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

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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

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

\[
\delta L(t) = \sum_{i=1}^{n^l} A_i^l \log(1 + \frac{t - t_i^l}{\tau_i^l}) + \sum_{i=1}^{n^e} A_i^e (1 - e^{-\frac{t - t_i^e}{\tau_i^e}})
\]
ITRF2014 Site affected by PSD

Red Stars: EQ Epicenters
Green circles: ITRF2014 sites
Arequipa-GPS, SLR & DORIS

**GNSS**
AREQ_42202M005 trajectory

**SLR**
7403_42202M003 trajectory

**DORIS**
ARFB_42202S007 trajectory

Vertical gray lines represent discontinuities.

ICG-10, Boulder, USA, 1-6, November, 2015
Fairbanks: GPS, VLBI & DORIS

**GNSS**

FAR_40408M001 trajectory

**VLBI**

7225_40409S002 trajectory

**DORIS**

FAIB_40409S005 trajectory

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
Thank you