# Update on the International Terrestrial Reference Frame (ITRF) *and Handling Deformation Caused by Large Earthquakes*


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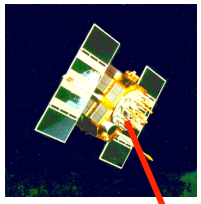
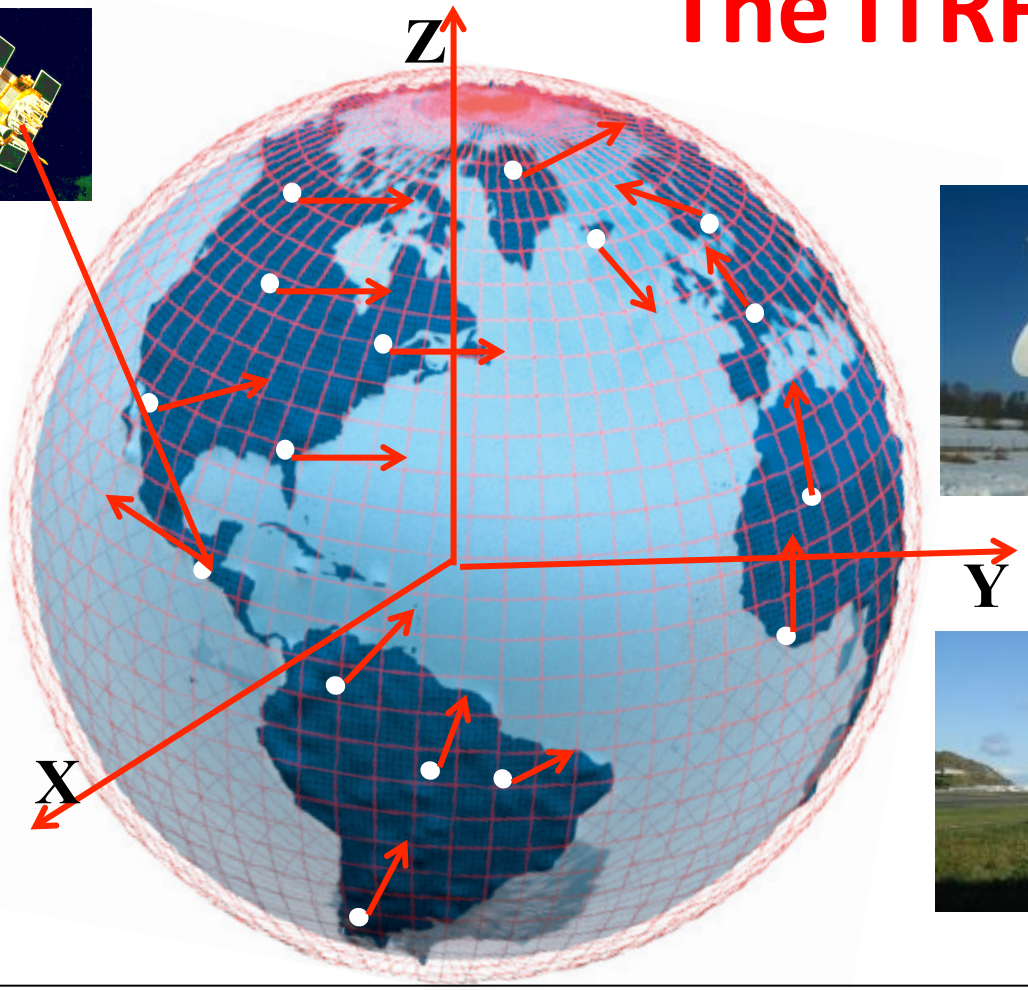
# The ITRF






VLBI

SLR

GNSS

DORIS

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

**ITRF defining parameters: Origin, Scale & Orientation**

# Why is a Reference Frame needed?

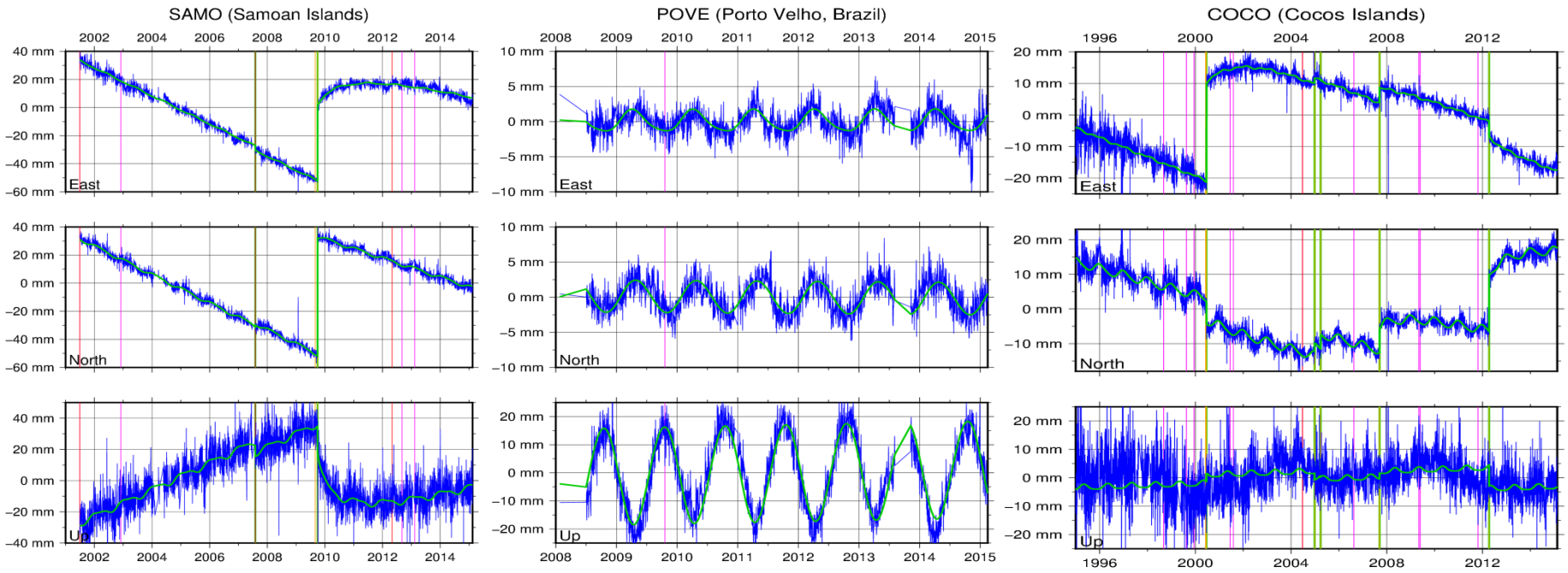
- **Precise Orbit Determination for:**
  - **GNSS: Global Navigation Satellite Systems**
  - **Other satellite missions: Altimetry, Oceanography, Gravity**
- **Earth Science & Societal Applications**
  - **Mean sea level variations**
  - **Hazard mitigation and tsunami warning**
  - **Plate motion and crustal deformation**
  - **Glacial Isostatic Adjustment (GIA)**
  - **…**
- **Geo-referencing applications : positioning, navigation, surveying…**
- **GNSS is today's tool for all the above and for accessing the ITRF**

**==> Inter-Operability between GNSS is needed**

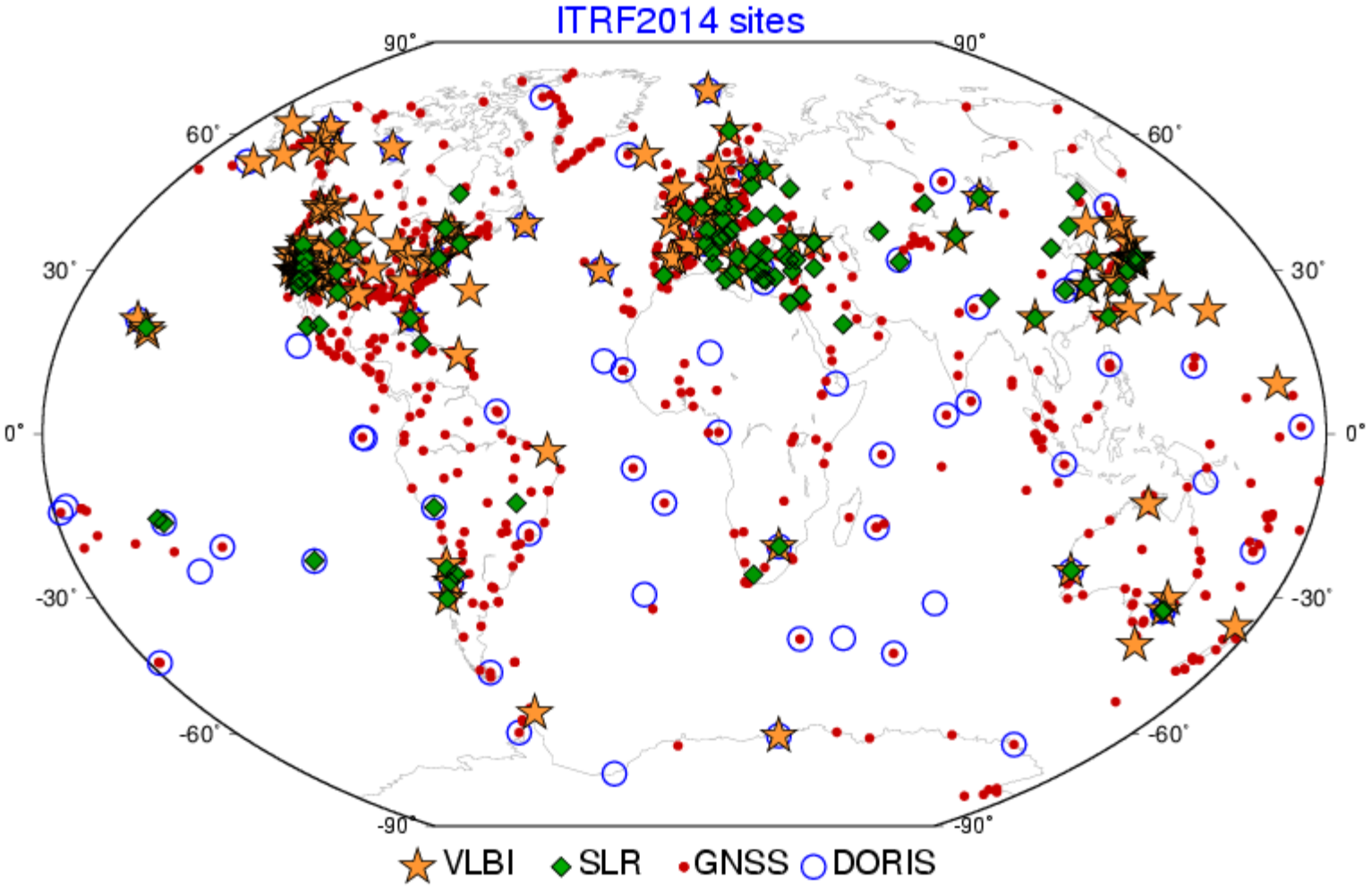
# Next ITRF solution (ITRF2014)

- To be ready by end-2015
- Expected Improvements & Developments:
  - Improved modeling of non-linear station motions
    - All kind of ruptures/discontinuities in the position time series
    - Seasonal signals
    - Modeling of post-seismic deformation

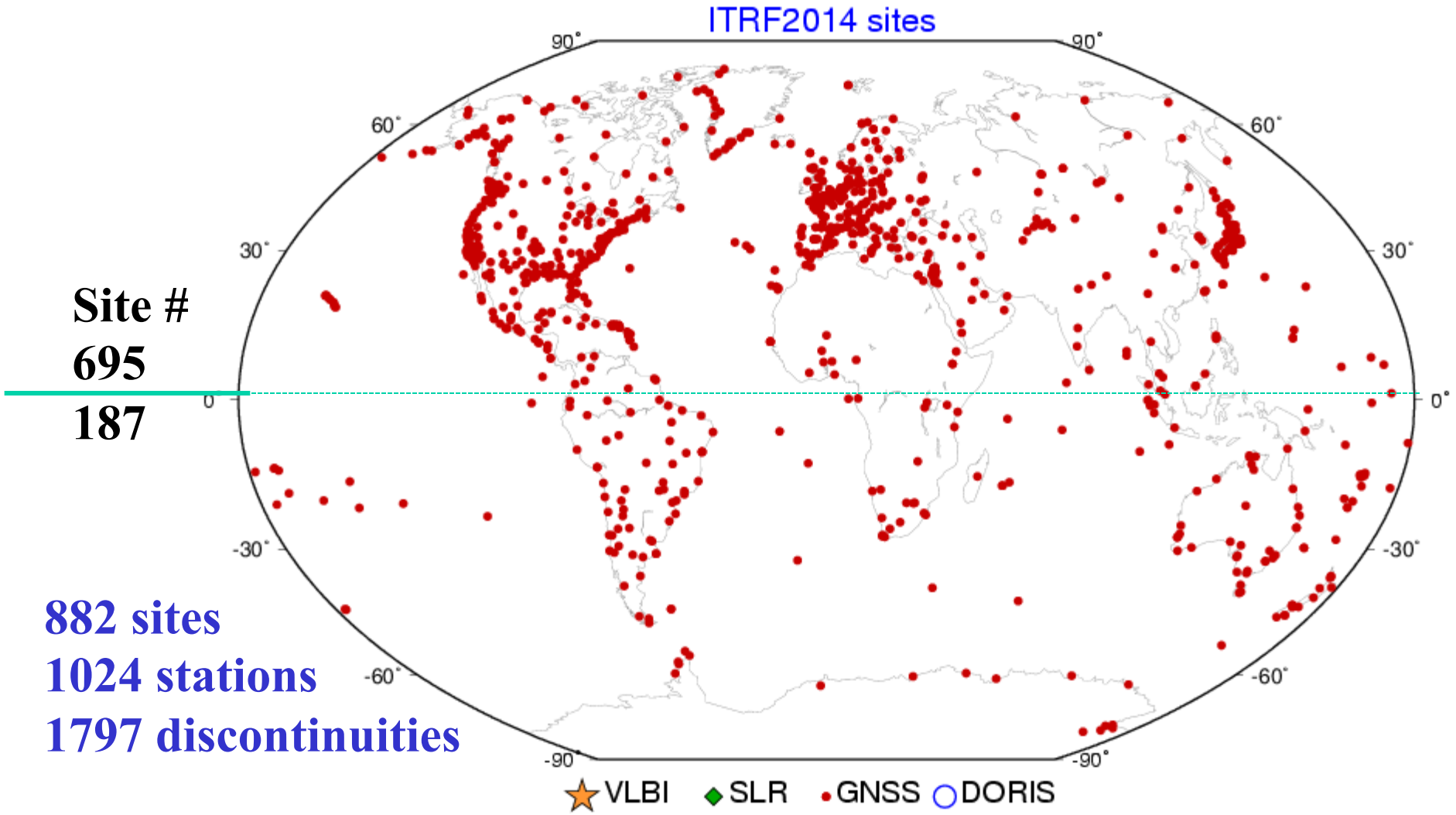
# Typical site non-linear motions



# ITRF2014 Network



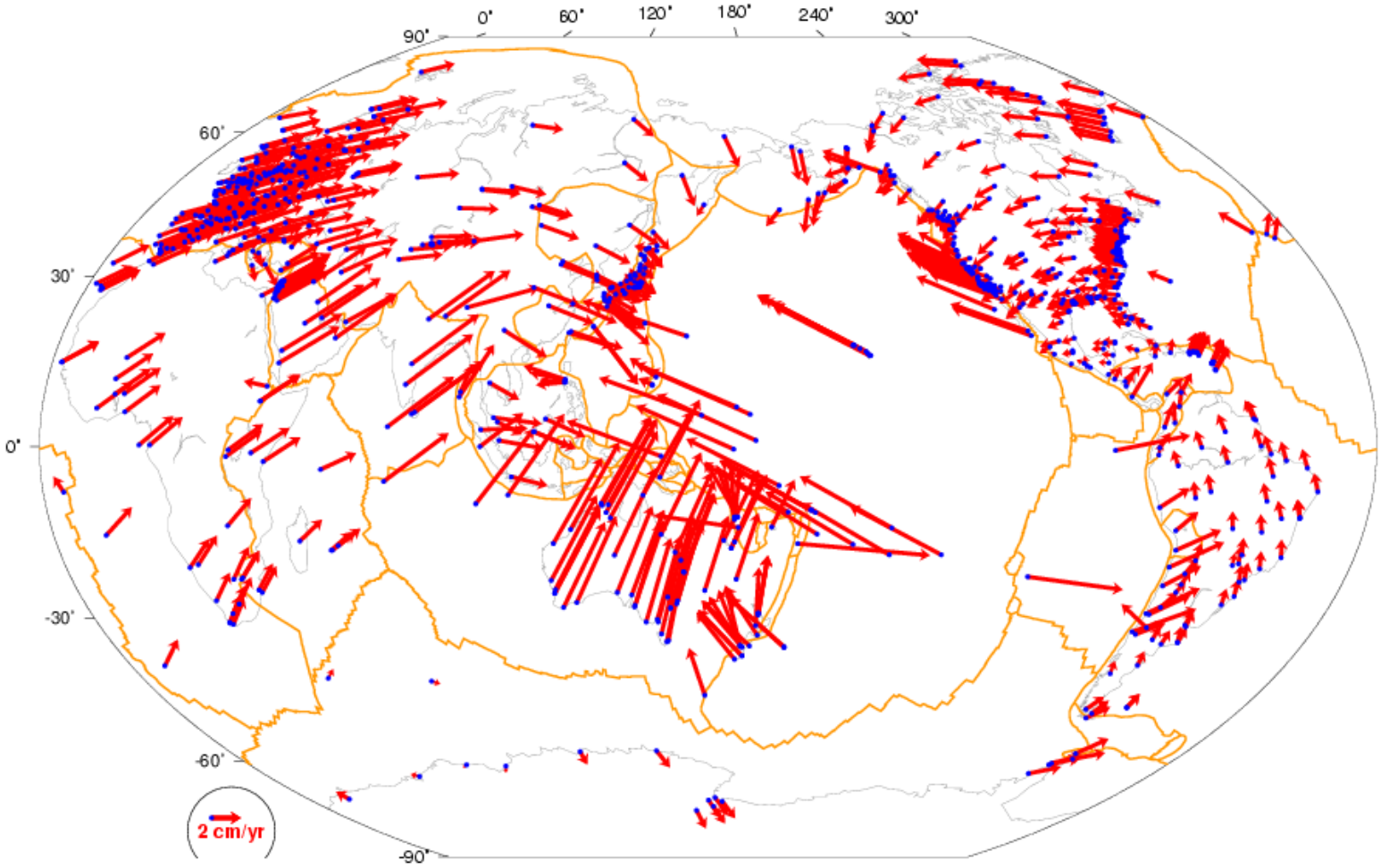
# ITRF2014: GNSS




**Site #**
**695**
**187**

**882 sites**
**1024 stations**
**1797 discontinuities**

# ITRF2014P Site Velocities:



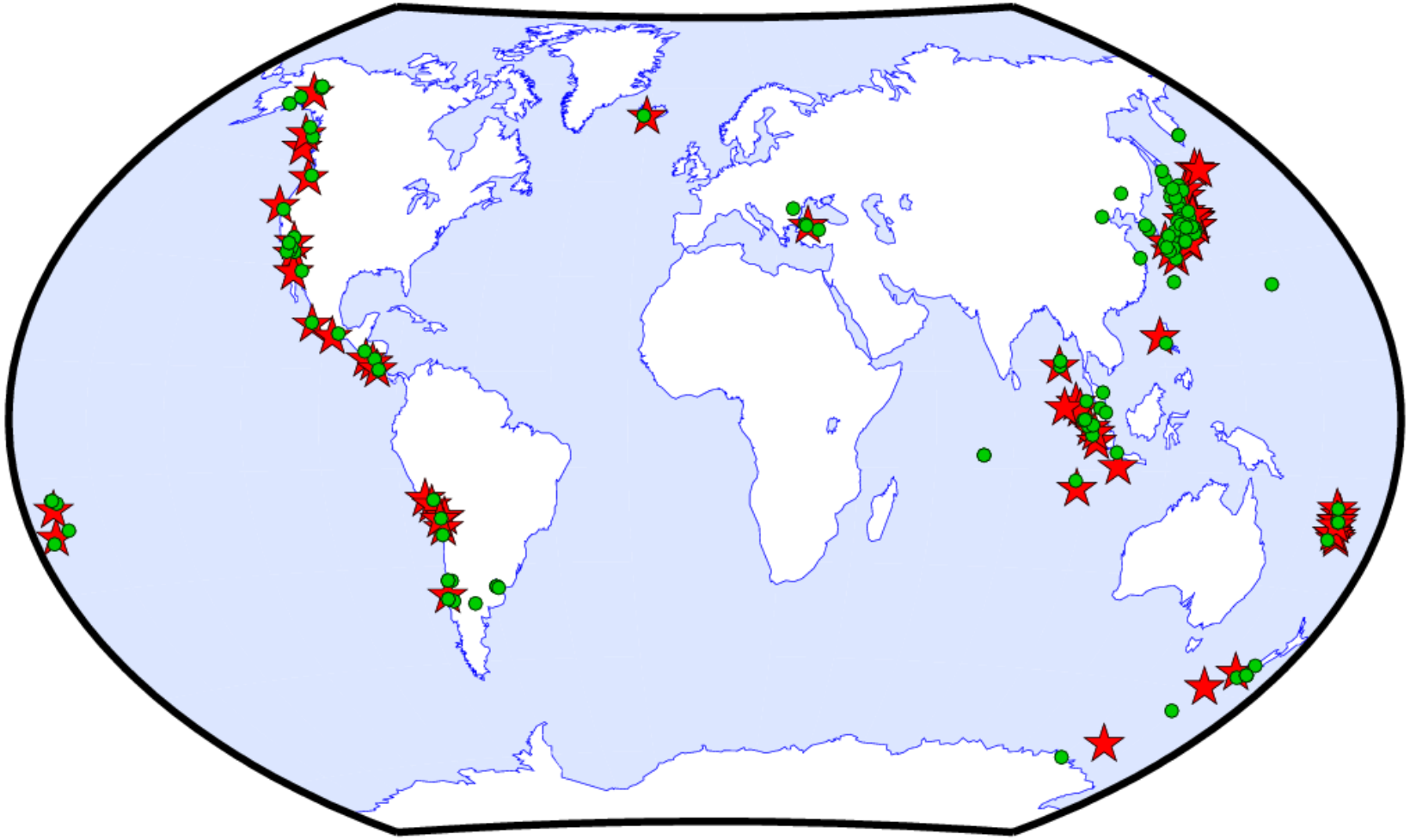

$$X(t) = X(t_0) + \dot{X}(t - t_0)$$

# Post-Seismic Deformations:

- **Fitting parametric models using GNSS/GPS data**
  - **at all GNSS/GPS Earthquake sites**
  - **Apply these models for the 3 other techniques at Co-location EQ sites**
- **Parametric models:**
  - **Logarithmic**
  - **Exponential**
  - **Log + EXP**
  - **Two EXP**

$$\delta L(t) = \sum_{i=1}^{n^l} A_i^l \log(1 + \frac{t - t_i^l}{\tau_i^l}) + \sum_{i=1}^{n^e} A_i^e (1 - \mathrm{e}^{-\frac{t - t_i^e}{\tau_i^e}})$$

# ITRF2014 Site affected by PSD

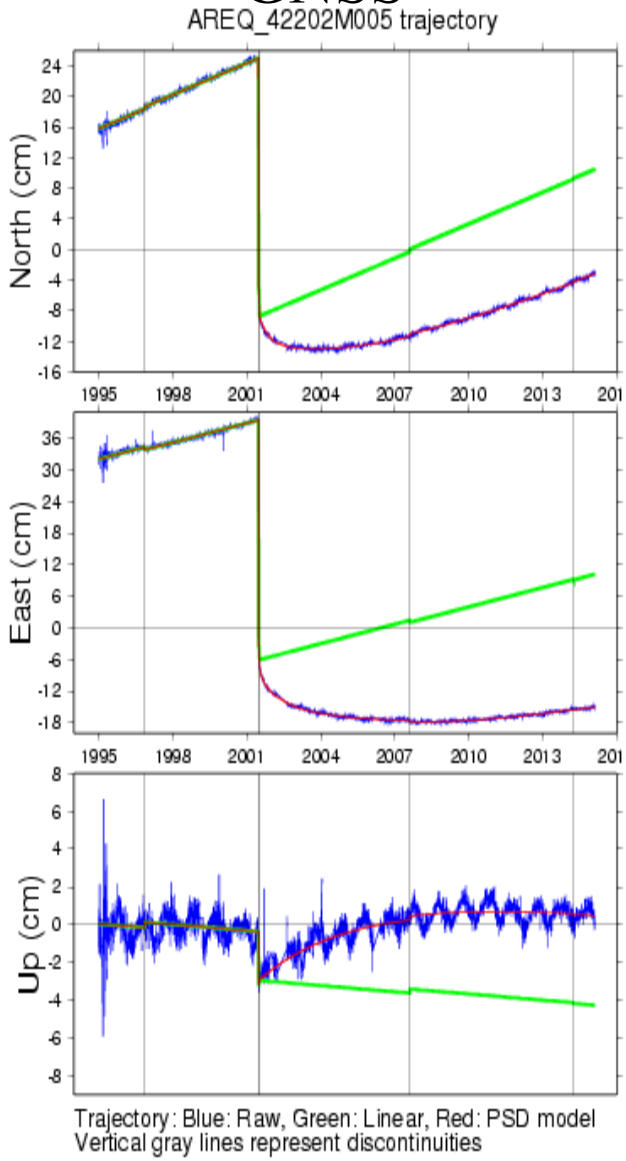


**Red Stars: EQ Epicenters**

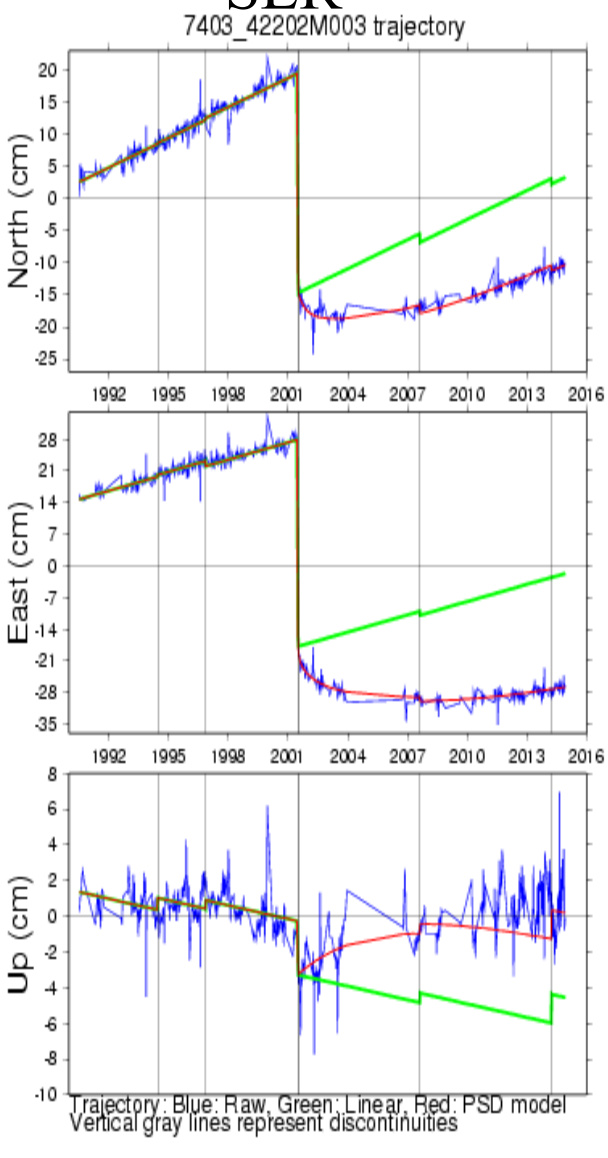
**Green circles: ITRF2014 sites**

# Arequipa-GPS, SLR & DORIS

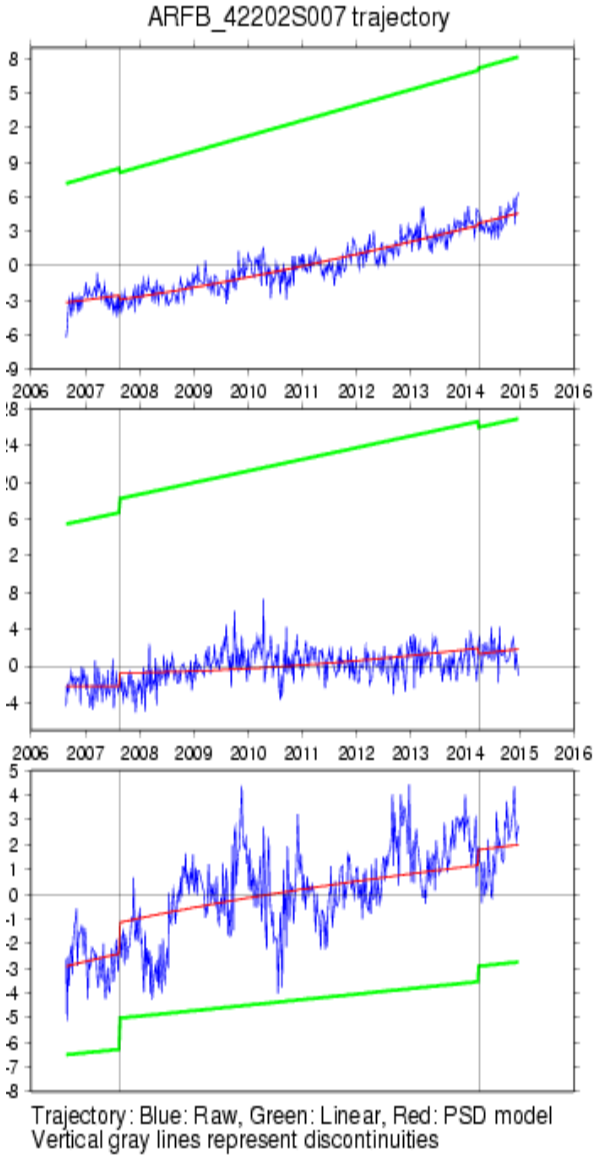
GNSS




SLR

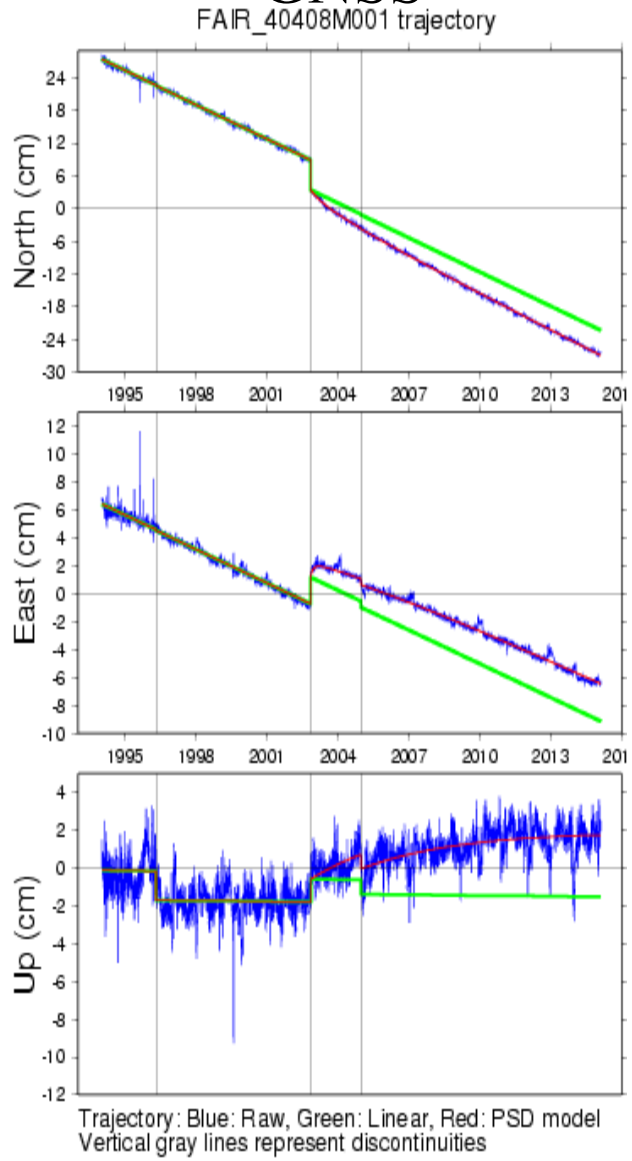



DORIS

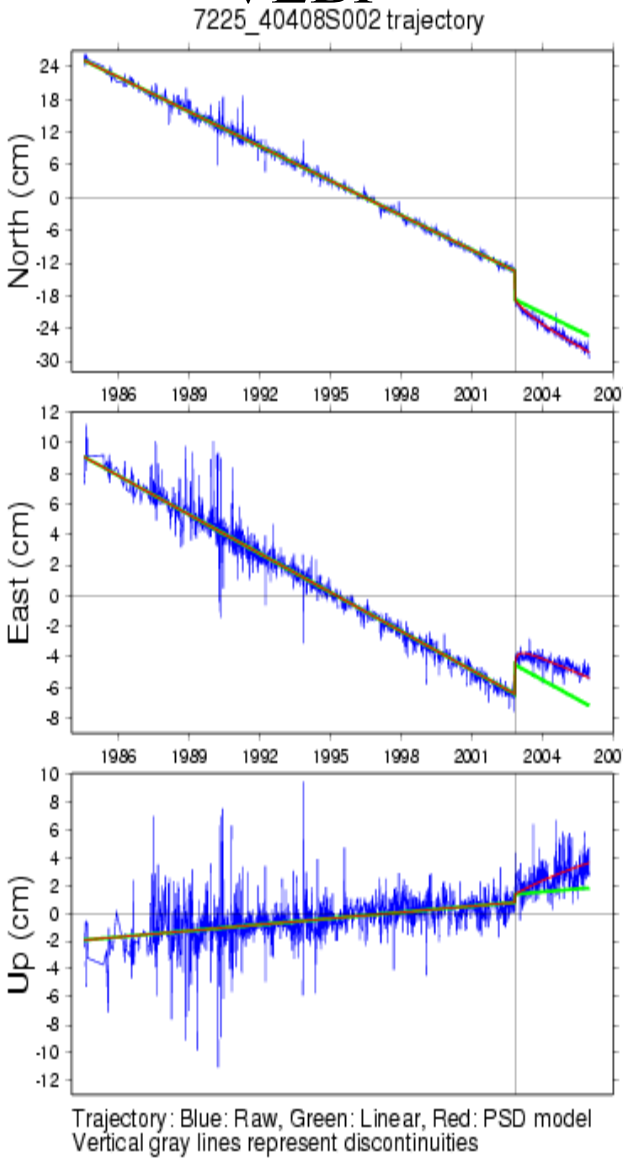


# Fairbanks: GPS, VLBI & DORIS

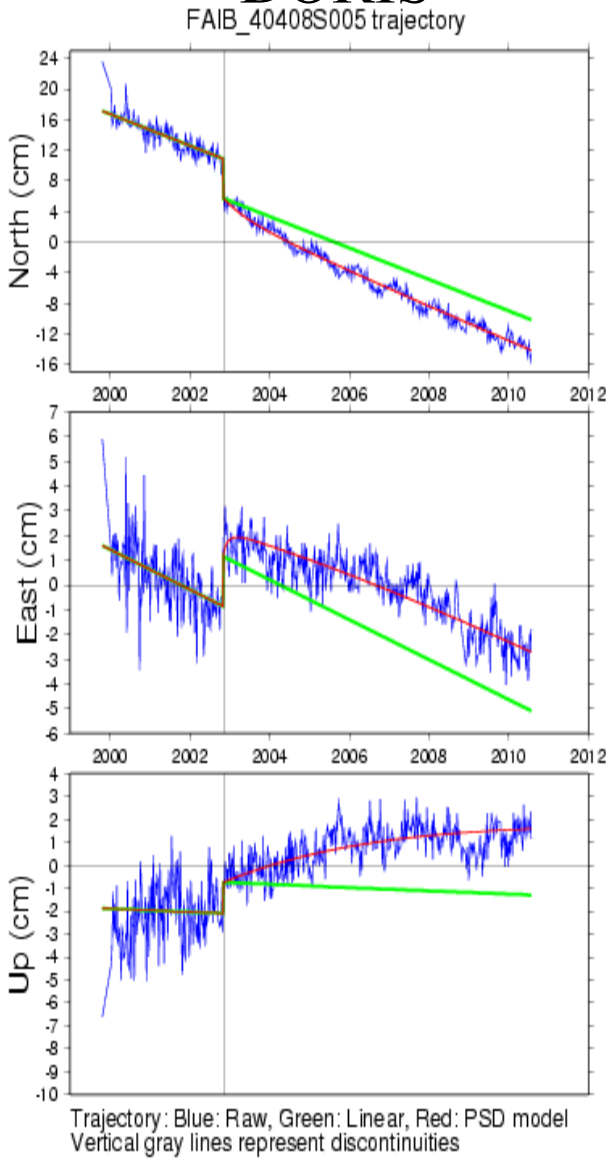
GNSS




VLBI




DORIS



# 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**

# Thank you