ITRF2014
Et la prise en compte des mouvements non linéaires

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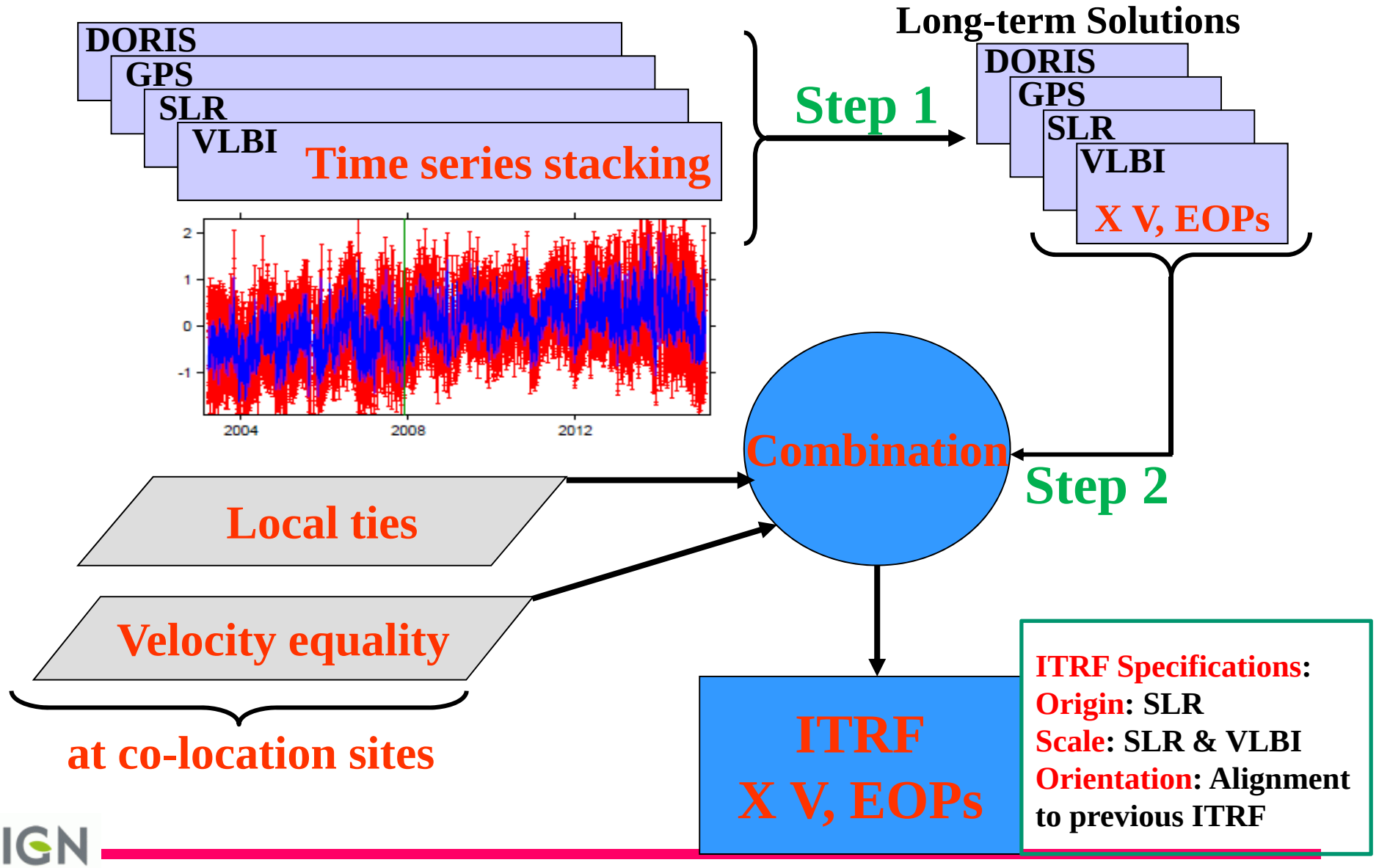
Key Points

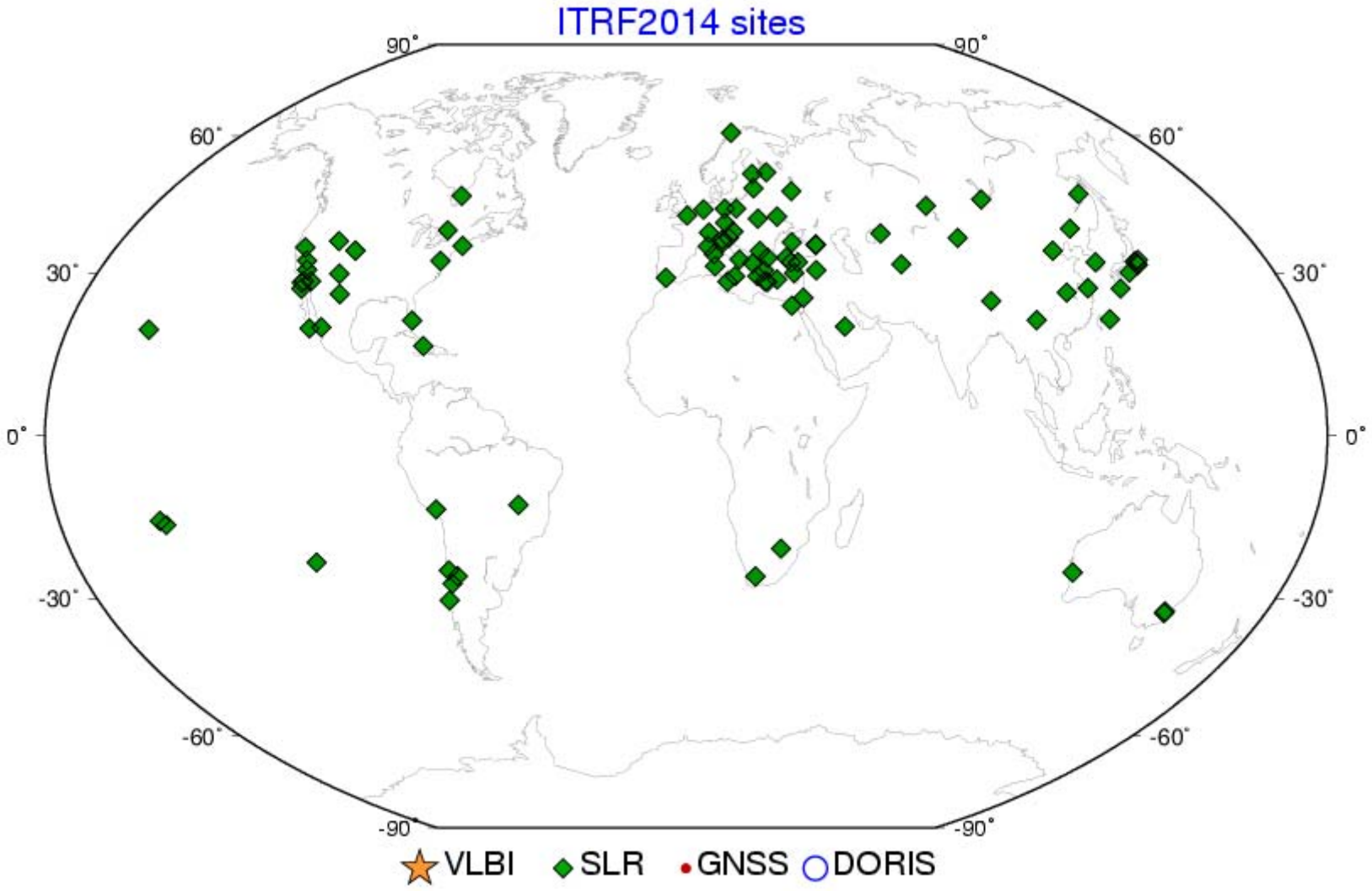
- **ITRF2014 Network**
- **Modelling of non-linear station motions**
  - **Periodic signals: annual, semi-annual**
  - **Post-Seismic Deformation (PSD)**
- **ITRF2014 frame definition : Origin, Scale, Orientation**
- **ITRF2014 horizontal & vertical velocity fields**

ITRF Construction

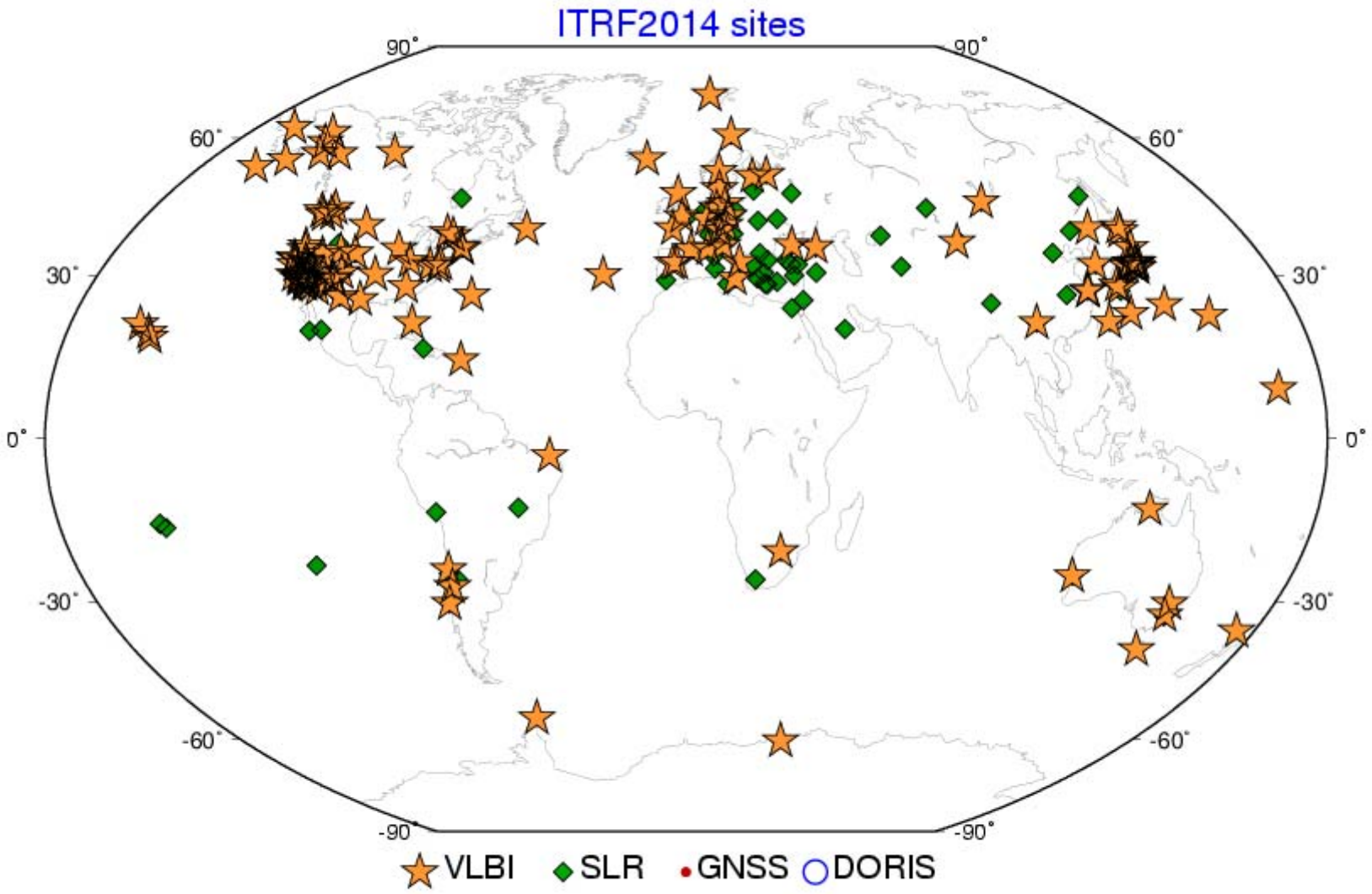


ITRF2014 Network

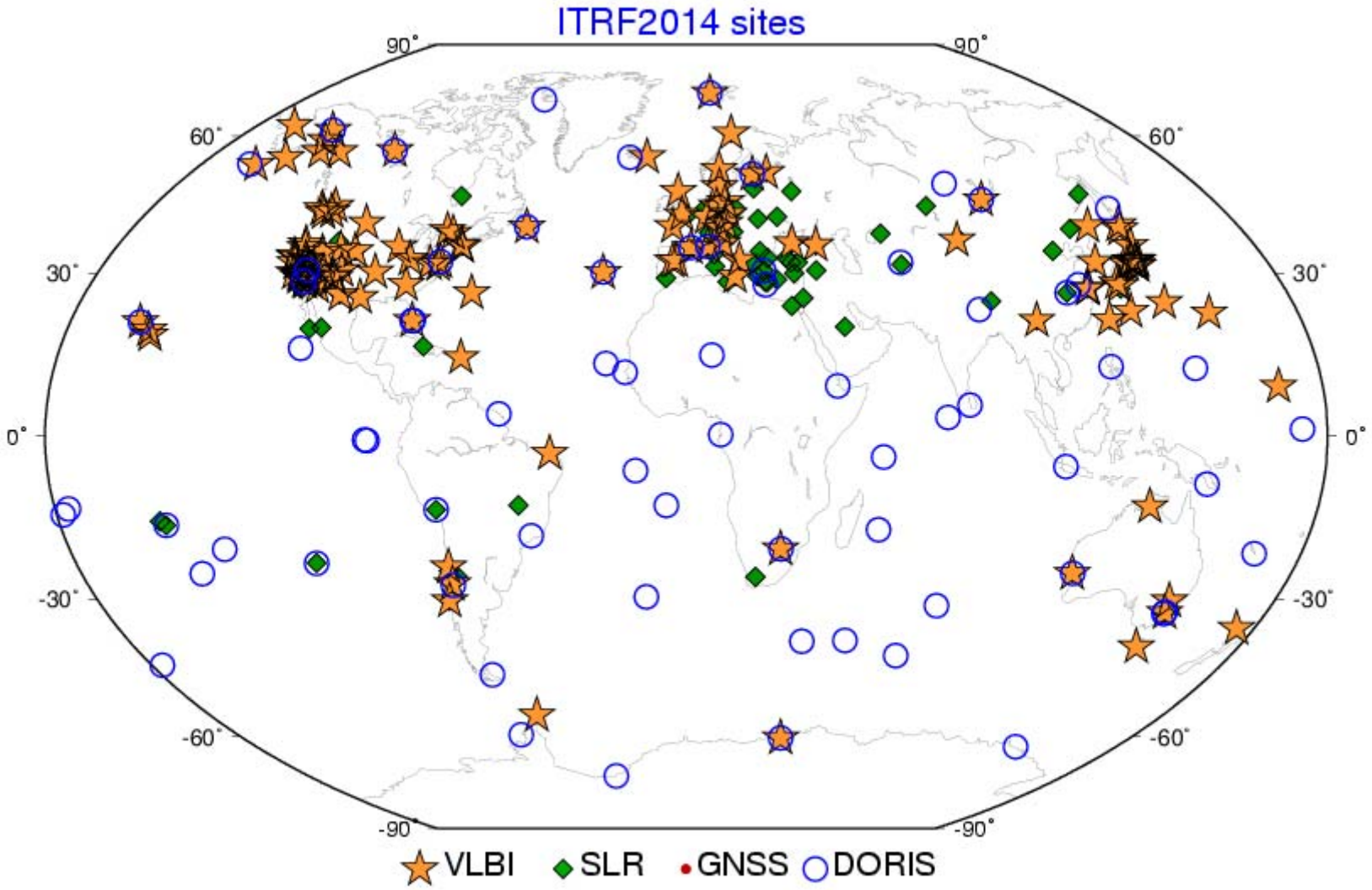
ITRF2014 Network : SLR



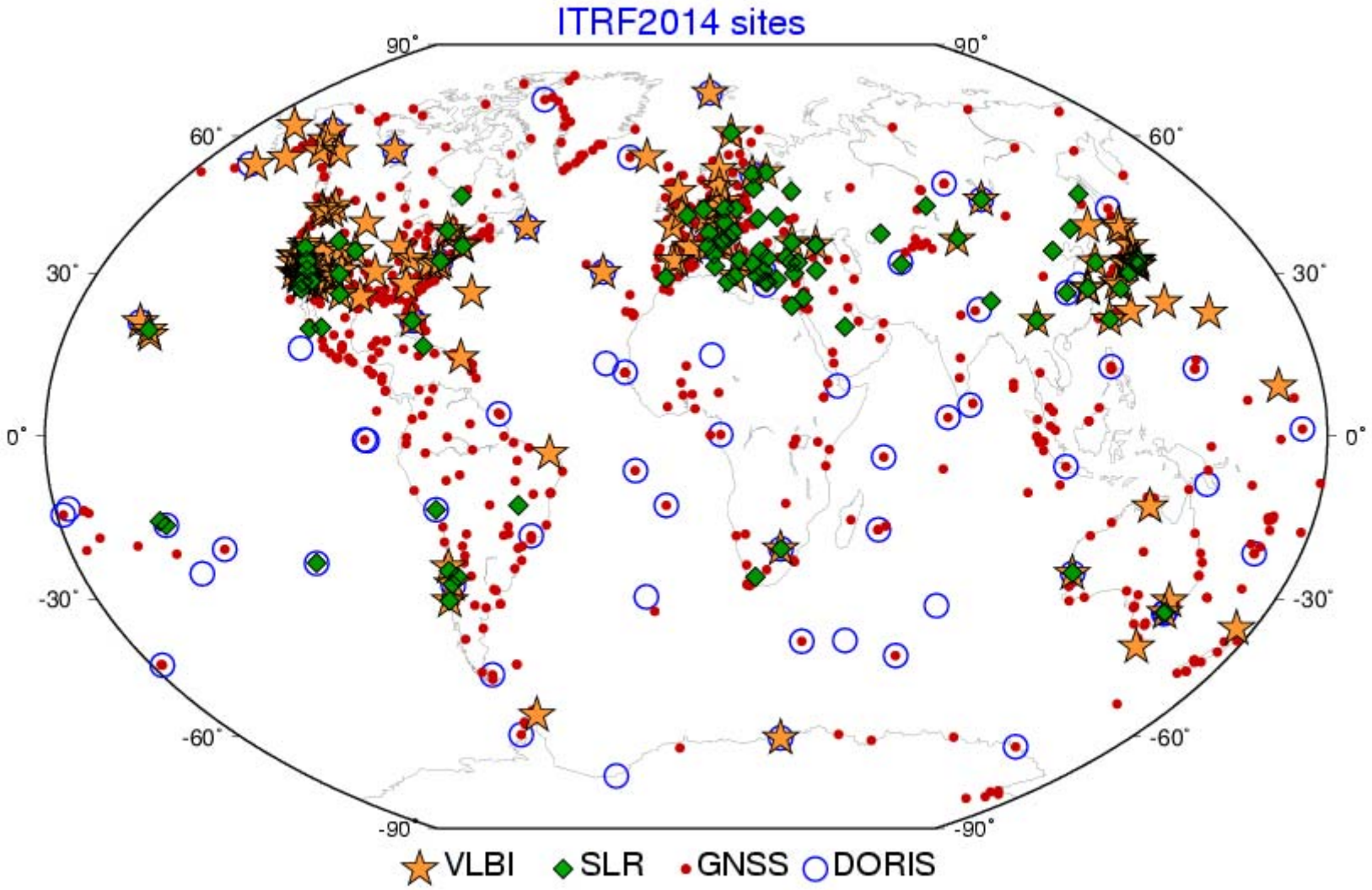
ITRF2014 Network: VLBI



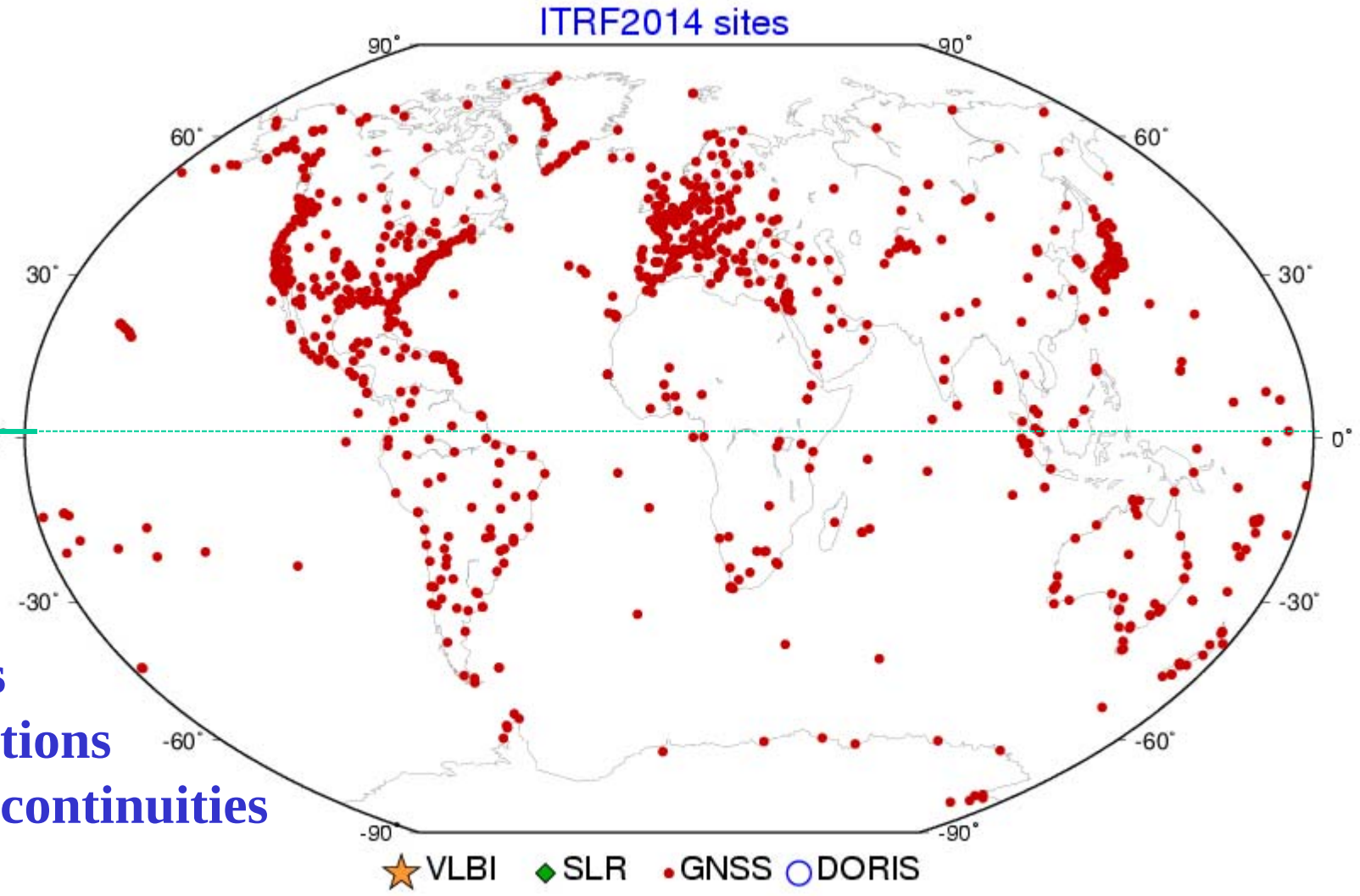
ITRF2014 Network: DORIS



ITRF2014 Network



ITRF2014: GNSS



Site #

696

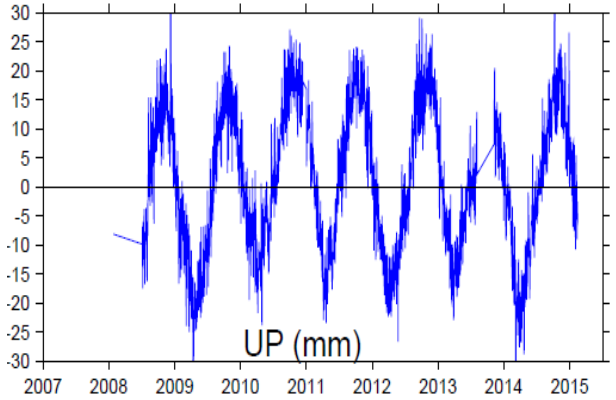
188

884 sites

1054 stations

1882 discontinuities

Periodic Signals

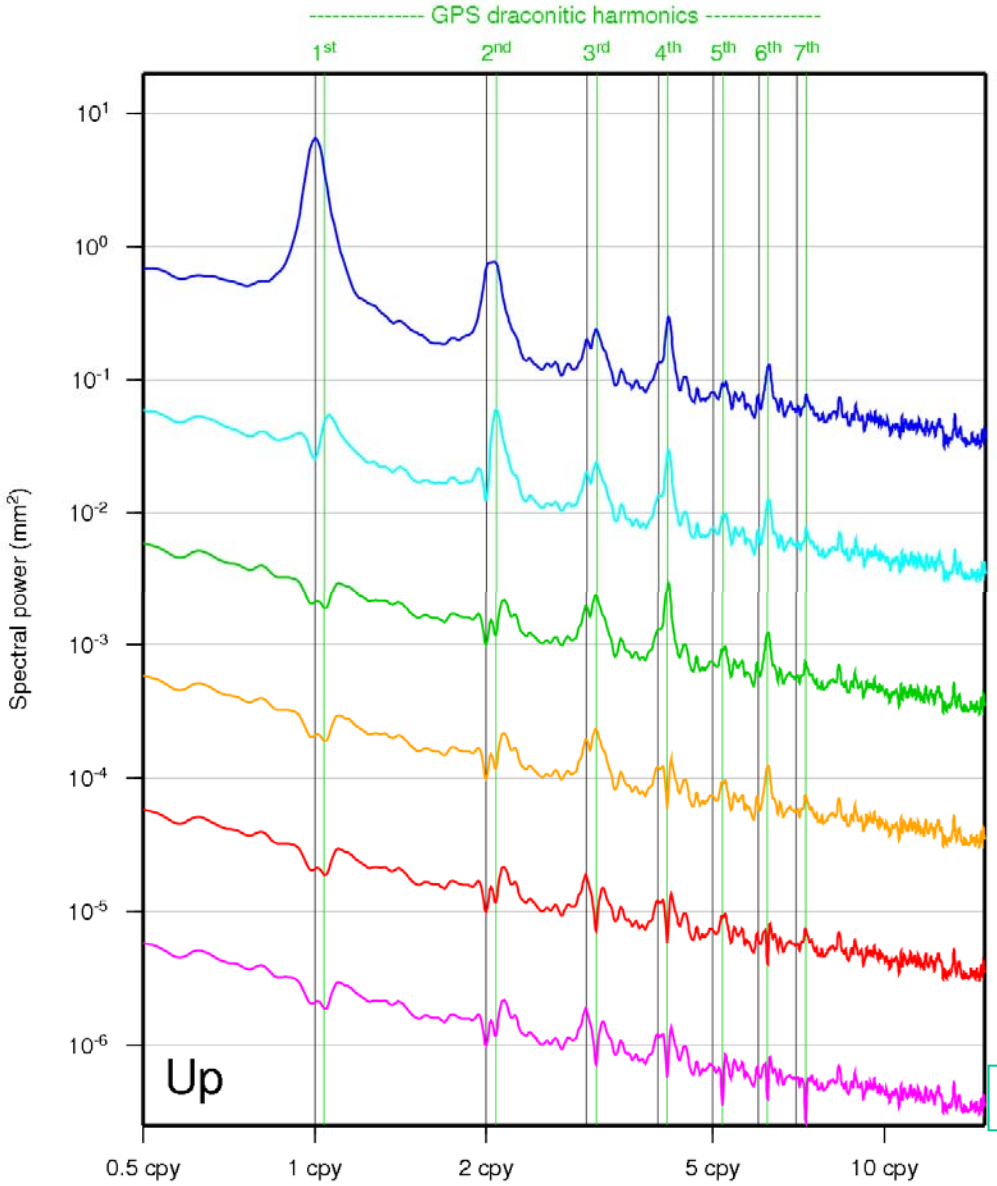


- **Loading effects:**
  - **Atmosphere**
  - **Terrestrial water (Hydrology)**
  - **Ocean circulation**

  ==> Annual, semi-annual, inter-annual, but also short periods (e.g. daily) variations

- **Technique systematic errors, e.g. GPS draconitic year (351.4 days)**

IGS station position Up residuals: stacked periodogram



Standard solution

Annual + SemiA

(+1st +2nd dracs)

(+1st +2nd +4th dracs)

(+3rd+6th dracs)

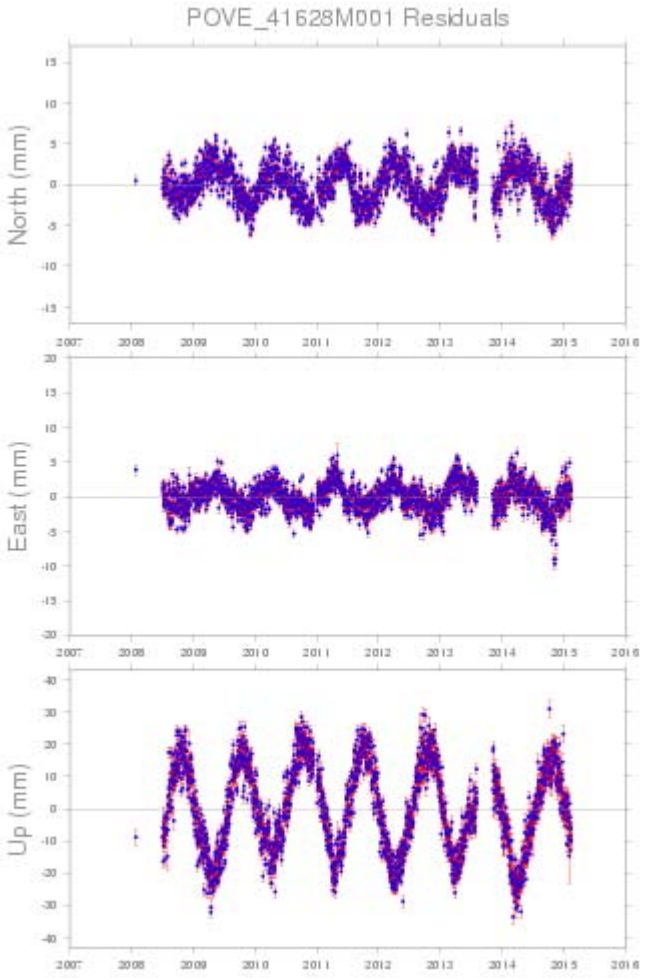
Annual + SemiA + 7 dracs

Periodic Signals

Annual & semi-annual terms estimated, using:

$$\sum \boldsymbol{a}\cos \boldsymbol{\omega t} + \boldsymbol{b}\sin \boldsymbol{\omega t}$$

Removing draconitics in addition to annuals and semi-annuals has no impact on site velocities



Periodic Signals

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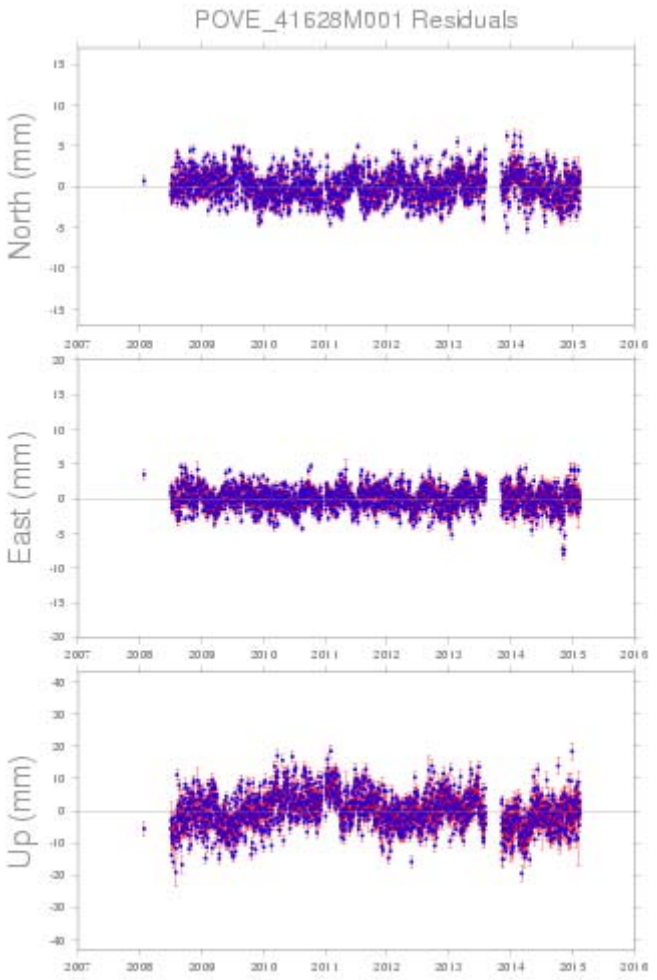
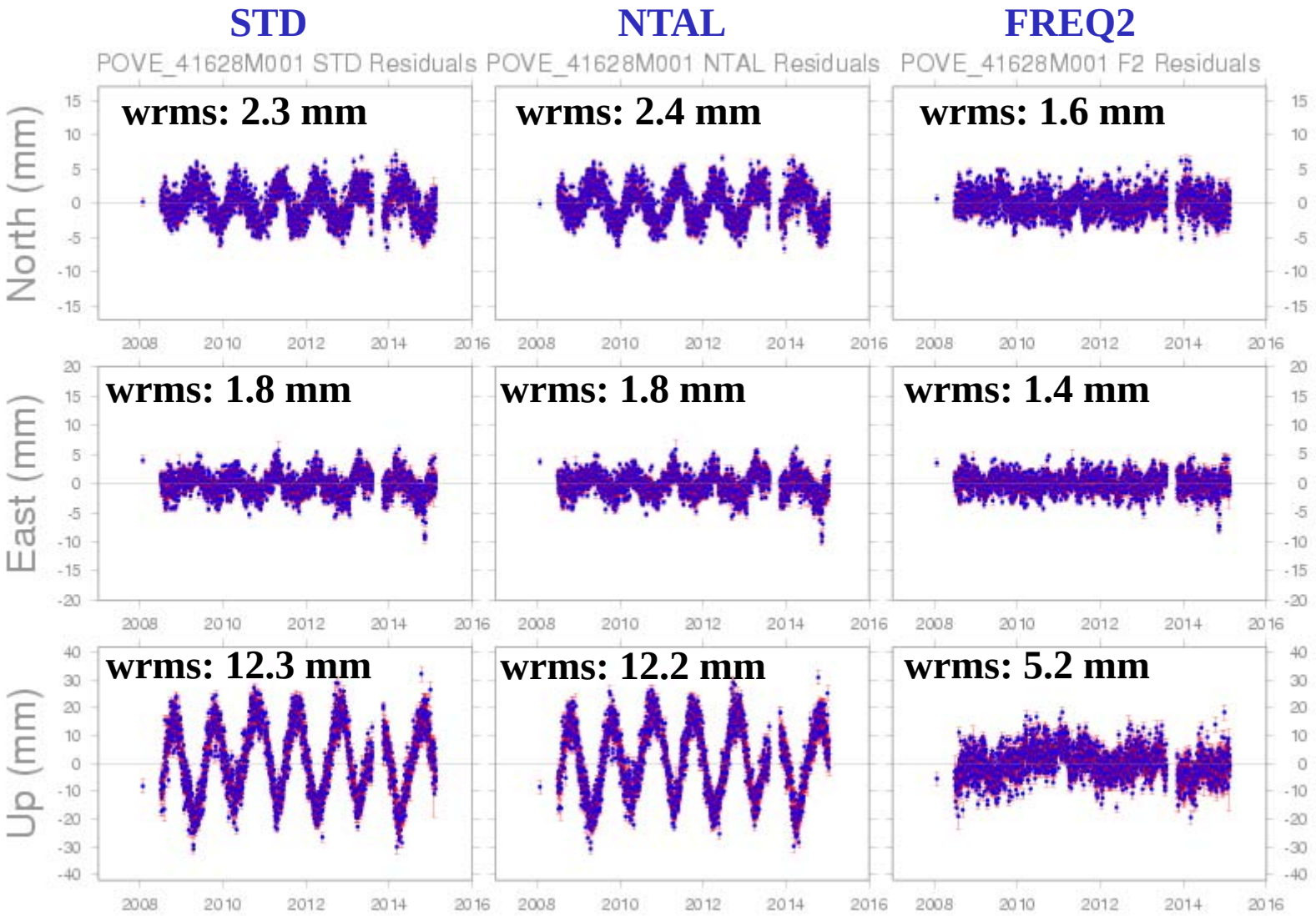
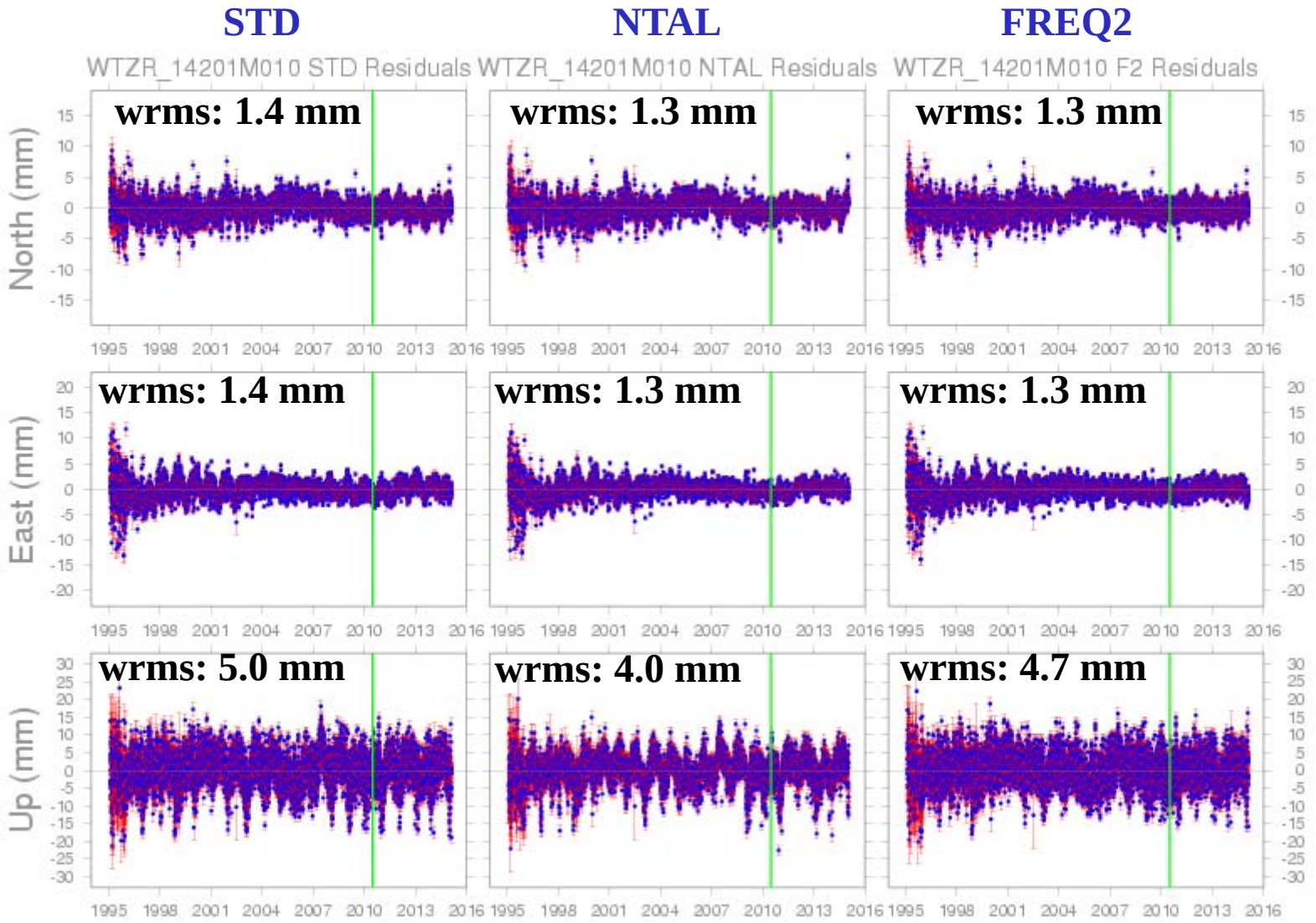


Estimating seasonal signals
vs
applying non-tidal atmospheric loading (NTAL) model ?

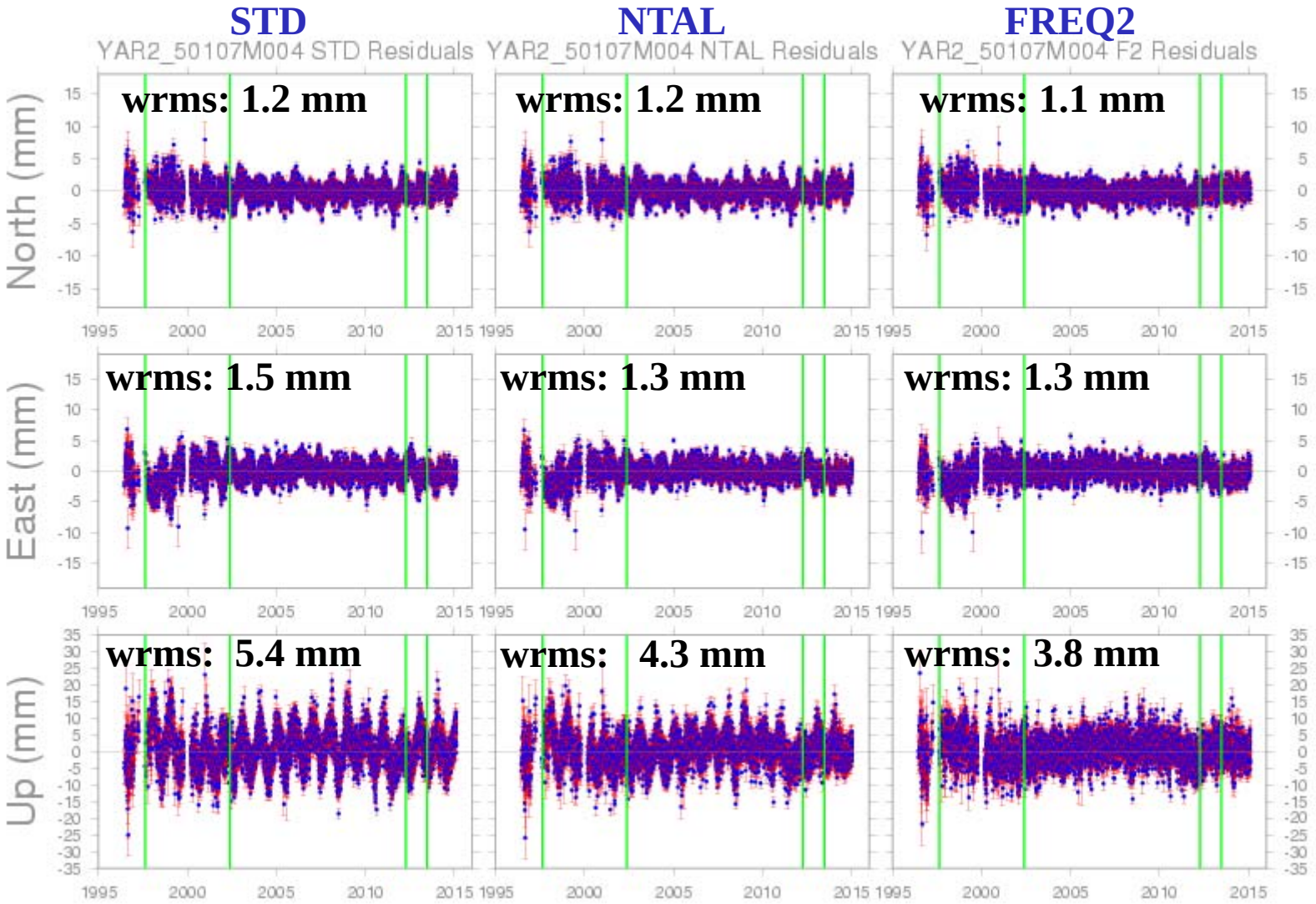
POVE (Brazil) Residuals



Wettzell (Germany) Residuals

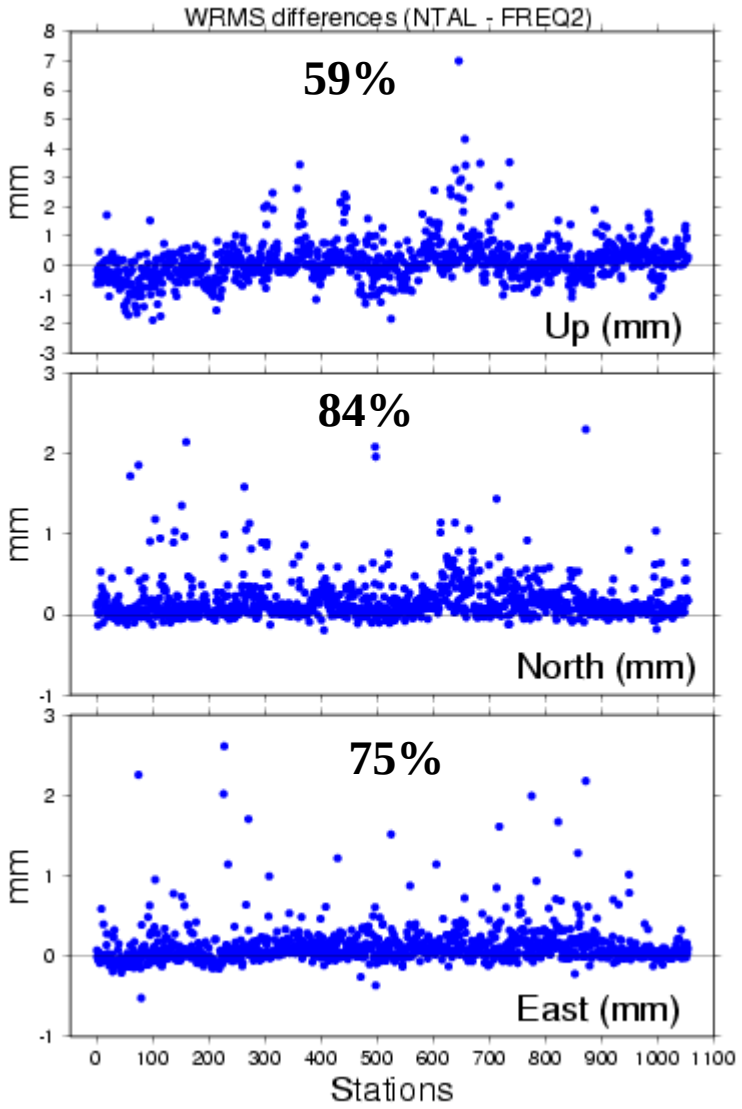


Yarragadee (Australia) Residuals

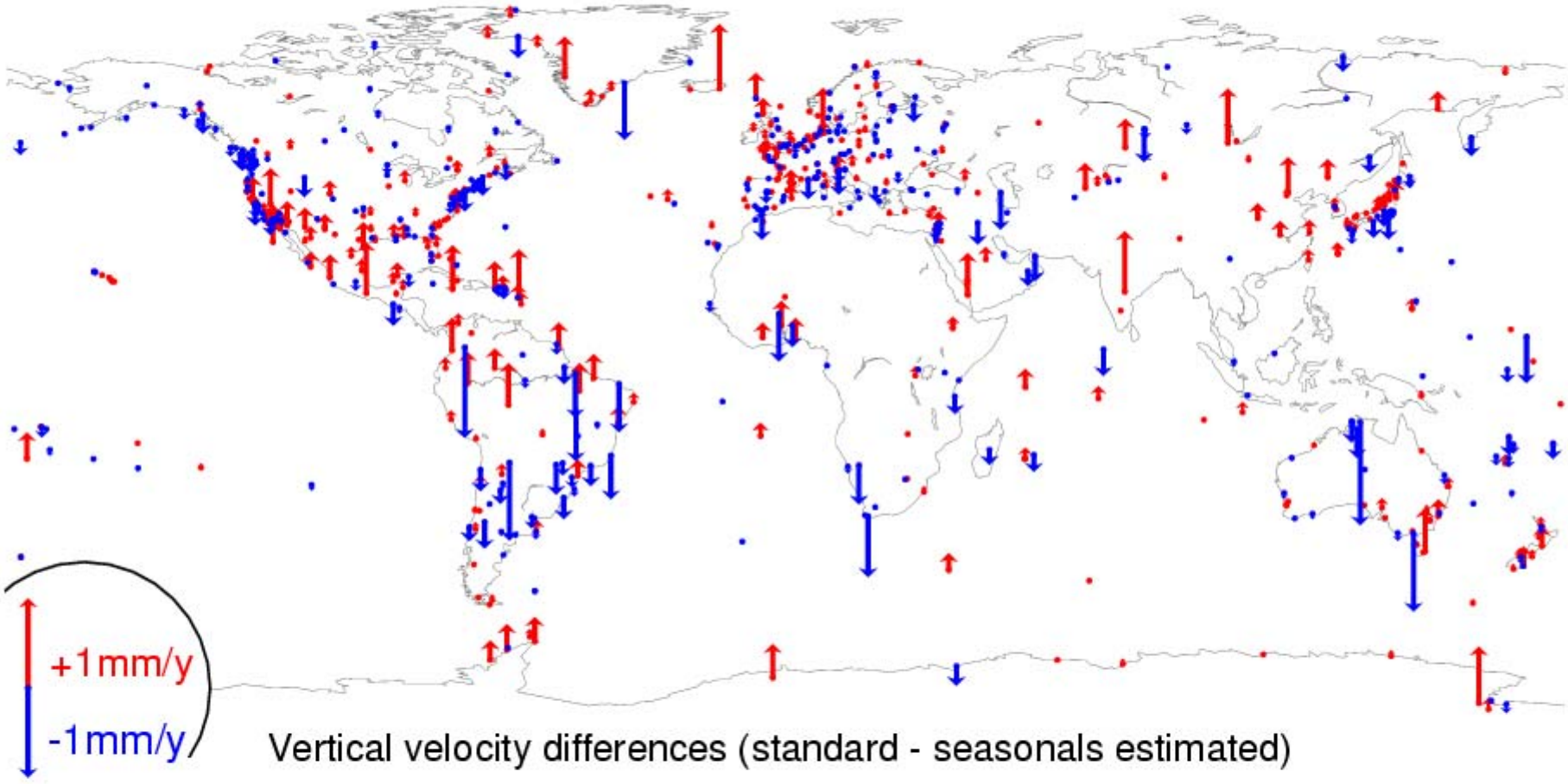


Station WRMS Diffs (NTAL – F2)

- **Positive values mean better performance for Seasonal terms estimation**
- **Negative values mean better performance for NTAL**

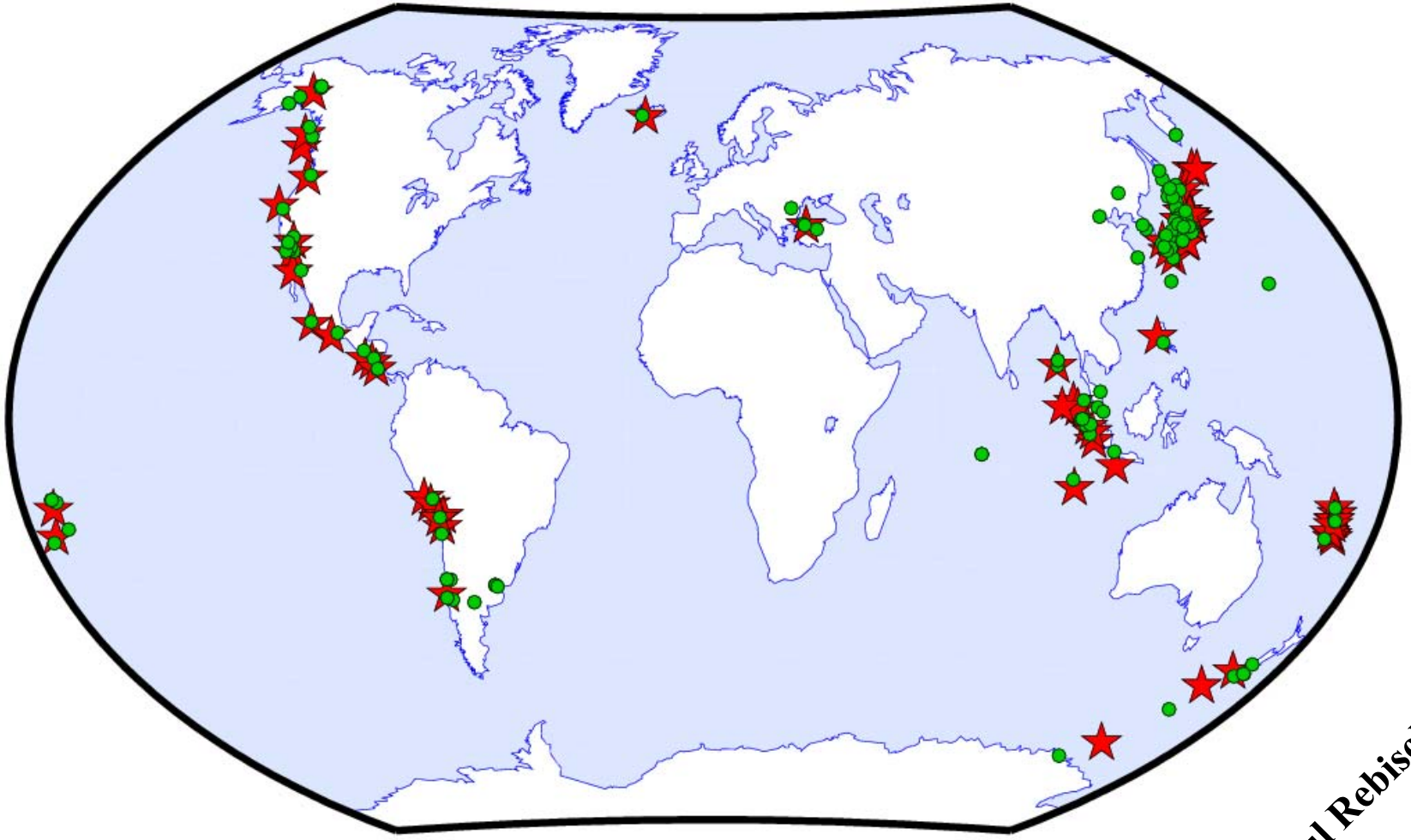


Velocity differences (STD – F2)



Post-Seismic Deformations

ITRF2014 Sites affected by PSD



Red Stars: EQ Epicenters

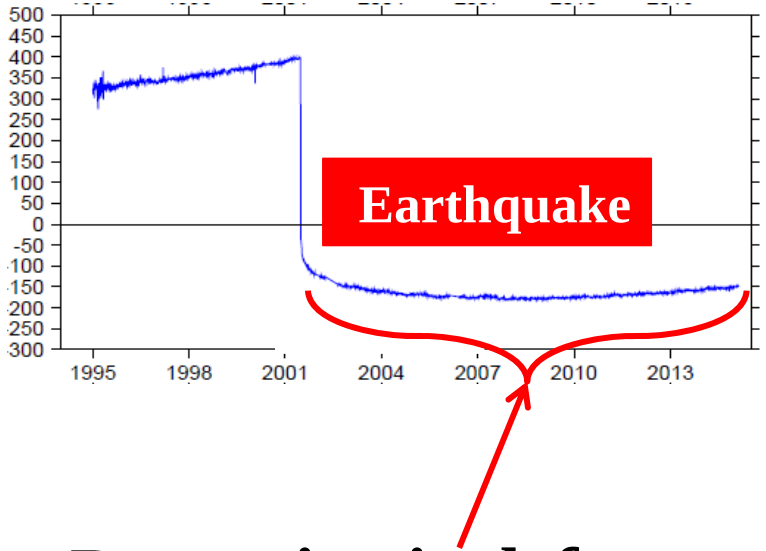
Green circles: ITRF2014 sites

Artist: Paul Rebischung

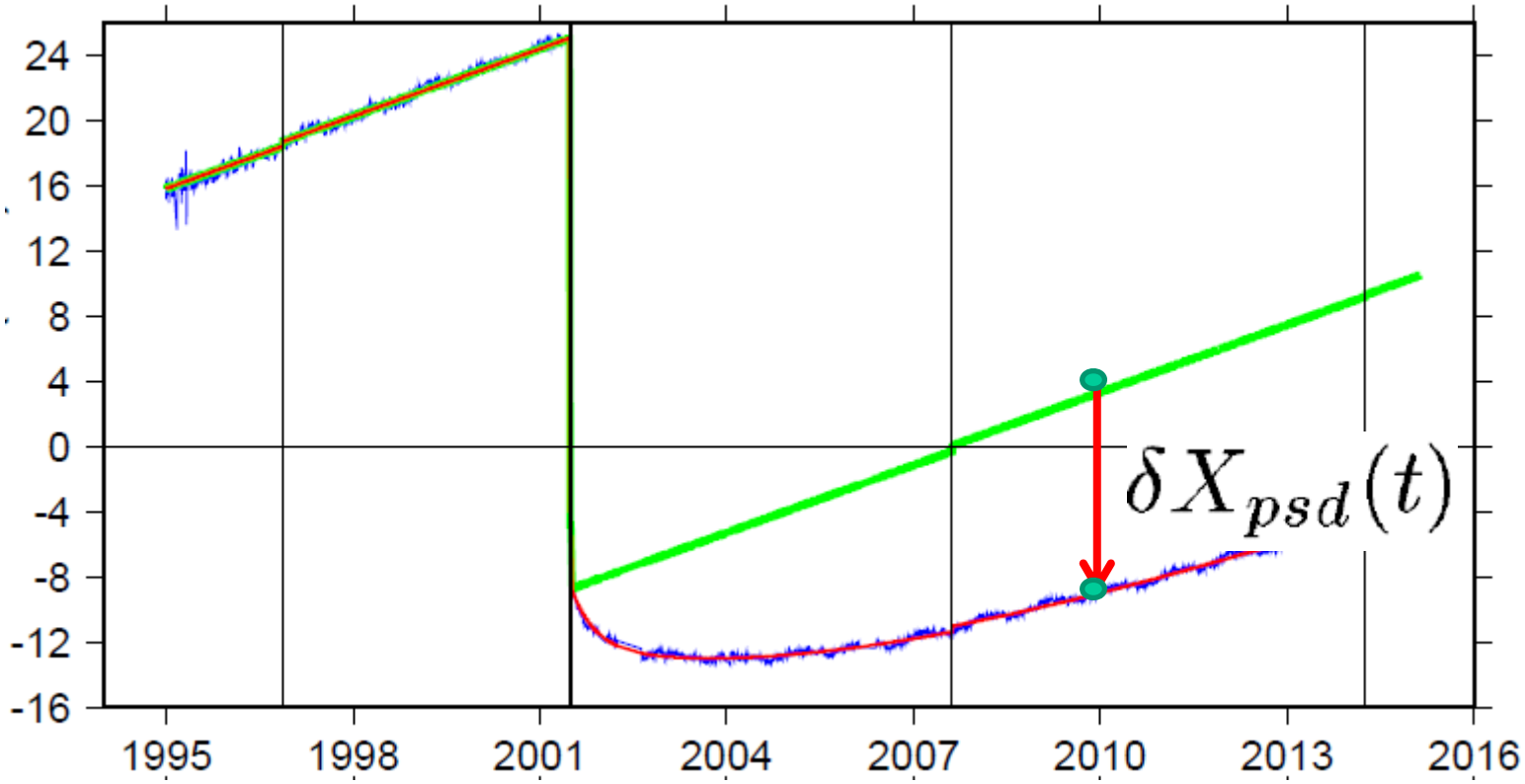
Post-Seismic Deformations

- **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**



PSD Correction



Post seismic parametric models

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

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

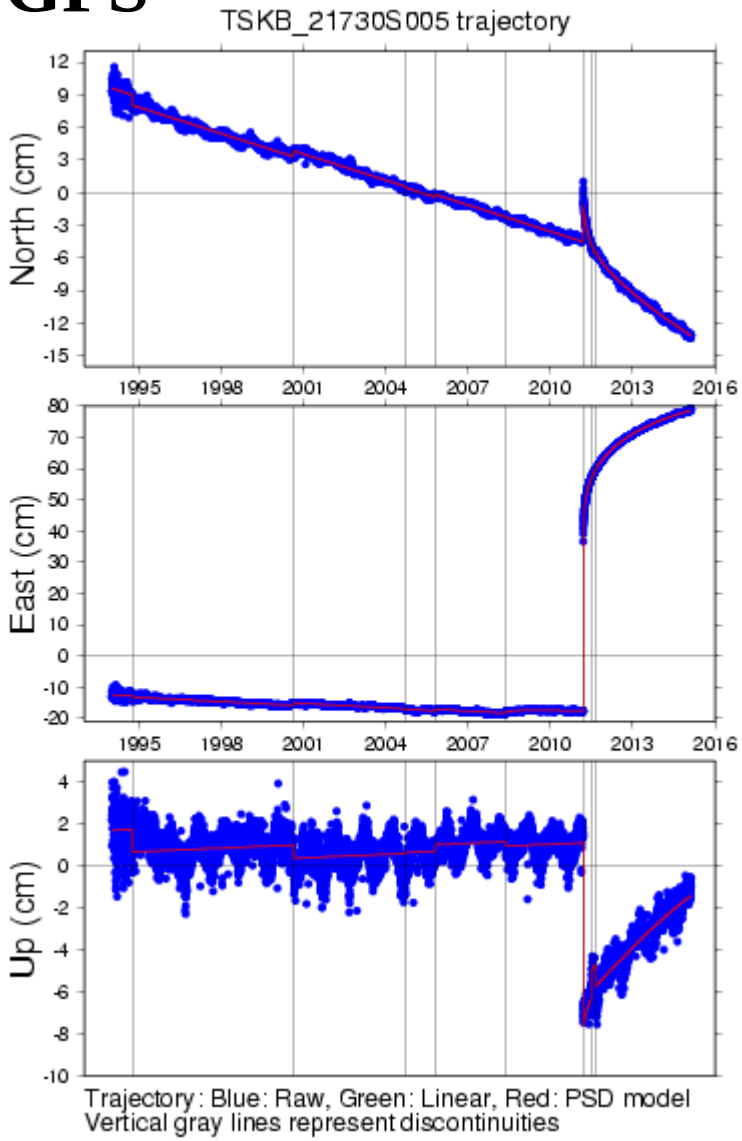
Local Frame

Applications:

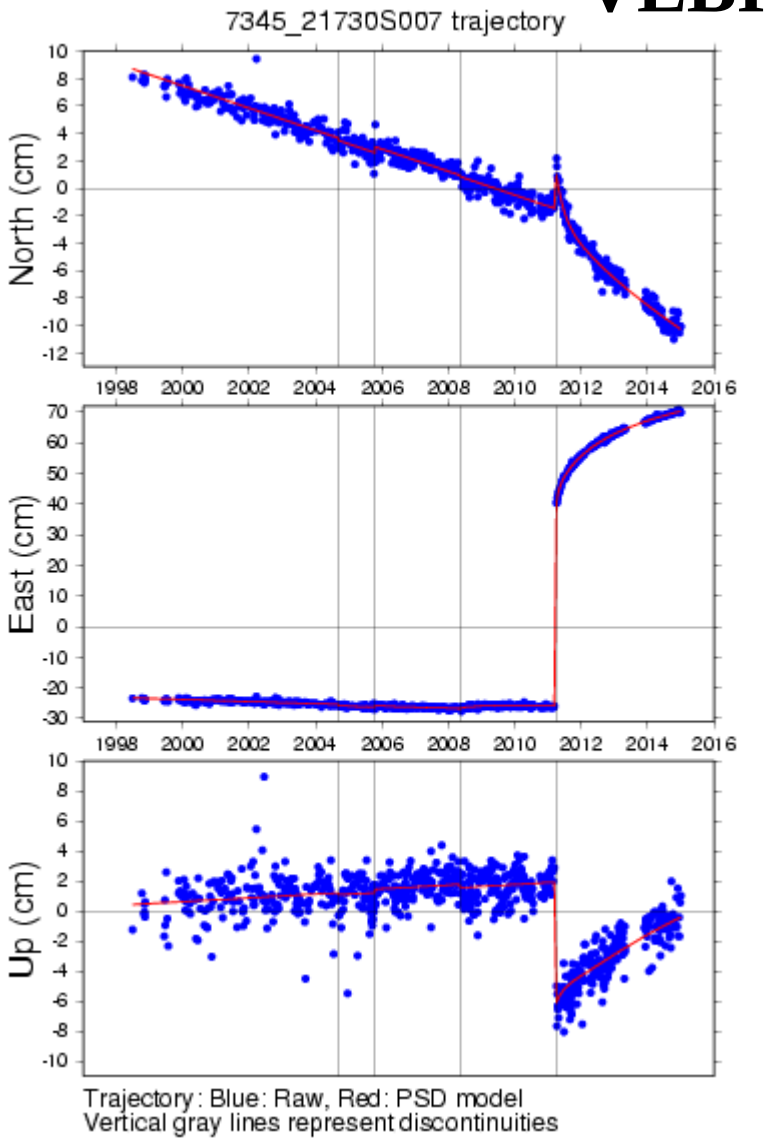
- **Propagate ITRF2014 stations positions from t_0 to t: Add (+)**
- **Apply to a time series before stacking: Subtract (-)**

Tsukuba Trajectory

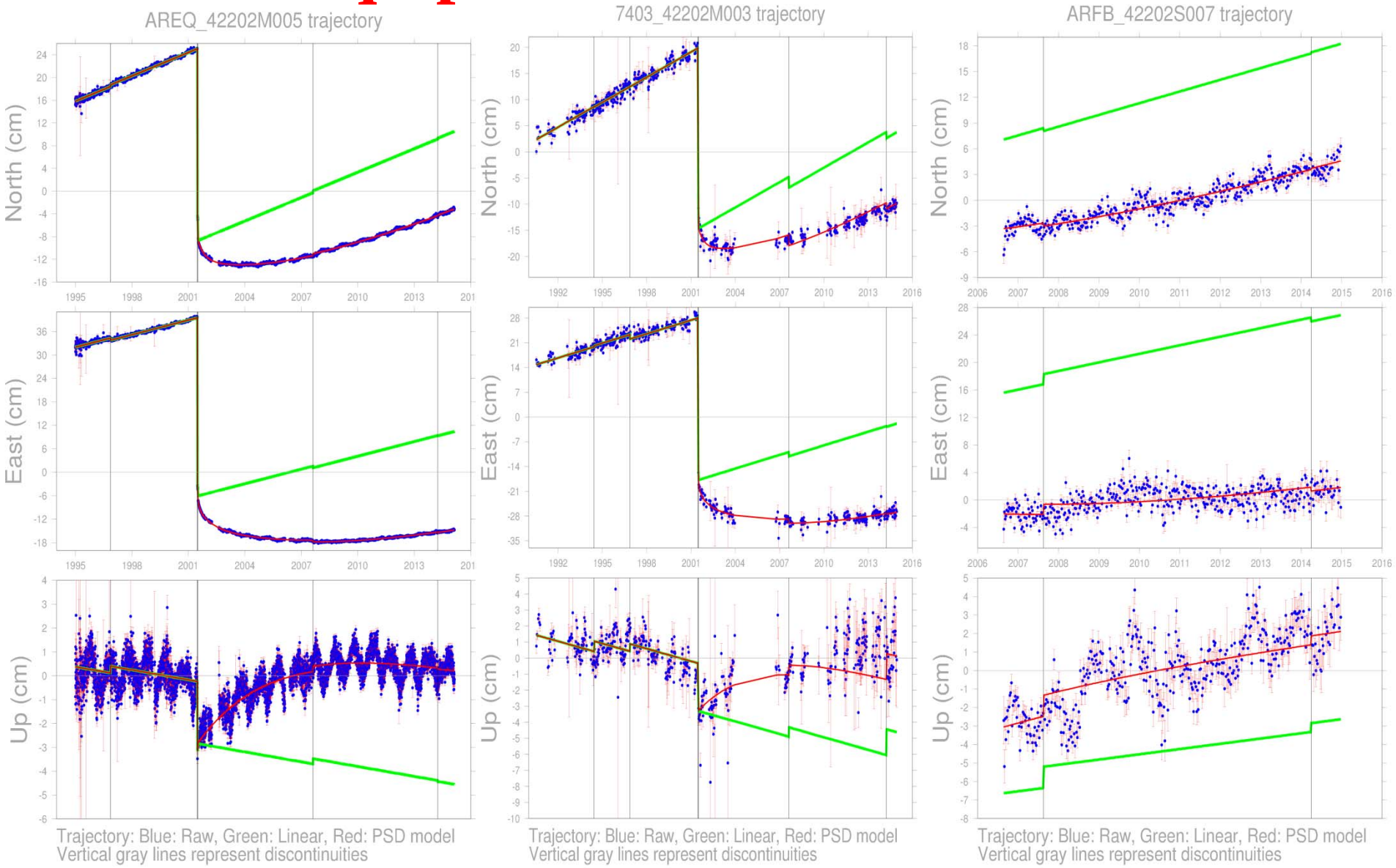
GPS



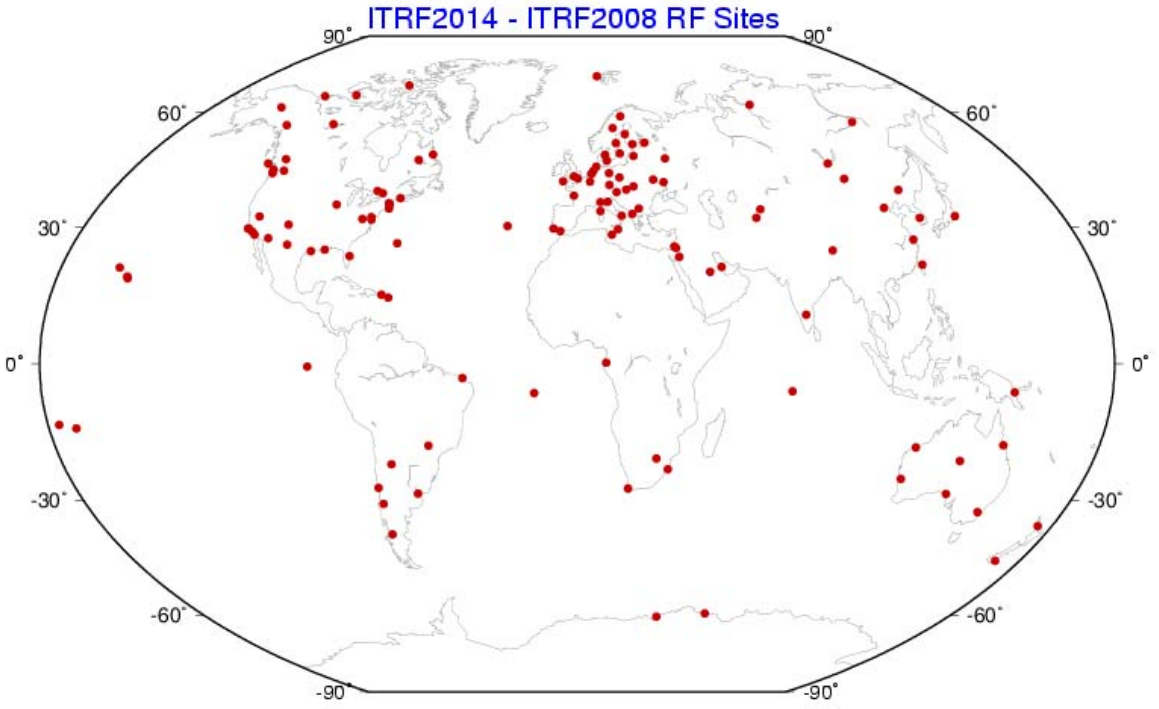
VLBI



Arequipa-GPS, SLR & DORIS



ITRF2014 Reference Frame Specifications

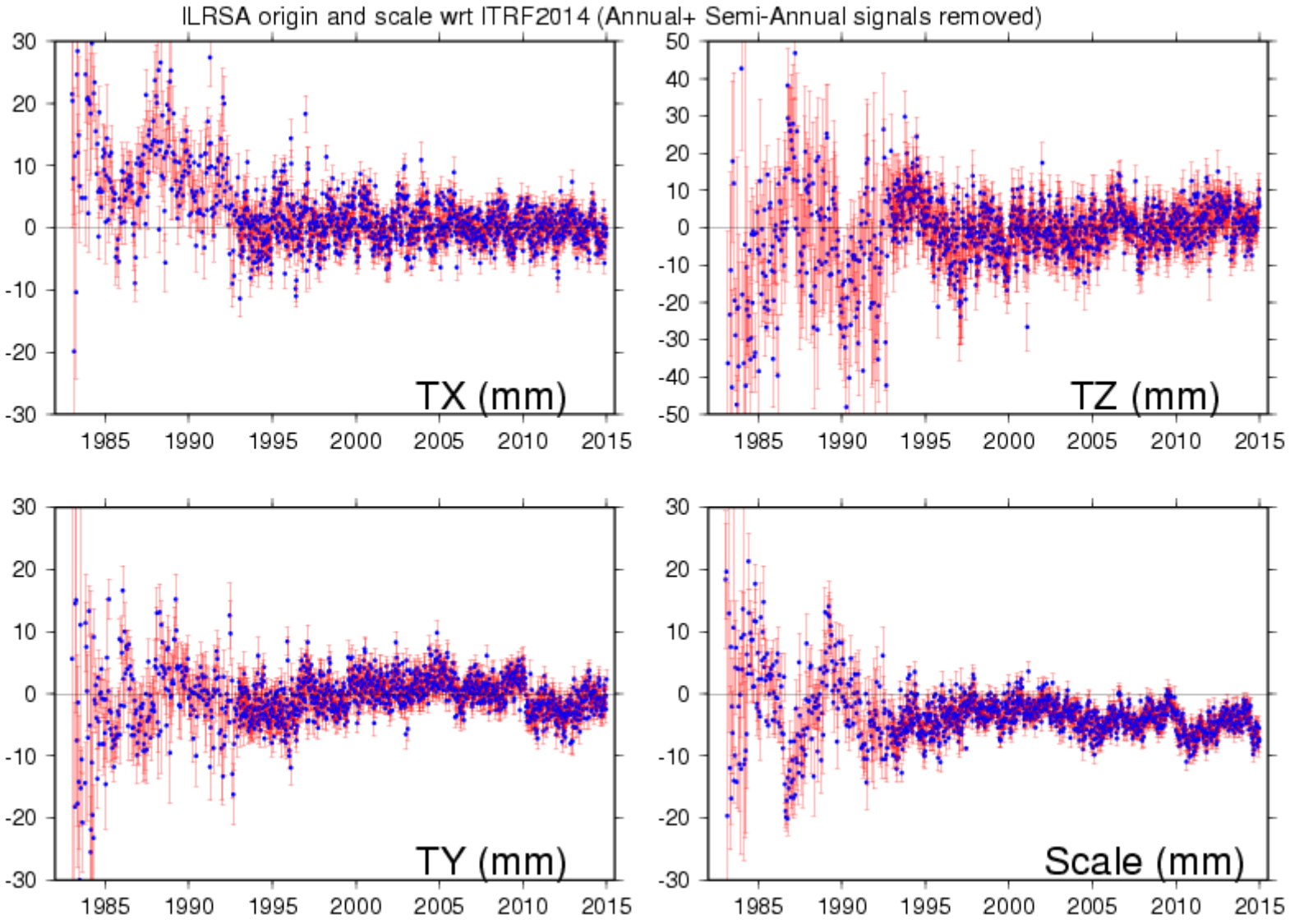


- **Origin: SLR**
- **Scale : Mean of SLR &VLBI**
- **Orientation: Aligned to ITRF2008**

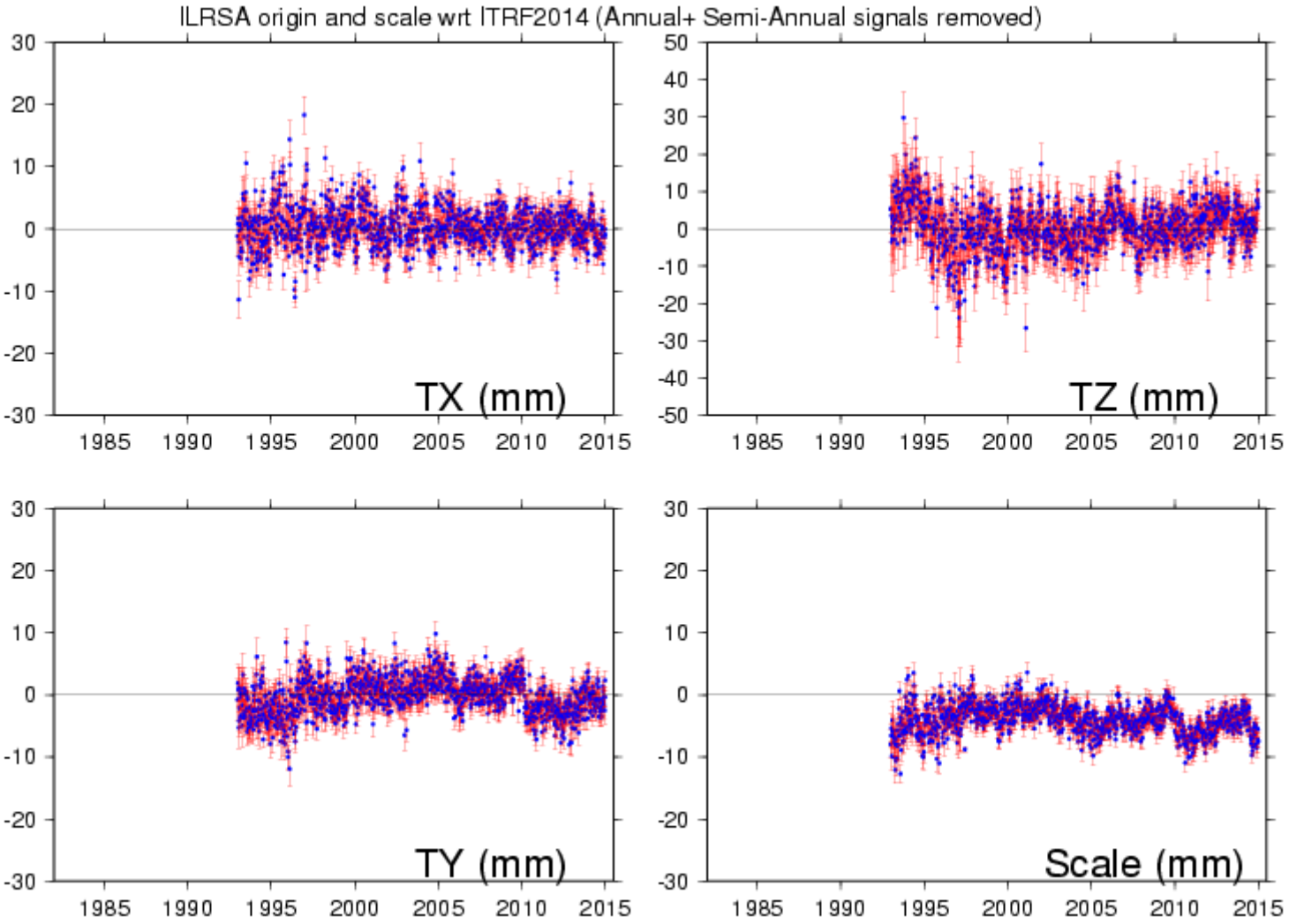
using 127 stations located at 125 sites:

99 at northern hemisphere and 26 at southern hemisphere

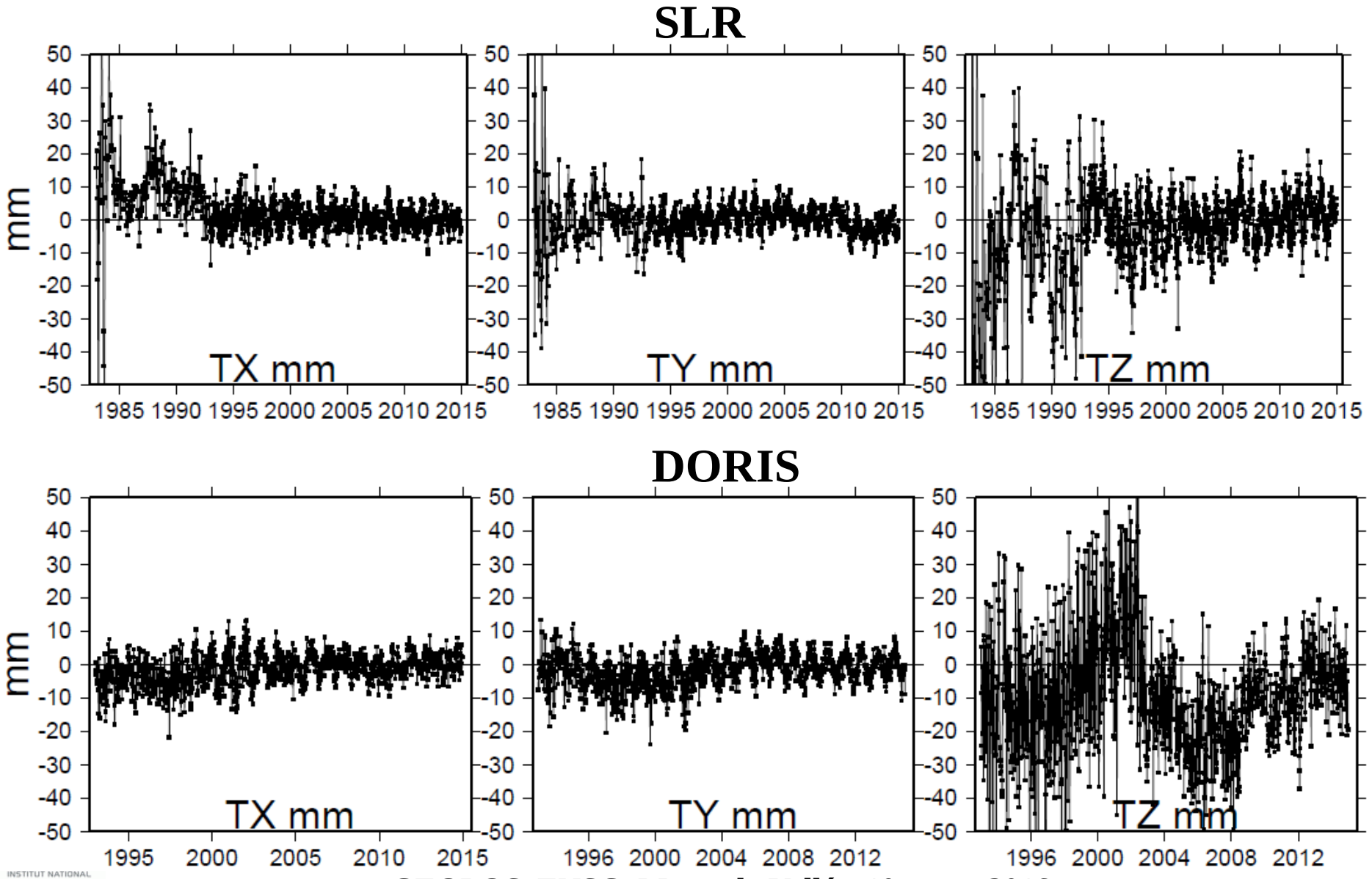
SLR Origin & Scale WRT ITRF2014



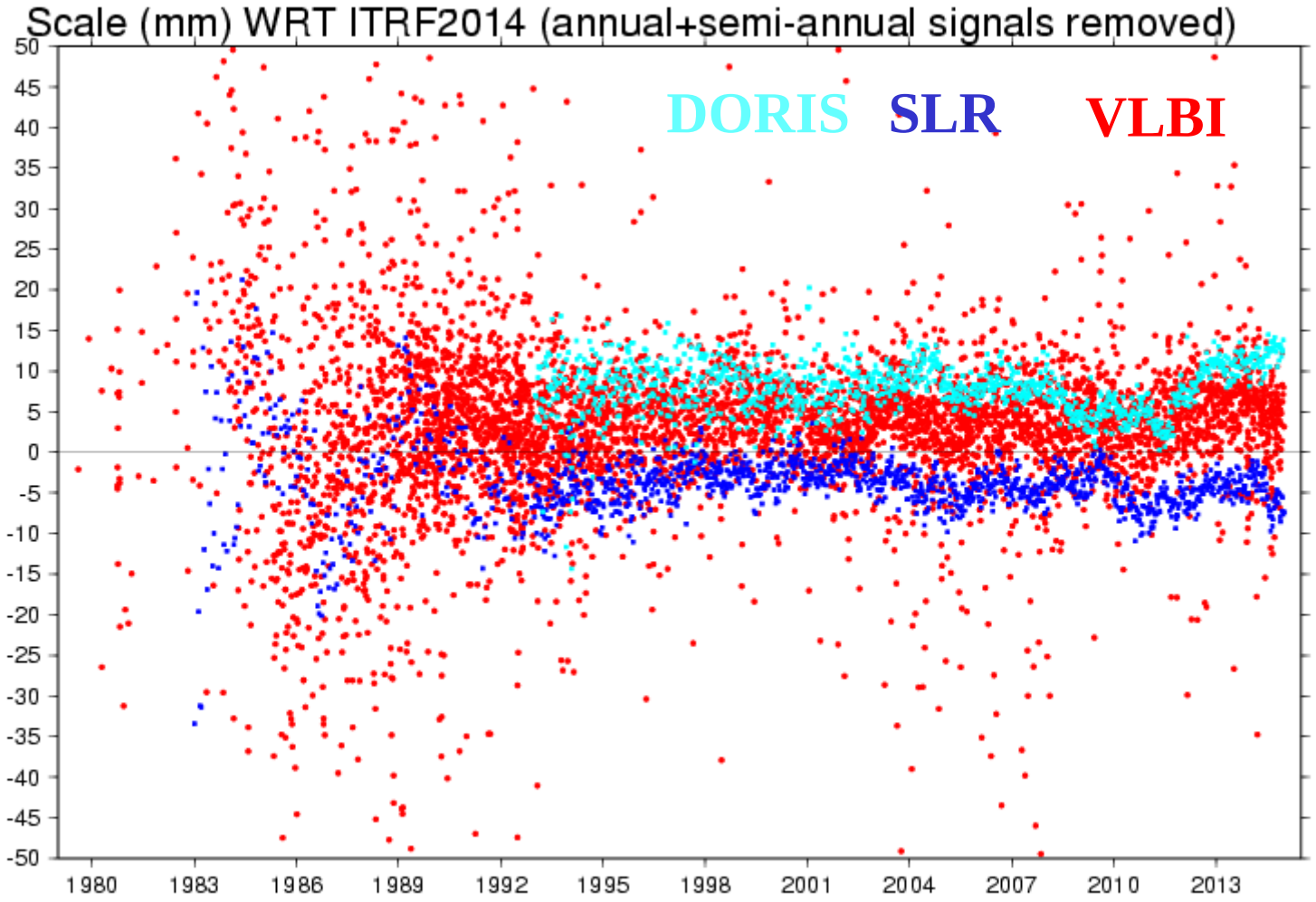
SLR Origin & Scale WRT ITRF2014



SLR & DORIS origin components wrt ITRF2014

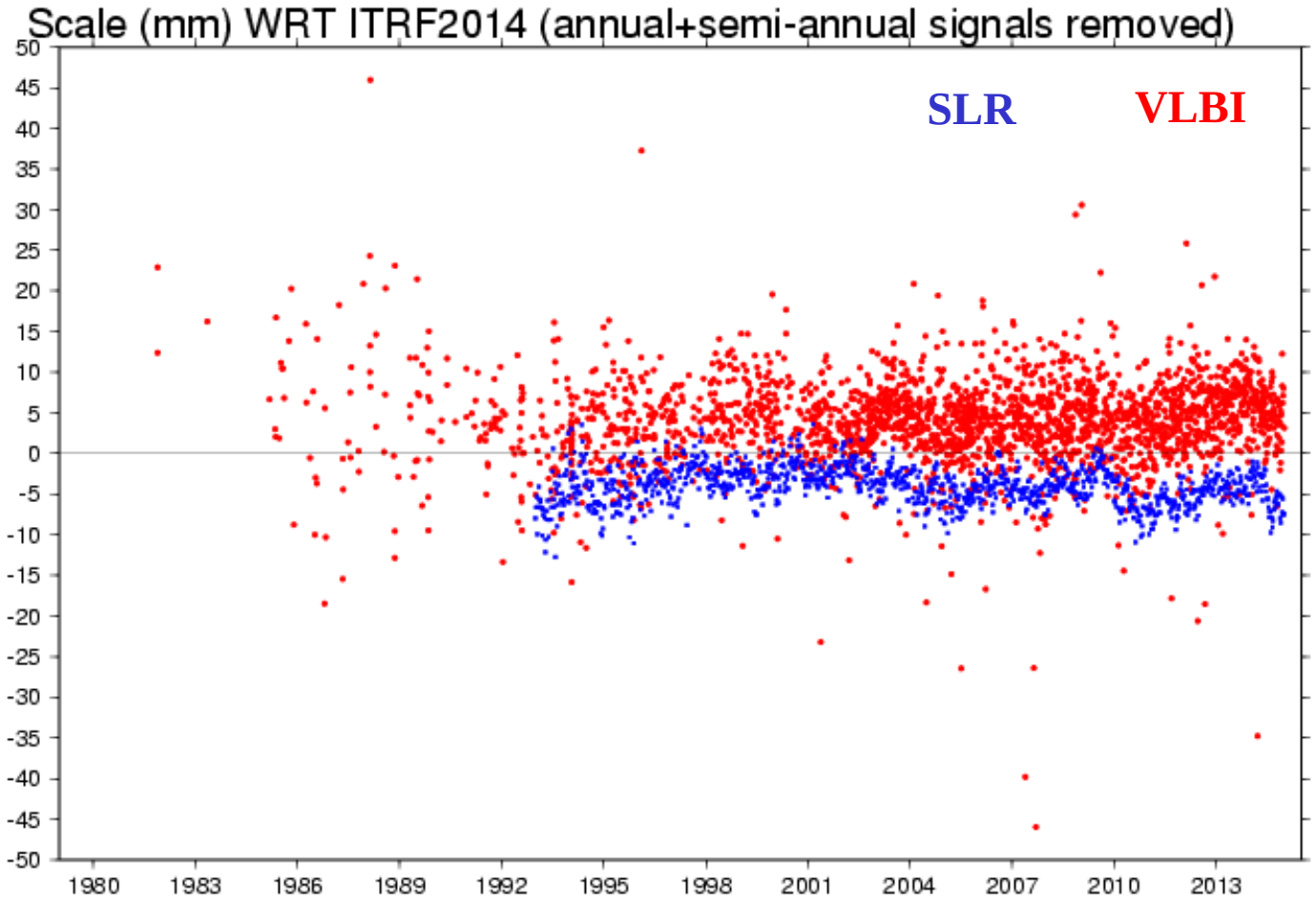


VLBI, SLR & DORIS Scales wrt ITRF2014



1.4 ppb
≈1 cm

ITRF2014 scale :
Average of selected VLBI & SLR intrinsic scales



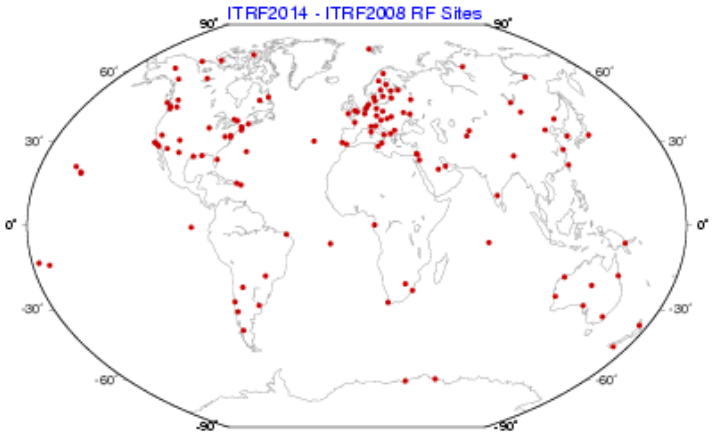
VLBI vs SLR Scale Difference : 1.37 (± 0.10) ppb

Scale rate negligible

From ITRF2014 to ITRF2008

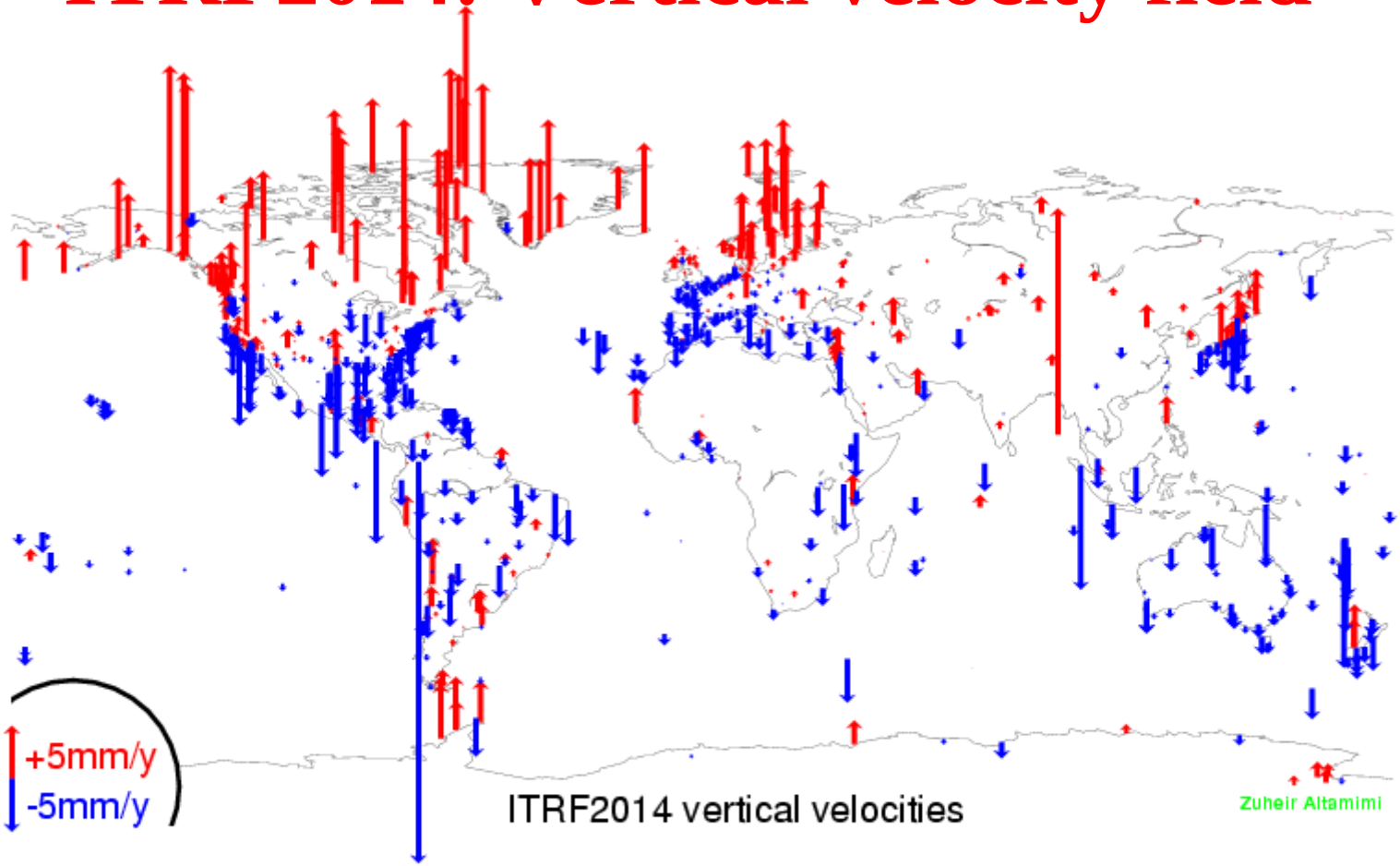
Using 127 stations

	TX(mm)	TY(mm)	TZ(mm)	Scale (ppb)	Epoch
Offset ±	1.6 ±0.2	1.9 ±0.1	2.4 ±0.1	-0.01 ±0.02	2010.0
Rate ±	0.1 ±0.2	0.0 ±0.1	-0.1 ±0.1	0.03 ±0.02	-

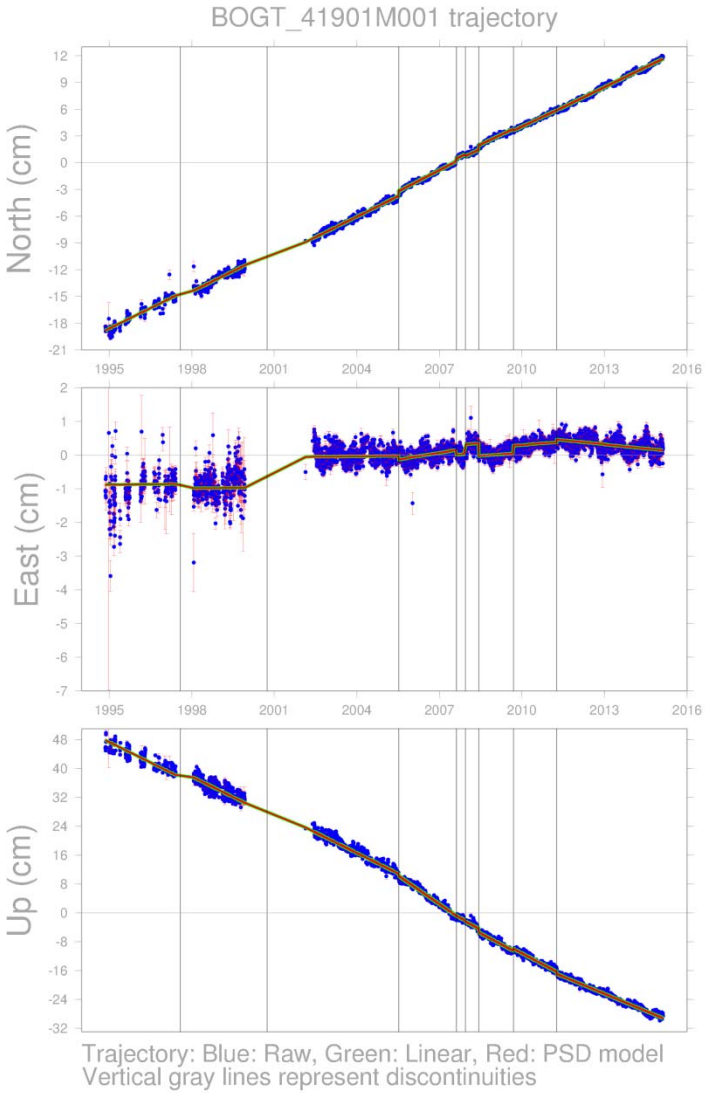


ITRF2014 vertical & horizontal velocity fields

ITRF2014: Vertical velocity field



Bogota

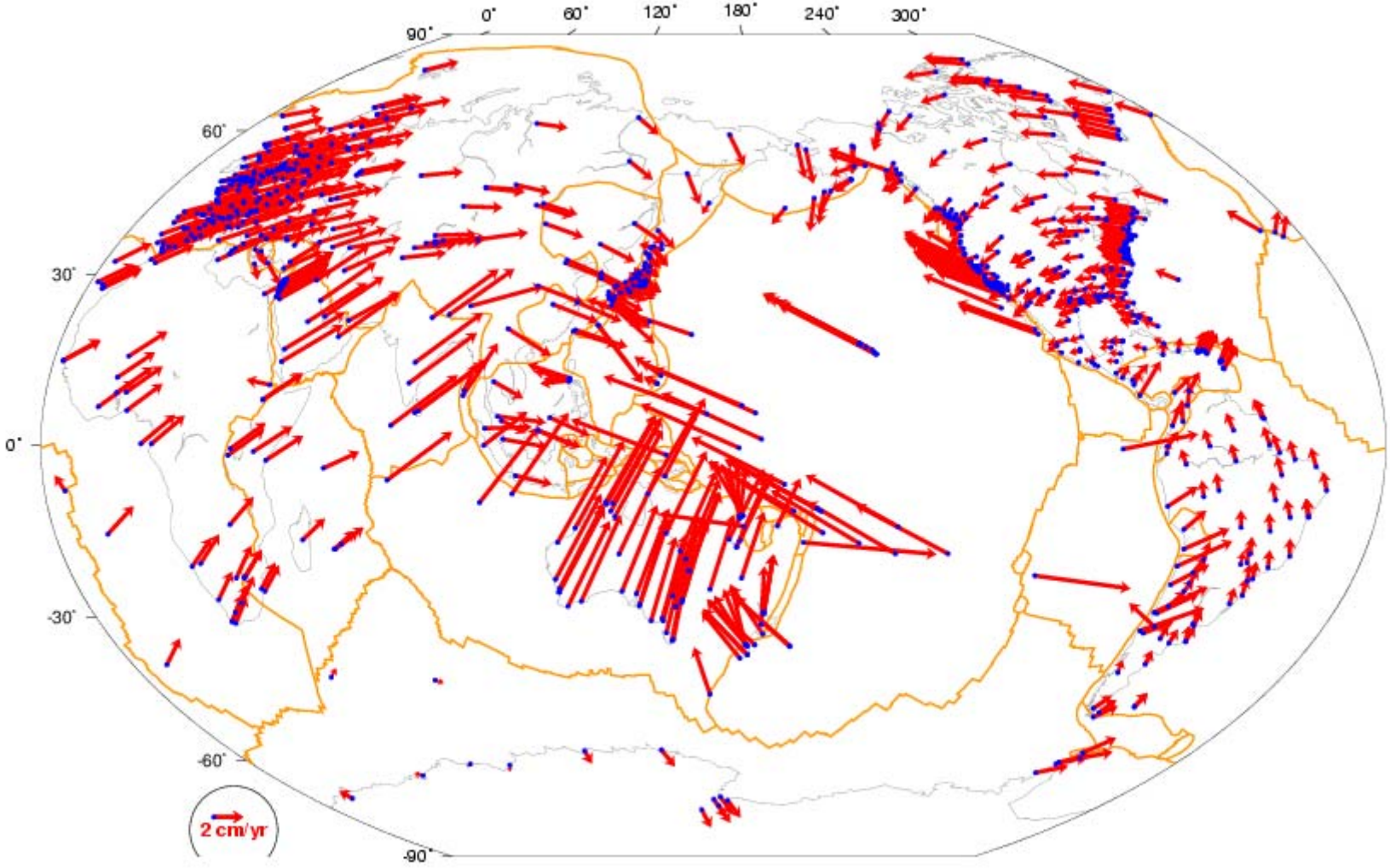


Vh = -3.7 cm/an

ITRF2014 & plate motion:

Elaboration of ITRF2014 Plate Motion Model is in progress

ITRF2014: Horizontal velocity field

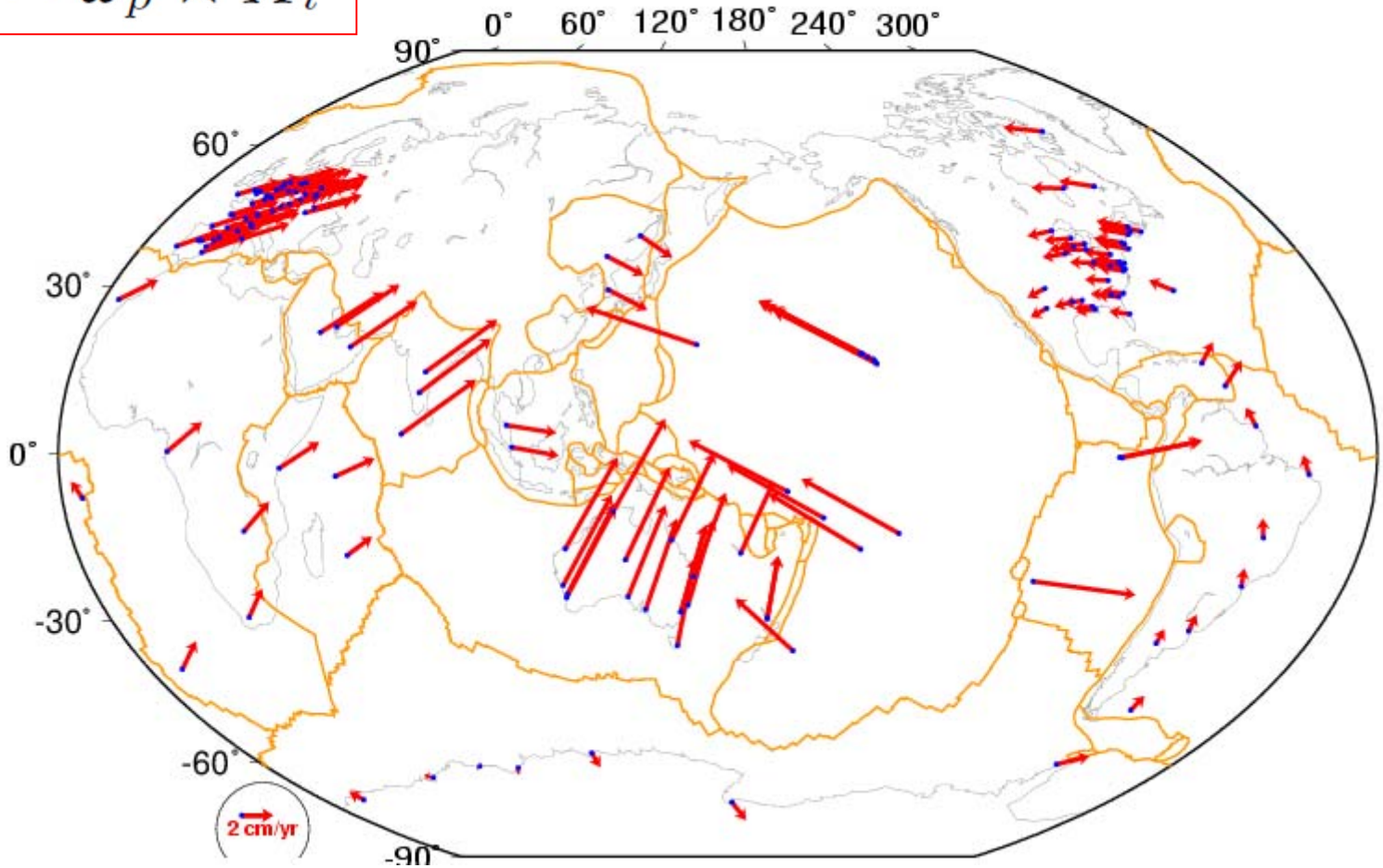


ITRF Plate Motion Model

Plate angular velocity ω_p is estimated by:

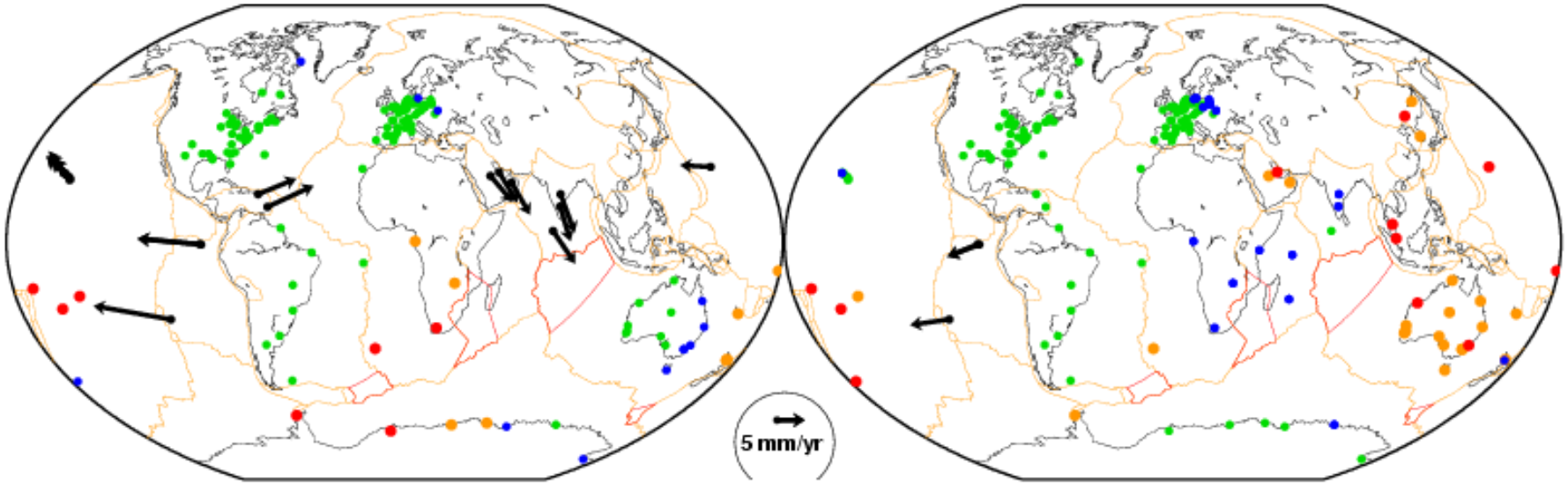
$$\dot{X}_i = \omega_p \times X_i$$

Selection ITRF2008



Comparison btw ITRF2008 and NNR-NUVEL-1 and NNR-MORVEL56

Velocity differences after rot. rate transformation



NNR-NUVEL-1A
RMS:
East : 2.5 mm/yr
North: 2.0 mm/yr

Ry = 0.025 mas/yr

- **Green: 1-2 mm/yr**
- **Blue : 2-3 mm/yr**
- **Orange: 3-4 mm/yr**
- **Red : 4-5 mm/yr**
- **Black : > 5 mm/yr**

NNR-MORVEL56
RMS:
East : 1.7 mm/yr
North: 1.7 mm/yr

Rx = 0.084 mas/yr

Conclusion

- **ITRF2014 innovations: modelling of non-linear station motions**
- **Estimating seasonal signals**
  - **Performs better than applying NTAL**
  - **No significant impact on horizontal velocities**
  - **May need to do both in the future**
- **Transformation parameters between ITRF2014 & ITRF2008 are small**
- **ITRF2014 PMM is in progress, expect to improve ITRF2008 PMM**