Review of IDS contribution to ITRF2014

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Key Points

- **ITRF2014 input data and some statistics**
- **IDS Contribution to ITRF2014**
  - **DORIS Network and co-locations**
  - **Origin & geocenter motion**
  - **Scale**
  - **Tie & velocity discrepancies**

ITRF2014: Input data

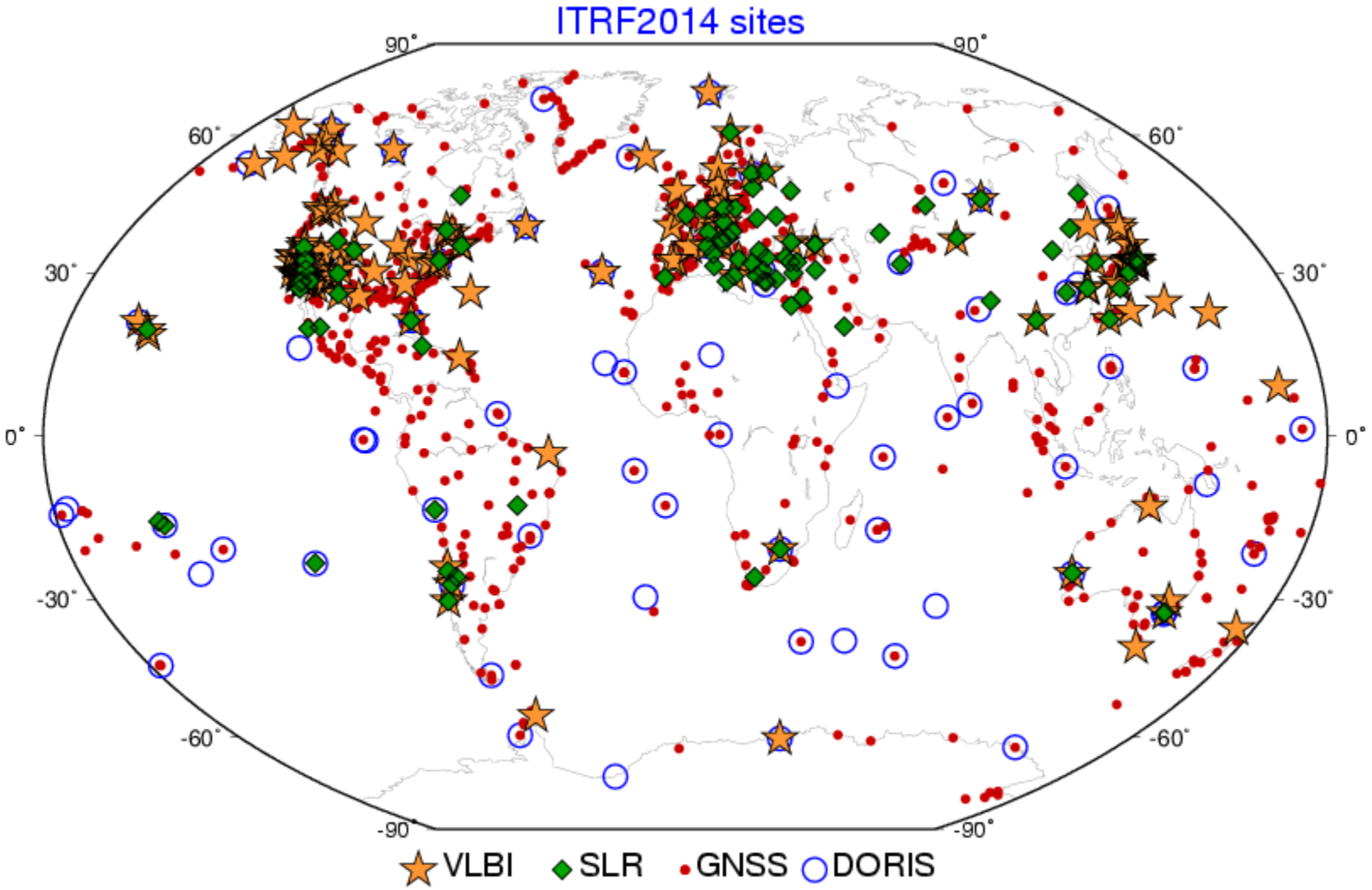
Service/Technique	Number of Solutions	Time span
IGS/GNSS/GPS	7714 daily	1994.0 – 2015.1
IVS/VLBI	5328 daily	1980.0 – 2015.0
ILRS/SLR	244 fortnightly	1980.0 – 1993.0
	1147 weekly	1993.0 – 2015.0
IDS/DORIS	1140 weekly	1993.0 – 2015.0

Same time-span

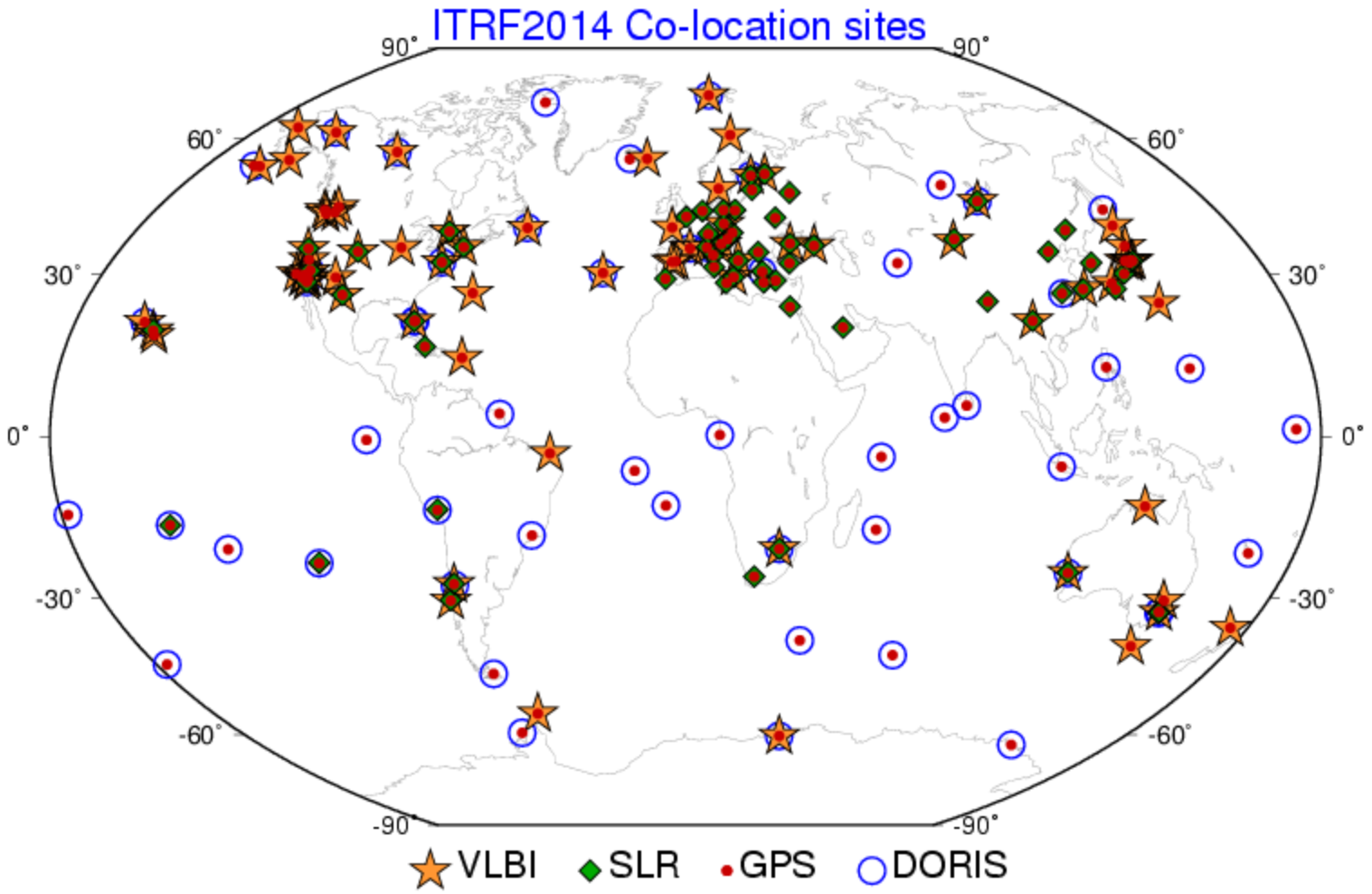
ITRF2014: Some statistics

- 1499 stations located in 975 sites
- 91 co-location sites with 2 or more instruments which were or are currently operating
- Colocations with GNSS:
  - 33 SLR
  - 40 VLBI
  - 46 DORIS
- 59 pairs of DORIS-DORIS ties

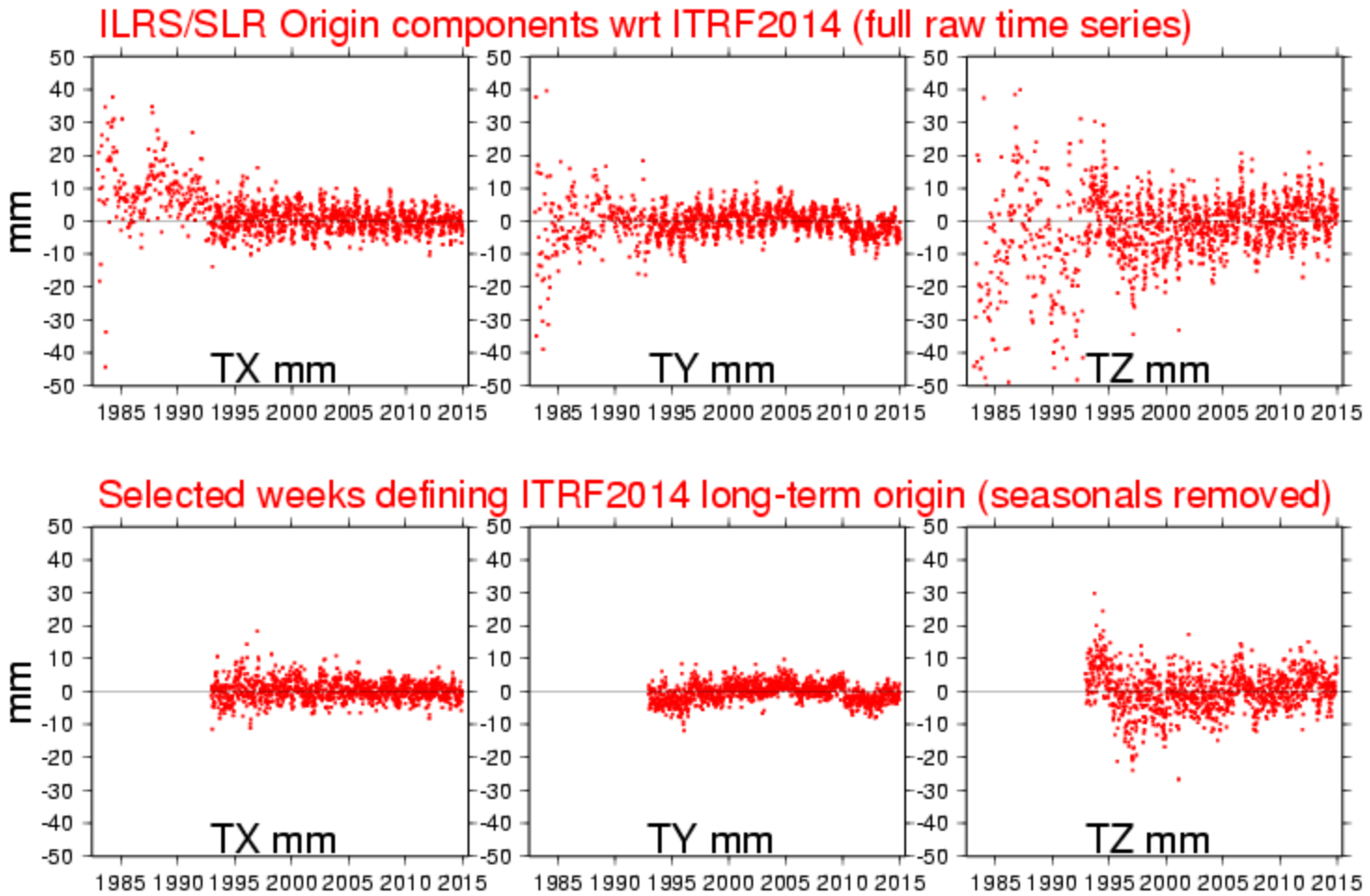
ITRF2014 Network



ITRF2014 Co-locations

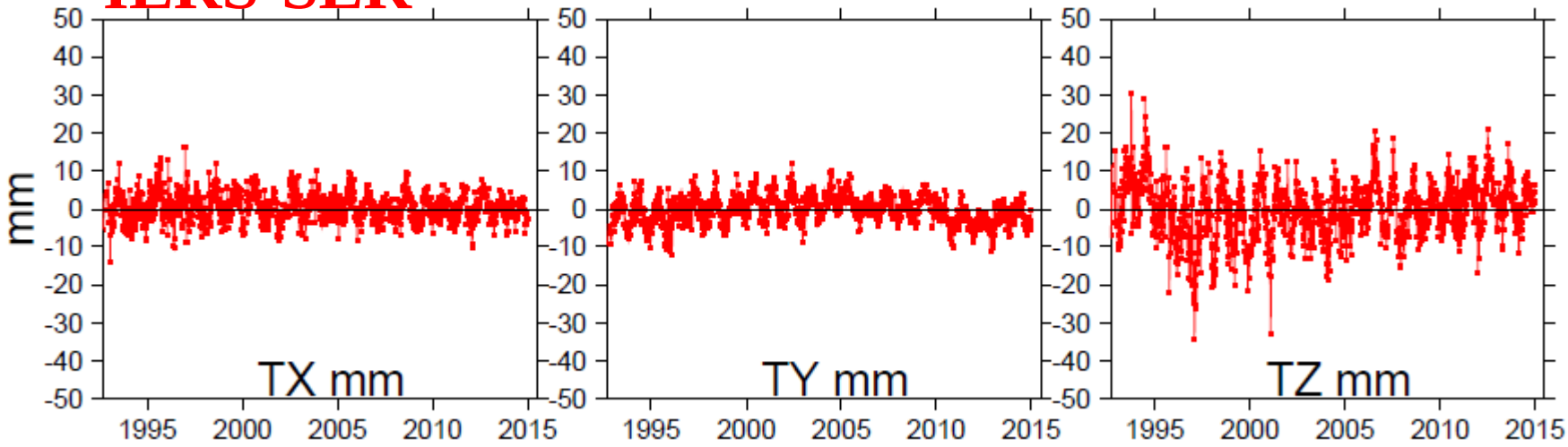


ILRS/SLR origin components wrt ITRF2014

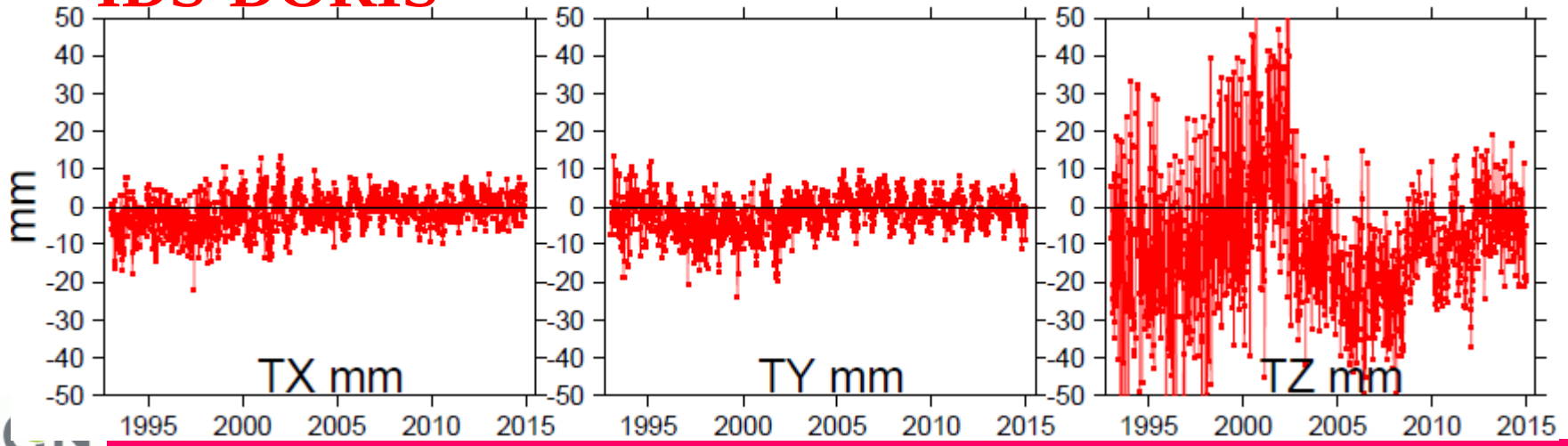


ILRS-SLR & IDS-DORIS origin components wrt ITRF2014

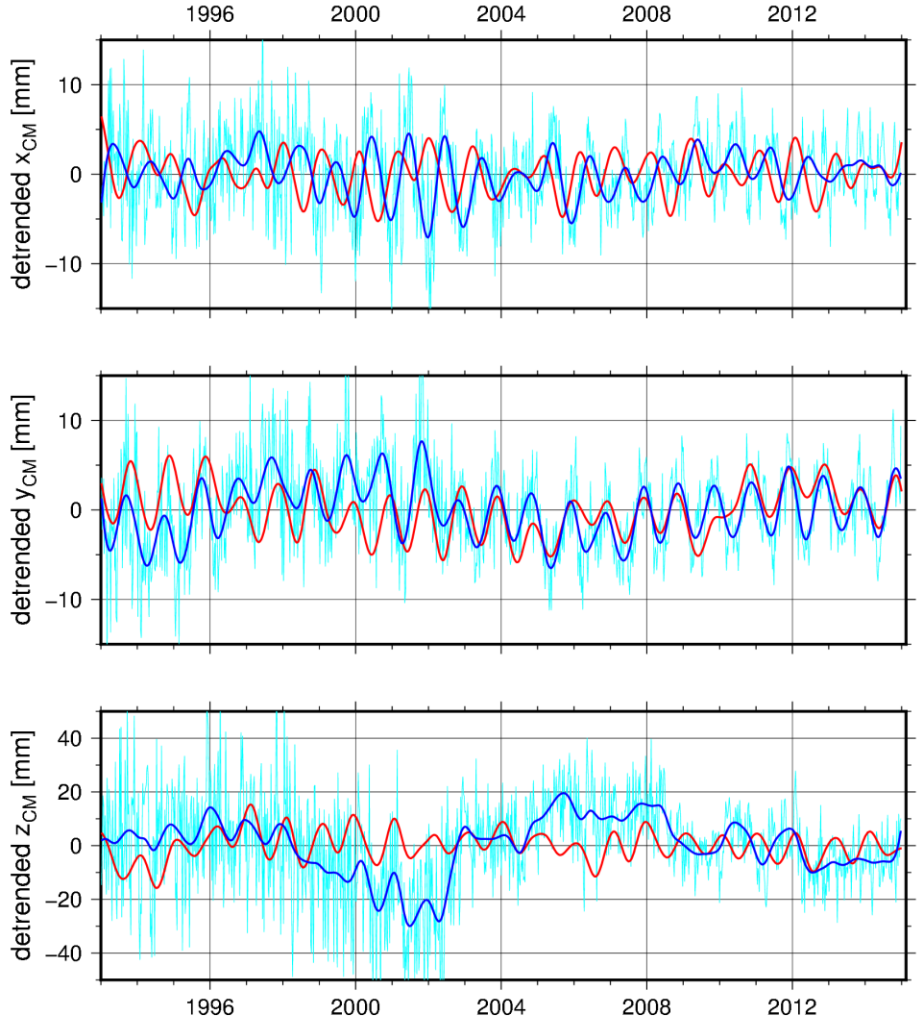
ILRS-SLR

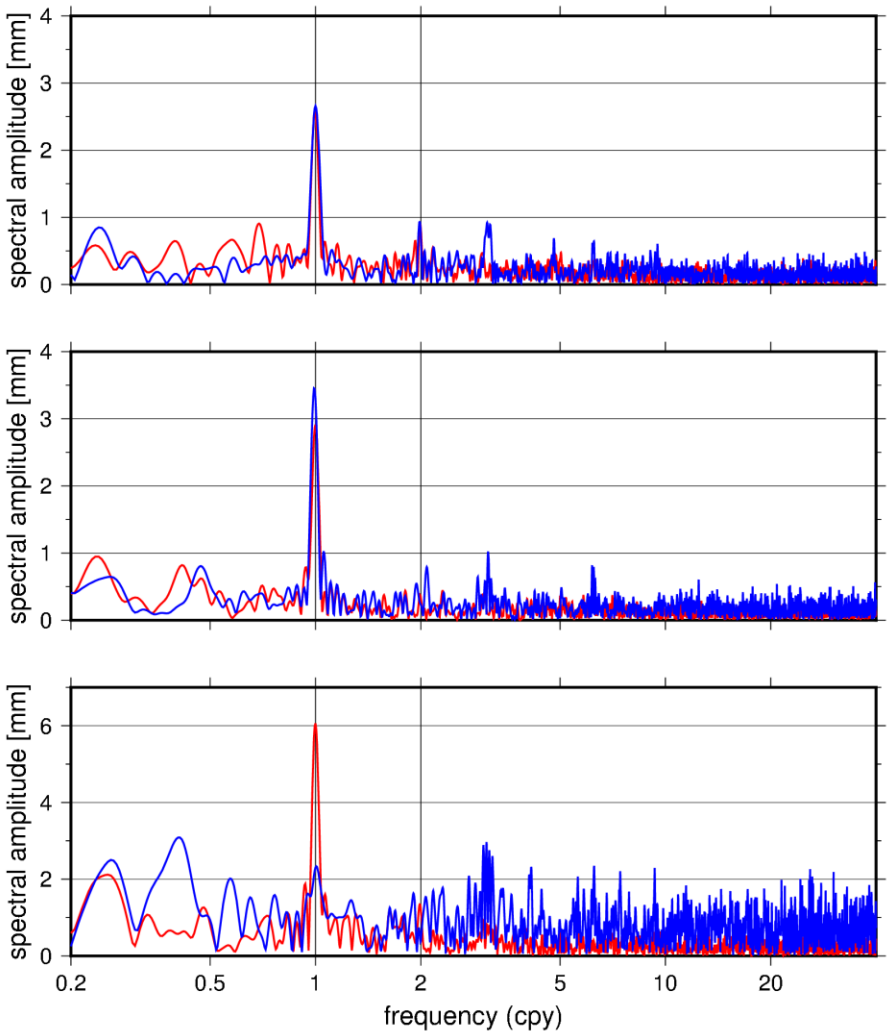


IDS-DORIS



Geocenter motion





Blue & Cyan: DORIS/IDS

Red: SLR/ILRS

Intrinsic prescision: WRMS

Table 2. WRMS Averages of Postfit Residuals, in mm, as Result of Three Stacking Tests: Standard Stacking (STD), Stacking With NTAL Applied, and Stacking Where the Annual and Semiannual Frequencies (FREQ2) Are Estimated With No NTAL Model Corrections Applied

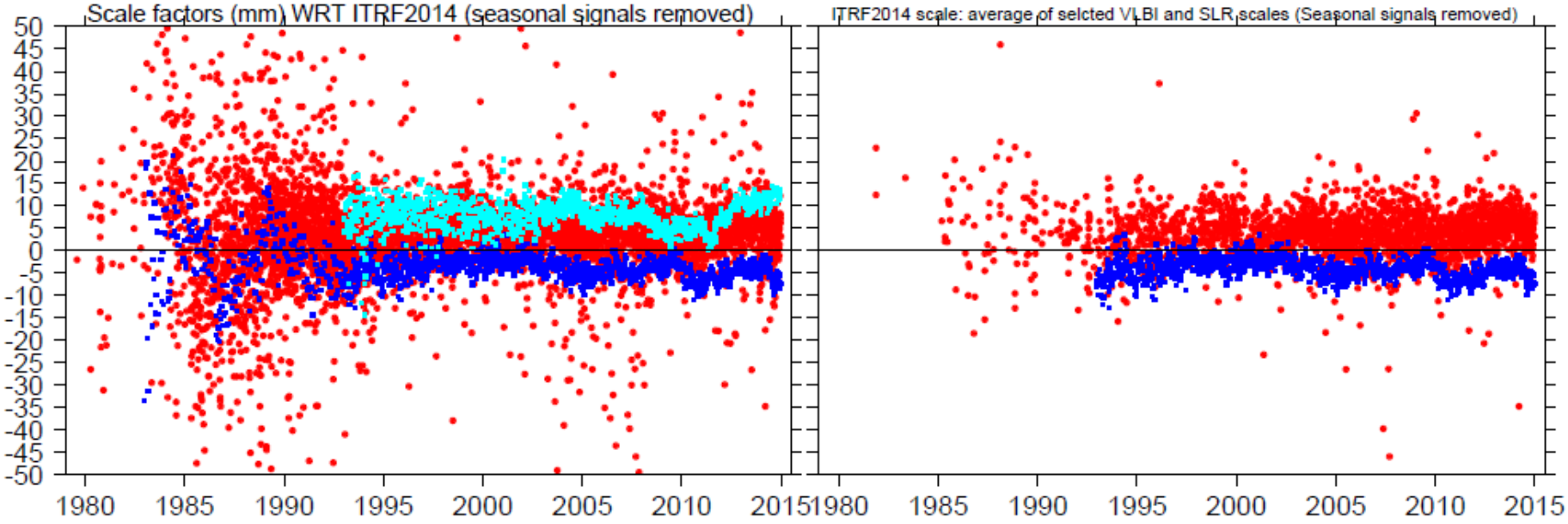
Solution	East	North	Up	
IVS/VLBI, Session-Wise Sampling				
STD	3.79	3.97	11.00	
NTAL	3.75	3.93	10.81	**VLBI**
FREQ2	3.74	3.91	10.81	
ILRS/SLR, Weekly Sampling				
STD	8.91	10.91	8.18	
NTAL	8.90	10.76	8.14	**SLR**
FREQ2	8.83	10.54	8.03	
IDS/DORIS, Weekly Sampling				
STD	13.34	10.21	11.84	
NTAL	13.32	10.18	11.89	**DORIS**
FREQ2	13.17	9.90	11.49	
IGS/GNSS, Daily Sampling				
STD	1.90	1.89	5.61	
NTAL	1.85	1.84	5.07	**GNSS**
FREQ2	1.74	1.71	5.04	

Altamimi et al., 2016

DORIS, SLR & VLBI scales wrt ITRF2014

Full time series of scale factors

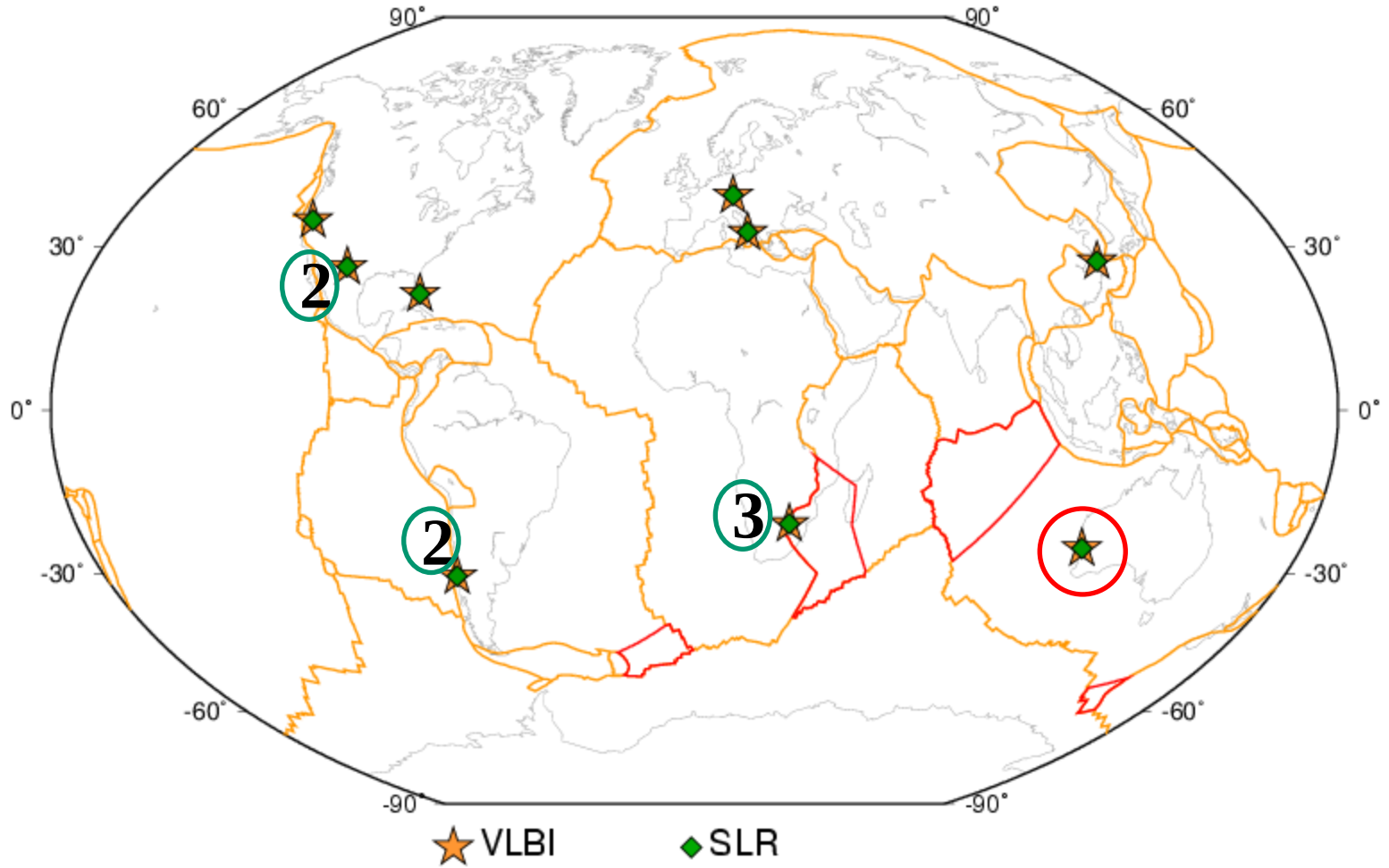
Scale factors of SLR and VLBI solutions selected to define ITRF2014 scale



DORIS SLR VLBI

ITRF2014 Co-locations

(VLBI & SLR co-locations, NO GNSS)



N : number of tie vectors if > 1

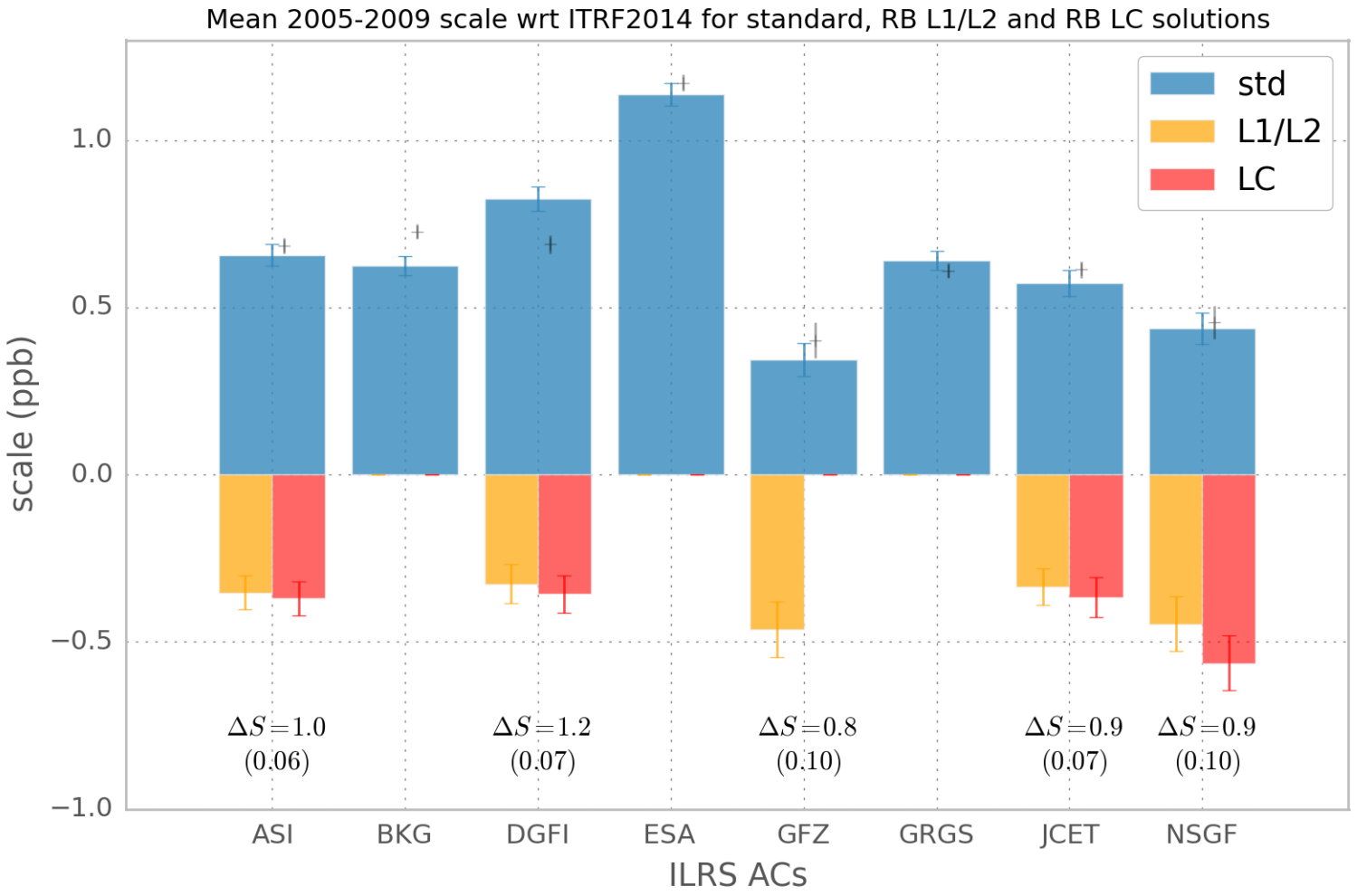
VLBI vs SLR Scale Difference

Solution	Scale at 2010.0 ppb	Comments
ITRF2014	1.37 ± 0.10	All Tie SNX files properly weighted
Rate	0.02 ± 0.02	

VLBI vs SLR Scale Difference

Solution	Scale at 2010.0 ppb	Comments
ITRF2014	1.37 ± 0.10	All Tie SNX files properly weighted
Rate	0.02 ± 0.02	
VLBI & SLR co-locations, No GPS	1.14 ± 0.29	9 sites (good distribution): 13 LT vectors, properly weighted
Rate	0.02 ± 0.02	

Impact of SLR Range Bias on the Scale



Courtesy Jose Rodriguez

VLBI vs SLR & DORIS Scale Differences

Solution	Scale at 2010.0 ppb	Comments
From VLBI to SLR	-1.37 ± 0.10	
Rate	-0.02 ± 0.02	
From VLBI to DORIS	0.48 ± 0.11	
Rate	-0.03 ± 0.02	

Speculation for now

From VLBI to SLR (SLR RB estimated)	-0.47 ± 0.02	From SLR to DORIS : 0.95 ± 0.11
Rate	-0.02 ± 0.02	0.01 ± 0.02

Tie Discrepancies

- **"Tie Discrepancies" means differences between terrestrial ties and space geodesy estimates**
- **Percentage of tie discrepancies < 5 mm**

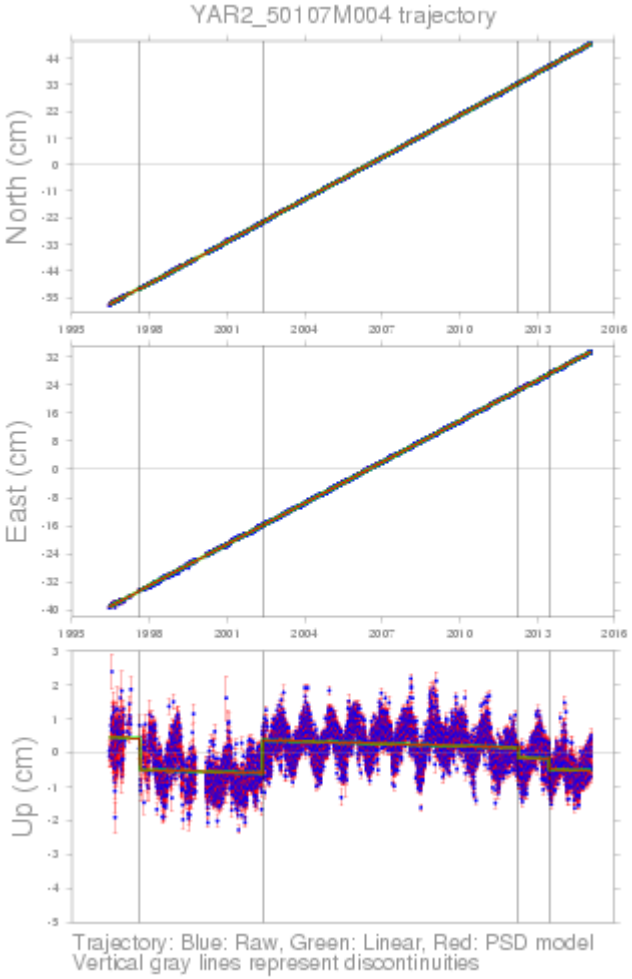
  wrt GNSS :
  - **VLBI: 42 %**
  - **SLR: 29 %**
  - **DORIS: 23 %**

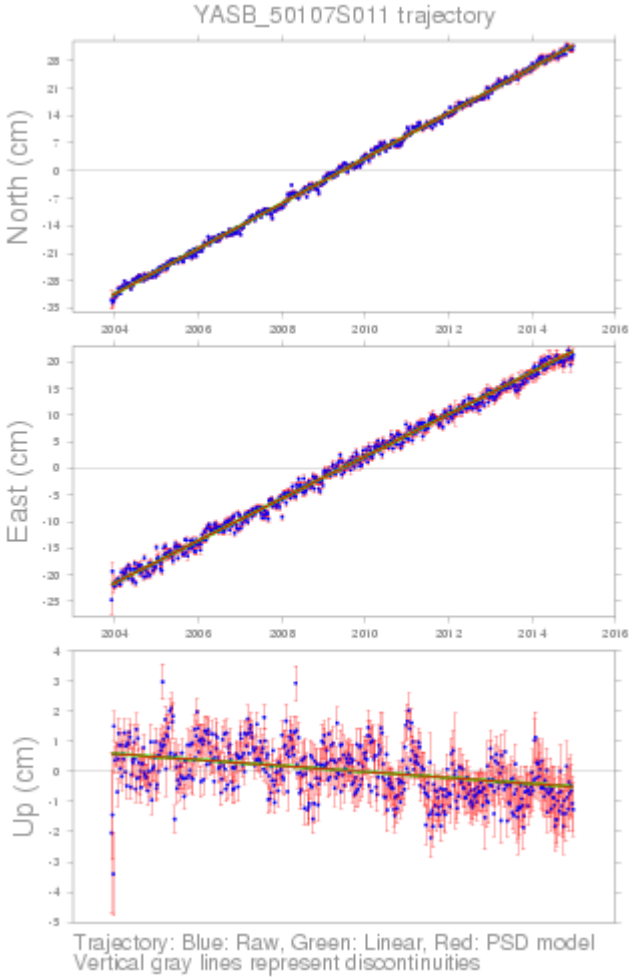
  DORIS – DORIS 34 %

GNSS – DORIS velocity agreements

Agreement between GNSS/IGS and DORIS/IDS velocities: roughly 1 mm/yr

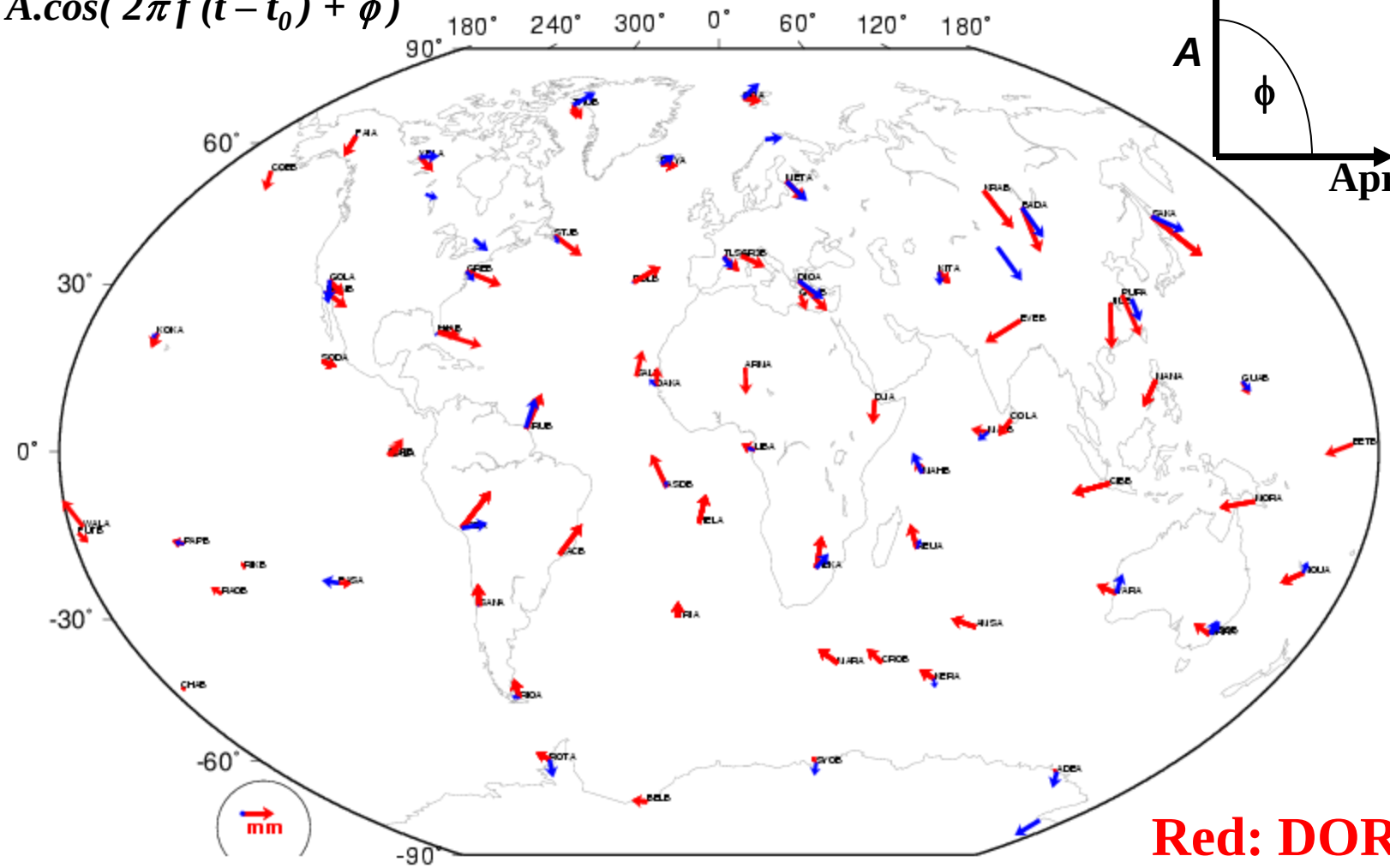
GPS **Yarragadee** **DORIS**





Up Annual Signals

$$Dh = A.\cos(2\pi f\,(t - t_0) + \phi)$$



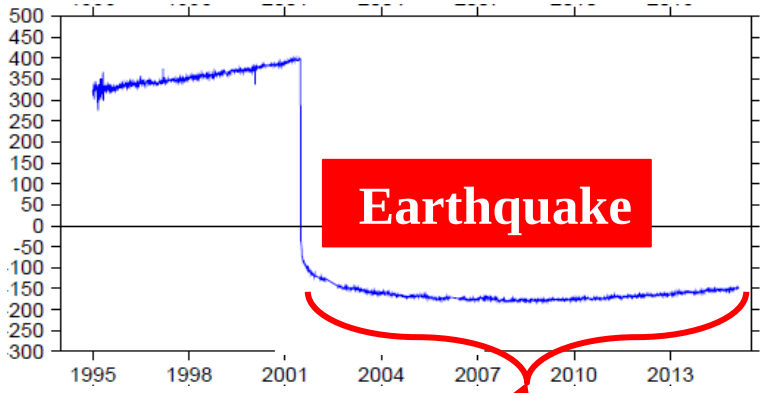
Red: DORIS

Blue: GNSS

Post-Seismic Deformations

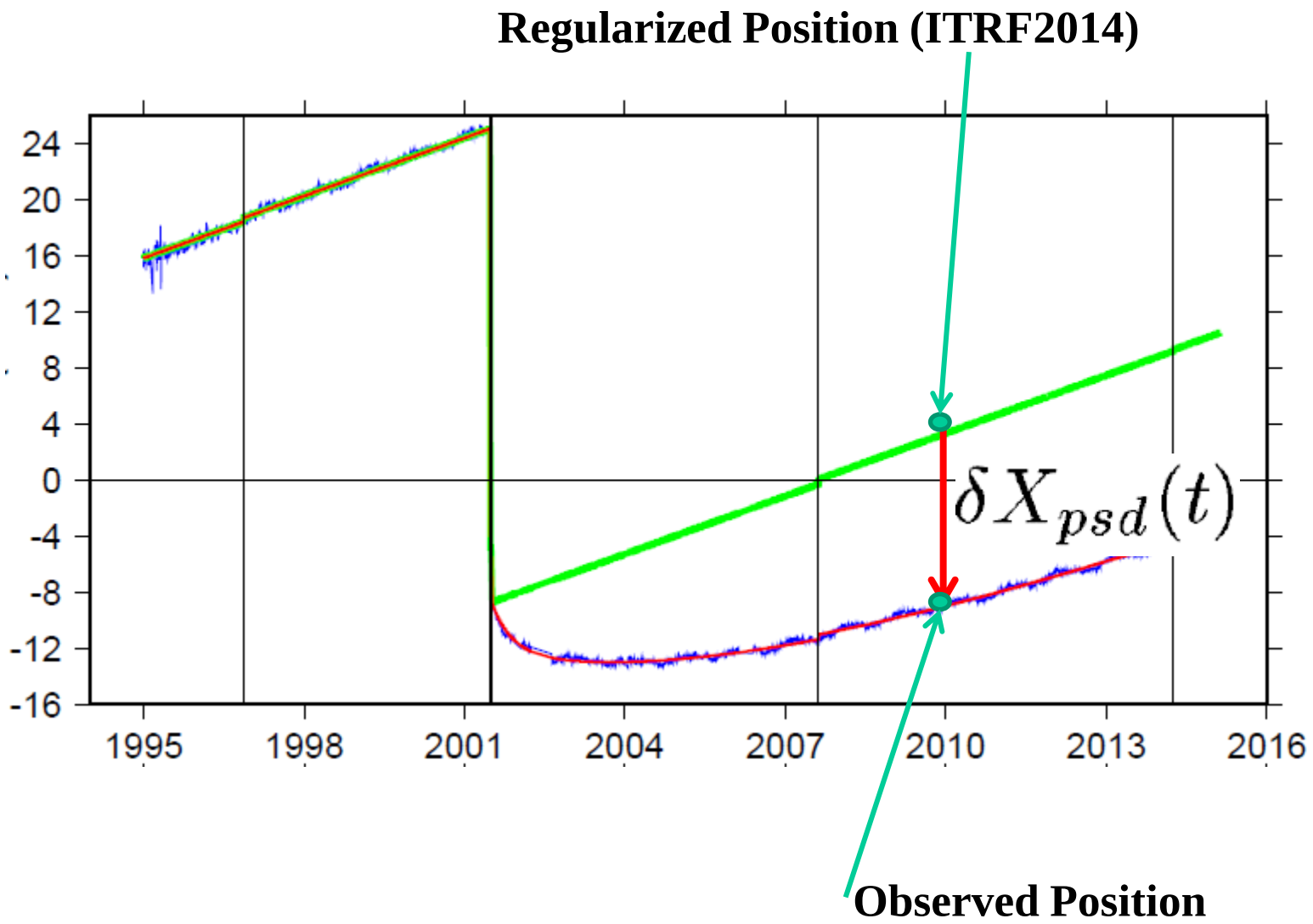
- **Fitting parametric models using GNSS/GPS data**
  - **at major GNSS/GPS Earthquake sites**
  - **apply these models to the 3 other techniques at co-location EQ sites**

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



Post-seismic deformation

PSD Correction



How to use ITRF2014 PSD models ?

Regularized Position (ITRF2014)

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

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

Local Frame

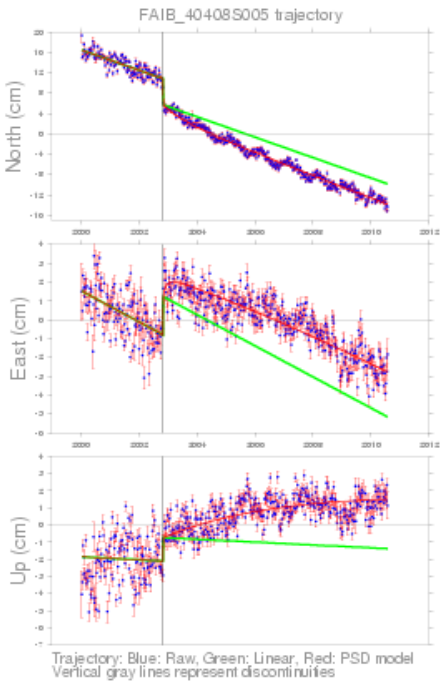
PSD Subroutines available at ITRF2014 Web site:
http://itrf.ign.fr/ITRF_solutions/2014/

Post-Seismic Deformations

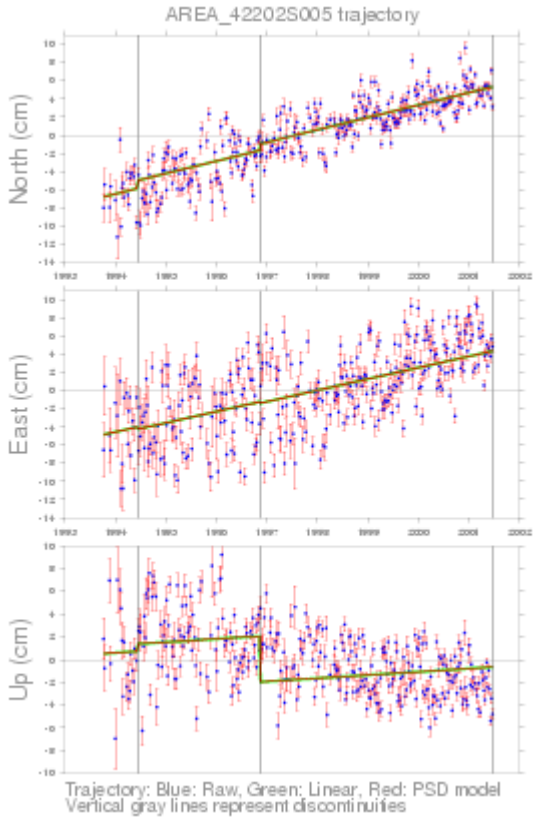
For DORIS, 7 sites in ITRF2014 have PSD:

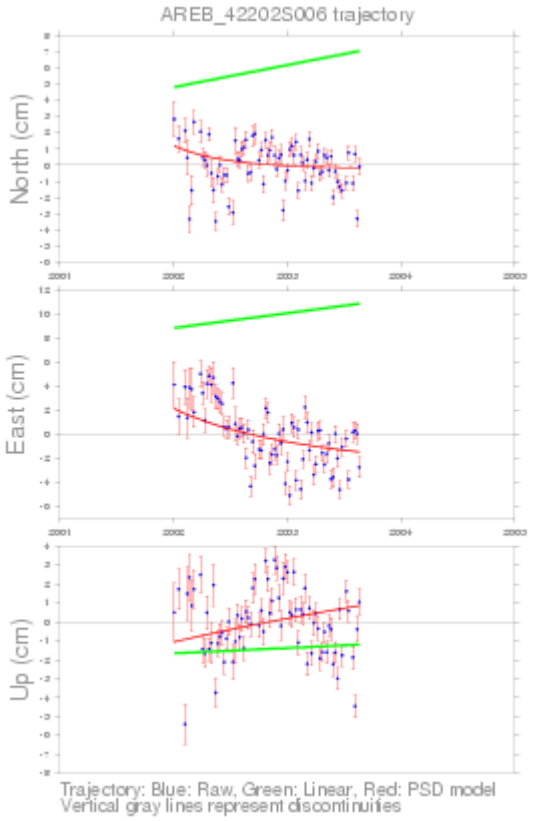
- Arequipa
- Terre Adelie
- Fairbanks
- Goldstone
- Reykjavik
- Santiago
- Sakhalinsk

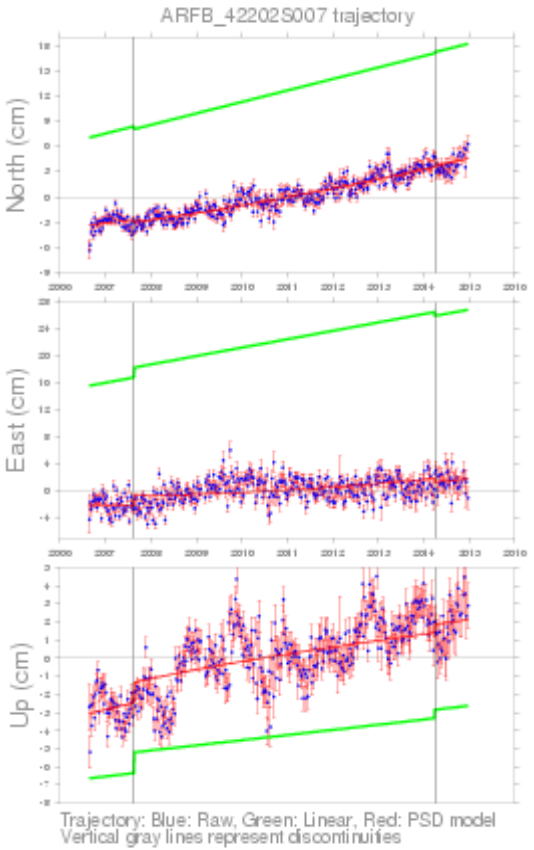
Fairbanks



Arequipa


AREA_42202S005 trajectory
North (cm)
East (cm)
Up (cm)
Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities


AREB_42202S006 trajectory
North (cm)
East (cm)
Up (cm)
Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities


ARFB_42202S007 trajectory
North (cm)
East (cm)
Up (cm)
Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

Conclusion

DORIS contribution to the ITRF2014

- **Origin & geocenter motion**
  - X and Y-translations are "comparable" to SLR, but not Z
  - X-geocenter is out of phase by 112 deg compared to SLR
- **Scale: Still work to do for the 3 techniques**
- **Tie discrepancies:**
  - Significant for DORIS-GNSS : 77% larger than 5 mm.
  - Caution when using DORIS-DORIS ties
  - An antenna change might create discontinuity
  - (Should be used with appropriate weighting):
  - Tie discrepancies are larger than 5 mm for 66% of 59 pairs used in ITRF2014!