Preparation for the ITRF2013

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Outline

- **Introduction**
- **Solicited solutions**
- **Analysis Strategy**
- **Preparation for the ITRF2013: Combination tests**
  - **Analysis of solutions submitted w/o NT-ATML corrections**
  - **Velocity and tie discrepancies**

ITRF2013

- **To be ready in mid 2014:**
  - **CfP Published March 2013**
  - **All techniques to submit solutions by Jan-Feb, 2014**

- **Expected Improvements & Developments:**
  - **Reprocessed solutions from 4 techniques;**
  - **Revisiting the weighting of Local Ties and Space Geodesy solutions included in the ITRF combination;**
  - **Improving the process of detection of discontinuities in the time series;**
  - **Modelling the post-seismic & non-linear station motions.**

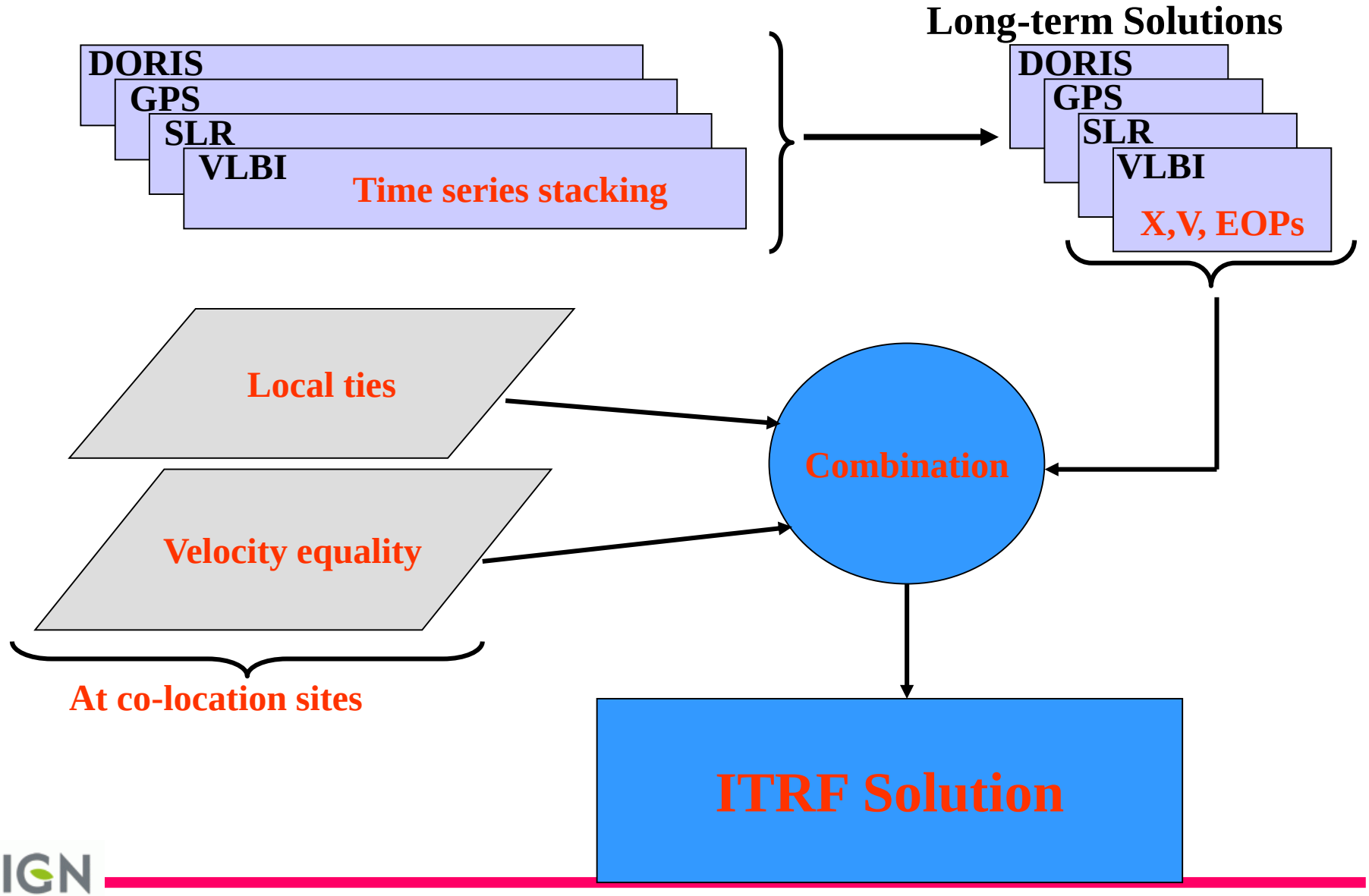
Solicited solutions

- Solutions with removable constraints;
- Loosely constrained solutions
  (constraint level: $\sigma > 1$ m);
- Free singular normal equations.
- NO loading corrections should be applied
- Should cover full history of observations of each technique

Outline of ITRF2013 analysis strategy

- **Remove original constraints (if any);**
- **Apply non-tidal atmospheric (and possibly other loading) effects corrections;**
- **Perform per-technique combinations (TRF + EOP) of each individual time series;**
- **Combine the per-technique combinations adding local ties in co-location sites.**

ITRF Construction



Impact of NT-ATML model corrections on an ITRF-like combination

Use three solutions per technique:

- **Standard (no correction at all)**
- **Corrected a priori (at the obs. level)**
- **Corrected a posteriori, before multi-technique combination**

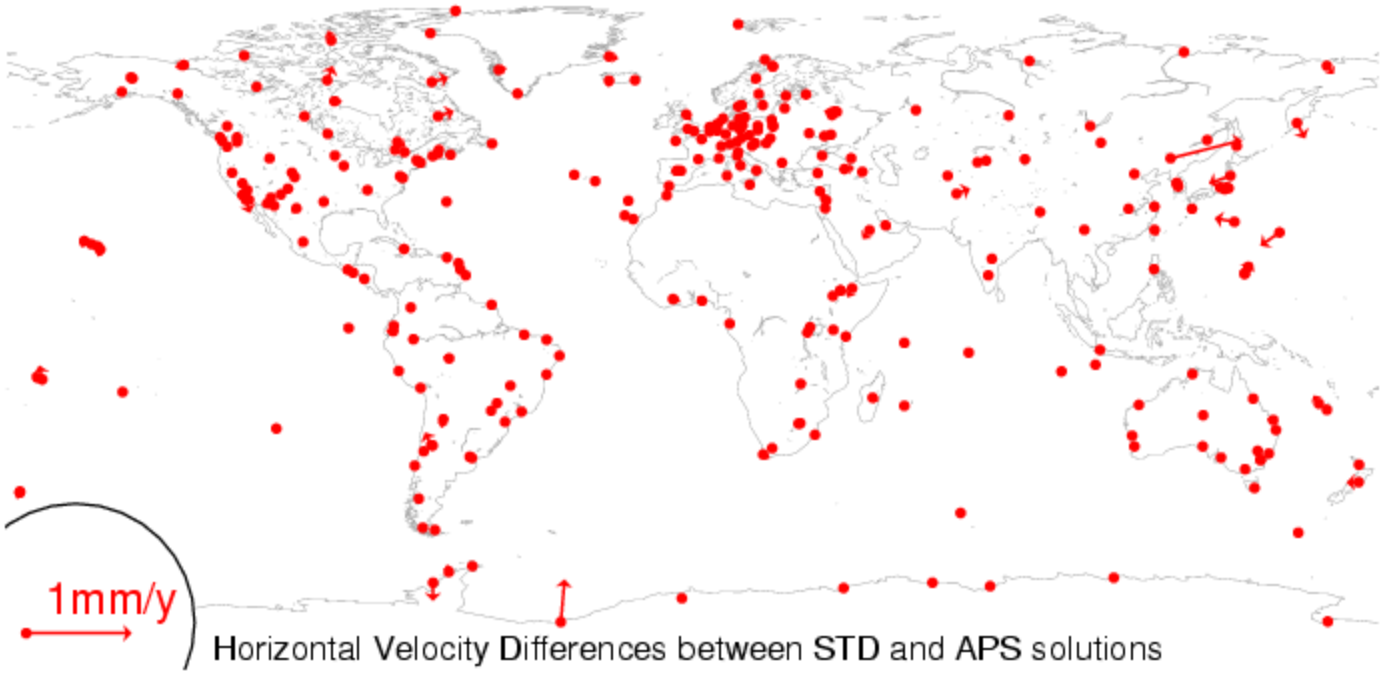
==> Combine long-term solutions with local ties

Results: the three test combinations are equivalent, except up velocities for stations with time-span < 3 years

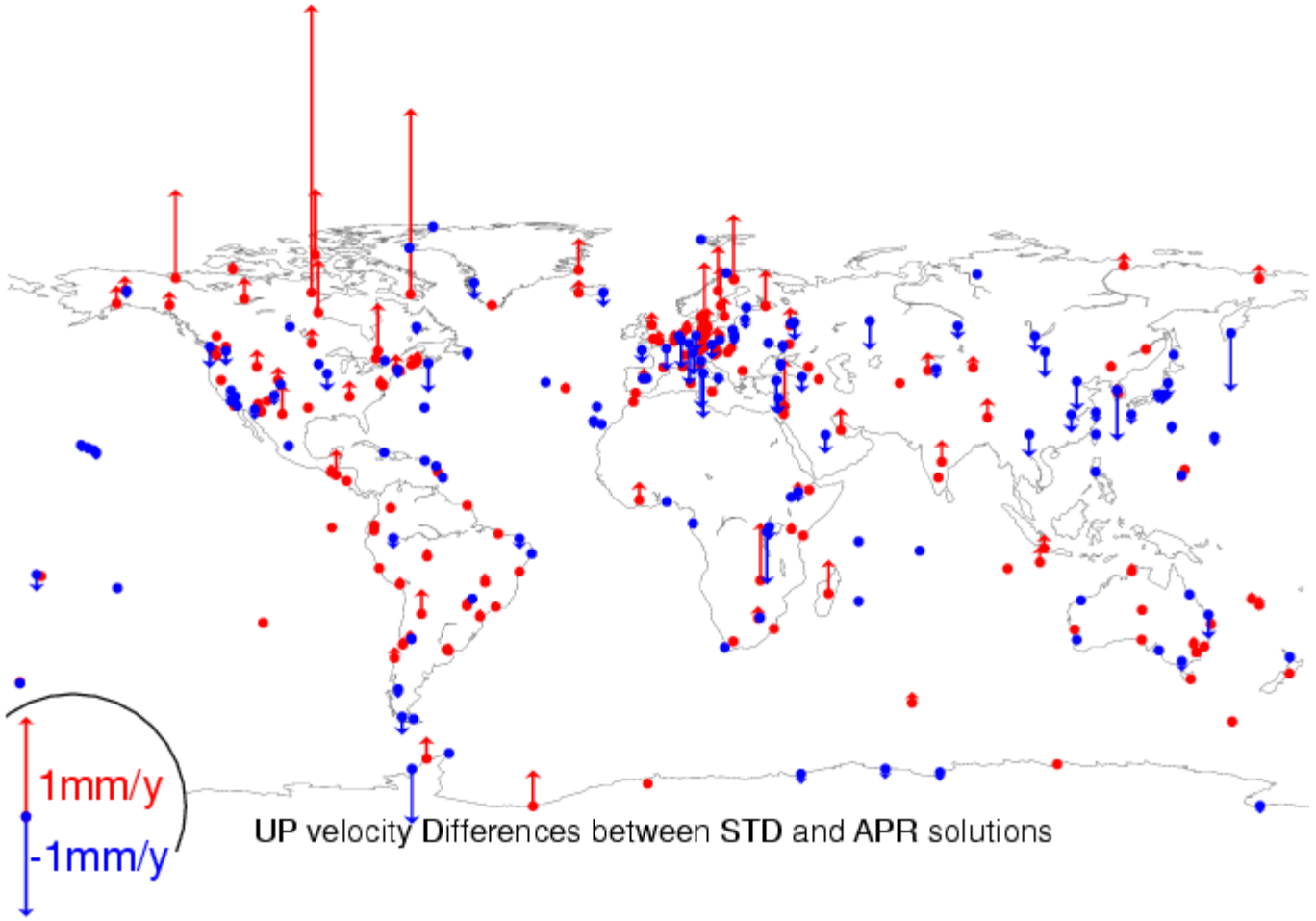
NT-ATML test campaign: analyzed solutions

Tech.	S/W	AC	contact	Loading model	Solution type
SLR	EPOSOC 06.69	GFZ	R. Koenig	GGFC	Solution
VLBI	CALC/ SOLVE	GSFC	D. MacMillan	GGFC	Solution + NEQ
DORIS	Geodyn/ Solve	GSFC	F. Lemoine	GGFC	NEQ
GPS	Bernese	CODE	R. Dach	GGFC	NEQ

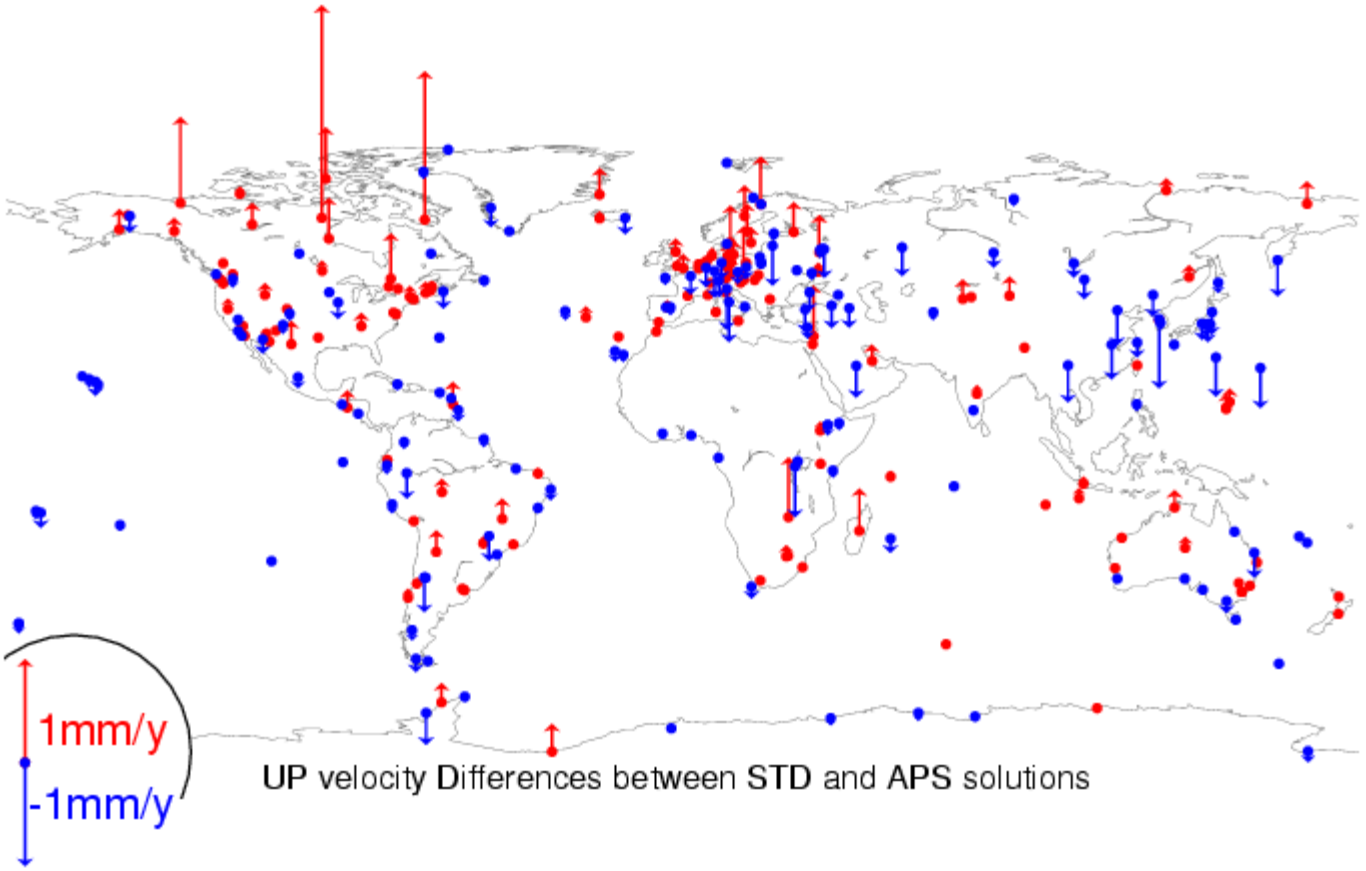
Horizontal Velocity differences btw standard and load corrected (a posteriori) solutions



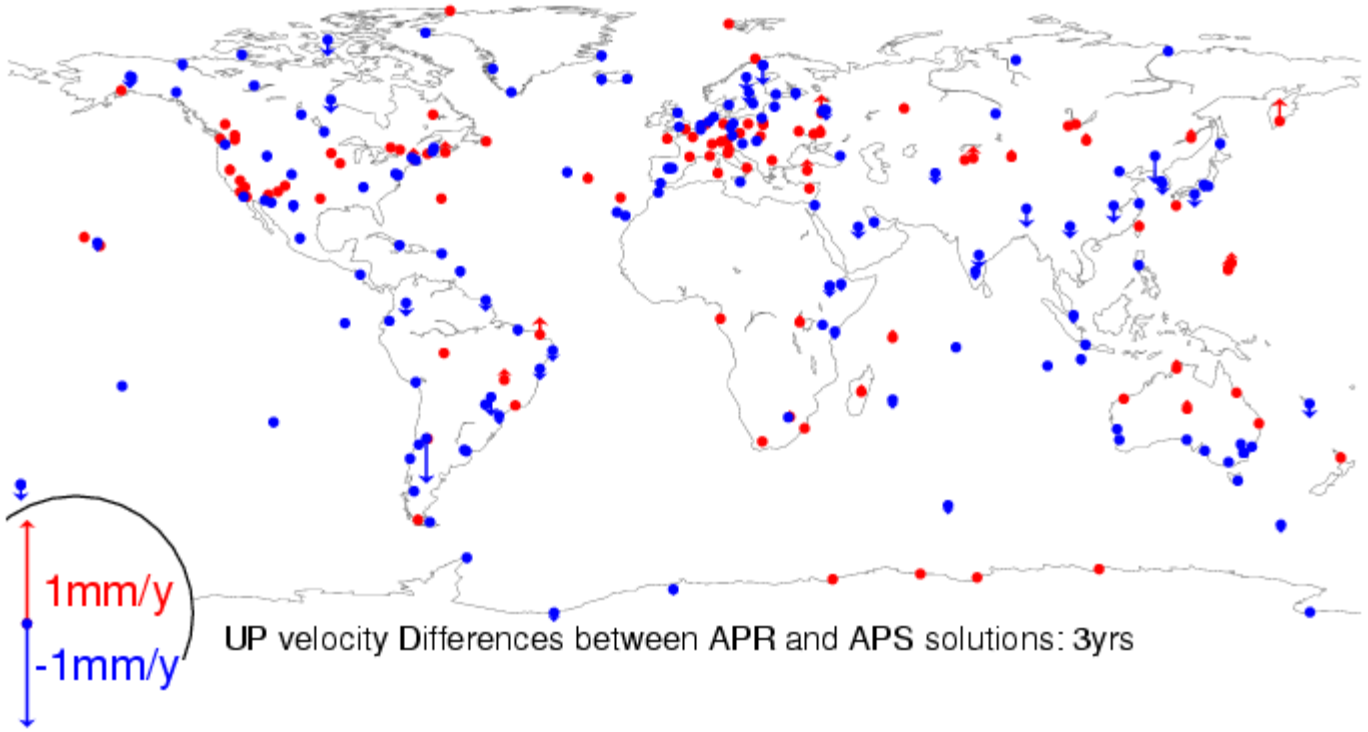
Vertical velocity differences btw standard and load corrected (a priori) solutions



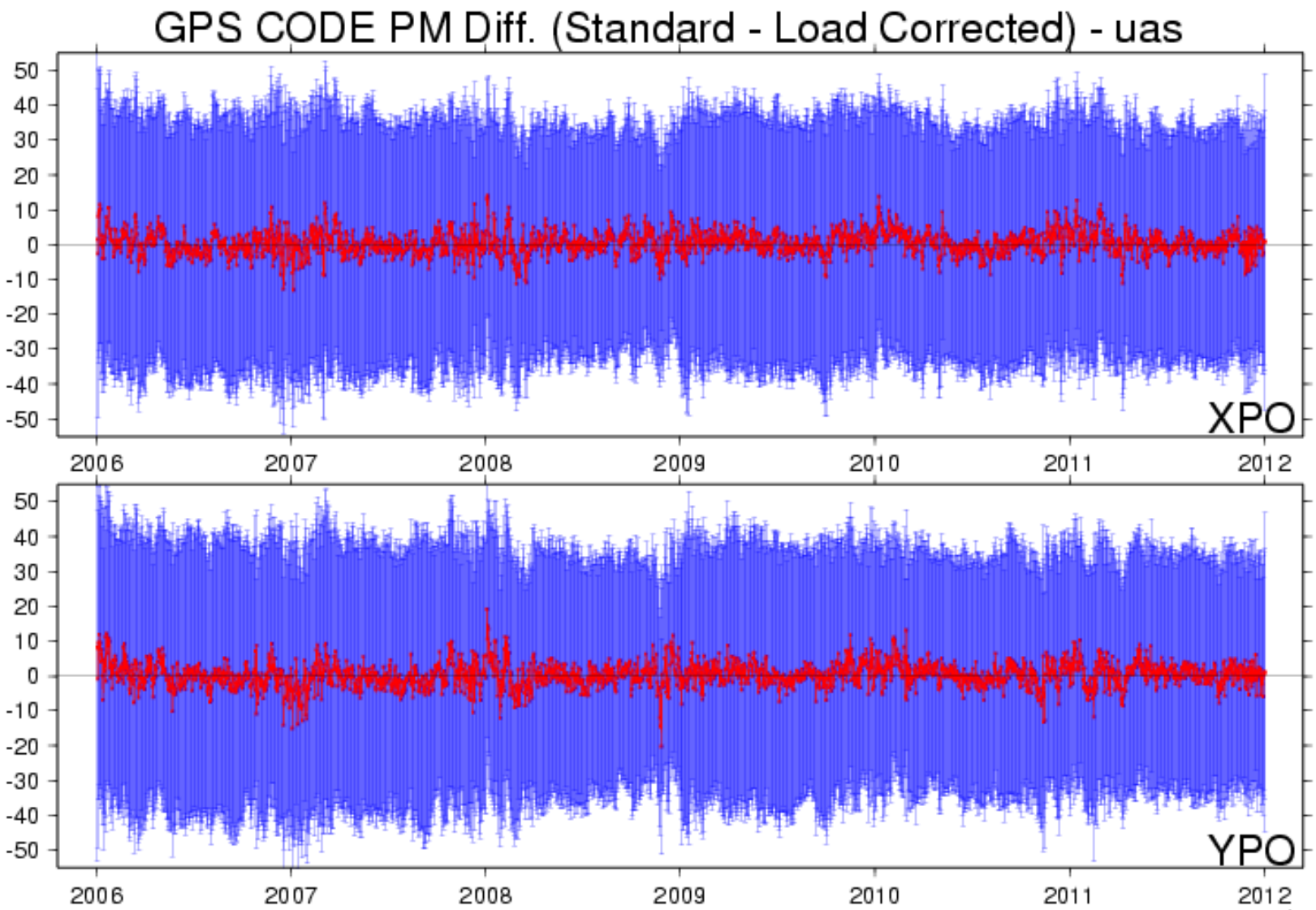
Horizontal Velocity differences btw standard and load corrected (a posteriori) solutions



Vertical velocity diffs btw load corrected a priori and a posteriori solutions (sites with time-span > 3 years)



NT-ATML impact on Polar Motion

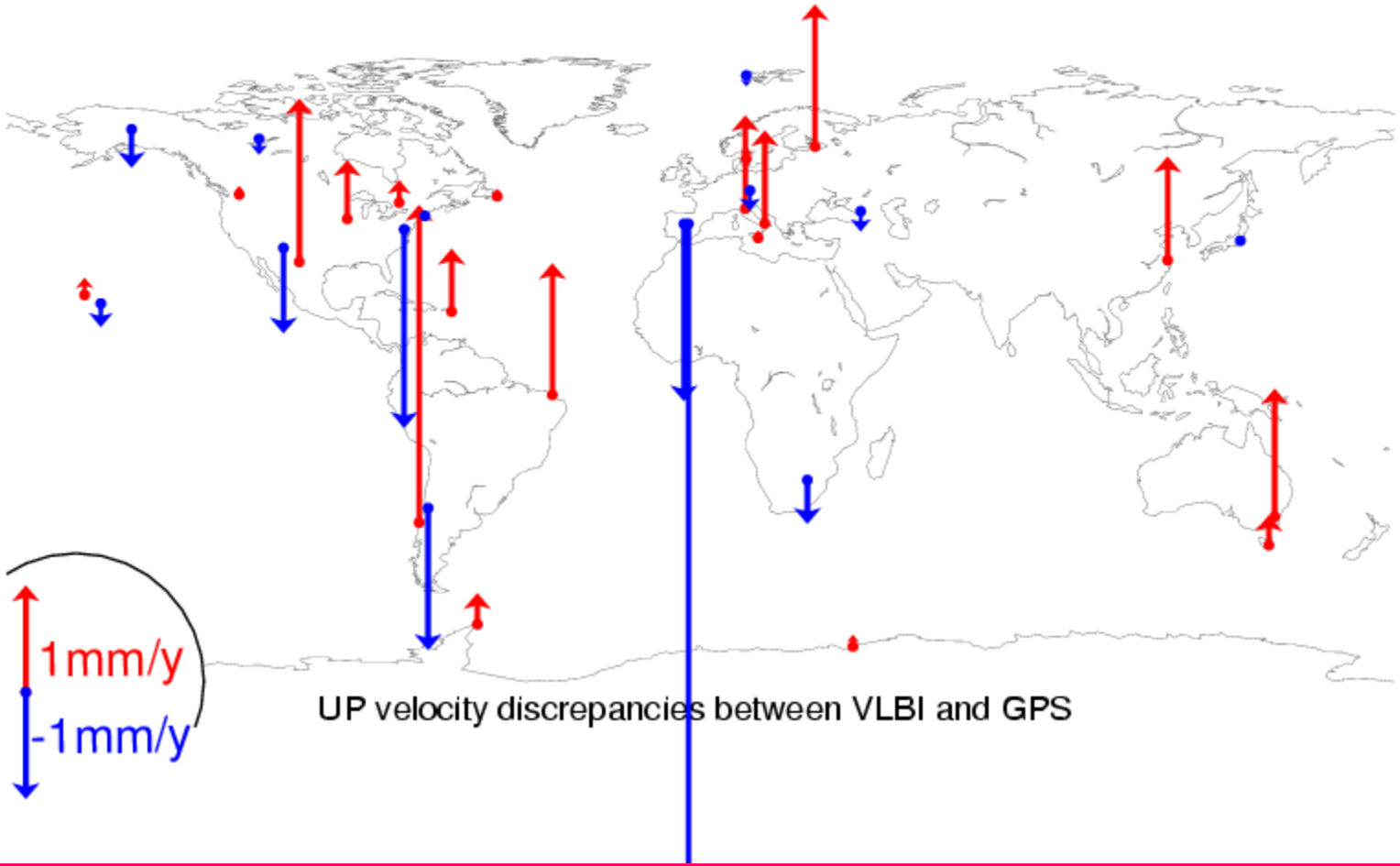


New combination tests to isolate velocity and tie discrepancies

GNSS & VLBI vertical velocity discrepancies

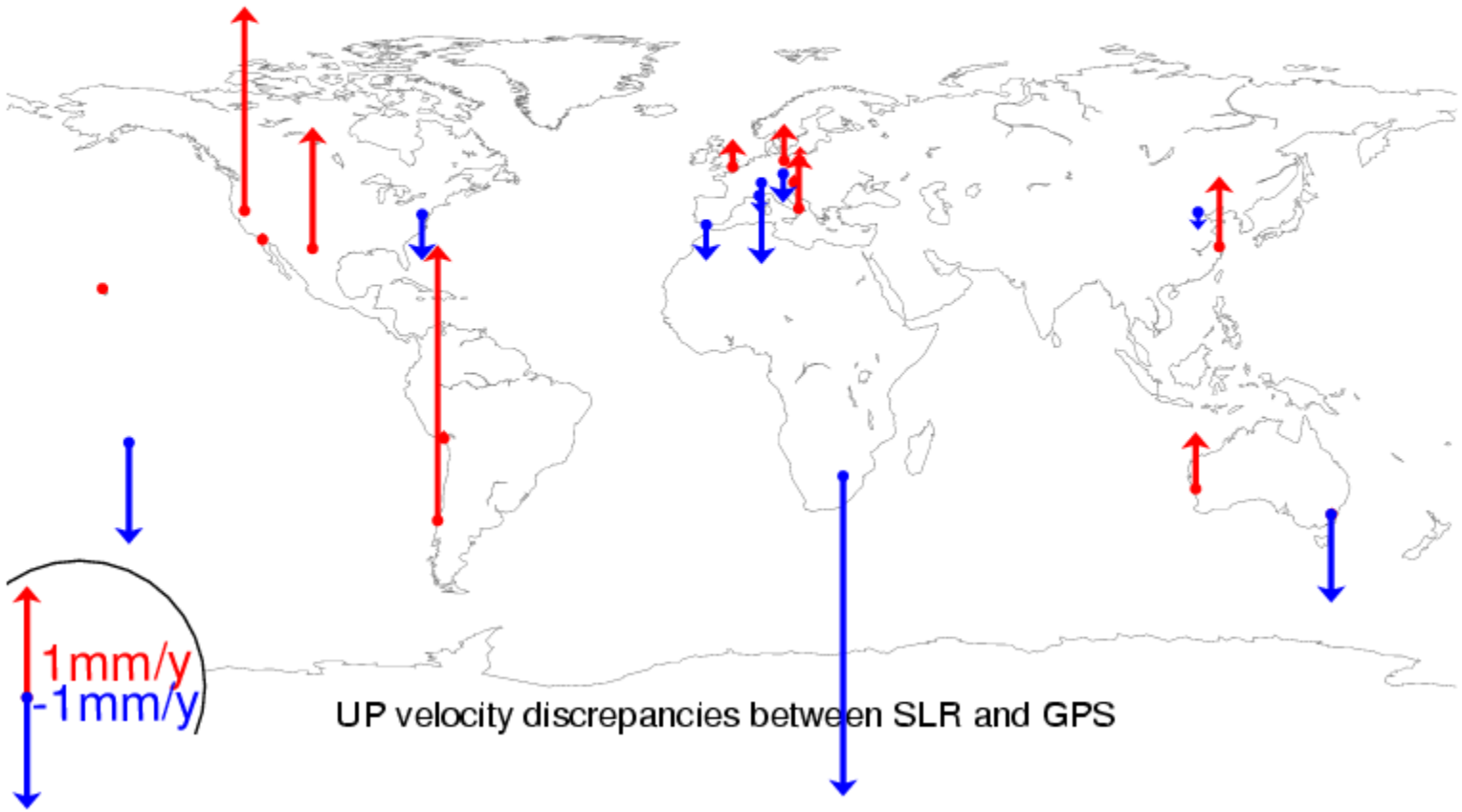
Formal error ± 0.3 mm/yr

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

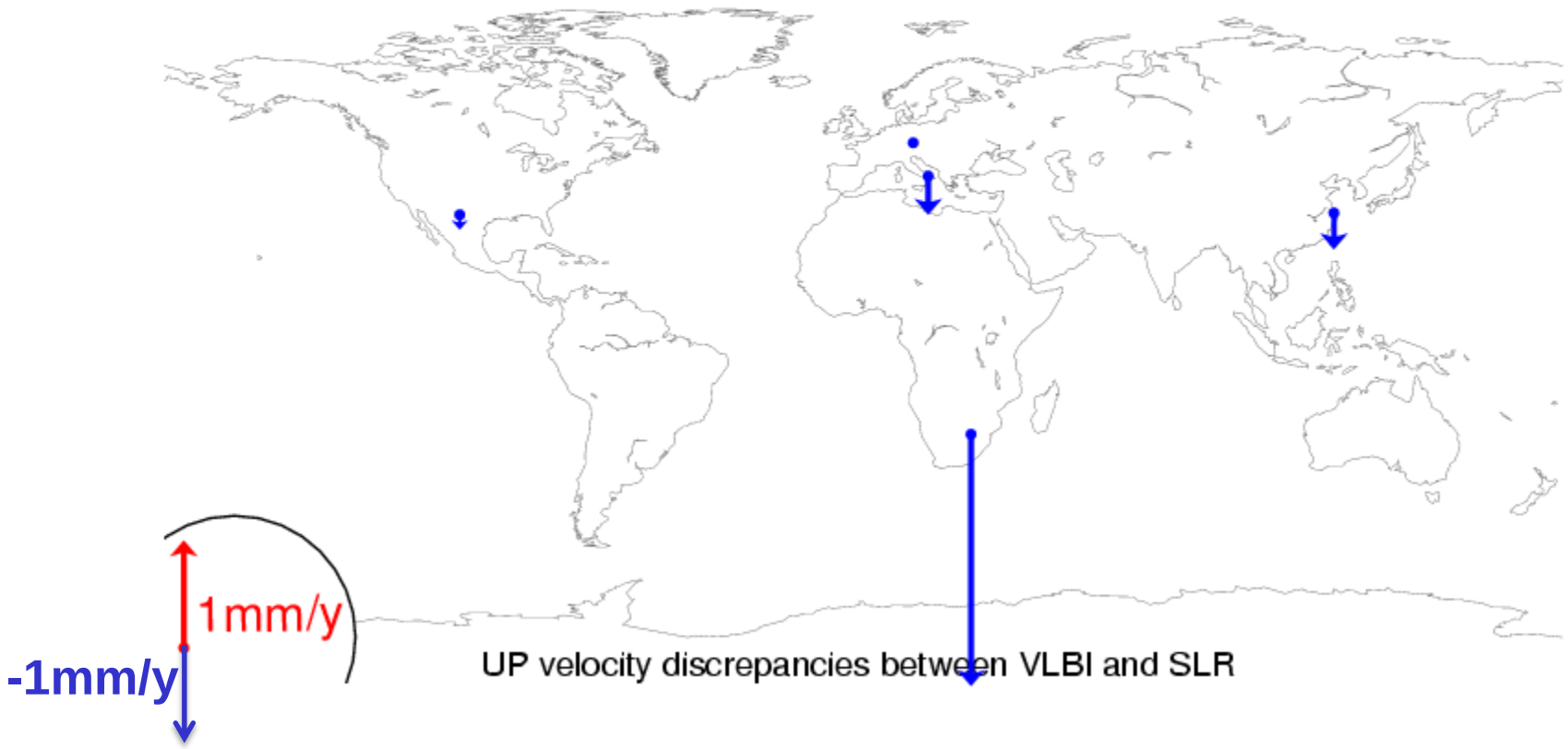


GNSS & SLR vertical velocity discrepancies

Formal error ± 0.3 mm/yr

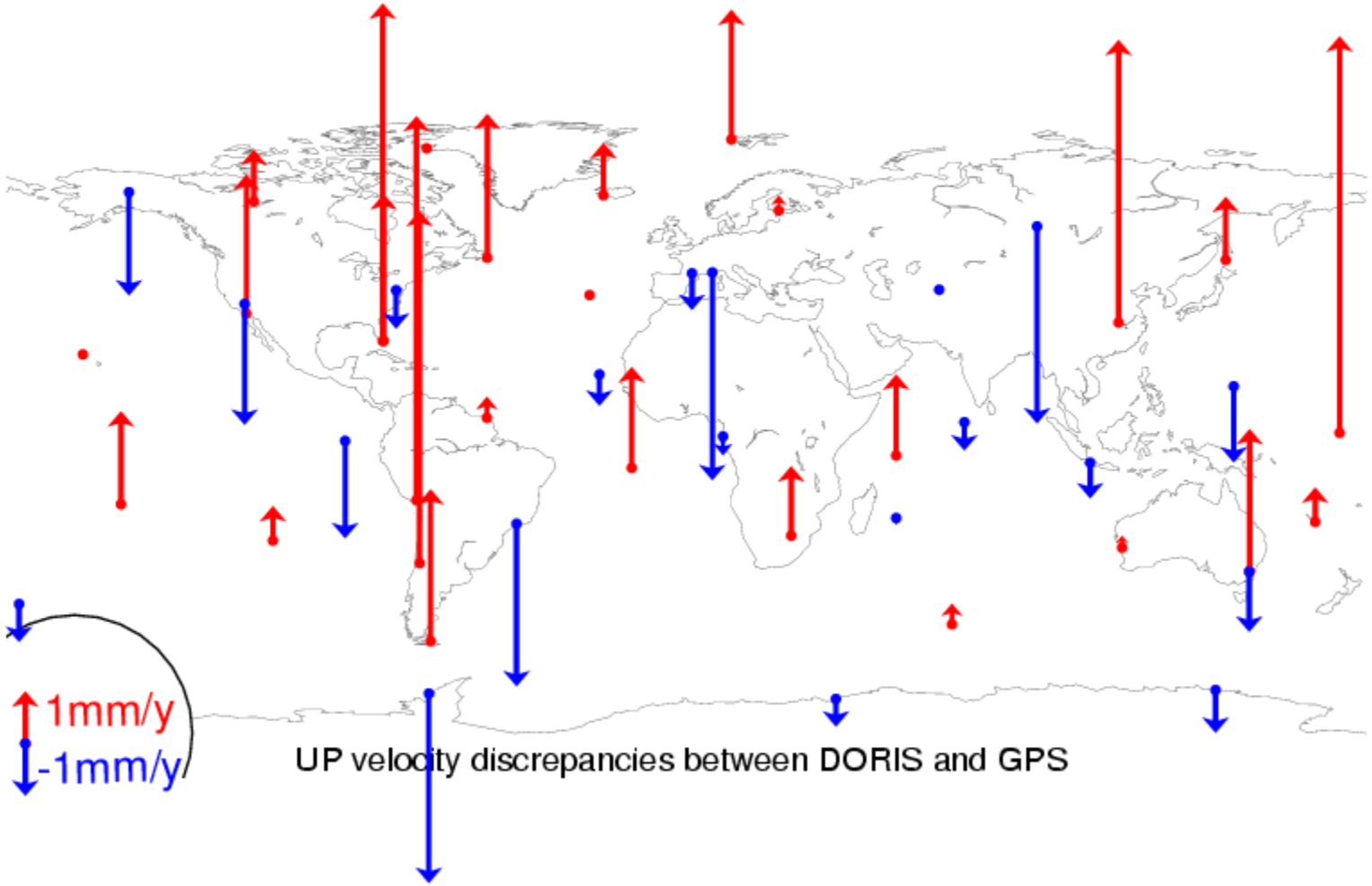


VLBI & SLR vertical velocity discrepancies



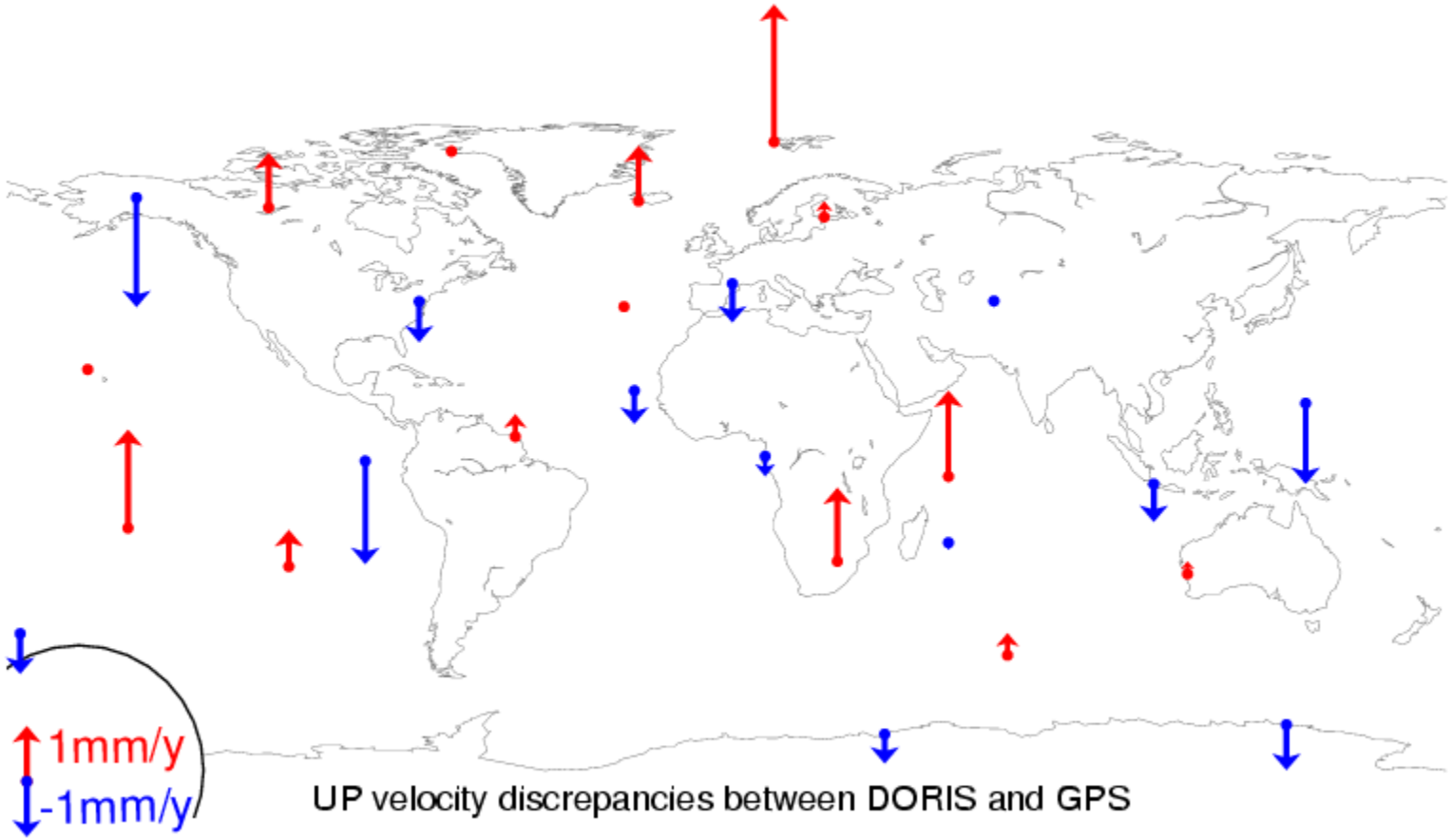
GNSS & DORIS vertical velocity discrepancies

Formal error ± 0.3 mm/yr



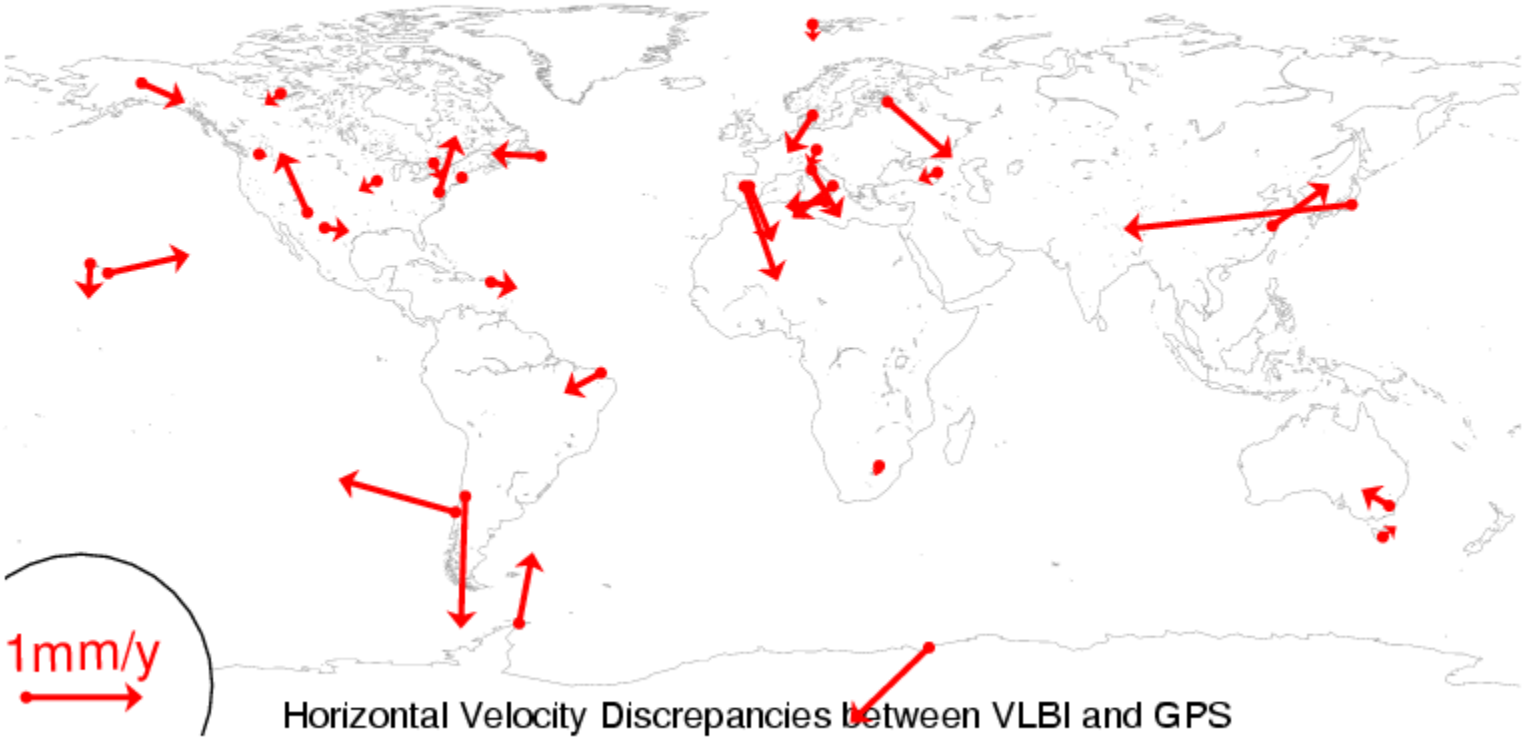
GNSS & DORIS vertical velocity discrepancies < 3mm/yr

Formal error ± 0.3 mm/yr



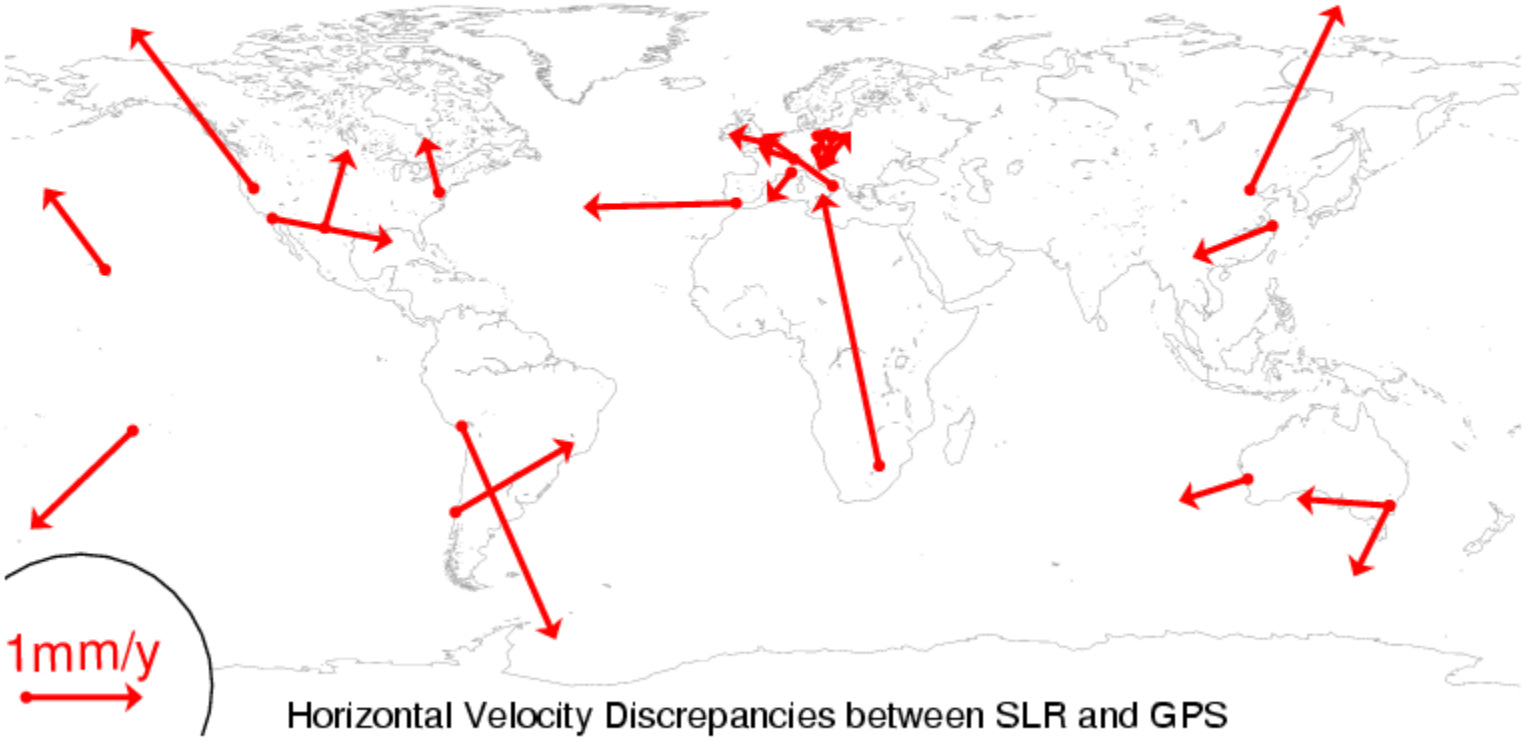
GNSS & VLBI horizontal velocity discrepancies

Formal error ± 0.2 mm/yr



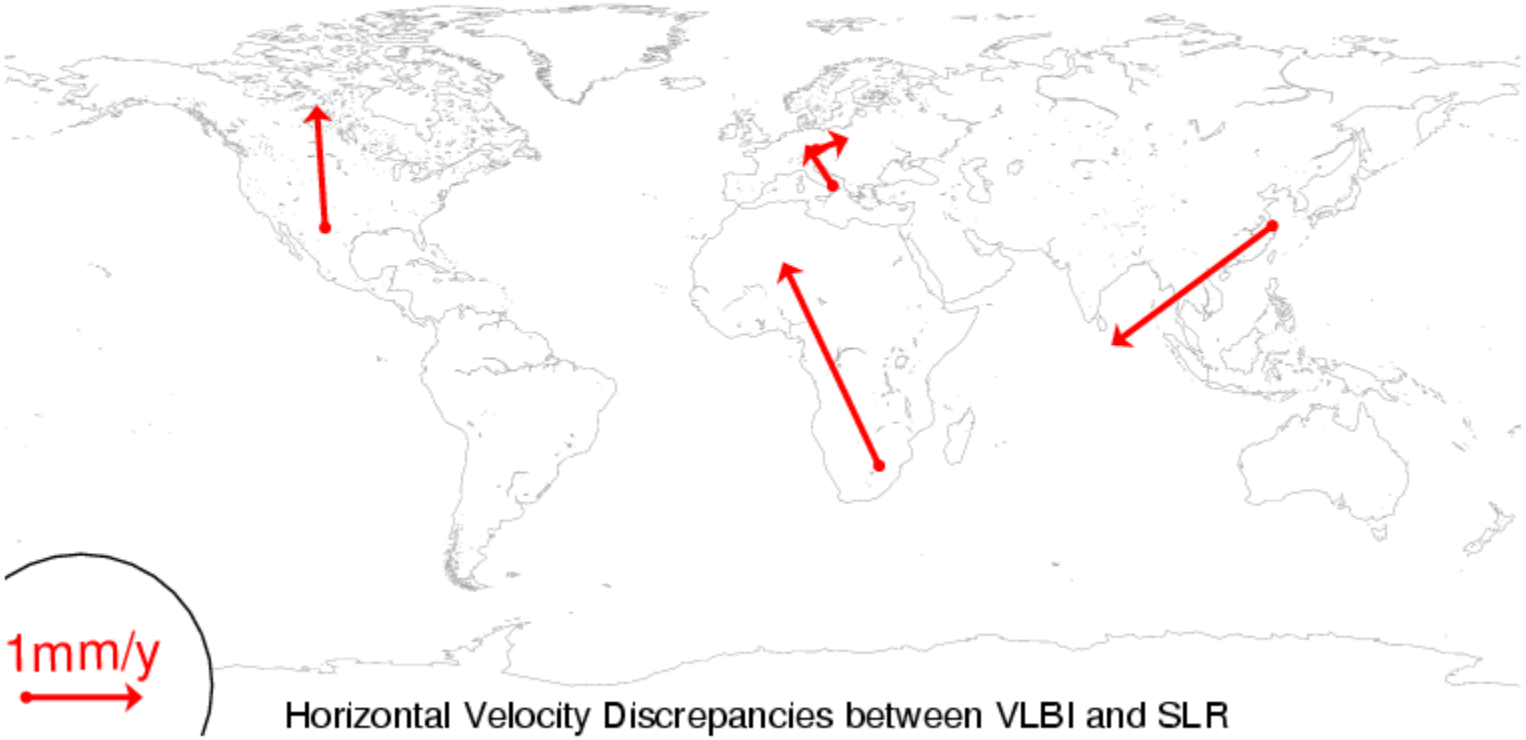
GNSS & SLR horizontal velocity discrepancies

Formal error ± 0.2 mm/yr



Horizontal Velocity Discrepancies between SLR and GPS

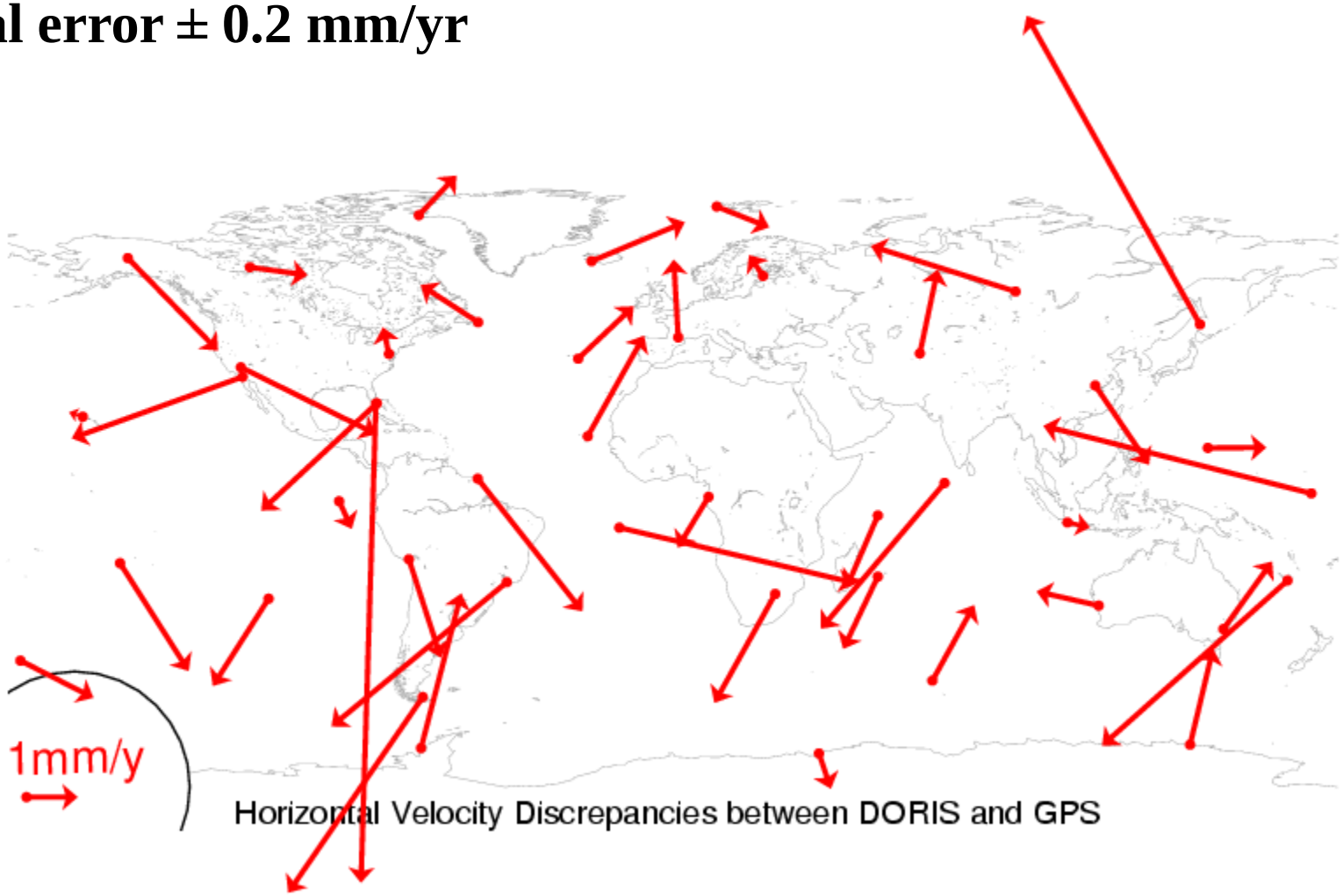
VLBI & SLR horizontal velocity discrepancies



Horizontal Velocity Discrepancies between VLBI and SLR

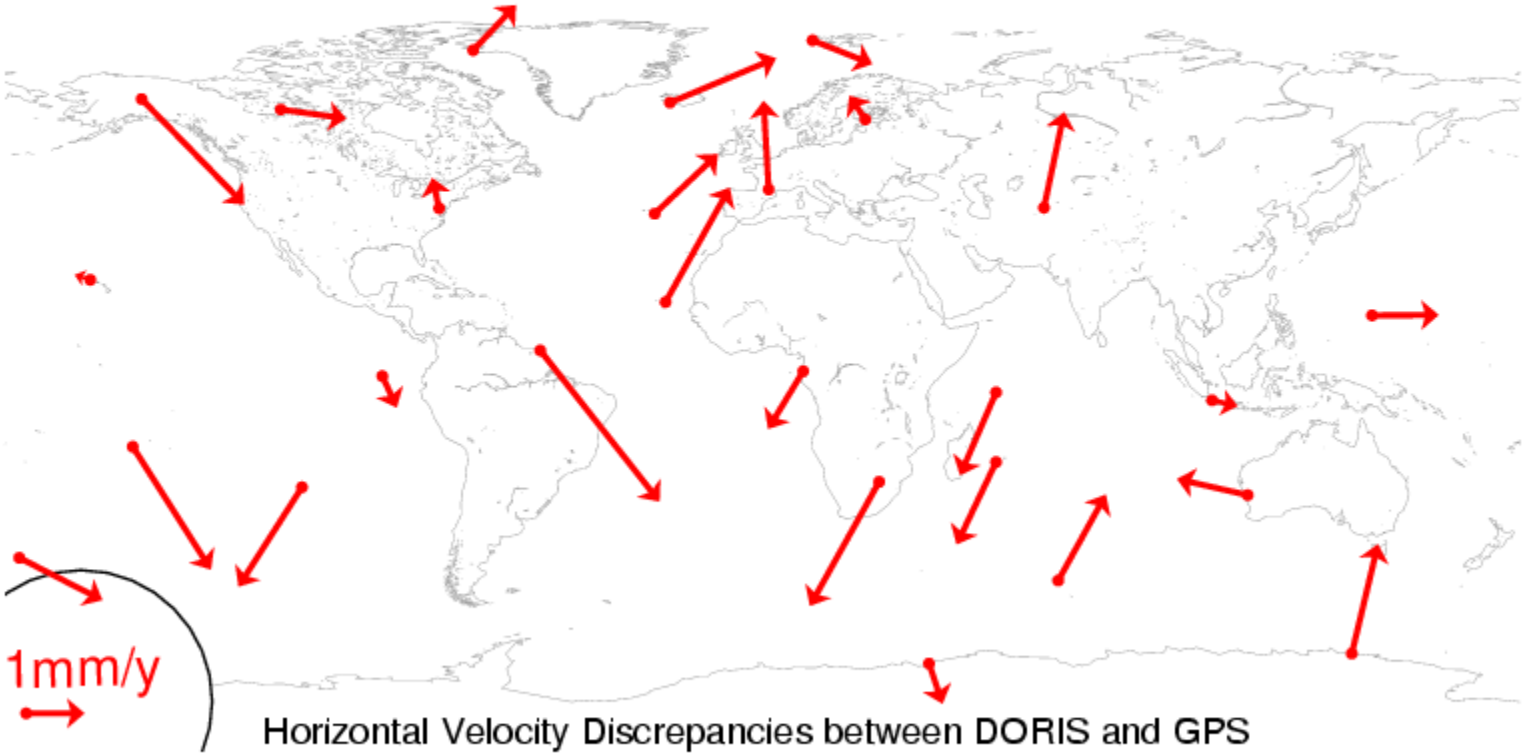
GNSS & DORIS horizontal velocity discrepancies

Formal error ± 0.2 mm/yr



GNSS & DORIS horizontal velocity discrepancies

Formal error ± 0.2 mm/yr



Horizontal Velocity Discrepancies between DORIS and GPS

Tie Discrepancies

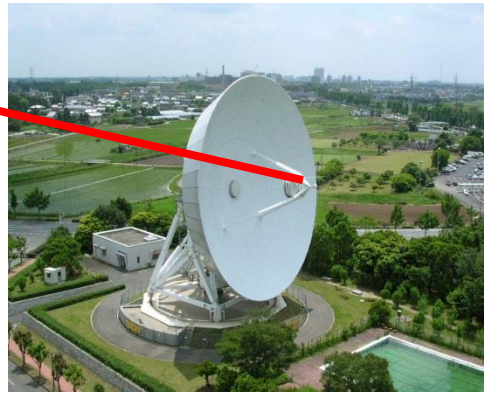
Differences between Terrestrial Tie and Space Geodesy estimates

Possible causes of tie discrepancies:

Local Survey &/or technique systematic errors

Precision of local survey:
probably not better that 3 mm

SLR/LLR



VLBI

GNSS

DORIS

Local Ties Usage in ITRF Combination

- Ties are used as **observations** with proper weighting
  - SINEX with variance-covariance information, treated as a space geodesy solution
  - Three translation components are estimated to account for Reference Frame differences
- Local Ties available & used in ITRF combinations:
  - ~90 co-location sites
  - All are in SINEX with known measurement epoch
  - ~65 % with full variance-covariance information
  - Others are with unknown variance, but computed as:

$$\sigma_{computed} = \sqrt{\sigma_1^2 + \sigma_2^2},$$

$$\sigma_1 = 3mm$$

$$\sigma_2 = 10^{-6} \times \sqrt{(\Delta x_s^{i,j})^2 + (\Delta y_s^{i,j})^2 + (\Delta z_s^{i,j})^2}$$

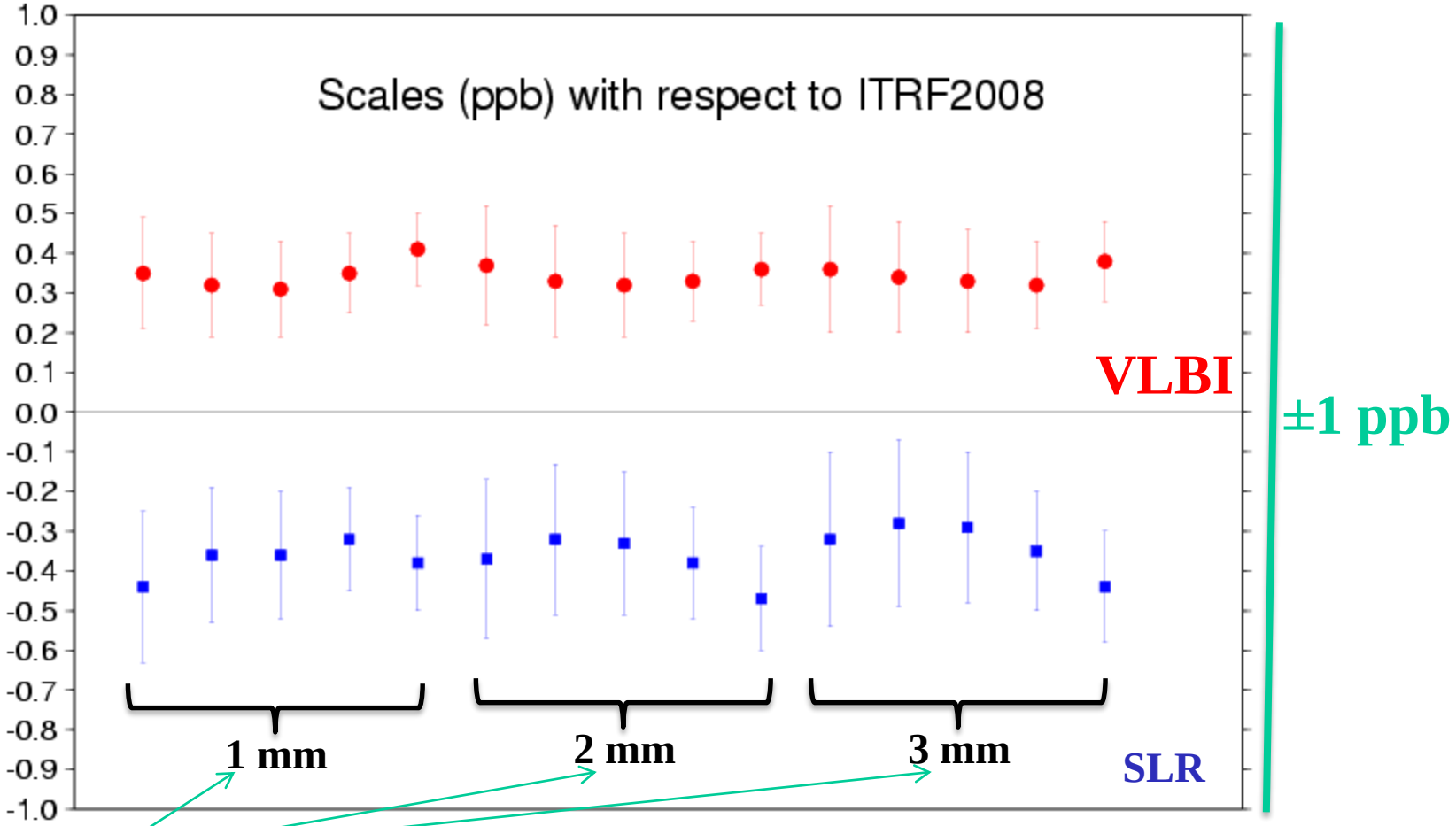
Weighting steps?

1. The var-cov matrices of the individual technique long-term solutions obtained by stacking of the time series are normalized by the global variance factor

$$VF = \frac{\sum_s^S v_s^T P_s v_s}{f}$$

2. Combination of velocity fields ==> obtain a VF per technique solution, to be fixed in 3rd step;
3. Global Combination (Pos & Vel) + Local Tie (LT) SNX files
   - VF per LT SNX with a floor sigma of 3mm
   - Iterate as necessary until convergence, i.e. VF per LT SNX close to 1.

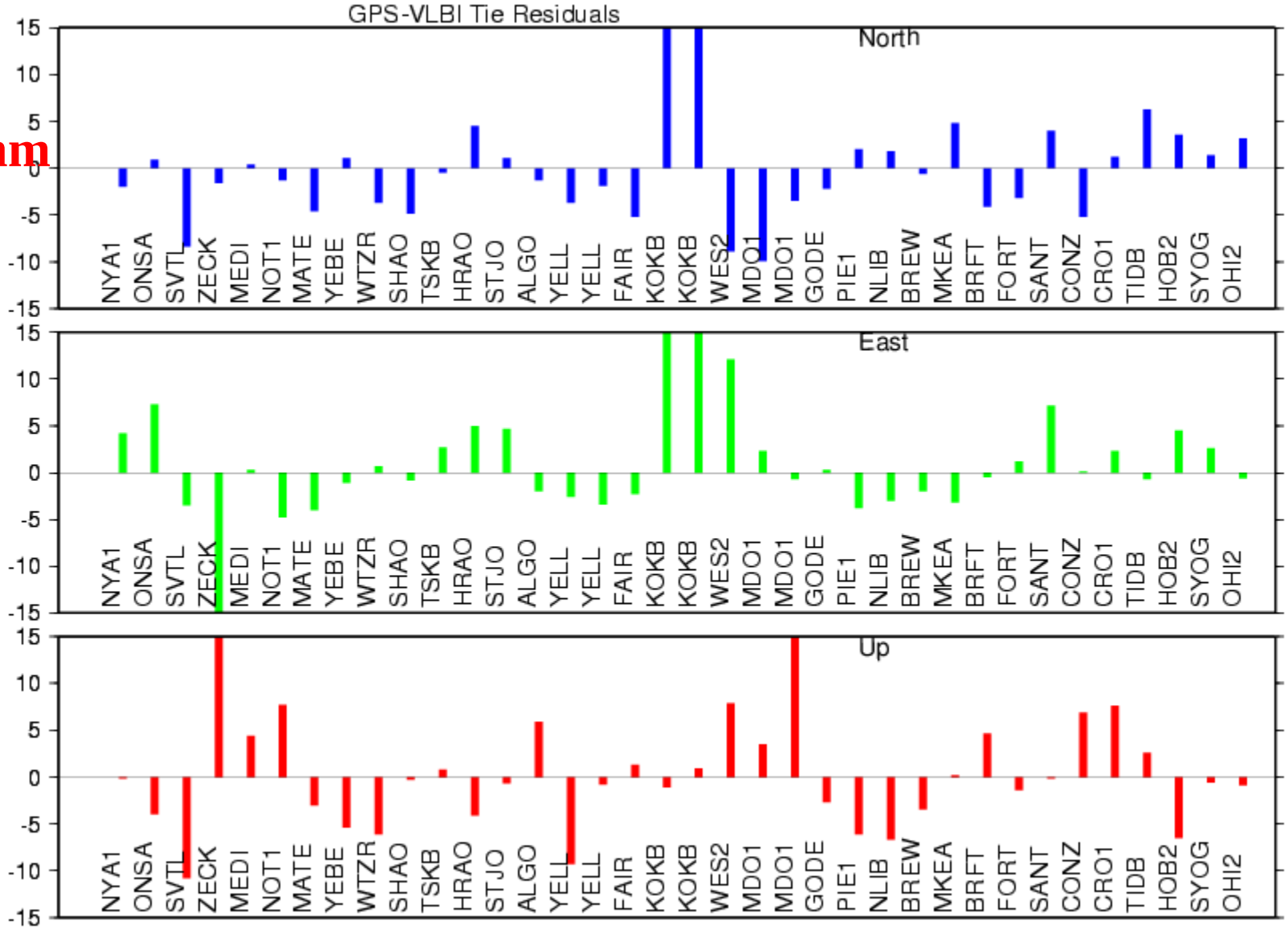
15 combination tests
Scale factors wrt ITRF2008



Tests : Floor σ Ties (1, 2, 3 mm), and σ Velocity (0.01, 0.05, 0.1, 0.5, 1 mm/yr)

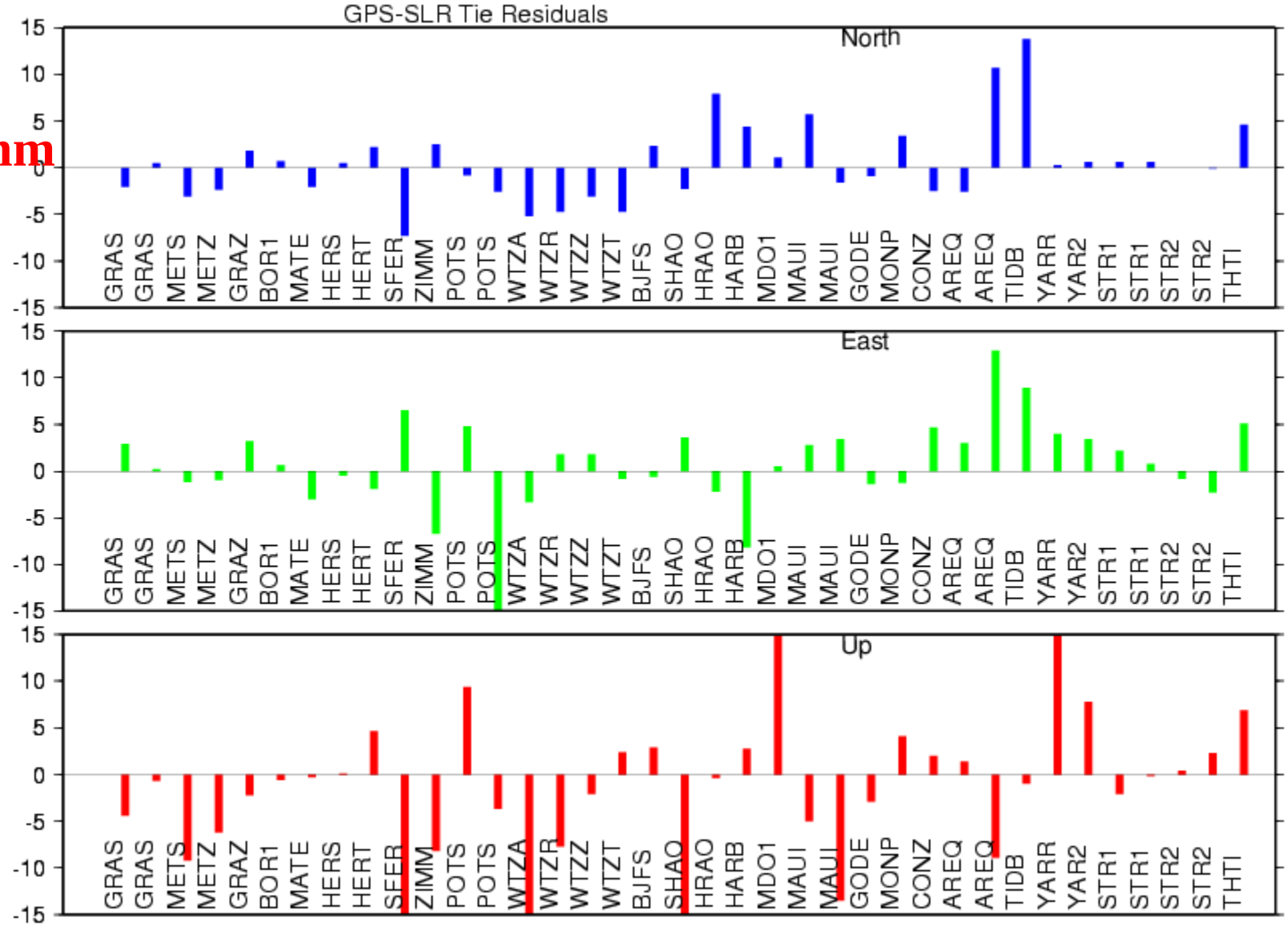
GNSS & VLBI Tie Discrepancies

60%
> 5mm



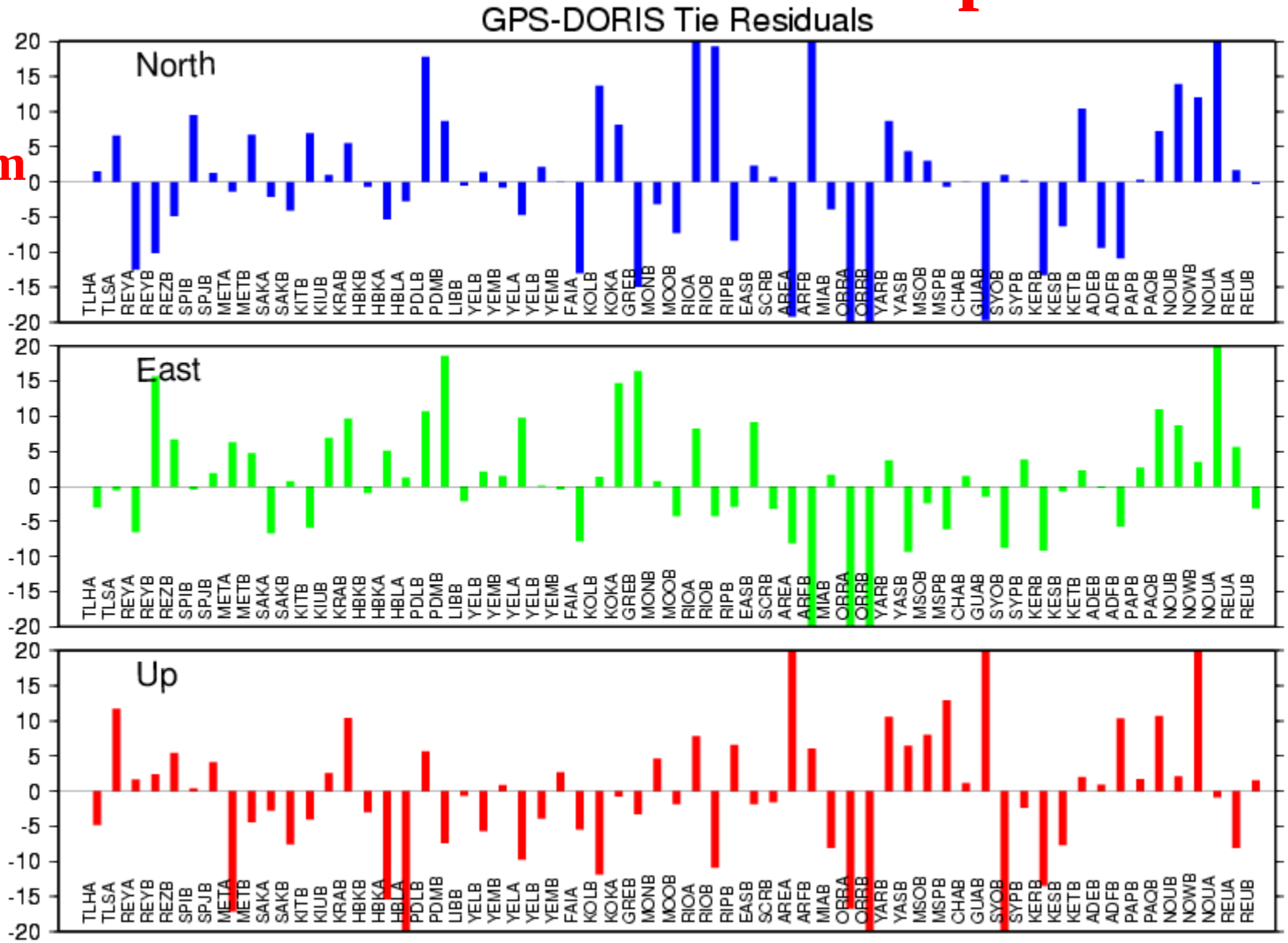
GNSS & SLR Tie Discrepancies

58%
> 5mm



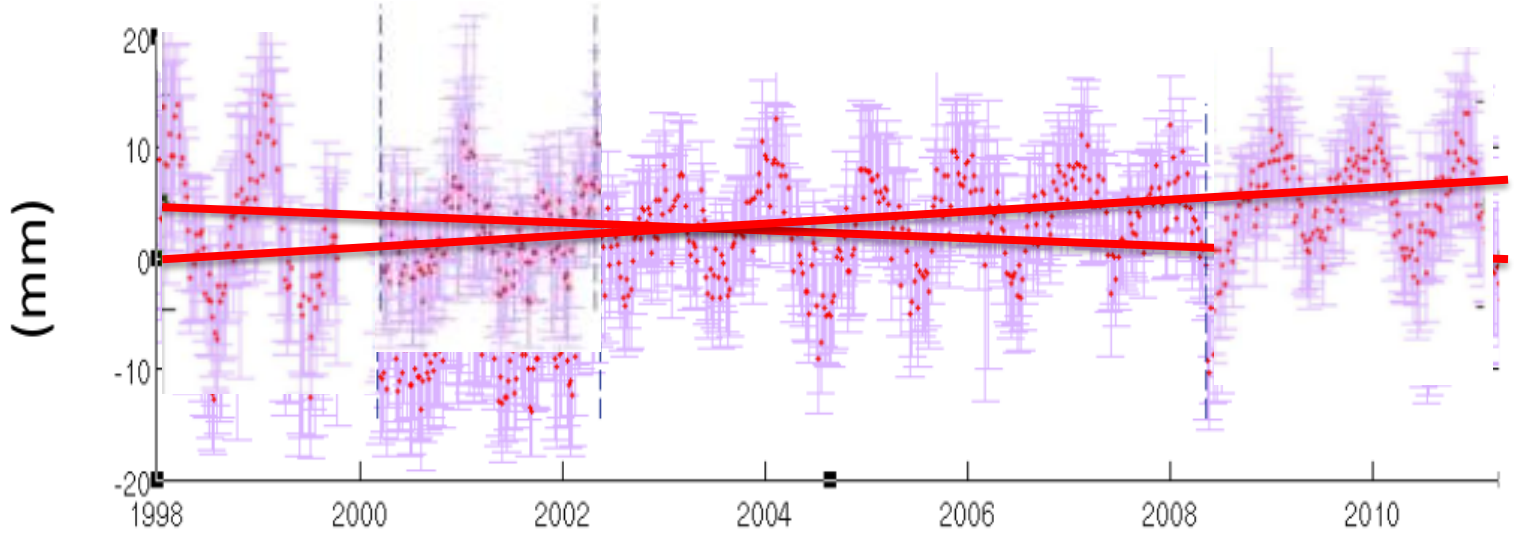
GNSS & DORIS Tie Discrepancies

72 %
> 5mm



Impact of discontinuities on site velocities

Yarragadee GPS up component



Up velocity = -0.18 ± 0.07 mm/yr (with 2 discontinuities)
= -0.29 ± 0.05 mm/yr (with 2 disc. + ann & semi-ann)

If we consider a 3rd discontinuity:

Up velocity = 0.73 ± 0.12 mm/yr (with 3 discontinuities)
= 0.33 ± 0.12 mm/yr (with 3 disc. + ann & semi-ann)

ITRF and tectonic motion: Co-seismic deformation

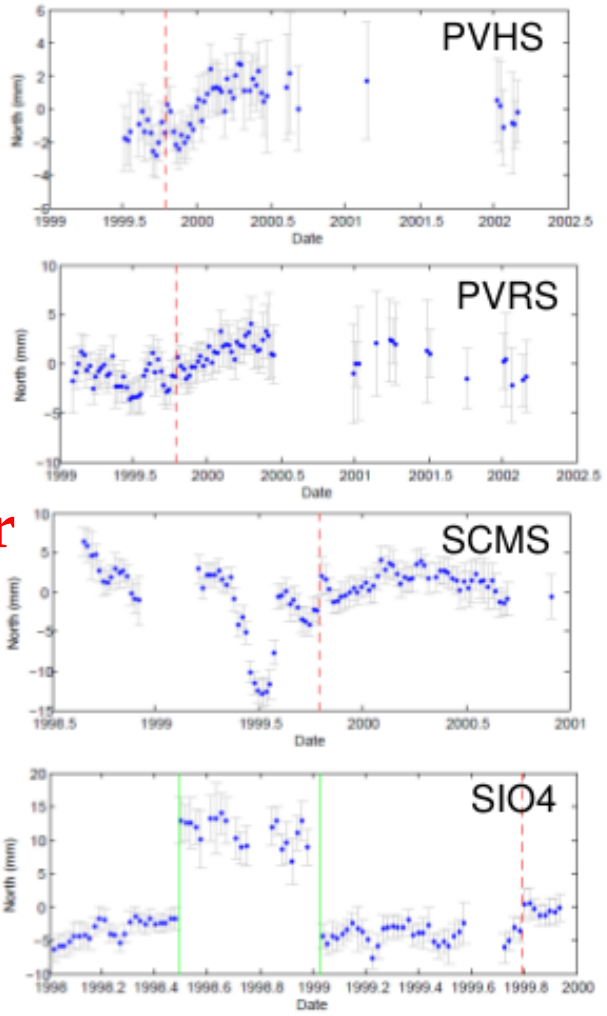
- **Magnitude : sub-mm to meters.**
- **Difficult to detect when the amplitude is small:**

➢**Same discontinuity list for co-located sites (identical epochs!)**

➢ **Discard observations at the time of the Earthquake, or/and**

➢**Estimate two positions: before and after the event**

Co-seismic models ?



How to detect co-seismic offsets?

- **Co-seismic models**
- **PPP solutions**
- **Web service with deformation maps**

More than 50 thousand EQs since 1980, according to USGS database

Modeling post-seismic deformations

Parametric model

$$X^i_{inst}(t) = X^i_{ITRF}(t) + \sum_j \Delta X^i_j(t)$$

$$\sum_k D(t - t_{eqk})$$

$$D(t - t_{eqk}) = c_{eqk} \log\left(1 + \frac{t - t_{eqk}}{\tau}\right)$$

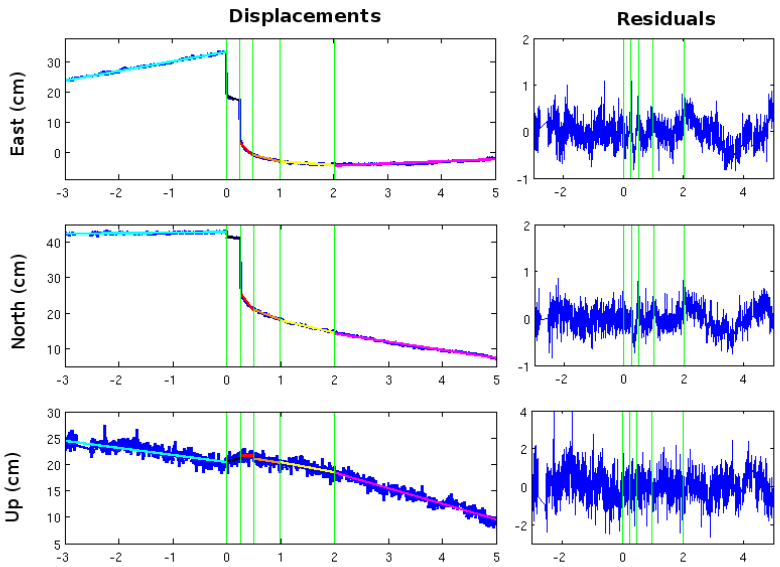
or

$$D(t - t_{eqk}) = c_{eqk}\left(1 - e^{-\frac{t - t_{eqk}}{\tau}}\right)$$

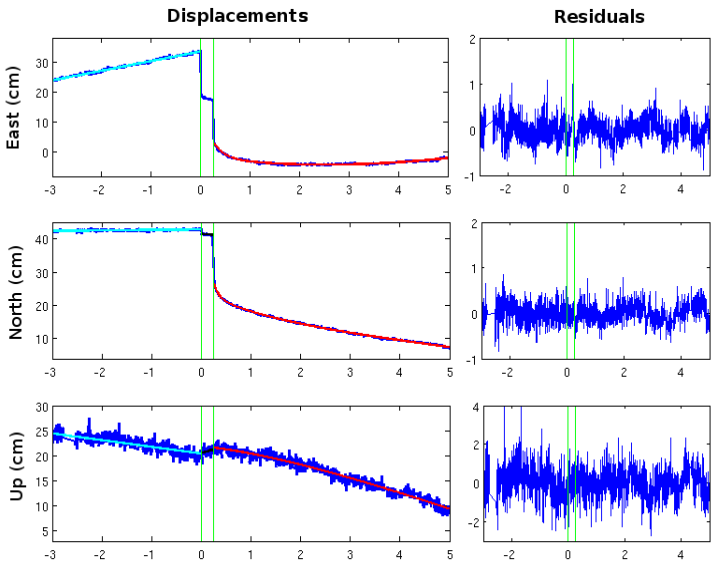
Kreemer et al., (2005)

OR

Use Geophysical models, e.g. Trubienko et al., (2013)



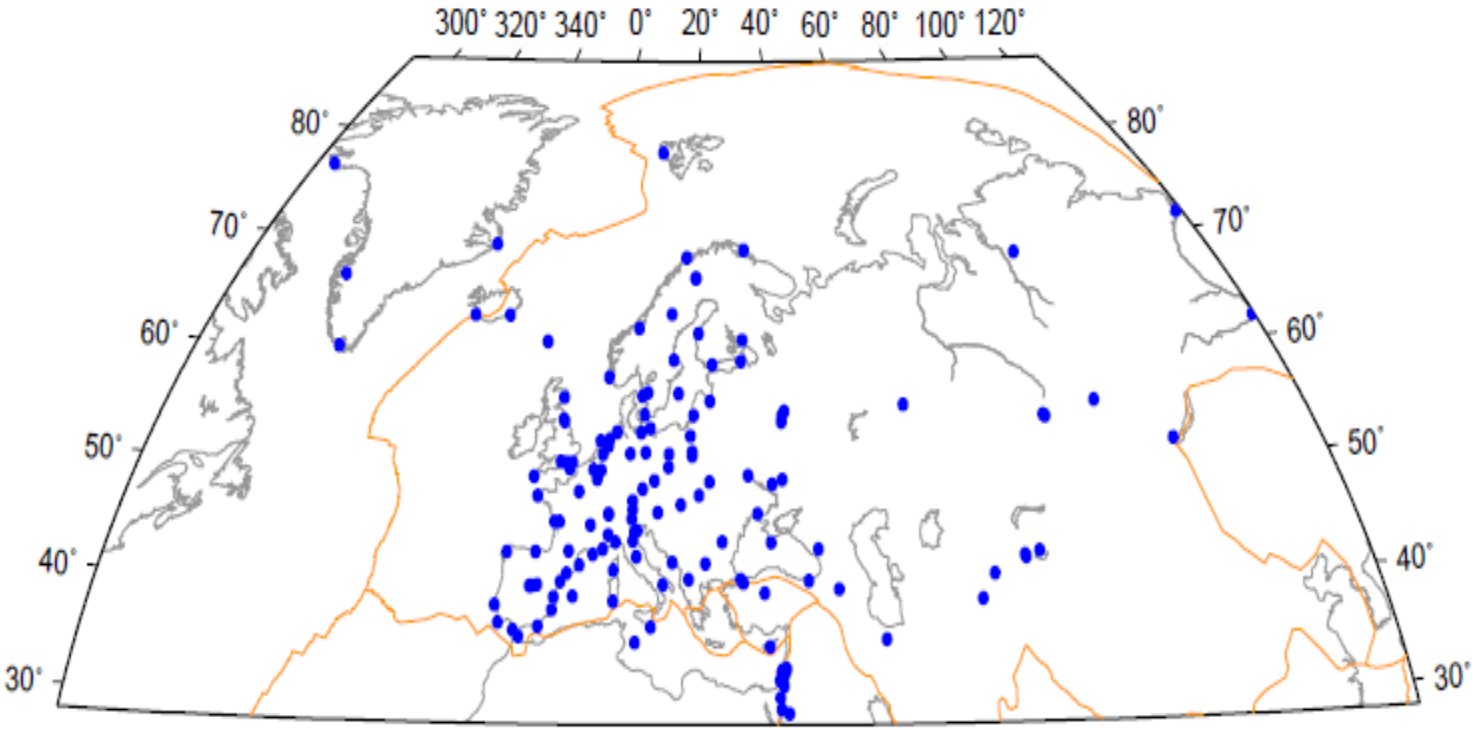
Piece-wise model



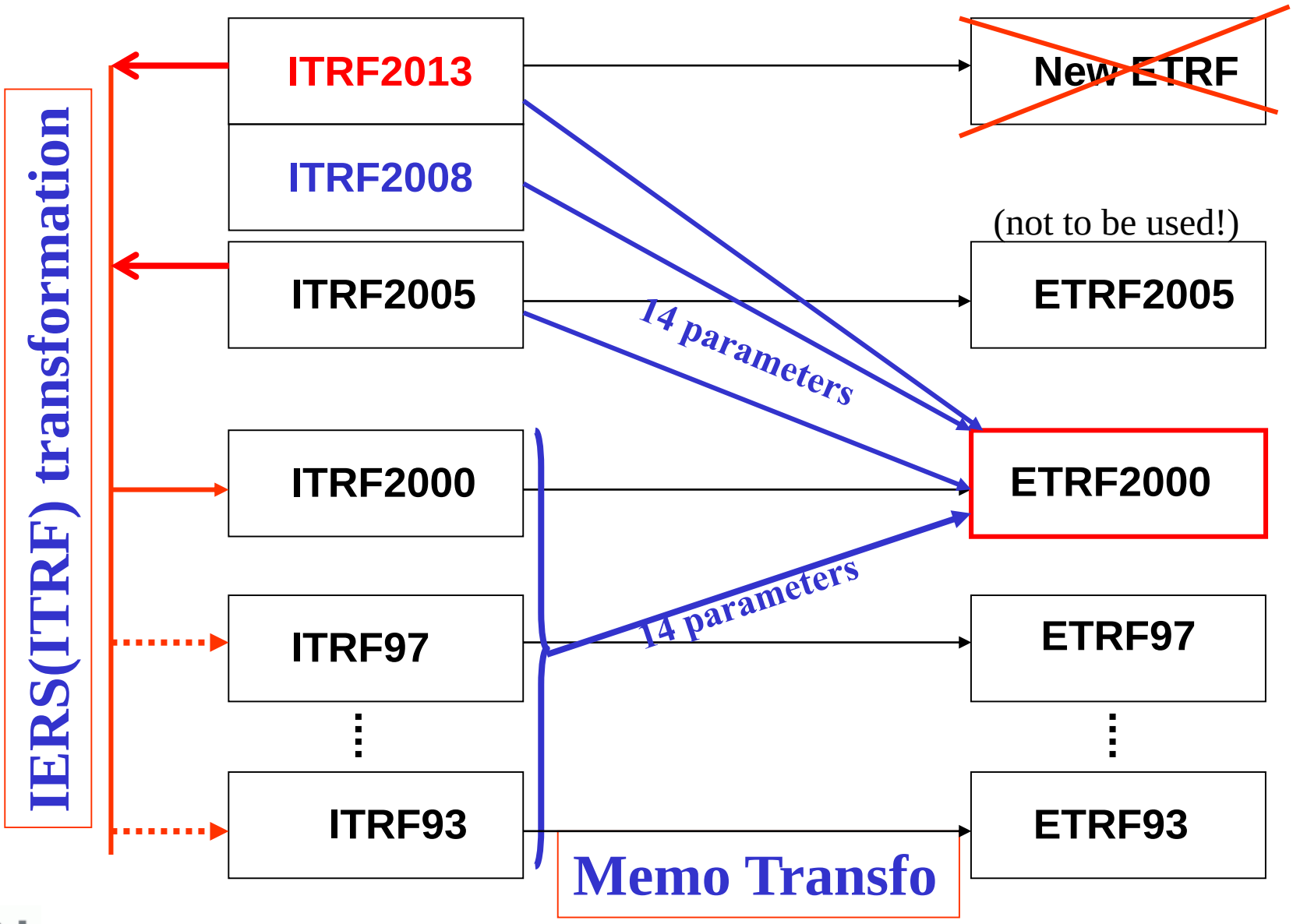
Parametric model

EPN in ITRF2008

145 sites



ITRFyy to ETRFyy



Conclusion

- **Expect ITRF2013 to be more accurate than ITRF2008**
  - **Reprocessed solutions from 4 techniques**
  - **Reduced number of or/and improved discontinuity detection**
  - **Non-tidal atmospheric (+) loading effect will be applied**
  - **==> improve site velocities for sites with short time-span**
- **Consequences for ITRS89/ETRF2000**
  - **Benefit from an improved solution**
  - **14 transformation parameters**

    ITRF2013 ==> ETRF2000