The National Spatial Reference System:
the Common Foundation of Surveying and GIS

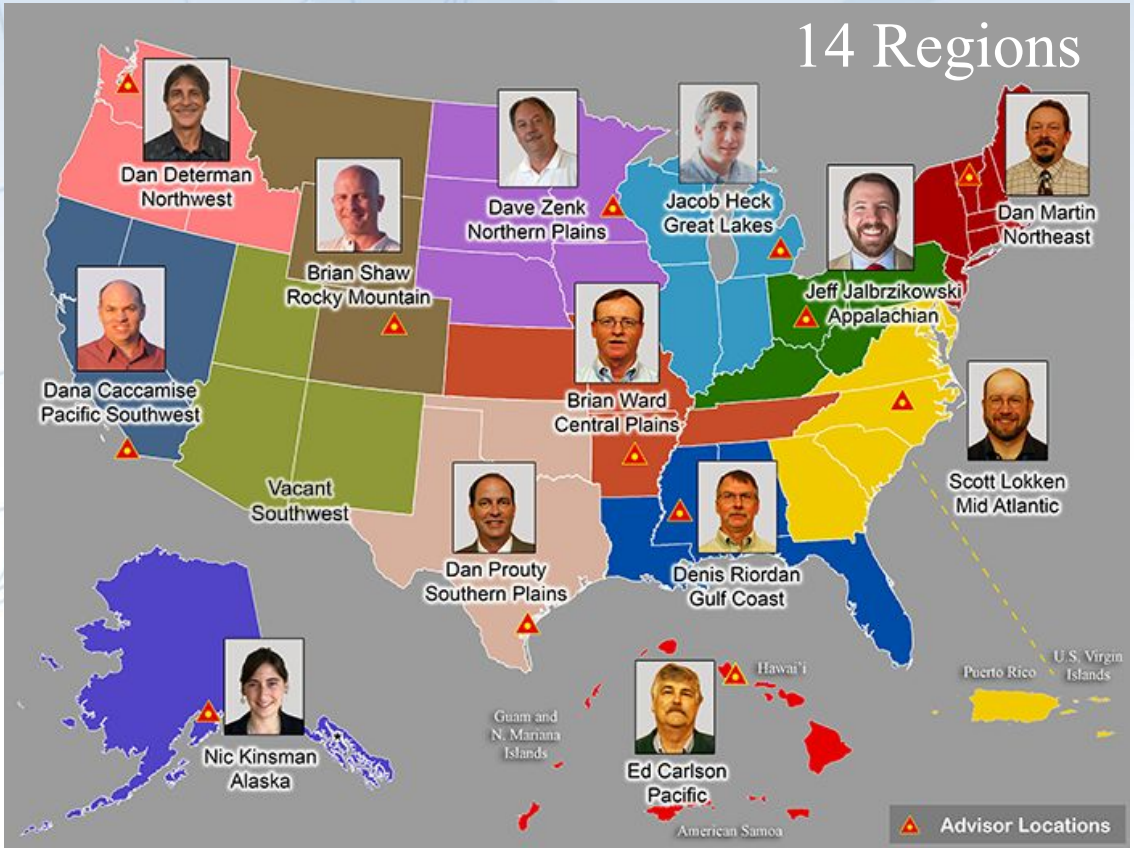
2022 GIS in the Rockies

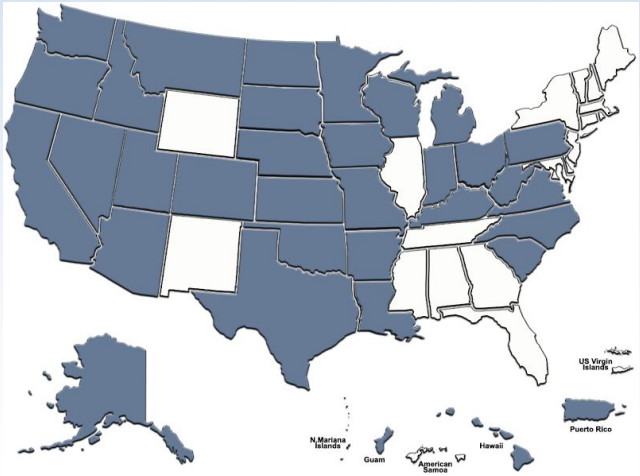
Brian Shaw
brian.shaw@noaa.gov

September 28, 2022

Brian Shaw
Rocky Mountain Advisor
brian.shaw@noaa.gov

Importance of Coordination





38 Coordinators

NSRS Modernization Delay

Operational, workforce retention and other issues have delayed NSRS Modernization (Likely to 2025)

SPCS2022 zones should be finalized in 2022 but will not be rolled out until all of the NSRS is modernized.

GPS on Bench Marks deadline extended
September 31, 2022

https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml
https://geodesy.noaa.gov/datums/newdatums/FAQNewDatums.shtml

NGS Resources

NGS Training Center

https://geodesy.noaa.gov/web/science_edu/training/

Educational Videos

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

NGS Webinar Series

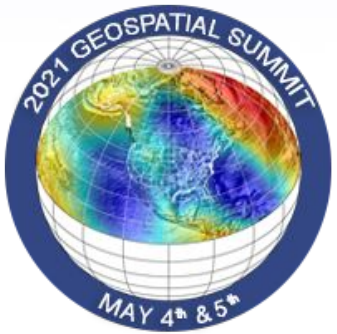
https://geodesy.noaa.gov/web/science_edu/webinar_series/

Geospatial Summit (2021, 2019 recorded sessions)

https://geodesy.noaa.gov/geospatial-summit/

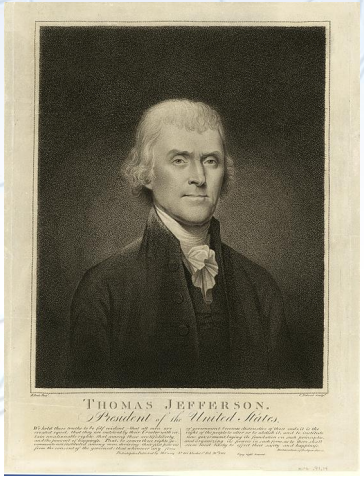
Presentation Library

https://geodesy.noaa.gov/web/science_edu/presentations_library/



NOAA and NGS

Our Nation's First Civilian Science Agency



1807
Thomas Jefferson
Survey of the Coast

1811
Ferdinand Hassler
Superintendent

1836
U.S. Coast
Survey

1878
U.S. Coast and
Geodetic Survey

1970
NOAA is established

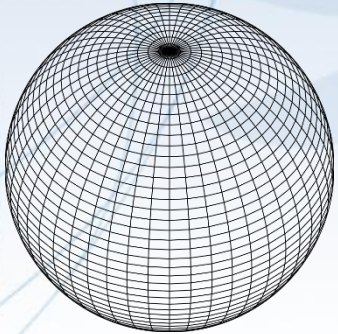
NGS' Mission

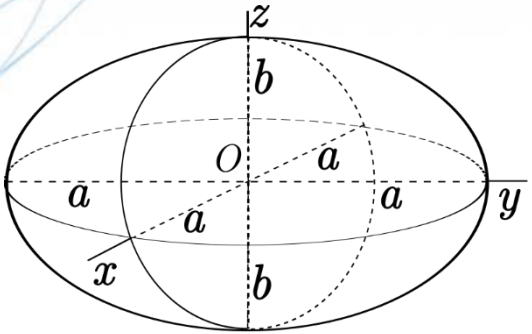
To define, maintain and provide access to the **National Spatial Reference System (NSRS)** to meet our Nation's economic, social, and environmental needs.

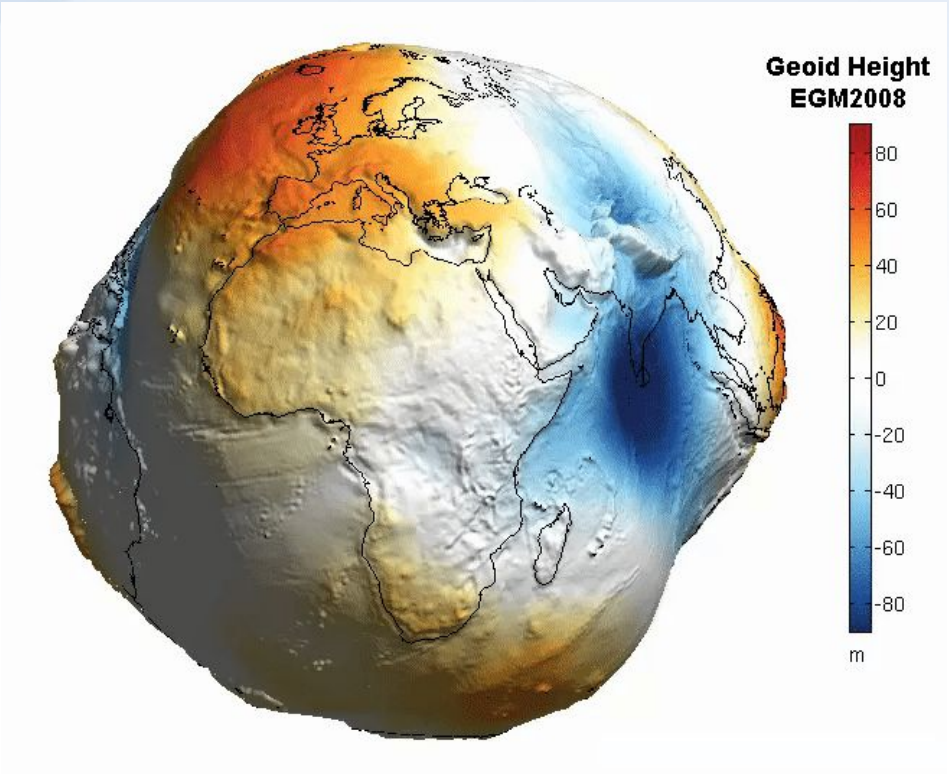
.....

The **NSRS** is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, orientation, and shoreline throughout the United States.

The Earth is Infinitely Complex

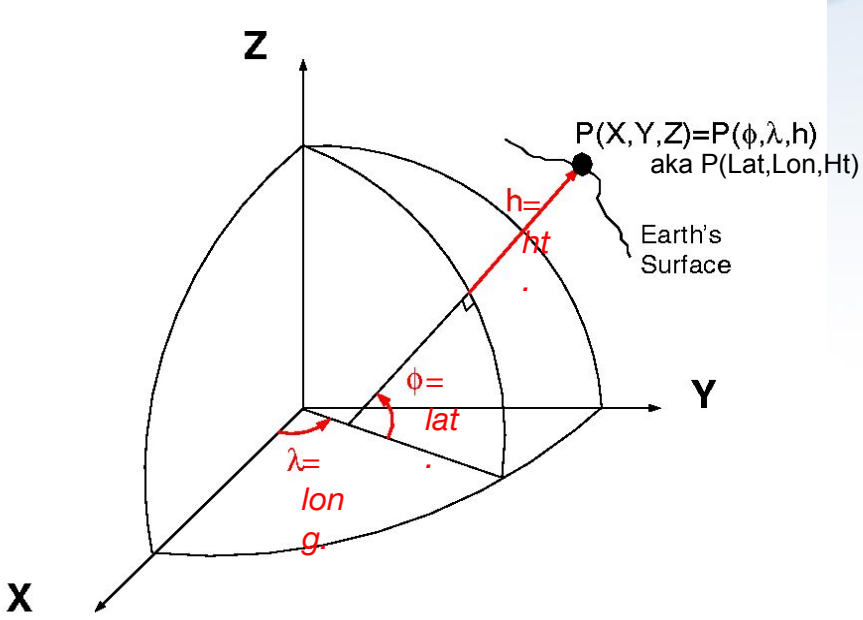




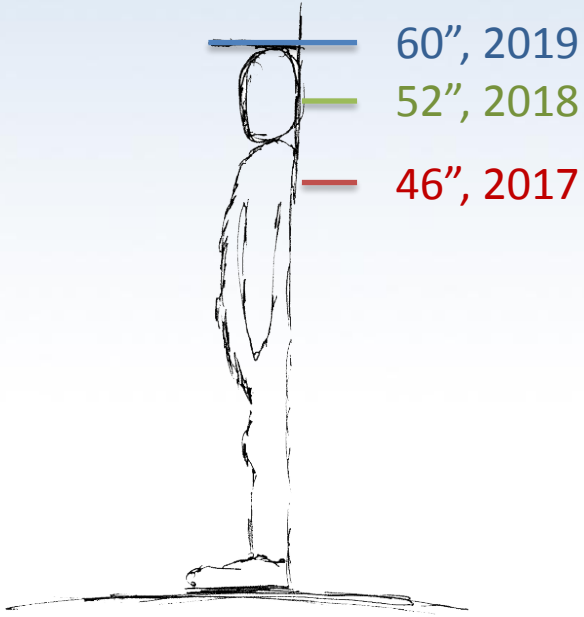


Build Models to Simplify

Datums and Reference Frames



X,Y,Z vs Lat,Lon,Ht



A reference surface or framework to reference your data to for consistency

Gravity is Fundamental

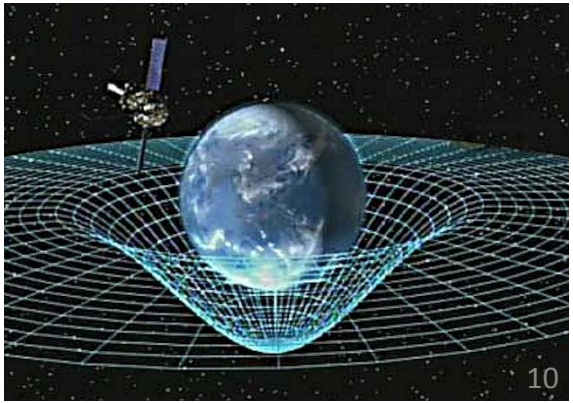
Aristotle (350BC)
Objects fall proportional to mass

Al-Khazini (1121)
Gravitational potential energy

Galileo (1590)
Terminal velocity

Newton (1687)
Gravity inverse-square law

Einstein (1913)
Theory of general relativity



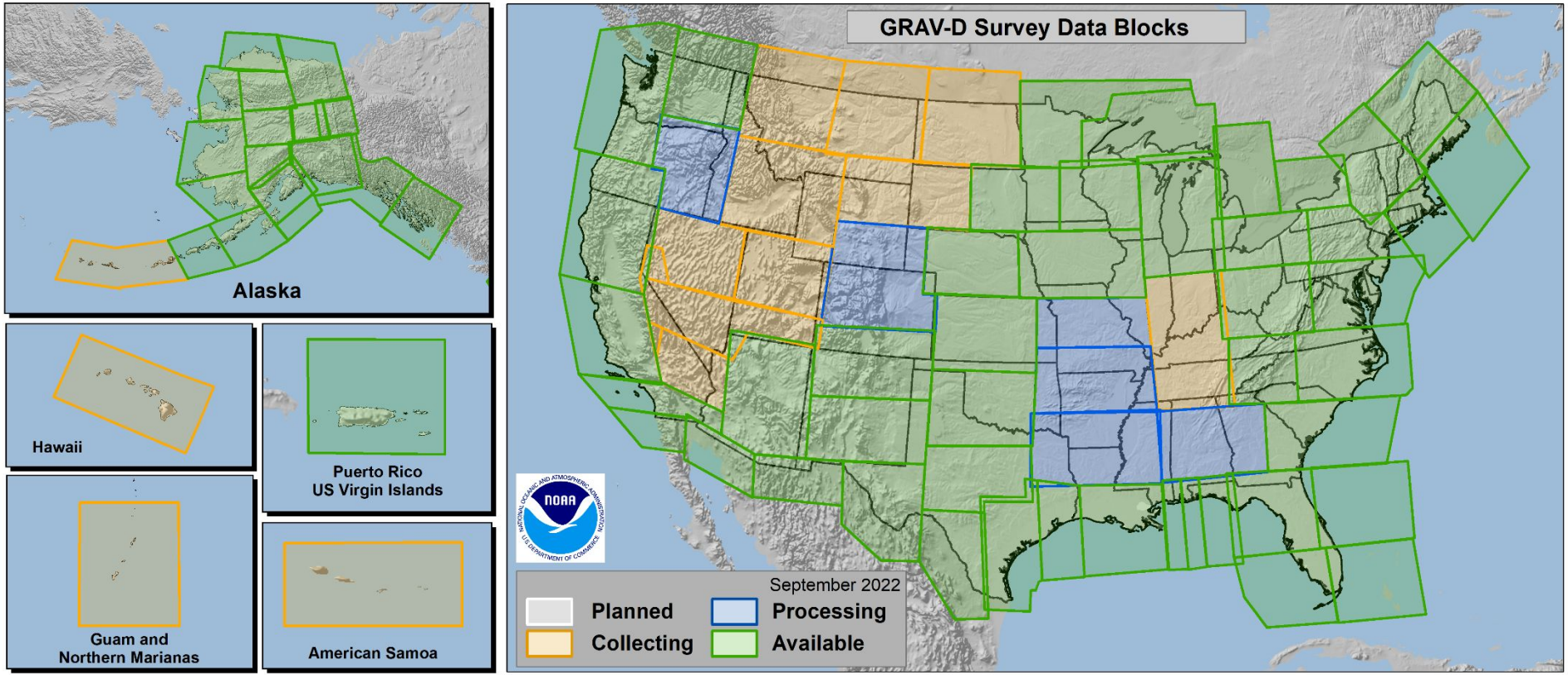
NOAA's National Geodetic Survey Positioning America for the Future

geodesy.noaa.gov

Gravity for the Redefinition of the American Vertical Datum

GRAV-D

95.7% Complete (9/7/2022)



Why Modernize the NSRS

Current models built on old technology

- NAD 83 not truly Geocentric (~2.2m)
- NAVD 88 relies on marks in the ground and is not easily maintained
- Today's technology needs better accuracy

Main Benefits of Modernized NSRS

Fast, Accurate, Consistent Elevations Everywhere

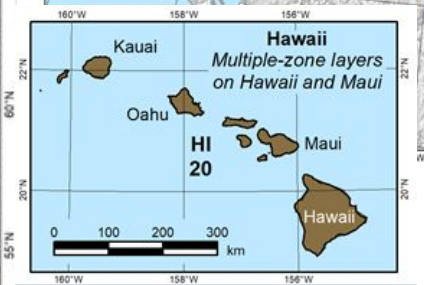
Improved Public Safety
- Flood Plain Maps
- Emergency Route Planning

Accurate Positioning
- Autonomous vehicles, BIMs, Smart Cities

State Plane Coordinate System of 2022 (CONUS, Alaska and Hawaii)

Three territory zones not shown:

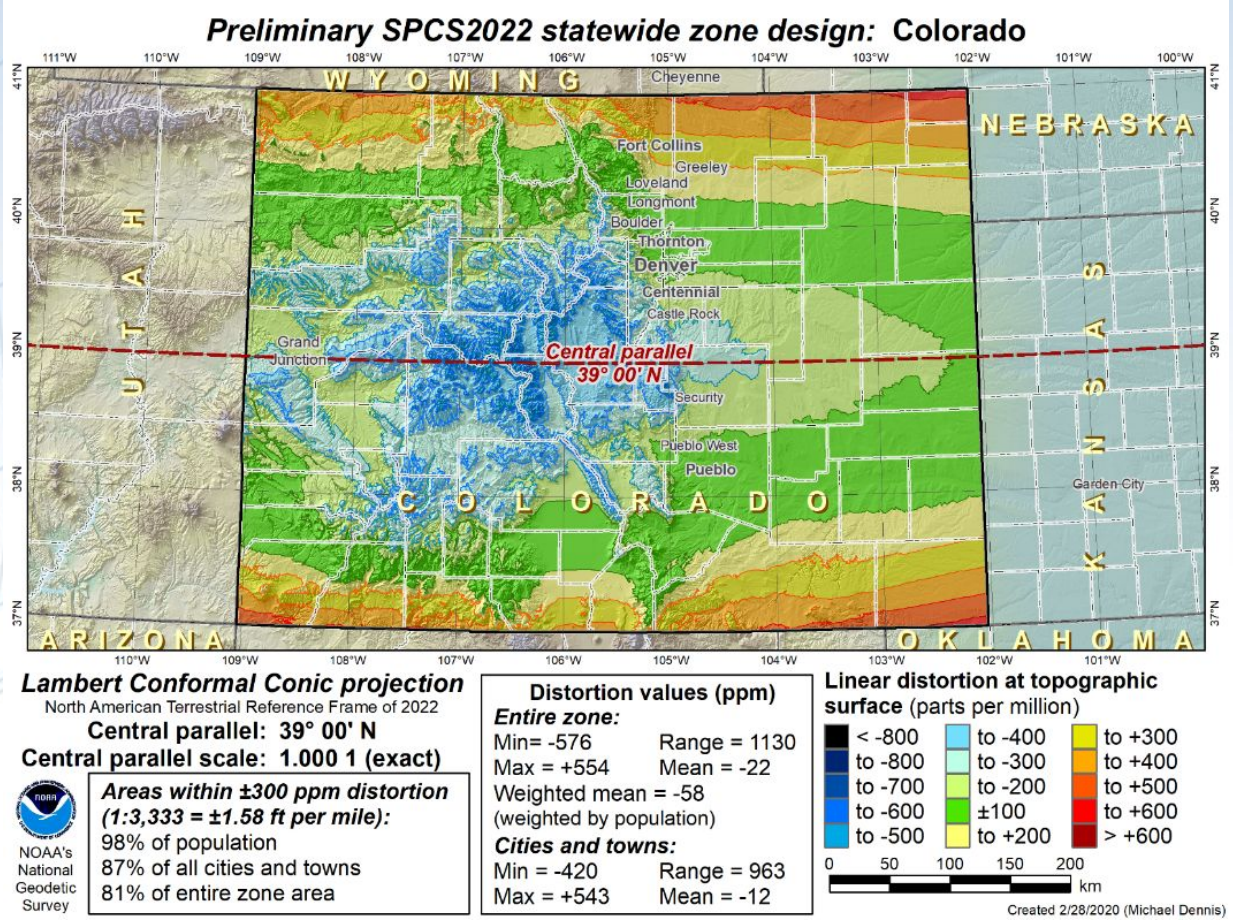
- Puerto Rico and U.S Virgin Islands
- American Samoa
- Guam and Commonwealth of the Northern Mariana Islands



Total 965 zones (12/9/2021)

- 1 zone (18 states)
- 3 - 9 zones (14 states)
- 10 - 19 zones (6 states)
- 20 - 40 zones (11 states)
- 56 - 90 zones (7 states)

https://geodesy.noaa.gov/SPCS/



SPCS of 2022

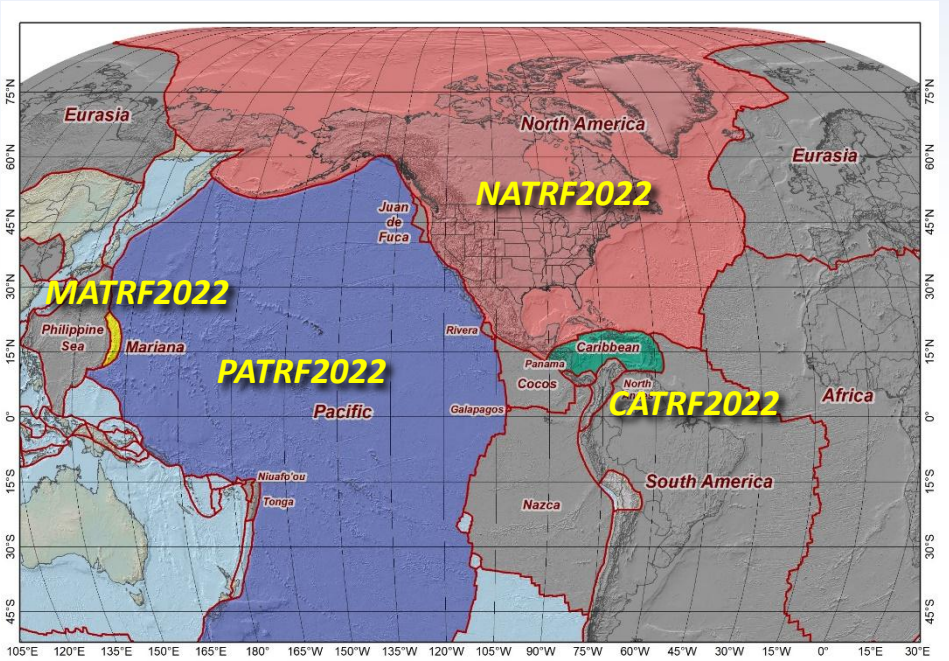
https://geodesy.noaa.gov/SPCS/

The Future Reference Frames

Tectonic Plate based:

North America [NATRF]
Caribbean [CATRF]
Pacific [PATRF]
Mariana [MATRF]

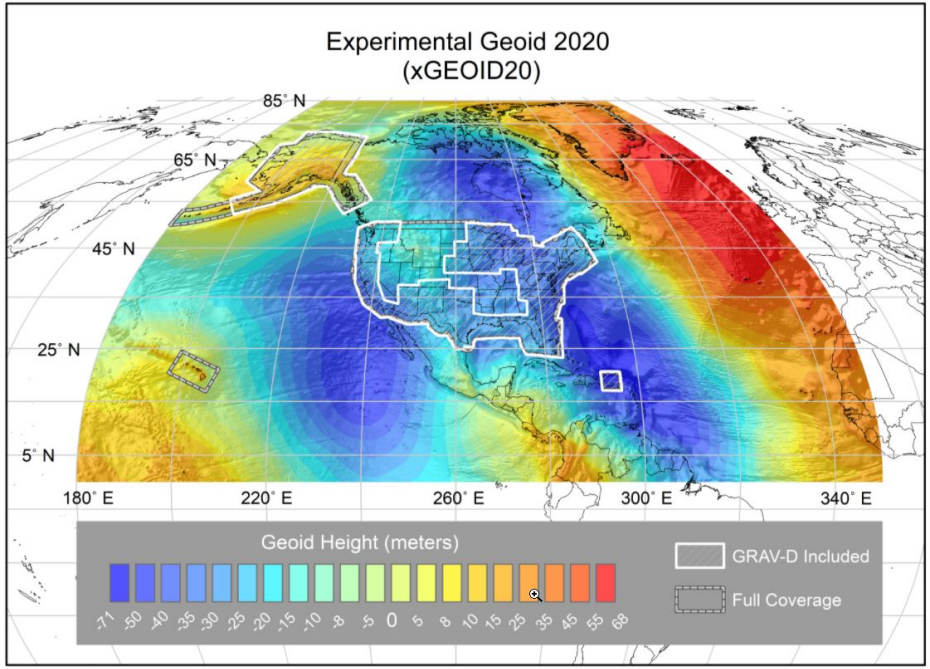
The tectonic plates "fixed" for the 2022 Terrestrial Reference Frames



NAPGD2022 Geopotential Datum

North American-Pacific Geopotential Datum of 2022

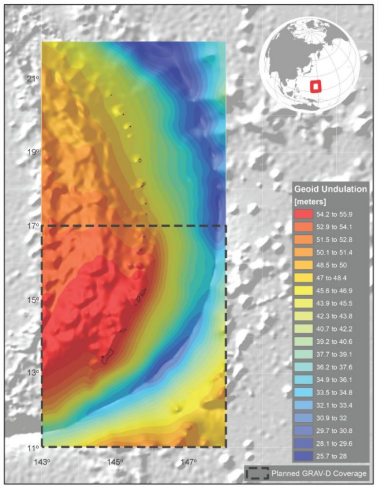
Not a vertical datum, it is more than just heights.



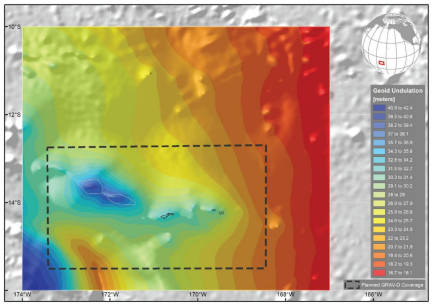
¼ Earth's Surface

Models included:

- Geopotential
- Deflection
- Gravity
- Geoid



Guam/CNMI



American Samoa


AutoGifs

Shift and Drift

A sudden ***shift***

- Horizontal change: **0.5 to 4 m (1.5 to 13 ft)**
- Ellipsoid height change: **±2 m (±6 ft)**
- Elevation change: **-0.5 to +2 m (-1.5 to +6 ft)**

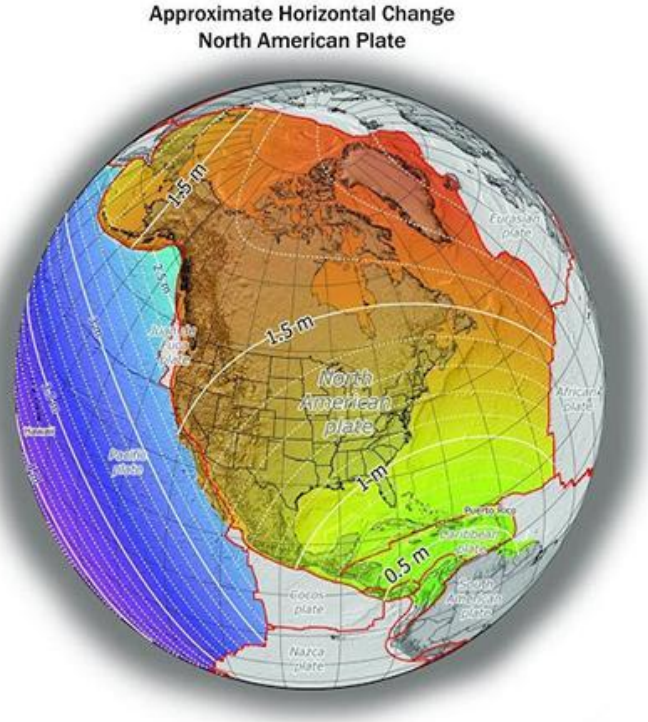
A continuous ***drift***

- Coordinates associated with specific dates

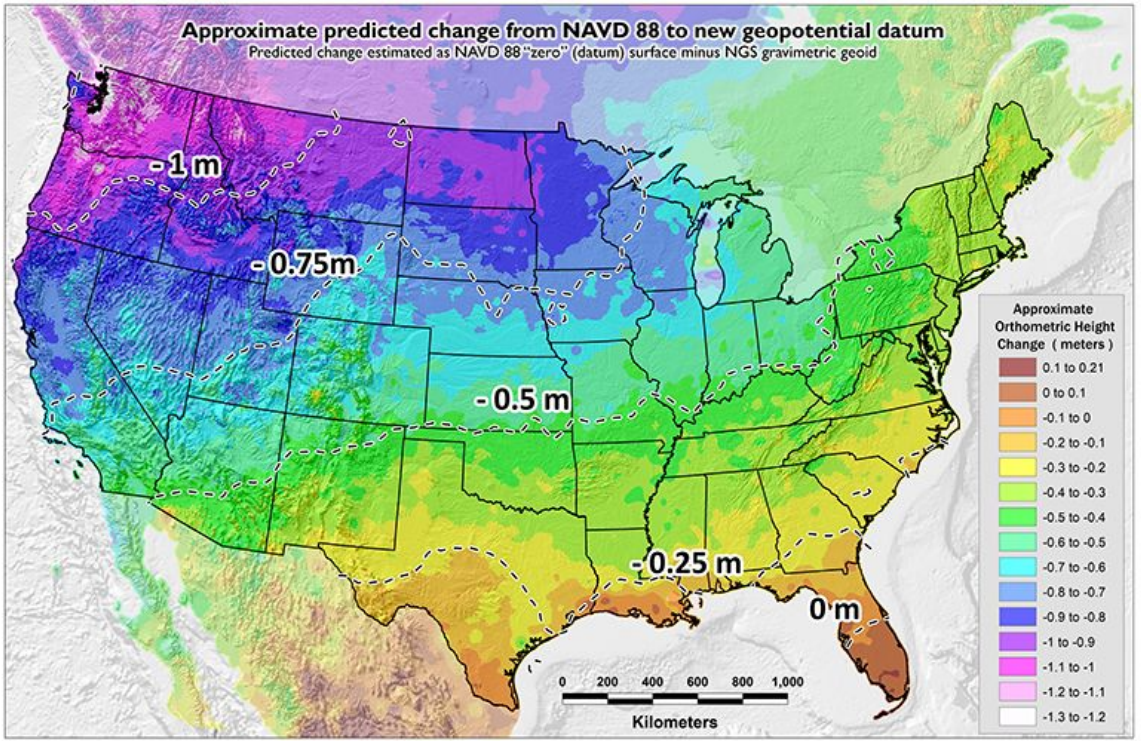
Two components of drift:

- Tectonic plate rotation (easy to model, 2D only)
- All other residual motion (hard to model, 3D)

Shift: datum changes

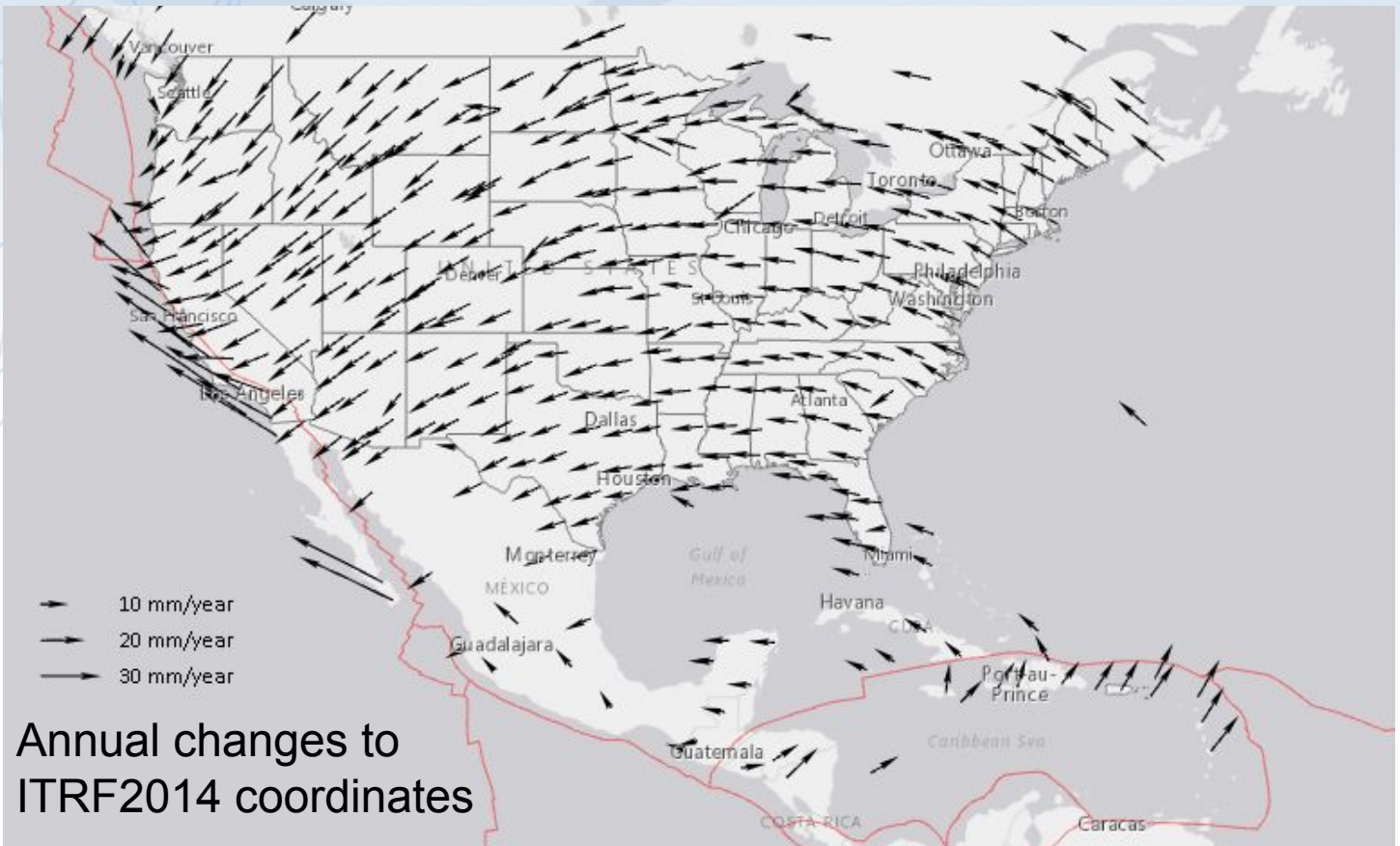


~1 to 1.5 meters North America
~2.5 to 4 meters in Pacific



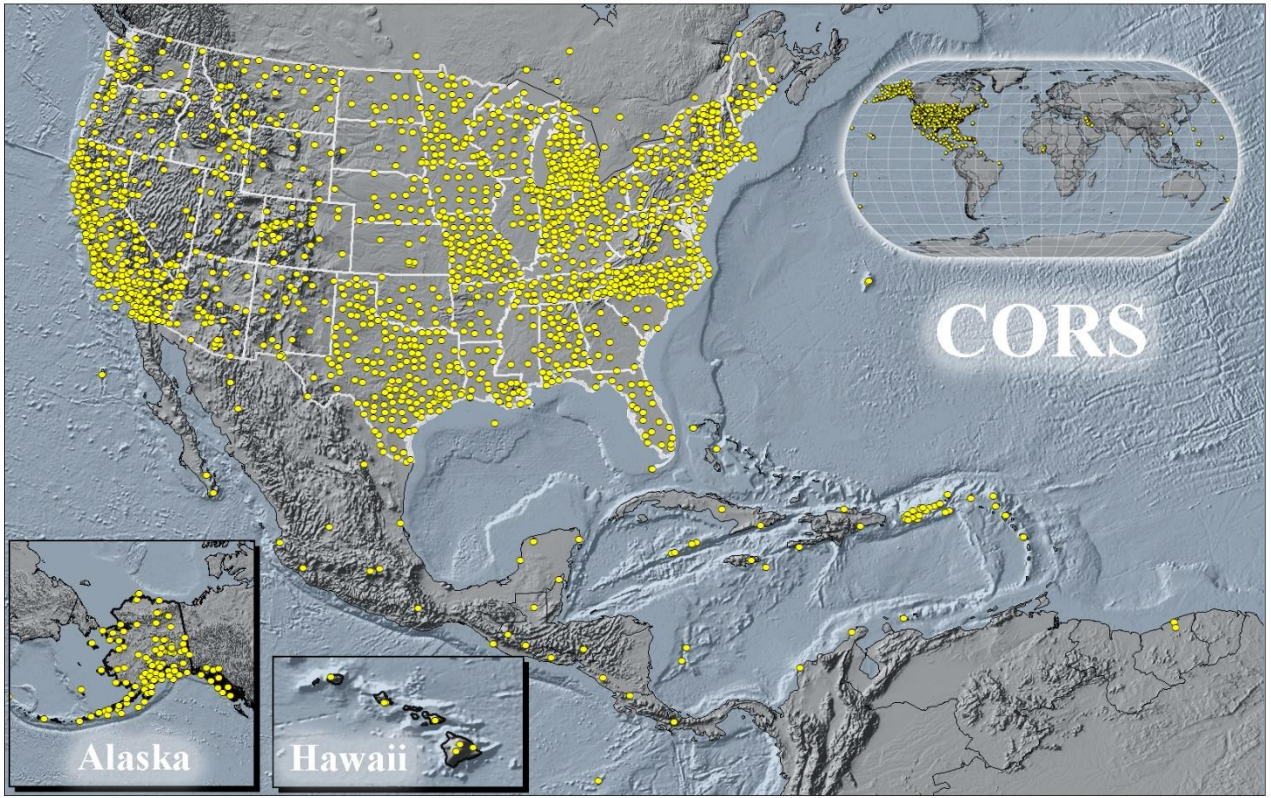
0 to 1.3 meters CONUS

Drift: Plate Tectonics and Velocities



Annual changes to ITRF2014 coordinates

Continuously Operating Reference Stations



COBK
Breckenridge
Colorado

STBT
Steamboat Springs
Colorado

Vertical Motion

Subsidence

Ground fluid withdrawal, sedimentation

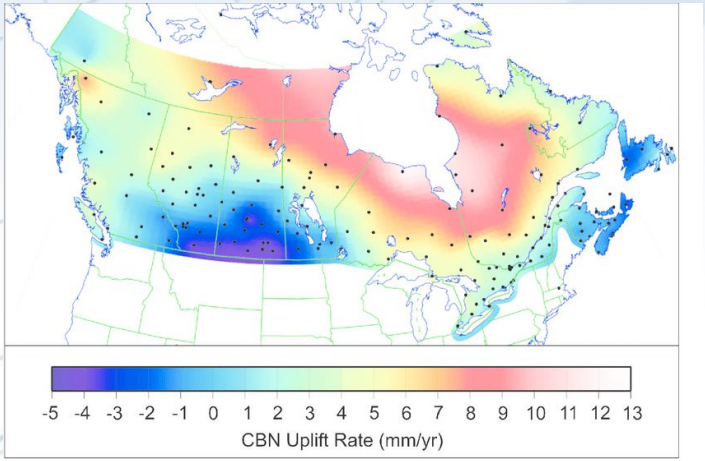
Glacial Isostatic Adjustment (GIA)

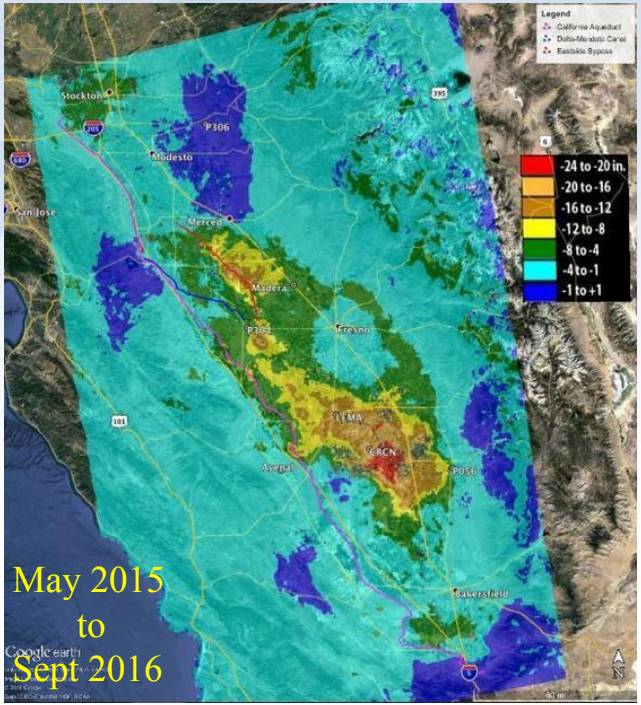
Crustal rebound from glaciers (uplift)

Geophysical Phenomena

Earthquakes, calderas, Earth tides

Vertical Motion

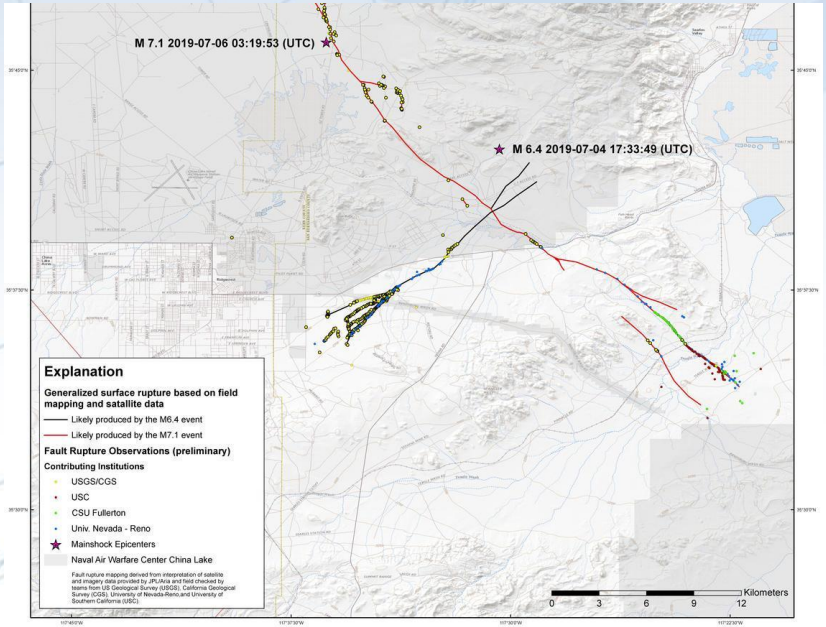




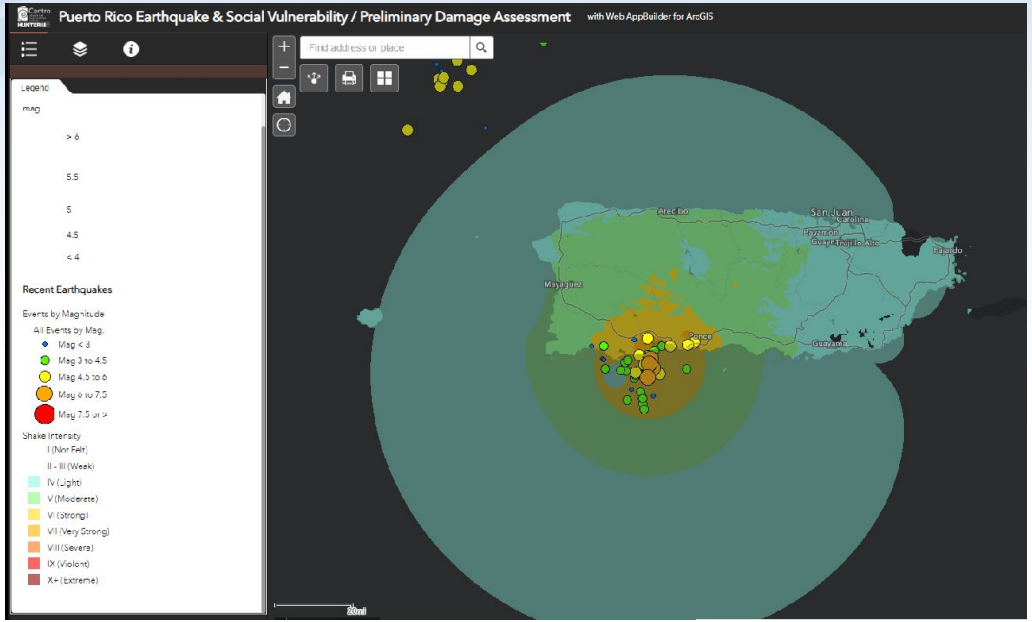
Hudson Bay Uplifting
8 -13 mm/year

San Joaquin Subsiding
20-24" in 16 months

Horizontal and Vertical Motion from Earthquakes

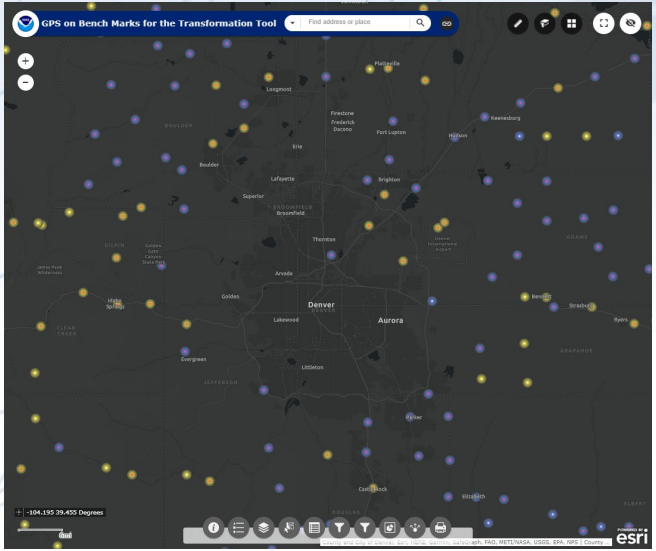


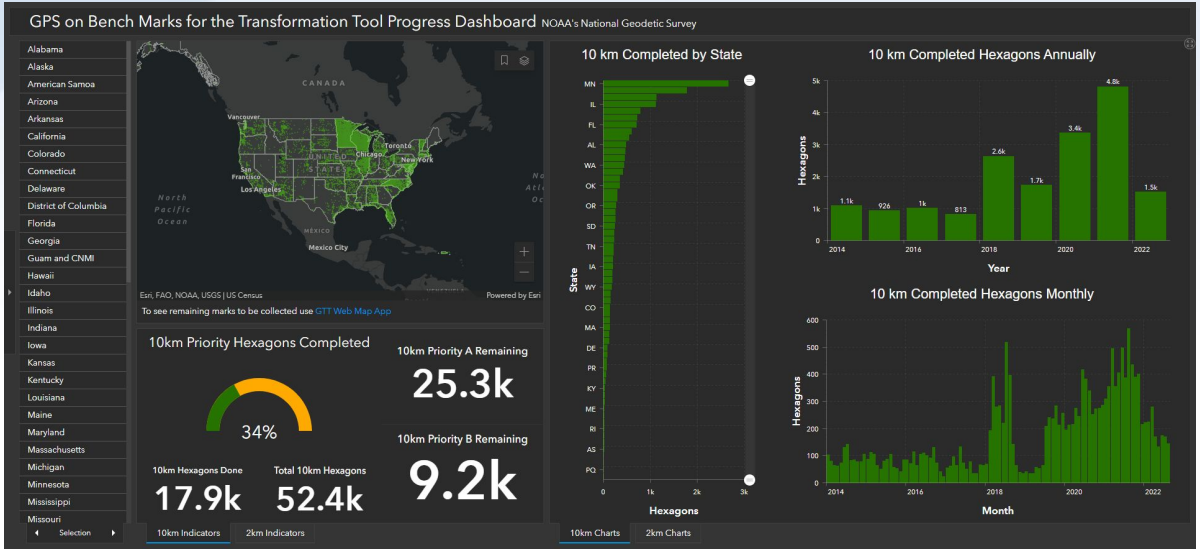
China Lake, CA
6-10 feet Horizontally



Puerto Rico
16 cm Vertically

GPS on Bench Marks





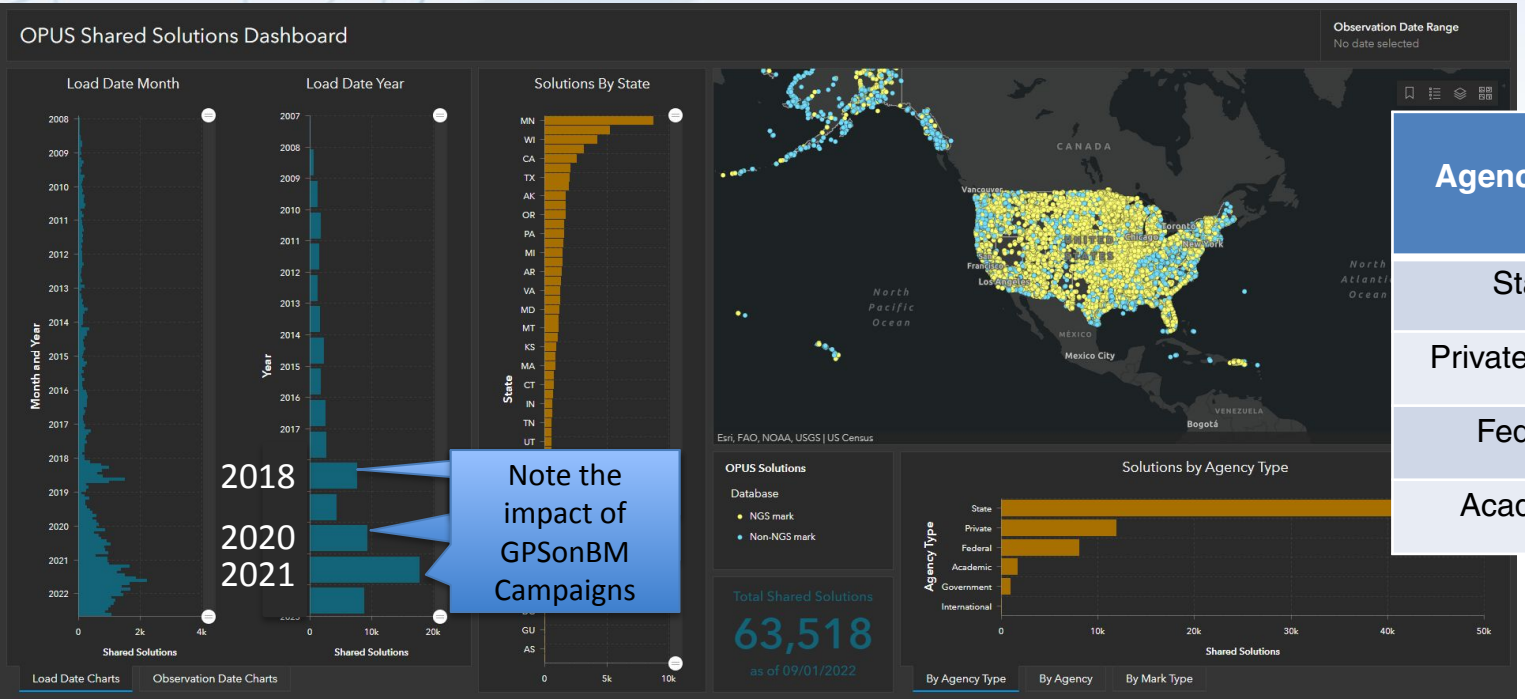
Web Map Application

Dashboard

~3,400 Completed in 2020
~4,800 Completed in 2021
~1,500 Completed in 2022 (as of 09/2022)

OPUS Shared Solutions Dashboard

Dashboard enables sorting and visualization of Shared Solutions by Month & Year, State, Agency Type, and submitting agency



Agency type	# Shared Solutions on NGS marks
State	~35,900
Private Sector	~6,200
Federal	~3,900
Academic	~1400

NGS Mark Recovery Webpage

Crowd sourced mark recoveries help update the GPSonBM map, let NGS and others know if the mark is still usable, and pictures make it easier to find.

https://geodesy.noaa.gov/surveys/mark-recovery/

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education | Search

Mark Recovery Links
- Survey Mark Recovery Home
- NGS Data Explorer
- NGS Photo Submission Guidelines
- Survey Mark Datasheets
- Preserving Marks During Railroad Abandonment

Mark Descriptions Help
- Mark Position
- Mark Condition
- Mark Descriptive Notes
- Mark Photos
- Mark Stamping & Designation
- Mark Type
- Mark Setting & Specific Setting
- Rod/Sleeve Depths
- Magnetic Property
- Mark Stability

Related Links
- USACE's U-SMART Tool
- Geocaching

Survey Mark Recovery

Survey mark refers to any permanent marks or disks placed in the ground or attached to a permanent structure with known latitude, longitude or height information. Its utility depends on the surveyor's ability to recover the mark in good condition. If a mark has been damaged or destroyed, the positional information may have been compromised. If the mark has been completely removed, it's no longer useful.

In an effort to maintain updated records on more than 800,000 survey marks set around the country and its territories, the National Geodetic Survey encourages the public to submit the current mark recovery information.

Submit Survey Mark Recovery Data

To submit your survey mark data to NGS, please use our online **Mark Recovery Form**.

Mark Recovery Form

Mark Recovery Form Instructions:

1. In the first field under the **Marker ID** section, enter the recovered mark's Permanent Identifier (PID) to auto-populate existing mark descriptive fields from the NGS database. Please review and update the fields as needed. If you don't know the mark's PID, please use the **Survey Mark Datasheets** tool to find it.
2. In the **Recoverer ID** section, enter your user information including Agency Code and Agency. An individual can use the code "M" (non-specific designators) and recovery agency "INDIV".

Tools: Recovery Agency | Register an Agency | More Info

Mark Recovery Form

Marker ID

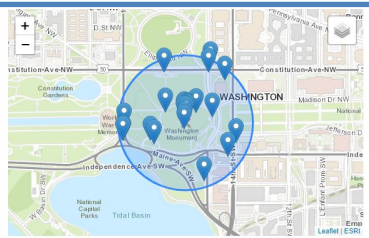
PID:	DE8888
Designation:	CHA 05A
Stamping:	CHA-05A
Latitude:	N400131.85369
Longitude:	W0882207.65630
Country:	US
State:	IL
County:	CHAMPAIGN

Recoverer ID

Agency Type:	Select agency code
Recovery Agency:	
Date mark was recovered:	YYYYMMDD
Name:	ex. John Smith
Email:	ex. JohnSmith@gmail.com

Privacy Statement: Your name and email address will be used only to contact you if there is a problem in loading your recovery. They will not be used for any other purpose.

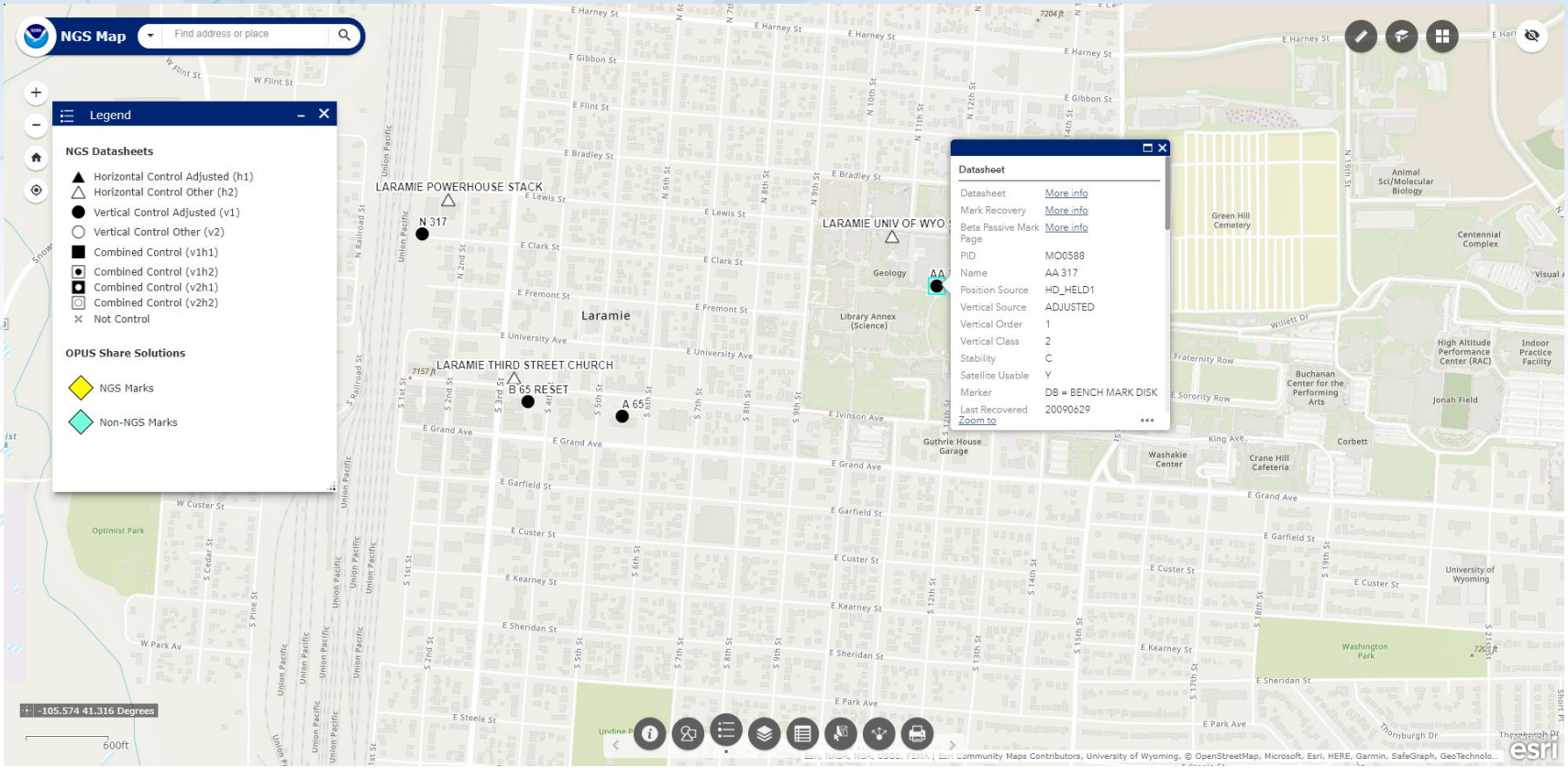
Now with Find Marks Near Me!



HV1841	A	ADJUSTED	ADJUSTED	70 ft.	S
HV4442	WASHINGTON MONUMENT	ADJUSTED	VERT ANG	80 ft.	N
DP2634	W M FLOOR 3	HD_HELD1	ADJUSTED	80 ft.	NNE
DP2635	W M FLOOR 4	HD_HELD1	ADJUSTED	80 ft.	NNE
AI4425	W M BASE NE	HD_HELD1	ADJUSTED	100 ft.	N
AJ1996	W M CASEY NE	HD_HELD1	ADJUSTED	100 ft.	N
HV8076	A 8	HD_HELD1	ADJUSTED	100 ft.	N
AI4424	W M BASE NW	HD_HELD1	ADJUSTED	110 ft.	NNW
AJ2000	W M CASEY NW	HD_HELD1	ADJUSTED	110 ft.	NNW

Close | Select

New NGS Map



https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=190385f9aadb4cf1b0dd8759893032db

Best ways to determine coordinates in Modernized NSRS

1. **Resurvey**: Return to the field and collect new observations, relying upon geodetic control that has coordinates in the new datum
2. **Readjust**: Using existing observations, re-compute new coordinates based upon geodetic control (CORS) that has been defined in the new datum
3. **Transform**: Take finished products which have coordinates in the old datum and use transformation software to estimate coordinates in the new datum

How Can You Prepare

Metadata is **essential**

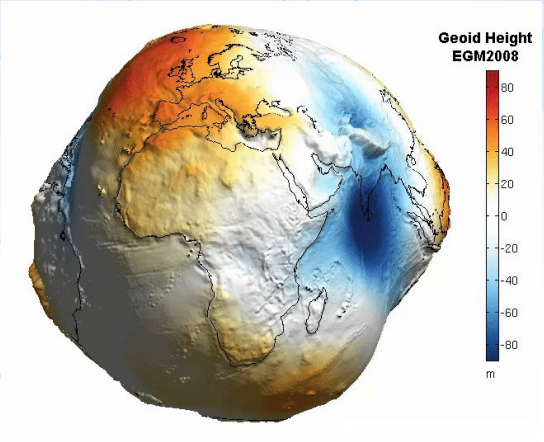
- Improves reliability and accuracy of data
- Increases value and usefulness

Transform and collect data in current datums

- NAD 83 (2011), NAVD 88

Make sure to note Geoid Models used for GNSS data

Questions?



Brian Shaw
brian.shaw@noaa.gov

Magnitude of the Deflection of the Vertical