Preparing for Change…New Datums

New York State Association of Professional Land Surveyors
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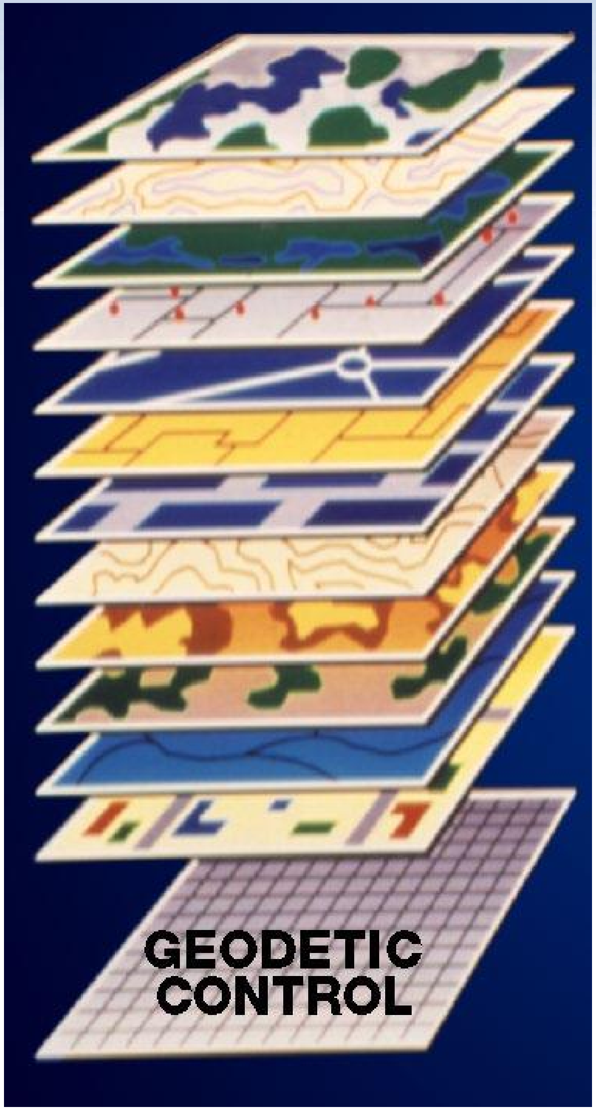
National Spatial Reference System (NSRS)

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



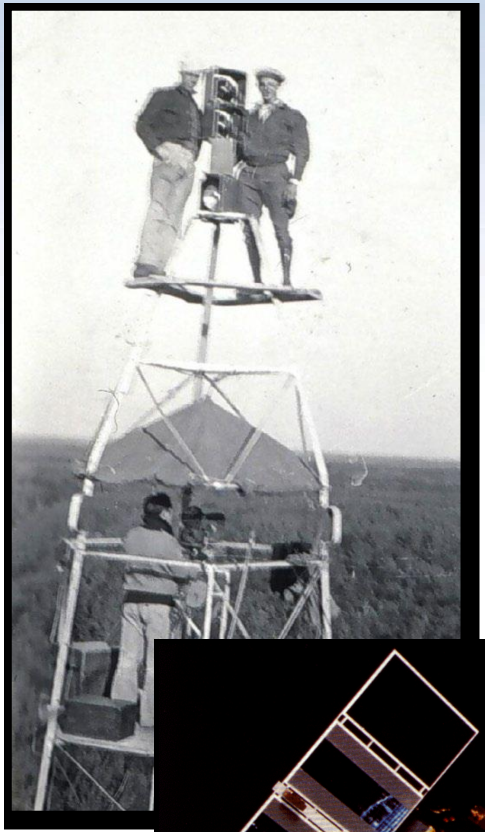
Consistent National Coordinate System

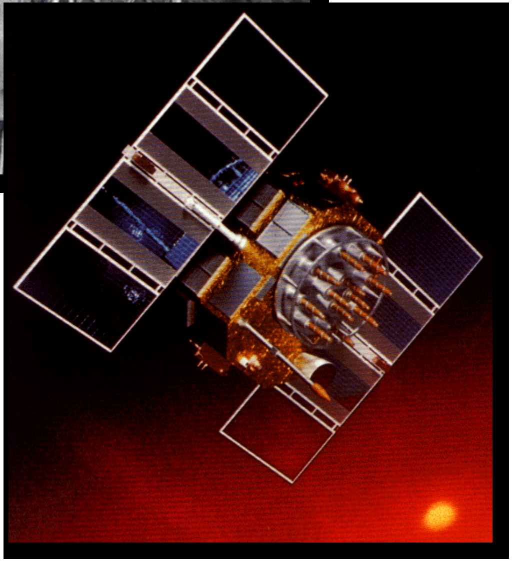
- Latitude/Northing
- Longitude/Easting
- Height
- Scale
- Gravity
- Orientation

& how these values change with time

A (very) brief history of NAD 83

- Original realization completed in 1986
  - Consisted (almost) entirely of classical (optical) observations
- "High Precision Geodetic Network" (HPGN) and "High Accuracy Reference Network" (HARN) realizations
  - Most done in 1990s, essentially state-by-state
  - Based on GNSS but classical stations included in adjustments
- National Re-Adjustment of 2007
  - NAD 83(CORS96) and (NSRS2007)
  - Simultaneous nationwide adjustment (GNSS only)
- ***New realization: NAD 83(2011) epoch 2010.00***





Why change datums/Realizations

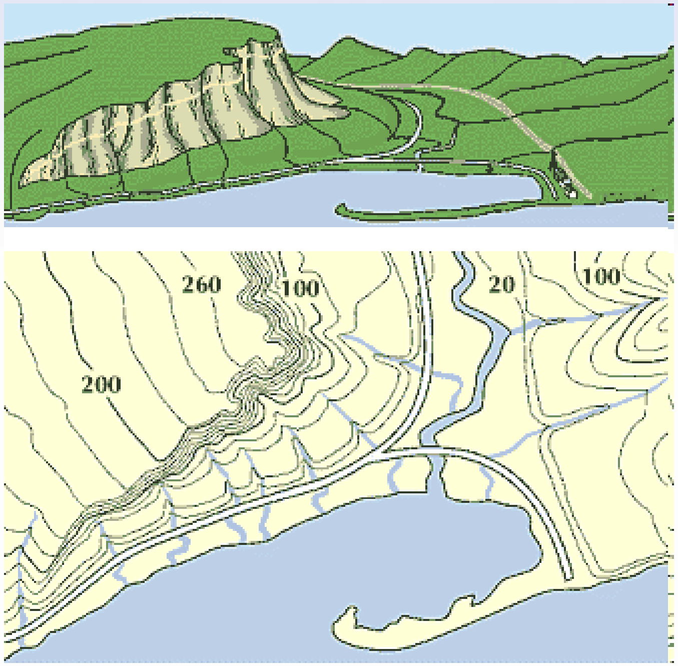
- NAD27 based on old observations and old system
- NAD83(86) based on old observations and new system
- NAD83(96) based on new and old observations and same system (HARN)
- NAD83(NSRS2007) based on new observations and same system. Removed regional distortions and made consistent with CORS
- NAD83(2011) based on new observations and same system. Kept consistent with CORS

Horizontal Datums/Coordinates…What do we (you) use in your state?

- NAD 27
- NAD 83 (Lat-Lon) SPC
  - Which one???
    - NAD 83 (1986)
    - NAD 83 (19xx) - HARN
    - NAD 83 (1996) - FBN
    - NAD 83 CORS96(2002)
    - NAD 83 (NSRS2007)
    - NAD 83 (2011) epoch 2010.00
- WGS 84
  - Which one???
    - WGS 84 (1987)
    - WGS 84 (G730)
    - WGS 84 (G873)
    - WGS 84 (G1150)
    - WGS 84 (G1674)
    - WGS 84 (G1762)
- ITRFxx (epoch xxxx)
- IGSxx (epoch xxxx)

What is a Vertical Datum?

- Strictly speaking, a vertical datum is a ***surface*** representing zero elevation
- Traditionally, a vertical datum is a ***system*** for the determination of heights above a zero elevation surface
- Vertical datum comprised of:
  - Its ***definition:*** Parameters and other descriptors
  - Its ***realization:*** Its physical method of accessibility



"*topographic map*." Online Art. Britannica Student Encyclopædia. 17 Dec. 2008 <http://student.britannica.com/ebi/art-53199>

History of vertical datums in the USA

- **NGVD 29**
  - National Geodetic Vertical Datum of 1929
  - Original name: "Sea Level Datum of 1929"
  - "Zero height" held fixed at 26 tide gauges
    - Not all on the same tidal datum epoch (~ 19 yrs)
  - Did not account for Local Mean Sea Level variations from the geoid
    - Thus, not truly a "geoid based" datum

NGVD29
The National Geodetic Vertical Datum of 1929 is 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
Old Point Comfort
Norfolk
Annapolis
Perth Amboy
Boston
Portland
Yarmouth
Halifax
Father's Point
© 2008 Europa Technologies
© 2008 Tele Atlas
Image NASA
Image © 2008 TerraMetrics
42°34'34.62" N 95°04'11.11" W
Eye alt 2488.07 mi

Current Vertical Datum in the USA

Father Point Lighthouse, Quebec

- **NAVD 88**: North American Vertical Datum of 1988
- ***Definition:*** The surface of equal gravity potential to which orthometric heights shall refer in North America*, and which is 6.271 meters (along the plumb line) below the geodetic mark at "Father Point/Rimouski" (NGSIDB PID TY5255).
- ***Realization:*** Over 500,000 geodetic marks across North America with published Helmert orthometric heights, most of which were originally computed from a minimally constrained adjustment of leveling and gravity data, holding the geopotential value at "Father Point/Rimouski" fixed.

**Not adopted in Canada*

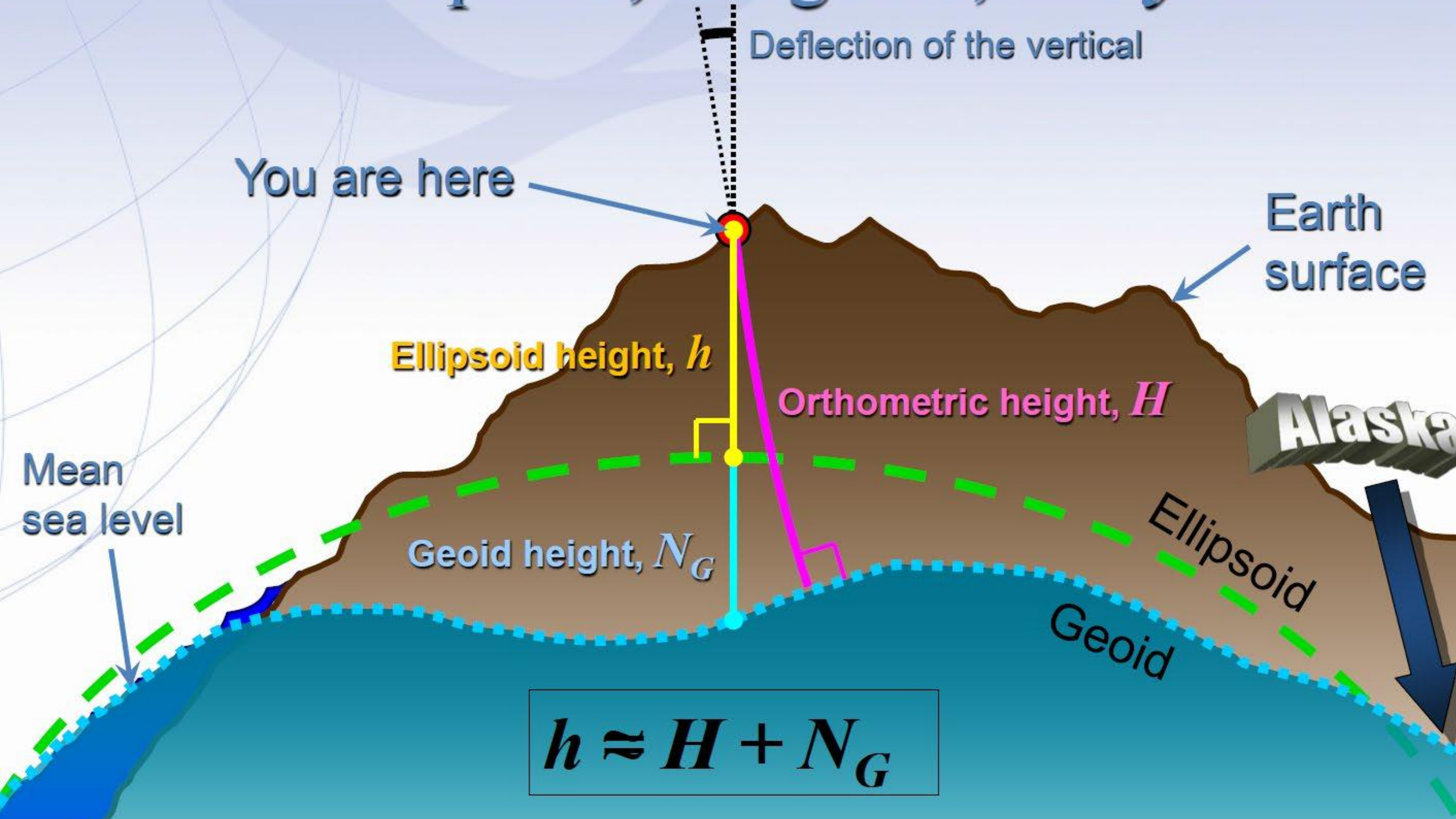
History of vertical datums in the USA

- **NAVD 88**
  - North American Vertical Datum of 1988
  - One height held fixed at "Father Point" (Rimouski, Canada)
  - …height chosen was to minimize 1929/1988 differences on USGS topo maps in the eastern U.S.
  - Thus, the "zero height surface" of NAVD 88 wasn't chosen for its closeness to the geoid (but it was close…few decimeters)

History of vertical datums in the USA

- **NAVD 88** (continued)
  - Use of one fixed height removed local sea level variation problem of NGVD 29
  - Use of one fixed height did open the possibility of unconstrained cross-continent error build up
  - H=0 surface of NAVD 88 was supposed to be parallel to the geoid…(close again)

The ellipsoid, the geoid, and *you*

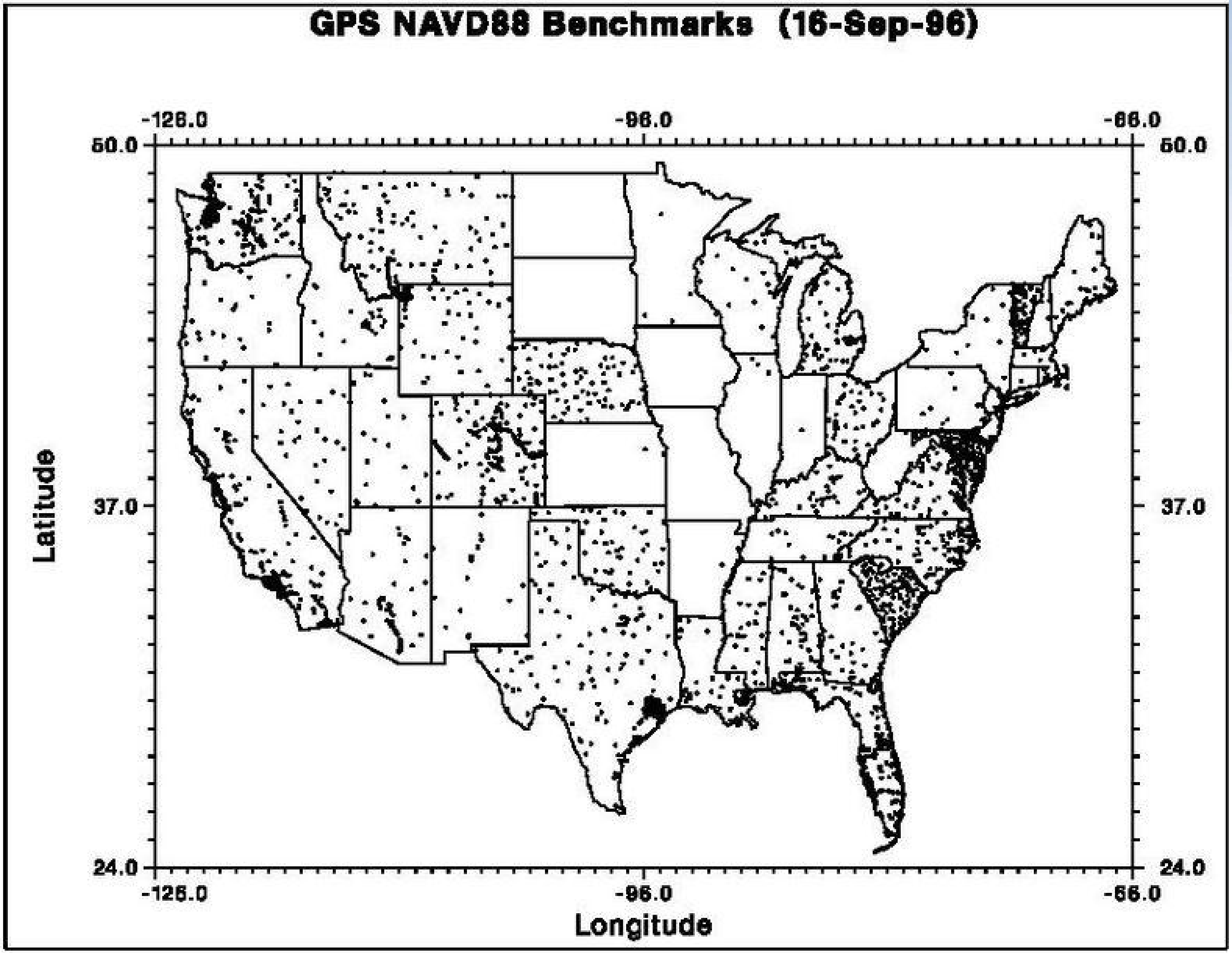


$$h \approx H + N_G$$

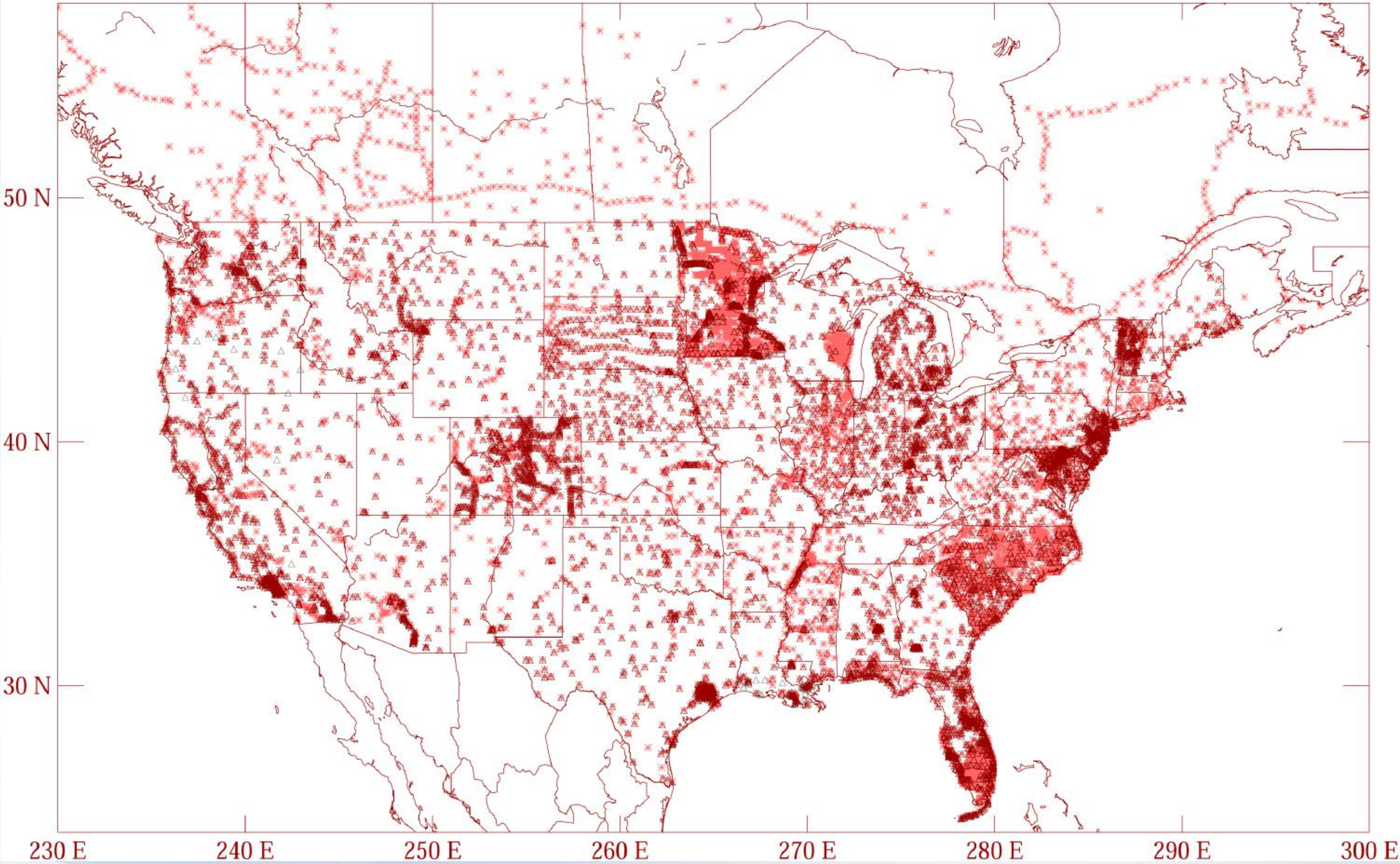
Note: Geoid height is **negative** everywhere in the coterminous US (but it is **positive** in most of Alaska)

Types Uses and History of Geoid Height Models

- Gravimetric (or Gravity) Geoid Height Models
  - Defined by gravity data crossing the geoid
  - Refined by terrain models (DEM's)
  - Scientific and engineering applications
- Composite (or Hybrid) Geoid Height Models
  - Gravimetric geoid defines most regions
  - Warped to fit available GPSBM control data
  - Defined by legislated ellipsoid (NAD 83) and local vertical datum (NAVD 88, PRVD02, etc.)
  - May be statutory for some surveying & mapping applications



GPSBM1996: 2,951total 0 Canada STDEV ≈ 5 cm (2σ)

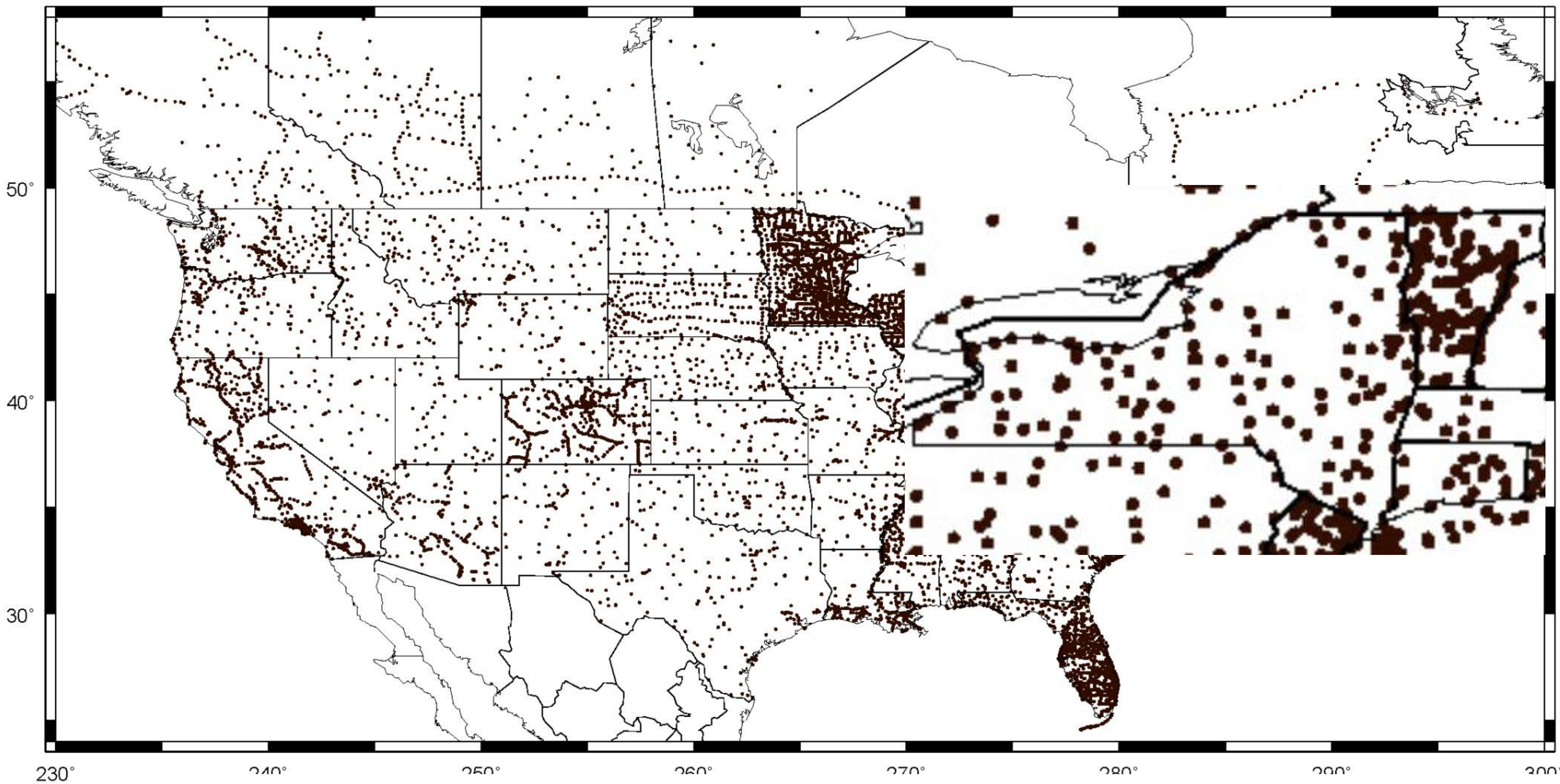


GPSBM1999: 6,169 total 0 Canada STDEV 9.2 cm (2σ)

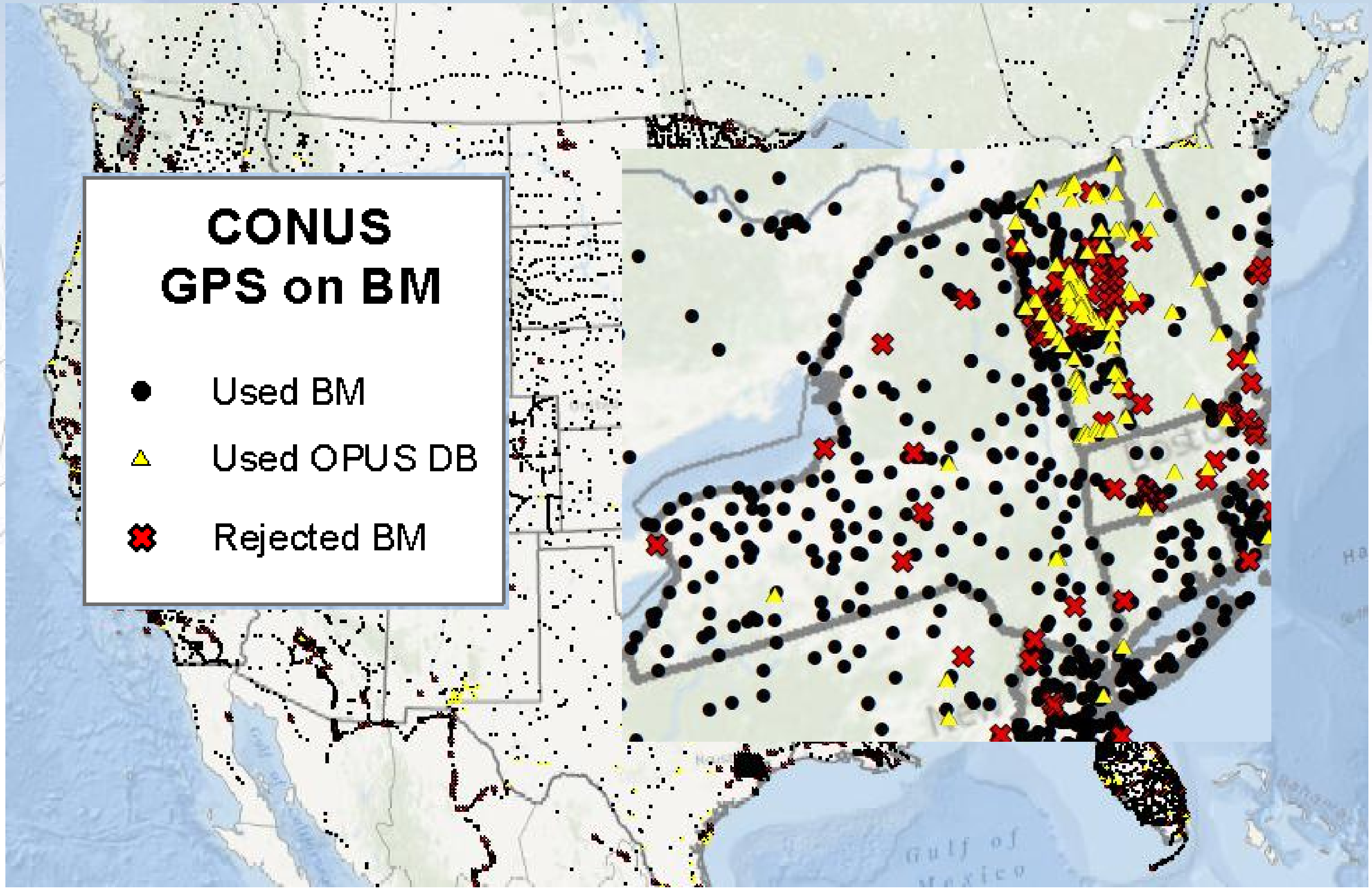
GPSBM2003: 14,185 total 579 Canada STDEV 4.8 cm (2 σ)

Nati

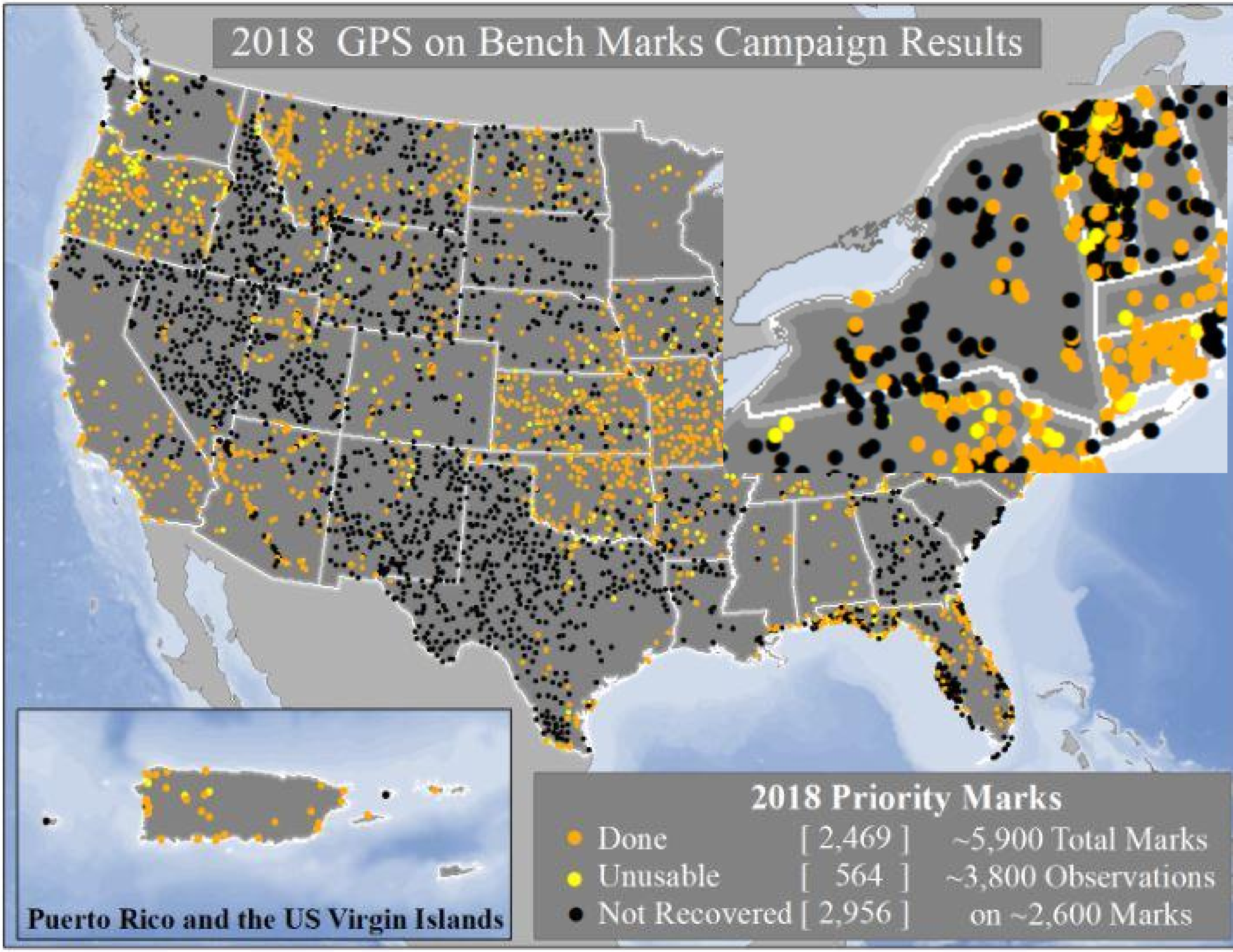
GPS BMs for GEOID09

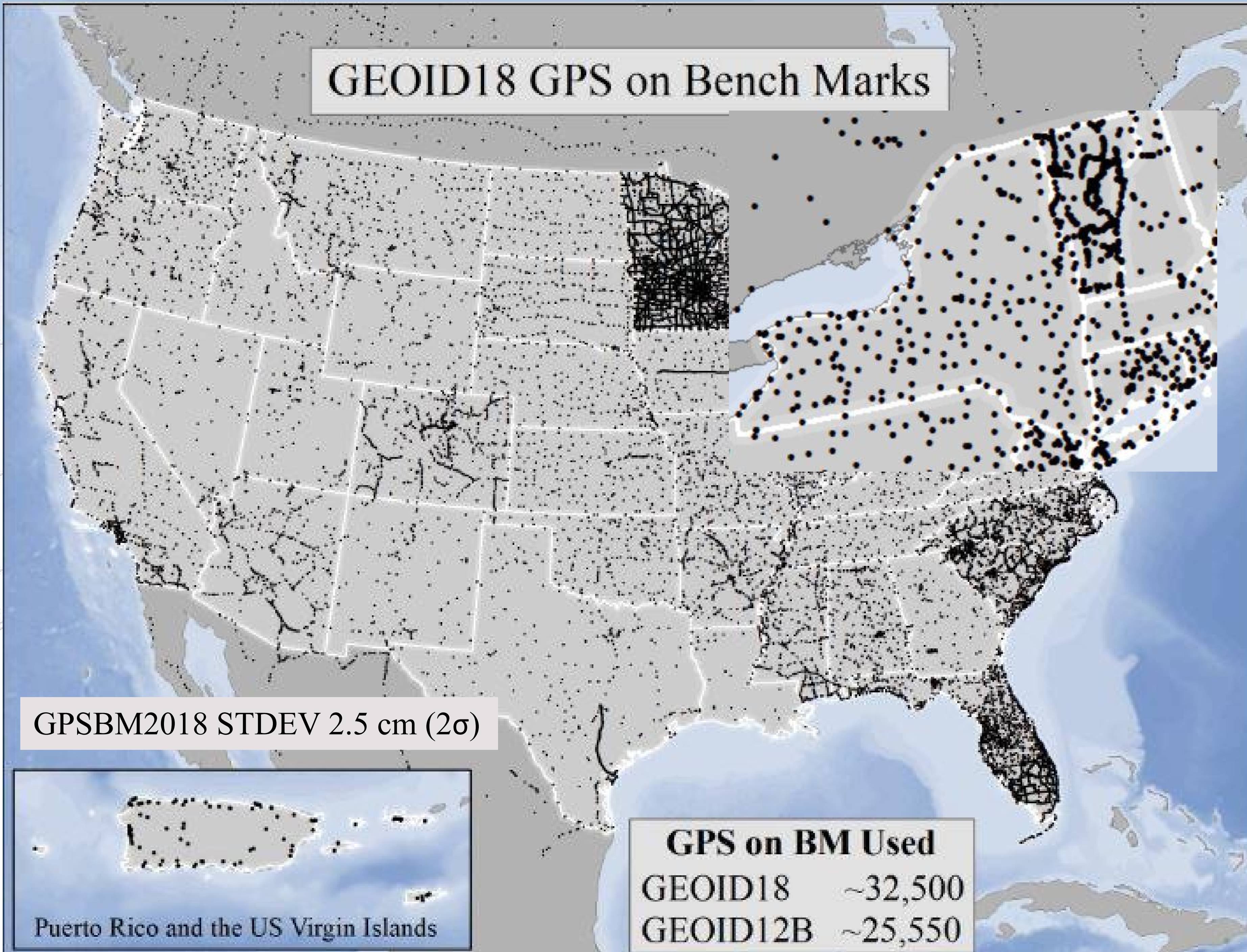


GPSBM2009: 18,398 STDEV 2.8 cm (2σ)



GPSBM2012B: 23,961 (CONUS)
499 (OPUS on BM)
574 (Canada)
177 (Mexico)


2018 GPS on Bench Marks Campaign Results
Puerto Rico and the US Virgin Islands
2018 Priority Marks
Done [2,469] ~5,900 Total Marks
Unusable [564] ~3,800 Observations
Not Recovered [2,956] on ~2,600 Marks


GEOID18 GPS on Bench Marks
GPSBM2018 STDEV 2.5 cm (2σ)
Puerto Rico and the US Virgin Islands
GPS on BM Used
GEOID18 ~32,500
GEOID12B ~25,550

Which Geoid for Which NAD 83?

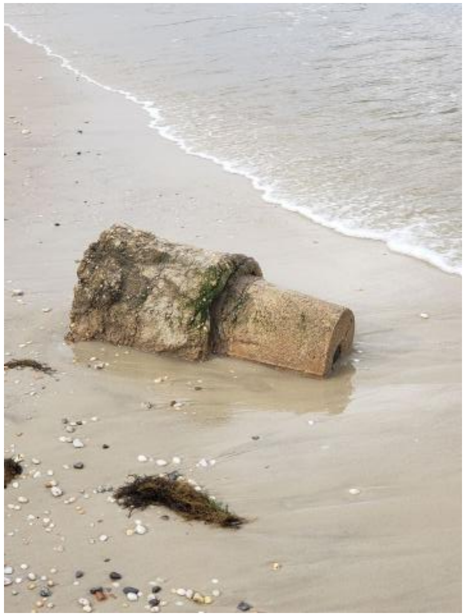
- NAD 83(2011)
- Geoid18
- Geoid12A/12B

- NAD 83(2007)
- Geoid09
- Geoid06 (AK only)

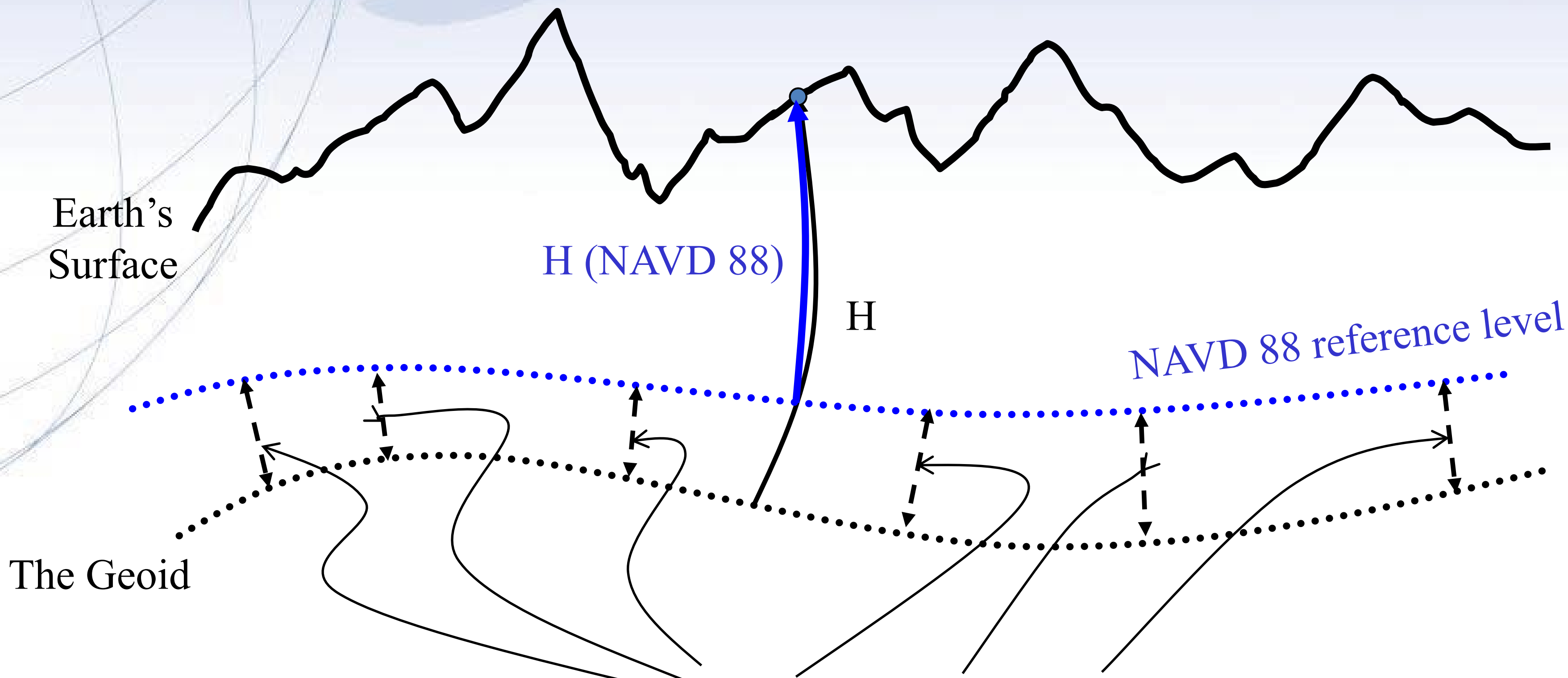
- NAD 83(1996) & CORS96
- Geoid03
- Geoid99
- Geoid96

Problems with NAD 83 and NAVD 88

- **NAD 83** is not as geocentric as it could be (approx. 2 m)
  - Positioning Professionals don't see this - **Yet**
- **NAD 83** is not well defined with positional velocities
- **NAVD 88** is realized by passive control (bench marks) most of which have not been re-leveled in at least 40 years.
- **NAVD 88** does not account for local vertical velocities (subsidence and uplift)
  - Post glacial isostatic readjustment (uplift)
  - Subsurface fluid withdrawal (subsidence)
  - Sediment loading (subsidence)
  - Sea level rise (Up to 1.34 ft per 100 years)
    - **Montauk, NY 3.32 mm/yr (0.010 ft/yr) 1947-2018**
    - **Sandy Hook, NJ 4.09 mm/yr (0.013 ft/yr) 1932-2018**



Why isn't NAVD 88 good enough anymore?



Errors in NAVD 88 : ~50 cm average,
100 cm CONUS tilt,
1-2 meters average in Alaska

Why replace NAVD 88 and NAD 83?

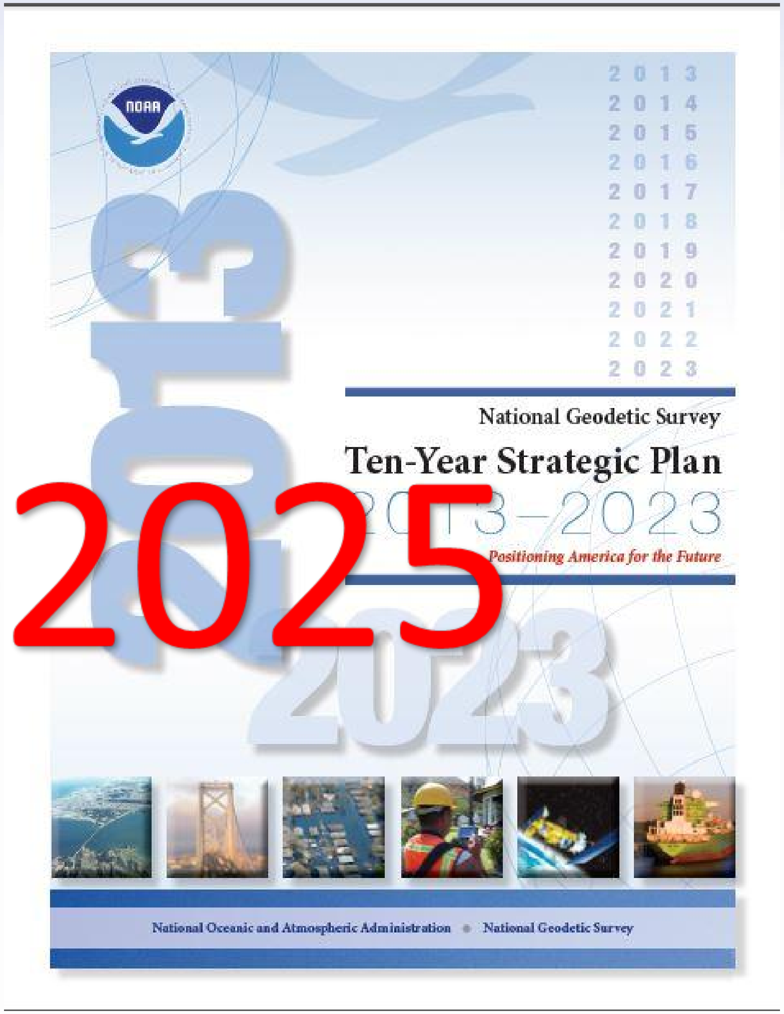
- **ACCESS!**
  - easier to find the sky than a 60-year-old bench mark
  - GNSS equipment is cheap and fast
- **ACCURACY!**
  - easier to trust the sky than a 60-year old bench mark
  - immune to passive mark instability
- **GLOBAL STANDARDS!**
  - systematic errors of many meters across the US
  - aligns with GPS, international efforts
  - aligns with Canada, Mexico

The National Geodetic Survey 10 year plan
Mission, Vision and Strategy
2008 – 2018, 2013-2023

http://www.ngs.noaa.gov/INFO/NGS10yearplan.pdf

- *Official NGS policy as of Jan 9, 2008*
  - *Modernized agency*
  - *Attention to accuracy*
  - [redacted]*to time-changes*
  - [redacted]*products and services*
  - [redacted]*n with other fed missions*
  - [redacted]*n NAVD 88 re-defined*
  - [redacted]*acy access to all*
    [redacted]*es*
  - [redacted]*-focused agency*
  - [redacted]*entific leadership*

X 2024-2025

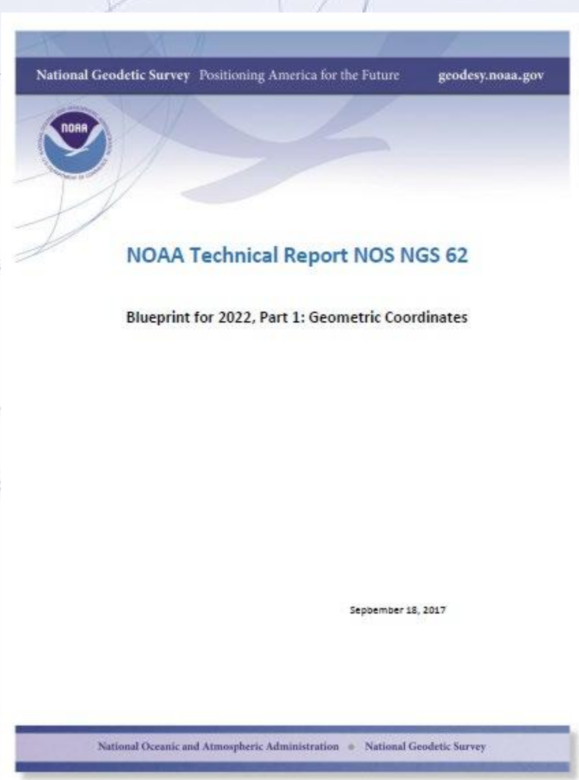


Why not 2022??

- 2018 – three government shutdown
  - Third shutdown coincided with GRAV-D deployment in Pacific (delay of 1 year)
  - Growing complexity
  - Personnel
  - 2020!!!!
  - See Dru Smith's Webinar for full details.
    - https://www.ngs.noaa.gov/web/science_edu/webinar_series/delayed-release-nsrs.shtml

Modernizing the NSRS

The "blueprint" documents: Your best source for information

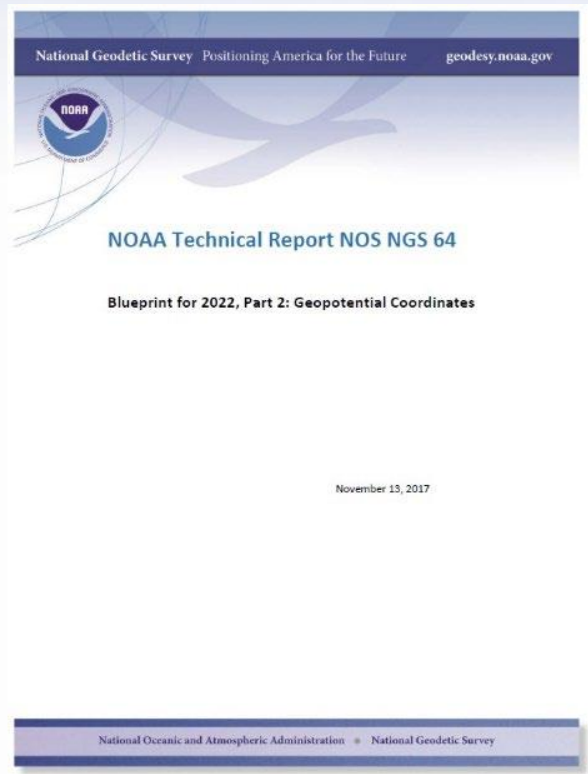

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov

NOAA Technical Report NOS NGS 62

Blueprint for 2022, Part 1: Geometric Coordinates

September 18, 2017

National Oceanic and Atmospheric Administration • National Geodetic Survey

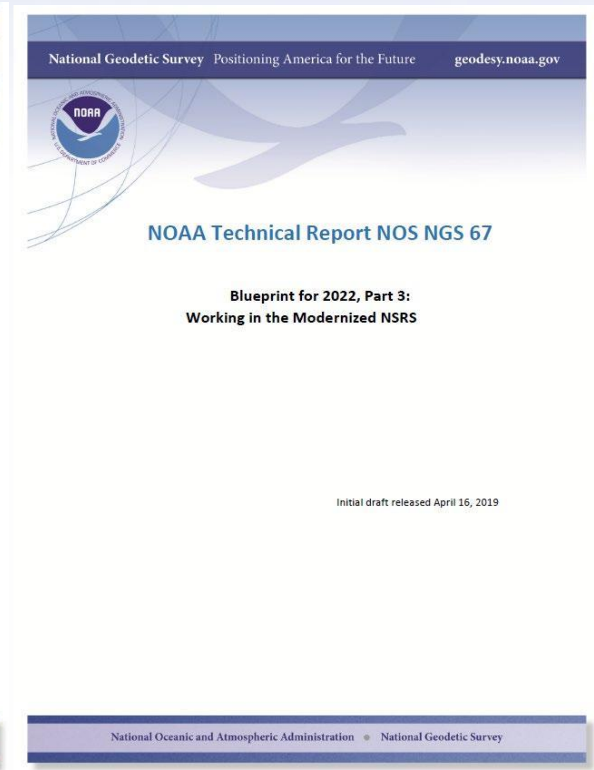

National Geodetic Survey Positioning America for the Future geodesy.noaa.gov

NOAA Technical Report NOS NGS 64

Blueprint for 2022, Part 2: Geopotential Coordinates

November 13, 2017

National Oceanic and Atmospheric Administration • National Geodetic Survey


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

NOAA Technical Report NOS NGS 67

Blueprint for 2022, Part 3:
Working in the Modernized NSRS

Initial draft released April 16, 2019

National Oceanic and Atmospheric Administration • National Geodetic Survey

Geometric:
Sep 2017

Geopotential:
Nov 2017

Working in the modernized NSRS:
April 2019 (currently being revised)

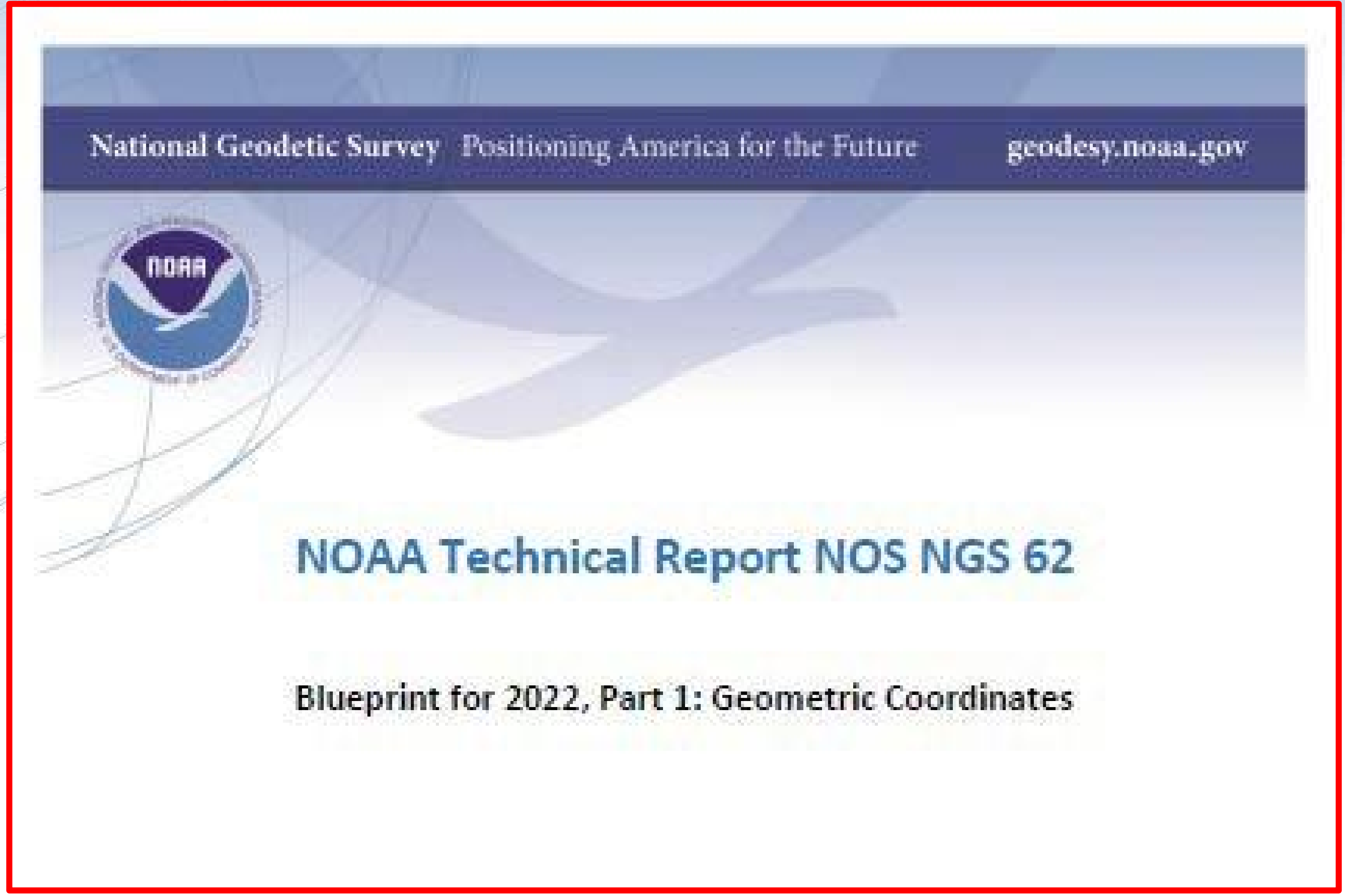
The wrong question, circa 2022:

"What's the position of that point?"

The right question, circa 2022:

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

Drift…



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

NOAA Technical Report NOS NGS 62

Blueprint for 2022, Part 1: Geometric Coordinates

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.

Replacing NAD83

[redacted]

2. remove non-geocentricity of NAD83

3. align to ITRF2020 at epoch 2020.00

4. remove most of tectonic plate rotation from ITRF2020 via Euler Pole Parameters
   (pronounced: "oiler")

Shift and Drift…

Four "Plate-Fixed" Reference Frames

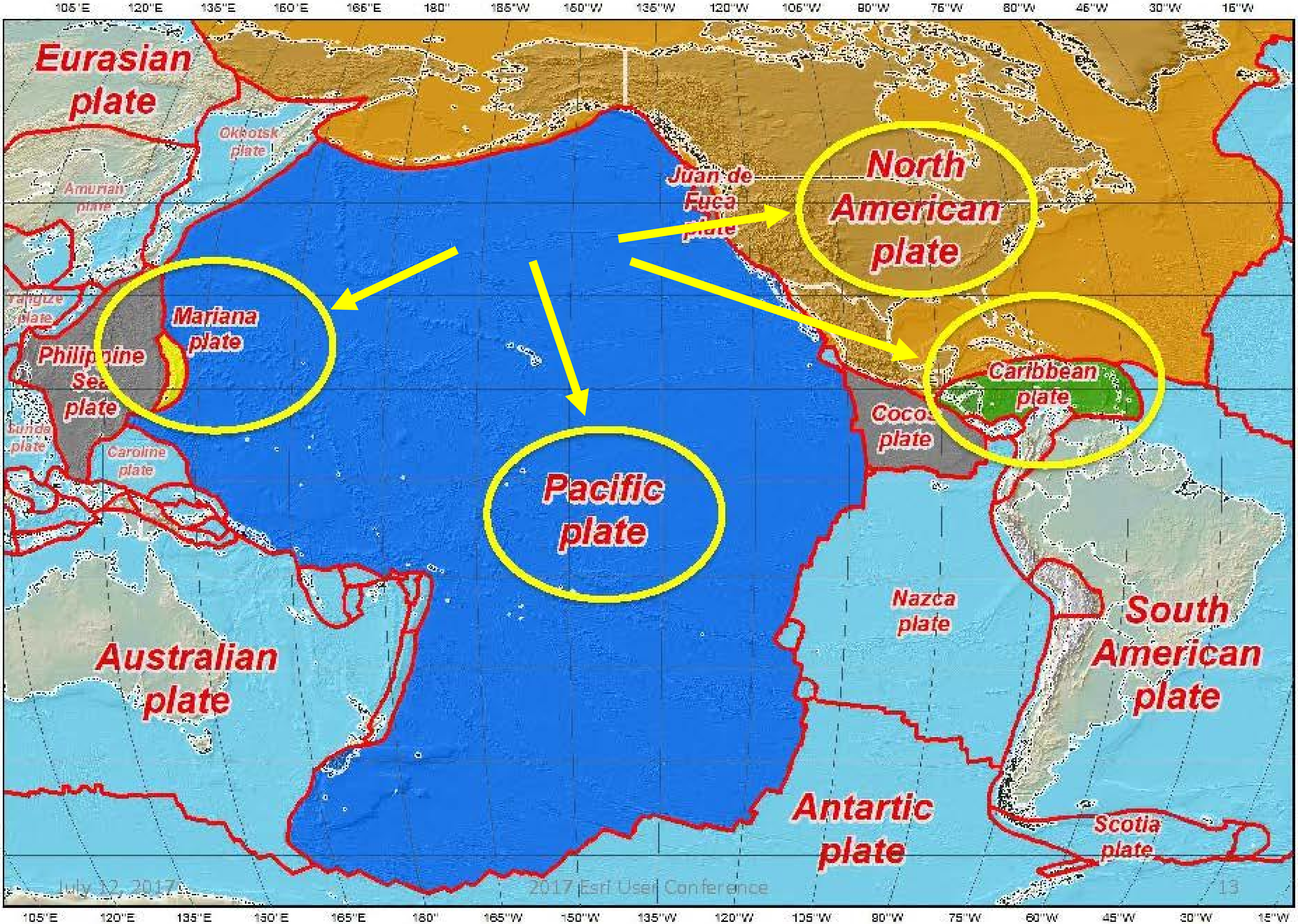
[redacted]

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



Replacing NAD83

1. develop four "plate-fixed" reference frames

[redacted]

3. align to ITRF2020 at epoch 2020.00
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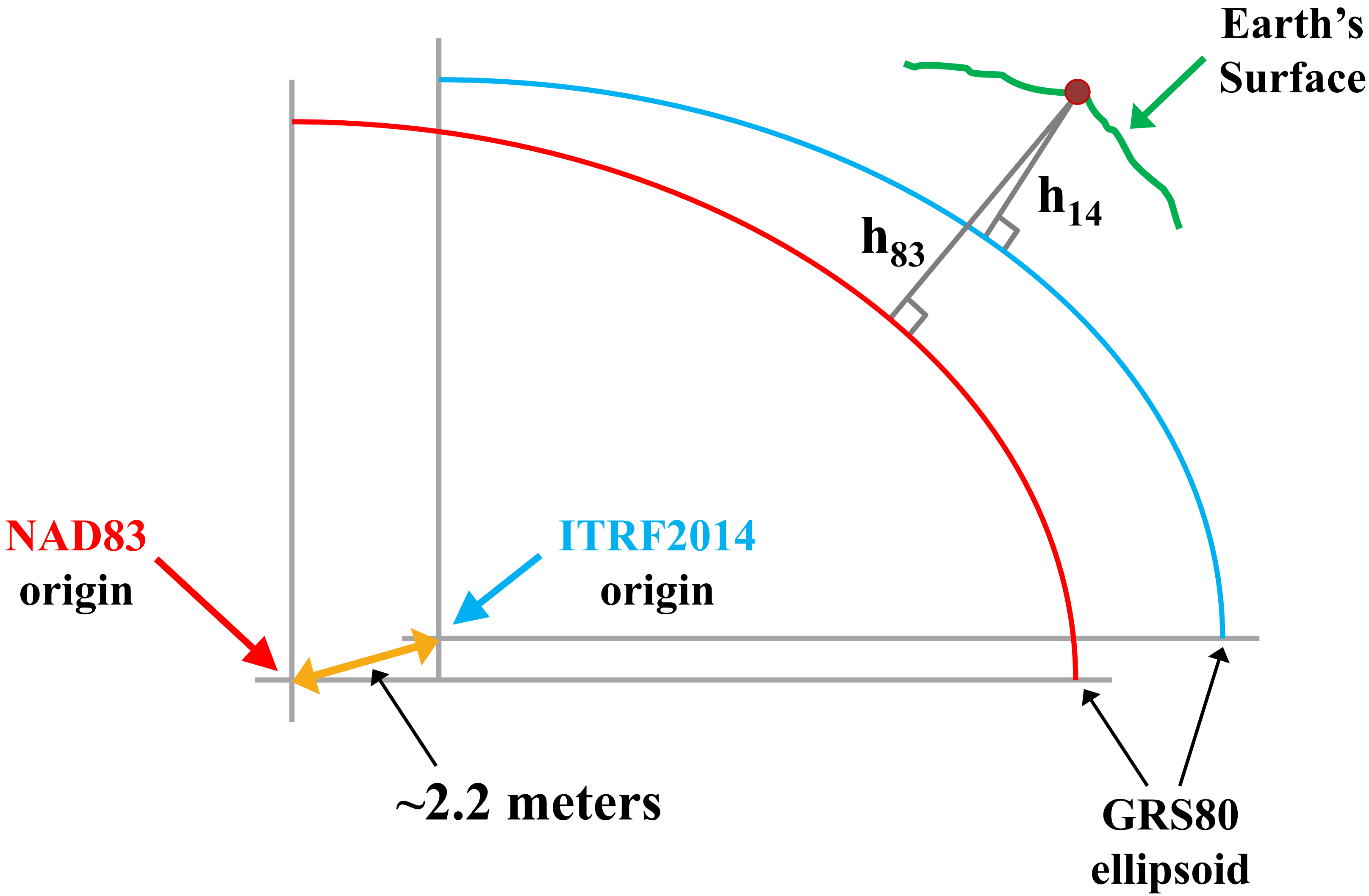
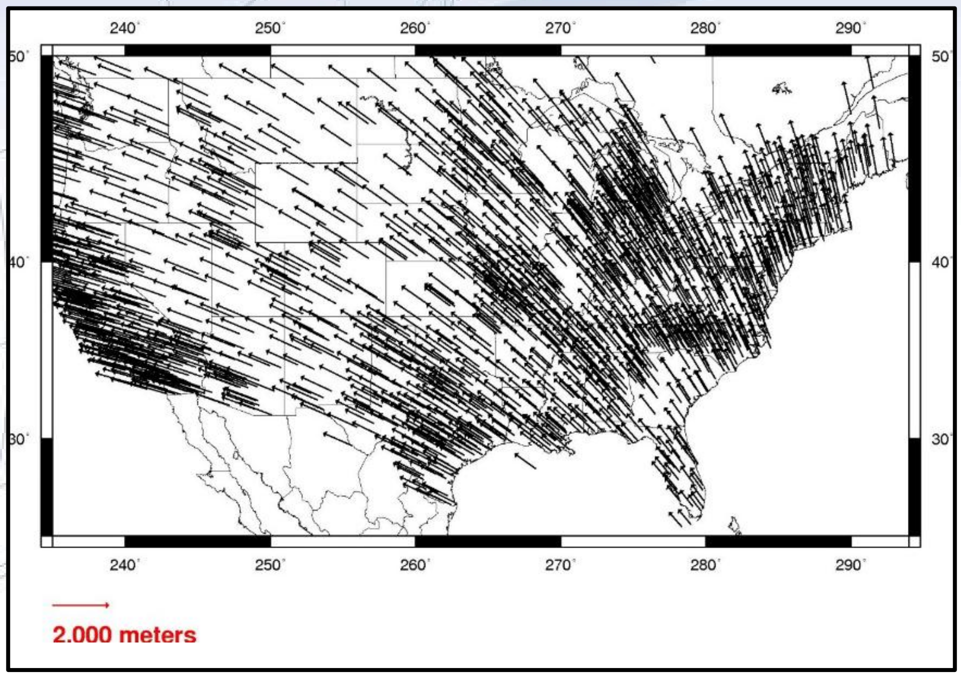
Shift and Drift…

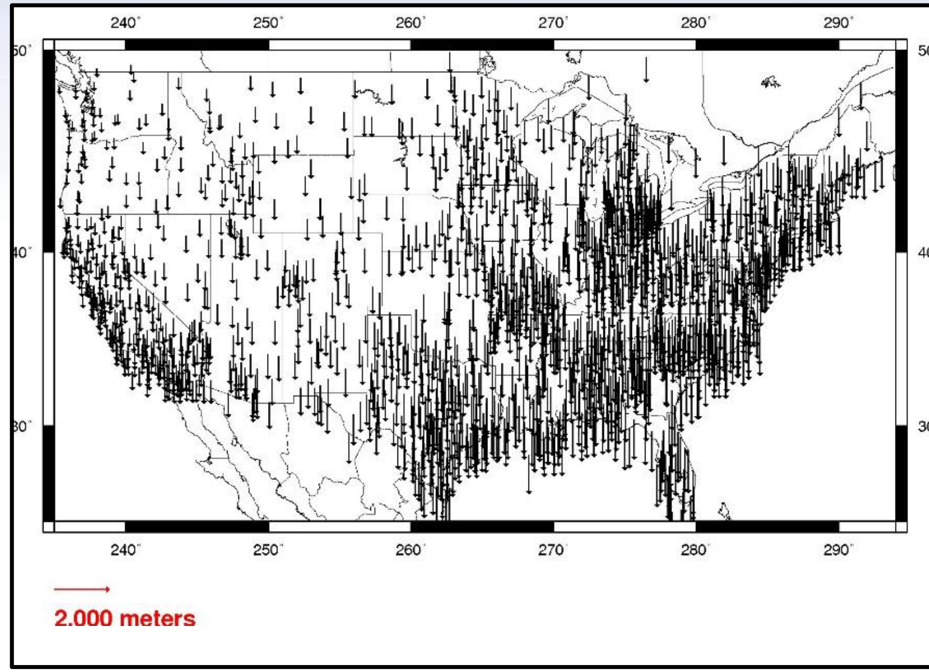
Non-geocentricity of NAD83



Geometric change due to ellipsoid non-geocentricity



Horizontal (Lat, Lon)



Ellipsoidal (h)

Shift…

What are we trying to say??

Replacing NAD83

1. develop four "plate-fixed" reference frames

2. remove non-geocentricity of NAD83

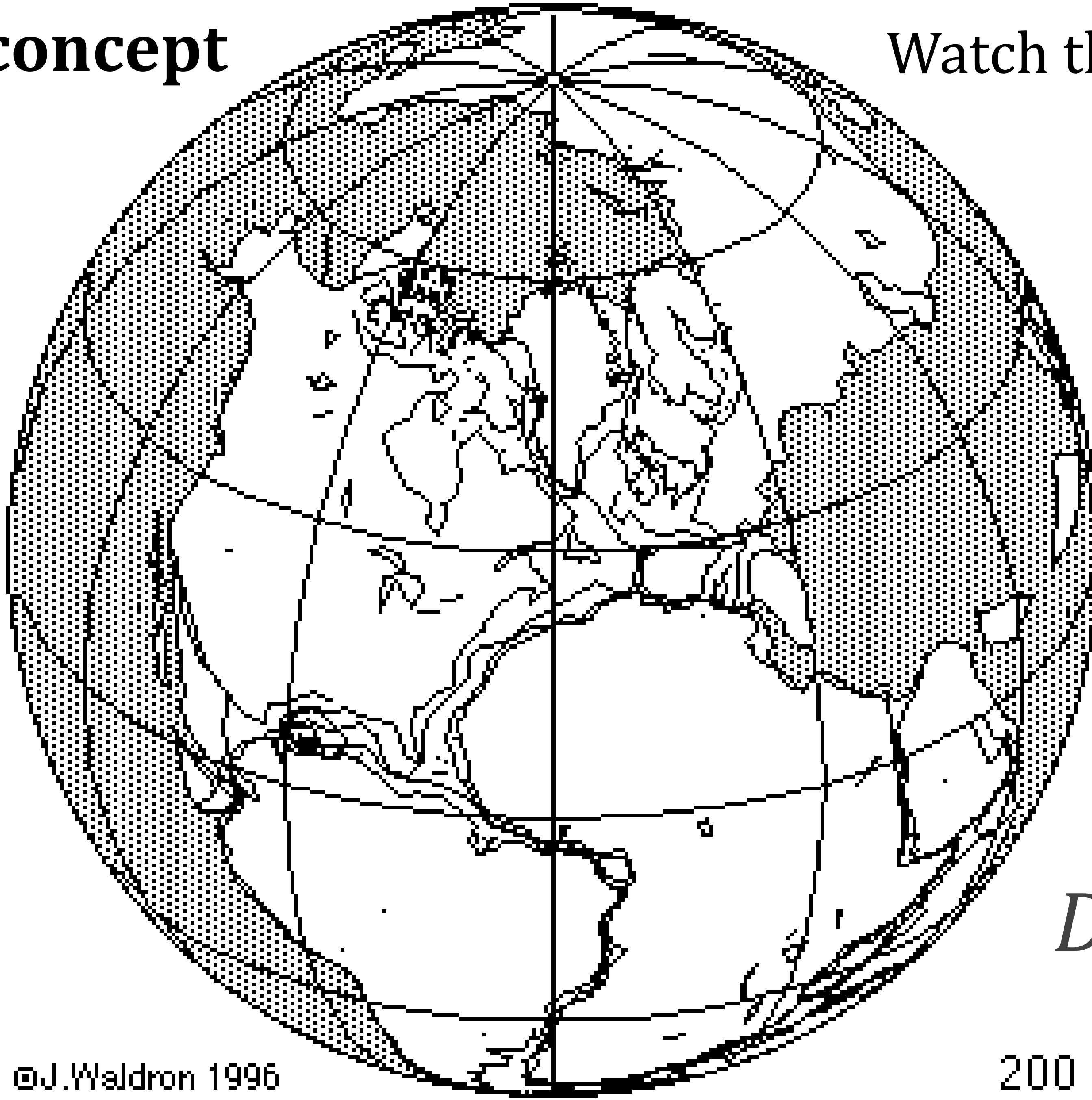
3. **align to ITRF2020 at epoch 2020.00**

[redacted]

Shift and Drift…

ITRF concept

Watch the grid!



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

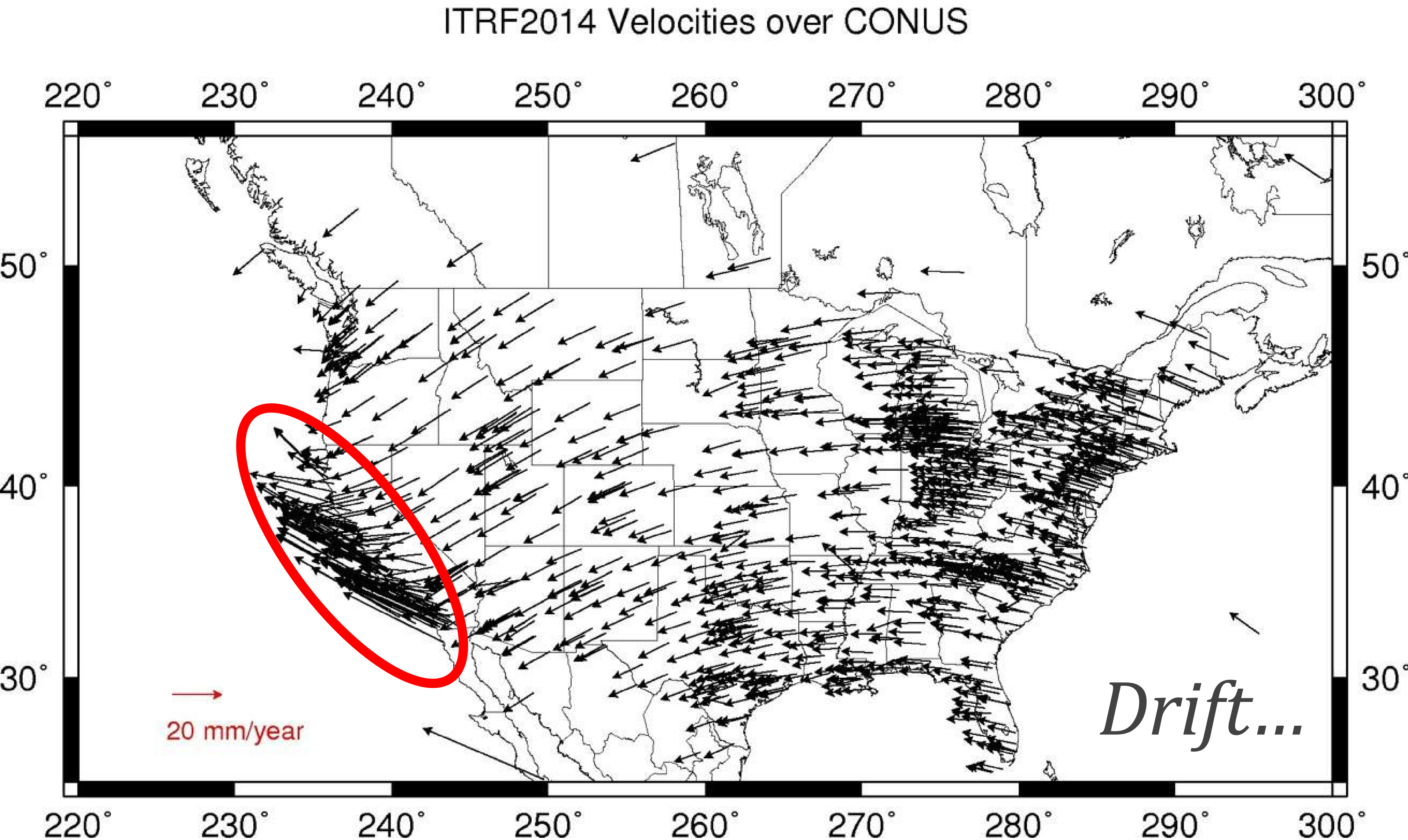
Tectonic Plate Rotation

- Horizontal *simple to model*

Euler Pole Parameters of 2022

EPP2022

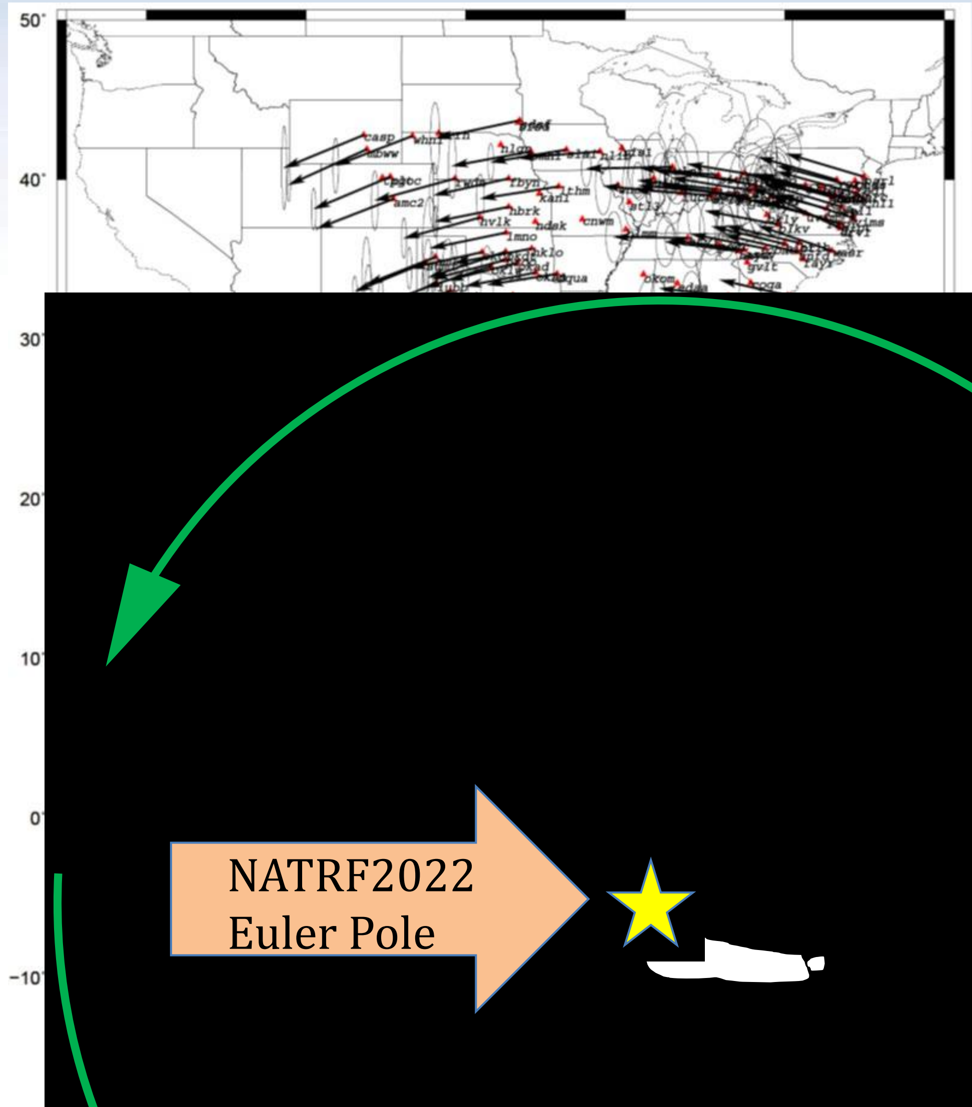
Plate Rotation visualized



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 Pole Parameters
  - *Lat*
  - *Lon*
  - *Rotation Rate*



Euler Poles and "Plate-Fixed"

ITRF

Frame = constant

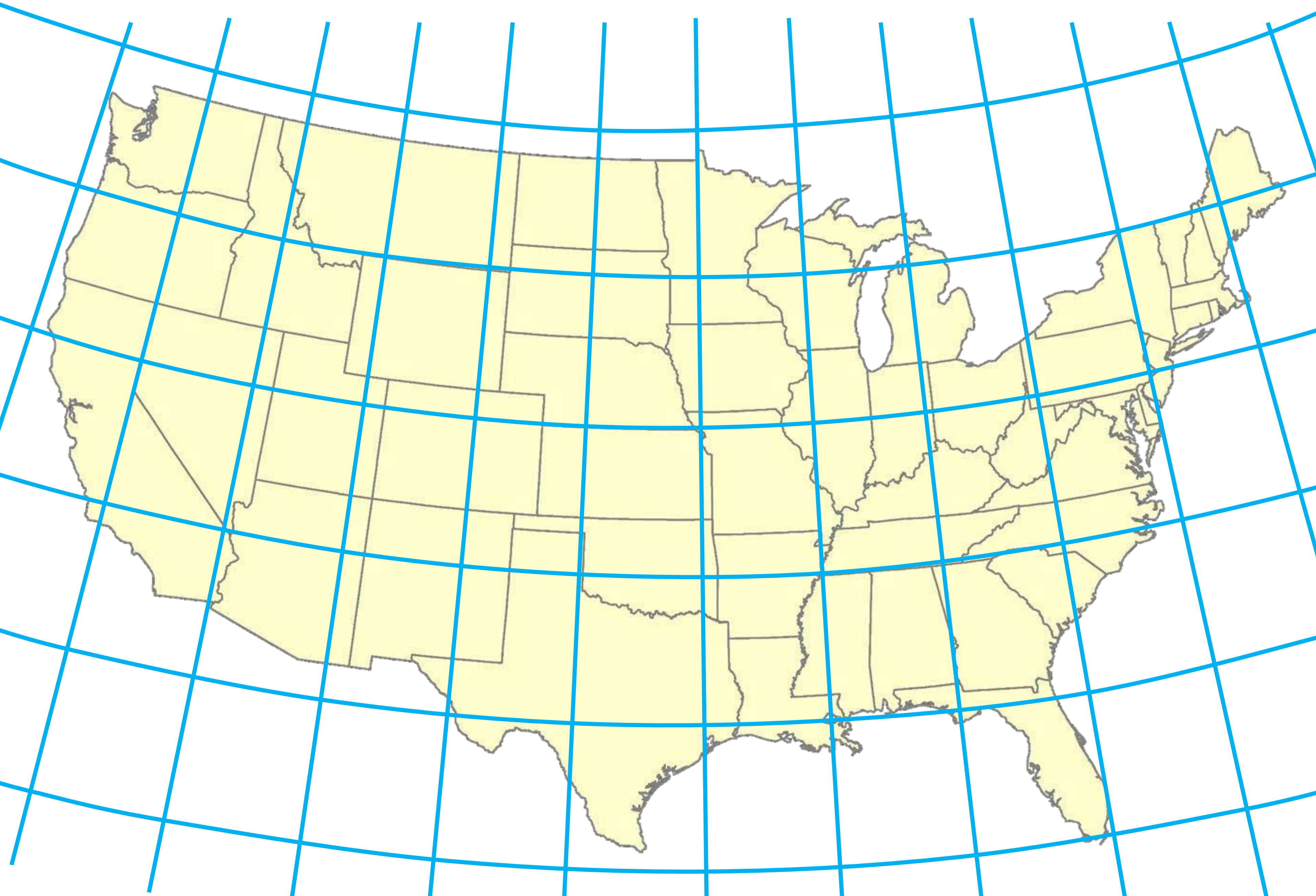
NA Plate = rotating

NATRF

Frame = rotating (*relative to ITRF*)

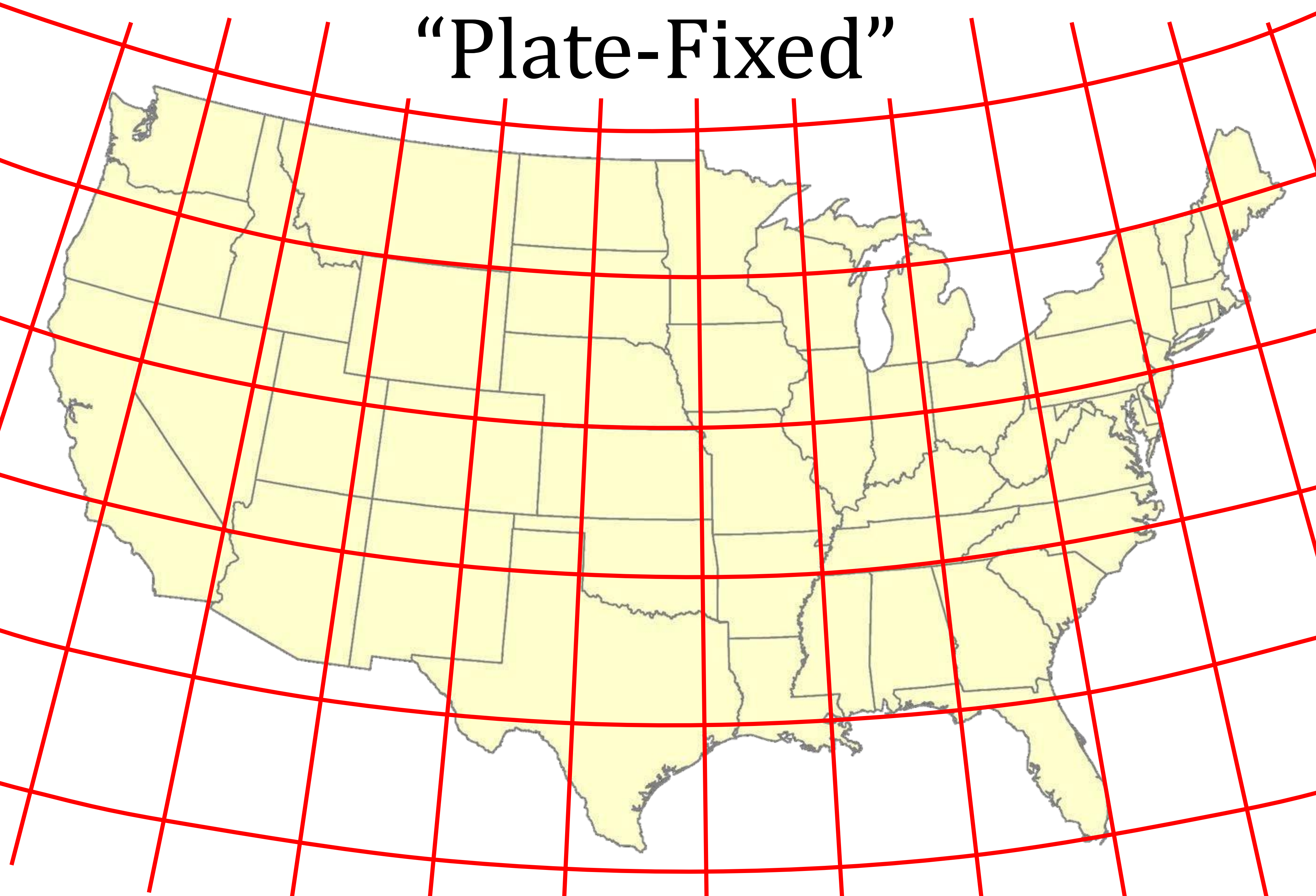
NA Plate = constant (*relative to NATRF2022*)

ITRF – constant frame, rotating plate

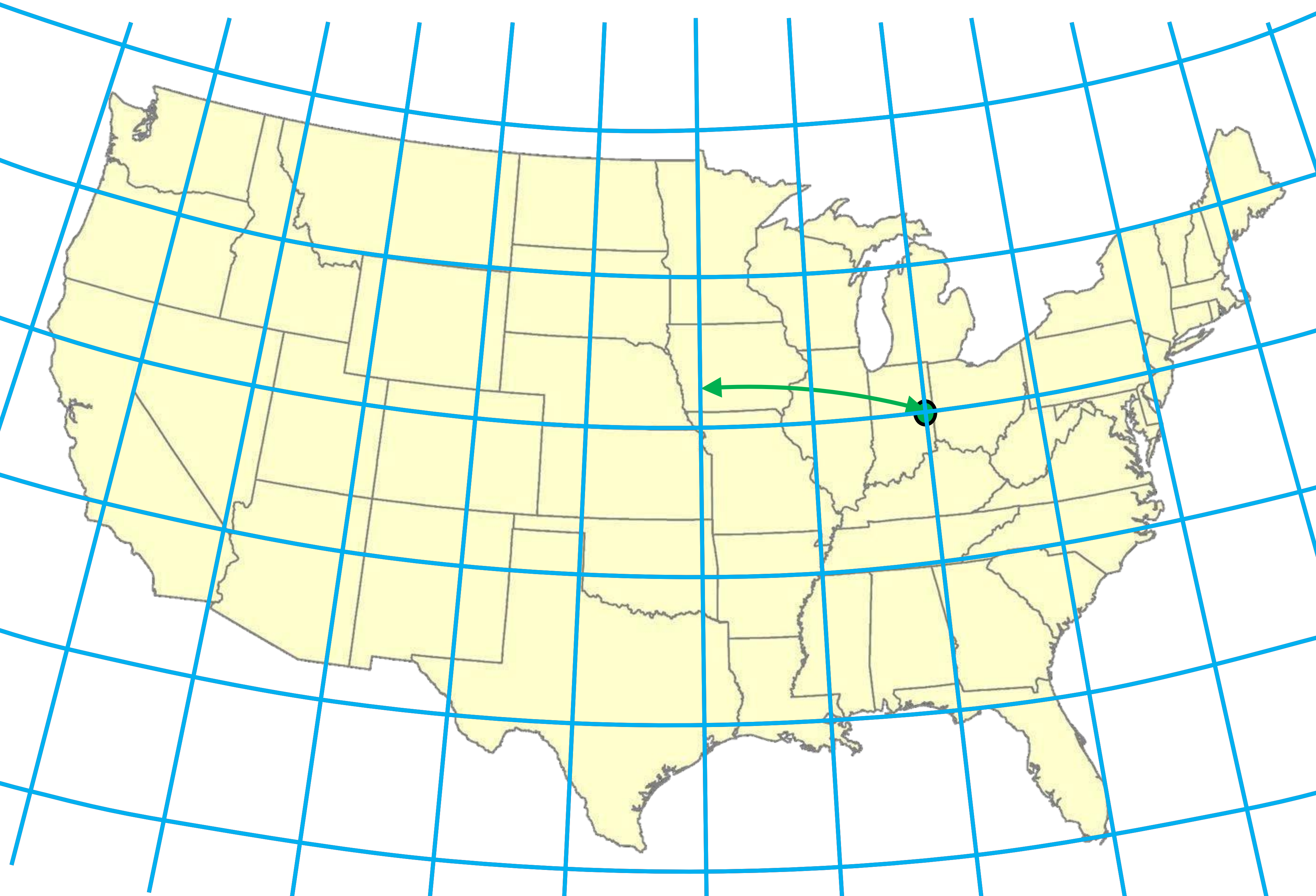


NATRF – rotating frame, constant with plate

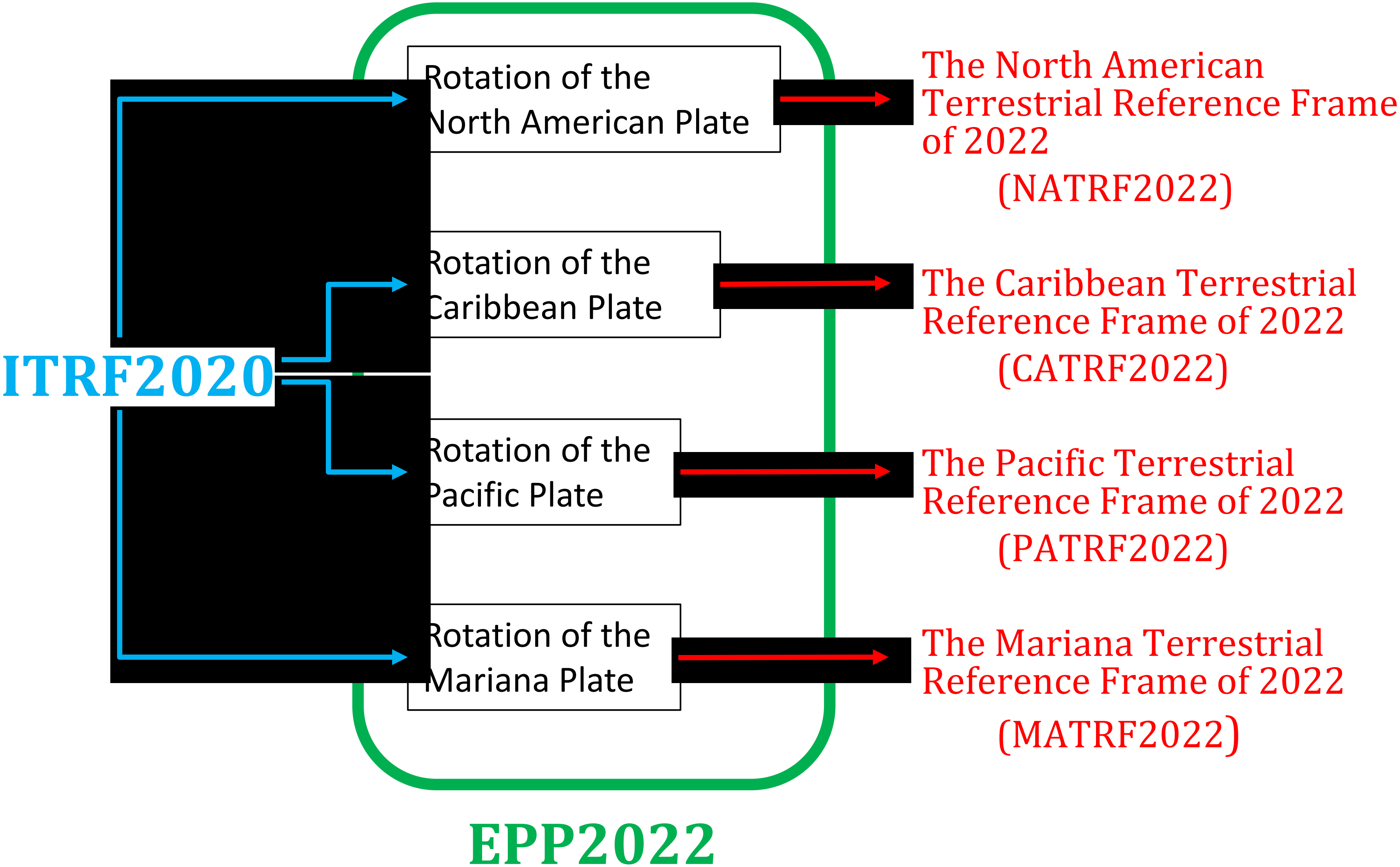
"Plate-Fixed"



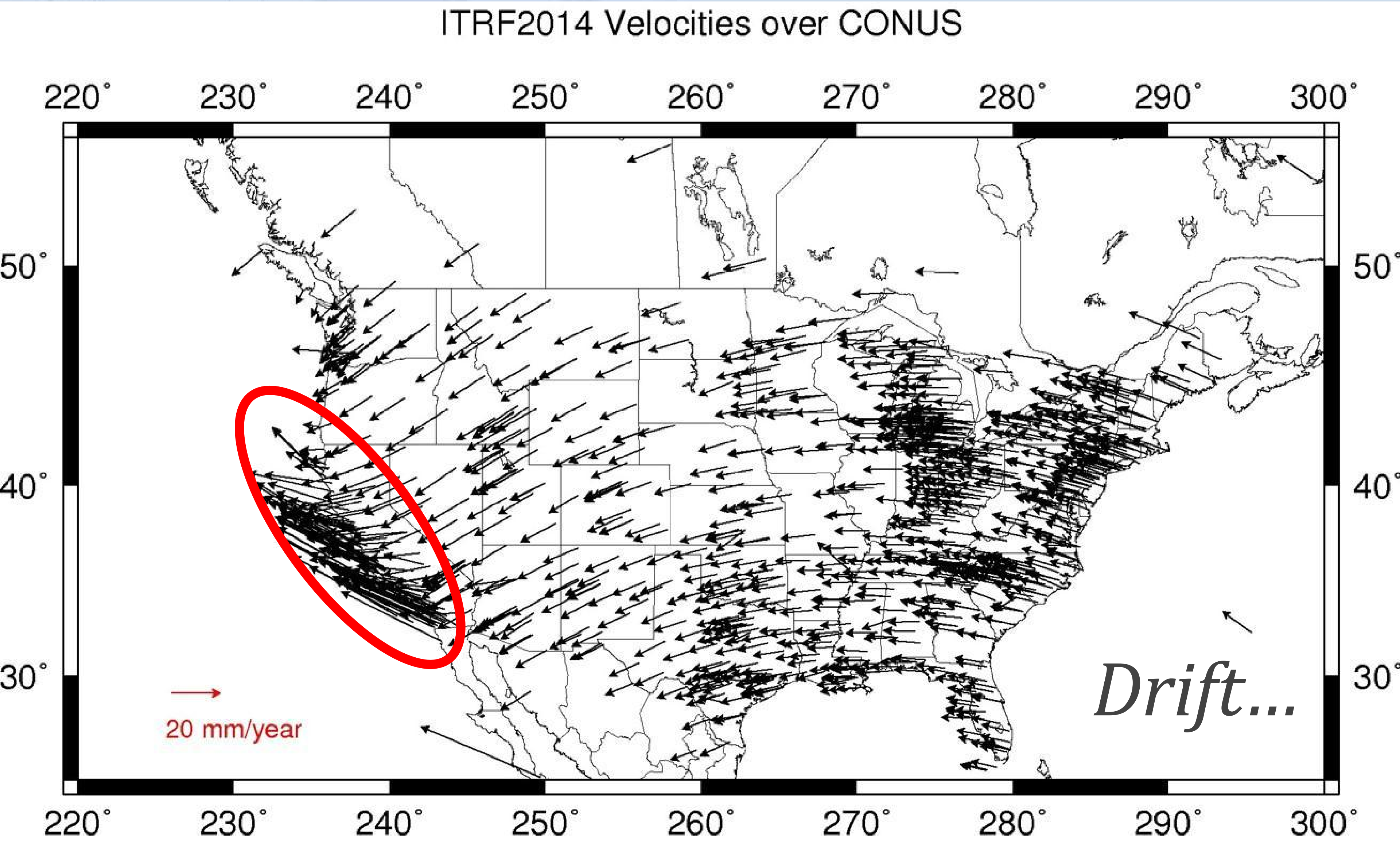
ITRF or NATRF – your choice, just use EPP



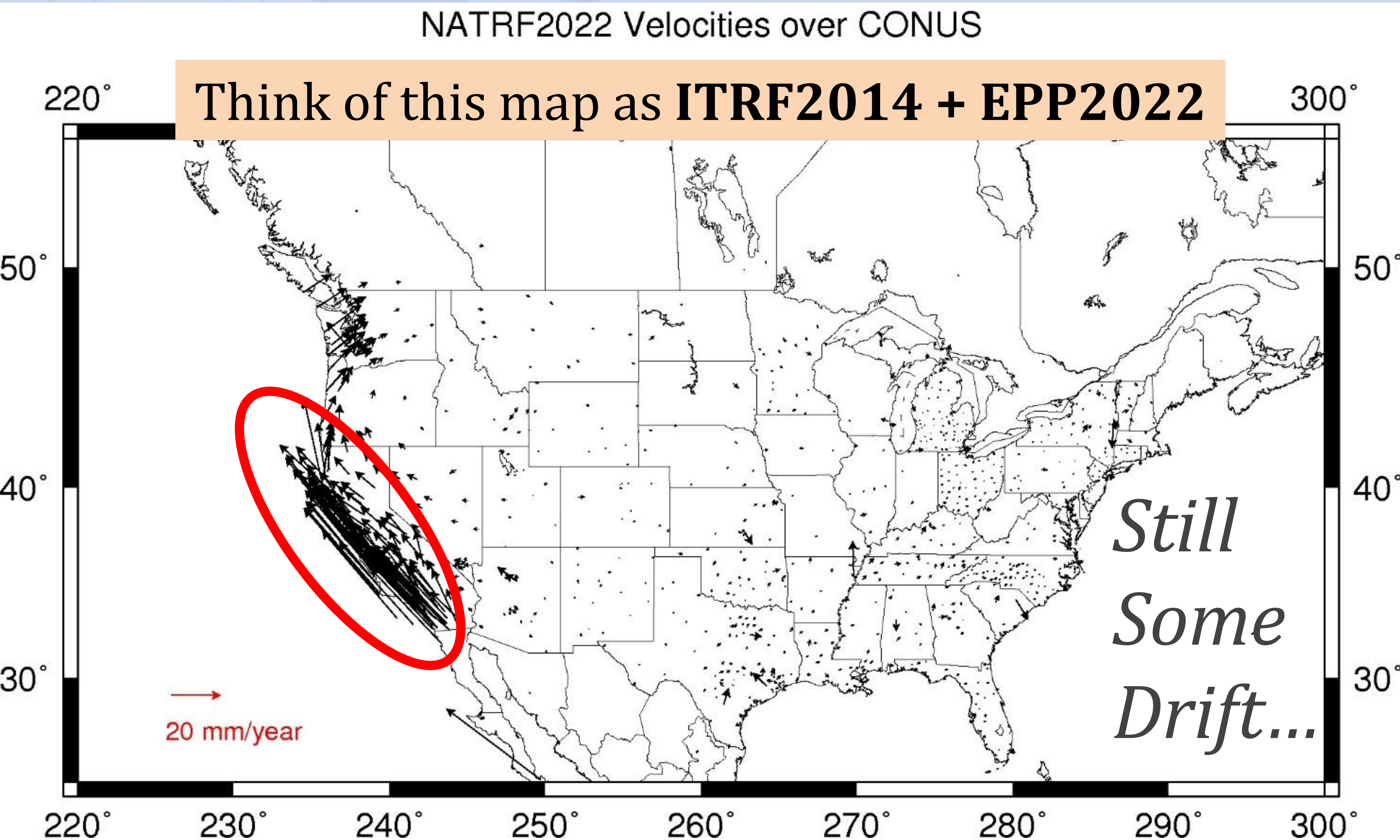
ITRF2020 + EPP2022 = --TRF2022



CORS Velocities in ITRF2014



CORS Velocities in NATRF2022



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

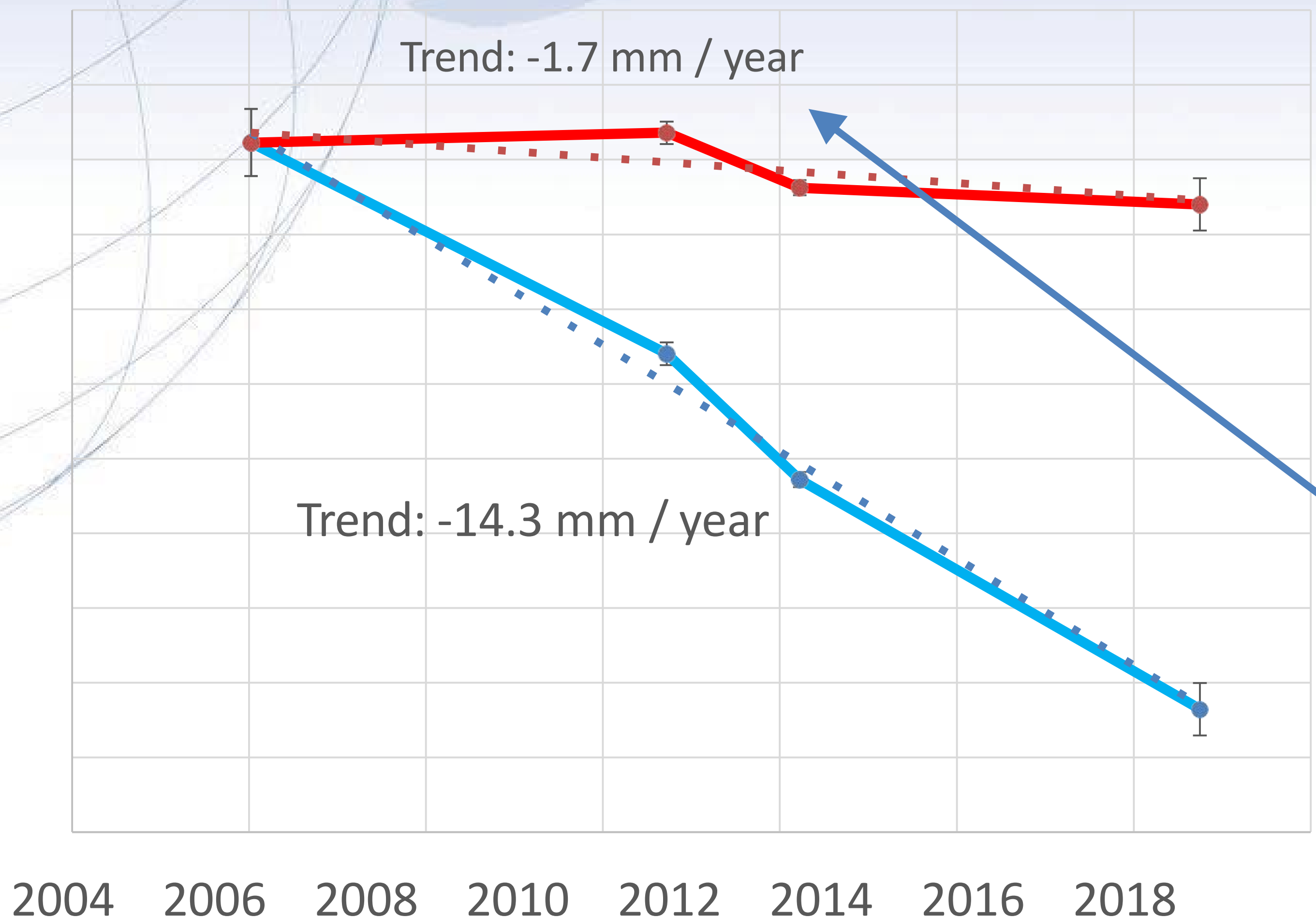
complex

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

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 is 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 Df, Dl, Dh at any point, accounting for all motions (drifts, earthquakes, GIA, etc.)
- Likely be built upon CORS data, geodynamic models and InSAR

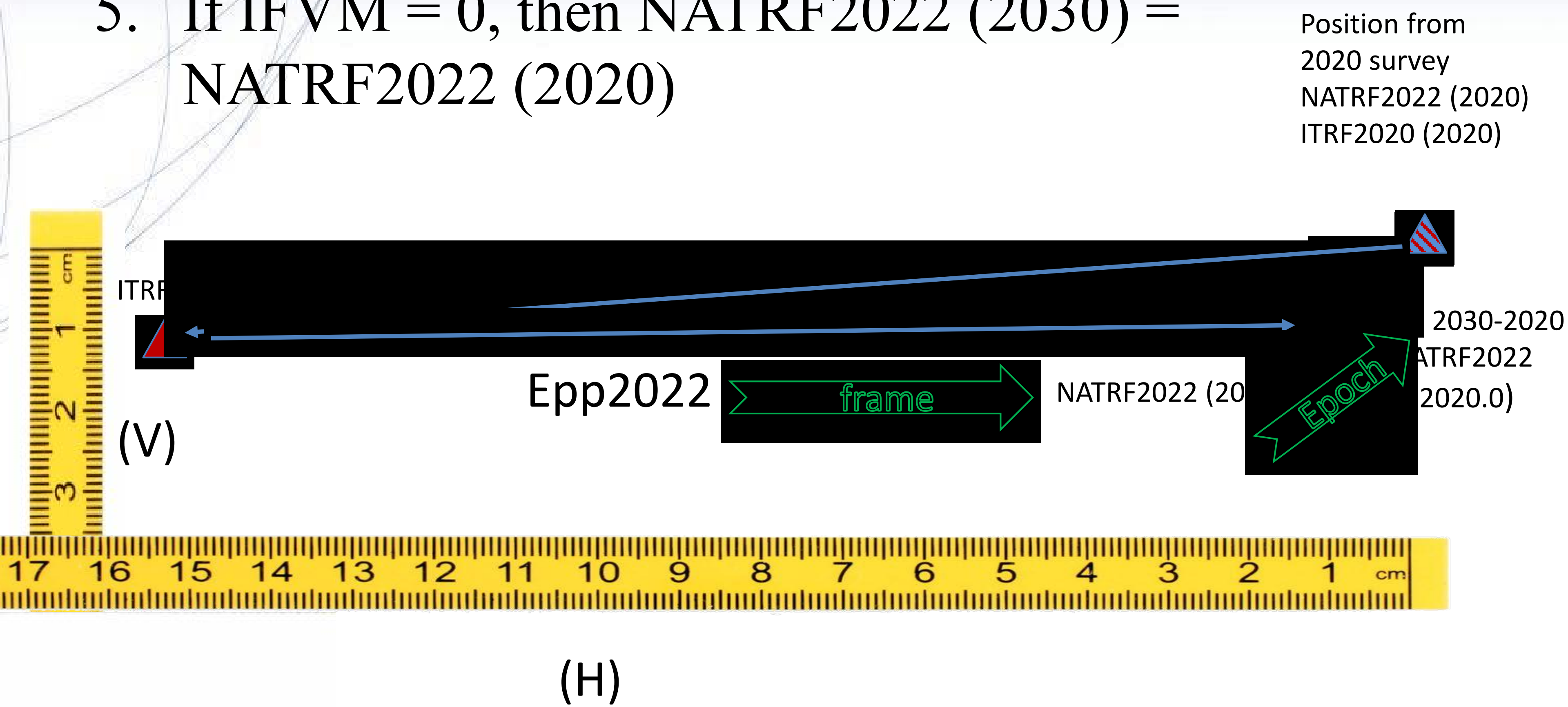
EPP2022 – Euler Pole Parameters – Simple Rotation

- Three parameters: lat, lon, rotation speed
- Horizontal *only*: just latitude and longitude
- Changes the *frame*: ITRF2020 + 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

1. A survey done Jan 1, 2020
2. New Survey (same point) done Jan 1, 2030
3. Position of point in NATRF2022(2030)
4. Position of point in NATRF2022(2020)
5. If IFVM = 0, then NATRF2022 (2030) = NATRF2022 (2020)

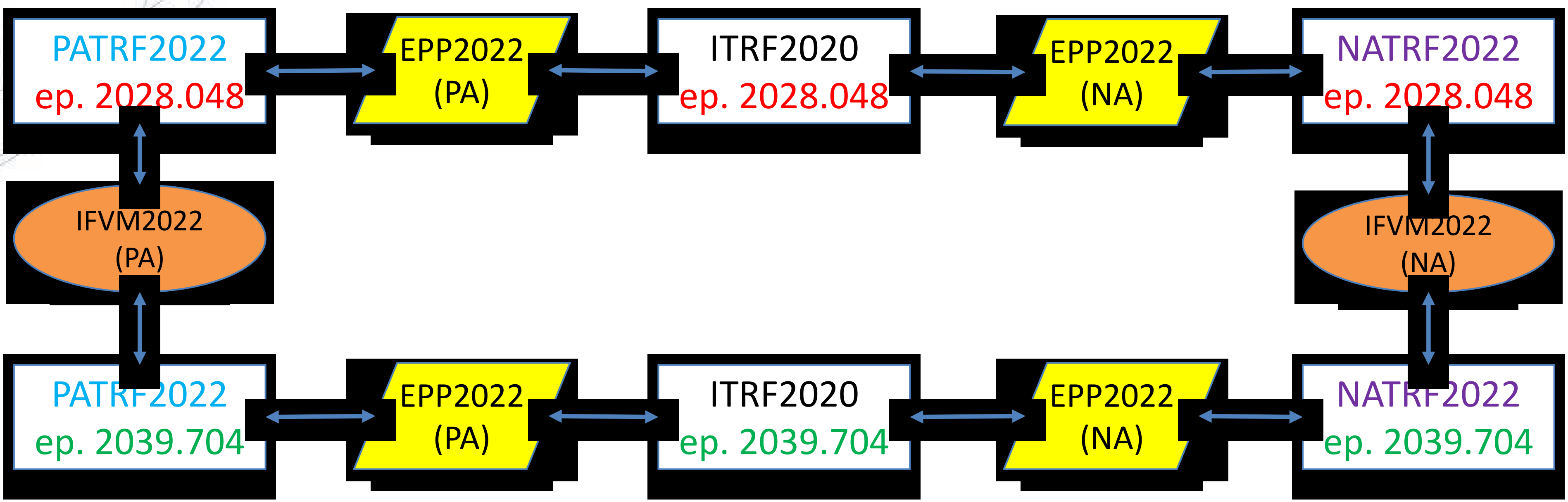


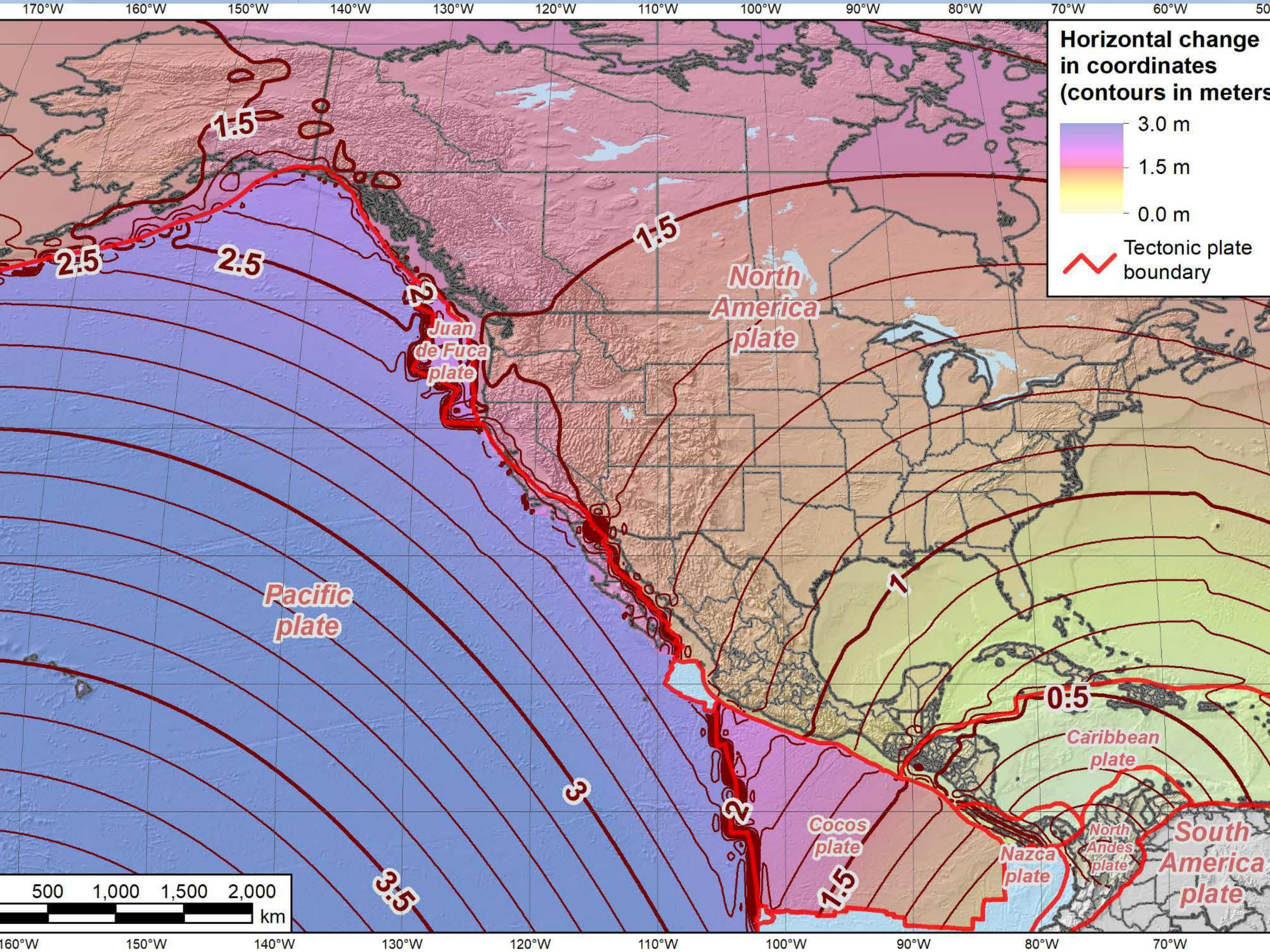
Example of application of EPP and IFVM

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

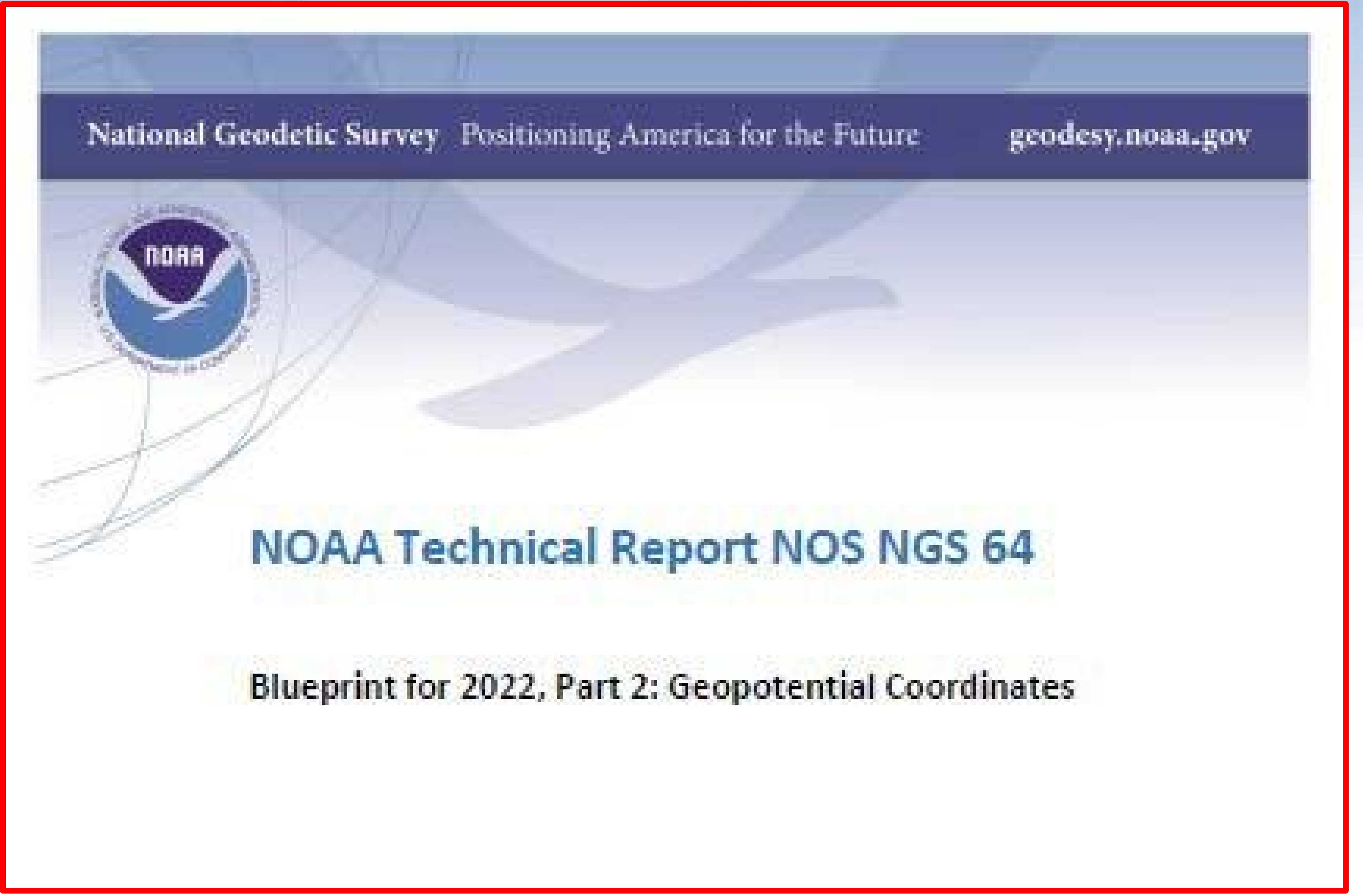
Important: This slide only covers *geometric* coordinates.

…the catch is, that survey was done in PATRF2022





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



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Blueprint for 2022, Part 2: Geopotential Coordinates

North American-Pacific Geopotential Datum of 2022

NAPGD2022

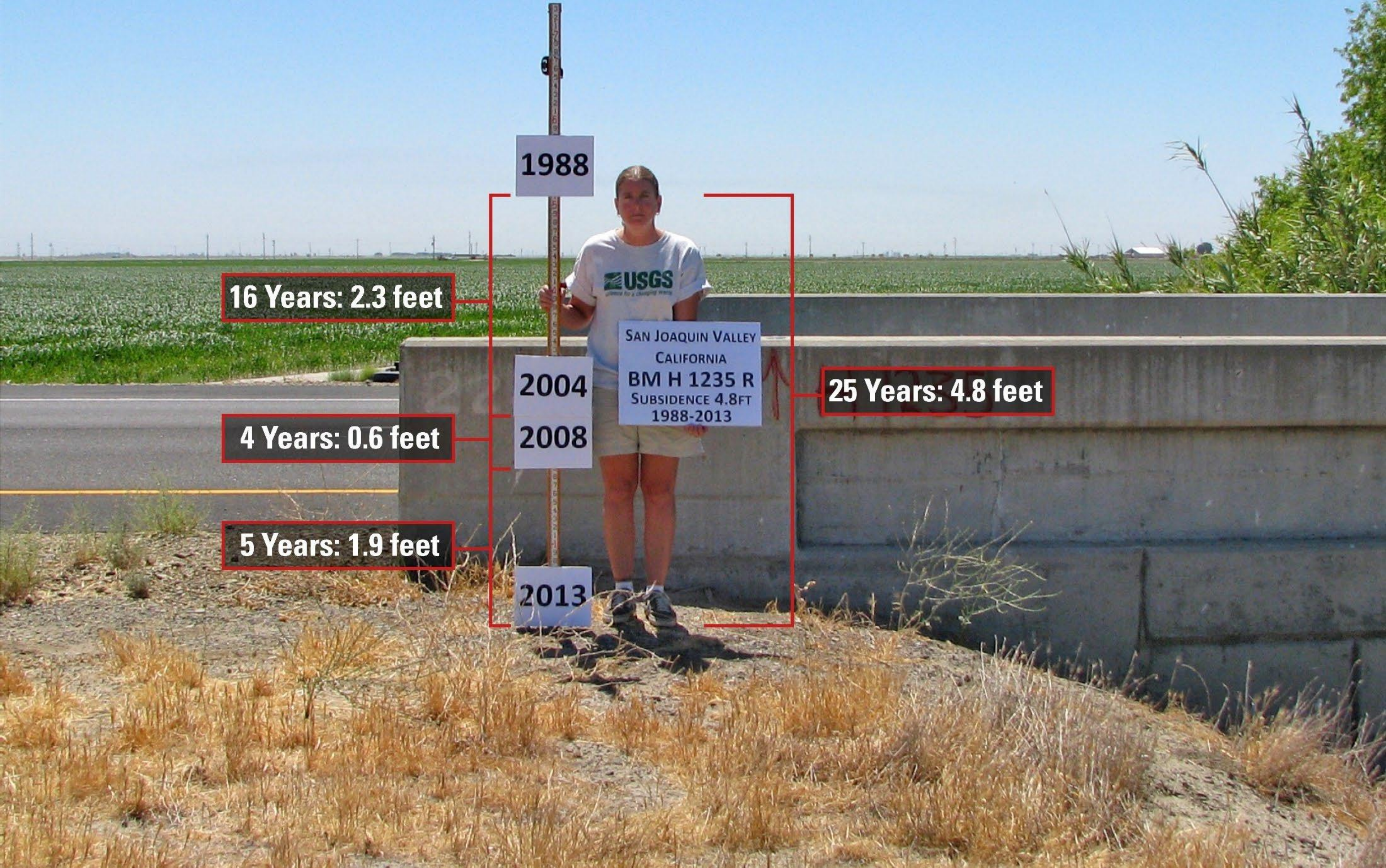
(pronounced: nap-jee-dee)

Overview NAPGD2022

- primary access via GNSS and geoid (think OPUS)
- accurate continental **gravimetric** geoid
- aligned with:
  1) --TRF2022
  2) **global** mean sea level (GMSL)
- monitor time-varying nature of gravity
  – via the <u>Ge</u>oid <u>M</u>onitoring <u>S</u>ervice (GeMS)

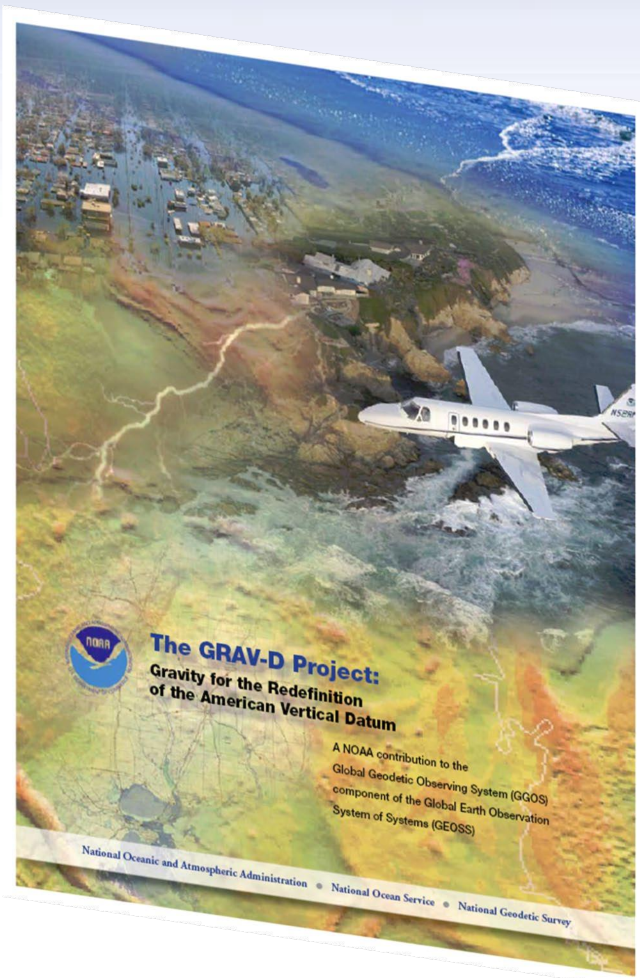
Passive marks may lie still… but they still may lie!

small instability x long time = large inaccuracy



Gravity for the Redefinition of the American Vertical Datum

- **2022 Goal**: 2 cm accurate ortho heights (H)
  - GNSS plus geoid model
- **GRAV-D Goal**: Gravimetric geoid (N_g) accurate to 1 cm where possible using airborne gravity data
- Leverage partnerships to improve and validate gravity data
  - State-based gravity programs?

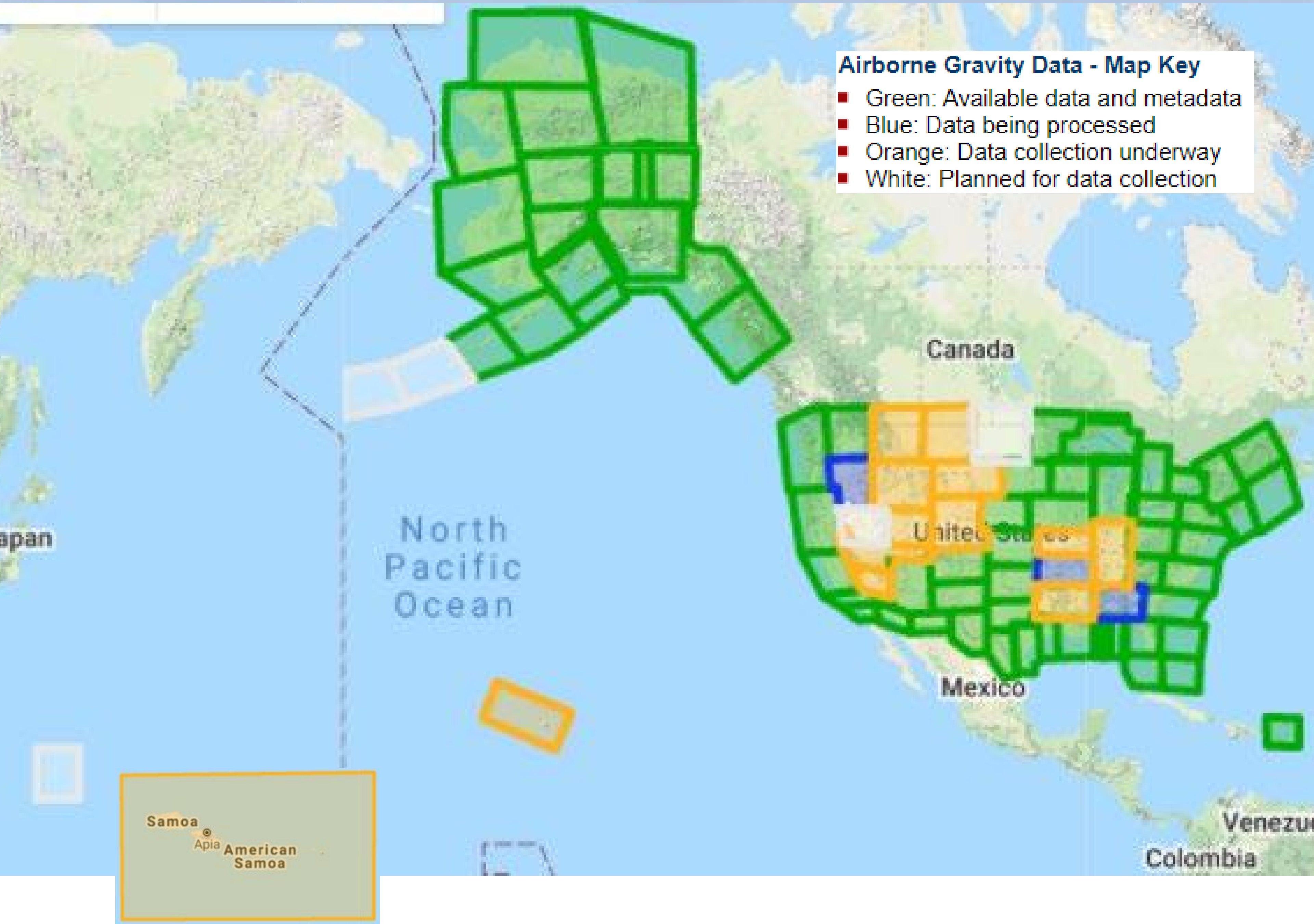


Gravity for the Redefinition of the American Vertical Datum

There are two major campaigns within GRAV-D

1. High-resolution snapshot of gravity
   – primarily airborne observations, all **relative gravity**, covering the US and Territories at an estimated cost of ~$39 million

2. Low-resolution "movie" of gravity changes
   – primarily terrestrial, episodic observations of **absolute gravity** sites to monitor long-term change

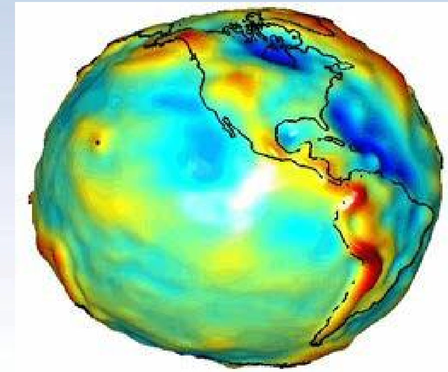

Airborne Gravity Data - Map Key
Green: Available data and metadata
Blue: Data being processed
Orange: Data collection underway
White: Planned for data collection
Canada
North Pacific Ocean
Mexico
Samoa
Apia
American Samoa
Colombia

Building a Geopotential Field Model

[redacted]

GRACE/GOCE/Satellite Altimetry

Long Wavelengths (> 250 km)

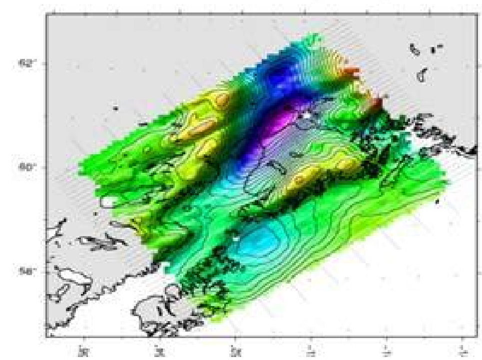


+

[redacted]

Airb[redacted]tions

Intermediate Wavelengths (20km to 300 km)

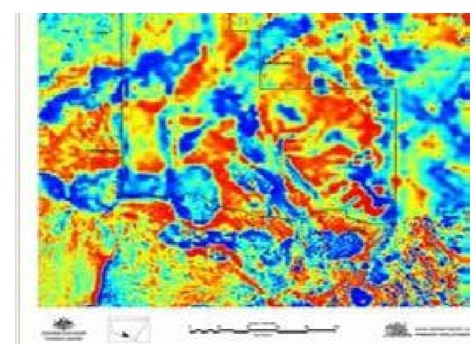


+

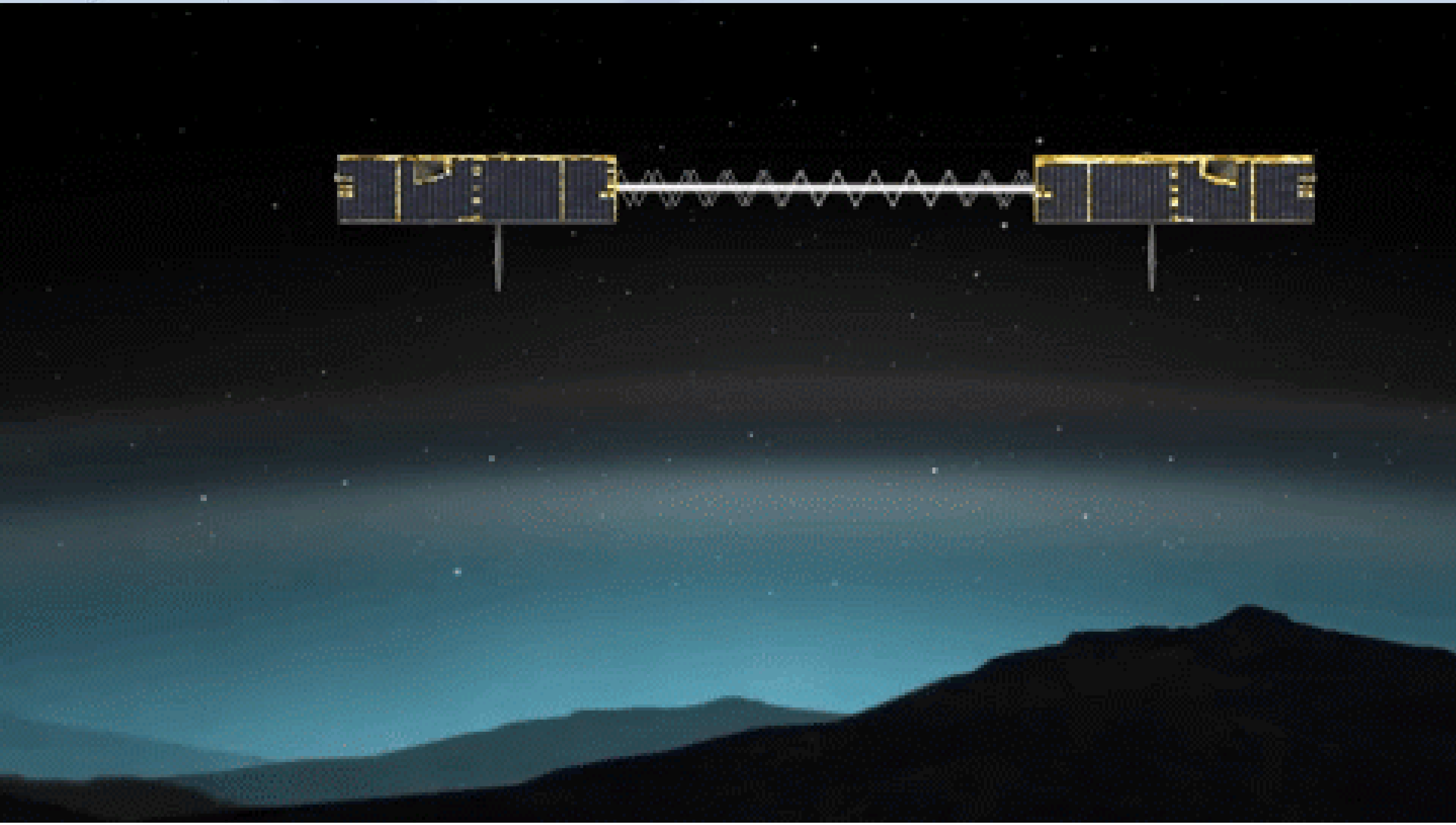
[redacted] 

Terrestrial/Surface Observations and Predicted Gravity from Topography

Short Wavelengths (< 100 km)



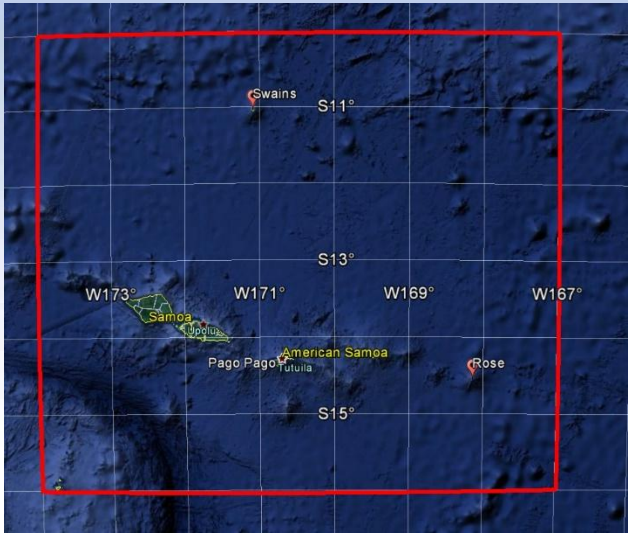
GRACE – satellite observations

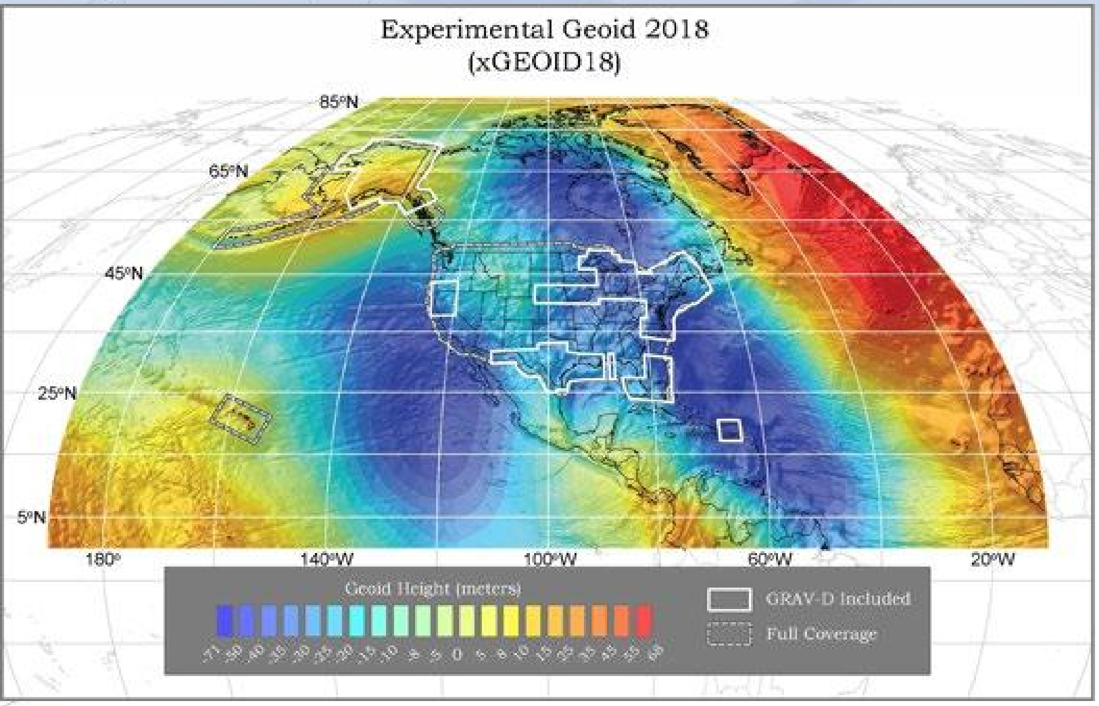


Gravity Survey Plan

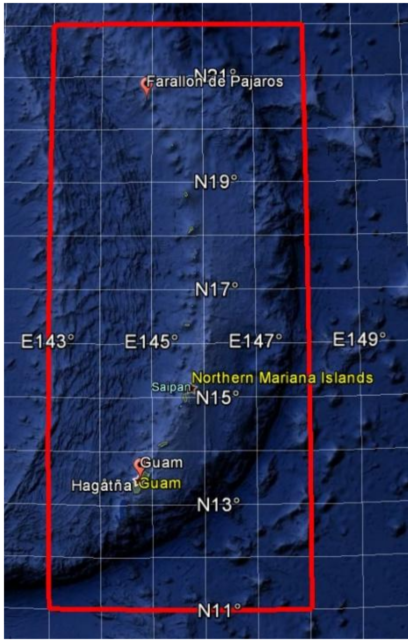
- National Scale Part 1
  - Predominantly through airborne gravity
  - With Absolute Gravity for ties and checks
  - Relative Gravity for expanding local regions where airborne shows significant mismatch with existing terrestrial

GEOID2022 (et al) over American Samoa:
-16 to -10, 186-193





GEOID2022 (et al) over Guam/CNMI:
11-22, 143-148



GEOID2022 (et al) over the North America/Pacific/Caribbean/Central America/Greenland region will range from 0 to 90 latitude and from 170 to 350 longitude.

Names

The Old:

Orthometric Heights	NAVD 88
Normal Orthometric Heights	PRVD 02
	VIVD09
	ASVD02
	NMVD03
	GUVD04
Dynamic Heights	IGLD 85
Gravity	IGSN71
Geoid Undulations	GEOID12B
Deflections of the Vertical	DEFLEC12B

The New:

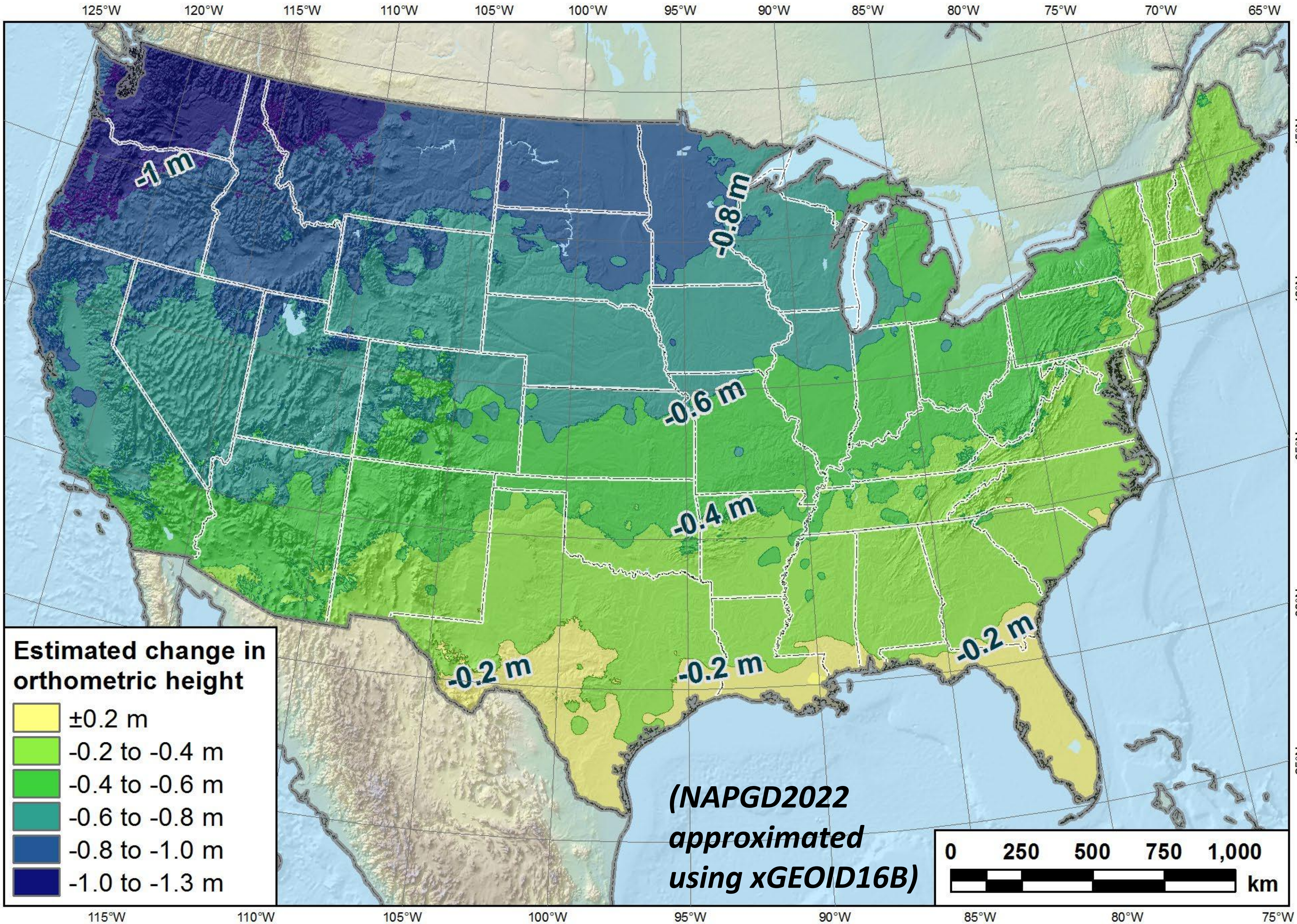
The North American Pacific Geopotential Datum of 2022 (NAPGD2022)

- Will include GEOID2022

one vertical datum

pole-to-equator

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



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Blueprint for 2022, Part 3:
Working in the Modernized NSRS

Initial draft released April 16, 2019

What is BP3?

- BP3 is a companion to BP1 (geometric) and BP2 (geopotential), both released in 2017
  - It is about "re-inventing bluebooking"
  - It's about how NGS will provide the frames/datum in the future
  - It's about how YOU will use the frames/datum in BP1 and BP2

Deadlines for SPCS2022 input

NGS.Feedback@noaa.gov
by **August 31, 2018**

Anyone can comment!

Federal Register Notice (FRN)

- Announcement and public comments
  - On draft **SPCS2022 policy & procedures**
  - On **"special purpose"** zones

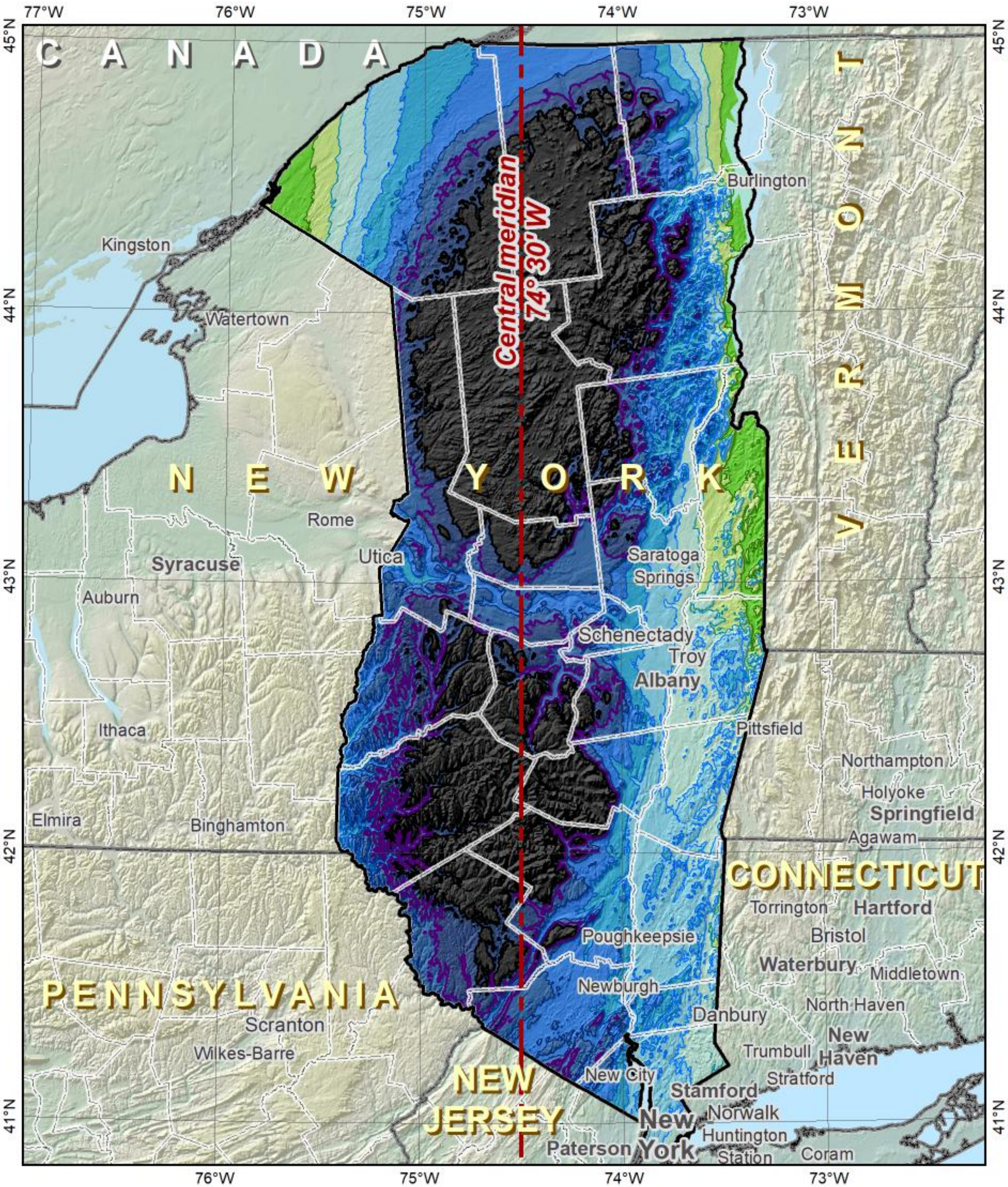
NGS.SPCS@noaa.gov
by **March 31, 2020** for ***requests*** and ***proposals***

by **March 31, 2021** for ***submittal*** of ***approved*** designs

State stakeholders only!

SPCS2022 Procedures (draft)

- **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



Existing SPCS 83 design: New York East Zone

NOAA's National Geodetic Survey

Transverse Mercator projection

North American Datum of 1983

Central meridian: 74° 30' W
Cen merid scale: 0.999 9 (exact)

Areas within ±50 ppm distortion (1:20,000 = ±0.26 ft per mile):
14% of population
15% of all cities and towns
10% of entire zone area

Distortion values (ppm)

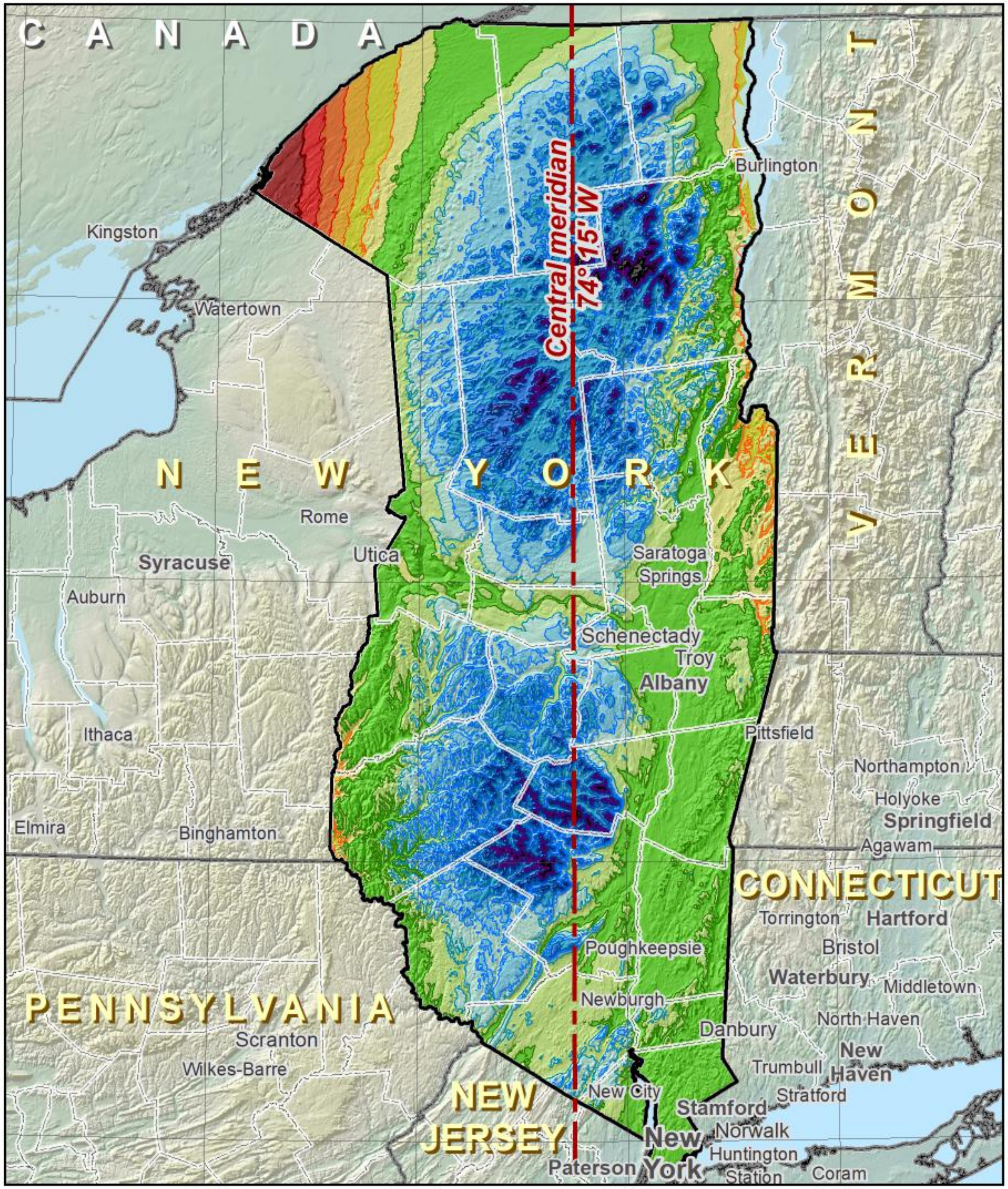
Entire zone:	***Cities and towns:***
Min = -313	Min, Max = -196, +9
Max = +33	Range = 206
Range = 346	Mean = -76
Mean = -123	(weighted by population)

Linear distortion at topographic surface (parts per million)

<-160	to -80	to +60
to -160	to -60	to +80
to -140	to -40	to +100
to -120	±20	to +120
to -100	to +40	>+120

0 50 100 150 km

Created 01/29/2019



Preliminary SPCS2022 default design: New York East Zone

(alternative 1)

NOAA's National Geodetic Survey

Transverse Mercator projection

North American Terrestrial Reference Frame of 2022

Central meridian: 74° 15' W
Cen merid scale: 0.999 99 (exact)

Areas within ±50 ppm distortion (1:20,000 = ±0.26 ft per mile):

97% of population
85% of all cities and towns
57% of entire zone area

Distortion values (ppm)

Entire zone:	*Cities and towns:*
Min = -241	Min, Max = -97, +140
Max = +180	Range = 238
Range = 421	Mean = -3
Mean = -35	(weighted by population)

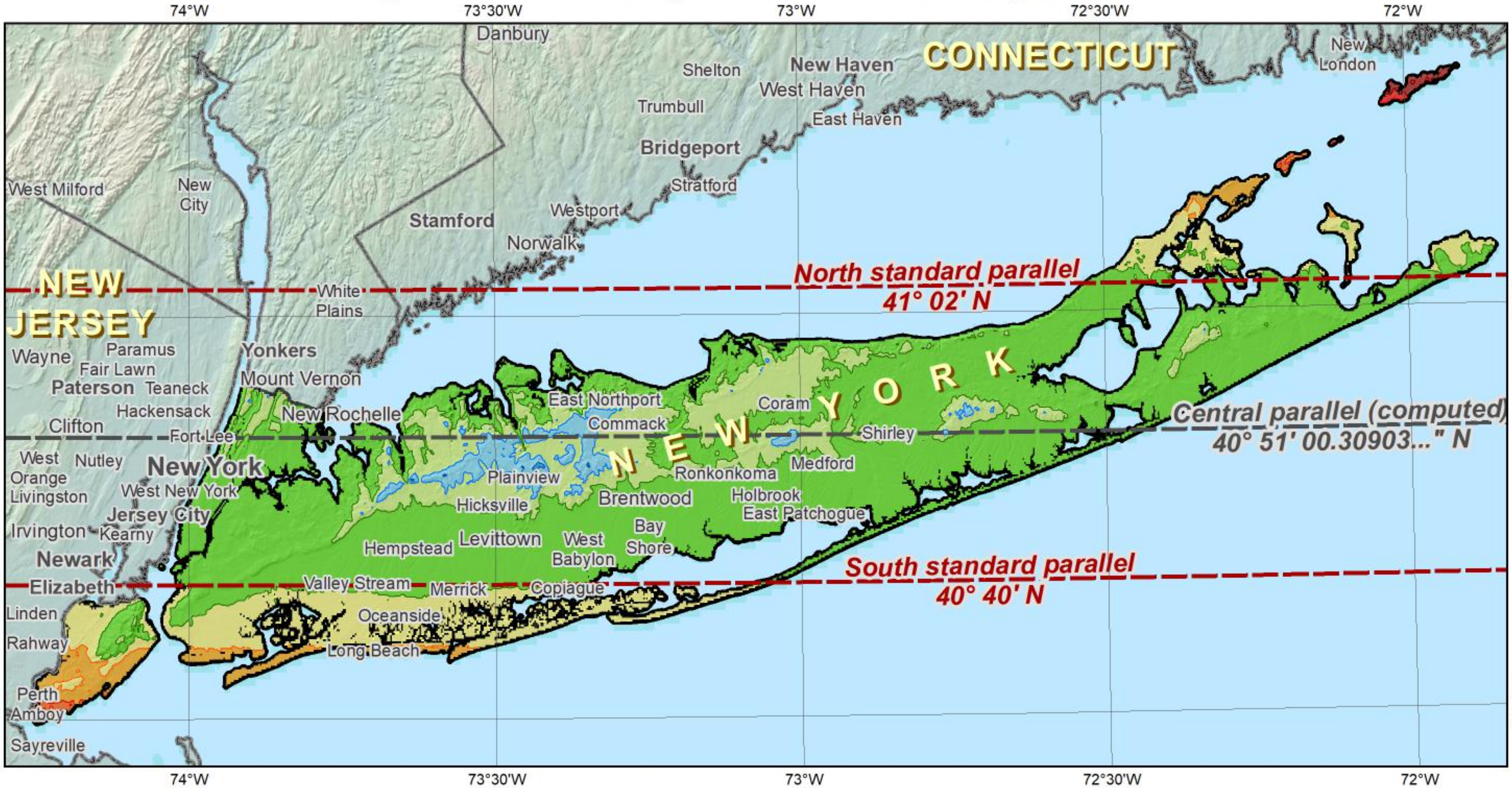
Linear distortion at topographic surface (parts per million)

<-160	to -80	to +60
to -160	to -60	to +80
to -140	to -40	to +100
to -120	±20	to +120
to -100	to +40	>+120

0 50 100 150 km

Created 01/27/2019

Existing SPCS 83 design: New York Long Island Zone



Lambert Conformal Conic projection

North American Datum of 1983

Central parallel: 40° 51' 00.31..." N

Central parallel scale: 0.999 994 900...

Areas within ±5 ppm distortion (1:200,000 = ±0.03 ft per mile):

96% of population

69% of all cities and towns

65% of entire zone area

NOAA's National Geodetic Survey

Distortion values (ppm)

Entire zone:

Min = -17 Range = 46

Max = +29 Mean = -0.8

Cities and towns:

Min = -14 Mean = -1.2

Max = +24 (weighted by

Range = 38 population)

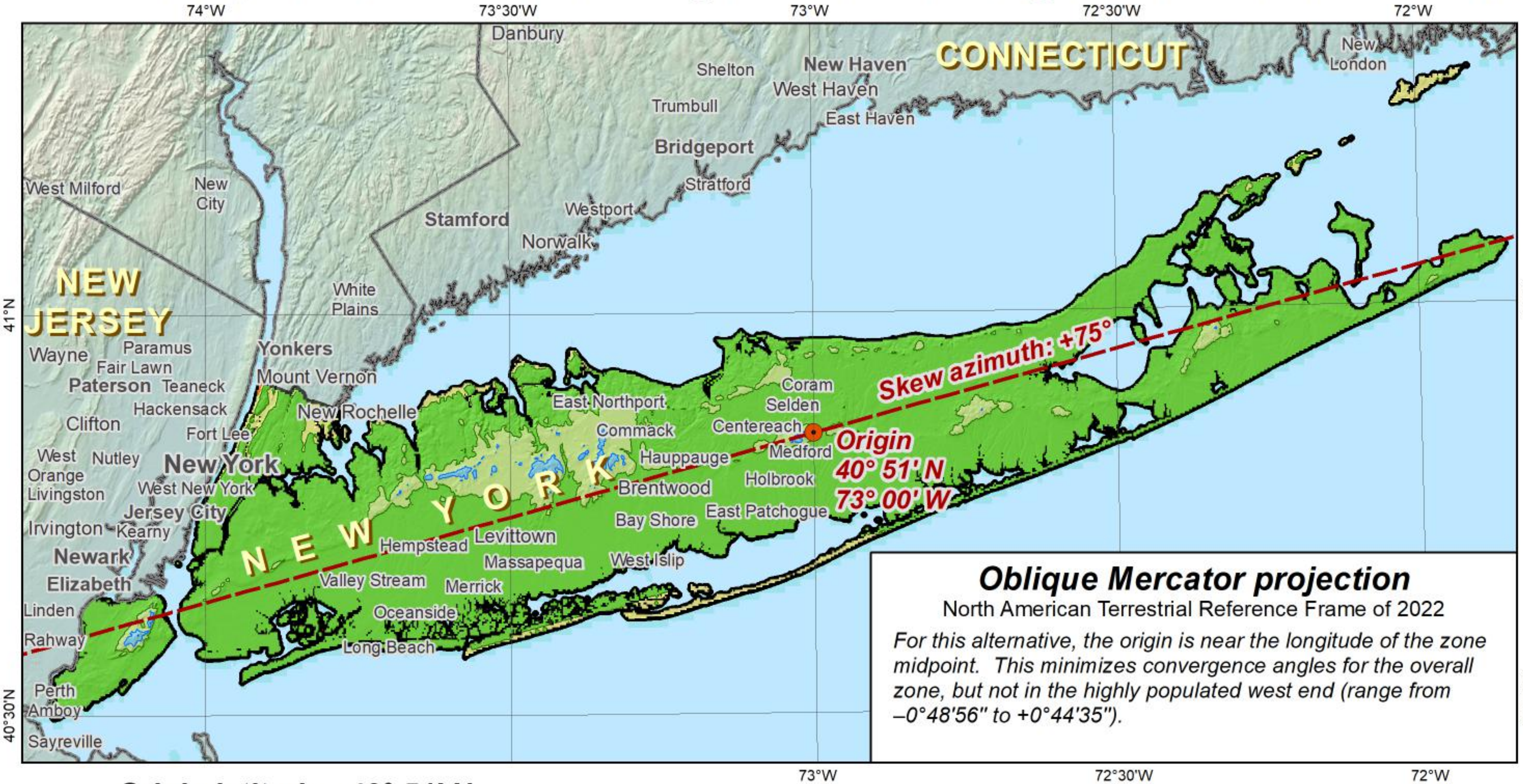
Created 01/27/2019

Linear distortion at topographic surface (parts per million)

< -30	to -15	to +15
to -30	to -10	to +20
to -25	±5	to +25
to -20	to +10	> +25

0 10 20 30 40 50 km

Preliminary SPCS2022 default design: New York Long Island Zone (alternative 1)



Origin latitude: 40° 51' N
Origin longitude: 73° 00' W
Skew axis scale: 0.999 997 (exact)
Skew azimuth: +75°

Areas within ±5 ppm distortion (1:200,000 = ±0.03 ft per mile):
96% of population
87% of all cities and towns
87% of entire zone area

NOAA's National Geodetic Survey

Distortion values (ppm)

Entire zone:

Min = -15	Range = 26
Max = +11	Mean = -0.4

Cities and towns:

Min = -11	Mean = +0.3
Max = +7	(weighted by
Range = 18	population)

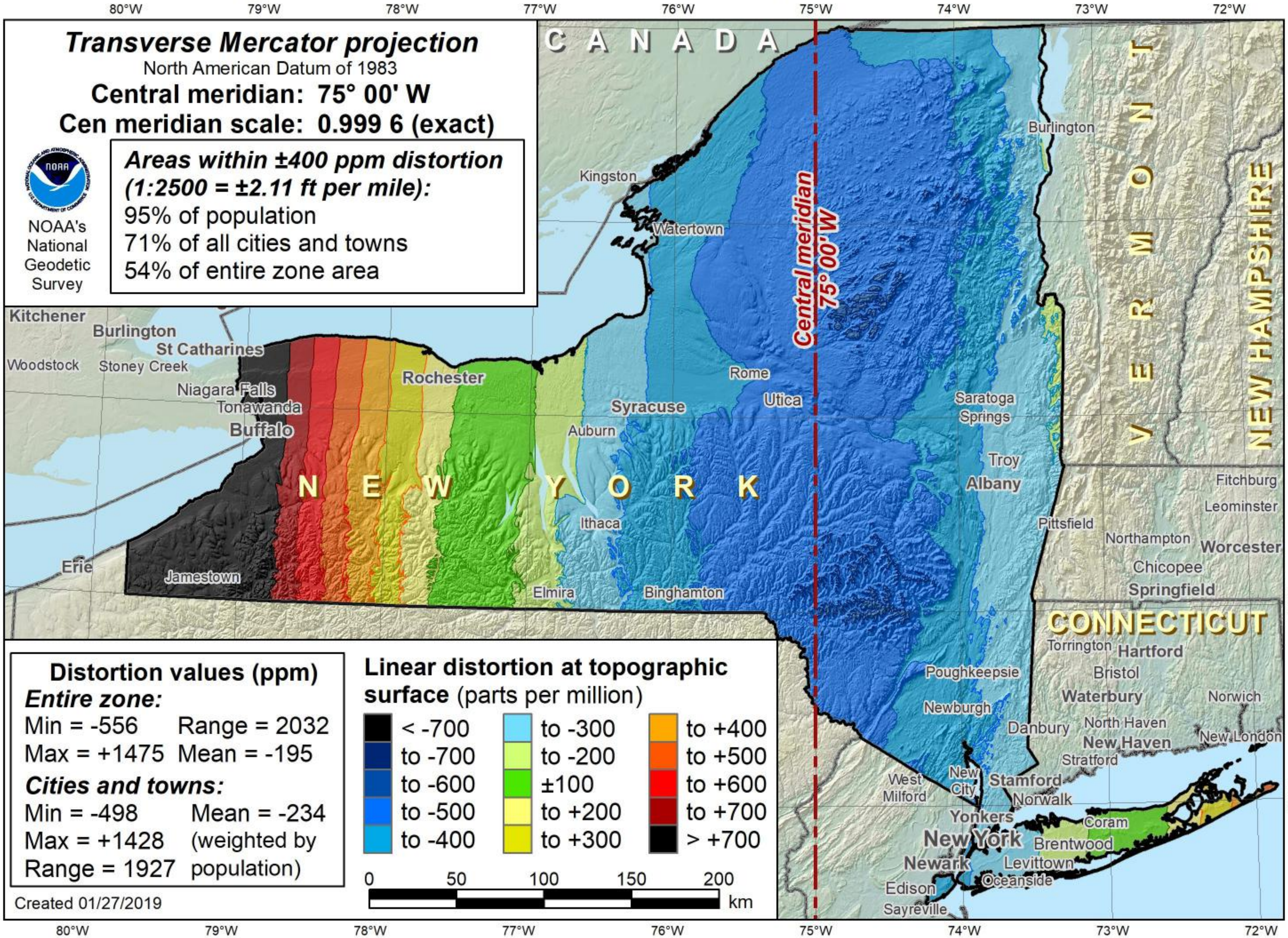
Created 01/28/2019

Linear distortion at topographic surface (parts per million)

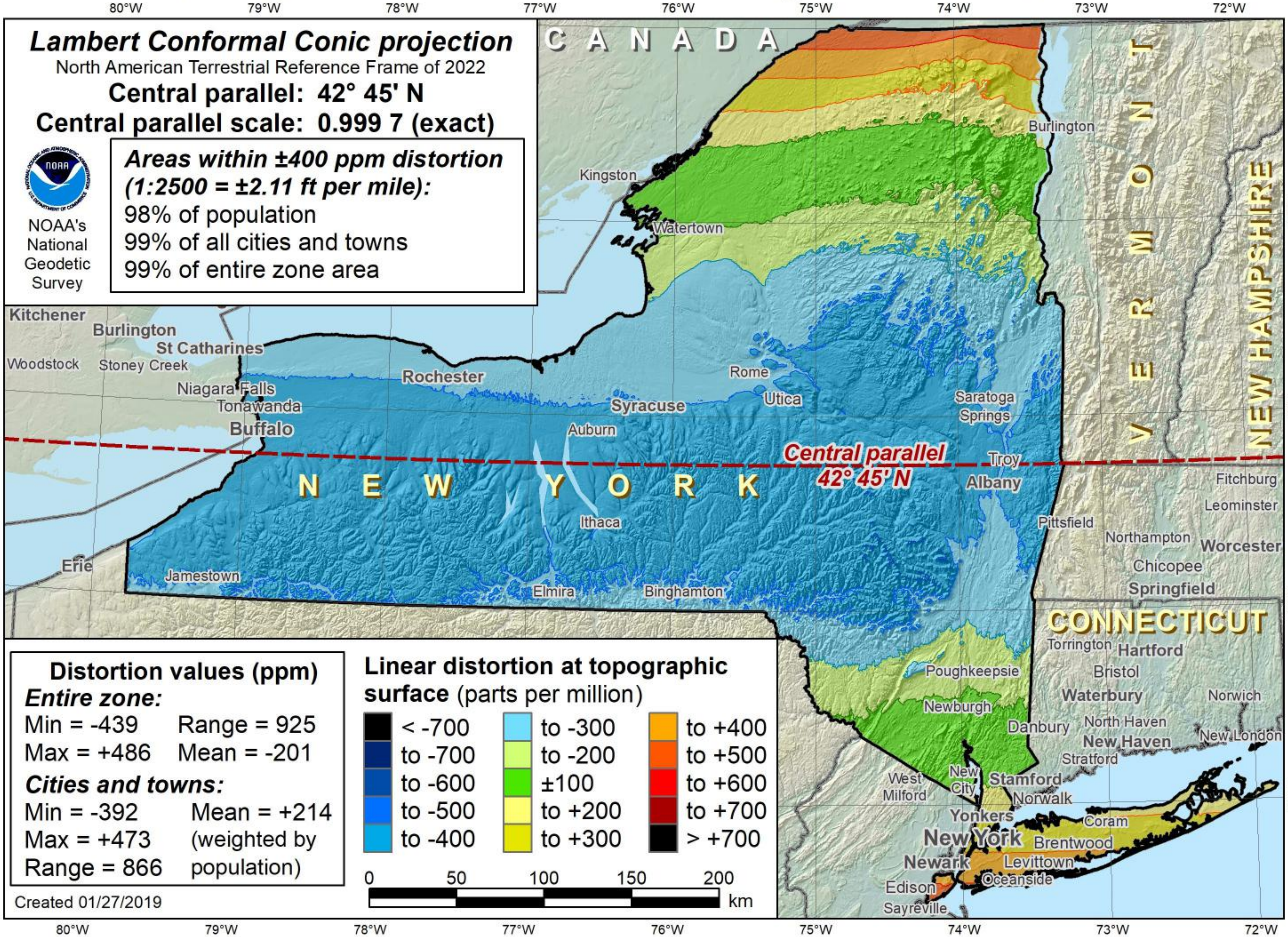
< -30	to -15	to +15
to -30	to -10	to +20
to -25	±5	to +25
to -20	to +10	> +25

0 10 20 30 40 50 km

Existing UTM Zone 19 North used as statewide zone: New York



Preliminary SPCS2022 statewide zone design: New York (alternative 2)



How to Prepare

- Does your work currently require referencing NAD 83?
- Do you collect the necessary metadata needed to move existing data into the new frames?
  - When was it surveyed?
  - How was it surveyed?
  - What was the source of control?
  - Full datum description? (datum, tag, epoch)

How to Prepare

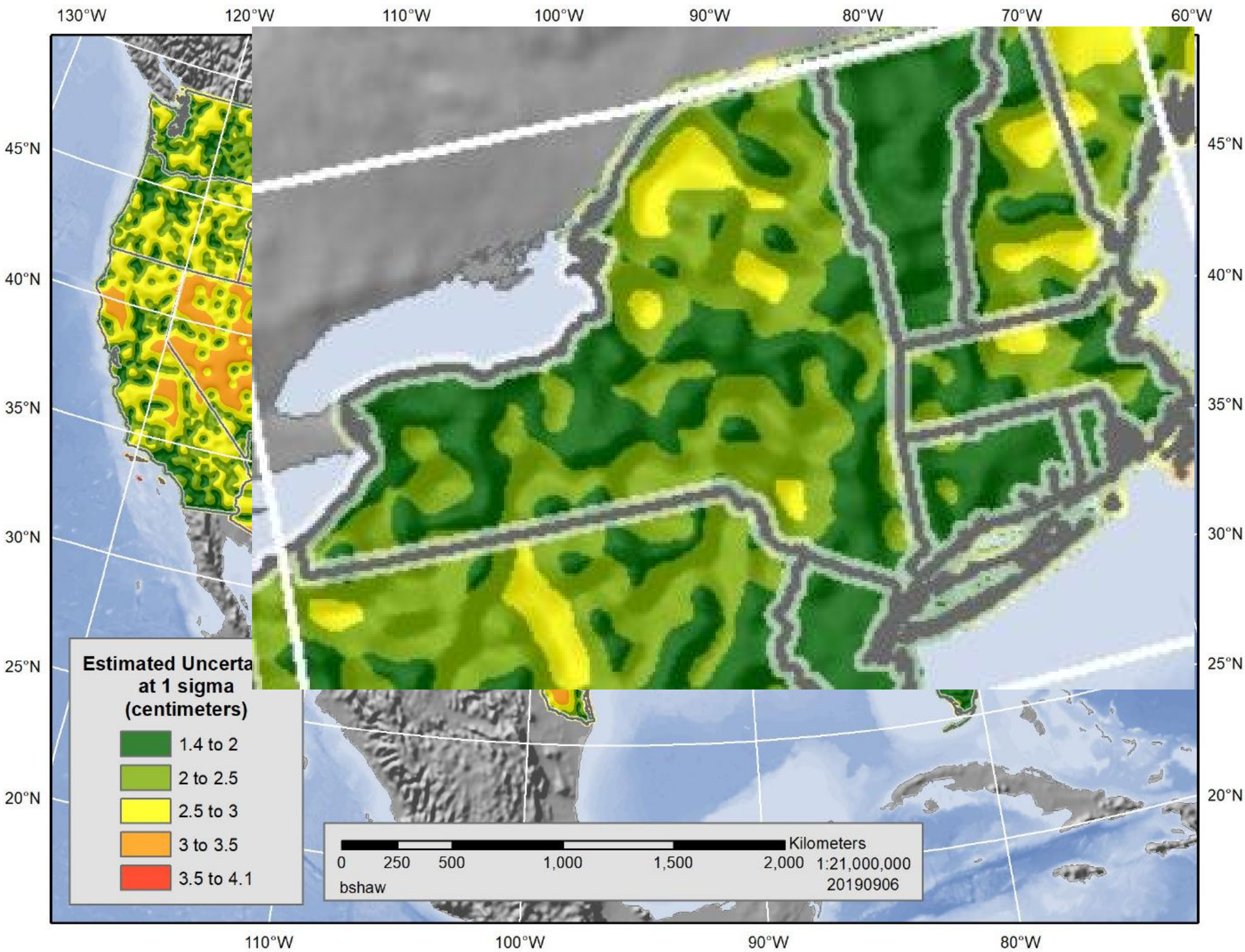
- Does your work currently require referencing NAVD 88?
- Do you collect the necessary metadata needed to move existing data into the new frames?
  - When was it surveyed?
  - How was it surveyed?
  - What was the source of control?
  - Is the geoid model adequate in your area to support transformation at the desired level? (more on that in a minute)

How to Prepare

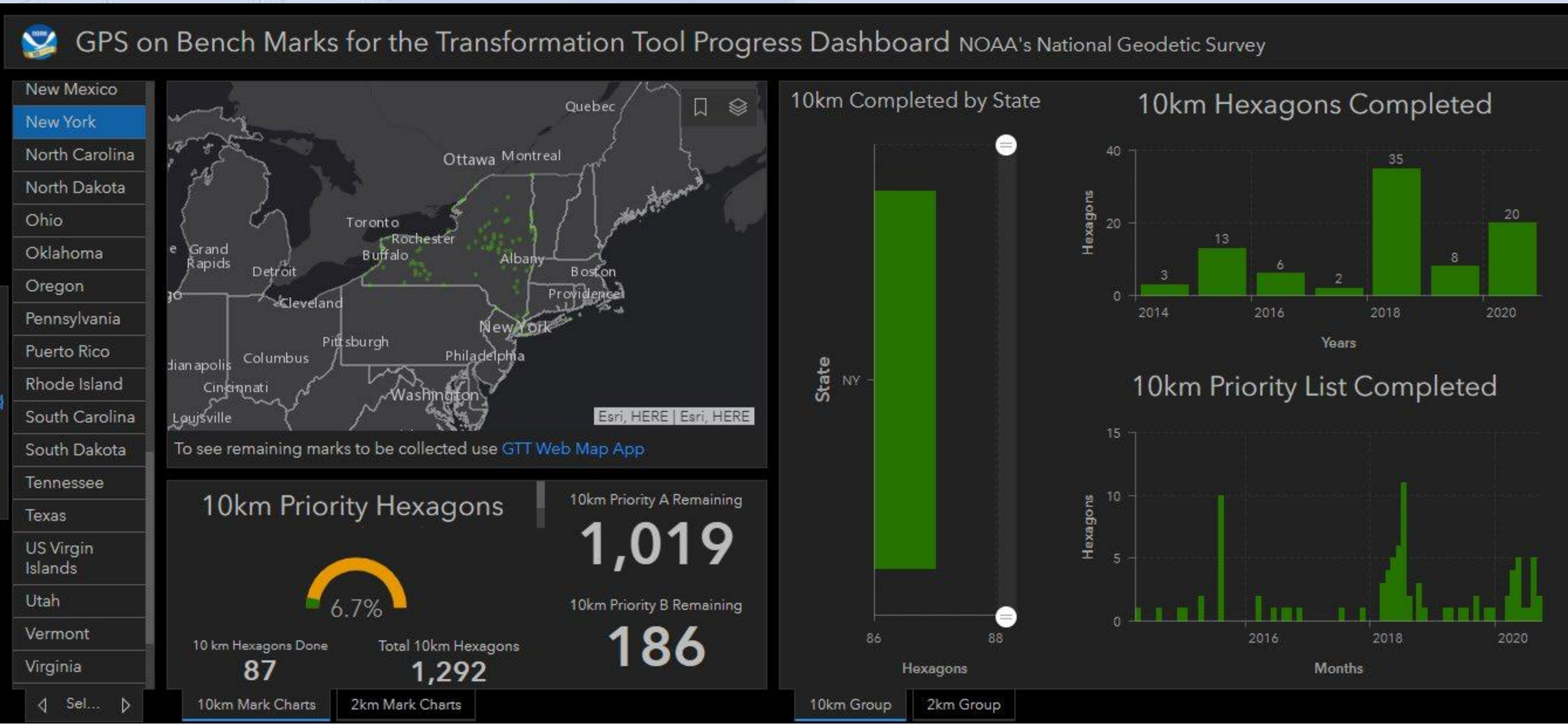
- Do you currently have GNSS equipment?
  - Remember that the primary method of establishing NAPGD2022 heights will be through GNSS and Geoid2022.
- Store Data…not just coordinates!
  - If you have your original data, it can always be reprocessed later
    - Maintains the integrity of your survey
    - Better than a transformation

How to Prepare

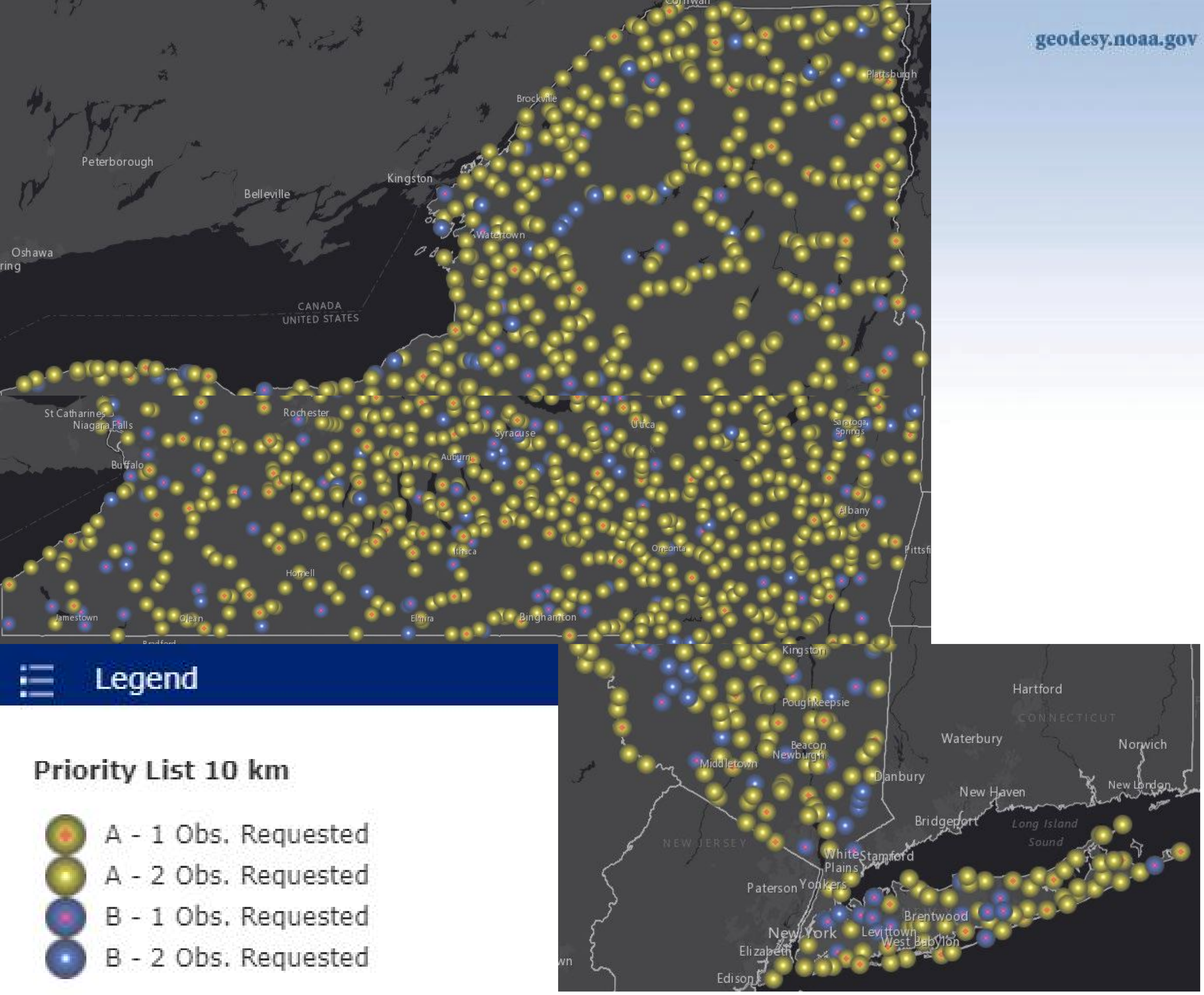
- Research the areas you work in most
- How is the quality of the CORSs in those areas
- Do you have RTN available?
  - Take note of the reference frame for the RTN, and inquire of plans to update it to the new frames
- Take note of density of GPSonBM and likely accuracy of vertical transformation (based on Geoid18)
- Conduct some GPSonBM in sparse areas



130°W
120°W
110°W
100°W
90°W
80°W
70°W
60°W
45°N
40°N
35°N
30°N
25°N
20°N
Estimated Uncerta
at 1 sigma
(centimeters)
1.4 to 2
2 to 2.5
2.5 to 3
3 to 3.5
3.5 to 4.1
Kilometers
0
250
500
1,000
1,500
2,000
1:21,000,000
bshaw
20190906


GPS on Bench Marks for the Transformation Tool Progress Dashboard NOAA's National Geodetic Survey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Puerto Rico
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
US Virgin Islands
Utah
Vermont
Virginia
Sel...
Quebec
Ottawa
Montreal
Toronto
Rochester
Buffalo
Grand Rapids
Detroit
Albany
Boston
Providence
Cleveland
New York
Pittsburgh
Philadelphia
Columbus
Cincinnati
Washington
Louisville
Esri, HERE | Esri, HERE
To see remaining marks to be collected use GTT Web Map App
10km Priority Hexagons
6.7%
10 km Hexagons Done
87
Total 10km Hexagons
1,292
10km Priority A Remaining
1,019
10km Priority B Remaining
186
10km Mark Charts
2km Mark Charts
10km Completed by State
State
NY
86
88
Hexagons
10km Hexagons Completed
3
13
6
2
35
8
20
2014
2016
2018
2020
Years
10km Priority List Completed
Months
10km Group
2km Group

geodesy.noaa.gov



NGS Coordinate Conversion and Transformation Tool (NCAT)

Transformed Coordinate

Input Coordinate		Output Coordinate		Total Change + Uncertainty	
Latitude	N42° 39′ 14.98295″ N423914.98295 42.6541619303	Latitude	N42° 39′ 14.98316″ N423914.98316 42.6541619882	Latitude	0.00021″ ±0.000013″ (0.006 m ±0.0004 m)*
Longitude	E286° 14′ 55.60547″ W0734504.39453 -73.7512207031	Longitude	E286° 14′ 55.60477″ W0734504.39523 -73.7512208968	Longitude	-0.00070″ ±0.000016″ (-0.016 m ±0.0004 m)*
Ellipsoid Height (m)	Not given	Ellipsoid Height (m)	Not given	Ellipsoid Height	Not given
Orthometric Height (m)	100.000	Orthometric Height (m)	99.770	Orthometric Height	-0.230 m ±0.011 m
Reference Frame	NAD83(2011)	Reference Frame	NAD83(NSRS2007)		
Geopotential Datum	NGVD29	Geopotential Datum	NAVD88		

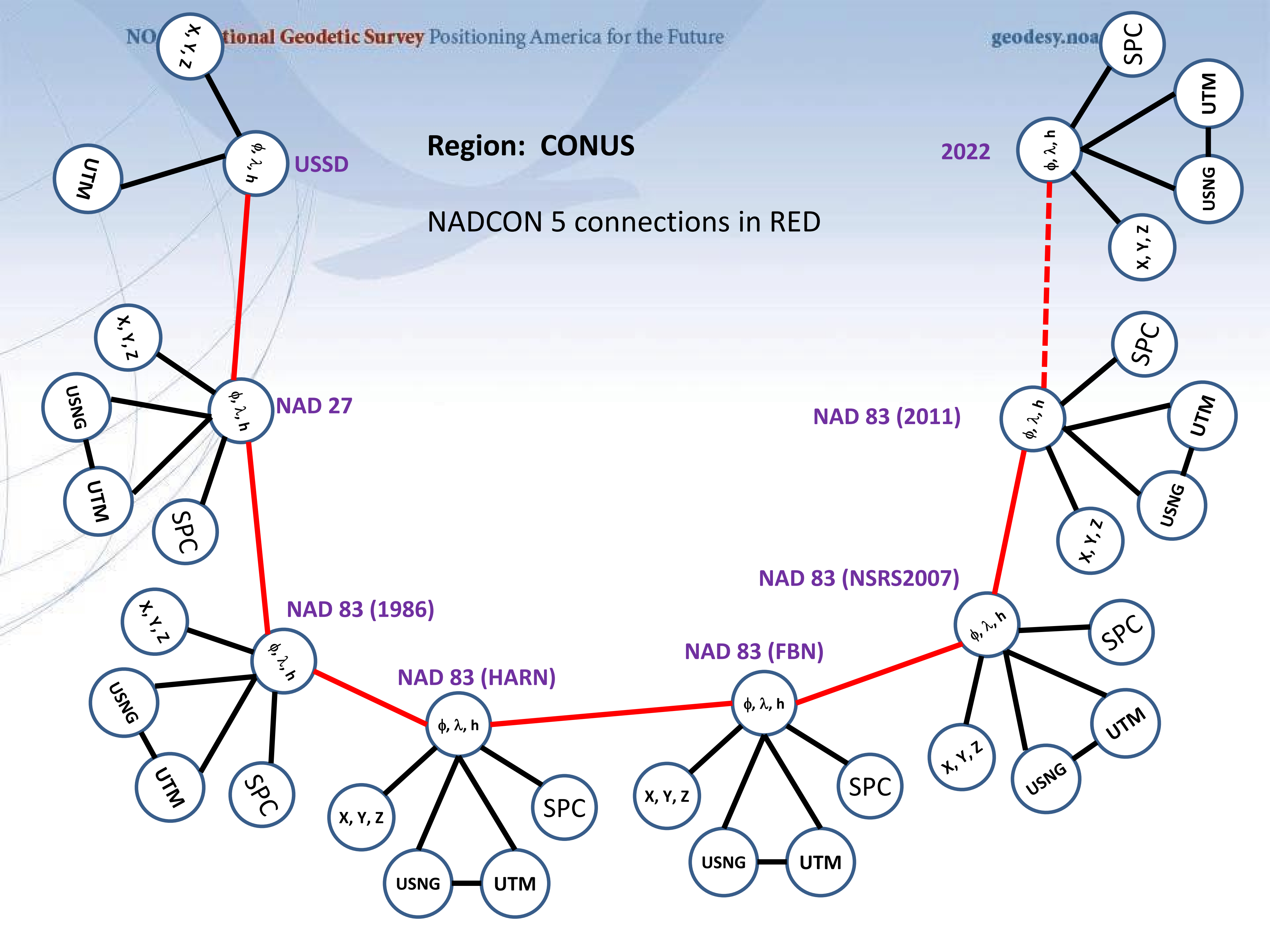
*Approximate value to aid interpretation and not an actual distance. See TM NOS NGS 82 for more details.

Converted Coordinate

Reference Frame:NAD83(NSRS2007)

Lat-Lon-Height		SPC		UTM/USNG		XYZ (m)	
Latitude	N42° 39′ 14.98316″ N423914.98316 42.6541619882	Zone	NY E-3101	Zone	18	X	N/A
Longitude	E286° 14′ 55.60477″ W0734504.39523 -73.7512208968	Northing	424,528.676 (m) 1,392,807.830 (usft) 1,392,810.616 (ift)	Northing (m)	4,723,167.088	Y	N/A
Ellipsoid Height (m)	Not given	Easting	211,391.489 (m) 693,540.245 (usft) 693,541.632 (ift)	Easting (m)	602,355.598	Z	N/A
		Convergence (dms)	00 30 26.52	Convergence (dms)	00 50 46.36		
		Scale factor	0.99994635	Scale factor	0.99972889		
		Combined factor	N/A	Combined factor	N/A		
				USNG	18TXN0235523167		

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


NO tional Geodetic Survey Positioning America for the Future
geodesy.noa
Region: CONUS
NADCON 5 connections in RED
USSD
NAD 27
NAD 83 (1986)
NAD 83 (HARN)
NAD 83 (FBN)
NAD 83 (NSRS2007)
NAD 83 (2011)
2022
ϕ, λ, h
X, Y, Z
UTM
USNG
SPC

Questions?

Dan Martin
Northeast Regional Geodetic Advisor
ME, NH, VT, MA, CT, RI, NY, NJ
Dan.martin@noaa.gov
240-676-4762