



# The National Spatial Reference System Modernization

## May 2024 SCPLS Chapter Meeting

May 21, 2024

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# NSRS Modernization Delay

Operational, workforce retention and other issues have delayed NSRS Modernization

SPCS2022 zones will be finalized in 2024 but will not be rolled out until all of the NSRS is modernized.

Beta rollout planned for 2025, full rollout in 2026

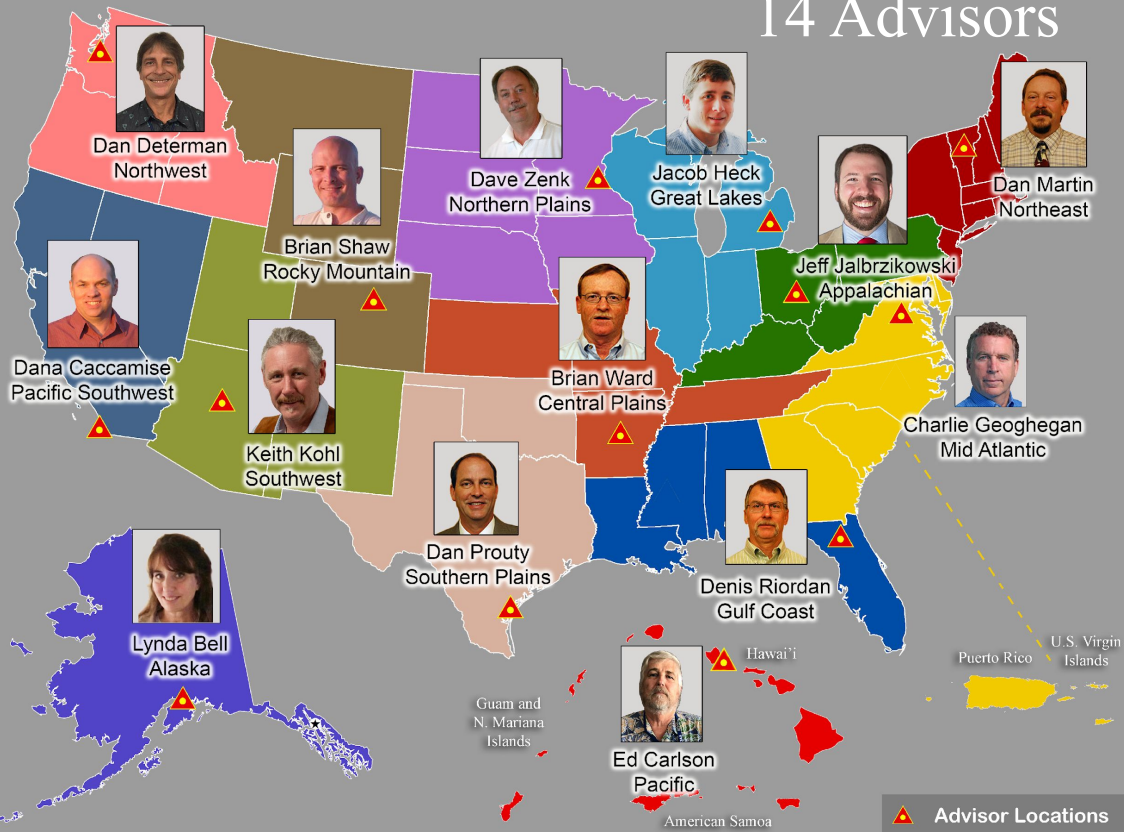
<https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml>

<https://geodesy.noaa.gov/datums/newdatums/FAQNewDatums.shtml>

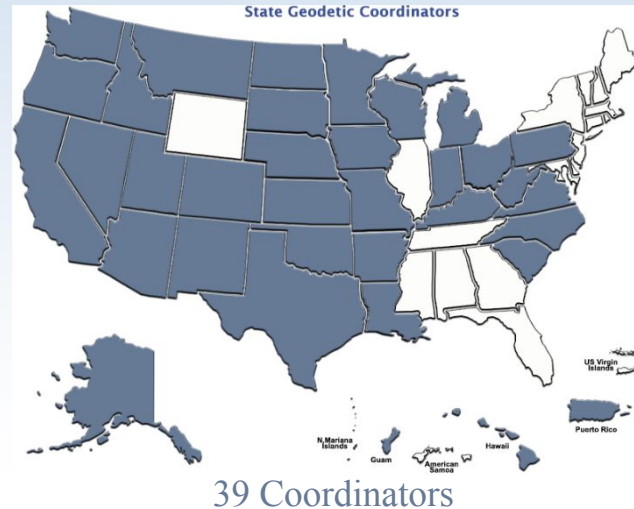


# Importance of Coordination

## 14 Advisors



## State Geodetic Coordinators





# NGS Resources

## NGS Training Center

[https://geodesy.noaa.gov/web/science\\_edu/training/](https://geodesy.noaa.gov/web/science_edu/training/)

## Educational Videos

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

## NGS Webinar Series

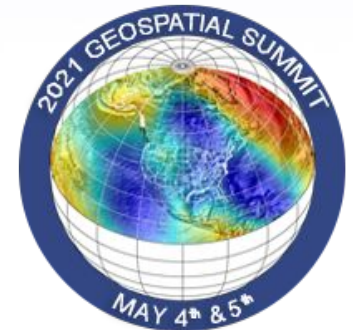
[https://geodesy.noaa.gov/web/science\\_edu/webinar\\_series/](https://geodesy.noaa.gov/web/science_edu/webinar_series/)

## Geospatial Summit (2021, 2019 recorded sessions)

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

## Presentation Library

[https://geodesy.noaa.gov/web/science\\_edu/presentations\\_library/](https://geodesy.noaa.gov/web/science_edu/presentations_library/)



# NGS Resources – Educational Videos

## 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?



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



What's Next for Geodetic Datums?



Precision and Accuracy in Geodetic Surveying



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



NOAA's VDatum Tool: Transforming Heights Between Vertical Datums



Geodetic Control in Land Surveying: Active vs. Passive



Location Science Improves Everyday Life

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

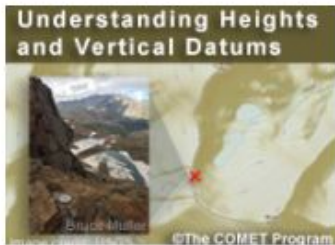
# NGS Resources – Online Lessons

## Online Lessons

NGS, in partnership with **The COMET Program**, has developed a series of self-paced lessons on geodetic and remote sensing topics. **Create a free user account** to gain access to the courses below and **many others that may be of interest**. You will have the option of printing out a certificate upon successful completion of the quiz at the end of each lesson.

These lessons are rated by skill level:

- 0 = Suitable for non-scientists
- 1 = Requires basic scientific literacy
- 2 = Requires some prior knowledge of the topic



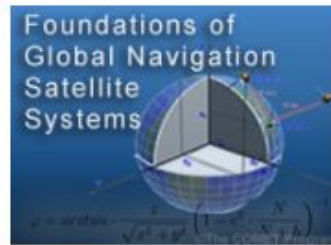
**Understanding Heights and Vertical Datums**

*Skill Level: 0*



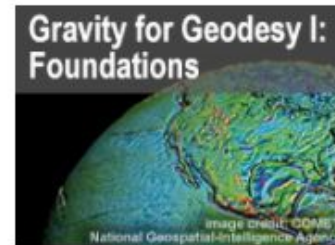
**GNSS Positioning: Survey Planning and Data Acquisition**

*Skill Level: 1*



**Foundations of Global Navigation Satellite Systems**

*Skill Level: 2*



**Gravity for Geodesy I: Foundations**

*Skill Level: 2*



**Gravity for Geodesy II: Applications**

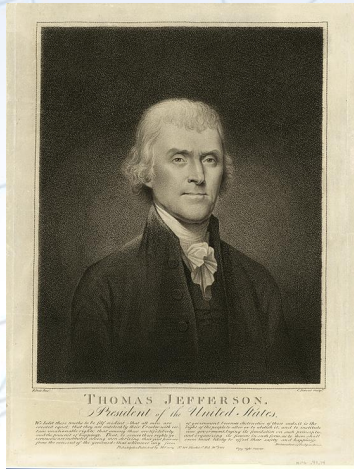
*Skill Level: 2*

[https://geodesy.noaa.gov/web/science\\_edu/online\\_lessons/index.shtml](https://geodesy.noaa.gov/web/science_edu/online_lessons/index.shtml)



# 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's 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 coordinate system that defines latitude, longitude, height, scale, and



Land Surveying



Engineering & Construction



Physical Sciences



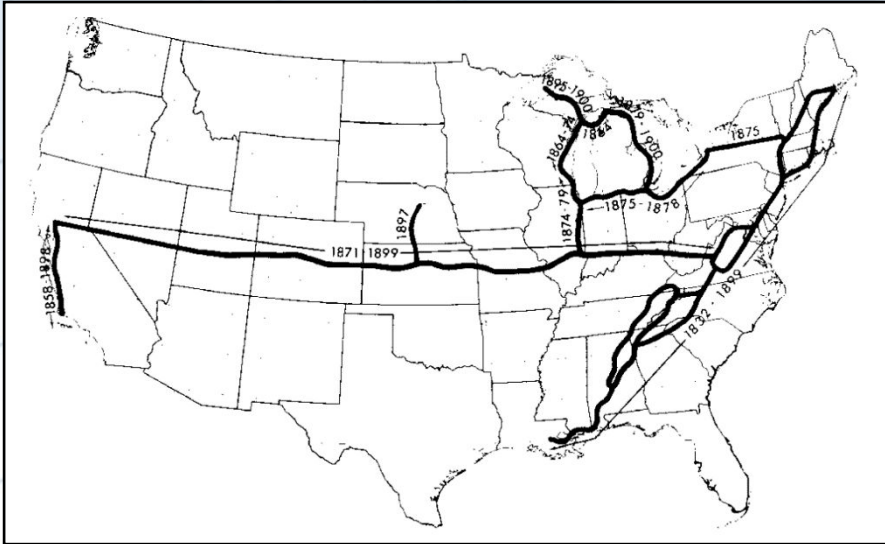
Floodplain Mapping



Land Parcels

Sectors that Rely on Geodesy

# NGS's Historical Horizontal Networks



US Standard Datum 1900



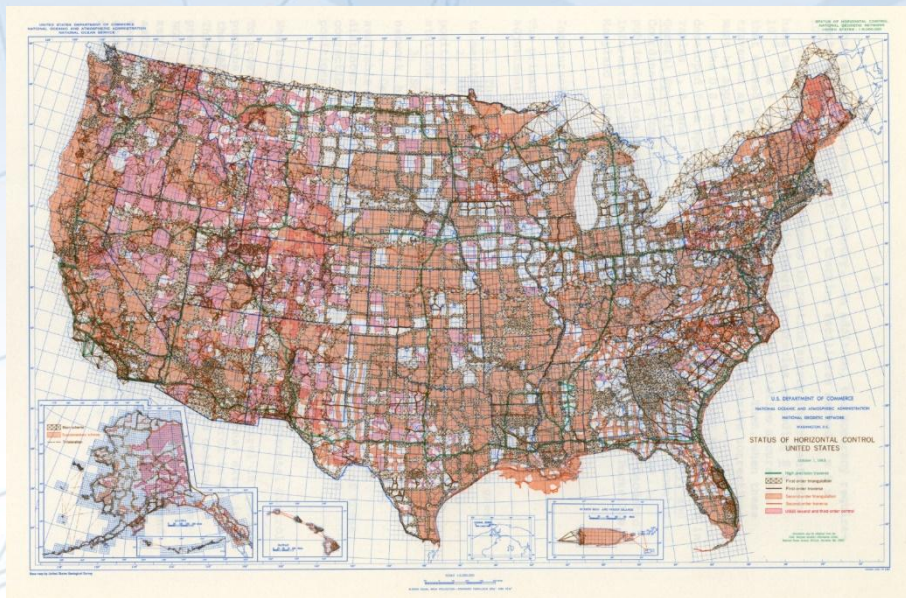
Figure 2.1. Adjustment closures for the North American Datum of 1927.

North American Datum of 1927 (NAD 27)

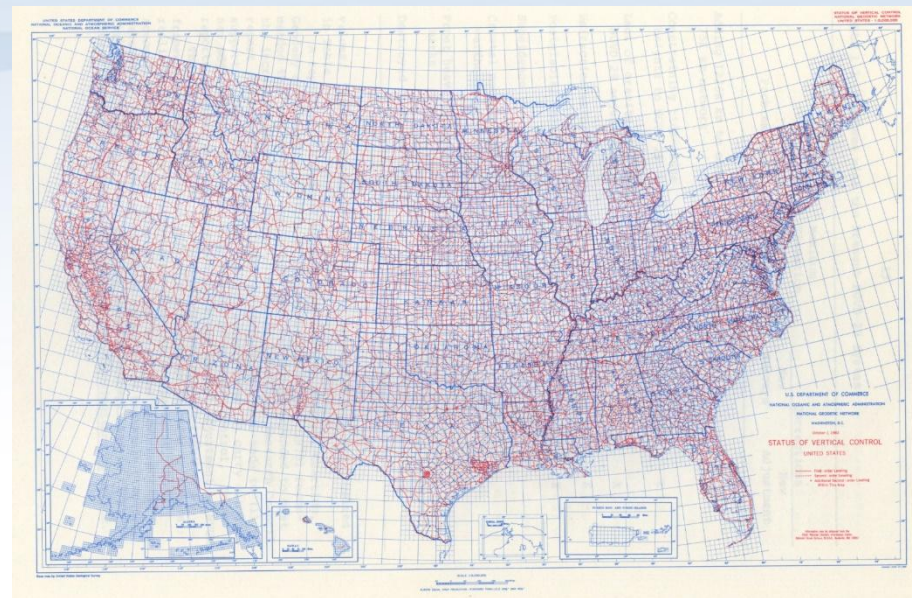
[http://www.geodesy.noaa.gov/PUBS\\_LIB/NADof1983.pdf](http://www.geodesy.noaa.gov/PUBS_LIB/NADof1983.pdf)



# 1983 Control Networks



Status of Horizontal Control 1983



Status of Vertical Control 1983

# The Bilby Tower

70

BILBY STEEL TOWER

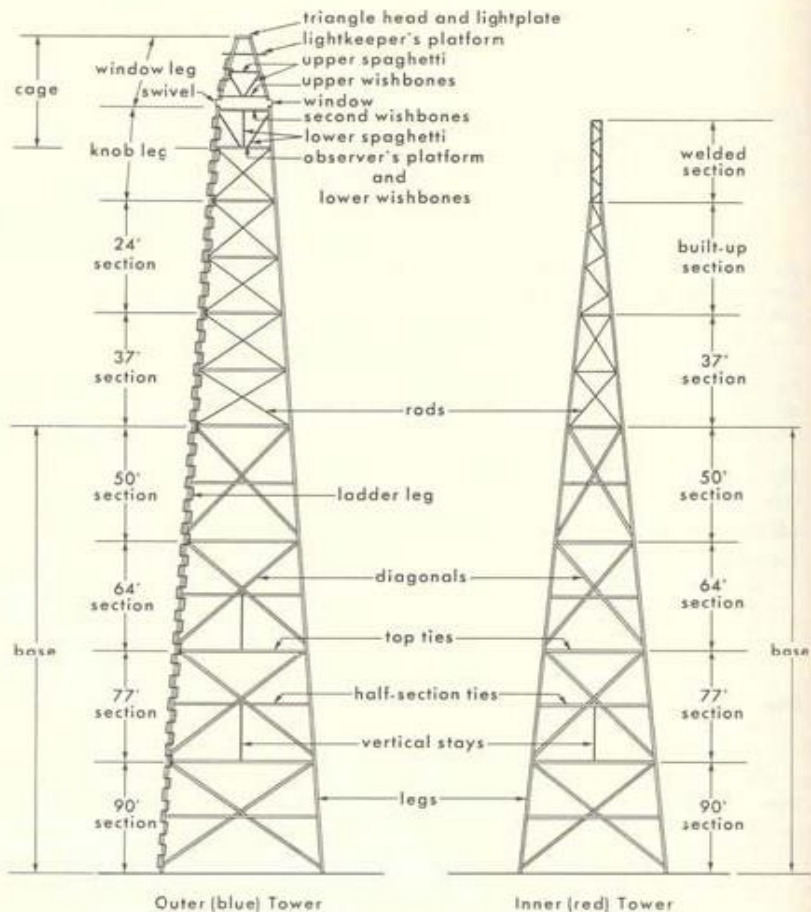


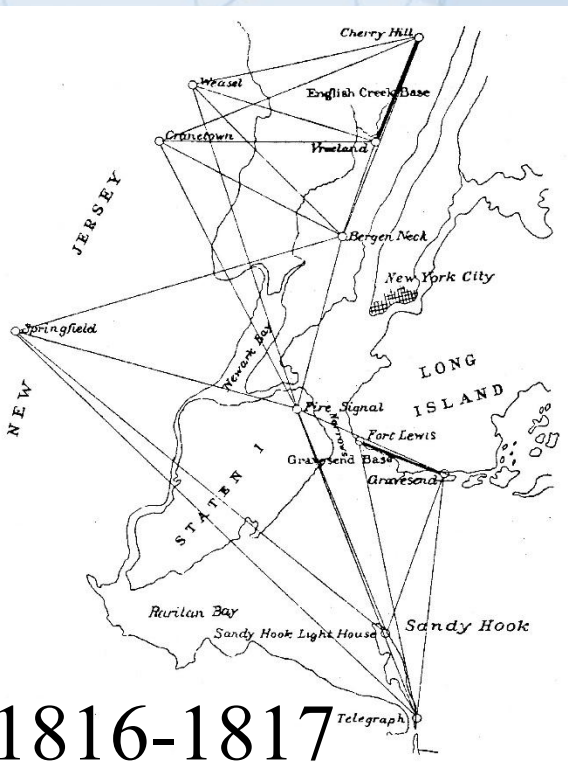
FIGURE A1.—Tower nomenclature.



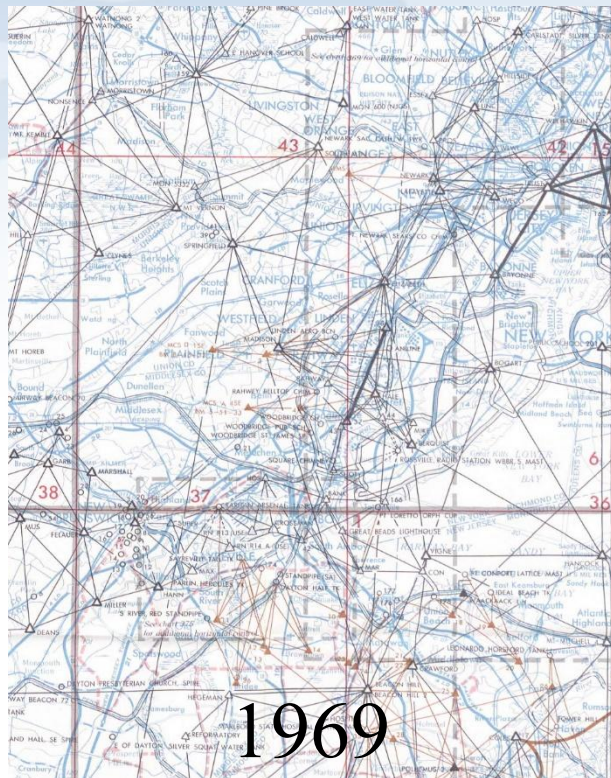
# Horizontal Network



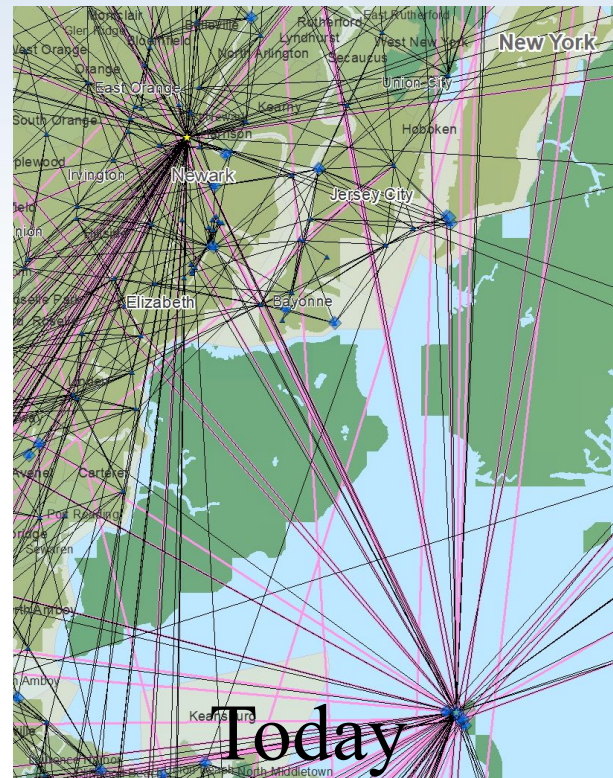
# The Importance of Geodesy



Hassler's First Field Work, 1816-1817

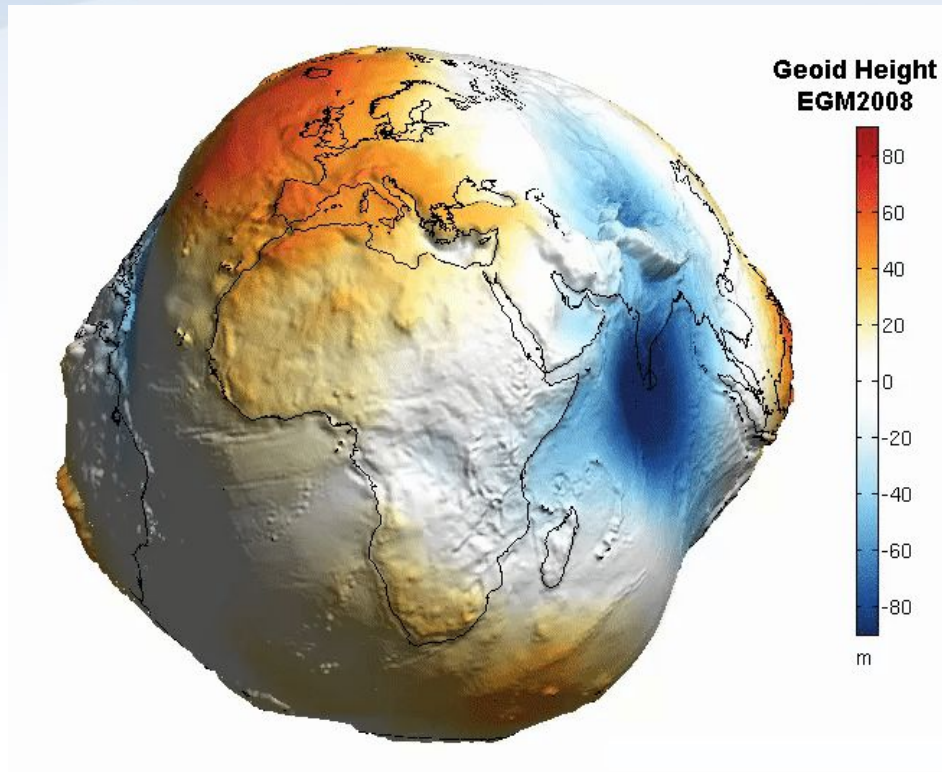
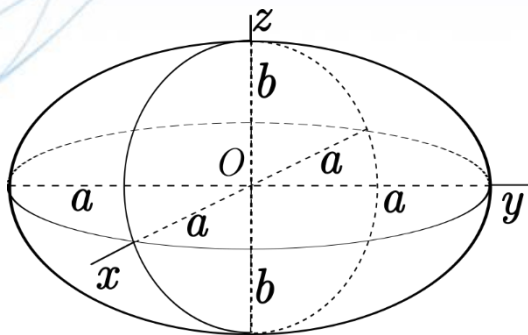
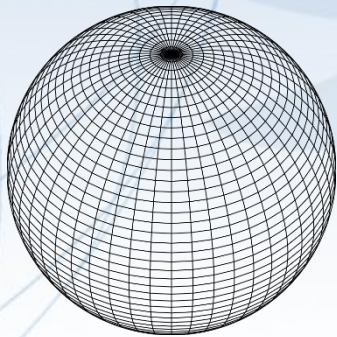


1969



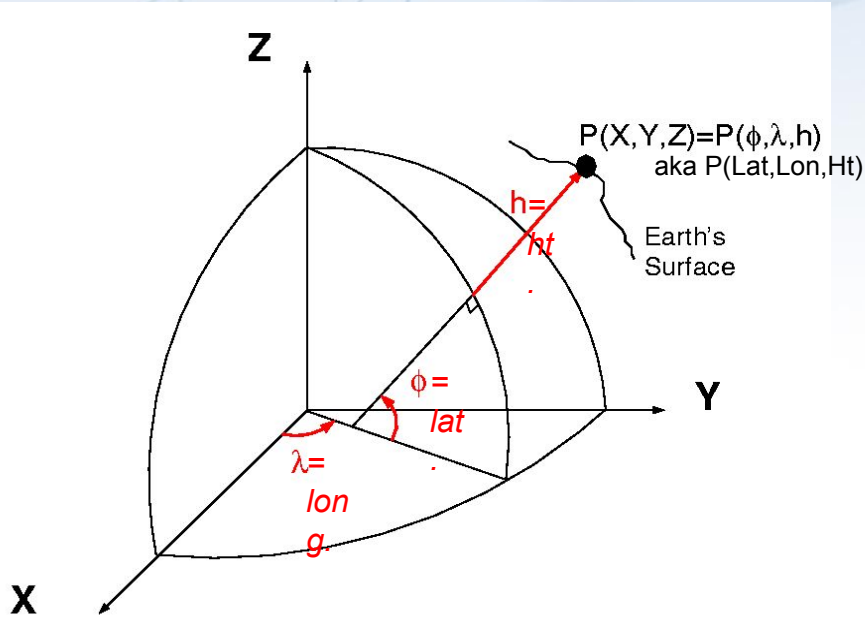
Today

# The Earth is Infinitely Complex

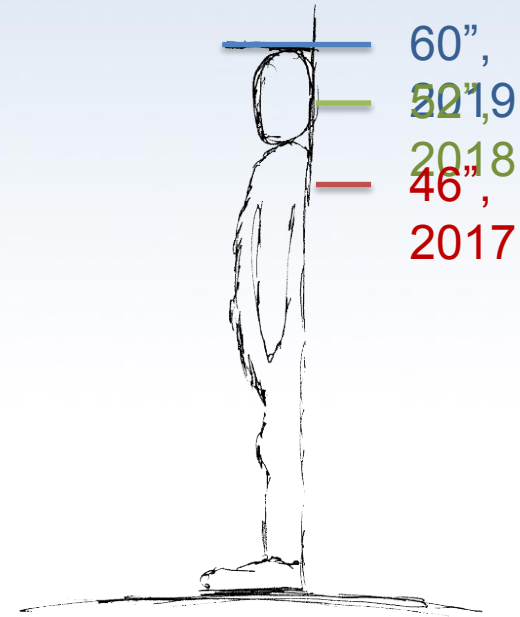


Build Models to Simplify

# 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)

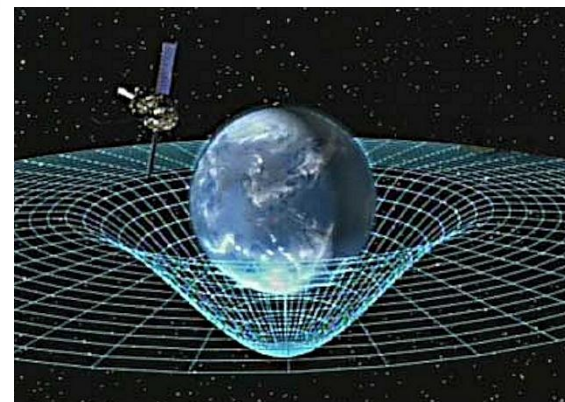
Terminal velocity

Newton (1687)

Gravity inverse-square law

Einstein (1913)

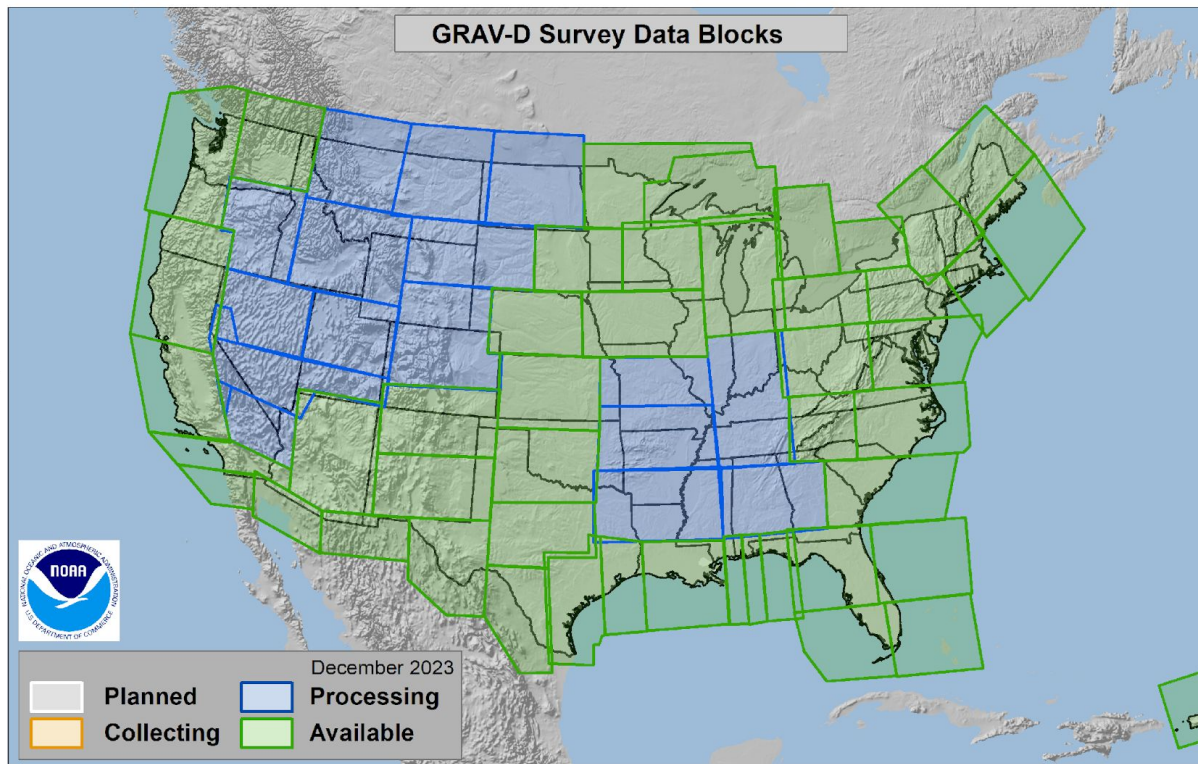
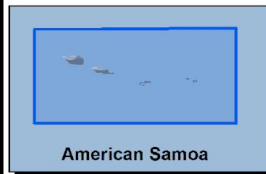
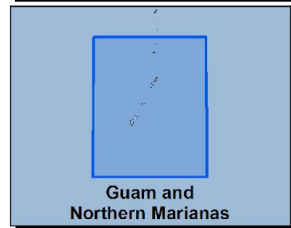
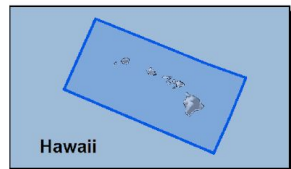
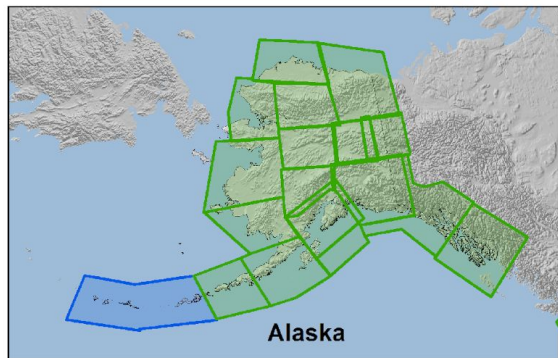
Theory of general relativity



# Gravity of the Redefinition of the American Vertical Datum

# GRAV-D

100% Complete (12/2023)



# 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

## 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

# The Future Reference Frames

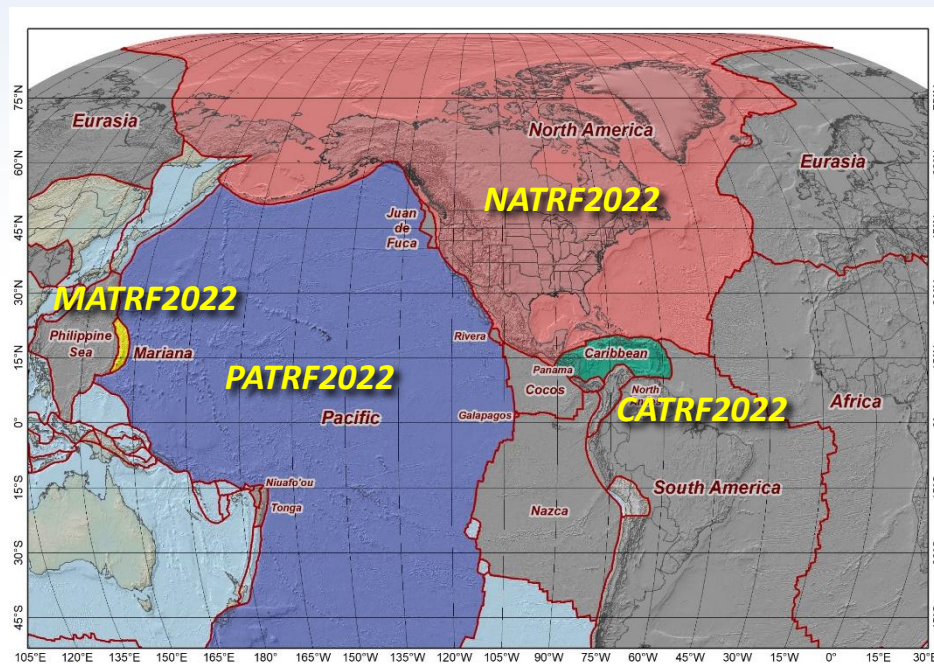
## Tectonic Plate based

Each Plate is based on the same densified ITRF model

North America  
Caribbean  
Pacific  
Mariana

NATRF  
CATRF  
PATRF  
MATRF

The tectonic plates “fixed” for the 2022 Terrestrial Reference Frames

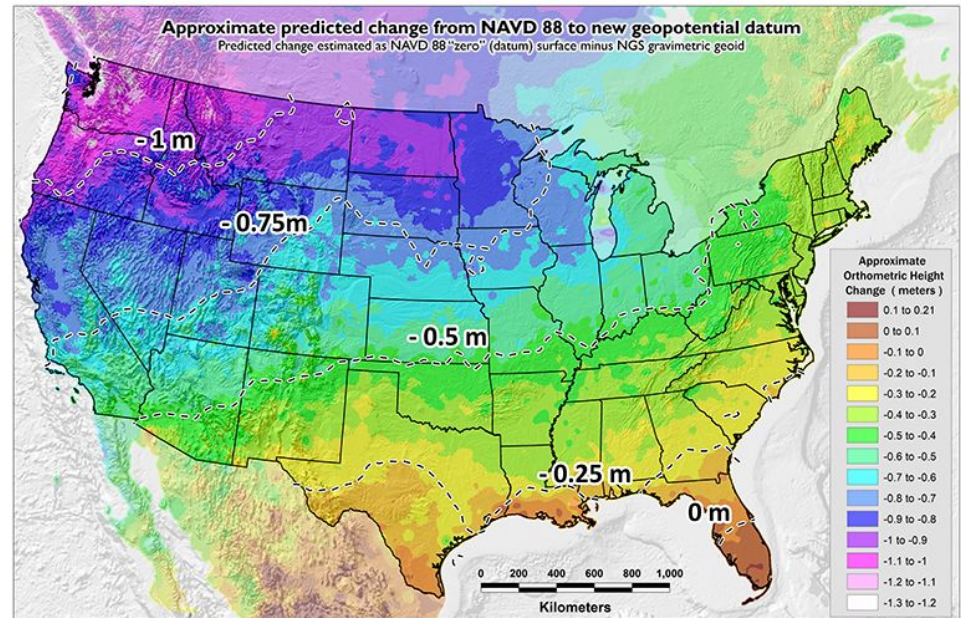
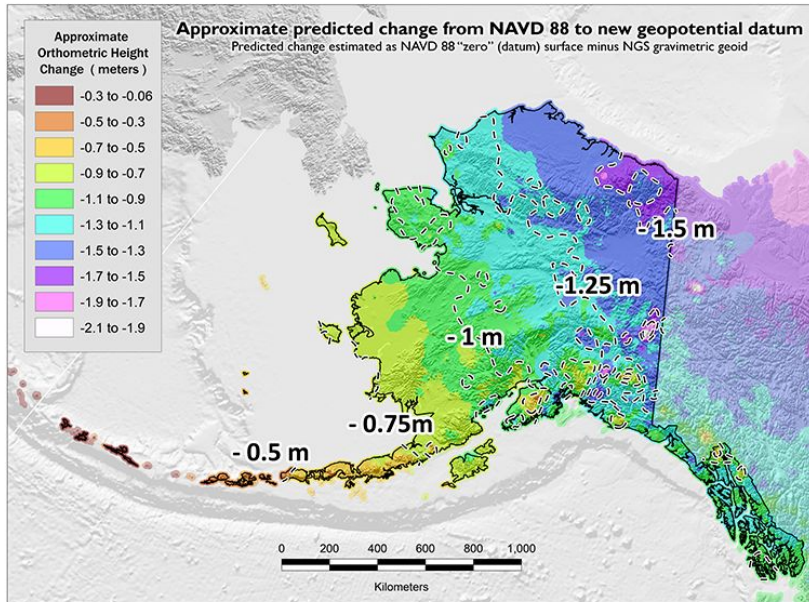




# NAVD 88 Issues

NAVD 88 suffers from a *known bias and tilt*

(about 1 meter across CONUS) relative to the gravimetric geoid

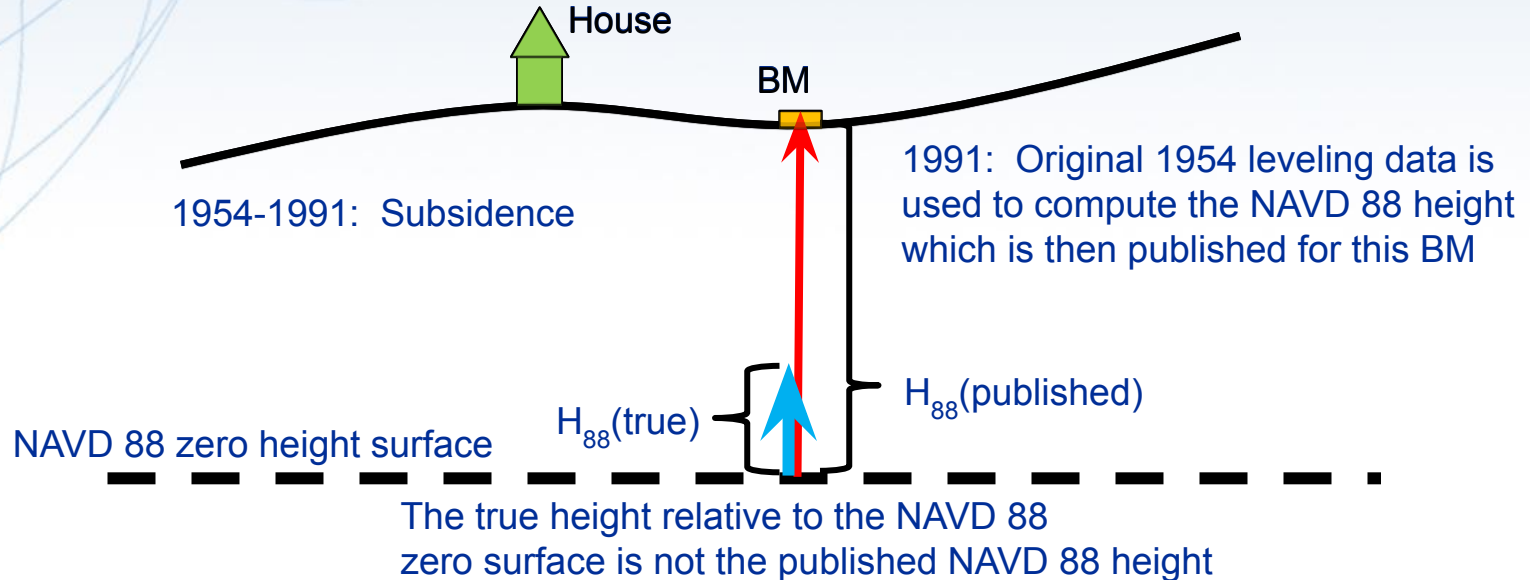


# NAVD 88 Issues

NAVD 88 suffers from **unknown movements** before, during and after its original adjustment

A hypothetical example...

1954: Leveling Performed to bench mark

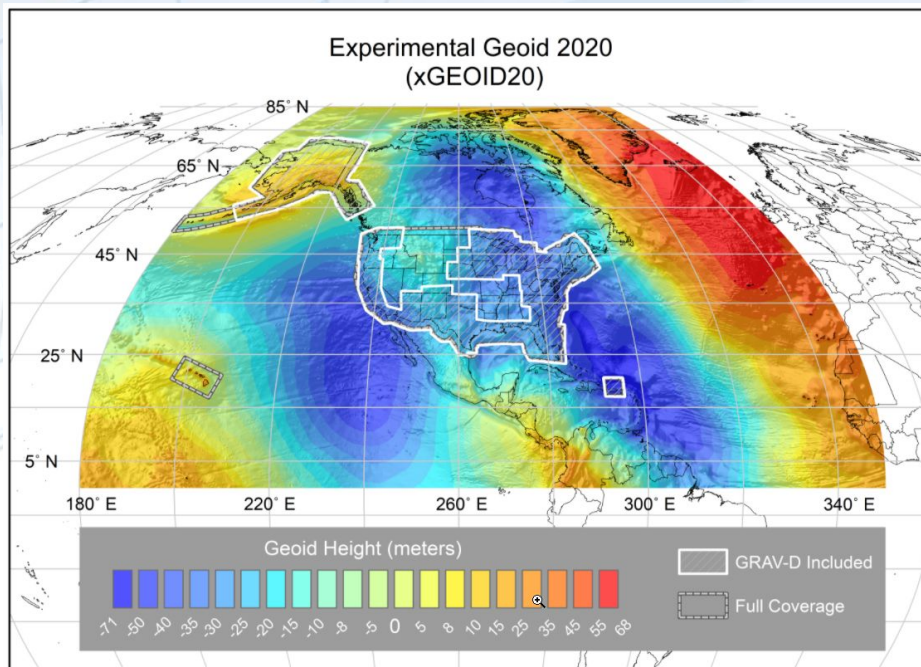


# NAPGD2022 Geopotential Datum

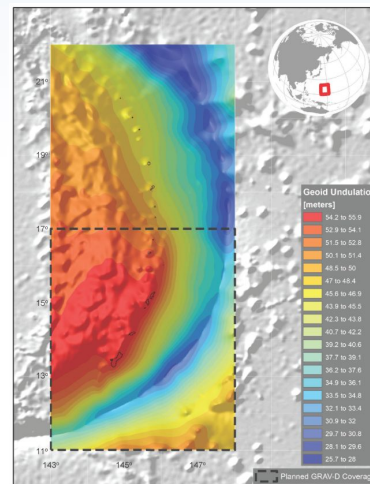
North American-Pacific Geopotential Datum of 2022

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

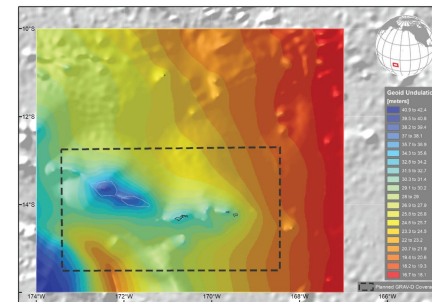
Models included:  
Geopotential  
Deflection  
Gravity  
Geoid



1/4 Earth's Surface



Guam/CNMI



American Samoa



# NSRS Modernization Catch Phrase



Shift and Drift

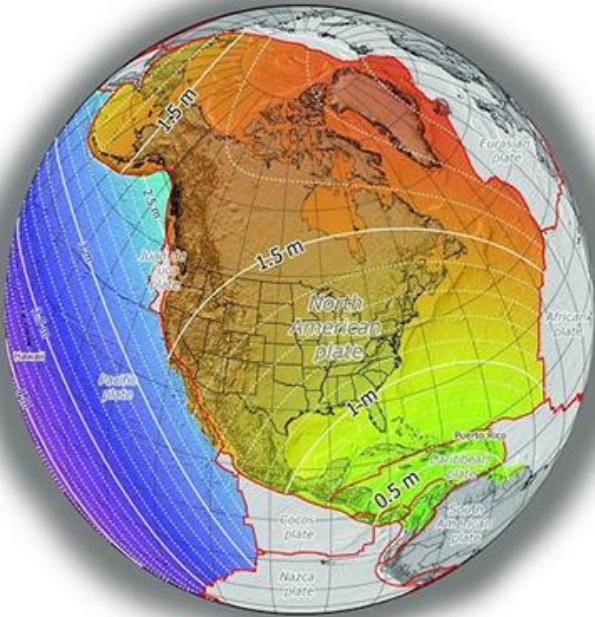
Not the Fast and Furious

# Shift and Drift

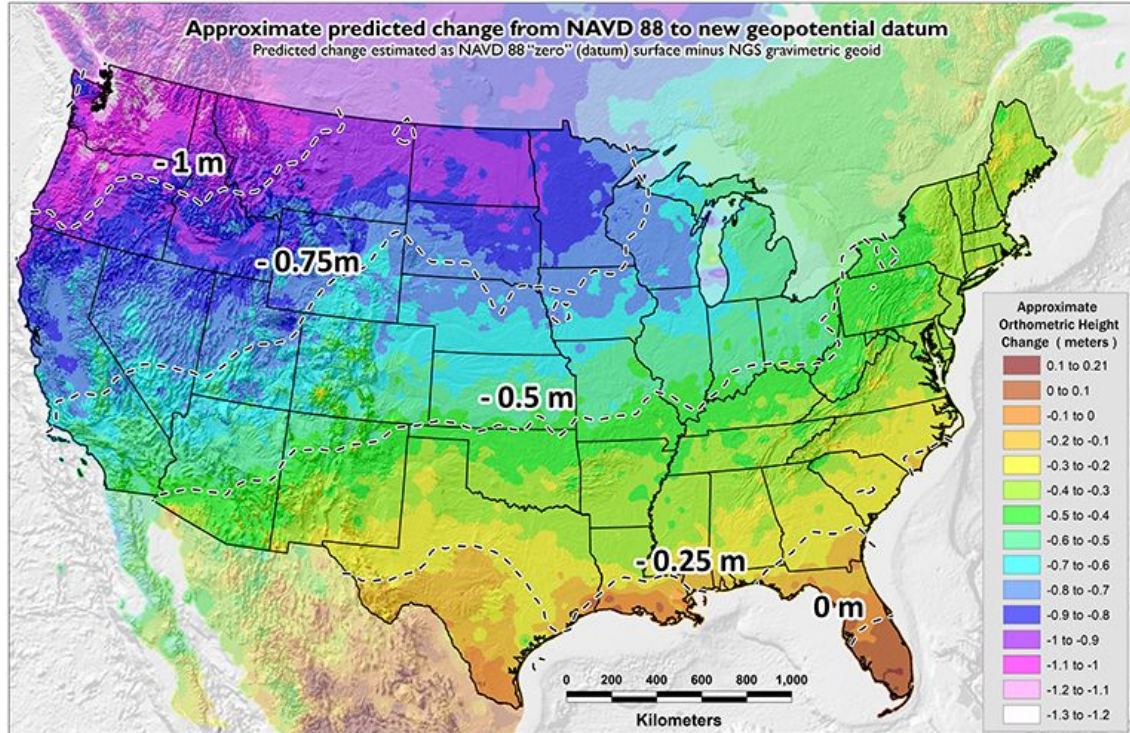
- A sudden **shift**
  - Horizontal change: **0.5 to 4 m (1.5 to 13 ft)**
  - Ellipsoid height change: **±2 m (±6 ft)**
  - Elevation change: **-0.5 to +2 m (-1.5 to +6 ft)**
- A continuous **drift**
  - Coordinates associated with specific dates
- Two components of drift:
  - Tectonic plate rotation (easy to model, 2D only)
  - All other residual motion (hard to model, 3D)

# Shift: datum changes

Approximate Horizontal Change  
North American Plate



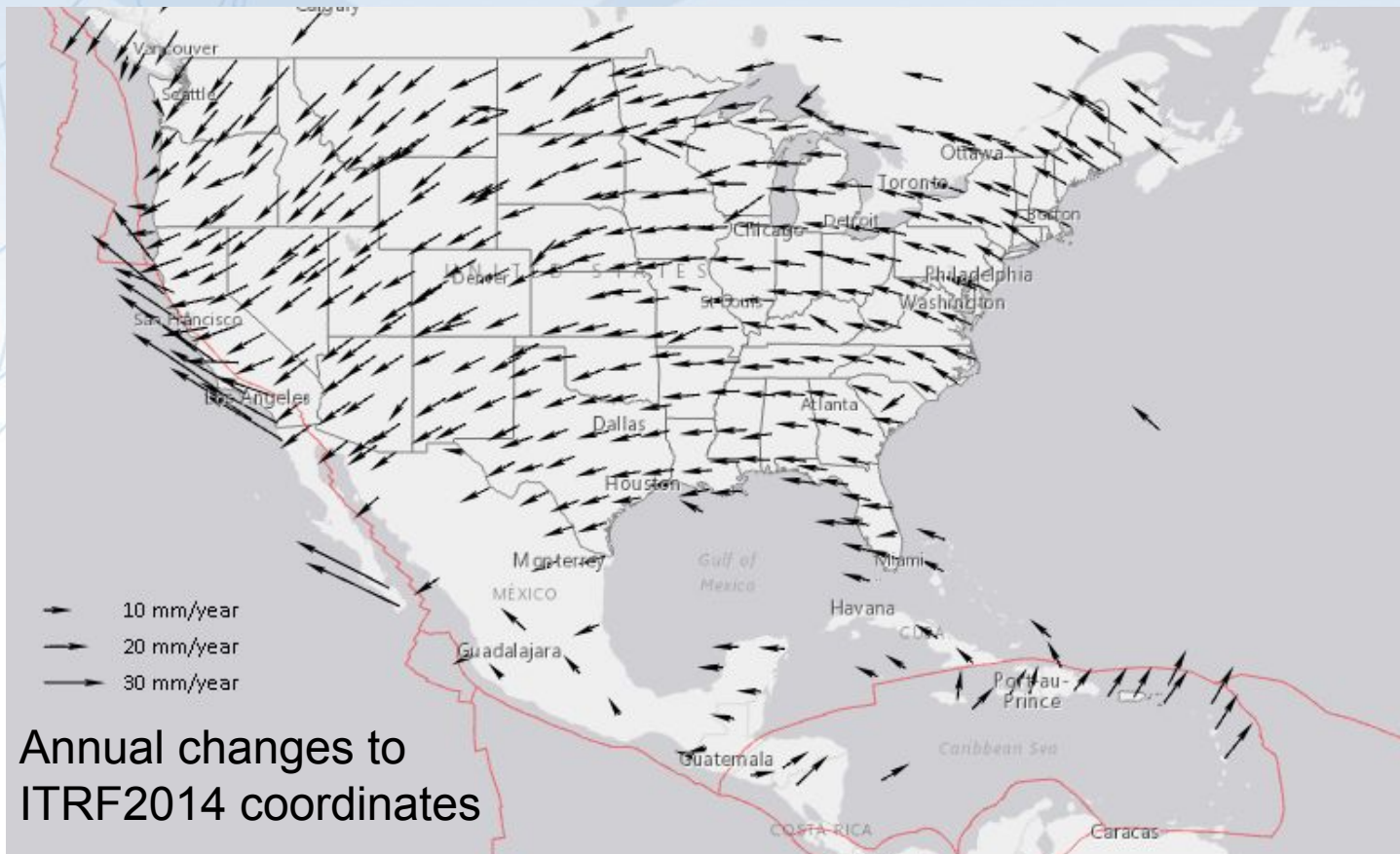
~1 to 1.5 meters North America  
~2.5 to 4 meters in Pacific



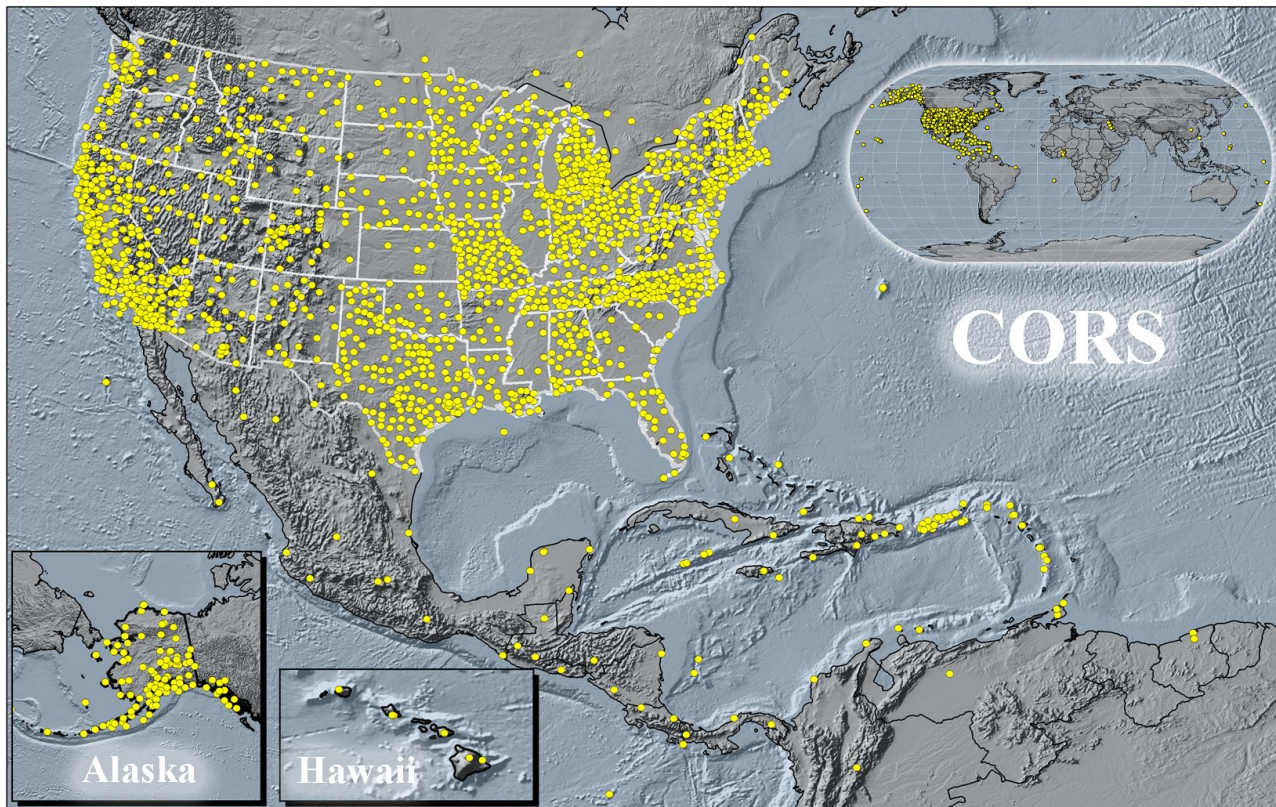
0 to 1.3 meters CONUS



# Drift: Plate Tectonics and Velocities



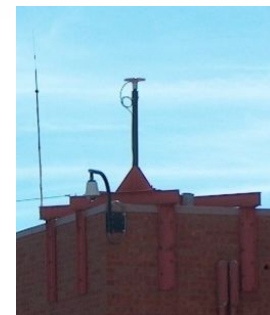
# Continuously Operating Reference Stations



P037  
Canyon City  
Colorado



CTMC  
Golden  
Colorado



# Vertical Motion

## Subsidence

Ground fluid withdrawal, sedimentation

## Glacial Isostatic Adjustment (GIA)

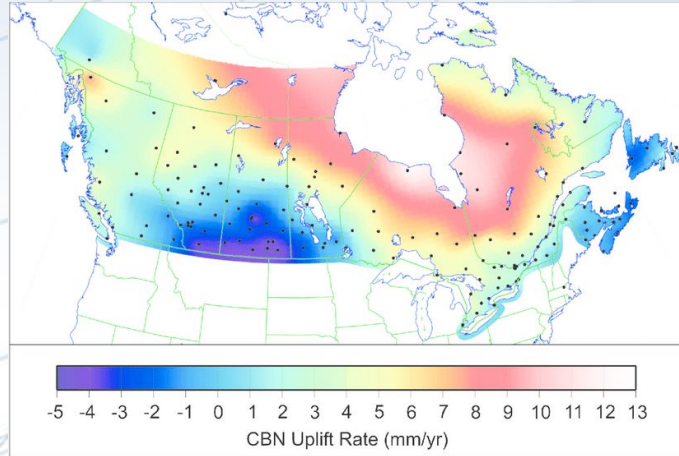
Crustal rebound from glaciers (uplift)

## Geophysical Phenomena

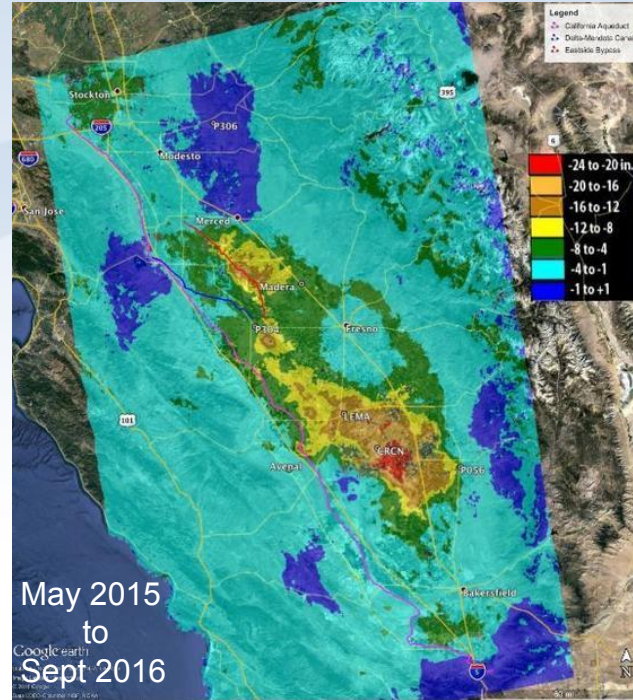
Earthquakes, calderas, Earth tides



# Vertical Motion



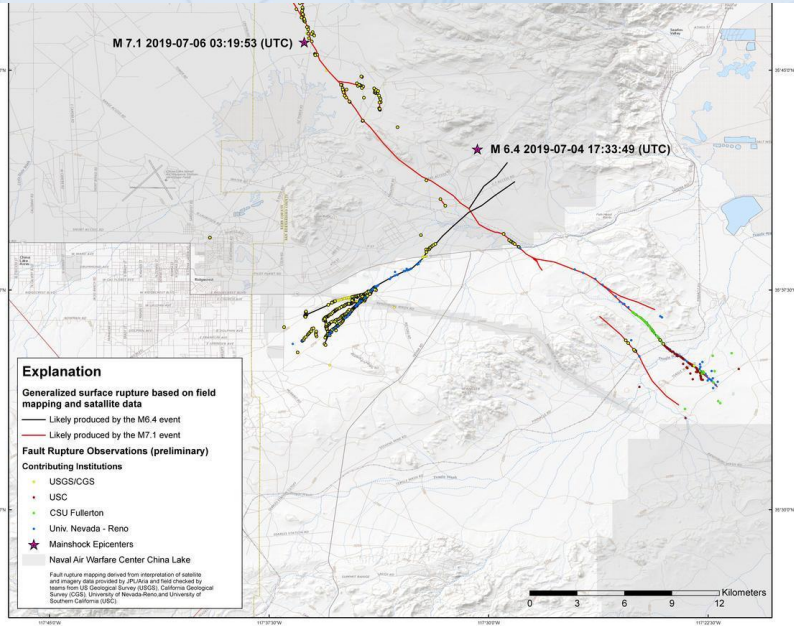
Hudson Bay Uplifting  
8 -13 mm/year



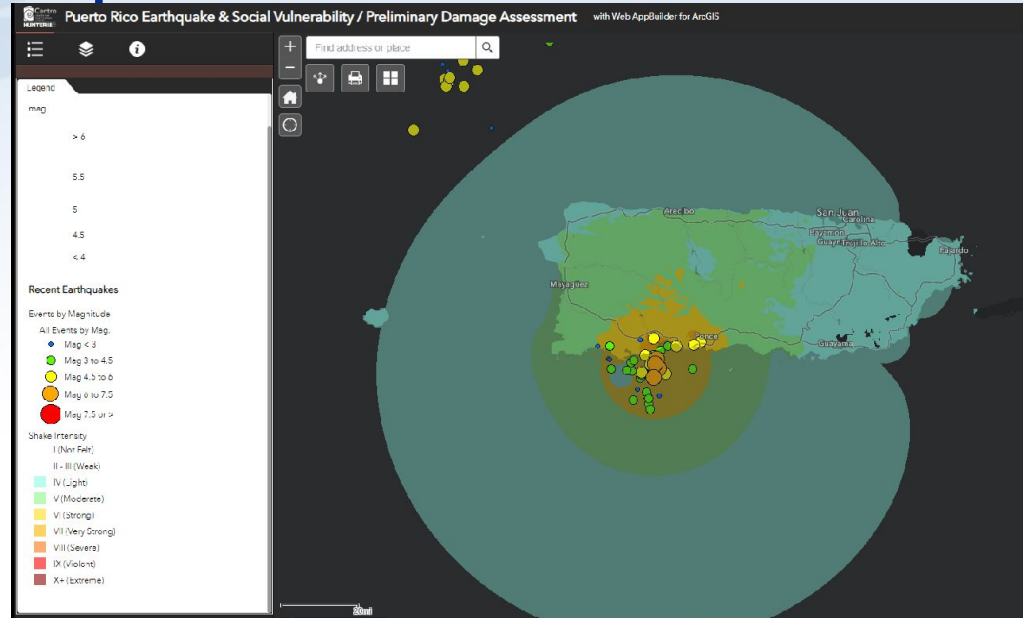
San Joaquin Subsiding  
20-24" in 16 months



# Horizontal and Vertical Motion - Earthquakes

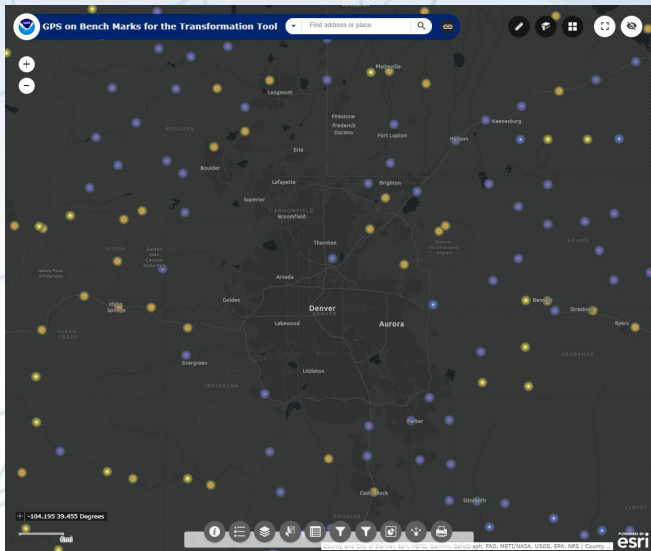


2019 China Lake, CA  
6-10 feet Horizontally

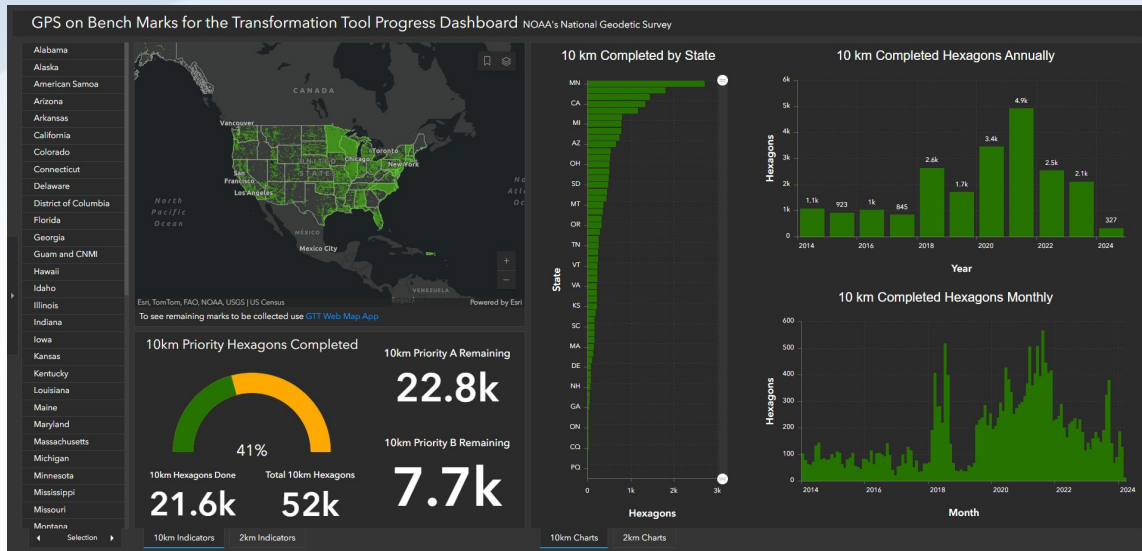


2020 Puerto Rico  
16 cm Vertically

# GPS on Bench Marks



Web Map Application



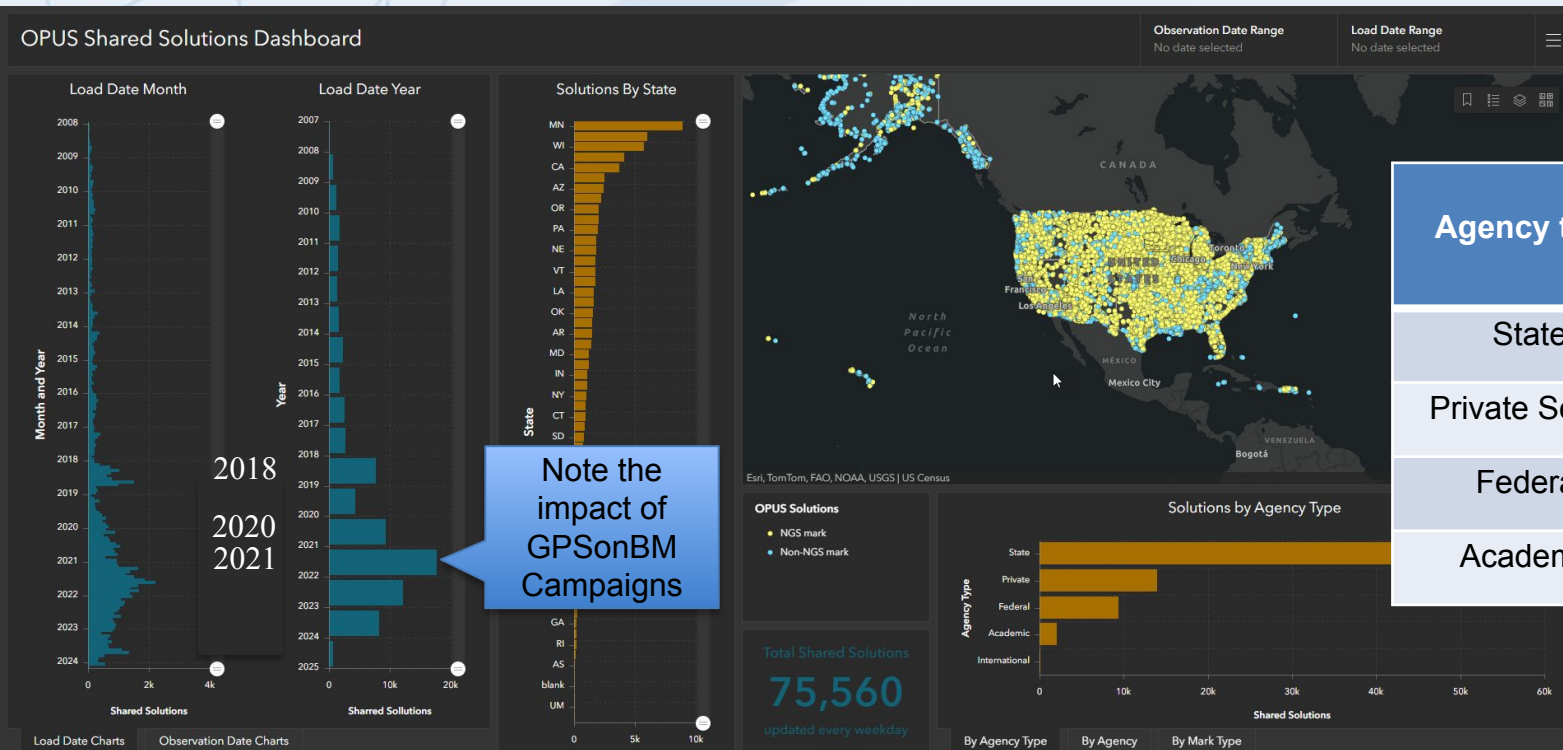
**Dashboard**  
 CO 14% Complete  
 WY 21% Complete

~3,400 Completed in 2020  
 ~4,900 Completed in 2021  
 ~2,500 Completed in 2022  
 ~2,100 Completed in 2023



# OPUS Shared Solutions Dashboard

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



Note the impact of GPSONBM Campaigns

| Agency type    | # Shared Solutions on NGS marks |
|----------------|---------------------------------|
| State          | ~44,900                         |
| Private Sector | ~7,900                          |
| Federal        | ~4,700                          |
| Academic       | ~1,800                          |

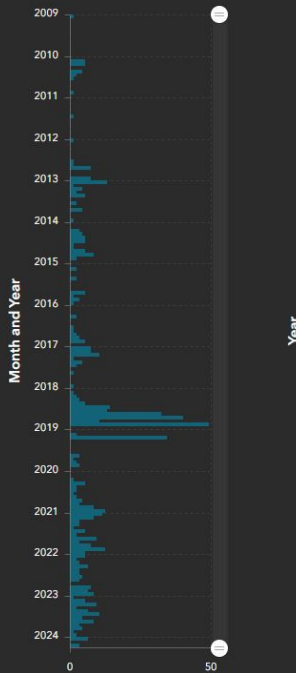
# CO OPUS Shared Solutions

## OPUS Shared Solutions Dashboard

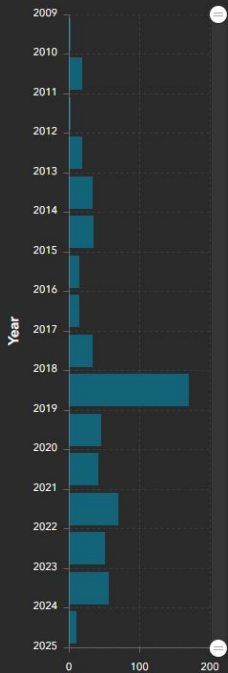
Observation Date Range  
No date selected

Load Date Range  
No date selected

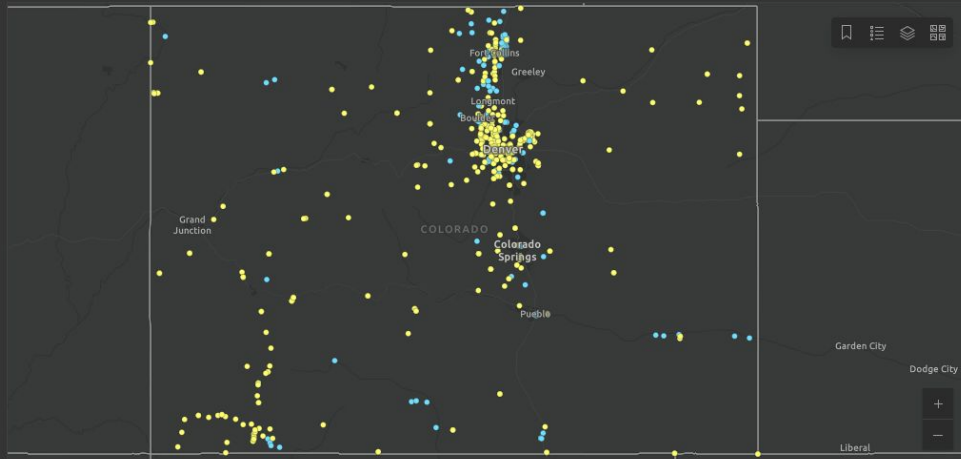
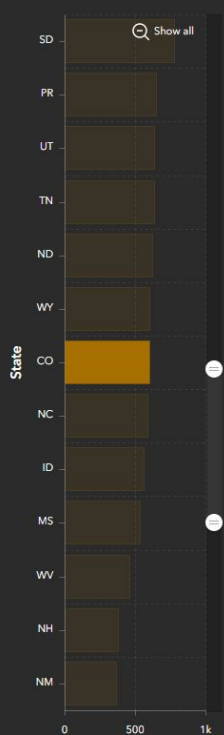
Load Date Month



Load Date Year



Solutions By State



Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS | US Census

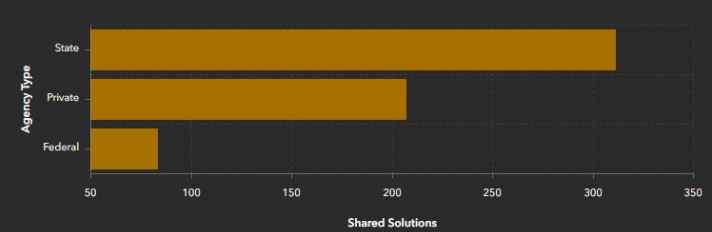
Powered by Esri

OPUS Solutions

- NGS mark
- Non-NGS mark

Total Shared Solutions  
**601**  
updated every weekday

Solutions by Agency Type



# OPUS Shared Solutions Dashboard Demo



# 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>

**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 mark survey marks set around the country and its National Geodetic Survey encourages the public to submit current mark recovery information.

**Submit Survey Mark Recovery Data**

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

**Mark Recovery Form Instructions:**

1. In the first field under the **Marker ID** section (PID) to auto-populate existing mark data and update the fields as needed. If you do not have a PID, use the **Datasheets** tool to find it.
2. In the **Recoverer ID** section, enter your name or the individual can use the code "M" (non-surveyor).

Tools: [Recovery Agency](#) | [Register an Agency](#) | [More Info](#)



**Mark Recovery Form**

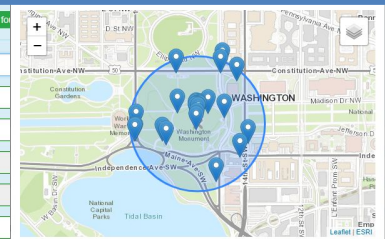
Marker ID

PID:

Designation:

Maintain your local control network:  
 Submit a Recovery Note for each mark you find (up to once per year)  
 Did you find it?  
 Is it GPSable?  
 Got new photos?

**Now with Find Marks Near Me!**



| Marker ID | Agency              | Status   | Height   | Direction   |
|-----------|---------------------|----------|----------|-------------|
| HV1841    | A                   | ADJUSTED | 79 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  |
| AM425     | 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   |
| AM424     | W M BASE NW         | HD_HELD1 | ADJUSTED | 110 ft. NNW |
| AJ2000    | W M CASEY NW        | HD_HELD1 | ADJUSTED | 110 ft. NNW |

# NAD 83 Overview

## Time Assembling Data (1974-1986)

Data from:

Canada, Caribbean, Central America,  
Greenland, Hawaii, Mexico, United States

Included:

1,785,772 geodetic observations

266,436 stations

# NAD 83 Overview

## US Portion of NAD 83:

- (a) 258,982 horizontal control stations
- (b) 1,541,090 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> order directions (horizontal angles)
- (c) 188,629 geodetic distances
- (d) 4,470 astronomic azimuth observations
- (e) 666 doppler observations (Navy Navigation Satellite System Doppler)
  - 655 observations on 612 stations in Conterminous US and Alaska
  - 11 observations at 10 stations in Hawaii
- (f) 112 VLBI observations (Very Long Baseline Interferometry)
  - 45 stations
- (g) 5 GPS (relative position observations) ties to VLBI



# NAD 83 Overview

## Canada Portion of NAD 83:

- (a) 7,454 horizontal control stations
- (b) 28,460 directions (horizontal angles)
- (c) 10,333 geodetic distances
- (d) 398 astronomic azimuth observations
- (e) 726 doppler observations (Navy Navigation Satellite System Doppler)

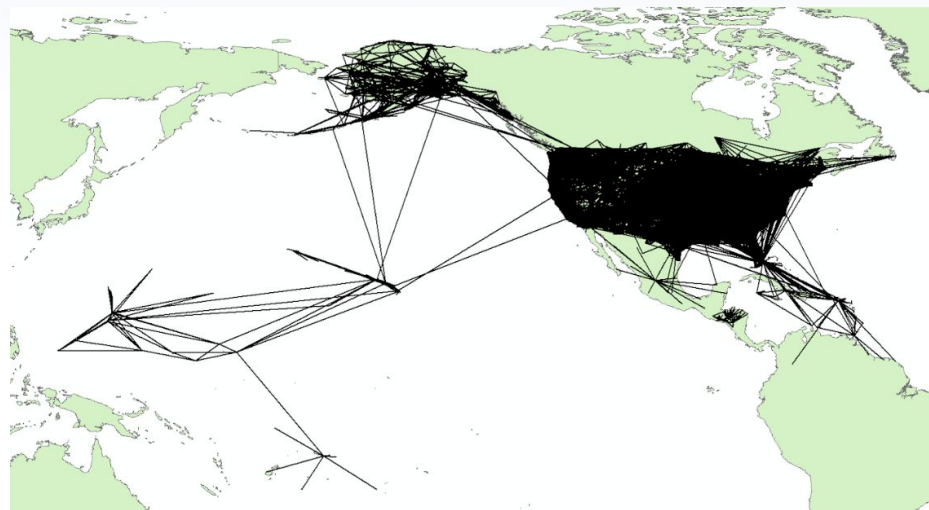
# National Adjustments

Geometric (approximate numbers)

Projects: ~5,300

Stations: ~107,000

Vectors : ~446,000



# National Adjustments

## Orthometric (approximate numbers)

### USA

Projects : ~23,900

Stations : ~1M

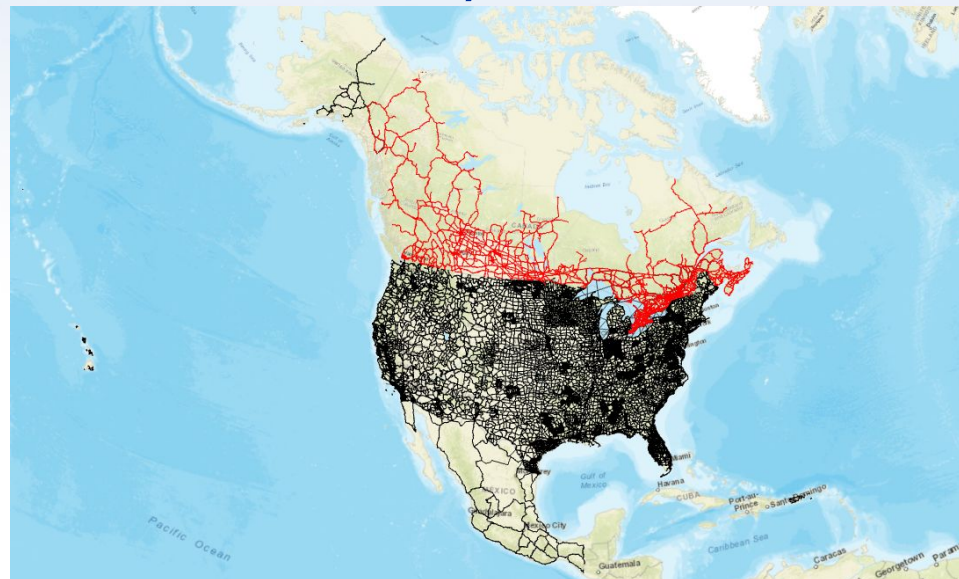
Observations : ~2.1M

### Canada

Projects : ~2,900

Stations : ~177,000

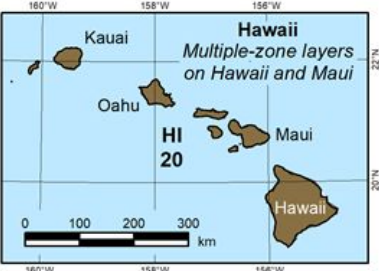
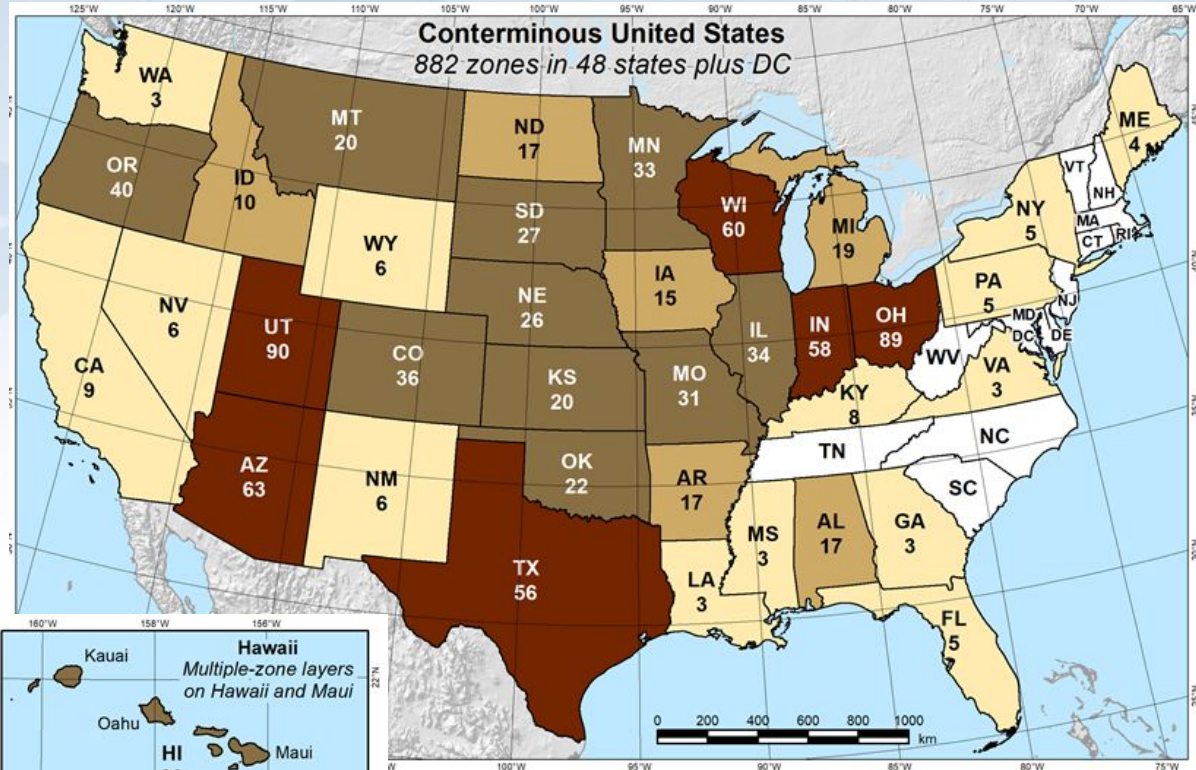
Observations : ~204,000





## 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



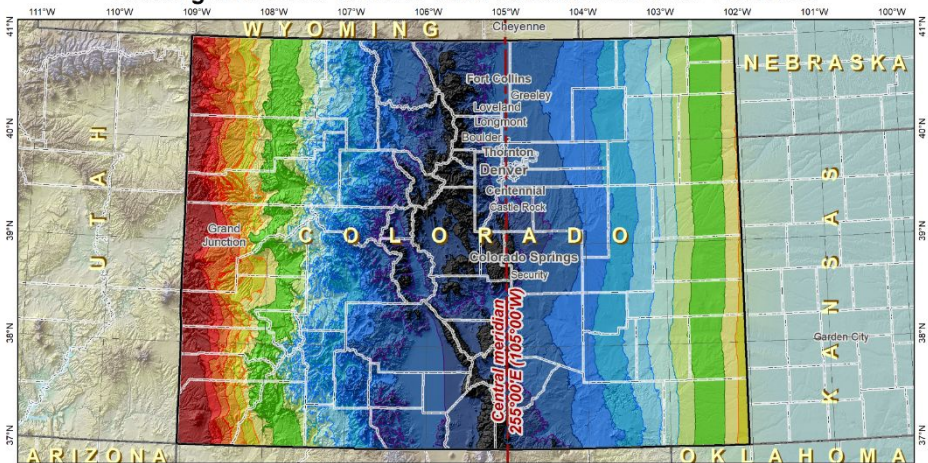
**Total 965 zones (12/9/2021)**

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



# CO SPCS 2022

Existing UTM Zone 13 North used as statewide zone: Colorado



**Transverse Mercator projection**

North American Datum of 1983  
 Central meridian: 255° 00' E  
 Central merid scale: 0.999 6 (exact)

**Areas within ±300 ppm distortion (1:3,333 = ±1.58 ft per mile):**  
 2% of population  
 6% of all cities and towns  
 8% of entire zone area

**Distortion values (ppm)**

**Entire zone:**  
 Min = -1058    Range = 2036  
 Max = +978    Mean = -320  
 Weighted mean = -576  
 (weighted by population)

**Cities and towns:**  
 Min = -869    Range = 1723  
 Max = +855    Mean = -418

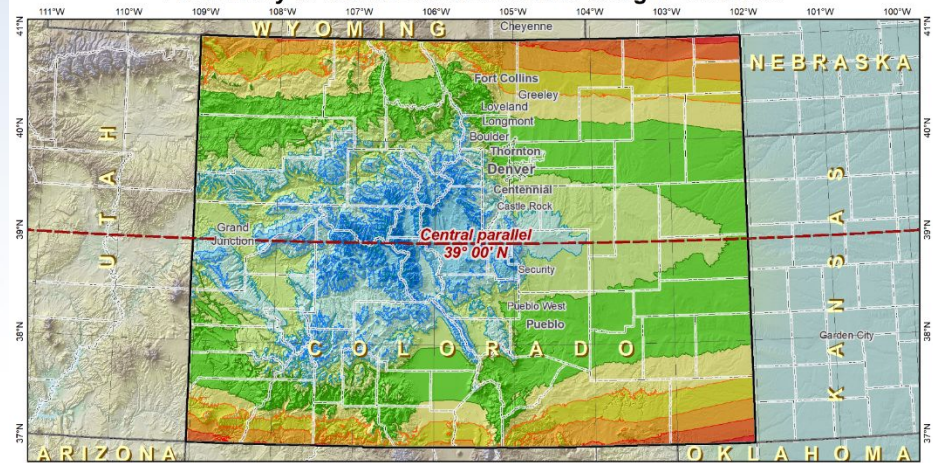
**Linear distortion at topographic surface (parts per million)**

|         |         |         |
|---------|---------|---------|
| < -800  | to -400 | to +300 |
| to -800 | to -300 | to +400 |
| to -700 | to -200 | to +500 |
| to -600 | ±100    | to +600 |
| to -500 | to +200 | > +600  |



Created 2/21/2020 (Michael Dennis)

Preliminary SPCS2022 statewide zone design: Colorado



**Lambert Conformal Conic projection**

North American Terrestrial Reference Frame of 2022  
 Central parallel: 39° 00' N  
 Central parallel scale: 1.000 1 (exact)

**Areas within ±300 ppm distortion (1:3,333 = ±1.58 ft per mile):**  
 98% of population  
 87% of all cities and towns  
 81% of entire zone area

**Distortion values (ppm)**

**Entire zone:**  
 Min = -576    Range = 1130  
 Max = +554    Mean = -22  
 Weighted mean = -58  
 (weighted by population)

**Cities and towns:**  
 Min = -420    Range = 963  
 Max = +543    Mean = -12

**Linear distortion at topographic surface (parts per million)**

|         |         |         |
|---------|---------|---------|
| < -800  | to -400 | to +300 |
| to -800 | to -300 | to +400 |
| to -700 | to -200 | to +500 |
| to -600 | ±100    | to +600 |
| to -500 | to +200 | > +600  |

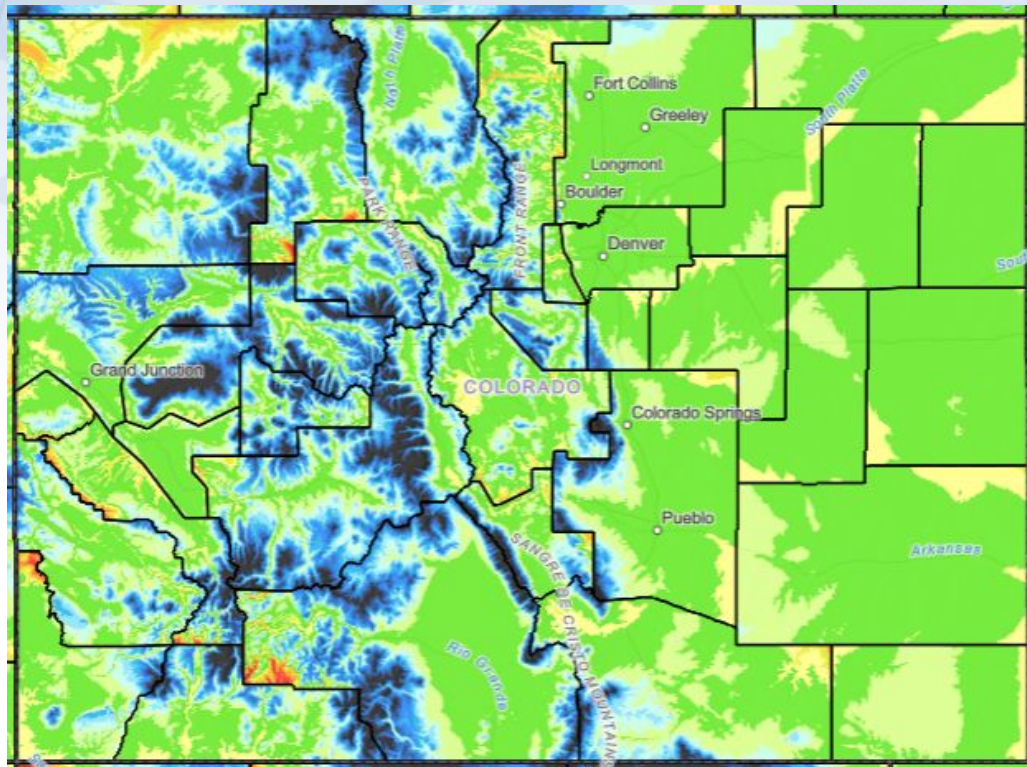
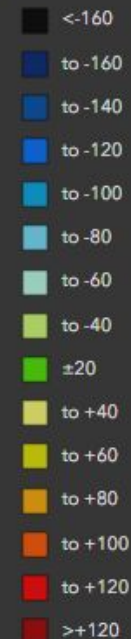


Created 2/28/2020 (Michael Dennis)

# CO SPCS2022 Experience

## Multizone Complete Zones (20ppm)

ppm



1 Statewide Zone  
35 LDPs

<https://experience.arcgis.com/experience/dddb7bc0be6f4e56a1c370c8d529d1a0>



# Alpha State Plane Coordinate System of 2022 Experience

## Demo

<https://experience.arcgis.com/experience/dddb7bc0be6f4e56a1c370c8d529d1a0/>

# Alpha NCAT with SPCS2022

**ALPHA**  
Preliminary Products

NGS Coordinate Conversion and Transformation Tool (NCAT)  
National Geodetic Survey

Search

---

NGS Alpha Home
Single Point Conversion
Multipoint Conversion
Web services
Downloads
Tutorial & FAQs
About NCAT

Last Updated: Dec 05 2023

Convert/Transform from:

Horizontal
  Horizontal+height
  XYZ (Cartesian geocentric)

Select the type of horizontal coordinate:

Geodetic lat-long
  SPC (State Plane)
  UTM
  USNG

Enter lat-long in decimal degrees

Lat:

Lon:

or degrees-minutes-seconds

Lat:

Lon:

or drag map marker to a location of interest

**Note the following for this alpha NCAT implementation:**  
 Enables preliminary (alpha) State Plane Coordinate System of 2022 (SPCS2022). ITRF2020 is a proxy for the 2022 Terrestrial Reference Frames. Transformations to other frames are not available at this time. Auto Pick will return an SPC2022 zone in most areas of the NERS but may not give the desired zone because of zone layers. In those cases, select the desired zone from the pull-down list. NAD83 latitude and longitude can be used as input, but the output coordinates will differ horizontally from actual SPC2022 by up to a few meters, depending on location (likewise for UTM and USNG). If NAD 83 ellipsoidal heights are used, the linear distortion and combined factor will differ from SPCS2022 values by a small amount, within +/- 3 parts per million (ppm). To reduce these differences, NAD83 epoch 2010.0 coordinates can first be transformed to ITRF2020 epoch 2020.0 using the Horizontal Time-Dependent Positioning (HTDP) tool.

Input reference frame (historically called 'horizontal datum'):  Output reference frame (historically called 'horizontal datum'):

Don't see a reference frame in the list? [Click here to learn more](#)

SPC zone:

Click here to expand/collapse

**Converted Coordinate**

Reference Frame:

You may change the default UTM zone. The change is processed interactively once a lat-long is converted. DO NOT click the Submit button.

[Customize Export](#)

Website Owner: National Geodetic Survey | Last modified by: ngs-hcm | Dec 19, 2023

https://alpha.ngs.noaa.gov/SPCS/index.shtml

# What is linear distortion and ppm?

Linear distortion is the same as map scale error at the ground surface, given in parts per million (ppm) rather than as a ratio.

Ex:

Distortion of 100 ppm is the same as:

10 cm per km, 0.53 ft per mile, or a ratio 1 part in 10,000

So for an actual horizontal distance of 1 mile, the projected (map grid) distance would be 0.53 ft shorter for negative 100 ppm distortion, and 0.53 ft longer for positive 100 ppm distortion.

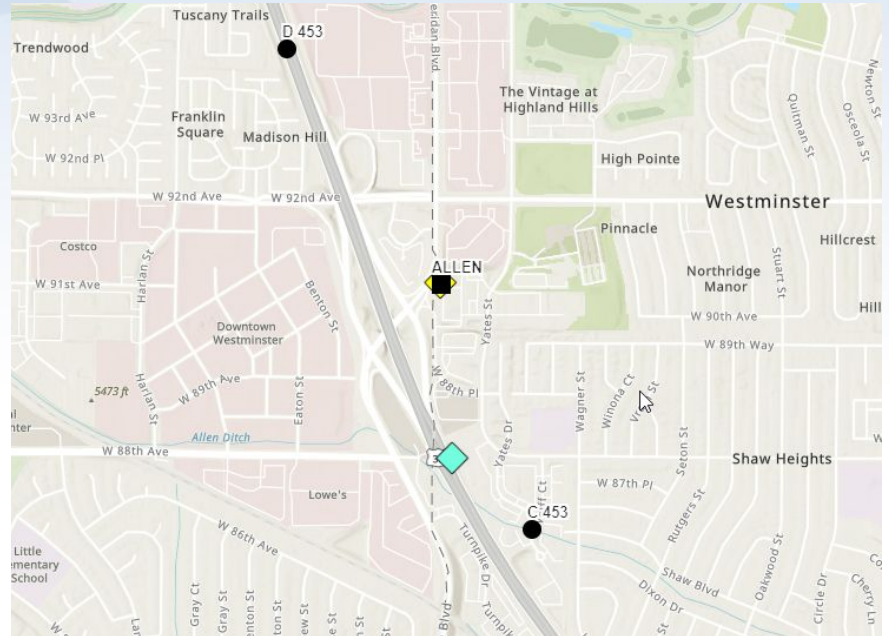
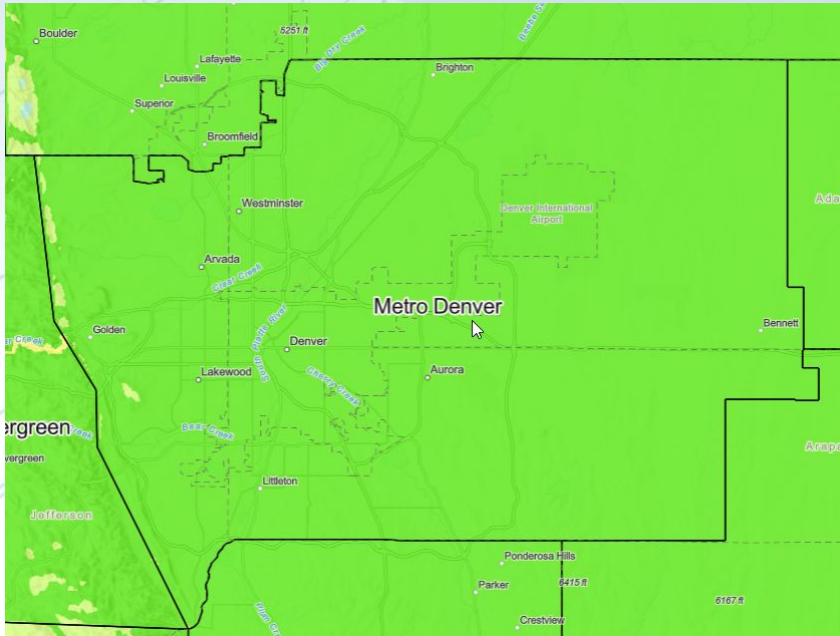


# Linear distortion and ppm

| Parts per million | Centimeters per kilometer | Feet per mile | Dimensionless ratio | Examples                                      |
|-------------------|---------------------------|---------------|---------------------|---|
| 20 ppm            | 2 cm/km                   | 0.11 ft/mile  | 1:50,000            | Typical "low distortion projection" limit     |
| 50 ppm            | 5 cm/km                   | 0.26 ft/mile  | 1:20,000            | Minimum distortion for designs by NGS         |
| 100 ppm           | 10 cm/km                  | 0.53 ft/mile  | 1:10,000            | Historic State Plane distortion design limit* |
| 400 ppm           | 40 cm/km                  | 2.11 ft/mile  | 1:2,500             | UTM distortion design limit*                  |

\*For distortion with respect to the ellipsoid, not the topographic surface.

# SPCS 83 versus SPCS2022



ALLEN (Westminister, CO)

# SPCS 83 versus SPCS2022

## ALLEN (Colorado State Zone)

```

KK1753 *****
KK1753 DESIGNATION - ALLEN
KK1753 PID - KK1753
KK1753 STATE/COUNTY- CO/ADAMS
KK1753 COUNTRY - US
KK1753 USGS QUAD - ARVADA (2019)
KK1753
KK1753 *CURRENT SURVEY CONTROL
KK1753
-----
KK1753* NAD 83(2011) POSITION- 39 51 40.26600(N) 105 03 10.68534(W) ADJUSTED
KK1753* NAD 83(2011) ELLIP HT- 1672.849 (meters) (06/27/12) ADJUSTED
KK1753* NAD 83(2011) EPOCH - 2010.00
KK1753* NAVD 88 ORTHO HEIGHT - 1689.919 (meters) 5544.34 (feet) ADJUSTED
KK1753;
KK1753;SPC CO N - North East Units Scale Factor Converg.
KK1753;SPC CO N - 363,504.220 952,651.856 MT 0.99997982 +0 17 19.8
KK1753;SPC CO N - 1,192,596.76 3,125,491.96 sFT 0.99997982 +0 17 19.8
KK1753;UTM 13 - 4,412,351.639 495,469.512 MT 0.99960025 -0 02 02.2
KK1753
KK1753! - Elev Factor x Scale Factor = Combined Factor
KK1753!SPC CO N - 0.99973763 x 0.99997982 = 0.99971746
KK1753!UTM 13 - 0.99973763 x 0.99960025 = 0.99933799
    
```

| SPC             |                                   |
|-----------------|-----------------------------------|
| Zone            | CO-080001 (Statewide)             |
| Northing        | 476,719.044 m<br>1,564,038.858 ft |
| Easting         | 990,758.954 m<br>3,250,521.504 ft |
| Convergence     | +00° 16' 52.77"                   |
| Scale factor    | 1.000212990                       |
| Combined factor | 0.999950566                       |
| Distortion      | -49.434 ppm                       |

SPCS 83 CO N -282.5 ppm  
UTM 13 -662 ppm

SPCS2022 CO -49.4 ppm



# SPCS 83 versus SPCS2022

## ALLEN (DENVER METRO Zone LDP)

```

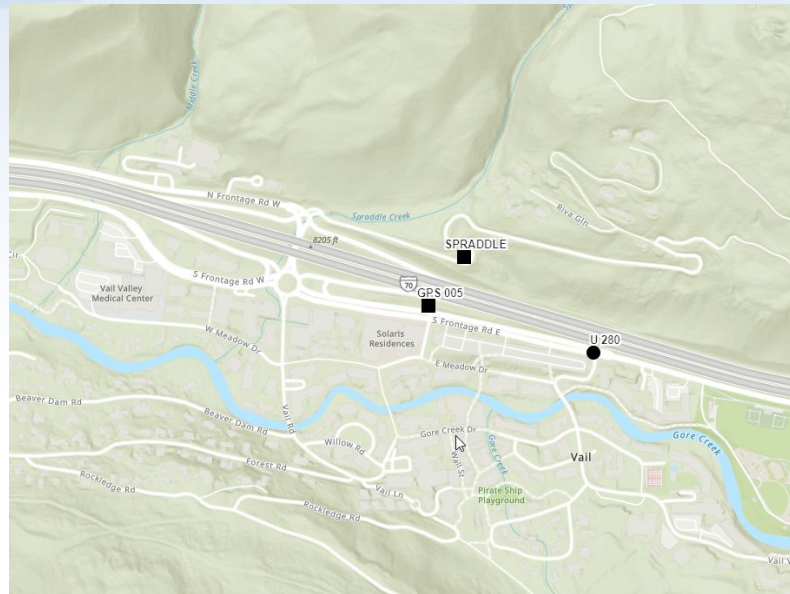
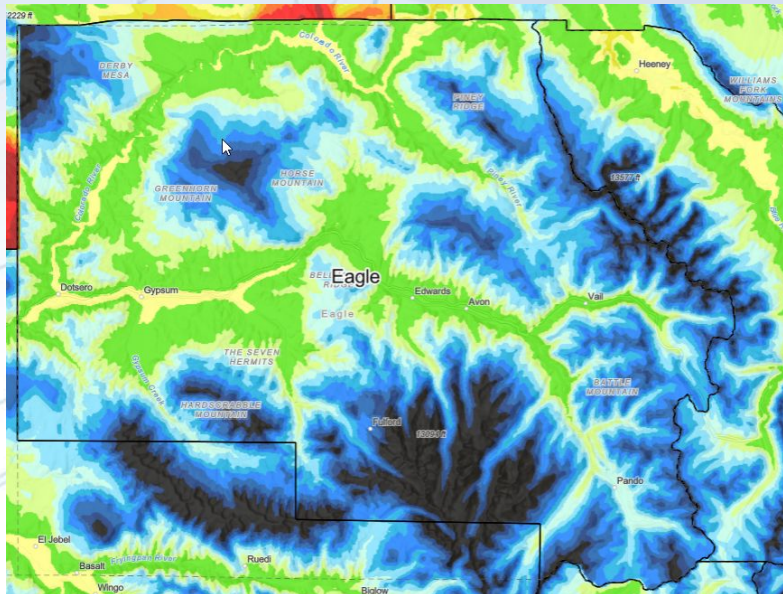
KK1753 *****
KK1753 DESIGNATION - ALLEN
KK1753 PID - KK1753
KK1753 STATE/COUNTY- CO/ADAMS
KK1753 COUNTRY - US
KK1753 USGS QUAD - ARVADA (2019)
KK1753
KK1753 *CURRENT SURVEY CONTROL
KK1753
KK1753* NAD 83(2011) POSITION- 39 51 40.26600(N) 105 03 10.68534(W) ADJUSTED
KK1753* NAD 83(2011) ELLIP HT- 1672.849 (meters) (06/27/12) ADJUSTED
KK1753* NAD 83(2011) EPOCH - 2010.00
KK1753* NAVD 88 ORTHO HEIGHT - 1689.919 (meters) 5544.34 (feet) ADJUSTED
KK1753;
KK1753;SPC CO N - 363,504.220 952,651.856 MT 0.99997982 +0 17 19.8
KK1753;SPC CO N - 1,192,596.76 3,125,491.96 sFT 0.99997982 +0 17 19.8
KK1753;UTM 13 - 4,412,351.639 495,469.512 MT 0.99960025 -0 02 02.2
KK1753
KK1753! - Elev Factor x Scale Factor = Combined Factor
KK1753!SPC CO N - 0.99973763 x 0.99997982 = 0.99971746
KK1753!UTM 13 - 0.99973763 x 0.99960025 = 0.99933799
    
```

| SPC             |                                     |
|-----------------|-------------------------------------|
| Zone            | CO DENV-081026 (Multizone complete) |
| Northing        | 73,457.466 m<br>241,002.186 ft      |
| Easting         | 130,748.971 m<br>428,966.440 ft     |
| Convergence     | -00° 09' 43.69"                     |
| Scale factor    | 1.000255767                         |
| Combined factor | 0.999993332                         |
| Distortion      | -6.668 ppm                          |

SPCS 83 CO N -282.5 ppm  
UTM 13 -662 ppm

SPCS2022 DENV -6.67 ppm

# SPCS 83 versus SPCS2022



SPRADDLE (Eagle County)

# SPCS 83 versus SPCS2022

## SPRADDLE (Colorado State Zone)

```

AB2083 *****
AB2083 HT_MOD      - This is a Height Modernization Survey Station.
AB2083 DESIGNATION - SPRADDLE
AB2083 PID         - AB2083
AB2083 STATE/COUNTY- CO/EAGLE
AB2083 COUNTRY     - US
AB2083 USGS QUAD   - VAIL EAST (2019)
AB2083
AB2083                               *CURRENT SURVEY CONTROL
AB2083
AB2083* NAD 83(2011) POSITION- 39 38 38.53766(N) 106 22 25.48745(W) ADJUSTED
AB2083* NAD 83(2011) ELLIP HT- 2513.514 (meters) (01/19/24) ADJUSTED
AB2083* NAD 83(2011) EPOCH  - 2010.00
AB2083* NAVD 88 ORTHO HEIGHT - 2526.04 (meters) 8287.5 (feet) GPS OBS
AB2083;
AB2083;SPC CO C      -      North      East      Units  Scale Factor Converg.
AB2083;SPC CO C      - 506,167.958  839,405.863  MT  0.99998076  -0 33 03.8
AB2083;SPC CO C      - 1,660,652.71  2,753,950.74  sFT 0.99998076  -0 33 03.8
AB2083;UTM 13        - 4,389,151.814  382,128.671  MT  0.99977105  -0 52 35.7
AB2083
AB2083!              - Elev Factor x Scale Factor = Combined Factor
AB2083!SPC CO C      - 0.99960582 x 0.99998076 = 0.99958659
AB2083!UTM 13        - 0.99960582 x 0.99977105 = 0.99937696
    
```

| SPC             |                                    |
|-----------------|------------------------------------|
| Zone            | CO-080001 (Statewide)              |
| Northing        | 452,870.768 m<br>1,485,796.483 ift |
| Easting         | 877,490.352 m<br>2,878,905.355 ift |
| Convergence     | -00° 32' 59.52"                    |
| Scale factor    | 1.000163124                        |
| Combined factor | 0.999768884                        |
| Distortion      | -231.116 ppm                       |

SPCS 83 CO C -413 ppm  
UTM 13 -623 ppm

SPCS2022 CO -231 ppm



# SPCS 83 versus SPCS2022

## SPRADDLE (EAGLE Zone LDP)

```

AB2083 *****
AB2083 HT_MOD      - This is a Height Modernization Survey Station.
AB2083 DESIGNATION - SPRADDLE
AB2083 PID         - AB2083
AB2083 STATE/COUNTY- CO/EAGLE
AB2083 COUNTRY     - US
AB2083 USGS QUAD   - VAIL EAST (2019)
AB2083
AB2083                *CURRENT SURVEY CONTROL
AB2083
AB2083* NAD 83(2011) POSITION- 39 38 38.53766(N) 106 22 25.48745(W) ADJUSTED
AB2083* NAD 83(2011) ELLIP HT- 2513.514 (meters) (01/19/24) ADJUSTED
AB2083* NAD 83(2011) EPOCH - 2010.00
AB2083* NAVD 88 ORTHO HEIGHT - 2526.04 (meters) 8287.5 (feet) GPS OBS
AB2083;
AB2083;SPC CO C - North East Units Scale Factor Converg.
AB2083;SPC CO C - 506,167.958 839,405.863 MT 0.99998076 -0 33 03.8
AB2083;SPC CO C - 1,660,652.71 2,753,950.74 sFT 0.99998076 -0 33 03.8
AB2083;UTM 13 - 4,389,151.814 382,128.671 MT 0.99977105 -0 52 35.7
AB2083
AB2083! - Elev Factor x Scale Factor = Combined Factor
AB2083!SPC CO C - 0.99960582 x 0.99998076 = 0.99958659
AB2083!UTM 13 - 0.99960582 x 0.99977105 = 0.99937696
    
```

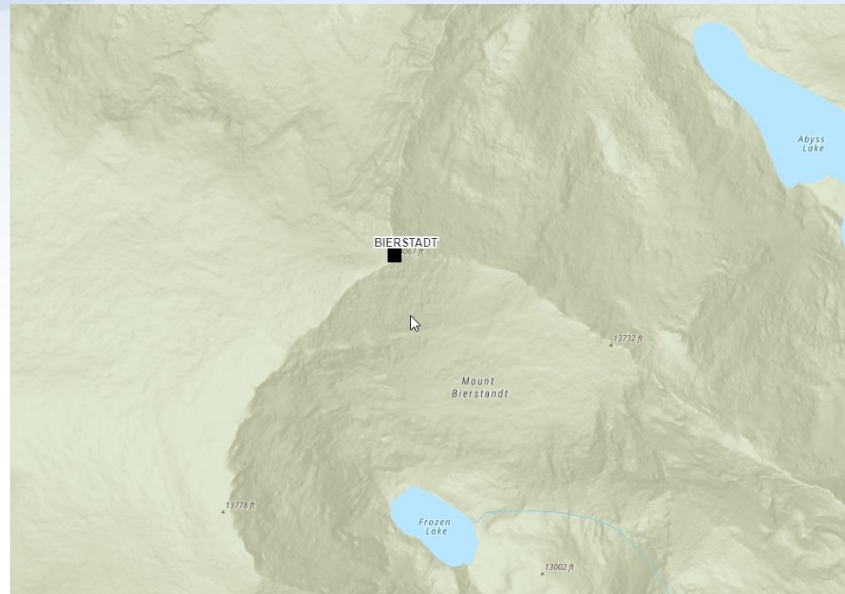
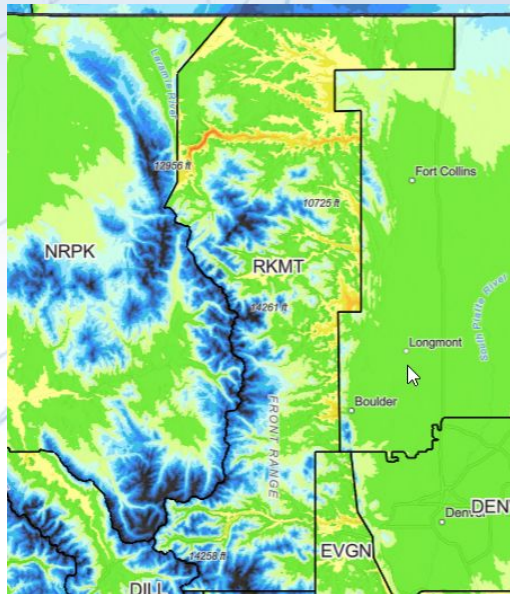
| SPC             |                                     |
|-----------------|-------------------------------------|
| Zone            | CO EGLE-081014 (Multizone complete) |
| Northing        | 60,786.948 m<br>199,432.246 ft      |
| Easting         | 151,438.373 m<br>496,845.056 ft     |
| Convergence     | +00° 33' 32.72"                     |
| Scale factor    | 1.000389642                         |
| Combined factor | 0.999995313                         |
| Distortion      | -4.687 ppm                          |

SPCS 83 CO C -413 ppm  
UTM 13 -623 ppm

SPCS2022 EGLE -4.69 ppm



# SPCS 83 versus SPCS2022



BIERSTADT (Clear Creek County)

# SPCS 83 versus SPCS2022

## BIERSTADT (Colorado State Zone)

```

KK2029 *****
KK2029 HT_MOD - This is a Height Modernization Survey Station.
KK2029 DESIGNATION - BIERSTADT
KK2029 PID - KK2029
KK2029 STATE/COUNTY- CO/CLEAR CREEK
KK2029 COUNTRY - US
KK2029 USGS QUAD - MOUNT EVANS (2019)
KK2029
KK2029 *CURRENT SURVEY CONTROL
KK2029
KK2029* NAD 83(2011) POSITION- 39 34 57.36550(N) 105 40 07.62495(W) ADJUSTED
KK2029* NAD 83(2011) ELLIP HT- 4274.507 (meters) (01/18/24) ADJUSTED
KK2029* NAD 83(2011) EPOCH - 2010.00
KK2029* NAVD 88 ORTHO HEIGHT - 4286.78 (meters) 14064.2 (feet) GPS OBS
KK2029;
KK2029; SPC CO C - North East Units Scale Factor Converg.
KK2029; SPC CO C - 498,999.793 899,901.705 MT 0.99997117 -0 06 23.2
KK2029; SPC CO C - 1,637,135.15 2,952,427.51 sFT 0.99997117 -0 06 23.2
KK2029; UTM 13 - 4,381,645.332 442,566.425 MT 0.99964061 -0 25 34.2
KK2029
KK2029! - Elev Factor x Scale Factor = Combined Factor
KK2029! SPC CO C - 0.99932984 x 0.99997117 = 0.99930103
KK2029! UTM 13 - 0.99932984 x 0.99964061 = 0.99897069
    
```

| SPC             |                                     |
|-----------------|-------------------------------------|
| Zone            | CO RKMT-081017 (Multizone complete) |
| Northing        | 32,712.343 m<br>107,323.960 ift     |
| Easting         | 123,301.076 m<br>404,531.088 ift    |
| Convergence     | -01° 03' 48.65"                     |
| Scale factor    | 1.000443024                         |
| Combined factor | 0.999772569                         |
| Distortion      | -227.431 ppm                        |

SPCS 83 CO N -699 ppm  
 UTM13 -1029 ppm

SPCS2022 CO -227 ppm

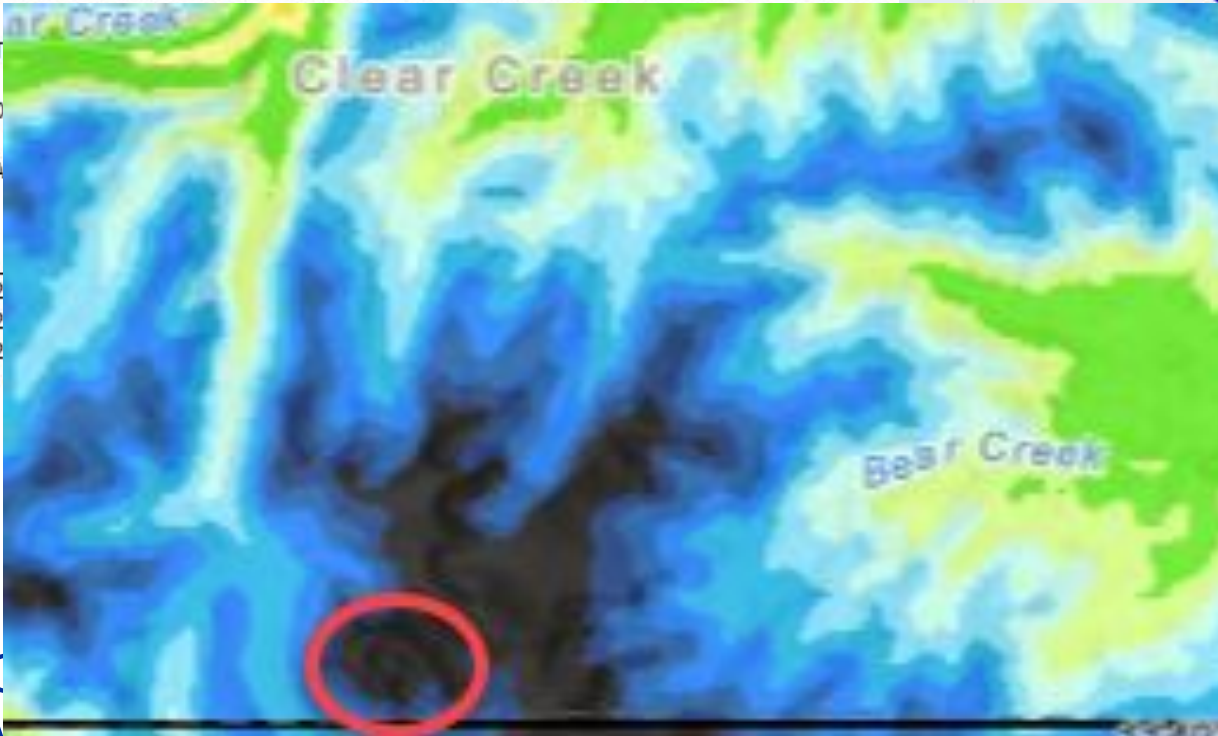
# SPCS 83 versus SPCS2022

## BIERSTADT (Rocky Mountain Zone LDP)

```

KK2029 *****
KK2029 HT_MOD
KK2029 DESIGNAT
KK2029 PID
KK2029 STATE/CO
KK2029 COUNTRY
KK2029 USGS QUA
KK2029
KK2029
KK2029
KK2029* NAD 83 (2
KK2029* NAD 83 (2
KK2029* NAD 83 (2
KK2029* NAVD 88
KK2029;
KK2029; SPC CO C
KK2029; SPC CO C
KK2029; UTM 13
KK2029
KK2029!
KK2029! SPC CO C
KK2029! UTM 13

```



| SPC |                    |
|-----|--------------------|
| CO- | 080001 (Statewide) |
|     | 445,702.056 m      |
|     | 1,462,277.086 ift  |
|     | 937,997.259 m      |
|     | 3,077,418.829 ift  |
|     | 00° 06' 22.39'     |
|     | 1.000151640        |
|     | 0.999481379        |
|     | 518.621 ppm        |

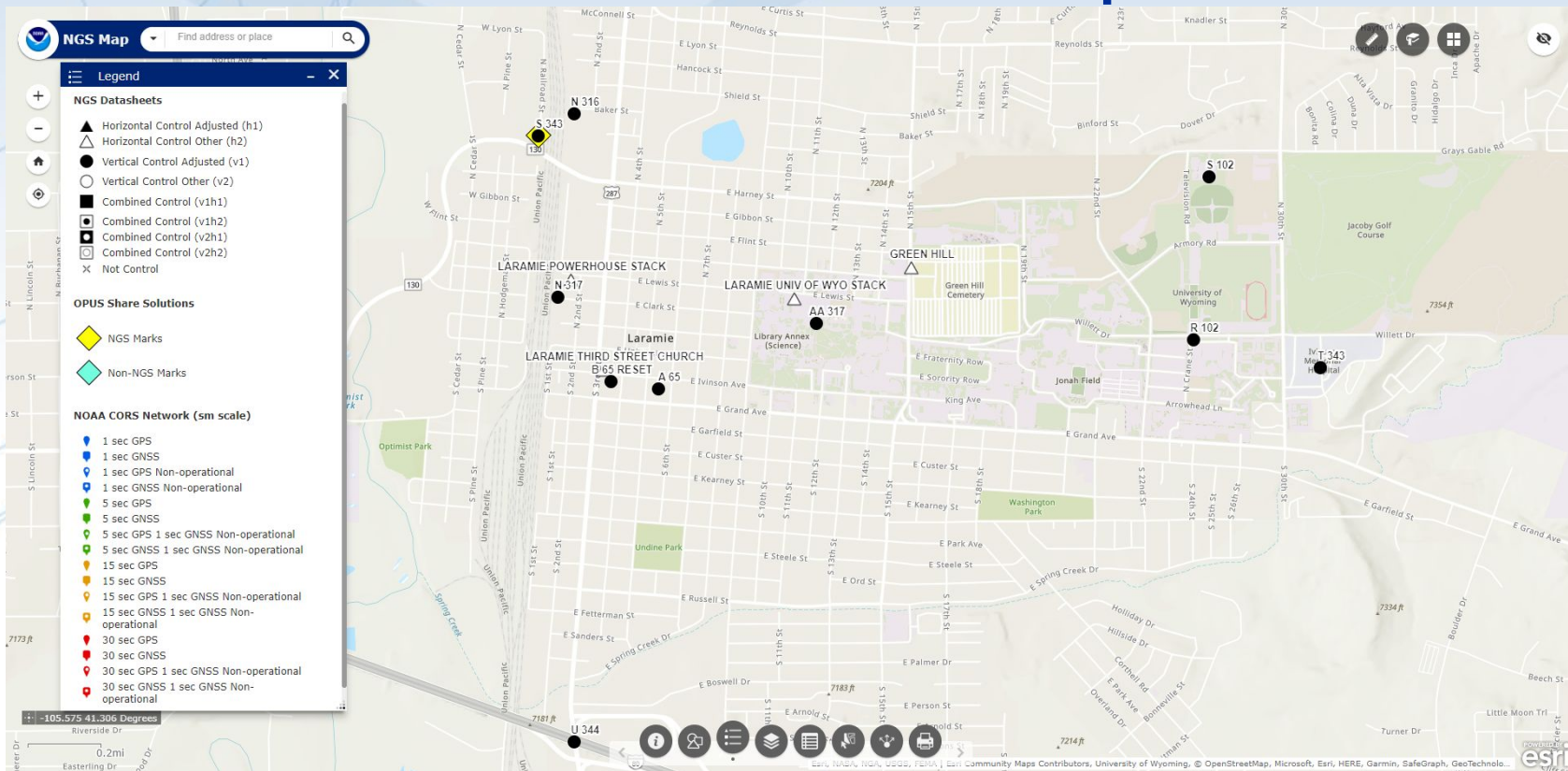
SPC  
UTM 13

-1029 ppm

MT -518.6 ppm



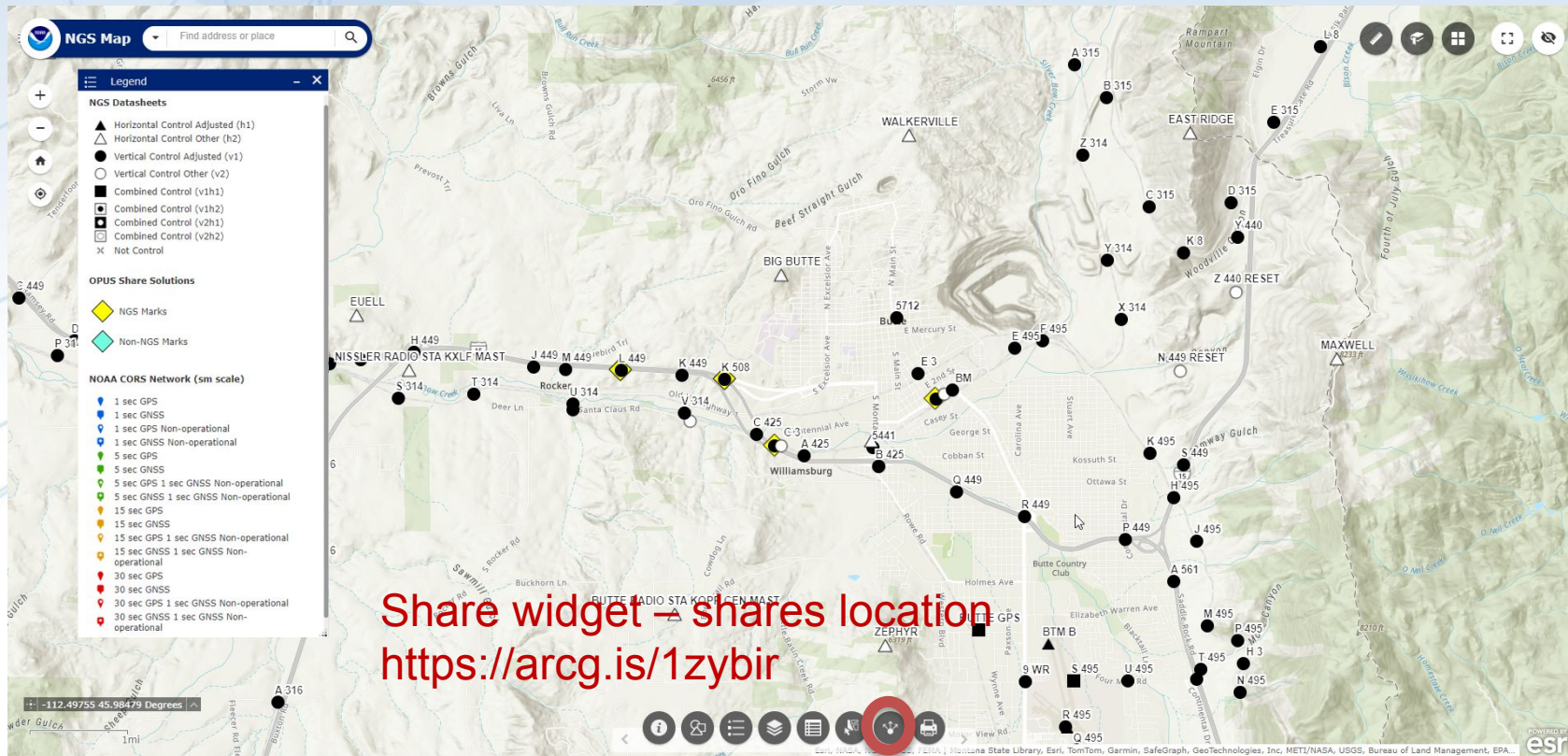
# Newish NGS Map



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



# Newish NGS Map



# NGS Map Demo

# NGS ArcGIS Online Resources

## Feature Services

[NGS Datasheets](#)

[NOAA CORS Network](#)

[GPS on Benchmarks Priority List](#)

(4 layers - marks, hexagons)

[GEOID18 GPS on Benchmarks](#)

[GEOID12B GPS on Benchmarks](#)

[OPUS Shared Solutions](#)

[Mark Recoveries Submitted to NGS](#)

## Raster Tile Services

GEOID18 Height ([CONUS](#), [PRVI](#))

GEOID18 Difference ([CONUS](#), [PRVI](#))

GEOID18 Uncertainty ([CONUS](#), [PRVI](#))

GEOID18 Improvements ([CONUS](#), [PRVI](#))

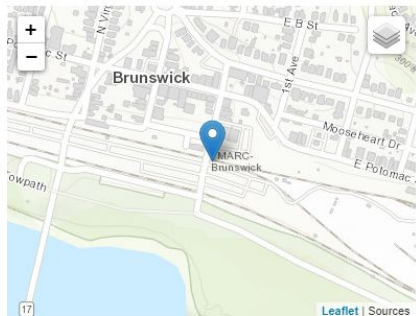
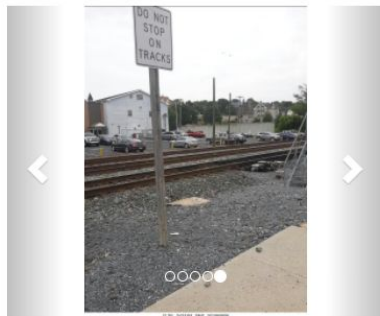
# Passive Marks Page

Enter PID:

|                                    |   |
|------------------------------------|---|
| Designation: ⓘ                     | Q 35  |
| Setting: ⓘ                         | 36 = SET IN A MASSIVE STRUCTURE                       |
| Last Recovery Date/Condition/By: ⓘ | 05/16/2014 - Recovered in good condition - GEOCACHING |

|                        |          |
|------------------------|----------|
| PID: ⓘ                 | JV3192   |
| Stability: ⓘ           | B        |
| GNSS Useable: ⓘ        | Y        |
| Orthometric Ht. (m): ⓘ | 75.185   |
| Vertical Datum: ⓘ      | NAVD 88  |
| Vertical Source: ⓘ     | ADJUSTED |
| Order/Class:           | 1/2      |
| Geoid Ht (m): ⓘ        | -33.056  |
| Geoid Model: ⓘ         | GEOID18  |

|                                |                   |
|--------------------------------|-------------------|
| State, County: ⓘ               | MD.FREDERICK      |
| Country: ⓘ                     | US                |
| Latitude: ⓘ                    | N 39° 18' 42.63"  |
| Longitude: ⓘ                   | W 077° 37' 37.59" |
| Ellipsoid Ht.: ⓘ               |                   |
| Position Datum: ⓘ              | NAD 83(1986)      |
| Position Source: ⓘ             | HD_HELD1          |
| Network Accuracy Hz (cm): ⓘ    |                   |
| Network Accuracy Ellip (cm): ⓘ |                   |



| Projects                 |            |        |   |           |     |
|--------------------------|------------|--------|---|-----------|-----|
| <b>Leveling Projects</b> |            |        |   |           |     |
| <b>L24378/1</b>          |            |        |   |           |     |
| Start Date:              | 05/07/1979 | Order: | 1 | Agency:   | NGS |
| End Date:                | 06/06/1979 | Class: | 2 | BM Count: | 84  |
| <b>L9532/3</b>           |            |        |   |           |     |
| Start Date:              | 04/10/1942 | Order: | 2 | Agency:   | NGS |
| End Date:                | 04/21/1942 | Class: | 0 | BM Count: | 22  |
| <b>L8007</b>             |            |        |   |           |     |
| Start Date:              | 05/27/1938 | Order: | 1 | Agency:   | NGS |
| End Date:                | 06/25/1938 | Class: | 2 | BM Count: | 71  |

| Descriptive Information |                   |                       |      |
|-------------------------|-------------------|-----------------------|------|
| PID: ⓘ                  | JV3192            | Designation ⓘ         | Q 35 |
| Setting Agency: ⓘ       | CGS               | Setting Date: ⓘ       | 1938 |
| Marker Type: ⓘ          | DB                | Magnetic Code: ⓘ      |      |
| Stability Code: ⓘ       | B                 | Setting Class: ⓘ      | 36   |
| Setting Phrase: ⓘ       | BRIDGE FOUNDATION | Logo: ⓘ               | CGS  |
| Stamping: ⓘ             | Q 35 1938         | UDG Mark Type: ⓘ      |      |
| UDG Magnetic Code: ⓘ    |                   | UDG Mark Stability: ⓘ |      |
| UDG Mark Setting: ⓘ     |                   | UDG Mark Set Date: ⓘ  |      |
| Rod/Pipe Depth: ⓘ       |                   | Sleeve Depth: ⓘ       |      |
| Position Source: ⓘ      | O                 | Position Quality: ⓘ   | 4    |
| Position Technique: ⓘ   | X                 | Alias: ⓘ              |      |



# OPUS-Projects 5.2 for RTN/RTK Vectors

Results From ALL GVX VECTORS

| Controls  | LEGEND  |
|---|---|
| ? ← ↻<br>Preferences<br>Project List<br>Solutions<br>Add Project Tracking Number<br>Show File<br>Send Email<br>Upload Serfil<br>Upload Description<br>Upload Field Logs<br>Refresh PID Information<br>Upload GNSS Vectors<br>Set up Adjustment<br>Upload Project Report<br>Review and Submit to IDB<br>Delete Project | MARKS: <span style="color: green;">●</span> meet preferences <span style="color: orange;">●</span> do not meet preferences <span style="color: grey;">●</span> are not included <span style="color: red;">●</span> have error<br>CORS: <span style="color: green;">▲</span> meet preferences <span style="color: orange;">▲</span> do not meet preferences <span style="color: grey;">▲</span> are not included<br>Baselines: <span style="color: blue;">—</span> |

Map Satellite

| LEGEND                               | MARKS |
|--------------------------------------|-------|
| <span style="color: green;">●</span> | baco  |
| <span style="color: green;">●</span> | bcc1  |
| <span style="color: green;">◆</span> | bell  |
| <span style="color: green;">◆</span> | brun  |
| <span style="color: green;">◆</span> | calv  |
| <span style="color: green;">◆</span> | dew1  |
| <span style="color: green;">◆</span> | e087  |
| <span style="color: green;">◆</span> | fran  |
| <span style="color: green;">◆</span> | gorf  |
| <span style="color: green;">◆</span> | jmt2  |
| <span style="color: green;">◆</span> | mas2  |
| <span style="color: green;">◆</span> | n102  |
| <span style="color: green;">◆</span> | paac  |
| <span style="color: green;">◆</span> | pacb  |
| <span style="color: green;">◆</span> | pond  |

| Add MARKS                             | CORS |
|---------------------------------------|------|
| <span style="color: orange;">▲</span> | algo |
| <span style="color: orange;">▲</span> | corb |
| <span style="color: orange;">▲</span> | dene |
| <span style="color: orange;">▲</span> | gode |
| <span style="color: orange;">▲</span> | pafu |
| <span style="color: orange;">▲</span> | pass |
| <span style="color: orange;">▲</span> | york |

Add/Del CORS

NGS is developing a new Standardized **G**NSS **V**ector **E**Xchange Format (GVX) that will be used to ingest vectors into OPUS Projects

# OPUS-Projects 5.2 for RTN/RTK Vectors

Results from ALL SESSIONS

**Controls**

Preferences  
Project List  
Solutions  
Add Project Tracking Number  
Show File  
Send Email  
Upload Serfil  
Upload Description  
Upload Field Logs  
Refresh PID Information  
Upload GNSS Vectors  
Set up Adjustment  
Upload Project Report  
Review and Submit to IDB  
Delete Project

**LEGEND**

MARKS: ● meet preferences ● do not meet preferences ● are not included ● have error

CORS: ▲ meet preferences ▲ do not meet preferences ▲ are not included

Baselines: —

Map Satellite

**LEGEND**

**MARKS**

- baco
- bcc1
- ◆ bell
- ◆ brun
- ◆ calv
- ◆ dew1
- ◆ e087
- ◆ fran
- ◆ gorf
- ◆ jmt2
- ◆ mas2
- ◆ n102
- ◆ paac
- ◆ pacb
- ◆ pond

**Add MARKS**

**CORS**

- ▲ algo
- ▲ corb
- ▲ dene
- ▲ gode
- ▲ pafu
- ▲ pass
- ▲ york

**Add/Del CORS**

Occupation ▼ From ALL SESSIONS ▼



# NOAA Technical Memorandum NOS NGS 92

## Classifications, Standards, and Specifications for GNSS Geodetic Control Surveys using OPUS Projects

|     | Description               | PRIMARY | SECONDARY | LOCAL  |
|-----|---------------------------|---------|-----------|--------|
| 1.1 | Ellipsoid Height (cm) *   | 2 cm    | 3 cm      | 5 cm   |
| 1.2 | Horizontal (cm) *         | 1 cm    | 1.5 cm    | 2.5 cm |
| 1.3 | Orthometric Height (cm) * | 3 cm    | 4 cm      | 6 cm   |

\* Network and Local Accuracies are stated at the 95% confidence level.

## Classifications of Network and Local Accuracy



# NOAA Technical Memorandum NOS NGS 92

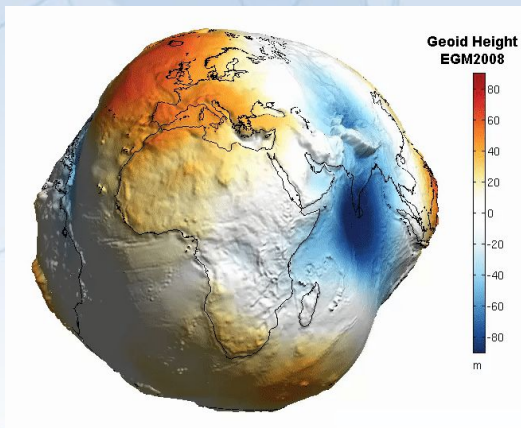
Table 4 - Standards for Observation Requirements by Method

|     | Requirement  | PRIMARY   | SECONDARY  | LOCAL  |
|-----|--|---|--|--|
| 4.1 | <b>Requirements for ALL METHODS</b><br>- Repeat occupations and offset time  | Offset sessions/occupations by 3 to 21 hours.   |  |  |
| 4.2 | <b>Requirements for OPUS PP</b><br>- Required <b>TOTAL Static GNSS Observation Time (T)</b> and Recommended <b>GNSS sessions</b> | T = 20 hours<br>(for 0 to 200 km)<br><br>(2) 10 hour sessions or<br>(3) 7 hour sessions or<br>(4) 5 hour sessions<br><br>Requires at least 2 sessions, with at least 1 session on a different day | T = 8 hours<br>(for 0 to 200 km)<br>(2) 4 hour sessions<br><br>T = 6 hours<br>(for 0 to 150 km)<br>(2) 3 hour sessions<br><br>T = 4 hours<br>(for 0 to 100 km)<br>(2) 2 hour sessions<br><br>Requires at least 2 sessions. | T = 4 hours<br>(for 0 to 200 km)<br>(2) 2 hour sessions<br><br>Requires at least 2 sessions. |

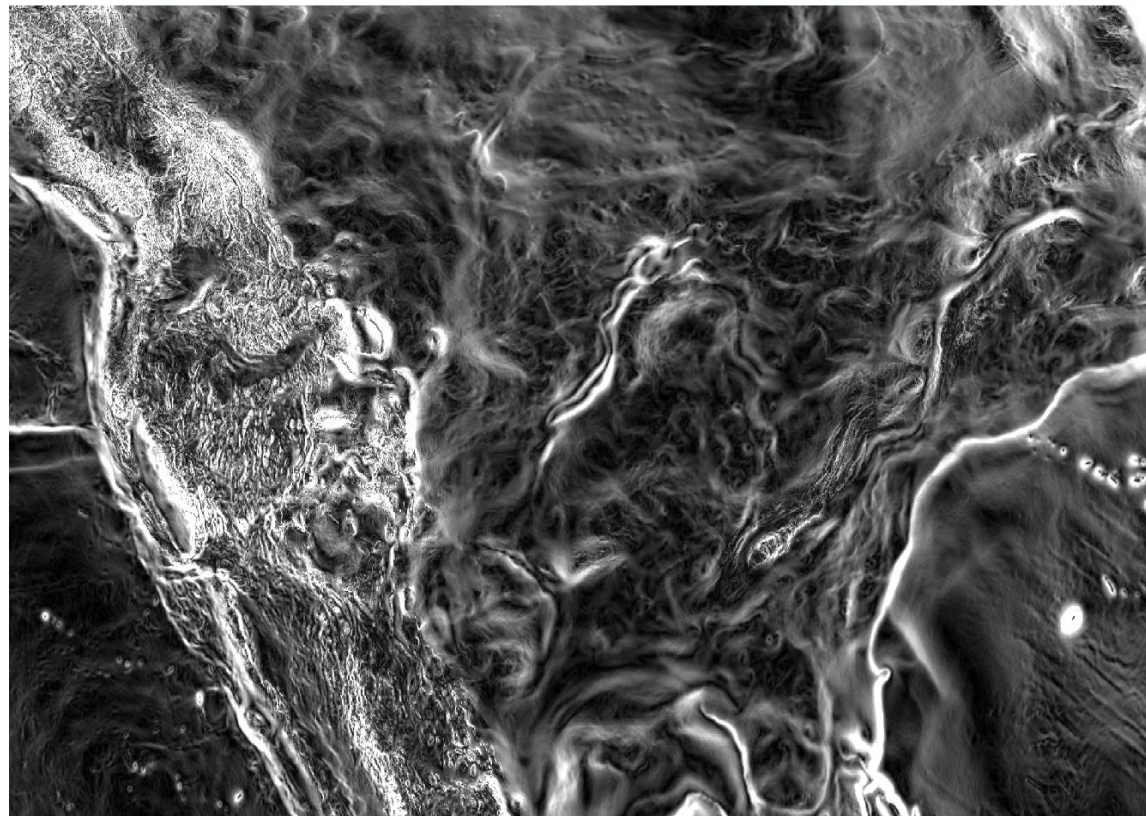
# NOAA Technical Memorandum NOS NGS 92

Table 4 - Standards for Observation Requirements by Method

|     | Requirement  | PRIMARY   | SECONDARY   | LOCAL   |
|-----|--|---|---|---|
| 4.3 | <b>Requirements for<br/>GVX PP</b><br>- Number and duration of sessions      | 3 sessions<br><br>60 minutes each<br>(for 0 to 25 km)<br><br>90 minutes each<br>(for 25 to 50 km)<br><br>Requires at least 1<br>session on a different day. | 3 sessions<br><br>30 minutes each<br>(for 0 to 25 km)<br><br>60 minutes each<br>(for 25 to 50 km) | 3 sessions<br><br>15 minutes each<br>(for 0 to 25 km)<br><br>30 minutes each<br>(for 25 to 50 km) |
| 4.4 | <b>Requirements for<br/>GVX NRTK</b><br>- Number and duration of occupations | (6) 5 minutes<br><br>Requires at least 3<br>occupations on a different<br>day.  | (3) 5 minutes   | (3) 5 minutes   |
| 4.5 | <b>Requirements for<br/>GVX SRTK</b><br>- Number and duration of occupations | Not allowed   | (5) 5 minutes<br><br>Requires at least 2<br>occupations on a<br>different day.                    | (4) 5 minutes<br><br>Requires at least 1<br>occupation on a<br>different day.                     |



## Magnitude of the Deflection of the Vertical



# Questions?

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