FIG WORKING WEEK 2019
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"Geospatial Information for a Smarter Life and Environmental Resilience"

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Abstract TS01E
(10002)

Practical considerations for determining Euler Pole Parameters for the terrestrial reference frames in the United States

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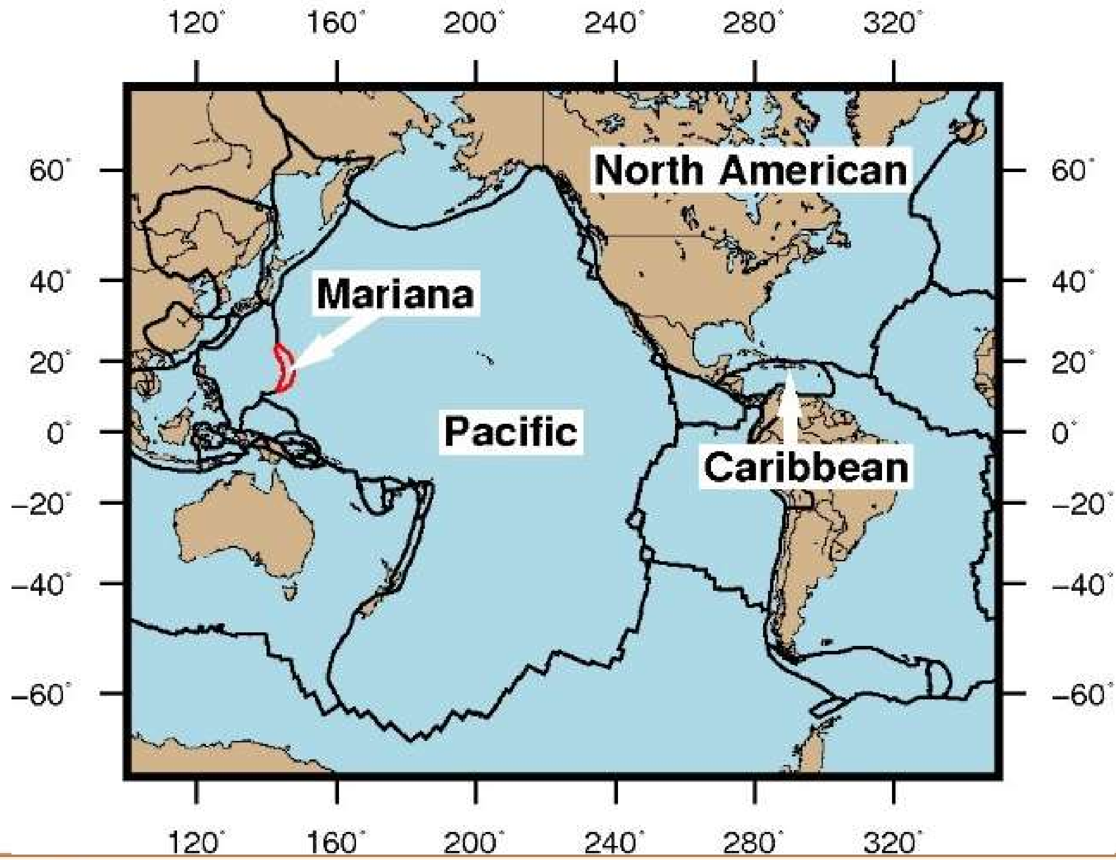
Outline

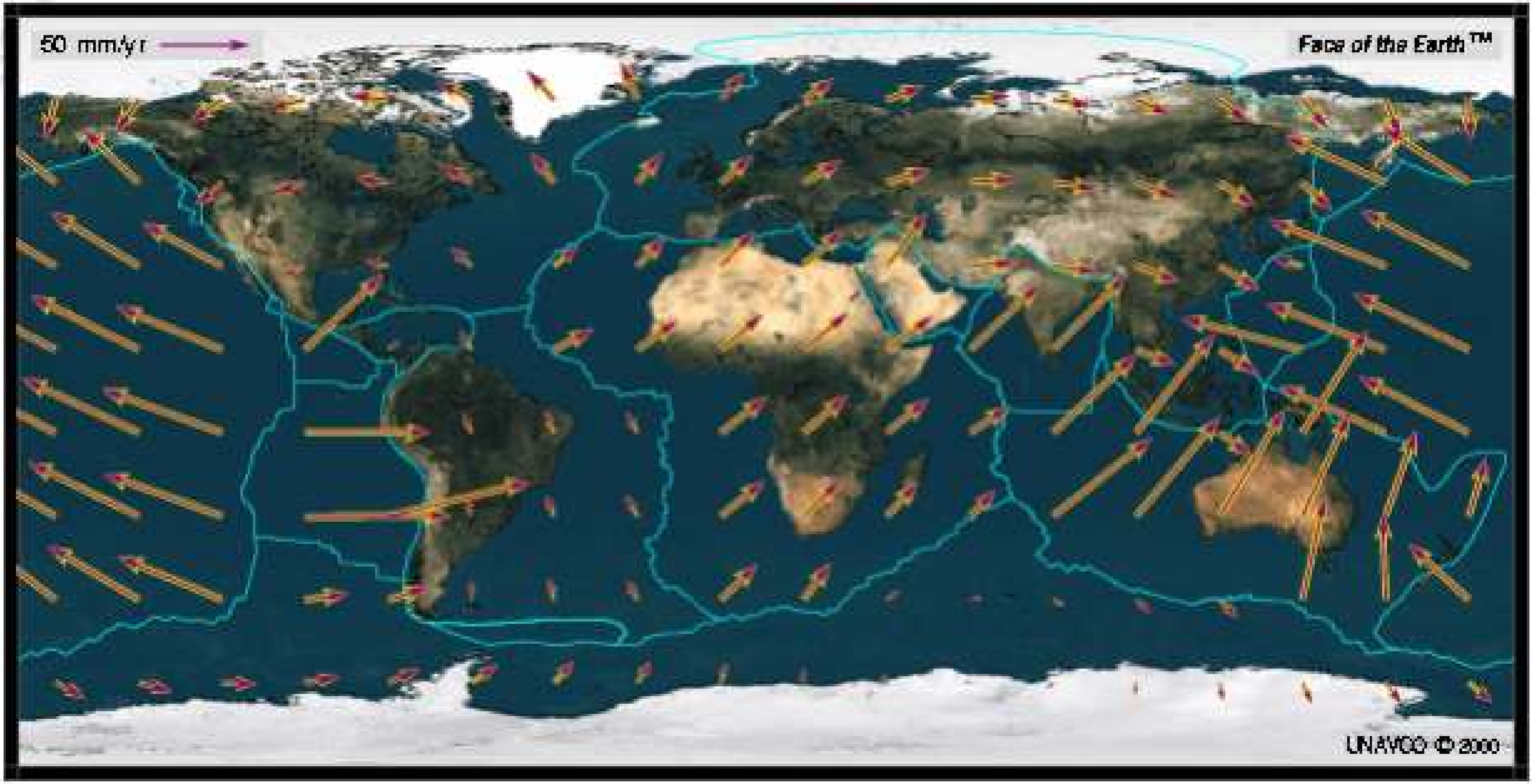
- 4 new plate-fixed terrestrial reference frames planned for the United States
- Euler pole parameter fundamentals
- Data availability
- Challenges for each of the 4 plates

New Geometric Terrestrial Reference Frames in 2022

- NATRF2022 – North American Terrestrial Reference Frame of 2022
- PATRF2022 – Pacific Terrestrial Reference Frame of 2022
- CATRF2022 – Caribbean Terrestrial Reference Frame of 2022
- MATRF2022 – Mariana Terrestrial Reference Frame of 2022

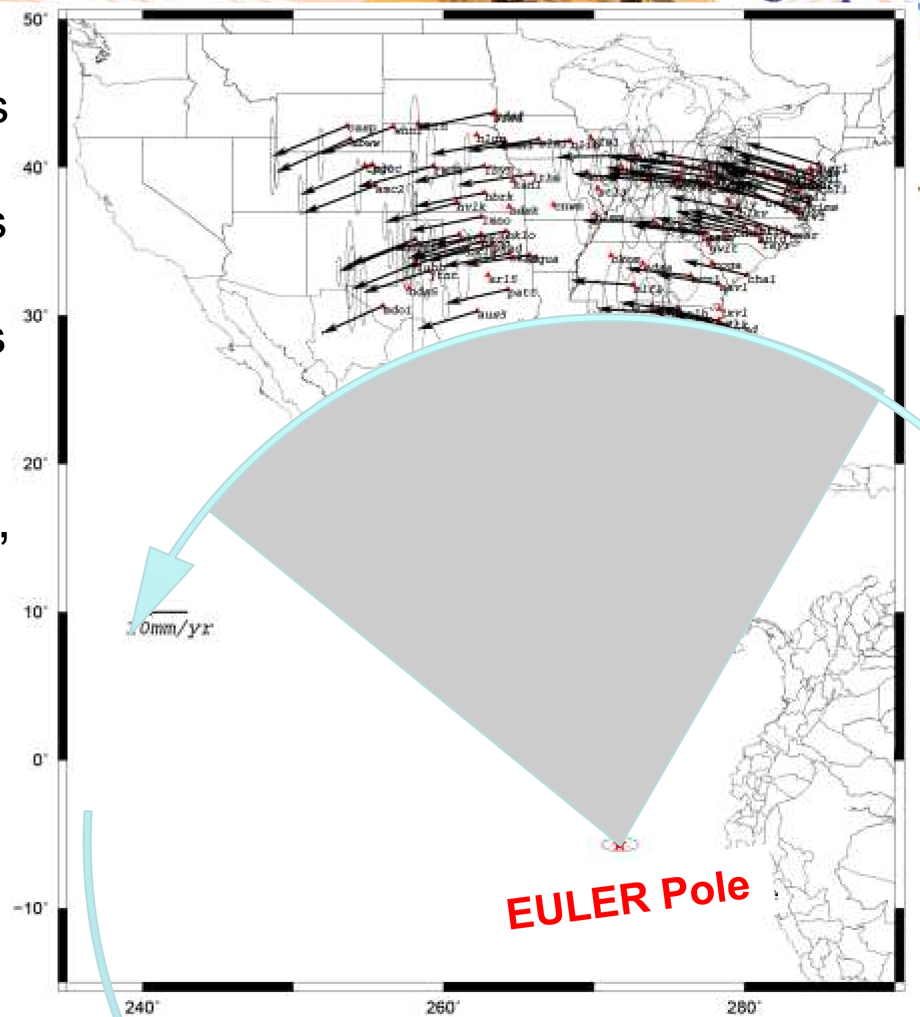
- EPP2022 – Euler Pole Parameters 2022 will define the rotations between ITRF2014 and the four *TRF2022 frames


120°
160°
200°
240°
280°
320°
60°
40°
20°
0°
−20°
−40°
−60°
North American
Mariana
Pacific
Caribbean


50 mm/yr
Face of the Earth™
UNAVCO © 2000

Each reference frame will get:

- Micro-rotational rate about ITRF2014 X axis (mas/year)
- Micro-rotational rate about ITRF2014 Y axis (mas/year)
- Micro-rotational rate about ITRF2014 Z axis (mas/year)



From which, Euler pole latitude, longitude, and rotation rate can be derived.

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

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

Data Availability

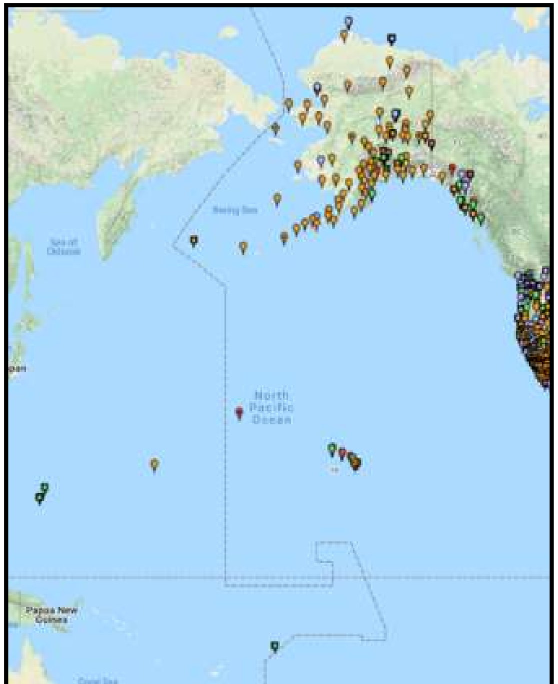
Ideally CORS sites will be used with:

- Long data time spans (several years at least) and few data gaps
- Demonstrated stability
- Located in a stable region

Non-CORS data sources include:

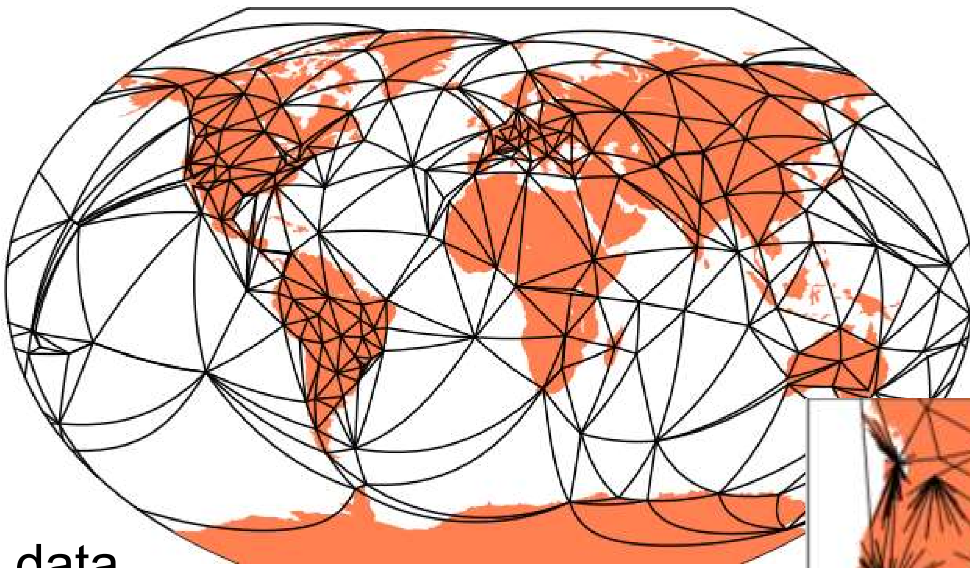
- Survey GNSS data
- Paleomagnetic data (seafloor spreading rates)
- focal mechanisms and earthquake slip vectors
- transform fault geometry
- InSAR

Continuously Operating Reference Station (CORS) Network

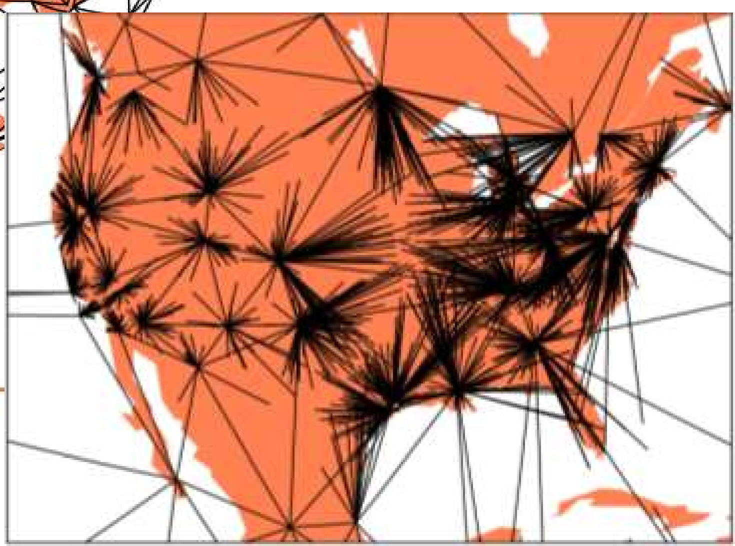


NGS Multi-year CORS Solution-2 Processing Transitioning to ITRF2014/IGS14 (@2010.00)

International Terrestrial Reference Frame
I T R F



- 1996 -2016 data
- 3050 stations
- 25 TerraBytes of data (cloud processing)



North American plate

Much of the US land mass and population is located on the North American Plate, including parts of 49 states. Determination of the EPPs for North America will be done in conjunction with IAG SC 1.3c: North American Reference Frame (NAREF).

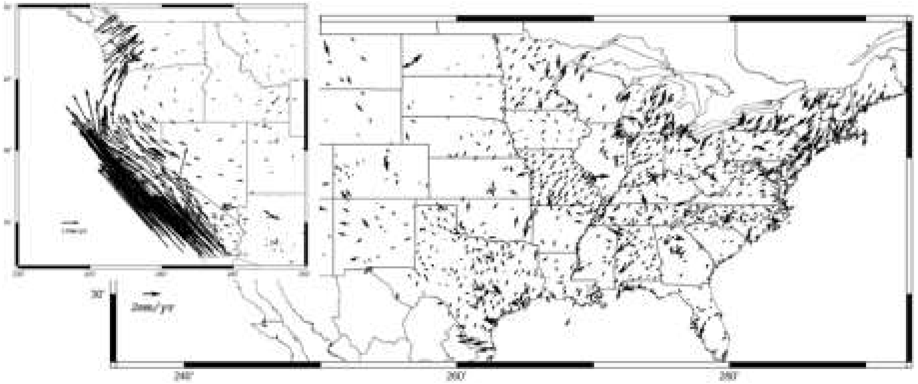
North American has:

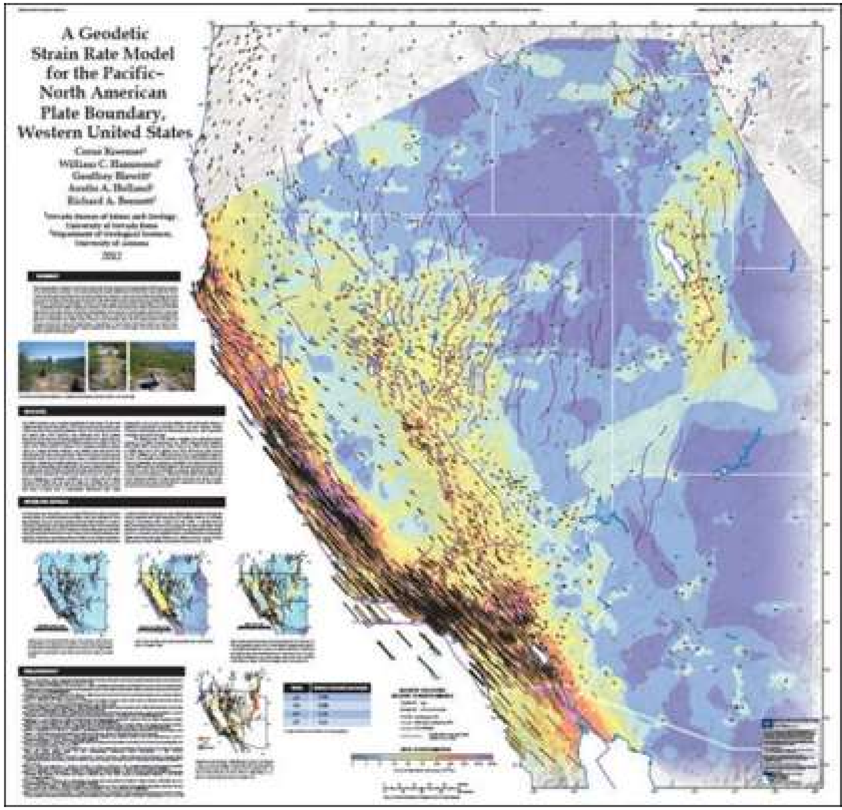
- Lots of data (>2400 CORSs)
- Lots of studies into the rigid plate motion
- Large, stable part of plate

Challenges:

- Alaska bending non-rigidly
- Plate boundary deformation west of the Rockies
- Hudson Bay uplift

Residual Velocities in CONUS

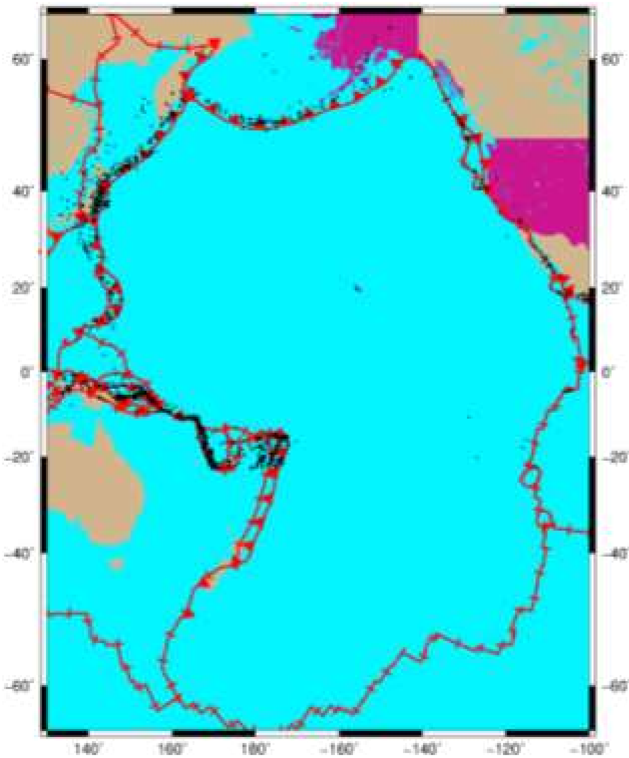




(at right) Geodetic strain rate model for the Pacific-North American plate boundary, from Nevada Geodetic Lab (http://geodesy.unr.edu/greatbasinstrain.php)

Pacific plate

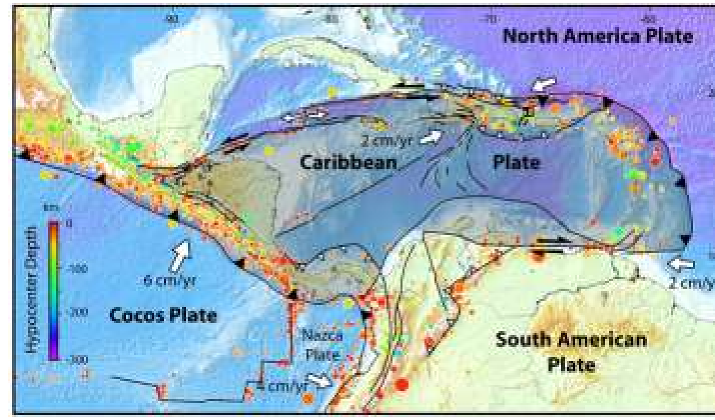
The Pacific plate is mostly oceanic. In places where it has land such as southwestern California, Hawaii, and Samoa, there are many CORSs (>100) to use for data to use to derive the EPPs. NGS will work to align PATRF with the Asia-Pacific Reference Frame (APREF), which is part of IAG SC 1.3e.



Challenges:

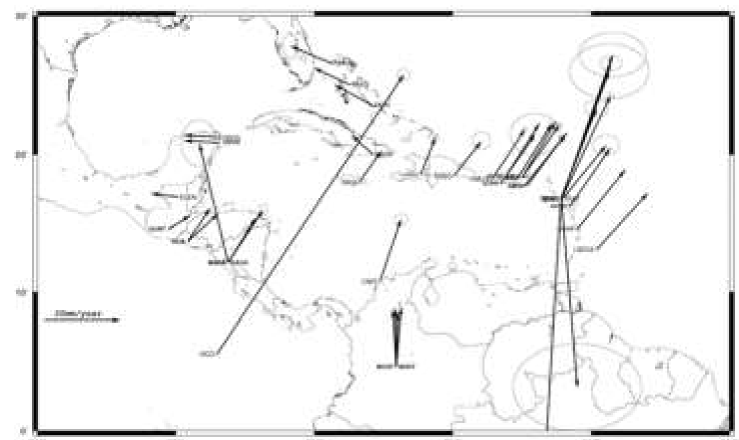
- Mostly ocean
- Many places are deformation zones (at plate boundary or on active volcanoes)

(From DeMets 2007).



Caribbean plate

Puerto Rico and the U.S. Virgin Islands are located on the Caribbean plate. NGS will work in conjunction with SIRGAS and IAG SC 1.3b to define the rotation of this plate for the NSRS.



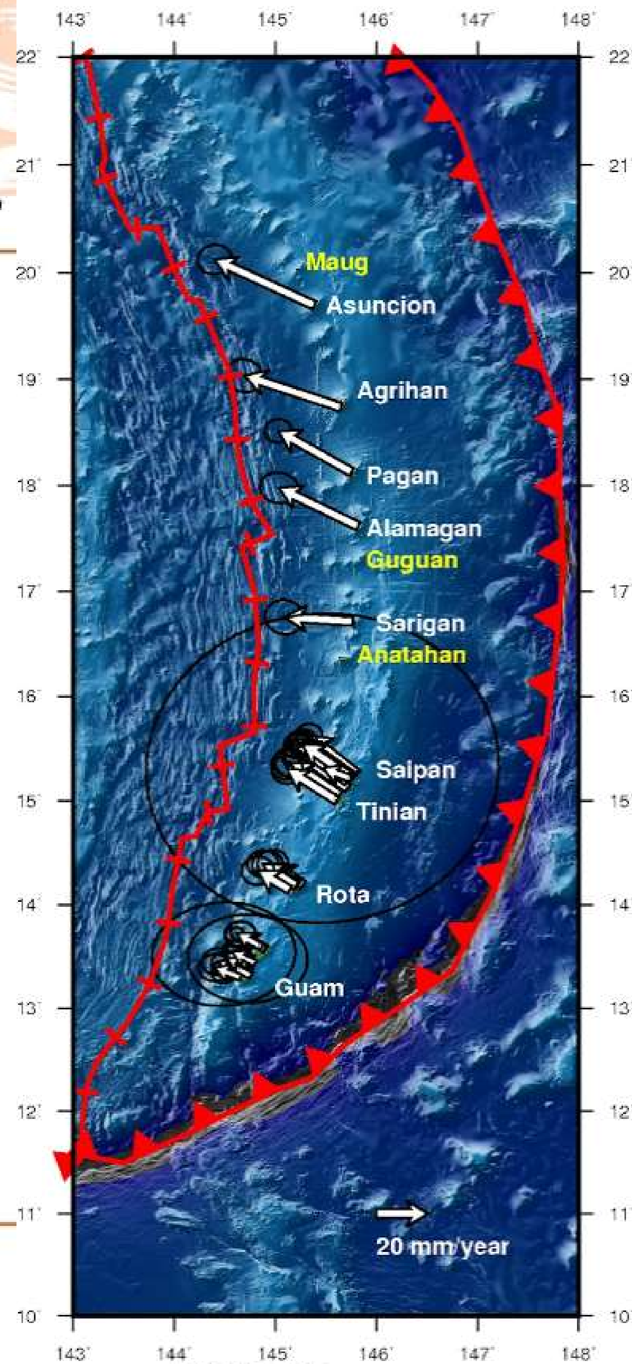
- Small plate, dense with CORSs
- Almost all land is deforming at the edge
- Plate boundary is not completely known in the north
- Data are from many different sources/networks

Mariana plate

- Contains Guam and the Commonwealth of the Northern Mariana Islands.
- Clear rotational signal in the plate.
- 2017 campaign GPS survey expedition to specifically develop a rotational model.

Challenges:

- Contaminated by deformation
- Many large (>Mw6.5) earthquakes
- Only 5 CORSs have ever operated on the plate, 1 has been non-operational for many years, 1 is non-NGS, all in the southern ⅓ of the plate.



Alpha values

Euler Pole Parameters for the North American Plate	Converts XYZ(ITRF2014,t)↔XYZ(NATRF2022,t) Part 1 of 4 of **EPP2022**	Alpha: ITRF2014 Plate Motion Model Final: IAG Working Group	ω^X : +0.024 ± 0.002 mas/year ω^Y : -0.694 ± 0.005 mas/year ω^Z : -0.063 ± 0.004 mas/year
Euler Pole Parameters for the Pacific Plate	Converts XYZ(ITRF2014,t)↔XYZ(PATRF2022,t) Part 2 of 4 of **EPP2022**	Alpha: ITRF2014 Plate Motion Model Final: IAG Working Group	ω^X : -0.409 ± 0.003 mas/year ω^Y : +1.047 ± 0.004 mas/year ω^Z : -2.169 ± 0.004 mas/year
Euler Pole Parameters for the Caribbean Plate	Converts XYZ(ITRF2014,t)↔XYZ(CATRF2022,t) Part 3 of 4 of **EPP2022**	Alpha: ITRF2008 Plate Motion Model Final: IAG Working Group	ω^X : +0.049 ± 0.201 mas/year ω^Y : -1.088 ± 0.417 mas/year ω^Z : +0.664 ± 0.146 mas/year
Euler Pole Parameters for the Mariana Plate	Converts XYZ(ITRF2014,t)↔XYZ(MATRF2022,t) Part 4 of 4 of **EPP2022**	Alpha: computations at NGS from the 2017 survey (paper pending) Final: TBD	Withheld from public release until publication of paper

Summary

- In 2022, the U.S. National Geodetic Survey will release 4 new TRFs.
- Euler pole parameters based on ITRF2014 will be determined and used to remove plate rotation in order to determine the plate-fixed frame.
- Residual motion will be compensated in an Intra-Frame Velocity Model.

Questions?

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