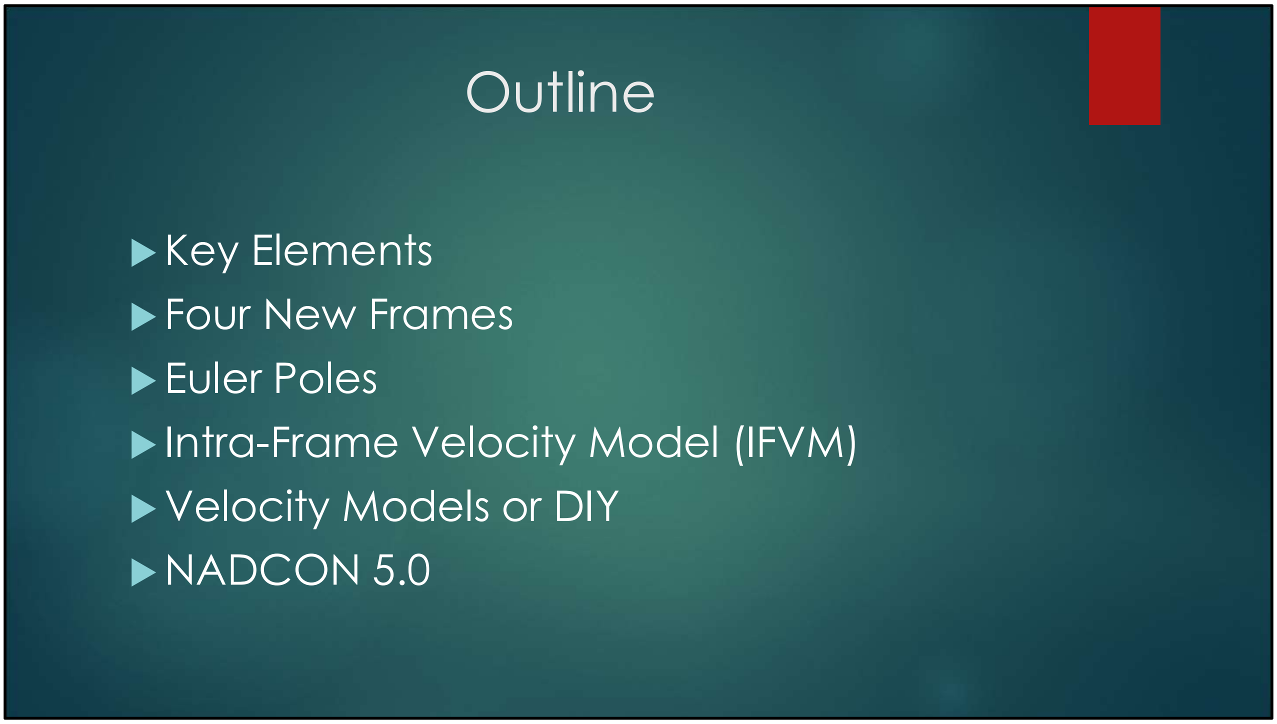
In 2022, the entire National Spatial Reference System (NSRS) will be modernized.

This class addresses the *geometric* aspects of the NSRS.

<CLICK>



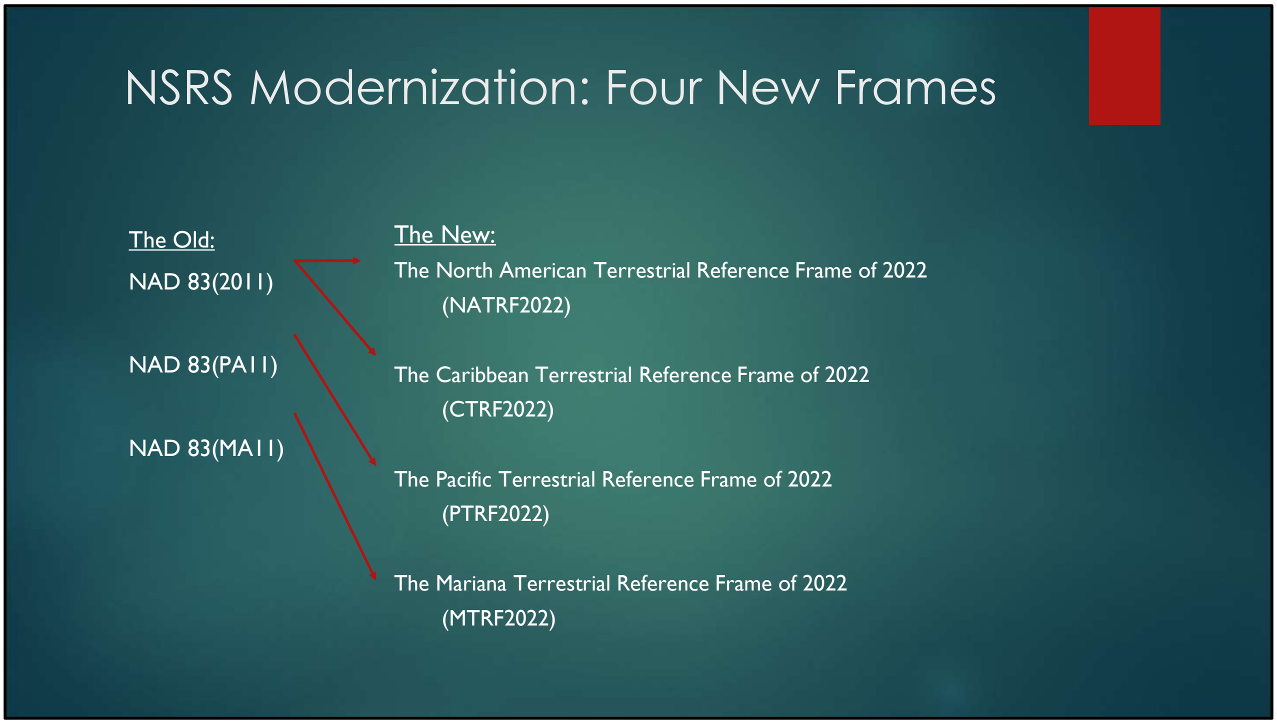
2022 is coming.

We will be discussing the Key Elements, The Reference Frames, the Euler poles, NEV or IFV, Velocity models, and NADCON 5.0.

<CLICK>

Key Elements

- Will be tied to most recent ITRF (2020?)
  - Epoch date TBD – likely 2020.0
  - Four Frames: North America, Pacific, Caribbean, and Mariana
- At epoch date, all frames identical to ITRF
- Then each frame rotates about an Euler pole
- Velocity models describe motion in frame
- Access to the four frames via OPUS tool

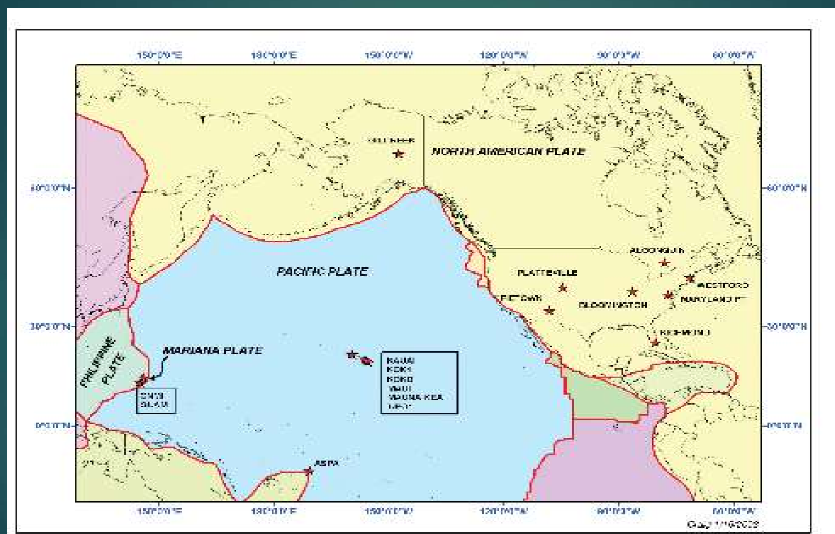


The NSRS currently contains three reference frames (historically “horizontal datums”), known as NAD 83(2011), NAD 83(PA11) and NAD 83(MA11) which are used to define the geodetic latitudes, geodetic longitudes and ellipsoid heights of all points in the USA.

These three frames will be replaced with four new reference frames, called:

North American Terrestrial Reference Frame of 2022 (NATRF2022)
Pacific Terrestrial Reference Frame of 2022 (PTRF2022)
Caribbean Terrestrial Reference Frame of 2022 (CTRF2022)
Mariana Terrestrial Reference Frame of 2022 (MTRF2022)

Four Frames/Plates in 2022



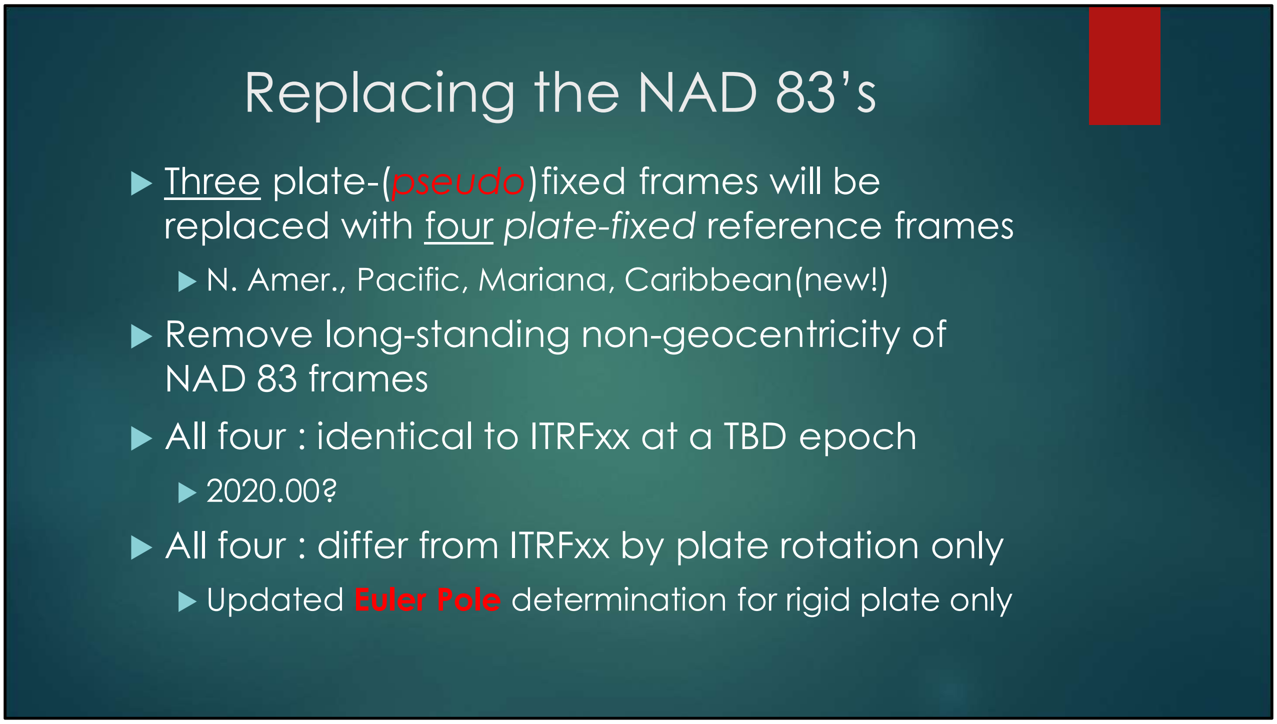
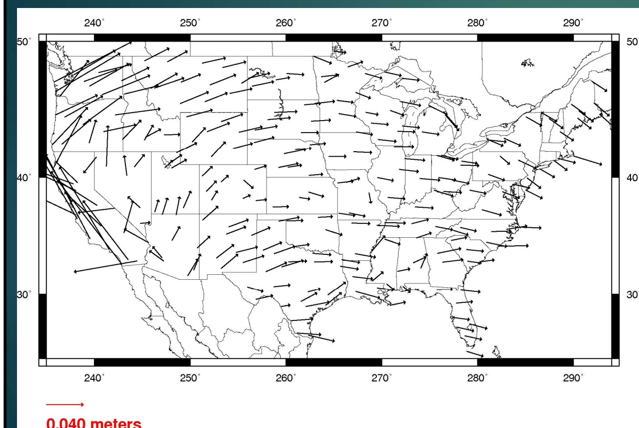

Replacing the NAD 83's
Three plate-(pseudo)fixed frames will be replaced with four plate-fixed reference frames
N. Amer., Pacific, Mariana, Caribbean(new!)
Remove long-standing non-geocentricity of NAD 83 frames
All four : identical to ITRFxx at a TBD epoch
2020.00?
All four : differ from ITRFxx by plate rotation only
Updated Euler Pole determination for rigid plate only

Plate-(pseudo)fixed frames

NAD 83(2011) minus NAD 83(NSRS2007)



NAD 83(NSRS2007)
- Epoch **2002.0**

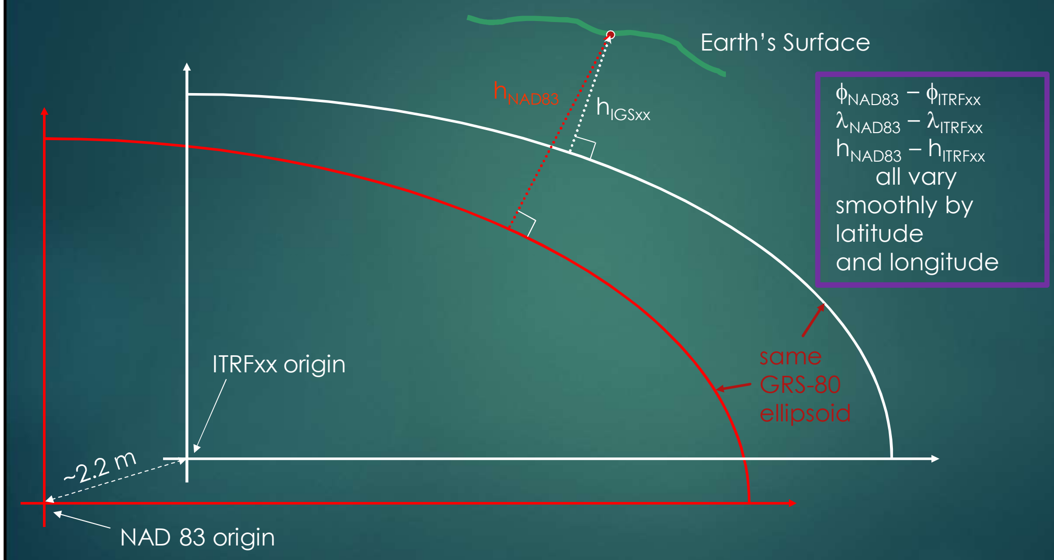
NAD 83(2011)
- Epoch **2010.0**

If NAD 83 were truly "plate fixed" then <u>an 8 year epoch change would not yield the systematic plate rotation seen here</u>.

(*)TRF2022 will determine a new Euler Pole rotation for each of the 4 plates.

(*)=NA, C, T or P

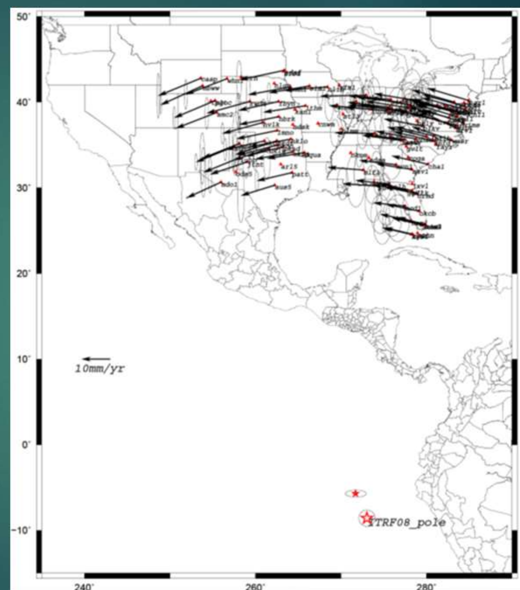
NAD 83's non-geocentricity



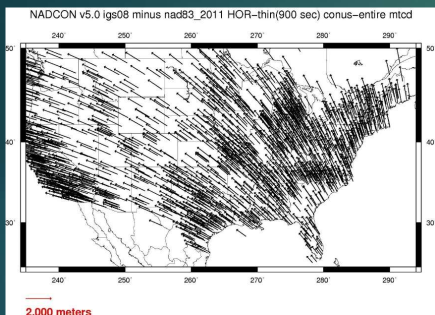
Each frame will
get 3 parameters

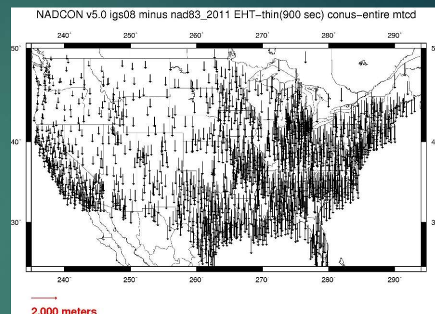
- Euler Pole Latitude
- Euler Pole Longitude
- Rotation rate (rad/yr)

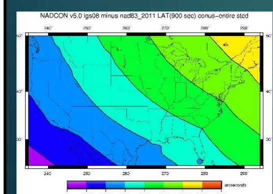
Used to compute
time-dependent TRF2022
coordinates from time-dependent
ITRF coordinates.

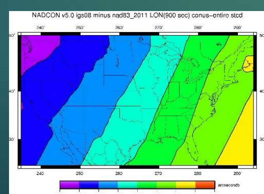


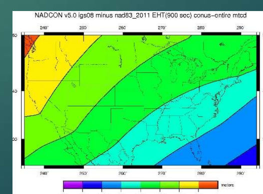
Fixed-Epoch Transformation NAD 83 to "2022"



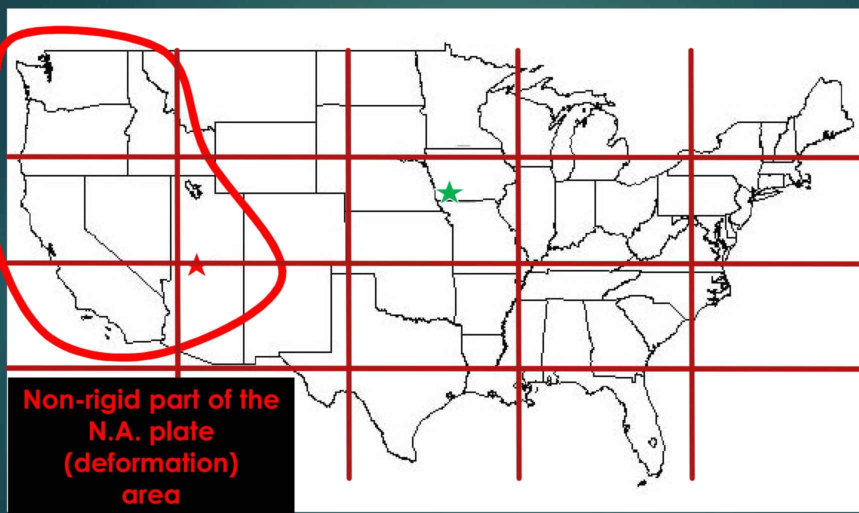


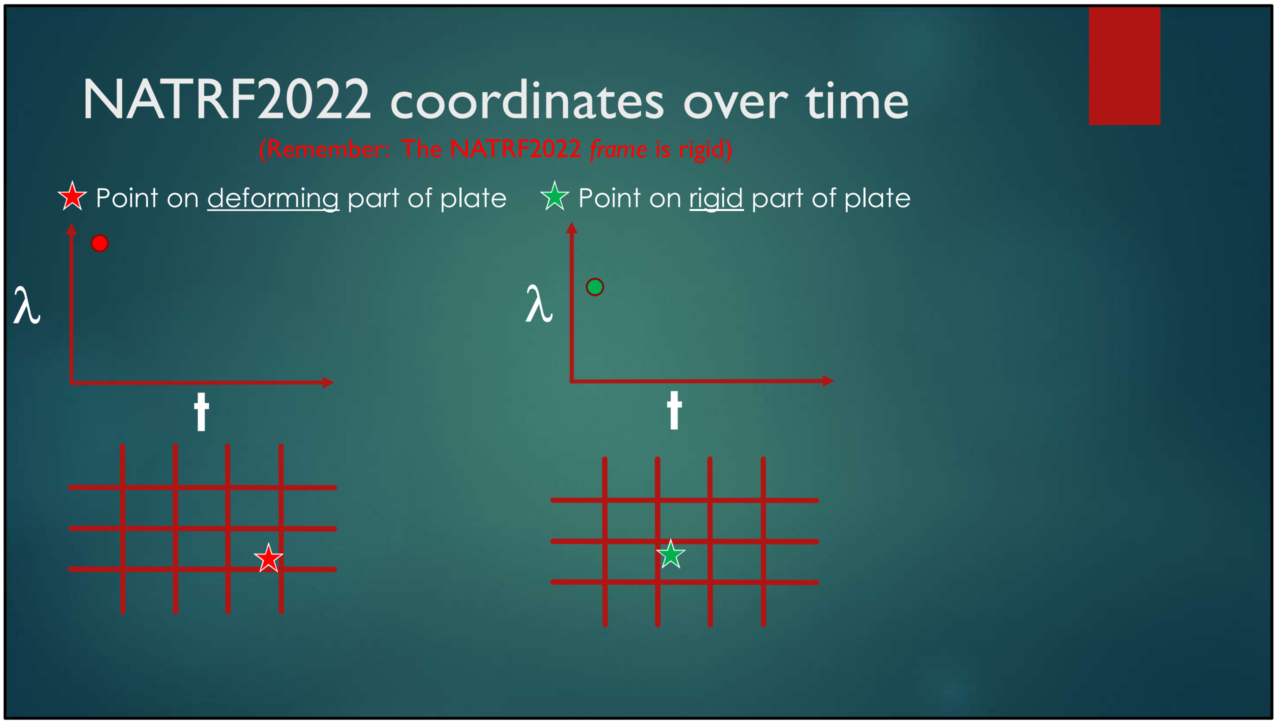


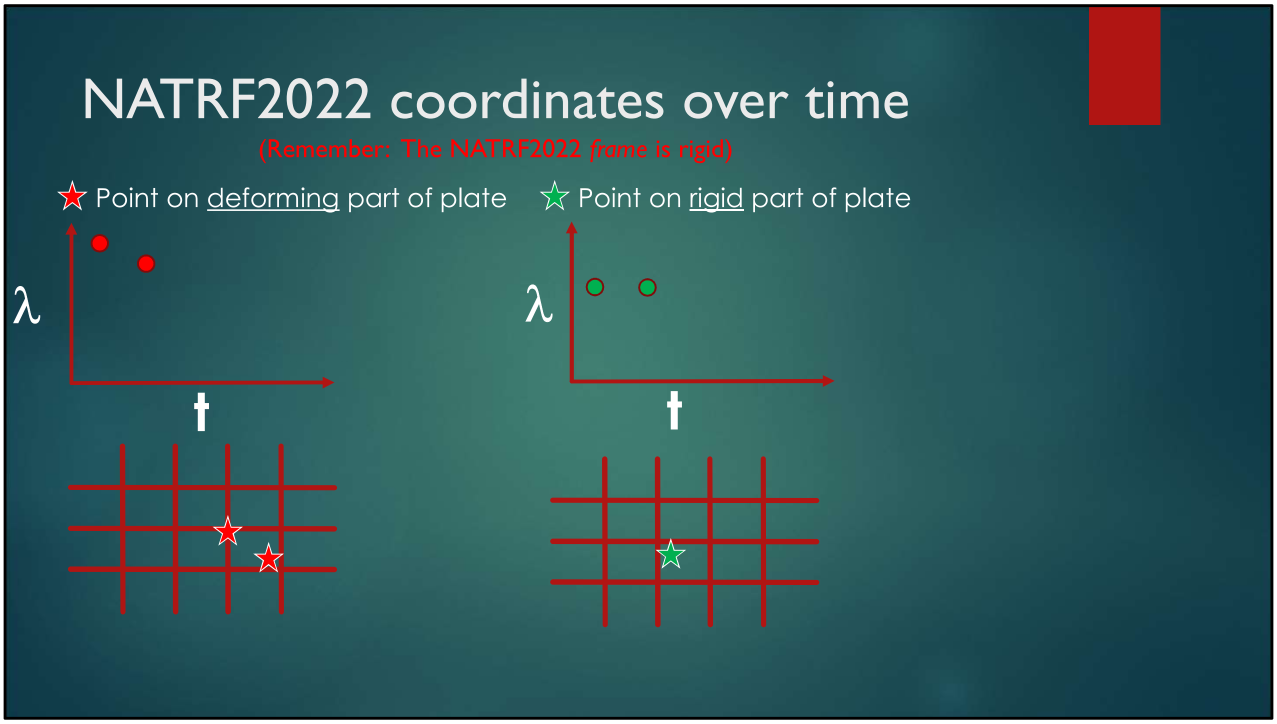


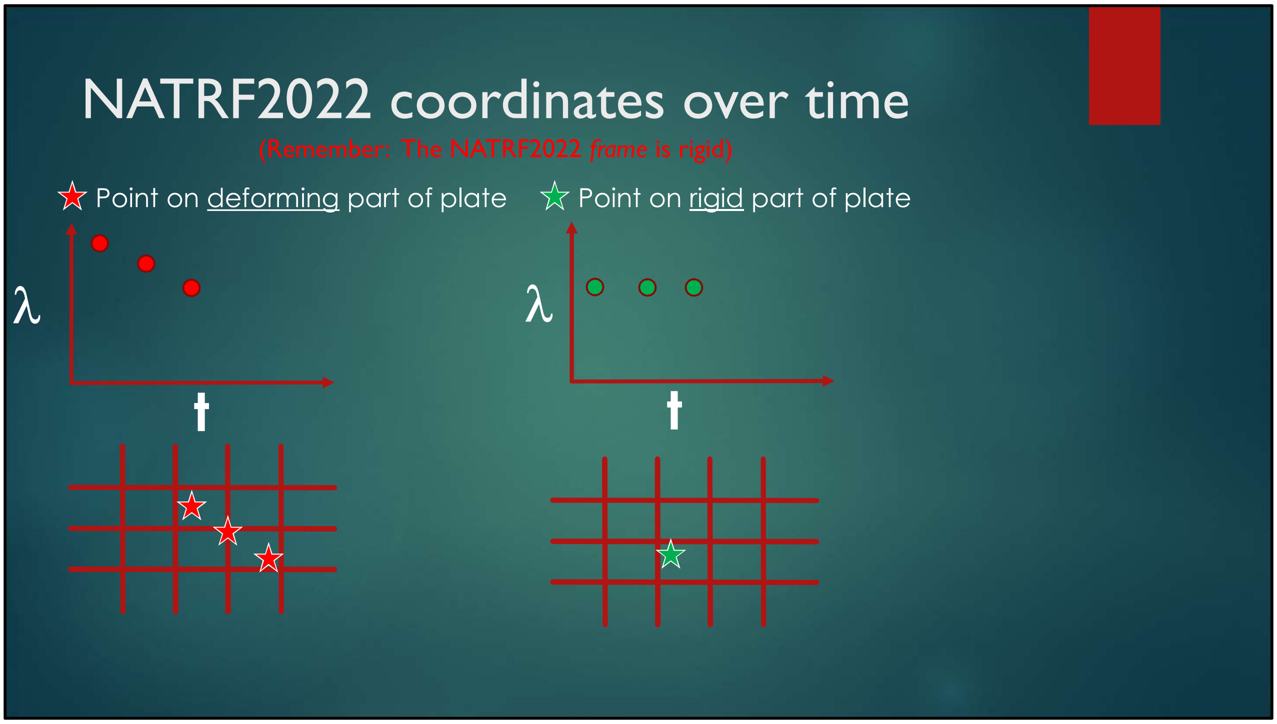


NATRF2022 frame is rigid and fixed to rigid part of the N.A. plate

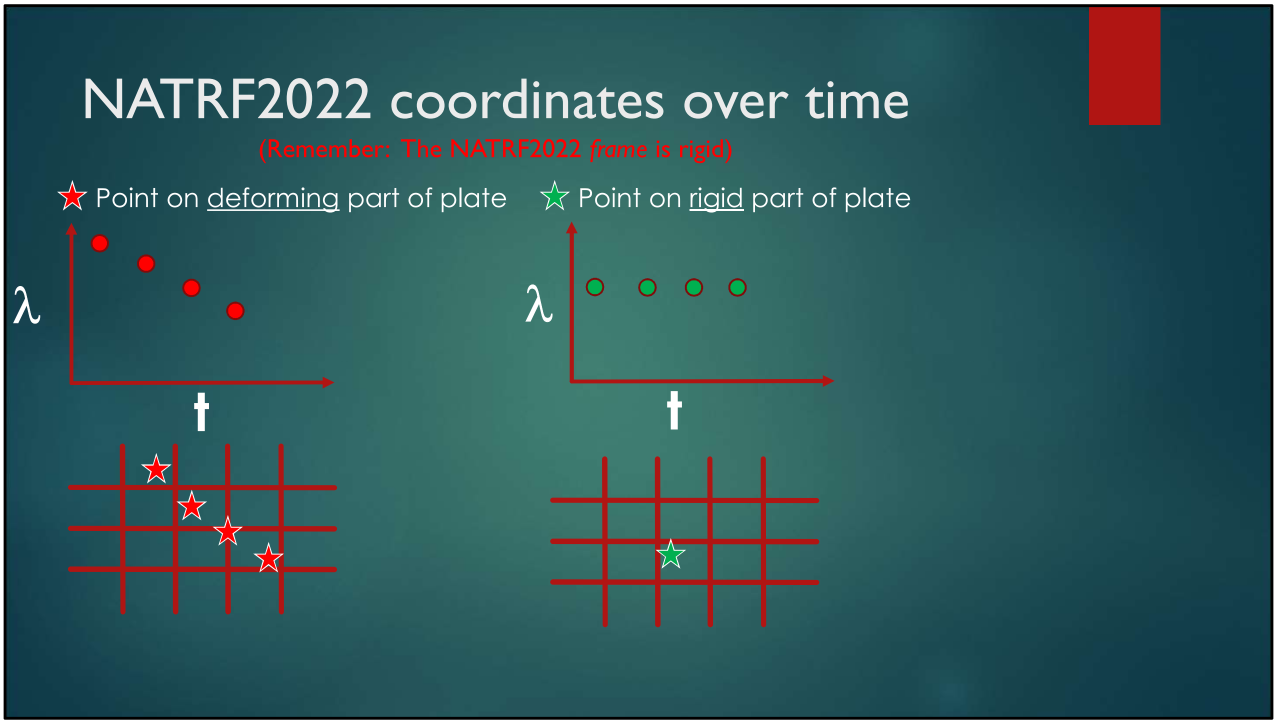



NATRF2022 coordinates over time
(Remember: The NATRF2022 frame is rigid)
Point on deforming part of plate
Point on rigid part of plate
λ
t
λ
t


NATRF2022 coordinates over time
(Remember: The NATRF2022 *frame* is rigid)
Point on deforming part of plate
Point on rigid part of plate
λ
t
λ
t



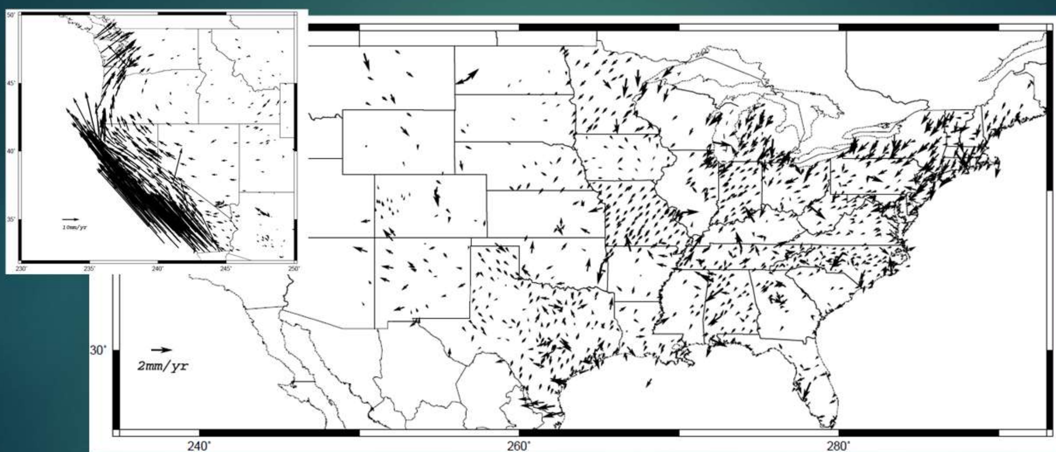
NATRF2022 coordinates over time
(Remember: The NATRF2022 frame is rigid)
Point on deforming part of plate
Point on rigid part of plate
λ
t
λ
t


NATRF2022 coordinates over time
(Remember: The NATRF2022 frame is rigid)
Point on deforming part of plate
Point on rigid part of plate
λ
t
λ
t

NEV or IFV

- Euler poles mostly account for horizontal vel.
  - Remaining signal currently modeled by HTDP
  - HTDP complicated to maintain and only horizontal
- So if not HTDP, then what?
  - A TBD velocity model needed for horizontal **and** vertical motions (e.g. 3D)
  - Non-Eulerian Velocity (NEV) vs. Intra-Frame Velocity (IFV)
- Simplest solution is to grid CORS velocities

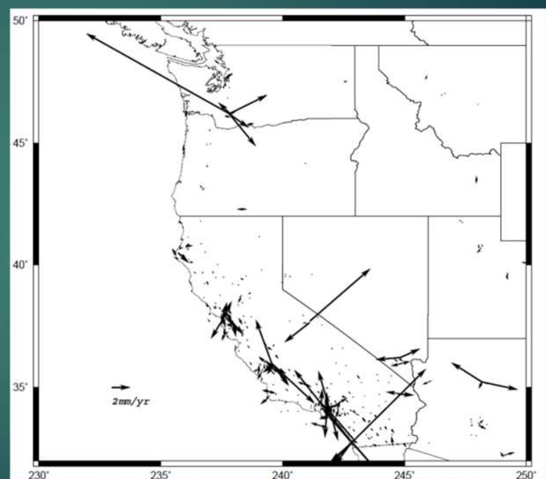
Horizontal velocities after Repro1



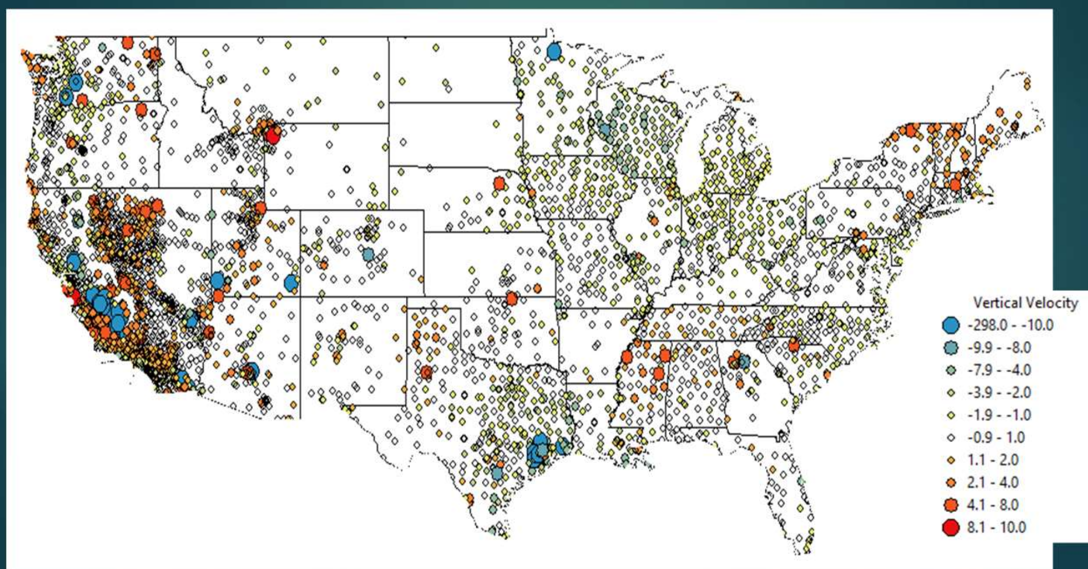
Note scale difference between West (10 mm/yr) and east (2 mm/yr)

Residual Horizontal Velocities
CONUS – gridded CORS

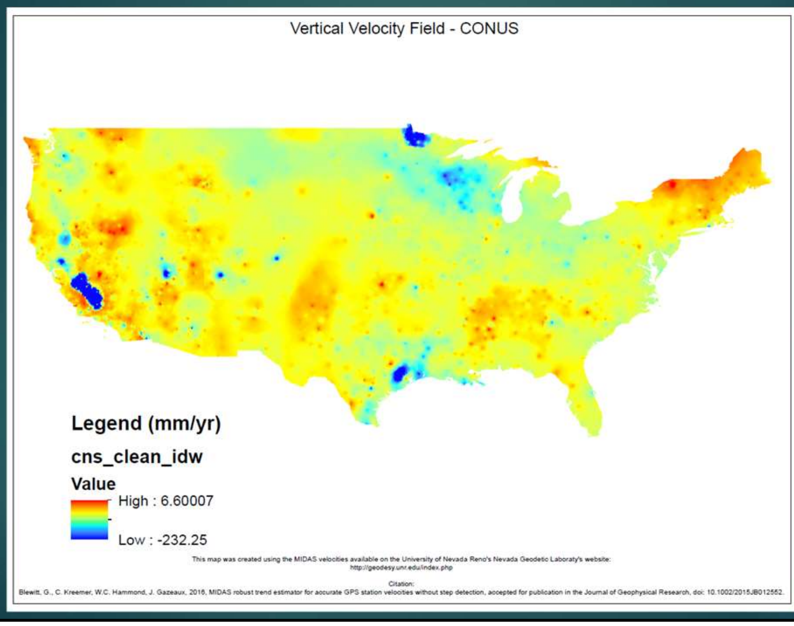
- Eastern CONUS will largely be resolved
- Western CONUS has some anomalies



CORS Implied Vertical Velocities - Control

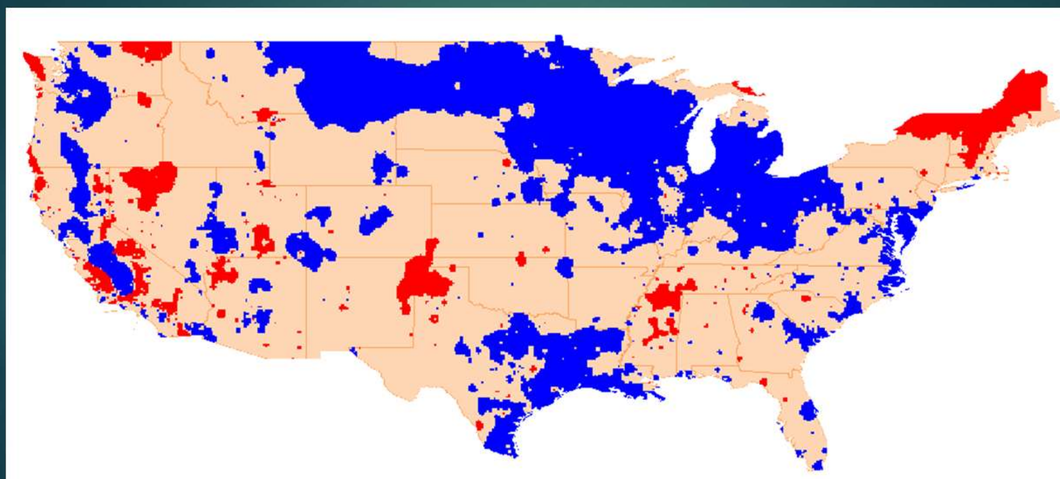


CORS Implied Vertical Velocities – Heat Map



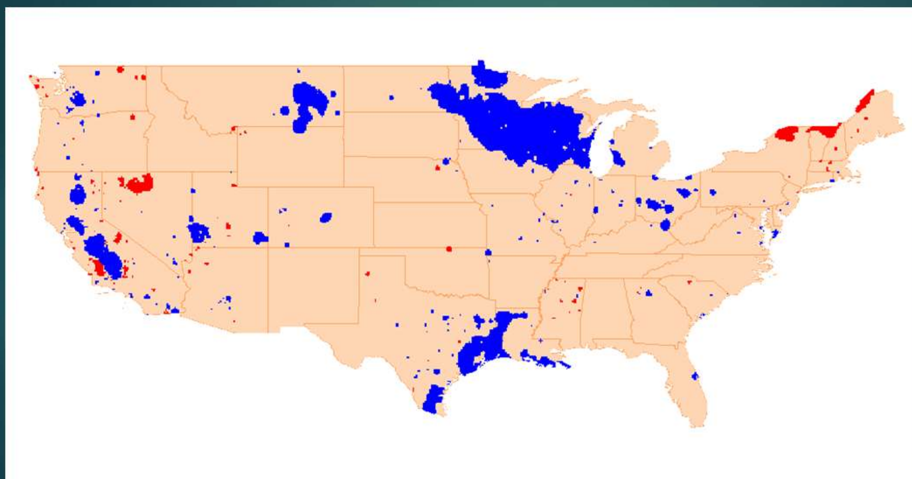
CONUS with 1+ mm/yr

Red is uplift, Blue is subsidence



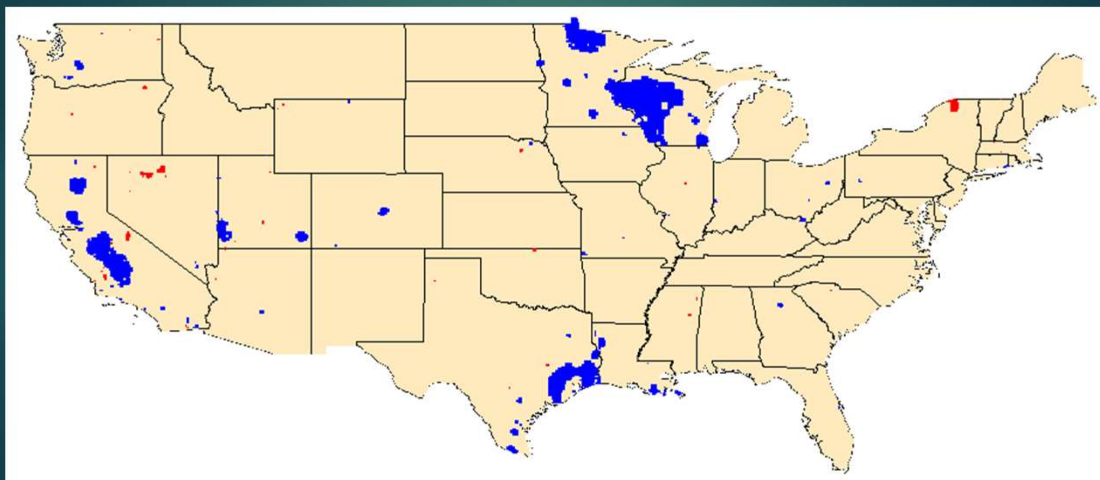
CONUS with 2+ mm/yr

Red is uplift, Blue is subsidence



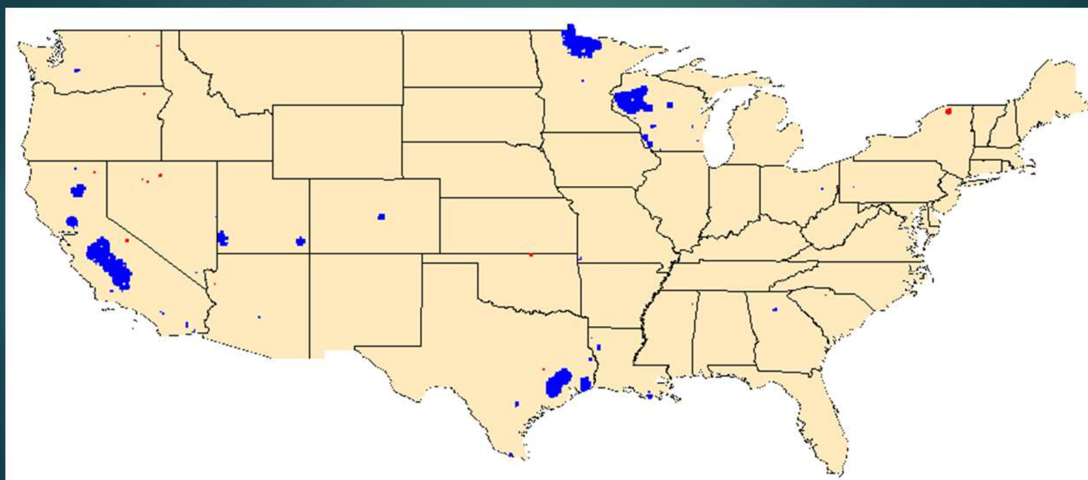
CONUS with 3+ mm/yr

Red is uplift, Blue is subsidence

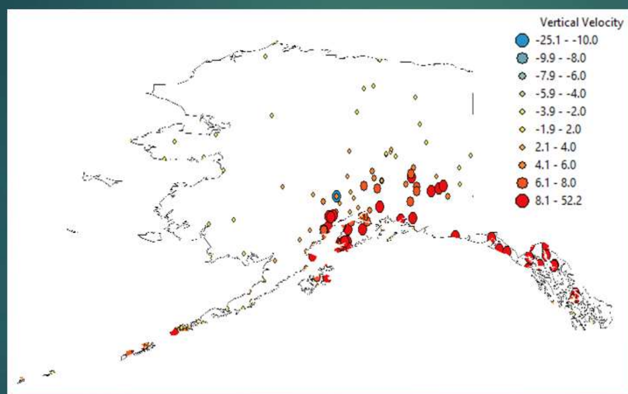


CONUS with 4+ mm/yr

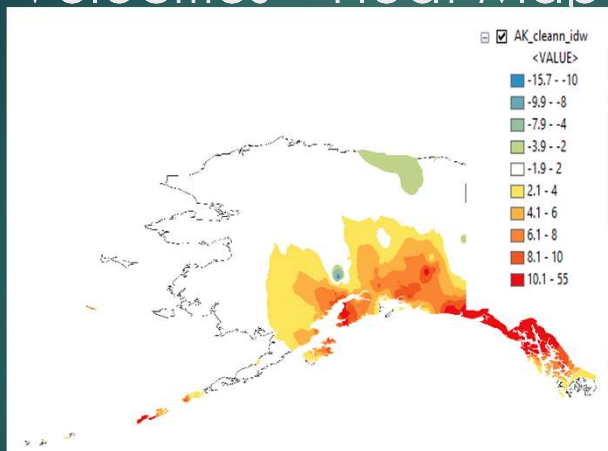
Red is uplift, Blue is subsidence



AK CORS Implied Vertical Velocities – Control



AK CORS Implied Vertical Velocities – Heat Map



How to use this information?

- Assuming CORS spacing is sufficient – grid
  - Yields horizontal (NEV & GIA) plus vertical signal
- Vertical important for orthometric heights:

  $H^t = (h^{t0} + (t-t_0)*\mathbf{dh/dt}) - (N^{t0} + (t-t_0)*dN/dt)$
    - Where H^t is orthometric height at desired time
    - h^{t0} is ellipsoidal height at epoch (maybe 2020.0)
    - N^{t0} is geoid height at epoch
    - **dh/dt** is change in ellipsoid height over time
    - dN/dt is change in geoid height over time (GeMS)

Velocity Models or DIY

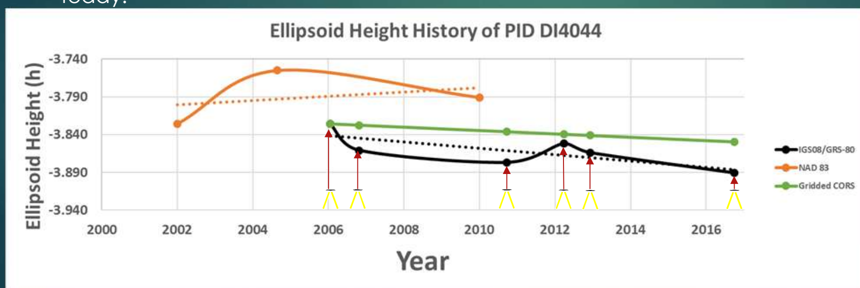
- We will investigate sufficiency of gridded CORS
- Concern is dynamic areas: horizontal & vertical
  - Will gridded CORS work in Alaska?
  - What if this isn't enough?
- Will look at other models to evaluate
- Cost – benefit
  - What we can easily do in-house and support
  - increased complexity from outside models
- Alternatively, users can model their own …

Time-Dependencies as a service: NATRF2022 and actual survey epochs

NAD 83 forcibly combined data spanning many years (using HTDP with no vertical modeling) to compute and find *one* height at *one* epoch.

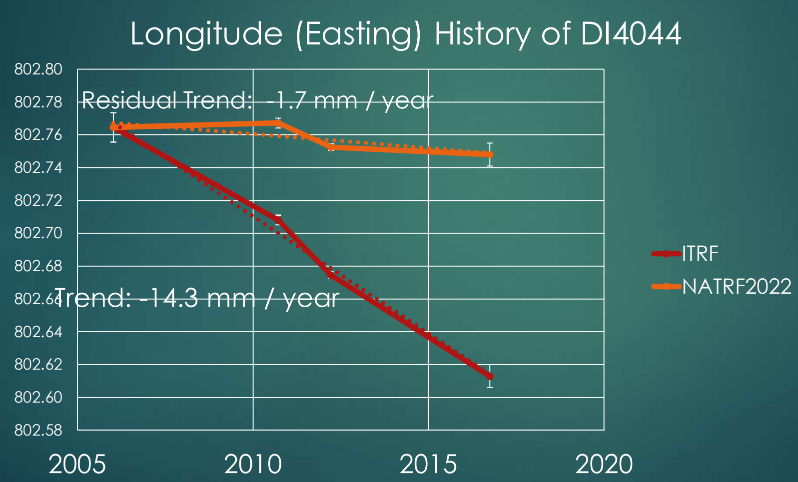
NATRF2022 will compute coordinates at survey epoch to show actual motion.

Even gridding surrounding CORS yields better subsidence rates than you have today.



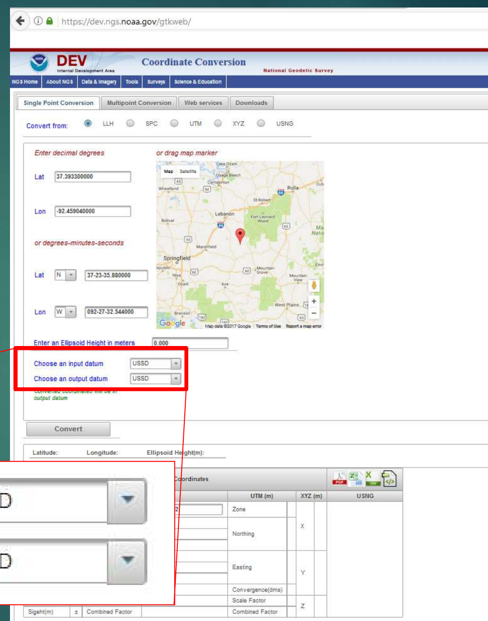
NAD 83 best estimate of dh/dt: +2.8 mm / year
NATRF2022 best estimate of dh/dt: -4.2 mm / year
CORS best estimate of dh/dt: -2.2 mm / year

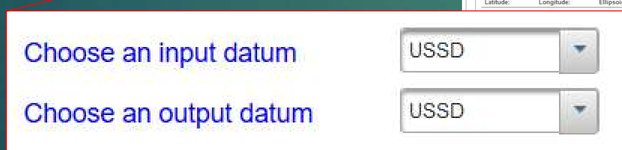
Time Dependencies as a service: Intra-plate motions



The new Geodetic Toolkit with NADCON 5.0

https://dev.ngs.noaa.gov/gtkweb/

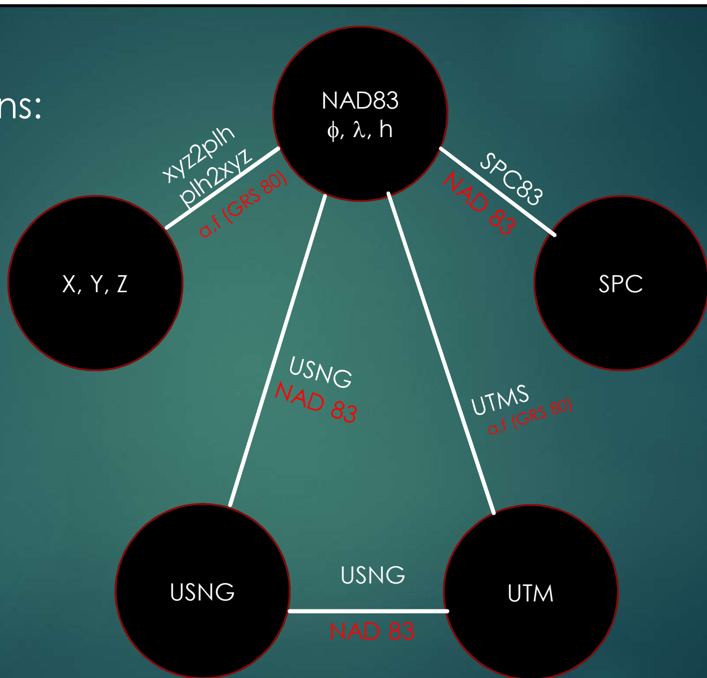


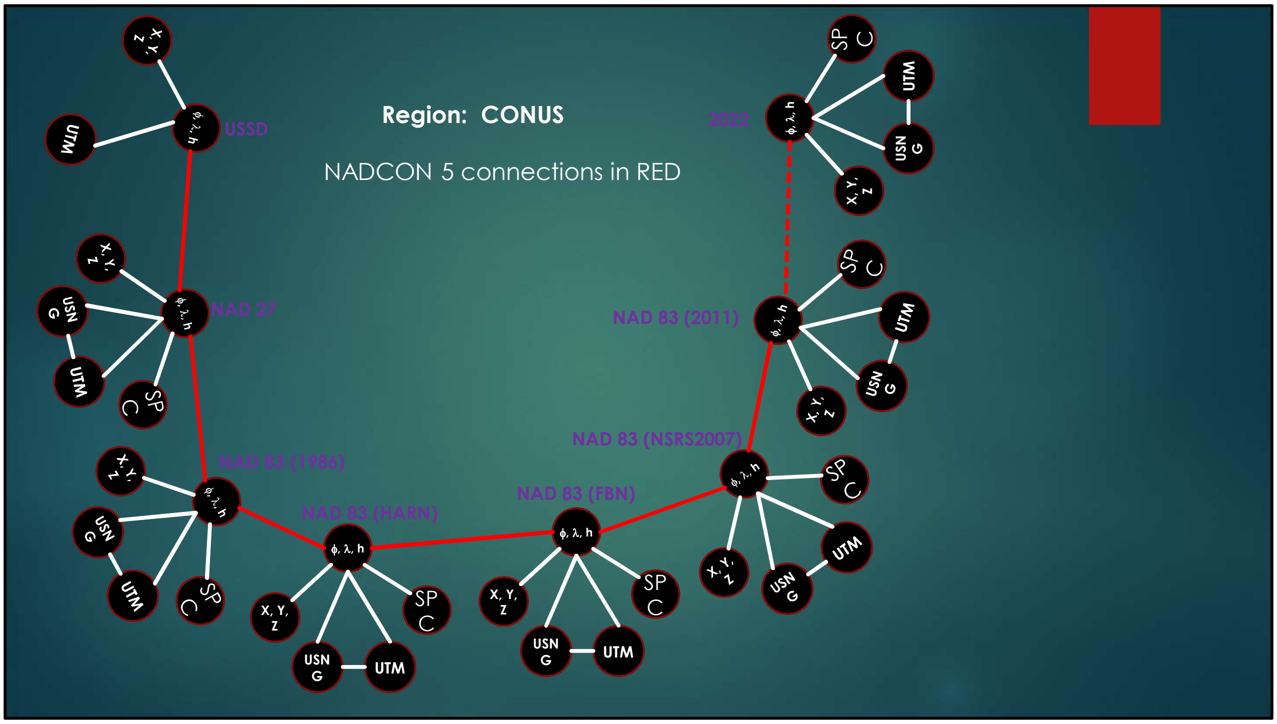


NAD 83 (2011)

Allowable Regions:

- CONUS
- Alaska
- Hawaii
- PR/VI
- AS
- Guam/CNMI
- St. Paul
- St. George
- St. Lawrence




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
USNG
UTM
SPC

QUESTIONS