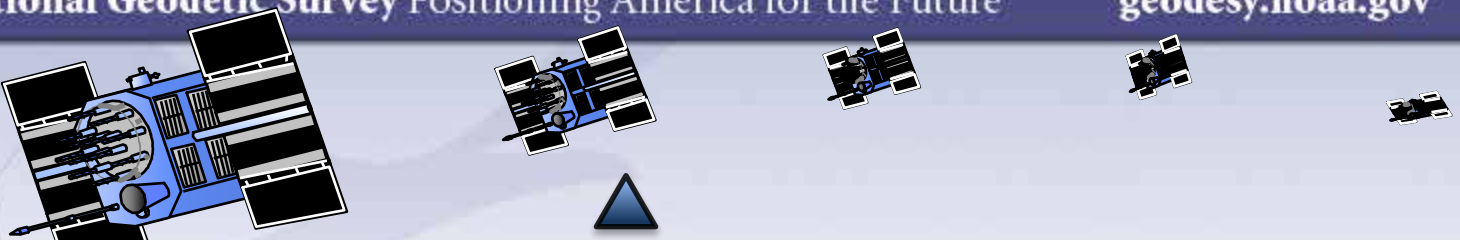


The National Spatial Reference System of the Future

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

NOAA's National Geodetic Survey
geodesy.noaa.gov

Esri Southwest User Conference

Salt Lake City
November 13, 2013

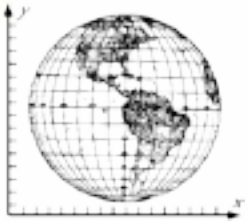
U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Geodetic Survey

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**
- Scale
- Gravity
- Orientation

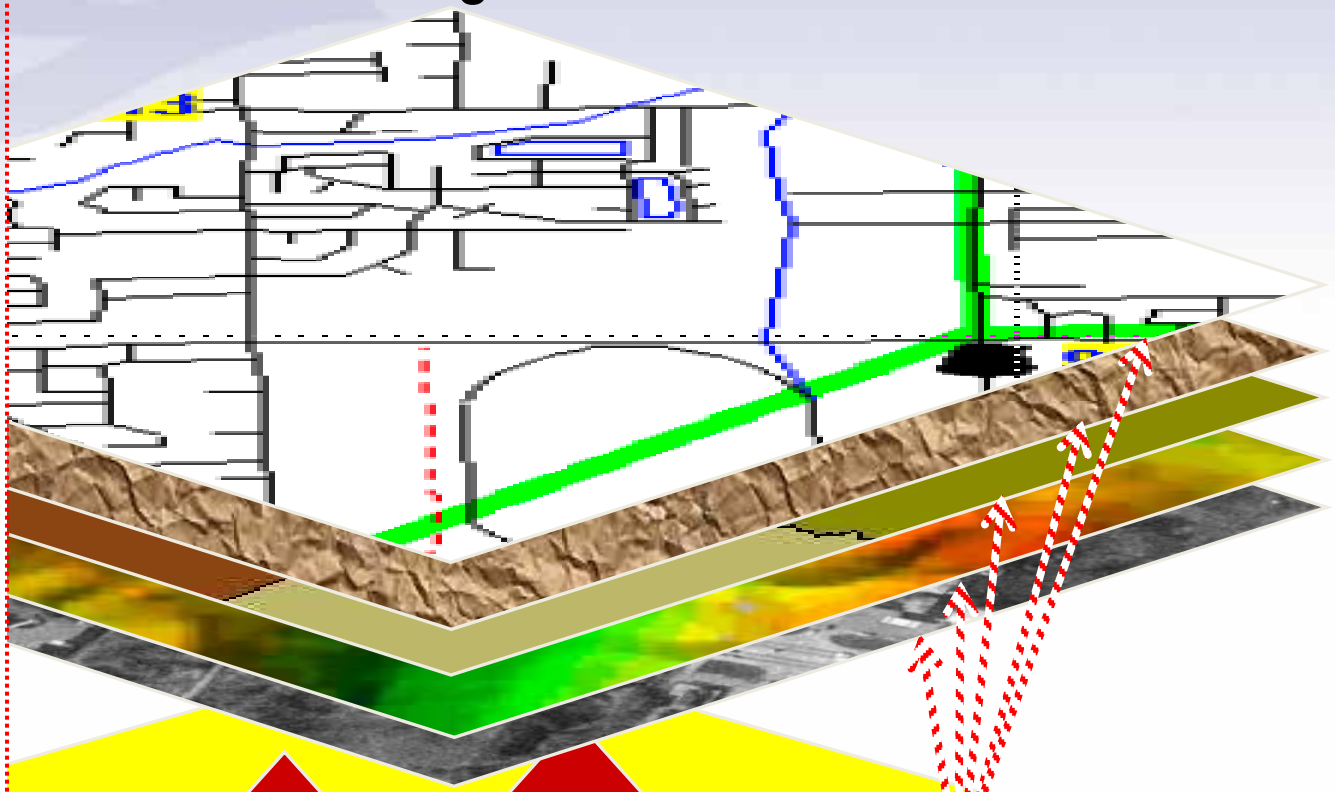
& their time variations

(& geoid models, satellite orbits transformation tools, etc.)

$2.5B / year benefit

National Spatial Reference System - Ties It All Together

- LiDAR
- Digital Terrain Model
- Aerial Photography
- Cartography
- Parcels
- Engineering
- Laser Scan Model
- Satellite Imagery
- Hydrography
- Natural Resources
- Flood Risk

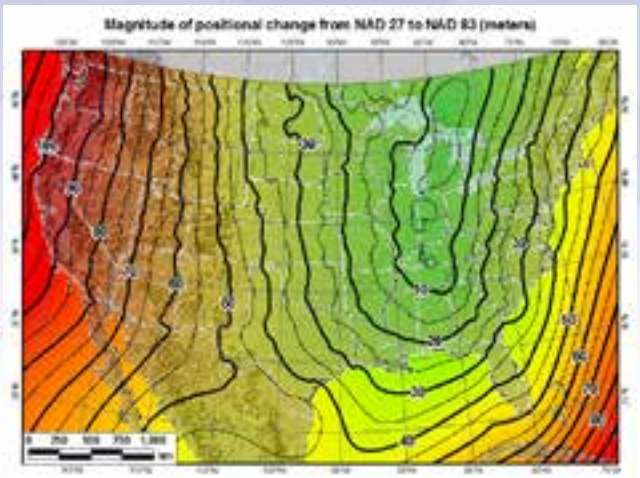


Horizontal / Vertical Geodetic Control
(National Spatial Reference System)

NAVD88

NAD83

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



U.S. Standard Datum

NAD27

NAD83 (1986)

NAD83 (HARN /199X)

NAD83 (2007)

NAD83 (2011)

"2022"

time

shift: < 10 m | tens of meters | few 0.1m | few 0.01m | few 0.01m | (1-2 meters)

National Geodetic Survey, Retrieval Date = NOVEMBER 7, 2013

DESIGNATION - OLYMPIC
PID - DF4639
STATE/COUNTY- UT/SALT LAKE
COUNTRY - US
USGS QUAD - FORT DOUGLAS (1975)

*CURRENT SURVEY CONTROL

NAD 83(2011) POSITION-	40 45 32.75742(N)	111 50 41.20648(W)	ADJUSTED
NAD 83(2011) ELLIP HT-	1419.212 (meters)	(06/27/12)	ADJUSTED
NAD 83(2011) EPOCH -	2010.00		
NAVD 88 ORTHO HEIGHT -	1435.8 (meters)	4711. (feet)	GPS OBS
NAVD 88 orthometric height was determined with geoid model			GEOID99
GEOID HEIGHT -	-16.51 (meters)		GEOID99
GEOID HEIGHT -	-16.57 (meters)		GEOID12A
NAD 83(2011) X -	-1,800,624.867 (meters)		COMP
NAD 83(2011) Y -	-4,491,699.191 (meters)		COMP
NAD 83(2011) Z -	4,143,122.642 (meters)		COMP
LAPLACE CORR -	14.32 (seconds)		DEFLEC12B

FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)

Type	Horiz	Ellip	Dist(km)
NETWORK	0.82	1.33	
MEDIAN LOCAL ACCURACY AND DIST (013 points)	0.95	1.45	18.46

NOTE: Click here for information on individual local accuracy values and other accuracy information.

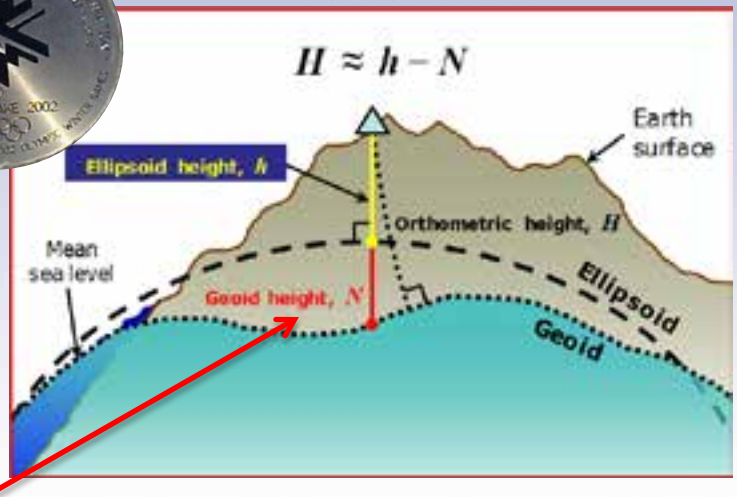
The horizontal coordinates were established by GPS observations and adjusted by the National Geodetic Survey in June 2012.

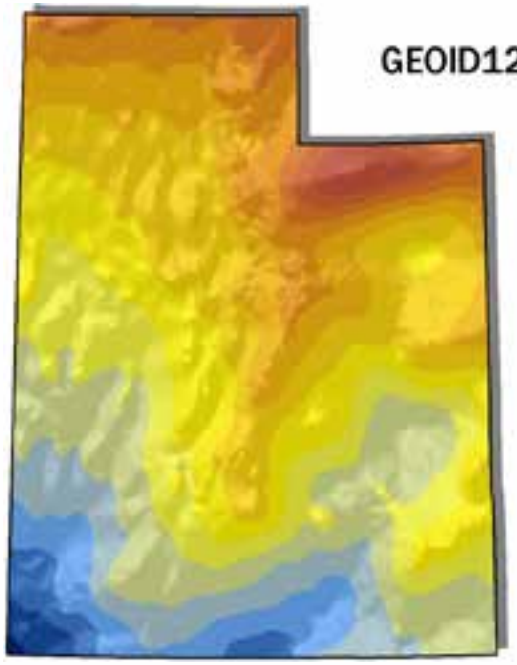
NAD 83(2011) refers to NAD 83 coordinates where the reference frame has been affixed to the stable North American tectonic plate. See NA2011 for more information.

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

geodesy.noaa.gov





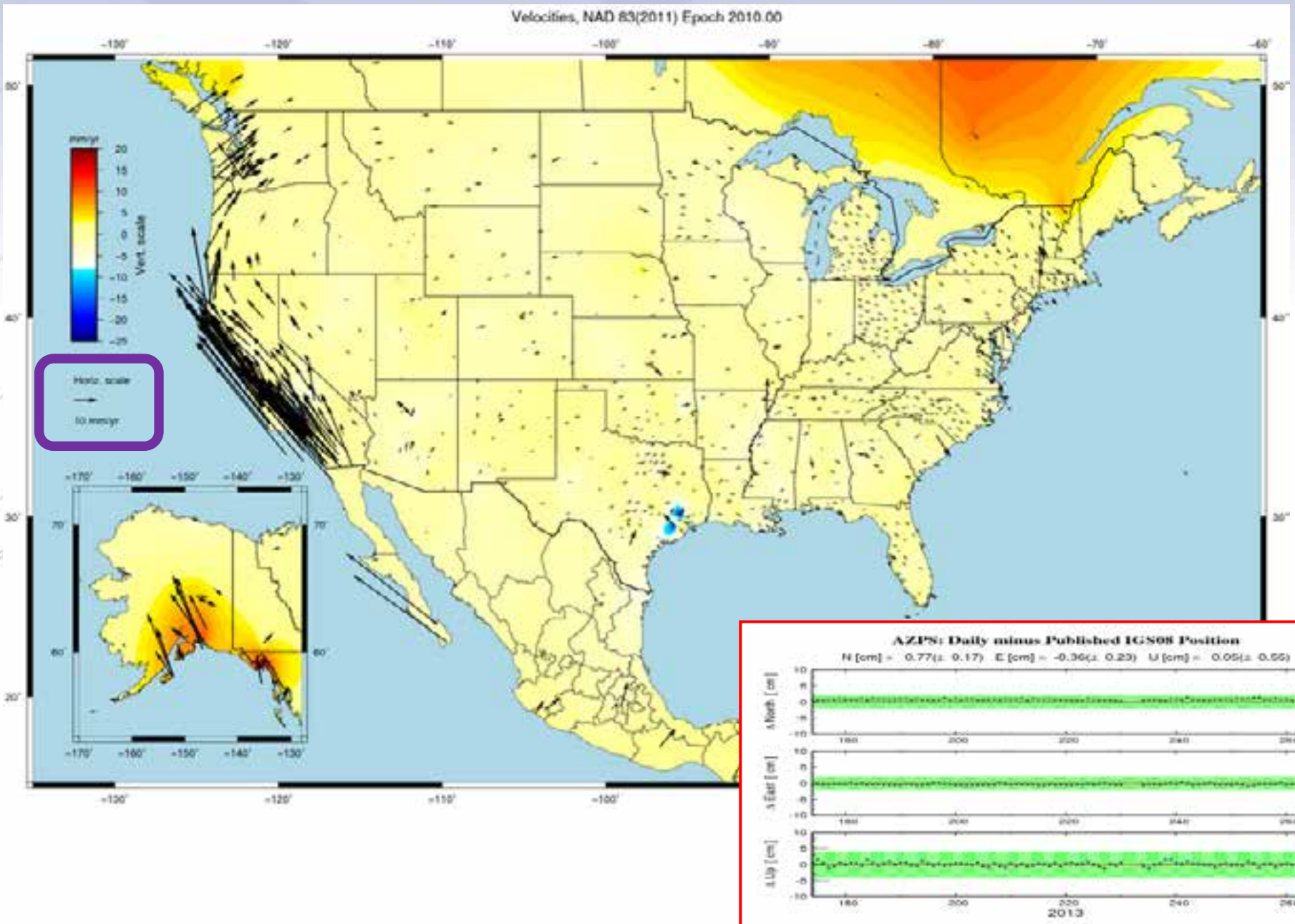
GEOID12A for Utah

Geoid Height (meters)
-13 to -12
-14 to -13
-15 to -14
-16 to -15
-17 to -16
-18 to -17
-19 to -18
-20 to -19
-21 to -20
-22 to -21
-23 to -22
-24 to -23
-25 to -24
-26 to -25

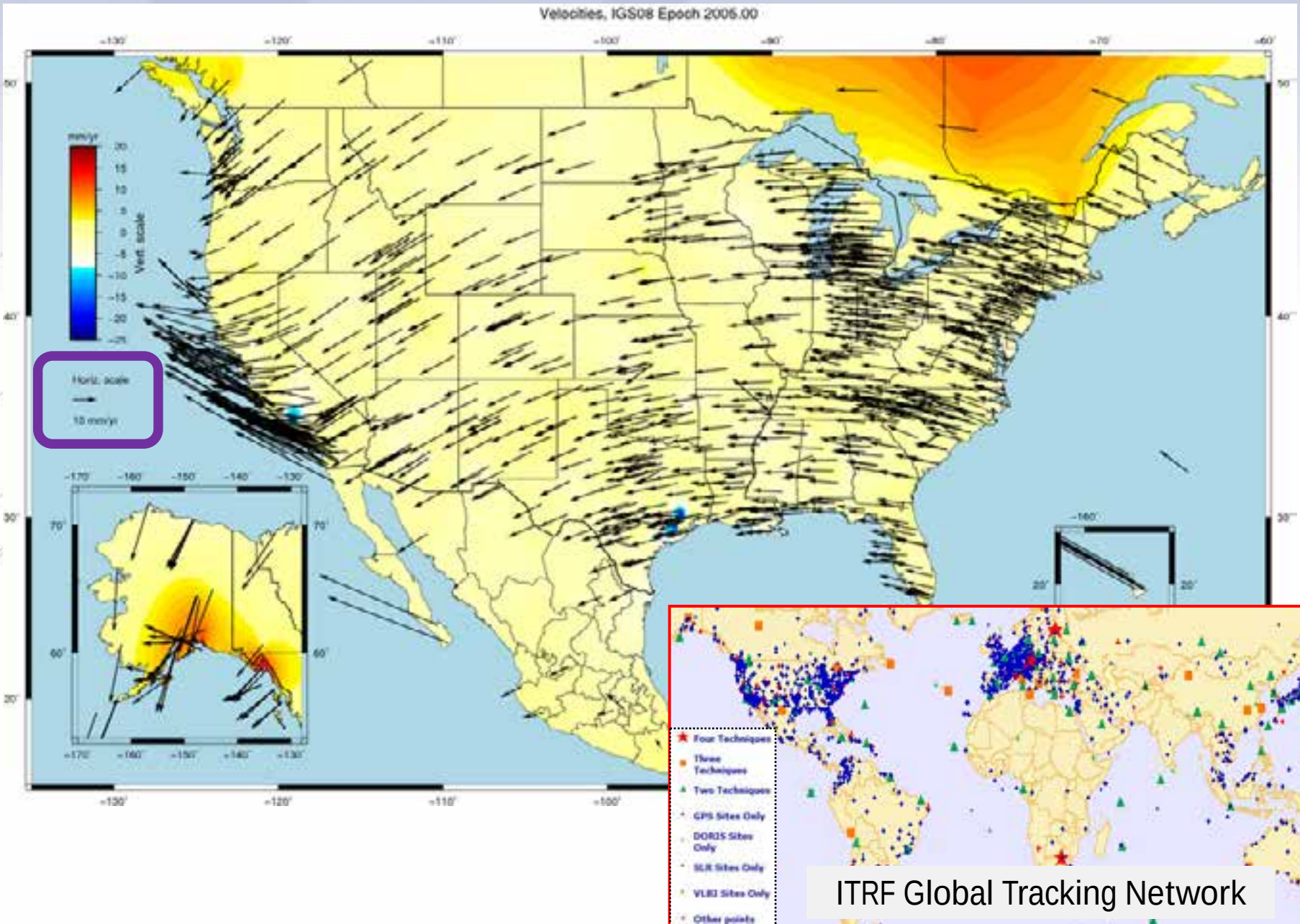
Continuously Operating Reference Station (CORS) Network

- 1950 sites
- 225 organizations

CORS Velocity Field: NAD83(2011) epoch 2010.00



CORS Velocity Field: International Terrestrial Reference Frame 2008



NGS ***Ten-Year Strategic Plan: 2013-2023***

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

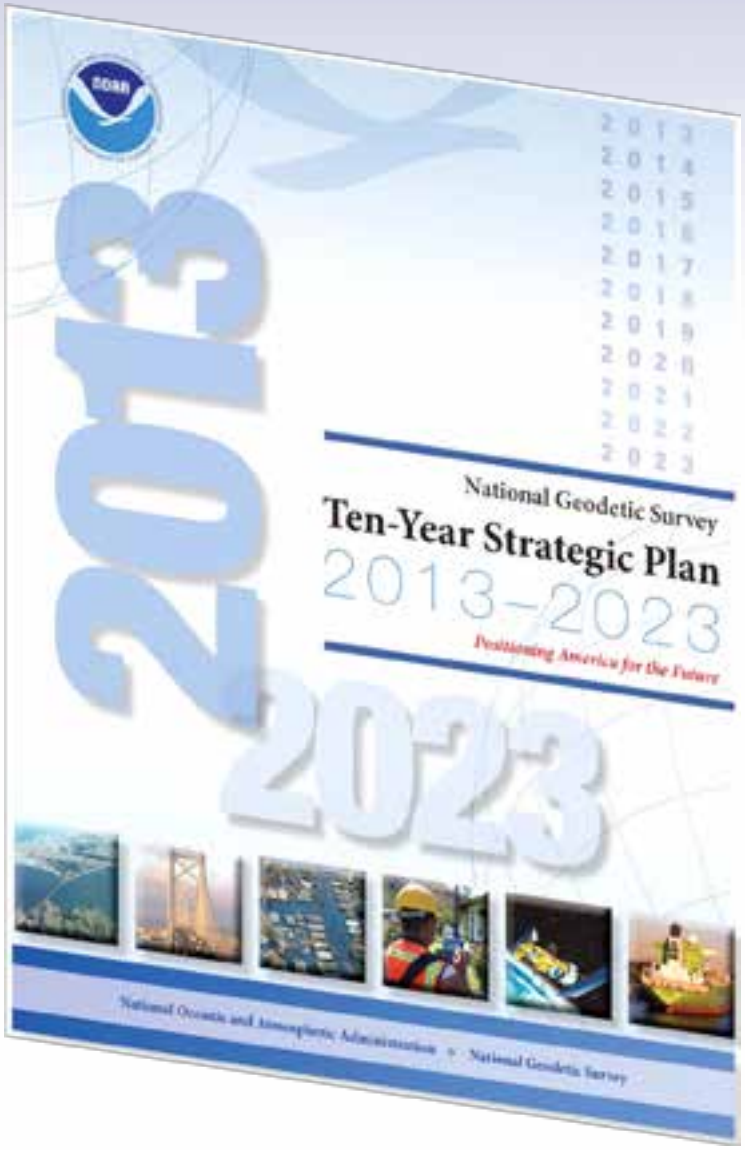
"**Replace NAD83**"

(North American Datum 1983)

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

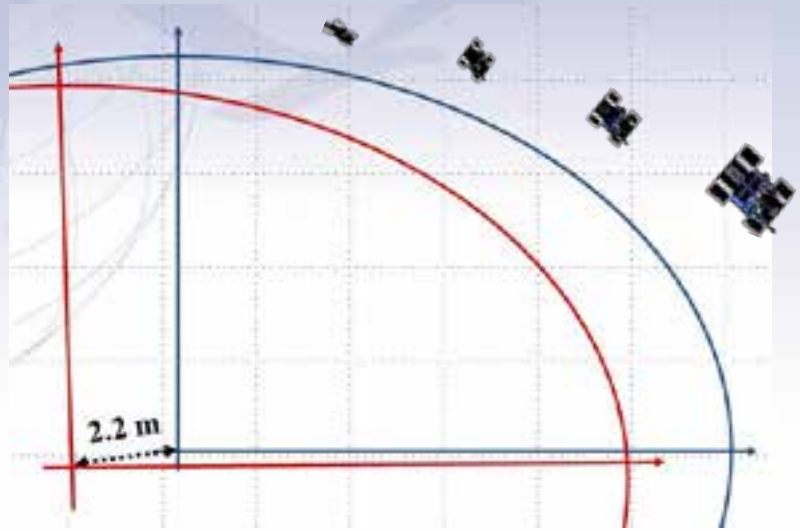
"**Replace NAVD88**"

(North American Vertical Datum 1988)



NAD83 Shortcomings

- **2.2 m offset**

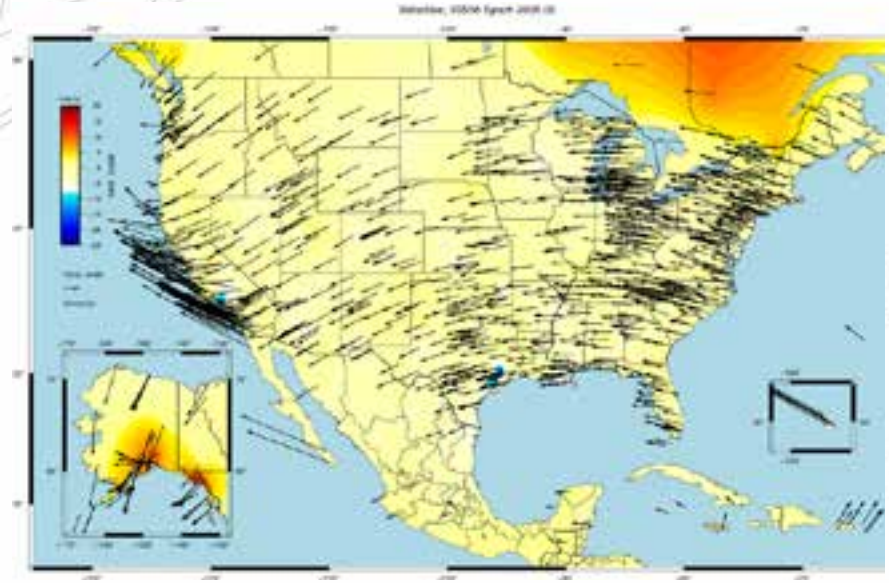


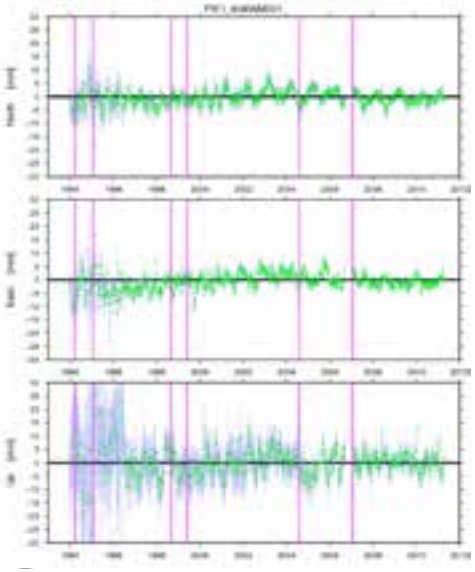
NAD 83

vs.

ITRF08 (& WGS84)

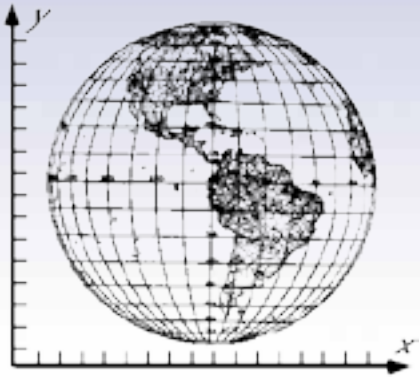
- **CORS vs. passive network consistency challenges**





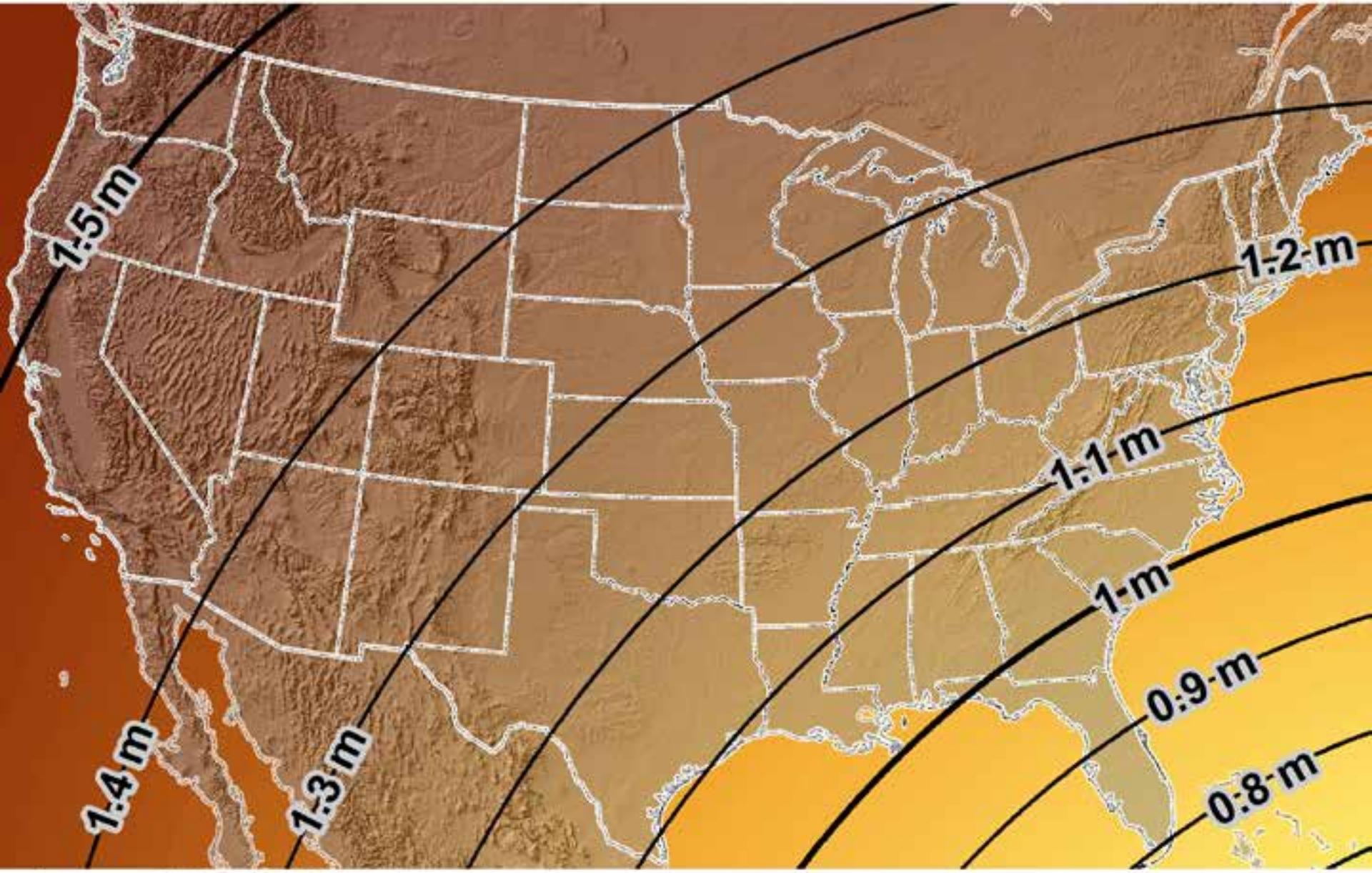
VS.

Future Geometric (lat, long, eHt) Datum



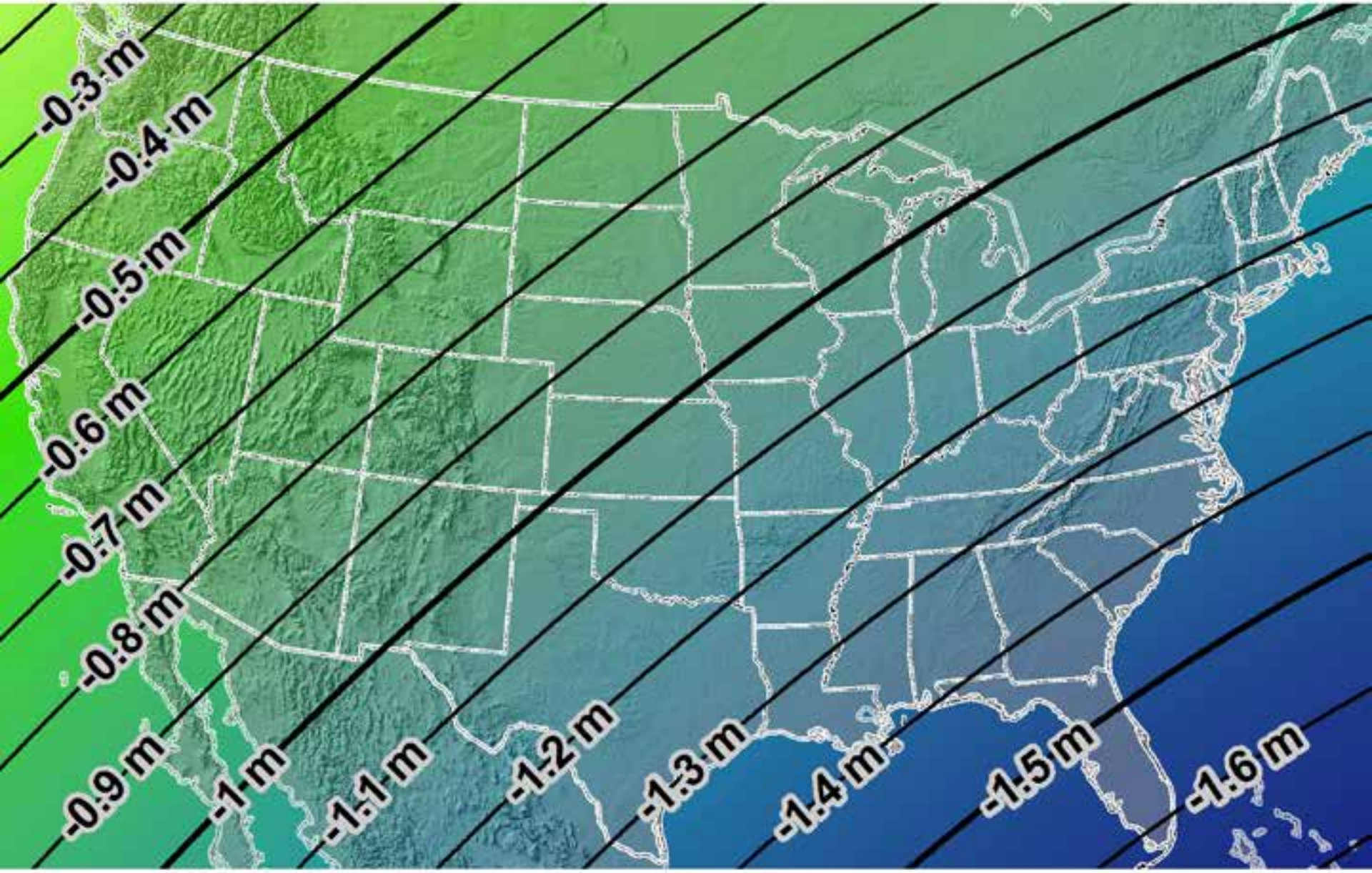
- by 2022 replace NAD83
- defined by Continuously Operating Reference Station (CORS) Network
- accessed by GNSS observations
- coordinates & velocities in ITRF & "US datum"
- passive control (monuments) tied to new datum

Estimated horizontal change from NAD 83 to new geometric datum



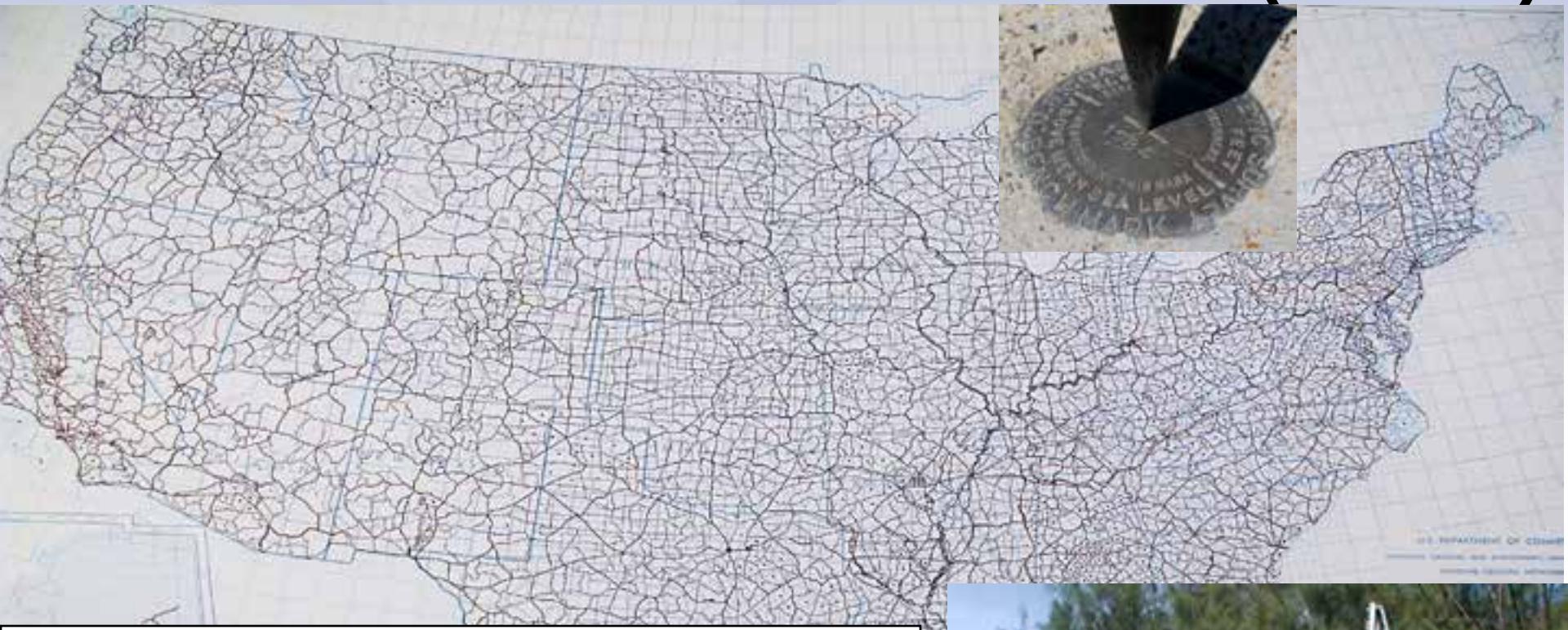
Delta Horizontal = (ITRF 05) minus (NAD 83) at 2020.0

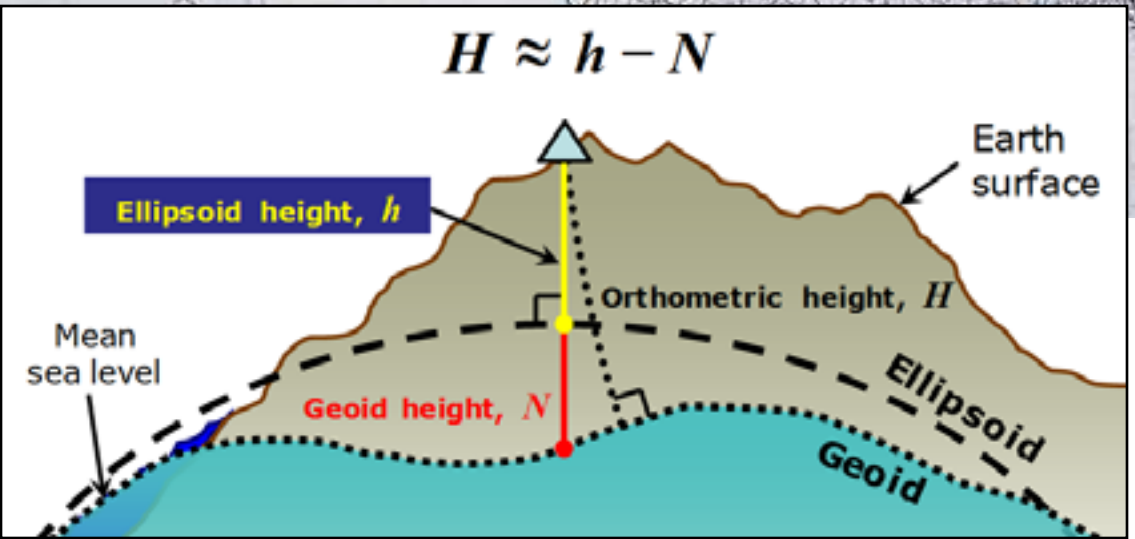
Estimated ellipsoid height change from NAD 83 to new geometric datum



Delta h = h(ITRF 05) minus h(NAD 83) at 2020.0

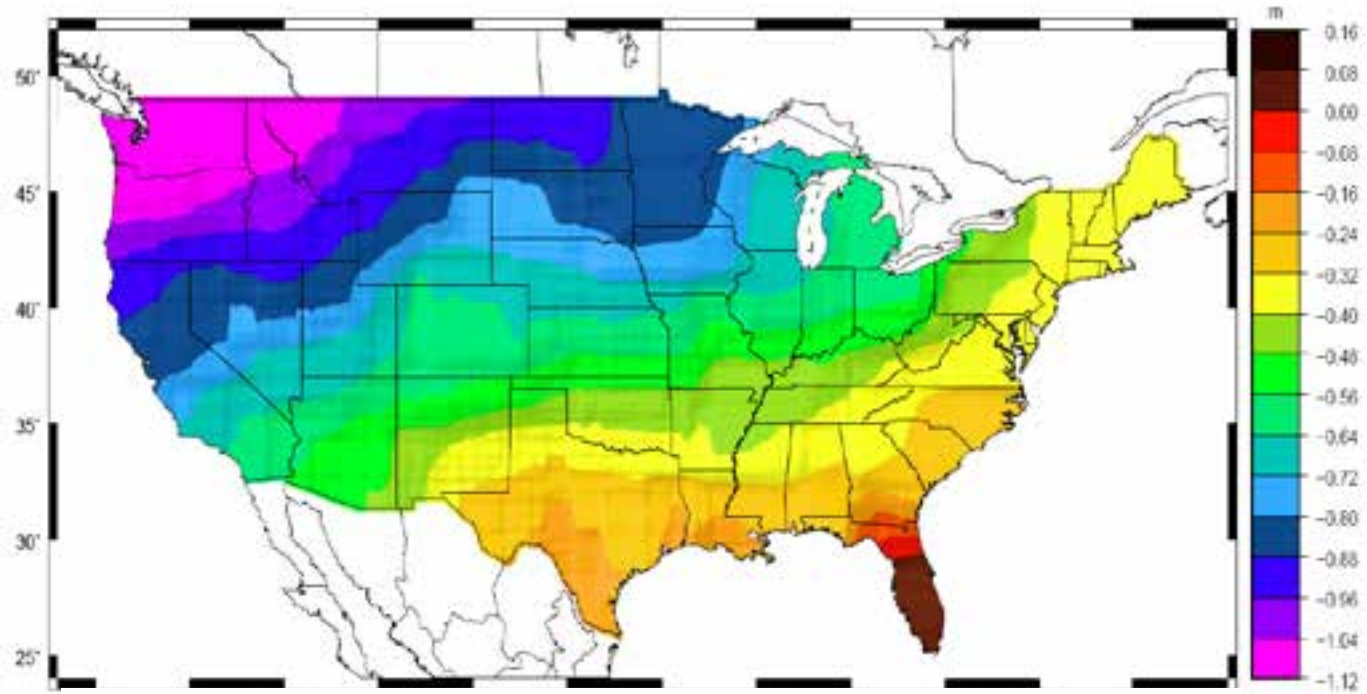
NORTH AMERICAL VERTICAL DATUM 1988 (NAVD88)





NAVD88 Shortcomings

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



Approximate Geoid Mismatch in the NAVD88 H=0 surface

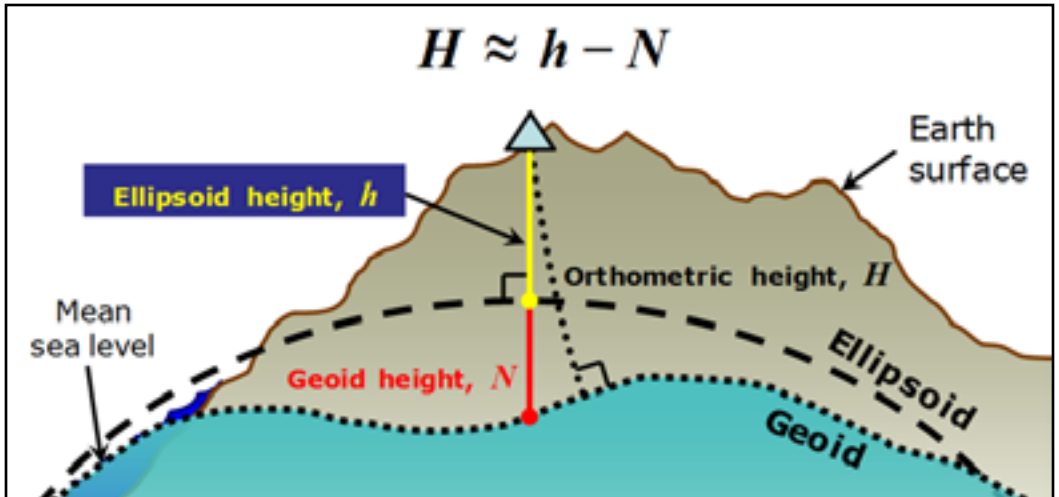
Future Geopotential (Vertical) Datum

Ø by 2022 replace NAVD88

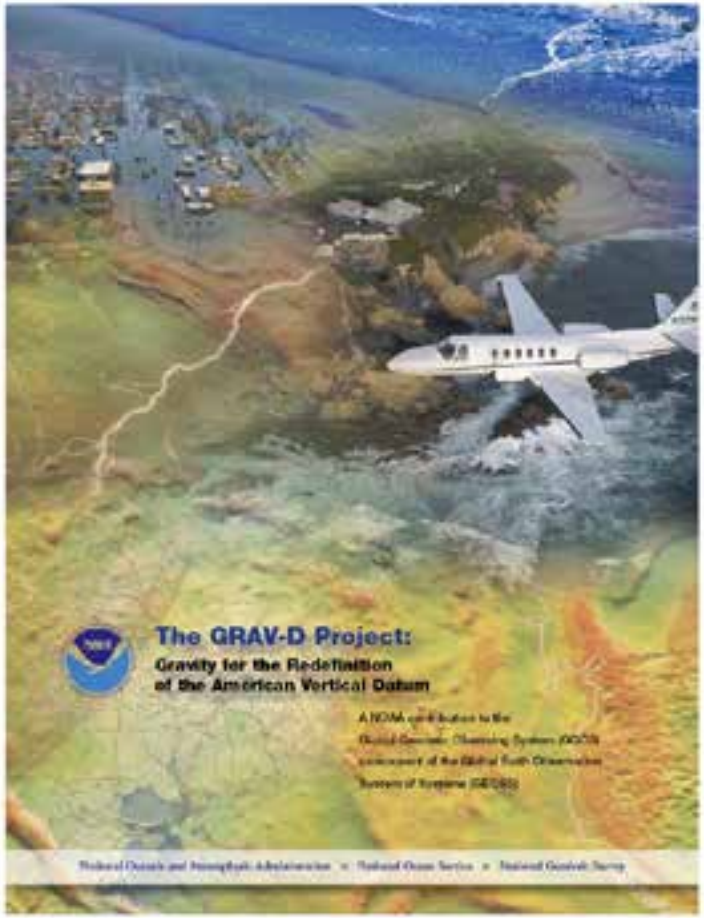
Ø accessed by GNSS & gravimetric geoid (N)

Ø monitor time-varying nature of gravity field

Ø most accurate continental gravimetric geoid model, ever



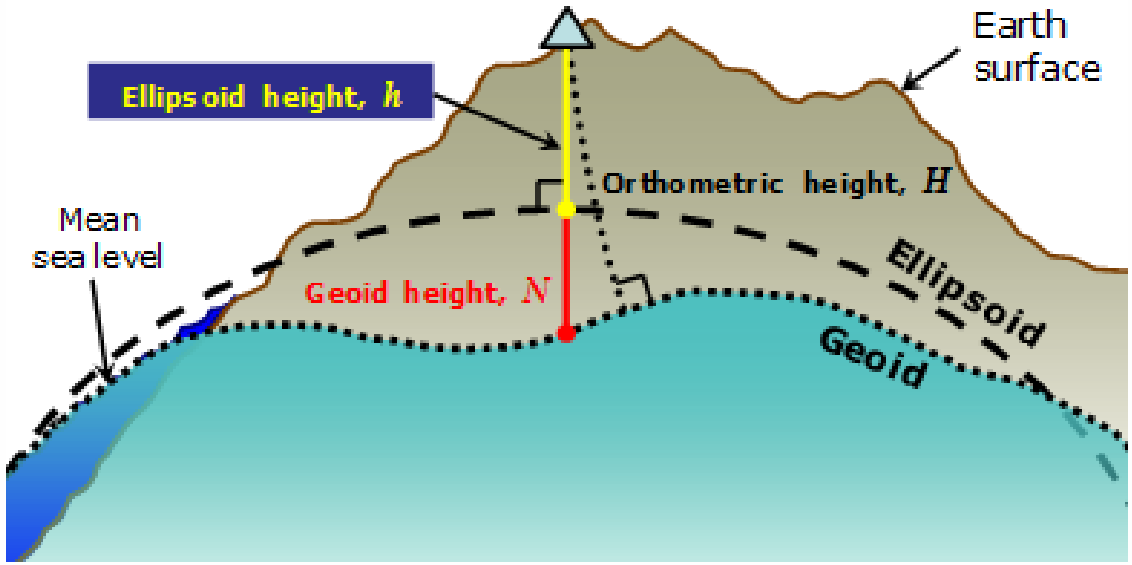
Gravity for the Redefinition of the American Vertical Datum (GRAV-D)



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

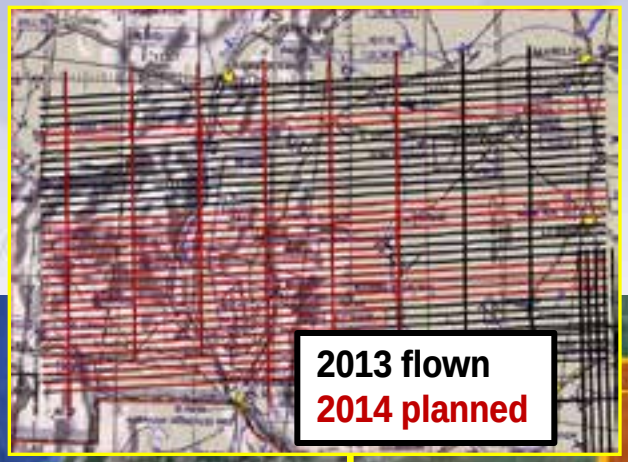
- Replace the US Vertical Datum by 2022 with **gravimetric geoid (N) accurate to 1 cm**
- 2 cm accurate orthometric heights via GNSS
- Airborne gravity survey of entire country
- Long-term monitoring of geoid change

$$H \approx h - N$$



GRAV-D Status (11/2013)

- 10 km spaced data lines
- 70 km spaced cross lines
- 20,000 ft altitude
- 230 kt flight speed
- 25% of US complete



2013 flown
2014 planned

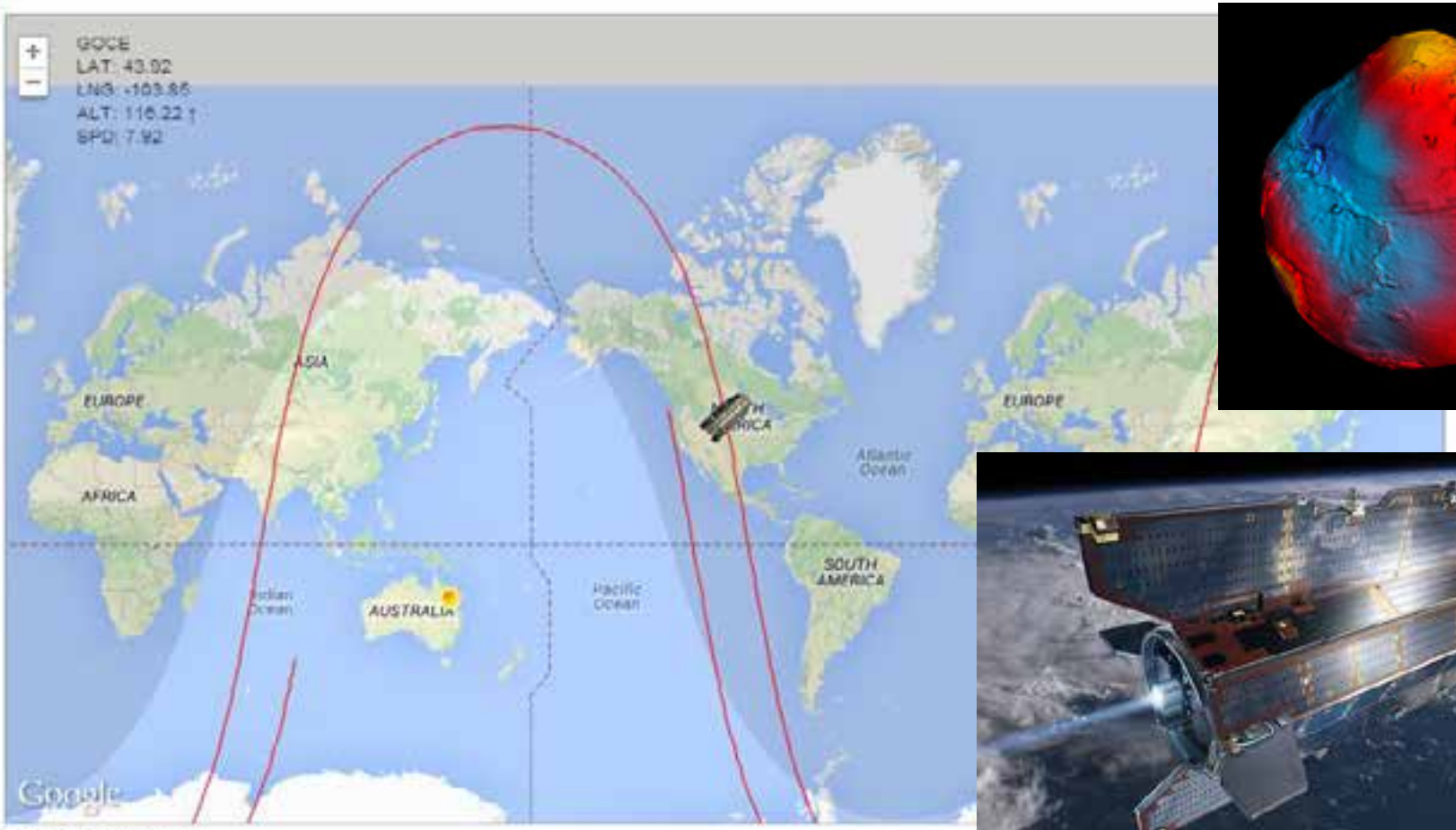
Green = FY11 and earlier
Orange = FY12
White = FY13
Blue = FY14 Plan
Filled white = Underway
Filled red = Incomplete

US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google

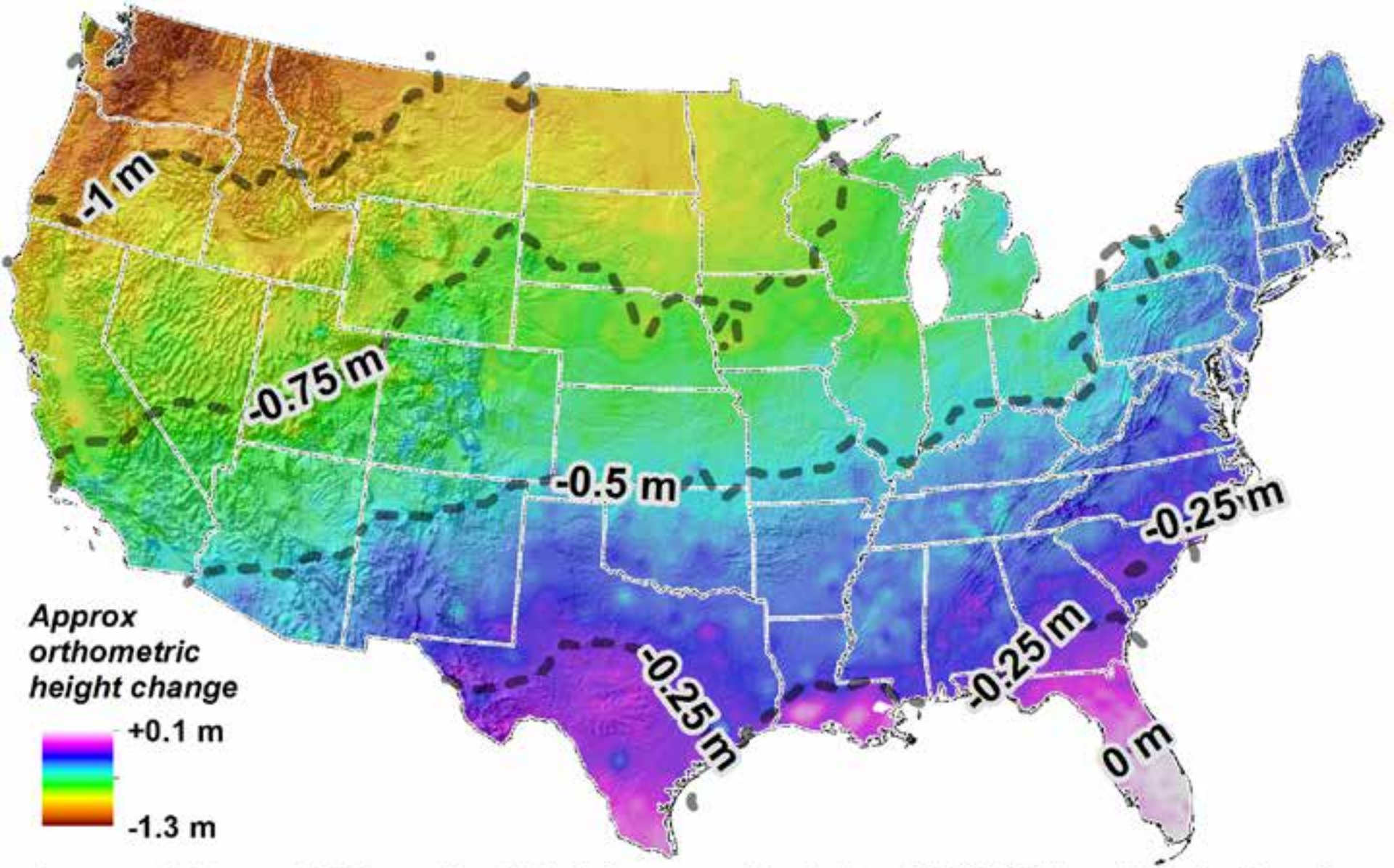
Gravity field & steady-state Ocean Circulation Explorer (GOCE)

Track Europe's falling, 2,000-pound satellite in real-time

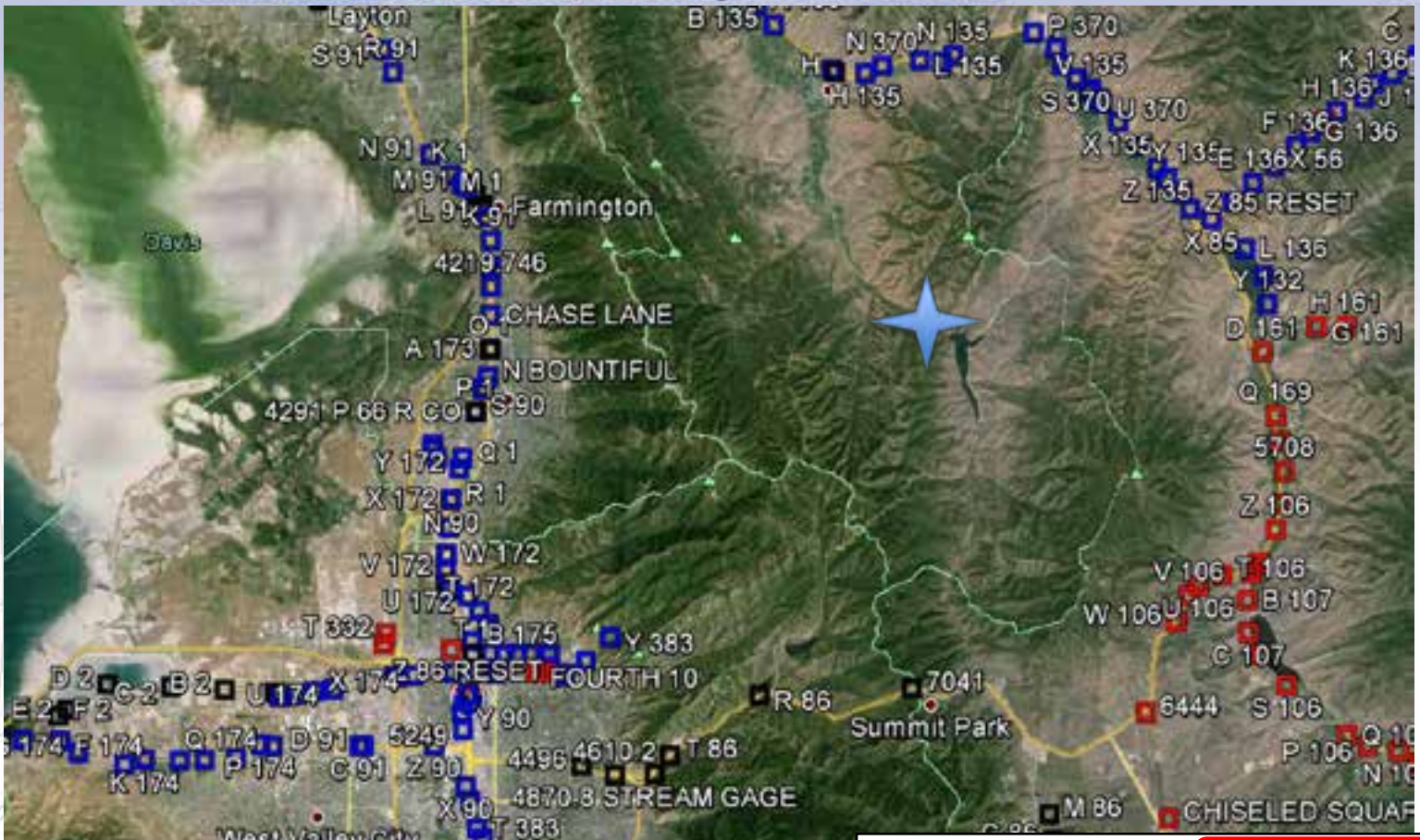
A defunct satellite from the European Space Agency the size of a Chevy Suburban is set to plunge to Earth somewhere between Sunday and Monday -- and experts say there's no way to precisely determine where it will crash. Where is it now? Thanks to a neat widget built by the satellite-tracking website N2YO.com, you can watch the falling satellite as it courses through the heavens.

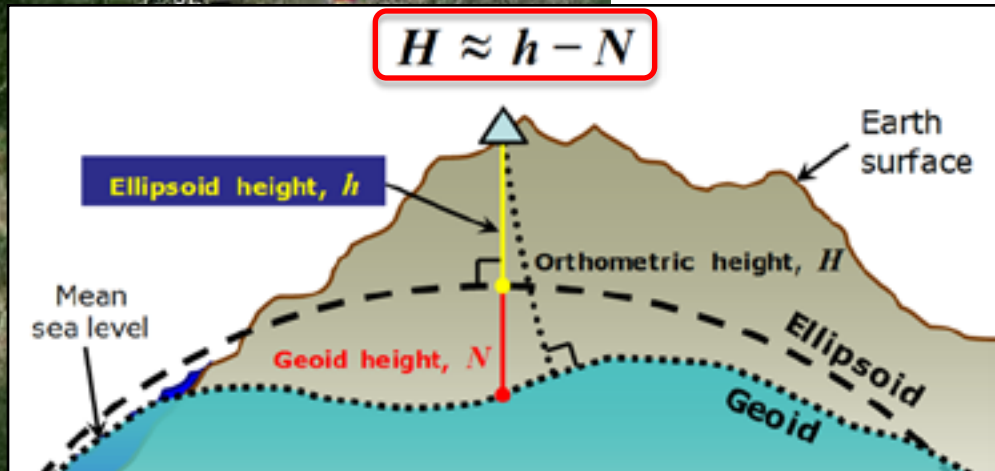


Approximate predicted change from NAVD 88 to new vertical datum



Predicted change estimated as NAVD 88 "zero" (datum) surface *minus* most recent NGS gravimetric geoid (USGG2009)


Layton
Farmington
CHASE LANE
N BOUNTIFUL
Summit Park
7041
6444
STREAM GAGE
CHISELED SQUAR
West Valley City
Murray
Sandy
Riverton
4426


$H \approx h - N$
Earth surface
Ellipsoid height, h
Orthometric height, H
Mean sea level
Geoid height, N
Ellipsoid
Geoid

How to Plan for 2022

- **Move to NAD 83(2011) epoch 2010.00**
  - conversion tools - NADCON, GEOCON & GEOCON11
- **Move to NAVD 88**
  - conversion tool – VERTCON (NGVD29 <> NAVD88)
- **Move from reliance on passive marks to GNSS**
  - utilize CORS, OPUS, real-time infrastructure, etc.
- **Use NGS Online Positioning User Service (OPUS) for GPSBMs**
  - improve next geoid model & relationship with new datum
- **METADATA!!!!**

NGS homepage: **geodesy.noaa.gov**

- Data access
- Geodetic Toolkit
- Publications
- Height Modernization
- Training opps
- Education resources
- Presentations
- CORS, OPUS, …

Mark your calendars …

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

Height Modernization Western States Regional Webinar

Tuesday, November 19, 2013

10:00 am to 2:00 pm Pacific Time

Remote participation only (internet access required)

Meeting webpage:
http://www.ngs.noaa.gov/corbin/class_description/HM_WesternRegion.shtml

Online registration:
https://www2.gotomeeting.com/register/952765650

Figure 1 NGS active (CORS) and passive GNSS control stations in the conterminous US. As of December 2011, there were approximately 1900 operational CORS and 75,000 passive GNSS stations.

Frames for the Future

New Datum Definitions for Modernization of the U.S. National Spatial Reference System (Part 1 of 4)

In 2008, the National Geodetic Survey (NGS) released its 10-Year Plan (NGS, 2008). In this plan, NGS describes the replacement of the two national datums currently in use. These are the horizontal datum (the North American Datum of 1983, or NAD 83) and the vertical datum (the North American Vertical Datum of 1988, or NAVD 88). Now that NAD 83 (1986) was originally a two-dimensional datum in that only latitude and longitude were provided (that is, it was a horizontal datum and is still commonly referred to as a horizontal datum). Subsequent realizations of NAD 83, such as NAD 83(HARN) or NAD 83(NSRS2007), also provide ellipsoidal heights; they are three-dimensional and properly called a geometric datum. For the remainder of this article there will be no further use

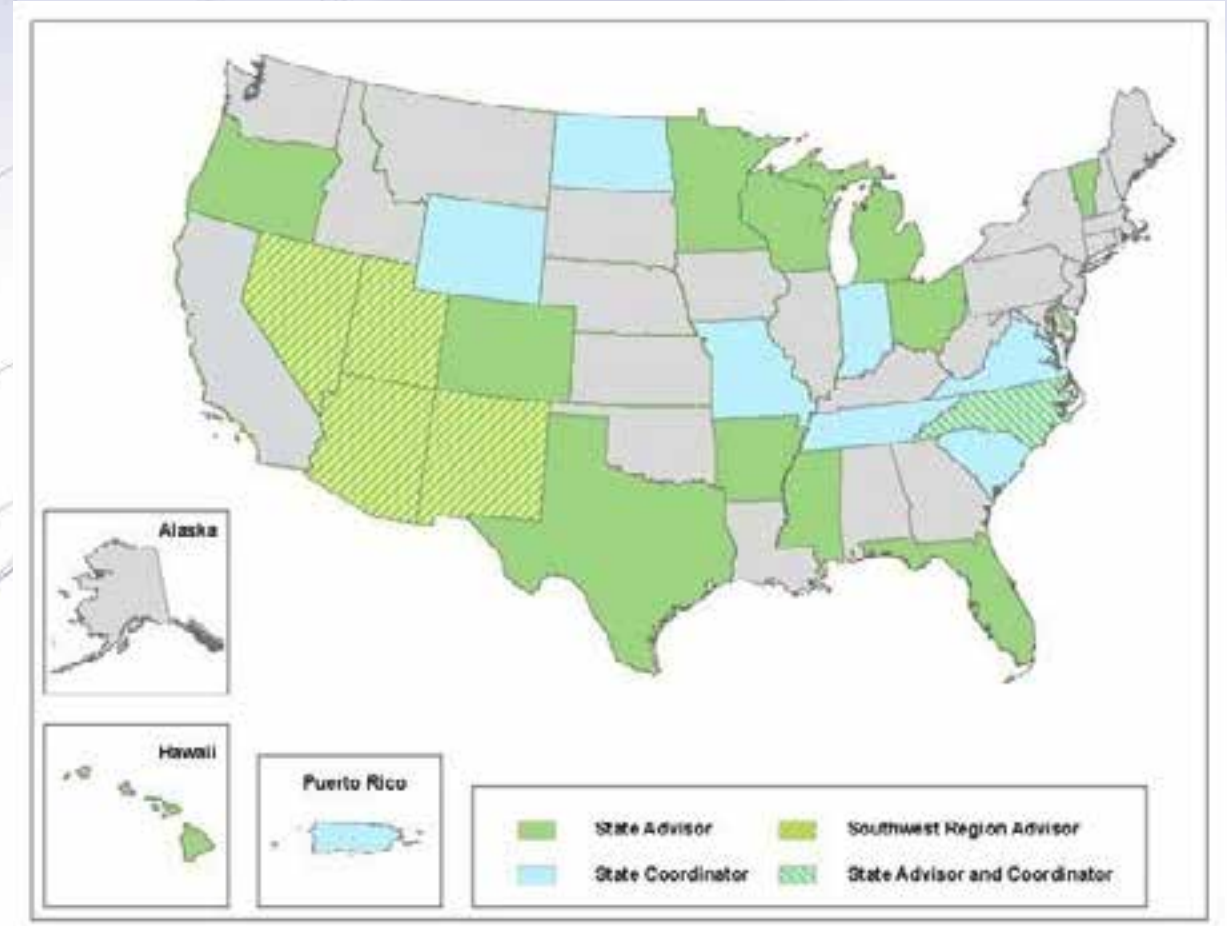
>> By David H. Minkel and Michael L. Dennis

THE American Surveyor

A Foot In The Past... An Eye To The Future

Find the article(s) in the Archives at: http://www.amerisurv.com

National Geodetic Survey
Geodetic Advisors



q SW Region
(AZ, NV, NM, UT)
Bill Stone

q Colorado
Pam Fromhertz

q Oregon
Mark Armstrong

Accurate positioning begins with *accurate* coordinates

Source: Zurich-American Insurance Group

William Stone
william.stone@noaa.gov
geodesy.noaa.gov