Review of the IGS Contribution to the ITRF

Zuheir Altamimi
Paul Rebischung
Laurent Métivier
Xavier Collilieux
IGN, France
Email: zuheir.altamimi@ign.fr

Key Points of the IGS Contribution to the ITRF

1. Inter-Technique link : reinforcing the ITRF definition (origin, scale & orientation)

2. Determination of Post-Seismic Deformation Models

3. ITRF2014 Plate Motion Model

4. Polar Motion

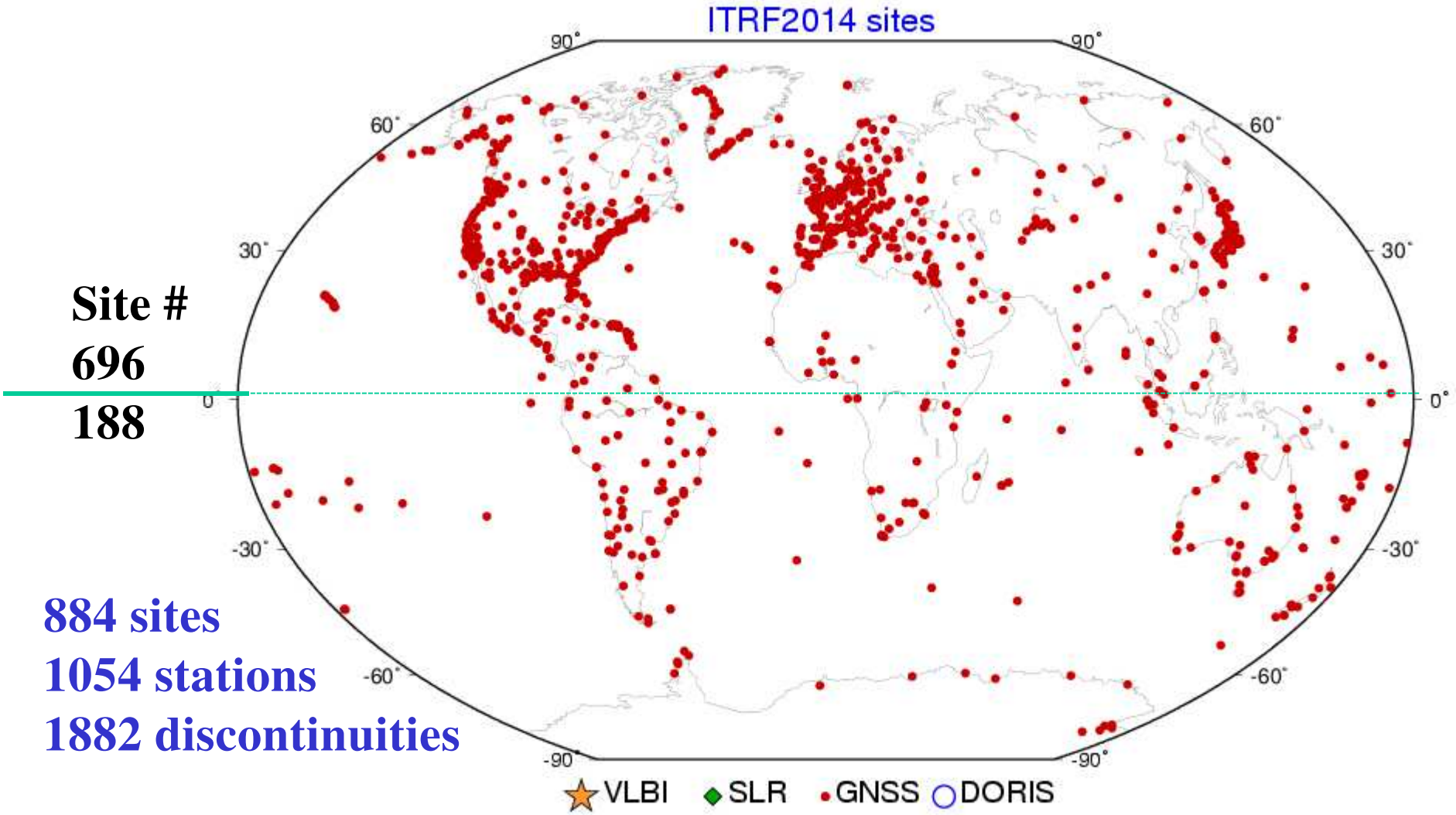
5. ITRF Access & densification through the IGS Products

Illustrations from ITRF2014 results

ITRF2014: Input data

Service/Technique	Number of Solutions	Time span	# of sites
IGS/GNSS/GPS	7714 daily	1994.0 – 2015.1 (21 yrs)	884
IVS/VLBI	5328 daily	1980.0 – 2015.0 (35 yrs)	124
ILRS/SLR	244 fortnightly 1147 weekly	1980.0 – 1993.0 1993.0 – 2015.0 (35 yrs)	96
IDS/DORIS	1140 weekly	1993.0 – 2015.0 (22 yrs)	71

ITRF2014: GNSS



Site #

696

188

884 sites

1054 stations

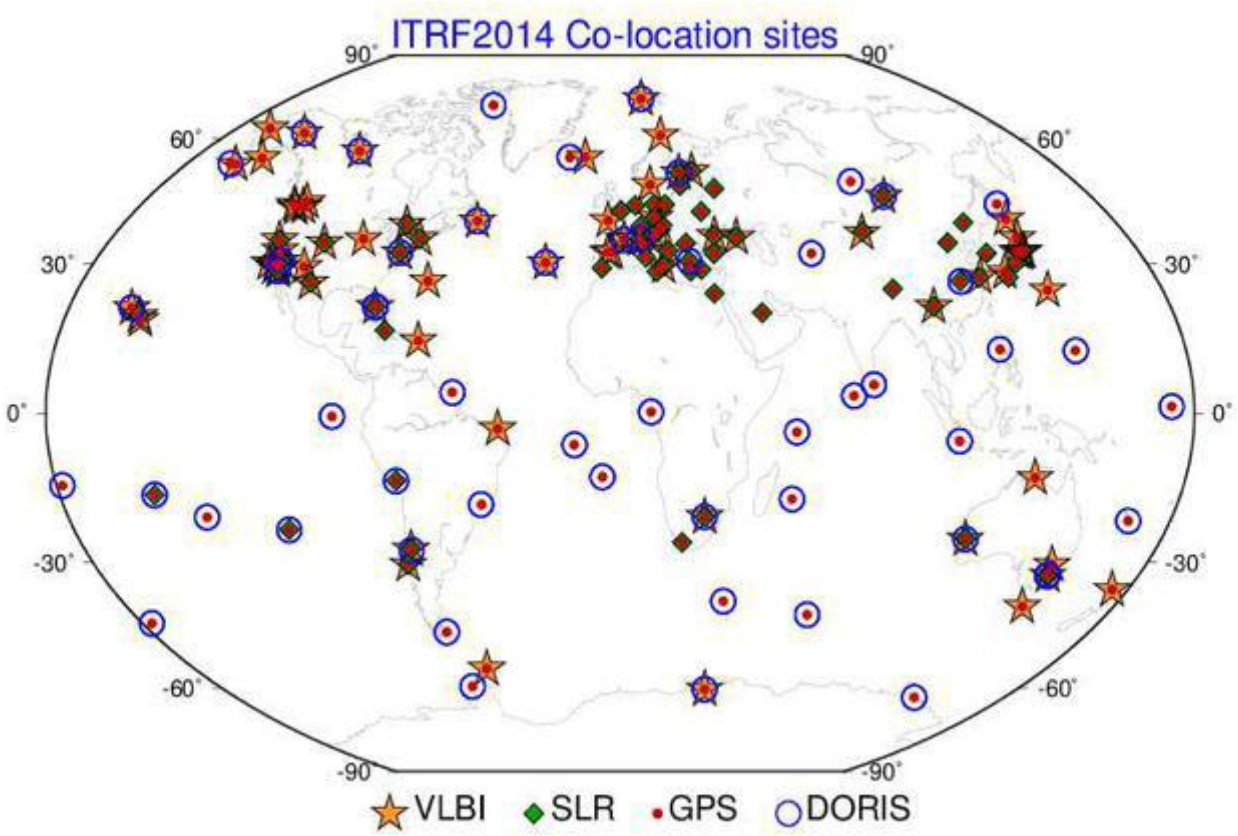
1882 discontinuities

ITRF2014 colocation sites

- **SLR-VLBI : 11**
- **SLR-DORIS: 11**
- **VLBI-DORIS: 12**

# of local ties vectors between GNSS &:

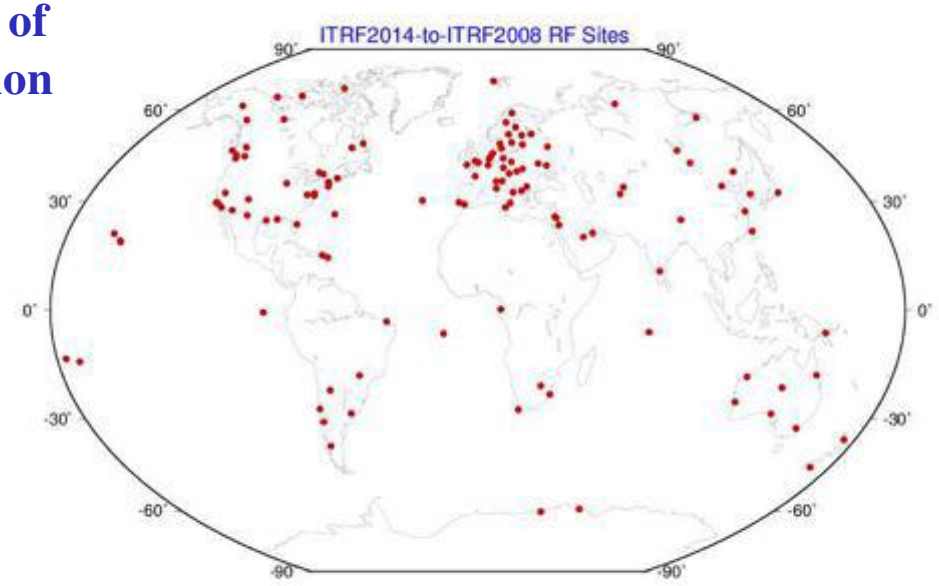
- **DORIS: 103**
- **SLR : 56**
- **VLBI: 62**
- **Total: 221**



1. Inter-Technique link : reinforcing the ITRF definition (orientation)

127 of stations used in the alignment of ITRF2014 to ITRF2008 in Orientation

- **GNSS: 93**
- **VLBI: 24**
- **SLR: 8**
- **DORIS: 2**



From ITRF2014 to ITRF2008

Solution	Tx mm	Ty mm	Tz mm	Scale ppb	Rx mas	Ry mas	Rz mas
Offset	1.6	1.9	1.4	-0.02	0.000	0.000	0.000
±	±0.2	±0.1	±0.1	±0.02	±0.006	±0.006	±0.006
Rate	0.0	0.0	0.0	0.02	0.000	0.000	0.000
±	±0.2	±0.1	±0.1	±0.02	±0.006	±0.006	±0.006

1. Inter-Technique link : reinforcing the ITRF definition (Frame uncertainties)

Example:

Compare VLBI frame uncertainties within

SLR+VLBI_only combination: 16 LT vectors
versus
ITRF2014 combination: 221 LT vectors

Uncertainties (formal errors) of the frame parameters

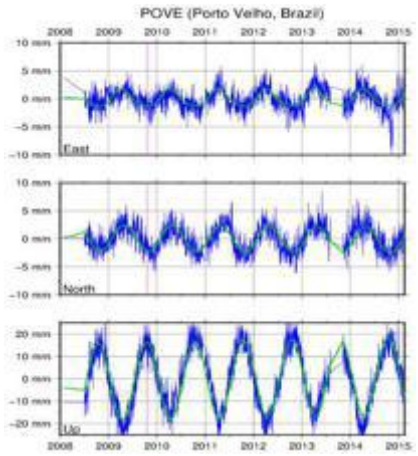
Solution	Tx mm	Ty mm	Tz mm	Scale ppb	Rx mas	Ry mas	Rz mas
SLR+VLBI	±1.4	±1.2	±1.5	±0.20	±0.050	±0.067	±0.050
ITRF2014	±0.6	±0.6	±0.7	±0.10	±0.007	±0.007	±0.015

1. Inter-Technique link : reinforcing the ITRF definition (scale)

VLBI vs SLR Scale Offset

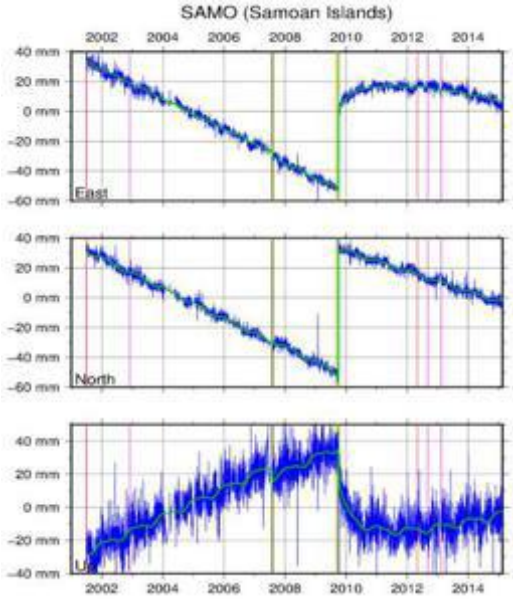
Solution	Scale at 2010.0 ppb	Comments
VLBI & SLR co-locations, No GNSS	1.02 ± 0.20	11 sites (good distribution): 16 LT vectors, properly weighted
Rate	0.02 ± 0.02	
ITRF2014	1.37 ± 0.10	All Tie SNX files properly weighted
Rate	0.02 ± 0.02	

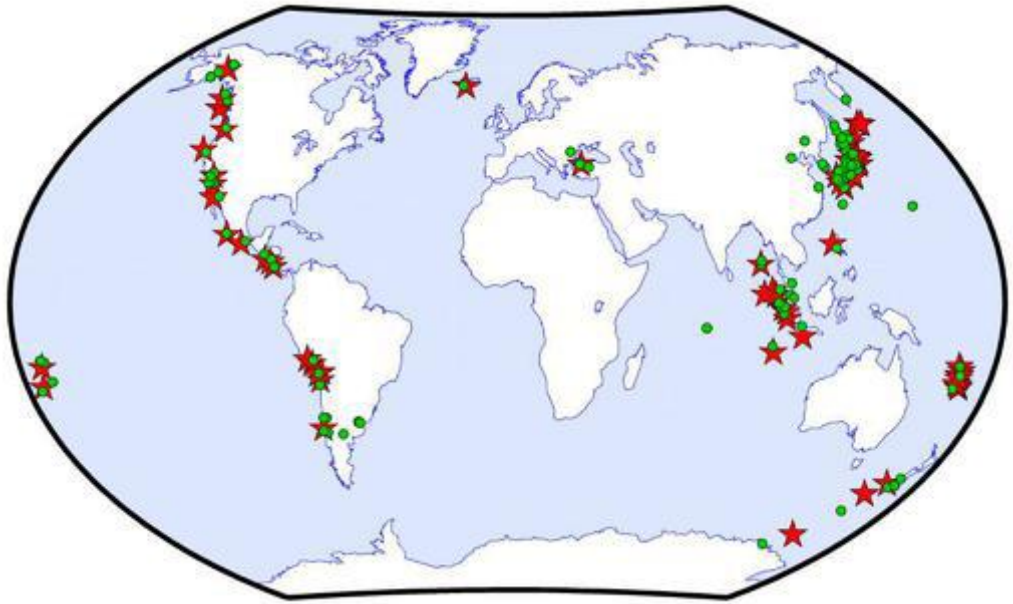
Modelling nonlinear station motions: Motivations



- **Position time series of all stations exhibit periodic signals**

- **More than 100 sites are subject to Post-Seismic Deformation due to major earthquakes**





Red Stars: EQ Epicenters (58)

Green circles: ITRF2014 sites (117)

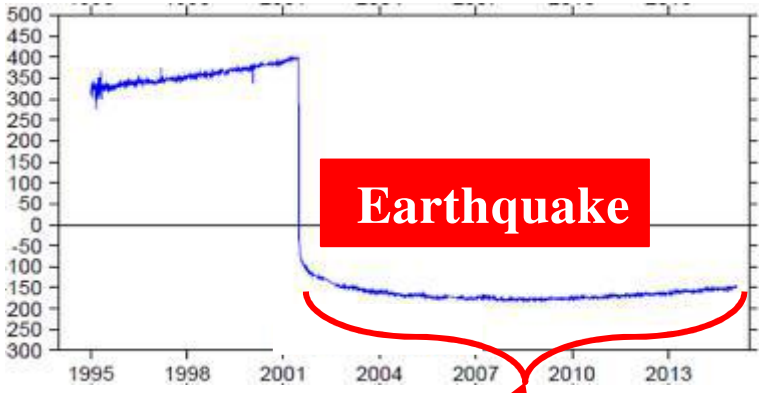
Precisely modeling the above leads to more robust secular frame and site velocities.

2. Post-Seismic Deformations

Post-Seismic Deformations

- **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**

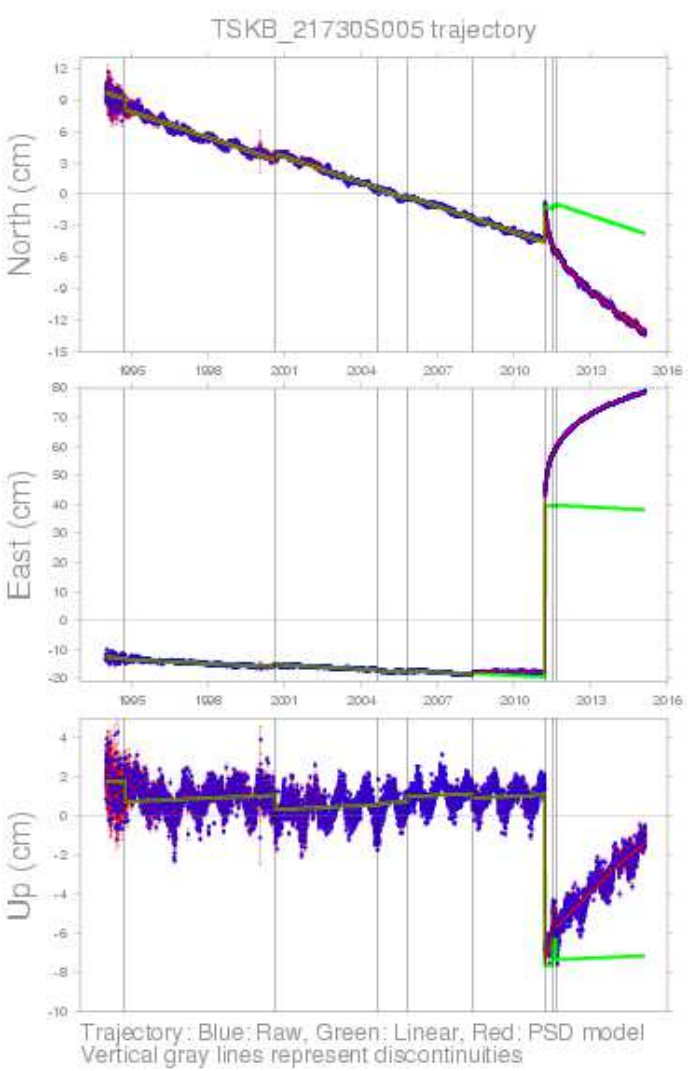
- **Parametric models:**
  - **Logarithmic**
  - **Exponential**
  - **Log + Exp**
  - **Two Exp**



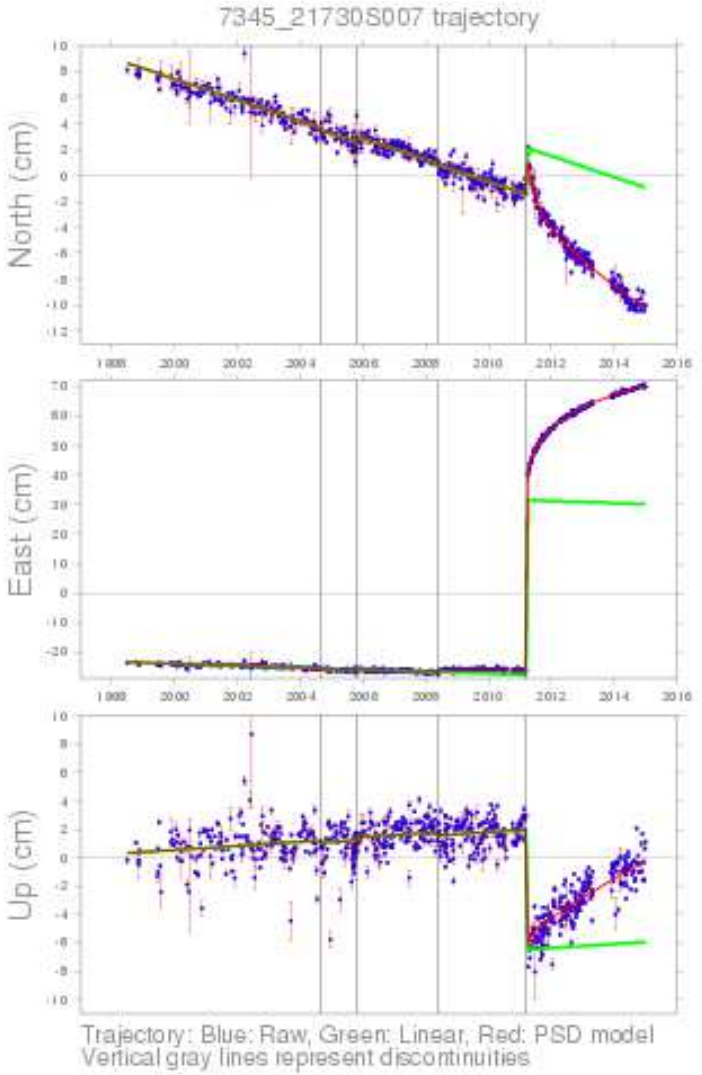
Post-seismic deformation

Tsukuba Trajectory

GNSS



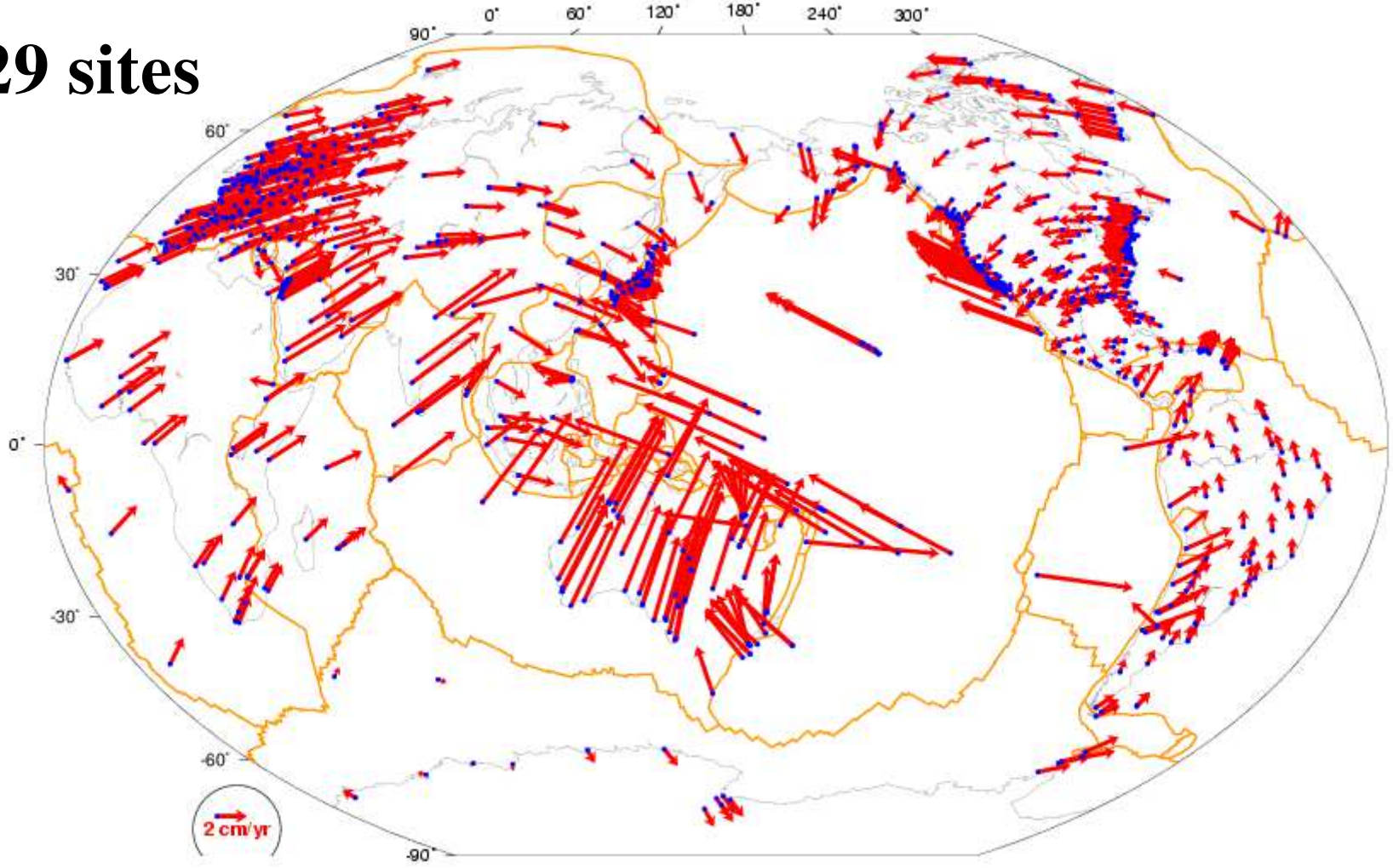
VLBI



3. ITRF2014 Plate Motion Model

ITRF2014: Horizontal velocity field

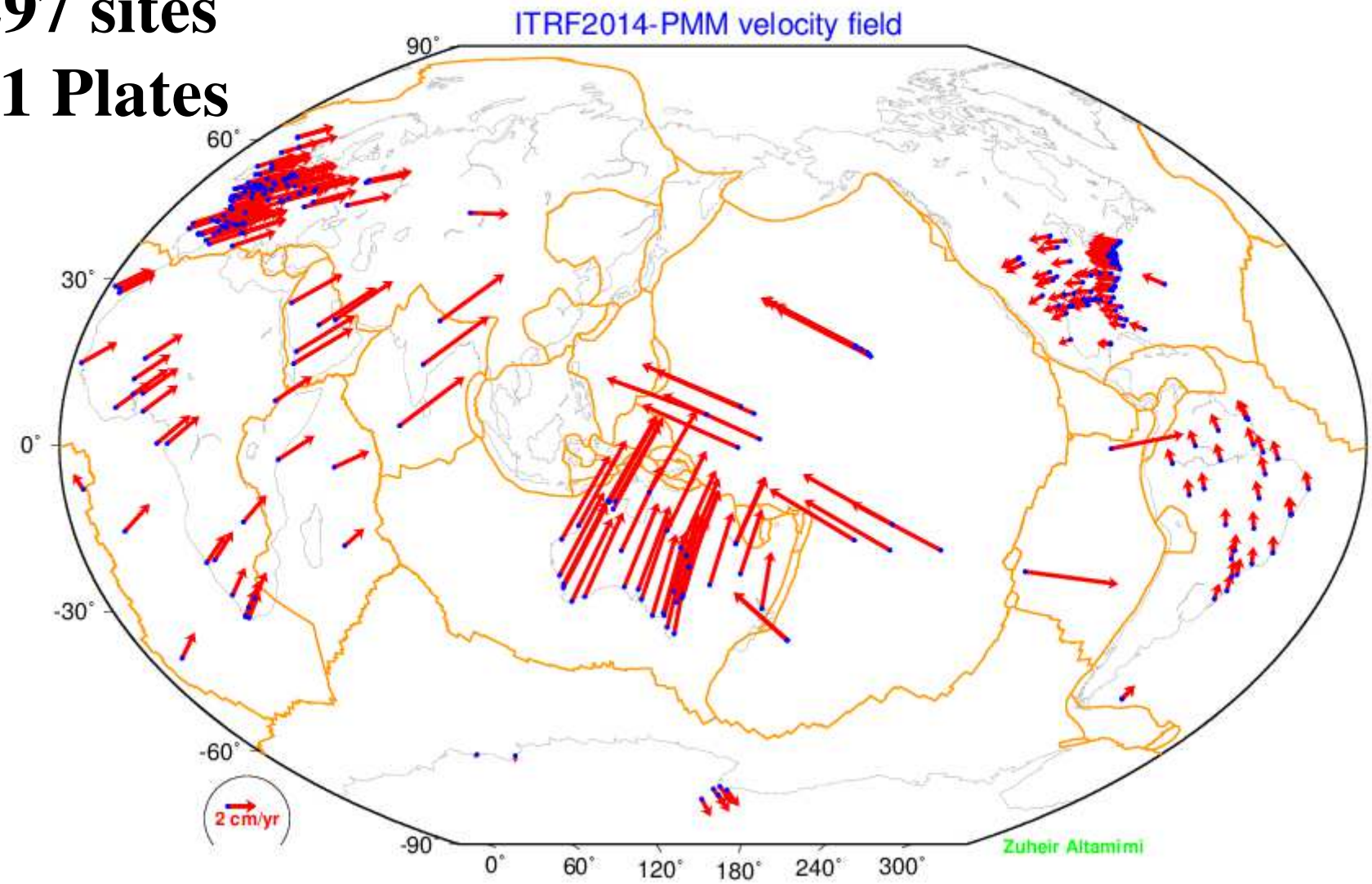
829 sites



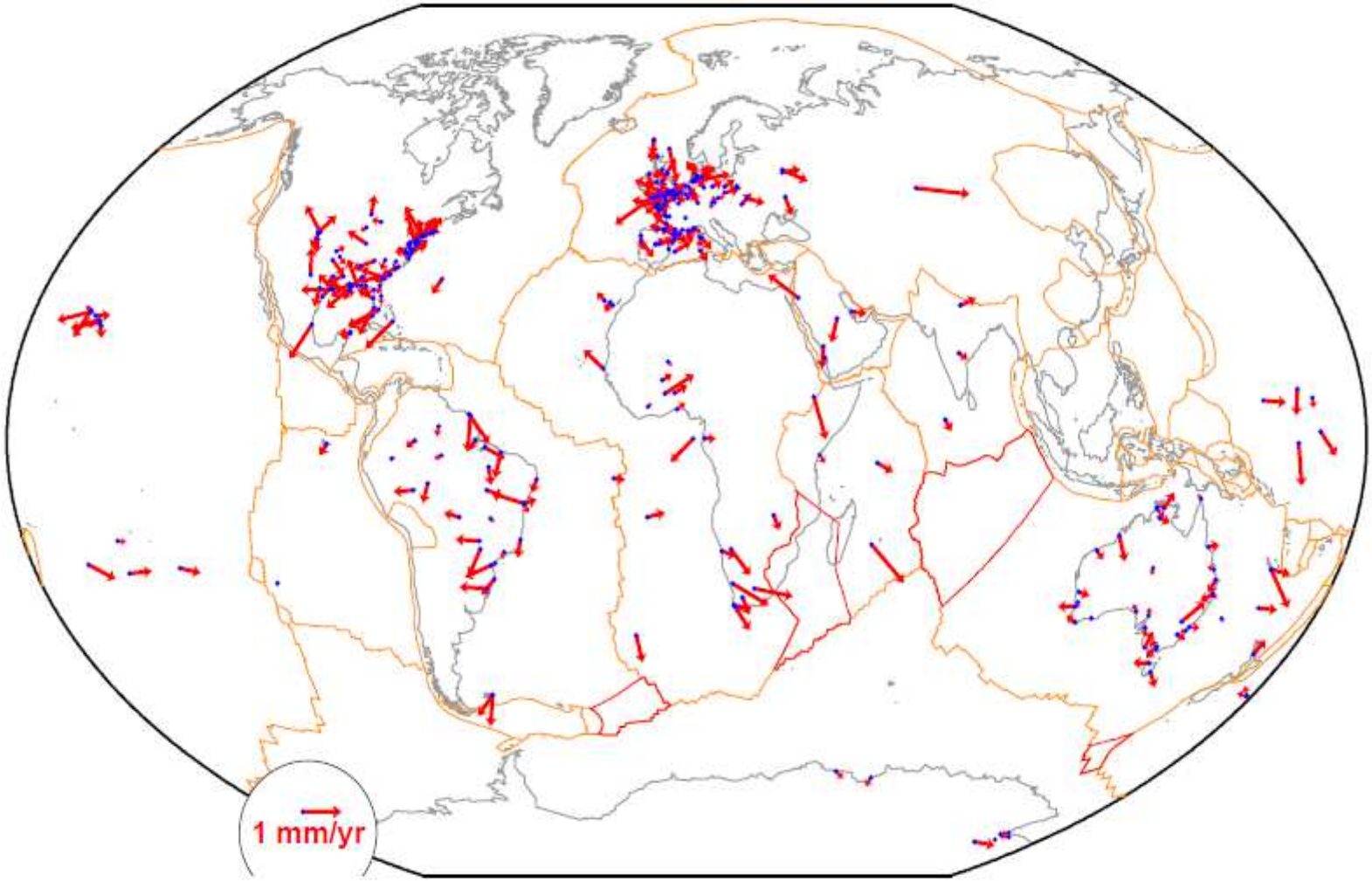
Retained sites (all IGS sites) after selection

297 sites

11 Plates

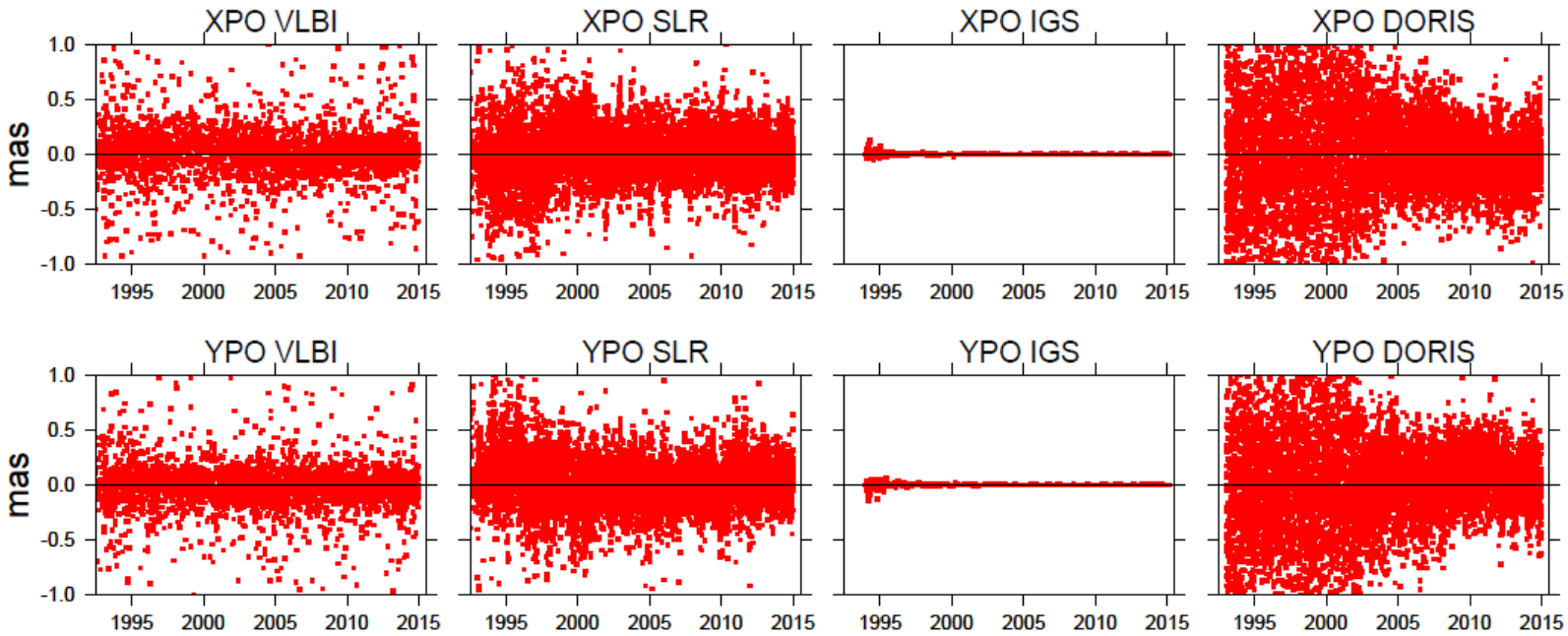


Selection of the final model : Residuals



WRMS of fit : E: 0.26 mm/yr
N: 0.26

4. ITRF2014 Polar Motion: Residuals

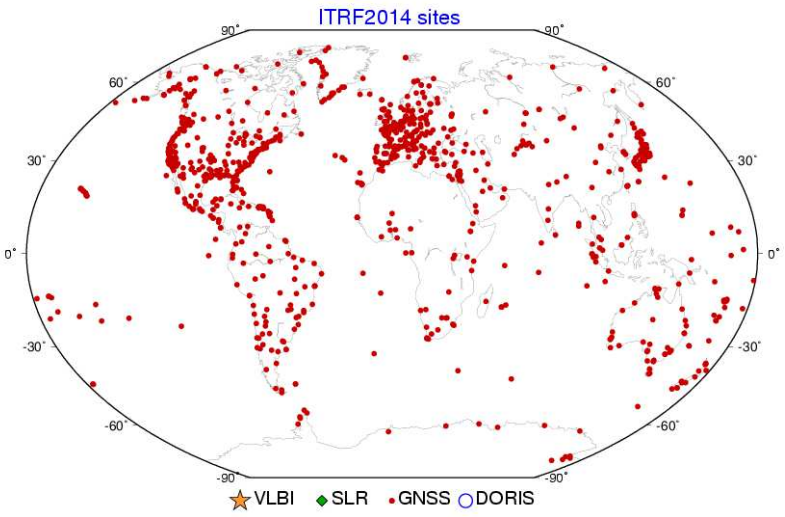


5. ITRF access & densification through the IGS Products

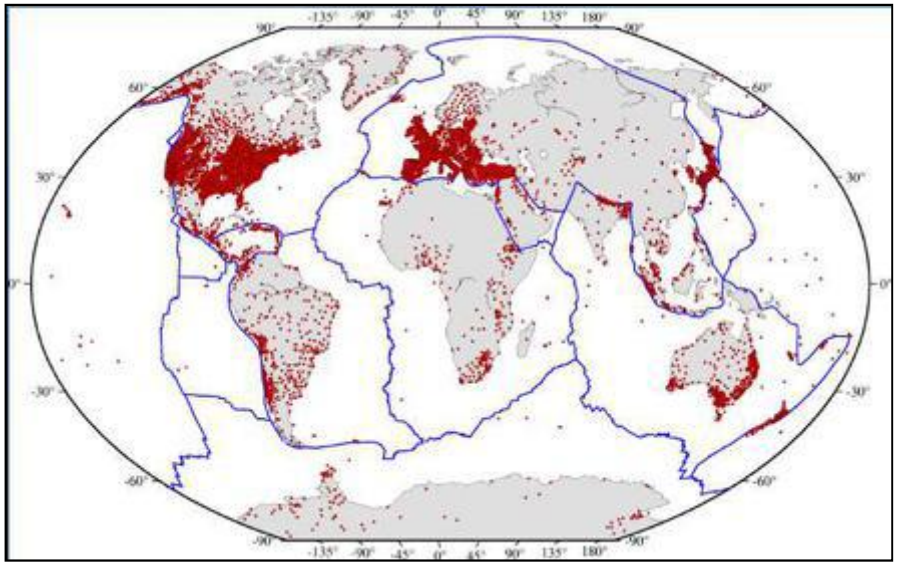
Some Facts

- **GNSS Exponential Data Explosion**
  - **Local, National & Reginal GNSS networks**

- **Using IGS Products provides Universal access to and densification of the ITRF**



13,400 stations processed by NGL (Blewitt et al., 2015)



ITRF2014:

- **884 GNSS Sites**
- **Facilitates the alignment of the GNSS-based frames to the ITRF**

More than 80% of National RFs are aligned to the ITRF (source: UN-GGIM GGRF questionnaire)

Conclusion

The fundamental contribution of the IGS to:

1. **Reinforcing the ITRF frame definition (origin, scale & orientation)**
2. **ITRF2014 Post-Seismic Deformation Models**
3. **ITRF2014 Plate Motion Model**
4. **ITRF Polar Motion**
5. **ITRF Access & densification through the IGS Products**