



# 36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018

Baltimore, Maryland | July 30 – August 3, 2018

*The State of the Art and Science of Coastal Engineering*

National Geodetic Survey Positioning America for the Future

[geodesy.noaa.gov](http://geodesy.noaa.gov)



## Replacing NAVD88: Effects Of Vertical Datum Modernization On Coastal Engineering

Nicole Kinsman, Alaska Geodetic Advisor, Ph.D.

*NOAA National Geodetic Survey*





*Allure of the Seas* passes under the Store Belt Bridge, Denmark (October, 2011)

# Importance of Vertical Datums to Coastal Engineering (in pictures)



Container barge in Bergum, Netherlands (C. Fries, 2011)



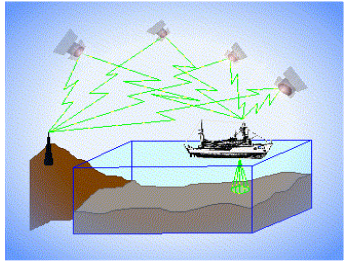
*Tianjin* passes under the Talmadge Bridge, Georgia (Steve Bisson, 2015)



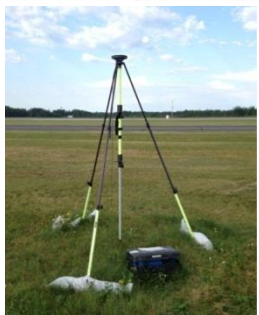


# 3 Categories of Vertical Datums

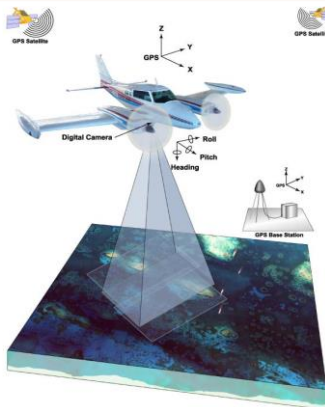
## Ellipsoidal



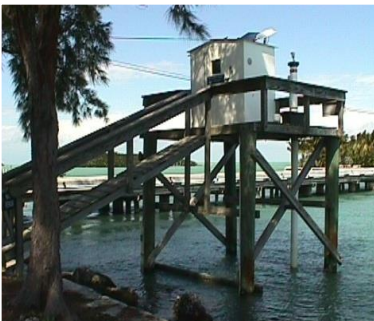
*Raw Hydrographic Surveys vertically referenced with RTK-GPS*



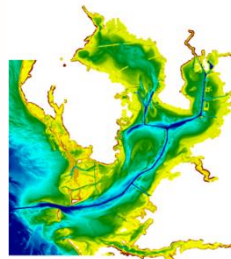
*Native GPS measurements*



*Raw Lidar*

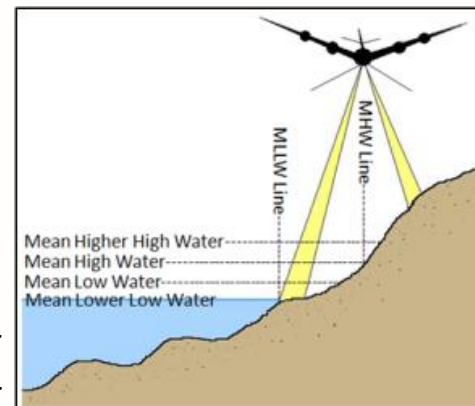


*Daily and Extreme Water Levels*



**Tidal**  
NOAA Bathymetry (MLLW)

*Shoreline Mapping (MHW) and Regulatory Boundaries at the Coast*



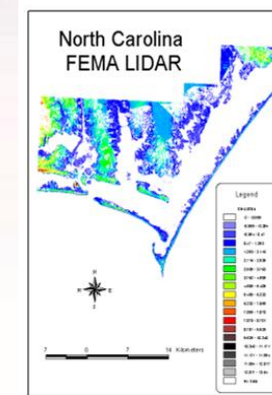
## Orthometric



*USGS Topography*



*Engineering and Development Site Surveys*



*FEMA Flood Insurance Rate Maps*



# The National Spatial Reference System (NSRS)

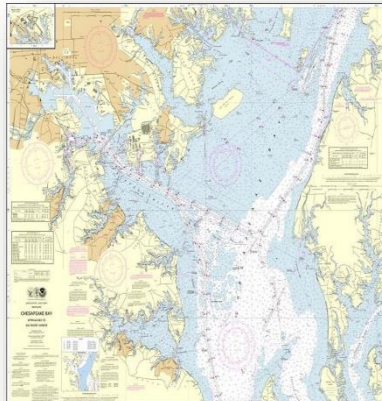
A **common** and **consistent** geospatial framework to meet the economic, social, and environmental positioning needs of our Nation.

Foundational elements include:

Latitude • Longitude •  
Elevation • Gravity •  
Shoreline Position  
+ changes over time



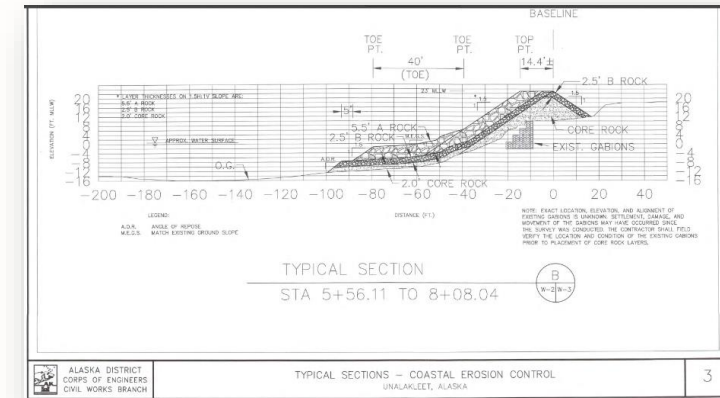
+



+



=



Reliable design heights require data from disparate sources and dates be consistently aligned

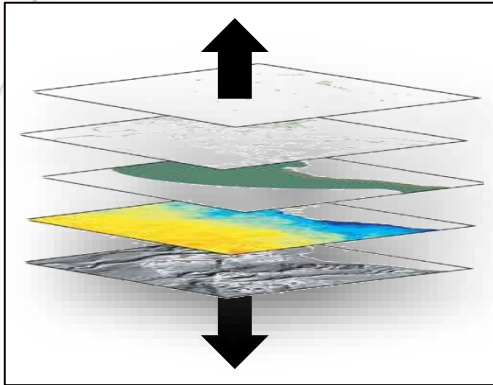




# NSRS Considerations – The 4 C's

## Requirements

### CONSISTENCY



### CONVENIENCE



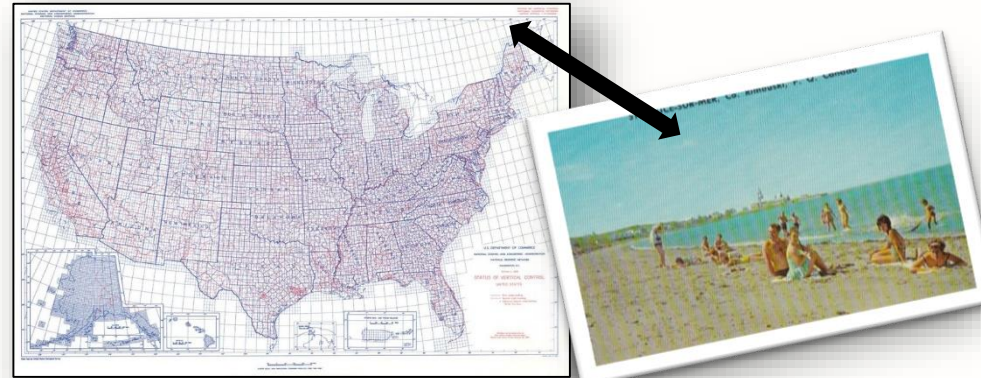
## Expectations

### Semi-CONSTANT Coordinates

*stamped with  
elevation*



### COHERENCE with Sea Level





# The NSRS of Today (*simplified*)

Primary elements:

- Horizontal North American Datum of 1983 - **NAD 83(2011)** coordinates
- Vertical North American Vertical Datum of 1988 - **NAVD88** orthometric heights

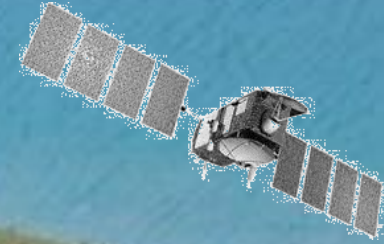
These elements are **geodetic datums** that define the shape and size of the earth to enable precise positioning

*System based on connections to published passive control*



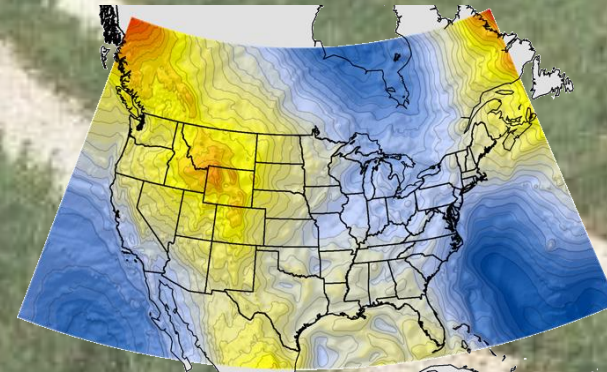


# NGS Supports Access to NAVD88 Heights



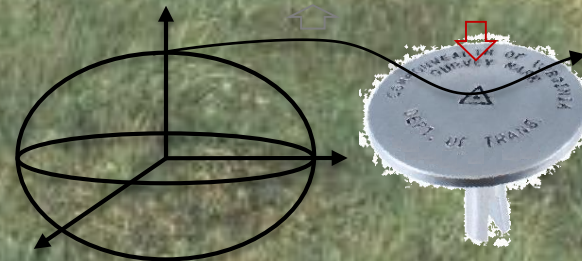
official path

**GEOID12B**



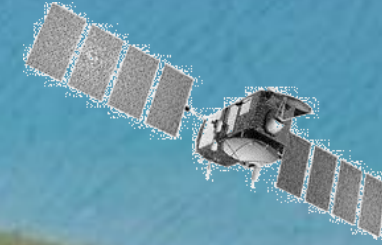
## The NGS Data Sheet

PROGRAM = databaset95, VERSION = 9.12.3  
1 National Geodetic Survey, Retrieval Date = SEPTEMBER 27, 2017  
C30146 \*\*\*\*\* This is a Tidal Bench Mark.  
C30146 TIDAL BM - JOHNSON  
C30146 DESIGNATION - C30146  
C30146 FID - SC/CHARLESTON  
C30146 STATE/COUNTY - US  
C30146 COUNTRY - CHARLESTON (1989)  
C30146 USGS QUAD -  
C30146 \*CURRENT SURVEY CONTROL  
C30146  
C30146  
C30146 WAD 88(2001) POSITION- 32 45 05.94606(N) 079 53 51.69504(W) ADJUSTED  
C30146 NAVD 88 ORTHO HEIGHT - 2.446 (meters) 8.02 (feet) ADJUSTED  
C30146 NAVD 88 ORTHO HEIGHT - -25.200 (meters) GEOID12B  
C30146 GEOID HEIGHT - -2.01 (meters) DEFLEC12B  
C30146 LAPLACE CORR - 2.442 (meters) COMP NAVD 88  
C30146 DYNAMIC HEIGHT - 979,535.3 (mgal)  
C30146 MODELED GRAVITY -  
C30146 HORIZ ORDER - THIRD CLASS I  
C30146 VERT ORDER - FIRST  
C30146 The horizontal coordinates were established by classical geodetic methods  
C30146 and adjusted by the National Geodetic Survey in March 2004.  
C30146 The orthometric height was determined by differential leveling and  
C30146 adjusted by the NATIONAL GEODETIC SURVEY  
C30146 in June 1991.  
C30146 Significant digits in the geoid height do not necessarily reflect accuracy.  
C30146 GEOID12B height accuracy estimate available here.  
C30146  
C30146 This Tidal Bench Mark is designated as VM 4219  
C30146 by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.  
C30146 The Laplace correction was computed from DEFLEC12B derived deflections.  
C30146  
C30146 The dynamic height is computed by dividing the NAVD 88  
C30146

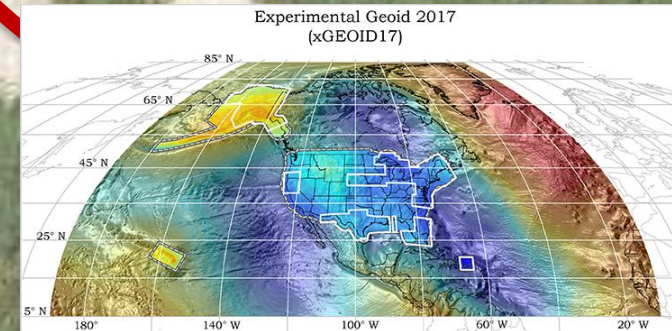




# NGS Will Support Access to the NSRS of the Future



**GEOID 2022**



**official path**

**Shared Solution**

**PD:** 888888  
**Designation:** LARRIMORE 2006  
**Stability:** May be held continuously subject to ground movement  
**Setting:** Object held continuously subject to ground movement  
**Description:** This station is established to permanently commemorate National Geographic Society Land Computer Specialist CRAIG B. LARRIMORE for his success in promoting access and maintenance for the National Spatial Reference System. This mark demonstrates the total use of the Internet to automatically upload, process, adjust, archive, and display field survey data, made possible through Craig's efforts.  
**Note:** The station resides within a memorial garden on private property. Recovery is not recommended.  
**Observed:** 2006-01-12T15:59:00Z  
**Source:** OPUS - pages 1209.04

**Click-up View**

**REF FRAME:** NAD 83(2011) **EPOCH:** 2010.0000 **WGS84:** NAVD83 (Computed using GEOID17) **UNITS:** m **REF PROFILE:** DETAILS

LAT		LONG		UTM 18		SPC 4701(WV N)	
99° 23' 51.77100"	+ 0.019 m	-177° 40' 21.55804"	+ 0.009 m	NORTHING:	4360880.958m	97391.754m	
ELL HT:	98.923 + 0.021 m			EASTING:	261128.820m	748840.721m	
				CONVERGENCE:	-1.75938721°	1.81016396°	
X:	1042792.598 + 0.009 m			POINT SCALE:	1.00030200	0.99995111	
Y:	4823830.607 + 0.024 m			COMBINED FACTOR:	1.00028708	0.99993559	
Z:	4023736.628 + 0.017 m						
ORTHO HT:	132.591 + 0.039 m						

**CONTRIBUTED BY**  
[Link to profile](#)  
National Geographic Society

**Horizon View**

**Map** **Satellite** **RIMORE 2006**  
Get directions [To here](#) (nearest road)

**Map data** ©2017 Google **Terms of Use** **Report a map error**



July 13, 2017



# The North American-Pacific Geopotential Datum of 2022 (**NAPGD2022**):

- Time-dependent and geocentric
- Defined by relationships to a global/international ideal frame
- Primarily accessed via GPS technology and a newly refined semi-dynamic geoid model

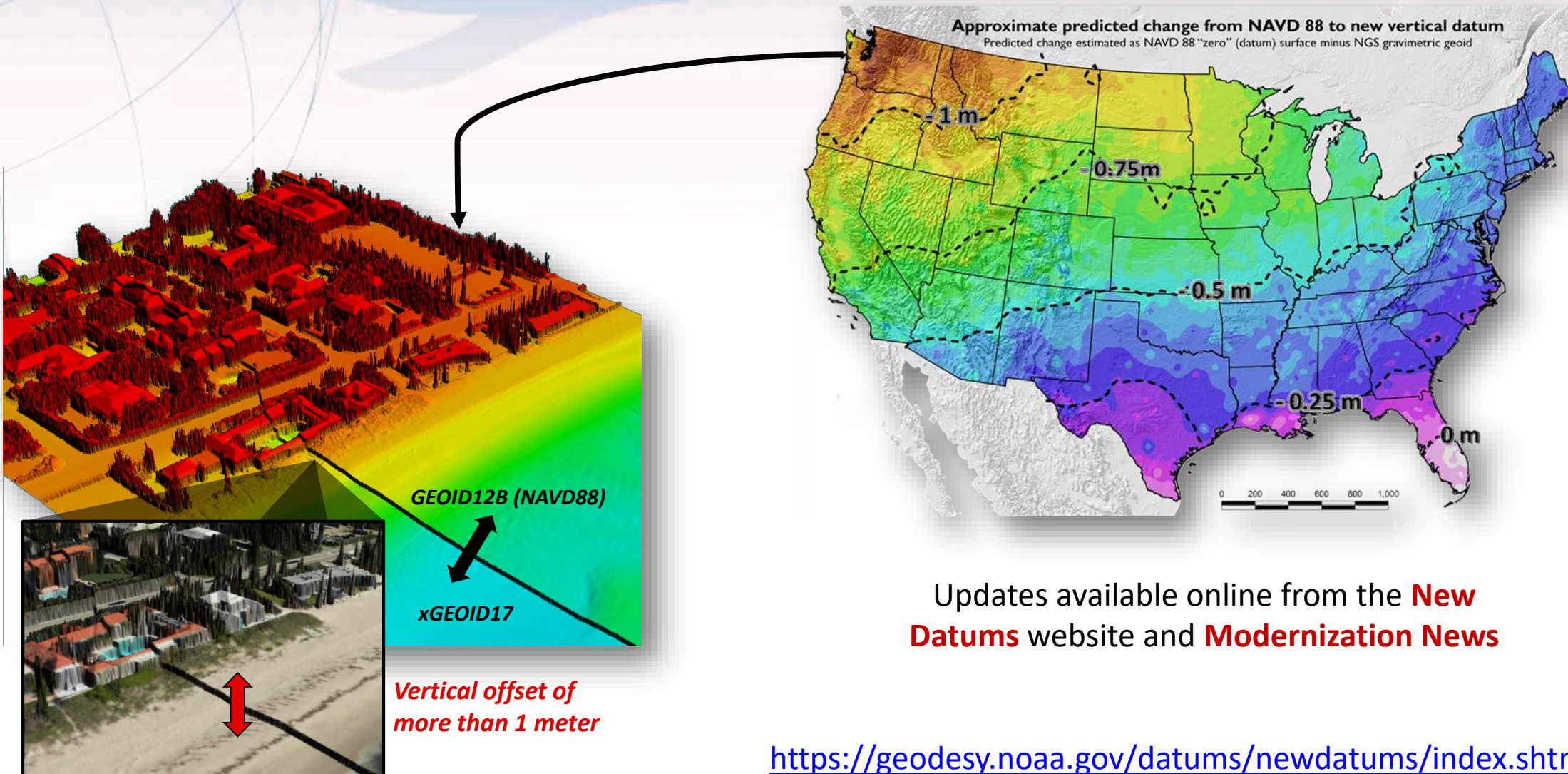
Benefits:

remove nationwide tilt  
UAS/UAV support  
improved subsidence/uplift monitoring  
international alignment  
NSRS access in remote areas  
improved tidal/geodetic ties





# NSRS Modernization: Vertical Change





# Continued Role of Passive Control



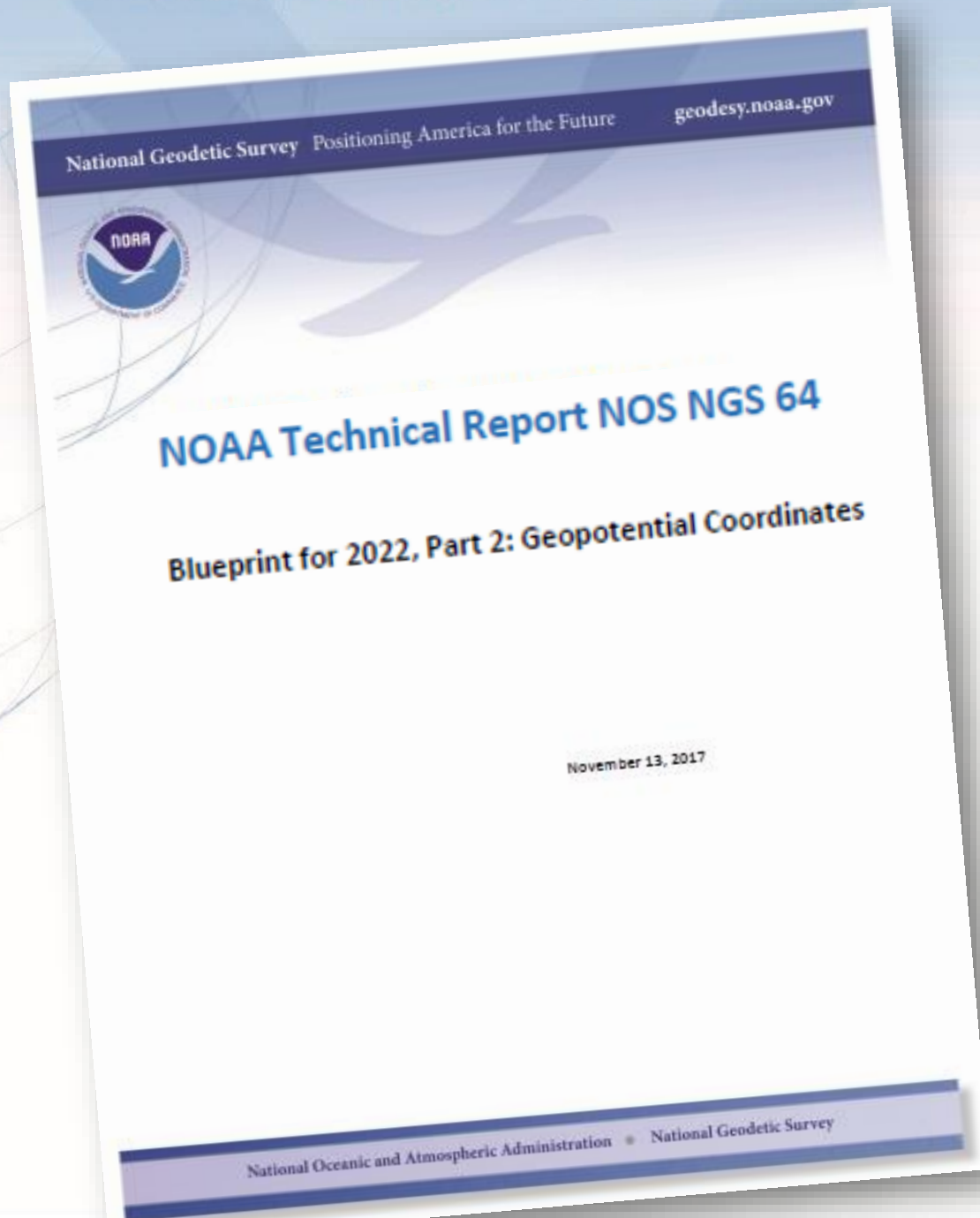
**Calibration** sites for GNSS technology, Real Time Network validation, and verification of datum transformation tool results.

Sites for **monitoring** motion to enhance velocity models (via repeat/campaign GNSS occupations)

**Convenience** for local project control, in areas with limited GNSS coverage (e.g. cities, forests), or in the event of GNSS failure (e.g. geomagnetic storms)







- Executive Summary
- An eloquent history of the role of leveling in 'Geodetic Control'
- Geoid Modeling 101
- Spherical Harmonics:  
*Gravitation, CF, and Gravity... oh my!*
- Does the geoid age well?
- Which comes first, the Sea Level or the GMSL  $W_0$  value?
- The many parts of the Geopotential Datum of 2022: *Creation, Use, and Maintenance*

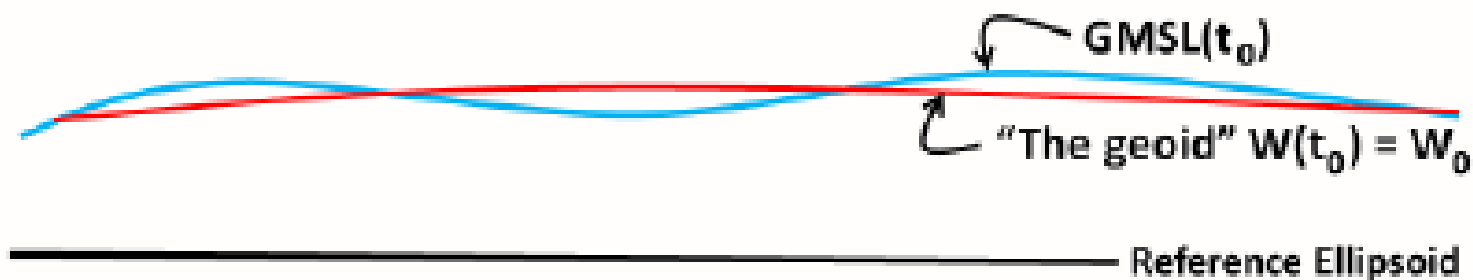
... GIVE IT A GLANCE!





# Sea Level and The Geoid

$$T = t_0$$



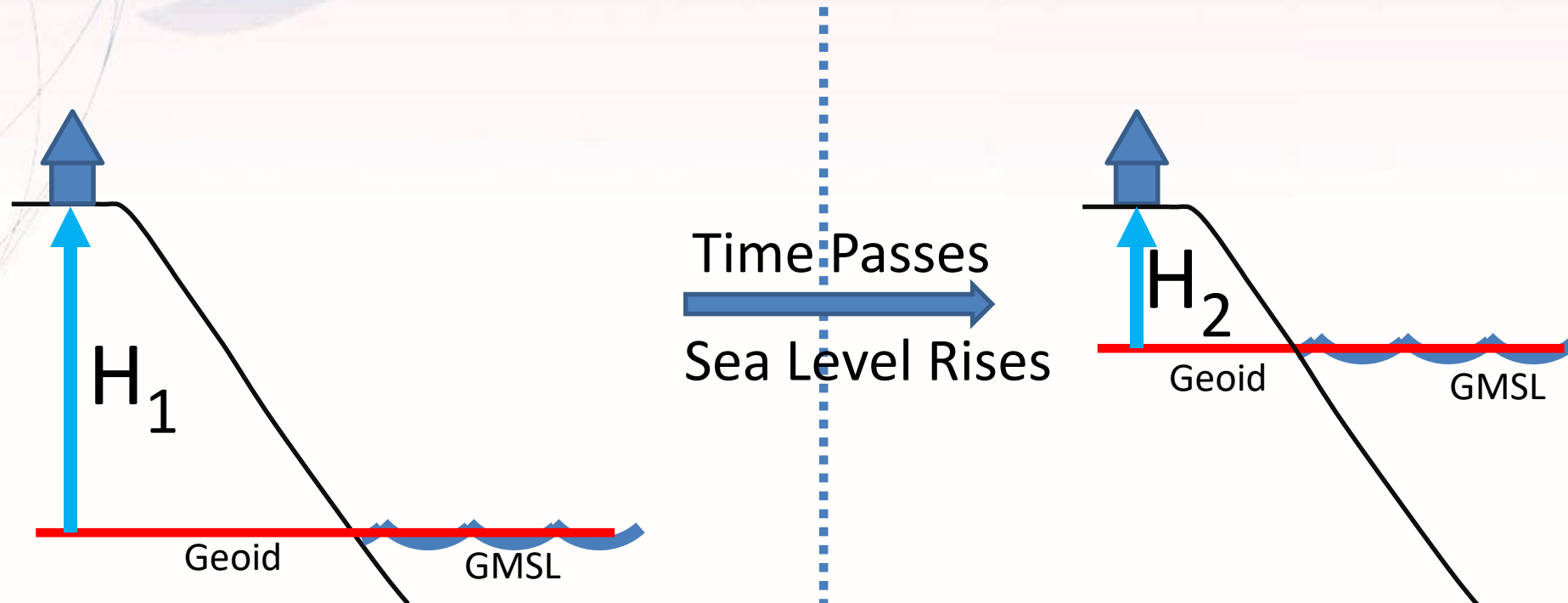
*Standing definition of geoid:*

*The equipotential surface of the Earth's Gravity Field which best fits, in a least squares sense, global mean sea level.*





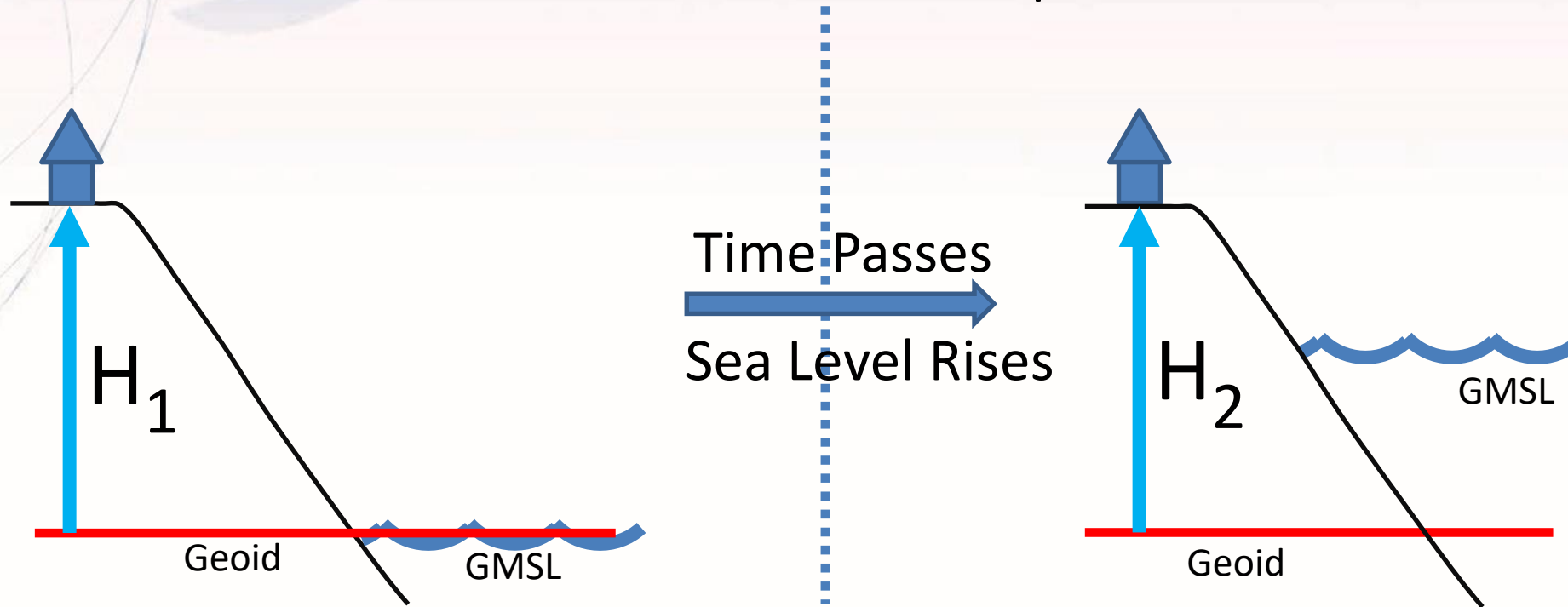
## Scenario 1: Geoid Definition remains tied to GMSL



As Global Mean Sea Level rises, orthometric height gets smaller





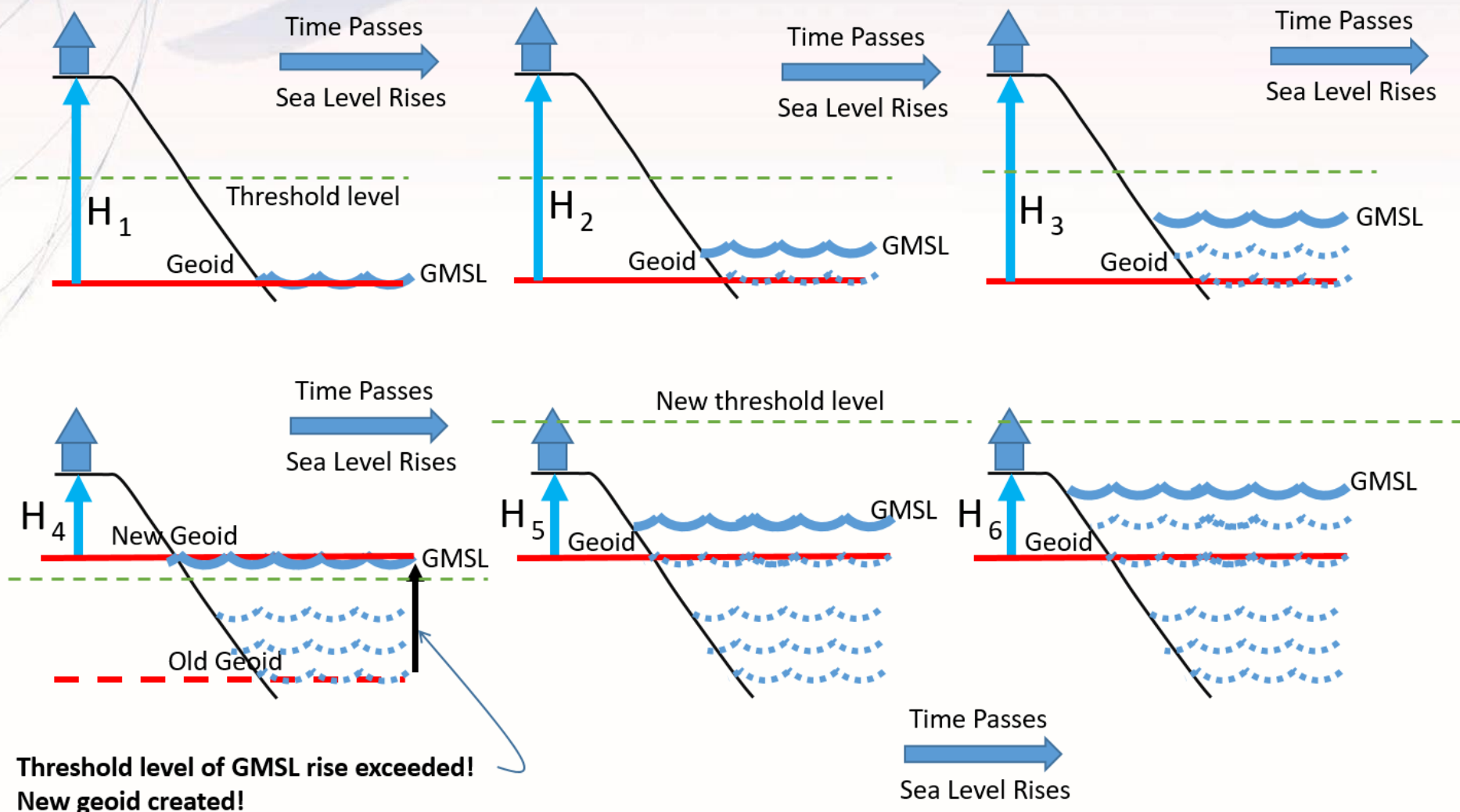
Scenario 2: Geoid Definition  
decoupled from GMSL

As Global Mean Sea Level rises, orthometric height remains constant





# The Threshold Compromise: Choosing a new geoid as GMSL changes



Threshold level of GMSL rise exceeded!  
New geoid created!

(Approximately 20cm of GMSL, or ~50-75 years)





# What can you do?

## Coordinate

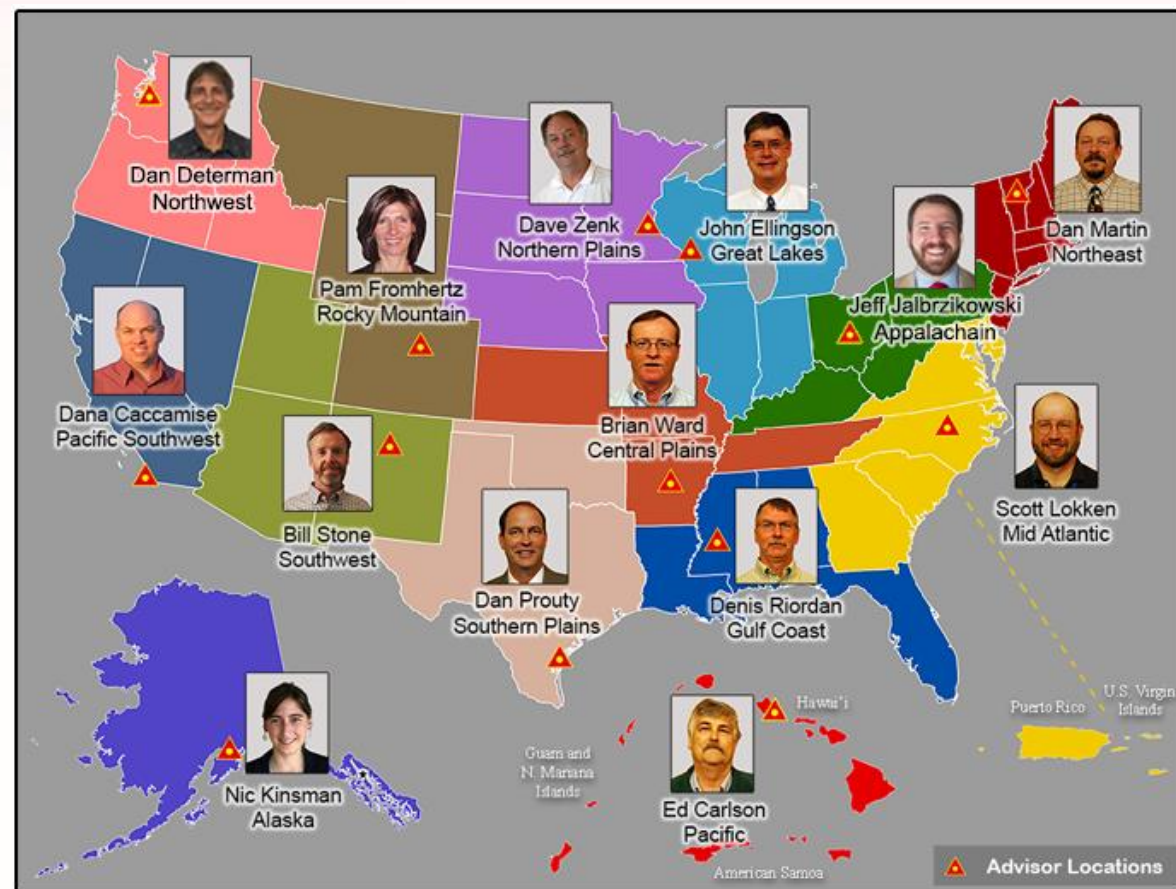
*Spread the word and tell others about NSRS Modernization*

## Educate

*Review materials and ask for support from NGS*


## Prepare

*Lead by example and use best metadata practices*



*NGS Regional Advisor Program can provide customized guidance*

# Resources from geodesy.noaa.gov




## National Geodetic Survey

Positioning America for the Future

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### New Datums

- Home
- What to expect
- Get prepared
- Track our progress
- Naming Convention
- Watch videos
- Related projects
- Learn more
- New Datums FAQ
- Contact Us

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### Events

- Industry Engagement
- 2017 Summit
- 2015 Summit
- 2010 Summit

### New Datums: Replacing NAVD 88 and NAD 83

NAD 83 and NAVD 88 will be replaced in 2022, and there are many related projects to make sure the transition goes smoothly. Read the **NGS Ten-Year Plan** to learn more and continue to visit this web-page for more information.

[What to Expect](#)[Get Prepared](#)[Track our Progress](#)[Naming Convention](#)[Watch Videos](#)[Related Projects](#)



### Why is NGS replacing NAD 83 and NAVD 88?

NAD 83 and NAVD 88, although still the official horizontal and vertical datums of the National Spatial Reference System (NSRS), have been identified as having shortcomings that are best addressed through defining new horizontal and vertical datums.

Specifically, NAD 83 is non-geocentric by about 2.2 meters. Secondly, NAVD

Visit  
*geodesy.noaa.gov* &  
click icon below



Coming  
in 2022:  
**New  
Datums!**  
Learn more...




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### Video Library


NGS, in partnership with **The COMET Program**, has developed short videos about topics related to geodesy and mapping. View or download our featured video or previous videos. Please visit the **COMET YouTube Channel** to view the **entire playlist**.




**What are Geodetic Datums?**




**How Were Geodetic Datums Established?**




**What Is the Status of Today's Geodetic Datums?**




**What's Next for Geodetic Datums?**




**Precision and Accuracy in Geodetic Surveying**




**Two Right Feet? U.S. Survey Feet vs. International Survey Feet**



**Geospatial Infrastructure for Coastal Communities: Informing Adaptation to Sea Level Rise**



**Best Practices for Minimizing Errors during GNSS Data Collection**



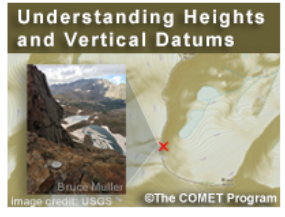
**The Importance of Accurate Coastal Elevation and Shoreline Data**

**COMET MetEd** Sign Up

HOME EDUCATION & TRAINING COMMUNITIES RESOURCES ABOUT MY METED

Lesson/Resource Listing » Description

## Understanding Heights and Vertical Datums



**Understanding Heights and Vertical Datums**

Languages: English  
Publish Date: 2015-03-31  
Skill Level: 0  
Completion Time: .75 - 1.00 h  
Includes Audio: yes  
Required Plugins: none  
Topics: Geospatial  
Included in Courses: Elements of Hydrography Distance Learning Course

**BEGIN LESSON**

Add to Queue Your Queue»

Take the quiz?

**Begin Quiz**

Share this resource:

Reviews: ★★★★★ (21 reviews)  
[Read or add reviews](#)

Videos are  
~3-5 minutes

Vertical Datums  
Tutorial is ~1 hour





Questions?

Nic Kinsman

[nicole.kinsman@noaa.gov](mailto:nicole.kinsman@noaa.gov)

[www.ngs.noaa.gov/datums/newdatums](http://www.ngs.noaa.gov/datums/newdatums)



ICCE  
2018

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