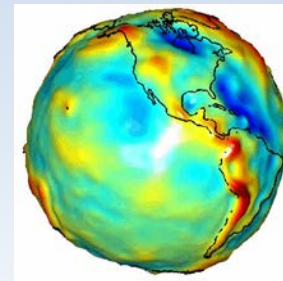


Of Heights and Gravity: a New Vertical Datum for North America and the Pacific



William Stone

Southwest Region (AZ, NM, UT) Geodetic Advisor

NOAA's National Geodetic Survey

william.stone@noaa.gov

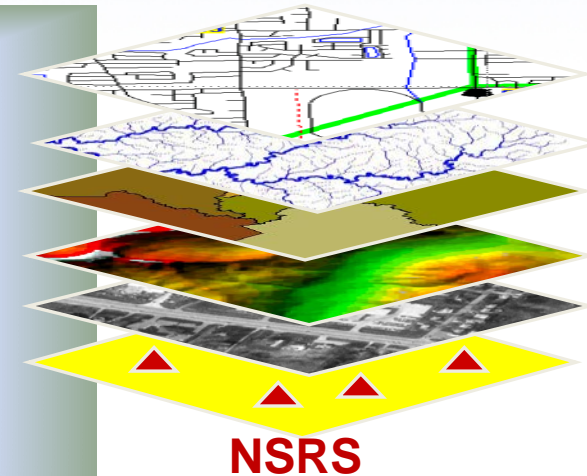
2018 Esri User Conference
July 11
San Diego



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

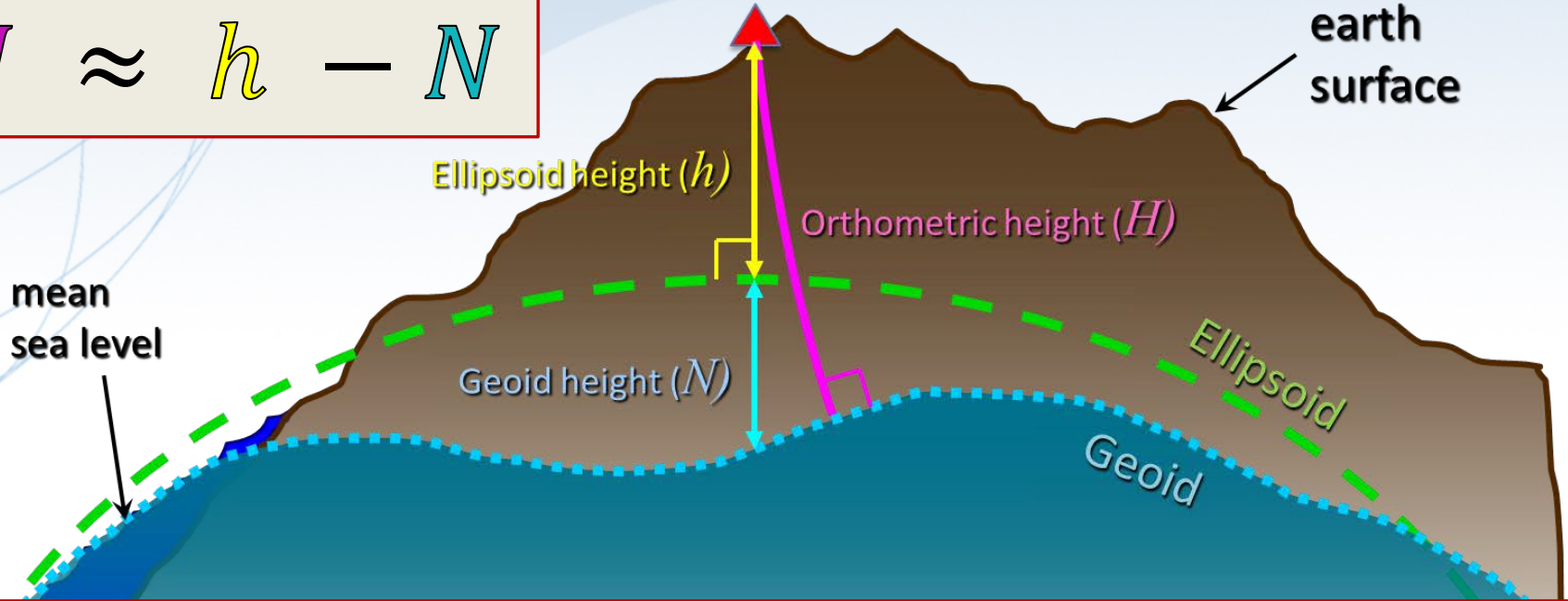
Mission: To ***define, maintain & provide access*** to the
National Spatial Reference System (NSRS)
to meet our Nation's economic, social & environmental needs

- NSRS**
- Latitude
 - Longitude
 - Height
 - Scale
 - Gravity
 - Orientation
- & their time variations***



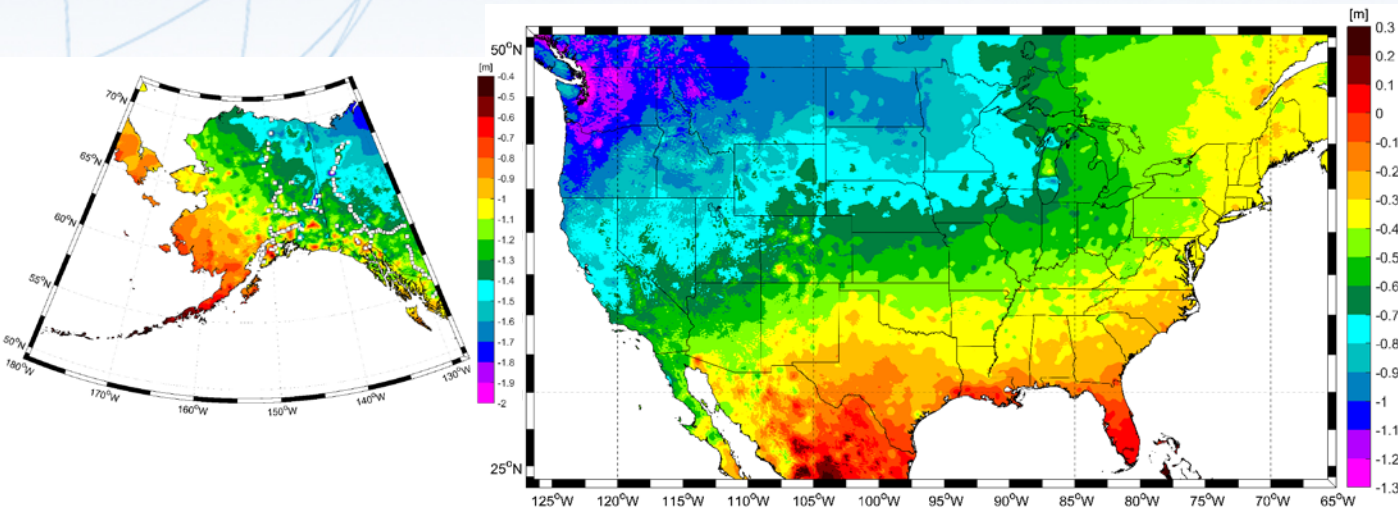
Geodetic Heights

$$H \approx h - N$$



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

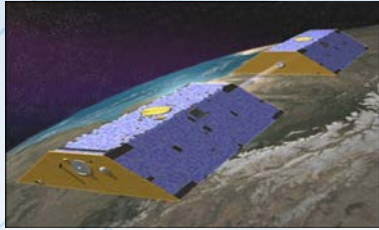


1925-1977 Subsidence
San Joaquin Valley, CA

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

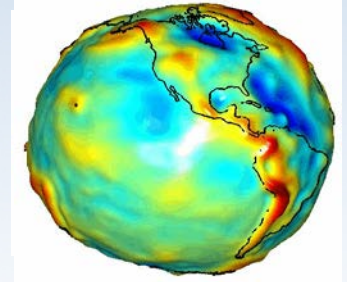
- replace NAVD88, etc. in 2022
- access via GNSS & gravimetric geoid model (+ local leveling)
- aligned w/ 2022 Terrestrial Ref. Frames (eg NATRF2022)
- most accurate continental gravimetric geoid (1-2 cm goal)
- referenced to global mean sea level
- geoid definition coordinated with Canada & Mexico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

Building a Geopotential Field Model



GRACE/GOCE/Satellite Altimetry

Long Wavelengths
(> 250 km)

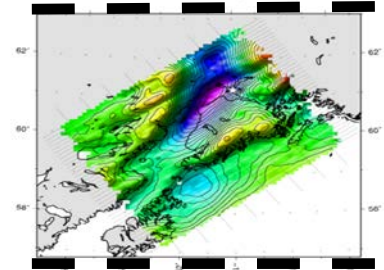


+



Airborne Measurement

Intermediate Wavelengths
(300 km to 20 km)

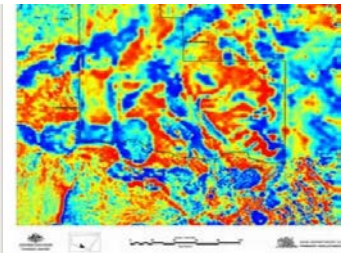


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Surface Measurement and
Predicted Gravity from Topography

Short Wavelengths
(< 100 km)



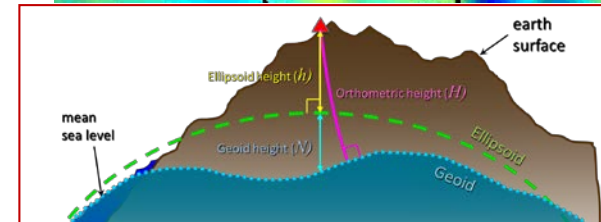
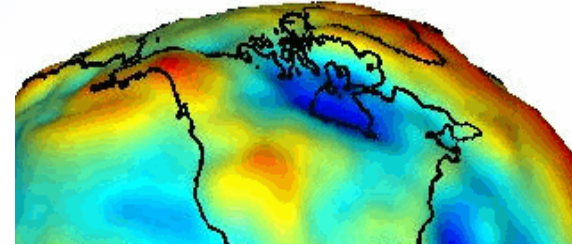
North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

Gravity
Potential
Energy

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

>>> global geopotential field model (GM2022)

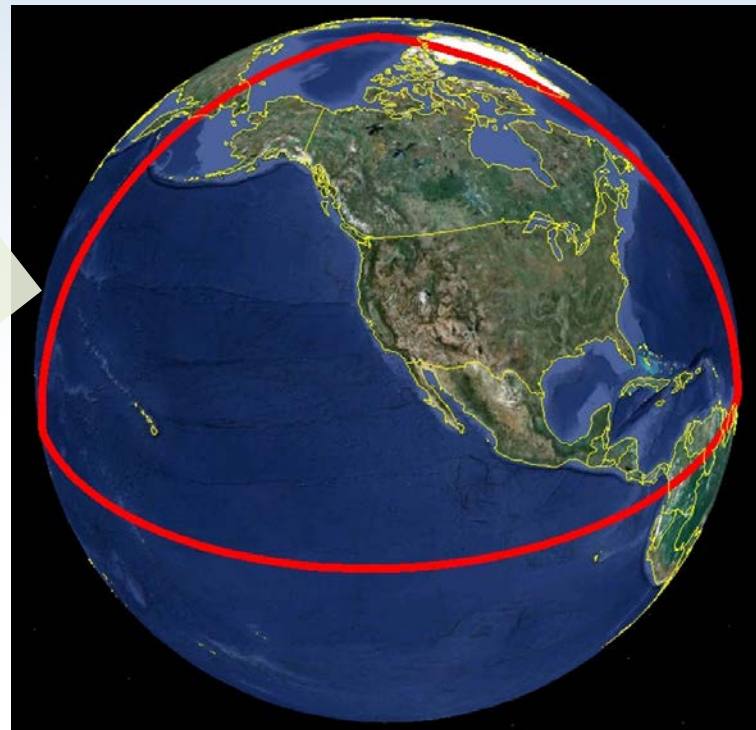
- orthometric height (elevation; via GNSS)
- geoid undulation (GEOID2022; 0 elev.)
- deflection of the vertical (DEFLEC2022)
- gravity anomalies (GRAV2022)



Current Vertical Datums / Models

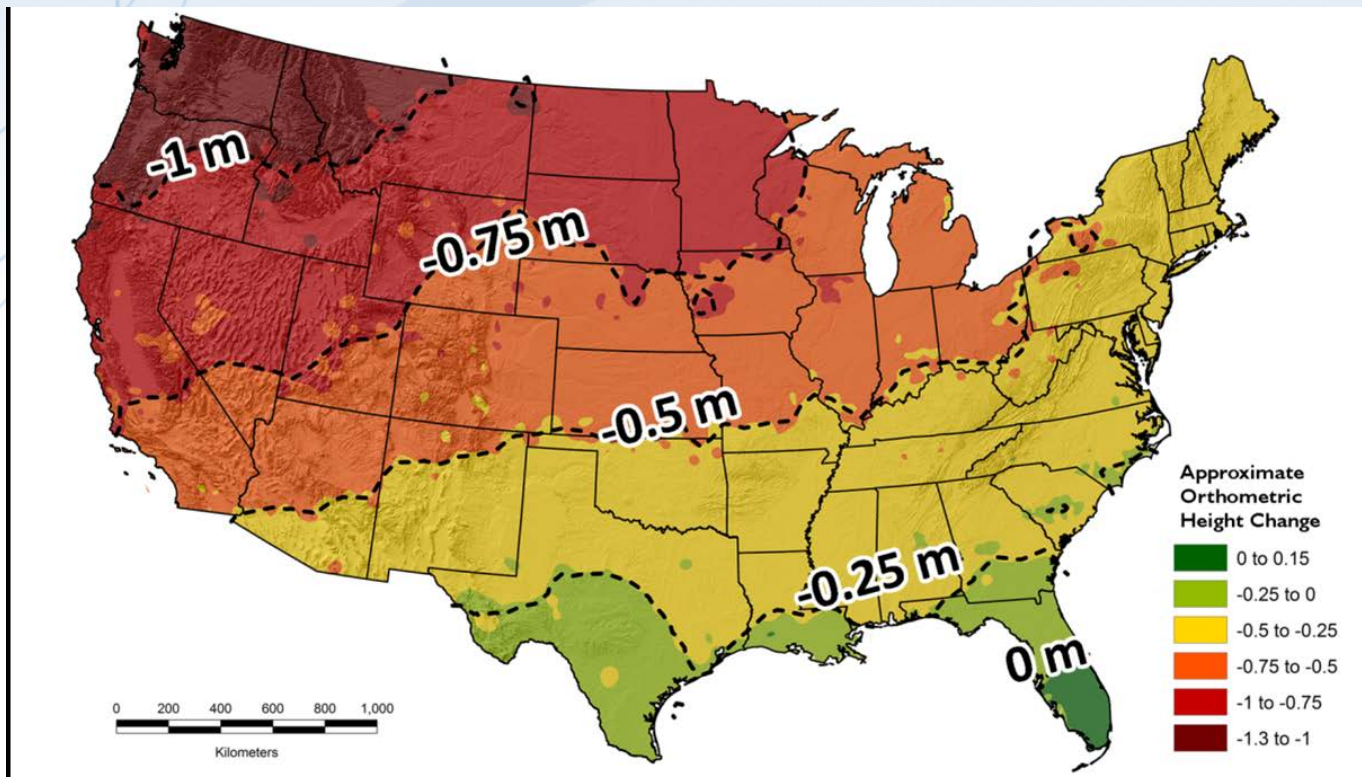
- Orthometric Height
 - NAVD88
 - PRVD88
- Normal Orthometric Height
 - NAVD09
 - ASVD02
 - NAVD03
 - GUV500
 - IGV85
 - IGSN71
- Dynamic Height
- Gravity
- Geoid Height
 - GEOID12B
- Deflections of Vertical
 - Deflec12B

**NAPGD2022:
one vertical datum
pole-to-equator**

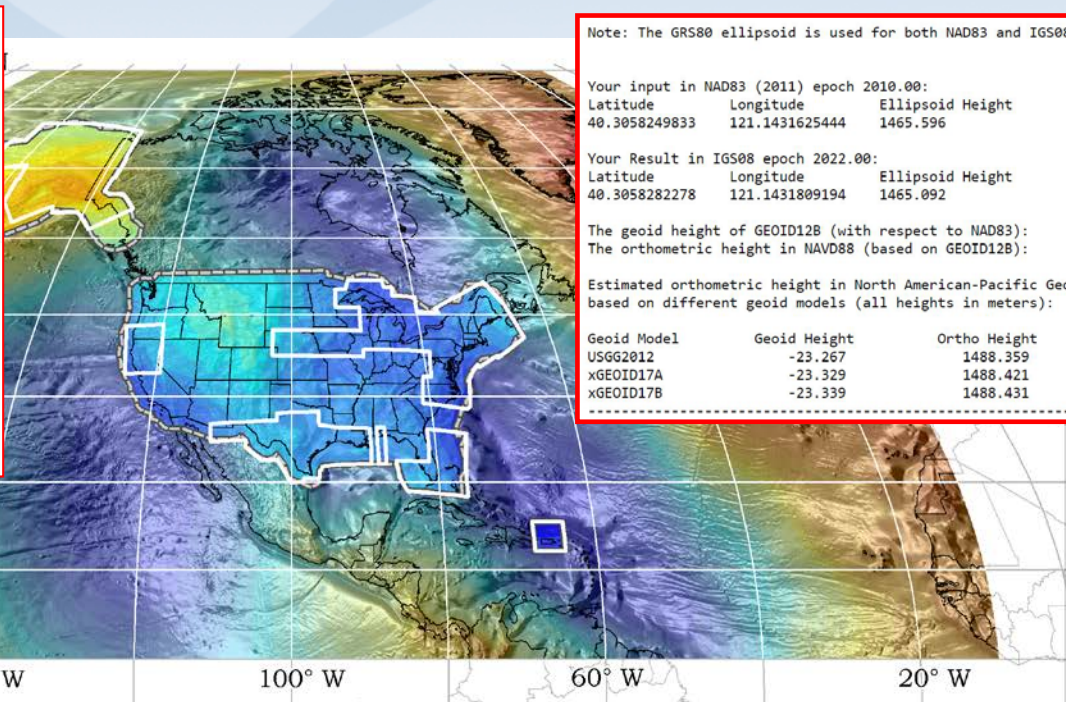
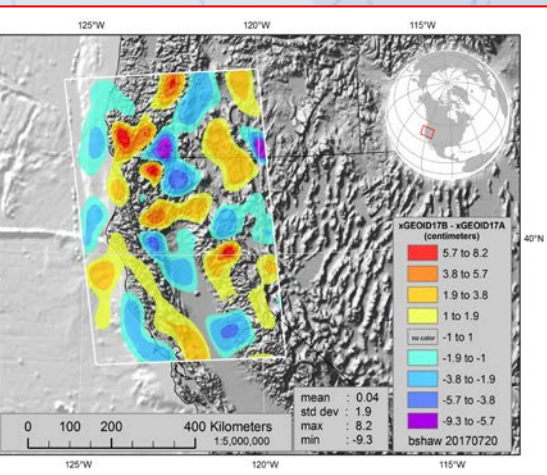


(+ American Samoa & Guam/CNMI)

Estimated Orthometric Height Change (NAVD88 >>> NAPGD2022)



Annual Experimental Geoid (xGeoid17)



Note: The GRS80 ellipsoid is used for both NAD83 and IGS08.

Your input in NAD83 (2011) epoch 2010.00:
 Latitude Longitude Ellipsoid Height Station
 40.3058249833 121.1431625444 1465.596 No Cal

Your Result in IGS08 epoch 2022.00:
 Latitude Longitude Ellipsoid Height
 40.3058282278 121.1431809194 1465.092

The geoid height of GEOID12B (with respect to NAD83): -23.556 m
 The orthometric height in NAVD88 (based on GEOID12B): 1489.152 m

Estimated orthometric height in North American-Pacific Geopotential Datum of 2022 (NAPGD2022) based on different geoid models (all heights in meters):

Geoid Model	Geoid Height	Ortho Height	Ortho(model)-NAVD88(GEOID12B)
USGG2012	-23.267	1488.359	-0.794
xGEOID17A	-23.329	1488.421	-0.732
xGEOID17B	-23.339	1488.431	-0.722



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 xGeoid17B,GRS80,IGS08)]

NSRS Modernization: the “Blueprints”

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov




NOAA Technical Report NOS NGS 62

Blueprint for 2022, Part 1: Geometric Coordinates

#1 Geometric:
May 2017
(update Sep. 2017)
September 18, 2017

National Oceanic and Atmospheric Administration • National Geodetic Survey

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov



NOAA Technical Report NOS NGS TBD(64)

Blueprint for 2022, Part 2: Geopotential Coordinates

#2 Geopotential:
Oct. 2017

National Oceanic and Atmospheric Administration • National Geodetic Survey

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov



NOAA Technical Report NOS NGS TBD(??)

Blueprint for 2022, Part 3: Re-inventing Bluebooking

#3 Bluebooking:
Coming Soon

National Oceanic and Atmospheric Administration • National Geodetic Survey



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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:

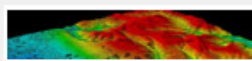
- Data and tools we provide
- Activities in your area
- Applications of geodesy



GNSS & GPS Data

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

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Remote Sensing

Download data and critical information into nautical charts.

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Land Surveying

View guidelines and get tools to support land surveyors.

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Geodesy

NGS works closely with the global researchers advancing geodetic science.

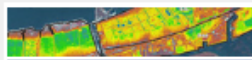
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Training & Education

Classes and educational resources on scientific topics relating to geodesy.

[Learn More](#)



Datums & Transformations

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

[Learn More](#)

Looking for Bench Marks?

Notices

Scoping the Value of the Regional Geodetic Advisor Program (PDF, 1.7 MB)

For Comment: Policy and Procedures Documents for the State Plane Coordinate System of 2022

In the News

06/29/2018 - Promoting the Importance of Modernizing the Nation's Vertical Datum

06/22/2018 - NGS Surveys Site to Improve International Terrestrial Reference Frame

06/15/2018 - Study Values NGS Program at \$18.6 to \$38.7 Million

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