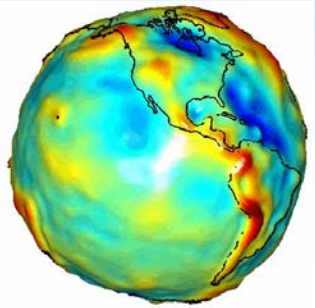
The Ongoing Modernization of the National Spatial Reference System

(New Datums Are Coming!)



Bill Stone

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AGIC Geospatial
Education & Training Symposium
September 19, 2018
Prescott

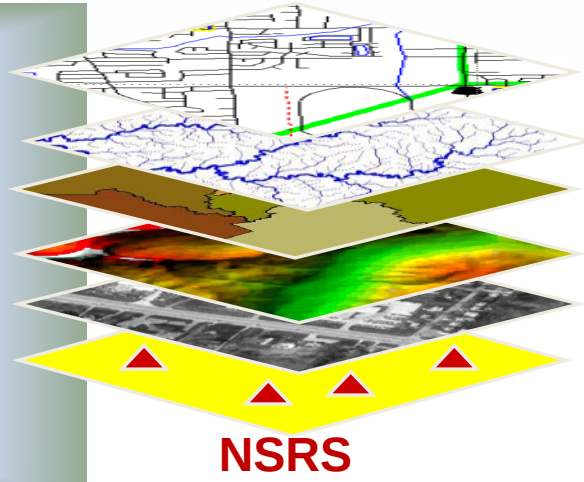
U.S. Department of Commerce
National Oceanic & Atmospheric Administration (NOAA)
National Geodetic Survey (NGS)

Mission: To ***define, maintain & provide access*** to the ***National Spatial Reference System (NSRS)*** to meet our Nation's economic, social & environmental needs

NSRS

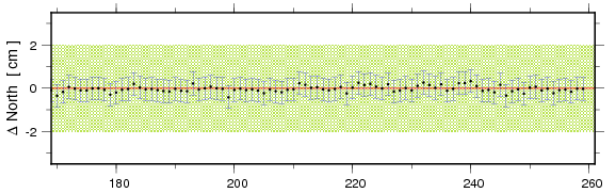
- Latitude
- Longitude
- Height
- Scale
- Gravity
- Orientation

& their time variations



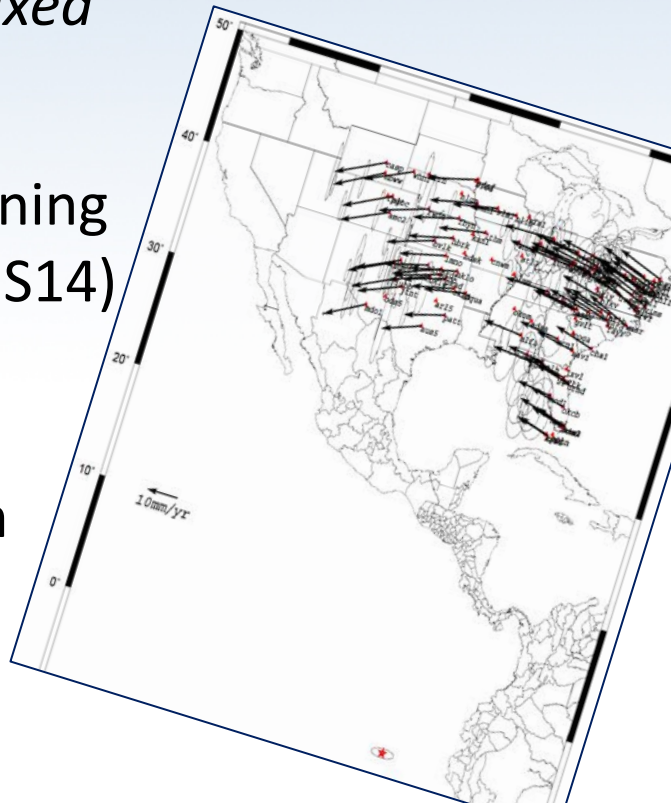
Why replace NAD 83 and NAVD 88?

- **Main driver:** ***Global Navigation Satellite System (GNSS)***
- **ACCESS!**
  - GNSS equipment is fast, inexpensive, reliable (and improving)
  - Reduces reliance on survey control monuments (passive control / "bench marks")
- **ACCURACY!**
  - Insensitive to distance-dependent errors
  - Immune to monument instability (relies on Continuously Operating Reference Stations)
- **CONSISTENCY!**
  - Eliminates systematic errors in current datums
  - Aligned with global reference frames
  - Integrated system for both position (latitude / longitude) and height ("elevations")



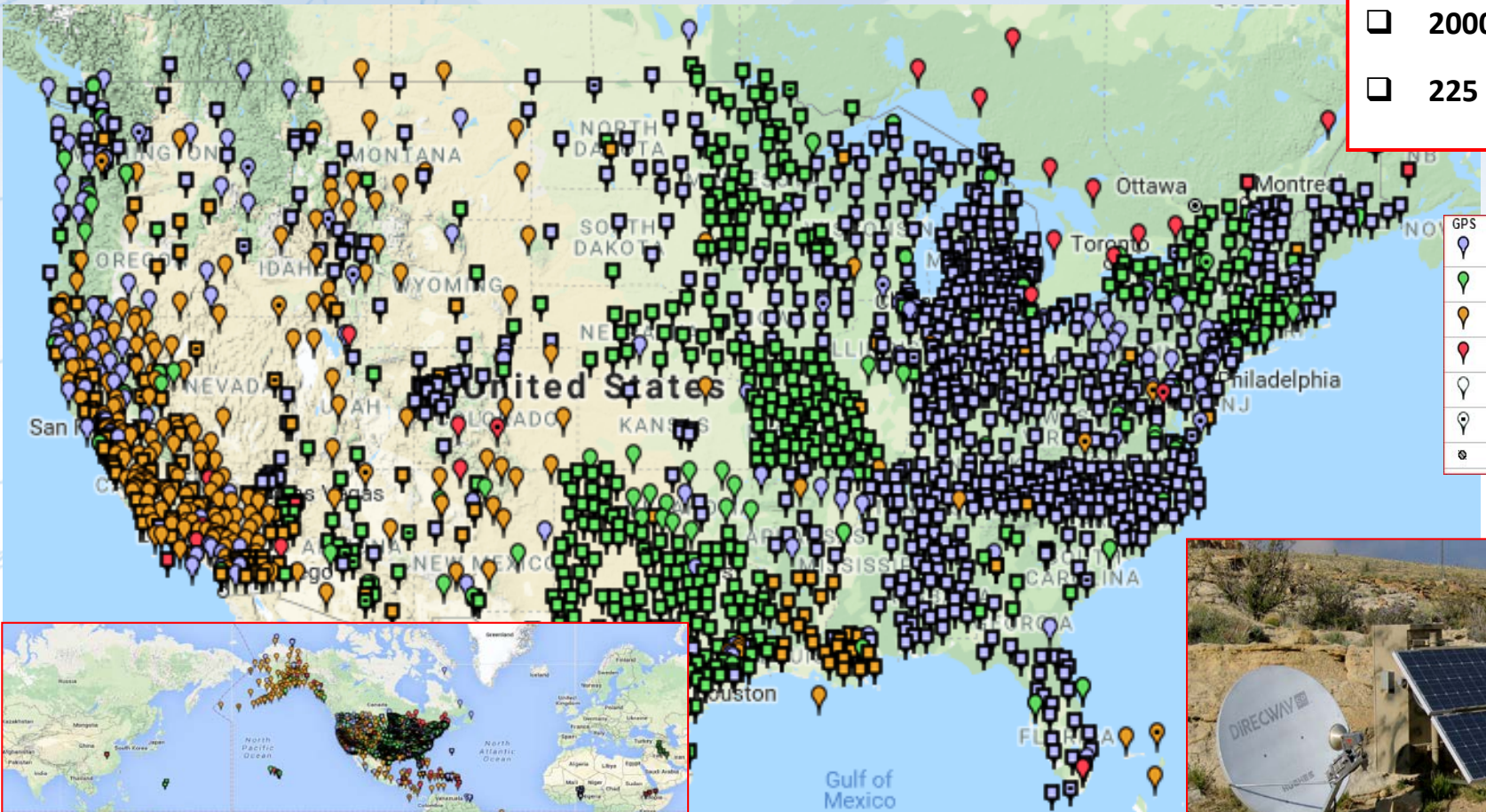
Replacing NAD83

- NAD83 will be replaced in 2022 by 4 "*plate-fixed*" reference frames
- removes non-geocentricity of NAD 83 by aligning w/ global Int. Terrestrial Reference Frame (IGS14)
- identical to IGS14 at 2020.00, then diverges
- removes most of tectonic plate rotation from IGS14 using updated **Euler Poles** >>>>>



Continuously Operating Reference Station (CORS) Network

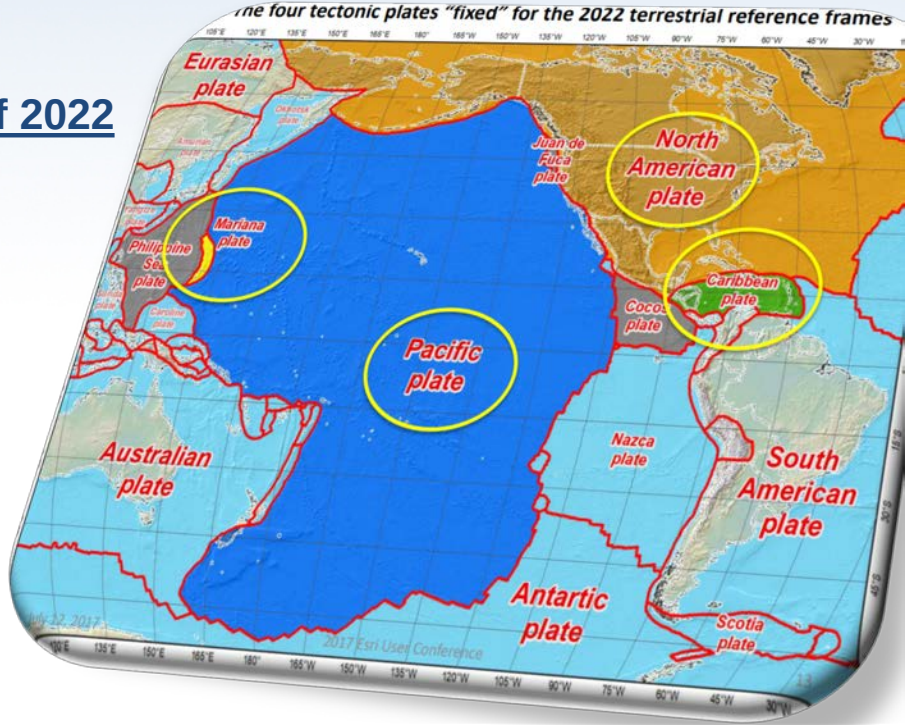
- ❑ 2000 sites
- ❑ 225 organizations



4 Reference Frames & Tectonic Plates

In 2022, the National Spatial Reference System will be modernized with
4 new geometric reference frames:

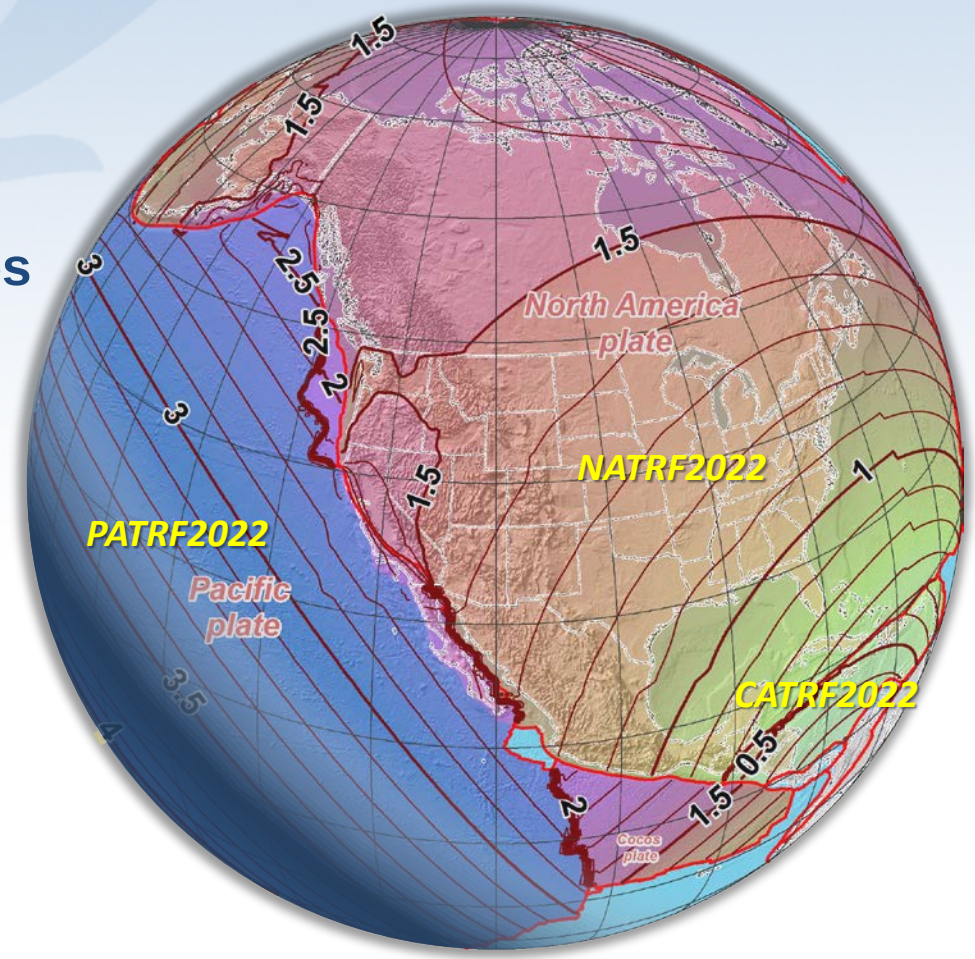
- **North American Terrestrial Reference Frame of 2022** (NATRF2022)
- Pacific Terrestrial Reference Frame of 2022 (PATRF2022)
- Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)
- Mariana Terrestrial Reference Frame of (MATRF2022)



NAD 83 (2011 / PA11 / MA11)

epoch 2010.00

→ 2022 Terrestrial Reference Frames



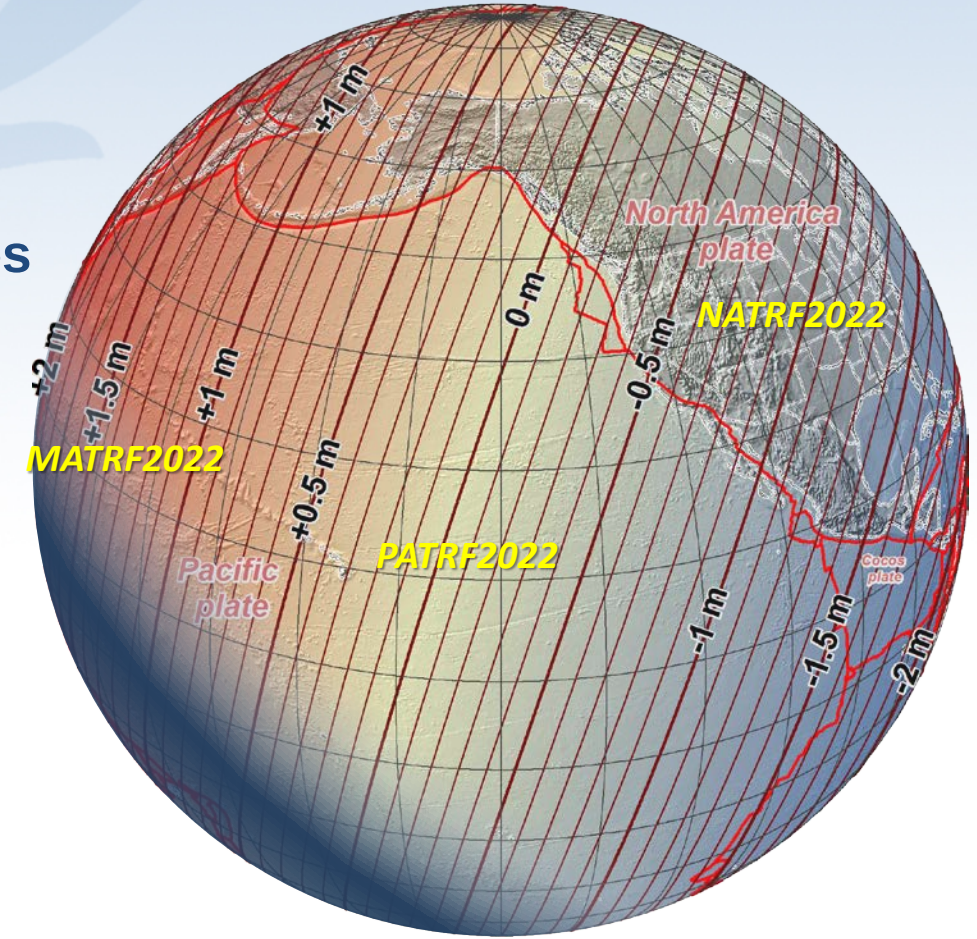
Horizontal change at epoch 2022.00

(contours in meters)

NAD 83 (2011 / PA11 / MA11)

epoch 2010.00

→ 2022 Terrestrial Reference Frames

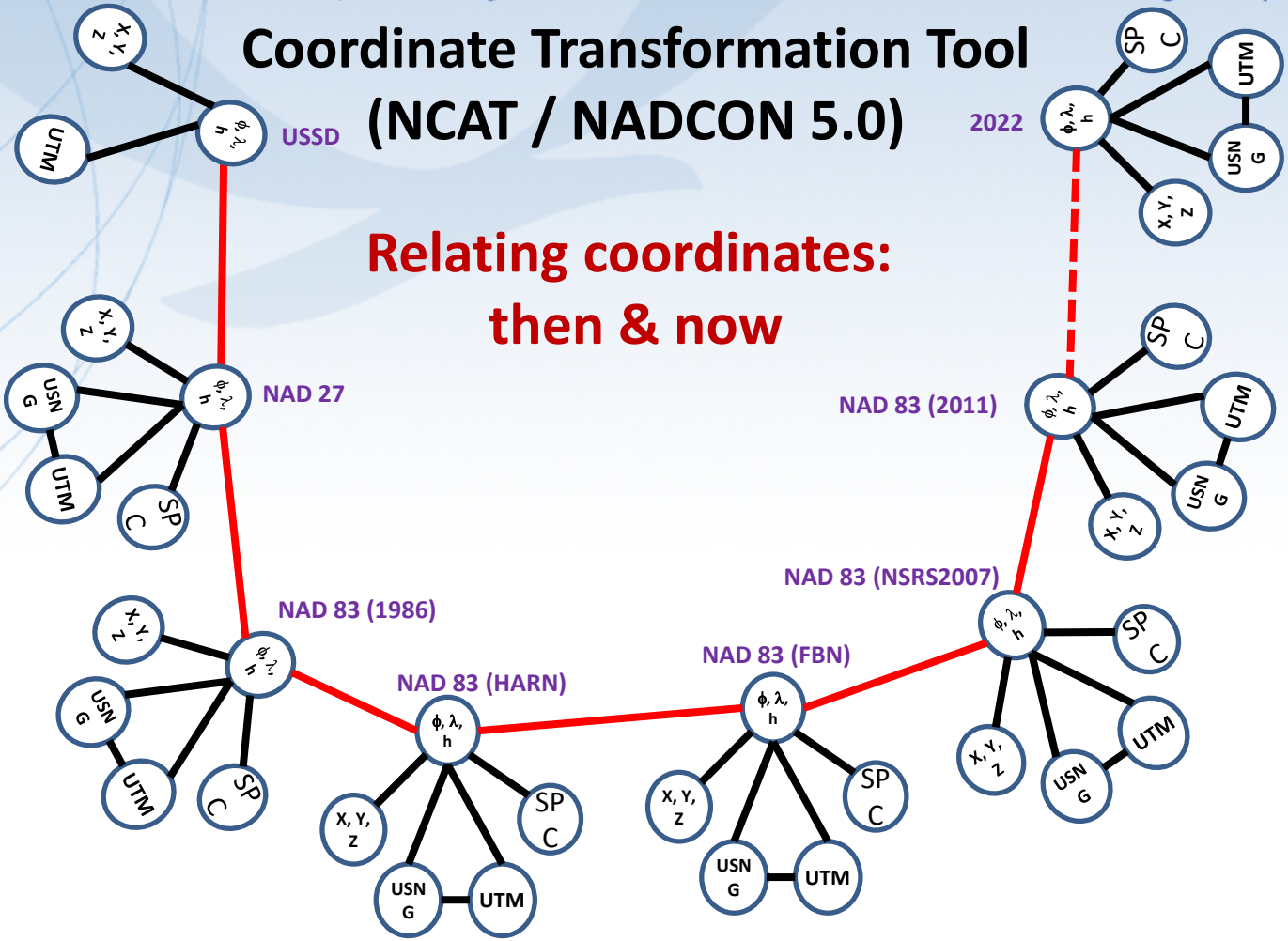


Ellipsoid Height change at epoch 2022.00

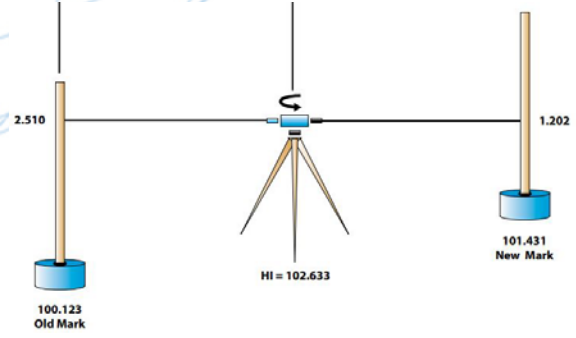
(contours in meters)

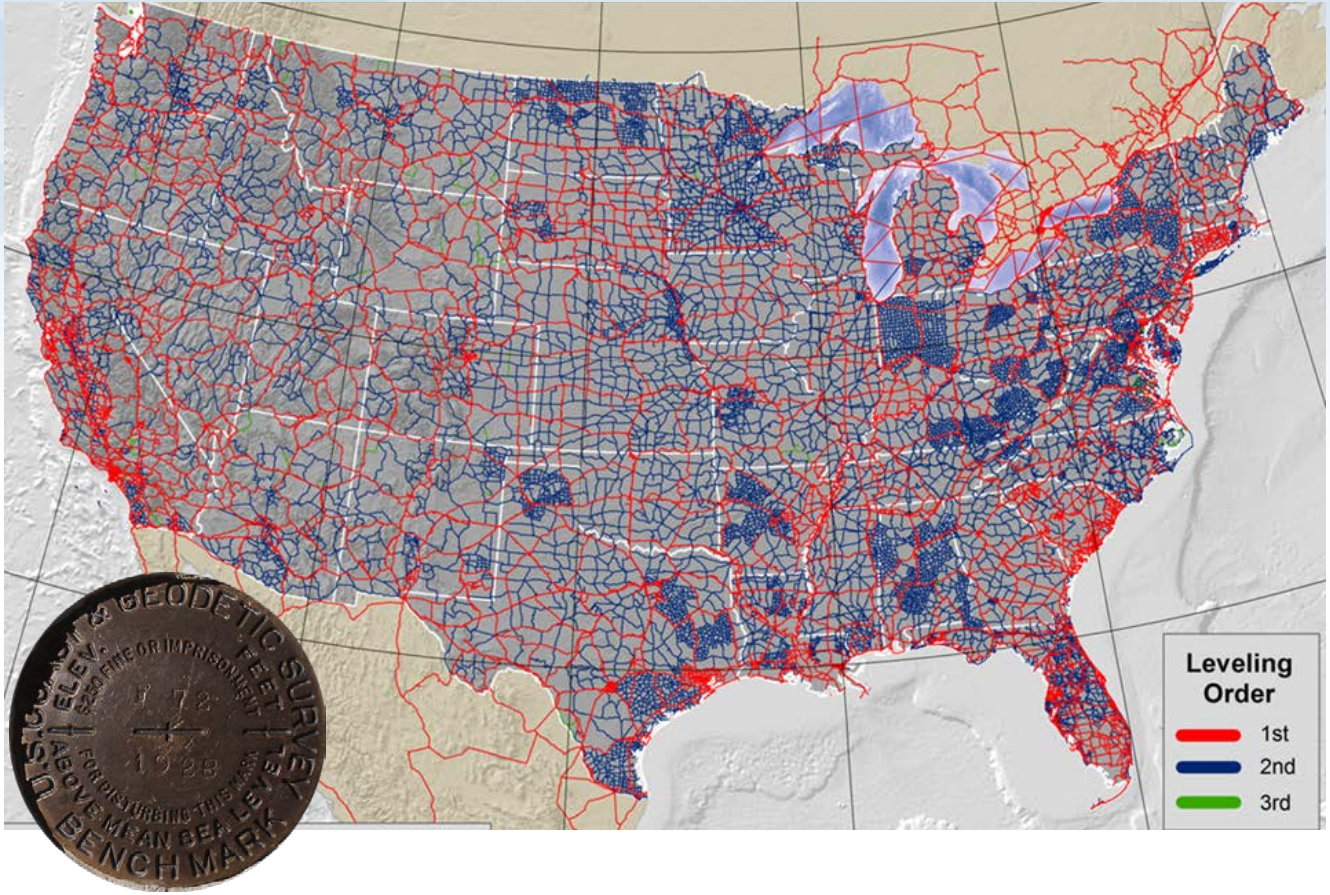
Coordinate Transformation Tool (NCAT / NADCON 5.0)

Relating coordinates: then & now



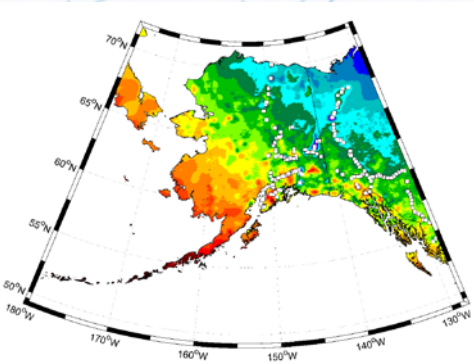
North American Vertical Datum of 1988 (NAVD88)

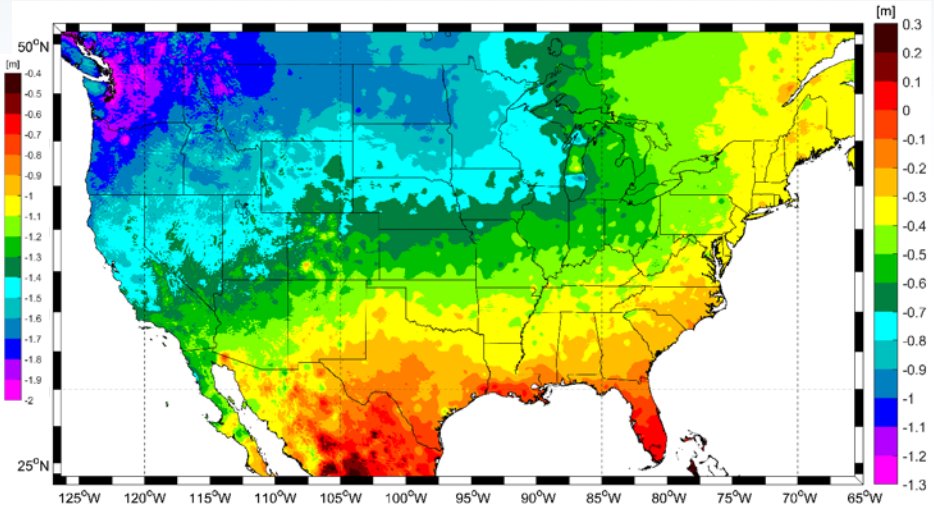




North American Vertical Datum 1988 Problems

- tilt / bias in zero reference surface
- subsidence, uplift, freeze / thaw of BMs
- limited access / availability





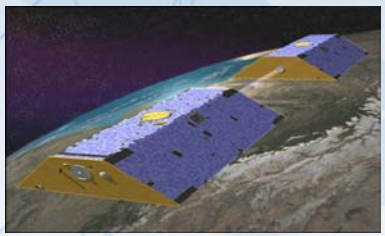
Approximate Error in NAVD88 H=0 surface

1925-1977 Subsidence
San Joaquin Valley, CA

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

- replace NAVD88, etc. in 2022
- access via GNSS & **gravimetric geoid** (+ leveling, per needs)
- aligned: 2022 Terrestrial Reference Frames (eg **NATRF2022**)
- most accurate continental gravimetric geoid (1-2 cm goal)
- referenced to global mean sea level
- geoid definition coordinated with Canada & Mexico
- monitor time-varying nature of gravity

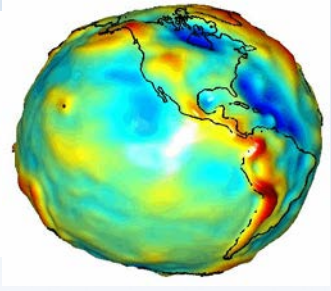
Building a Geopotential Field Model



GRACE / GOCE / Satellite Altimetry

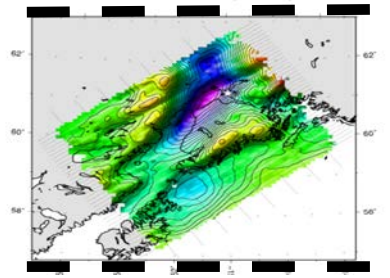
Long Wavelengths
(> 250 km)

+



Airborne Measurement

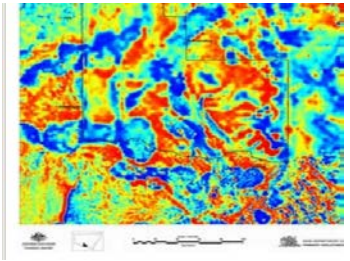
Intermediate Wavelengths
(300 km to 20 km)



Surface Measurement and
Predicted Gravity from Topography

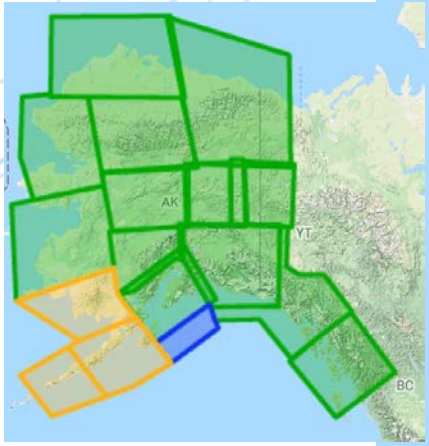
+

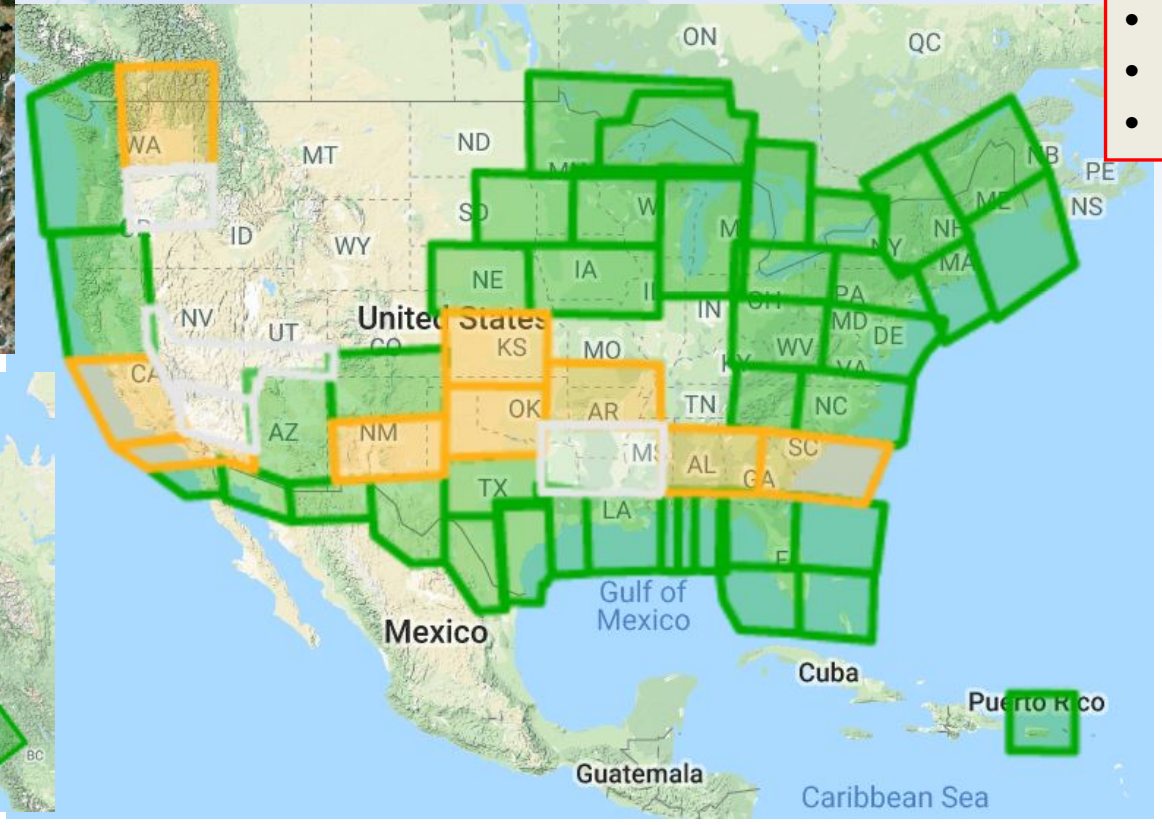
Short Wavelengths
(< 100 km)



Gravity for the Redefinition of the American Vertical Datum (GRAV-D)

- 10 km data lines
- 70 km cross lines
- 20,000 ft altitude
- 230 kt flight speed





Planned
Partially Collected
Processing
Released
Target Area

2018-Q3:
70% complete

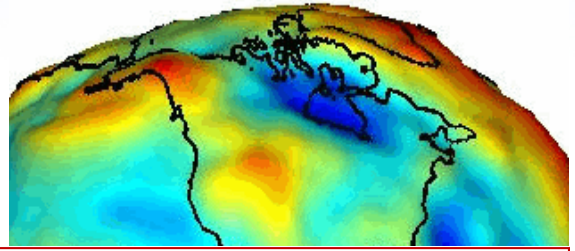
North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

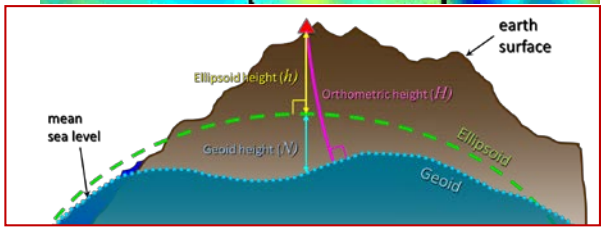
Gravity Potential Energy

$$V^{(1)}(r,\theta,\lambda) = \frac{(GM)_1}{r}\sum_{n=0}^{N}\left(\frac{a_1}{r}\right)^n \sum_{m=0}^{n}\left(\bar{C}_{n,m}cos(m\lambda) + \bar{S}_{n,m}sin(m\lambda)\right)\bar{P}_{n,m}(cos\theta)$$

>>> <u>global</u> geopotential field model (GM2022)

- orthometric height (elevation; via GNSS)
- geoid undulation (GEOID2022; 0 elev.)
- deflection of the vertical (DEFLEC2022)
- gravity anomalies (GRAV2022)

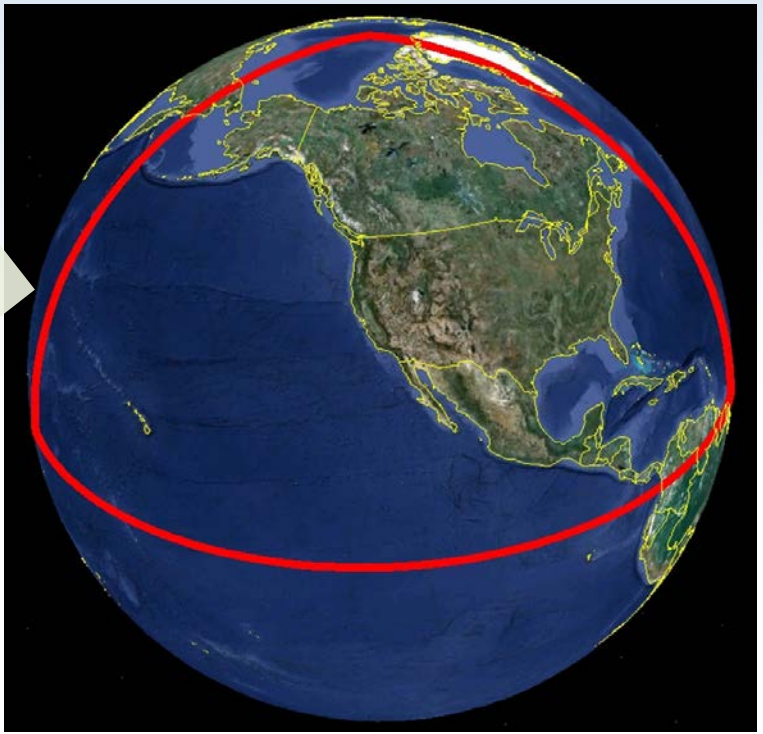




Current Vertical Datums / Models

- Orthometric Height
  - NAVD88
  - PRVD88
  - HVD09
  - ASVD02
  - GUVD04
  - IGLD85
  - IGSN71
  - GEOID12B
  - Deflec12B
- Normal Orthometric Height
- Dynamic
- Gravity
- Geoid Height
- Deflections of Vertical

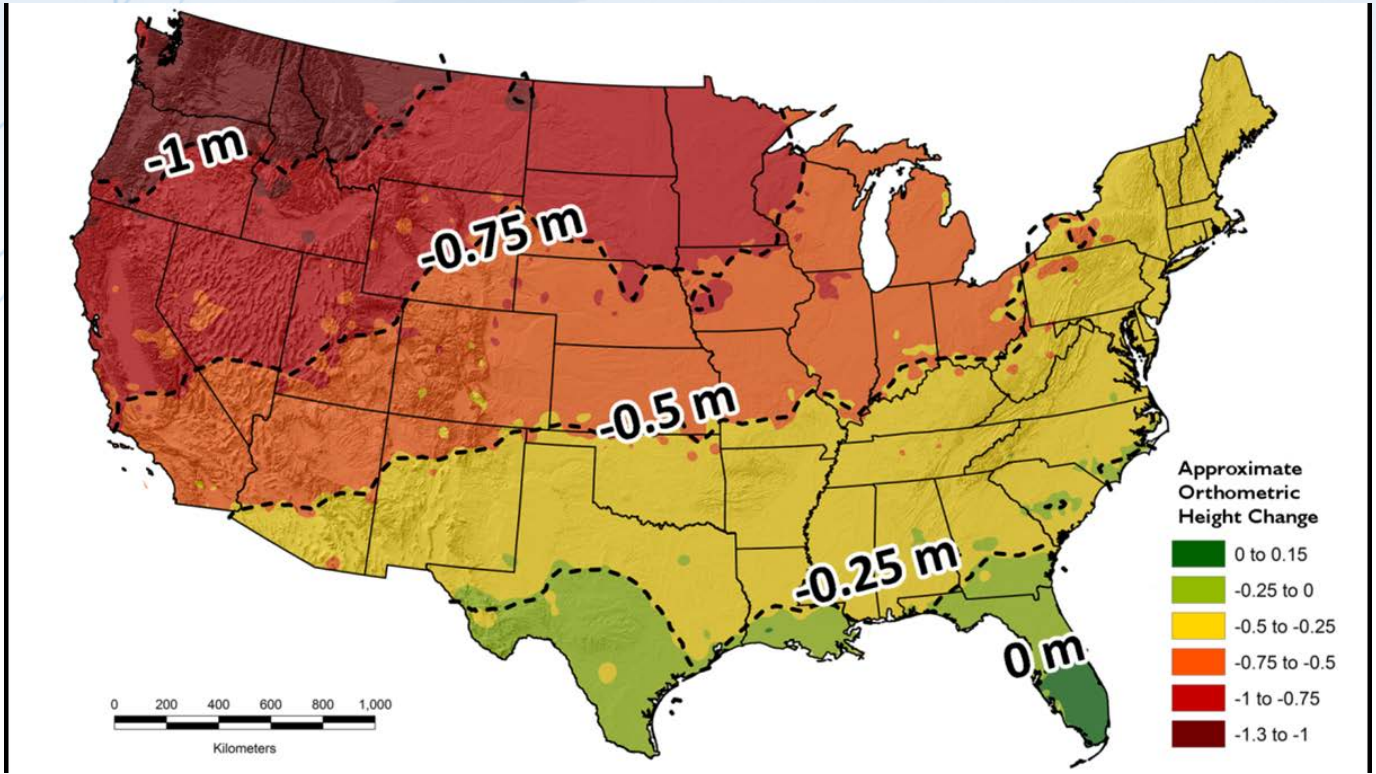
NAPGD2022: one vertical datum pole-to-equator



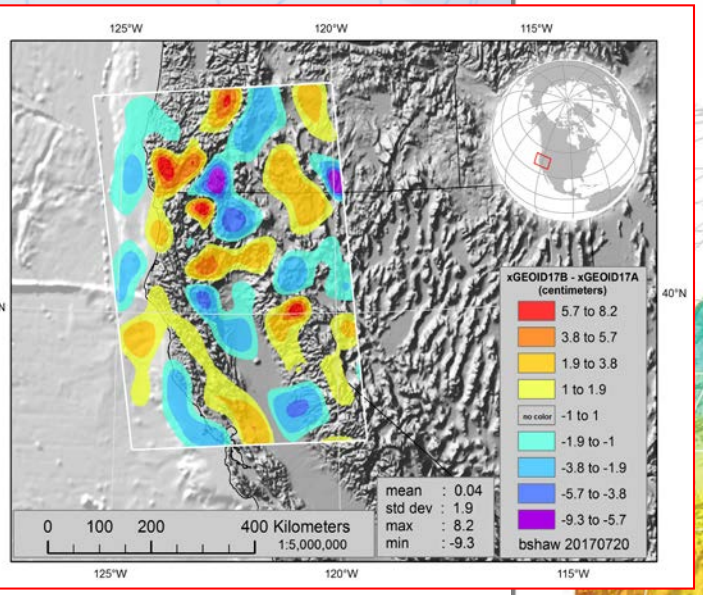
(+ American Samoa & Guam/CNMI)

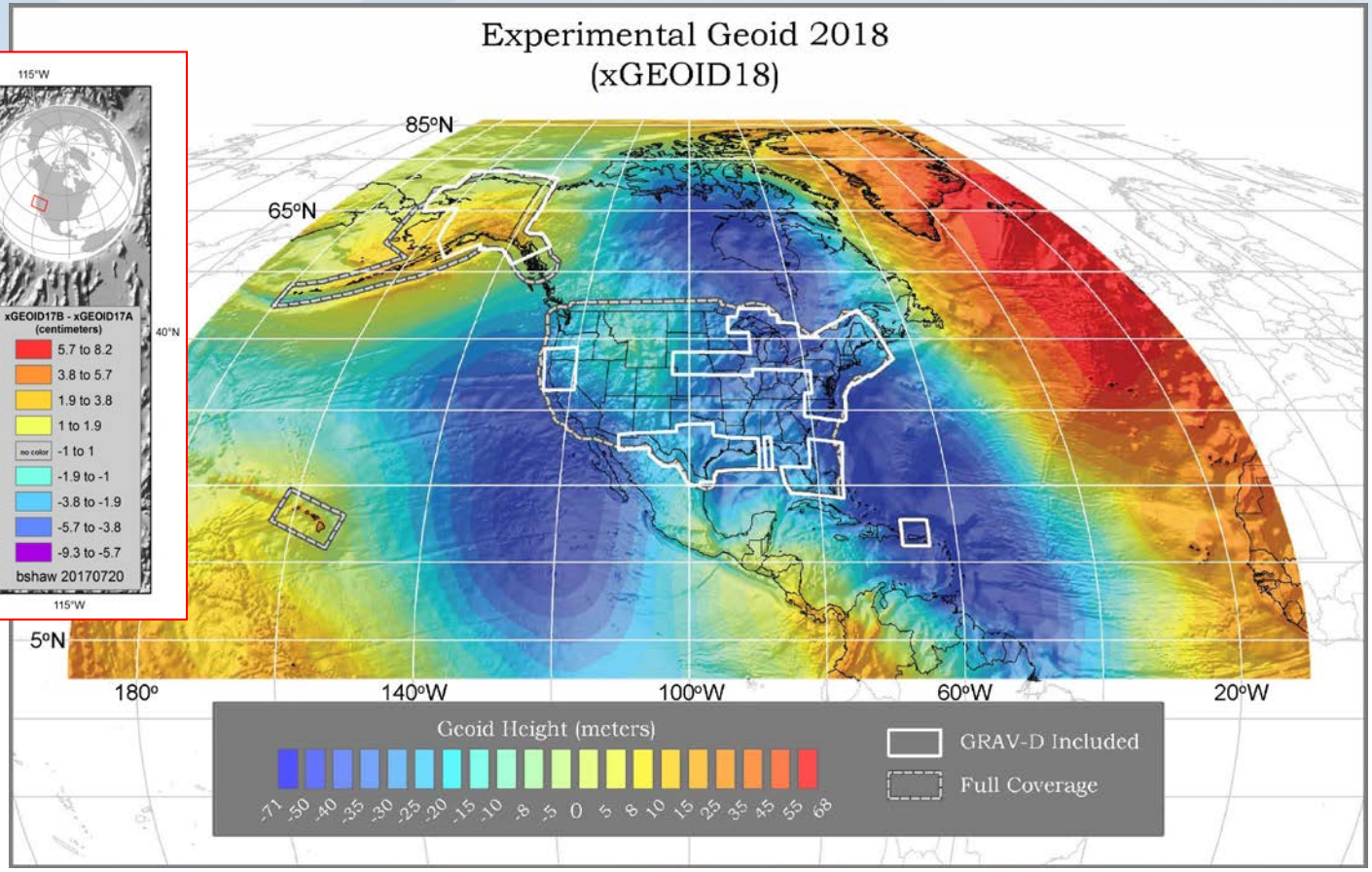
Estimated Orthometric Height Change

(NAVD88 >>> NAPGD2022)



Annual Experimental Geoid (xGeoid18)





Geoid Slope Validation Surveys

Phase 1 - GSVS11: Low/Flat/Simple: **TX** (2011)

Phase 2 - GSVS14: High/Flat/Complex: **IA** (2011)

Phase 3 - GSVS17: High/Rugged: **CO** (2011)

Preparing for Tomorrow:
Online Positioning User Service (OPUS) NAPGD2022 Preview

********** New Reference Frame Preview **********

We are replacing the nation's NAD 83 and NAVD 88 datums, to improve access and accuracy of the National Spatial Reference System. More at https://geodesy.noaa.gov/datums/newdatums/

Below are approximate coordinates for this solution in the new frames:

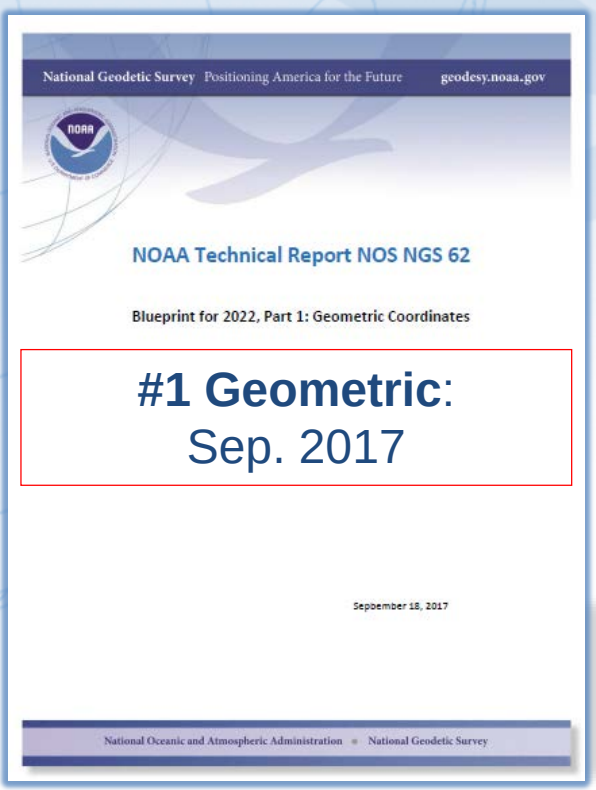
APPROX ORTHO HGT: 1480.951 (m)

(NAVD88: 1481.549 m)

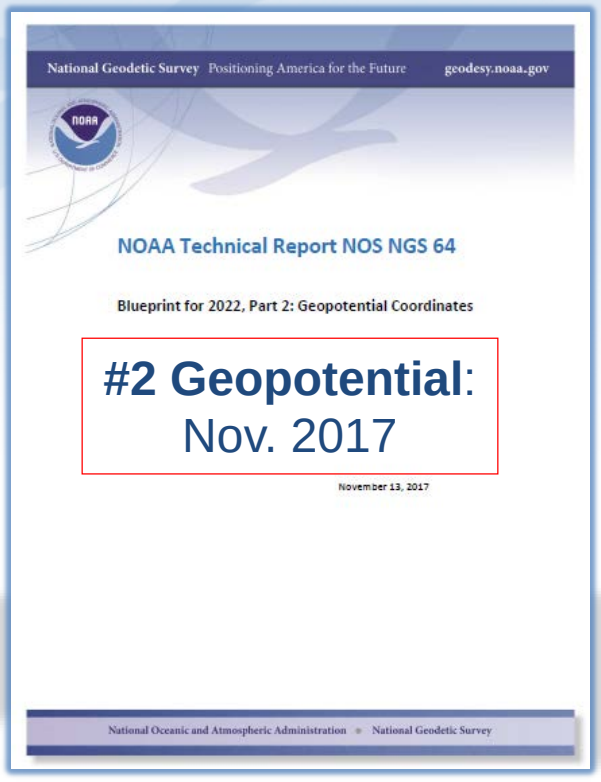
[PROTOTYPE (Computed using xGeoid18B,GRS80,IGS08)]

(Extracted from OPUS Extended Output)

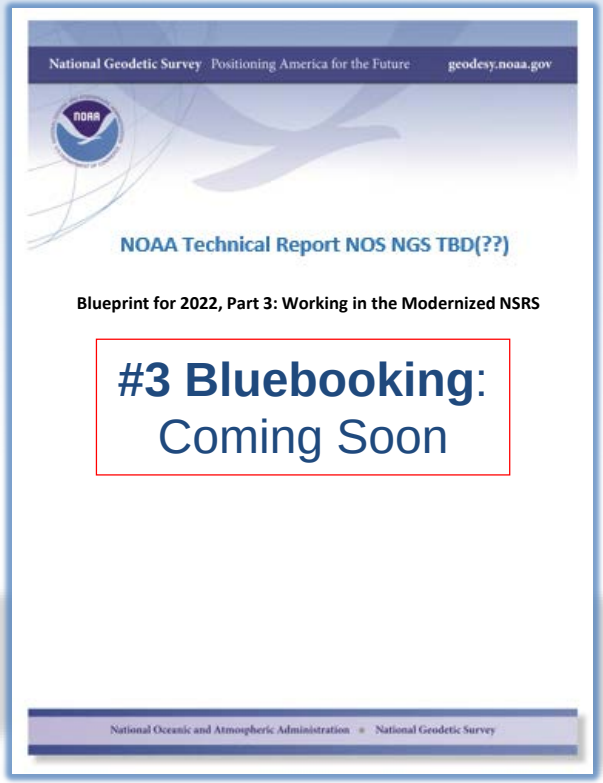
NSRS Modernization: the "Blueprints"



#1 Geometric: Sep. 2017



#2 Geopotential: Nov. 2017



#3 Bluebooking: Coming Soon

geodesy.noaa.gov

National Geodetic Survey

Positioning America for the Future

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

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, shoreline information impact a wide range of important activities.

Learn more about:

- Data and tools we provide
- Activities in your area
- Applications of geodesy

GNSS & GPS Data

Get coordinate information and the tools you need to work independently.

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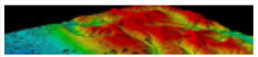

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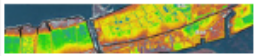


Datums & Transformations

NGS defines datums to help align data and tools to transform coordinates.

Learn More

Looking for Bench Marks?

Emergency Response

Post Event Aerial Imagery:
Tropical Storm Gordon

Previous Storm Imagery

Notices

GPS on Bench Marks Deadline Extended

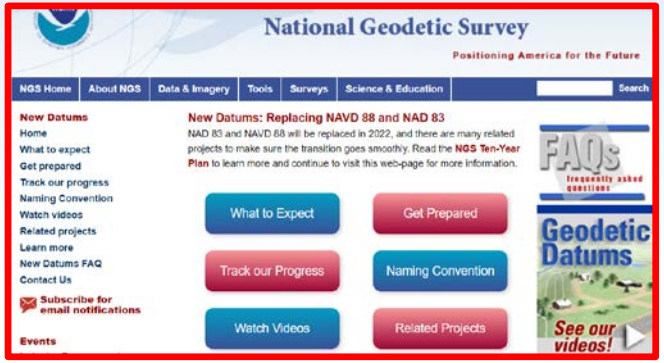
Critical Updates:
Windesc, Translev and DSWorld

In the News

09/06/2018 - CORS Sites Upgraded in the Great Lakes Region

08/31/2018 - Improving the International Terrestrial Reference Frame

08/23/2018 - GRAV-D Data Collection Completed for Mainland Alaska



Always sandbag your tripod!

. . . and enjoy your modernized NSRS (in 2022)!!

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