Update on the International Terrestrial Reference Frame (ITRF) : ITRF2014

Zuheir Altamimi

Head of the IERS ITRF Product Center

IAG Vice President

IGN, France

**E-mail:** zuheir.altamimi@ign.fr

Key Points

- **Introduction: Reference Frames for science and societal applications**

- **The UN-GGIM Initiative: a great opportunity for global geodesy**

- **ITRF2014:**
  - **Some results**
  - **GNSS Contribution**

What is a Reference Frame in practice?

- Earth fixed/centred RF: allows determination of station location/position as a function of time

- It seems simple, but … we have to deal with:
  - Relativity theory
  - The atmosphere
  - Earth rotation
  - Solid Earth and ocean tides
  - Tectonic motion
  - …

- **For improved positioning accuracy, we need a Precise Orbit Determination & clock parameters:**
  - **Model all Forces acting on the satellite**
  - **Satellite data information is crucial**
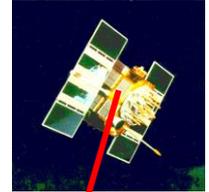
Origin, Scale & Orientation

Earth Fixed/Centred Reference Frame

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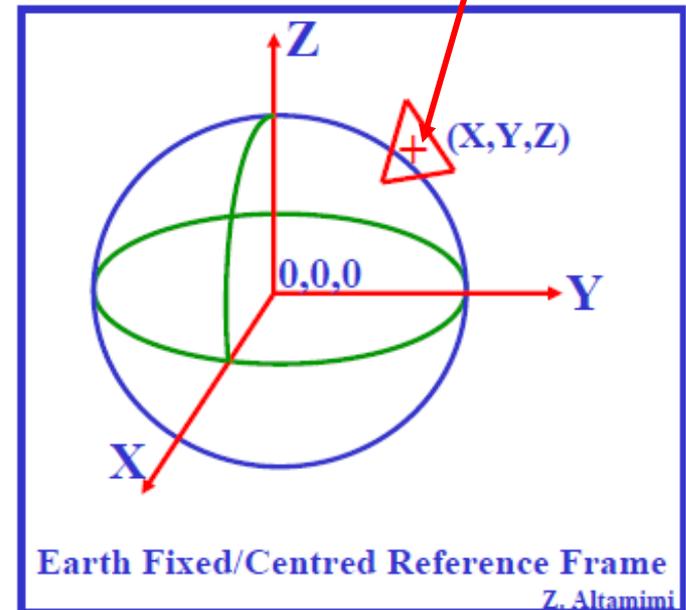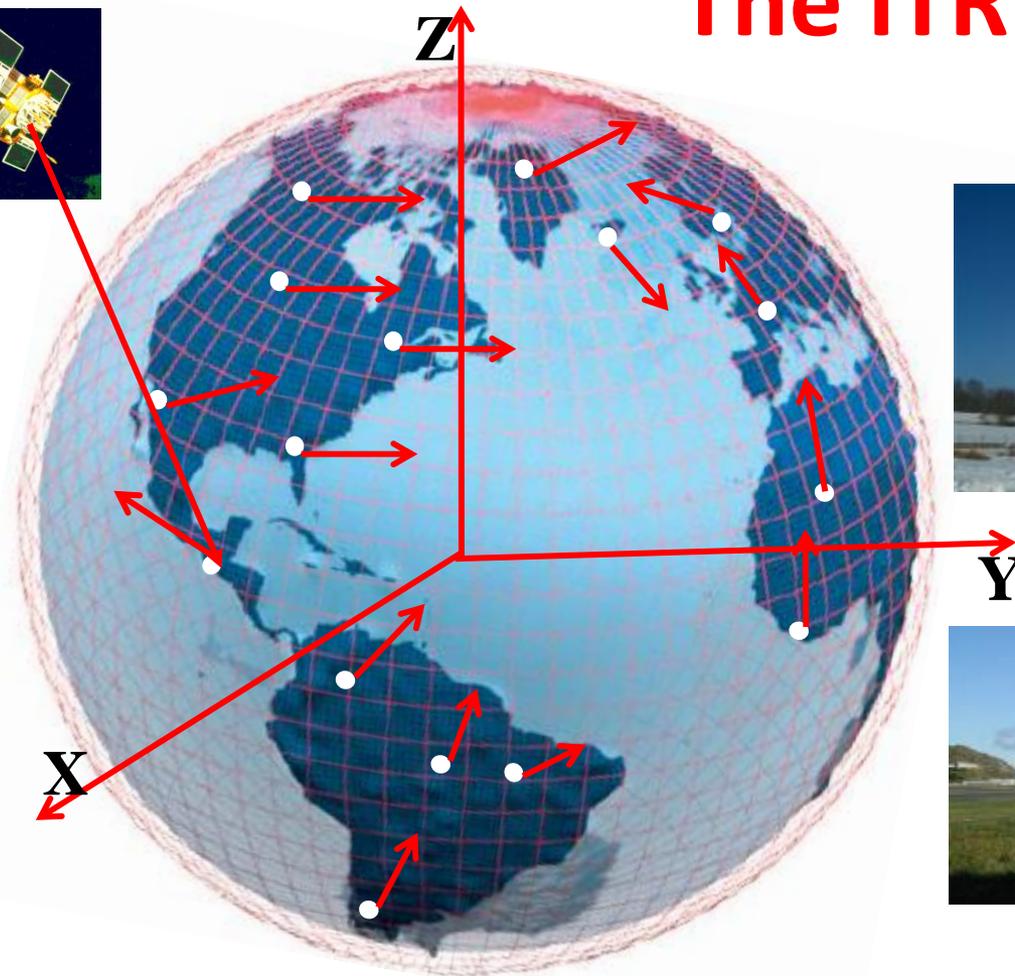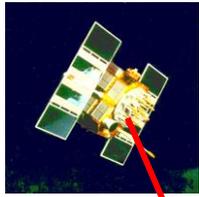
The ITRF

VLBI

SLR

GNSS

DORIS

Goal & Challenge: determine locations & deformations with an improved precision, Everywhere & Anytime on Earth, to satisfy societal and science requirements

Universal access to the ITRF through GNSS/IGS Products
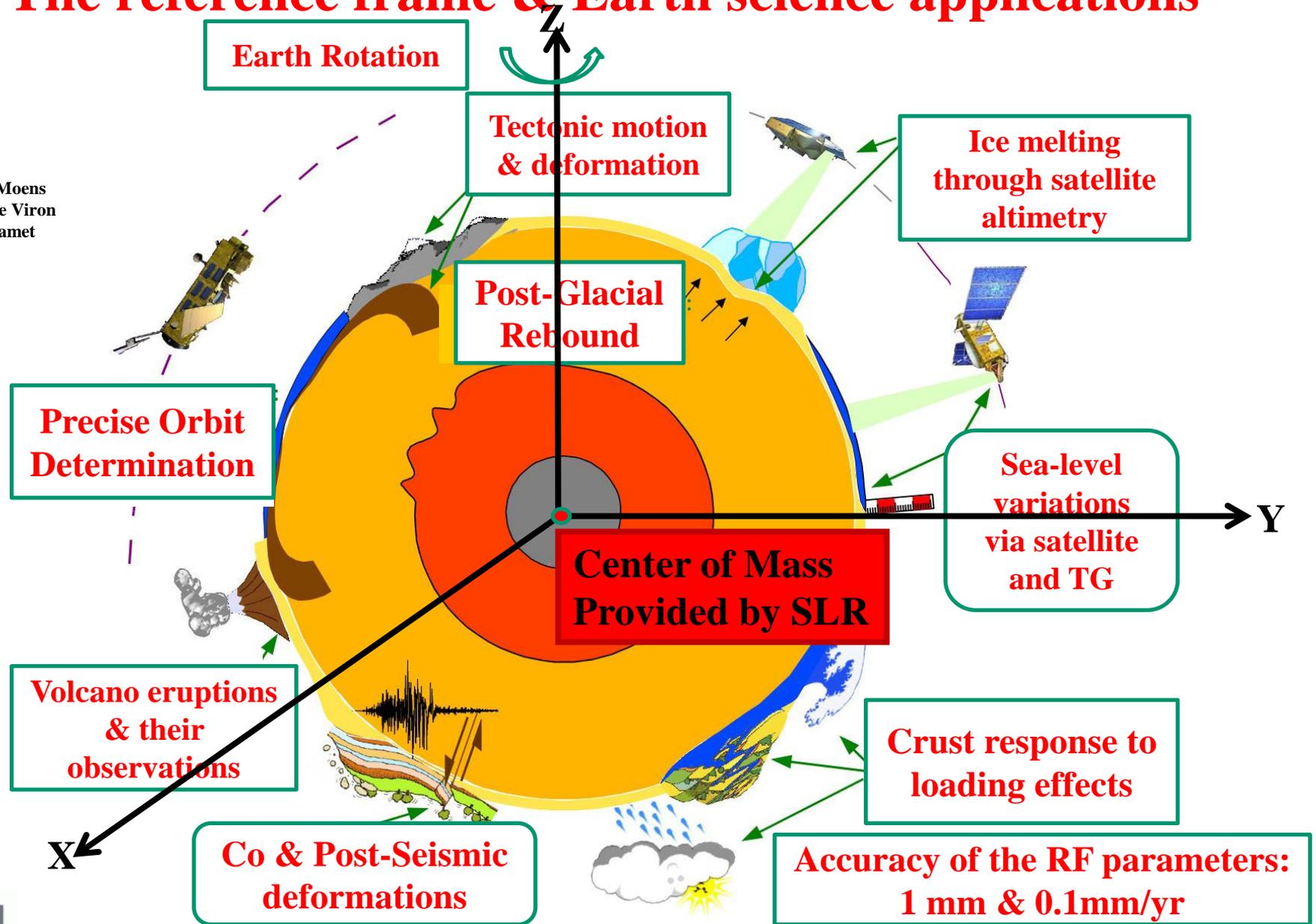
The reference frame & Earth science applications

Earth Rotation

Tectonic motion & deformation

Image:
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Post-Glacial Rebound

Ice melting through satellite altimetry

Precise Orbit Determination

Sea-level variations via satellite and TG

Center of Mass Provided by SLR

Volcano eruptions & their observations

Crust response to loading effects

Co & Post-Seismic deformations

Accuracy of the RF parameters: 1 mm & 0.1mm/yr

Z

Y

X

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Reference frames and Societal Applications

- **There are plenty of societal applications, mainly:**
  - **Positioning (location-based) applications** (navigation, surveying, precision agriculture, land & territory management, boundary dispute, cartography, cadaster…)
  - **National & Continental Reference Frames**

- **The UN GA resolution (February 26, 2015) on the:**
Global Geodetic Reference Frame for Sustainable Development

- **UN-GGIM sub-committee on Geodesy**

- **In response to a UN geodetic questionnaire:**

80% of the responding countries use the International Terrestrial Reference Frame (ITRF) to underpin their national coordinate systems

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ITRF2014

- **Published January, 2016**
- **Full article with Open Access**
- **Improved modeling of non-linear station motions**
  - **All kind of ruptures/discontinuities in the position time series**
  - **Seasonal signals**
  - **Modeling of post-seismic deformation**
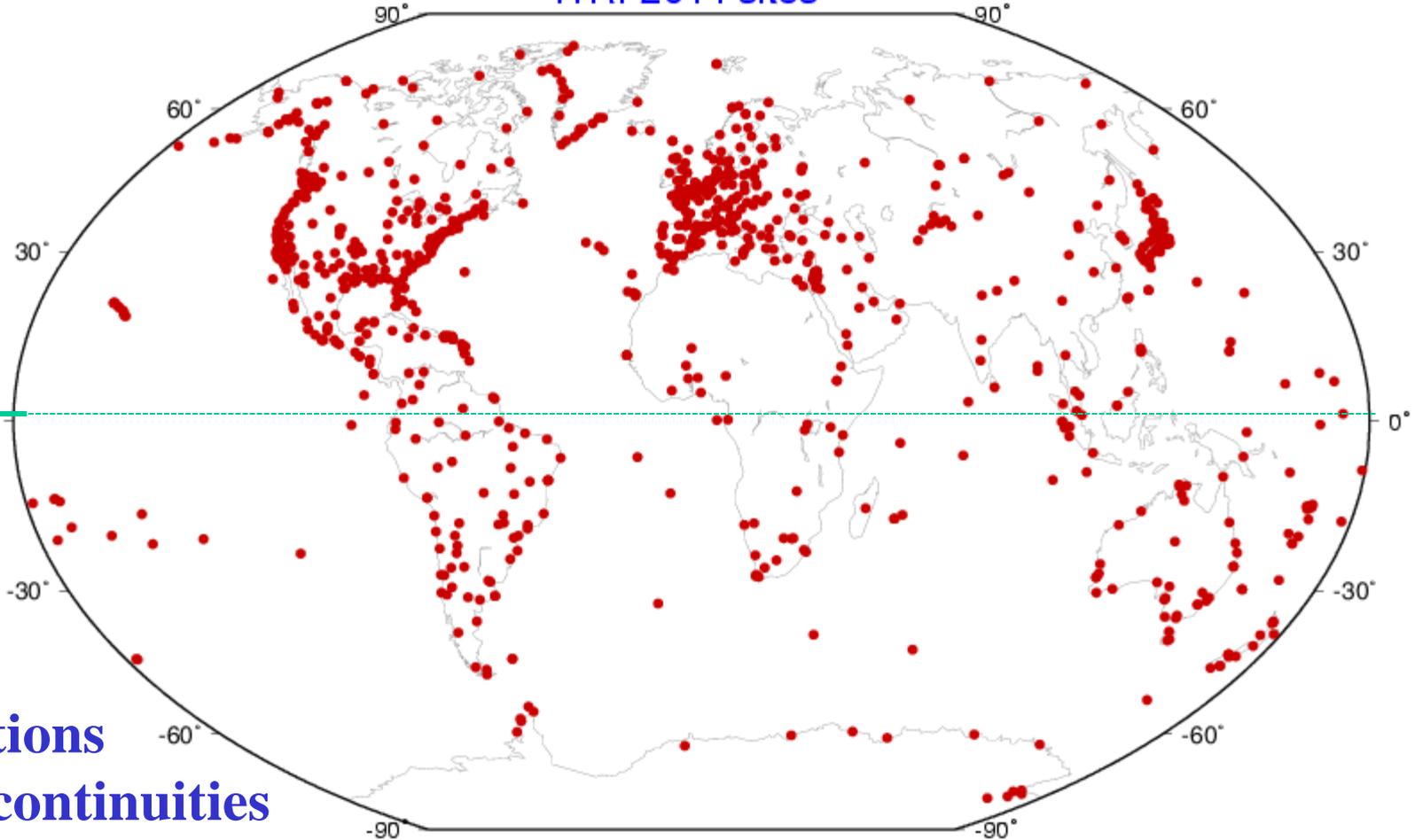 - **GNSS contribution is fundamental to all the above**
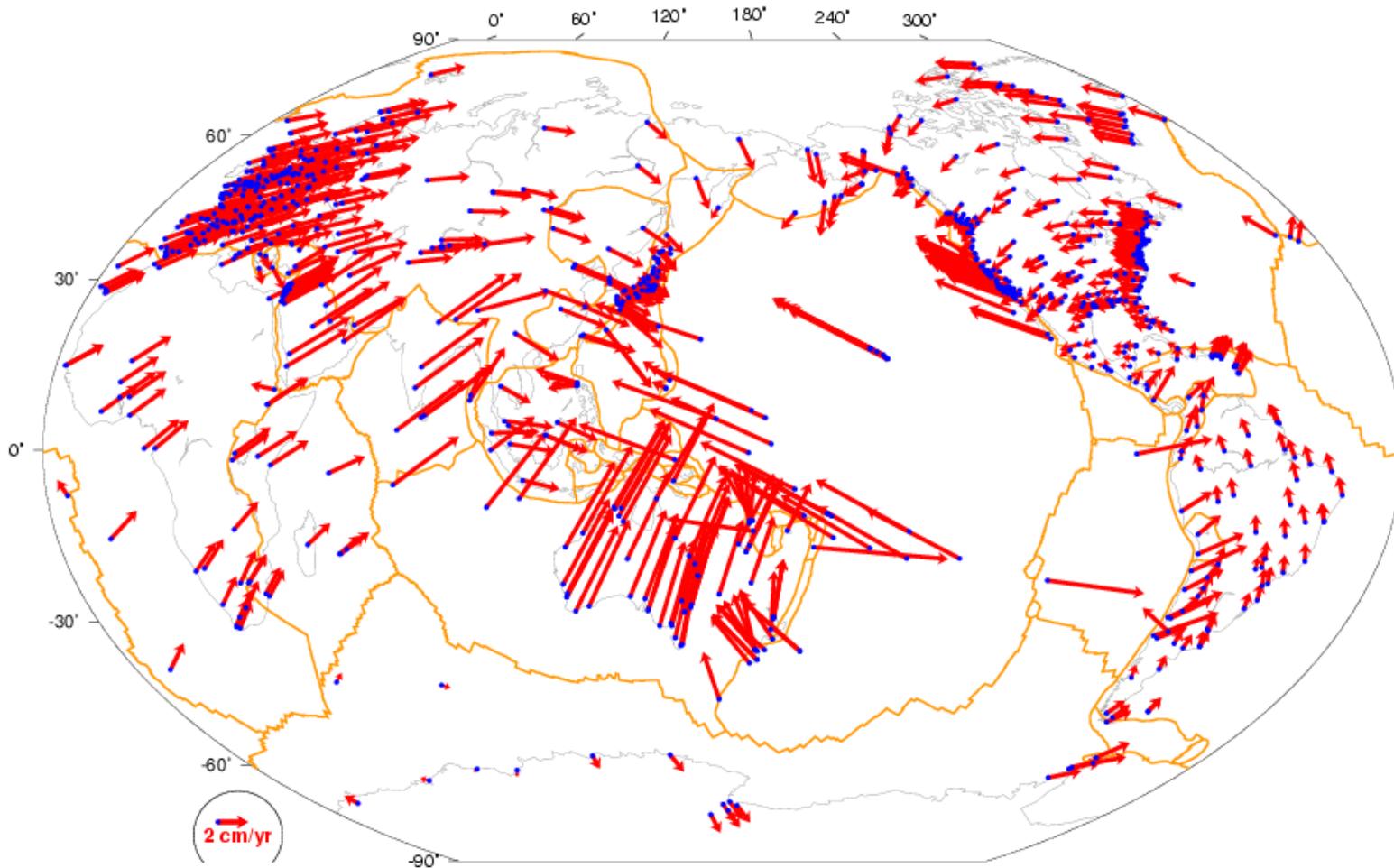
ITRF2014 Network

ITRF2014 sites

★ VLBI ◆ SLR ● GNSS ○ DORIS
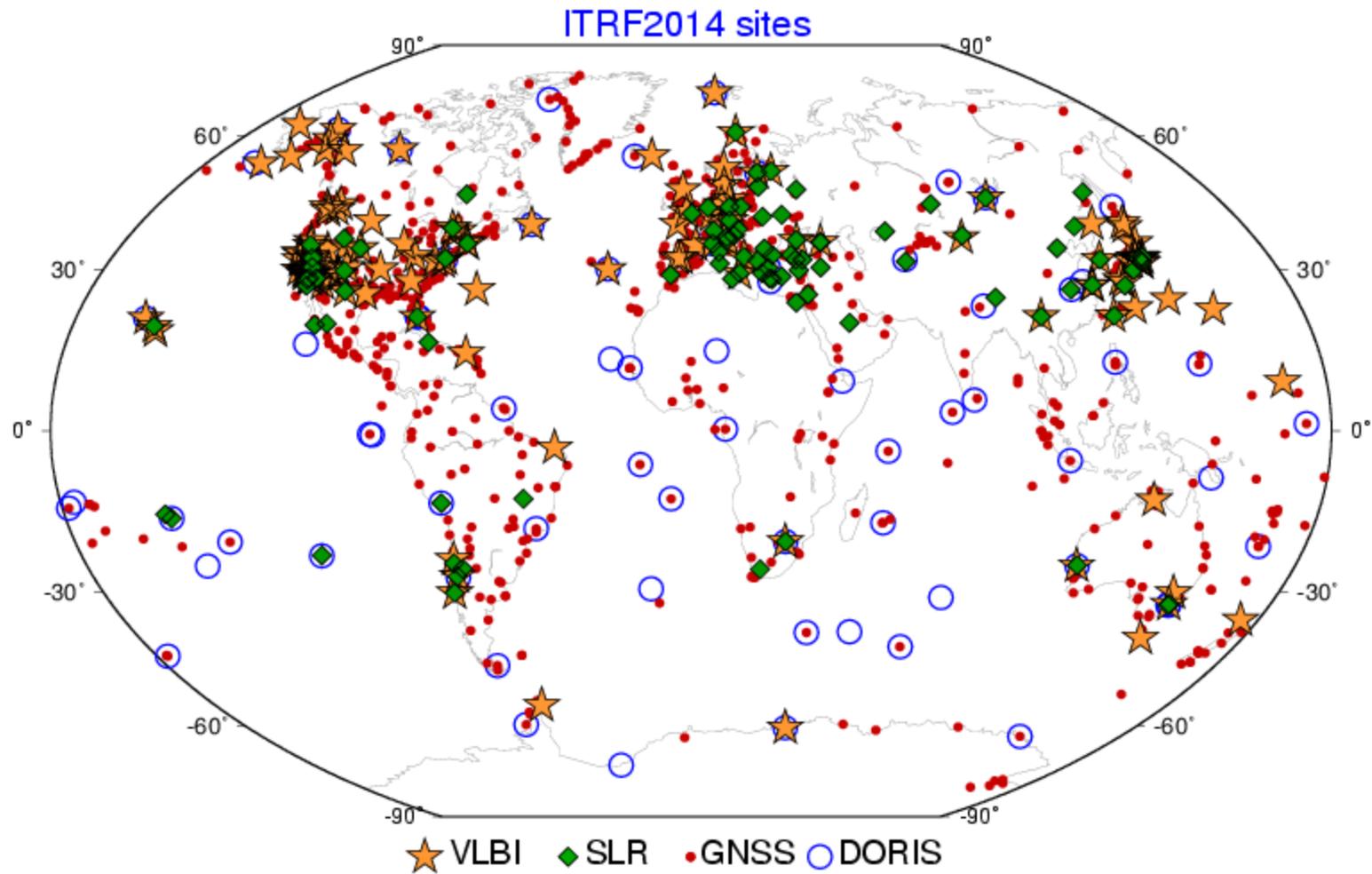
ITRF2014: GNSS

ITRF2014 sites

Site #
695

187

882 sites
1024 stations
1797 discontinuities

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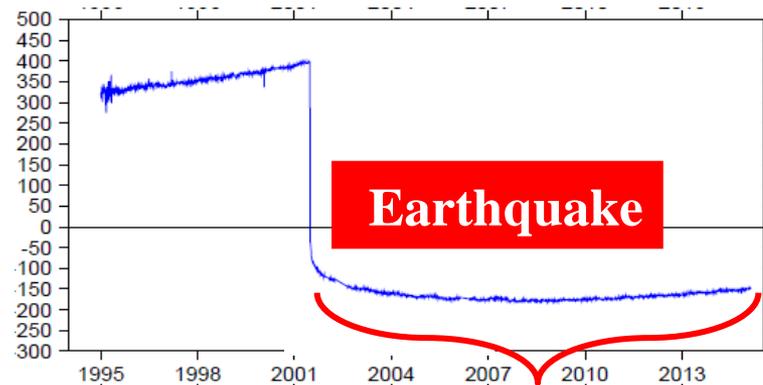# ITRF2014 Site Velocities:

$$X(t) = X(t_0) + \dot{X}(t - t_0)$$
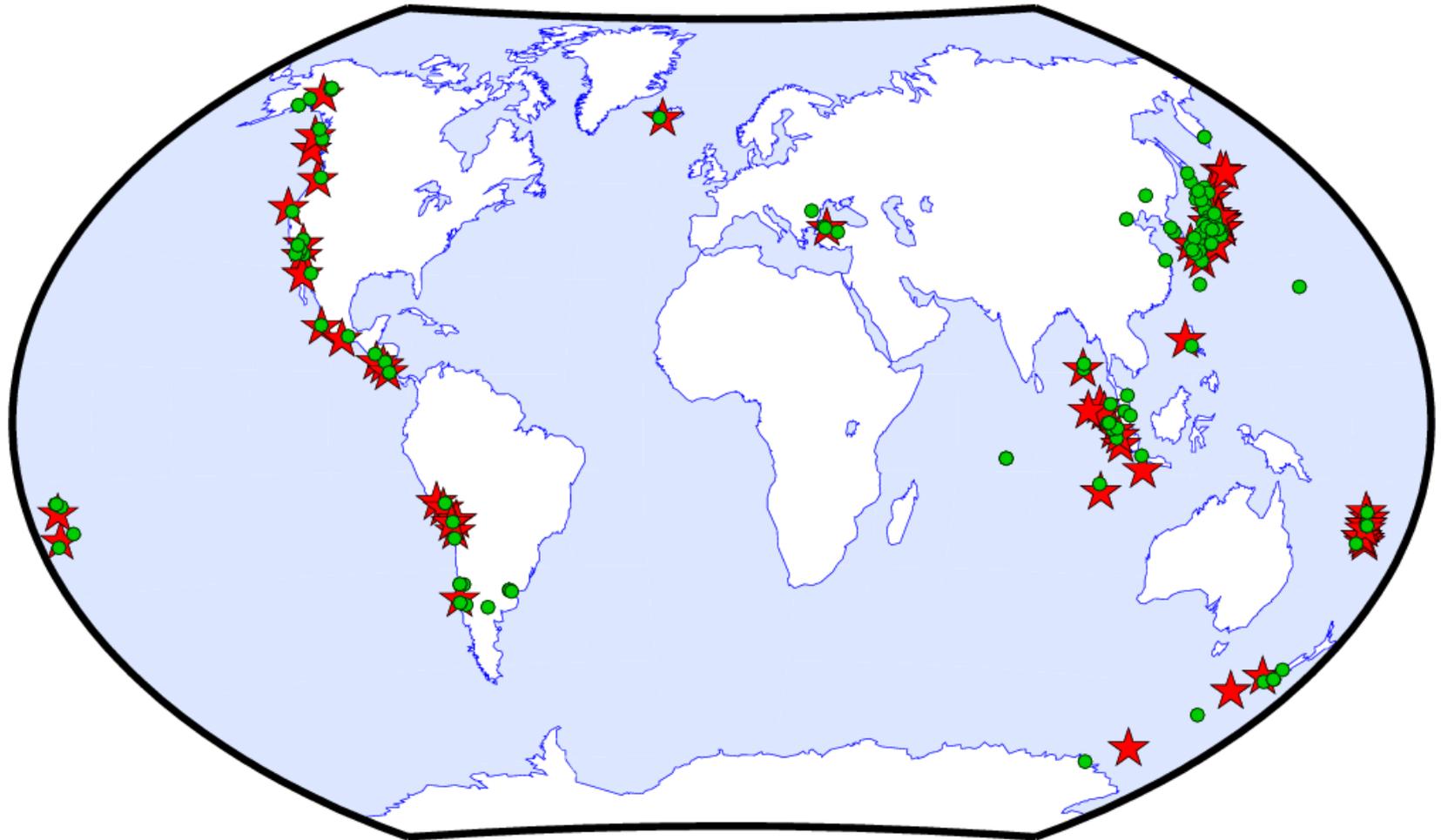
Post-Seismic Deformation (PSD)

- **Fitting parametric models using GNSS/GPS data**
  - **at major GNSS/GPS Earthquake sites**
  - **apply these models to the 3 other techniques at co-location EQ sites**

- **Parametric models:**
  - **Logarithmic**
  - **Exponential**
  - **Log + Exp**
  - **Two Exp**

Earthquake

Post-seismic deformation

ITRF2014 Site affected by PSD

Red Stars: EQ Epicenters
Green circles: ITRF2014 sites

Trajectory of Tsukuba (Japan) before and after the 2011 Tohoku earthquake

GNSS station

VLBI station

TSKB_21730S005 trajectory

Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

7345_21730S007 trajectory

Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

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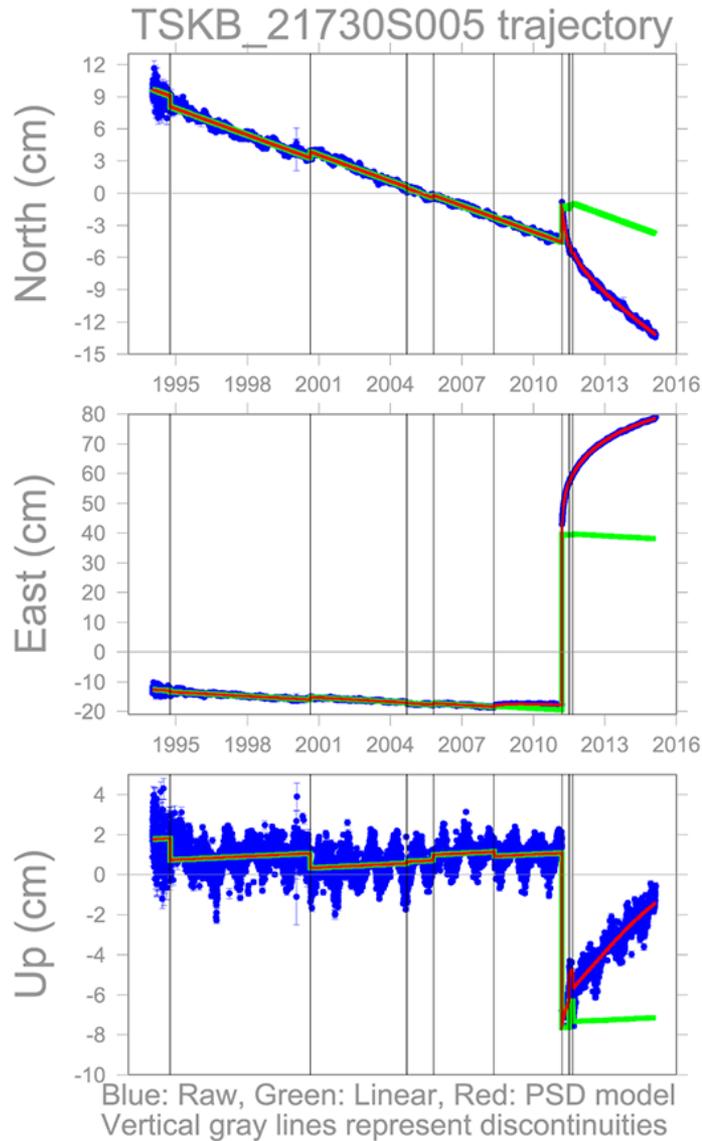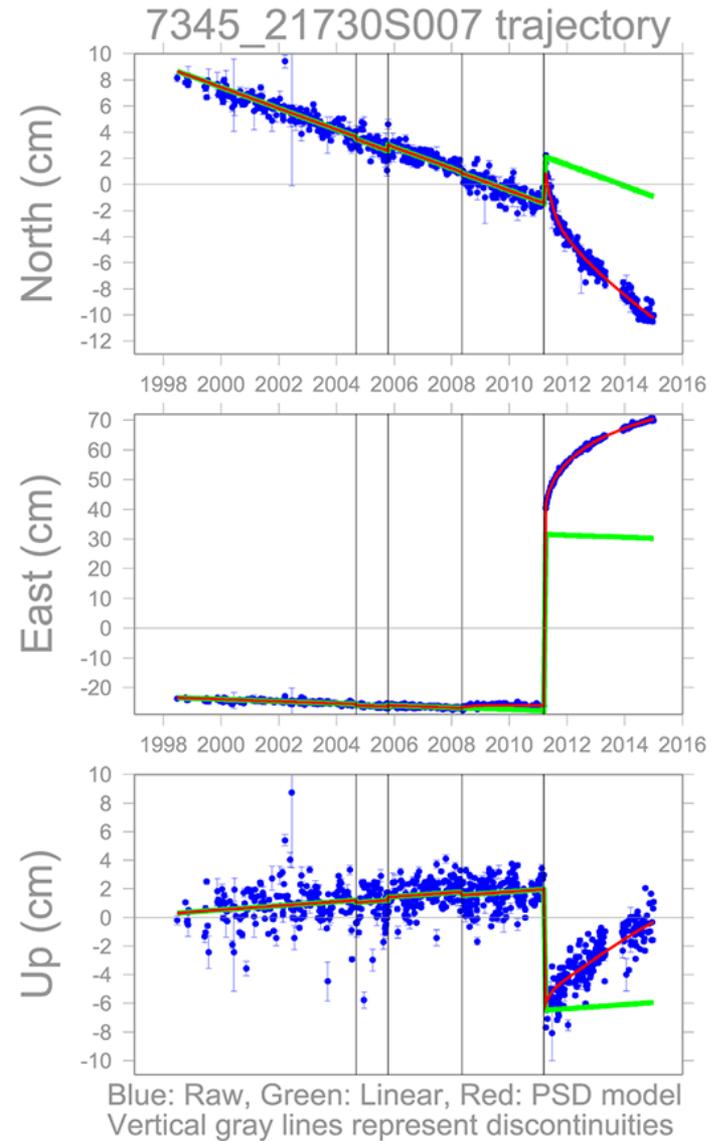
Conclusion: Key Points

- **GNSS provides high accuracy for positioning applications**
- **IAG/IERS provides the International Terrestrial Reference Frame (ITRF), the most accurate global RF available today;**
- **GNSS data/products are fundamental to the ITRF, through the IGS contribution:**
  - **Connect the 3 other techniques;**
  - **Determine Post-seismic deformations at EQ Sites**
- **GNSS inter-operability is critical for Science applications**

- **GNSS Providers are invited to provide satellite data to the IGS for better orbit dynamics modeling**

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Thank you