NSRS Modernization

PSLS Annual Conference

January 2020

Jeff Jalbrzikowski, P.S., GISP, CFS
Appalachian Regional Geodetic Advisor

jeff.jalbrzikowski@noaa.gov
240-988-5486

My Background

- Licensed Surveyor in OH, PA, and WV (PS)
- Certified GIS Professional (GISP)
- Certified Floodplain Surveyor (CFS)
- BS in Surveying & Mapping, Univ. of Akron
- Came to NGS from USACE Pittsburgh District
  - primary experience is engineering surveys, including structural deformation, hydrographic/bathymetric, terrestrial lidar, GNSS control, local/legacy datum resolution

Have you already heard that NAD83 and NAVD88 are scheduled to be replaced?

Who's nervous?

Who's ready?

Who's already working in ITRF?

Organizational Structure

- Federal Government – Executive Branch

-Department of Commerce (DoC)

(~47,000 employees)

↓

-National Oceanic and Atmospheric Administration (NOAA)

↓

-National Ocean Service (NOS)

↓

-National Geodetic Survey (NGS)

(~175 employees)

NGS Mission

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

NGS Overview

Modernizing the NSRS

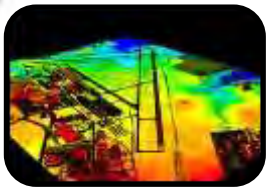

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

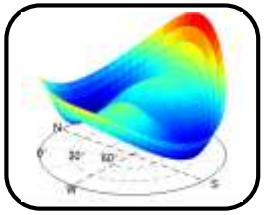

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT

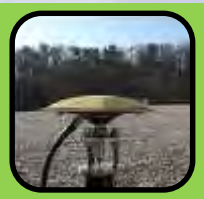

CUSP


CBL


Outreach

NGS Overview

Modernizing the NSRS

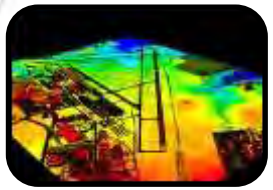

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

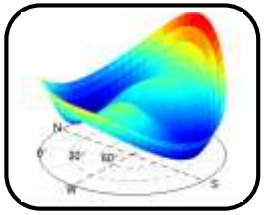

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT

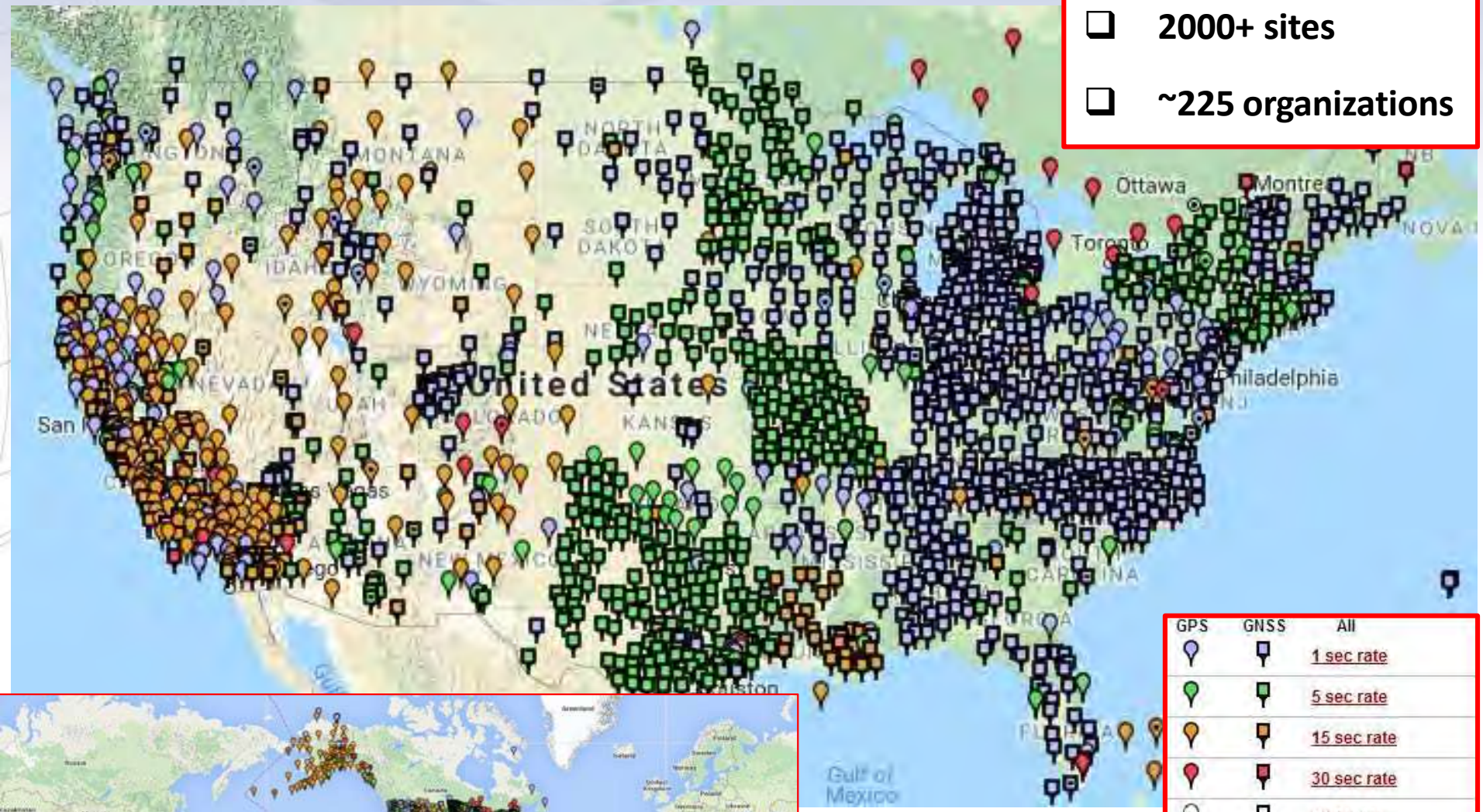

CUSP


CBL


Outreach

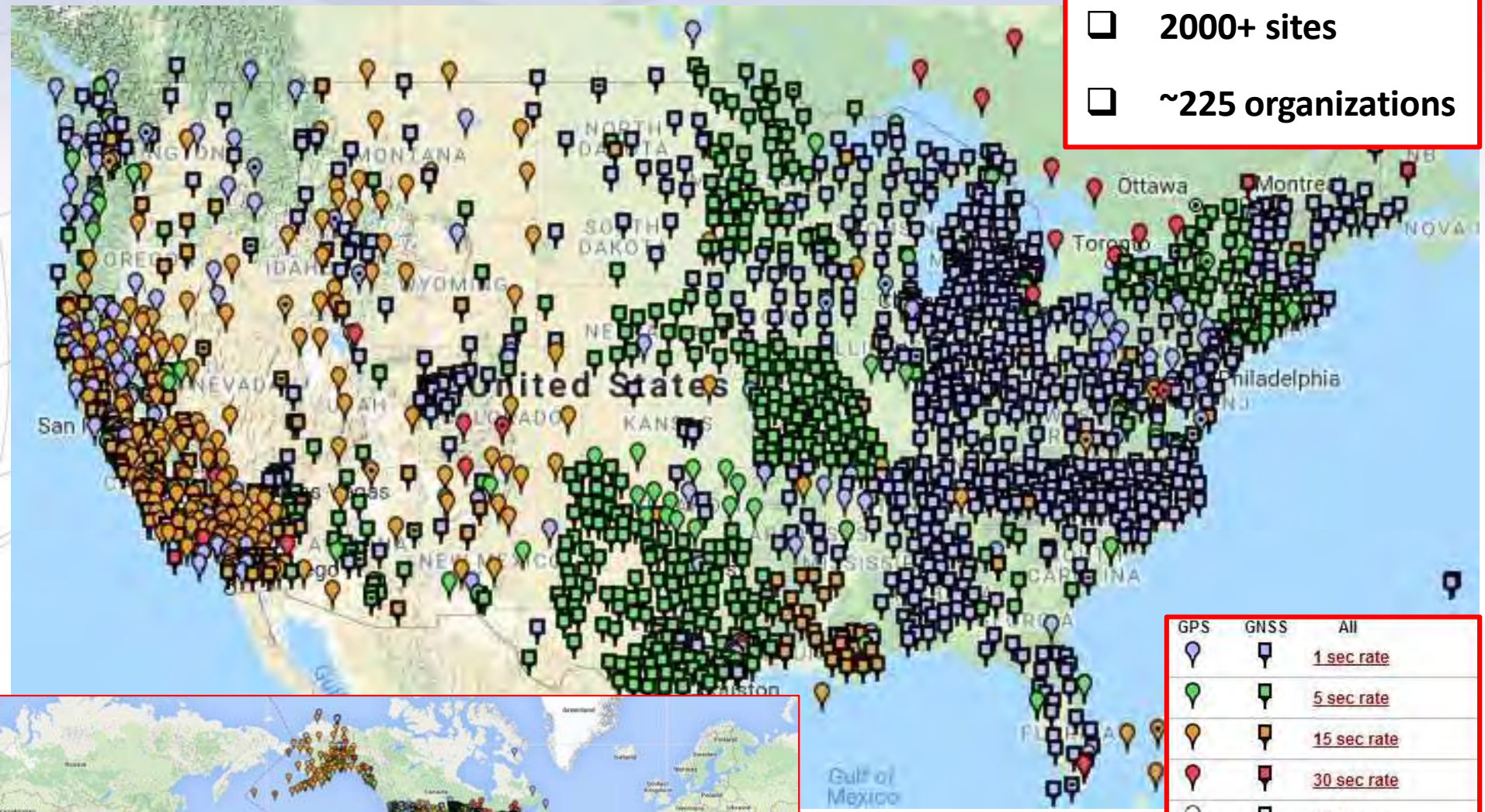
Continuously Operating Reference Station (CORS)

- ❑ 2000+ sites
- ❑ ~225 organizations



NOAA CORS Network (NCN)

- ❑ 2000+ sites
- ❑ ~225 organizations



NGS Overview

Modernizing the NSRS

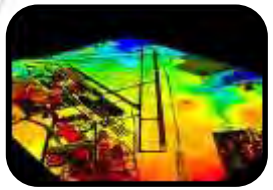

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

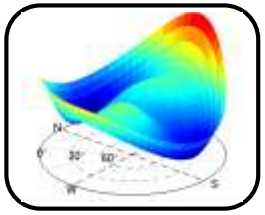

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

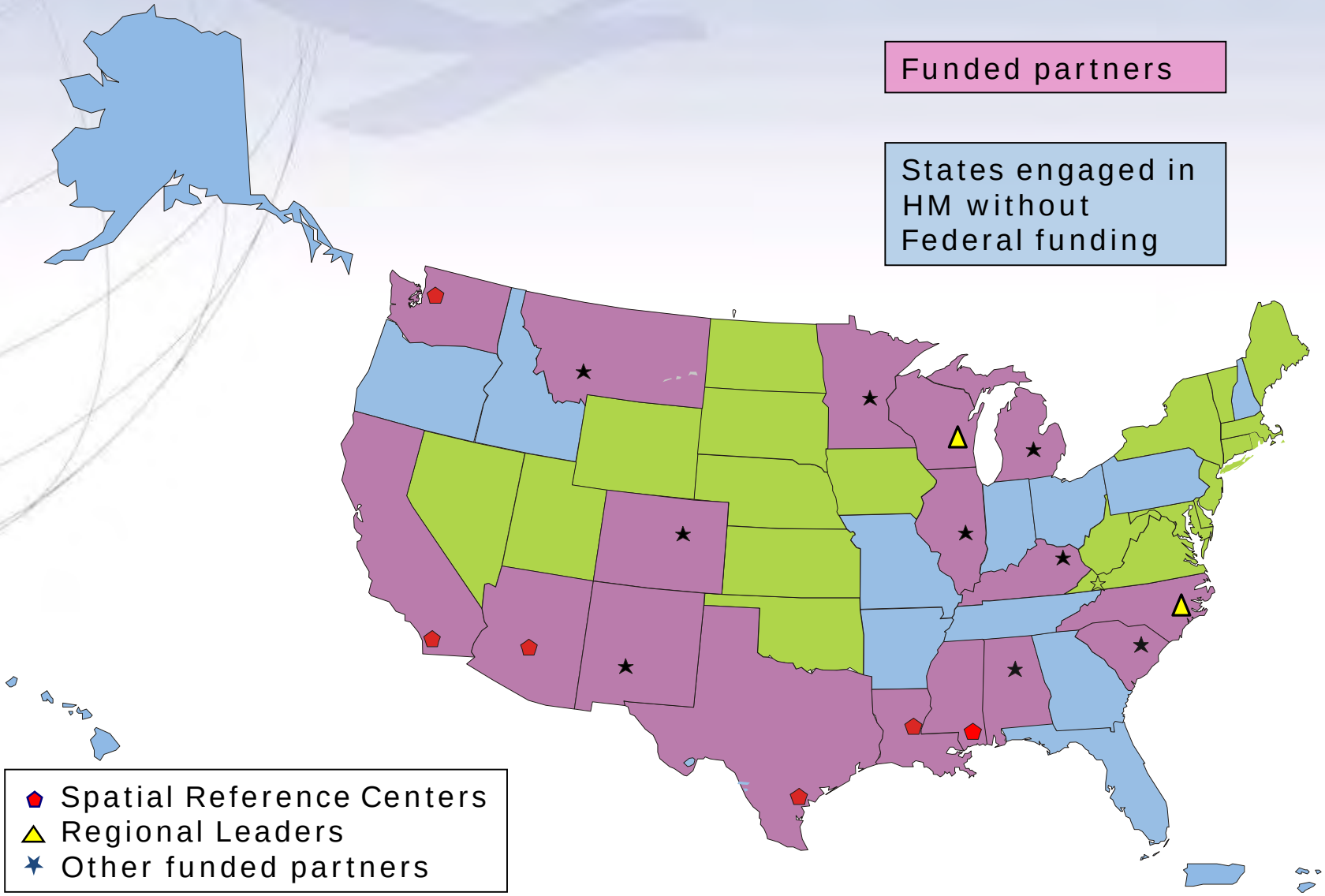
National Height Modernization Program

…the establishment of *accurate, reliable heights using GNSS technology* in conjunction with traditional leveling, gravity, and modern remote sensing information…

-propagation and long-term monitoring of control thru static GPS campaigns, GPS on BMs, digital leveling

-combined with relative gravity data, lidar, etc.

National Height Modernization Program



National Height Modernization Program

- supports various Federal Programs
  - FEMA Flood Hazard Mapping Program (FIRM, etc.)
  - USACE: Levee & Dam Safety Programs, etc.
- and countless non-Federal programs
- technically still an active program but there have not been any grants in a few years

NGS Overview

Modernizing the NSRS

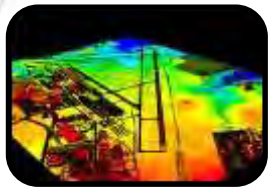

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

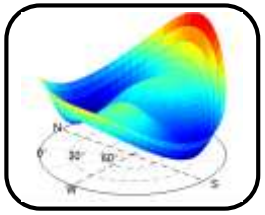

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

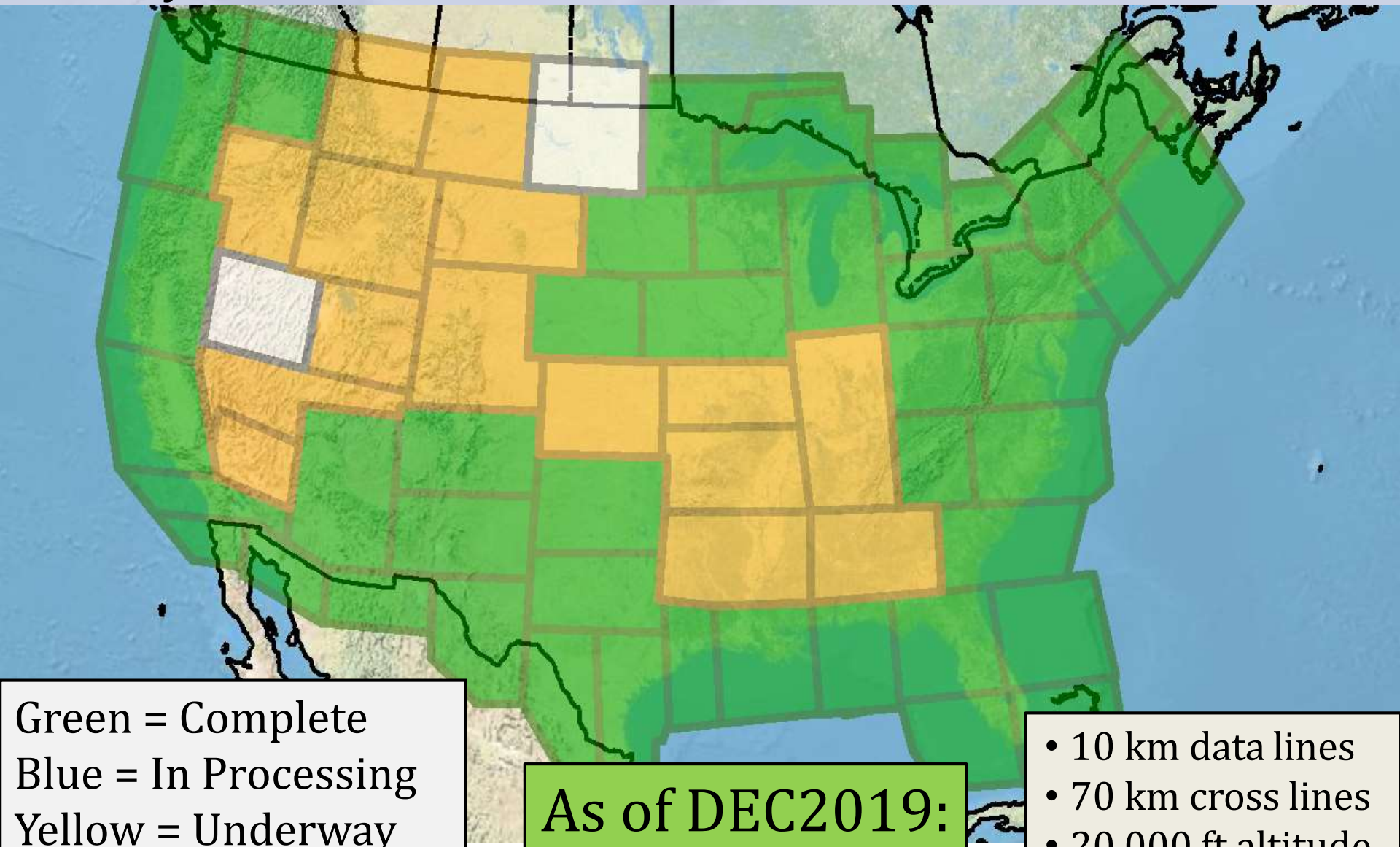
Gravity for the Redefinition of the American Vertical Datum

- Two major campaigns within GRAV-D

1. High-resolution snapshot of gravity
   - primarily airborne observations, all *relative gravity*, estimated cost of ~$39 million

2. Low-resolution "movie" of gravity changes
   - primarily terrestrial, episodic observations of *absolute gravity* sites

Gravity for the Redefinition of the American Vertical Datum



Green = Complete
Blue = In Processing
Yellow = Underway
White = Planned

As of DEC2019:
81% complete

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

Dynamic Aviation's King Air 200T

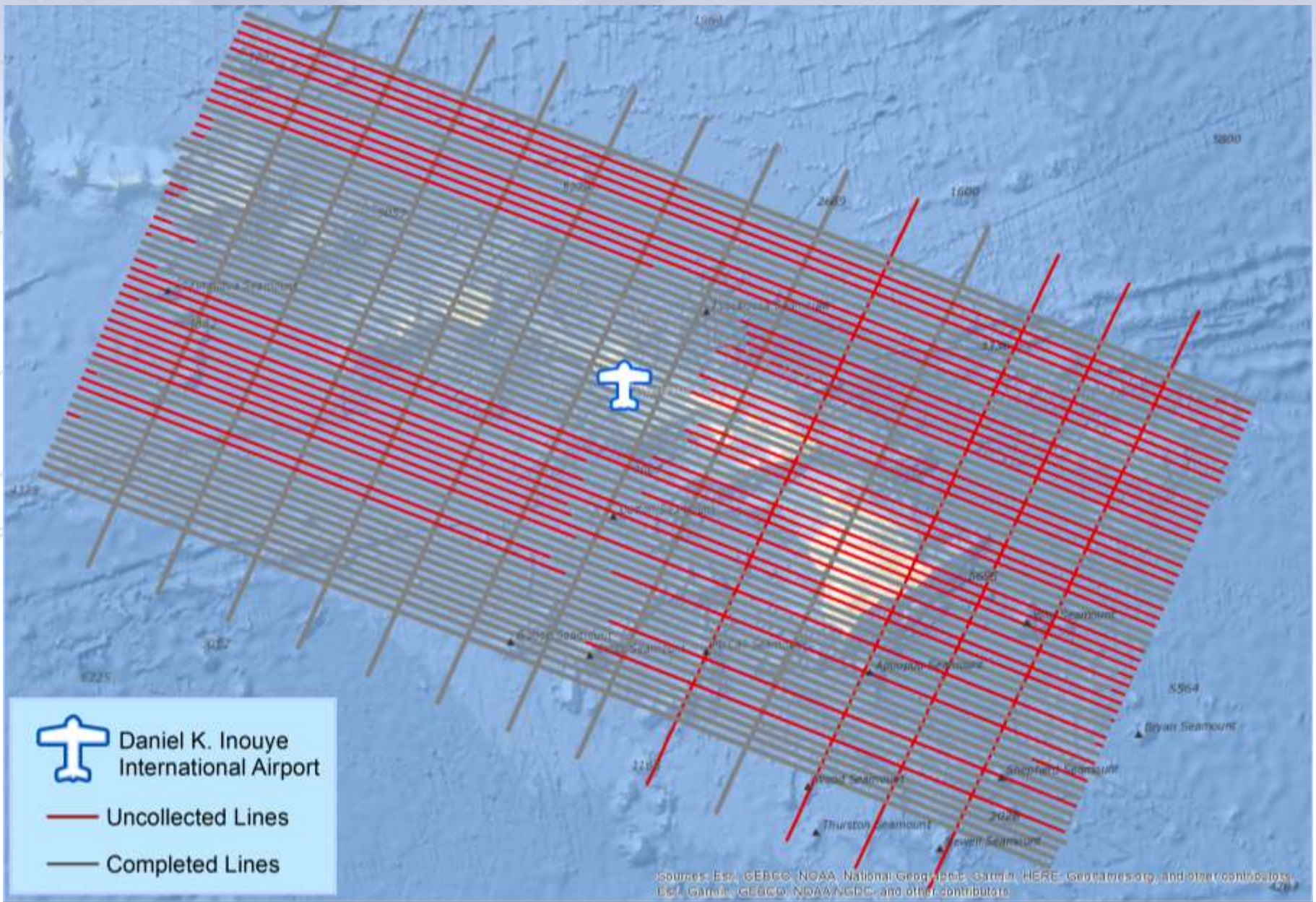

NOAA’s Gulfstream IV-SP

Gravimeters in the Aircraft

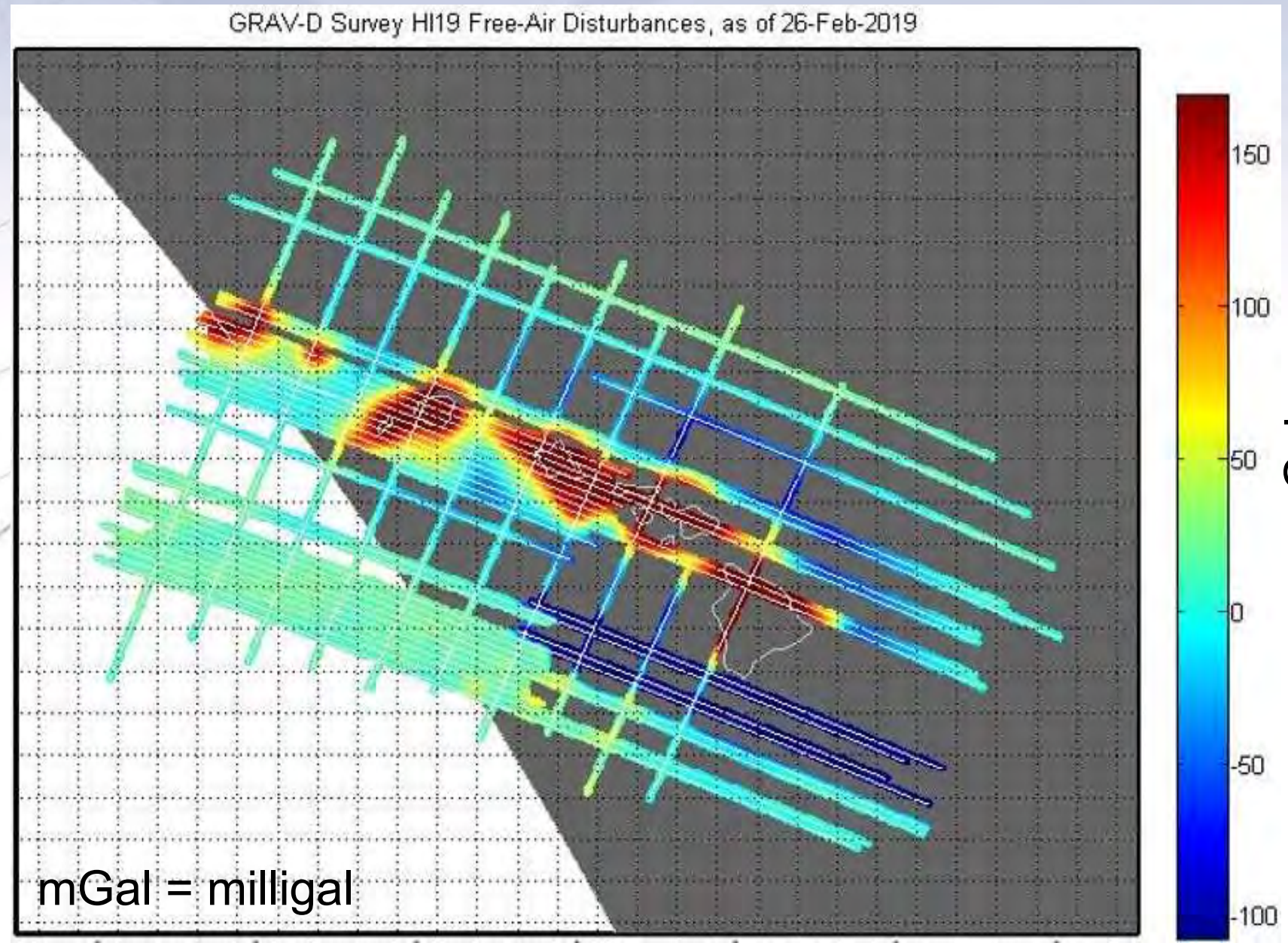
in the
King Air

in the
Gulfstream IV

What does a flight plan look like?



What does processed data look like?



NGS Overview

Modernizing the NSRS

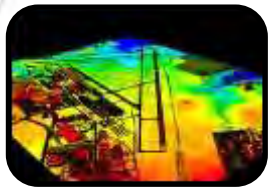

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

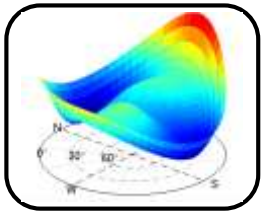

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations

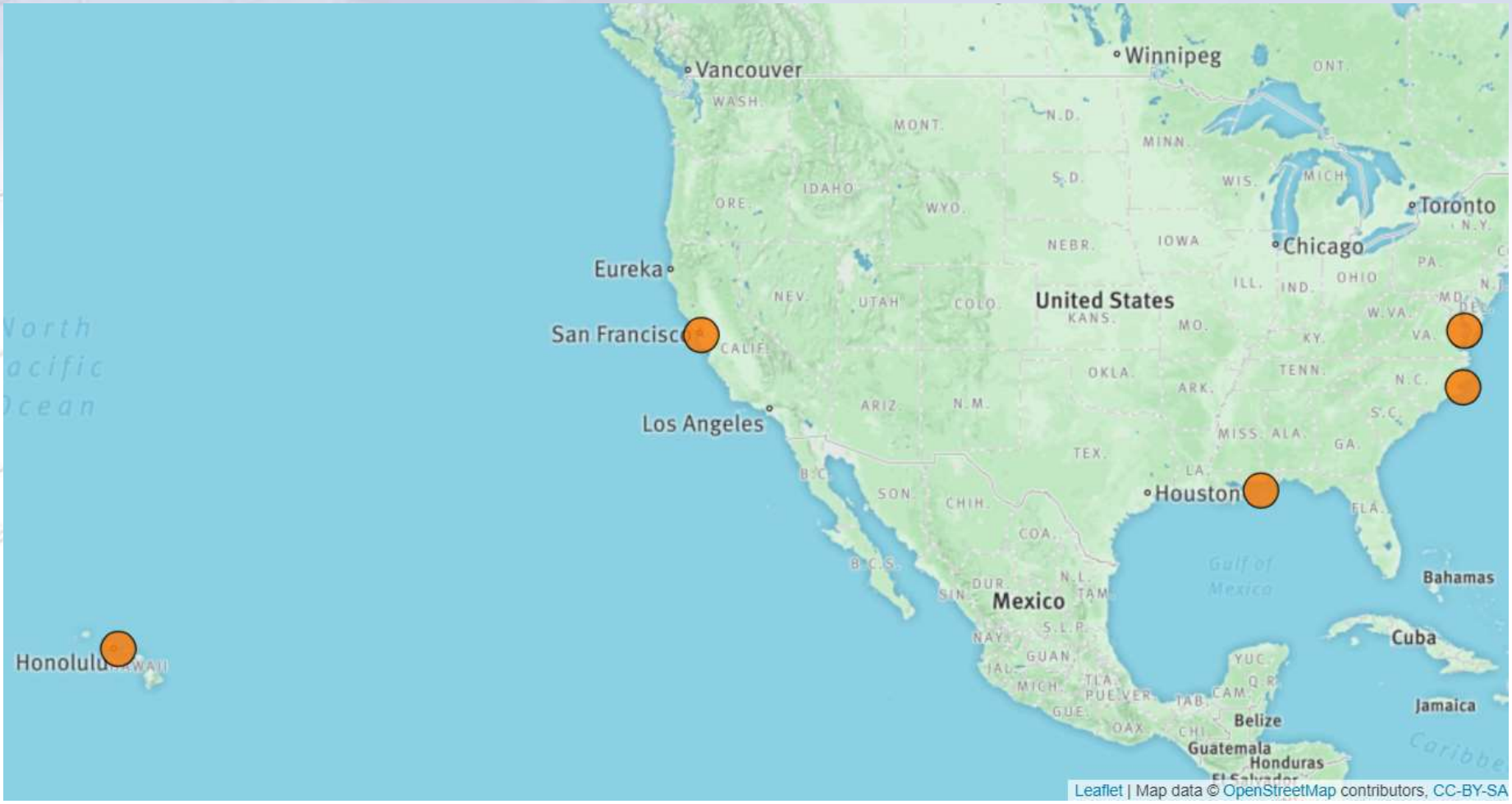

NCAT


CUSP

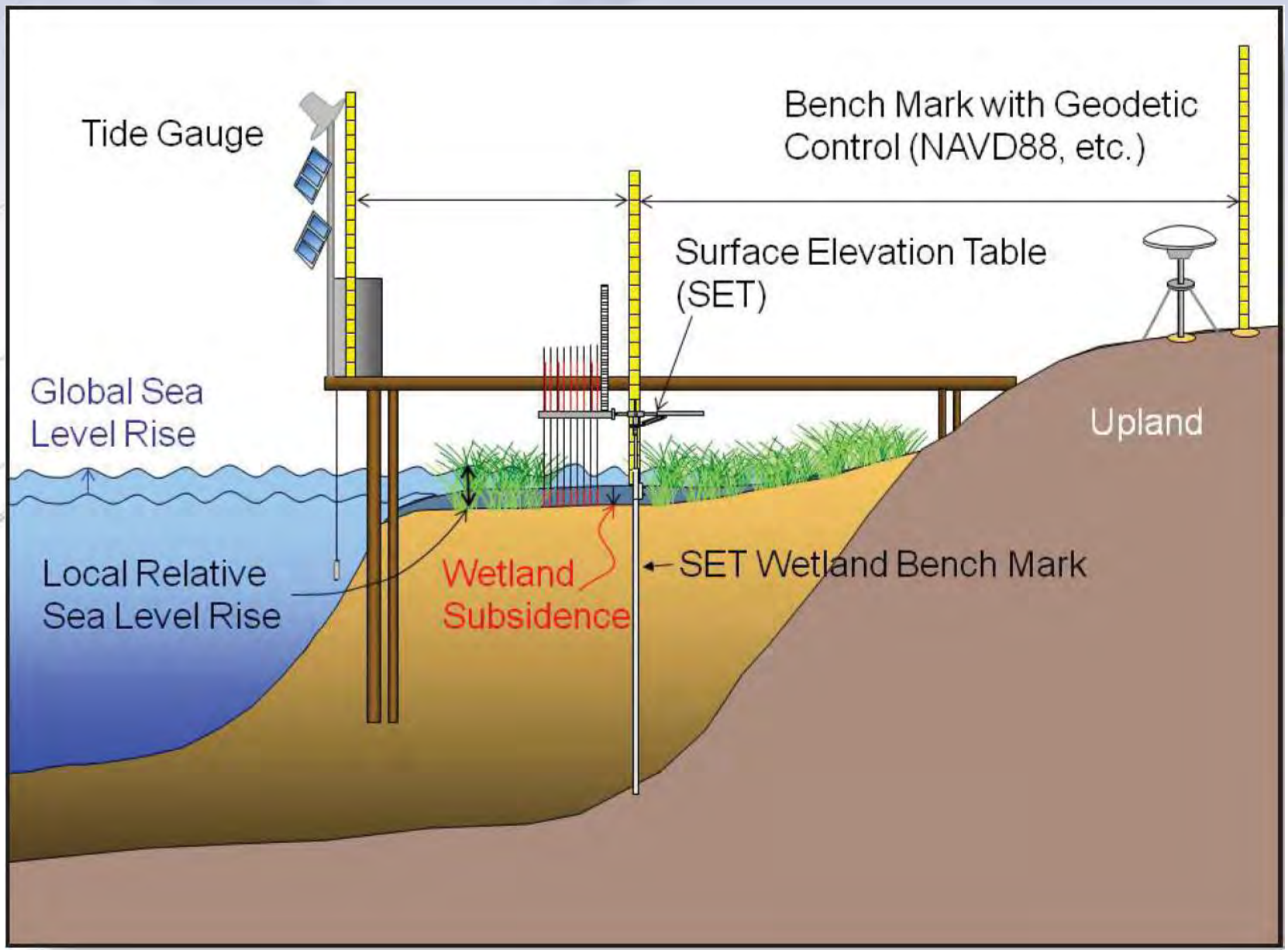

CBL


Outreach

Ecosystem and Climate Operations



Ecosystem and Climate Operations



NGS Overview

Modernizing the NSRS

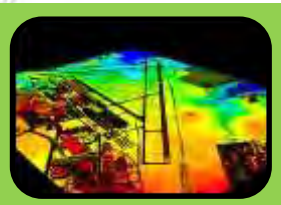

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

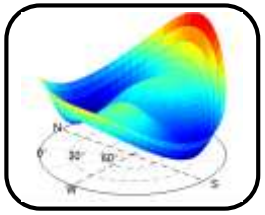

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

Aeronautical Survey Program

- Interagency Program: FAA and NGS
  - Primary Airport Control Station (PACS) and Secondary Airport Control Stations (SACS)
  - Airports GIS (AGIS)
  - Airport Obstruction Charts (AOC)

- Primary function of NGS is to serve as QA and subject-matter expert for ASP surveys that are contracted by airports

NGS Overview

Modernizing the NSRS

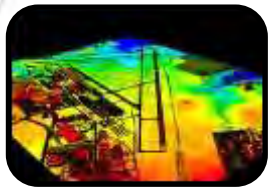

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

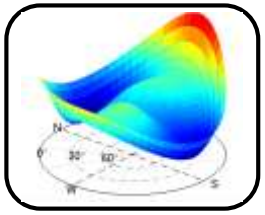

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

Online Positioning User Service

OPUS Rapid Static (OPUS-RS)

- dual frequency receiver data
- static sessions only
- 30 seconds epoch rate (aka recording interval)
- 15 minutes to 2 hours of GPS data

OPUS Static (OPUS-S)

- same requirements as above
- 2 to 48 hours of GPS data

OPUS Projects (OP)

- adds session processing and network adjustment
- training by NGS required; typically 12 hours
- files uploaded to OPUS with a "Project ID" keyed in Options

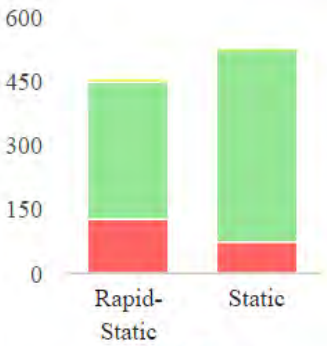
Beta OPUS Projects (BOP)

- enhancements and added features

a note on OPUS "my profile"

projects
shared solutions

support / feedback



OPUS Today
as of 2019-02-05T16:00 EST

antenna - choosing wrong may degrade your accuracy.

2.000 *meters above your mark.*
antenna height of your antenna's reference point.

jeff.jalbrzikowski@noaa.gov
* **email address** - your solution will be sent here. **Privacy Act Statement**

Options to **customize** your solution.

formats standard ▾ **formats explained**

base stations **Use:** **Exclude:** identify any CORS you wish to explicitly include or exclude from your solution by typing in 4-char site IDs separated with line break
-- **sample**
-- **find site IDs**

state plane let OPUS choose ▾ your **SPCS zone**

project identifier enter the id provided by your project manager

my profile customize OPUS defaults for future solutions

share my solution No, don't share ▾ **sharing explained**

be careful!

Upload to Rapid-Static for data 15 min. - 2 hrs.

Upload to Static for data 2 hrs. - 48 hrs.

NGS Overview

Modernizing the NSRS

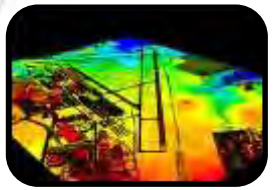

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

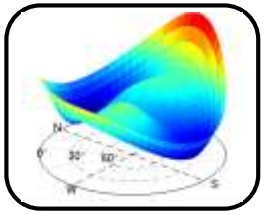

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

GPS Orbit Data aka Ephemerides

- NGS orbit analysis and computation is performed together with, and as a component of, the International GNSS Service (IGS)
  - IGS coordinates the collection of satellite tracking data
  - these orbits are what give us post-processed accuracy
- Designated with this responsibility by the Civil GPS Service Interface Committee (CGSIC)
- If you're using OPUS, it's all behind-the-curtain!

.sp3 file

```
#cP2019  2  2  0  0  0.00000000      96 ORBIT IGS14 HLM  IGS
## 2038 518400.00000000   900.00000000 58516 0.0000000000000
+   32   G01G02G03G04G05G06G07G08G09G10G11G12G13G14G15G16G17
+        G18G19G20G21G22G23G24G25G26G27G28G29G30G31G32  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         2  2  2  0  2  2  2  2  2  2  2  2  2  2  2  2  2
++         2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
%c G  cc GPS ccc cccc cccc cccc cccc cccc cccc cccc cccc
%c cc cc ccc ccc cccc cccc cccc cccc cccc cccc cccc cccc
%f  1.2500000  1.025000000  0.00000000000  0.000000000000000
%f  0.0000000  0.000000000  0.00000000000  0.000000000000000
%i    0    0    0    0      0      0      0      0         0
%i    0    0    0    0      0      0      0      0         0
/* RAPID ORBIT COMBINATION FROM WEIGHTED AVERAGE OF:
/* cod emr esa gfz jpl ngs sio usn whu
/* REFERENCED TO IGS TIME (IGST) AND TO WEIGHTED MEAN POLE:
/* PCV:IGS14_2038 OL/AL:FES2004  NONE     Y  ORB:CMB CLK:CMB
*  2019  2  2  0  0  0.00000000
PG01  13437.349428 -22533.825195  -3020.021023   -155.699413  6  5  8 101
PG02 -18700.020078   8840.721941 -15952.780514   -128.881387 10  6  8 135
PG03  10767.110381 -13273.460770 -20347.578363    180.785610  8  6  6 104
PG04 -10449.506966 -24418.091054    -82.323706 999999.999999
PG05 -25719.091844   2911.653438   6293.176799      0.986391 10  8  7 118
PG06 -14819.885392  -4360.519946 -21567.819154    284.674426  8 10  6 121
PG07   1980.265085 -21420.080954  15511.265473     40.501514  8  6  7 110
PG08  10678.202262 -11598.467946  21394.467487   -131.229325  6  4  5 123
PG09  -6792.912765 -24820.891566  -6606.064077    464.192431  9  7  9  81
PG10  19816.960585  11312.638749  13803.908016    124.876183  4  7  8 107
PG11   9453.366960 -23878.546071   6683.833134   -666.681330  8  7 10 125
PG12 -13617.007336  11308.890190 -19943.335351    271.455927  6  7  3 117
PG13 -14747.539817   3103.603089  21753.246530    -76.304745  6  9  6 106
PG14  16674.543333  13311.867074 -15626.715466    -92.154310 10  8  7  76
PG15  -8687.635927  14768.504077  19946.620585   -329.712456  7  8  7 117
```

Link to NGS GPS Calendar

NGS Overview

Modernizing the NSRS

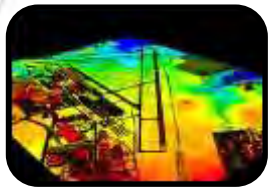

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

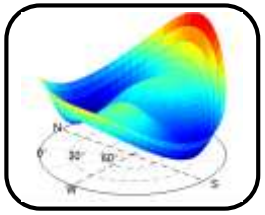

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI

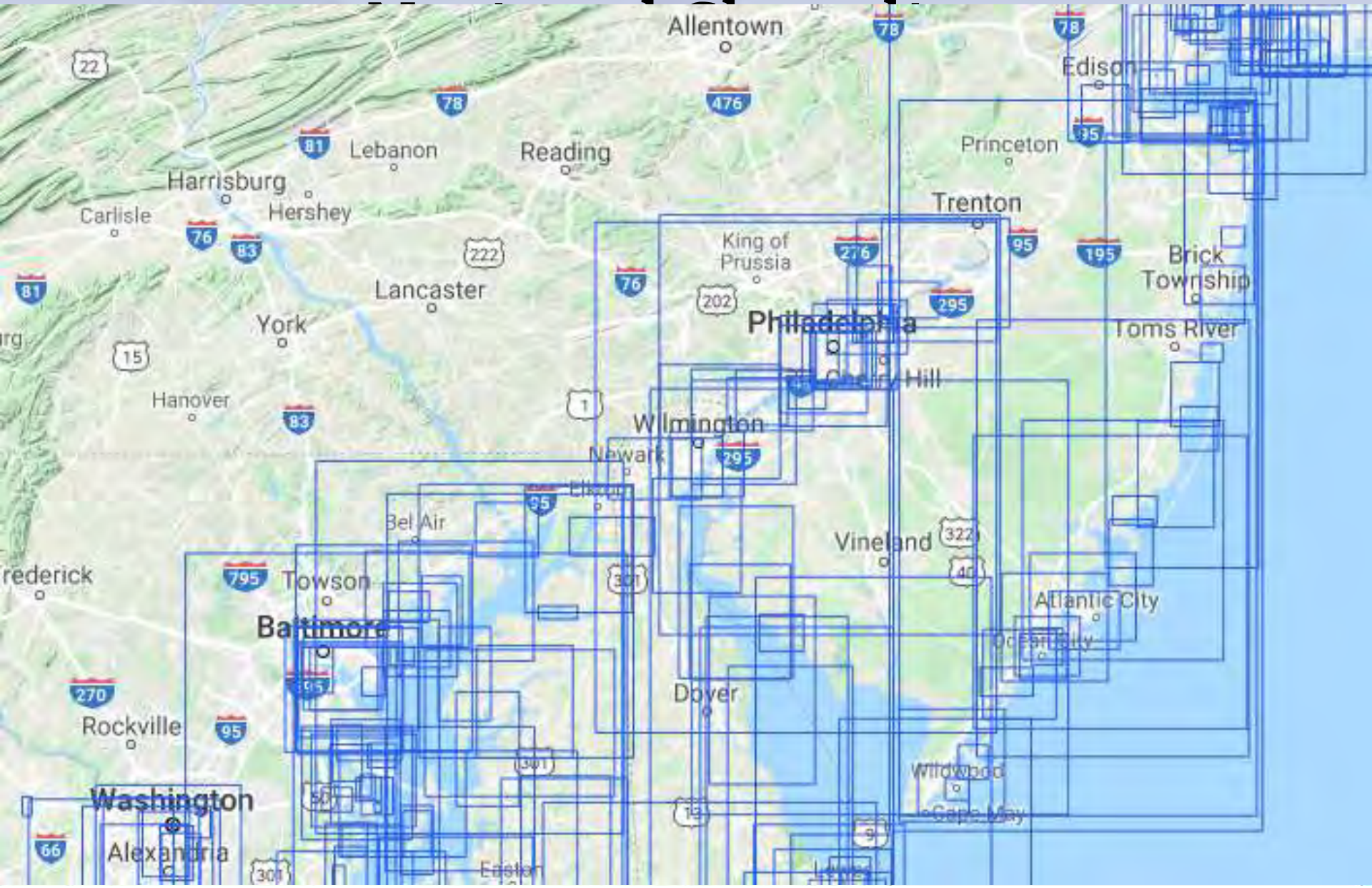

Antenna Calibrations


NCAT


CUSP


CBL


Outreach



hyperlink to the National Shoreline homepage

NGS Overview

Modernizing the NSRS

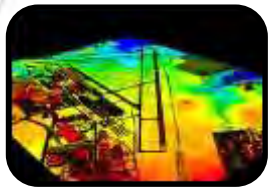

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

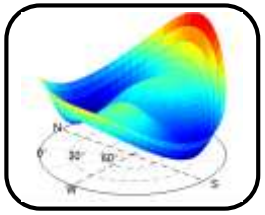

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

https://www.ngs.noaa.gov/ADVISORS/

Regional Geodetic Advisor Program

- www.ngs.noaa.gov/ADVISORS/
- query any major search engine: "ngs advisors"

Appalachian

(KY, OH, PA, and WV)

Jeff Jalbrzikowski, NOAA, P.S., GISP
NOAA/NOS/National Geodetic Survey
125 South Oval Mall
318 Mendenhall Lab
Columbus, OH 43228
Mobile: (240) 988-5486
jeff.jalbrzikowski@noaa.gov

State Geodetic Coordinators

- Not an NGS employee
- Serves as a liaison between the State's geospatial community and the NGS
- Brian Naberezny over at PSU
- Are you in here Brian?

Pennsylvania

Brian J. Naberezny, PLS, GISP
Instructor of Surveying
Department of Civil and Environmental Engineering
The Pennsylvania State University
223A Sackett
University Park, PA 16802
Phone: (814) 865-9433

bjn108@psu.edu

NGS Overview

Modernizing the NSRS

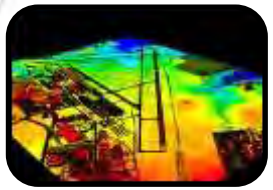

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

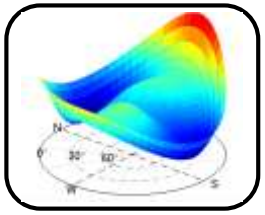

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

Emergency Response Imagery

- Mission of our Remote Sensing Division
- Pre-Storm and Post-Storm photos are taken mostly along the coastal CONUS, and some other disasters natural or human
- Supports Dept. of Homeland Security (DHS) and other emergency management organizations (FEMA, State, local, etc.)

Emergency Response Imagery

NGS Overview

Modernizing the NSRS

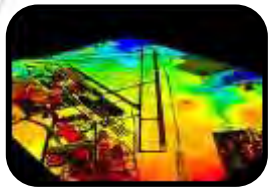

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

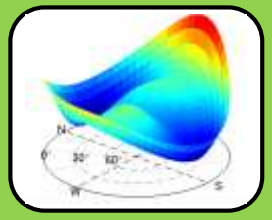

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT

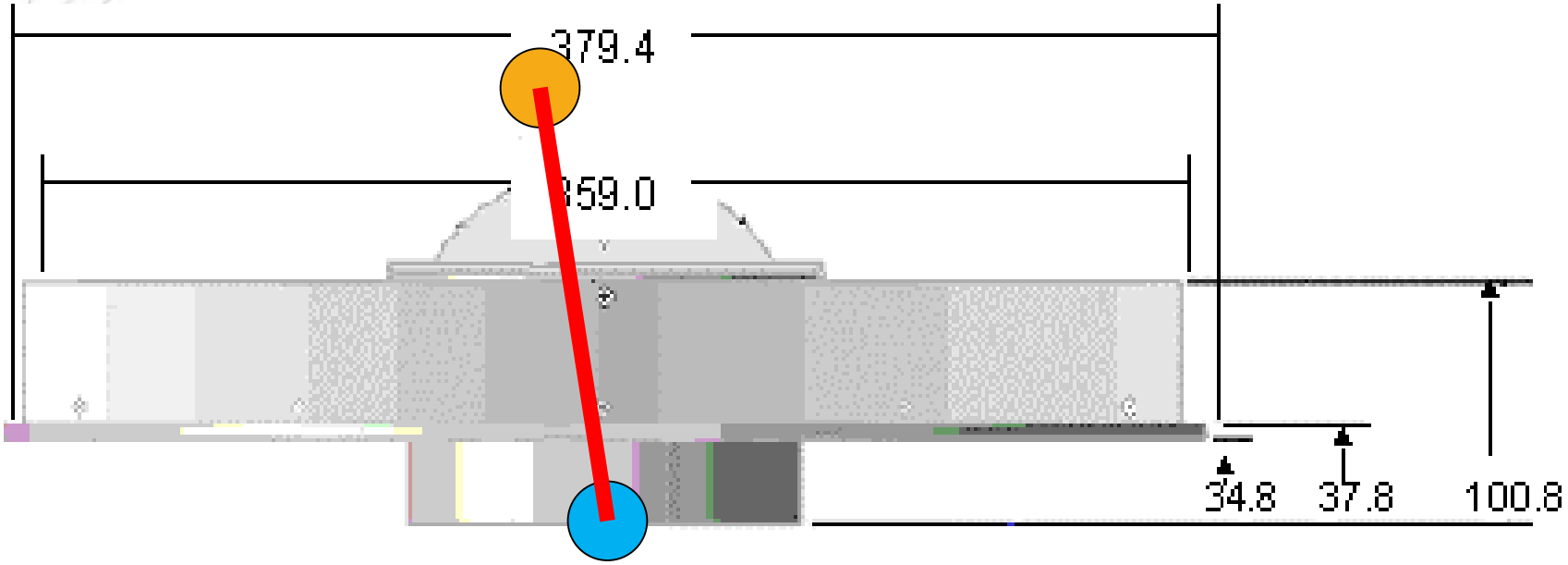

CUSP


CBL


Outreach

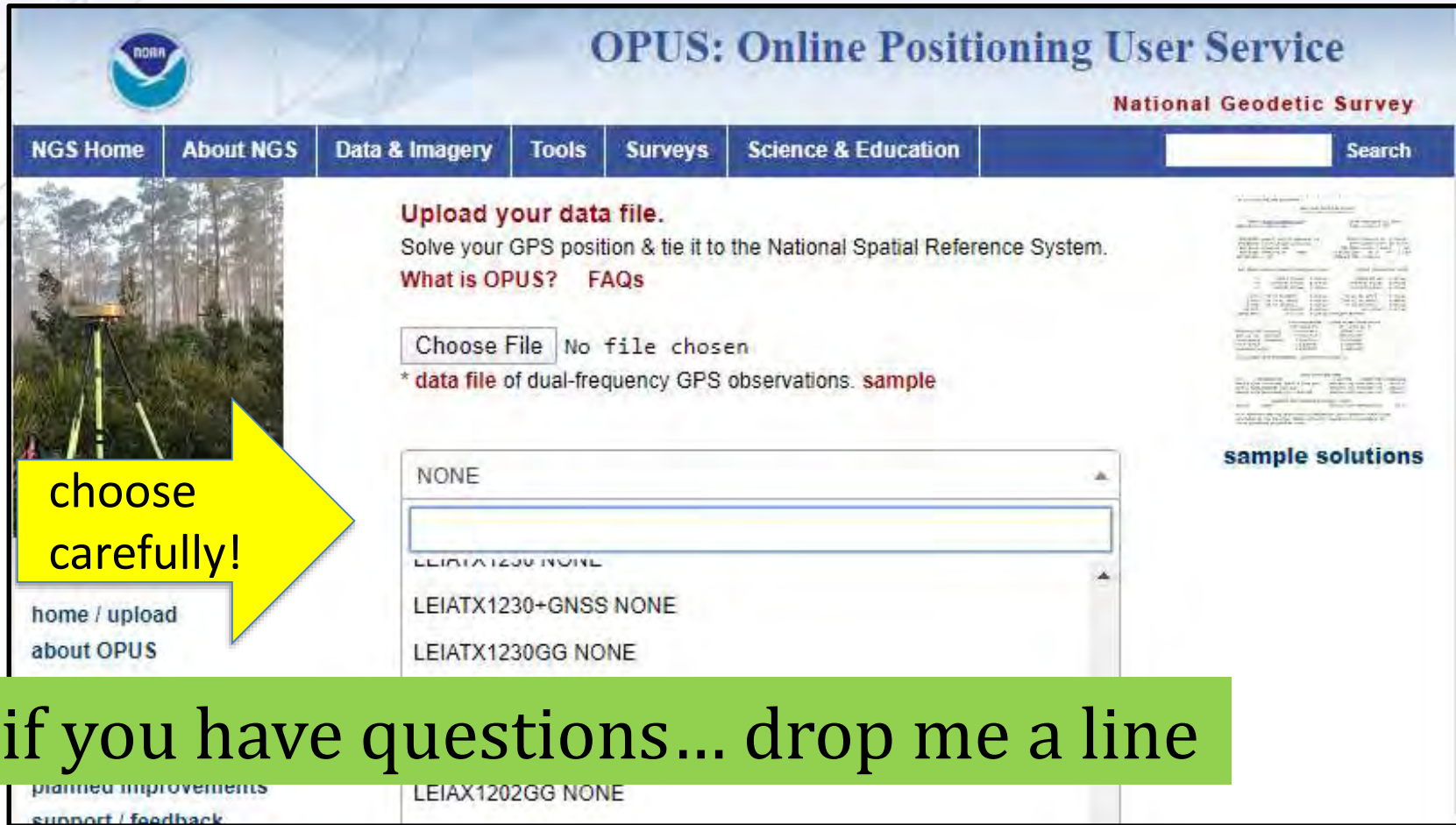
Phase Center Offset - *conceptual*

- **Orange dot** = mean point of signal reception
- **Blue dot** = Antenna Reference Point (ARP)
- **Red line** = Phase Center Offset (PCO)



Phase Center Offset

- The PCO is one reason it is important to select the correct antenna for OPUS upload!



NGS Overview

Modernizing the NSRS

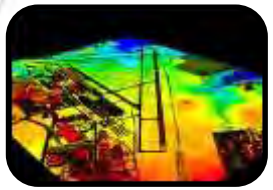

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

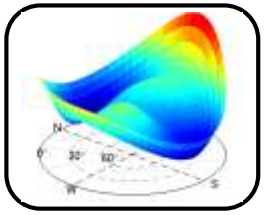

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI

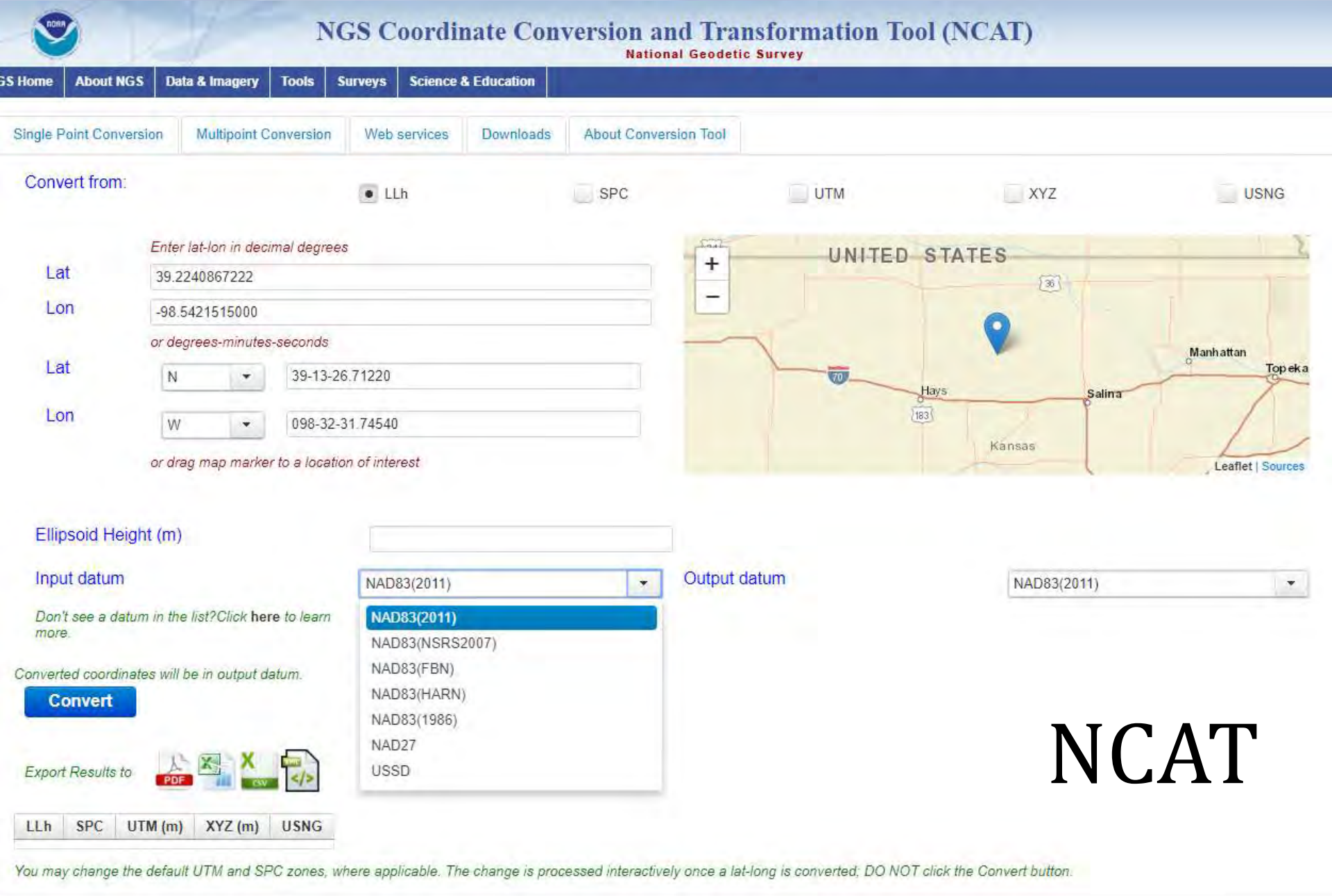

Antenna Calibrations


NCAT


CUSP

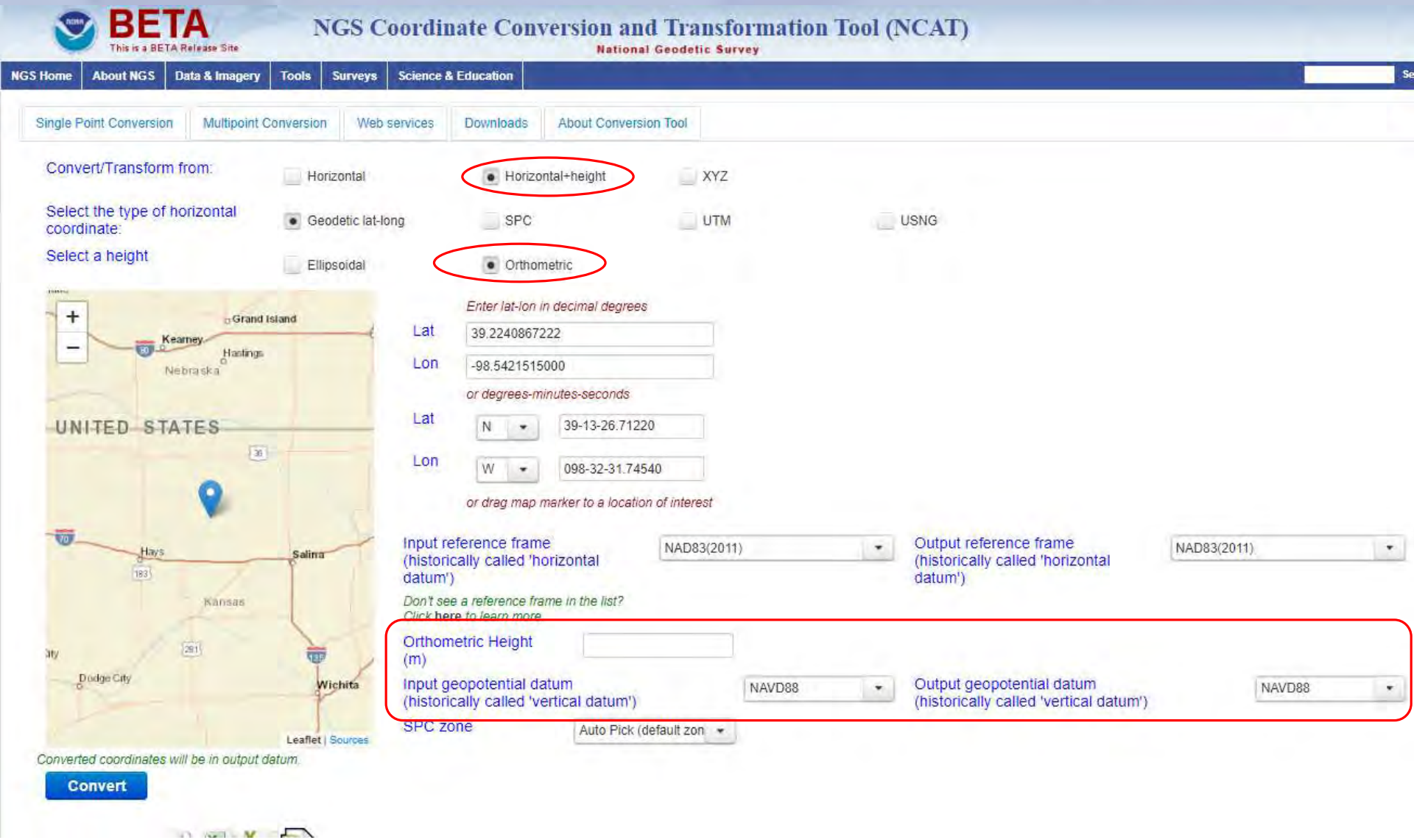

CBL


Outreach



NCAT

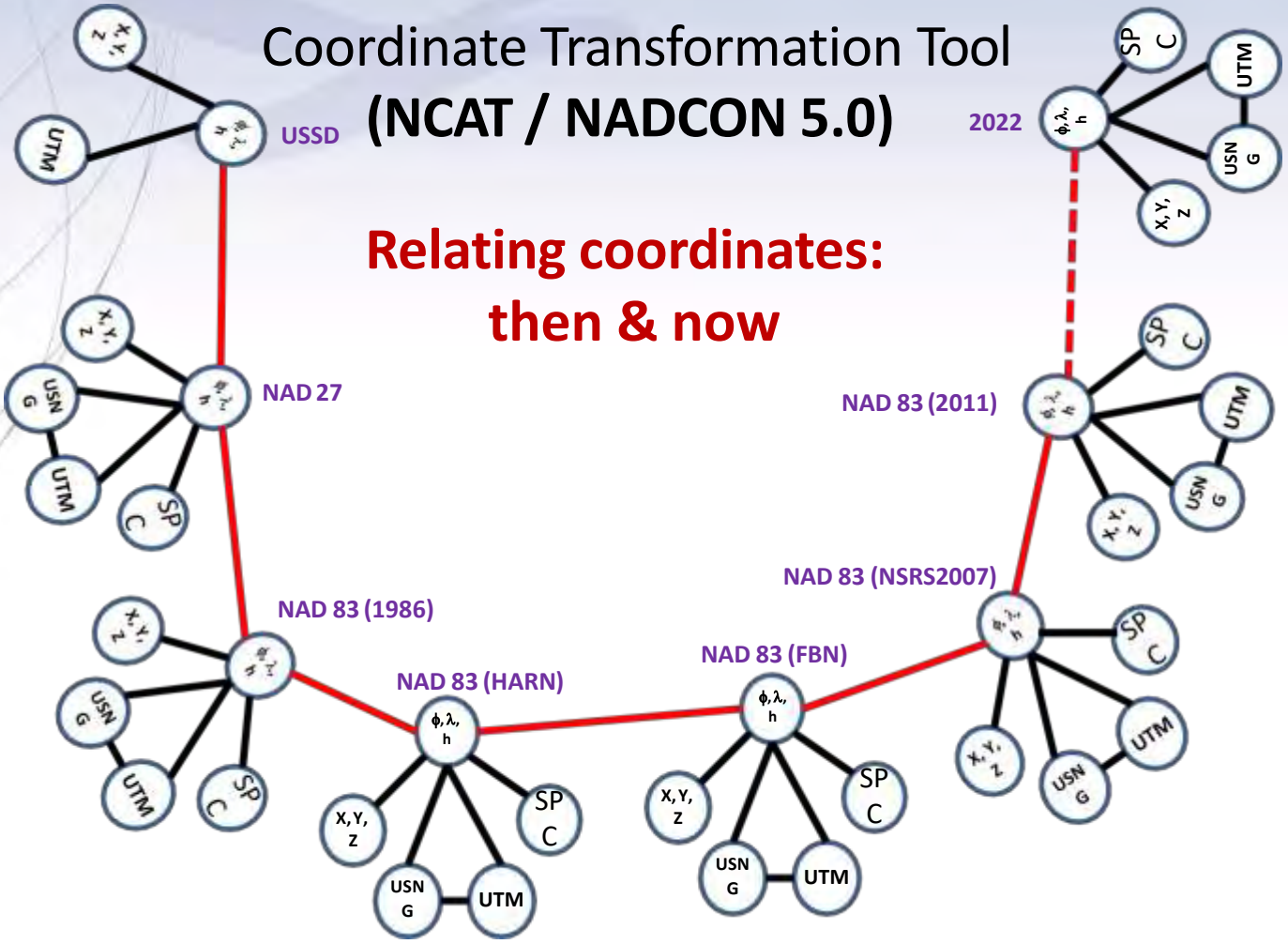
NGS Coordinate Conversion and Transformation Tool



Beta NCAT – includes VERTCON 3.0 for NGVD29 to NAVD88 transformation

Coordinate Transformation Tool
(NCAT / NADCON 5.0)

Relating coordinates: then & now



NGS Overview

Modernizing the NSRS

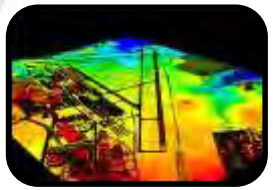

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

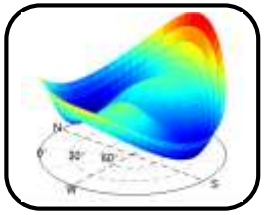

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

Co ct

hyperlink

NGS Overview

Modernizing the NSRS

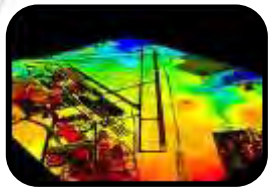

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

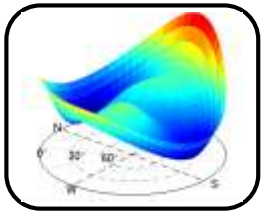

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL

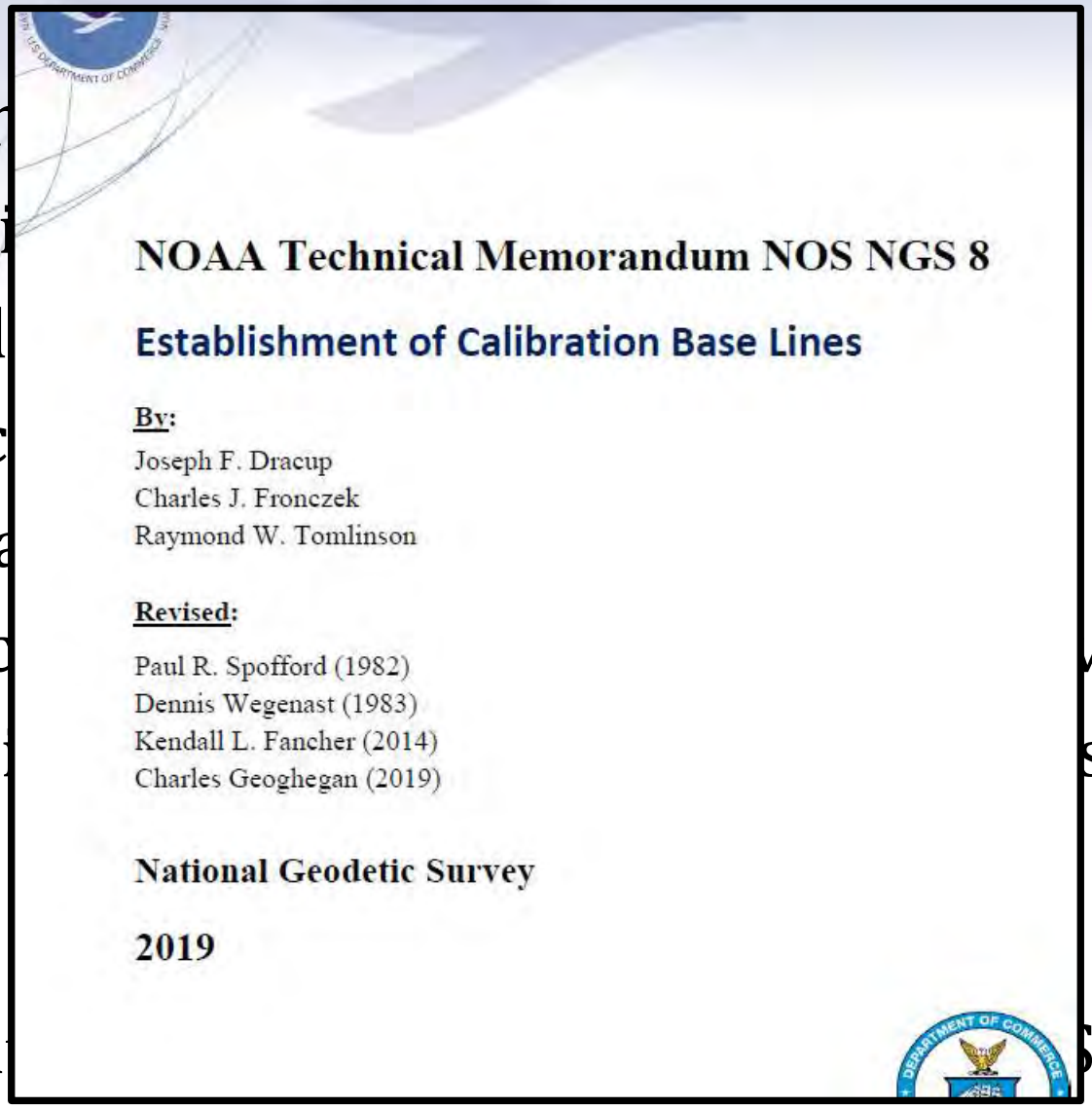

Outreach

Calibration Base Lines - CBL

- Three types of CBL defined by NGS
  - **Primary** CBL (**PCBL**): in Woodford, VA at NGS TTC; it is open for use to organizations like the PLSO
  - **Federal** CBL (**FCBL**): established with EDM checked at the NGS PCBL and IAW NOAA TM NGS-8
    - 8 across Pennsylvania; *1 reported destroyed in Warminster*
  - **Cooperative** CBL (**CCBL**): established with EDM checked on an FCBL and IAW that same NGS-8 manual

Calibration Base Lines - CBL

- NGS cor
  - A mini
  - Establ
  - Public
  - Softwa
  - Verific
  - Techni



NOAA Technical Memorandum NOS NGS 8

Establishment of Calibration Base Lines

By:
Joseph F. Dracup
Charles J. Fronczek
Raymond W. Tomlinson

Revised:
Paul R. Spofford (1982)
Dennis Wegenast (1983)
Kendall L. Fancher (2014)
Charles Geoghegan (2019)

National Geodetic Survey

2019

view

sonnel)

h S/

CBL Datasheets

STATE OF PENNSYLVANIA
CONTENTS

BASE LINE DESIGNATION	STATE	COUNTY	QUAD
BUTLER	PENNSYLVANIA	BUTLER	N400794
DALTON (DESTROYED)	PENNSYLVANIA	LACKAWANNA	N410754
HARRISBURG CBL (2011 REMEASURED)	PENNSYLVANIA	YORK	N400763
LOCK HAVEN	PENNSYLVANIA	CLINTON	N410772
NOCKAMIXON CBL (1993 REMEASURED)	PENNSYLVANIA	BUCKS	N400752
OGLE	PENNSYLVANIA	SOMERSET	N400783
SPROUL	PENNSYLVANIA	BLAIR	N400782
TITUSVILLE	PENNSYLVANIA	CRAWFORD	N360794
WARMINSTER CBL	PENNSYLVANIA	BUCKS	N400752

US DEPARTMENT OF COMMERCE - NOAA
NOS - NATIONAL GEODETIC SURVEY
ROCKVILLE MD 20852

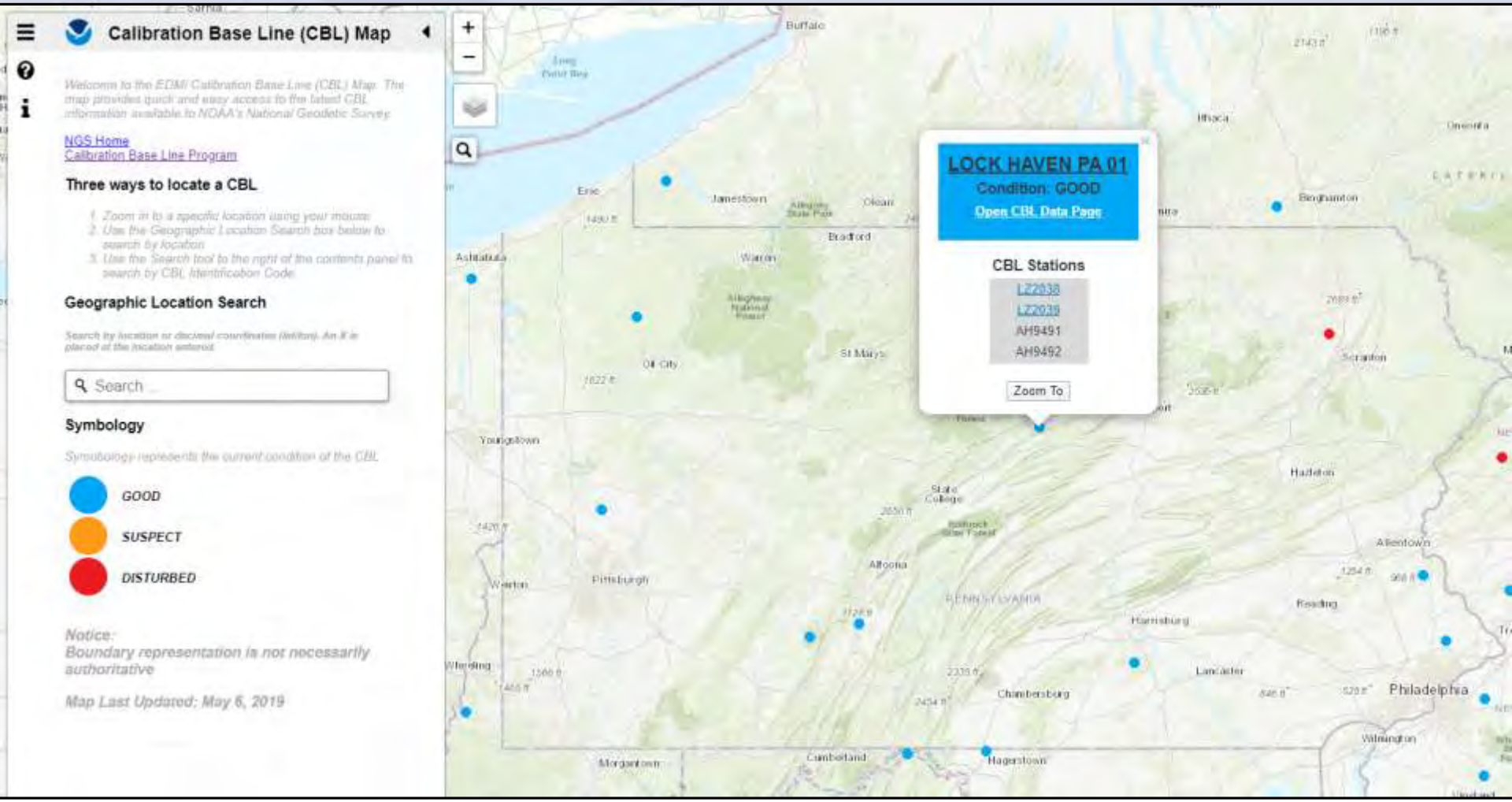
CALIBRATION BASE LINE DATA
BASE LINE DESIGNATION: BUTLER
PROJECT ACCESSION NUMBER: G16309
NEAREST TOWN: BUTLER

QUAD: N400794
PENNSYLVANIA
BUTLER COUNTY

LIST OF ADJUSTED DISTANCES (JULY 29,1987)

FROM STATION	ELEV.(M)	TO STATION	ELEV.(M)	ADJ. DIST.(M) HORIZONTAL	ADJ. DIST.(M) MARK - MARK	STD. ERROR(MM)
0	100.000	150	99.472	149.9983	149.9992	0.1
0	100.000	430	98.712	429.9955	429.9974	0.5
0	100.000	1020	95.424	1019.9890	1019.9993	0.8
150	99.472	430	98.712	279.9972	279.9982	0.5
150	99.472	1020	95.424	869.9908	870.0002	0.7
430	98.712	1020	95.424	589.9936	590.0028	0.5

Beta CBL Map Viewer



https://www.ngs.noaa.gov/CBLINES/

NGS Overview

Modernizing the NSRS

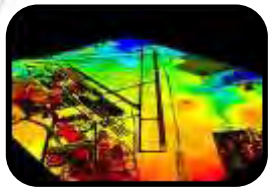

CORS


NHMP


GRAV-D


ECO

NGS Products and Services


ASP


OPUS

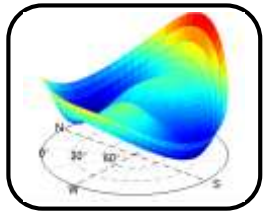

VDatum


Orbit Data


National Shoreline


Geodetic Advisors


ERI


Antenna Calibrations


NCAT


CUSP


CBL


Outreach

Cooperative program for Operational Meteorology, Education, and Training

- Meteorology… why?
- The origin of the program was the National Weather Service, also a NOAA office
- It expanded to various NOAA missions, including NGS

Outreach and COMET

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

NGS Mission

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

National Spatial Reference System (NSRS)

A consistent coordinate system that defines

- latitude
- longitude
- height
- scale
- orientation
- gravity

…and their time variants

throughout the United States.

National Spatial Reference System (NSRS)

These items ARE part of the NSRS

Horizontal Datums (aka Geometric Reference Frames)	Vertical Datums	Great Lakes Datums	Geoid Models	Transformations and Conversions
NAD83	NAVD88	IGLD85	GEOID12A & B	NADCON
NAD27	NGVD29	IGLD55	GEOID09	VERTCON
USSD	VIVD09		GEOID06	
	GUVD04		GEOID03	SPCS83
	NMVD03		GEOID99	SPCS27
	ASVD02		GEOID96	
	PRVD02		ALASKA94	
			GEOID93	
			GEOID90	

~~National Spatial Reference System (NSRS)~~

These items are NOT part of the NSRS

Horizontal Datums (aka Geometric Reference Frames)	Vertical Datums	Geoid Models	Transformations and Conversions
WGS84	IHRS (by IAG)	OSU91A	CORPSCON
WGS72		EGM96	Appendix B.6 of DMA TR 8350.2 (WGS 84)
ITRF (Intl. Terrestrial Reference Frame by IERS)		EGM2008	Oregon Coordinate Reference System (ORCS)
IGS (Intl. GNSS Service reference frame)			The Kansas Regional Coordinate System

Hyperlink to ITRF station map

NSRS … do I have

- OMB Circular A-16

Hyperlink to NAVD88 FRN Hyperlink to NAD83 FRN

NSRS … do I have to use it?

- Not necessarily, but it's a great idea!
- States may mandate use (not Pennsylvania)
- All spatial data and GIS activities financed directly or indirectly, in whole or in part, by federal funds are required to be tied to the NSRS
- If you want to get involved in survey contracting with the Federal Government it's a necessity

Not just new datums…

NSRS Modernization

- Replace NAD83 → **Blueprint for 2022, Part 1**
- Replace NAVD88 → **Blueprint for 2022, Part 2**
- Re-invent Bluebooking
- Improve Geodetic Toolkit
- Better Surveying Methods

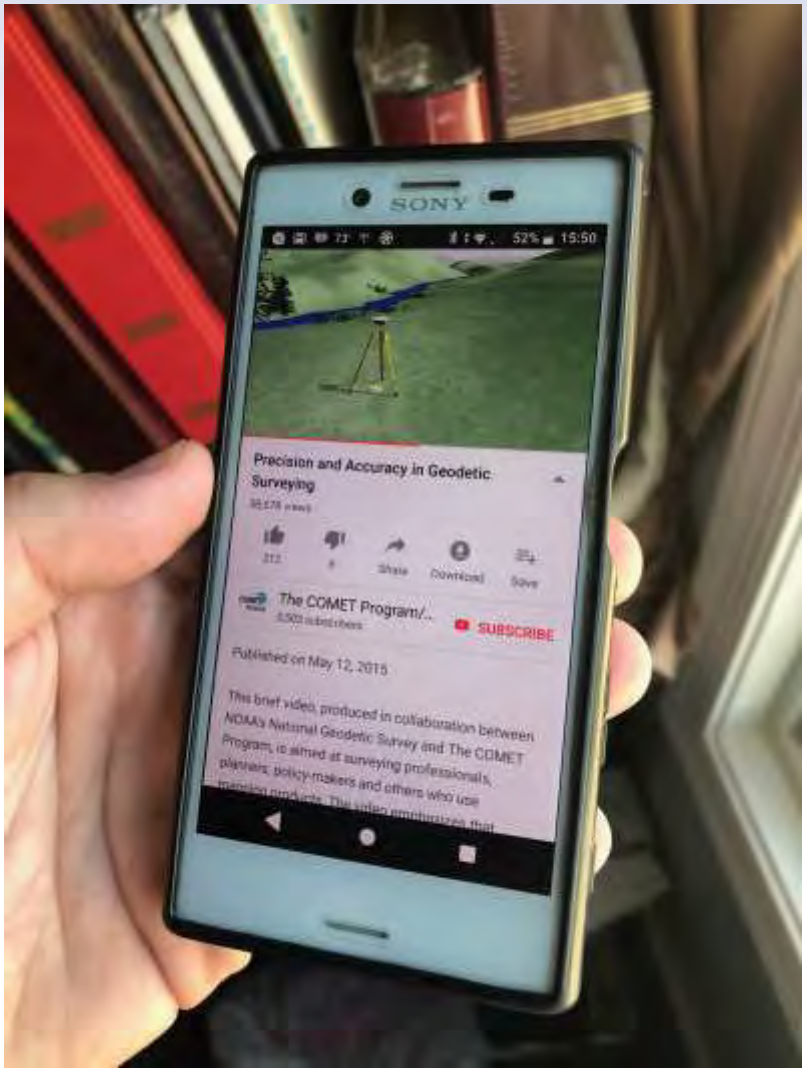
→ **Blueprint for 2022, Part 3**

Evolution of the NSRS

NAD27 → NAD83 (1986) → NAD83 (2011)

Modernized NSRS is our "smartphone"

- You resisted it for a while…
- It was a little cumbersome to get used to…
- But soon you were hooked!



Two Major Components of Modernized NSRS

Geometric (LLh)

Latitude, Longitude, Ellipsoid Height

Geopotential (H)

Orthometric Height

North American Terrestrial Reference Frame of 2022

NATRF2022

(pronounced: nat-ref)

Reference Frame ≈ Datum

- Reference Frame is a more *scientifically appropriate* way of saying "datum"
- could be debated that "datum" was misused
- you will continue to see NGS use the phrase "New Datums" for 2022

Reference Frame Defined

A point of view or a 'frame of reference'.

If your reference frame is North America, you are standing somewhere within North America, **seeing how other places move** from your point of view.

Why replace NAD83?

Main driver: Global Navigation Satellite System (GNSS)

ACCESS

- GNSS equipment is fast, inexpensive, reliable
- Reduces reliance on physical control marks

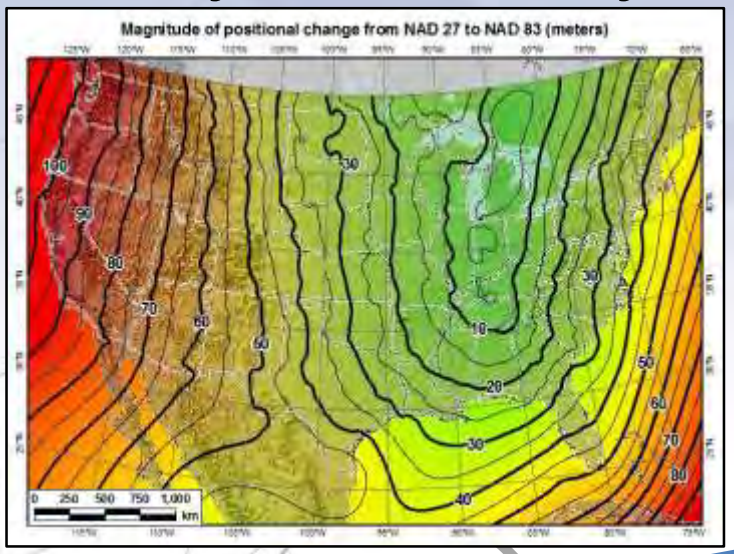
ACCURACY

- Insensitive to distance-dependent errors
- Immune to instability; active control via CORS

CONSISTENCY

- Eliminates systematic errors in current datums
- Aligned with global reference frame

A very brief history of U.S. horizontal & geometric datums



triangulation

GNSS

US Standard Datum

NAD27

NAD83(1986)

NAD83(HARN/199#)

NAD83(2007)

NAD83(2011)

NATRF2022

time

shift

<10 m	tens of meters	few 0.1m	few 0.01m	few 0.01m	~2m

Replacing NAD83

1. develop four "plate-fixed" reference frames
2. remove non-geocentricity of NAD83
3. align to ITRF2014 at epoch 2020.00
4. remove most of tectonic plate rotation from ITRF2014 via Euler Pole Parameters

Shift and Drift…

Replacing NAD83

1. **develop four "plate-fixed" reference frames**
2. remove non-geocentricity of NAD83
3. align to ITRF2014 at epoch 2020.00
4. remove most of tectonic plate rotation from ITRF2014 via Euler Pole Parameters

Shift and Drift…

Four "Plate-Fixed" Reference Frames

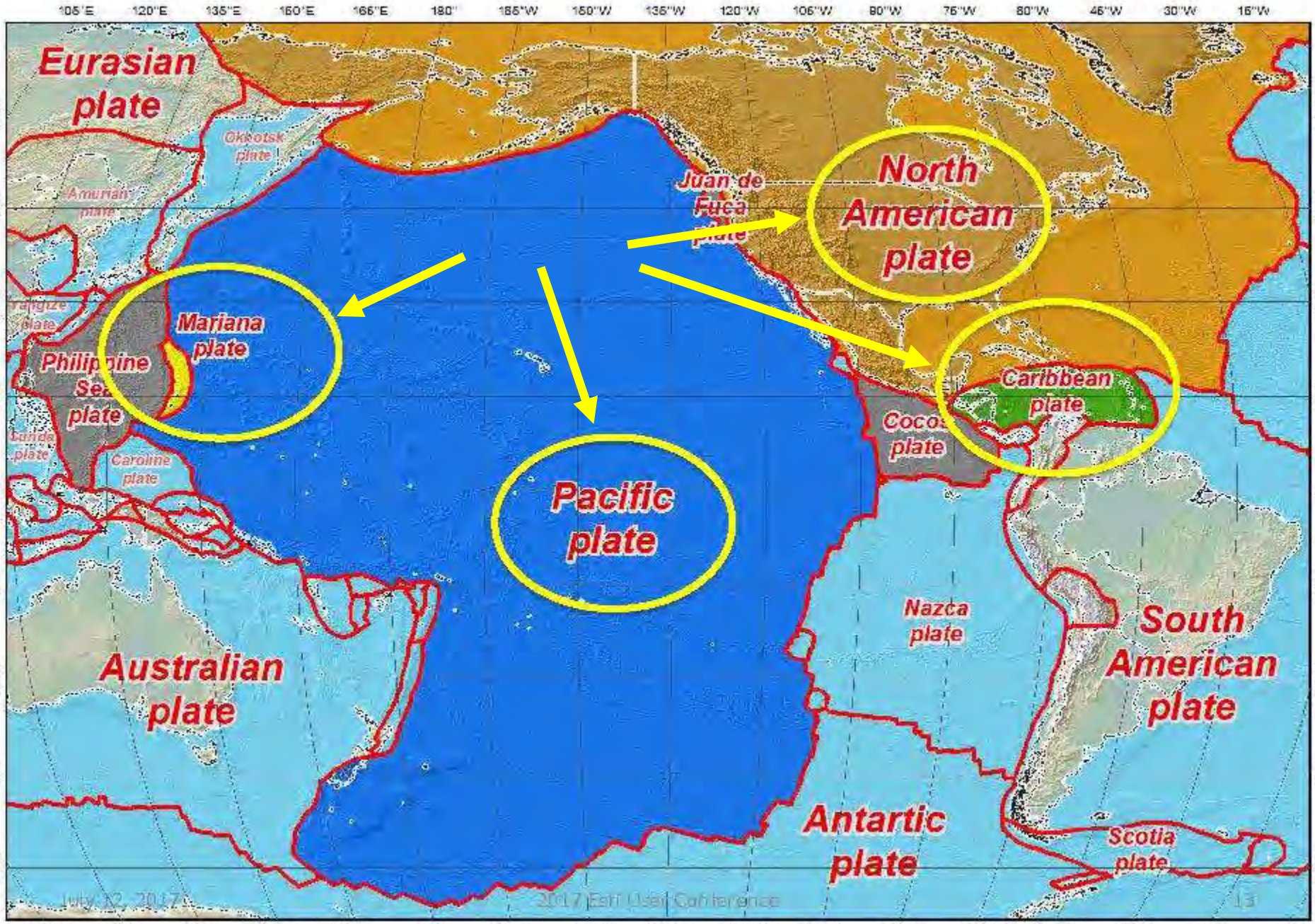
North American Terrestrial Reference Frame of 2022 (NATRF2022)

Pacific Terrestrial Reference Frame of 2022 (PATRF2022)

Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)

Mariana Terrestrial Reference Frame of 2022 (MATRF2022)

The four tectonic plates "fixed" for the 2022 terrestrial reference frames



Four "Plate-Fixed" Reference Frames

North American Terrestrial Reference Frame of 2022 (NATRF2022)

Pacific Terrestrial Reference Frame of 2022 (PATRF2022)

Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)

Mariana Terrestrial Reference Frame of 2022 (MATRF2022)

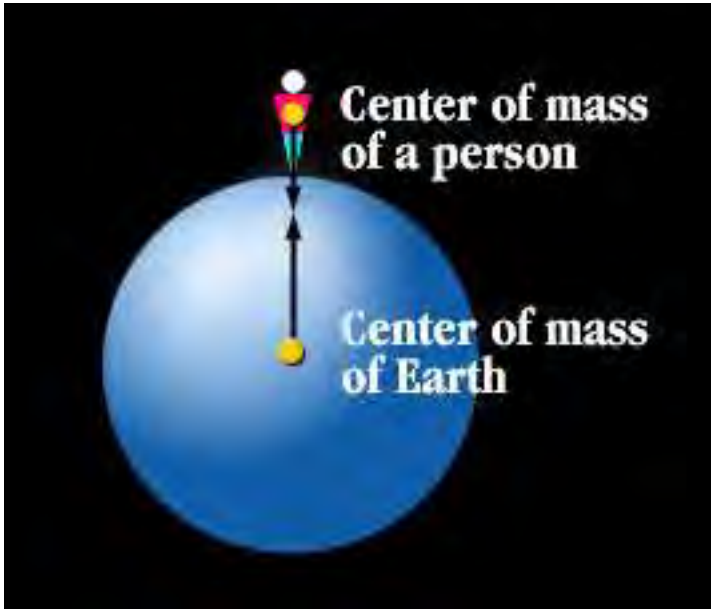
Replacing NAD83

1. develop four "plate-fixed" reference frames
2. **remove non-geocentricity of NAD83**
3. align to ITRF2014 at epoch 2020.00
4. remove most of tectonic plate rotation from ITRF2014 via Euler Pole Parameters

Shift and Drift…

Non-geocentricity?

- Geocentric:
  - relating to, measured from, or as if observed from the earth's center of mass



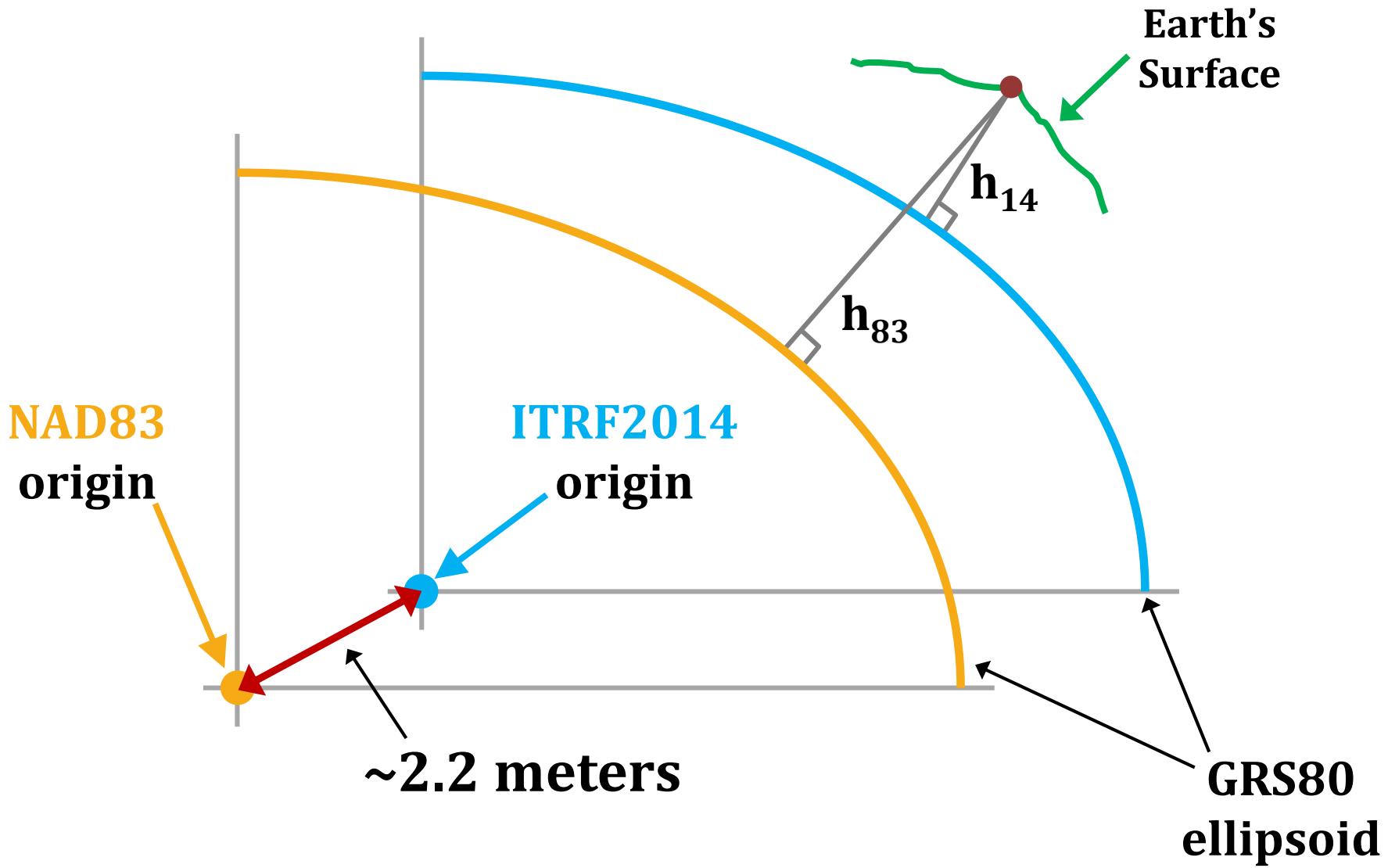
- The goal was to accomplish that… but didn't.

Non-geocentricity of NAD83

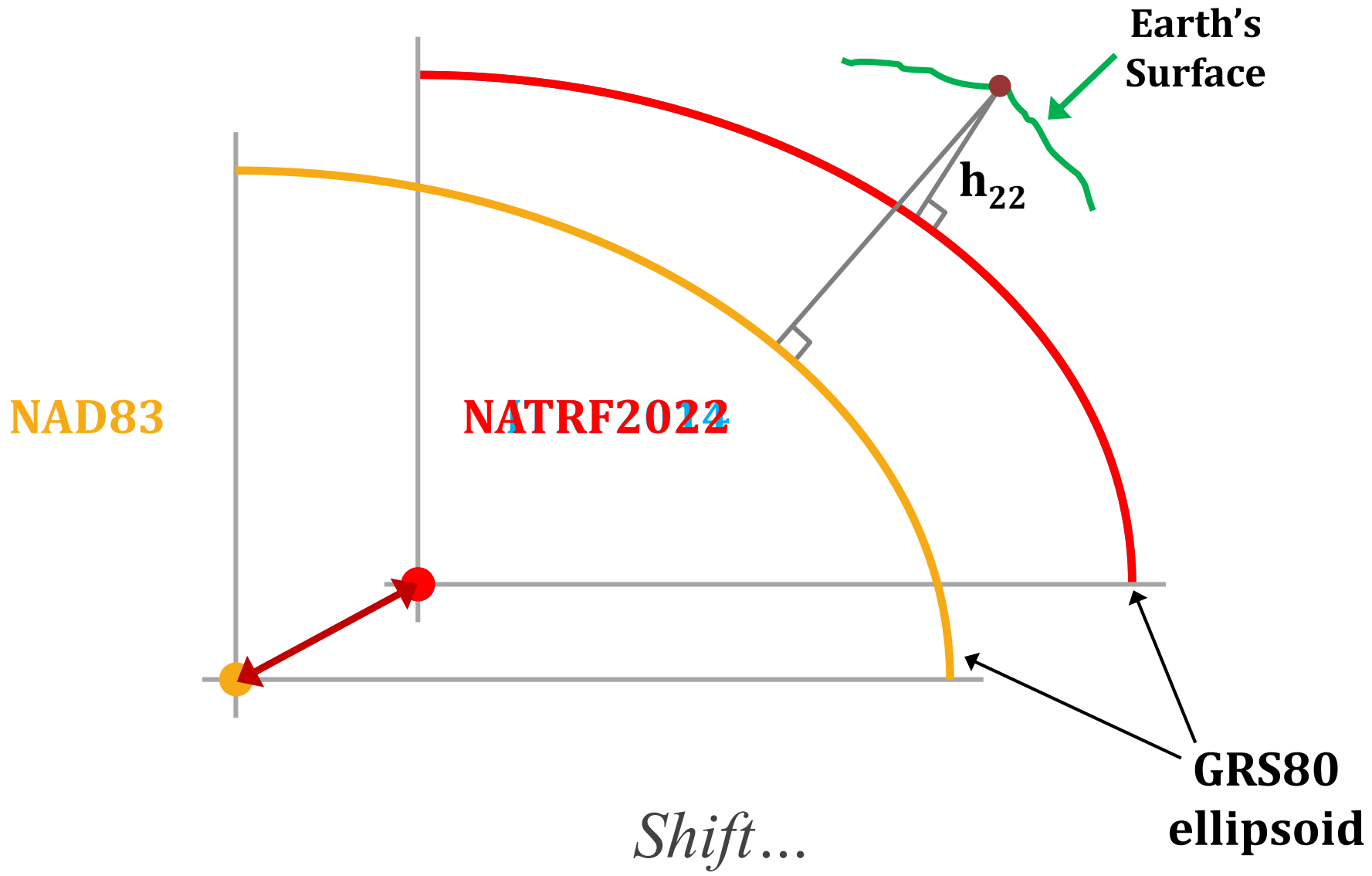
GRS = Geodetic Reference System

Non-geocentricity of NAD83

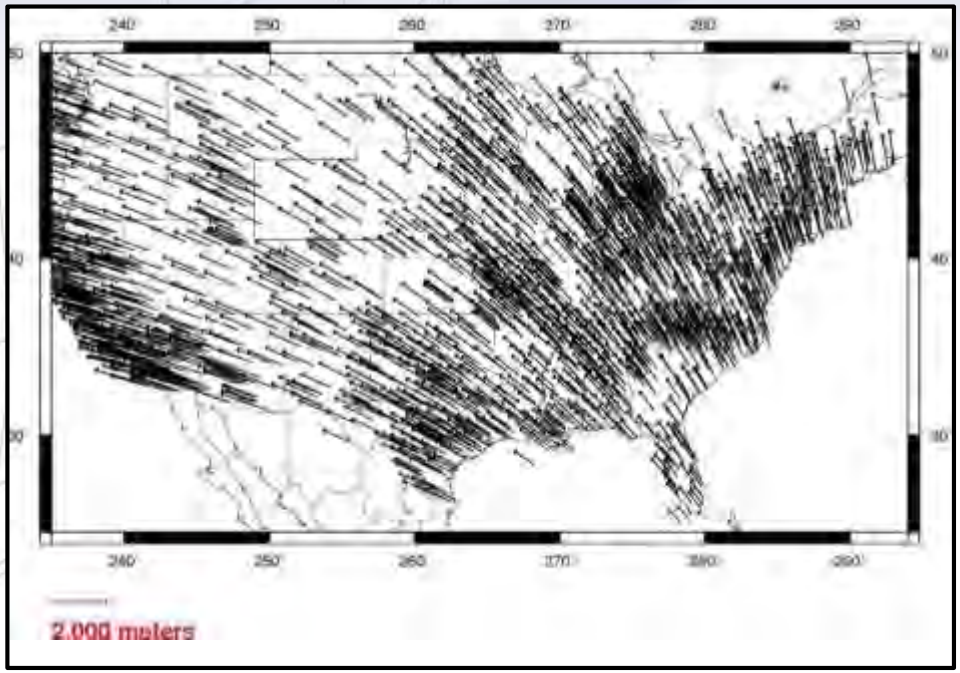
Non-geocentricity of NAD83

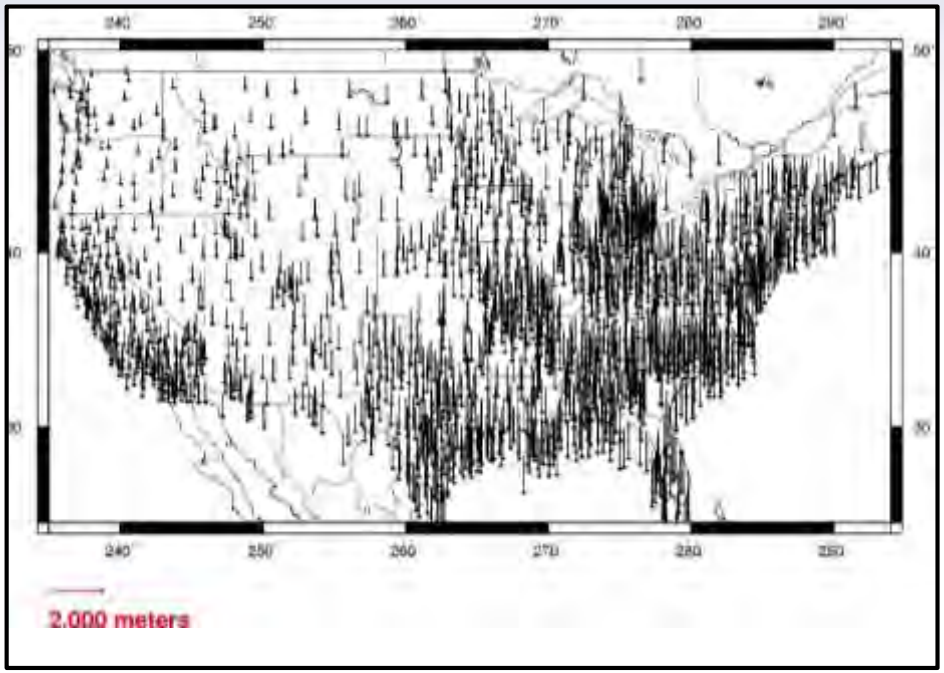


Non-geocentricity of NAD83



Geometric change due to ellipsoid non-geocentricity





Horizontal (Lat, Lon)

Ellipsoidal (h)

Shift…

Replacing NAD83

1. develop four "plate-fixed" reference frames
2. remove non-geocentricity of NAD83
3. **align to ITRF2014 at epoch 2020.00**
4. remove most of tectonic plate rotation from ITRF2014 via Euler Pole Parameters

Shift and Drift…

International Terrestrial Reference Frame (ITRF)

International Earth Rotation and Reference Systems Service (IERS)

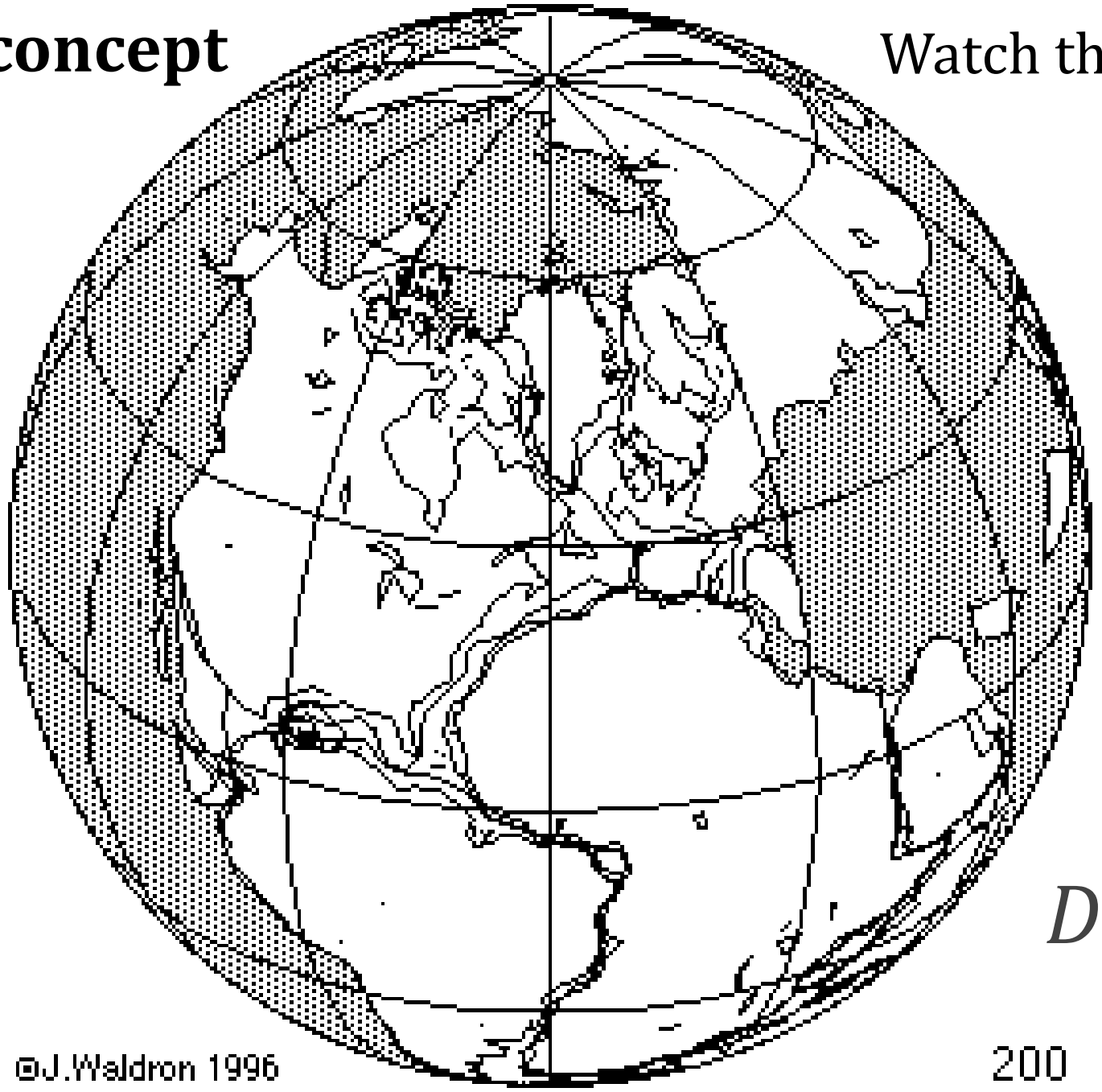
International Union of Geodesy and Geophysics (IUGG)

International Terrestrial Reference Frame

- The stable coordinate system that allows us to measure **change over space, time** and evolving technologies.
- An accurate, stable set of station positions and velocities.
- Network measurements interconnected by **co-location of different space geodetic techniques**.
- "*Approximately represents the motions of the tectonic plates with respect to the Earth's deep interior*"… huh?

ITRF concept

Watch the grid!



Drift…

Epoch?

- eh-puck? ee-pock? … *to-may-to, to-mah-to*
  - **an instant of time** or a date selected as a point of reference

```
                        NGS OPUS SOLUTION REPORT
                        ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

      USER: jeff.jaibrzikowski@noaa.gov          DATE: December 02, 2019
RINEX FILE: 1flo336f.19o                         TIME: 16:21:18 UTC


  SOFTWARE: page5  1801.18 master93.pl 160321      START: 2019/12/02  05:00:00
 EPHEMERIS: igu20821.eph [ultra-rapid]              STOP: 2019/12/02  08:00:00
  NAV FILE: brdc3360.19n                       OBS USED:  2267 /  2437   :  93%
  ANT NAME: NONE            NONE             # FIXED AMB:    13 /    17   :  76%
ARP HEIGHT: 0.000                            OVERALL RMS: 0.010(m)
```

Replacing NAD83

1. develop four "plate-fixed" reference frames
2. remove non-geocentricity of NAD83
3. align to ITRF2014 at epoch 2020.00
4. **remove most of tectonic plate rotation from ITRF2014 via Euler Pole Parameters**
   (pronounced: “oiler”)

Shift and Drift…

The wrong question, circa 2022:

"What's the position of that point?"

The right question, circa 2022:

"What's the position of that point, **on some specific date**?"

Drift…

Two types of drift

Tectonic Plate Rotation

- horizontal

simple to model

Everything Else

- residual motions left after rotation
- regional linear motions
- localized subsidence or uplift

complex

Tectonic Plate Rotation

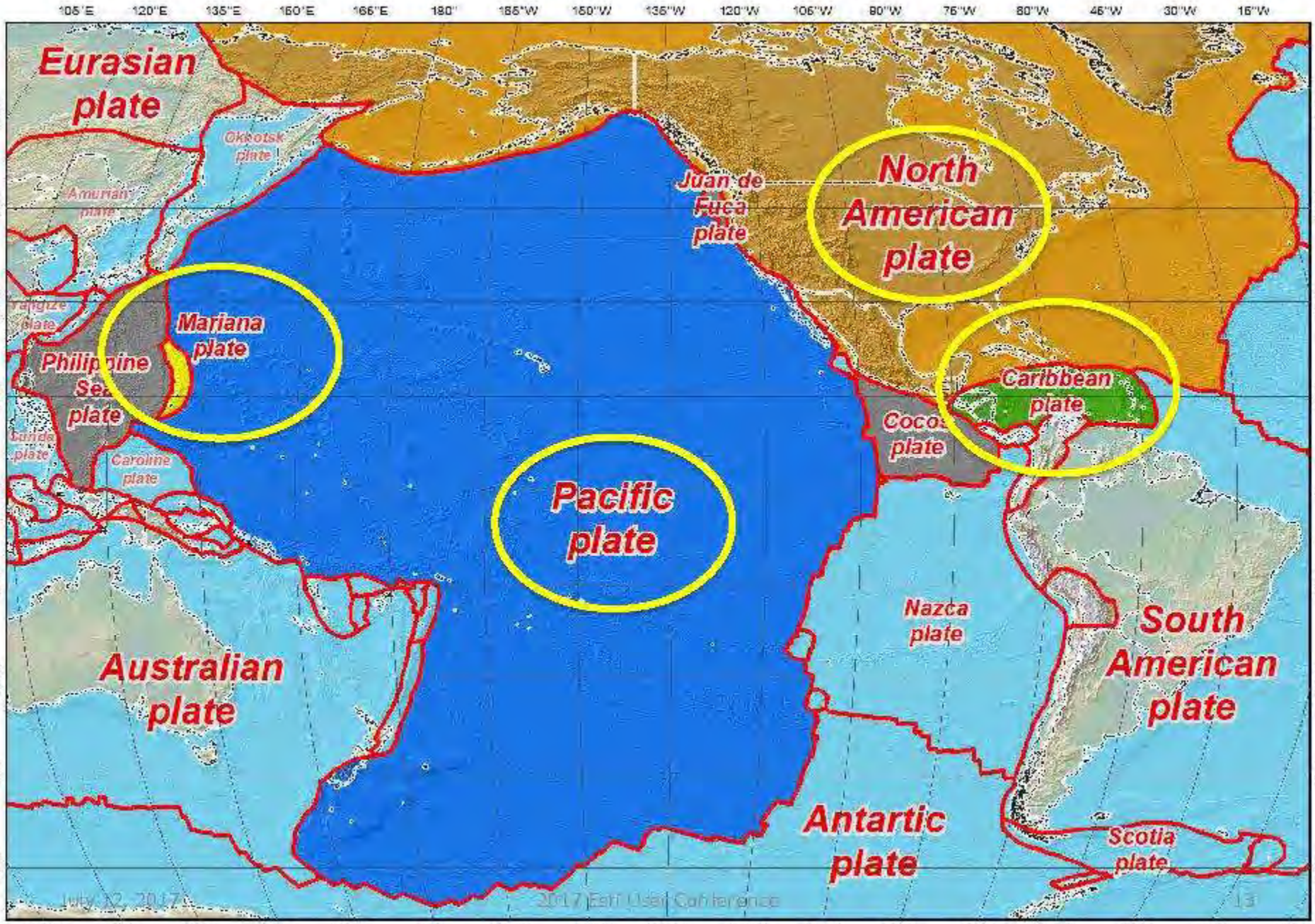
- horizontal

simple to model

Euler Pole Parameters of 2022

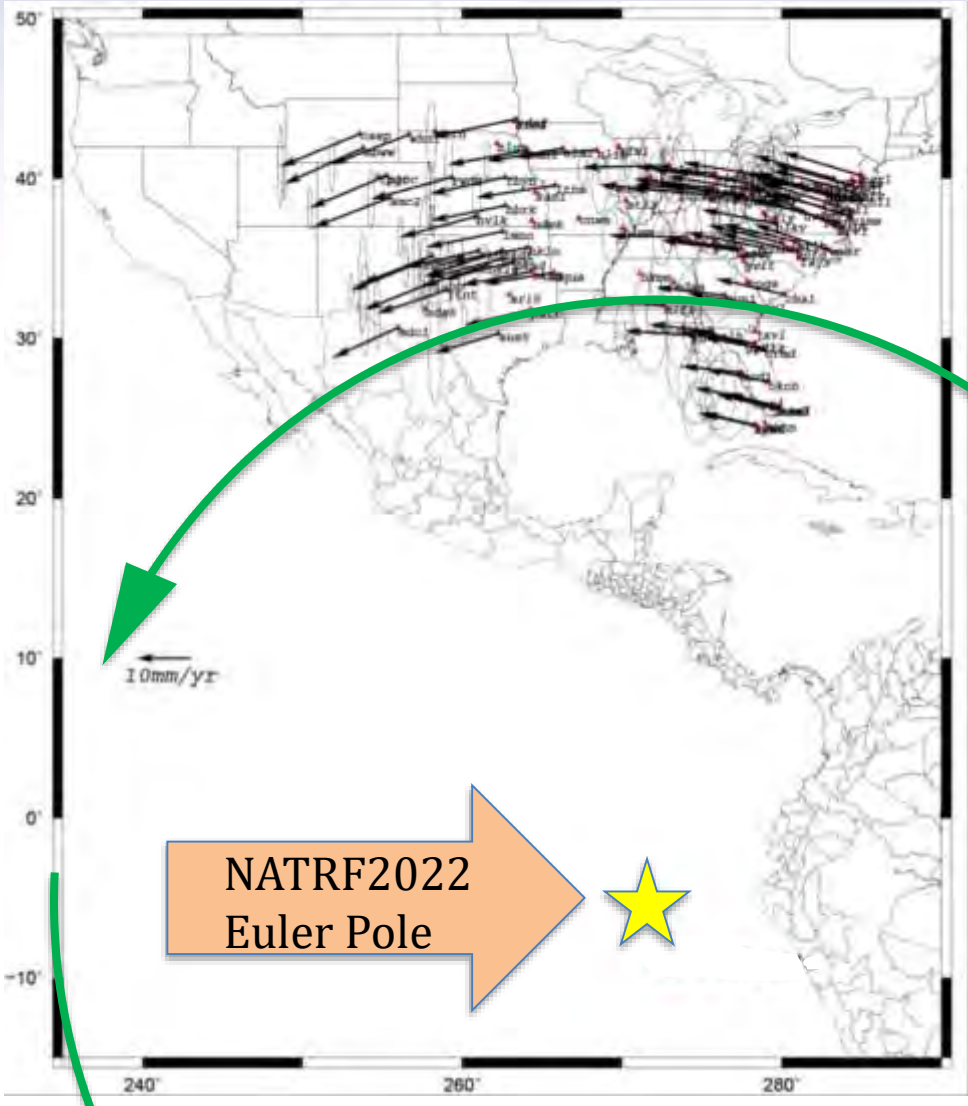
EPP2022

The four tectonic plates "fixed" for the 2022 terrestrial reference frames



Euler Poles and "Plate-Fixed"

- In the ITRF, many tectonic plates have a *dominant* motion: **rotation**
- **Euler Pole** - point about which a plate rotates (yellow star)



Euler Poles and "Plate-Fixed"

ITRF	NATRF
Frame = constant	Frame = rotating
NA Plate = rotating	NA Plate = constant

Euler Poles and "Plate-Fixed"

ITRF

Frame = constant

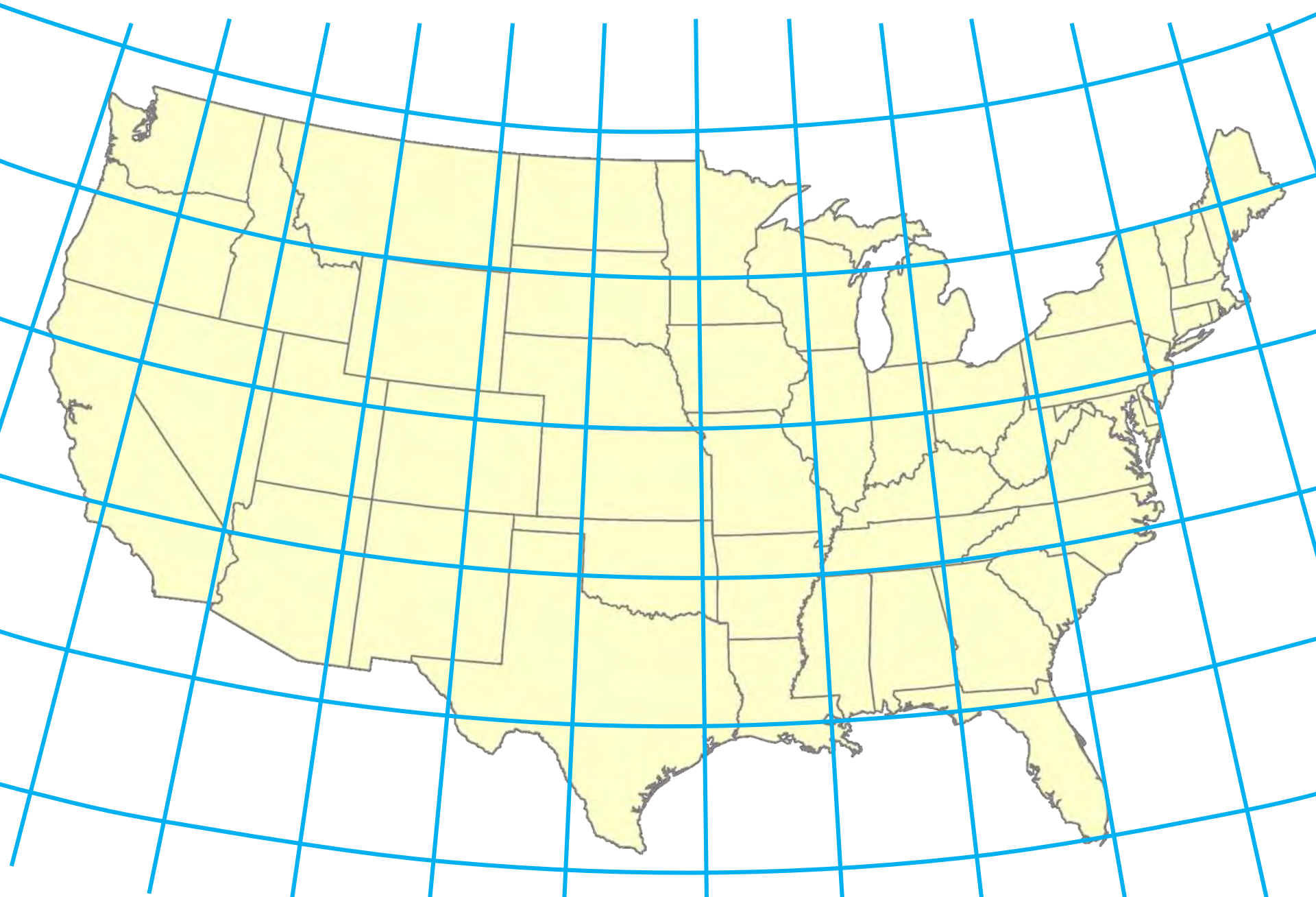
NA Plate = rotating

NATRF

Frame = rotating
(*relative to ITRF*)

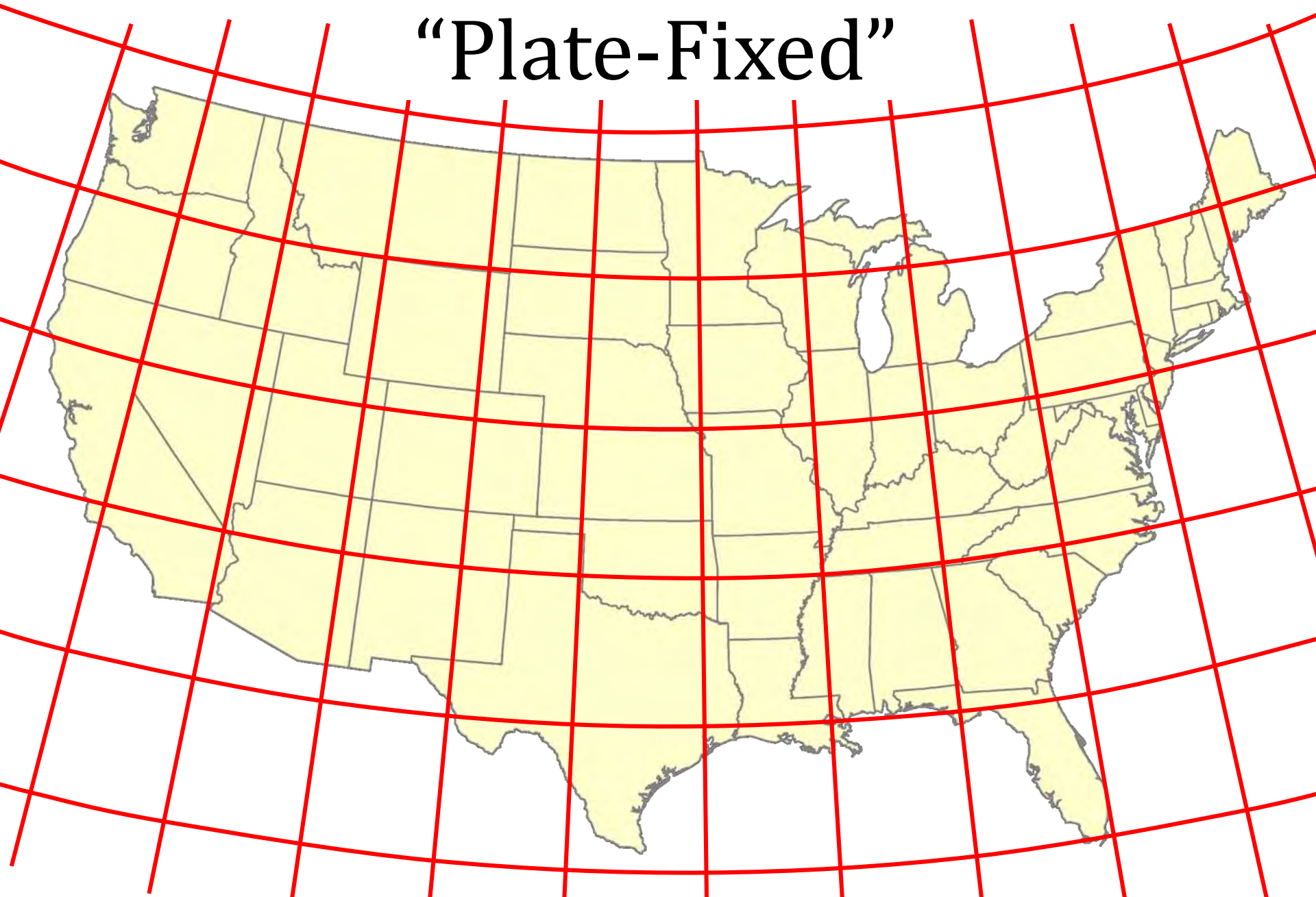
NA Plate = constant
(*relative to NATRF2022*)

ITRF – constant frame, rotating plate

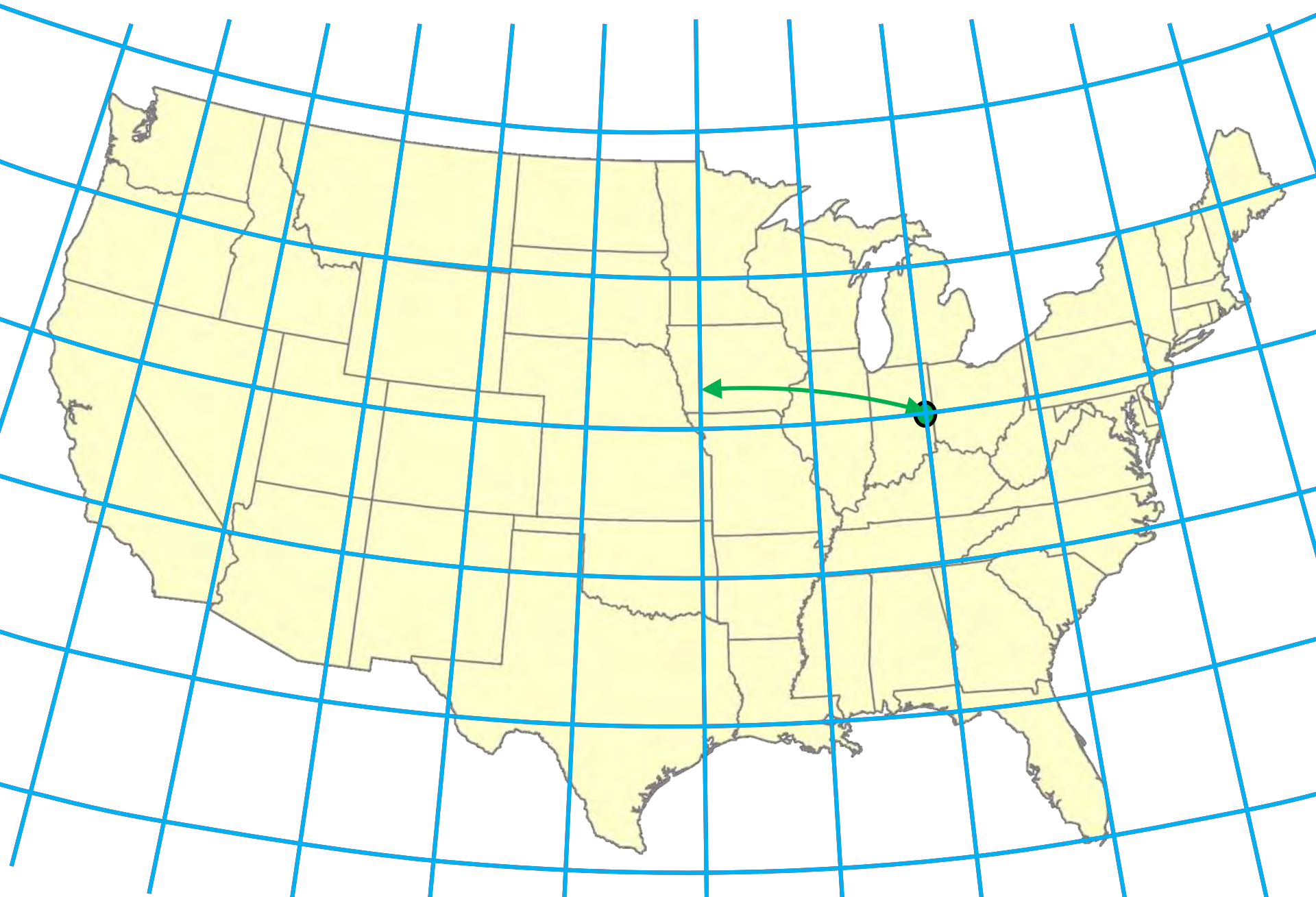


NATRF – rotating frame, constant with plate

"Plate-Fixed"



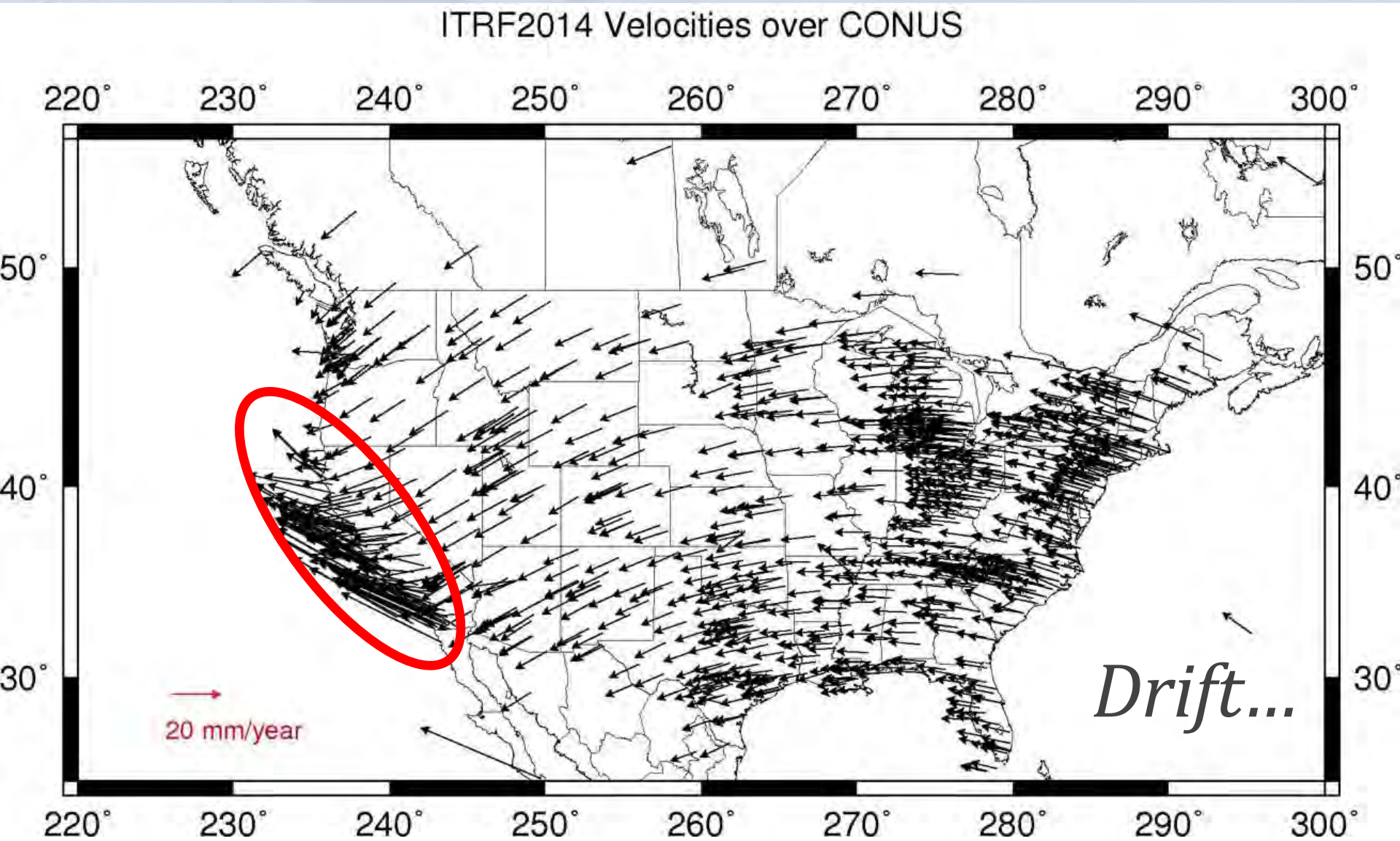
ITRF or NATRF – your choice, just use EPP



EPP – Euler Pole Parameters

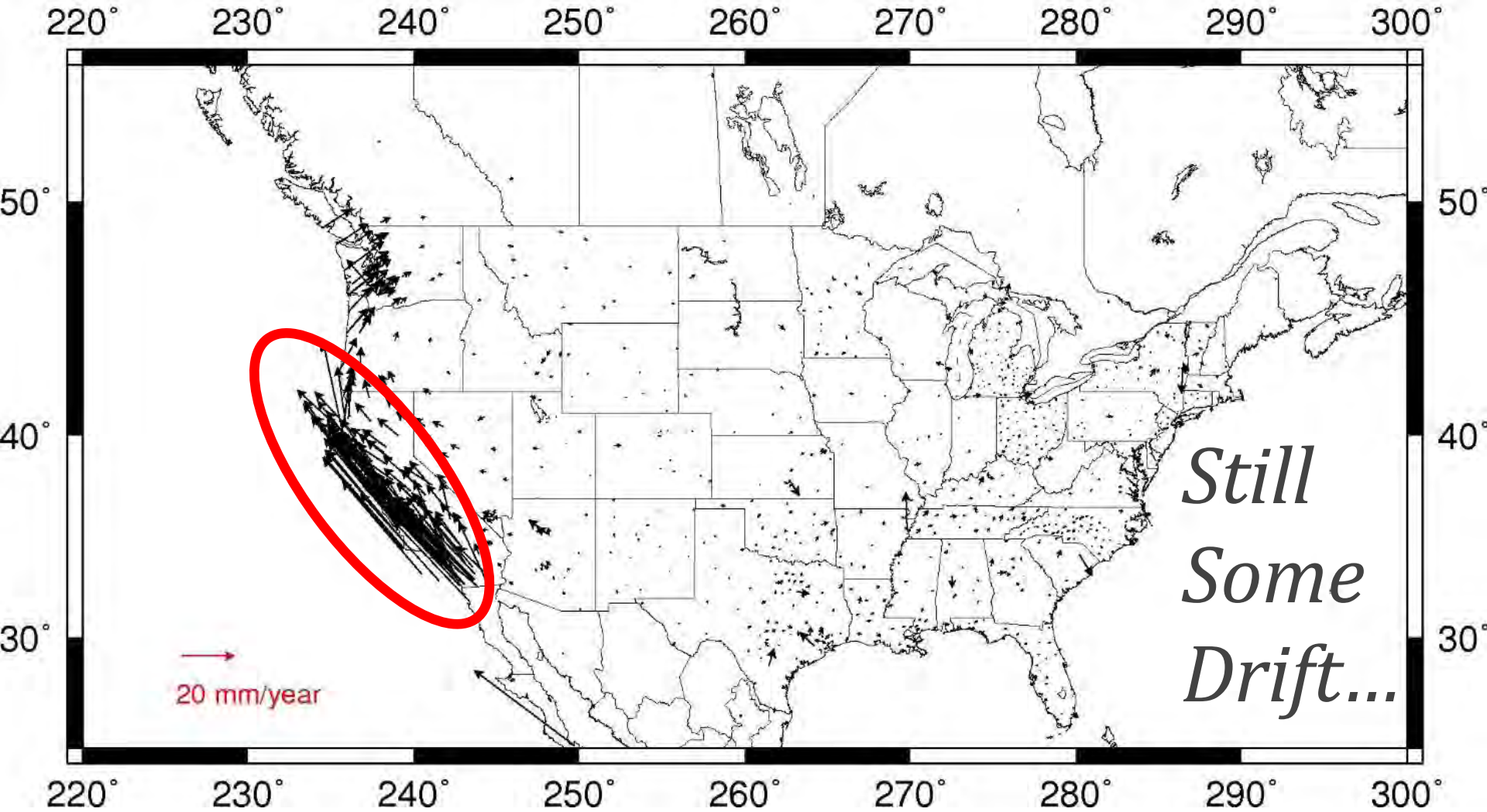
Latitude
Longitude
} yellow star off west coast of S. America
Rotation Speed

CORS Velocities in ITRF2014

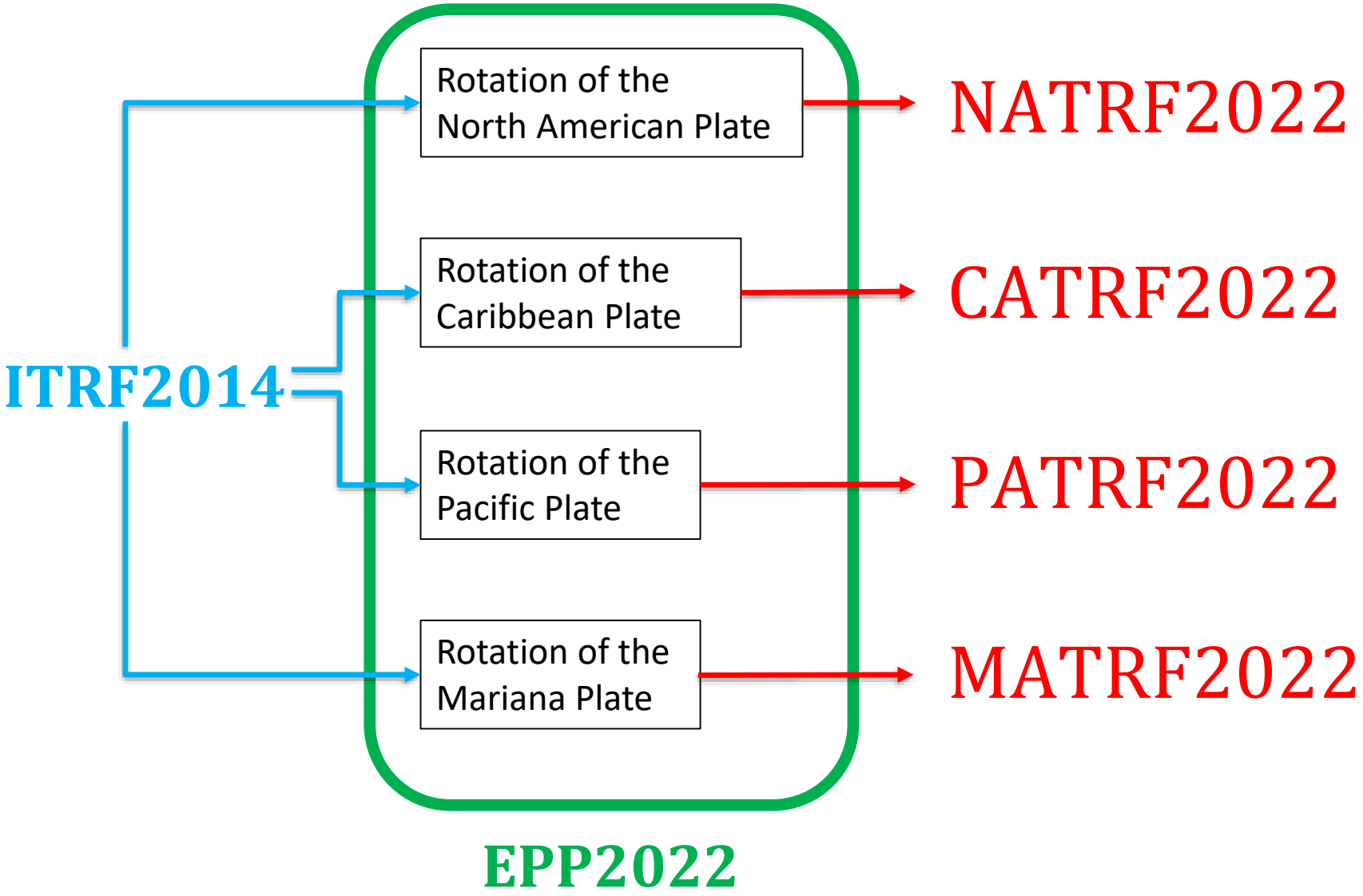


CORS Velocities in NATRF2022

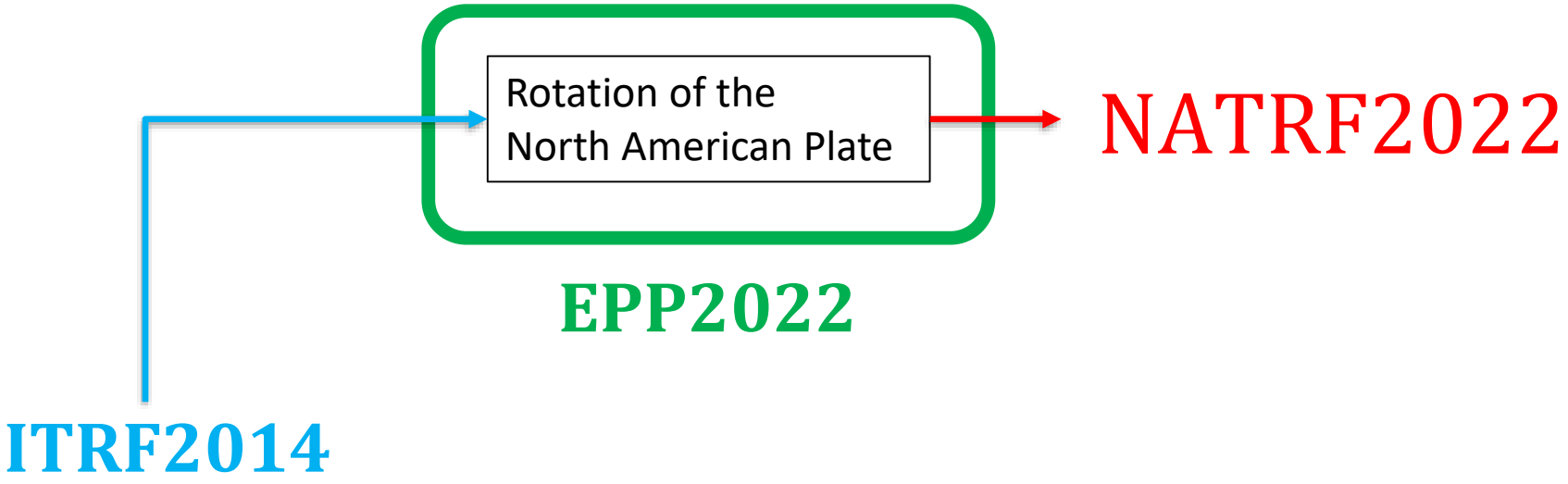
Think of this map as **ITRF2014 + EPP2022**



ITRF2014 + EPP2022 = --TRF2022



ITRF2014 + EPP2022 = --TRF2022



Two types of drift

Tectonic Plate Rotation

- horizontal

simple to model

Everything Else

- residual motions left after rotation
- regional linear motions
- localized subsidence or uplift

complex

Still Some Drift…

Everything Else

- residual motions left after rotation
- regional linear motions
- localized subsidence or uplift

complex

Intra-Frame Velocity Model of 2022

IFVM2022

Concept of goal of IFVM

Longitude (Easting) History of DI4044

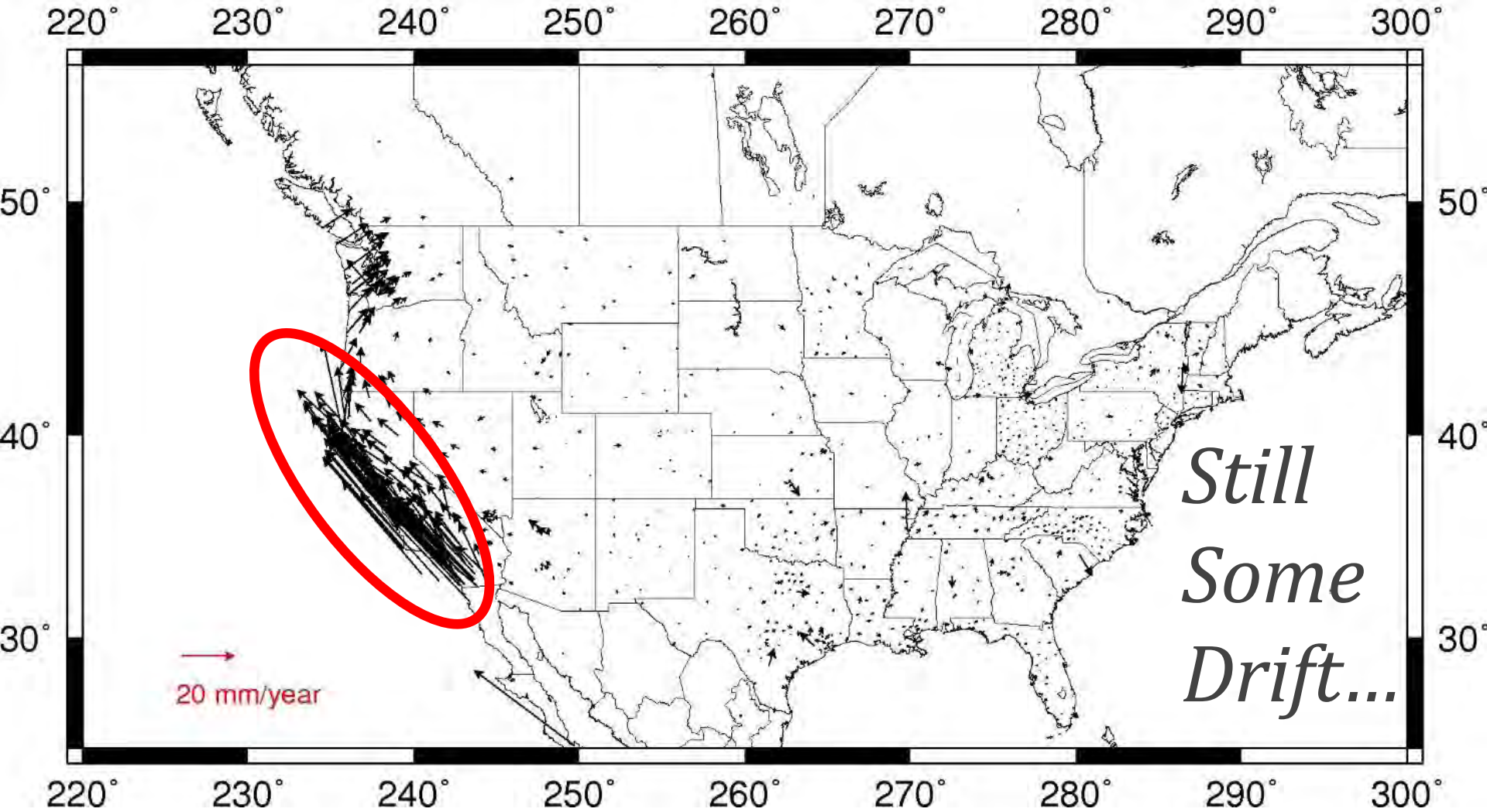
RED IS NATRF2022 COORDINATE

Still Some Drift…

BLUE IS ITRF COORDINATE

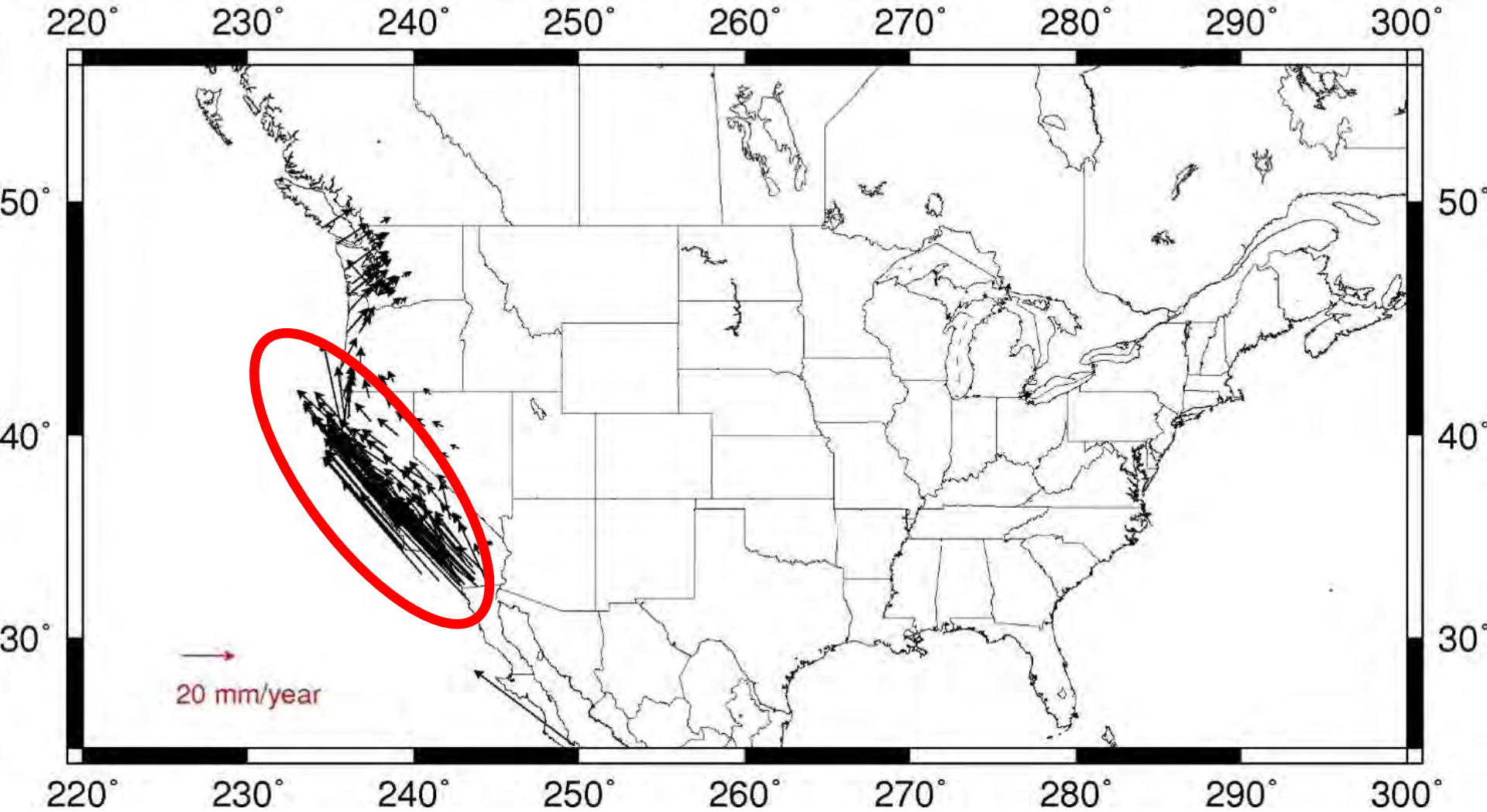
CORS Velocities in NATRF2022

Think of this map as **ITRF2014 + EPP2022**



IFVM goal = model all velocities

Think of this map as **ITRF2014 + EPP2022 + IFVM2022**



Still Some Drift…

- **Everything** in the world moves
- Coordinates will be associated with the actual date when the data was collected!
- Velocities at all marks can be *estimated* using this Intra-Frame Velocity Model
- IFVM goal being to move collected data thru time to Reference Epochs for coordinate comparisons/analysis

Intra-Frame Velocity Model

- A model of all residual velocities, *after removal of tectonic rotation via EPP*:
  - Horizontal residual motion
  - Total vertical motion (ellipsoid heights)
  - Replaces / Improves upon HTDP
- Given t_1 and t_2, compute $\Delta\lambda$, $\Delta\phi$, Δh at any point, accounting for all motions
- Likely be built upon CORS data, geodynamic models and InSAR, but not yet finalized

EPP2022 – Euler Pole Parameters – Simple Rotation

- Three parameters: lat, lon, rotation speed
- Horizontal *only*: just latitude and longitude
- Changes the *frame*: ITRF2014 + EPP2022 = NATRF2022
- Does **not** change the *epoch*

IFVM2022 – Intra-Frame Velocity Model - Complex

- Complex set of parameters
- *Residual* horizontal motion: all the motion leftover after Euler Pole rotation
- *All* vertical motion: localized subsidence or uplift
- Changes the *epoch*
- Does **not** change the *frame*: "intra" = on the inside; within

EPP2022
IFVM2022

Two new tools that will make time dependent geodetic control practical

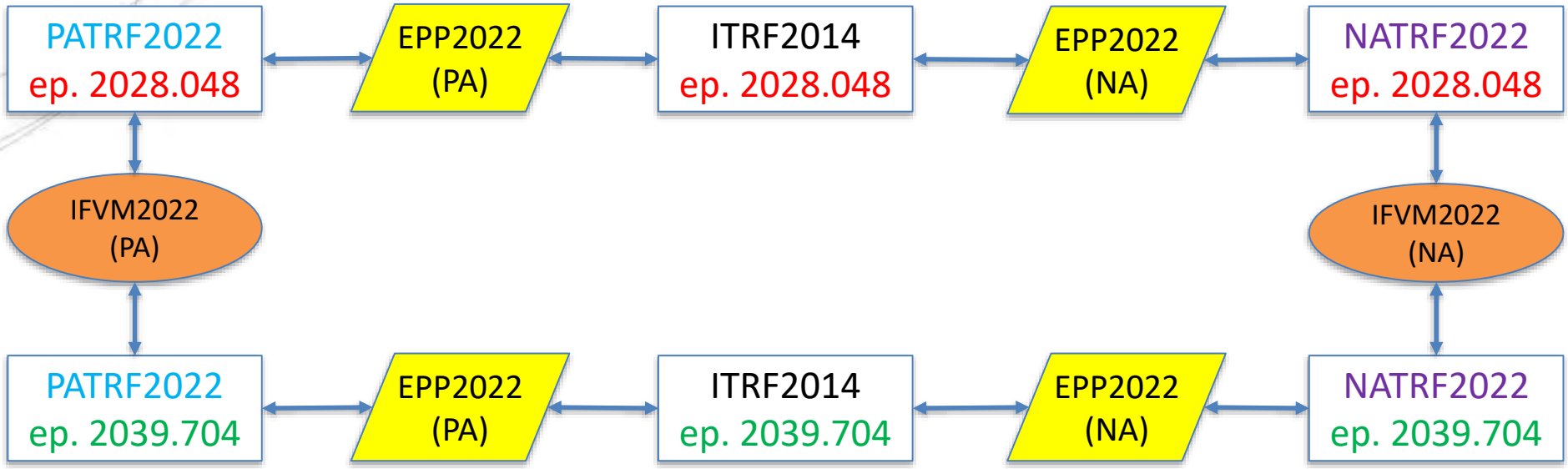
They work together to account for the Drift…

Example of application of EPP and IFVM

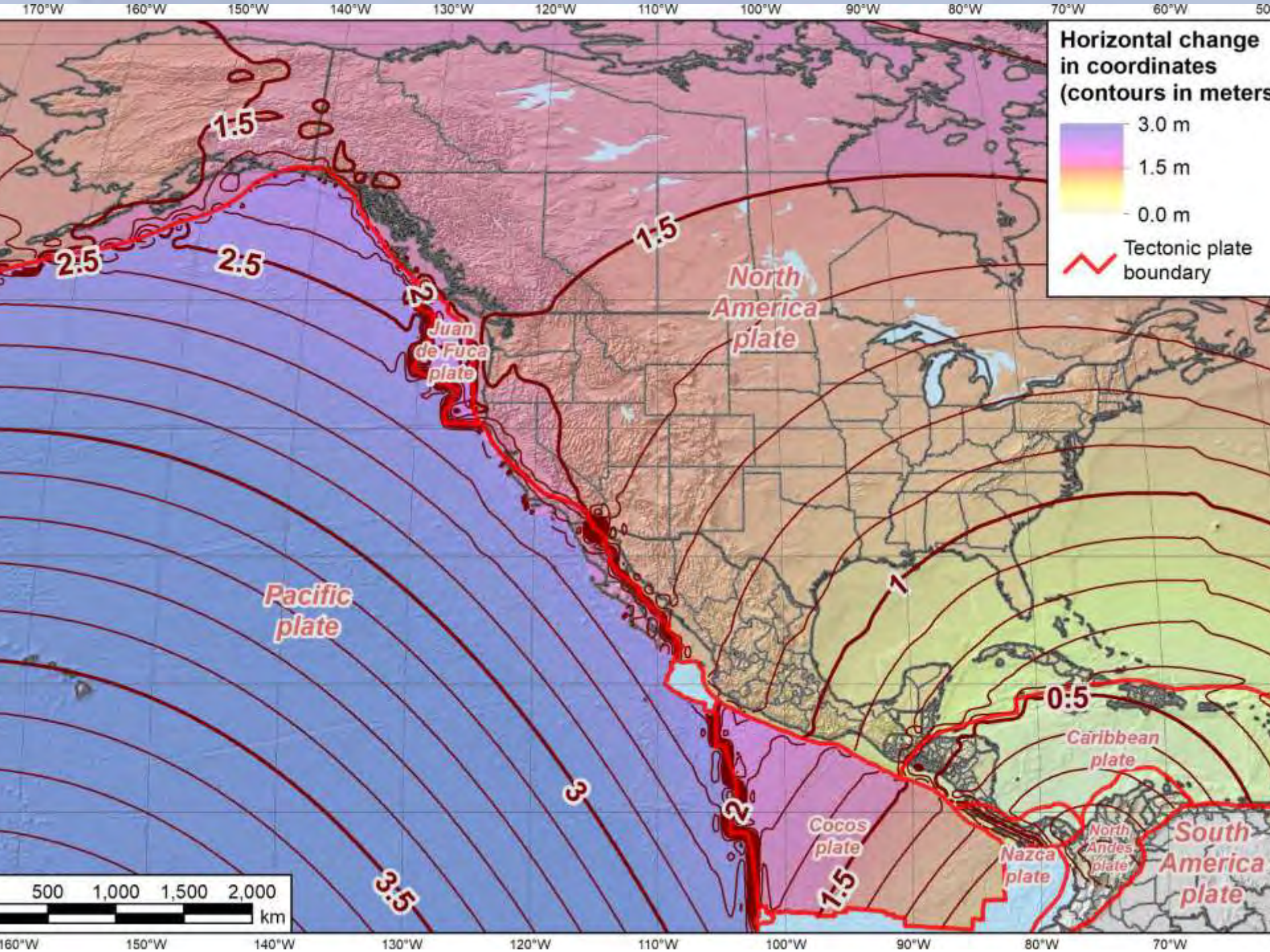
- It's 2039 and you are working in San Diego using NATRF2022
- And you want to compare your work to another survey from 2028

Important: This slide only covers *geometric* coordinates.

...the catch is, that survey was done in PATRF2022



Alright Jeff... enough jibba-jabba, what's the impact?


Horizontal change in coordinates (contours in meters
3.0 m
1.5 m
0.0 m
Tectonic plate boundary
North America plate
Pacific plate
Juan de Fuca plate
Cocos plate
Nazca plate
Caribbean plate
North Andes plate
South America plate
1.5
2.5
2
1
0.5
3
3.5
500 1,000 1,500 2,000 km
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W

What's that going to look like?

PHOTO = NAD83
RED = NAD83 shoreline data
GREEN = shoreline transformed to NATRF2022

If ...


National Geodetic Survey Positioning America for the Future geodesy.noaa.gov
NOAA
NOAA Technical Report NOS NGS 62
Blueprint for 2022, Part 1: Geometric Coordinates

North American-Pacific Geopotential Datum of 2022

NAPGD2022

(pronounced: nap-jee-dee)

A very brief history of (the most prevalent) U.S. vertical datums


NGVD29
Referenced to 26 tide gauges in the US and Canada
Prince Rupert
Fort Stephens
San Francisco
San Diego
Galveston
Biloxi
Pensacola
Cedar Keys
Fernandina Beach
Brunswick
St. Augustine
Perth Amboy
Norfolk
Boston
Portland
Yarmouth
Halifax
Father's Point
© 2008 Google

NAVD88

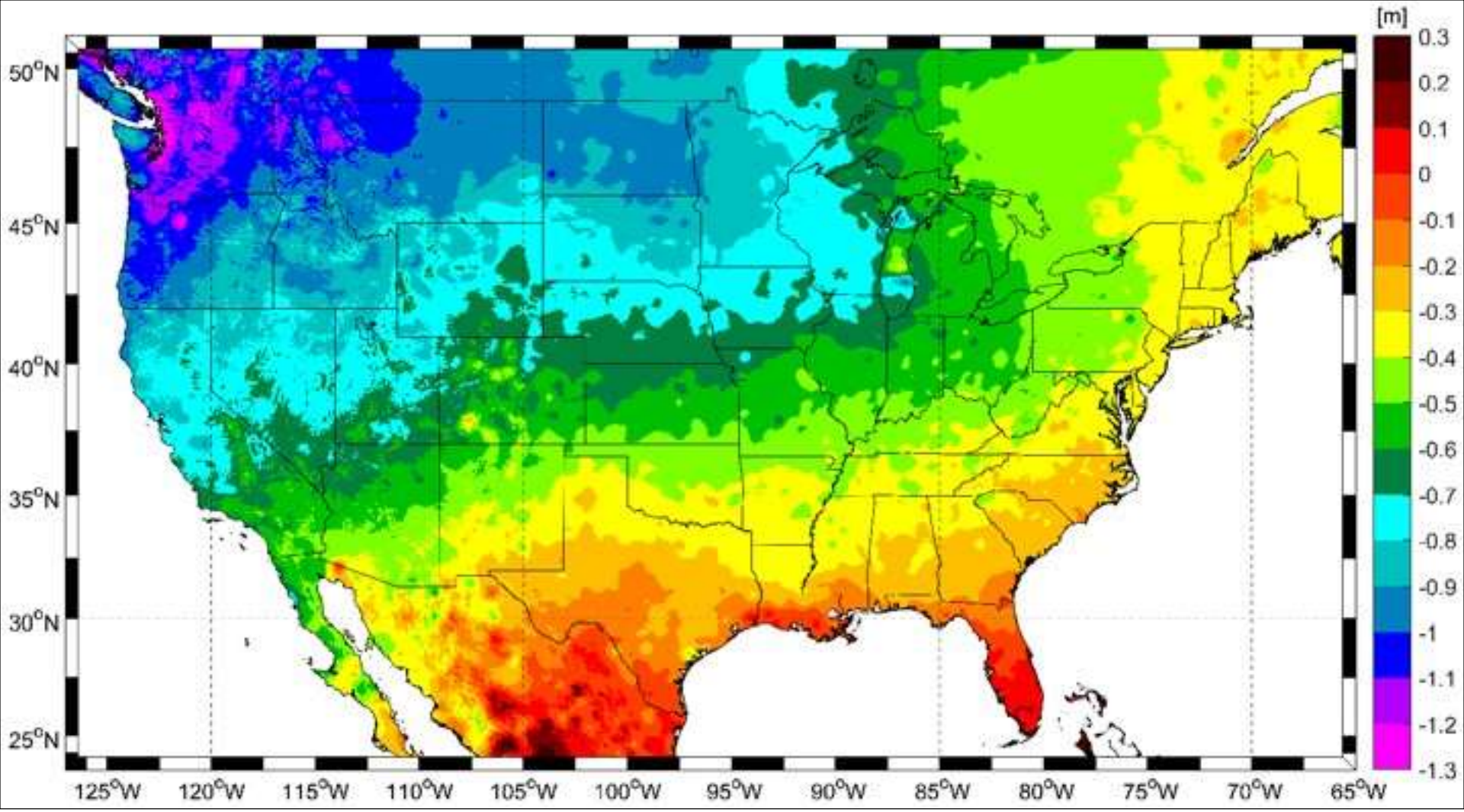
Referenced to a single tide gauge in Canada

Why one gage fixed this time?

–removed local sea level variation problem of NGVD29

But it did introduce possibility of cross-continent error build-up…

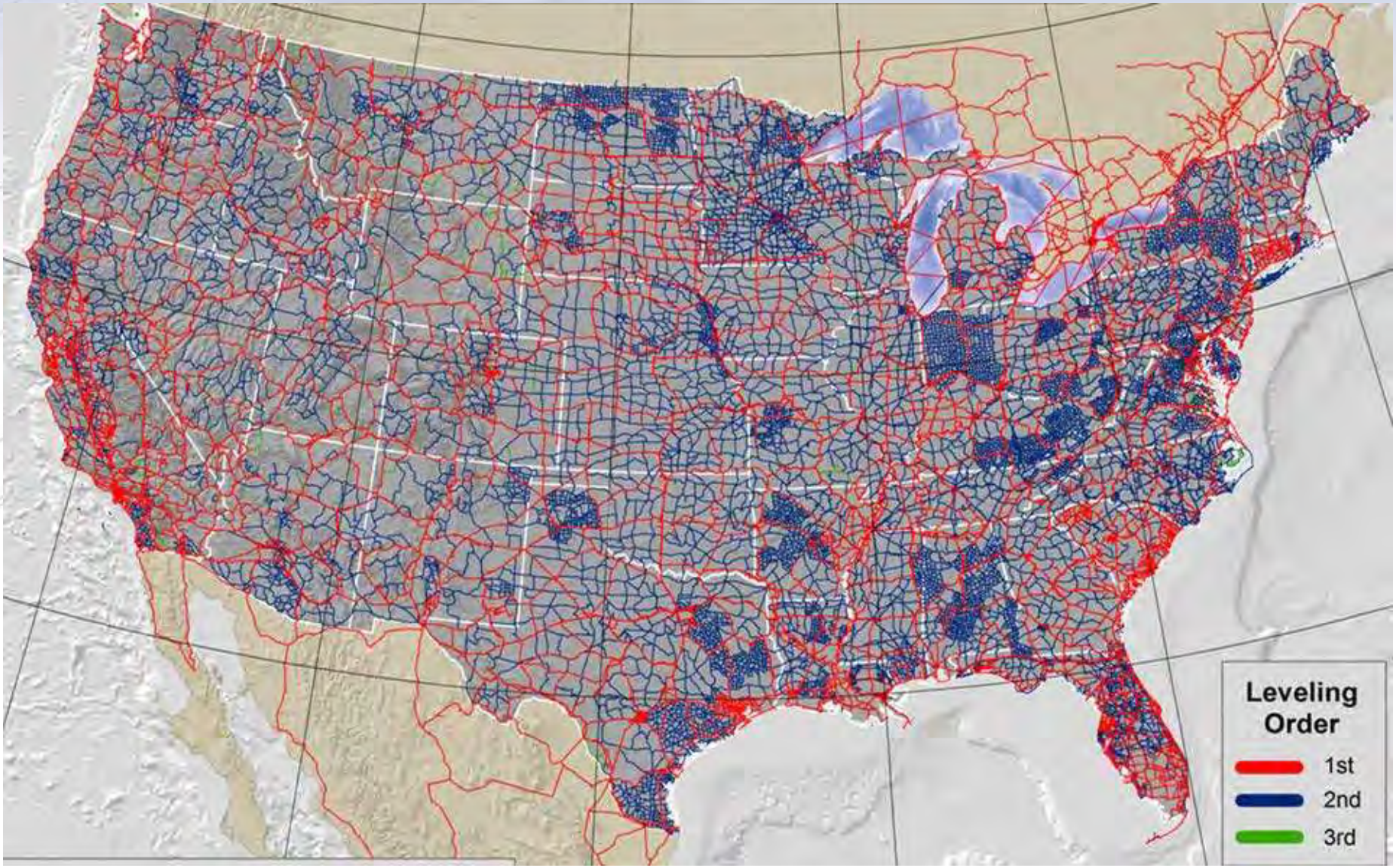
Father Point Lighthouse, Quebec



Approximate Error in NAVD88 "zero elevation" (H=0)

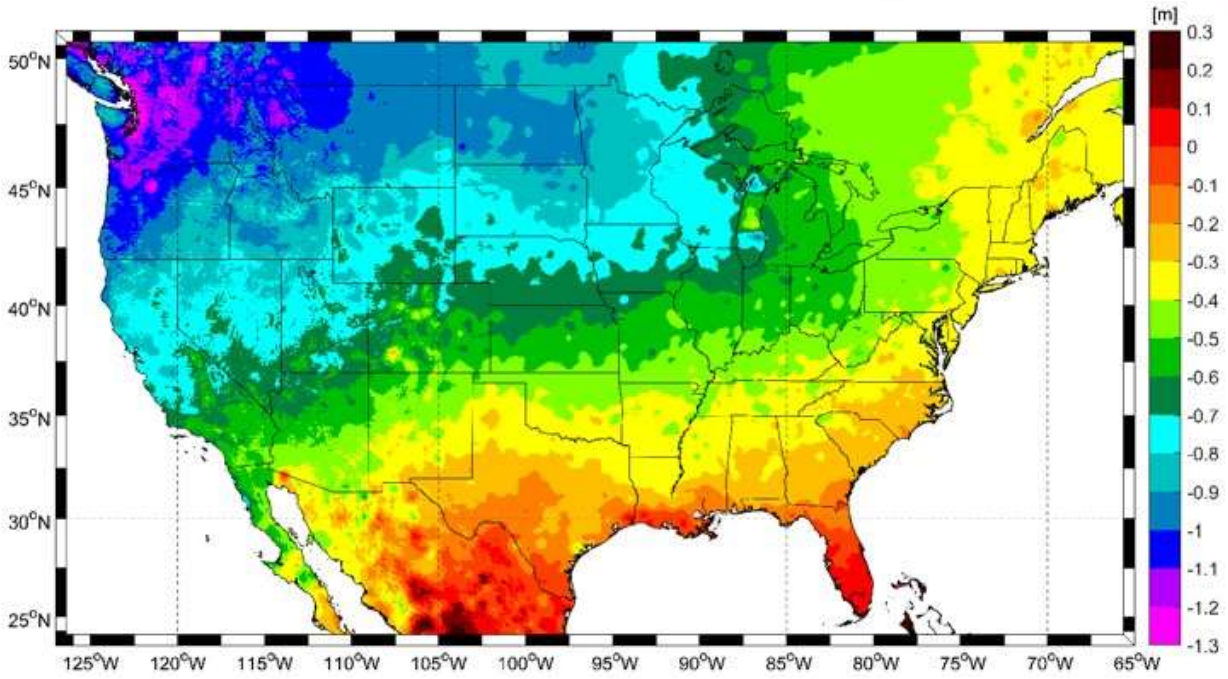
Map is the H=0 surface overlaid onto satellite gravity data

Why Replace NAVD88?



Known Issues with NAVD88

- tilt/bias in zero reference surface
- subsidence, uplift, freeze/thaw of BMs
- limited access, availability of undisturbed marks



Approximate Error in NAVD88 "zero elevation"

Passive marks may lie still… but they still may lie!

small instability x long time = large inaccuracy

Replacing NAVD88

- primary access via GNSS and geoid (OPUS, etc.)
- accurate continental **gravimetric** geoid (1-2 cm)
- aligned with:
  1) NATRF2022 (or CATRF, PATRF, MATRF)
  2) global mean sea level (GMSL)
- monitor time-varying nature of gravity (NGS Geoid Monitoring Service **GeMS**)

Two flavors of geoid models…

- **Gravimetric**

- **Hybrid**

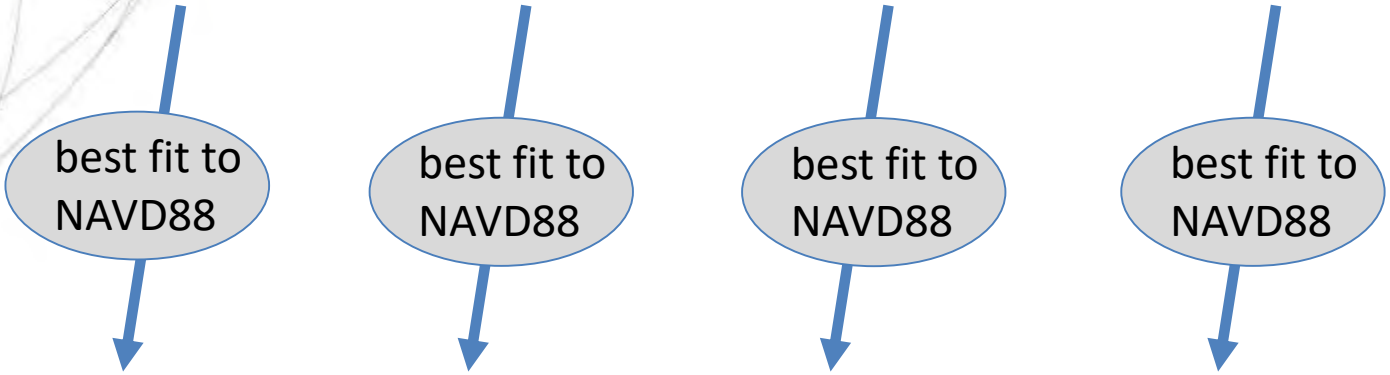
Gravimetric → Hybrid

- **Gravimetric** geoid is created from "scratch" with various types of gravity data
  - USGG2003, USGG2009, USGG2012, xGEOID19

- **Hybrid** geoid is simply a gravimetric geoid warped to fit some vertical datum… like NAVD88
  - GEOID03, GEOID09, GEOID12B, GEOID18

Gravimetric → Hybrid

– USGG2003, USGG2009, USGG2012, xGEOID19

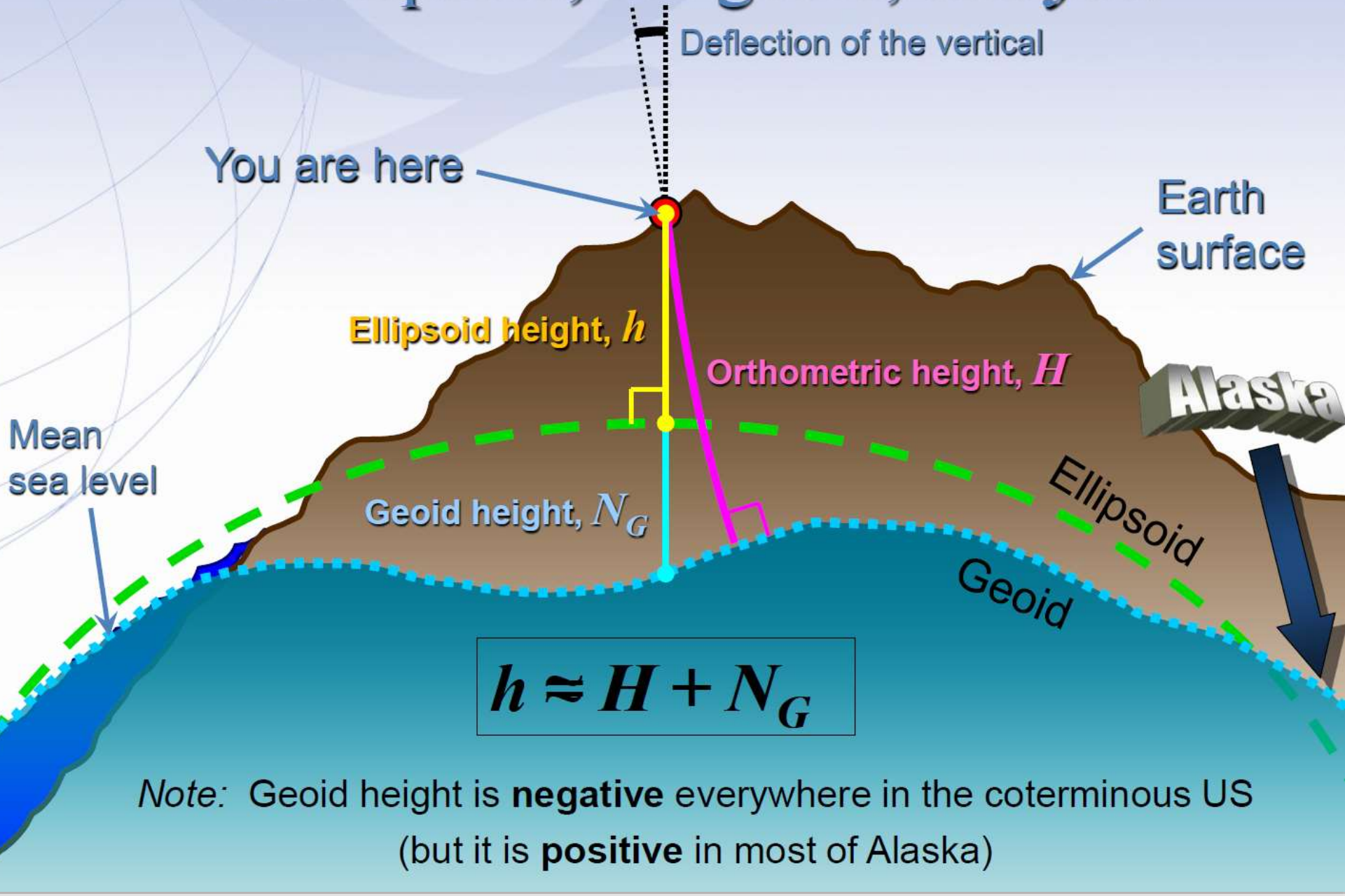


– GEOID03, GEOID09, GEOID12B, GEOID18

Which NAD83 with which geoid?

- NAD83(2011) → Geoid18, Geoid12A/B
- NAD83(2007) → Geoid09, Geoid06 (AK only)
- NAD83(HARN/FBN), NAD83(CORS96) → Geoid03, Geoid99, Geoid96

The ellipsoid, the geoid, and *you*



$$h \approx H + N_G$$

Note: Geoid height is **negative** everywhere in the coterminous US (but it is **positive** in most of Alaska)

Obtaining N_g is *not easy*!

- First you need a gravity field (data from diff. distances)
  - combine satellite, airborne, terrestrial, ship track data, etc.
- Next calculate gravity anomaly, or **Δg**
- Then, just solve Stokes' integral!

$$N_G = \frac{R}{4\pi\gamma_0}\iint \Delta g S(\psi)\, d\,\sigma$$

- **R** is the mean radius of the earth
- **γ0** is mean surface gravity on ellipsoid
- **S** is a geometric function of position

…there's a catch

- Need to know **Δg** over entire surface of the earth

Obtaining N_g is *not easy*!

- First you need a gravity field (data from diff. distances)
  - combine satellite, airborne, terrestrial, ship track data, etc.
- Next calculate gravity anomaly, or **Δg**
- Then, just solve Stokes' integral!

$$N_G = \frac{R}{4\pi\gamma_0}\iint \Delta g S(\psi)\, d\,\sigma$$

- **R** is the mean radius of the earth
- **γ0** is mean surface gravity on ellipsoid
- **S** is a geometric function of position

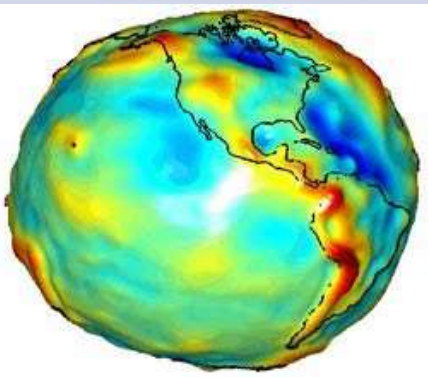
…there's a catch

- Need to know **Δg** over entire surface of the earth

Building a Geopotential Field Model

GRACE/GOCE/Satellite Altimetry

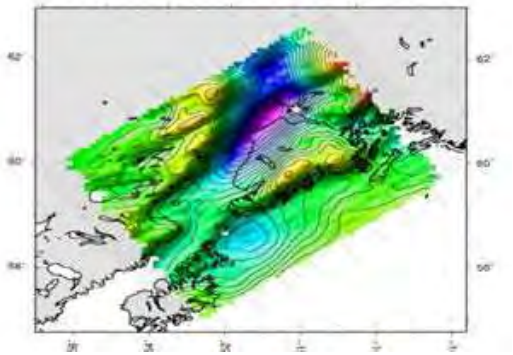
Long Wavelengths
(> 250 km)



+

Airborne Observations

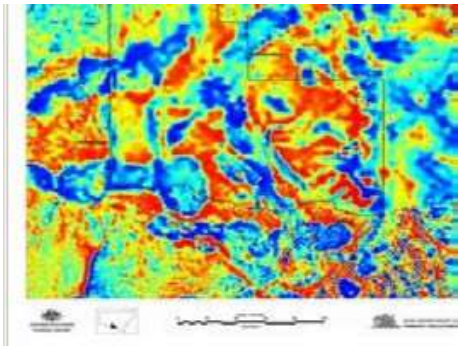
Intermediate Wavelengths
(20km to 300 km)



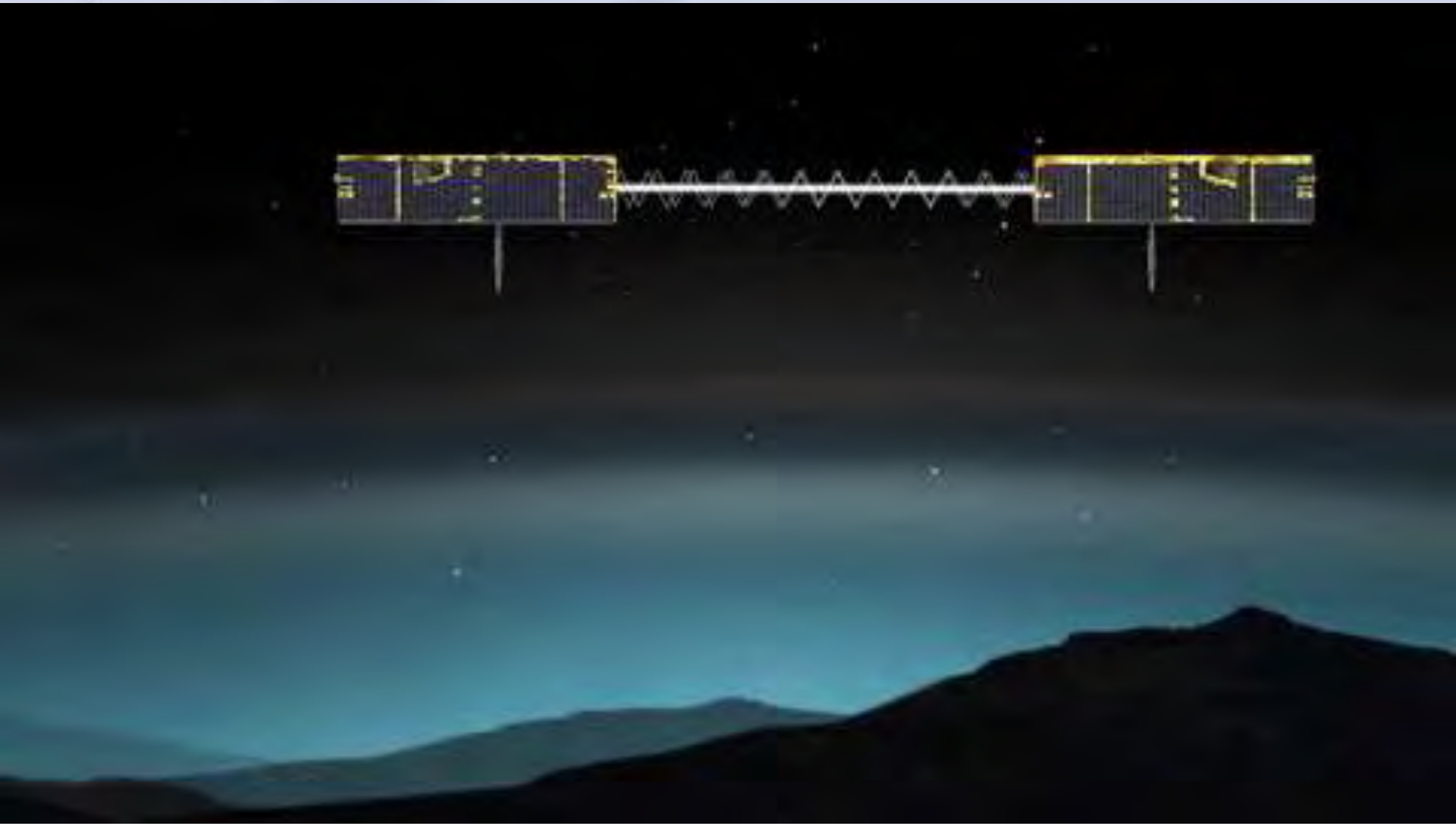
+

Terrestrial/Surface Observations and Predicted Gravity from Topography

Short Wavelengths
(< 100 km)



GRACE - 2 Satellites measuring separation



GRAV-D – airborne relative gravimeters

Terrestrial Gravimeter - Relative

Terrestrial Gravimeter - Relative

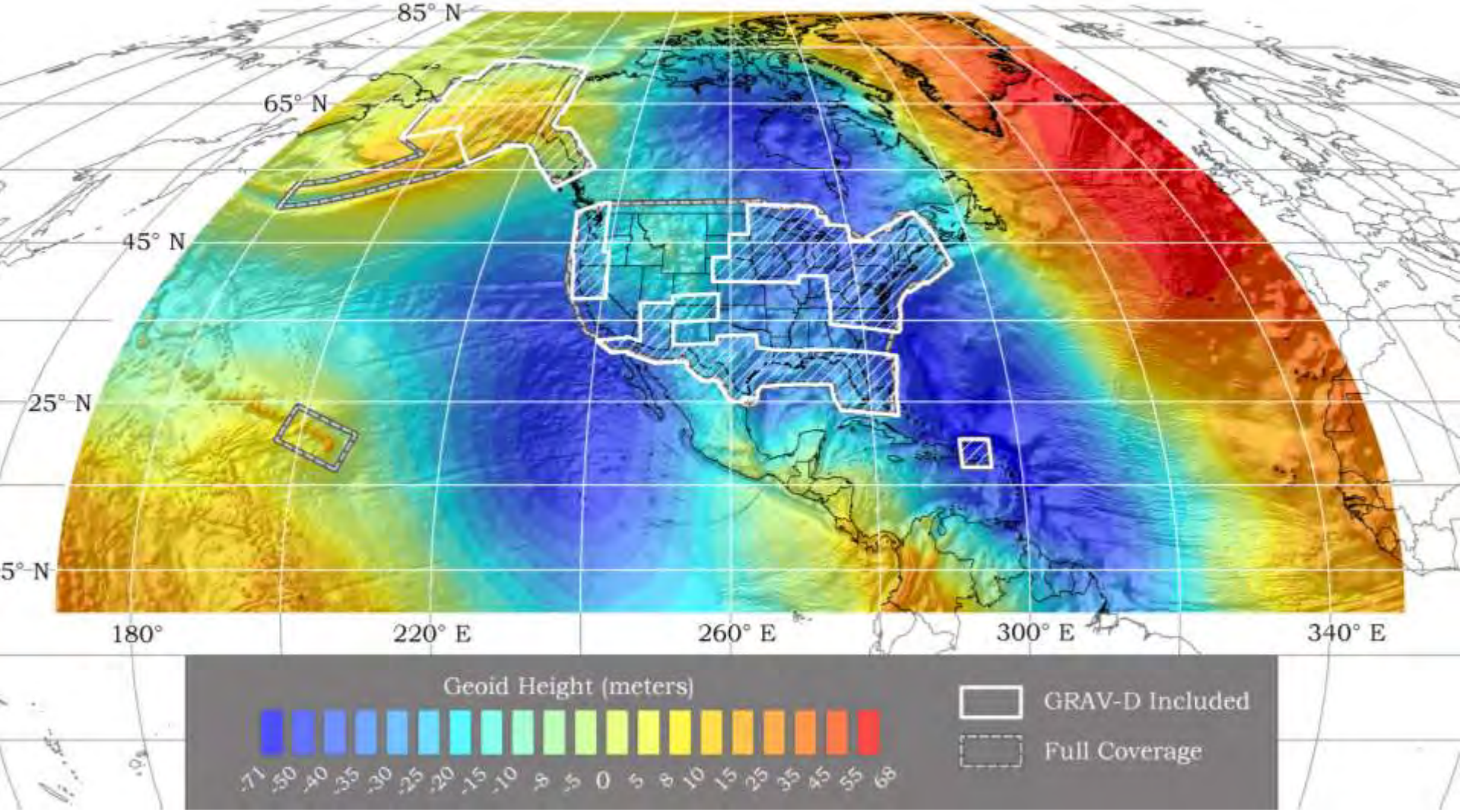
Terrestrial Gravimeter - Absolute

Terrestrial Gravimeters - Absolute and Relative

Individual Components of NAPGD2022

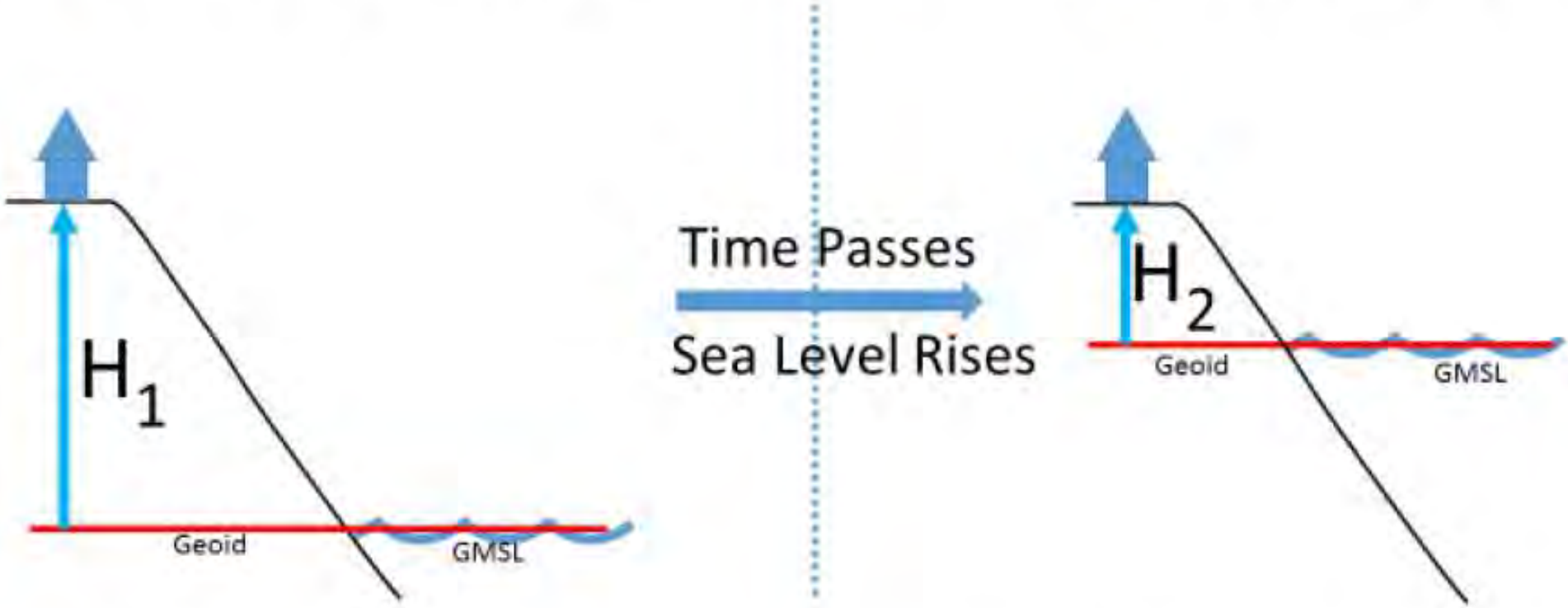
- Global Model of the geopotential field
  - **GM2022**
- Geoid undulation models by region
  - **GEOID2022** aka "0 elevation"
- Deflection of the Vertical (DoV) models by region
  - **DEFLEC2022**
- Surface Gravity models by region
  - **GRAV2022**

Experimental Geoid 2019 (xGEOID19)



Sea Level Change and the Geoid

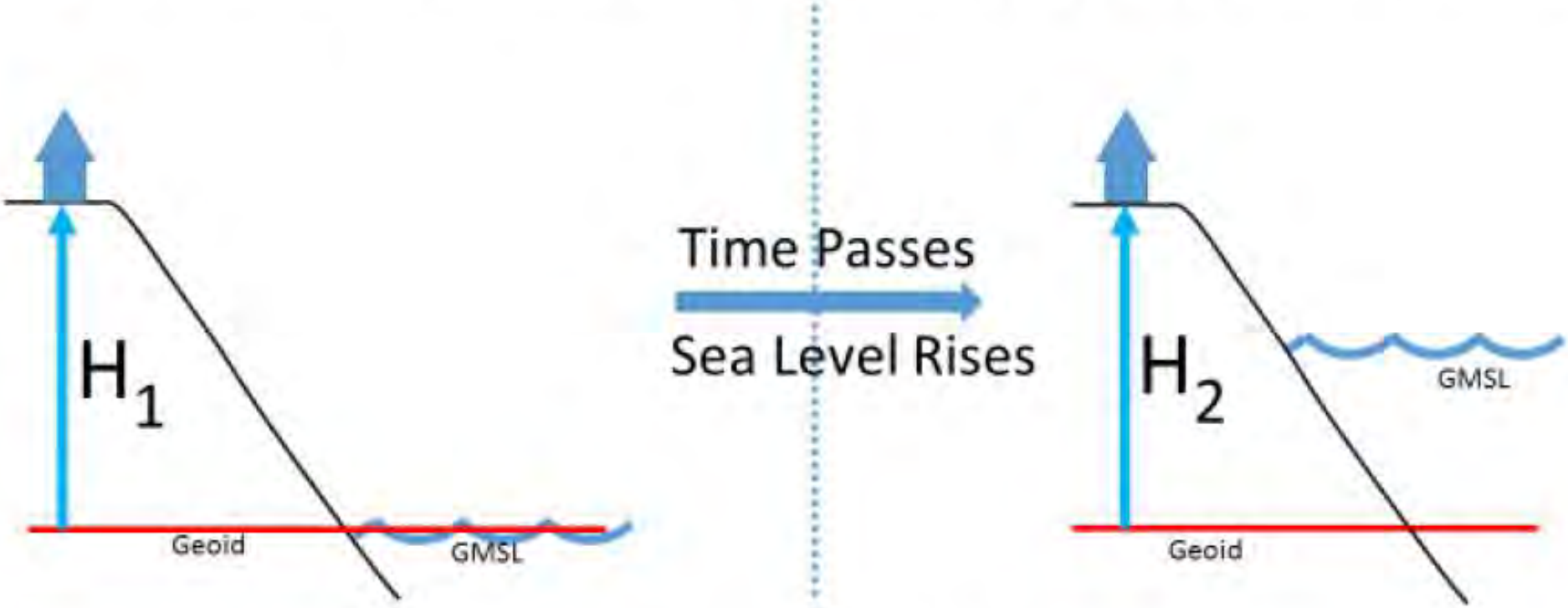
Scenario 1: Geoid Definition remains tied to GMSL



As Global Mean Sea Level rises, orthometric height gets smaller

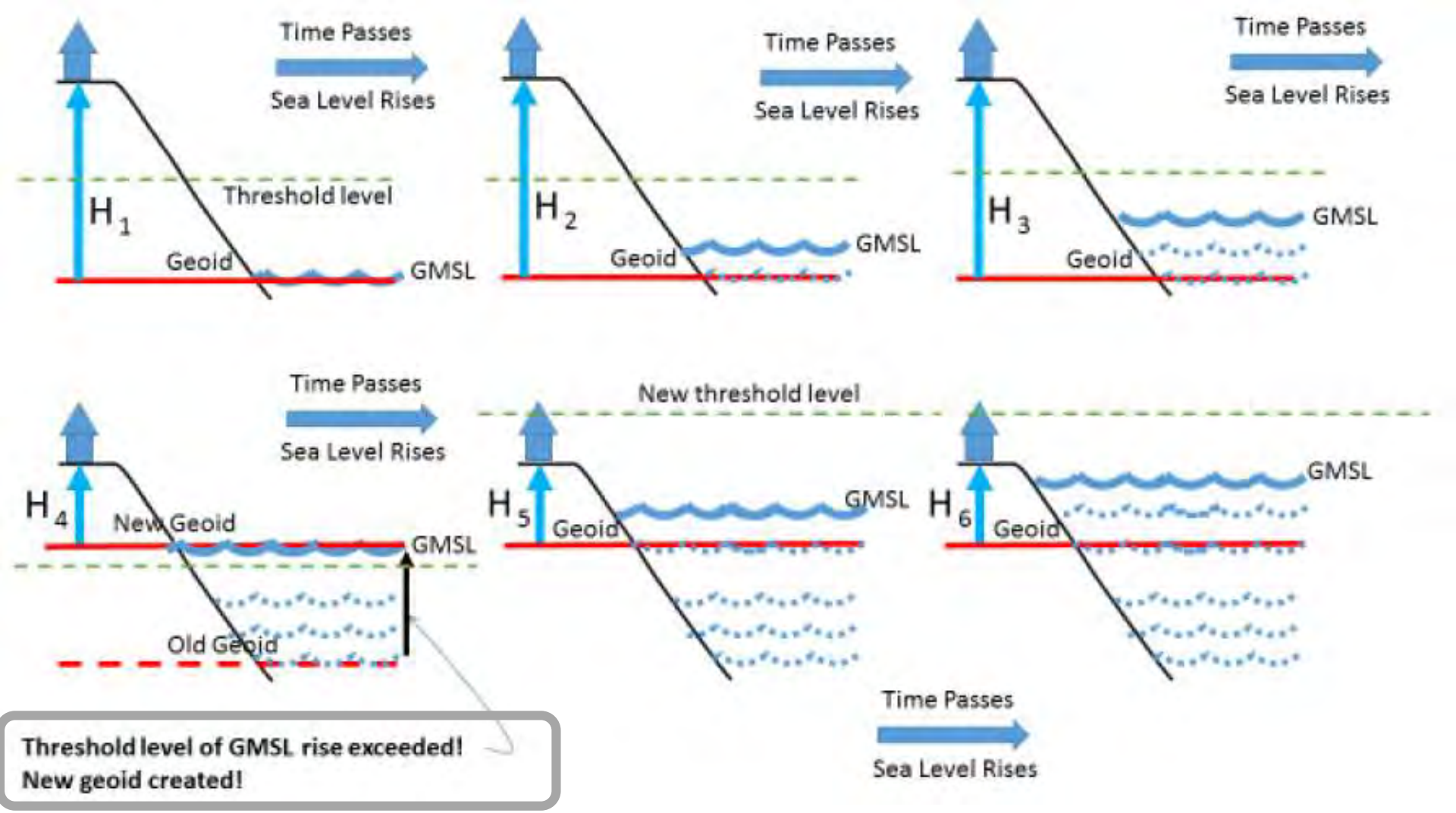
Sea Level Change and the Geoid

Scenario 2: Geoid Definition decoupled from GMSL

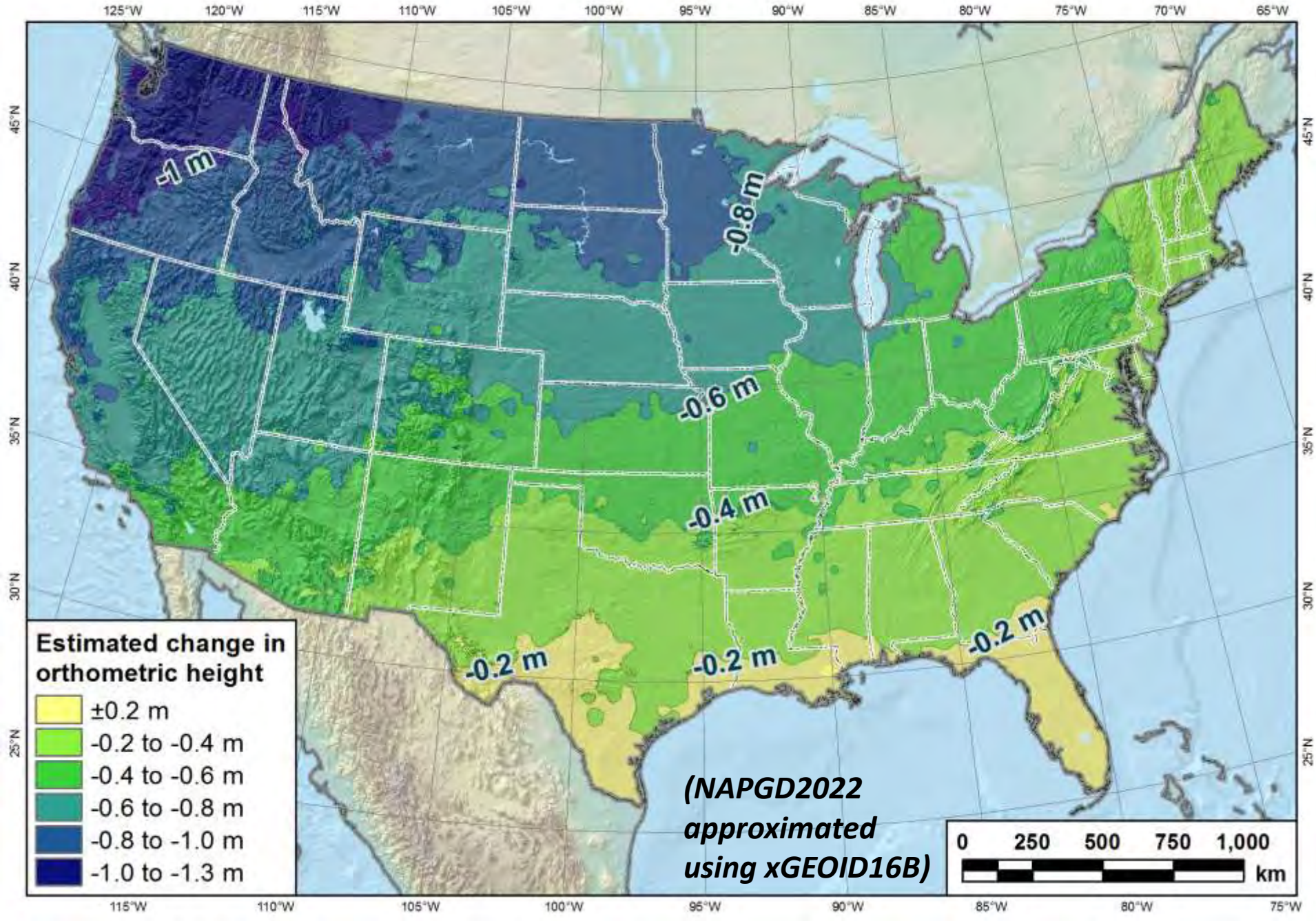


As Global Mean Sea Level rises, orthometric height remains constant

Sea Level Change and the Geoid



Estimated change in orthometric heights from NAVD88 to **NAPGD2022**



Estimated change in orthometric heights from NAVD88 to **NAPGD2022**

Vertical change of about -0.6 to -2.0 feet

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

NOAA Technical Report NOS NGS 64

Blueprint for 2022, Part 2: Geopotential Coordinates

How can I prepare?
Where did this all start?
How is all this possible?
What's the benefit to me?

Well, besides learning a whole new set of terminology and methods…

How can surveyors prepare?

- Get familiar with terms, ask now, be ready
- Set/occupy RTN Validation Stations (OPUS)
- Research your published control
  - pre-1995 will **NOT** get new coordinates (GPS only)
- Use OPUS Projects to re-observe/process

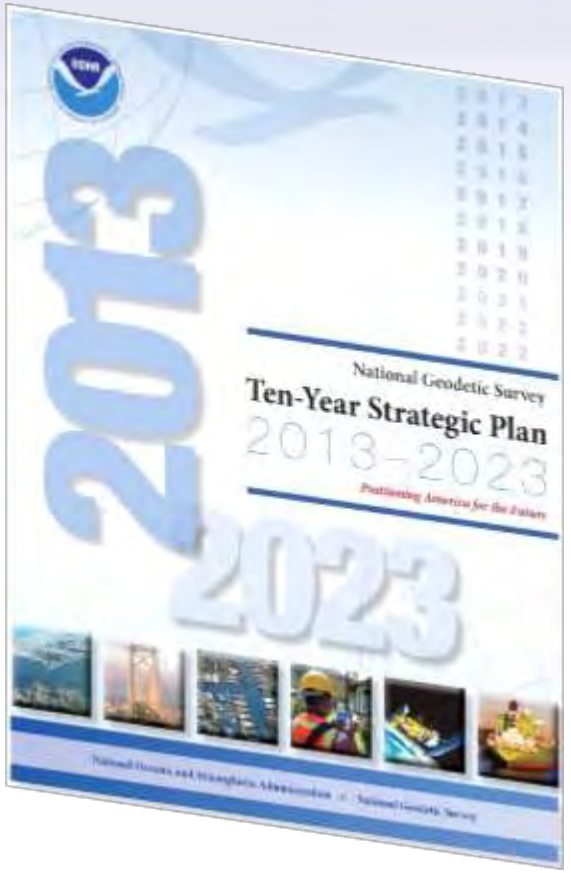
NGS Ten-Year Strategic Plan

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

aka "Replace NAD83"

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

aka "Replace NAVD88"



https://geodesy.noaa.gov/web/about_ngs/info/tenyearfinal.shtml

Science!

Co-location Site

NASA Goddard Space Flight Center, Greenbelt MD, USA

- GNSS, SLR, VLBI, DORIS

Co-location Site

NASA Goddard Space Flight Center, Greenbelt MD, USA

- GNSS, SLR, VLBI, DORIS

Co-location Site

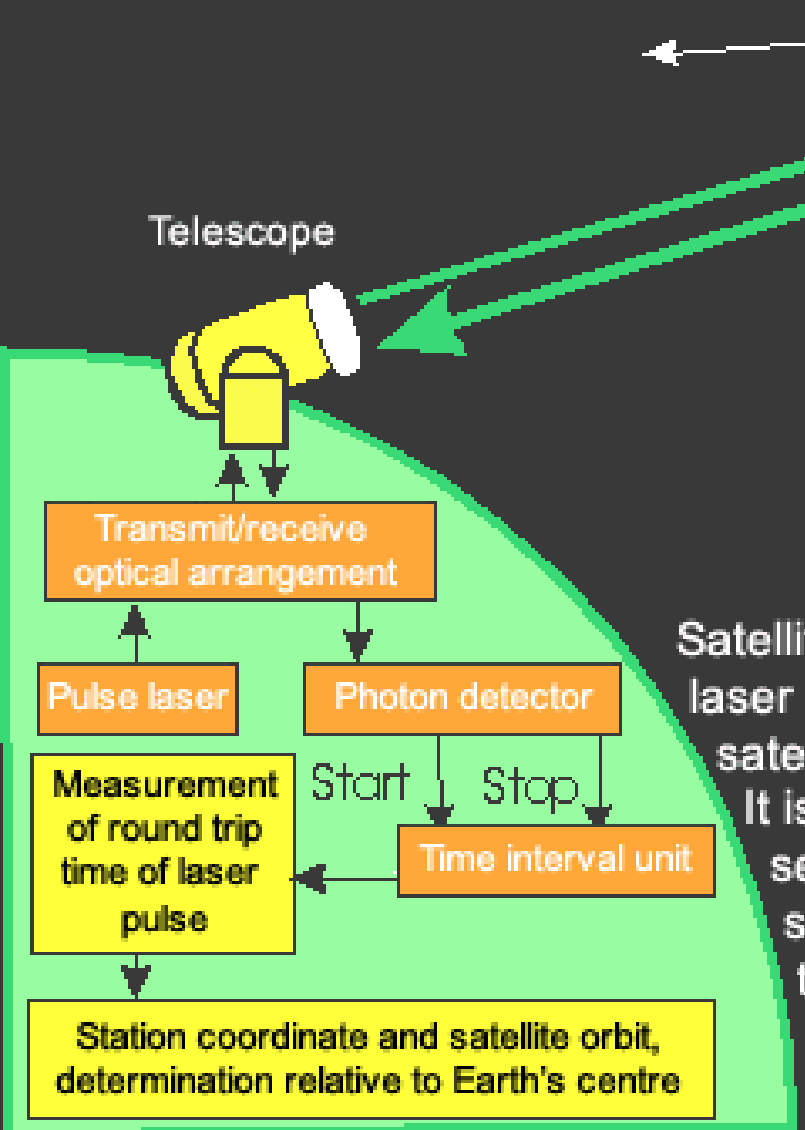
NASA Goddard Space Flight Center, Greenbelt MD, USA

- GNSS, SLR, VLBI, DORIS

SLR

Satellite **L**aser **R**anging

What is SLR?



Satellite Laser Ranging (SLR) involves firing a very short laser pulse to reflect off a corner cube prism on a satellite ad then measuring the round trip time of flight. It is possible to accurately measure this up to 30 pico seconds (30 x 10 to the power of -12). Since the speed of light is constant, measuring the round time is equivalent to measuring the round trip distance. The observatory is achieving sub-centimetre accuracy.

Co-location Site

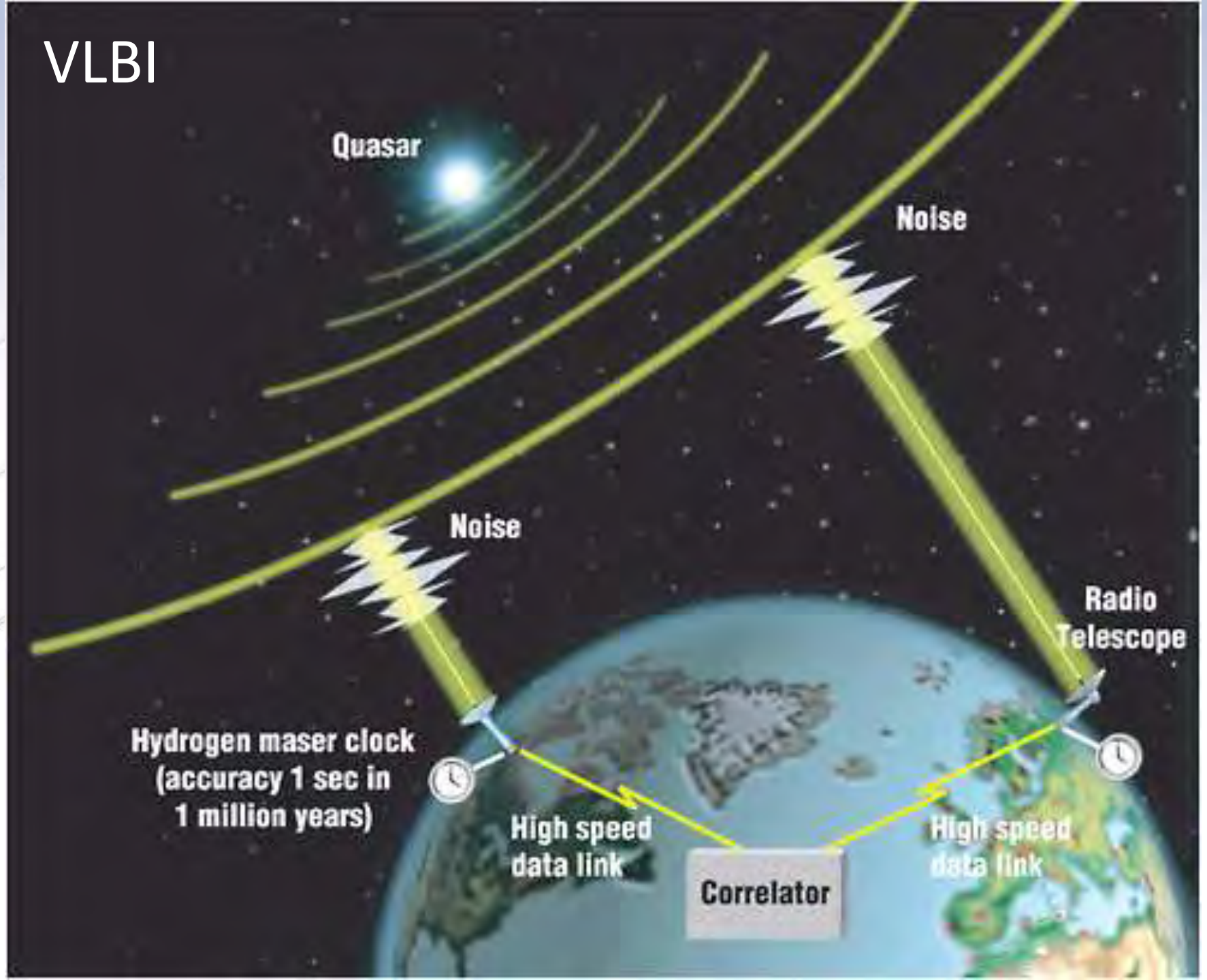
NASA Goddard Space Flight Center, Greenbelt MD, USA

- GNSS, SLR, VLBI, DORIS

VLBI

Very **L**ong
Baseline
Interferometry

VLBI


Quasar
Noise
Noise
Radio Telescope
Hydrogen maser clock (accuracy 1 sec in 1 million years)
High speed data link
Correlator
High speed data link

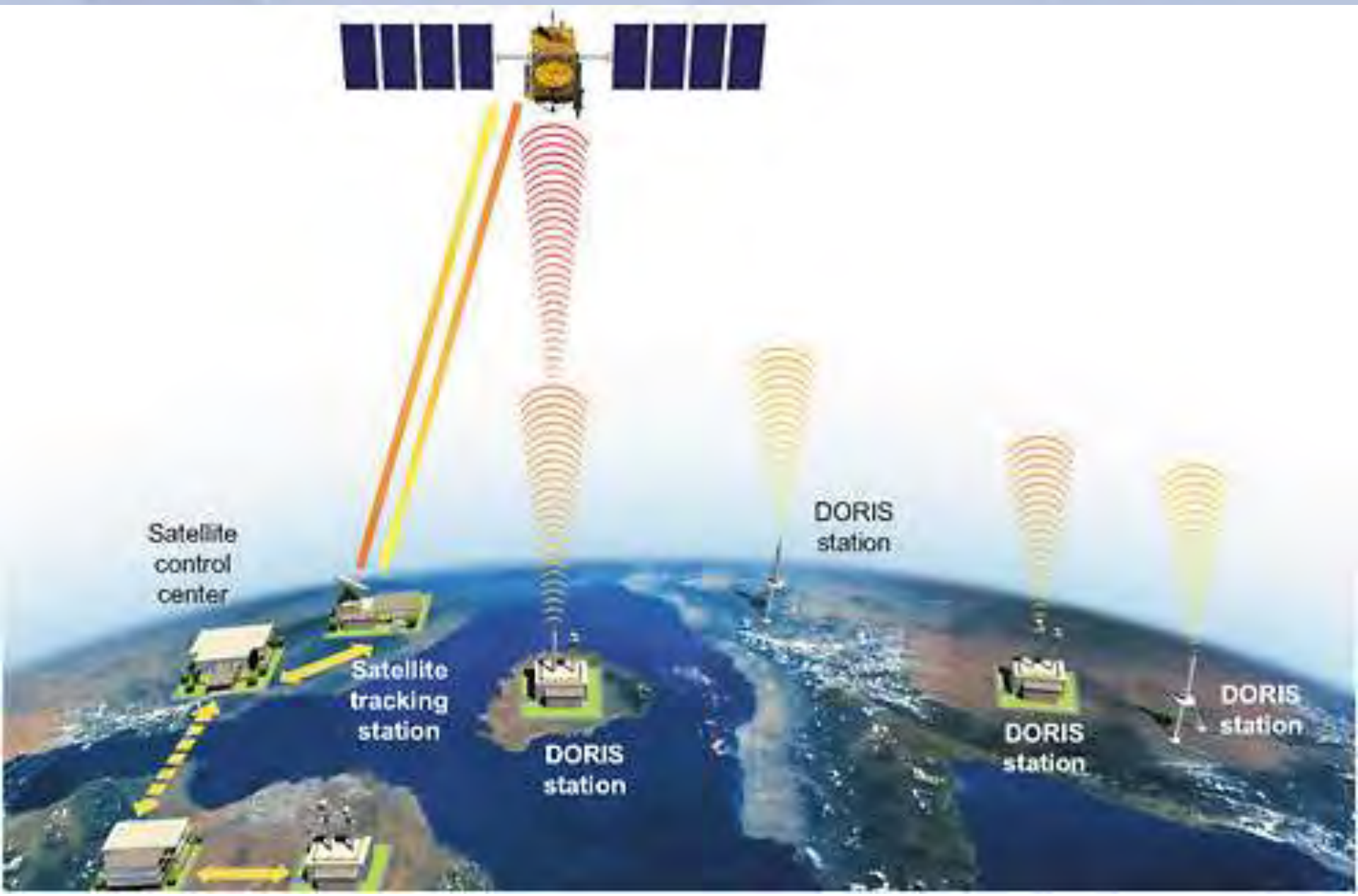
Co-location Site

NASA Goddard Space Flight Center, Greenbelt MD, USA

- GNSS, SLR, VLBI, DORIS

DORIS

Doppler **O**rbitography and **R**adiopositioning **I**ntegrated by **S**atellite



Doppler **O**rbitography and **R**adiopositioning **I**ntegrated by **S**atellite

Space Geodesy Co-location Diagram

Generic concept of "co-location survey", typically more complex.

Altogether now!

All these techniques work together to create a well-defined, robust reference frame that improves positioning for users globally.

Not *just* new datums…

NSRS Modernization

-OPUS enhancements/additions
-new types of coordinates
-new methods for establishing control
-streamlined Bluebooking
-retire the US Survey Foot

Blueprint for 2022, Part 3

Let's look at some new terminology

The NOAA CORS Network (NCN)

- As of 2019, this is the official name of the network managed at NGS
  - Historically referred to as "CORS" or "the CORS"

GPS Month

- A span of four consecutive GPS weeks, where the first GPS week in the GPS month is an integer multiple of 4
  - GPS Month 0 = GPS Weeks 0, 1, 2 and 3
  - GPS Month 1 = GPS Weeks 4, 5, 6 and 7
  - GPS Month 2 = GPS Weeks 8, 9, 10, and 11
  - GPS Month 3 = GPS Weeks 12, 13, 14, and 15
  - You get the idea…

New Types of Coordinates

Five types of coordinates in Modernized NSRS

Name	Generally on…	Description
Reported	Passive	"Quick and Dirty". Smartphone accuracy. (aka HD_HELD)
Preliminary	Passive	Computed by you with OPUS using your data. Unchecked by NGS.
Final Discrete	Passive	**Most accurate**. Time-dependent. Computed by NGS every four weeks.
Final Running	CORS	Continuous time-dependent CORS coordinates. Checked by NGS every day.
Reference Epoch	Passive and CORS	Modeled from Final Discrete, Final Running, IFVM2022 and GeMS. Computed by NGS every five years.

Reported Coordinates

These are from any source in which the coordinate is directly reported to NGS ***without the data necessary for NGS to replicate the coordinate***.

Compares to:

- SCALED – like on a datasheet
- HD_HELD – like on a datasheet
- Smartphone/Device GNSS
- From NCAT or VDatum
- Coordinates from and RTK/RTN rover *without data files*

Reported Coordinates

Preliminary Coordinates

These are coordinates **at survey epoch that have been computed from OPUS**, but not yet quality checked and loaded into the National Spatial Reference System Database (NSRS DB).

Compares to:

- OPUS Solution Report – NGS does not QC these
- OPUS-Projects results – only QC'd if submitted

Note:

- These are the ***only*** coordinates a user will get directly from OPUS

Final Discrete Coordinates

These are coordinates **computed by NGS using submitted data and metadata**, checked, adjusted, and **referenced to a single survey epoch** for loading into the NSRS DB.

- Represent the best *estimates* of the time-dependent coordinates at any mark

What will the Survey Epochs be?

- GNSS: GPS Month
  - –Stand-alone occupations, RTK/RTN, Campaigns, etc.
- Leveling: Calendar Year; Annually
  - –Will be adjusted to GNSS-based orthometric heights

Final Running Coordinates

These are the **only type** which will have a published coordinate **at any epoch**.

- Generally will only be available at CORSs
- Will be generated by a "fit" to daily processed data
- Another new term!
  - We'll refer to these as the **Coordinate Function**

Reference Epoch Coordinates

These are coordinates which have been **estimated** by NGS based on time-dependent (final discrete and final running) coordinates, at an Official NSRS Reference Epoch (ONRE).

Compares to:

- NAD 83(2011) epoch 2010.00 on a Datasheet

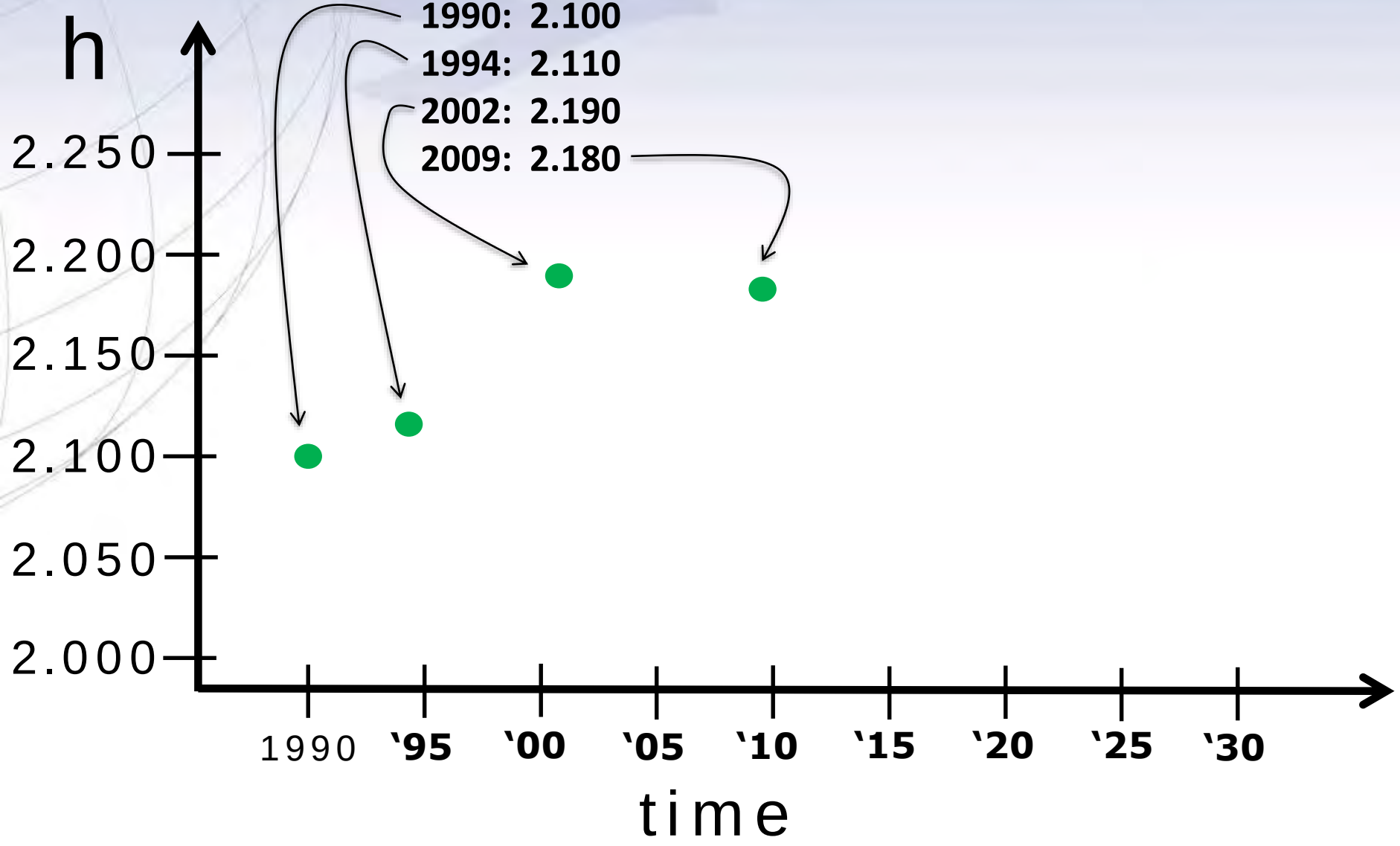
When will NGS compute these?

- Every 5 years, on a timeline of 2-3 years post-date
  - 2020.00 coordinates will be computed in 2022
  - 2025.00 coordinates will be computed in 2027

Reference Epoch Coordinates from Time-Dependent Coordinates

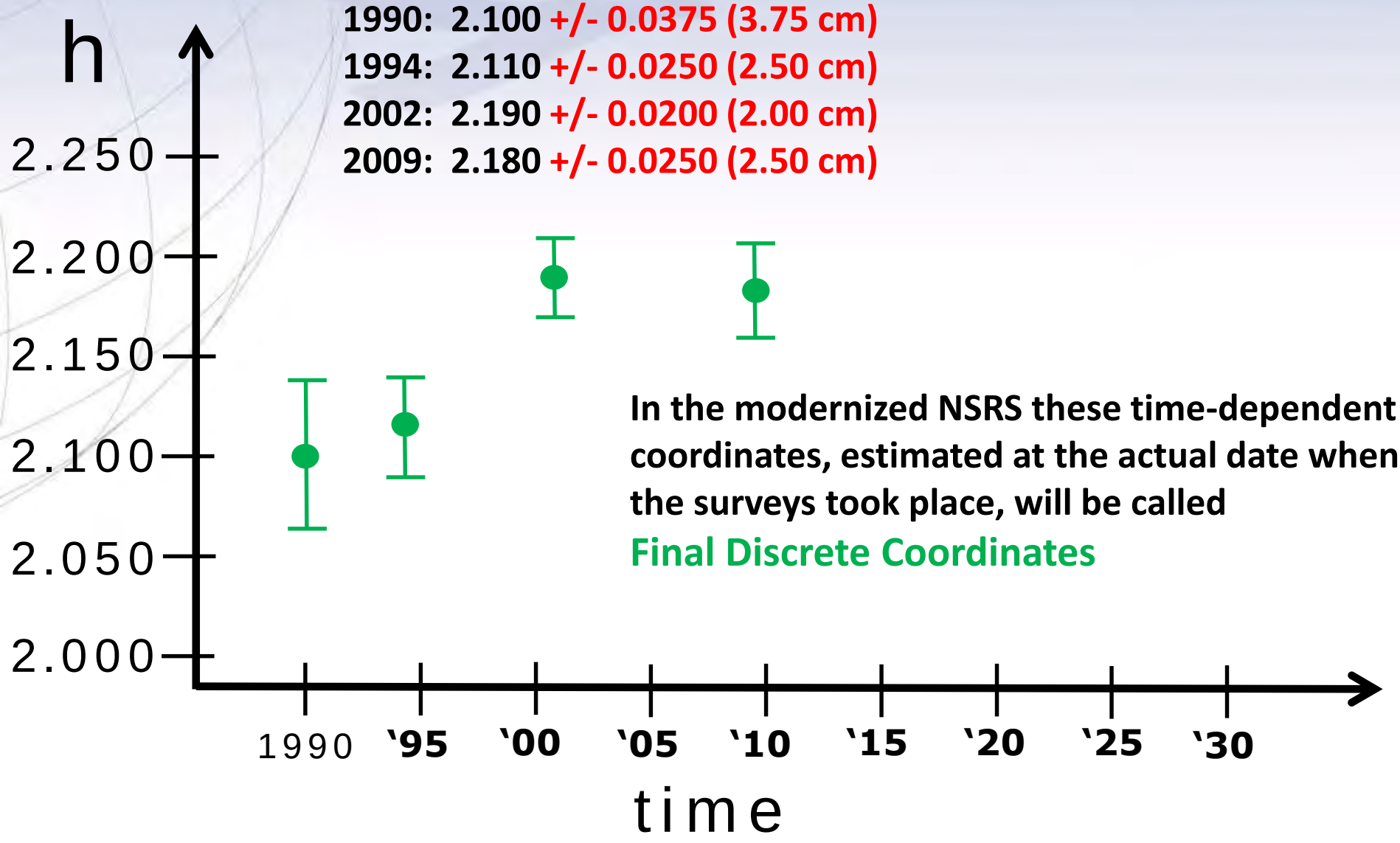
Assume "h" was determined four different times:

1990: 2.100
1994: 2.110
2002: 2.190
2009: 2.180



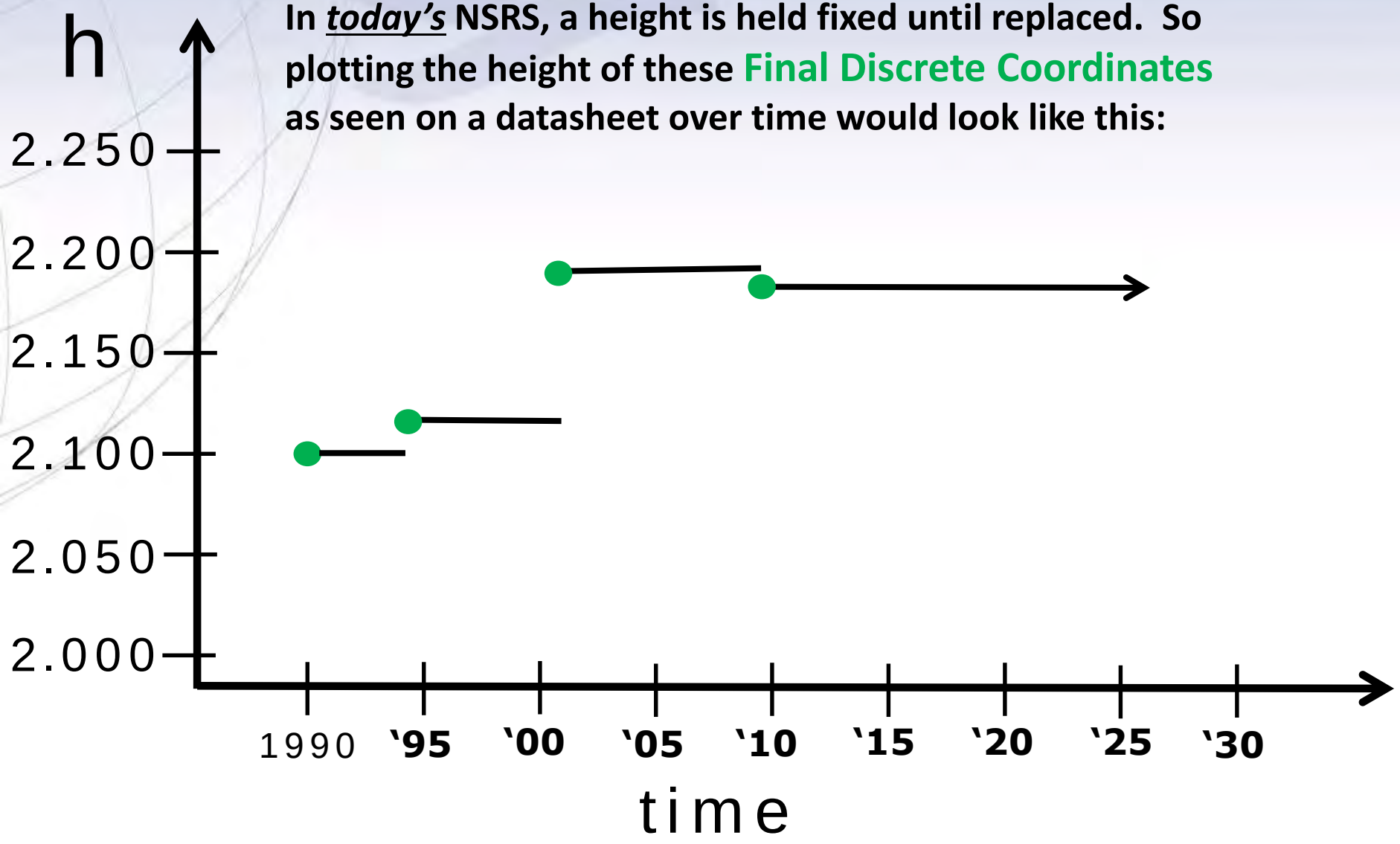
All measurements have error. Shown here are the same Values of "h", but with their error estimates.

1990: 2.100 +/- 0.0375 (3.75 cm)
1994: 2.110 +/- 0.0250 (2.50 cm)
2002: 2.190 +/- 0.0200 (2.00 cm)
2009: 2.180 +/- 0.0250 (2.50 cm)

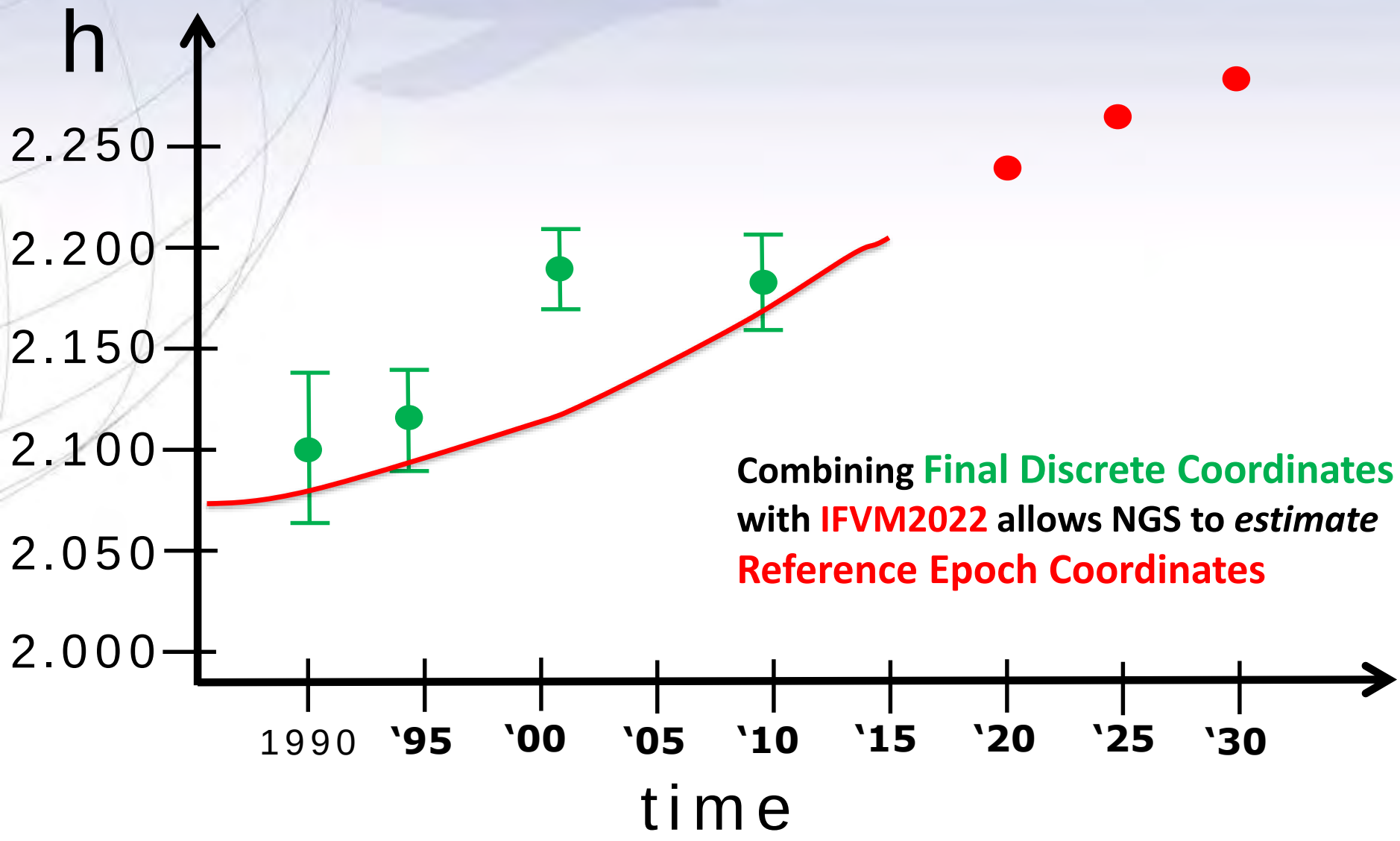


In the modernized NSRS these time-dependent coordinates, estimated at the actual date when the surveys took place, will be called
Final Discrete Coordinates

In *today's* NSRS, a height is held fixed until replaced. So plotting the height of these Final Discrete Coordinates as seen on a datasheet over time would look like this:

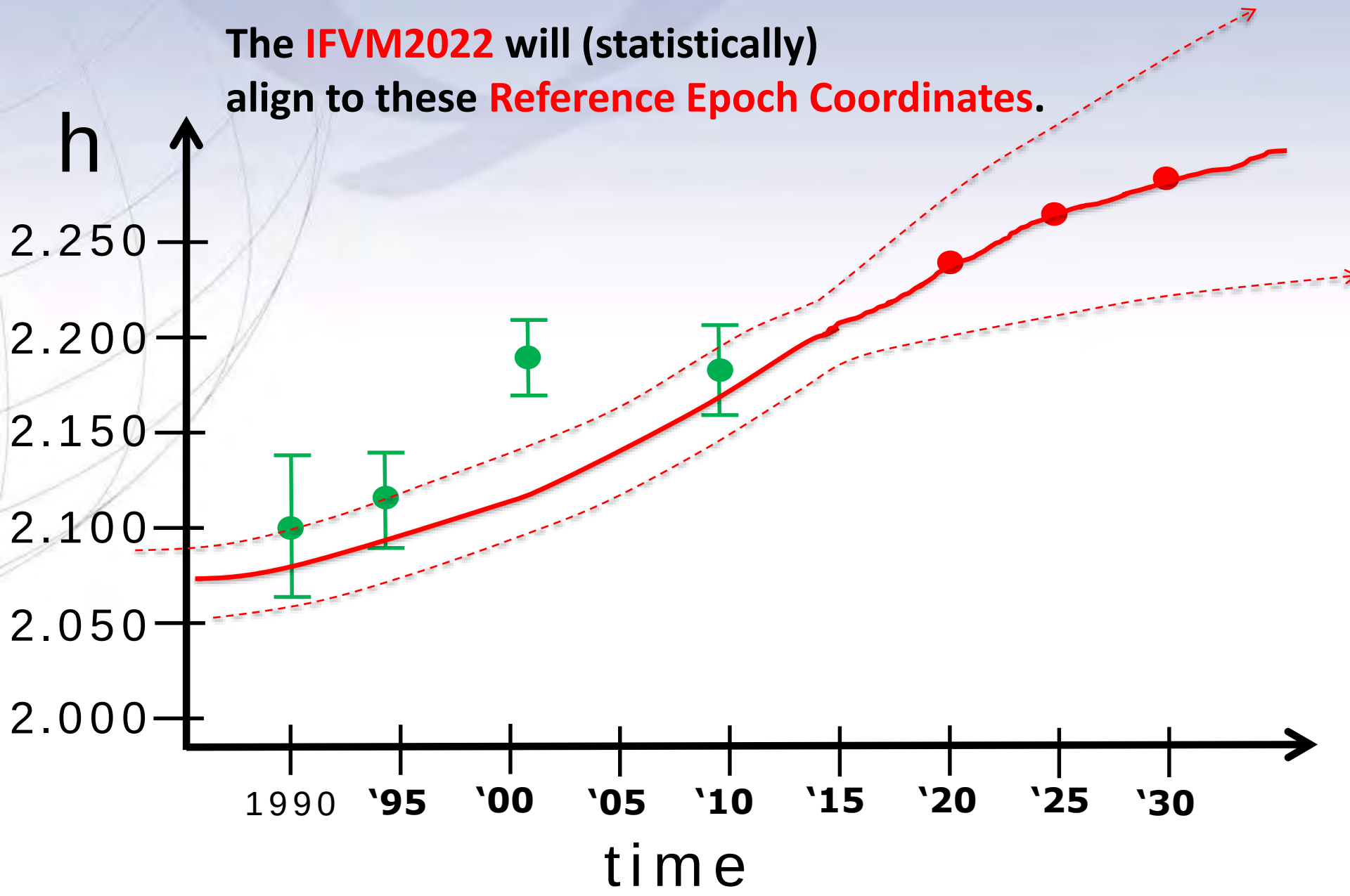


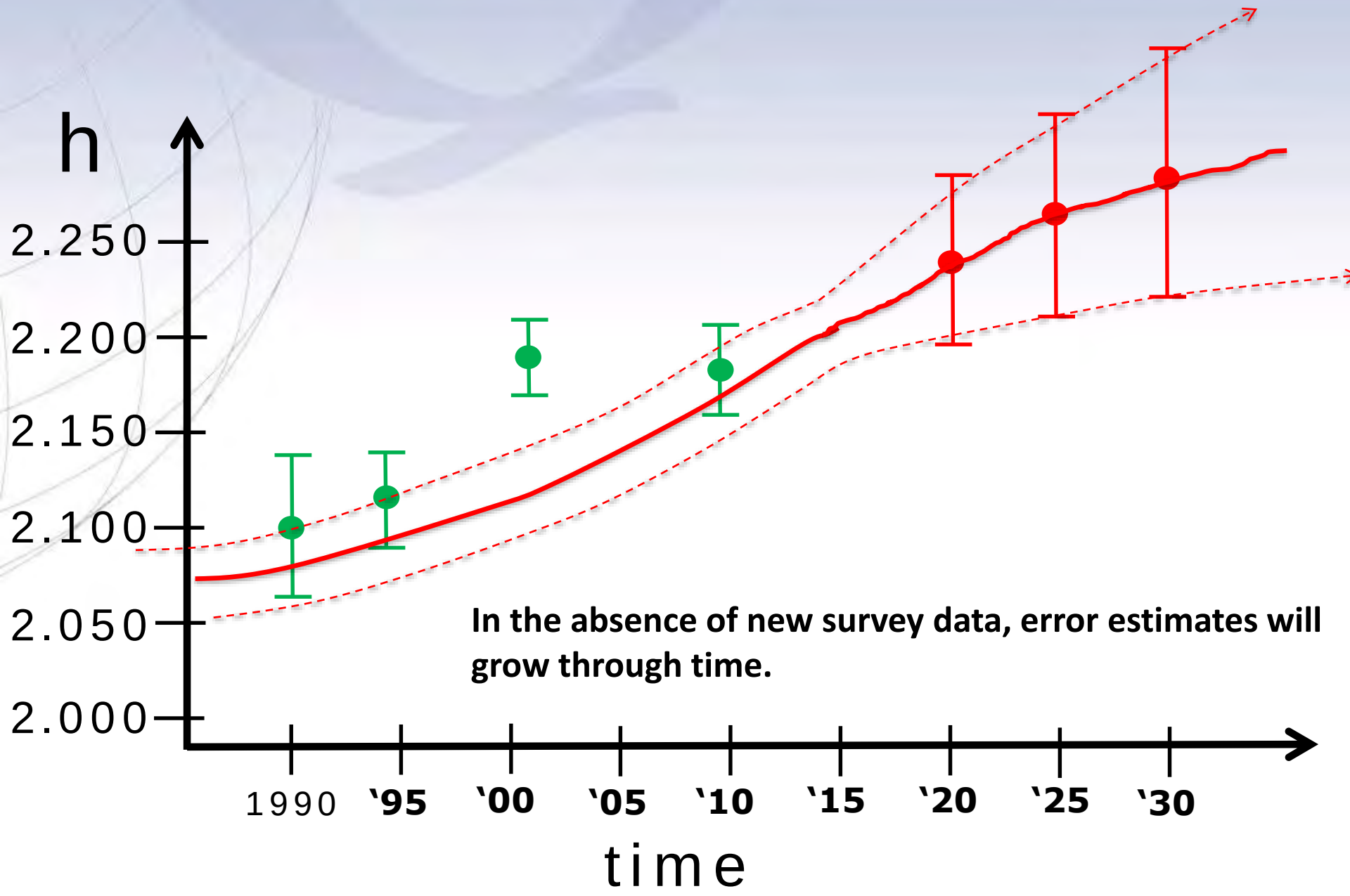
In the *modernized* NSRS we will also have an estimate of crustal motion from IFVM2022

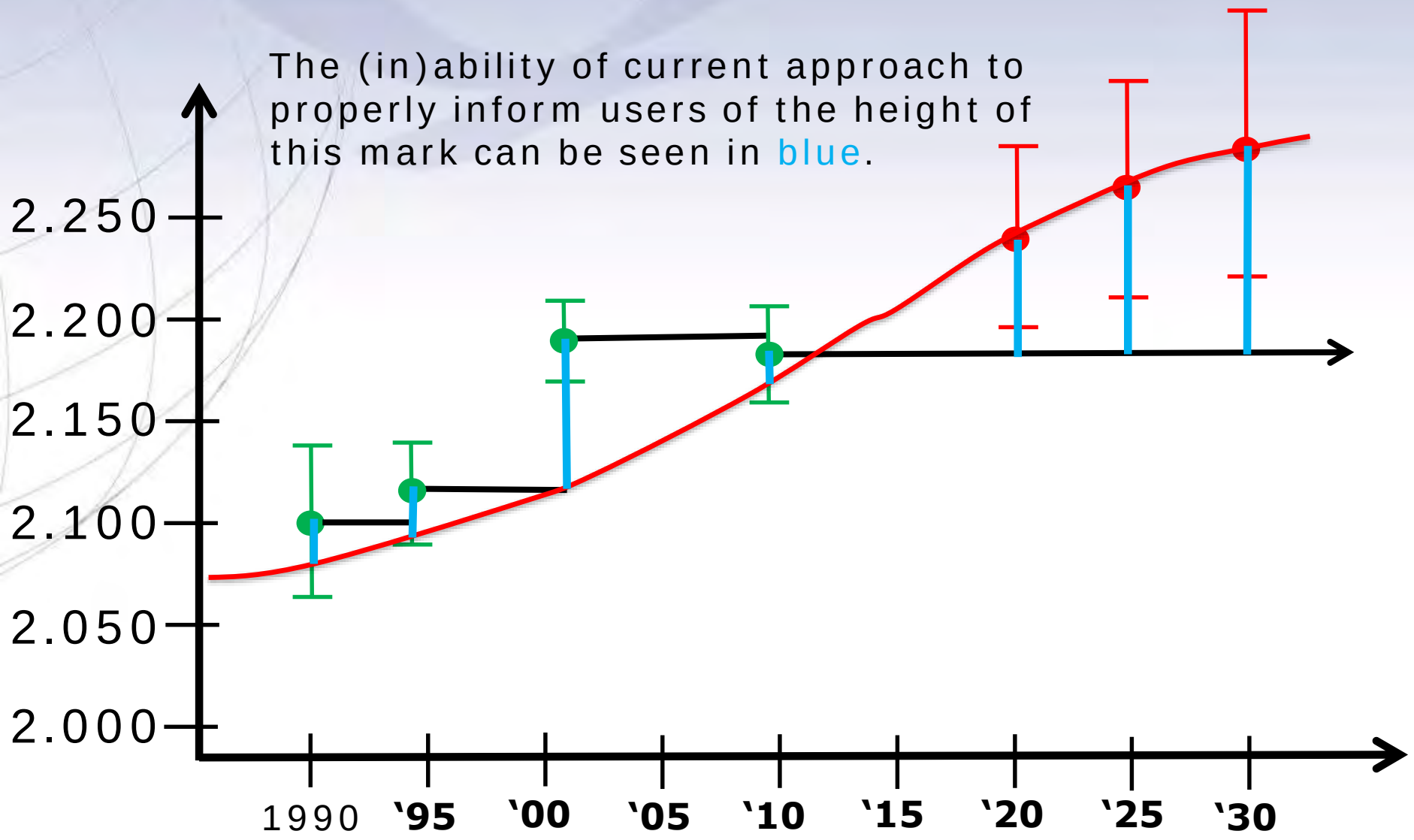


Combining Final Discrete Coordinates with IFVM2022 allows NGS to *estimate* Reference Epoch Coordinates

The IFVM2022 will (statistically) align to these Reference Epoch Coordinates.




h
2.250
2.200
2.150
2.100
2.050
2.000
1990
'95
'00
'05
'10
'15
'20
'25
'30
time
In the absence of new survey data, error estimates will grow through time.


The (in)ability of current approach to properly inform users of the height of this mark can be seen in blue.
2.250
2.200
2.150
2.100
2.050
2.000
1990
'95
'00
'05
'10
'15
'20
'25
'30

State Plane Coordinate System of 2022

SPCS2022

geodesy.noaa.gov

National Geodetic Survey

Positioning America for the Future

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

State Plane Coordinate System
- Home
- Maps
- Download Design Maps
- Convert Coordinates
- Current Policy
- 2022 Policy Changes
- Learn More

Have State Plane Questions?
- Contact Us

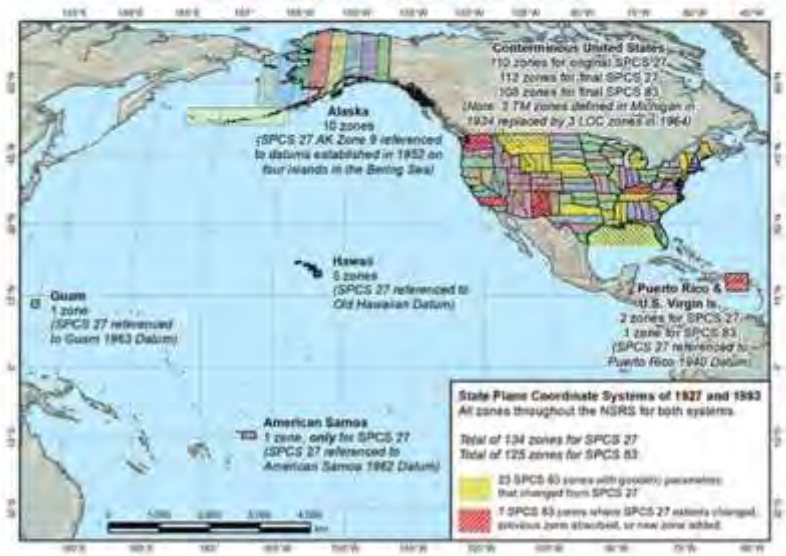
State Plane Coordinate System (SPCS)

SPCS is a system of large-scale conformal map projections originally created in the 1930s to support surveying, engineering, and mapping activities throughout the U.S. and its territories. As a reminder, a map projection is a systematic transformation of the latitudes and longitudes of locations on the surface of a sphere or ellipsoid representing the Earth to grid coordinates (x, y or easting, northing values) on a plane.

Since its inception, SPCS has served as a practical means for NGS customers to access to the National Spatial Reference System (NSRS). These web pages will help you convert coordinates, find related NGS policies and other documents, read about the history and status of current SPCS, and learn about how SPCS will change in 2022.

The map below shows the full extents and all zones of the 1927 and 1983 versions of SPCS (select the map for a higher resolution version). View **more detailed maps** or a **map depicting SPCS 83 legislation**.

State Plane Coordinate Systems of 1927 and 1983



Full extents and all zones of the 1927 and 1983 versions of SPCS. **Map High Res Version**

Website Owner: National Geodetic Survey / Last modified by NGS Infocenter Mar 05 2018

NOS Home • NGS Employees • Privacy Policy • Disclaimer • USA.gov • Ready.gov • Site Map • Contact Webmaster

---

ational Geodetic Survey

Positioning America for the Future

Surveys | Science & Education | Search

etic Survey (NGS) provides the framework for all
the Nation. The foundational elements of latitude,
horeline information impact a wide range of important

we provide
r area
geodesy

Looking for Bench Marks?

Notices

Register: Geospatial Summit on May 6-7, 2019

BETA Releases: BETA GEOID18

BETA CORS ITRF14 Coordinates

Data

mation and
work

Learn More

Remote Sensing

Download data and critical information into nautical charts.

Learn More

ying

get tools to
rs.

Learn More

Geodesy

NGS works closely with the global researchers advancing geodetic science.

Learn More

In the News

03/22/2019 - GPS on Bench Marks' Campaign Successes Presented at Conference

03/15/2019 - GEOID18 Products Released for Beta Testing and Public Comment

03/08/2019 - NGS Updates its Strategic Plan

Previous News Stories

ication

onal
ic topics

Learn More

Datums & Transformations

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

Learn More

Website Owner: National Geodetic Survey / Last modified by NGS.webmaster Jun 12 2017

NOS Home • NGS Employees • Privacy Policy • Disclaimer • USA.gov • Ready.gov • Site Map • Contact Webmaster

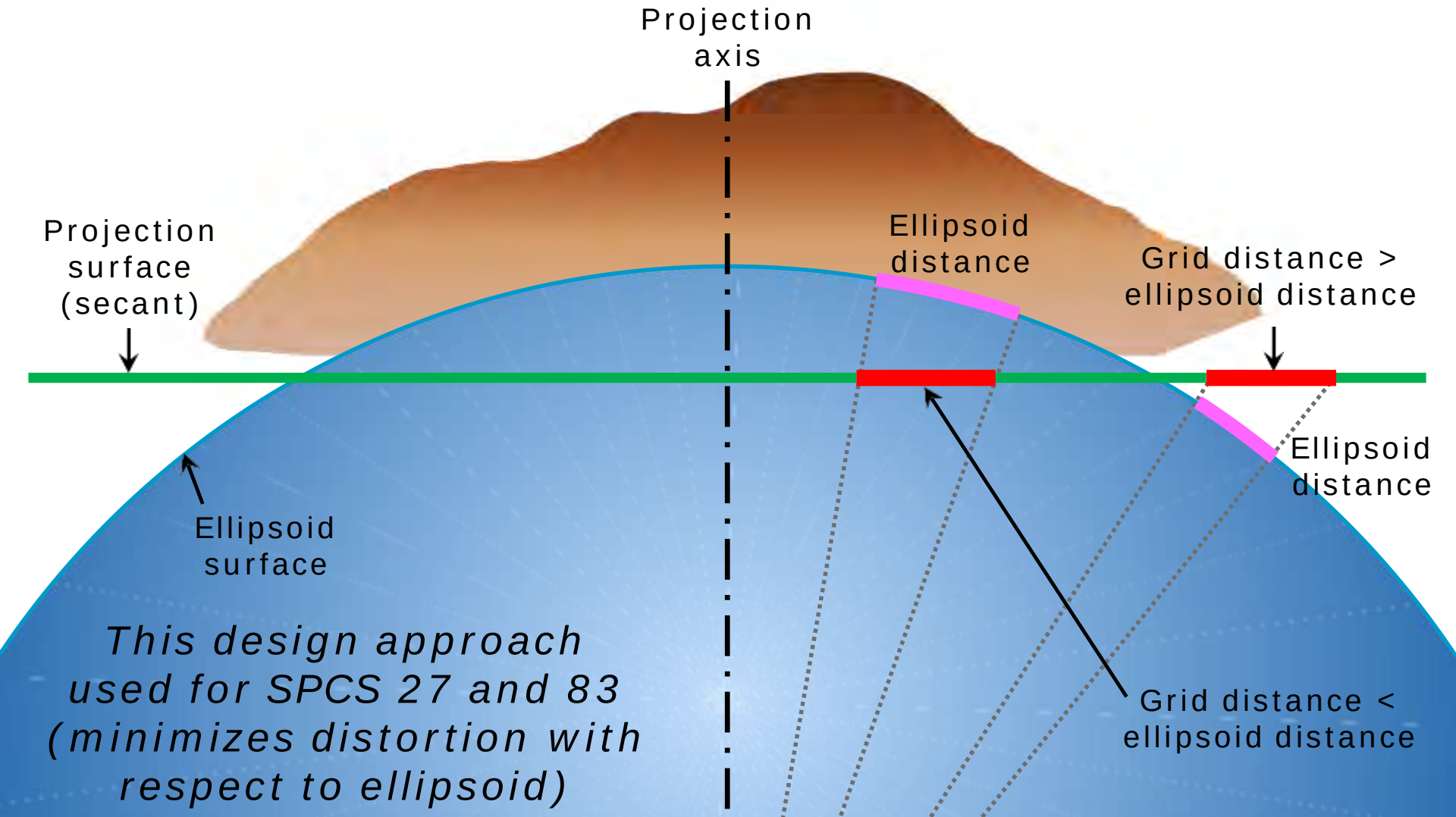
SPCS2022 stakeholders

- **State groups** that formally interface with NGS
  - Departments of transportation
  - Cartographer/GIS office
  - Professional surveying, engineering, GIS societies
  - Colleges/universities with geospatial curriculum
- Can submit ***requests*** and ***proposals*** for designs
  - ***Requests*** are for designs by NGS
  - ***Proposals*** are designs by stakeholders
- Stakeholder input must be ***unanimous***

General SPCS2022 characteristics

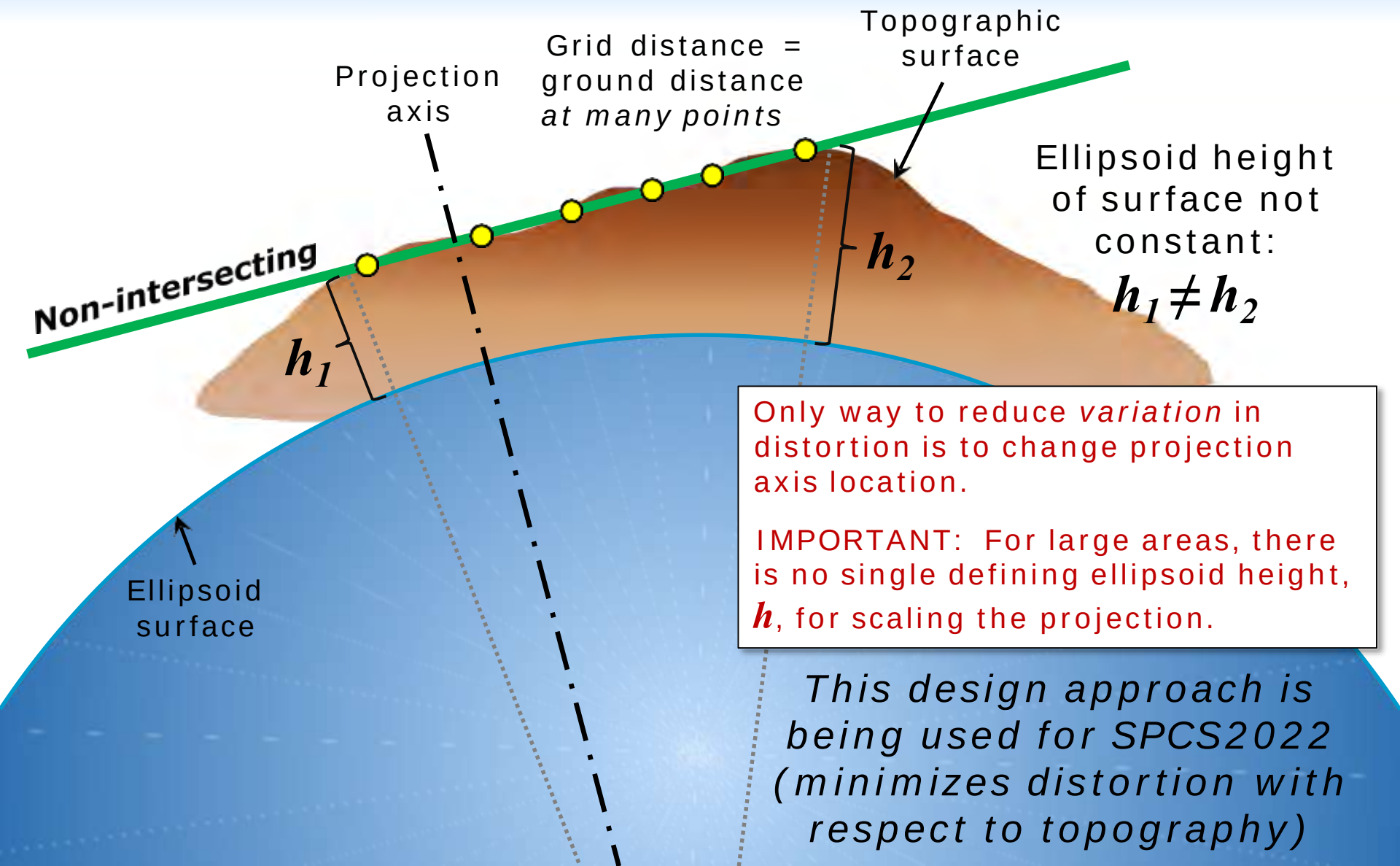
- Distortion design requirements
  - ***Linear distortion*** minimized at topographic surface (**not** at ellipsoid surface)
  - ***Purpose:*** to reduce difference between projected "grid" and actual "ground" distances
- Other characteristics
  - Default designs (if no consensus stakeholder input)
  - Statewide and "layered" zones
  - Positive east longitudes
  - Low-distortion projections (LDPs)
  - "Special use" zones

Linear distortion *with respect to ellipsoid*

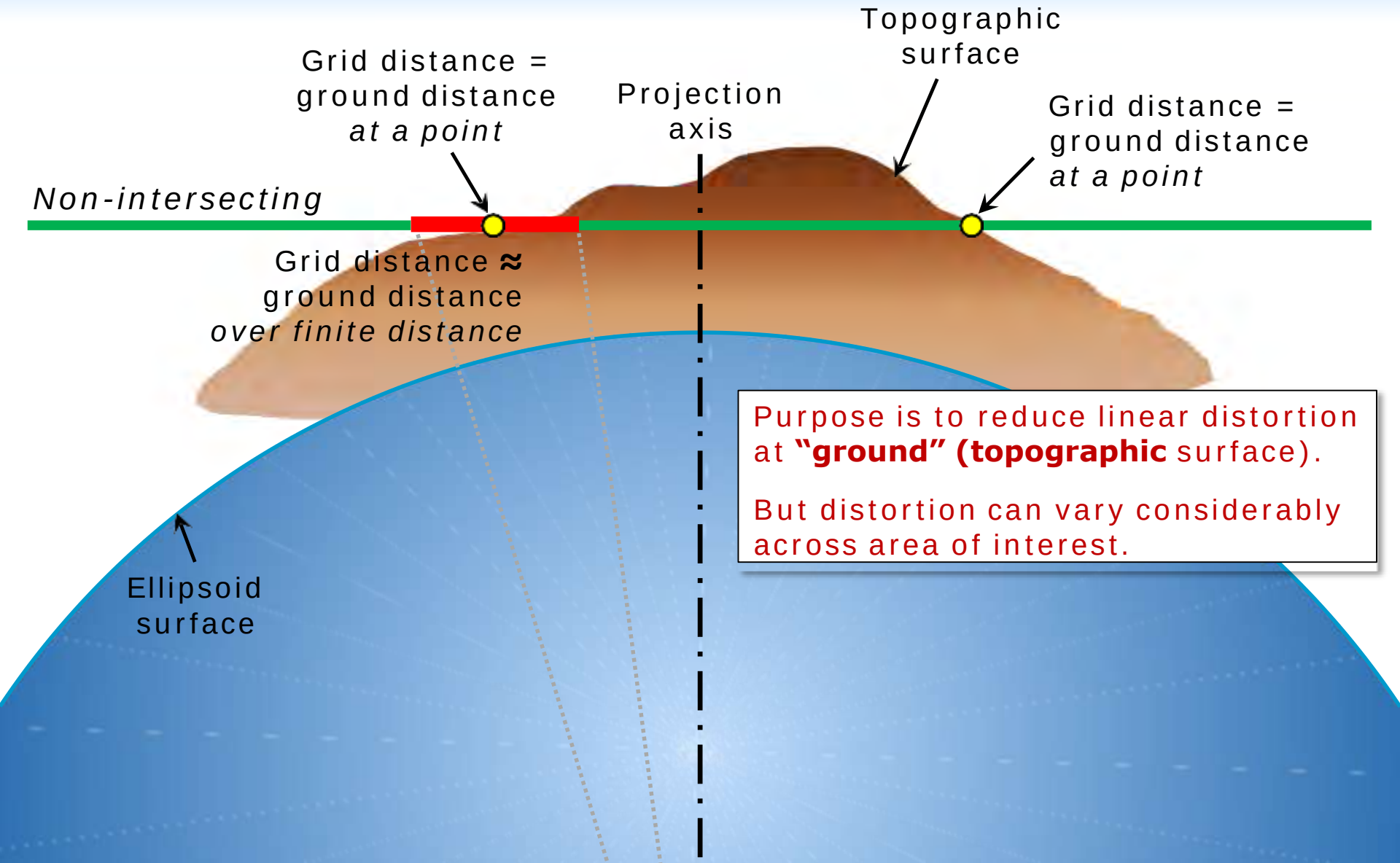


This design approach used for SPCS 27 and 83 (minimizes distortion with respect to ellipsoid)

Changing projection axis to reduce distortion variation



"Non-intersecting" conformal map projection



Purpose is to reduce linear distortion at **"ground" (topographic** surface).

But distortion can vary considerably across area of interest.

Default SPCS2022 zones

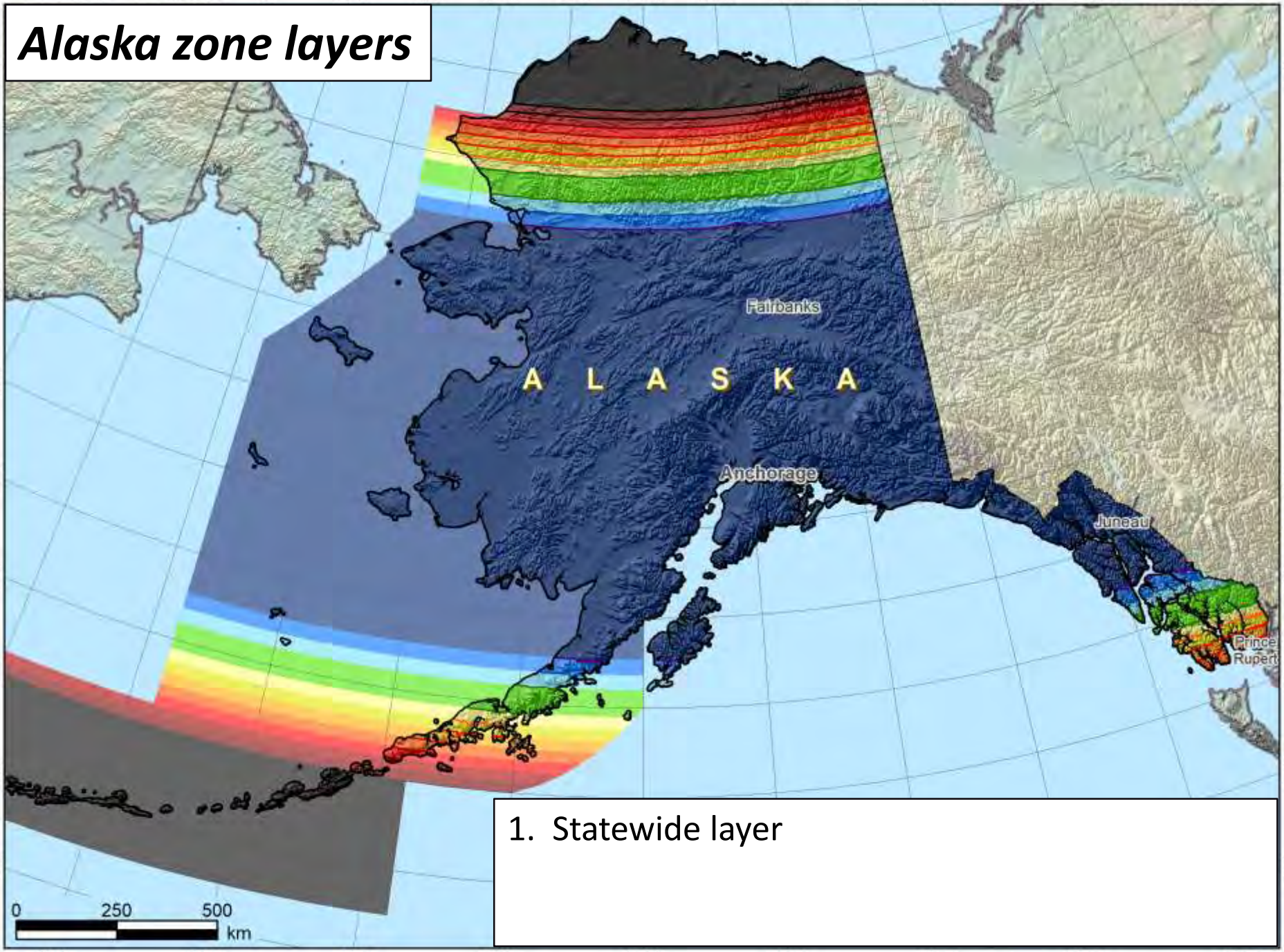
- To ensure ***all*** states and U.S. territories covered
  - For complete system if no consensus stakeholder input
  - Nearly same as SPCS 83 but with some changes
  - Almost all zone projection types and extents the same
- Modify existing zones to meet SPCS2022 policy
  - Scale redefined with respect to **topographic surface**
  - Use 1-parallel Lambert and local Oblique Mercator
- **NGS will create a statewide zone for *all* states**

Zone "layers" and LDPs

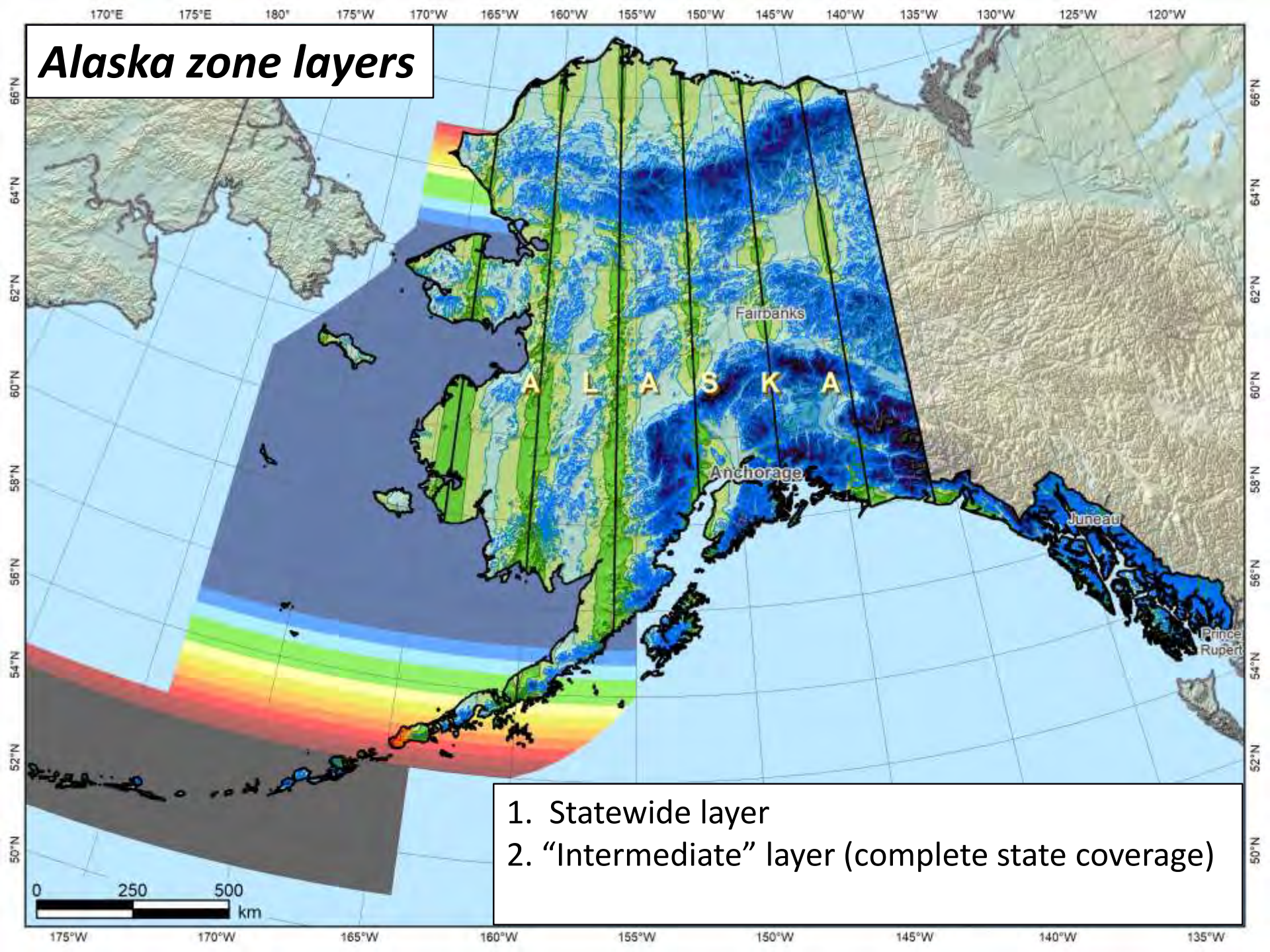
- Each state may have max of ***THREE*** zone "layers"
  - One layer *must* be statewide zone (designed by NGS)
  - Other layers have two or more zones ("multi-zone")
  - Only one layer can have discontinuous coverage

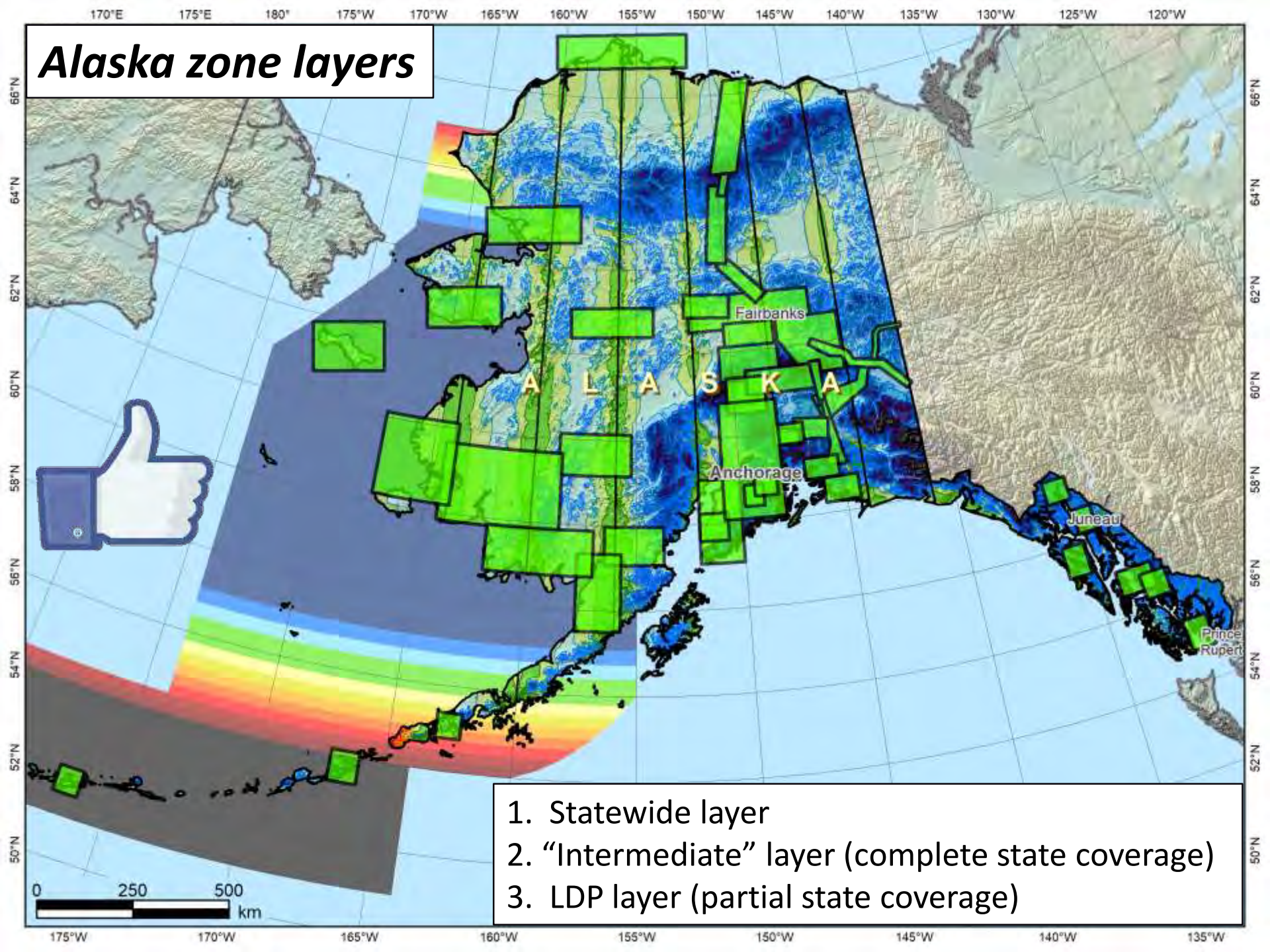
- Multi-zone layer can consist of LDPs
  - Designed by stakeholder "contributing partners"
  - Minimum zone width 50 km (if height range < 250 m)
    OR 10 km (if height range > 250 m)
  - LDP coverage can be discontinuous

Alaska zone layers



1. Statewide layer


Alaska zone layers
170°E
175°E
180°
175°W
170°W
165°W
160°W
155°W
150°W
145°W
140°W
135°W
130°W
125°W
120°W
66°N
64°N
62°N
60°N
58°N
56°N
54°N
52°N
50°N
A L A S K A
Fairbanks
Anchorage
Juneau
Prince Rupert
0
250
500
km
175°W
170°W
165°W
160°W
155°W
150°W
145°W
140°W
135°W
1. Statewide layer
2. “Intermediate” layer (complete state coverage)


Alaska zone layers
ALASKA
Fairbanks
Anchorage
Juneau
Prince Rupert
1. Statewide layer
2. “Intermediate” layer (complete state coverage)
3. LDP layer (partial state coverage)
0 250 500 km

SPCS2022 deadlines

- **Consensus** input per SPCS2022 procedures
  - ***Requests*** for designs done by NGS
  - ***Proposals*** for designs by contributing partners
- Submittal of **approved** designs
  - Proposal must first be approved by NGS
  - Designs must be complete for NGS to review
- Later requests will be for ***changes*** *to* SPCS2022

by **March 31, 2020** for ***requests*** and ***proposals***
by **March 31, 2021** for ***submittal*** of ***approved*** designs

SPCS2022 in Pennsylvania

- PSLS Geospatial Committee has formalized (and currently disseminating) desired criteria for submitting a request to NGS
  - 4-5 zones; respect county boundaries and metro areas
- NGS will design a single statewide Zone that covers the entire State (eliminate N-S zones)
  - this will enable Commonwealth agencies to maintain all data within one zone

…or Feets Don't Fail Me Now

The problem

- **Two versions of same unit in current use**
  - "New" international foot and "old" U.S. survey foot
  - "New" shorter than "old" by 2 ppm (**0.01 ft per mile**)
  - A ***real*** problem with ***real*** costs
- **What's in a name?**
  - "U.S. survey" versus "international"
- **Who is using U.S. survey feet?**
  - Surveyors exclusively, in most (*not all*) states
  - But it impacts everyone

2 parts per million (ppm)

- 1,000,000.00 sft = 999,998.00 ift
- 10,000,000.00 sft = 9,999,980.00 ift

- International → 1 ft = .3048 m
- US → 1 ft = .30480061 m (approx.)

  –frequently calculated by $\frac{1200}{3937}$

What's impacted?

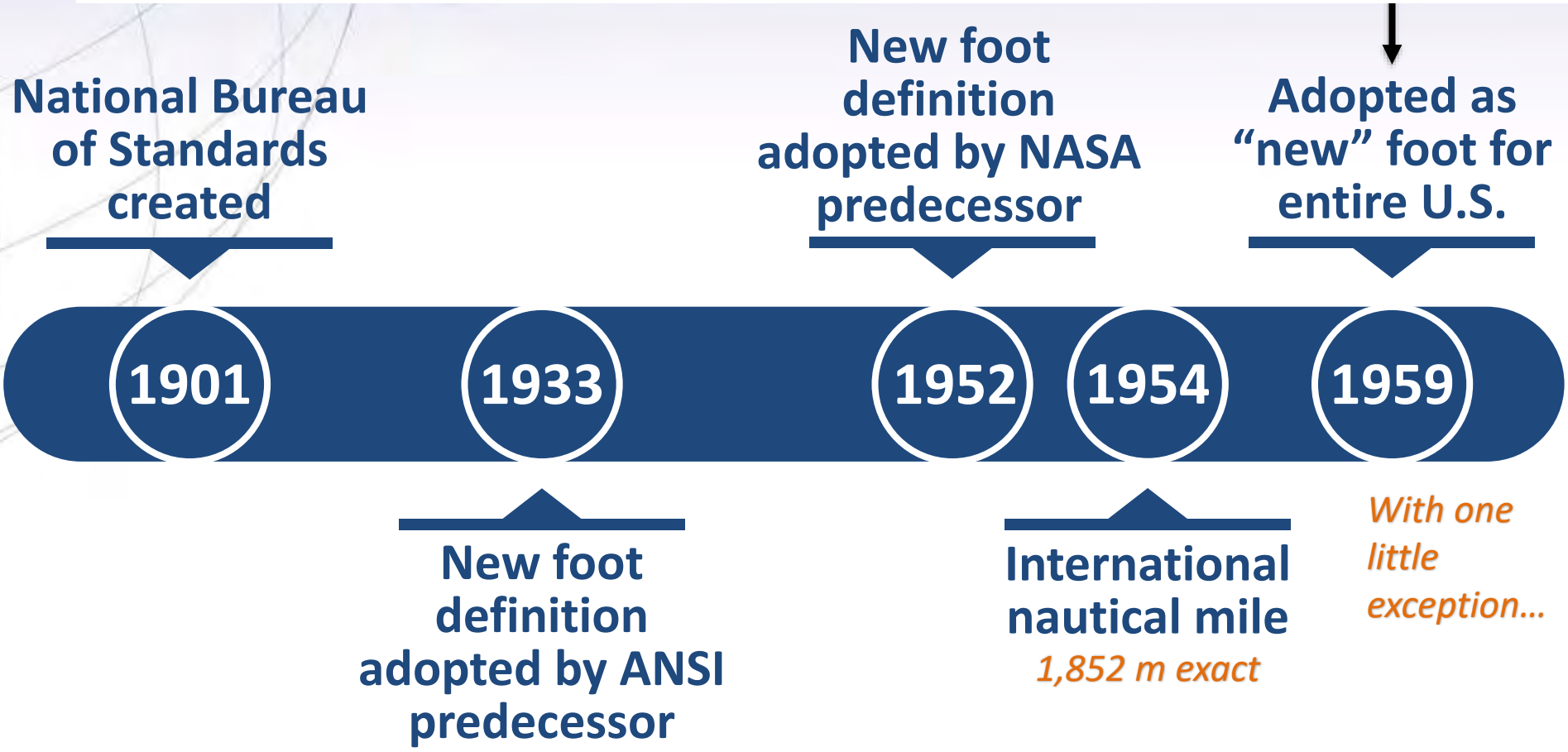
- **When does this matter?**
  - ***Not*** typically in lengths/distances
  - But in published planar coordinate systems
- **Like what?**
  - SPCS and UTM are very popular and both fall victim to mix-ups
- **Why?**
  - Large false eastings and northings

Who is responsible for standards?

National Institute of Standards and Technology

Adopted International Foot in 1959

1 foot = 0.3048 meter *exactly* (1 yard = 0.9144 m)

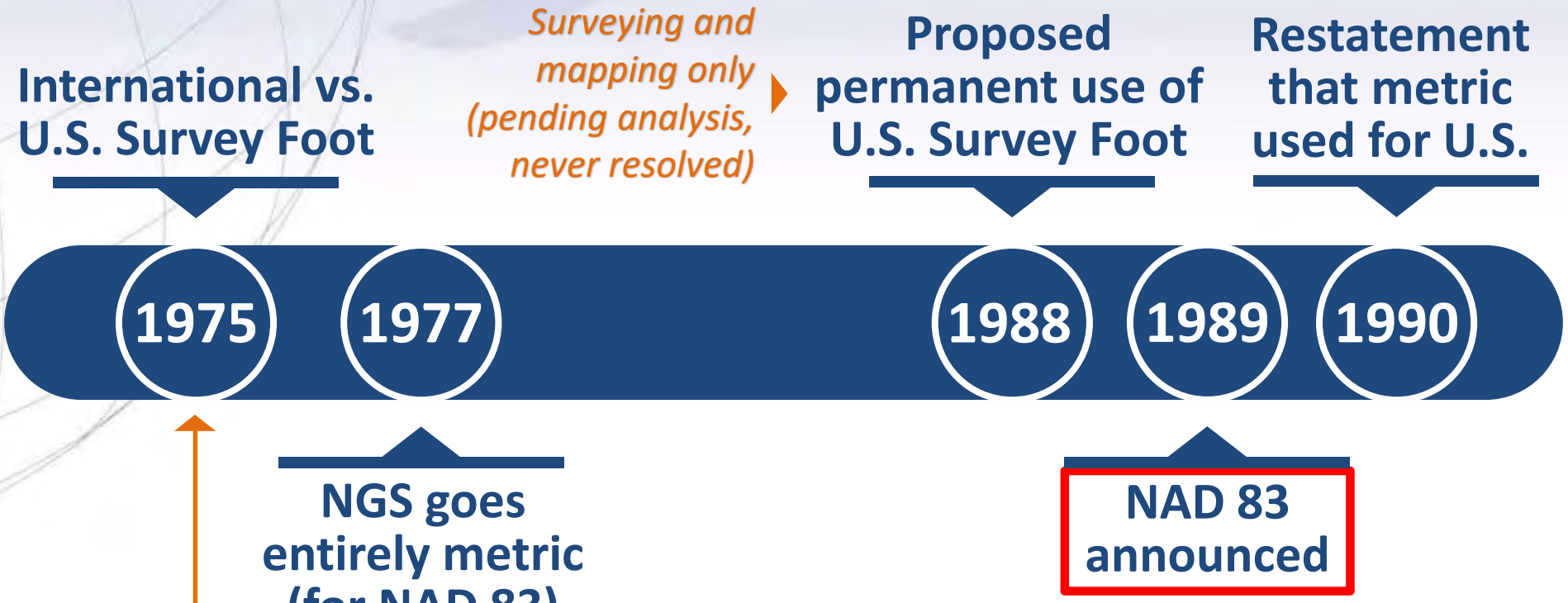


With one little exception…

"Any data expressed in feet derived from and published as a result of **geodetic surveys** within the United States will continue to bear the following relationship as defined in 1893: 1 foot = 1200/3937 meter

The foot unit defined by this equation shall be referred to as the **U.S. Survey Foot** and it shall continue to be used, for the purpose given herein, **until such a time as it becomes desirable and expedient to readjust the basic geodetic survey networks in the United States**, after which the ratio of a yard, equal to 0.9144 meter, shall apply."

More Federal Register Notices



We readjusted the basic geodetic network!

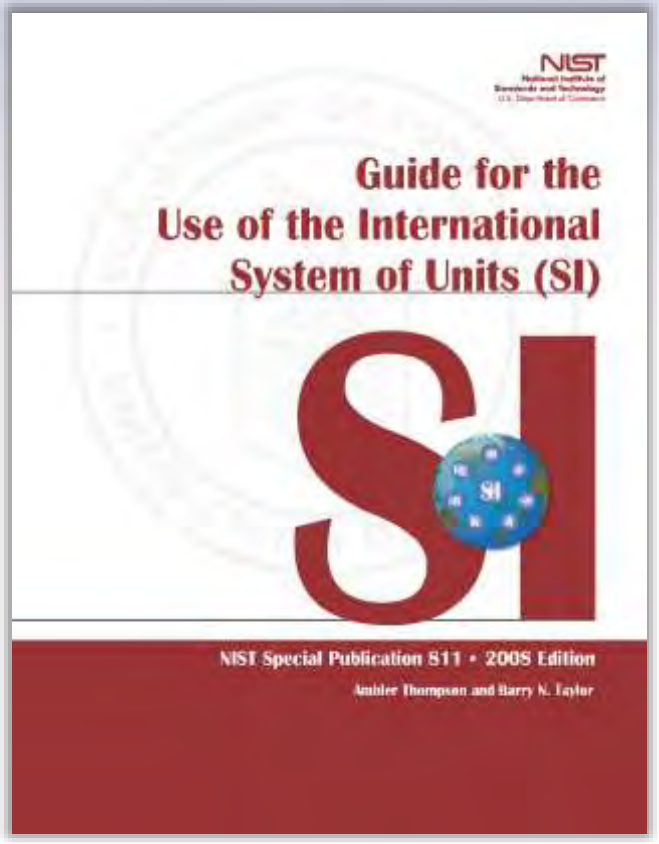
Out of order, *chaos*

A foot still in limbo

2008 - NIST "Guide to the Use of the SI"

- U.S. survey foot *still used*
  - but never **officially** permanently adopted
- Repeats 1975 FRN ideas about the two feet:
  - International ft used for ***engineering***
  - U.S. ft used for ***surveying & mapping***

At odds with very idea of "standards"



Oops!

- Problem created and perpetuated ***by NGS***
- In 1959. Then in 1986. And again in 2016…

Template Draft NSRS Legislation

II. The <state> Plane Coordinate System

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

What are the choices?

- **Do nothing** (i.e., NGS stays "metric" only)
  - States choose whatever foot they want
  - Both feet will creep back into NGS products & services
- **Officially adopt U.S. survey foot for specific things**
  - U.S. survey foot for surveying and mapping
  - International foot for engineering (and everything else)
- **Use international foot for everything**
  - Support only foot = 0.3048 meter after 2022
- **Use U.S. survey foot for everything** (highly unlikely)
- **Go entirely metric** (ideal situation, but also unlikely)

NGS proposal

- **Only one foot after 2022 (1 foot = 0.3048 meter)**
  - Make official through NIST
  - ***NO*** option for U.S. survey foot in NATRF/SPCS2022
- **NGS will help with the transition**
  - Will fully support backward compatibility
  - Use "correct" foot for SPCS83 and SPCS27
  - Automatically done by NGS products and services
- **Guiding ideas**
  - Of all changes in 2022, this is the least significant
  - About the ***future***, not the past

Putting our best "foot" forward…

- **NGS created problem, will help fix it**
  - Fully support backward compatibility (NAD83, NAD27)
  - Unit change minor compared to other 2022 changes
  - Contact us at NGS.Feedback@noaa.gov
- **Federal Register Notice – 17 October 2019**
  - Deprecate US Survey Foot on 31 December 2022
  - After, use International conversion (1 ft = 0.3048 m)
  - Drop "International" refer to unit simply as "foot"
  - ~~Comment period open thru 02 December 2019~~
  - Follow-up webinar was 12 December - recorded

Using the modernized NSRS

- OPUS
  - ***Guidance*** (such as pre-selected CORSs and assistance in locating marks in project areas)
  - ***Users will decide*** what control to hold fixed and what epochs they wish to set for the adjustment
    - "Preliminary coordinates"
  - If submitted to NGS (aka "Shared"), we will harvest your raw GNSS data and use it to compute Final Discrete coordinates

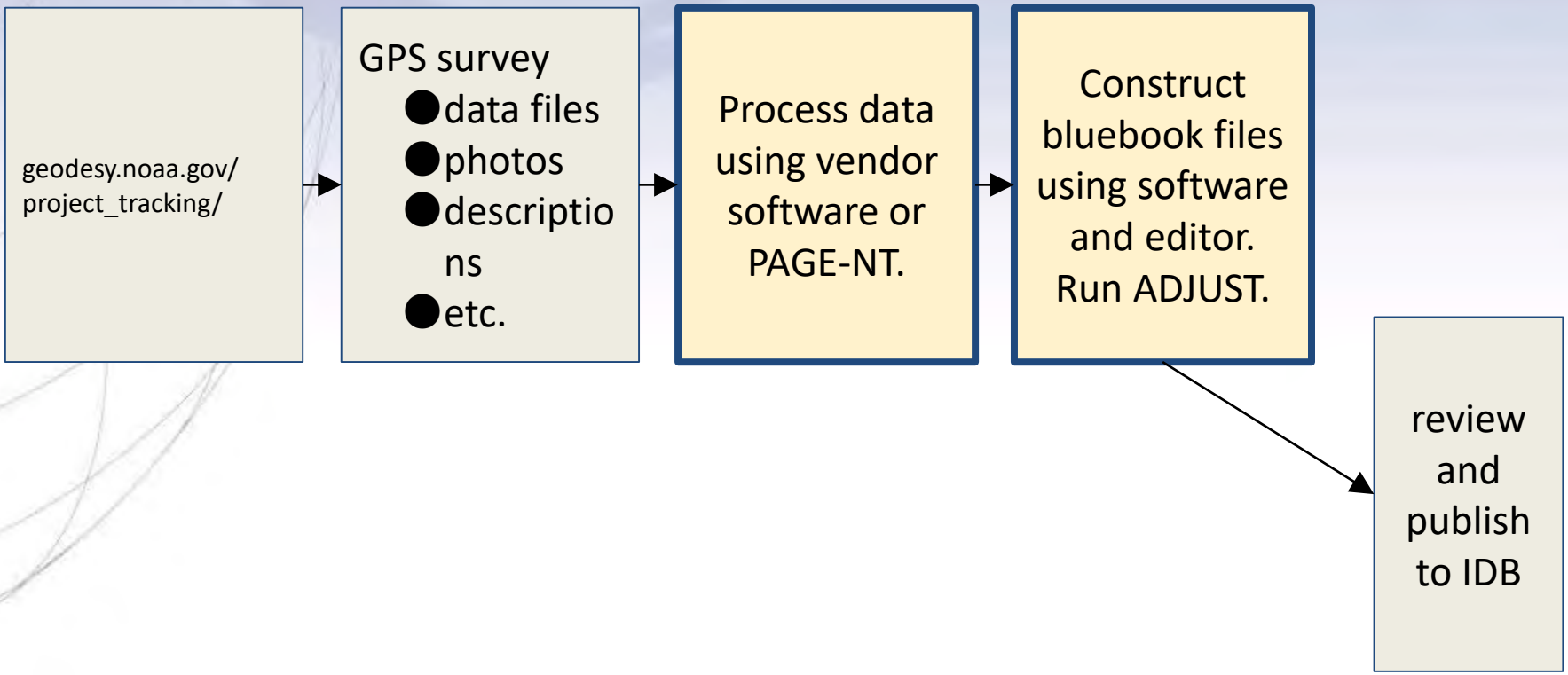
Using the modernized NSRS

- GNSS is your only entry (for now)
  - Leveling and Classical/TS surveys will need some GNSS if you wish to submit your survey to NGS for inclusion in the NSRS database
    - Some GNSS = RTK or RTN is fine
    - No decision yet on whether OP will operate if projects have no GNSS
      - If it does, this tends to encourage reliance upon passive control
        - » which is "so 90's" …1890s brah!

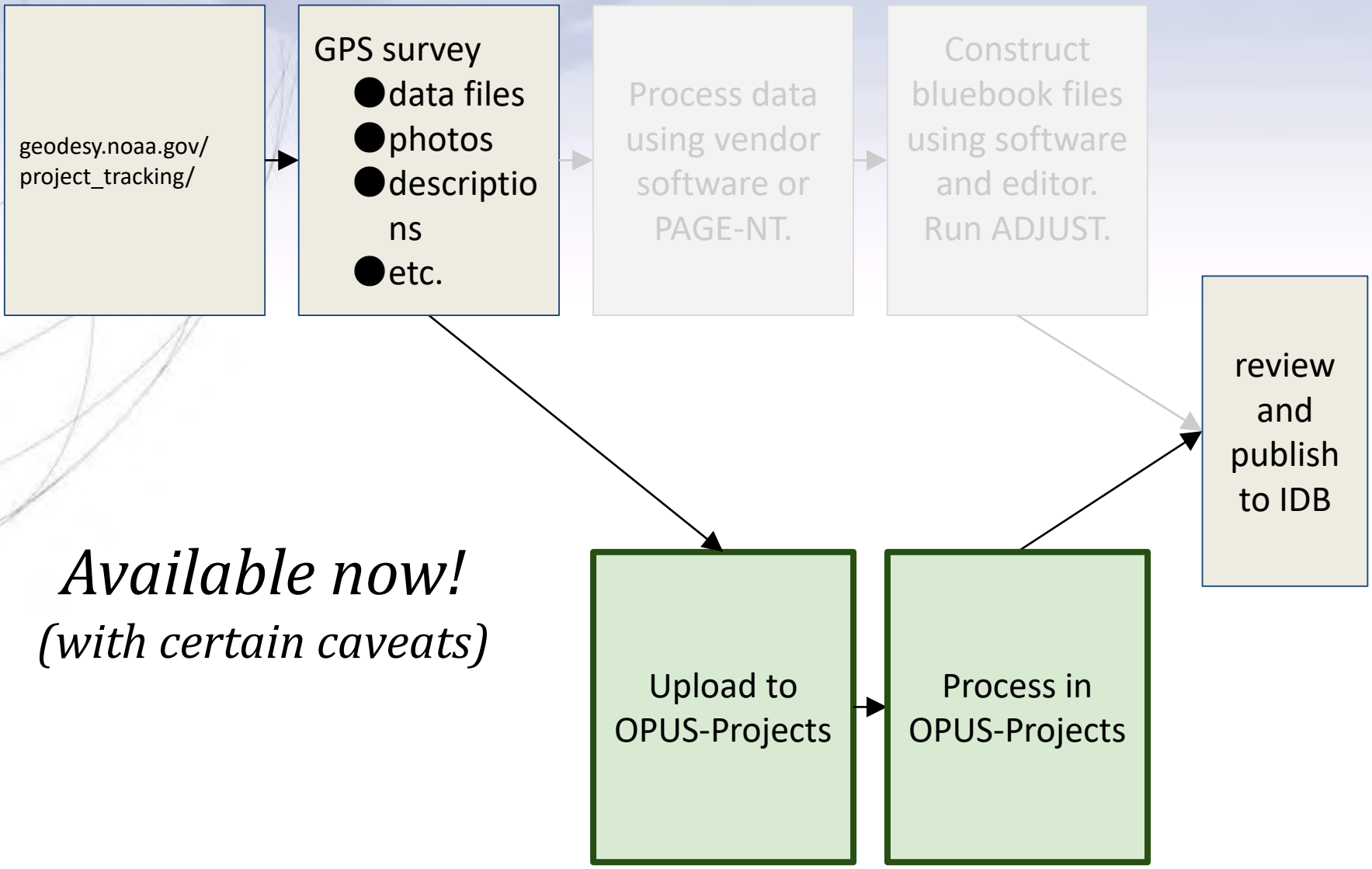
So much more to NSRS Modernization!

- New version of PAGES
  - Multi-Constellation → GPS, Galileo, GLONASS, Beidou, QZSS, etc.
  - Target: 15 minute occupations
- OPUS expansion plan
  - RTK/RTN: 2020 rollout, already mentioned
  - Leveling, Classical (Total Station), Gravity: 2020-2025
  - Fully integrated (GPS projects with leveling and gravity? No problem!)
  - Ease of submission to NGS for inclusion in the NSRS
- New Mark Recovery Tool
  - mentioned earlier, search: "NGS mark recovery" and go to Beta
- Fully integrated toolkit
  - NCAT and VDatum

Bluebooking a Project now



Bluebooking with OPUS Projects in the future



Available now!
(with certain caveats)

Mark Recovery – mobile browser compatible

- use your smartphone to submit recovery
- Any major search engine:

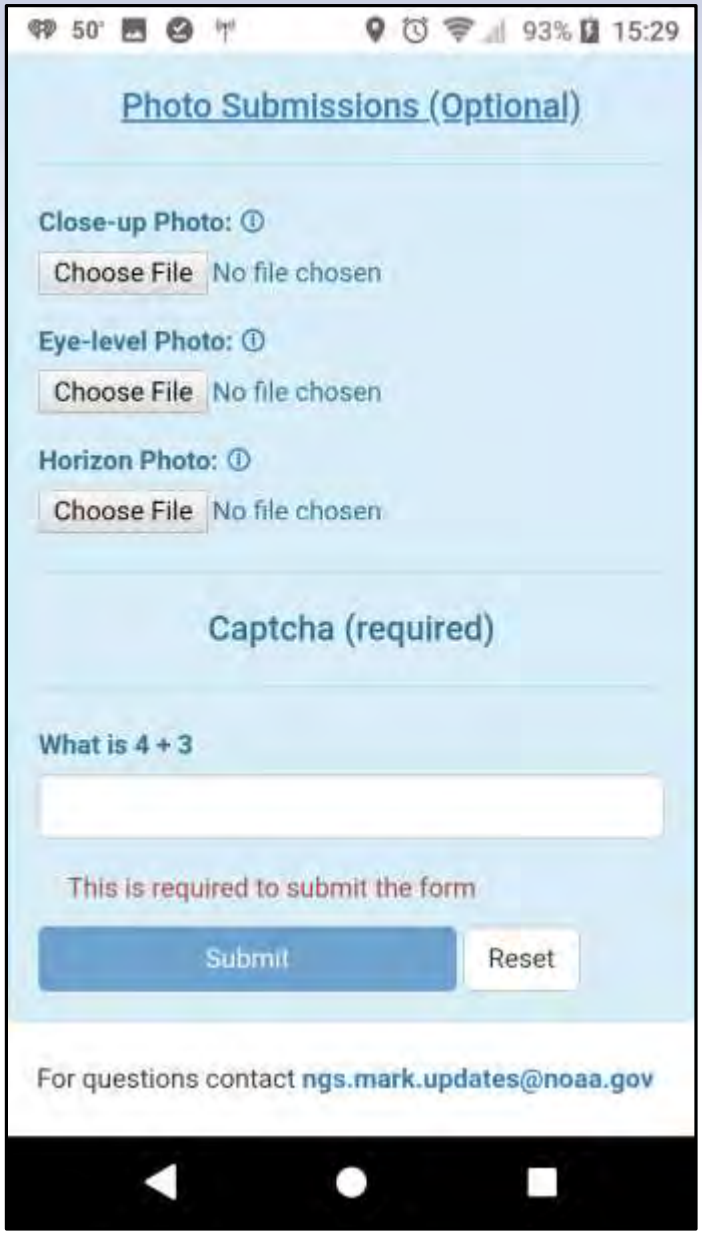
"**NGS survey mark recovery**"

beta.ngs.noaa.gov/cgi-bin/recvy_entry_www.prl

Try it out! Give us feedback!

NGS.Feedback@noaa.gov

Mark Recovery – mobile browser compatible



What new tools are already live?

- VERTCON 3.0 – functionality in Beta NCAT
- Mark Recovery – mobile browser compatible
- VDatum 4.0.1 – released in October
- GEOID18 – latest, greatest, *and last* hybrid
- GPSonBM – updated tracking map (AGOL)
    - *for NAVD88→NAPGD2022 transformation*

www.ngs.noaa.gov

beta.ngs.noaa.gov

https://www.ngs.noaa.gov/ADVISORS/

-use any major search engine: "NGS advisors"

Jeff Jalbrzikowski, P.S., GISP, CFS
Appalachian Regional Geodetic Advisor

jeff.jalbrzikowski@noaa.gov
240-988-5486