

Modernizing the National Spatial Reference System

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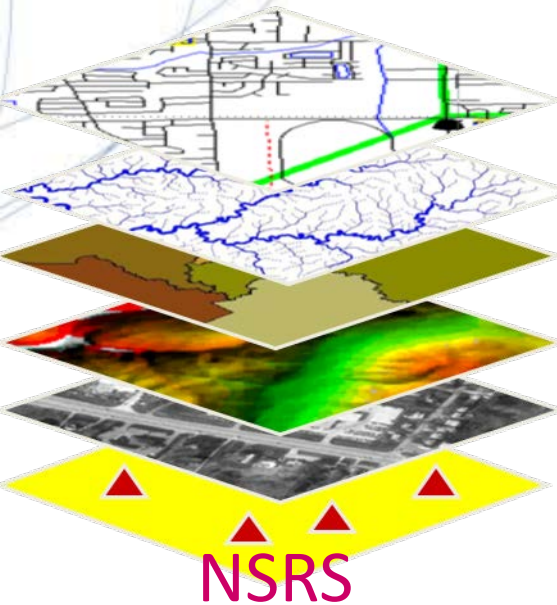


ASCE PIPELINES CONFERENCE

PHOENIX, ARIZONA | AUG 6-9, 2017

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



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

& their time variations

(& National Shoreline, etc.)

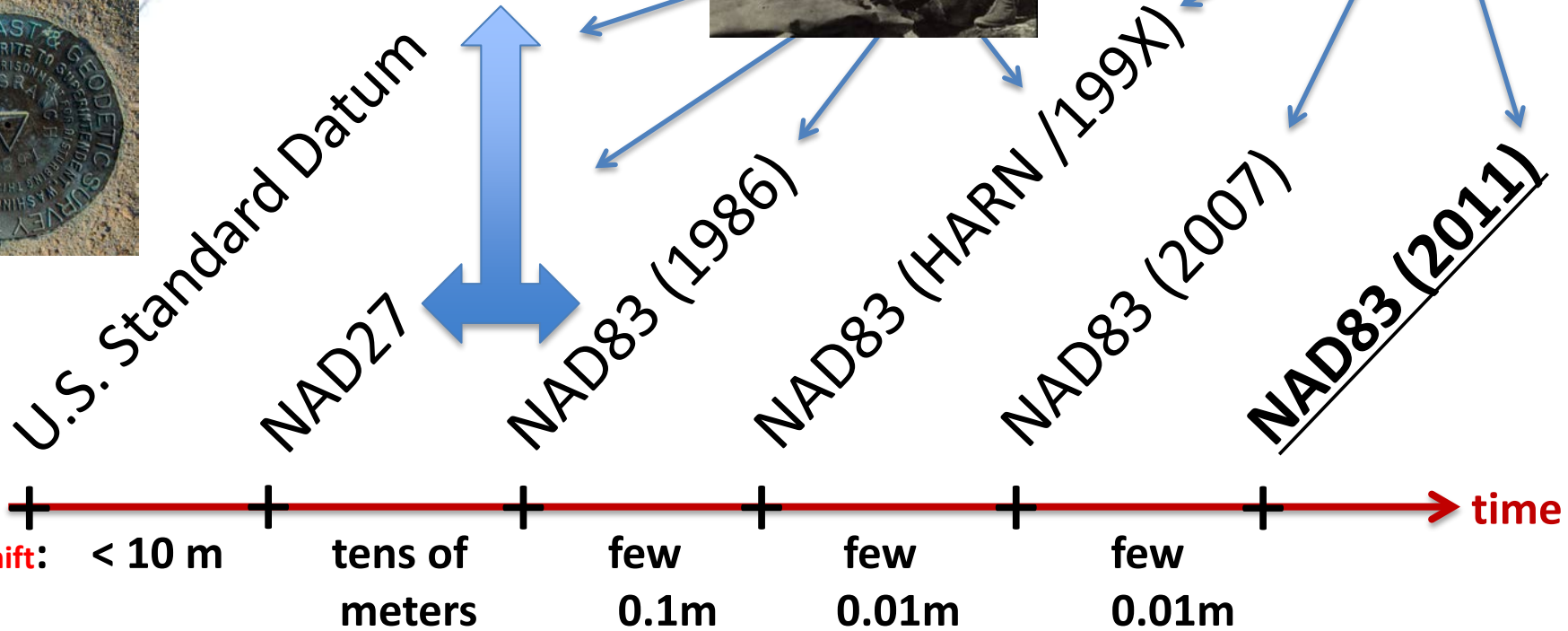
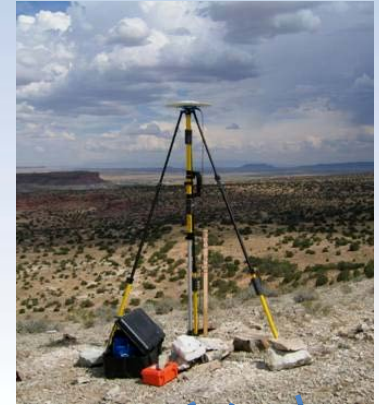
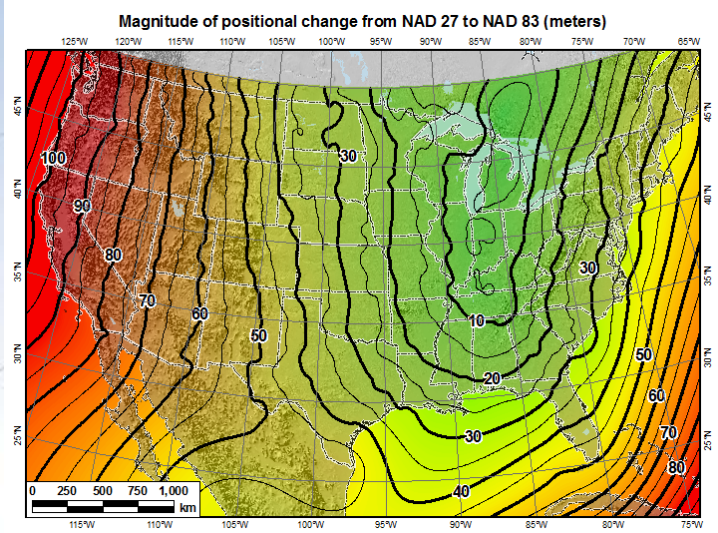
- North American Datum 1983 (NAD83)
- North American Vertical Datum 1988 (NAVD88)

Accurate positioning begins with *accurate* coordinates



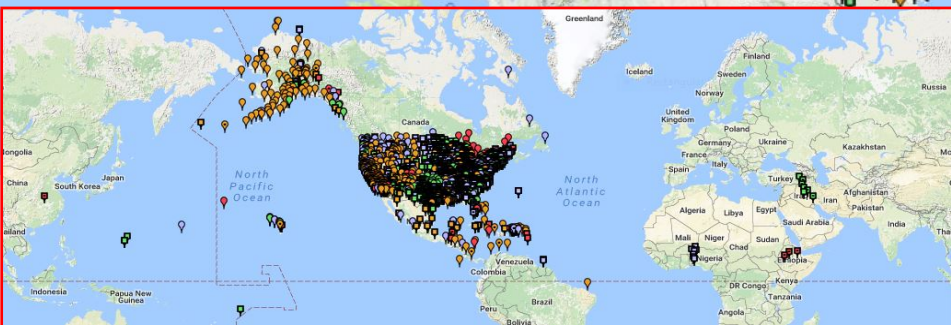
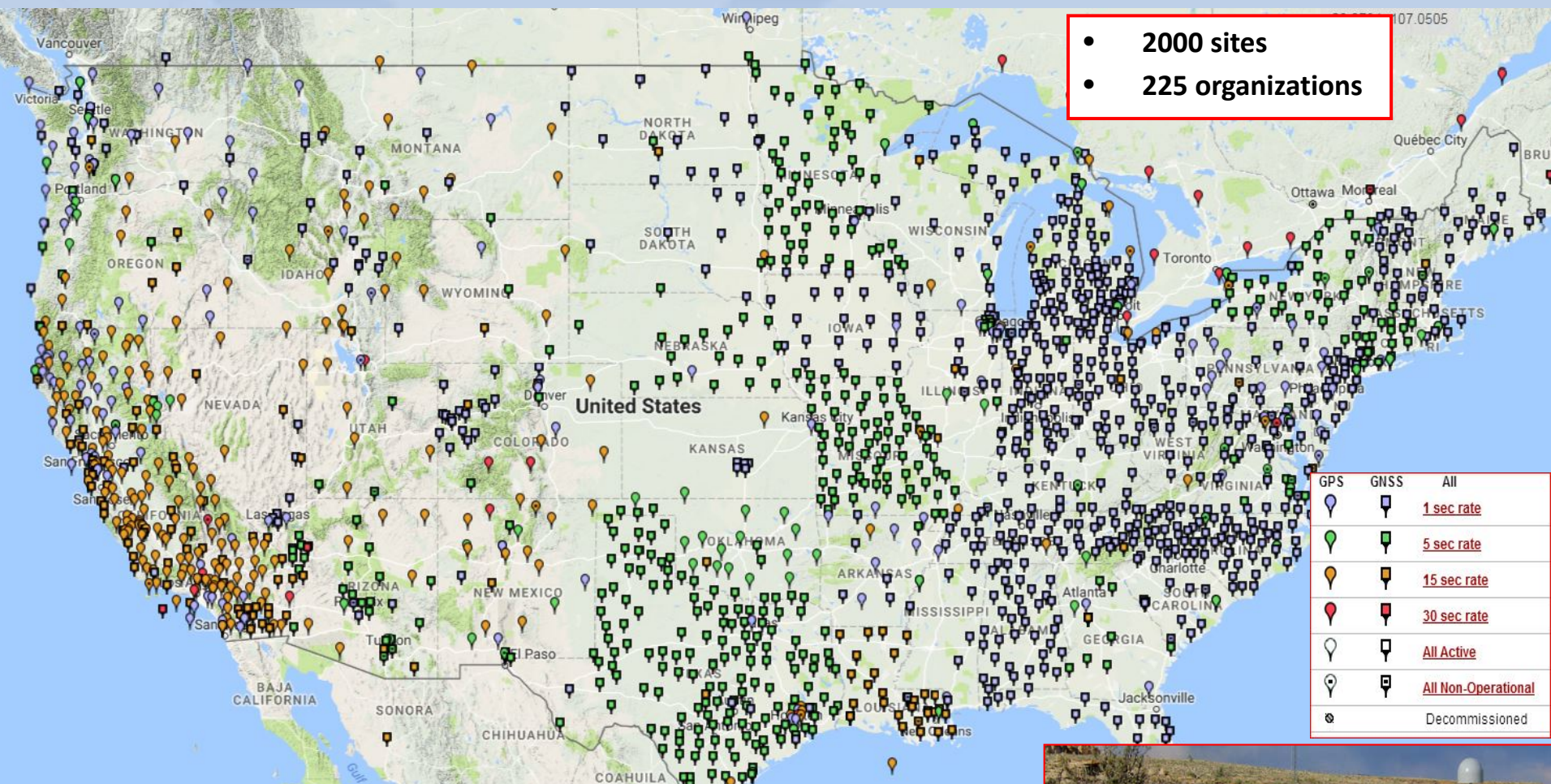
Source: Zurich-American Insurance Group

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



Continuously Operating Reference Station (CORS) Network

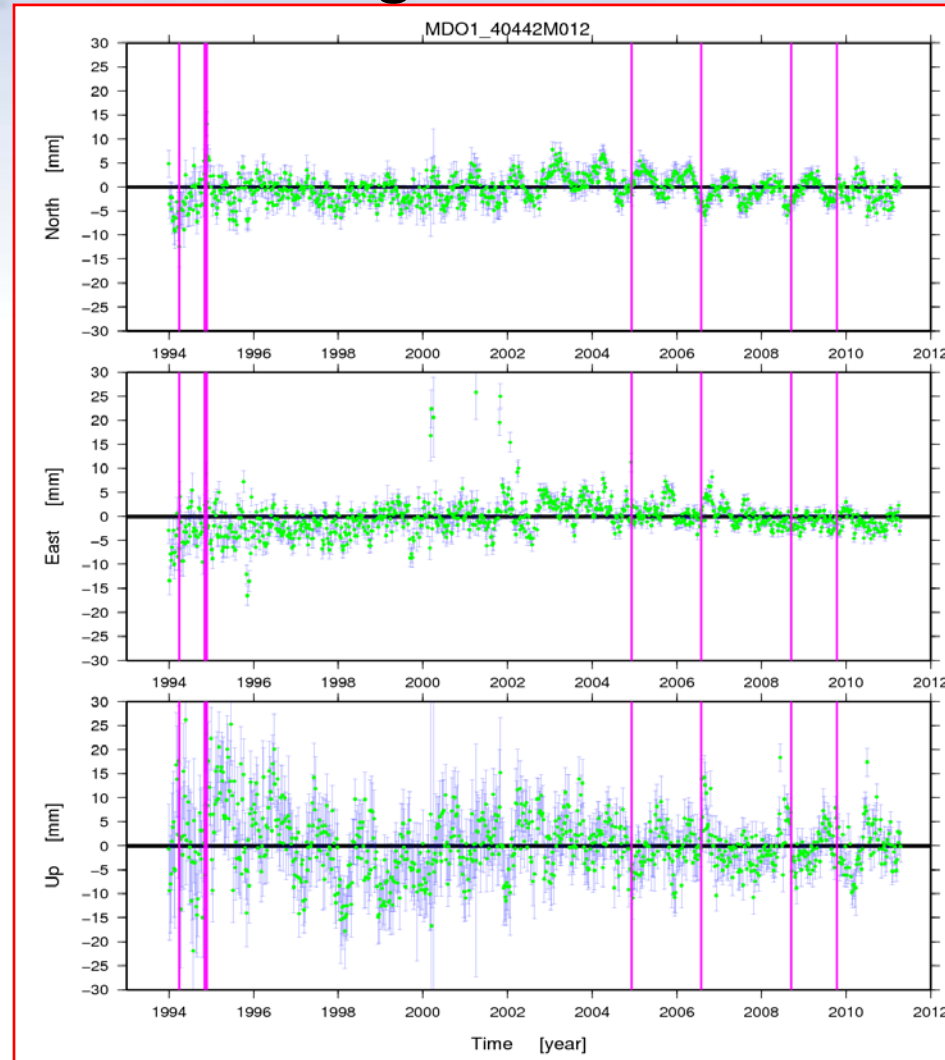
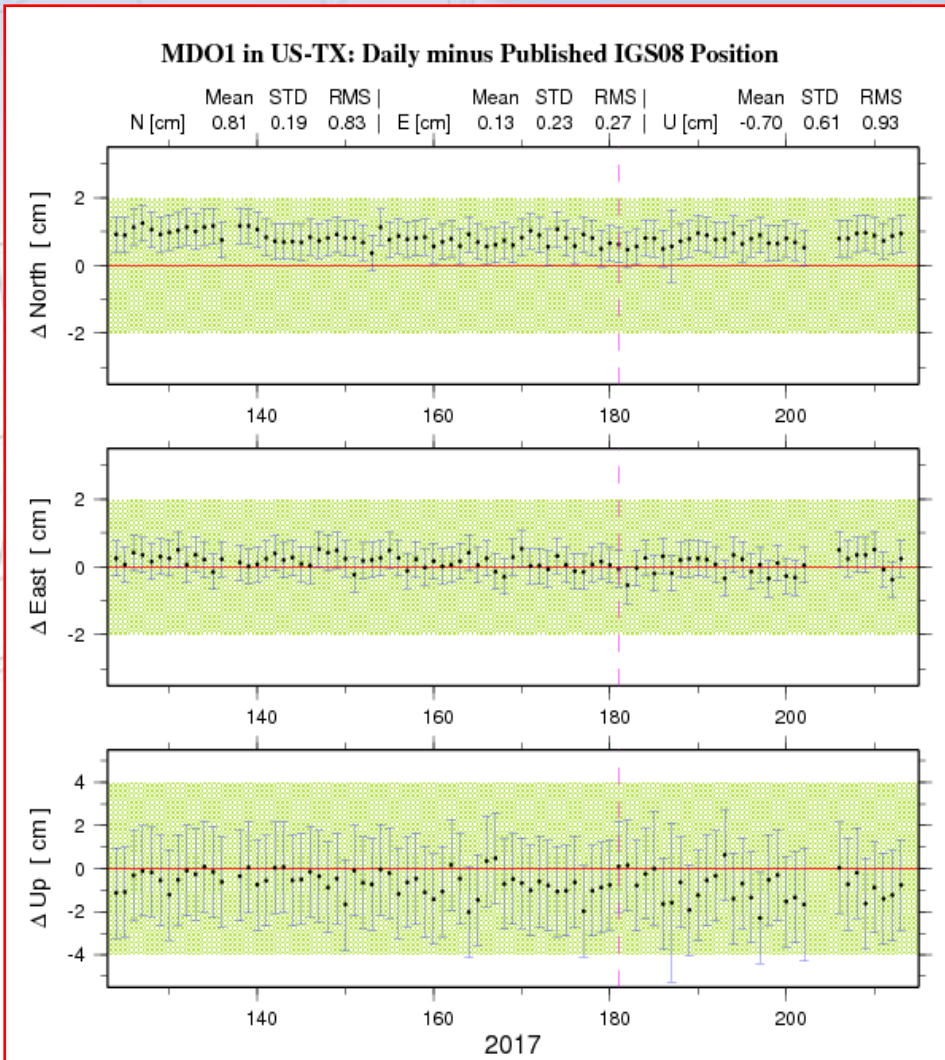
- 2000 sites
- 225 organizations



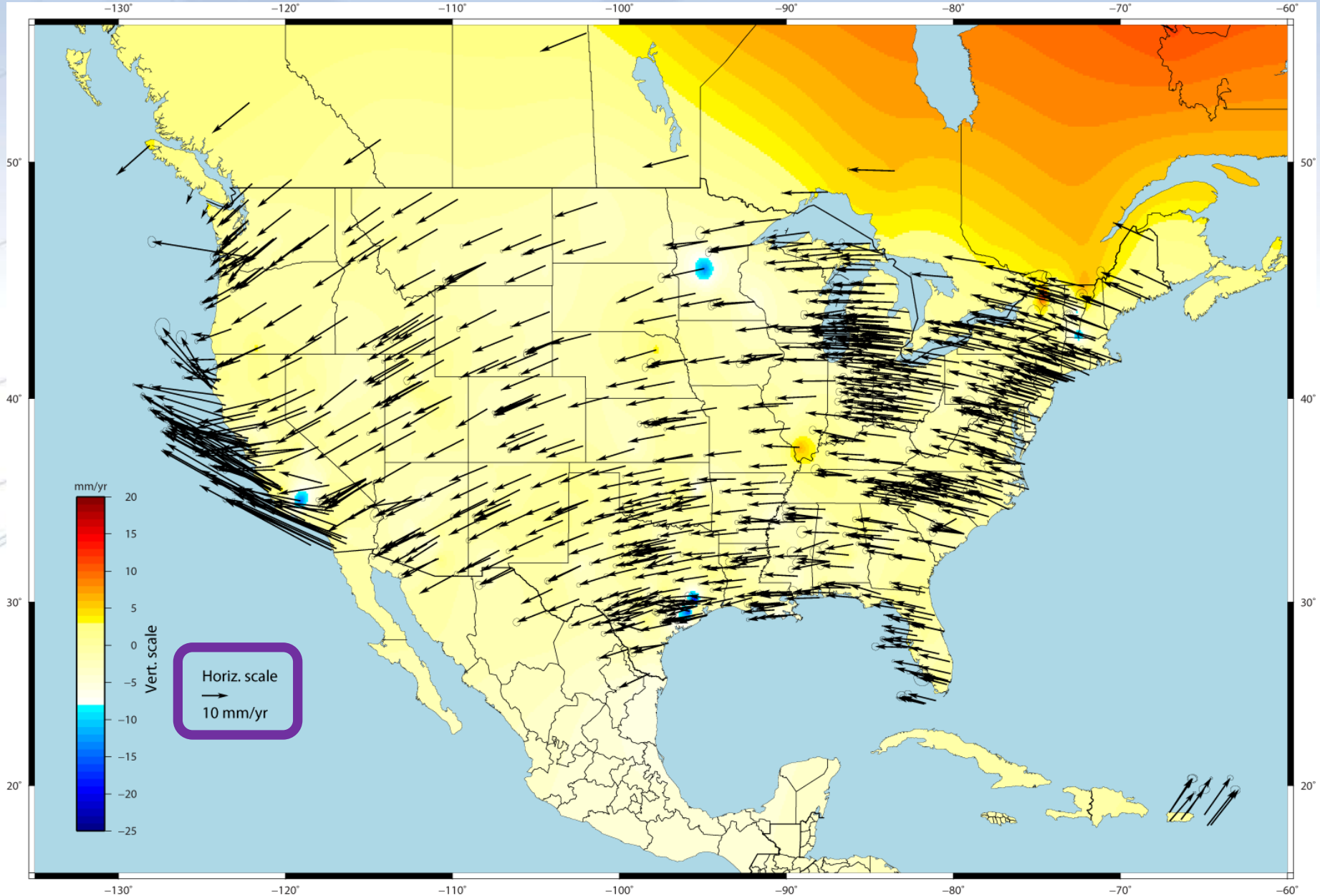
CORS Time Series Plots

short-term

long-term



CORS Velocity Field – ITRF2008 (IGS08 epoch 2005.0)



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

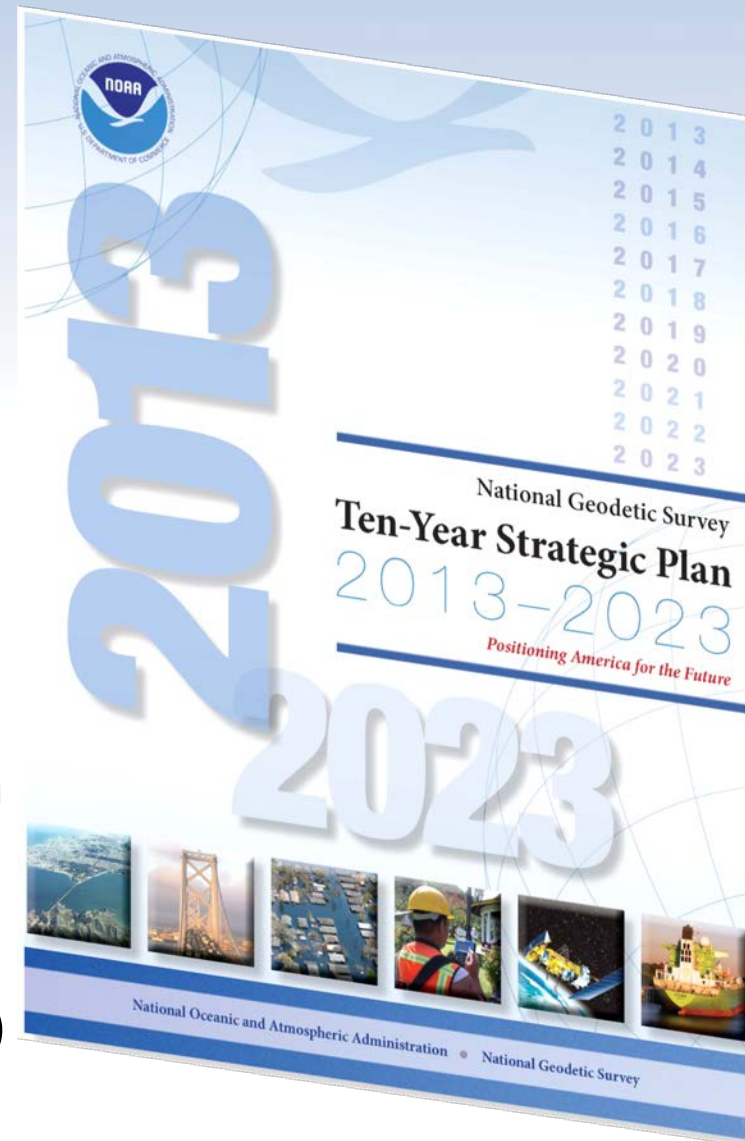
“Replace NAD83”

(NAD83 = North American Datum 1983)

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

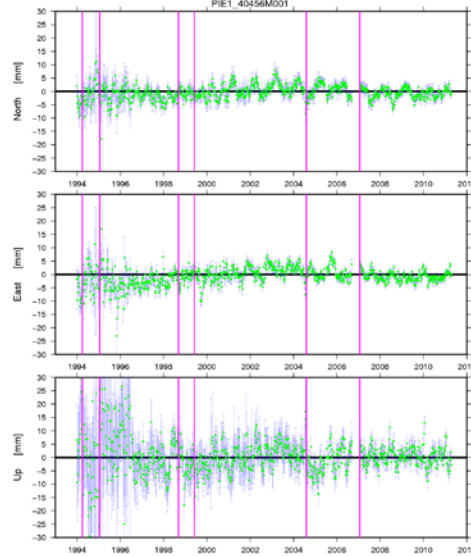
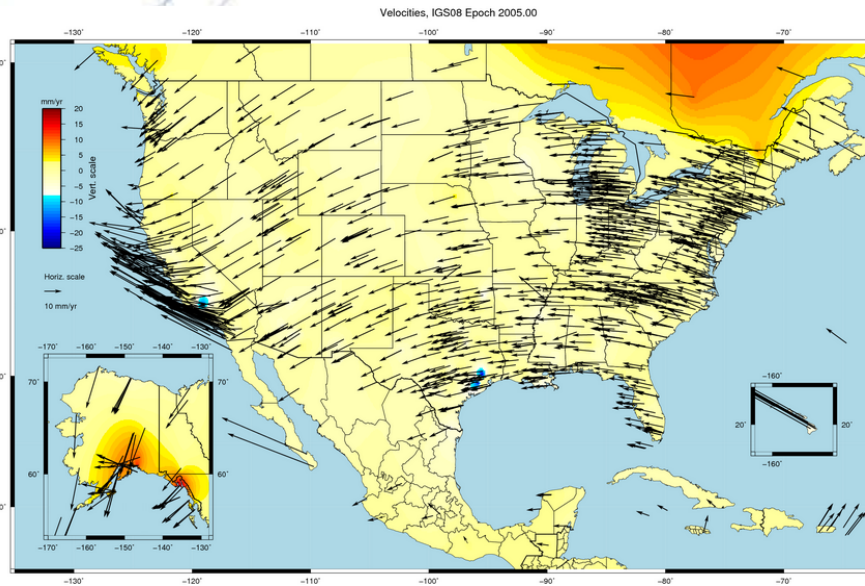
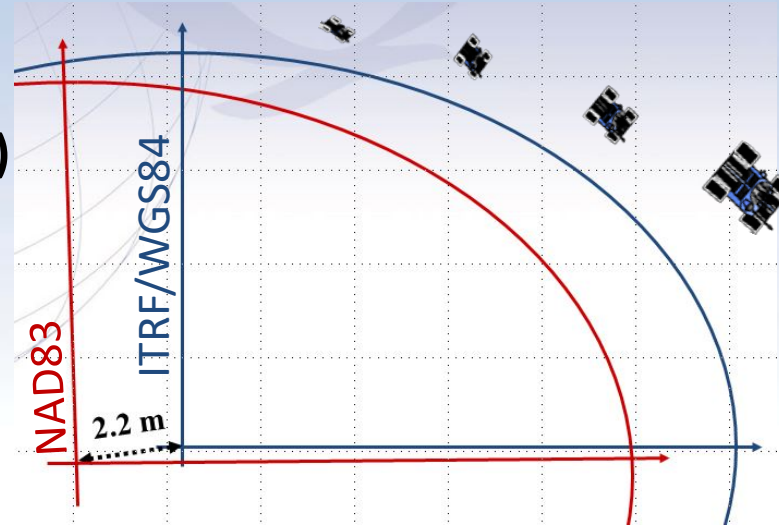
“Replace NAVD88”

(NAVD88 = North American Vertical Datum 1988)

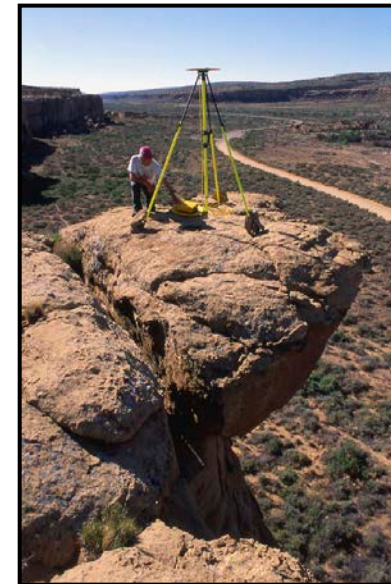


NAD83 Shortcomings

- 2.2 m offset – NAD83 vs.
- International Terrestrial Reference Frame (ITRF) [~ International GNSS Service (IGS)]
- World Geodetic System 1984 (WGS84)
- CORS <> passive network “disconnect”



VS.



Future Geometric (3-D) Reference Frames

- replace NAD83 with new geometric reference frames – by 2022
- CORS-based, accessed via GNSS observations
- coordinates & velocities in global & new US reference frames
- passive control tied to new reference frame
- transformation tool will relate historical <> new US reference frames

(NADCON 5.0)

Introducing...

North American Terrestrial Reference Frame of 2022 (NATRF2022)

(& Pacific / Mariana / Caribbean Terrestrial Reference Frame of 2022)
(PATRF2022 / MATRF2022 / CATRF2022)

- 4 (essentially) tectonic-plate-fixed reference frames
- identical to IGS~~XX~~* reference frame at TBD epoch (2022.0?)
- over time, will relate to IGS~~XX~~ frame via Euler Pole Rotation
- CORS velocities deviating from rigid-plate (Euler) rotation will be captured in 3-D velocity model (a secondary product to transform to fixed epoch)

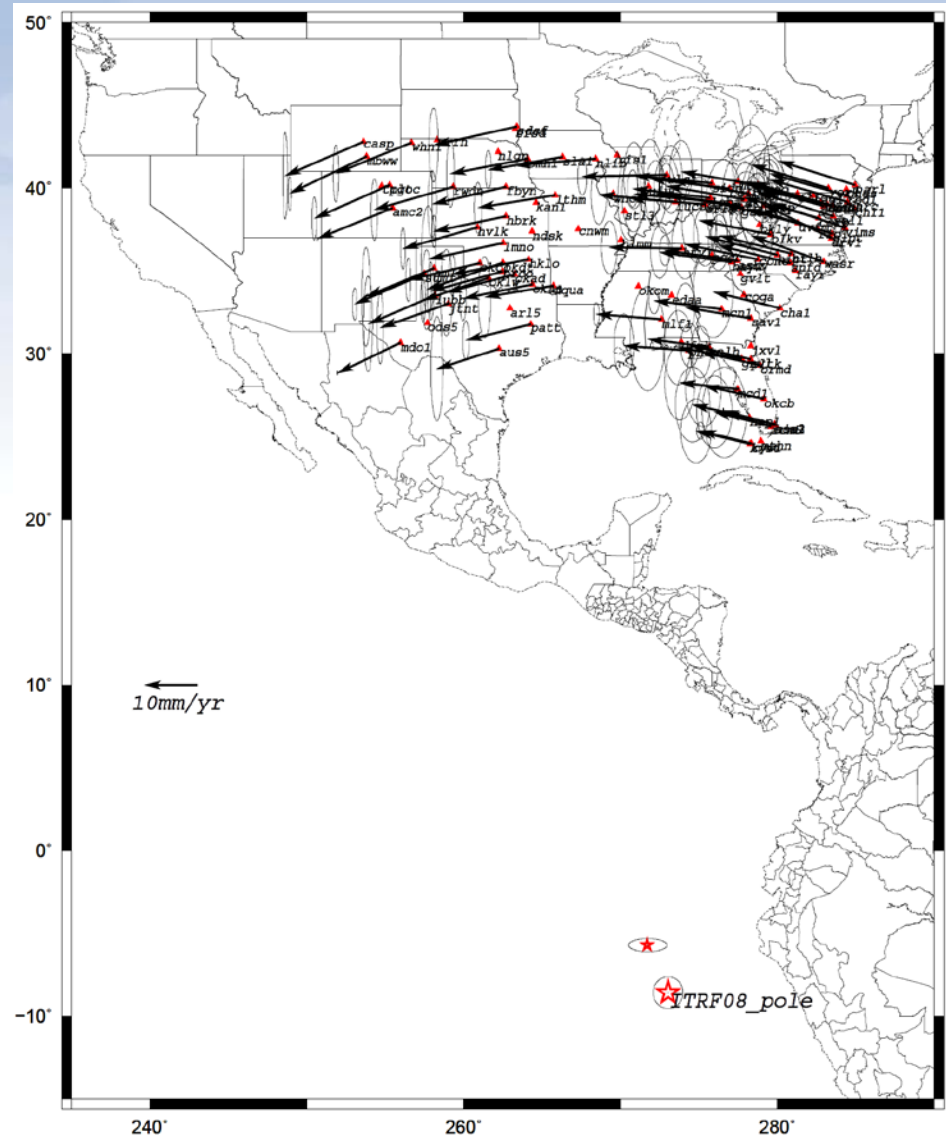
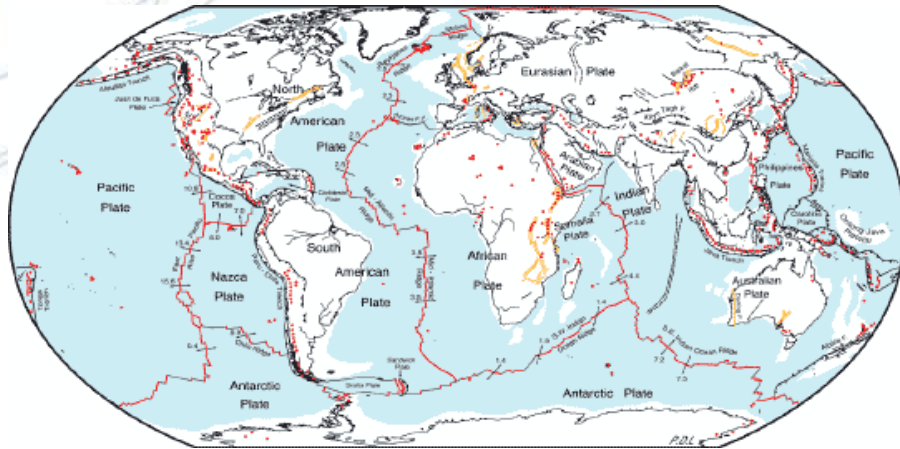
[e.g. IGS14 = International GNSS Service 2014]

Euler Pole

Each reference frame will get:

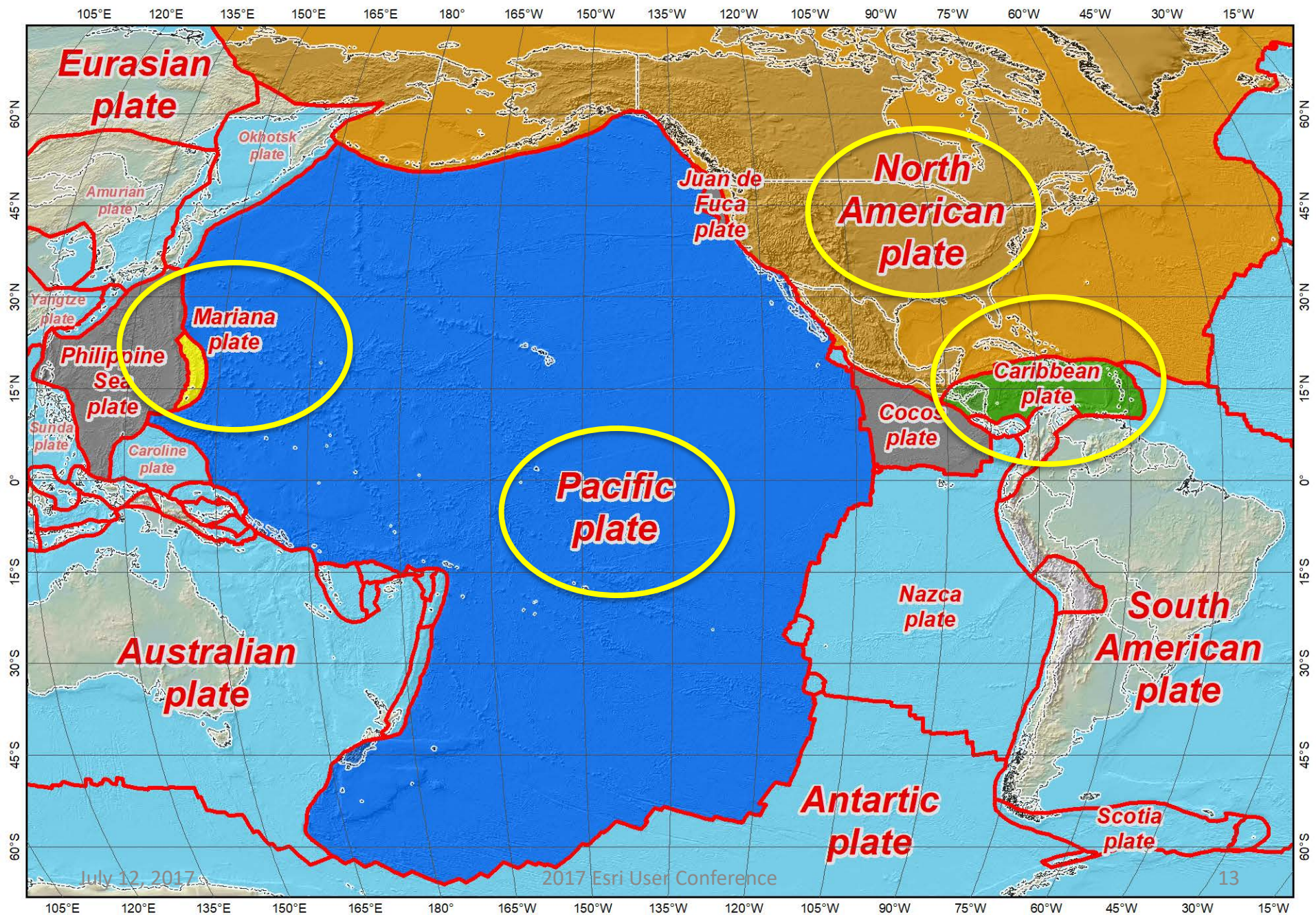
- Euler Pole Latitude/Longitude
- Rotation rate (radians/year)

Used to compute time-dependent TRF2022 coordinates from time-dependent global (IGS) coordinates



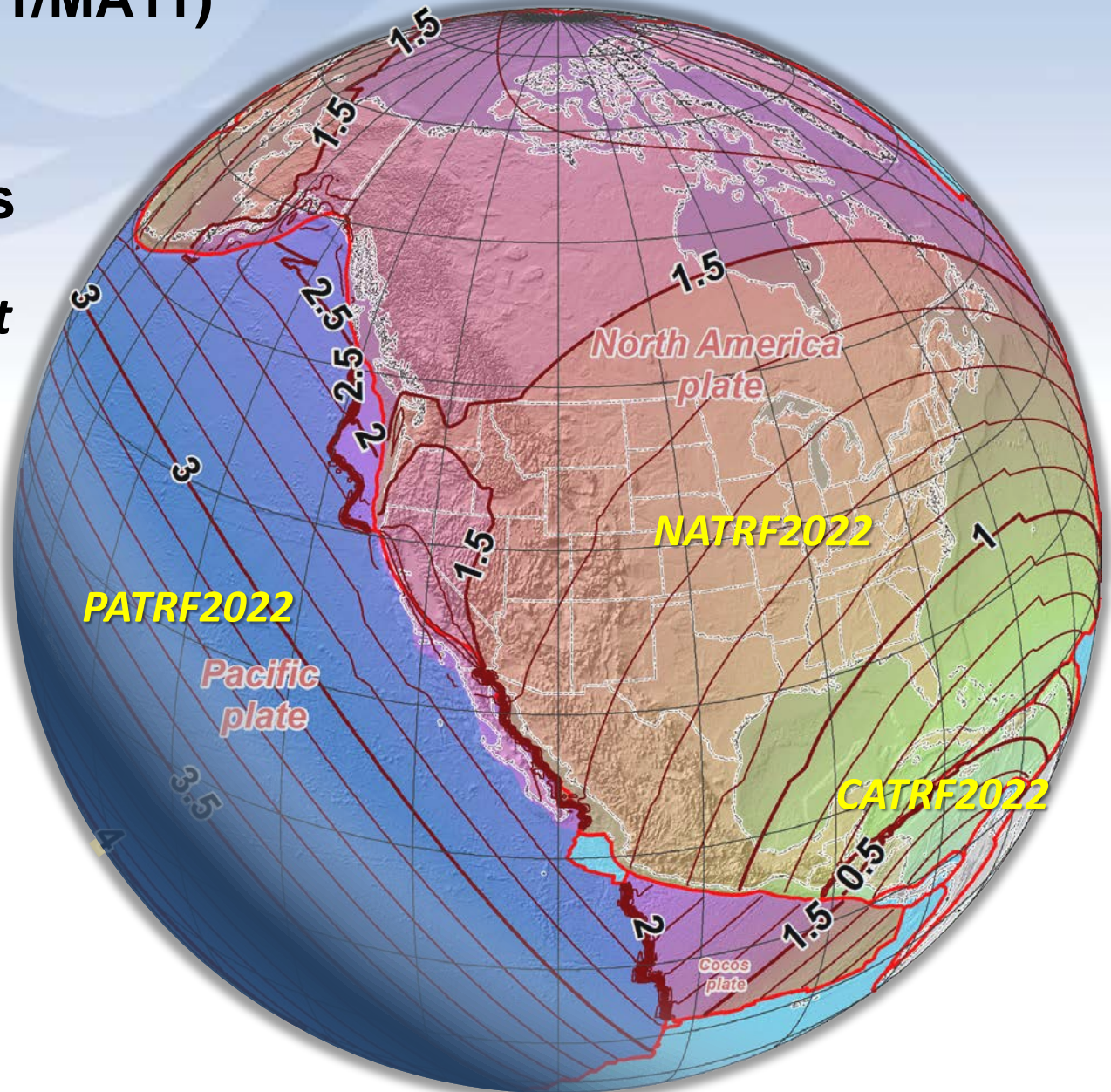
Euler's fixed point theorem states: any motion of a rigid body on the surface of a sphere may be represented as a rotation about an appropriately chosen rotation pole ("Euler Pole")

The four tectonic plates “fixed” for the 2022 terrestrial reference frames



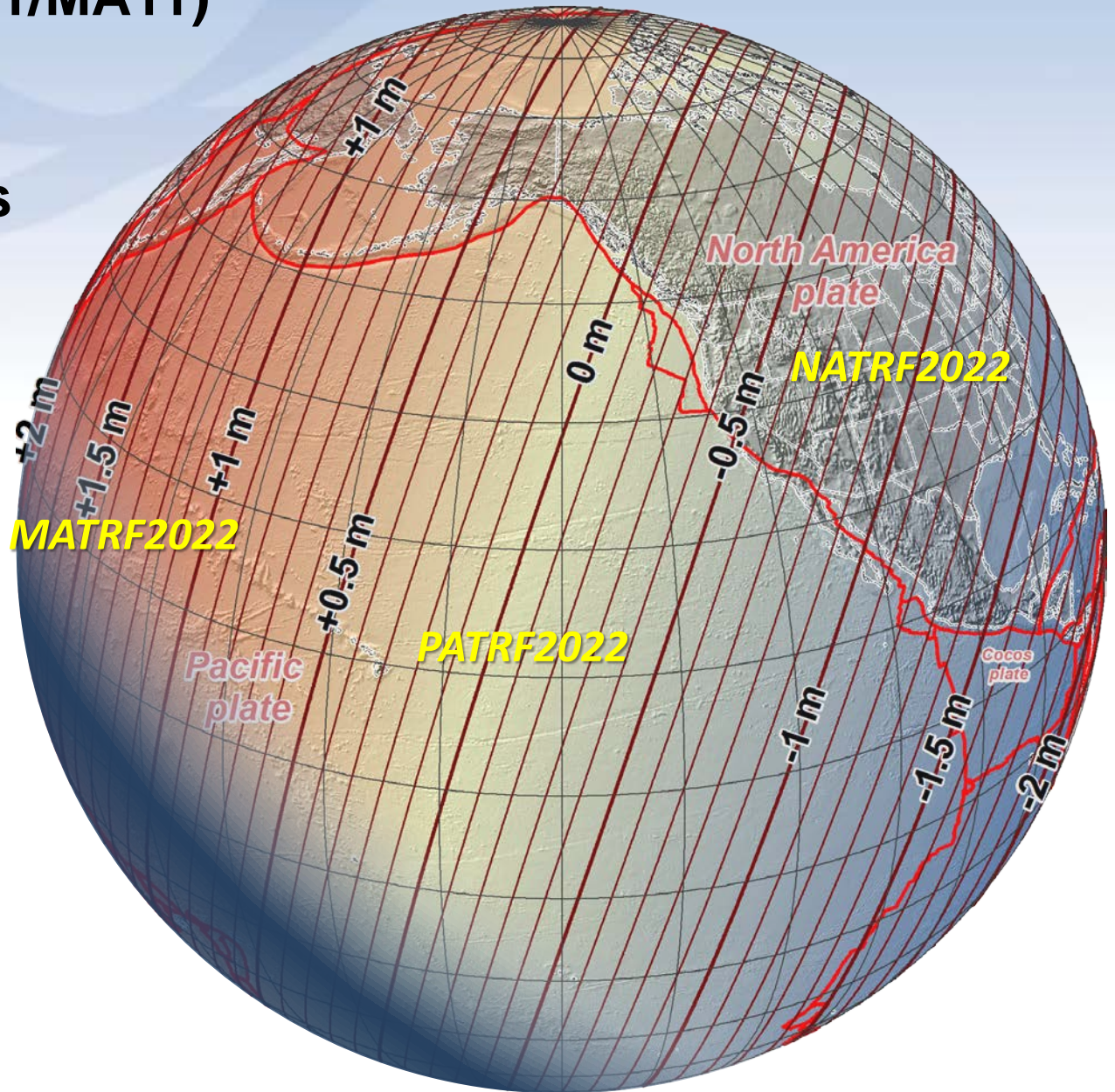
NAD 83 (2011/PA11/MA11) epoch 2010.00 → 2022 Terrestrial Reference Frames

*Horizontal change at
epoch 2022.00
(contours in meters)*

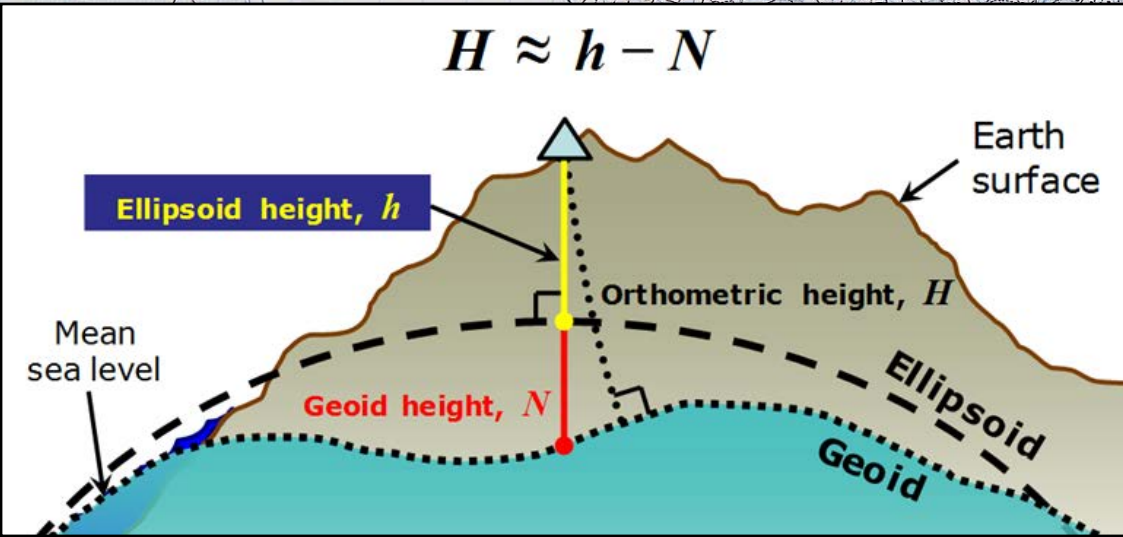
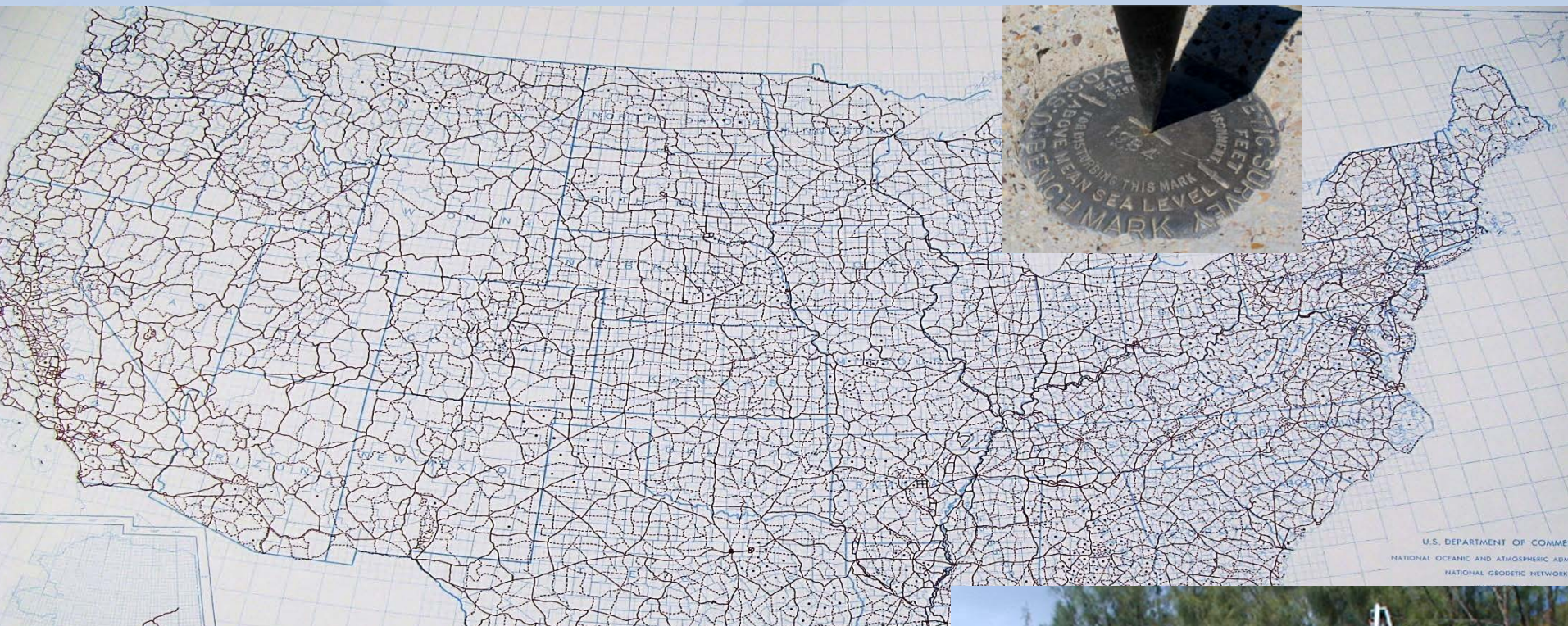


NAD 83 (2011/PA11/MA11) epoch 2010.00 → 2022 Terrestrial Reference Frames

*Change in ellipsoid
heights at epoch
2022.00
(contours in meters)*

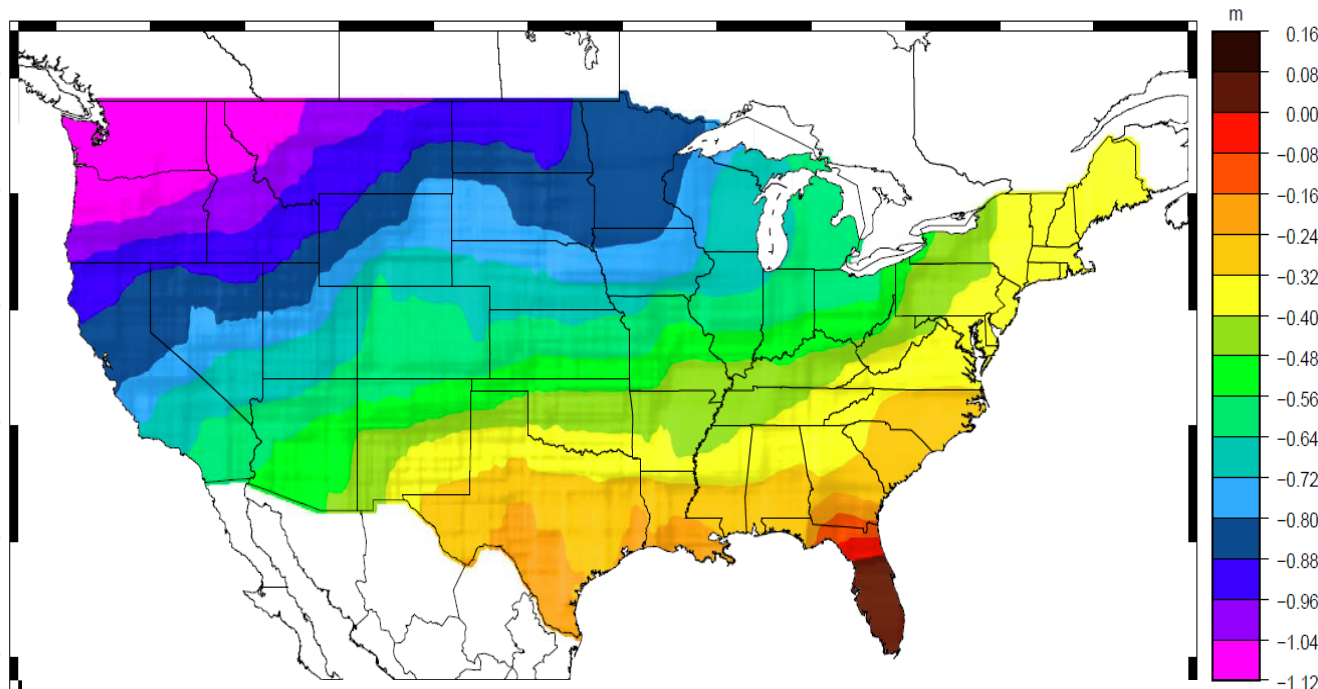


NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88)



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

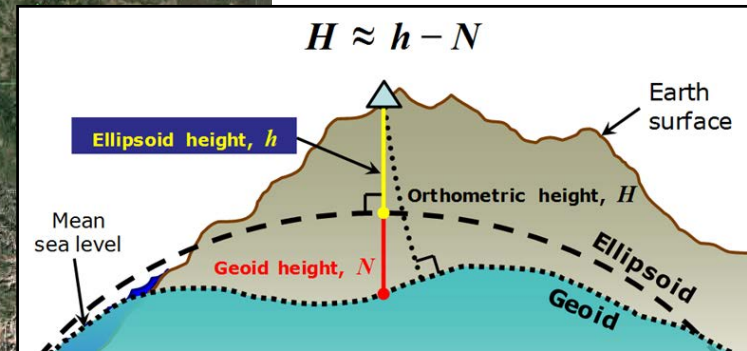
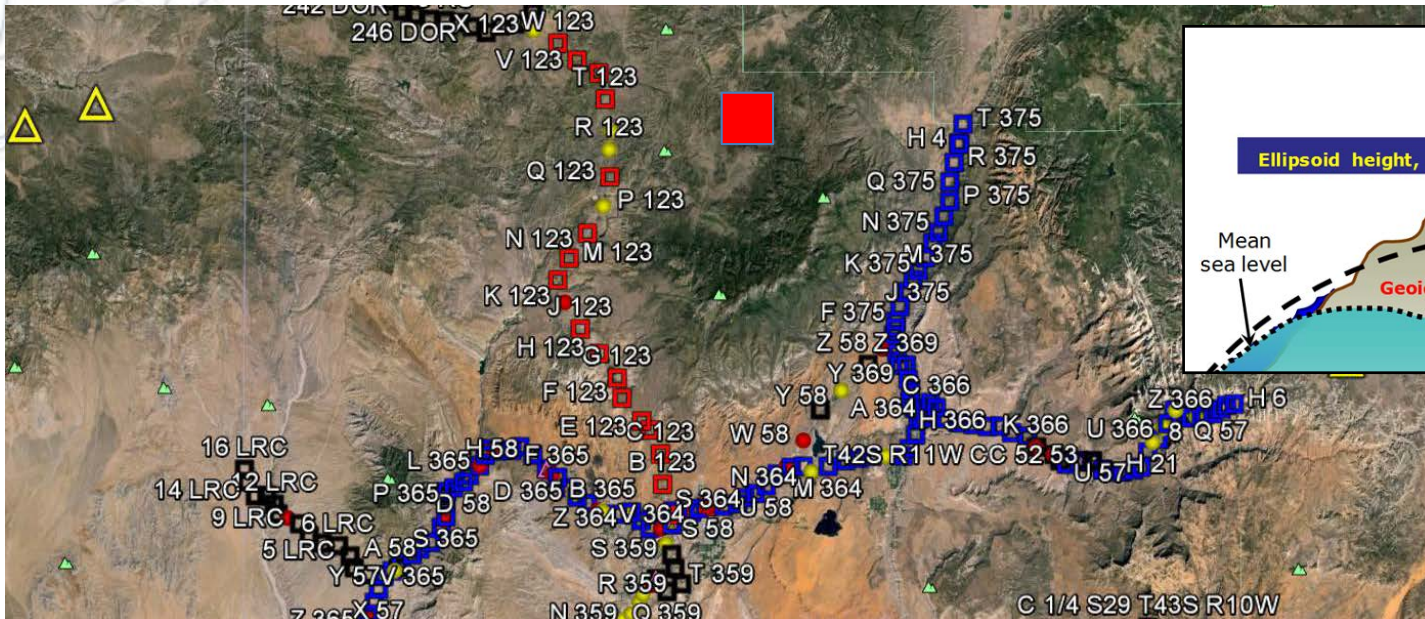


Approximate Geoid Mismatch in the NAVD88 H=0 surface



Future Geopotential (Vertical) Datum

- replace NAVD88, etc. – by 2022
- accessed by GNSS & gravimetric geoid
- monitor time-varying nature of gravity field
- most accurate continental gravimetric geoid model ever built: 1 cm (goal)



Current Vertical Datums / Models

Orthometric Heights

NAVD 88

PRVD 02

VI

Normal Orthometric Heights

Dynamic Heights
Gravity

IGLD 85

IGSN71

Geoid Heights

GEOID12B

Deflections of the Vertical

DEFLEC12B

one vertical datum pole-to-equator



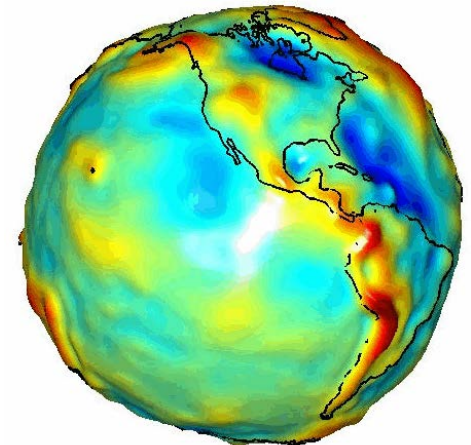
Introducing...

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

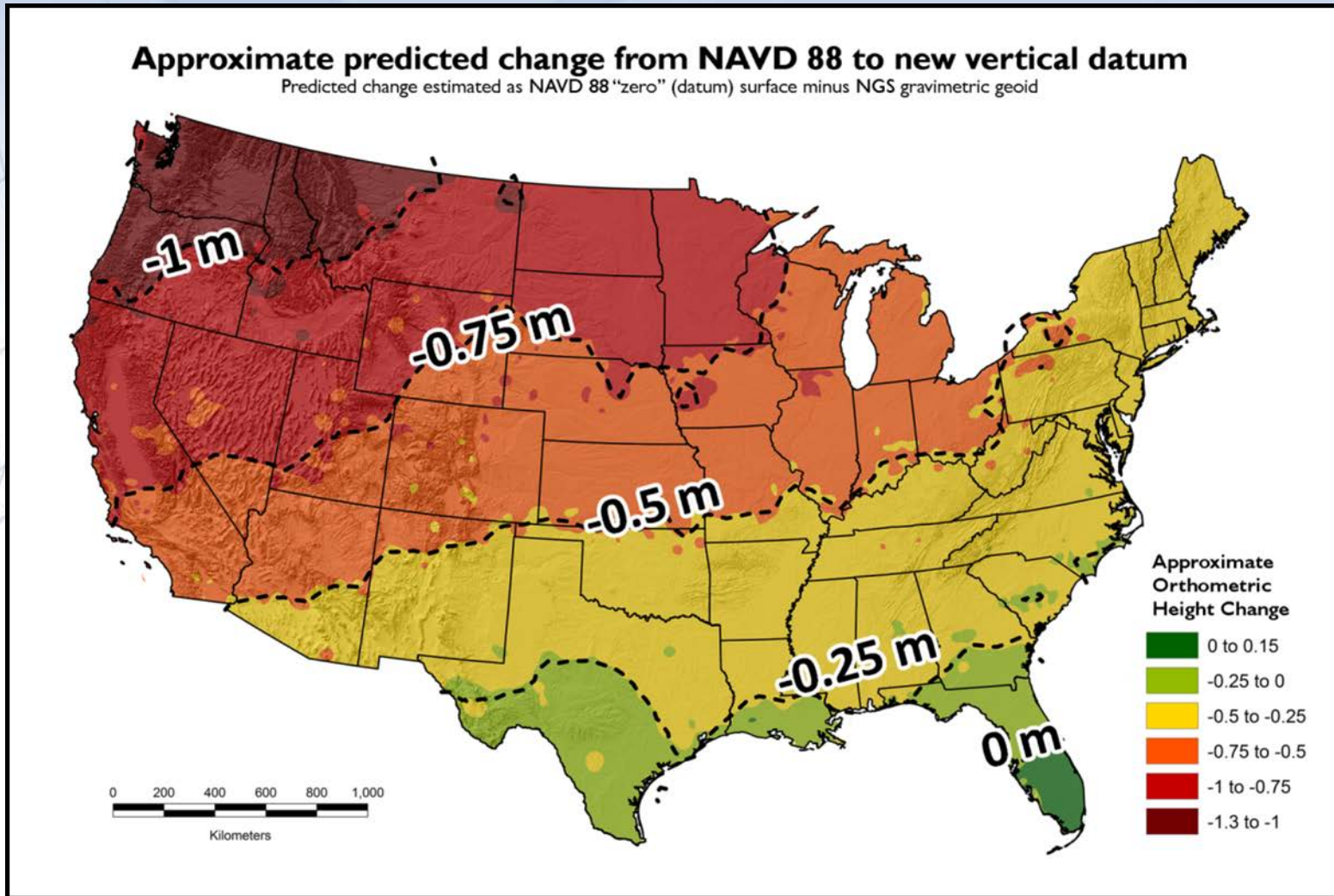
&

GEOID2022 (gravimetric geoid)

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



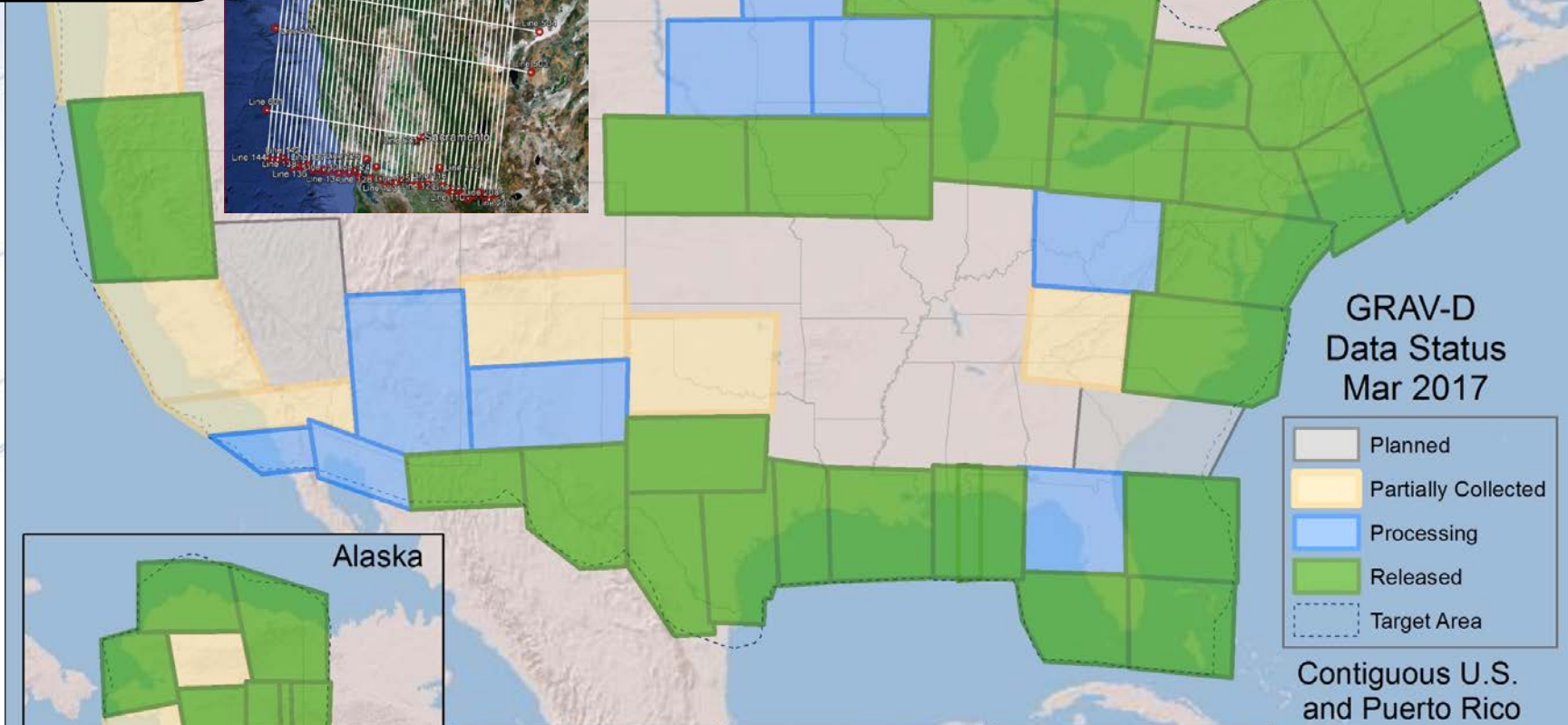
Predicted Change – NAVD88 to NAPGD2022



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

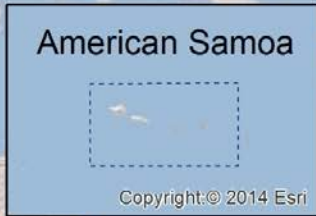
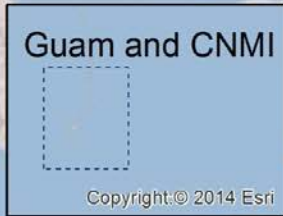
(GRAV-D)

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



GRAV-D Data Status
Mar 2017

	Planned
	Partially Collected
	Processing
	Released
	Target Area

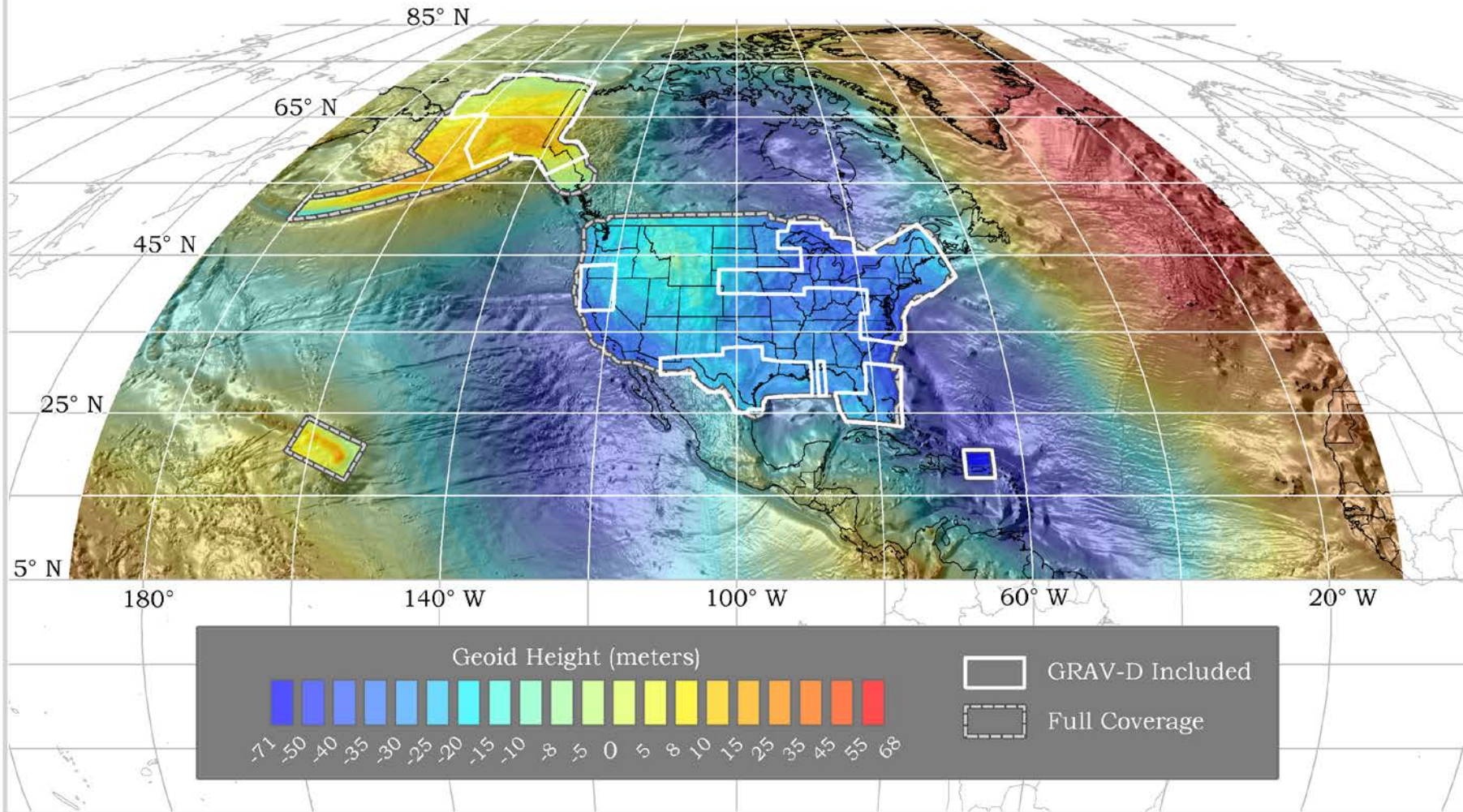


Contiguous U.S. and Puerto Rico

2017-Q2:
62% complete

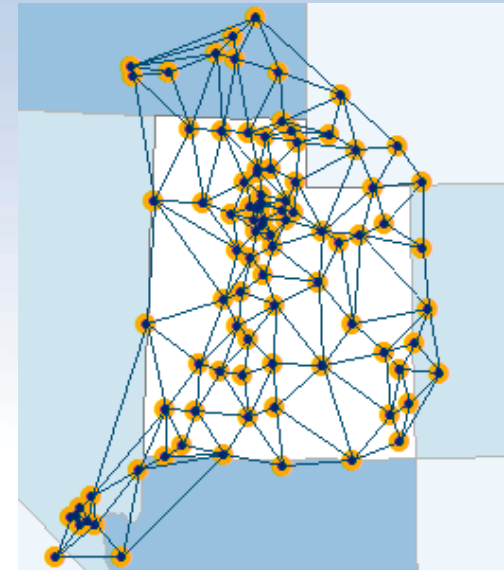
Annual Experimental Geoids

Experimental Geoid 2017
(xGEOID17)



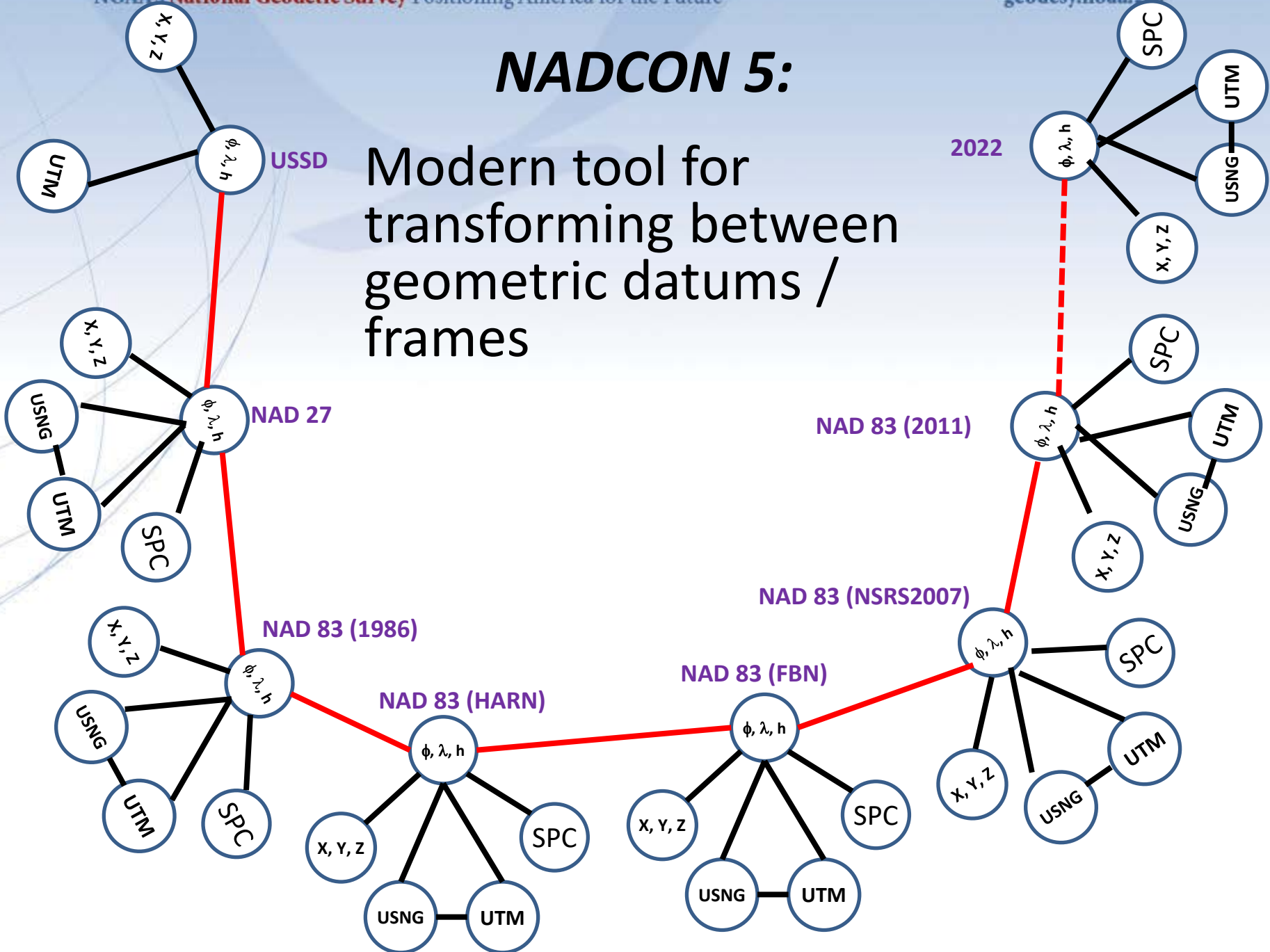
How to Plan for 2022

- **Move to NAD 83(2011) epoch 2010.00**
 - via surveys (or *possibly* via NADCON)
- **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!!!!**



NADCON 5:

Modern tool for transforming between geometric datums / frames





National Geodetic Survey

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- NGS Data Explorer
- OPUS Projects
- Geodetic Tool Kit
- State Plane Coordinates
- Antenna Calibration
- UFCORS
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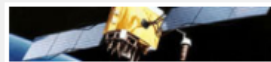
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Coming in 2022:
New Datums!
 Learn more..

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, shoreline information impact a wide range of important activities.

Learn more about:

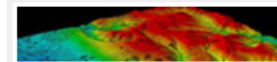
- Data and tools we provide
- Activities in your area
- Applications of geodesy



GNSS & GPS Data

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

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Remote Sensing

Download data and critical information into nautical charts.

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View guidelines and get tools to support land surveyors.

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NGS works closely with the global researchers advancing geodetic science.

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Classes and educational resources on scientific topics relating to geodesy.

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Datums & Transformations

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

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Looking for Bench Marks?

Notices

Beta Release:
NADCON 5

Beta Release: CORS & OPUS Share Maps

[Previous Notices](#)

In the News

06/22/2017 - NGS Recognized at Boulder, CO, Public Art Dedication

06/15/2017 - 'Foundations of Global Navigation Satellite Systems' Online Lesson

06/08/2017 - New Tool for Easy, Consistent Coordinate Transformations

06/01/2017 - NGS Participates in the International Federation of Surveyors Conference in Helsinki, Finland

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National Geodetic Survey

Positioning America for the Future

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New Datums

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Events

- [2017 Summit](#)
- [2015 Summit](#)
- [2010 Summit](#)

New Datums: 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](#)

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[Related Projects](#)

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.



**NGS
2017
Geospatial
Summit**

April 24-25



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



Issue 8, July 2017

NSRS Modernization News

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

Acronyms

We have received substantial stakeholder requests to change the official acronyms of the new terrestrial reference frames, originally announced in January 2017 as NATRF2022, PTRF2022, MTRF2022 and CTRF2022. The requests focused primarily on easier pronunciation and consistent character length. After careful consideration, and in agreement with the Canadian Geodetic Survey, we are pleased to announce the official acronyms have been changed to:

NATRF2022

North American Terrestrial Reference Frame of 2022

PATRF2022

Pacific Terrestrial Reference Frame of 2022

MATRF2022

Mariana Terrestrial Reference Frame of 2022

CATRF2022

Caribbean Terrestrial Reference Frame of 2022

Blueprints

We are finalizing NOAA Technical Report NOS NGS 64, "Blueprint for 2022, Part 2: Geopotential Coordinates," for an August 2017 release. The document describes the year 2022 replacement of all vertical datums and other NSRS geopotential quantities. It will serve as a companion document to NOAA Technical Report NOS NGS 62, "Blueprint for 2022, Part 1: Geometric Coordinates," released in March of this year. Work has begun on Part 3 to address the re-invention of Bluebooking.

New Projects

We continue to initiate new projects for completion prior to 2022 as part of the rollout of the modernized NSRS. Details on the four latest projects are below.

Euler Poles

Project Manager: Dr. Daniel Roman

To determine the Euler Pole Parameters that define the angular rotation, relative to the IGS frame, of the four tectonic plates associated with each of the four 2022 NSRS terrestrial reference frames.

Scoping study for Intra-frame Velocity Models

Project Manager: Dr. Daniel Roman

This one-year effort will investigate how various methods may be used to provide Intra-frame Velocity Models for each terrestrial reference frame. The goal is to determine a recommended way forward by addressing accuracy needs, methodologies, capabilities, and budget.

VERTCON 3

Project Manager: Dr. Dru Smith

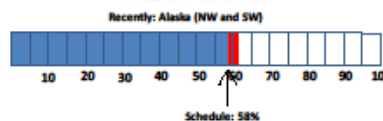
To improve and replace VERTCON 2.1 and DYN_HT, as well as to prepare for the roll-out of the **North American-Pacific Geopotential Datum of 2022 (NAPGD2022)**.

Comprehensive Toolkit Improvements

Project Manager: Dr. Dru Smith

A five-year effort to overhaul the entire Geodetic Toolkit, improving, replacing, and (where possible) integrating all code into more modern tools, and focusing on improved customer interaction and the removal of duplicate functions residing in multiple tools.

GRAV-D progress last quarter: **up 2.3% to 61.9%**
Ahead of Schedule!





NOAA Technical Report NOS NGS 62

Blueprint for 2022, Part 1: Geometric Coordinates

and ... coming soon:

**Blueprint for 2022, Part 2:
Geopotential Coordinates**

National Geodetic Survey – Regional Geodetic Advisors

