ITRF2013 Analysis and SLR Contribution

Zuheir Altamimi, Laurent Métivier,
Xavier Collilieux, Paul Rebischung,
Daphné Lercier
IGN, France

Outline

- ITRF2013: Status of submissions
- ITRF2013:
  - What's new ?
  - Combination strategy
- ITRF and site non-linear motions: some numerical results:
  - Periodic signals
  - Co- & Post-Seismic deformation
- SLR analysis for ITRF2013
- Conclusion

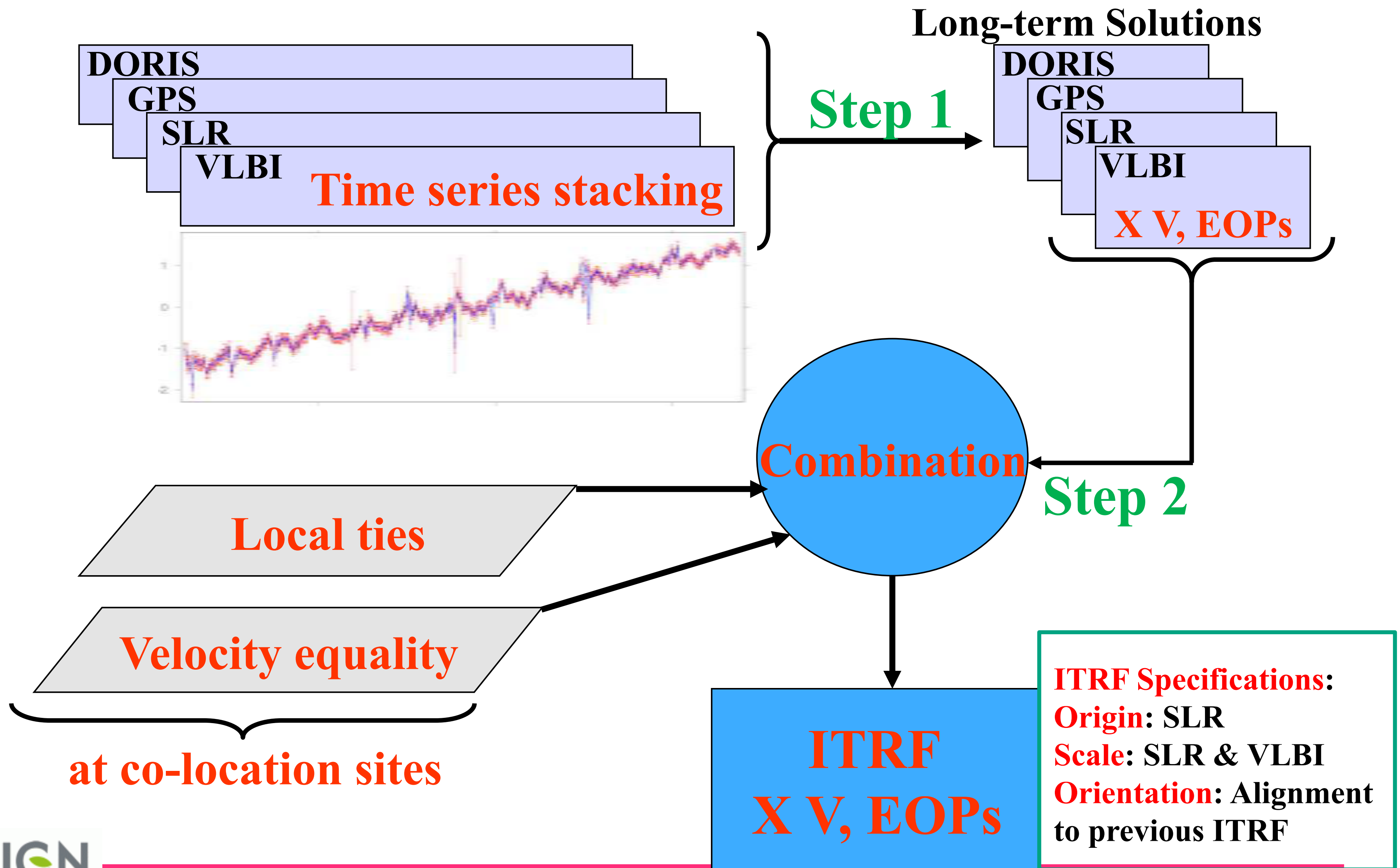
ITRF2013: Status of submission

- **IDS final/official solution (V5) submitted**
- **IGS, IVS still at the combination stage**
- **ILRS submitted**
  - 1993 – 2013 part in Oct. 10
  - 1983 – 1992 part in Oct. 24

ITRF2013

- **What's new ?**
  - Reprocessed solutions from the 4 techniques
  - Improving the process of detection of discontinuities in the time series
  - Applying NT-ATML (+) corrections to ITRF2013 input data
  - Periodic signals (at least annual & semi-annual)
    - Estimated per technique at the stacking level
    - Expect to provide more precise station velocities
    - Will not be equated at co-location sites: up to half of GPS signal is not geophysical
  - Co- & Post-seismic deformation (parametric models will be applied) for EQ sites

ITRF Construction

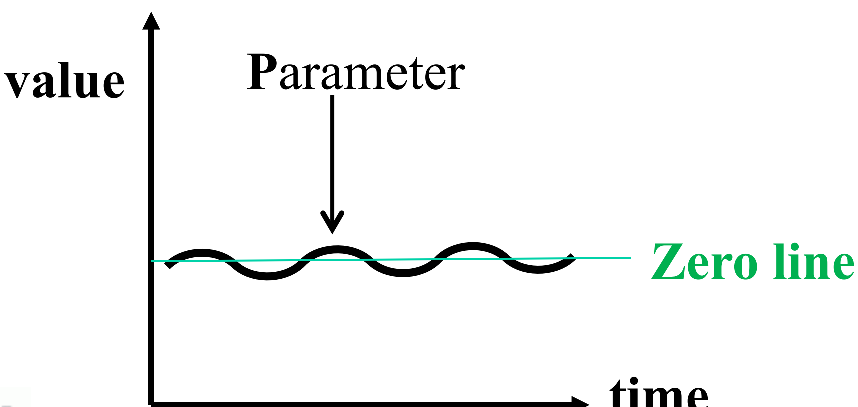


ITRF Combination: Step 1 (1/2)

- **Stacking/accumulating individual time series where the long-term**
  - **origin of SLR (and DORIS)**

  and
  - **scale of VLBI, SLR (and DORIS)**

are defined via internal (minimum-type) constraints:



$$
\boxed{\left\{ \begin{array}{lcl} \displaystyle\sum_{k \in K} P_k & = & 0 \\ \displaystyle\sum_{k \in K} (t_k - t_0) P_k & = & 0 \end{array} \right.}
$$

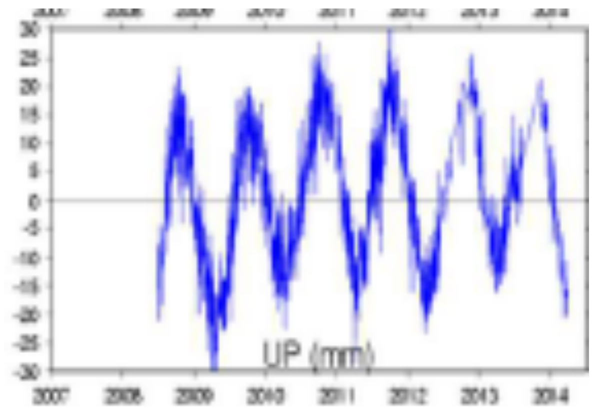
(Altamimi et al., 2007)

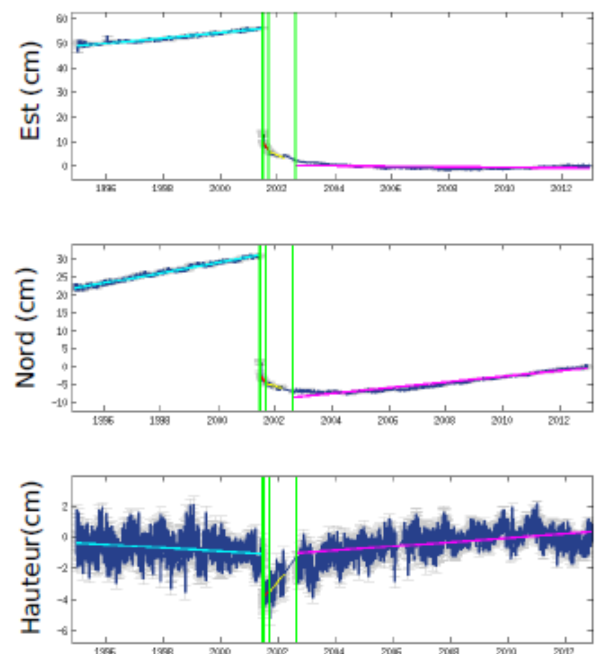
ITRF Combination: Step 1 (2/2)

- **Handling of non-linear station motions:**
  - **Periodic signals: using sinusoidal functions:**

$$\sum a\cos\omega t + b\sin\omega t$$

  - **Post-seismic deformation :**
    - **Piece-Wise Linear (PWL) function**
    - **Parametric models (logarithmic or/and exponential)**





ITRF Construction: Step 2
Weighting of LT and Equating Velocities

- **Weighting of Local Ties:**
  - Use of SINEX files
  - Use a variance factor per LT SNX, with 3 mm lower bound sigma
  - Weighting as a function of LT and SG agreement

  ==> down-weighting discrepant ties (normalized residual > 3), iteratively

- **Velocity equalities at co-location sites:**

$$\boxed{\dot{X}_i \quad = \quad \dot{X}_j \qquad\qquad (\sigma)}$$

  - Increase σ as a function of technique discrepancy, i.e. (normalized residual > 3)

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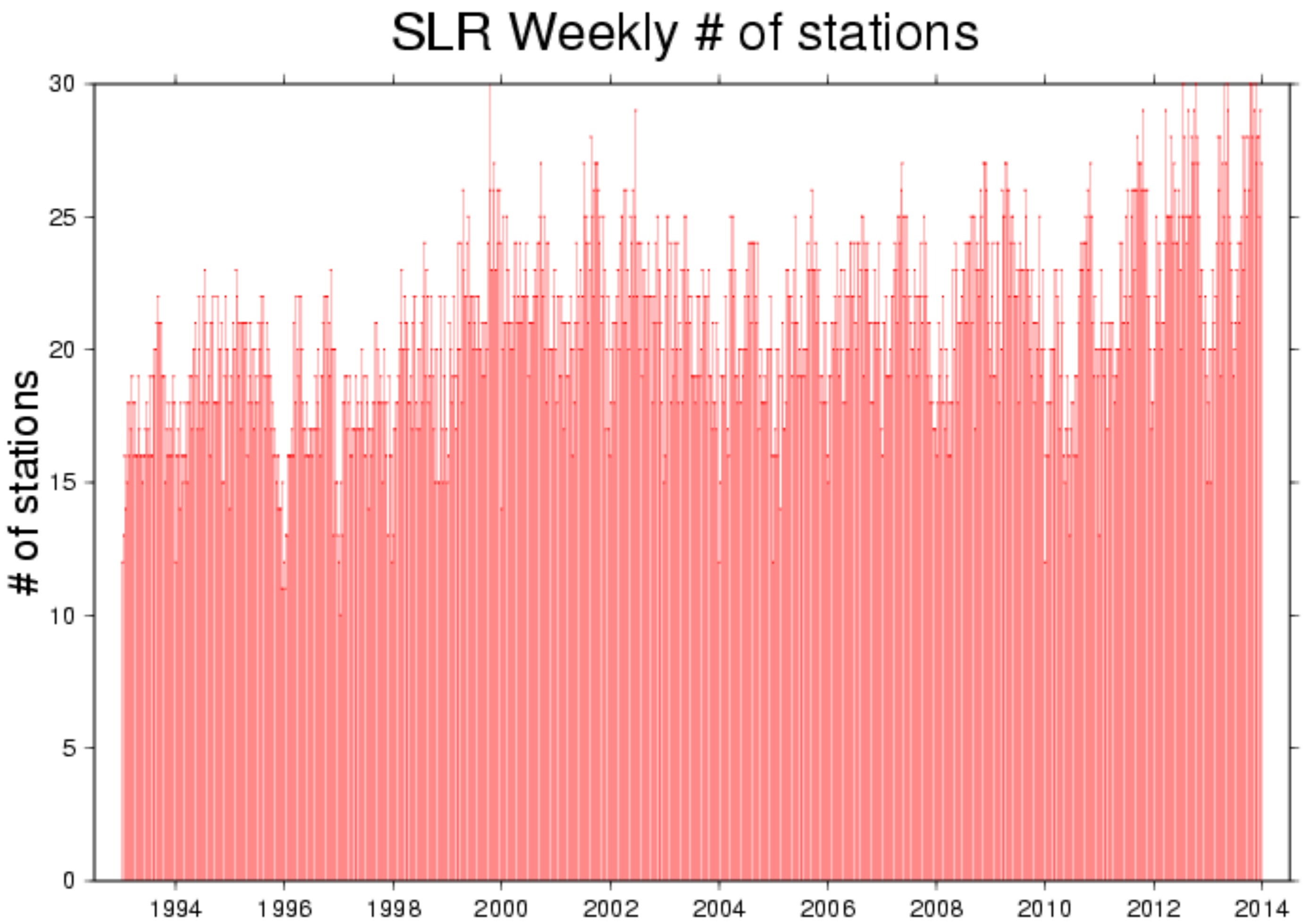
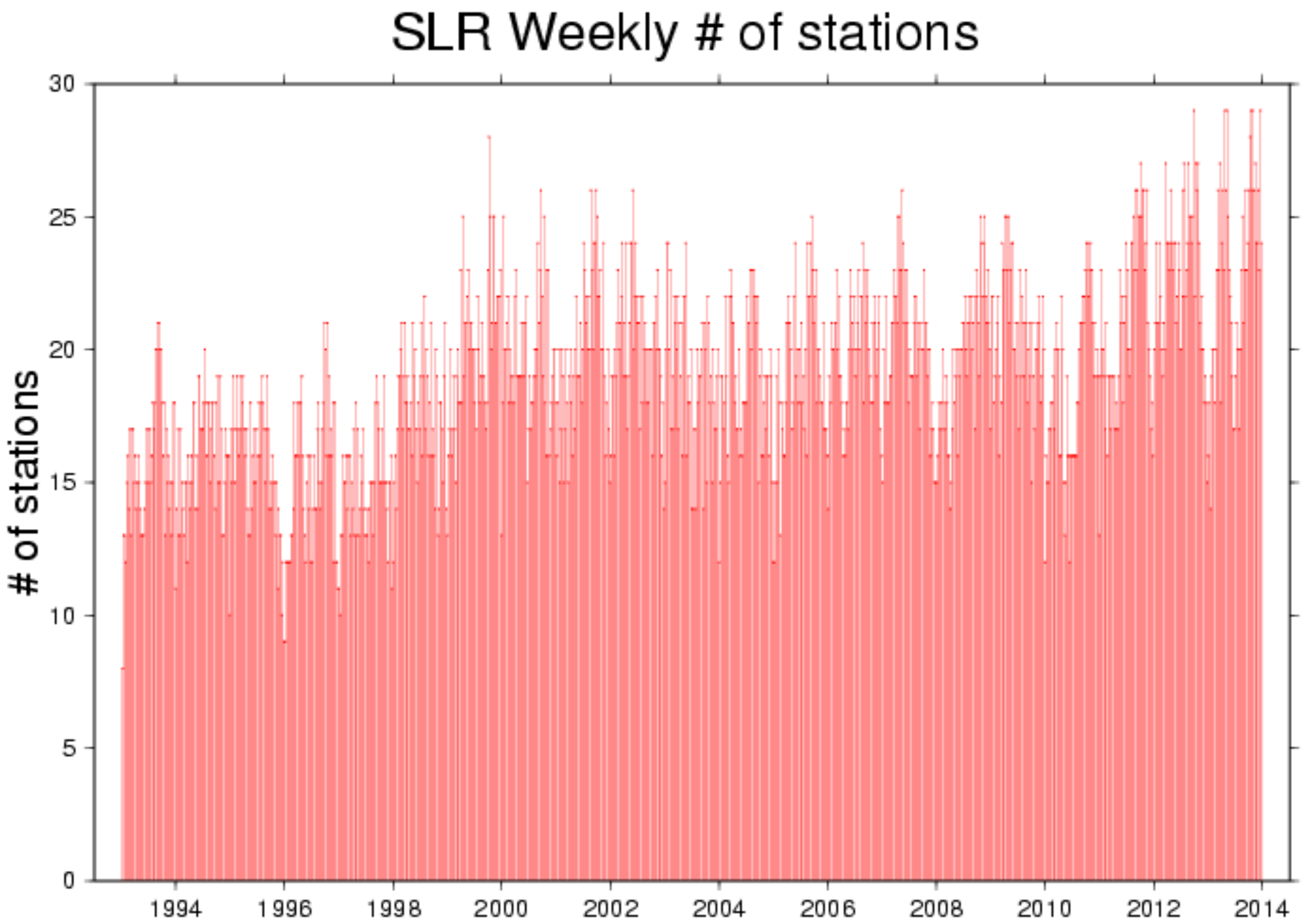
SLR Analysis for ITRF2013

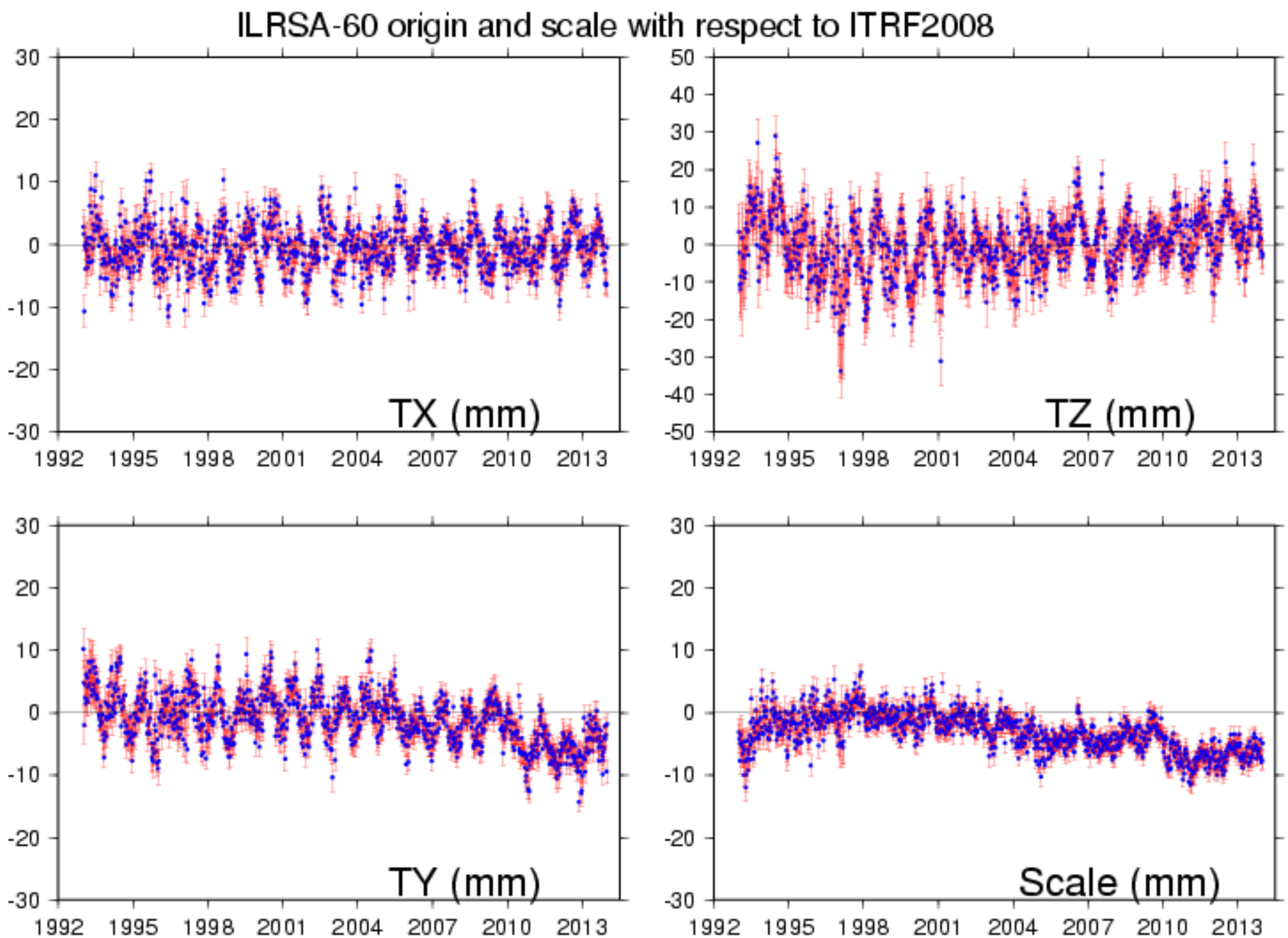
SLR/ILRS weekly number of stations before outliers rejection



SLR/ILRS weekly number of stations after outliers rejection

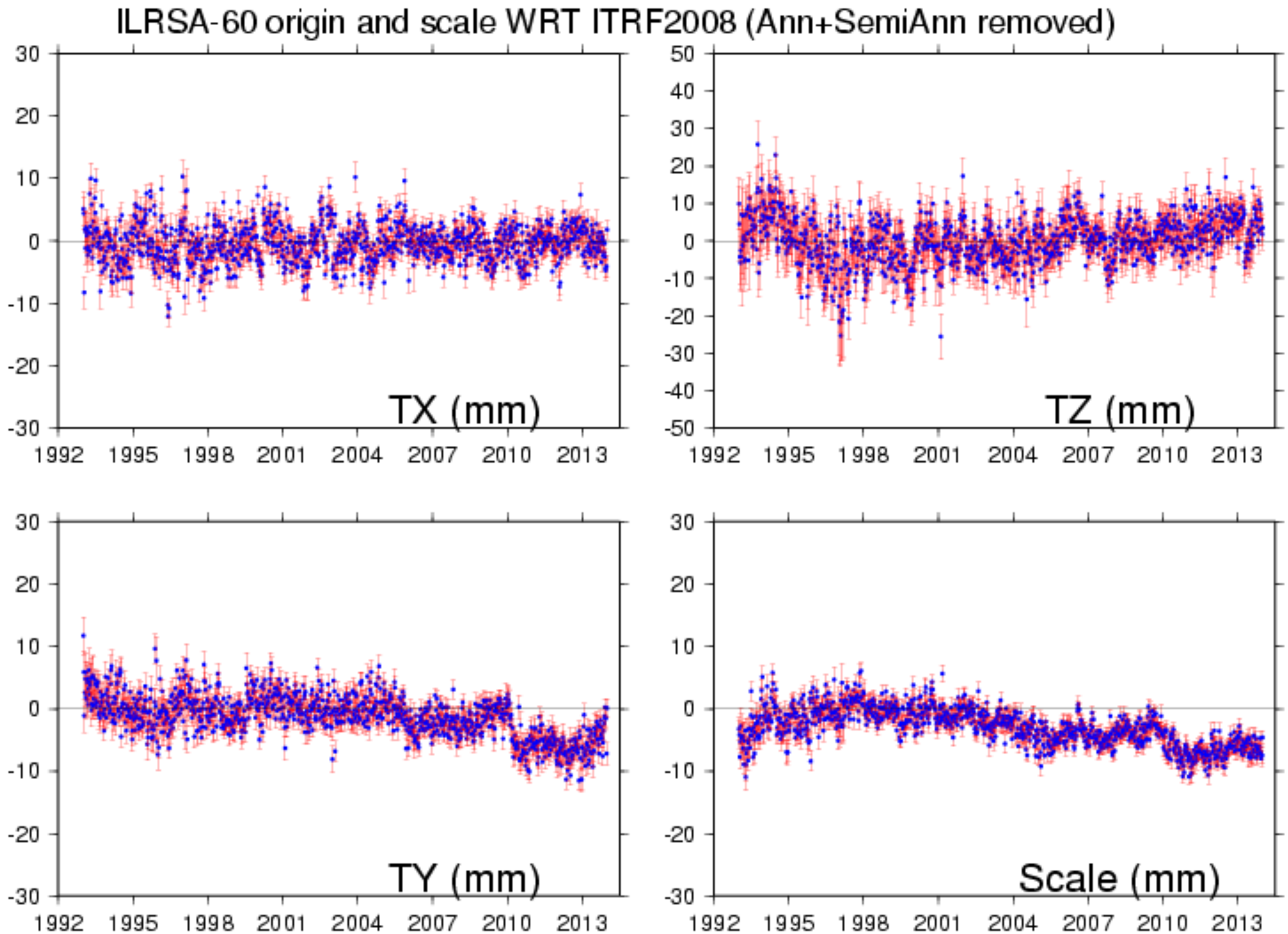


SLR/ILRS Origin & Scale wrt ITRF2008



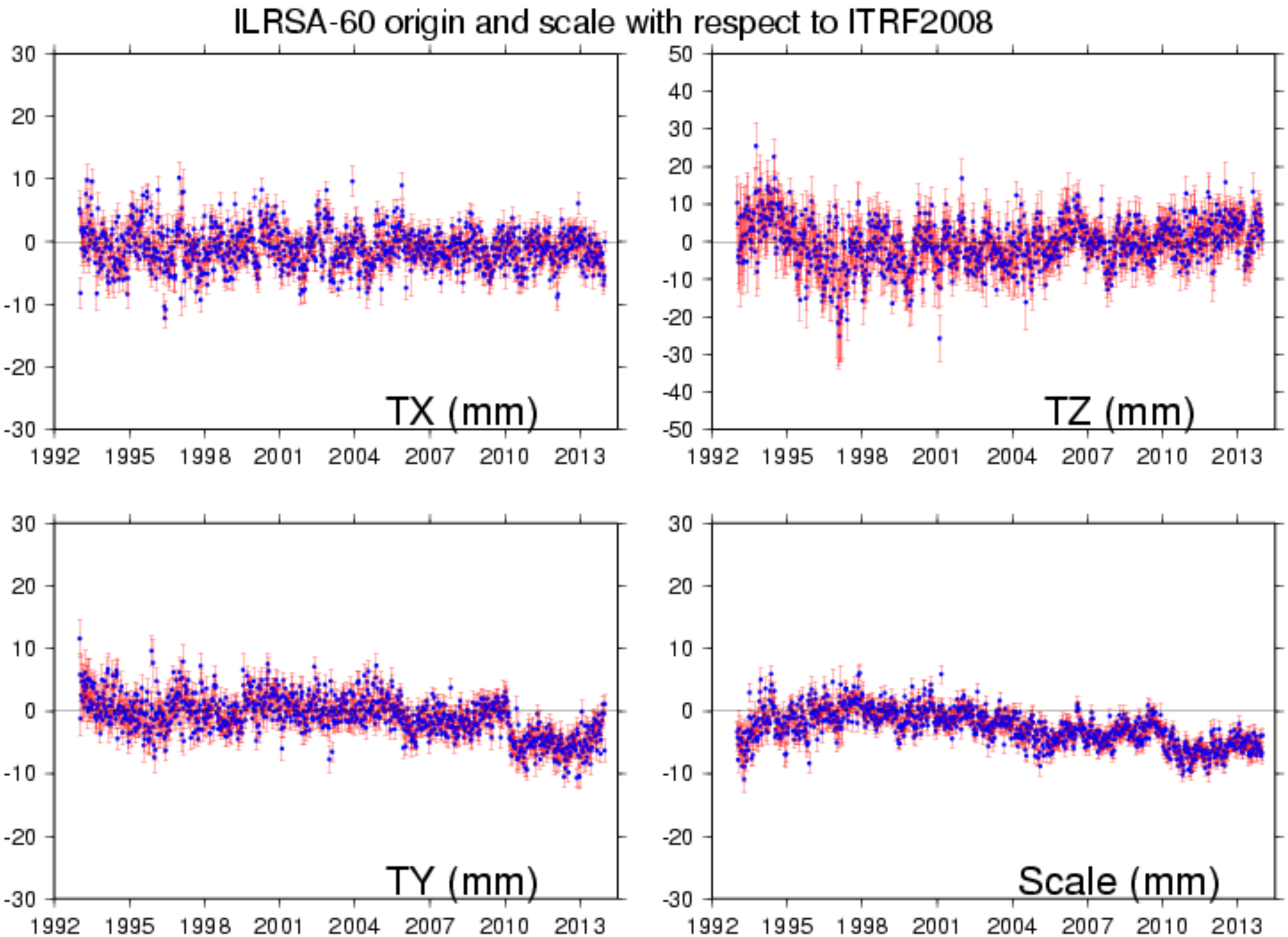
SLR/ILRS Origin & Scale wrt ITRF2008

Annual and Semi-Annual signals removed



SLR/ILRS Origin & Scale wrt ITRF2008

Annual and Semi-Annual signals removed + PSD for Arequipa & Concepcion



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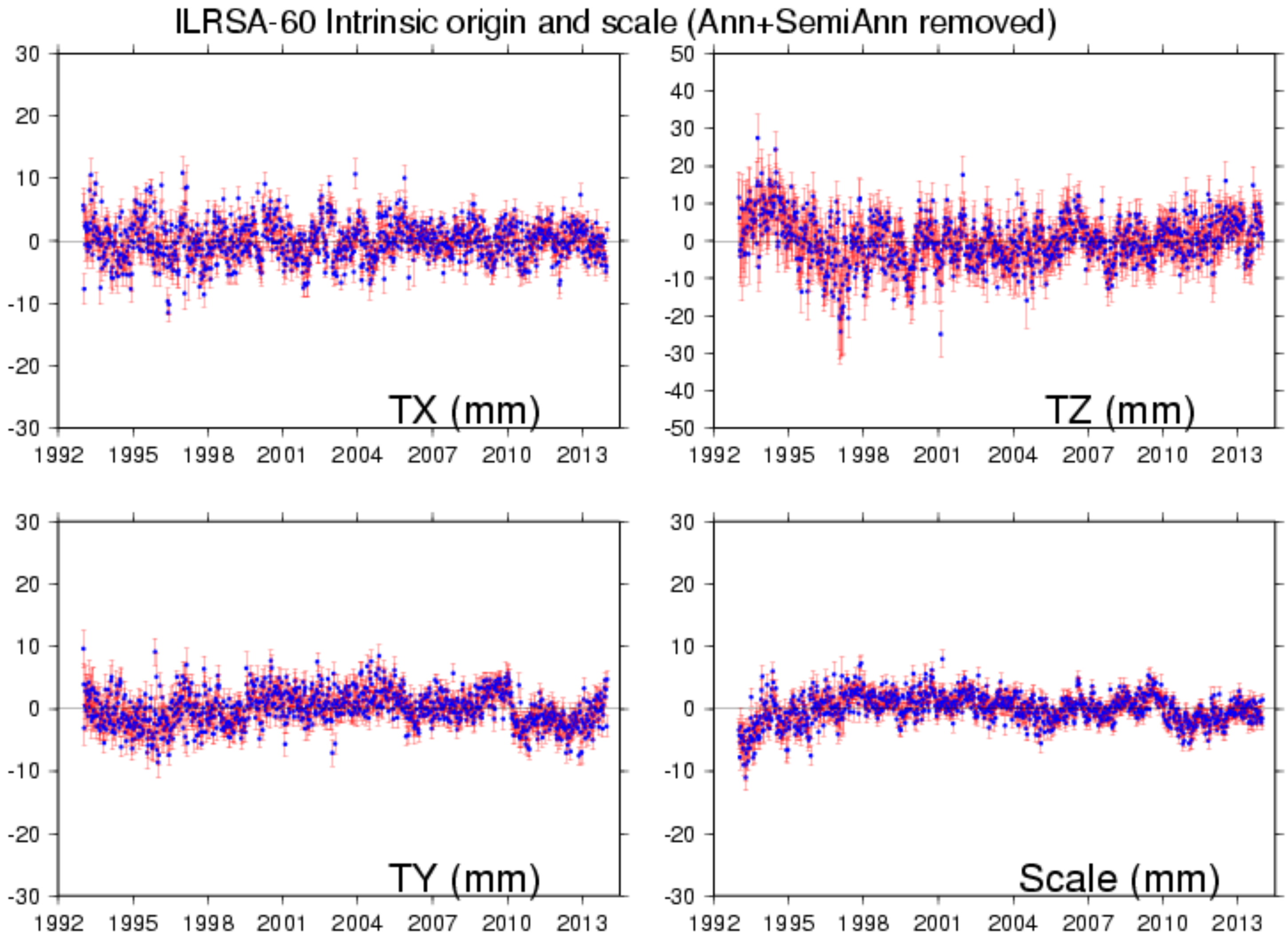
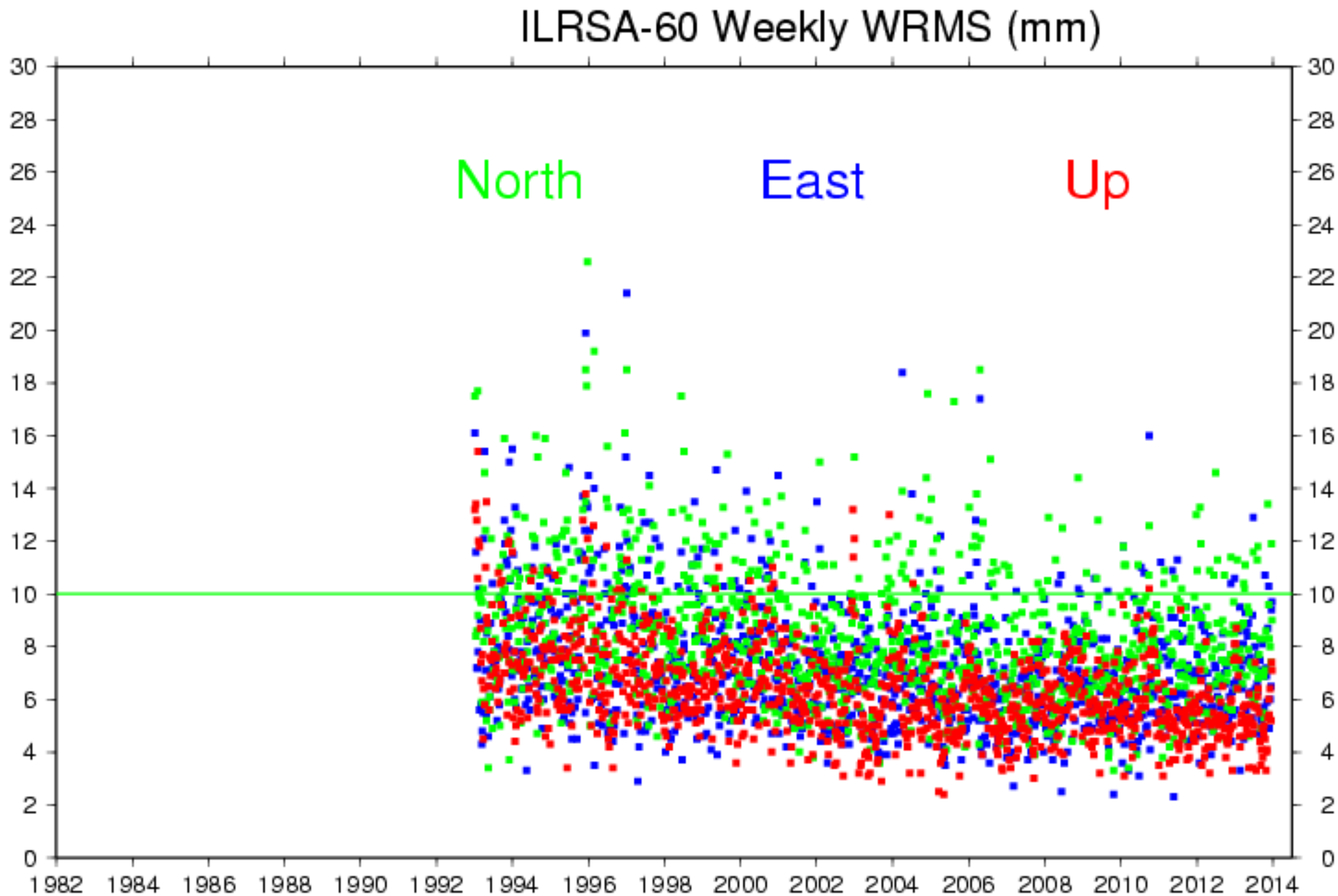
SLR/ILRS Internal Origin & Scale

Annual and Semi-Annual signals removed



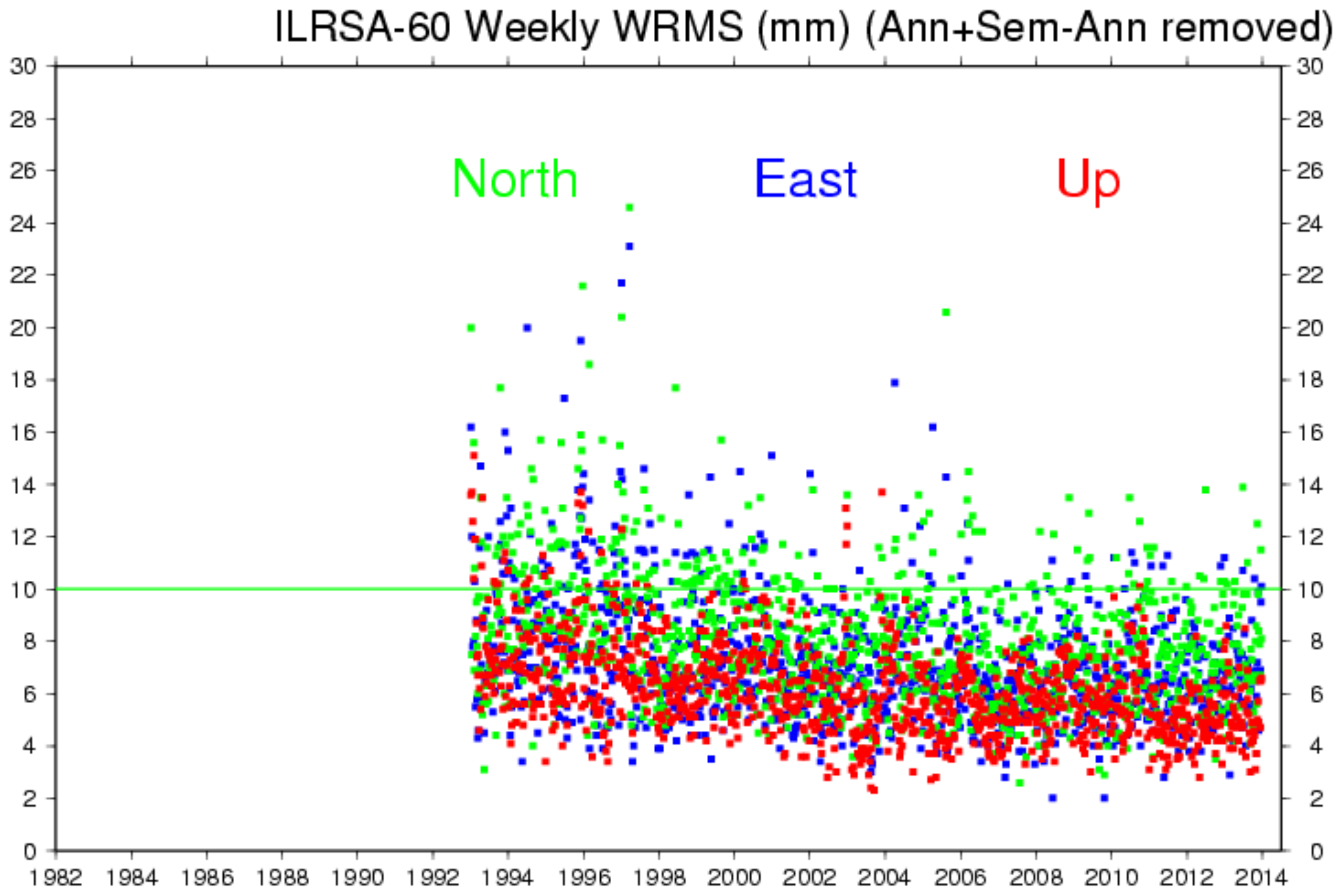
ILRS WRMS



ILRSA-60 Weekly WRMS (mm)
North
East
Up
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

ILRS WRMS

Annual & Semi-Annual signals removed



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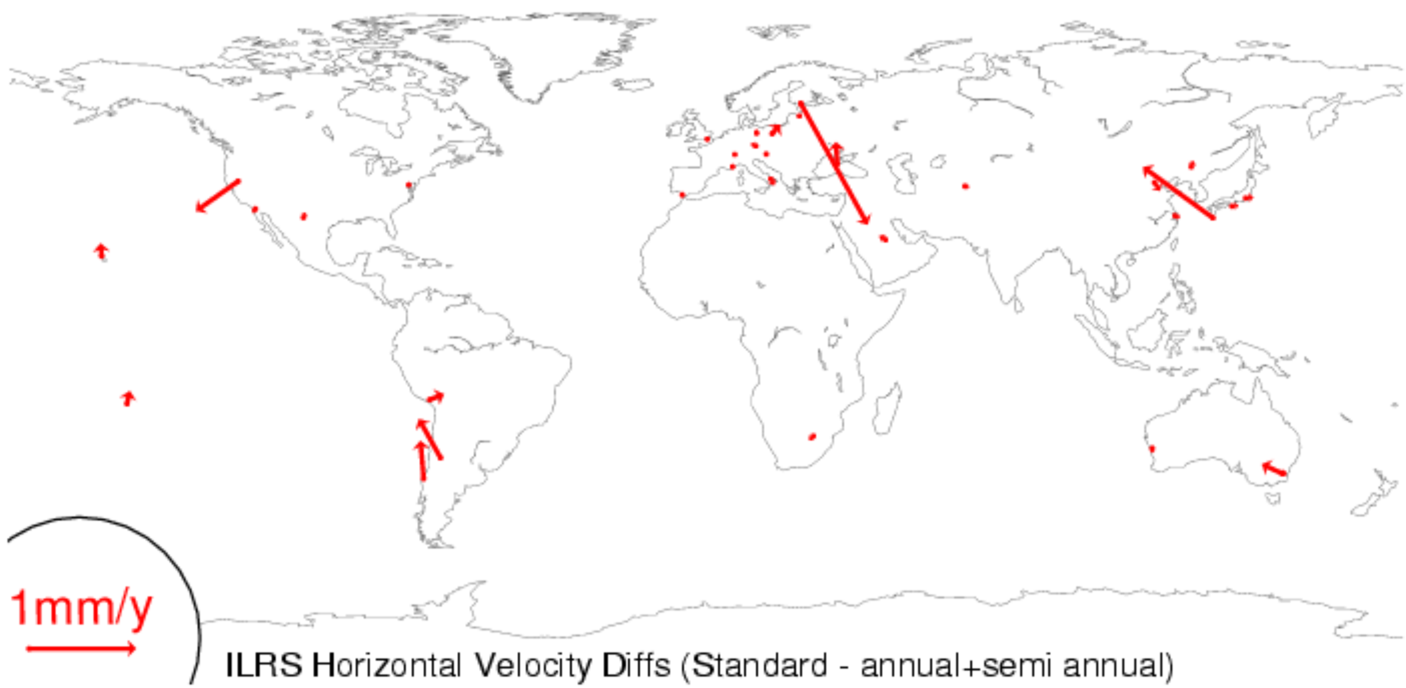
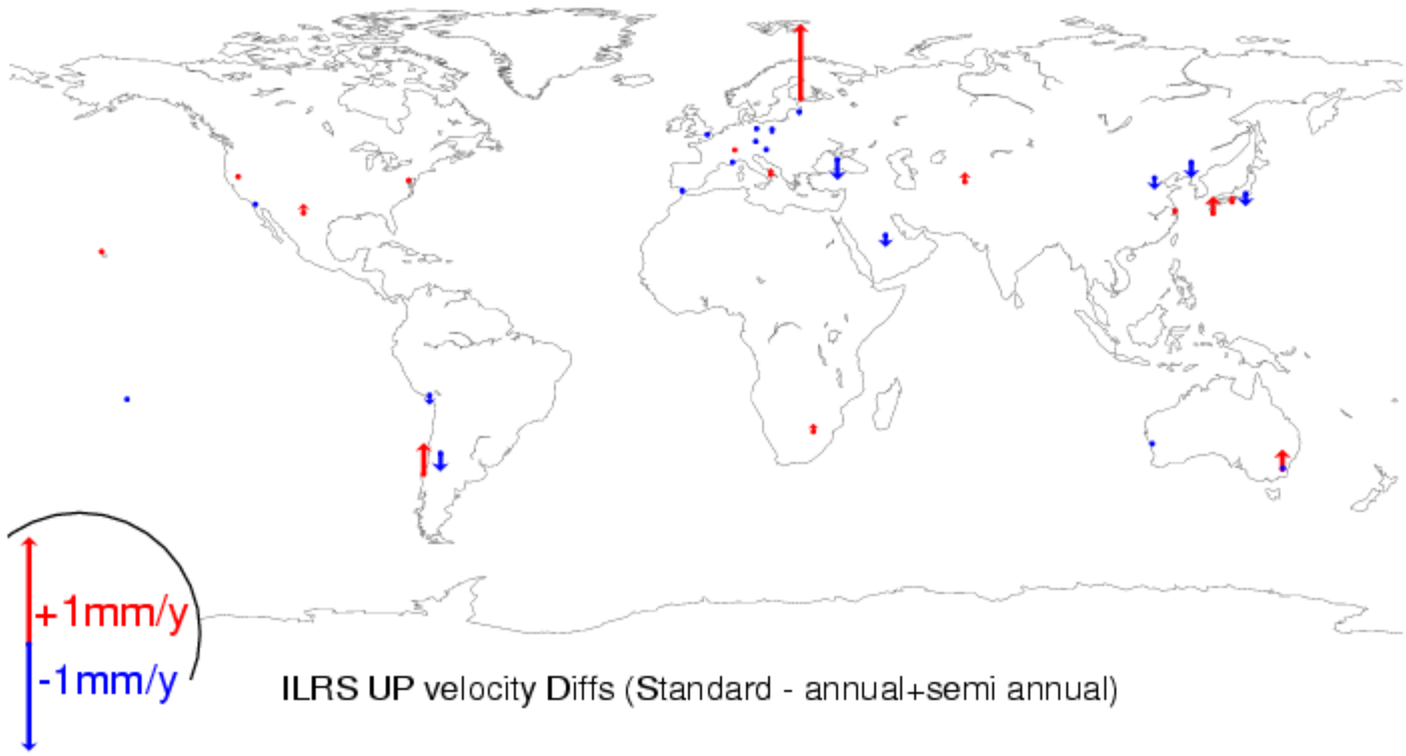
ILRS horizontal velocity differences (Standard – Annual+Semi-Annual)



ILRS Up velocity differences (Standard – Annual+Semi-Annual)



Parametric post seismic models

Parametric models for postseismic displacements :

$\forall i \in \{E, N, U\}, X_i(t) =$

$$\begin{cases} X_1(t_0) + V_1 \times (t - t_0) & , \quad t < t_{eq} \\ X_2(t_{eq}) + V_2 \times (t - t_{eq}) + D(t - t_{eq}), & \quad t > t_{eq} \end{cases}$$

Parametric postseismic models use logarithmic or exponential functions :

$D(t - t_{eqk})$ with

$$D(t - t_{eqk}) = A \, log(1 + \frac{t - t_{eqk}}{\tau}) \tag{1}$$

or

$$D(t - t_{eqk}) = A \, (1 - e^{-\frac{t - t_{eqk}}{\tau}}) \tag{2}$$

[e.g. : Kreemer et al., 2006]

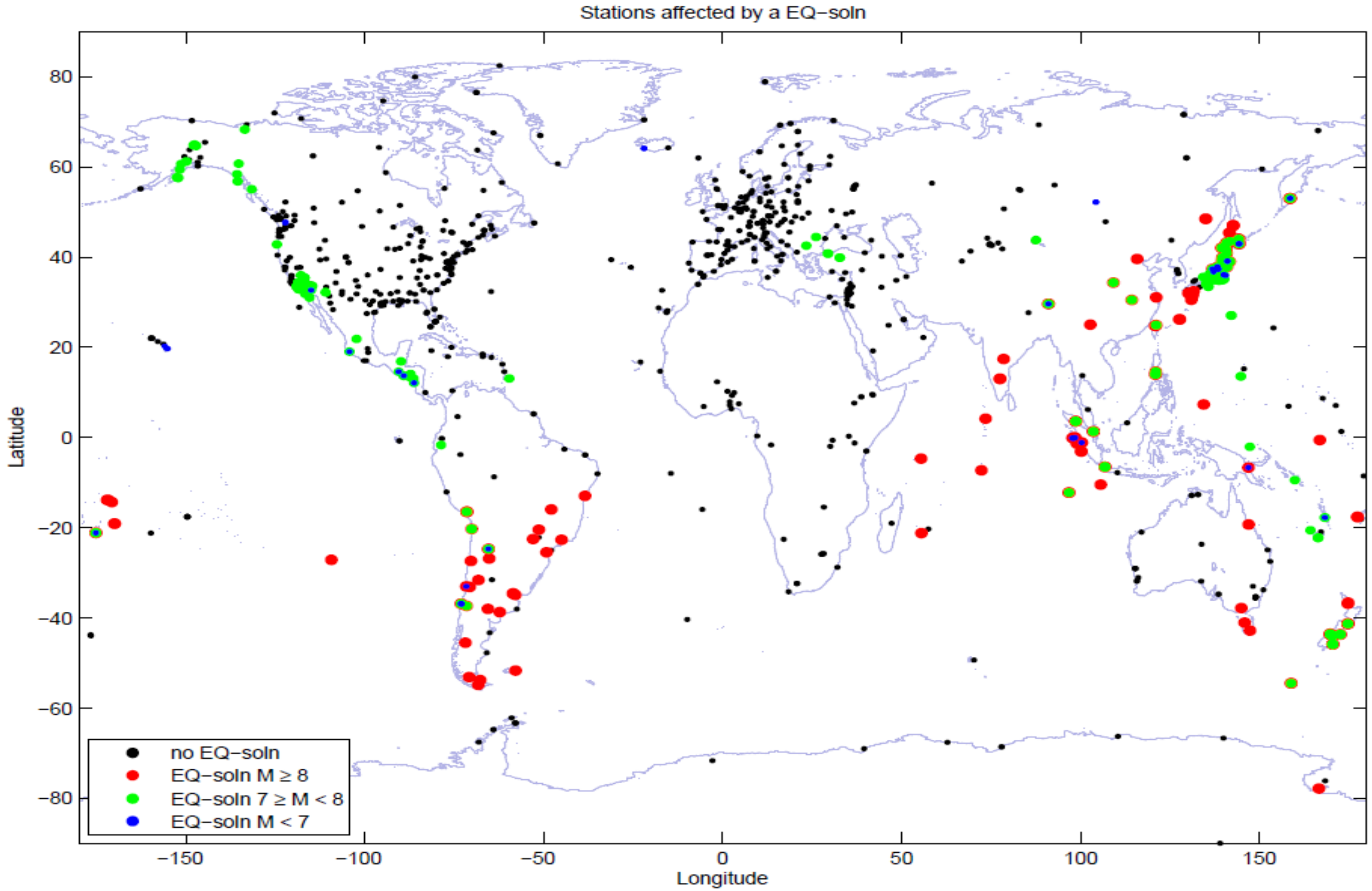
or

$$D(t - t_{eqk}) = A_1 \, log(1 + \frac{t - t_{eqk}}{\tau_1}) + A_2 \, (1 - e^{-\frac{t - t_{eqk}}{\tau_2}}) \tag{3}$$

or

$$D(t - t_{eqk}) = A_1 \, (1 - e^{-\frac{t - t_{eqk}}{\tau_1}}) + A_2 \, (1 - e^{-\frac{t - t_{eqk}}{\tau_2}}) \tag{4}$$

Sites affected by EQ discontinuities

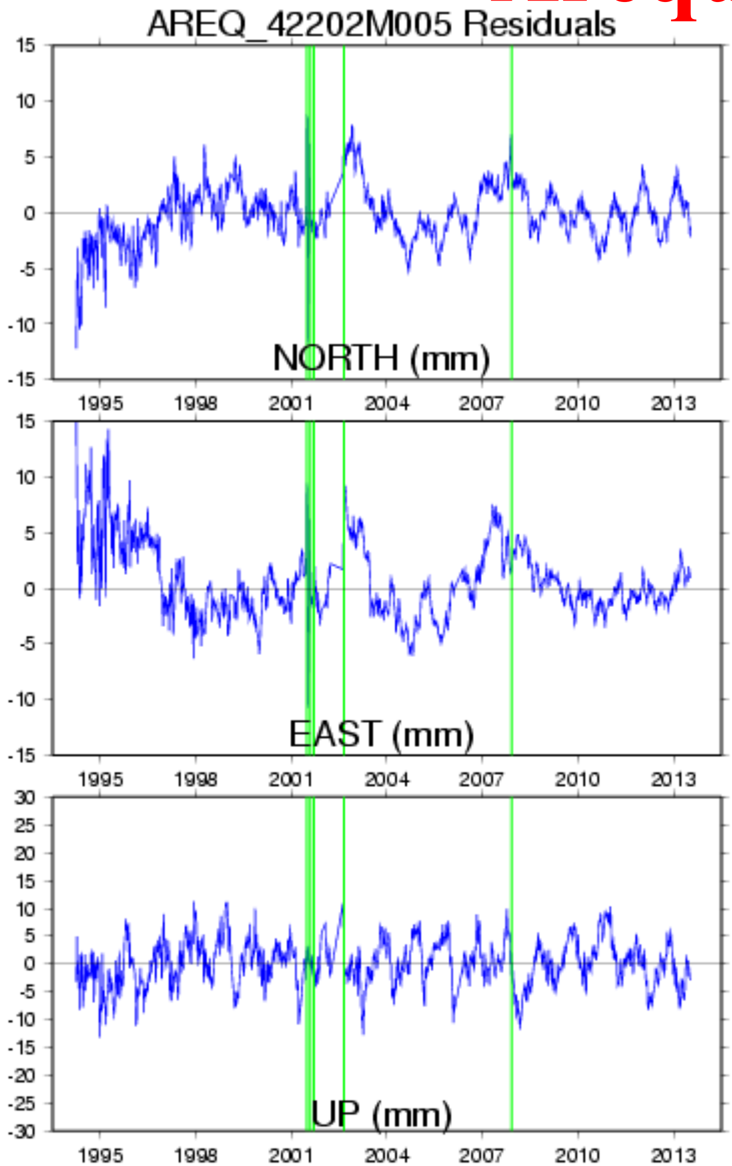


(Métivier et al., 2014)

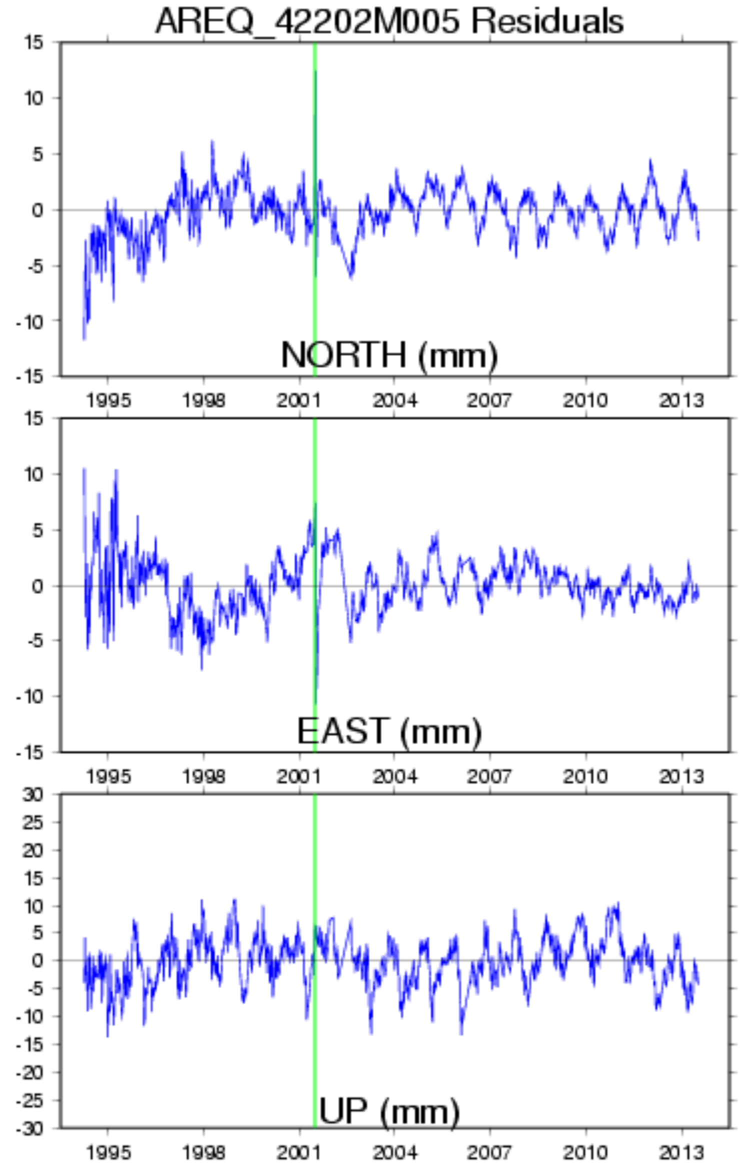
Arequipa GPS

Linear Function | **Parametric Model**

Multiple velocities estimated

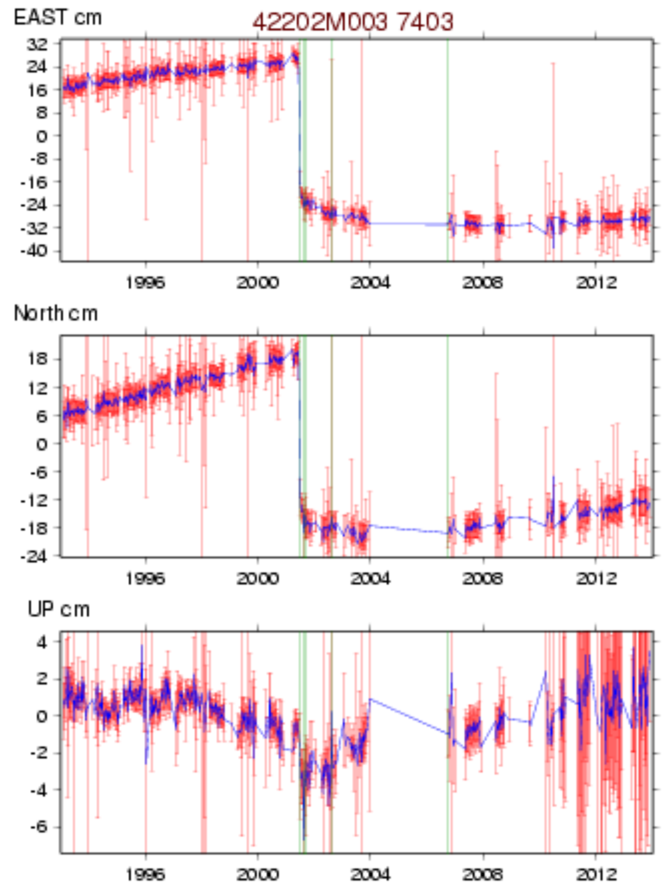


Post-fit residuals

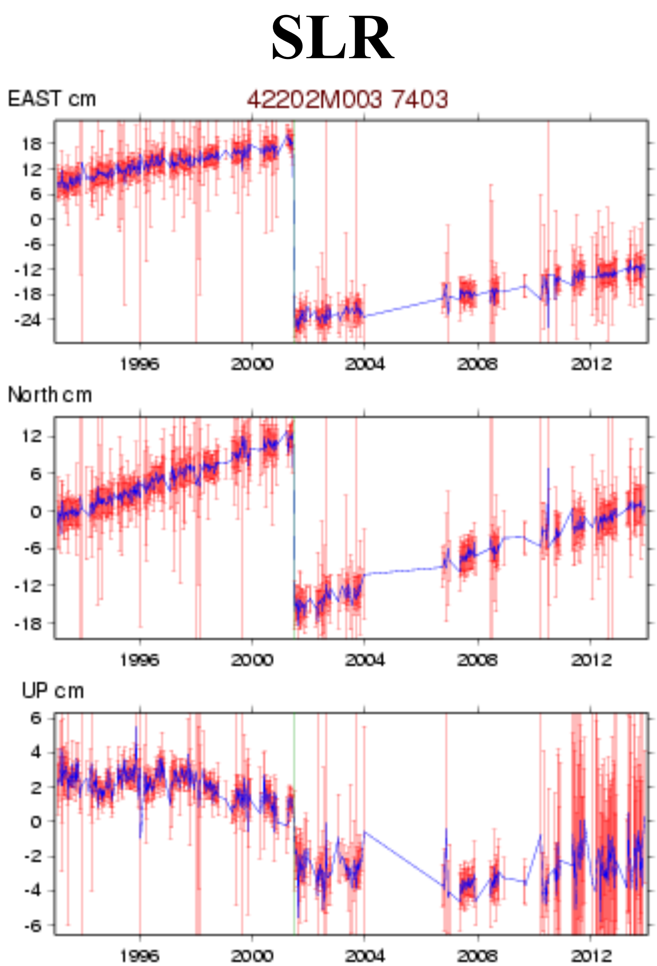


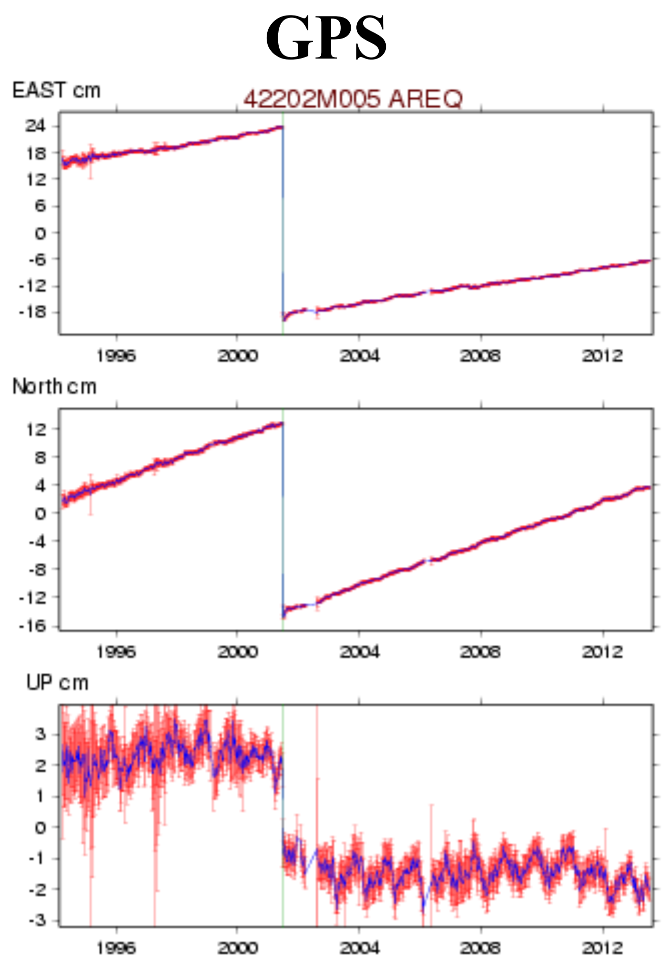
One velocity estimated

Arequipa SLR time series: EQ model "Linear Function"



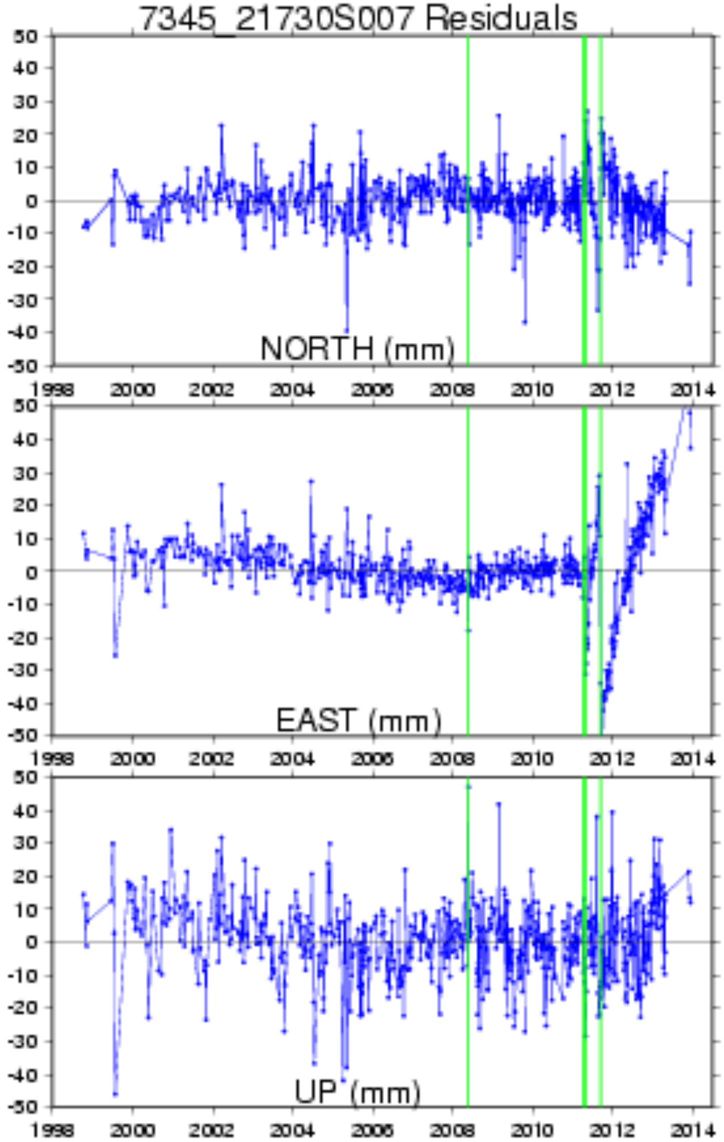
Arequipa SLR time series: EQ Parametric model



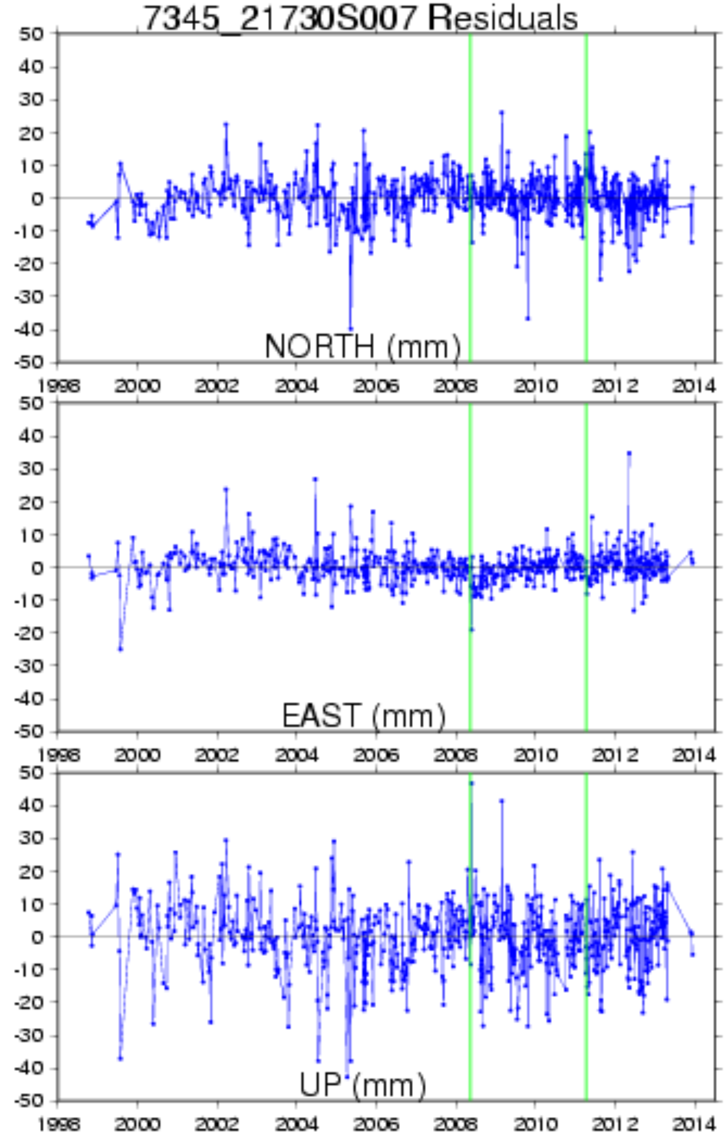


Linear Function **Tsukuba VLBI** Parametric Model

Multiple velocities estimated



Post-fit residuals



One velocity estimated

ITRF2013 Products

- **The usual products:**
  - Station positions, velocities and residuals;
  - EOPs

- **Additional/new products**
  - Geocenter motion model (amplitude & phase per component: X, Y, Z), probably from SLR only
  - Parametric models (amplitude A & relaxation time τ) Necessary to propagate coordinates at any epoch
  - On request: periodic signals (amplitudes & phases), per technique

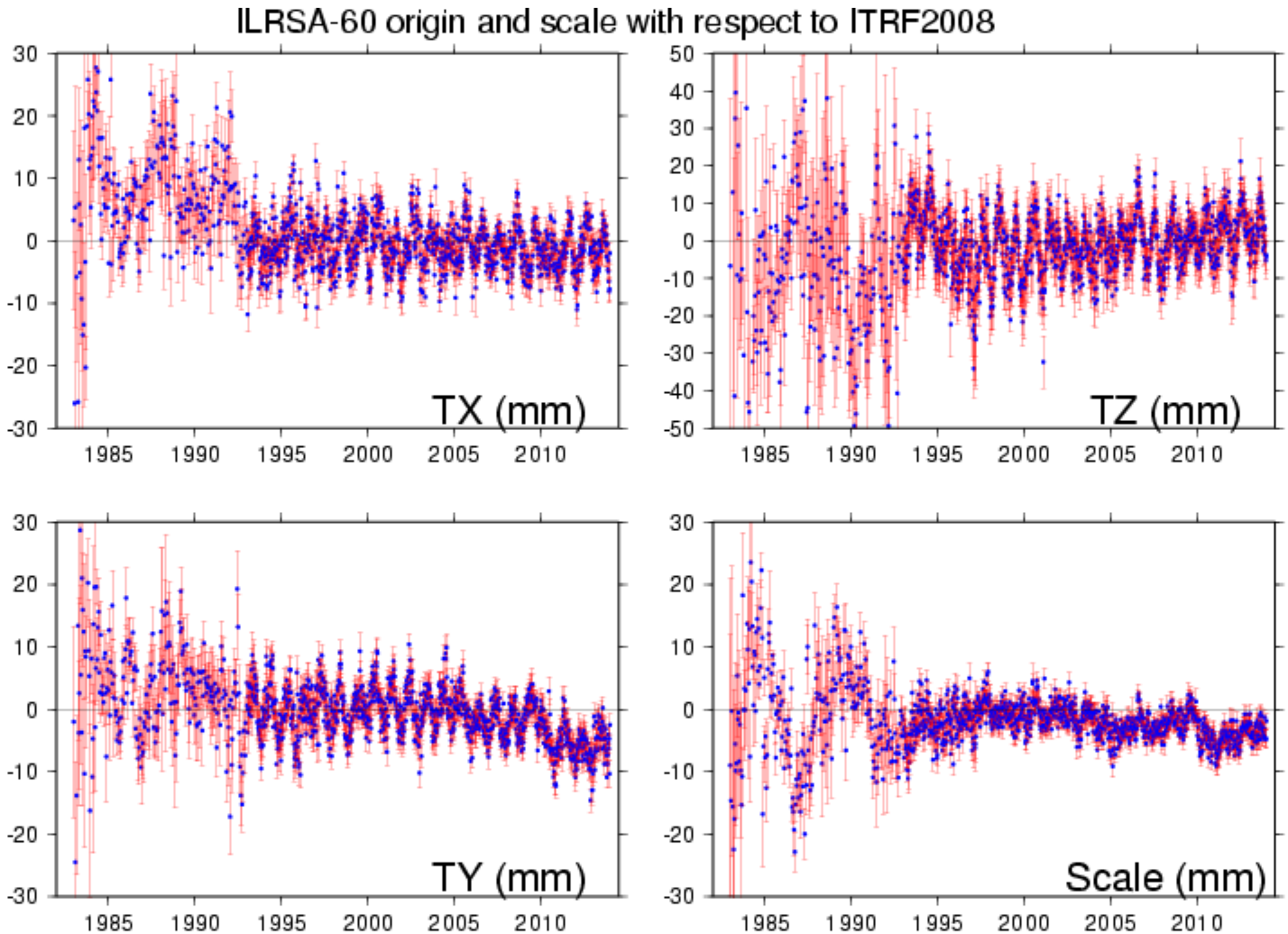
Conclusion

- **Impact of station non-linear motions on the ITRF**
  - **No impact on the RF defining parameters (origin, scale & orientation)**
  - **Negligible velocity changes (<< 1 mm/yr) for some sites when removing periodic signals**

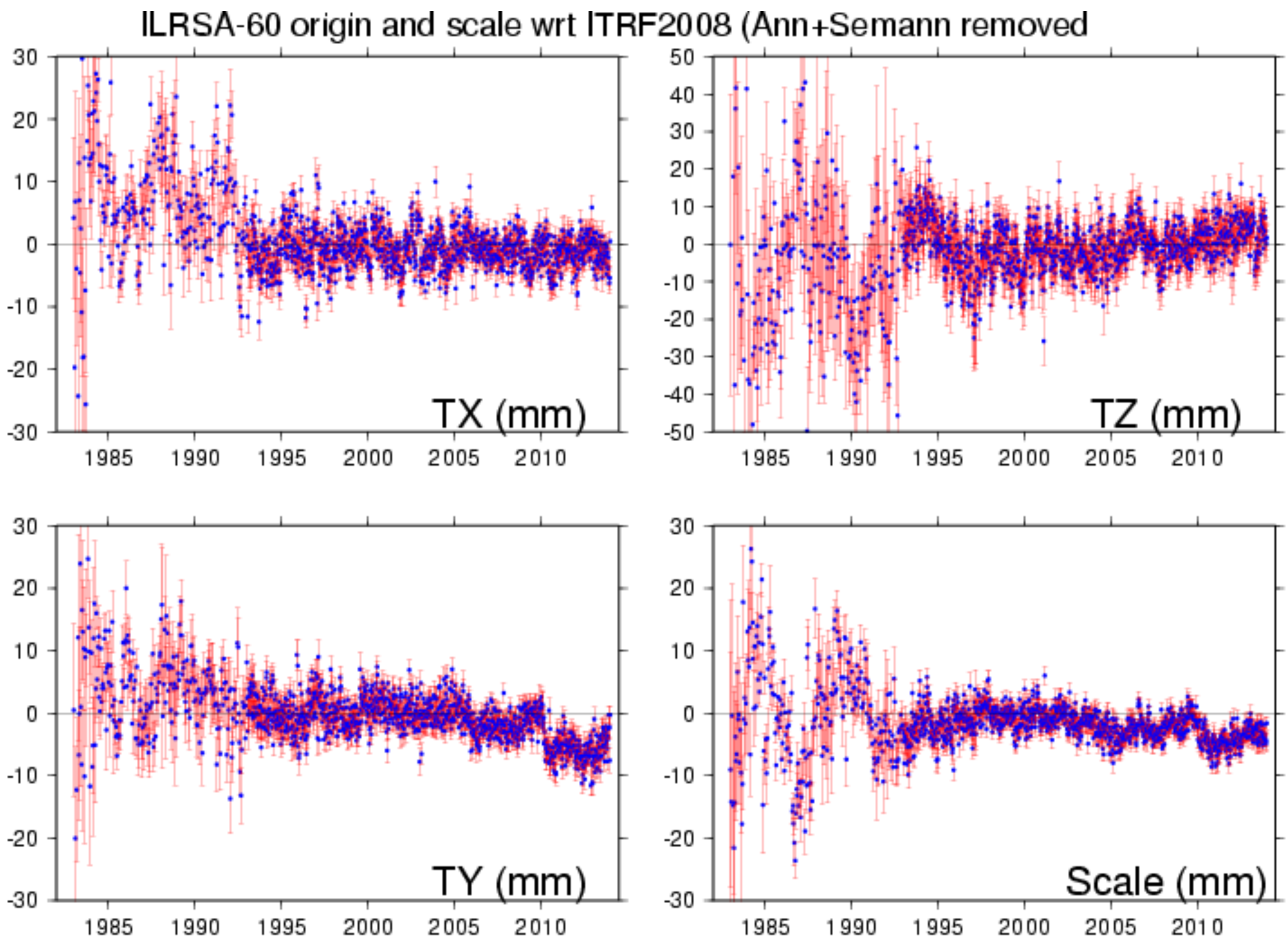
- **SLR analysis:**
  - **origin and scale consistent with SLR input data to ITRF2008**
  - **WRMS in ENU: ~ 7, 8, 6 mm for 1993 – 2013**
    ~ 10, 10, 8 mm for 1983 – 2013

- **Still waiting for submissions to be complete!**

SLR/ILRS Origin & Scale wrt ITRF2008

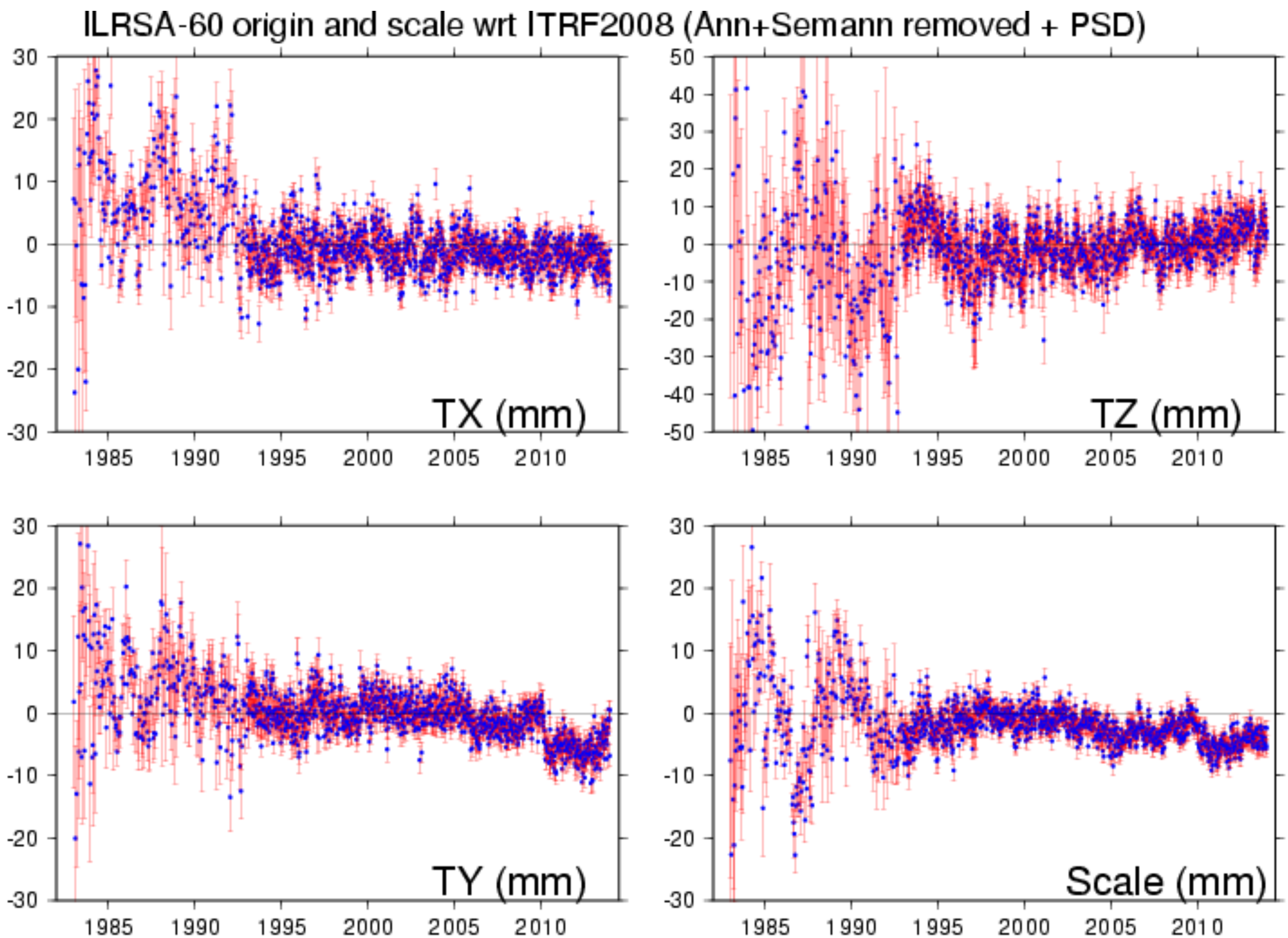


SLR/ILRS Origin & Scale wrt ITRF2008
Annual and Semi-Annual signals removed



SLR/ILRS Origin & Scale wrt ITRF2008

Annual and Semi-Annual signals removed + PSD



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