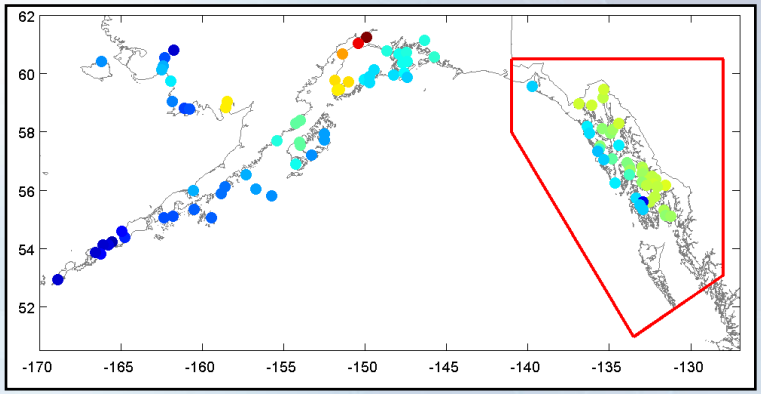
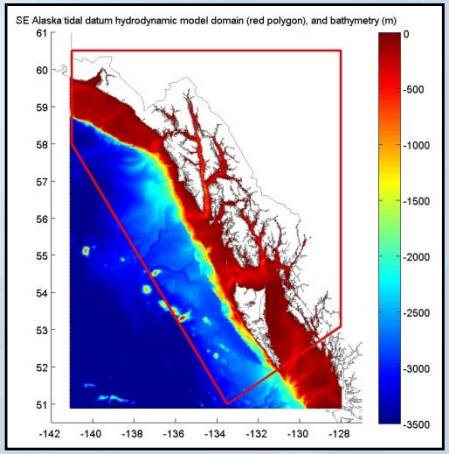
Exploratory Alaska Tidal Modeling

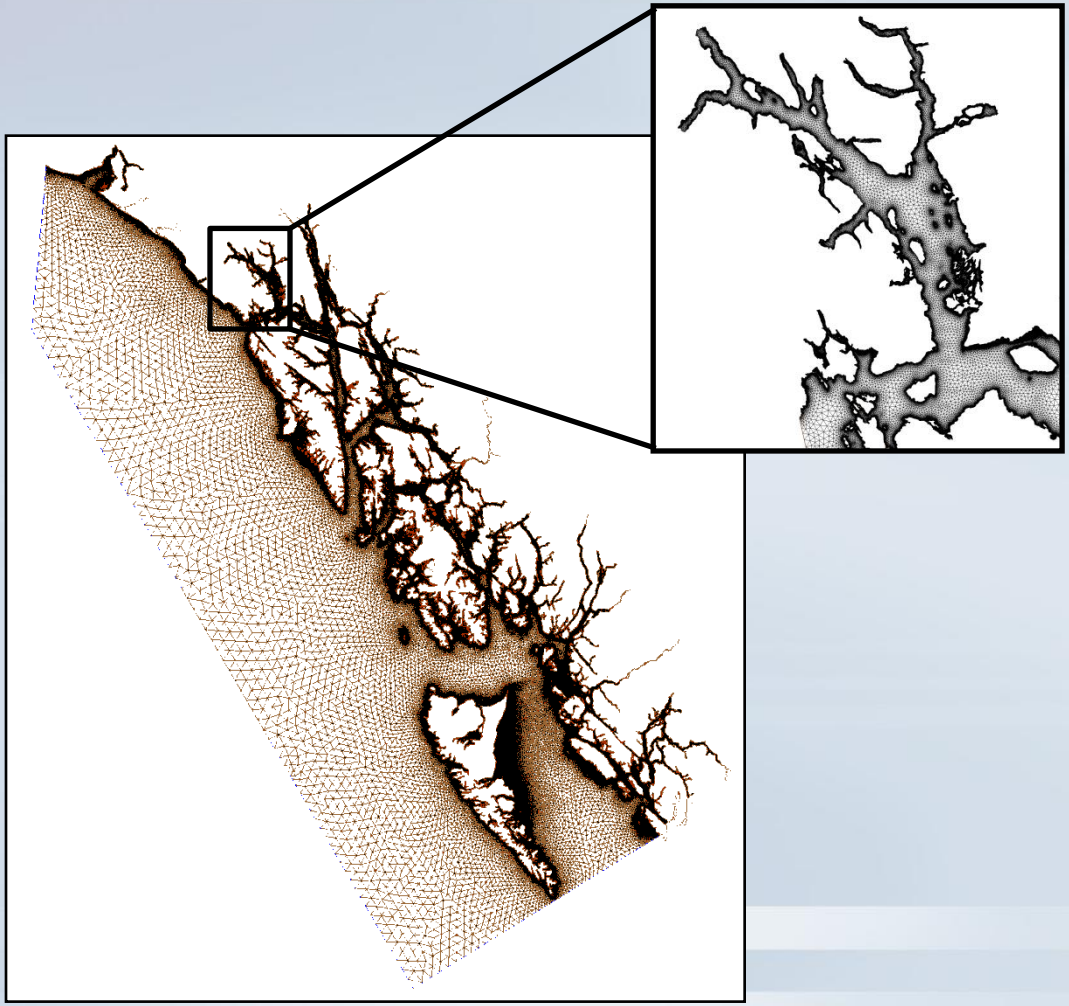
Southeast Alaska

Model Domain, Shoreline, and Tidal Data (M_2 amplitude shown in color)





Bathymetry



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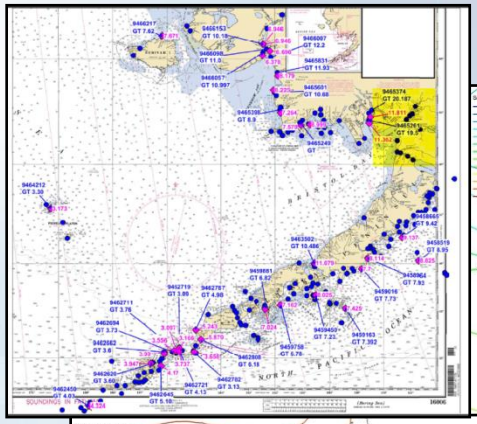
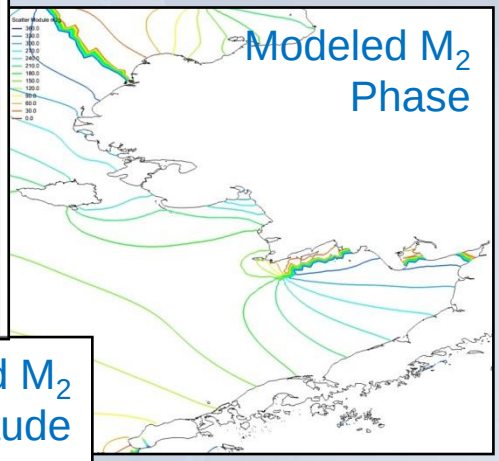
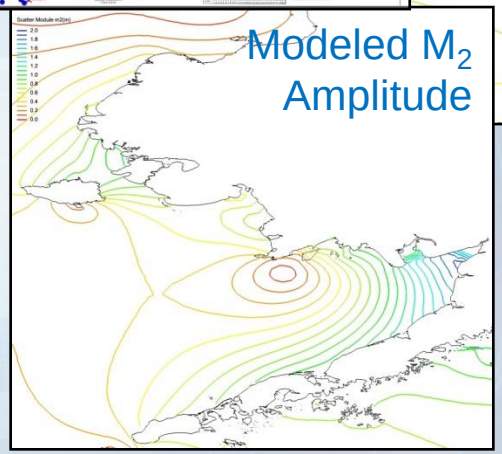
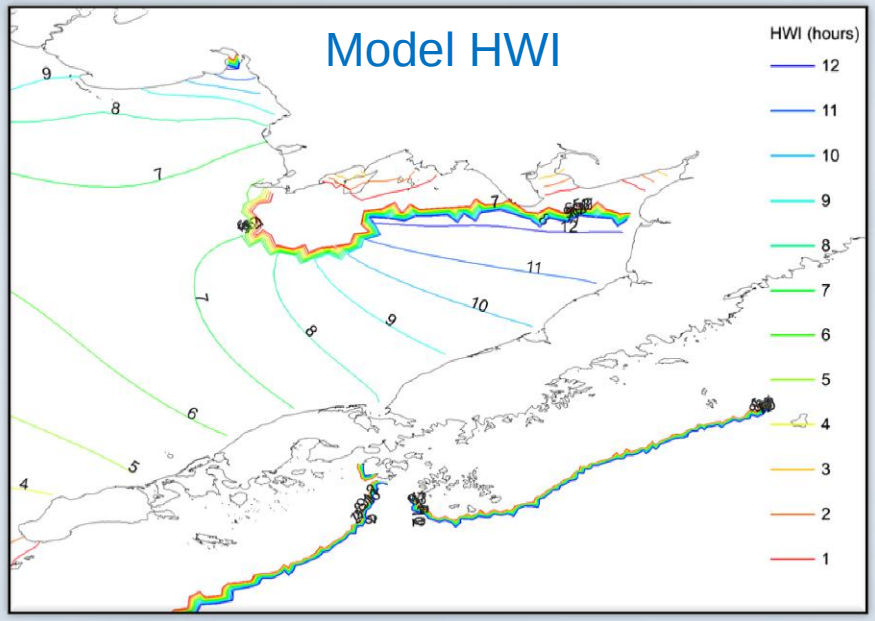
Exploratory Alaska Tidal Modeling

Western Alaska







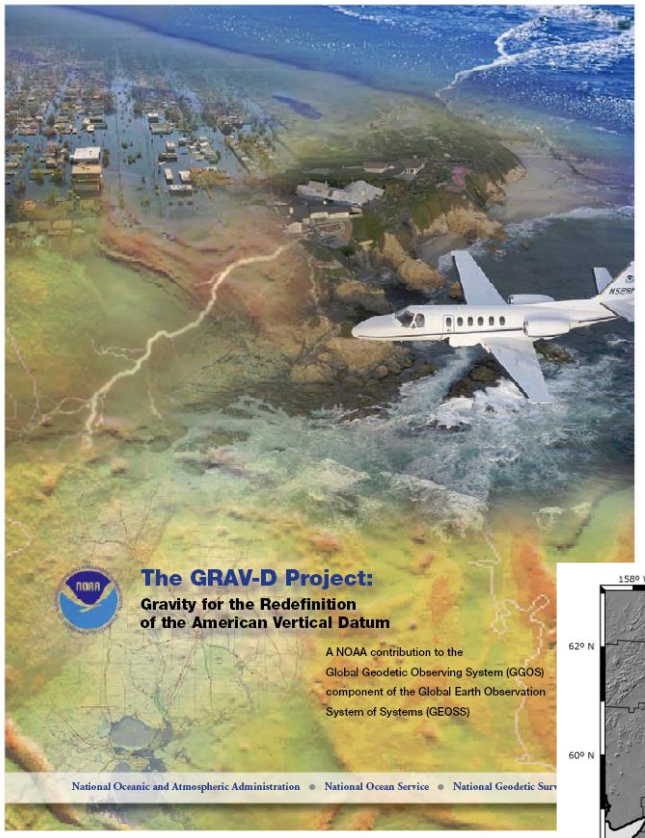


National Oceanic and Atmospheric Administration

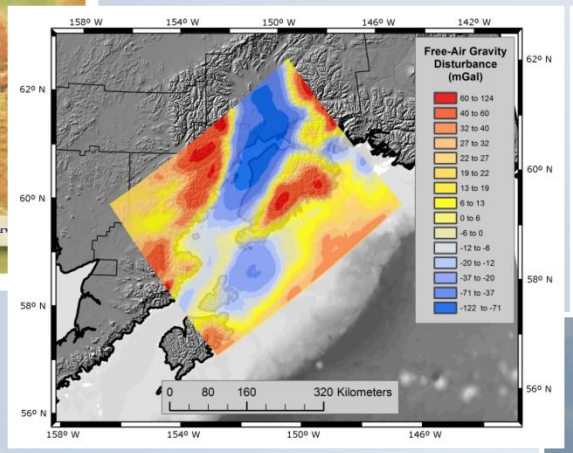
Future Enhancements:

Next Generation TSS

GRAV-D: (**G**ravity for the **R**edefinition of the **A**merican* **V**ertical **D**atum)



- An NGS project whose target is to redefine the official civilian vertical datum as the geoid, realized through the use of GNSS technology and a gravimetric geoid model over at least the United States and its territories
- *Official NGS policy as of Nov 14, 2007*
- *Re-define the Vertical Datum of the USA by 2022 (at current funding levels)*
- *Part of the NGS 10 year plan (2013-2023)*
- *Target: 2 cm accuracy orthometric heights from GNSS and a geoid model*



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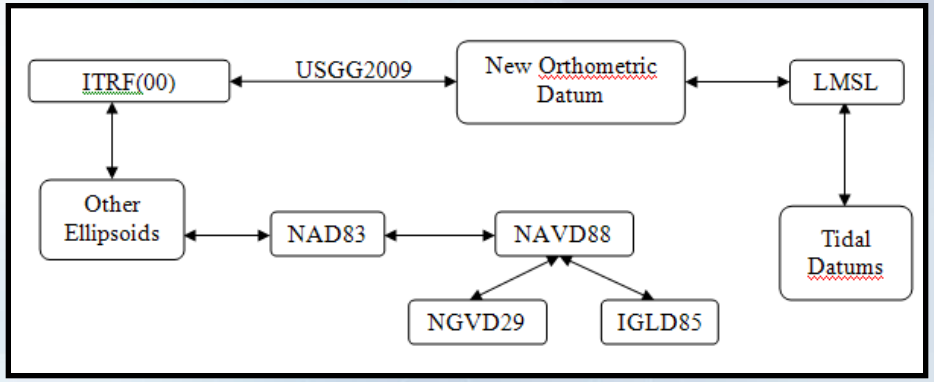
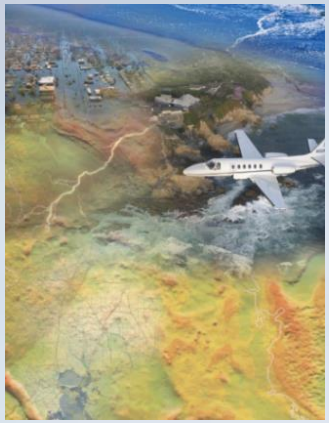
Future Enhancements: Next Generation TSS Development

New Proposed Transformation Roadmap based on a purely Gravimetric GEOID

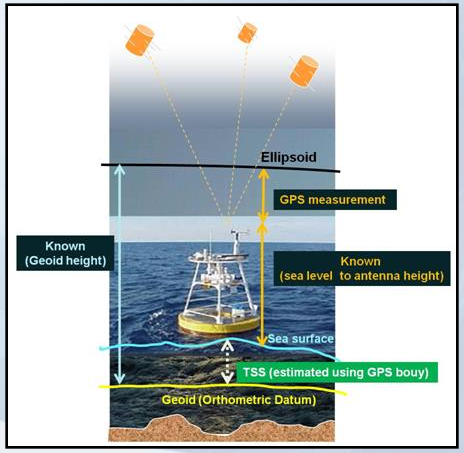


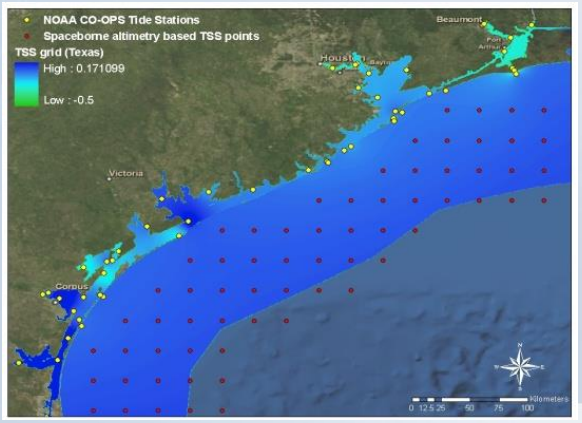
New GEOID: Coastal gravity field improvement



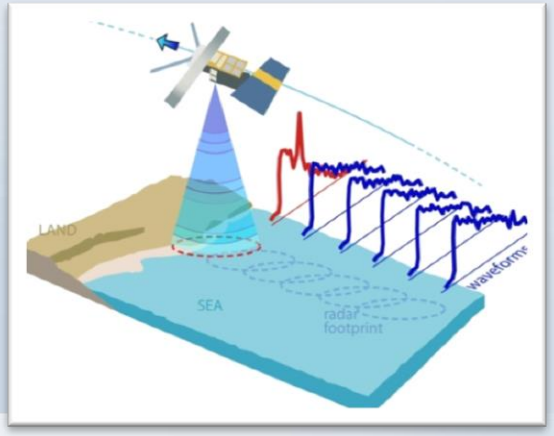
A Must: GPS Campaign on benchmarks to determine new relationships

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





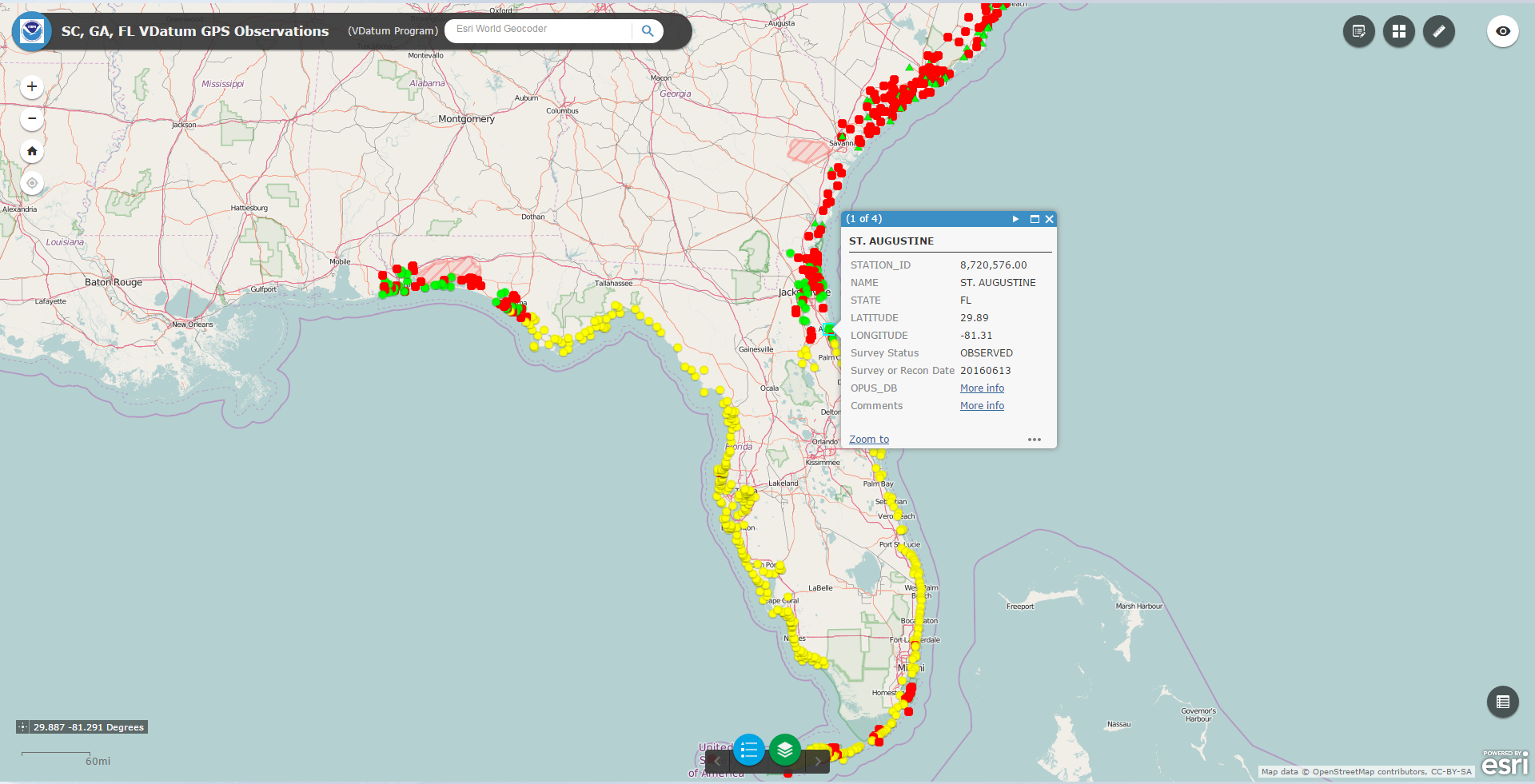
Satellite Altimetry/Derived Products to better understand offshore TSS



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

National Oceanic and Atmospheric Administration

Foundational Data: Geodetic



National Oceanic and Atmospheric Administration

Foundational Data: Geodetic

Shared Solution

PID: AL6199
Designation: 872 6907 TIDAL 2
Stamping: NO II
Stability: May hold commonly subject to ground movement
Setting: Set in top of concrete monument
Mark Condition: G
Description: The bench mark is a disk set in the top of a concrete monument, 3.66 m (12.0 ft) SW of the SW corner of the Bradley's two story frame house, located at the inside corner of sidewalk, below the grass.
Observed: 2016-02-06T16:08:00Z — See Also 1983
Source: OPUS - page5 1209.04

Close-up View

REF_FRAME: NAD_83(2011) | EPOCH: 2010.0000 | SOURCE: NAVD88 (Computed using GEOID12B) | UNITS: m | SET PROFILE | DETAILS

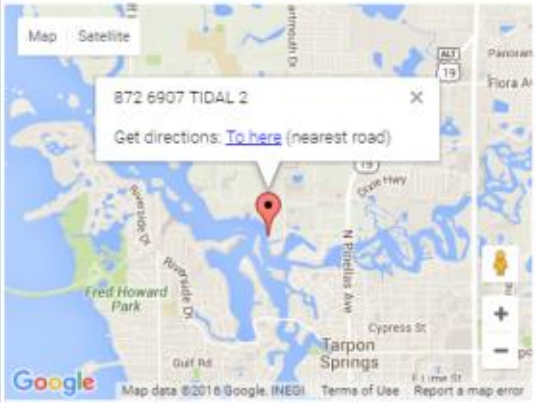
LAT:	28° 9' 34.27151"	± 0.012 m
LON:	-82° 46' 1.76794"	± 0.005 m
ELL HT:	-23.168	± 0.022 m
X:	708497.621	± 0.008 m
Y:	-5582599.630	± 0.024 m
Z:	2992091.614	± 0.005 m
ORTHO HT:	1.952	± 0.040 m

	UTM 17	SPC 902(FL W)
NORTHING:	3116136.435m	424124.109m
EASTING:	326489.766m	124655.519m
CONVERGENCE:	-0.83418006°	-0.36206031°
POINT SCALE:	0.99997158	1.00001121
COMBINED FACTOR:	0.99997522	1.00001485

CONTRIBUTED BY

stephen a white
National Geodetic Survey

Horizon View



The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the infor

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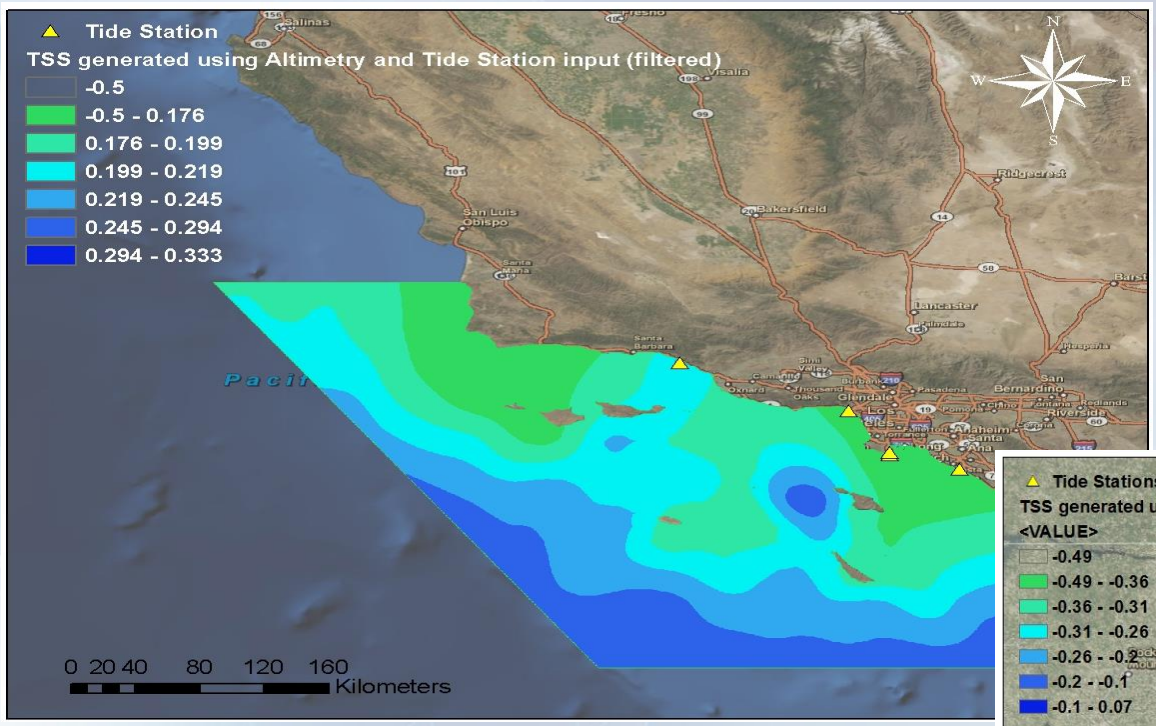
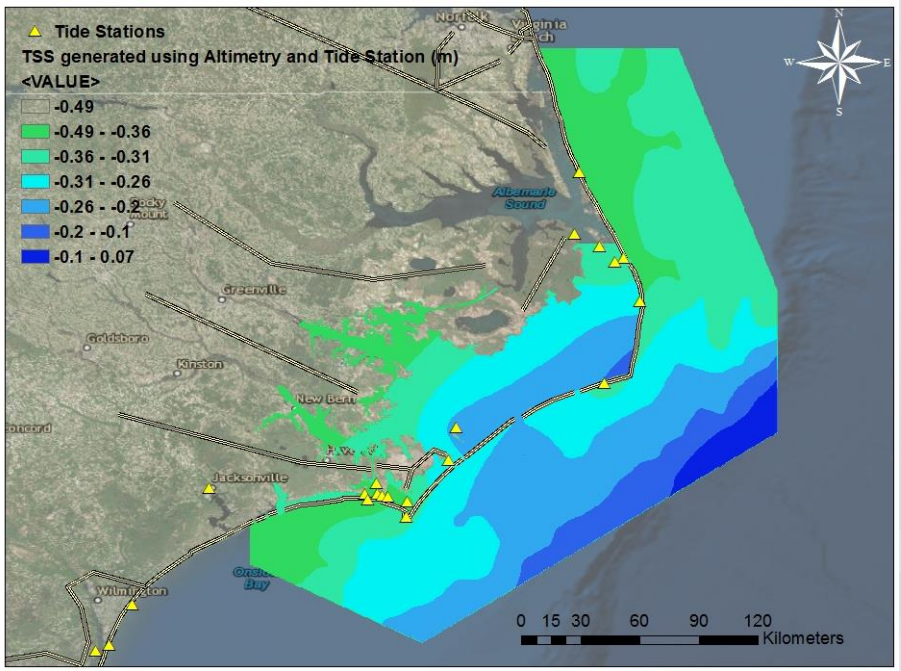
Future Enhancements: Next Generation TSS Development





Refined TSS grid created using the derived TSS points at CNES MSS points (Gaussian filtered), and newly determined geodetic relationships at tide stations

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Future Enhancements:

Spatially Variable Uncertainty (SVU) Estimation

Spatially Varying Uncertainty: Topography of the Sea Surface

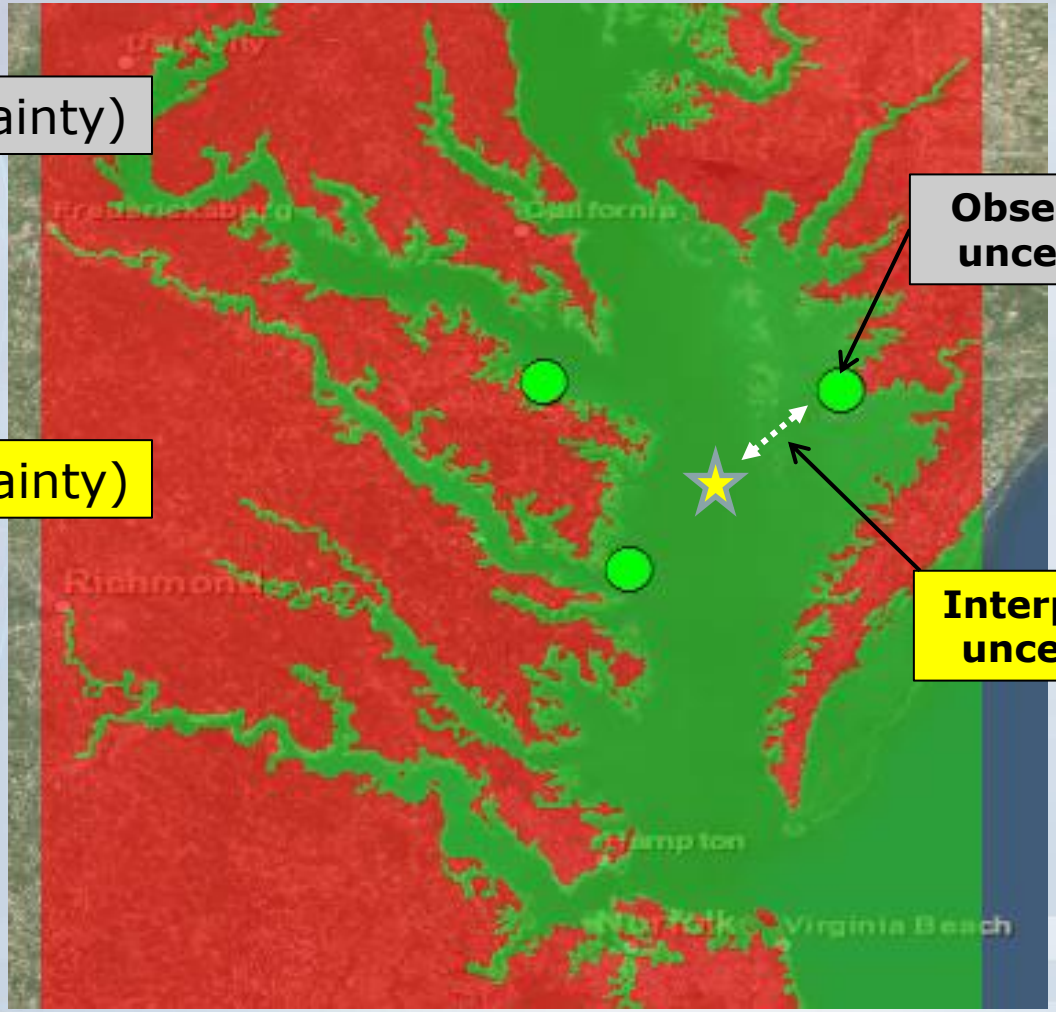
OU (Observation Uncertainty)

- given TSS uncertainty at tide gauge

+

IU (Interpolation Uncertainty)

- related to the interpolation performance over distance



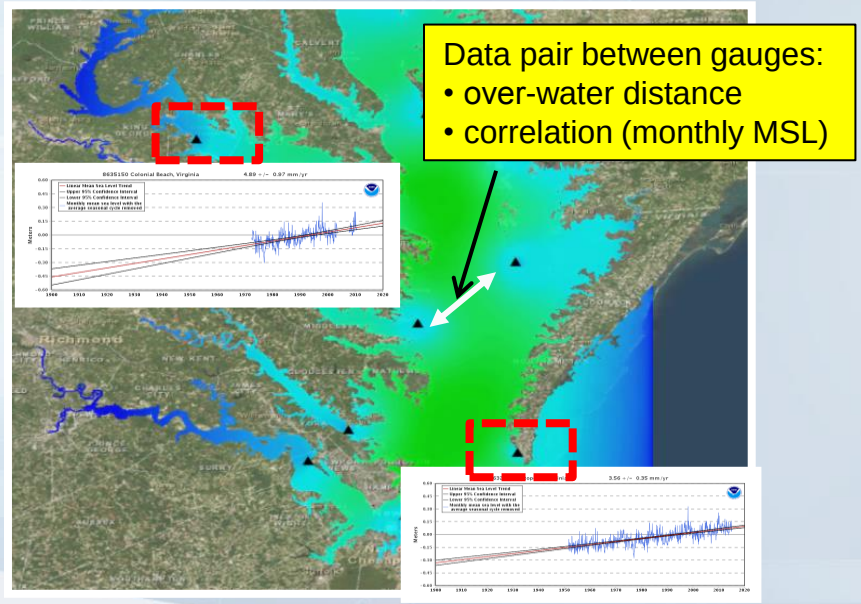
Spatially Varying Uncertainty: Topography of the Sea Surface

Rigorous Error Propagation

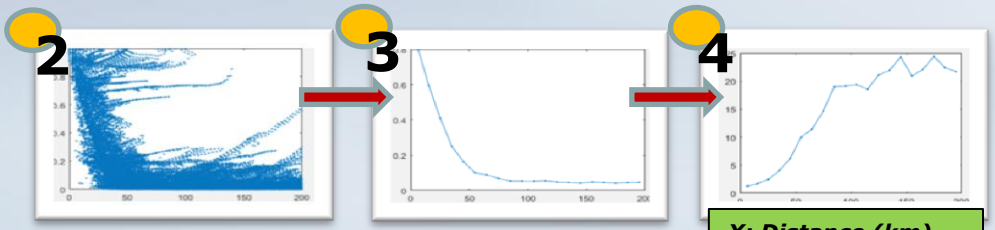
$$\Sigma_{TSS} = J_{TPU}\,\Sigma_{TSS\,obs}\,J_{TPU}^{T} + \Sigma_{Interpolation}$$

$$\Sigma_{TSS\,obs} = \begin{pmatrix} \sigma_1^2 & \cdots & \sigma_{1,K} \\ \vdots & \ddots & \vdots \\ \sigma_{K,1} & \cdots & \sigma_K^2 \end{pmatrix}$$

Deriving "Full" covariance matrix



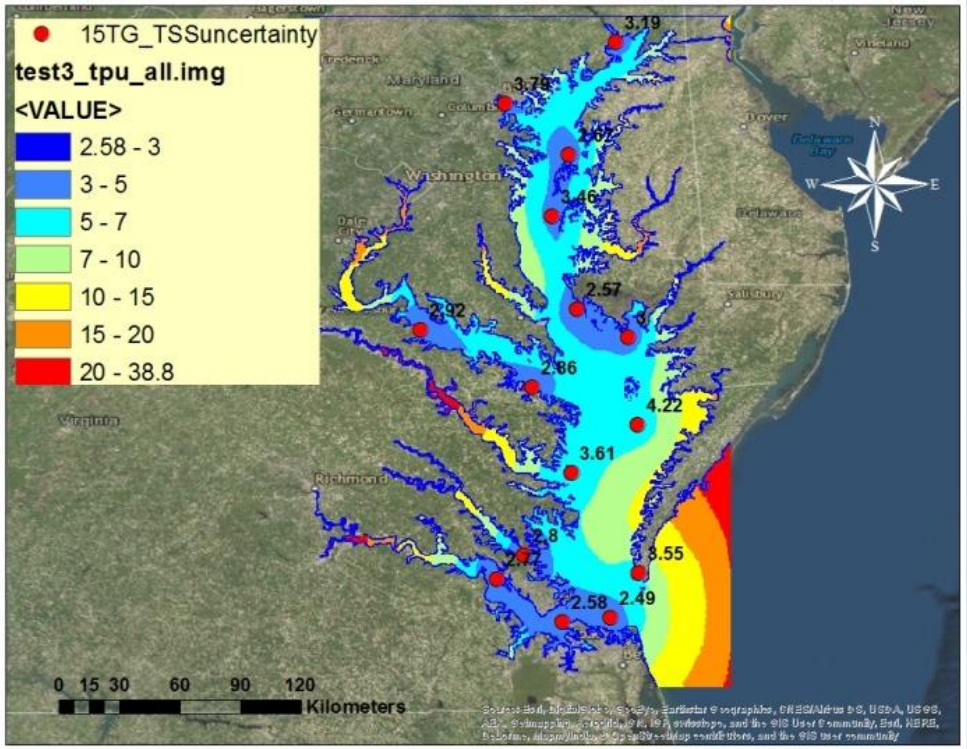
Interpolation Uncertainty



X: Distance (km), Y: Weight

X: Distance (km), Y: avg. Weight

X: Distance (km) Y: Scale factor for unit variance



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Spatially Varying Uncertainty: Tide Models

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

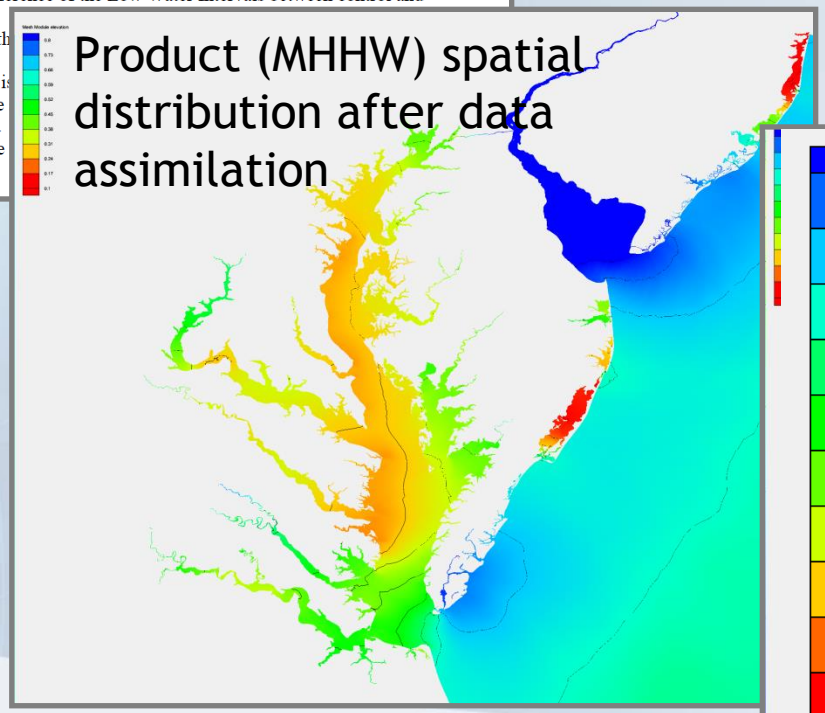
S6M = 0.0019 ADLWI + 0.0023 SRGDIST + 0.0207 MNR + 0.030

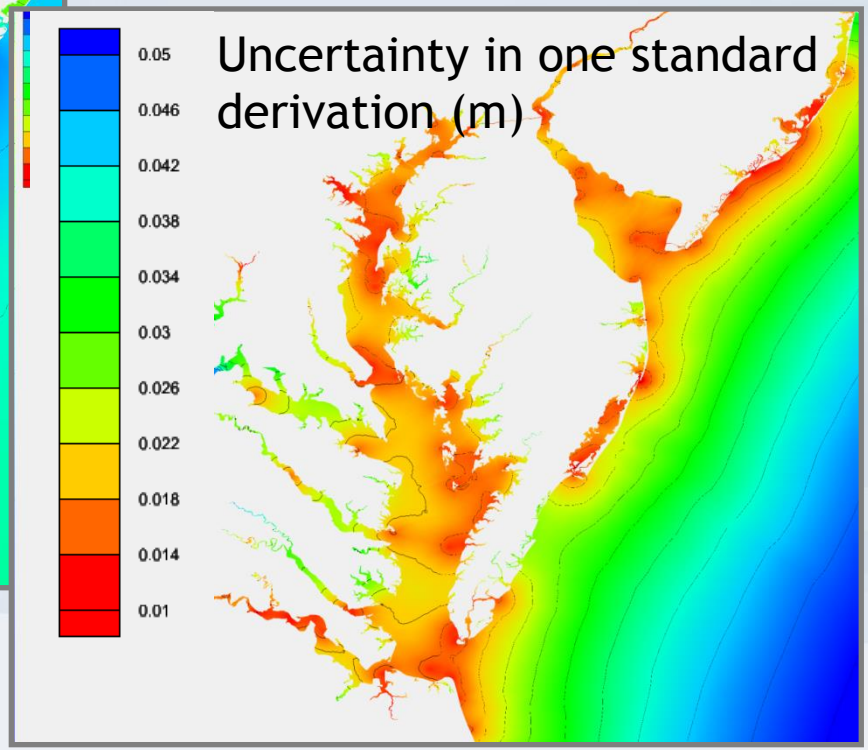
S12M = 0.0045 SRSMN + 0.128 MNR + 0.025

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 th
(in nautical miles),
MNR is a mean range ratio that is
between control and subordinate
(using range values in feet), and
SRSMN is the square root of the
(in feet).

- Statistical data assimilation is used to blend model results and data, also providing the associated uncertainty.
- Initial results for the Chesapeake Bay are shown below:





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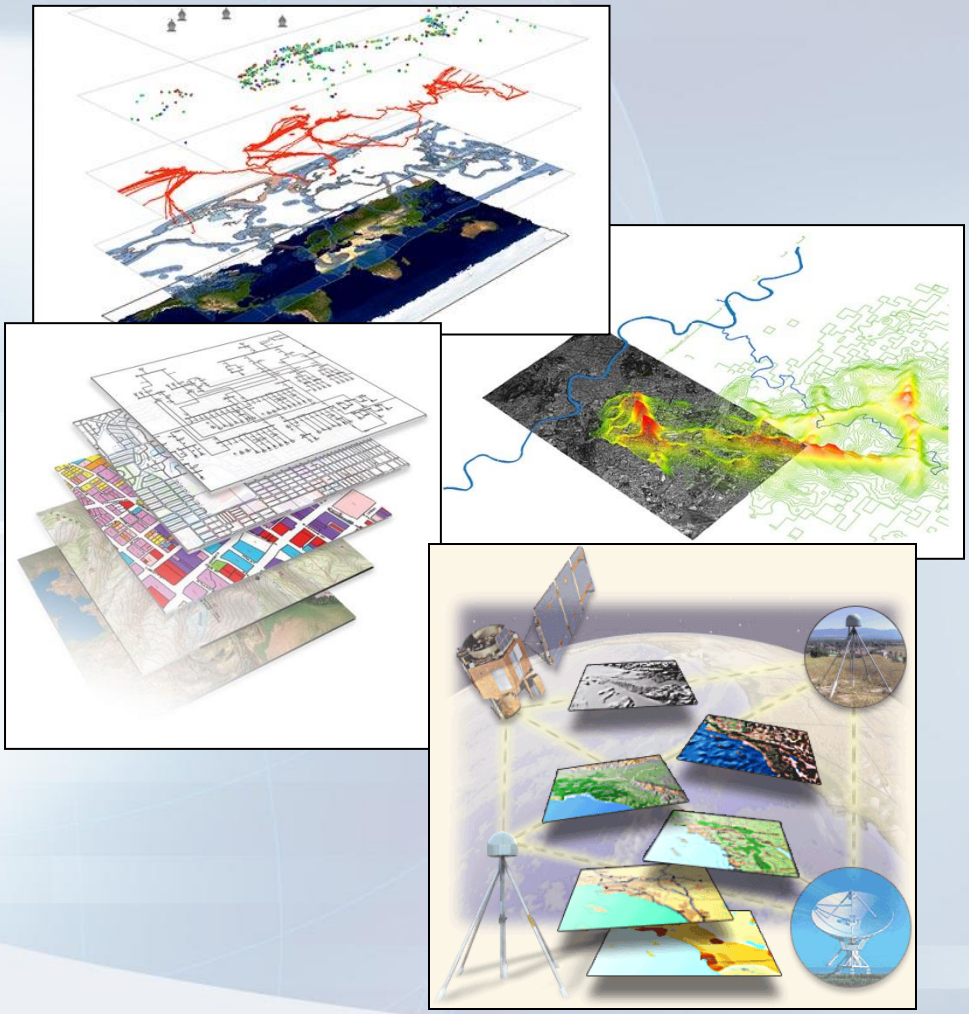
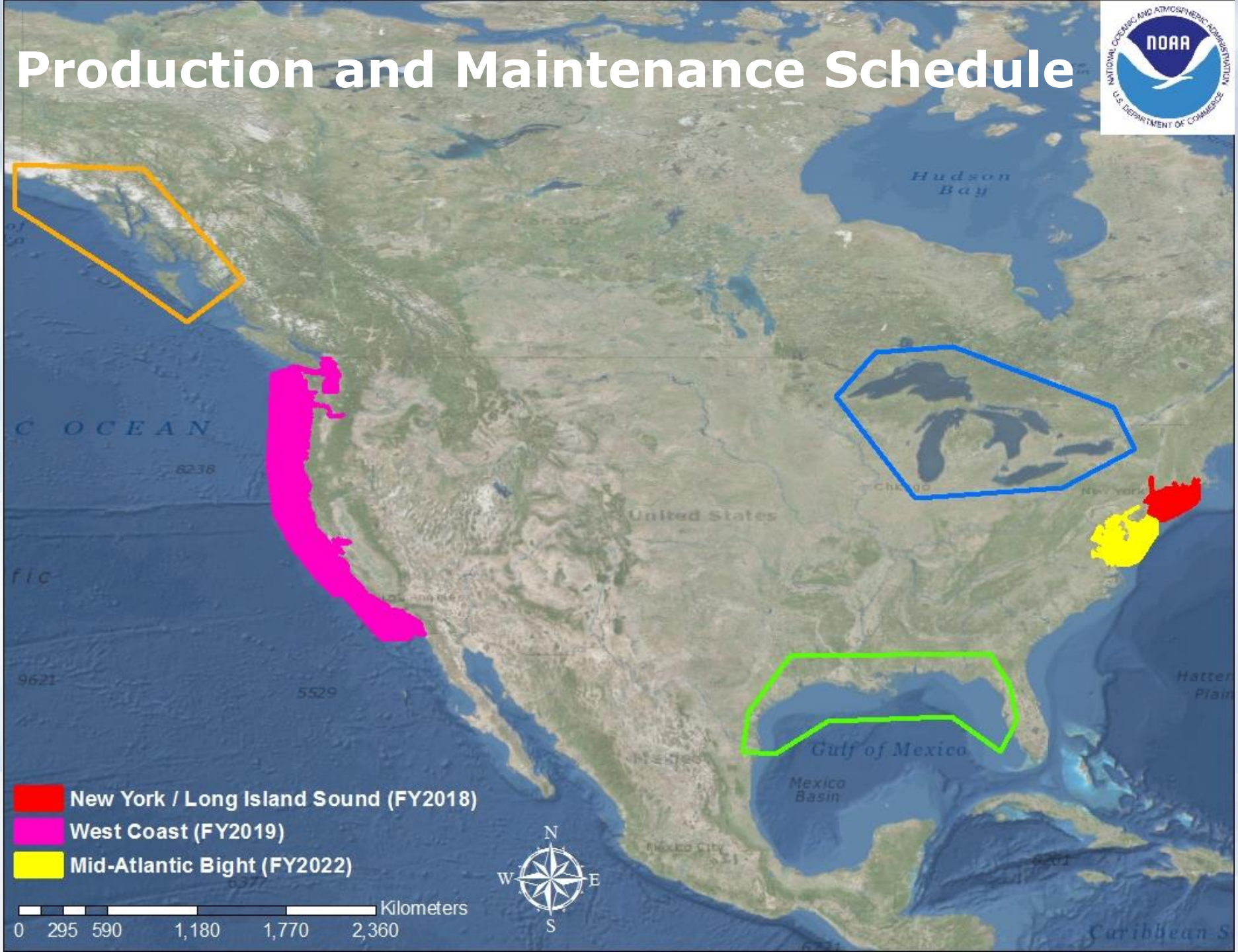
Software: Future Enhancements



- Bug Fixes
- Change Request
- GIS Format Support
  - GeoTiff
  - LAZ
  - LAS 1.3 and 1.4
- SVU Implementation
- Investigate integration of Gravimetric GEOID and new transformation roadmap
- Investigate integration of Next Generation TSS Grids
- Web Services (API?)

- GeoCon, Time Dependency

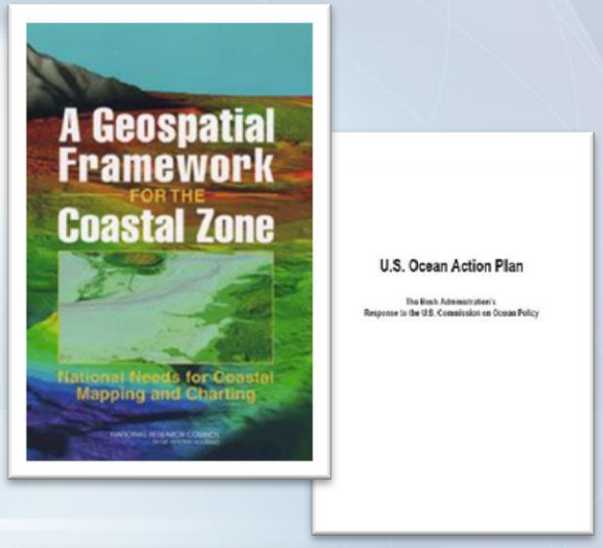
Production and Maintenance Schedule



VDatum Applications

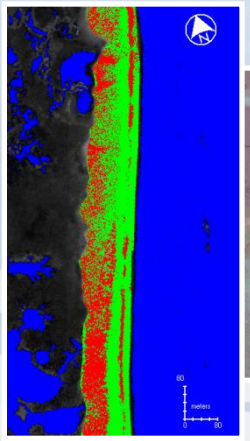
National Oceanic and Atmospheric Administration

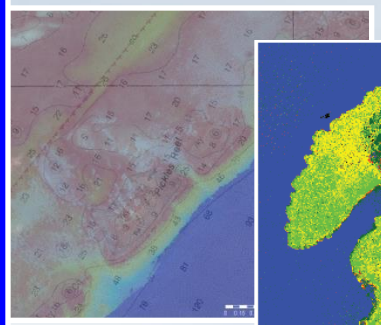
Integrated Ocean and Coastal Mapping (IOCM)

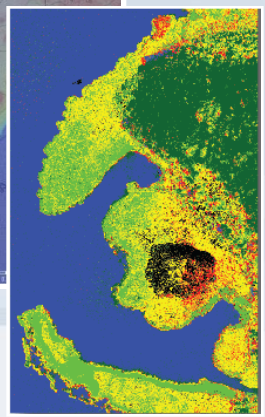


The practice of acquiring, managing, integrating and disseminating ocean and coastal geospatial mapping data in such a manner that permits these data and their derivative products to be easily accessed and used by and for the greatest range of users and purposes.

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.



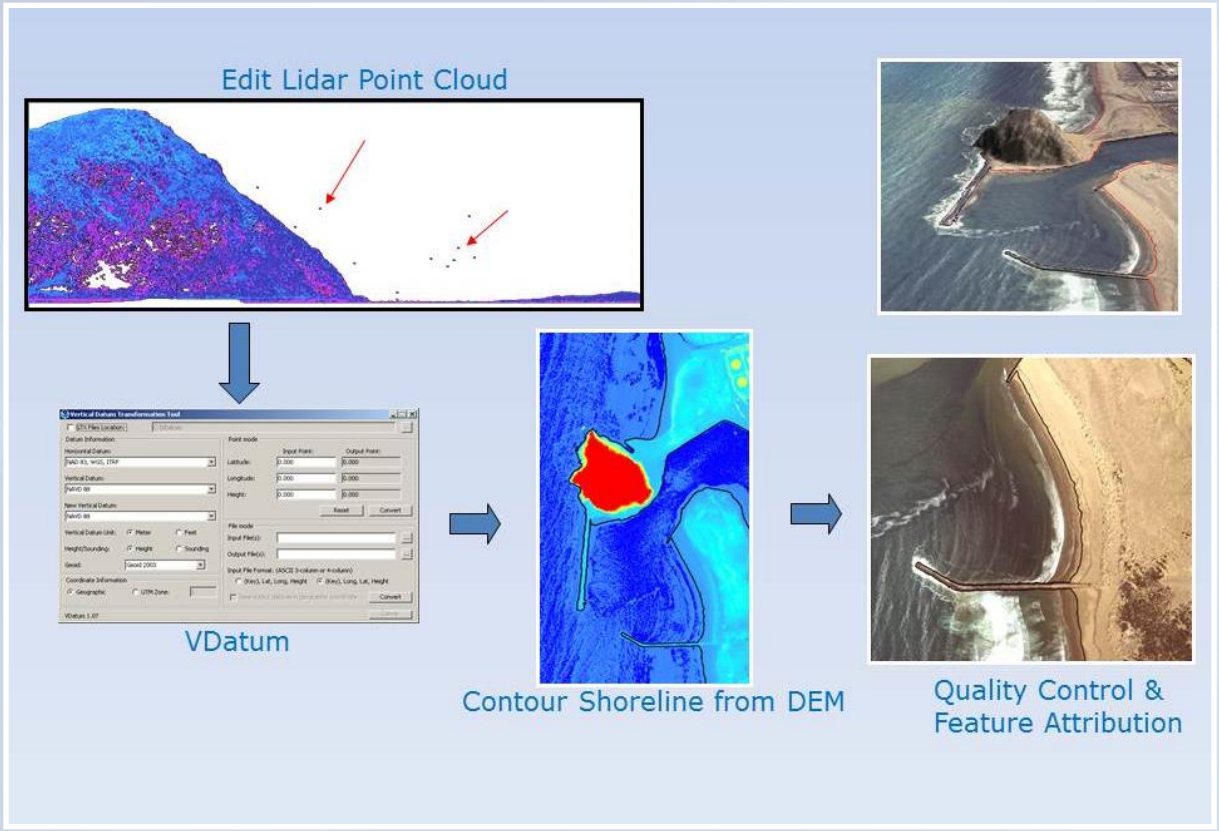




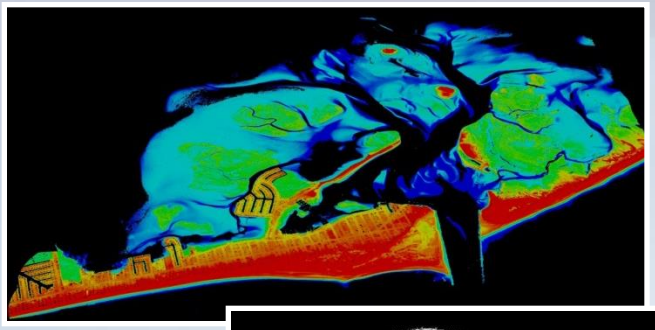
National Oceanic and Atmospheric Administration

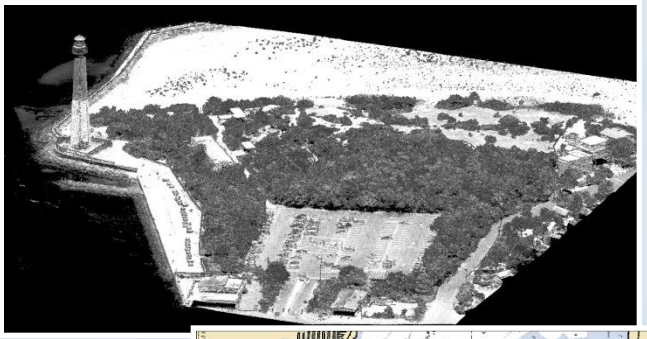
Shoreline Extraction: A VDatum Charting Application

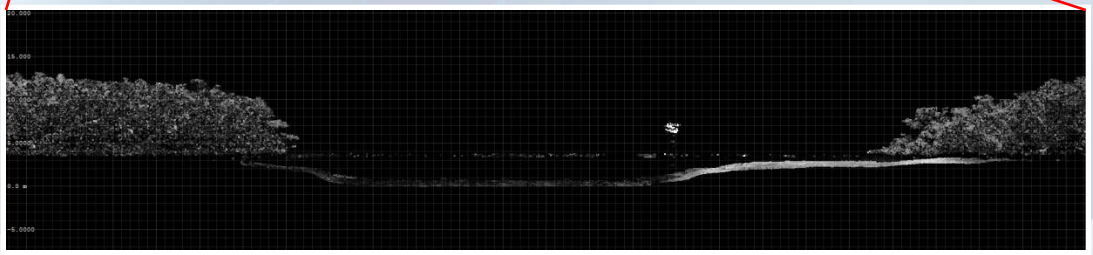
- **Supports delineating the National Shoreline.**
- **Support of other applications:**
  - NOAA nautical charts
  - Used in defining the United States' territorial limits
  - Coastal resource management
  - Storm surge and coastal flooding modeling
  - Coastal geomorphology studies
  - GIS analysis
  - Coastal Intelligence, Resiliency and Place-Based Conservation Applications

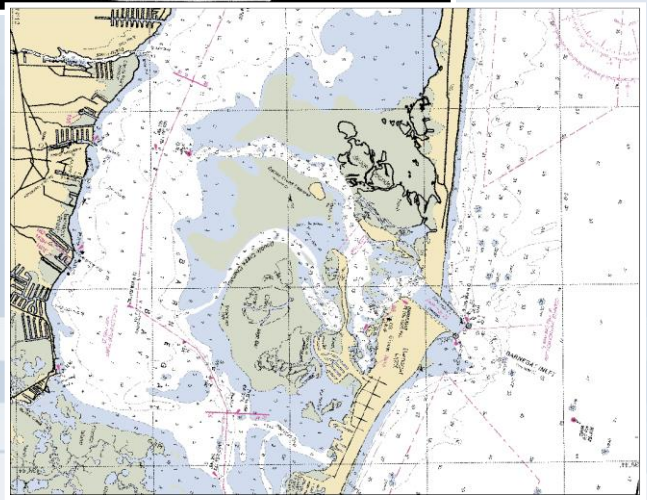


TopoBathy Lidar









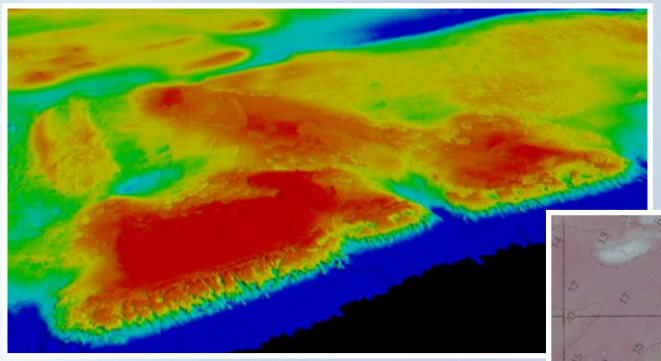
National Oceanic and Atmospheric Administration

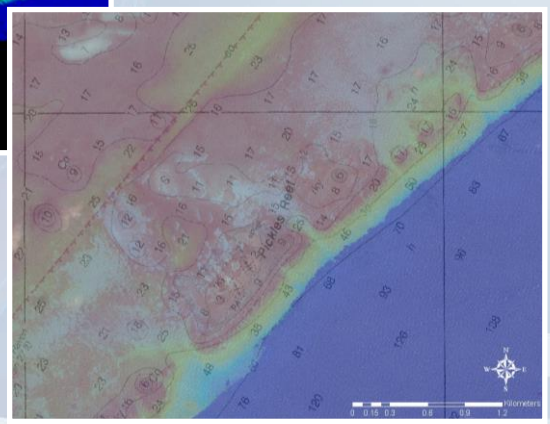
Surveying on the Ellipsoid:

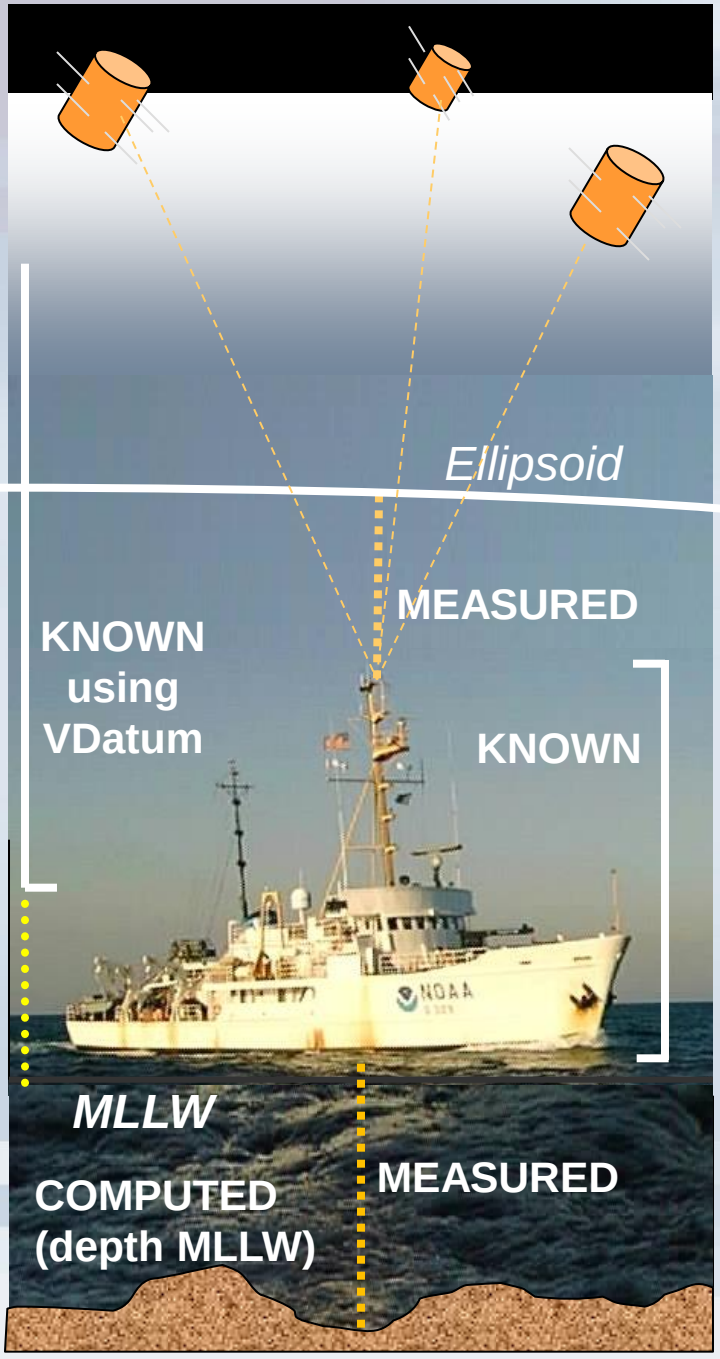
A VDatum Charting Application

Advantages:

- Decouple tide measurement from survey
- Reduce vertical uncertainty from heave, dynamic draft

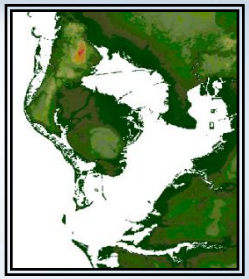




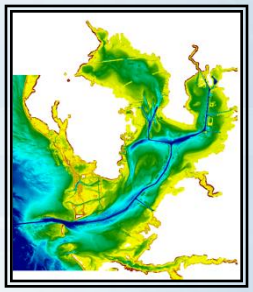


National Oceanic and Atmospheric Administration

VDatum: Used to Create Digital Elevation Models

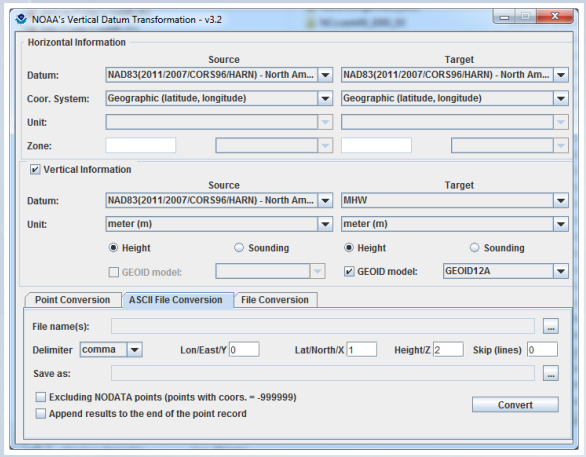


Topography

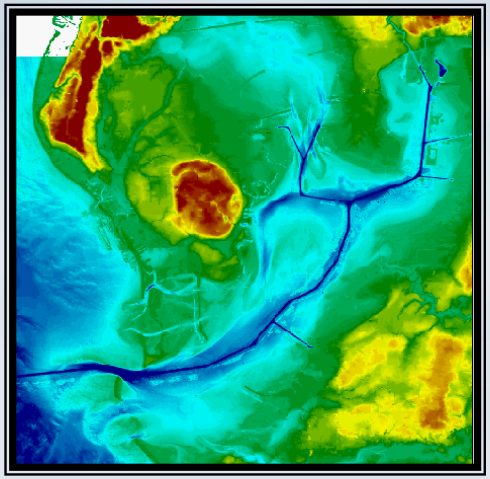


Bathymetry

VDatum



Topo/ Bathy Digital Elevation Model

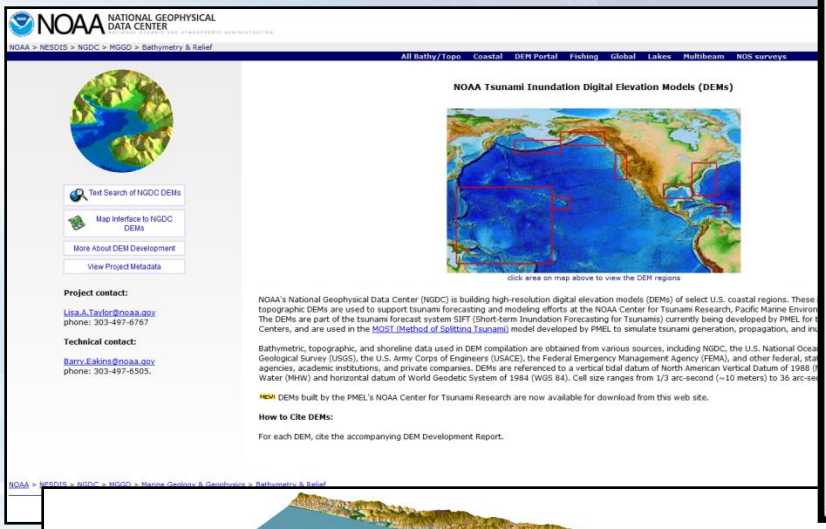


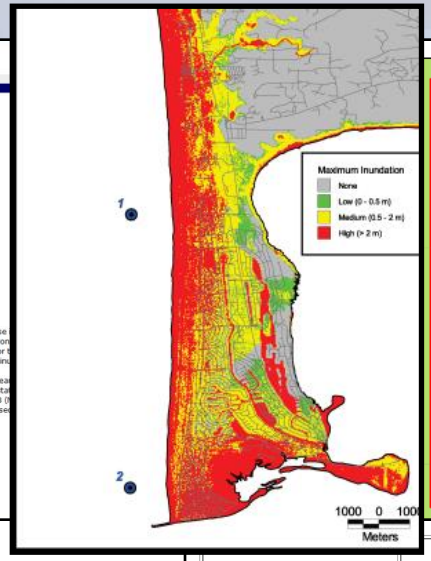
Applications for Seamless Bathy/Topo Datasets:

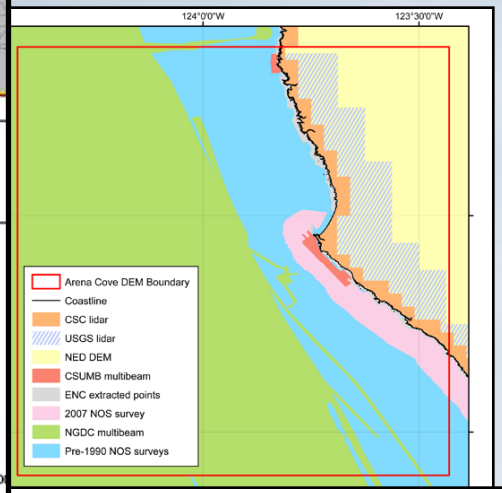
- Inundation modeling from storm surge, tsunamis, and sea level rise.
- Erosion, accretion, renourishment
- Analyzing storm impacts
- Determining setback lines
- Determining local, state, and national boundaries
- Navigation products and services
- Habitat restoration
- Shoreline Change Analysis
- Analyzing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

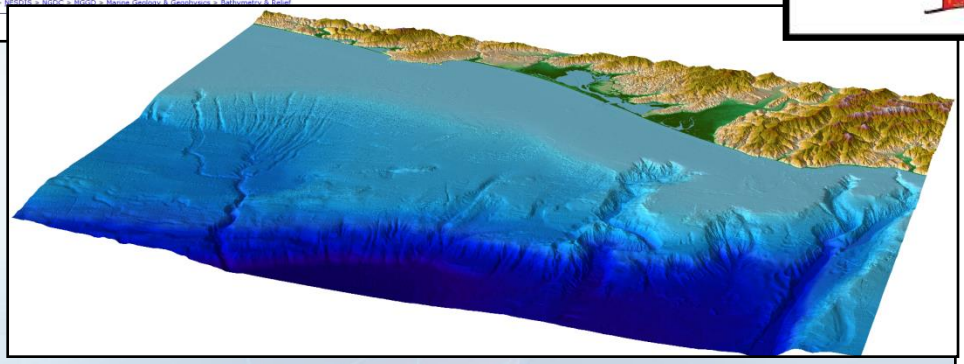
National Oceanic and Atmospheric Administration

Utilizing VDatum for Digital Elevation Model Creation: Tsunami Inundation





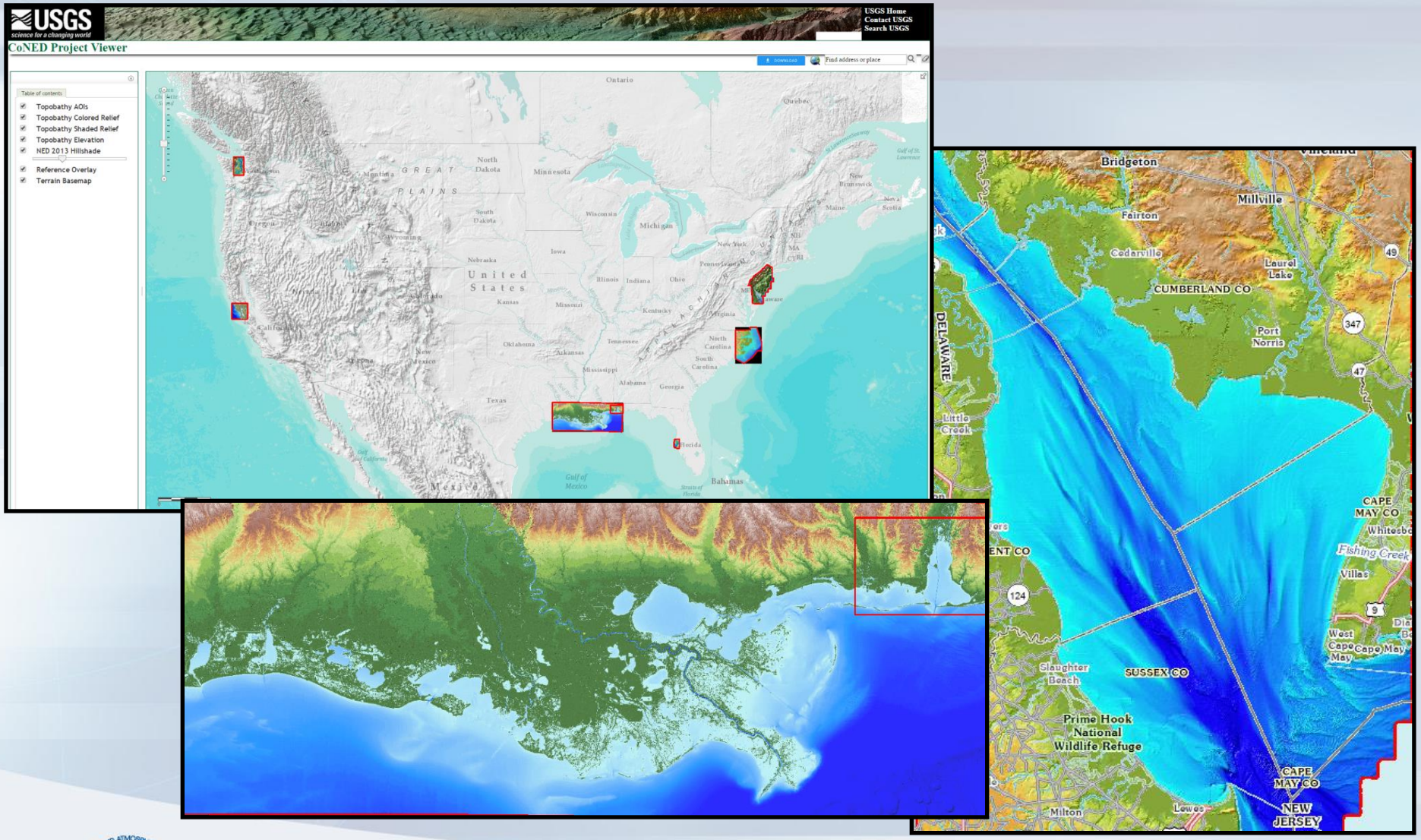




Source	Year	Data Type	Spatial Resolution	Original Horizontal Datum/Coordinate System	Original Vertical Datum
NGDC	1921 to 2008	NOS hydrographic survey soundings	Ranges from less than 10 m to 600 m (varies with scale of survey, depth, traffic, and probability of obstructions)	NAD 83 geographic	MLLW
NGDC	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

Utilizing VDatum for Digital Elevation Model Creation



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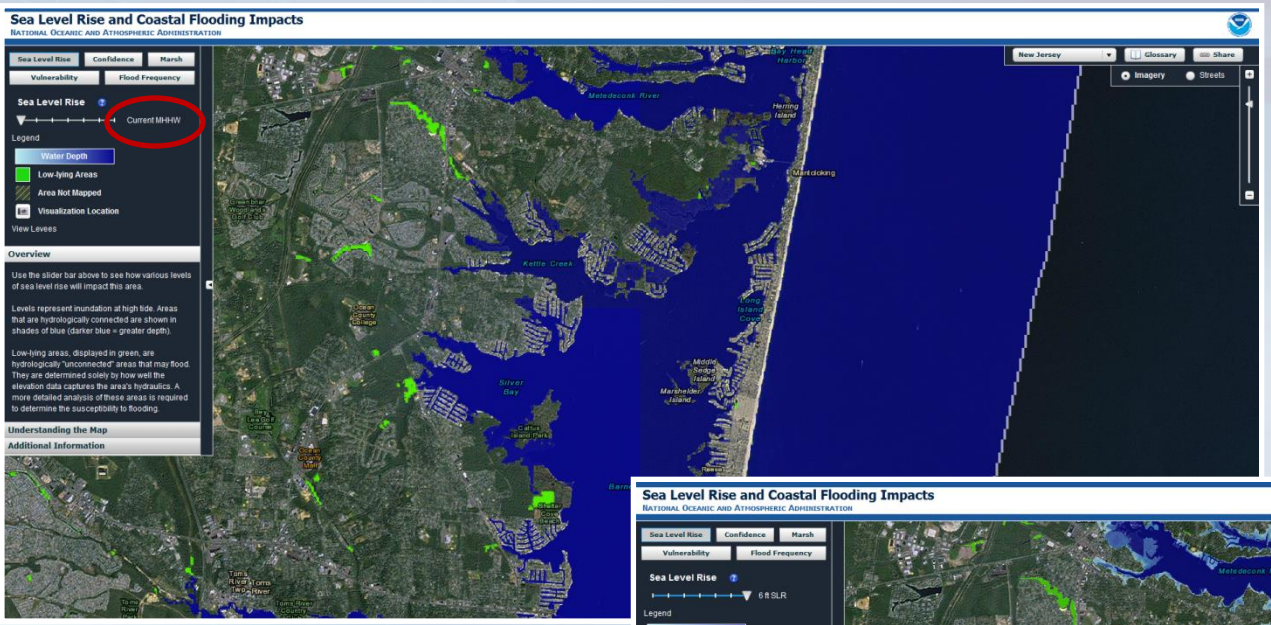
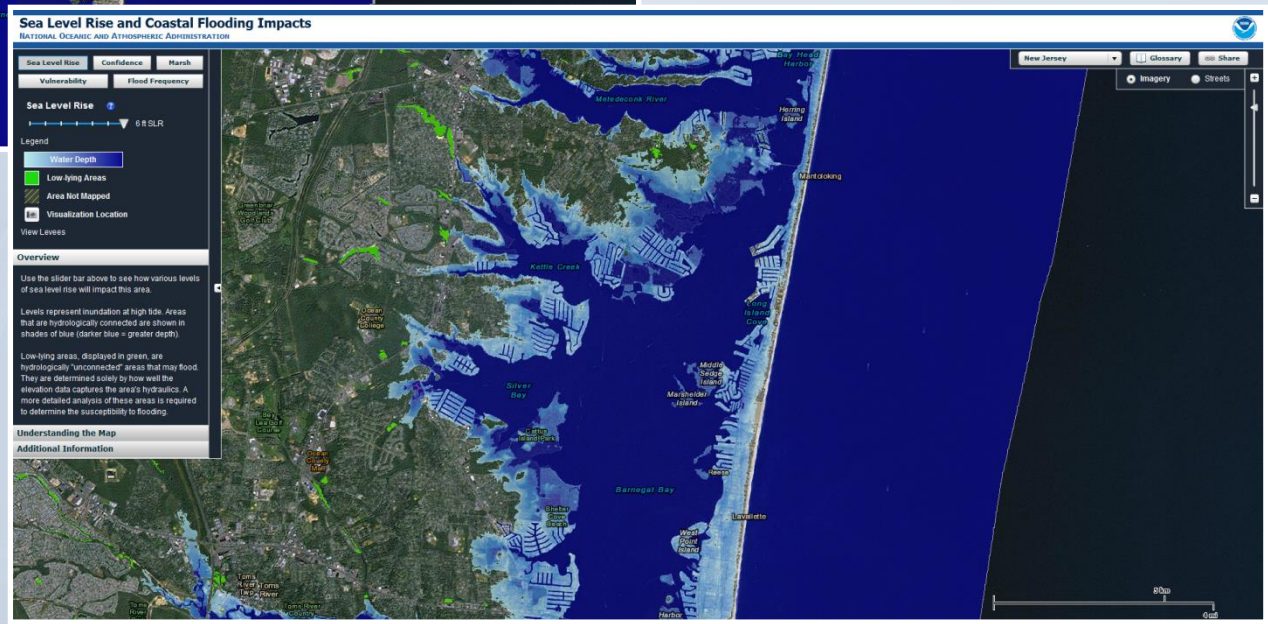
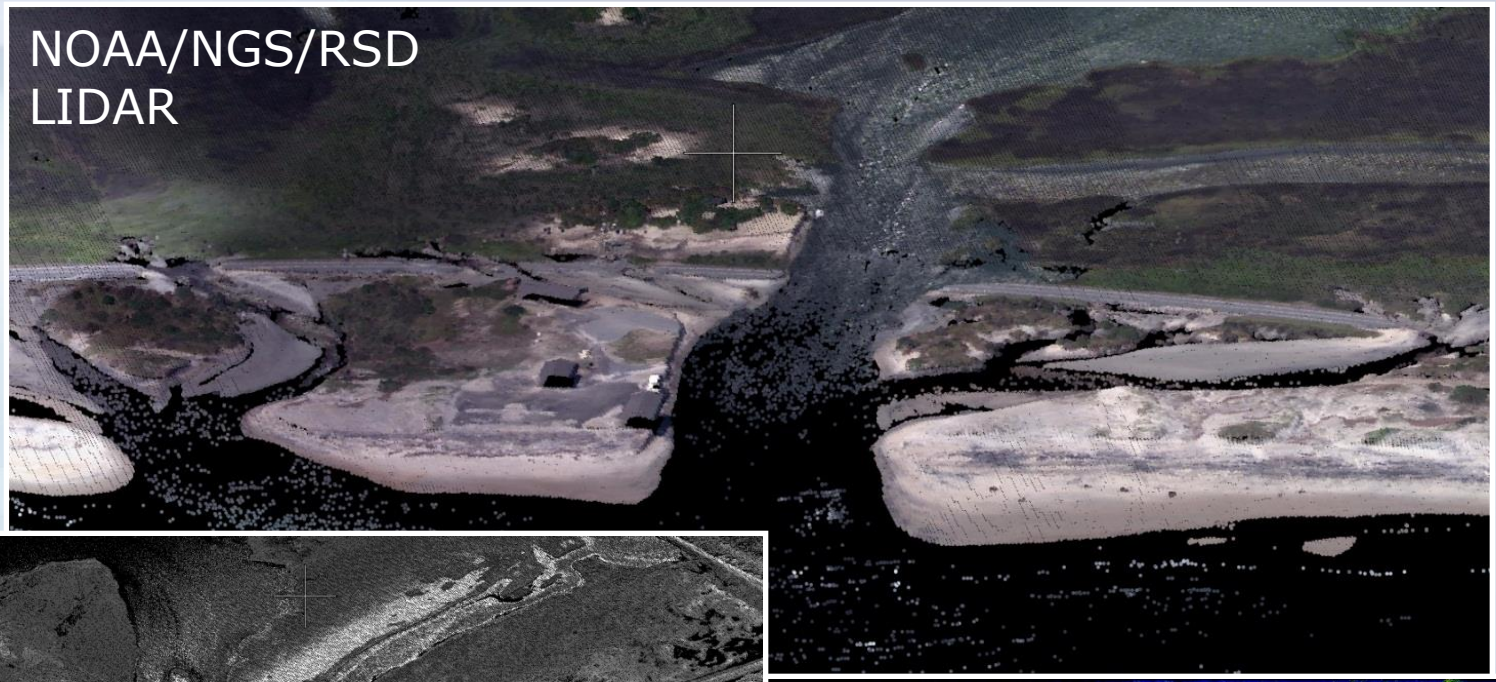
Sea Level Rise/Coastal Flooding

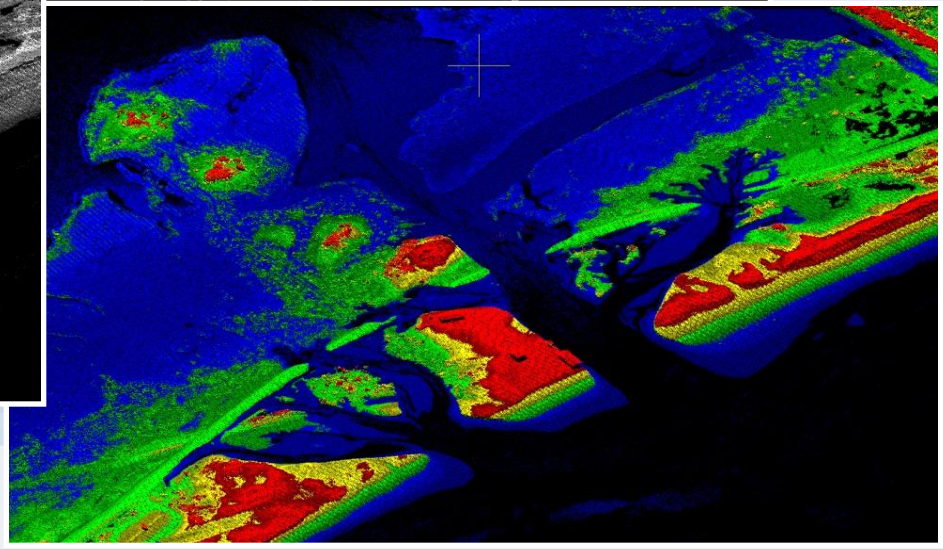




National Oceanic and Atmospheric Administration

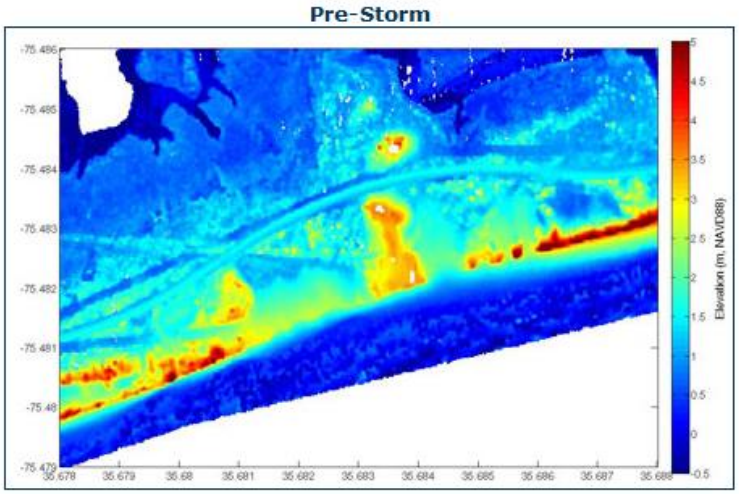
Emergency Response

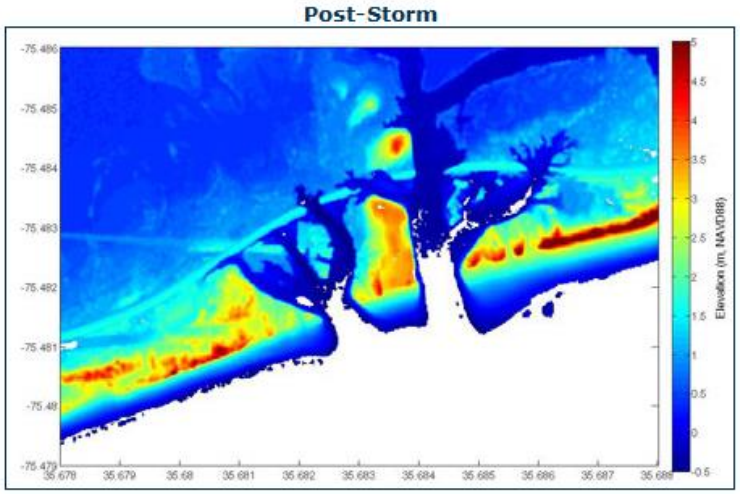


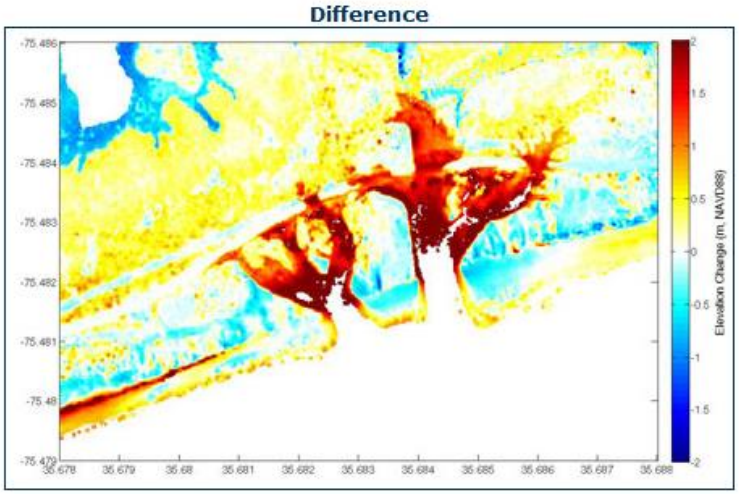


National Oceanic and Atmospheric Administration

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

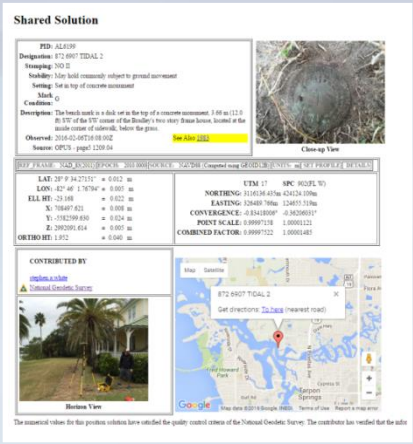
Summary

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.

What we need from you:

- Assistance collecting GPS on tidal benchmarks

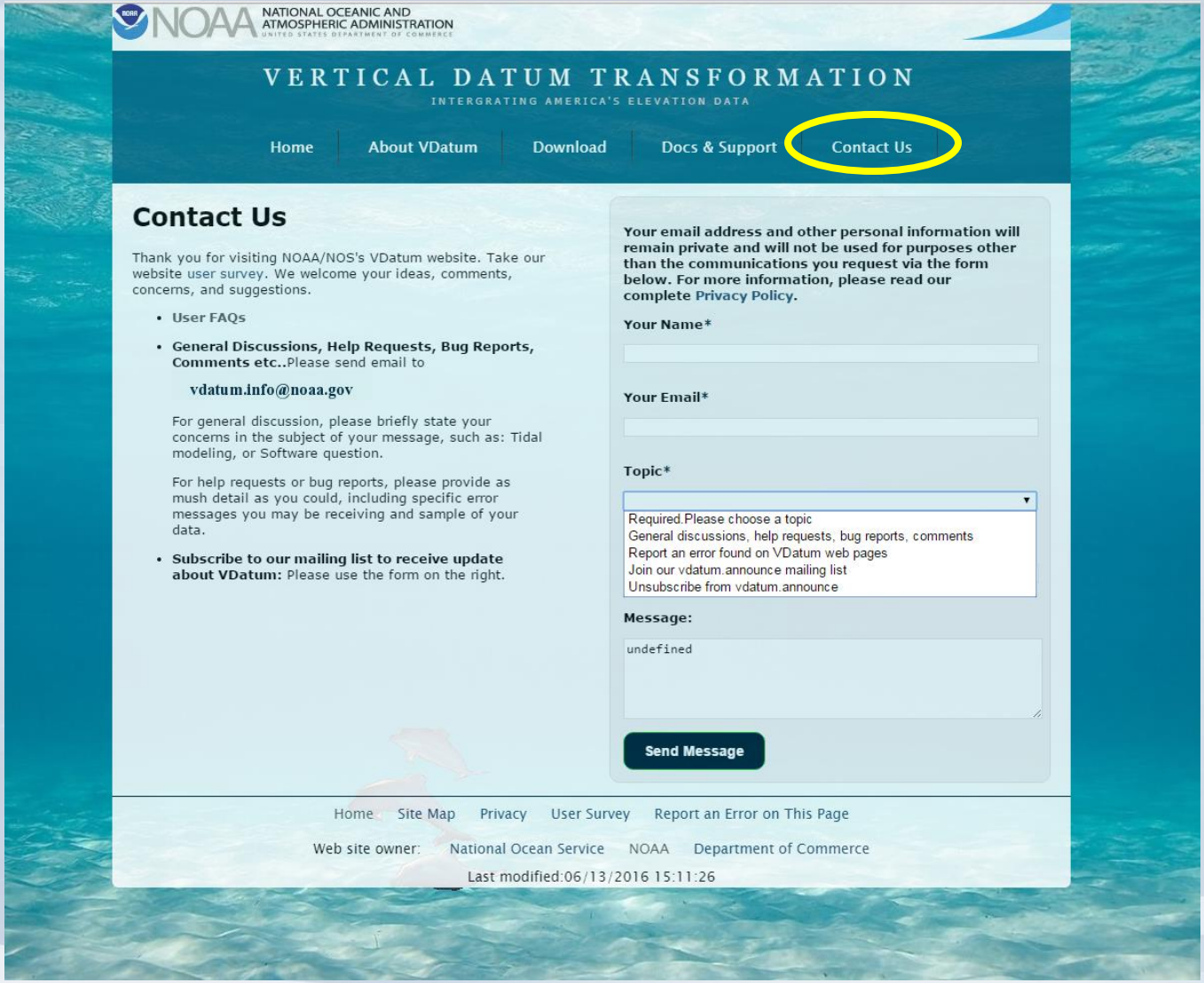


- Problems (Software or Models)

- Enhancements

National Oceanic and Atmospheric Administration

VDatum: Contact Us



National Oceanic and Atmospheric Administration

Thank You!

Contact Information:

Email: ***vdatum.info@noaa.gov***

Website: ***http://vdatum.noaa.gov***

Stephen White

Email: stephen.a.white@noaa.gov

Phone: (301) 713-1428 x167

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