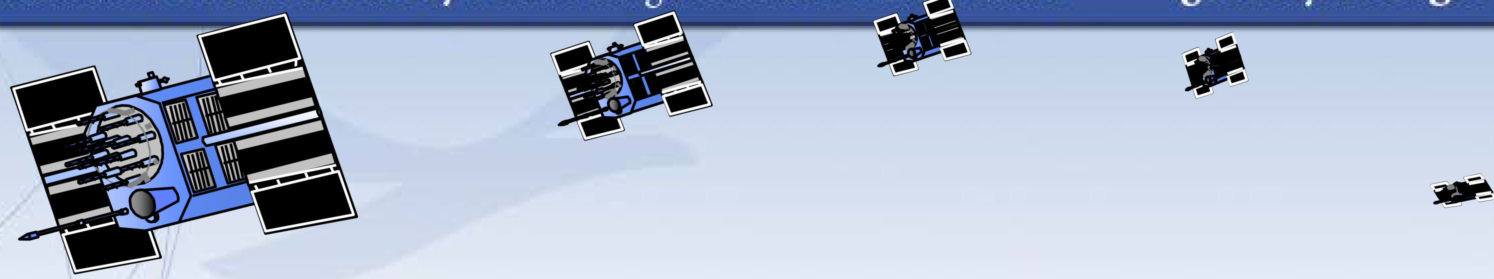


National Geodetic Survey – Preparing for Tomorrow (*New Datums are Coming!*)

William (Bill) Stone
Southwest Region (AZ, NM, UT) Geodetic Advisor
william.stone@noaa.gov

March 3-4, 2017
Oklahoma City

NOAA's National Geodetic Survey
geodesy.noaa.gov

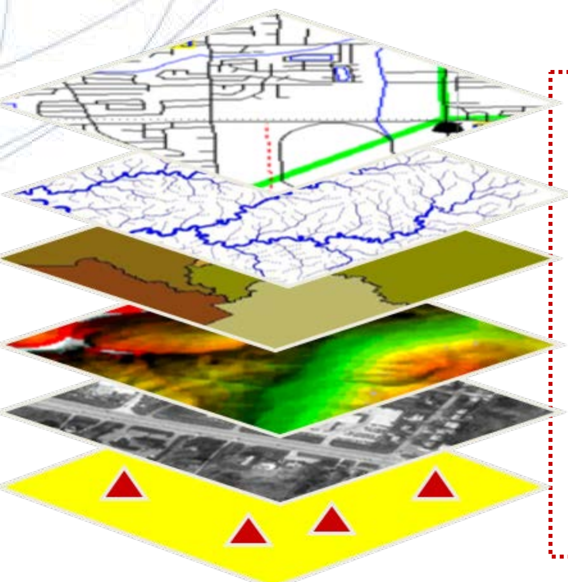
U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Geodetic Survey

Mission: To define, maintain & provide access to the

National Spatial Reference System (NSRS)

to meet our Nation's economic, social & environmental needs

National Spatial Reference System



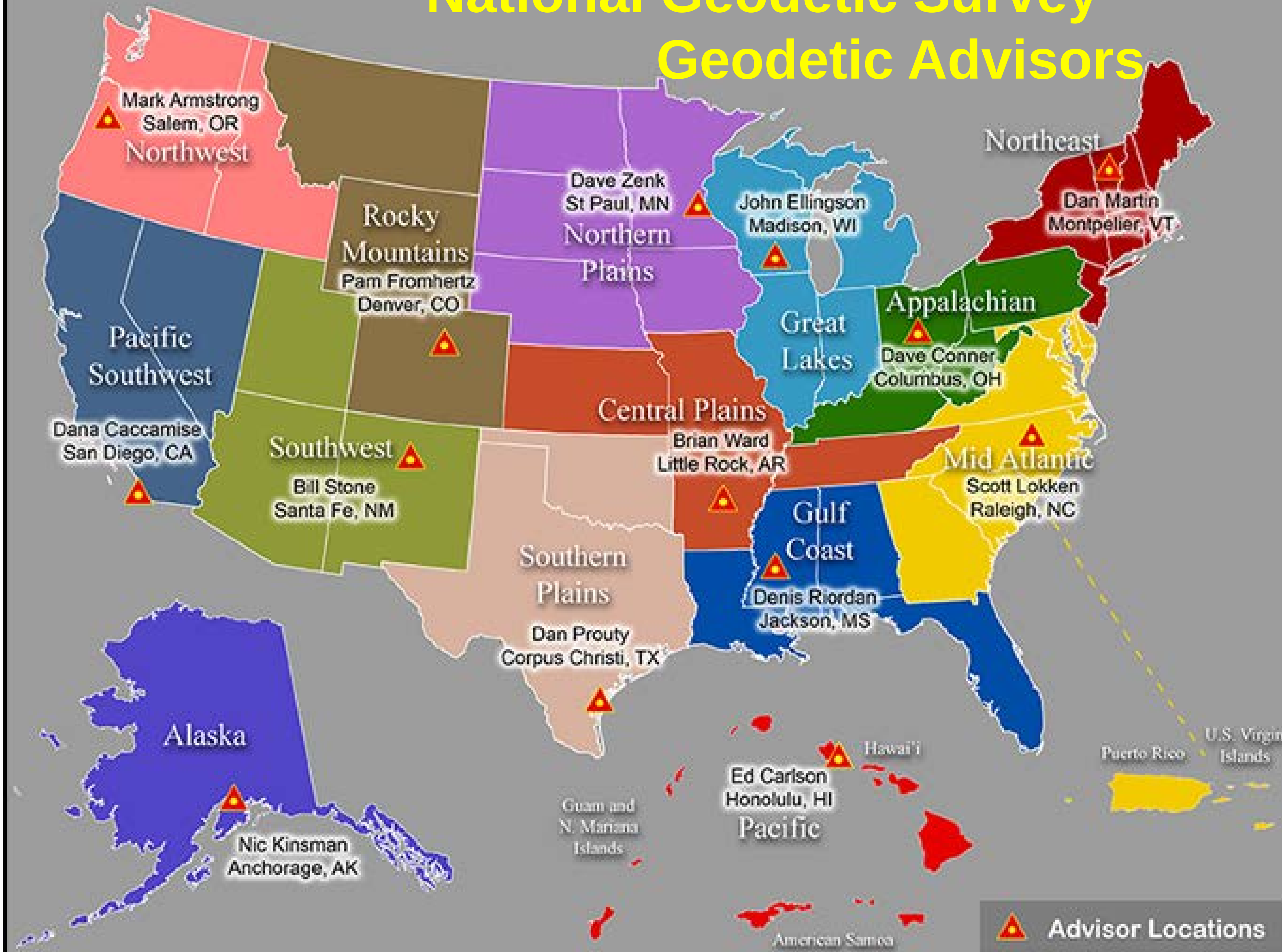
- **Latitude**
- **Longitude**
- **Height**
- Gravity
- Orientation
- Scale

& their time variations

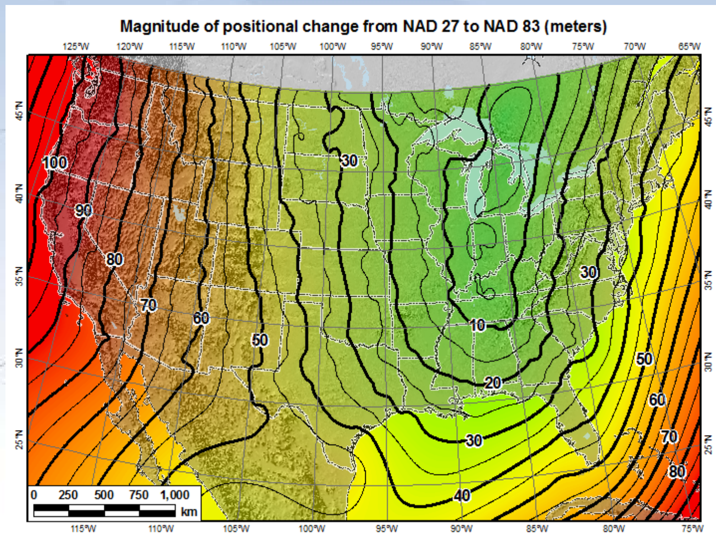
(& National Shoreline, etc.)

- North American Datum 1983 (NAD83)
- North American Vertical Datum 1988 (NAVD88)

National Geodetic Survey – Geodetic Advisors



A (very) Brief History of U.S. Horizontal / Geometric Datums



U.S. Standard Datum

NAD27

NAD83 (1986)

NAD83 (HARN /199X)

NAD83 (2007)

NAD83 (2011)

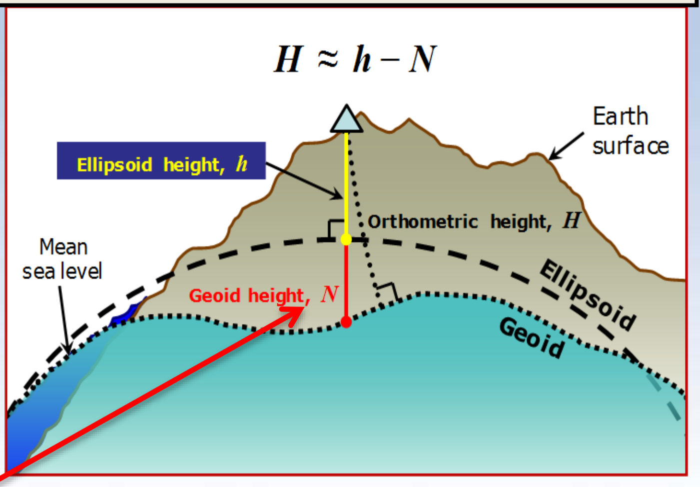
…

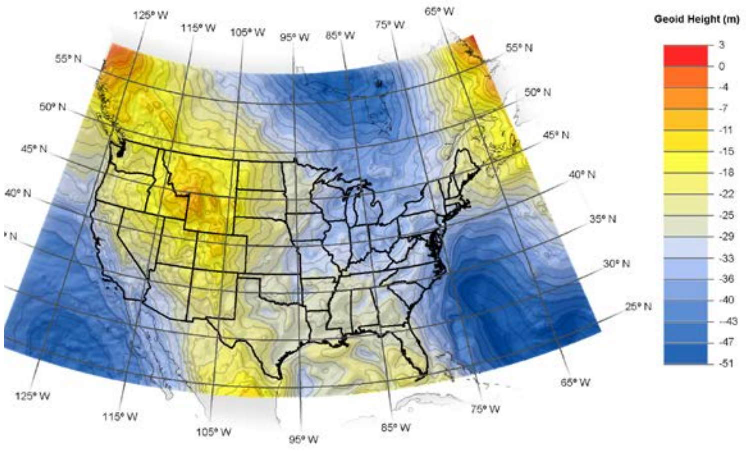
time

shift: < 10 m | tens of meters | few 0.1m | few 0.01m | few 0.01m | (two meters-ish)

NAD 83(2011) epoch 2010.00

```
********************************************************************************
 DESIGNATION -  BRECK
 PID         -  DN4403
 STATE/COUNTY-  OK/TULSA
 COUNTRY     -  US
 USGS QUAD   -  TULSA (1982)

                         *CURRENT SURVEY CONTROL
 ______________________________________________________________________
 NAD 83(2011) POSITION- 36 08 33.13900(N) 095 54 40.35699(W)   ADJUSTED
 NAD 83(2011) ELLIP HT-    190.825 (meters)        (06/27/12)   ADJUSTED
 NAD 83(2011) EPOCH    -  2010.00
 NAVD 88 ORTHO HEIGHT -    219.8    (meters)      721.     (feet) GPS OBS
 ______________________________________________________________________
 NAVD 88 orthometric height was determined with geoid model     GEOID09
 GEOID HEIGHT    -          -29.00  (meters)                    GEOID09
 GEOID HEIGHT    -          -29.01  (meters)                    GEOID12A
 NAD 83(2011) X  -    -531,088.328 (meters)                     COMP
 NAD 83(2011) Y  - -5,129,419.944 (meters)                      COMP
 NAD 83(2011) Z  -  3,741,088.165 (meters)                      COMP
 LAPLACE CORR    -           -2.19  (seconds)                   DEFLEC12A

 Network accuracy estimates per FGDC Geospatial Positioning Accuracy
 Standards:
        FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
           Horiz  Ellip           SD_N    SD_E    SD_h      (unitless)
 -------------------------------------------------------------------
 NETWORK    0.59   1.57            0.27    0.20    0.80      0.13115300
 -------------------------------------------------------------------
 Click here for local accuracies and other accuracy information.


.The horizontal coordinates were established by GPS observations
.and adjusted by the National Geodetic Survey in June 2012.

.NAD 83(2011) refers to NAD 83 coordinates where the reference
.frame has been affixed to the stable North American tectonic plate. See
.NA2011 for more information.

.The horizontal coordinates are valid at the epoch date displayed above
.which is a decimal equivalence of Year/Month/Day.

.The orthometric height was determined by GPS observations and a
.high-resolution geoid model.
```





GEOID12B

National Geodetic Survey Data Explorer

National Geodetic Survey

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

View Map | View List

Help

Map Layers

Horizontal

- ☑ ☆ CORS
- ☑ ▲ GPS Sites
- ☑ △ Classical Horizontal

Vertical

- ☑ ● Vertical Control
- ☑ ○ Approximate Heights

Find Marks | Clear Marks

Location radius 5 Miles

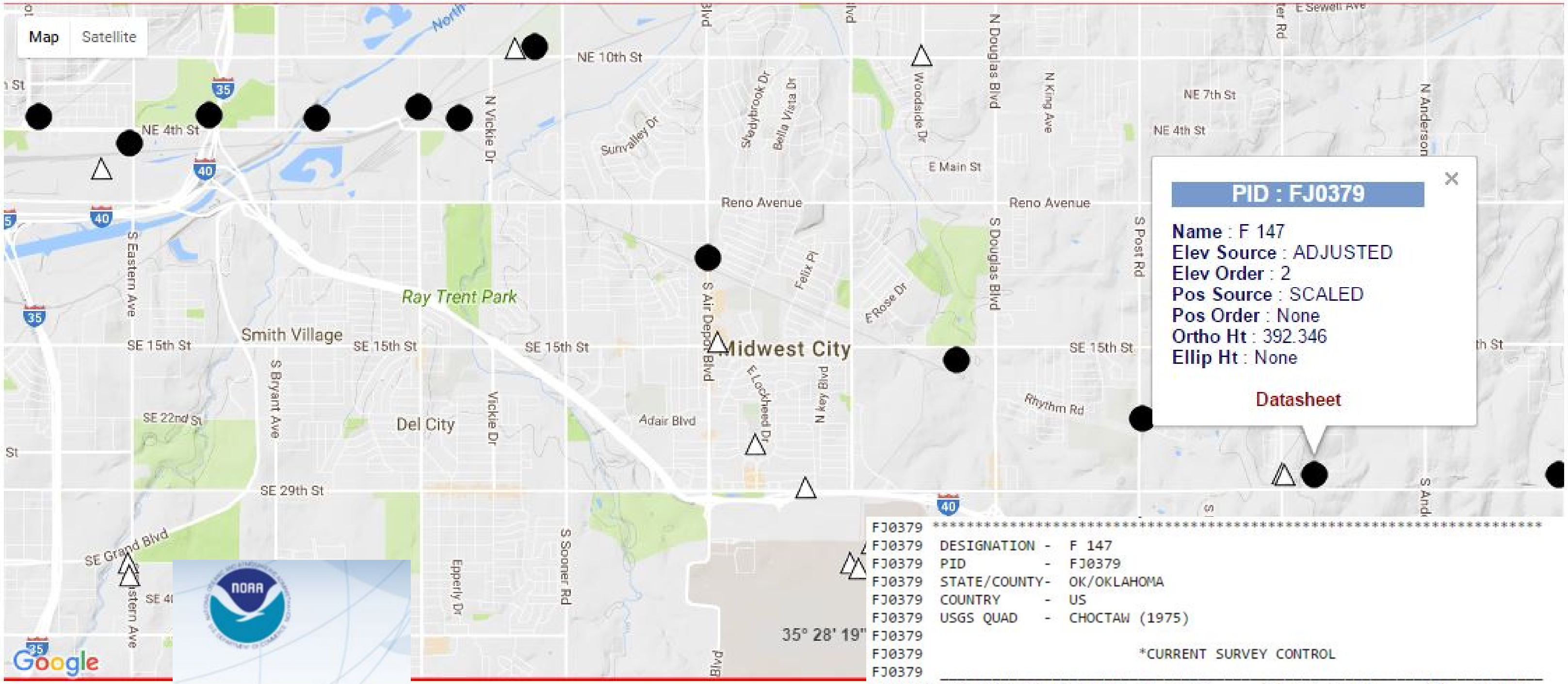
Mark Center

Go To Location

PID : FJ0989

Name : TINKER
Elev Source : SCALED
Elev Order : None
Pos Source : ADJUSTED
Pos Order : 1
Ortho Ht : 386.
Ellip Ht : None

Datasheet



PID : FJ0379

Name : F 147
Elev Source : ADJUSTED
Elev Order : 2
Pos Source : SCALED
Pos Order : None
Ortho Ht : 392.346
Ellip Ht : None

Datasheet

NGS Home | About NGS | Dat

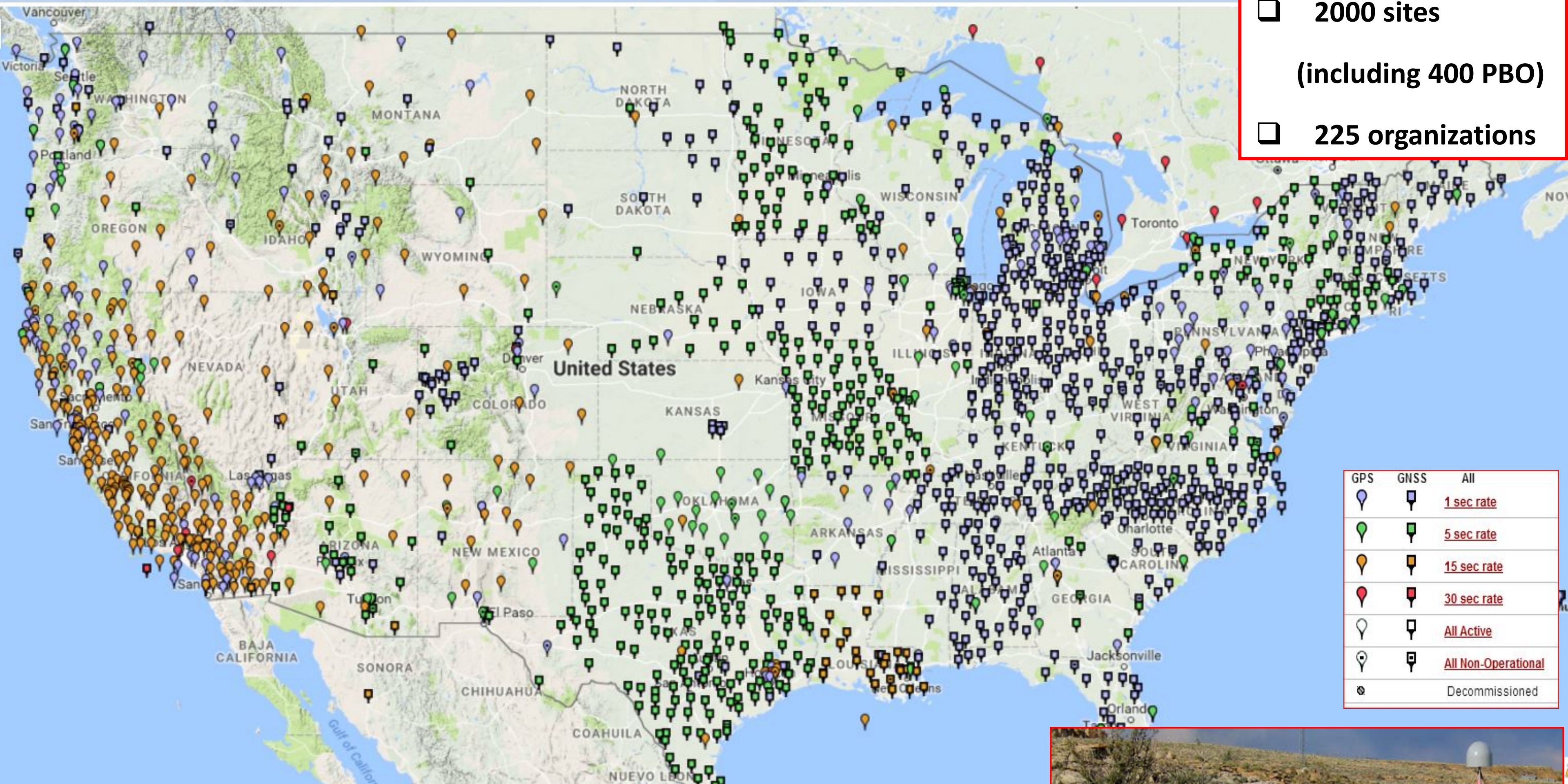
Most Popular

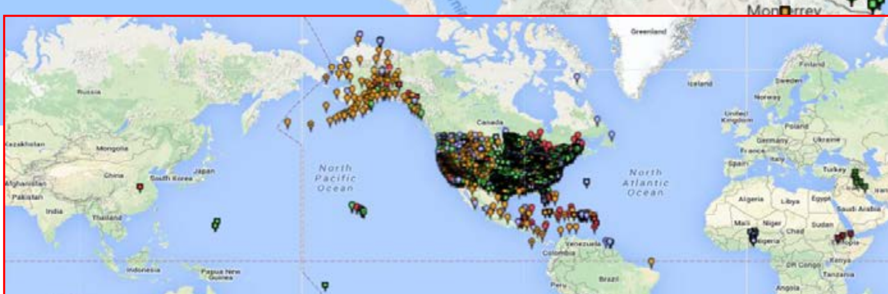
- Antenna Calibration
- Contact Us
- CORS
- FAQs
- Geodetic Advisors
- Geodetic Tool Kit
- LOCUS
- NAD 83(2011) epoch 2010.00
- NGS Data Explorer
- OPUS
- Publications
- Storm Imagery

```
FJ0379 ***********************************************************************
FJ0379  DESIGNATION -  F 147
FJ0379  PID         -  FJ0379
FJ0379  STATE/COUNTY-  OK/OKLAHOMA
FJ0379  COUNTRY     -  US
FJ0379  USGS QUAD   -  CHOCTAW (1975)
FJ0379
FJ0379                        *CURRENT SURVEY CONTROL
FJ0379  ___________________________________________________________________
FJ0379* NAD 83(1986) POSITION- 35 26 08.     (N) 097 19 54.      (W)   SCALED
FJ0379* NAVD 88 ORTHO HEIGHT -     392.346 (meters)     1287.22  (feet) ADJUSTED
FJ0379  ___________________________________________________________________
FJ0379  GEOID HEIGHT      -        -26.965 (meters)                     GEOID12B
FJ0379  DYNAMIC HEIGHT    -        391.972 (meters)     1285.99  (feet) COMP
FJ0379  MODELED GRAVITY   -    979,667.5   (mgal)                       NAVD 88
FJ0379
FJ0379  VERT ORDER        -  SECOND     CLASS 0
FJ0379
FJ0379.The horizontal coordinates were scaled from a topographic map and have
FJ0379.an estimated accuracy of +/- 6 seconds.
FJ0379.
FJ0379.The orthometric height was determined by differential leveling and
FJ0379.adjusted by the NATIONAL GEODETIC SURVEY
FJ0379.in August 1994.
FJ0379
FJ0379.Significant digits in the geoid height do not necessarily reflect accuracy
FJ0379.GEOID12B height accuracy estimate available here.
FJ0379
FJ0379.The dynamic height is computed by dividing the NAVD 88
FJ0379.geopotential number by the normal gravity value computed on the
FJ0379.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
FJ0379.degrees latitude (g = 980.6199 gals.).
FJ0379
FJ0379.The modeled gravity was interpolated from observed gravity values.
FJ0379
FJ0379;                     North         East     Units  Estimated Accuracy
FJ0379;SPC OK N      -     48,540.       660,690.     MT  (+/- 180 meters Scaled)
FJ0379
FJ0379_U.S. NATIONAL GRID SPATIAL ADDRESS: 14SPE514226(NAD 83)
```

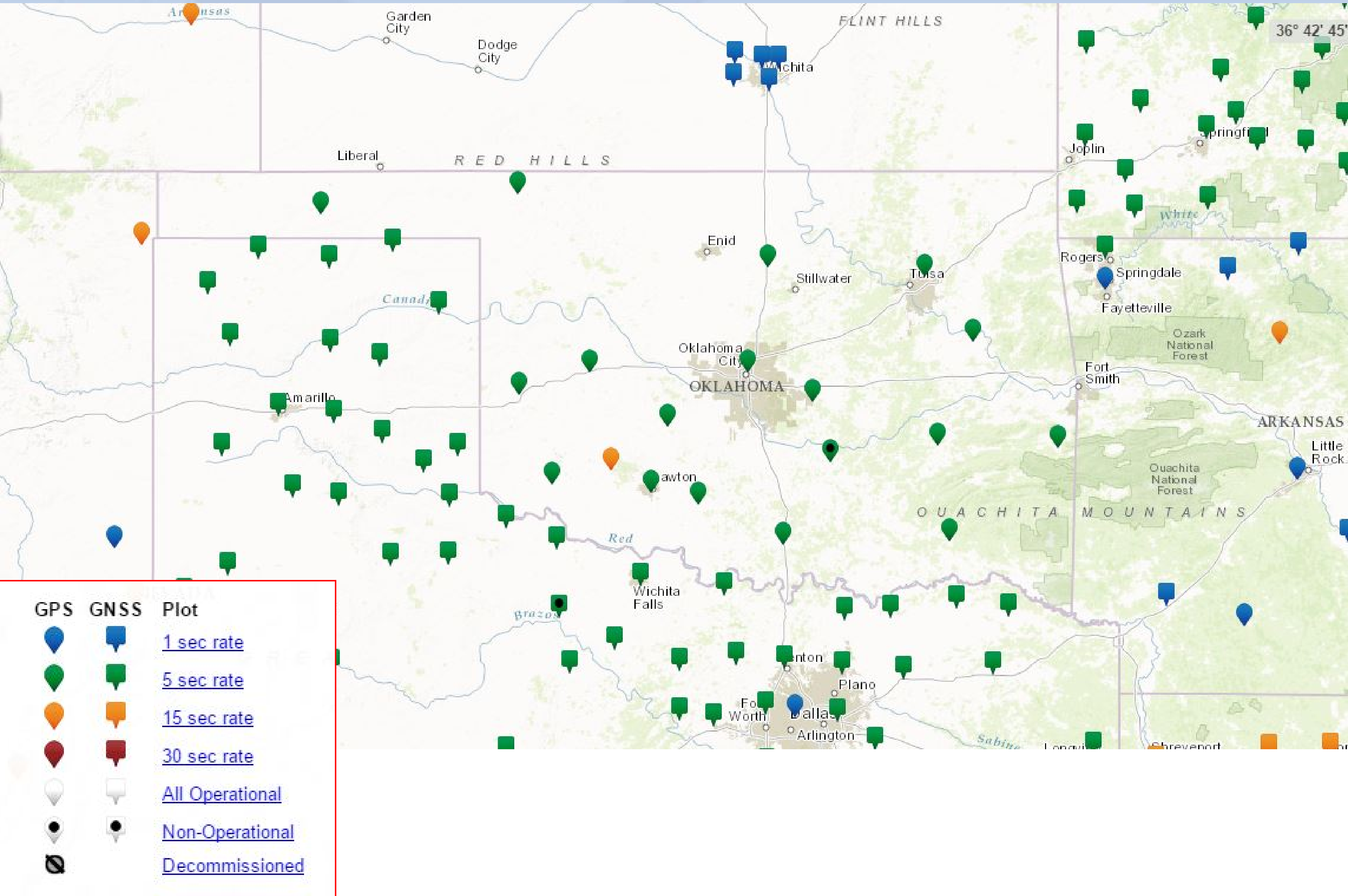
Continuously Operating Reference Station (CORS) Network

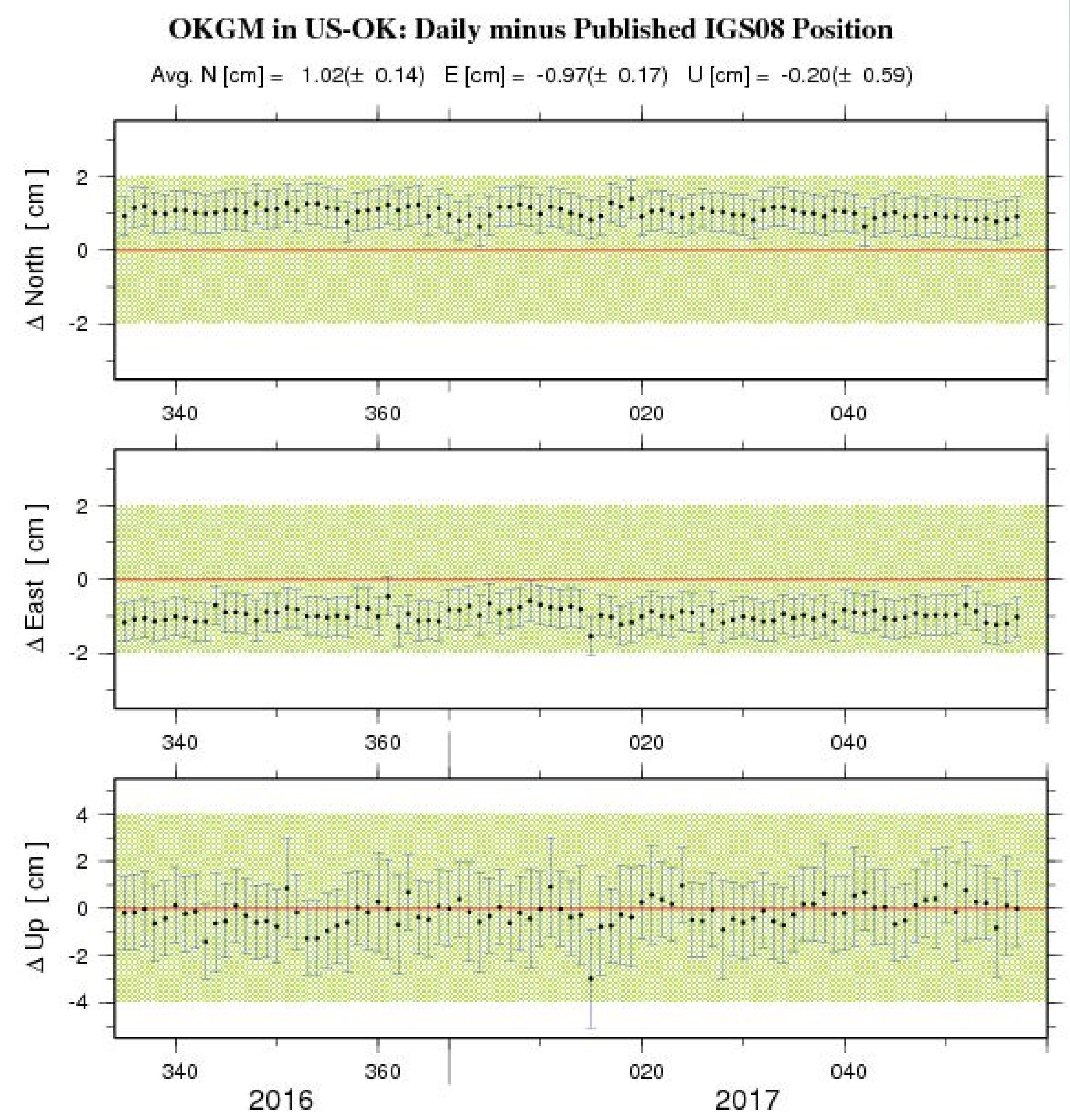
- 2000 sites
  (including 400 PBO)
- 225 organizations

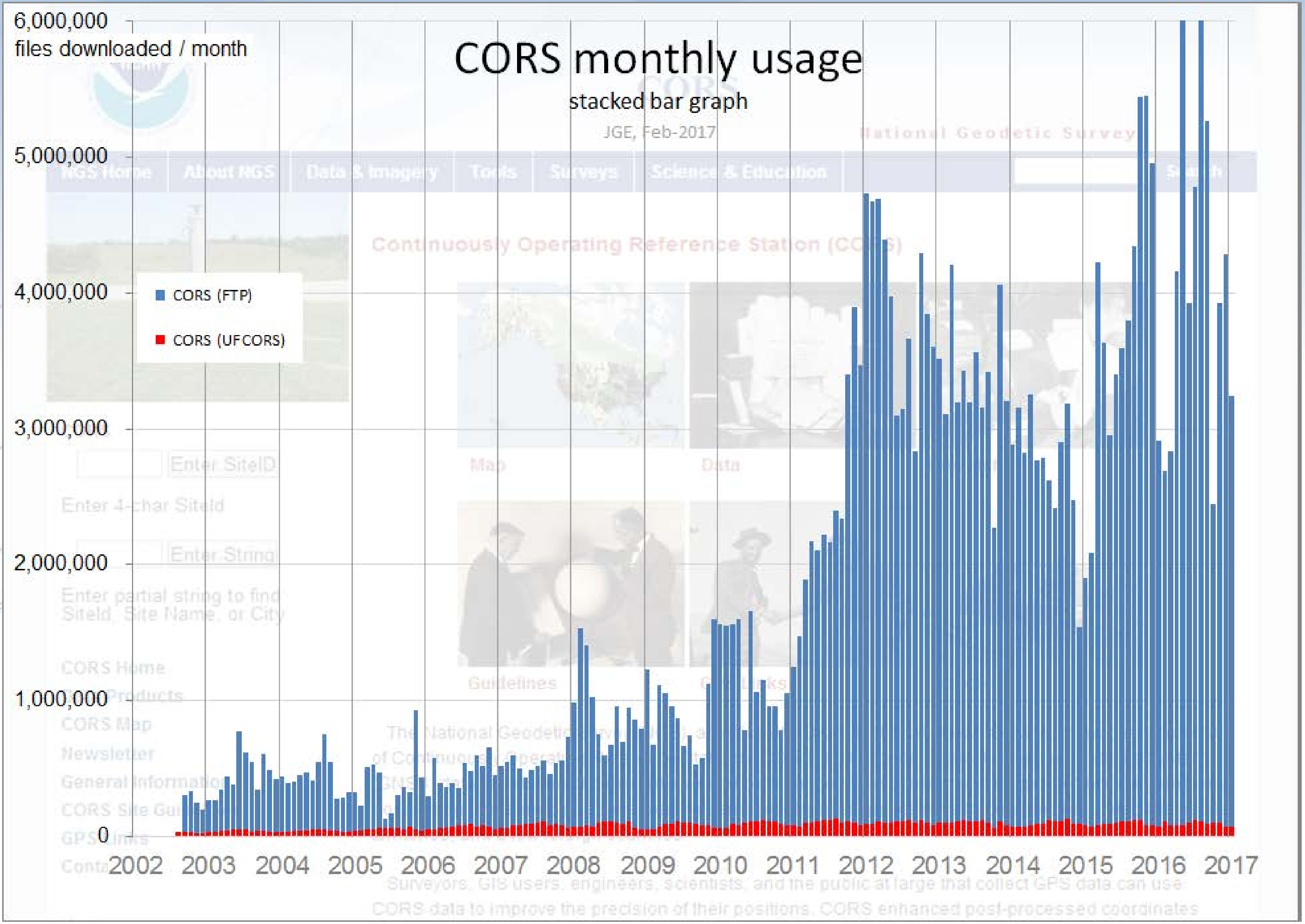




Continuously Operating Reference Station (CORS) Network




OKGM in US-OK: Daily minus Published IGS08 Position
Avg. N [cm] = 1.02(± 0.14) E [cm] = -0.97(± 0.17) U [cm] = -0.20(± 0.59)
Δ North [cm]
Δ East [cm]
Δ Up [cm]
340
360
020
040
2016
2017

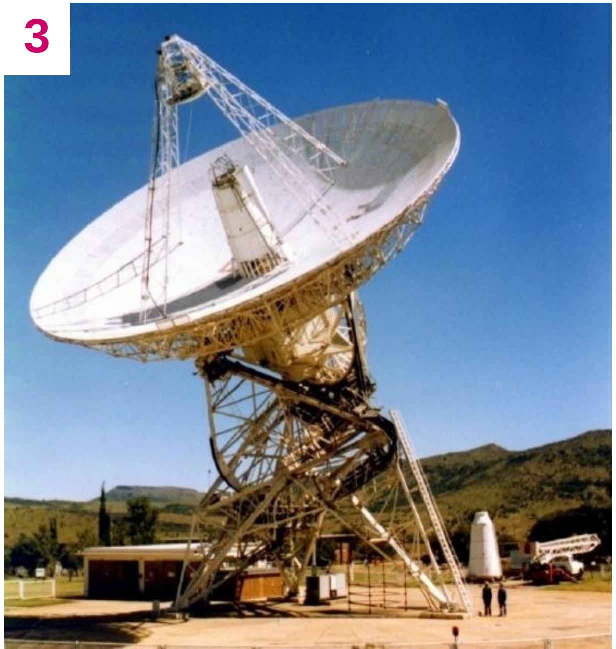

CORS monthly usage
stacked bar graph
JGE, Feb-2017
files downloaded / month
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
CORS (FTP)
CORS (UFCORS)
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

International Terrestrial Reference Frame I T R F

International Terrestrial Reference Frame (ITRF)

4 Global Independent Positioning Technologies

- 1. Global Navigation Satellite Systems (GNSS)
- 2. Satellite Laser Ranging (SLR)
- 3. Very Long Baseline Interferometry (VLBI)
- 4. Doppler Orbitography & Radiopositioning Integrated by Satellite (DORIS)

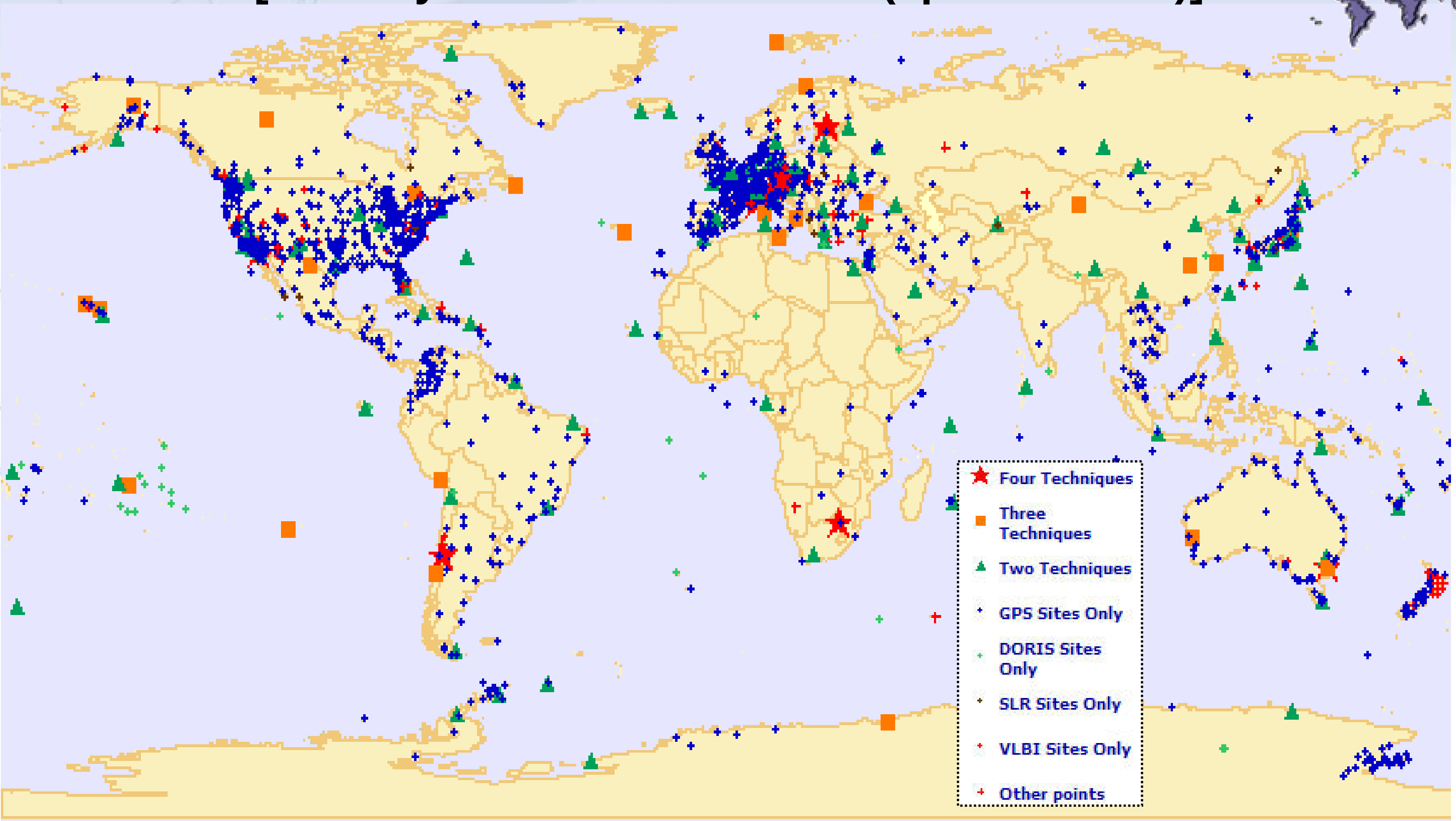


International Terrestrial Reference Frame (ITRF)

space-based techniques: VLBI, DORIS, SLR, GNSS

current version @ NGS: ITRF 2008 (epoch 2005.0)

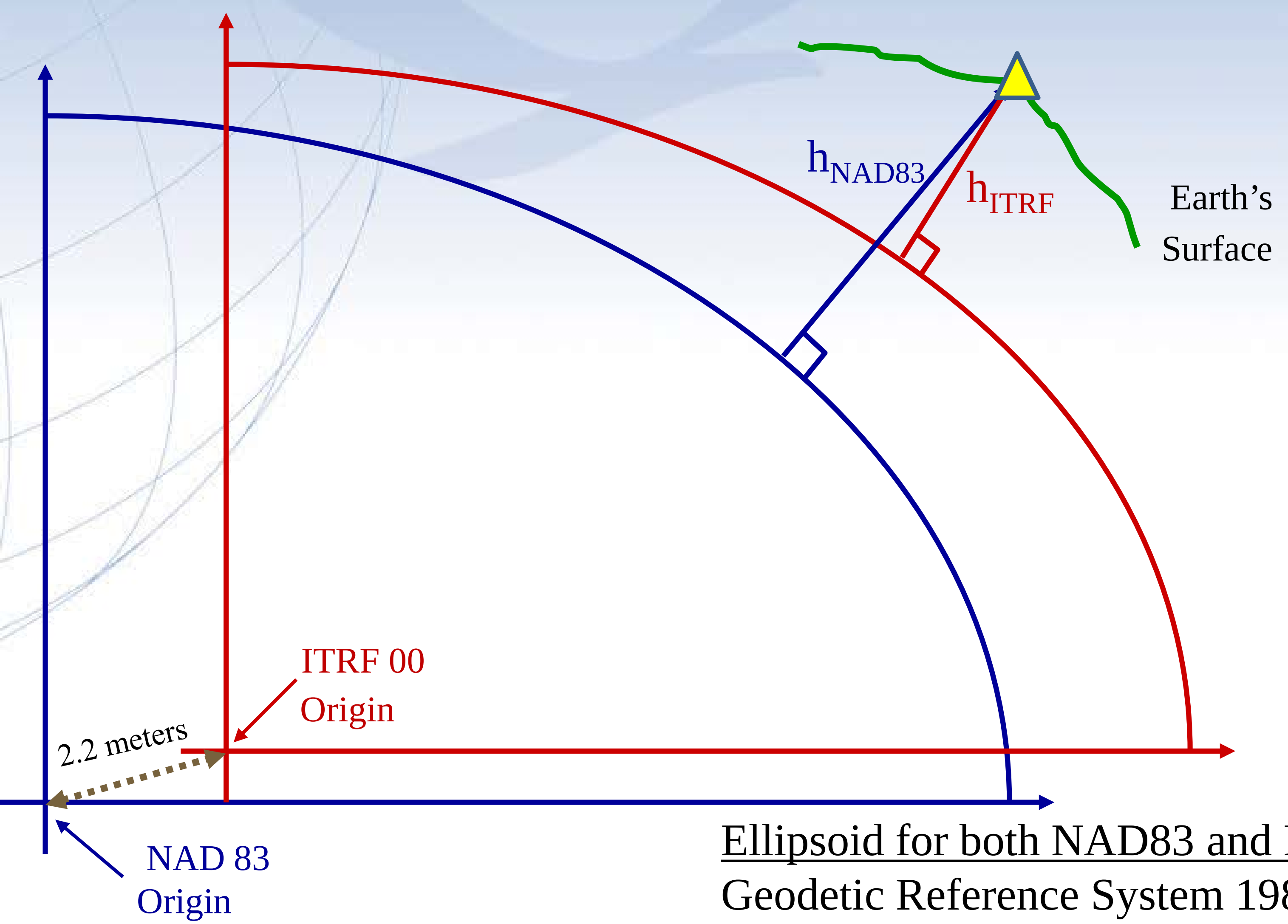
[recently released: ITRF 2014 (epoch 2010.0)]



International Earth Rotation and Reference System Service (IERS)

(http://www.iers.org)

Simplified Concept of NAD 83 vs. ITRF



<u>Ellipsoid for both NAD83 and ITRF:</u>

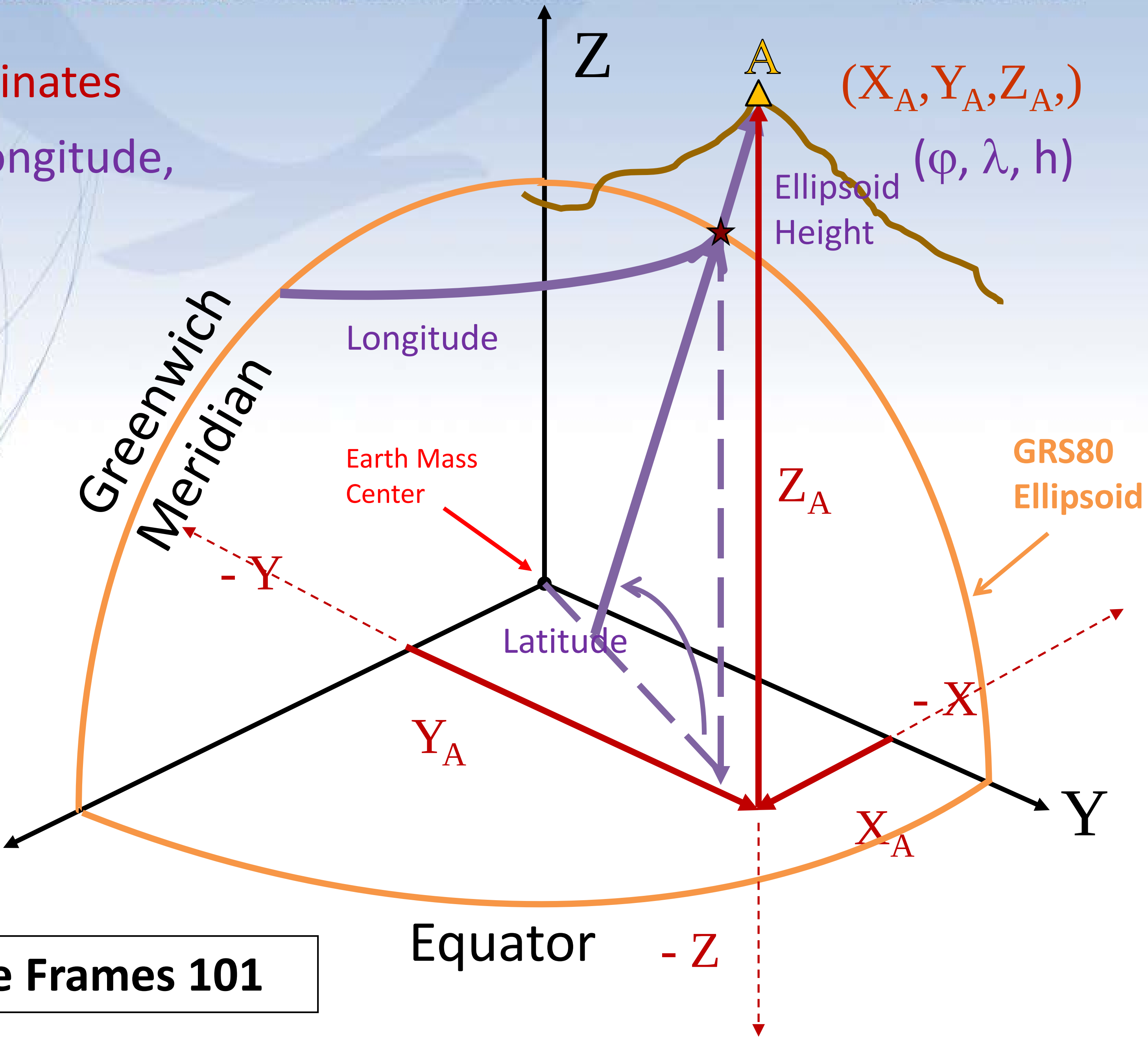
Geodetic Reference System 1980 (GRS80)

a = 6,378,137.000 meters (semi-major axis)

1/f = 298.25722210088 (flattening)

ECEF Coordinates

Latitude, Longitude, & Height



Reference Frames 101

CORS Coordinates

```
        Antenna Reference Point(ARP): GUYMON CORS ARP
        ---------------------------------------------
                          PID = DG9763


IGS08 POSITION (EPOCH 2005.0)
Computed in Aug 2011 using data through gpswk 1631.
    X =  -1019431.787 m     latitude     =  36 40 28.55349 N
    Y =  -5019923.423 m     longitude    = 101 28 45.69189 W
    Z =   3789047.249 m     ellipsoid height =  929.965    m

IGS08 VELOCITY
Computed in Aug 2011 using data through gpswk 1631.
    VX =  -0.0130 m/yr      northward =  -0.0056 m/yr
    VY =  -0.0007 m/yr      eastward  =  -0.0126 m/yr
    VZ =  -0.0045 m/yr      upward    =  -0.0001 m/yr

NAD_83 (2011) POSITION (EPOCH 2010.0)
Transformed from IGS08 (epoch 2005.0) position in Aug 2011.
    X =  -1019431.107 m     latitude     =  36 40 28.53240 N
    Y =  -5019924.793 m     longitude    = 101 28 45.65407 W
    Z =   3789047.338 m     ellipsoid height =  930.987    m

NAD_83 (2011) VELOCITY
Transformed from IGS08 velocity in Aug 2011.
    VX =   0.0031 m/yr      northward =  -0.0002 m/yr
    VY =   0.0002 m/yr      eastward  =   0.0030 m/yr
    VZ =  -0.0009 m/yr      upward    =  -0.0012 m/yr
```

IGS08 Position >>

IGS08 Velocity >>

NAD83 Position >>

NAD83 Velocity >>

IGS08 epoch 2005.0 =
International GNSS Service 2008
(@ January 1, 2005)
(GPS-only realization of ITRF2008)

NAD83 (2011) epoch 2010.00 =
North American Datum 1983 (2011)
(@ January 1, 2010)

Current 14-Parameter Transformation – IGS08 >> NAD83(2011)

IGS08 --> NAD 83 (2011)

[12 common points]

$t_0 = 1997.0$

$T_x(t_0) = 0.99343$ m; $T_y(t_0) = -1.90331$m; $T_z(t_0) = -0.52655$ m

$\varepsilon_x(t_0) = 25.91467$ mas; $\varepsilon_y(t_0) = 9.42645$ mas; $\varepsilon_z(t_0) = 11.59935$ mas

$s(t_0) = 1.71504 \cdot 10^{-9}$ (unitless)

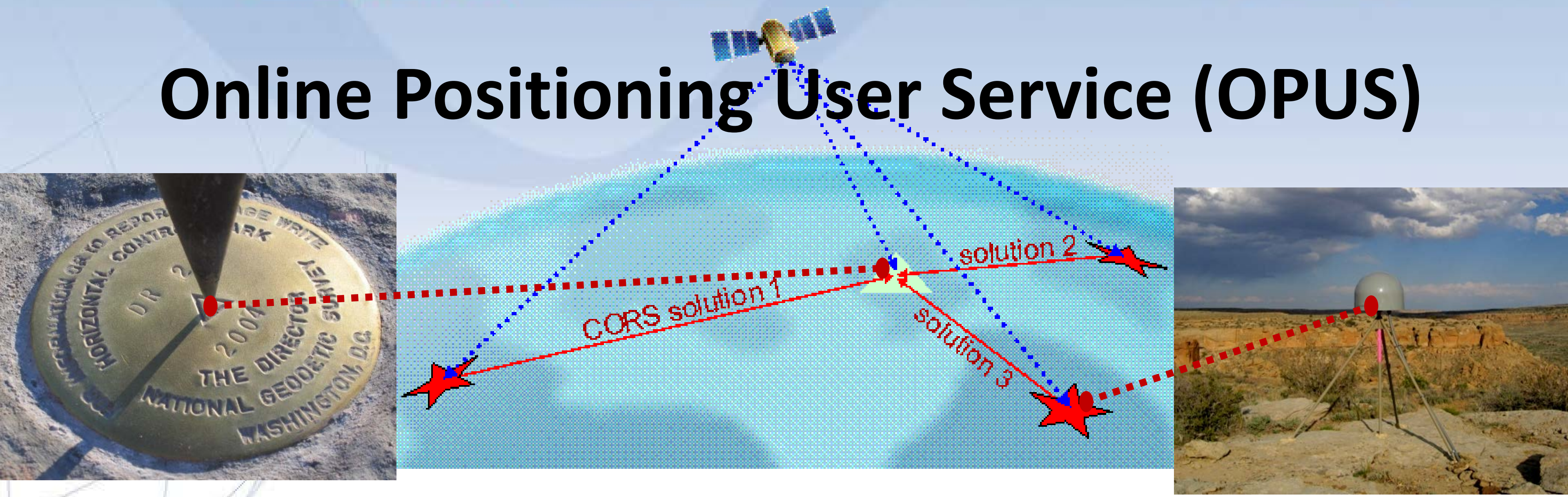
$\dot{T}_x = 0.00079 \text{ m} \cdot \text{year}^{-1}$; $\dot{T}_y = -0.00060 \text{ m} \cdot \text{year}^{-1}$; $\dot{T}_z = -0.00134 \text{ m} \cdot \text{year}^{-1}$

$\dot{\varepsilon}_x = 0.06667 \text{ mas} \cdot \text{year}^{-1}$; $\dot{\varepsilon}_y = -0.75744 \text{ mas} \cdot \text{year}^{-1}$; $\dot{\varepsilon}_z = -0.05133 \text{ mas} \cdot \text{year}^{-1}$

$\dot{s} = -0.10201 \cdot 10^{-9} \text{ year}^{-1}$

http://geodesy.noaa.gov/CORS/coords.shtml

Online Positioning User Service (OPUS)



- upload L1/L2 GPS data >>> solution via email in minutes
  - OPUS-RS (Rapid Static) ----15 min to 2 hr (per CORS)
  - OPUS-S (Static) ---- 2 to 48 hr (anywhere)
  - OPUS-DB (Database) --- sharing of results
  - OPUS-Projects --- network of multi-stations/occupations

Fast, easy, consistent access to NSRS

OPUS IGS14 Announcement

frame change to IGS14 begins with orbits

Orbits have been upgraded by IGS to their new IGS14 reference frame (**29 Jan 2017**.) As other sources remain in IGS08 for now, we expect no significant impact to OPUS users. A fully IGS14-based OPUS should be available in beta later this year.

Final

The final combinations are available at 12 days latency.

Rapid

The Rapid product is available with approximately 17 hours latency.

UltraRapid

The UltraRapid combinations are released four times each day (at 0300, 0900, 1500, and 2100 UT) and contain 48 hours worth of orbits; the first half computed from observations and the second half predicted orbit. The files are named according to the midpoint time in the file: 00, 06, 12, and 18 UT.

OPUS – Share (aka OPUS-DB)

❑ Sharing Criteria:

- NGS-calibrated antenna
- > 4 hour data span
- > 70% observations used
- > 70% fixed ambiguities
- < 0.04m H peak-to-peak
- < 0.08m V peak-to-peak

❑ Uses:

- GPS on BMs
- PLSS / GCDB
- Data archive
- Data sharing

Shared Solution

PID: GT0228
Designation: F 72
Stamping: F 72 1928
Stability: Most reliable; expected to hold position well
Setting: In rock outcrop or ledge
Mark Condition: G
Description: The station is located 6.2 miles along the Mount Whitney Trail from the trailhead at the Whitney Portal, west of Lone Pine. It is located at Trail Camp, about 250 feet south of the south shore of a lake and about 50 feet south of the trail, opposite a 10-feet-tall boulder that sits directly along the north side of the trail. The station is a USCGS bench mark disk set flush in the top of a granite outcrop measuring about 75 feet by 25 feet and standing about 10 feet above the level of the trail.
Observed: 2010-08-17T16:53:00Z See Also 1928
Source: OPUS - page5 1209.04

Close-up View

REF_FRAME: NAD_83(2011)	EPOCH: 2010.0000	SOURCE: NAVD88 (Computed using GEOID12A)	UNITS: m	SET PROFILE	DETAILS

LAT:	36° 33' 46.36644"	± 0.006 m
LON:	-118° 16' 46.29502"	± 0.003 m
ELL HT:	3645.963	± 0.013 m
X:	-2431390.178	± 0.006 m
Y:	-4519449.679	± 0.013 m
Z:	3780713.238	± 0.002 m
ORTHO HT:	3671.261	± 0.031 m

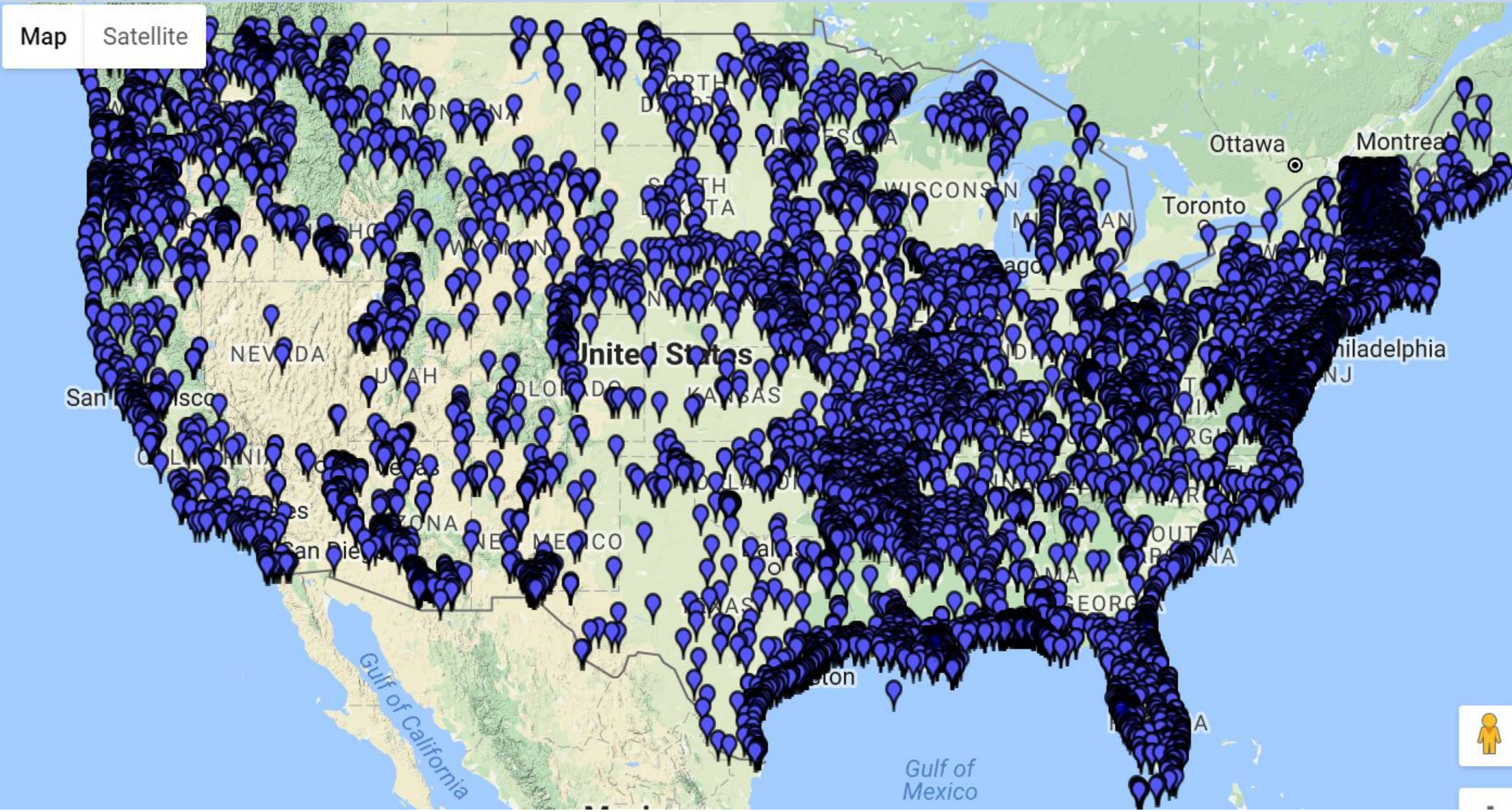
	UTM 11	SPC 404(CA 4)
NORTHING:	4047144.640m	636673.937m
EASTING:	385501.607m	2064491.407m
CONVERGENCE:	-0.76230261°	0.42982529°
POINT SCALE:	0.99976152	0.99994136
COMBINED FACTOR:	0.99918979	0.99936952

CONTRIBUTED BY

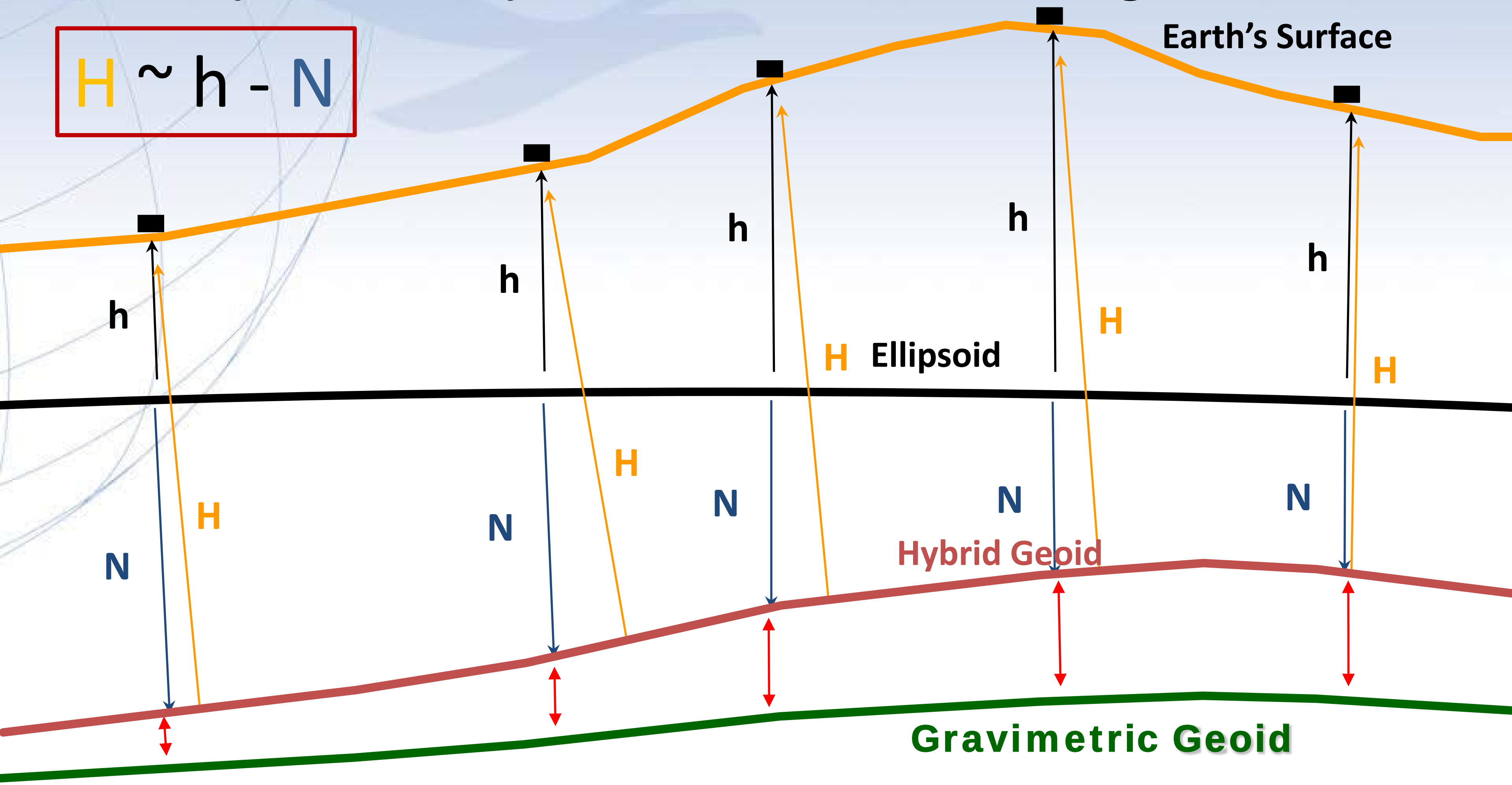
william.stone
National Geodetic Survey


Horizon View

Shared OPUS Solutions

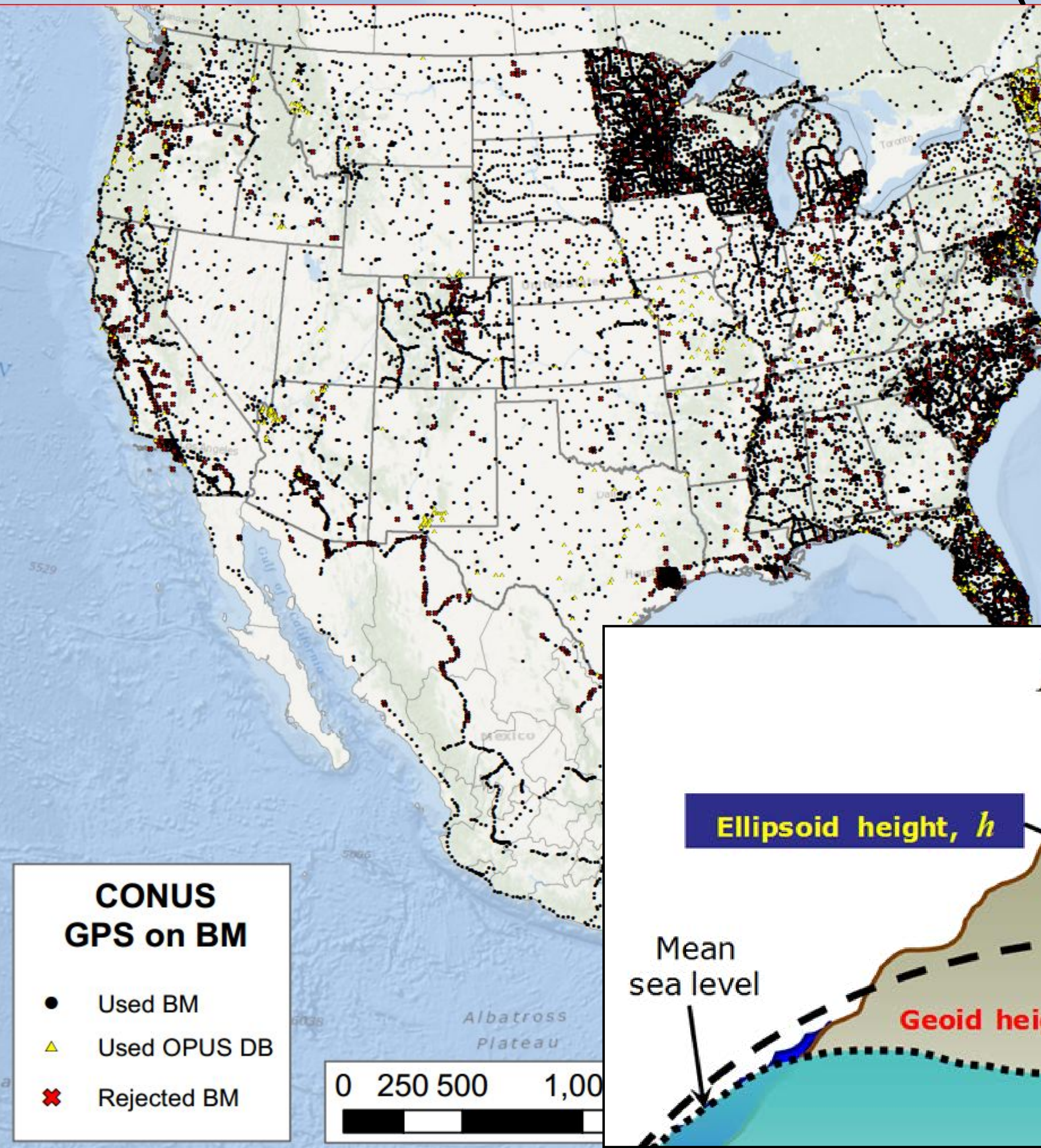


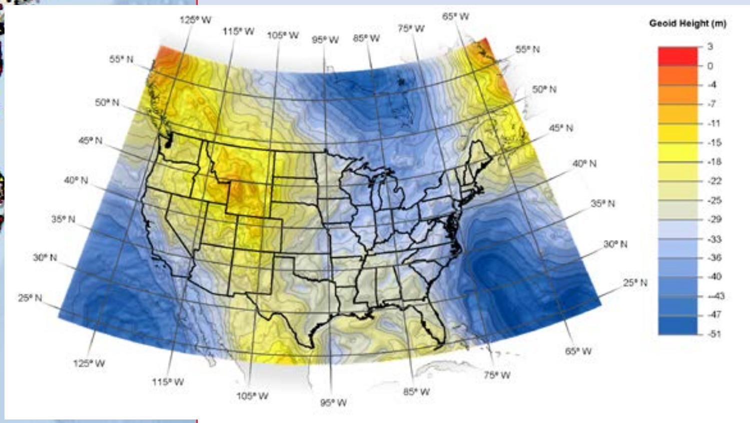
Hybrid Geoid Model (GEOID12B) & Gravimetric Geoid Model (USGG2012) Conversion Surface using GPSBM data

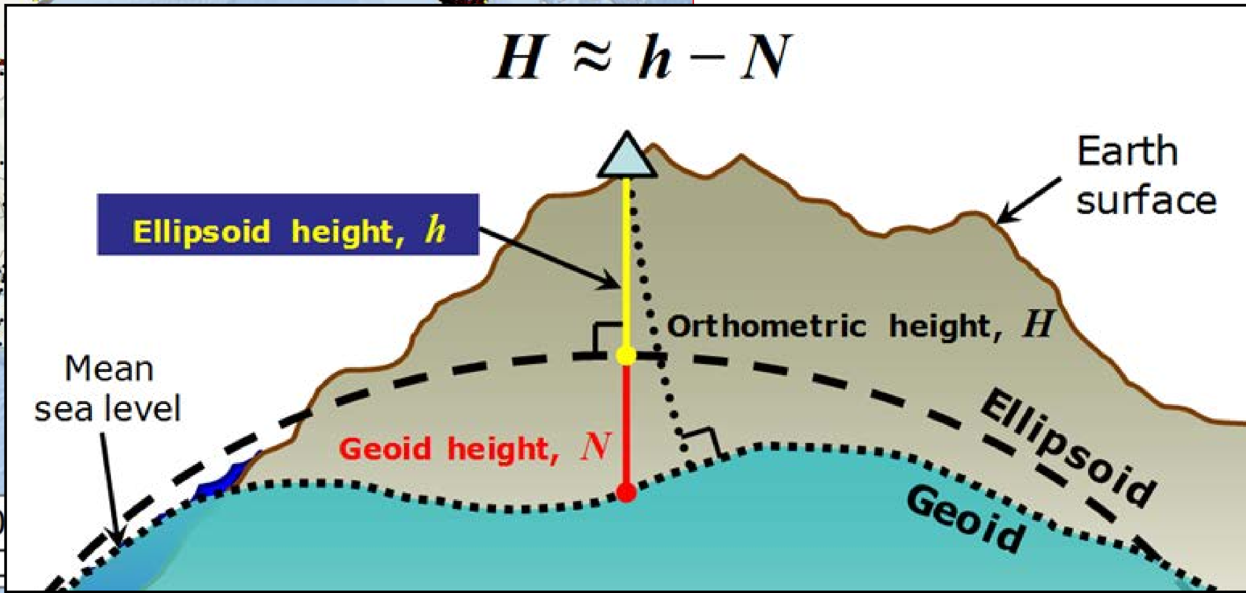


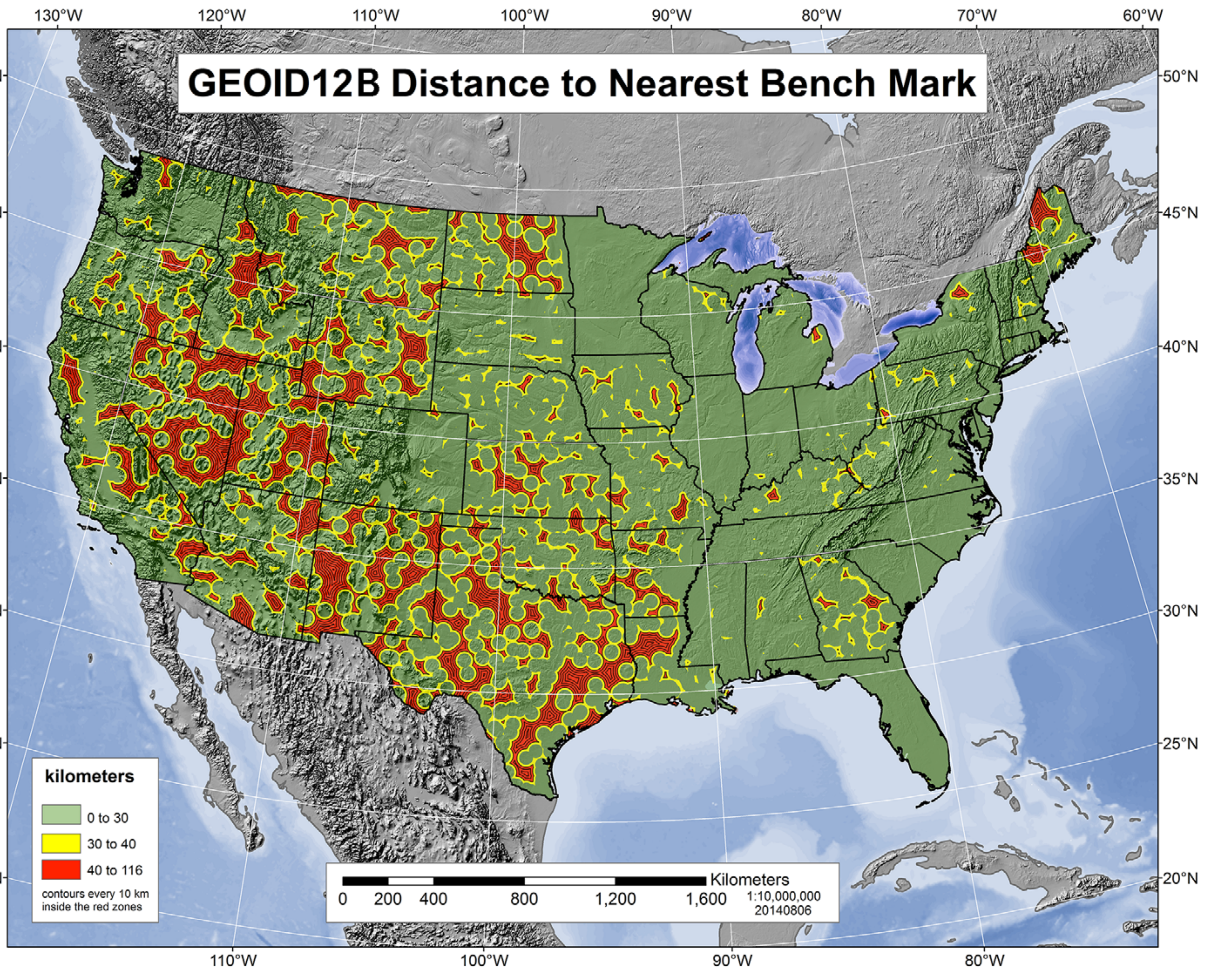
- Gravimetric Geoid systematic misfit to BMs but best fits "true" heights
- Hybrid Geoid "converted" to fit local BMs, so best fits NAVD 88 heights
- Conversion Surface model of systematic misfit derived from BMs in database

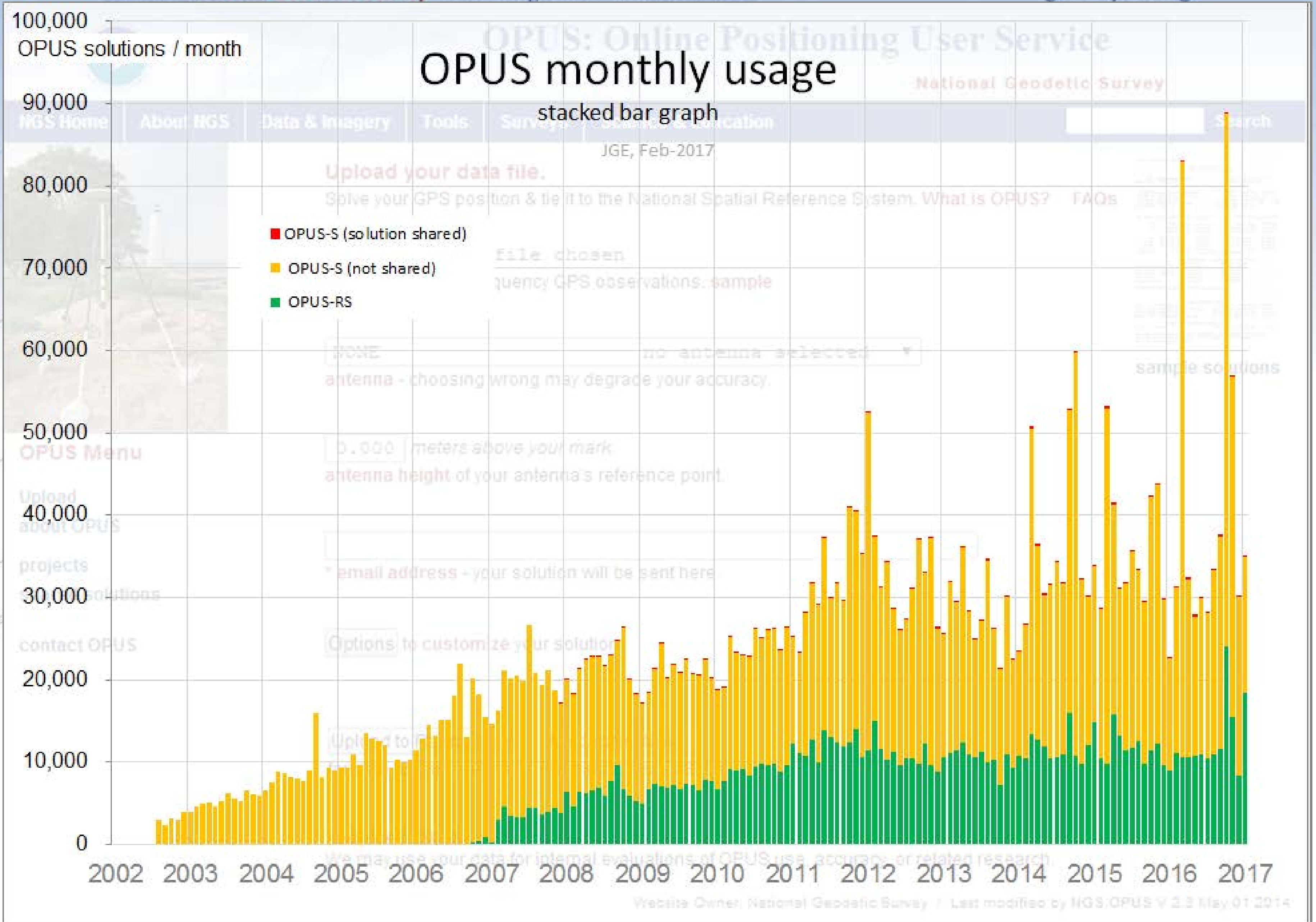
GEOID12B GPSBMs (~24,000)








GEOID12B Distance to Nearest Bench Mark
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
50°N
45°N
40°N
35°N
30°N
25°N
20°N
kilometers
0 to 30
30 to 40
40 to 116
contours every 10 km inside the red zones
0 200 400 800 1,200 1,600 Kilometers
1:10,000,000
20140806


OPUS monthly usage
stacked bar graph
JGE, Feb-2017
OPUS solutions / month
OPUS-S (solution shared)
OPUS-S (not shared)
OPUS-RS
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
OPUS: Online Positioning User Service
National Geodetic Survey

National Geodetic Survey ***Ten-Year Strategic Plan***

- By 2022, reduce all definitional & access-related errors in geometric reference frame to 1 cm when using 15 min of GNSS data

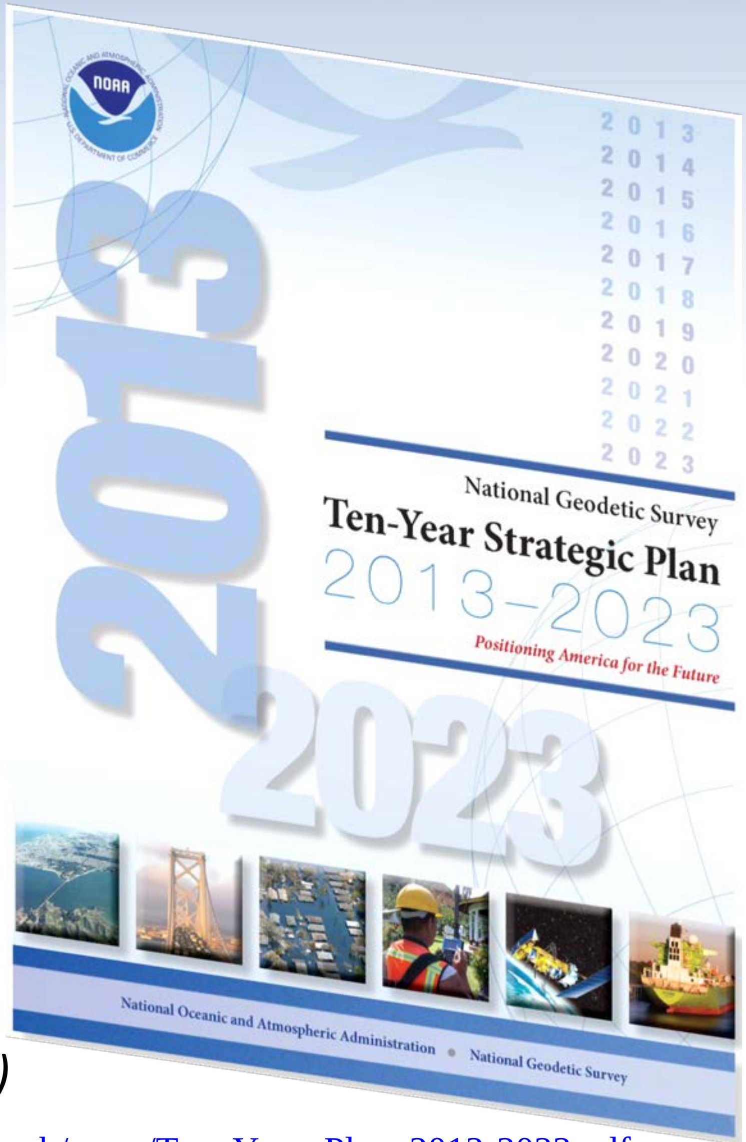
  "**Replace NAD83**"

(NAD83 = North American Datum 1983)

- By 2022, reduce all definitional & access-related errors in orthometric heights in geopotential reference frame to 2 cm when using 15 min of GNSS data

  "**Replace NAVD88**"

(NAVD88 = North American Vertical Datum 1988)



http://www.geodesy.noaa.gov/web/news/Ten_Year_Plan_2013-2023.pdf

NAD83 Shortcomings

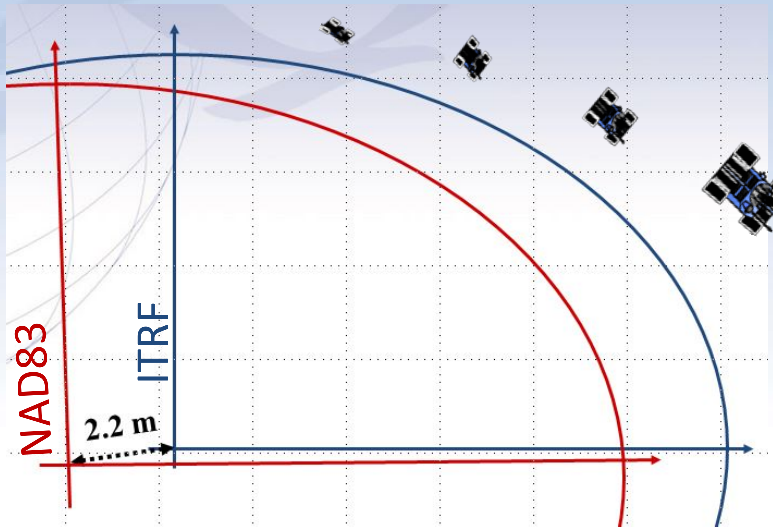
- **2.2 m offset –**

  NAD83 vs.

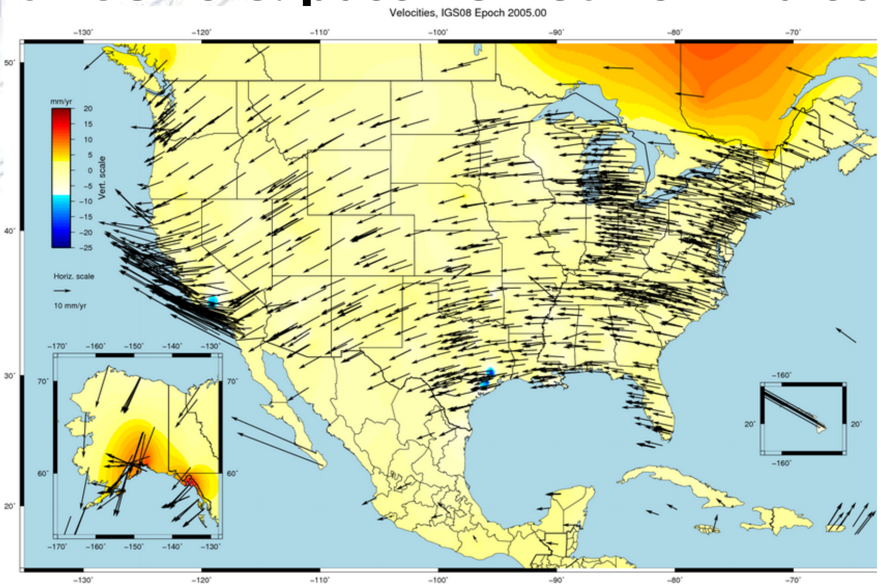
  International Terrestrial

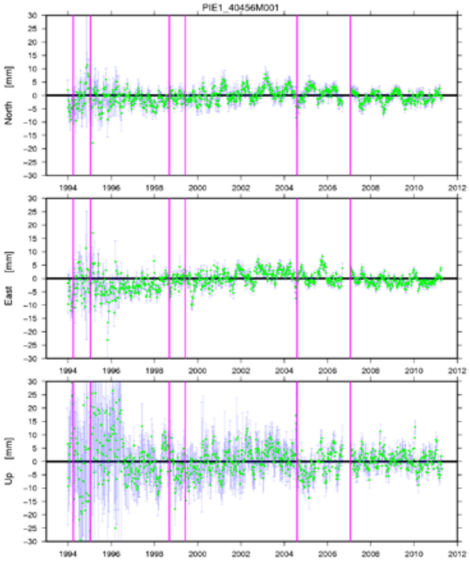
  Reference Frame (ITRF)

  (and WGS84)



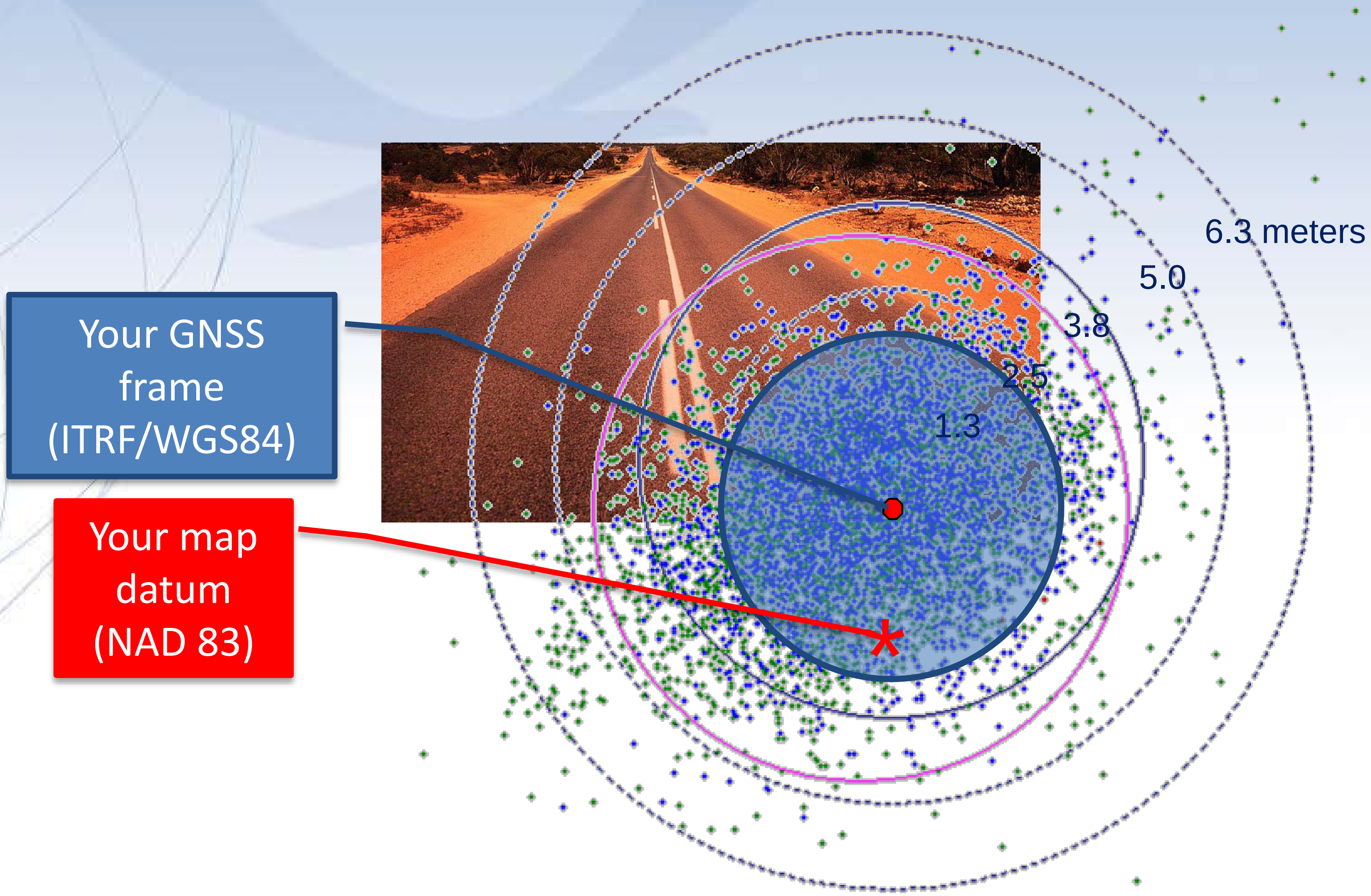
- **CORS & passive network "disconnect"**





vs.

Map the same way you navigate



As GNSS un-augmented user range error improves over time …

Future Geometric (3-D) Reference Frame

- **replace NAD83 with new geometric reference frame – by 2022**
- **CORS-based, accessed via GNSS observations**
- **coordinates & velocities in ITRF & new US reference frame**
- **passive control tied to new reference frame (not a component)**
- **transformation tools will relate NAD83 to new US reference frame**

  (HTDP / NADCON / GEOCON ...)

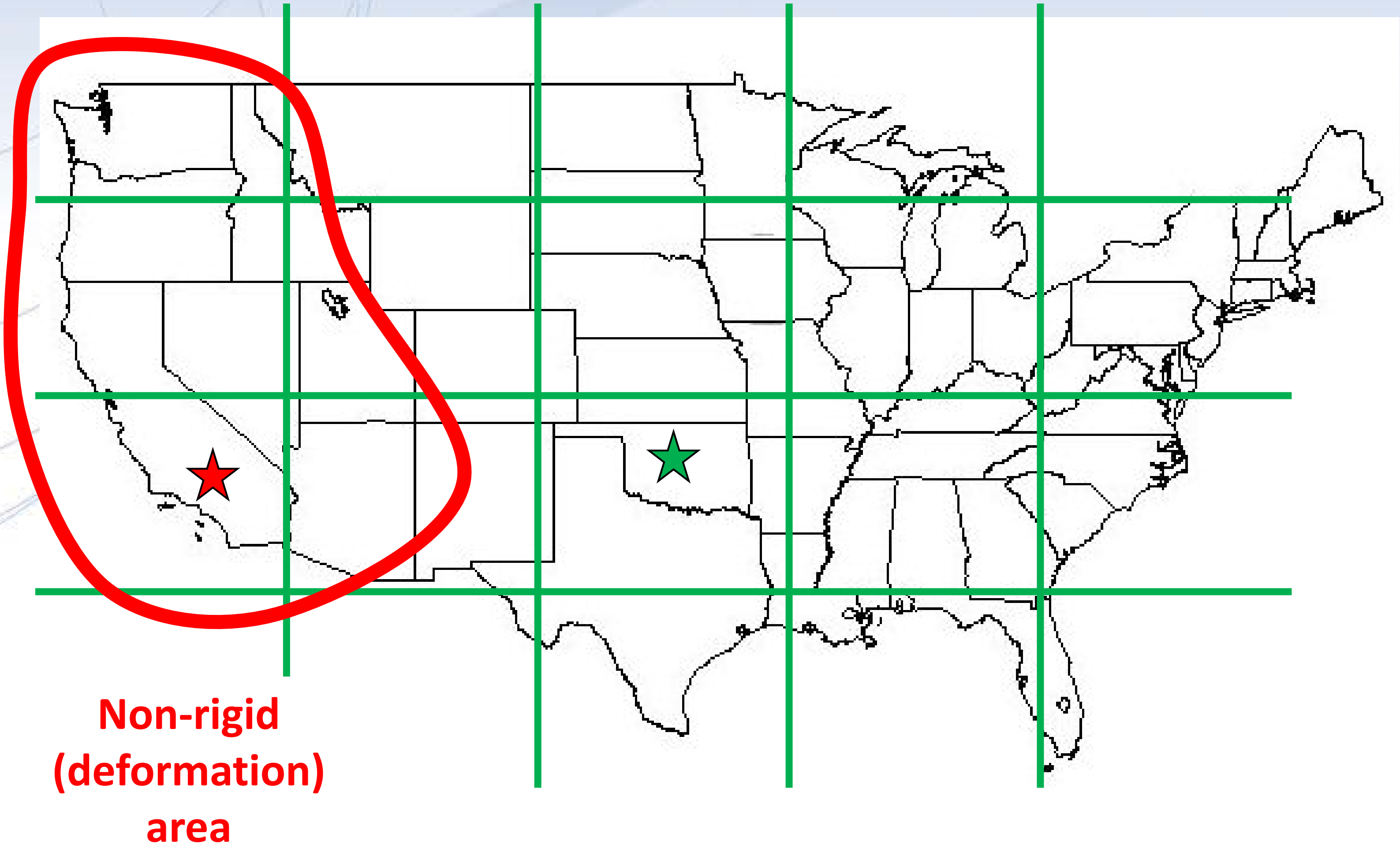
And it shall be called…

North American Terrestrial Reference Frame of 2022 (NATRF2022)

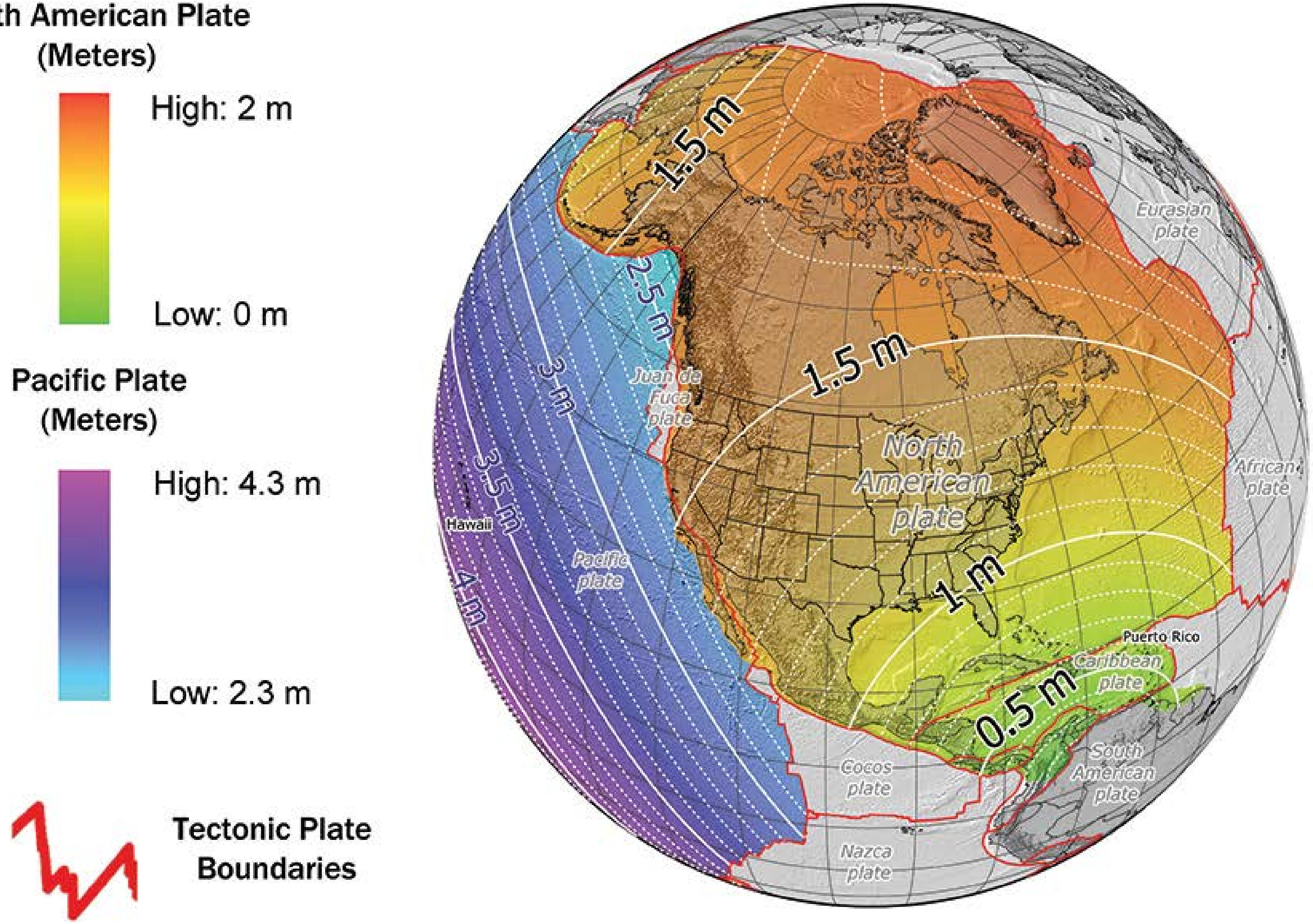
(& Pacific/Mariana/Caribbean Terrestrial Reference Frame of 2022)

- 4 plate-fixed frames
- identical to the IGSXX reference frame at a TBD epoch
- over time, will relate to IGS frame via Euler Pole Rotation
- all CORS velocities deviating from rigid-plate rotation will be captured in 3-D velocity model

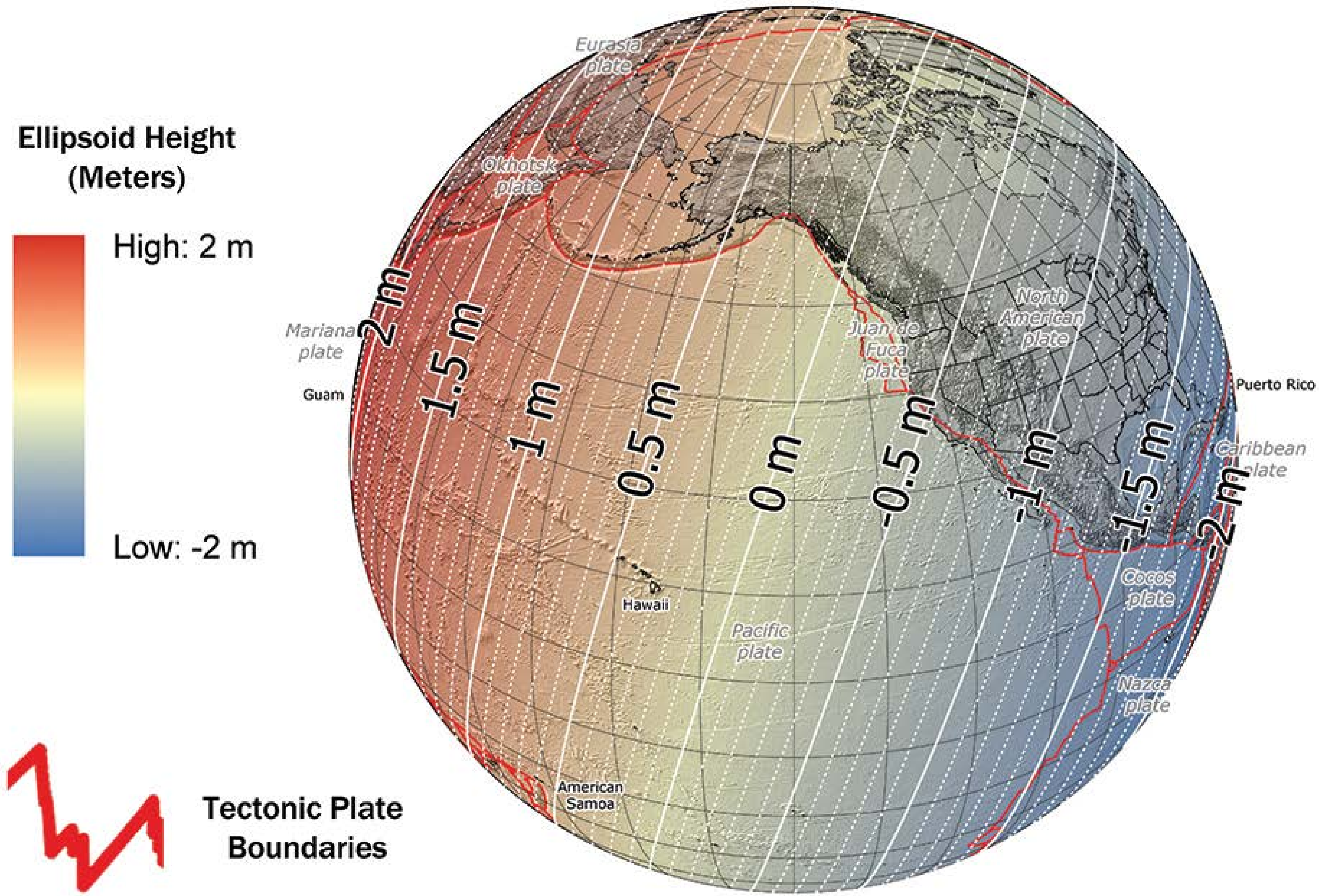
Frame is rigid and fixed to rigid part of plate



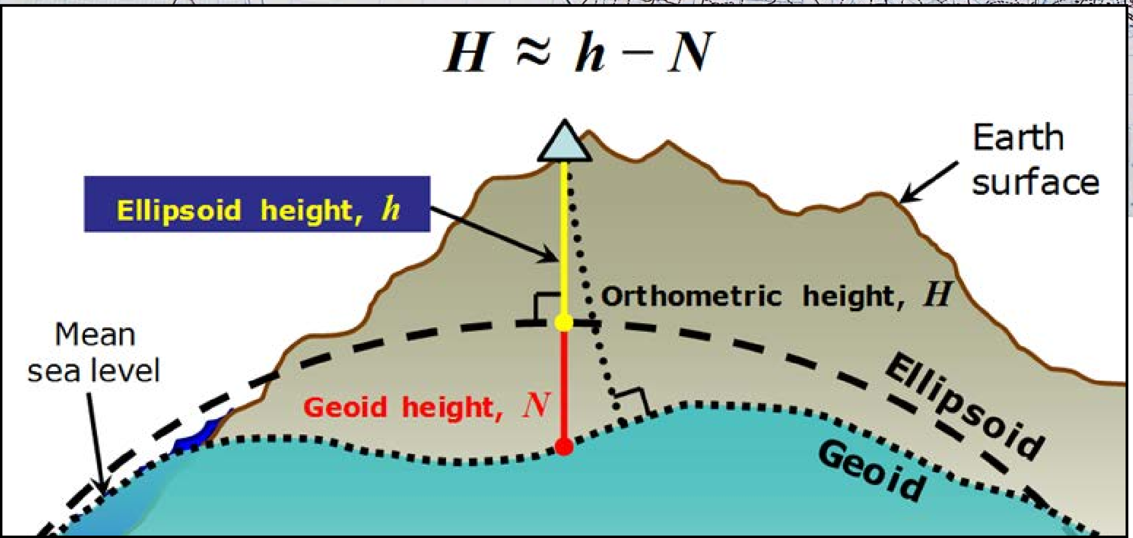
Approximate Horizontal Change North American Plate



Approximate Ellipsoid Height Change

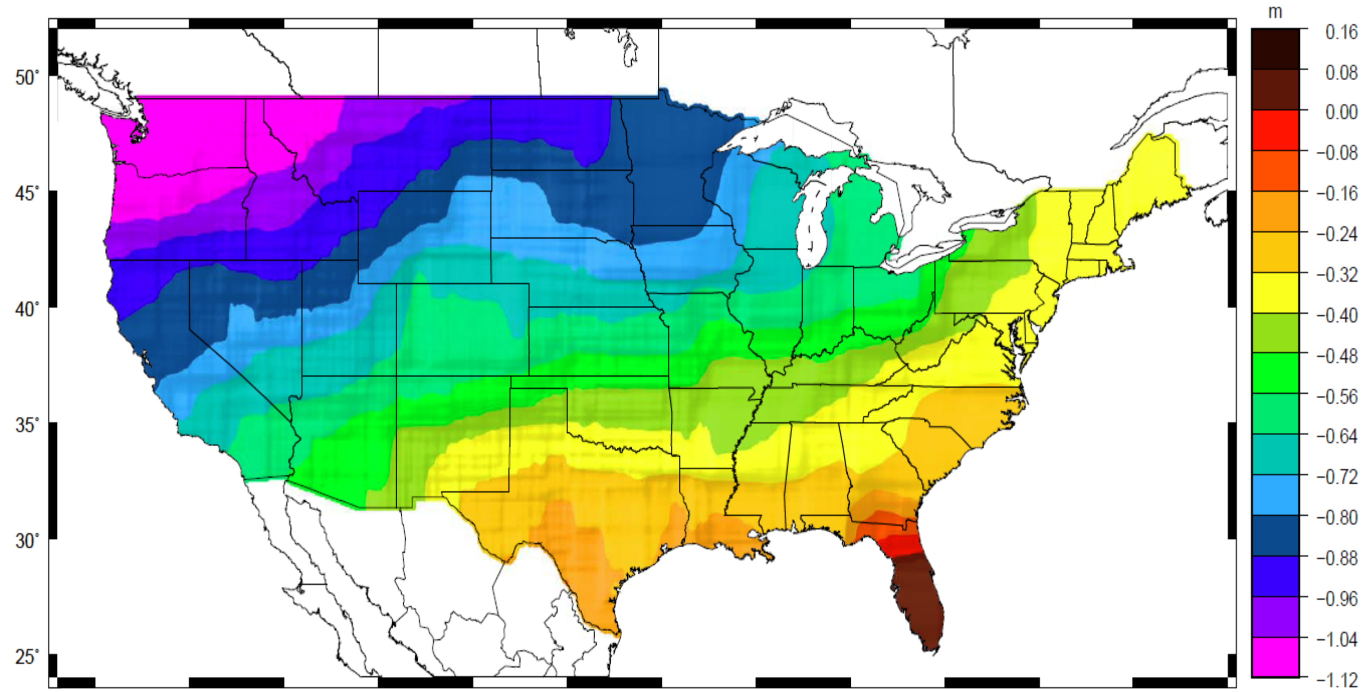


NORTH AMERICAL VERTICAL DATUM 1988 (NAVD88)



North American Vertical Datum 1988 (NAVD88) Shortcomings

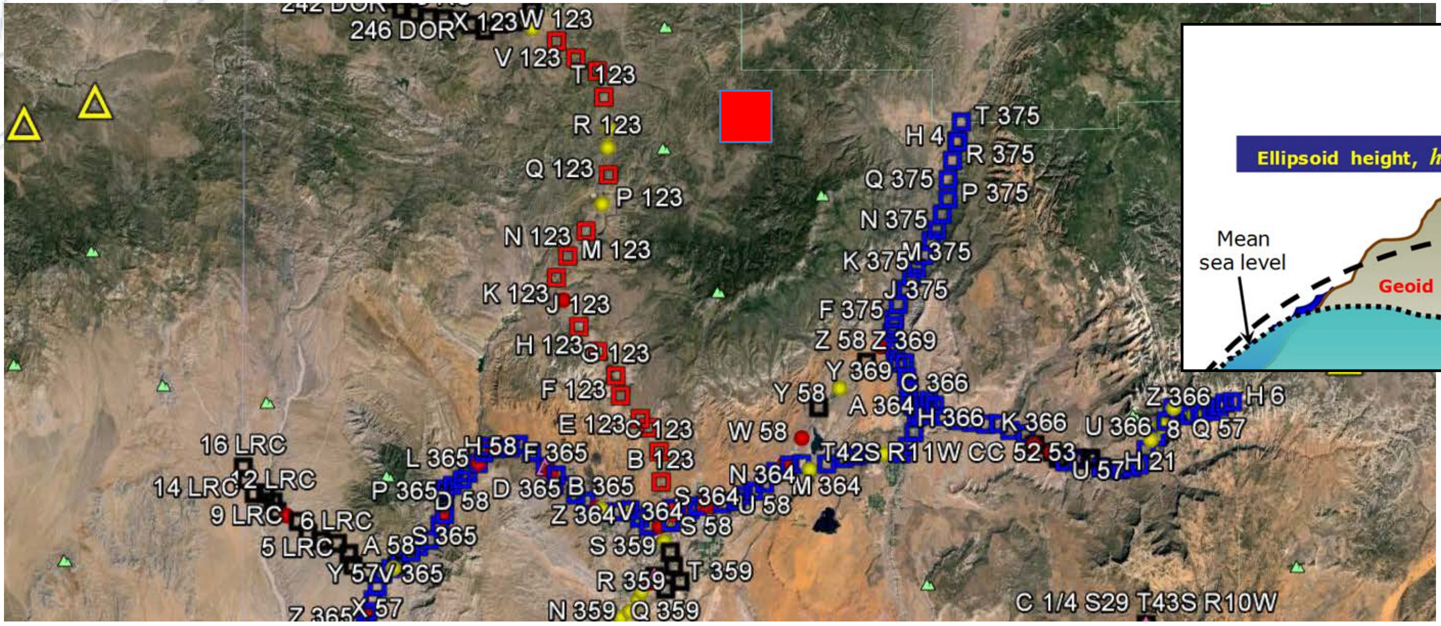
- Cross-country errors (1-m tilt)
- 0.5 m bias in reference surface vs. global mean sea level
- Subsidence, uplift, freeze/thaw invalidate BM elevations
- LIMITED AVAILABILITY / ACCESS

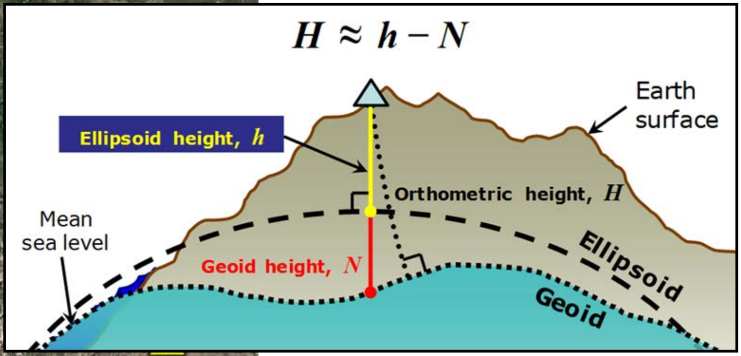


Approximate Geoid Mismatch in the NAVD88 H=0 surface

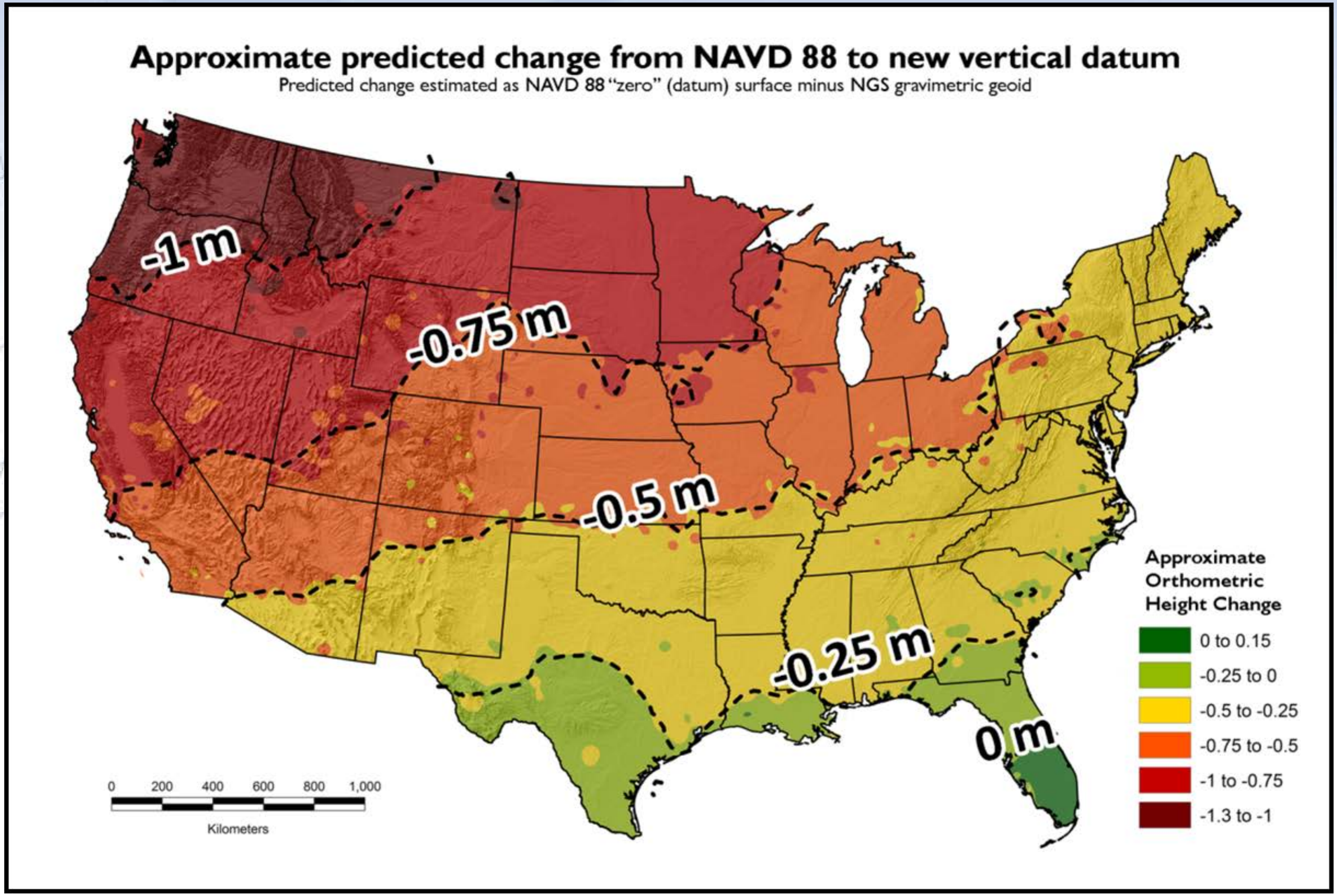
Future Geopotential (Vertical) Datum

- **replace NAVD88 – by 2022**
- **accessed by GNSS & gravimetric geoid**
- **monitor time-varying nature of gravity field**
- **most accurate continental gravimetric geoid model ever built: 1 cm**





Future Geopotential (Vertical) Datum



And they shall be called…

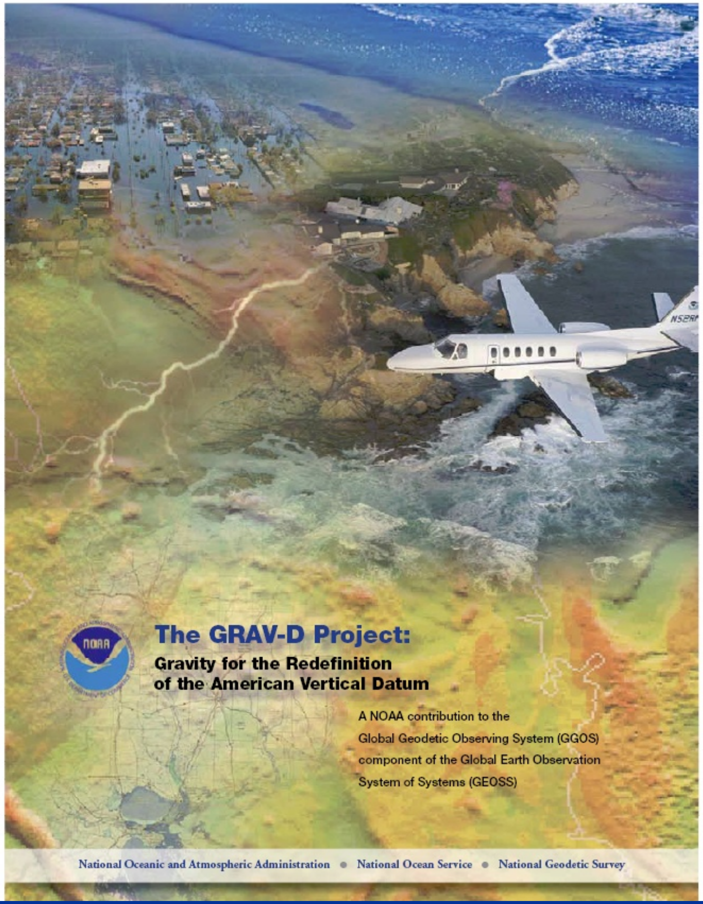
North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

&

GEOID2022

- NAPGD2022 will contain information for:
  - Orthometric heights
  - Geoid undulations
  - Gravity anomalies
  - Deflections of the vertical
  - & other gravity field information
- GEOID2022 will be time-dependent

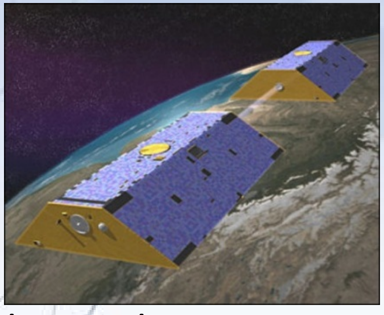
Gravity for the Redefinition of the American Vertical Datum (GRAV-D)



Gravity *and* ***Heights*** *are inseparably connected*

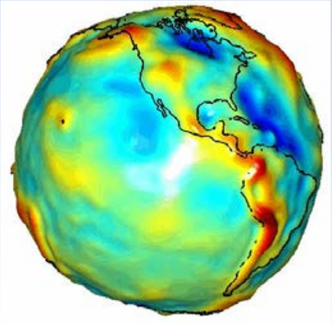
- Replace the national vertical datum (NAVD88) by 2022 with a ***1 cm accurate gravimetric geoid***
- Orthometric heights accessed via GNSS ***accurate to 2 cm***
- Thrusts of project:
  - Airborne gravity survey of entire country and its holdings
  - Long-term geoid change monitoring
  - Partnership surveys

Building a Gravity Field

GRACE/GOCE/Satellite Altimetry

Long Wavelengths
(≥ 250 km)



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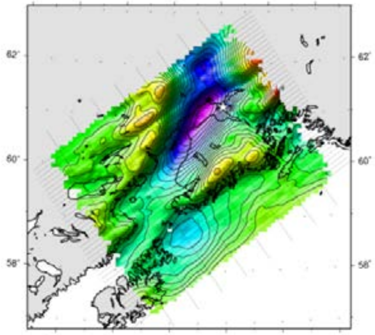
Airborne Measurement

Intermediate Wavelengths
(300 km to 20 km)



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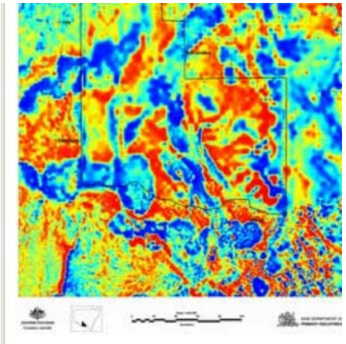
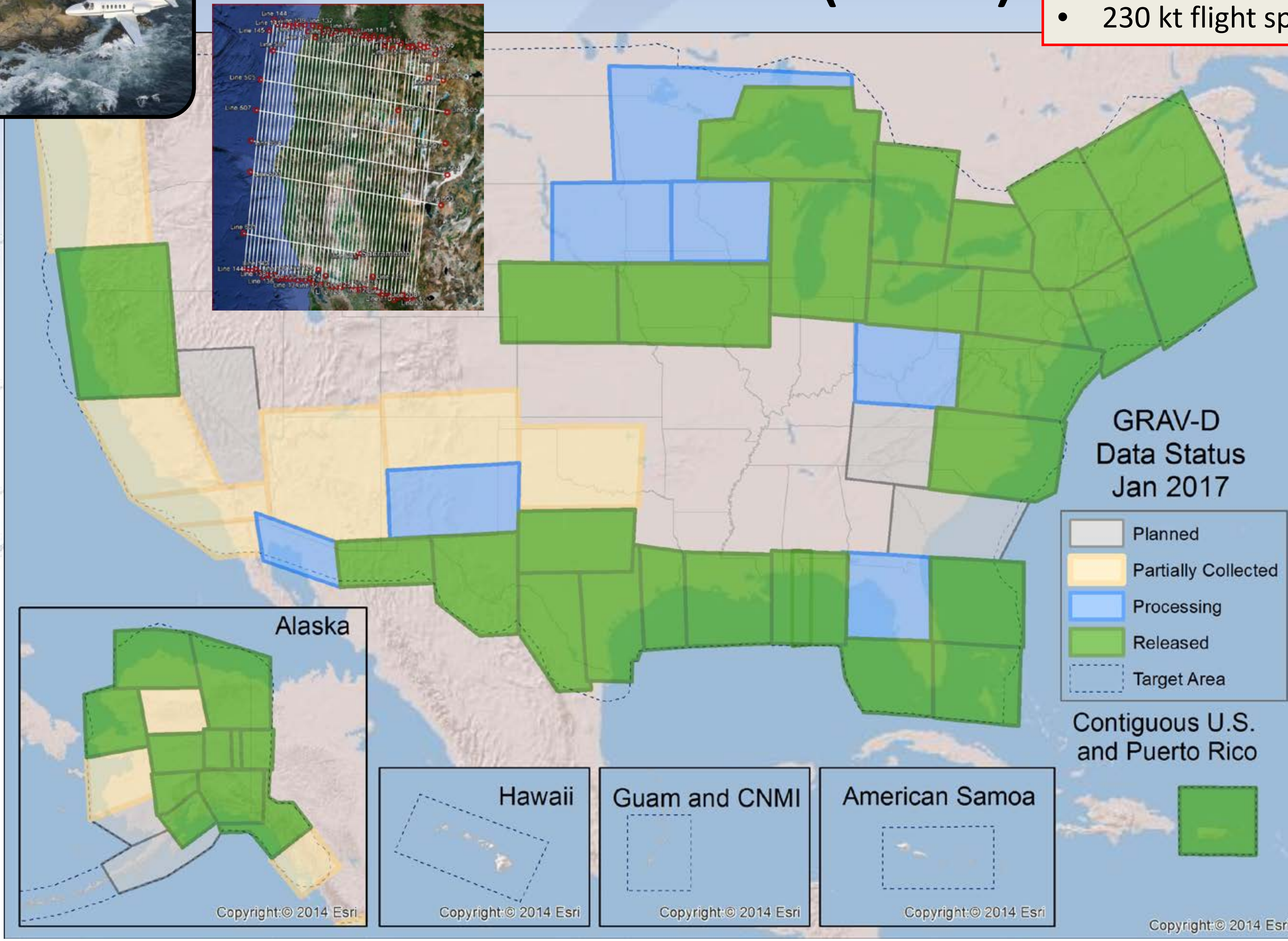
Surface Measurement and
Predicted Gravity from Topography

Short Wavelengths
(< 100 km)



GRAV-D Status (58%)

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



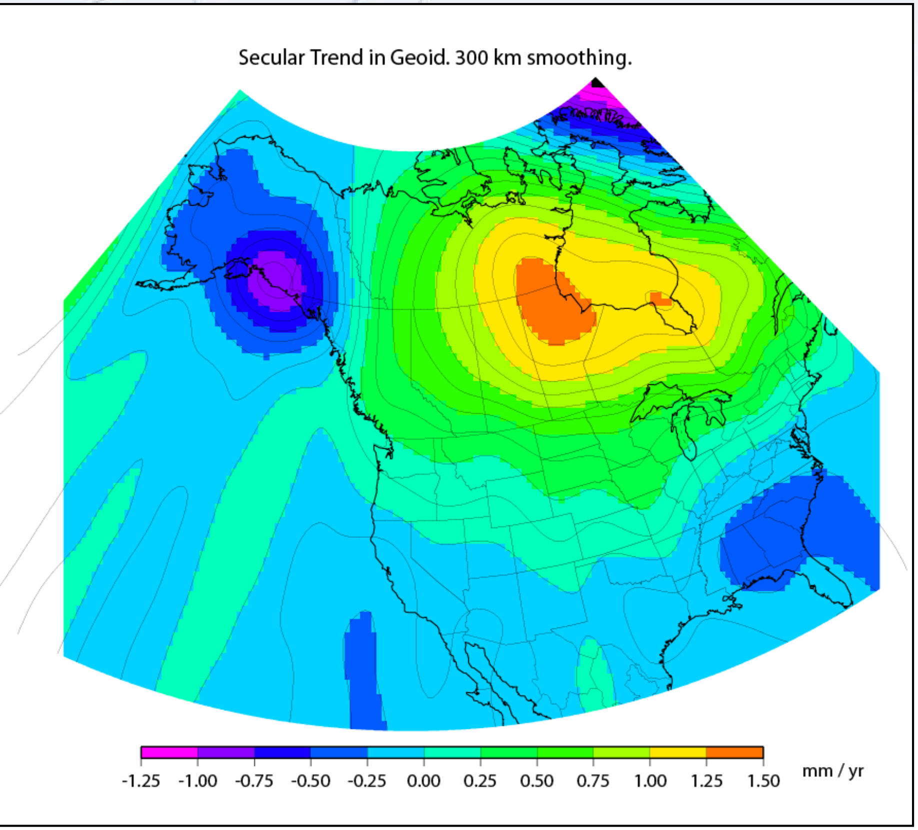
GRAV-D Data Collection Scope

- Entire U.S. and territories
  - Area: 15.6 million sq km
  - Initial target area for 2022
  - ~200 km buffer around territory or shelf break

Extent of 2022 gravimetric geoid model used for new geopotential reference frame

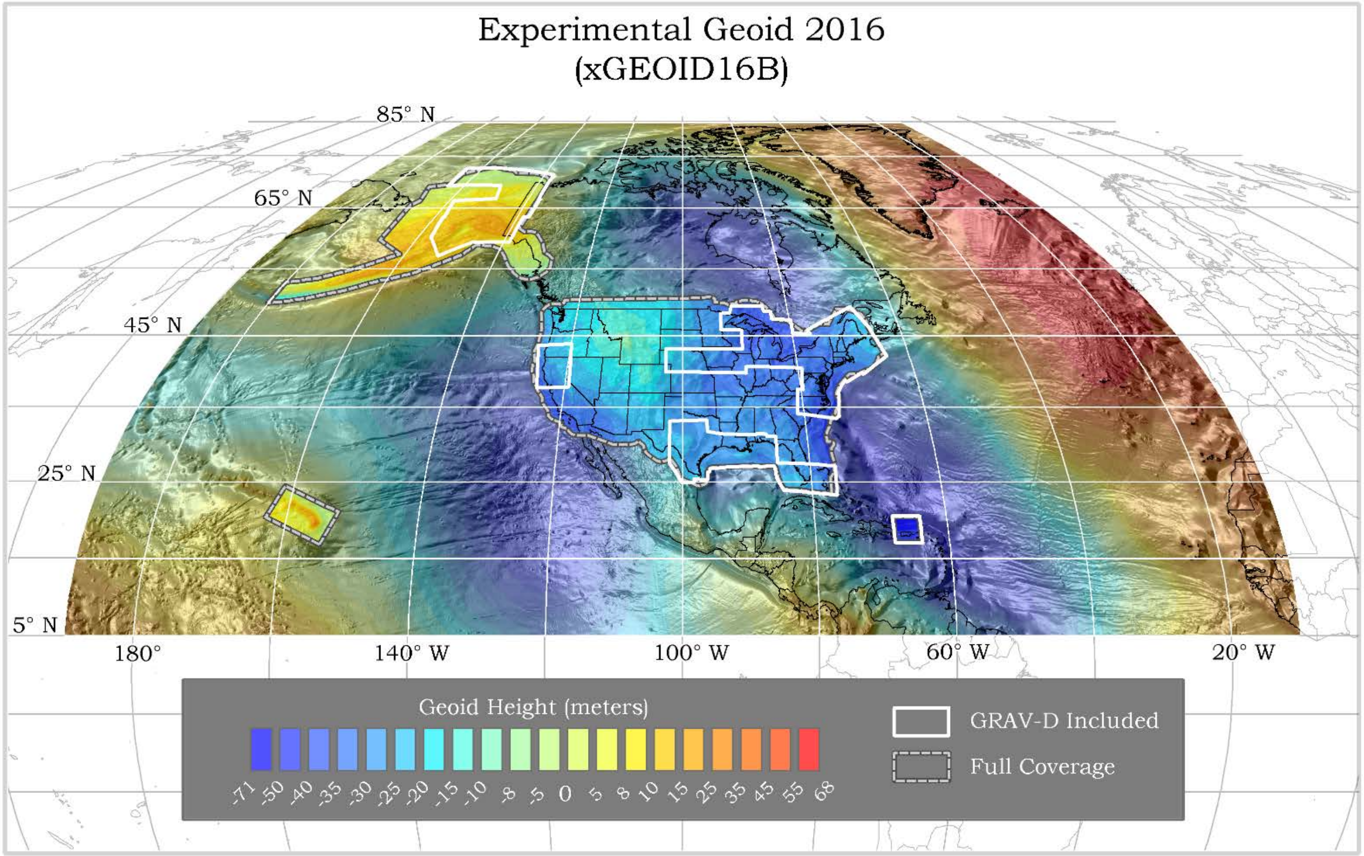
Time Dependencies

Geoid changes cause height changes



- The zero elevation surface will change with time
- Heights will be time tagged to respect:
  - Geoid change
  - Subsidence

Experimental Geoid 2016
xGEOID16B



https://beta.ngs.noaa.gov/GEOID/xGEOID16/

OPUS – Extended Report

********** 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: 778.126 (m) [PROTOTYPE (Computed using xGeoid16B,GRS80,IGS08)]

[for comparison, NAVD88 = 778.806 (m)]

Geoid Slope Validation Survey: 3 phases to validate accuracy of the gravimetric geoid model

Phase 1- GSVS11

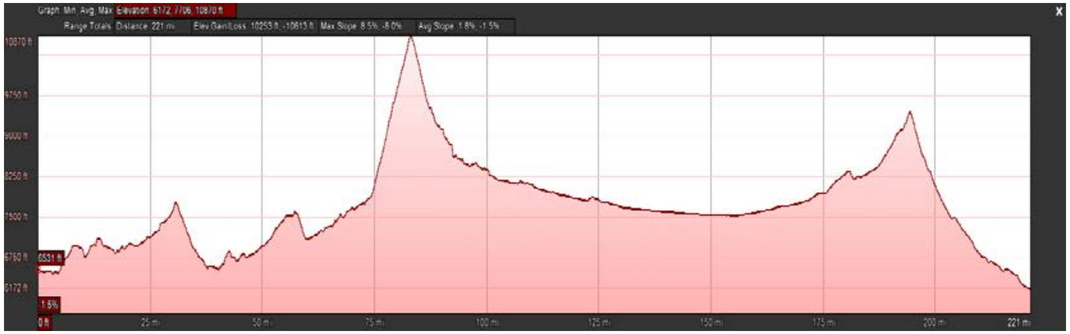
- 2011; Low/Flat/Simple: **Texas**

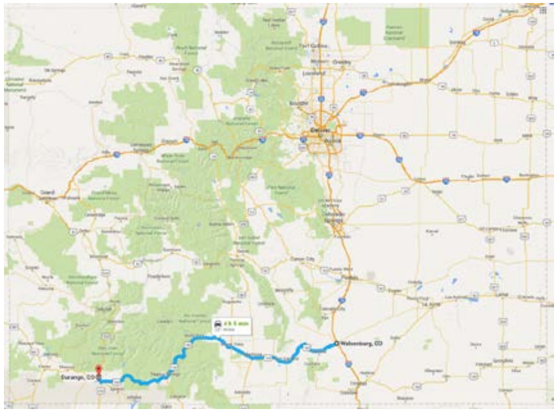
Phase 2- GSVS14

- 2014; High/Flat/Complicated: **Iowa**

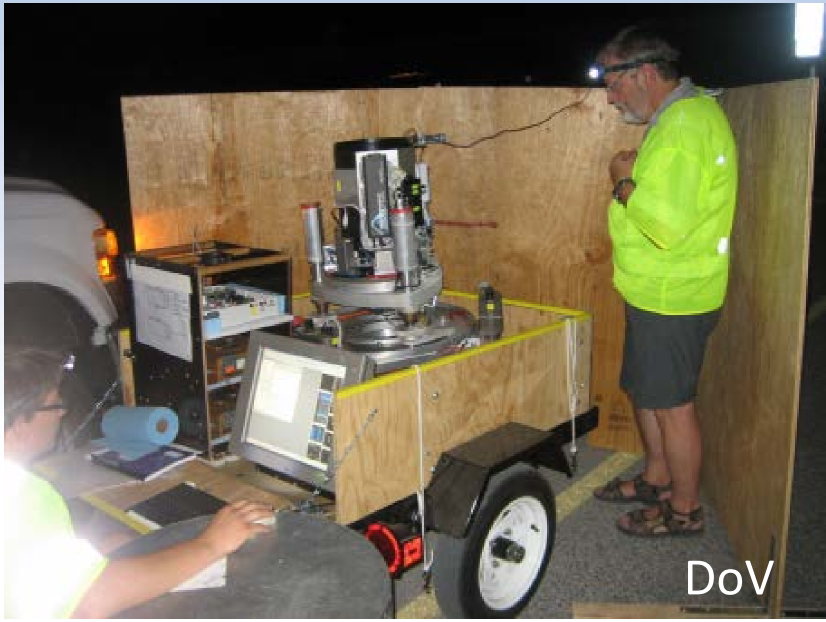
Phase 3 – GSVS17

- 2017; High/Rugged: **Colorado** (10,860ft)





Geoid Slope Validation Surveys – 2011 & 2014



How to Plan for 2022

- **Move to NAD 83(2011) epoch 2010.00**
  - via surveys (or *possibly* via NADCON/GEOCON)
- **Move to NAVD 88**
  - via surveys (or *possibly* via VERTCON)
- **Move from reliance on passive marks to GNSS infrastructure**
  - utilize CORS, OPUS, real-time networks, etc.
- **Use OPUS-Share/Database for GPSBMs & NAD83(2011) ties**
  - improve next geoid model & relationship with new datum
- **METADATA!!!!**

Stay Tuned For … NADCON 5

- Replacing NADCON 4.2 and GEOCON 2.0
- Support for nearly all horizontal datums since 1897
  - Exceptions: Regional Alaska
- No "state by state" grids
- Fixing all existing bugs
- Web service
- Consistent
- Documented
- Rigorous location-dependent error estimates
- **Ready to support 2022**

Legislation

- When NAD 83 replaced NAD 27, Federal NSRS users were required to switch to NAD 83
- Through the 1980s and 1990s NGS worked with *states* to update their laws
  - To encourage use of the new system beyond Feds
- 48 states now have laws that refer to NAD 83
  - A name which will be *retired* in 2022

Legislation

- In 2016, NSPS, AAGS, and NGS formed a committee to address this issue
  - The NSPS/AAGS/NGS Advisory Committee on National Spatial Reference System Legislation
- New Legislative Template completed June 2016
  - Generic terminology: "NSRS or its successor," etc.
  - NSPS will work with states to adopt new template
    - 2017 - 2022

NSPS Draft NSRS Legislation

Template Draft NSRS Legislation

How to use this template:

1) Whenever the word "state" is used below, it should be taken to mean "state or territory"
2) The intent of this template is to augment, not fully replace, existing state laws dealing with a state-specific coordinate system and its relationship to existing or prior datums of the National Spatial Reference System (NSRS).
3) The National Geodetic Survey (NGS) intends to release a new State Plane Coordinate System (SPCS) as part of the release of any new geometric datum, including that planned for release in 2022. As such, it is imperative that each state do the following:
   a. Ensure that any changes from the 1983 SPCS which the majority of geospatial professionals in the state wish to make, be agreed at the state level and communicated to NGS, prior to 2022 and
   b. Ensure that any law naming the state-specific coordinate system contains a definition of how that state-specific coordinate system relates to the SPCS.
      i. For example, if Michigan wishes to legislate that the "Michigan Plane Coordinate System" be used in the state of Michigan, then the law should specify that the "Michigan Plane Coordinate System" is identical to (or in some other way, defined in the law, related to) the "Michigan portion of the State Plane Coordinate System as defined by the National Geodetic Survey".
4) Related to #2 above, language should *connect* the state-desired coordinate system to the federally-defined SPCS, while leaving state and federal responsibilities independent.
   a. For example, both NGS and the California Spatial Reference Center (CSRC) cannot be *jointly* responsible for the California Plane Coordinate System (if that is the name chosen by California). If the CSRC is going to define the California Plane Coordinate System, they should solely define it, and have the law reflect how it relates to the federal (NGS-specified) SPCS.
5) Reference to specific years or datum names within the NSRS should be avoided, as the intent of the template is to provide legislation that will be accurate and relevant both today (under NAD 83), through the new datum (in 2022) and beyond to whatever datums come after 2022.
6) Wherever the phrase "<state>" is used in the template below, insert the name of your specific state or territory.
7) Sections which are considered optional are set aside (in parentheses and in red)
8) Sections which are explanatory and not to be copied into the law are in ***bold and italic.***
9) Parts of the law where a choice of options must be made are set <in brackets and highlighted>
10) While most states legislate the use of a *planar* coordinate system, this template addresses both *planar* and *geodetic* coordinates, to provide the greatest flexibility across all states.

I. Acronyms

The following acronyms will be used throughout this law in order to increase conciseness.

NSRS = The National Spatial Reference System or its successors
NGS = The National Geodetic Survey or its successors
SPCS = State Plane Coordinate System or its successors
*PCS = <state> Plane Coordinate System ***(where * is the first letter of the state)***

(If a state feels clarity about the above terms is necessary, then insert a possible hierarchical section here, outlining that the NSRS is the overarching system, and that below that are various datums. Below the datums are projected coordinates within the datums, including the SPCS)

II. The <state> Plane Coordinate System

The most recent system of plane coordinates which has been established by NGS, based on the NSRS, and known as the SPCS, for defining and stating the positions or locations of points on the surface of the earth within the State of <state> shall be known as the "<state> Plane Coordinate System." ***This paragraph should serve, provided states do not wish to deviate from the SPCS. If they do, see the third parenthetical below.***

(Details how such a system should be used within your state)

(Keep existing 27/83 definitions in place)

(Any state or territory wishing to define other projections besides those found in NGS's SPCS should do so here. If the state-specific Plane Coordinate System will include anything like this, which is outside the scope of the SPCS, make sure not to attribute any aspects of it to NGS nor to the SPCS, but only to whatever state agency is going to define this exo-SPCS component of the state-specific Plane Coordinate System)

The plane coordinates of a point on the earth's surface, to be used in expressing the position or location of the point in the appropriate zone of the *PCS, shall consist of two distances, expressed in feet and decimals of a foot or meters and decimals of a meter. When the values are expressed in feet, the <define which foot to be used. Either "U.S. Survey foot," (one U.S. Survey foot = 1200/3937 meters) or "International foot," (one International foot = 0.3048 meters)> shall be used as the standard foot for *PCS. One of these distances, to be known as the "East x-coordinate," shall give the distance east of the Y axis; the other, to be known as the "North y-coordinate," shall give the distance north of the X axis. The Y axis of any zone shall be parallel with the central meridian of that zone. The X axis of any zone shall be at right angles to the central meridian of that zone.

(insert text about accuracy and use of points in the system)

III. Geodetic Coordinates

This section would only be inserted for those states specifically wishing to legislate the use of geodetic coordinates.

NSPS

AAGS

NOAA

Your NAD 83-Based State Plane-Legislated Coordinates *Will Not* Be Maintained after 2022!

What will you and your fellow professionals do?
Panic? Ignore the Issue? *or Act?*
Please let us know!

What is changing?

The North American Datum of 1983 (NAD 83) will be replaced in 2022.
The new datum will have a different name.

The North American Vertical Datum of 1988 (NAVD 88) will also be replaced in 2022.
Its replacement will also have a new name.

Expected horizontal shifts from NAD 83 to the new datum are in the 1-2 meter range.
The National Geodetic Survey will provide a coarse, map-grade transformation tool (such as NADCON and GEOCON) to connect NAD 83 with the new datum.

Who will be affected?

All states and territories will be transitioned to the new datums.
Forty-eight states have a state-specific coordinate system law tied to NAD 83.
Your state law will not reflect the National Spatial Reference System after 2022.

Who can help?

The National Geodetic Survey (NGS), the National Society of Professional Surveyors (NSPS) and the American Association for Geodetic Surveying (AAGS) are here to help your state make these changes in legislation!

You can help by understanding your own state's laws and how these changes will impact you.

Should you change or modify your state law?

NGS, NSPS and AAGS believe it would benefit state surveyors and mapping professionals for laws or regulations to reflect the latest federal geodetic infrastructure, namely **the National Spatial Reference System.**

Why should you change or modify your state law?

1. Federal agencies will adopt the new datum, so national products like **Federal Emergency Management Agency (FEMA) flood insurance rate maps** will no longer reference NAD 83, nor NAVD 88. Using the current (most updated) datum will avoid confusion and increase consistency with federal engineering or constructions projects.

3. More geospatial data is being collected and shared every day. A consistent and regularly updated NSRS will provide greater efficiency across surveying and mapping sectors.

What do you think?

We welcome your feedback! Please provide any feedback you like to one of our committee members, below.

NSPS/AAGS/NGS Advisory Committee on National Spatial Reference System Legislation

J.B. Byrd	NSPS	jbyrd@jmpa.us
Dave Doyle	NSPS	base9geodesy@gmail.com

NGS Geospatial Summit
Silver Spring, MD (and via web) -- April 24-25, 2017

National Geodetic Survey

Positioning America for the Future

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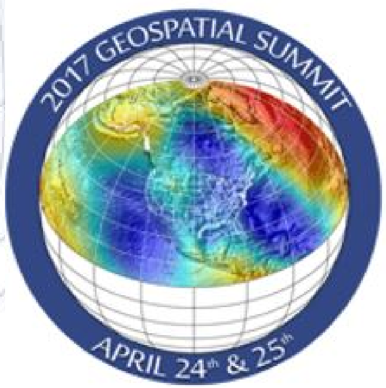


- 2017 Summit Home
- Register
- Logistics
- Agenda
- FAQs

Related Links

- NGS 10-year plan
- 2015 Summit Proceedings
- 2010 Summit Proceedings
- New Datums Web page

2017 Geospatial Summit

Registration Now Open

On April 24-25, 2017 we will host the 2017 Geospatial Summit at the Silver Spring Civic Building at 1 Veterans Pl, Silver Spring, MD 20910.

The 2017 Geospatial Summit will provide updated information about the planned modernization of the National Spatial Reference System (NSRS). Specifically, NGS plans to replace the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88) in 2022.

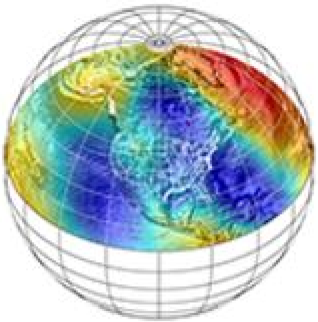
The Summit will provide an opportunity for NGS to share updates and discuss the progress of projects related to NSRS Modernization. NGS also looks forward to hearing feedback and collecting requirements from its stakeholders across the federal, public and private sectors. This event will help continue discussions from previous Geospatial Summits held in 2010 and 2015.

Additional information about the 2017 Geospatial Summit will be posted online. If you have questions or comments, contact us.

New Datums

National Geodetic Survey

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



New Datums Quick Links

- Home
- What to expect
- Get prepared
- Track our progress
- Related projects
- Watch videos
- Learn more
- New Datums FAQ
- Contact Us
- Sign up for list-serve

September 20, 2016

Replacing NAVD 88 and NAD 83

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

What to Expect | Get Prepared

Related Projects | Track Our Progress

Watch Our Videos | Learn More

Why is NGS replacing NAD 83 and NAVD 88?

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

Issue 6, January 2017

NSRS Modernization News

For all issues of **NSRS Modernization News**, visit: geodesy.noaa.gov/datums/newdatums/TrackOurProgress.shtml

Decision Points

The National Geodetic Survey (NGS), through a series of both internal debates and external discussions with the Canadian Geodetic Survey, has finalized certain key decisions in the replacement of the three NAD 83 reference frames, and in the replacement of the various vertical datums of the NSRS. These decisions cover both the science and nomenclature of the changes coming in 2022.

Four Terrestrial Reference Frames

Replacing the three existing NAD 83 reference frames will be four plate-fixed *terrestrial reference frames.* The tectonic plate for each frame may be inferred from their names, which are:

North American Terrestrial Reference Frame of 2022 (NATRF2022)

Pacific Terrestrial Reference Frame of 2022 (PTRF2022)

Mariana Terrestrial Reference Frame of 2022 (MTRF2022)

Caribbean Terrestrial Reference Frame of 2022 (CTRF2022)

Relationship to the IGS Frame

Each of the above four frames will be identical to the latest IGS reference frame (as available in 2022) at an epoch to be determined. Away from that epoch, the four frames will relate to the IGS frame through the definition of an Euler Pole rotation specific to that plate. All Continuously Operating Reference Stations (CORS) velocities which deviate from the rotation of a rigid plate will be captured in a residual 3-D velocity model.

Heights and Other Physical Coordinates

A *geopotential datum* will be created which will contain all of the necessary information to provide mutually consistent orthometric heights, geoid undulations, gravity anomalies, deflections of the vertical, and all other geodetic coordinates related to the gravity field. This geopotential datum will be called:

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

Geoid Model

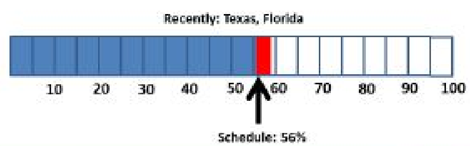
Within NAPGD2022, a variety of products will exist. The most prominent of these products will be a *time-dependent model of the geoid,* provided in three regions (the first covering the entirety of North and Central America, Hawaii, Alaska, Greenland, and the Caribbean; the second covering American Samoa; and the third covering Guam and the Commonwealth of the Mariana Islands). The name of this model will be:

GEOID2022

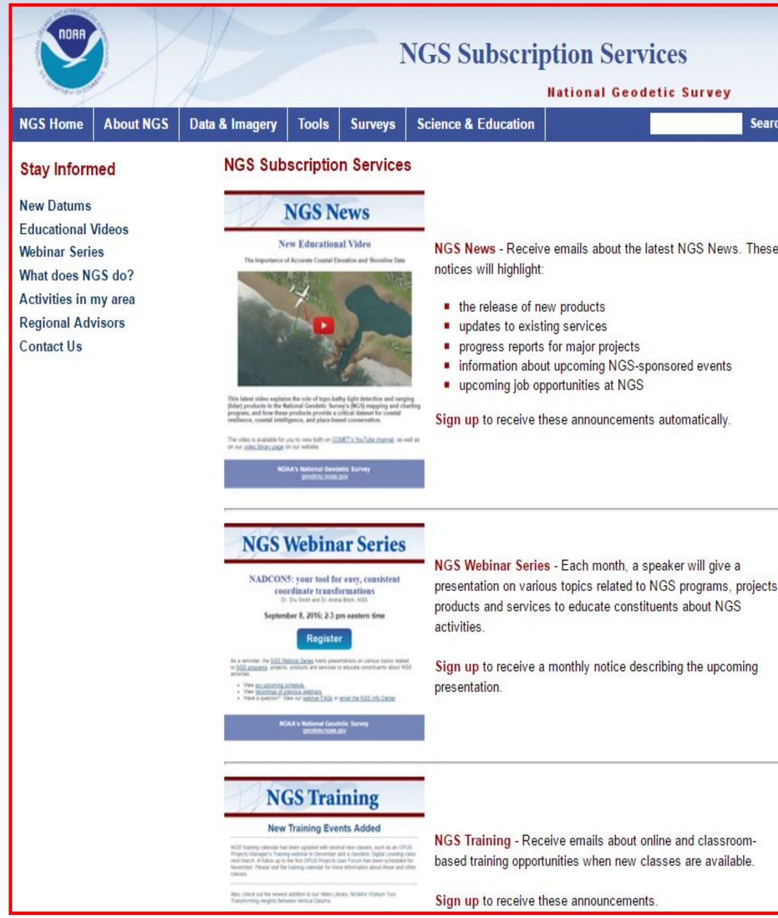
Further Information

A comprehensive white paper, outlining the technical details of the above decisions, is currently being drafted in NGS and we plan for it to be ready by the upcoming 2017 Geospatial Summit. In addition, details may be released on the NGS website and through our email listserv.

GRAV-D progress last quarter: up 3.0% to 58.4%
Ahead of Schedule!



geodesy.noaa.gov



Attend a Monthly Webinar

NGS Webinar Series

National Geodetic Survey

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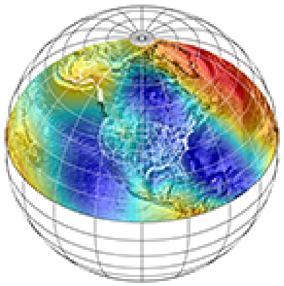


Webinar Series Quick Links

- Overview
- Upcoming Webinars
- Recorded Webinars
- Frequently Asked Questions (FAQ)

Contact information

- Email us
- Sign-up for webinar announcements
- Sign-up for list-serve

Overview

Each month, a speaker will give a presentation on various topics related to NGS programs, projects, products and services to educate constituents about NGS activities.

Webinars are held on the second Thursday of every month, from 2:00-3:00 p.m. East Coast time. You can register for any presentation on the "Upcoming Webinars" page, and you can sign-up to receive a monthly notice describing the upcoming presentation.

This webinar series is a continuation of monthly presentations sponsored by the National Height Modernization Program, and you can download previous presentations from the Program's online meeting archive.

Many additional NGS resources are available online, including:

- Continuously Operating Reference Station (CORS) weekly newsletter archive
- Ecosystem and Climate Operations newsletter archive
- Educational videos
- Height Modernization monthly meeting archive
- Online Learning Resources (e.g. recorded webinars and online training modules)
- Presentation library

NGS Video Library

National Geodetic Survey

Educational Videos Quick Links

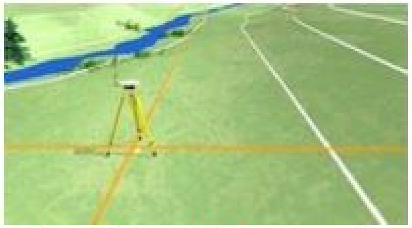
- Corbin Training Center
- Online Lessons
- Geospatial COMET MetED Resources
- National Ocean Service Lesson Plan Libary
- Other Videos +

What are Geodetic Datums?

How Were Geodetic Datums Established?

What Is the Status of Today's Geodetic Datums?

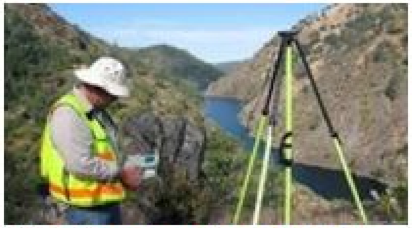
What's Next for Geodetic Datums?



Precision and Accuracy in Geodetic Surveying

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

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



Best Practices for Minimizing Errors during GNSS Data Collection

The Importance of Accurate Coastal Elevation and Shoreline Data

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NGS Training

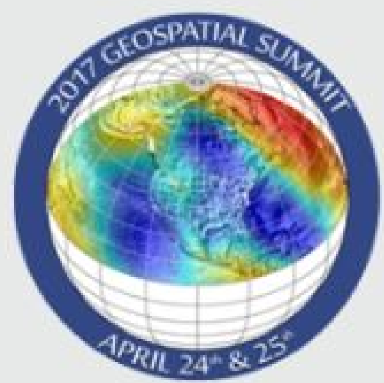
New Training Opportunities Posted

New training opportunities are available on the NGS Training Calendar.

OPUS Projects Manager's Training (webinar) - 5/16/17

OPUS Projects User Forum (webinar) - 6/7/17

Registration Open for 2017 Geospatial Summit April 24-25, Silver Spring, MD



You're Invited!

NGS plans to replace the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88) in 2022.

We will share updates and discuss the progress of related modernization projects. Stakeholders across the federal, public, and private sectors will also be providing feedback on these efforts.