Station Positioning and the ITRF

- Introduction
- ITRF2005 Experience
  - Positioning Performance (where are we ?)
  - Accuracy of the Frame Parameters (Origin & Scale)
  - Limitation Factors & Issues for Improvement
- Conclusion

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ITRF

- **One of the 3 IERS main products (Standards)**
- **Should be:**
  - **Accurate, Stable, Reliable, etc.**
  - **Consistent with the 2 other IERS global references (ICRF, EOPs)**
  - **Used as global reference/datum for e.g.:**

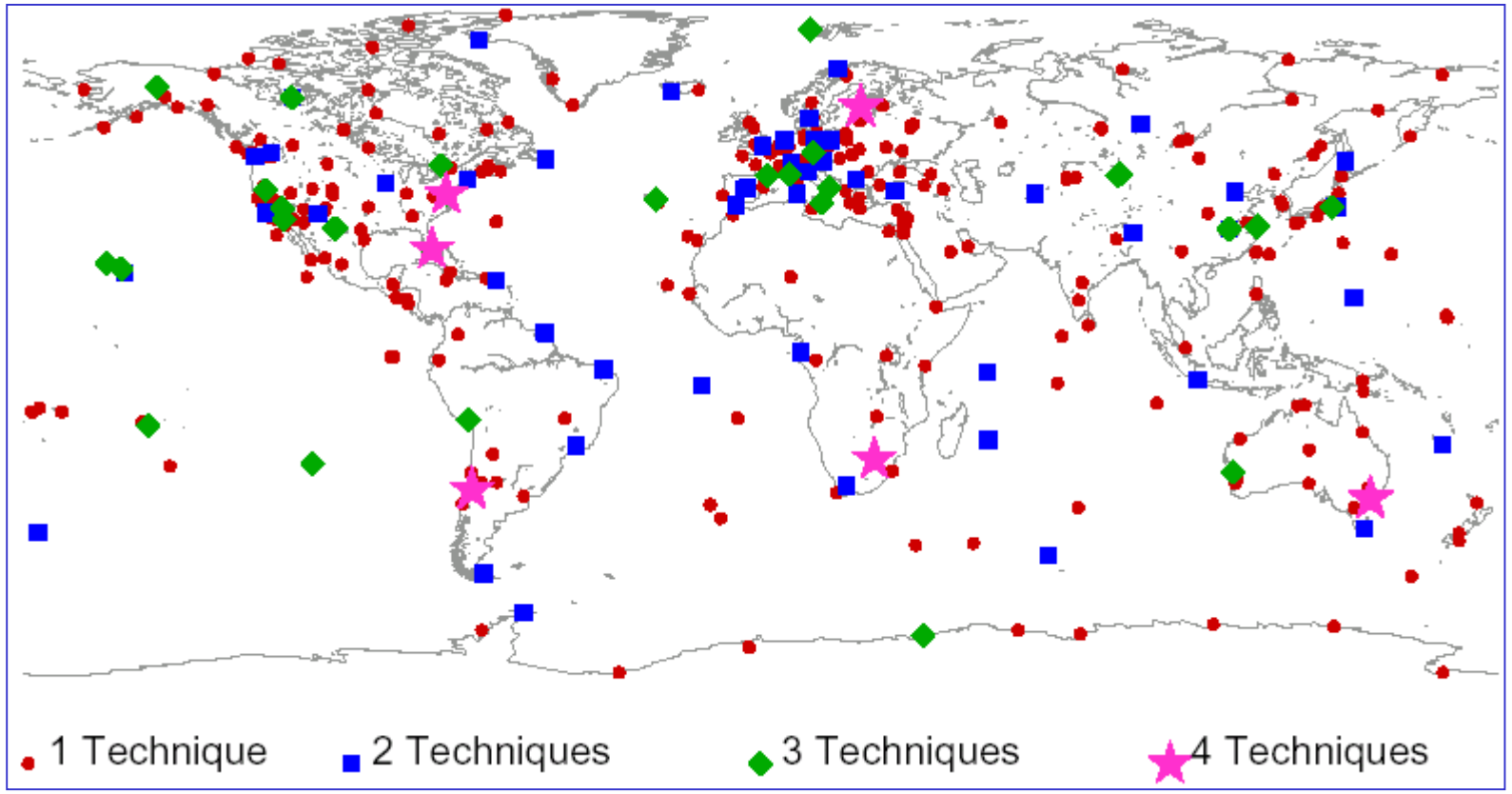
    ‘’high frequency’’ individual TC products: weekly, daily, sub-daily, etc.
- **Should:**
  - **Have the CoM as origin**
  - **Have stable Scale consistent with TCG time scale**
  - **Satisfy the NNR condition**

Examples from the ITRF2005 experience

Input data : time series of station positions and EOPs

- **Accuracy of the frame parameters**
- **Positioning Performance**

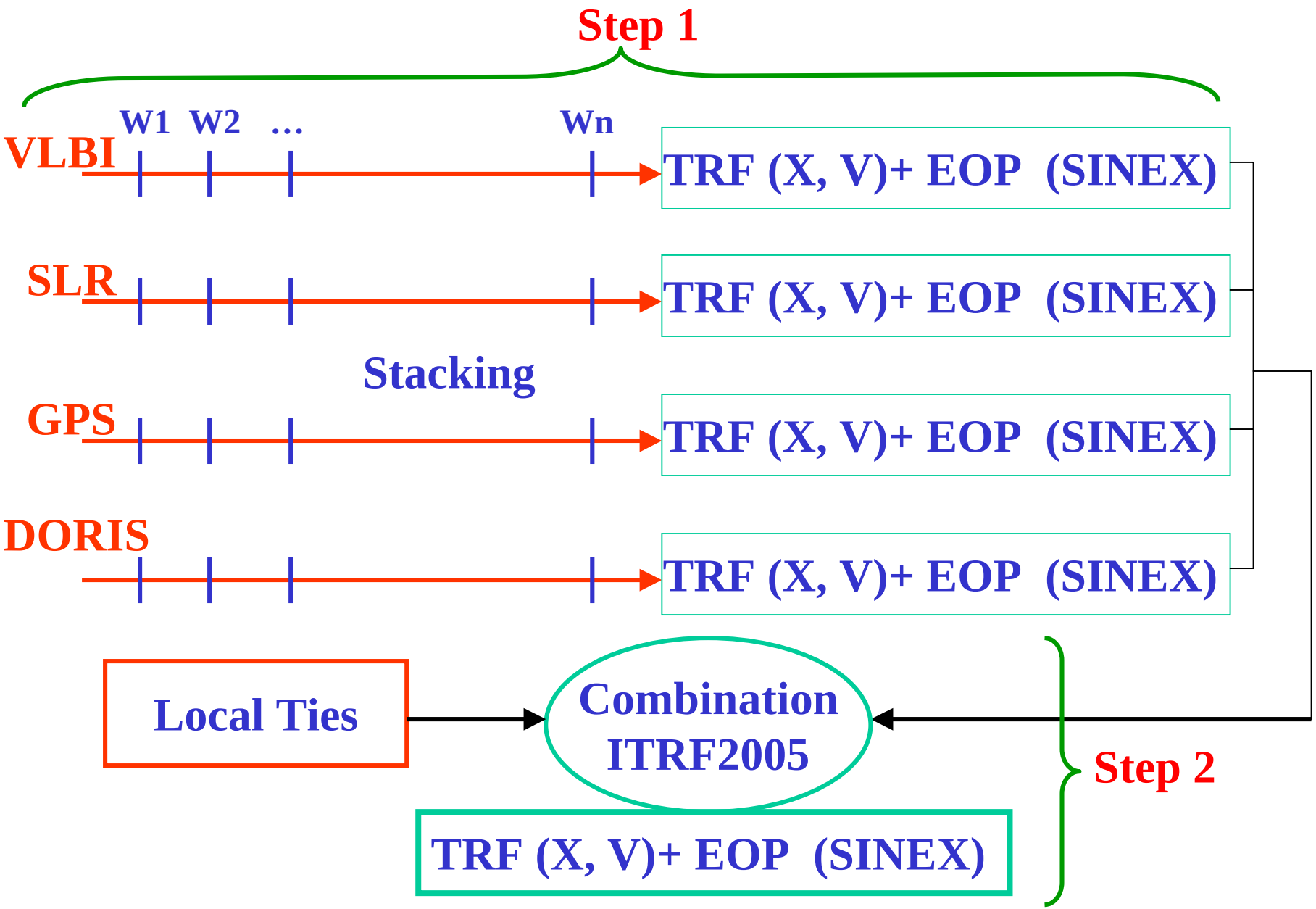
ITRF2005 Co-locations



(48) (25) (6)

175 tie vectors (~100 SINEX files)

ITRF2005 Derivation



Datum definition: current principles for time series stacking

- **(1) Define the frame at a given epoch t_0**

==> 7 degrees of freedom to be selected/fixed

- **(2) Define a linear (secular) time evolution**

==> 7 degrees of freedom to be selected/fixed

Assume linear station motion:

- **Add break-wise approach for discontinuities**
- **Investigate the non-linear part in the time series of the residuals**

Ways of implementation

- **(1) Select an external frame as a "reference" and apply minimum constraints approach:**

$$(A^T A)^{-1} A^T (X_R - X_c) = 0$$

Or

- **(2) Considering that for any Transf. Param.** P

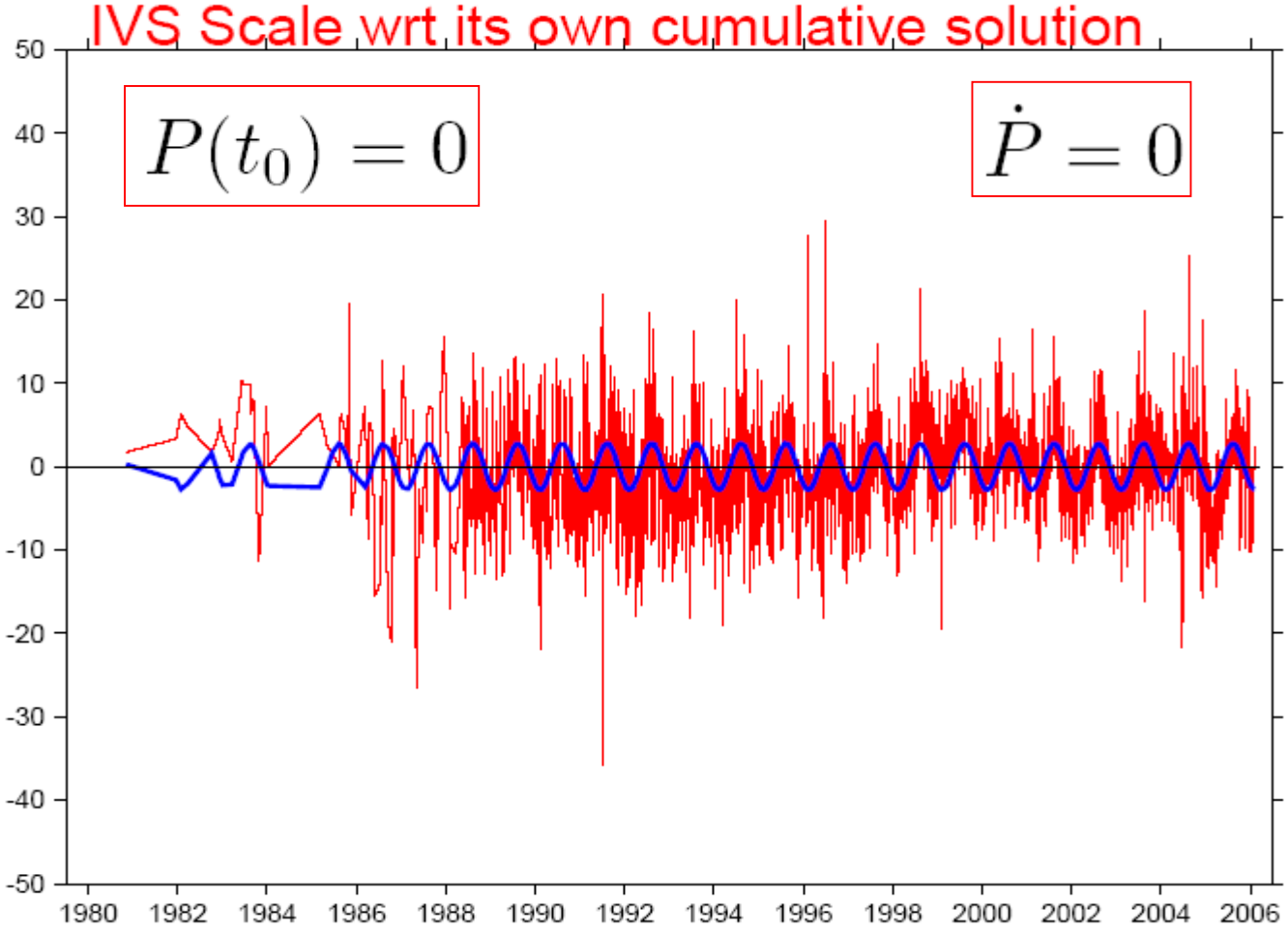
$$P(t) = P(t_0) + \dot{P} \times (t - t_0)$$

apply "inner/intrinsic" conditions:

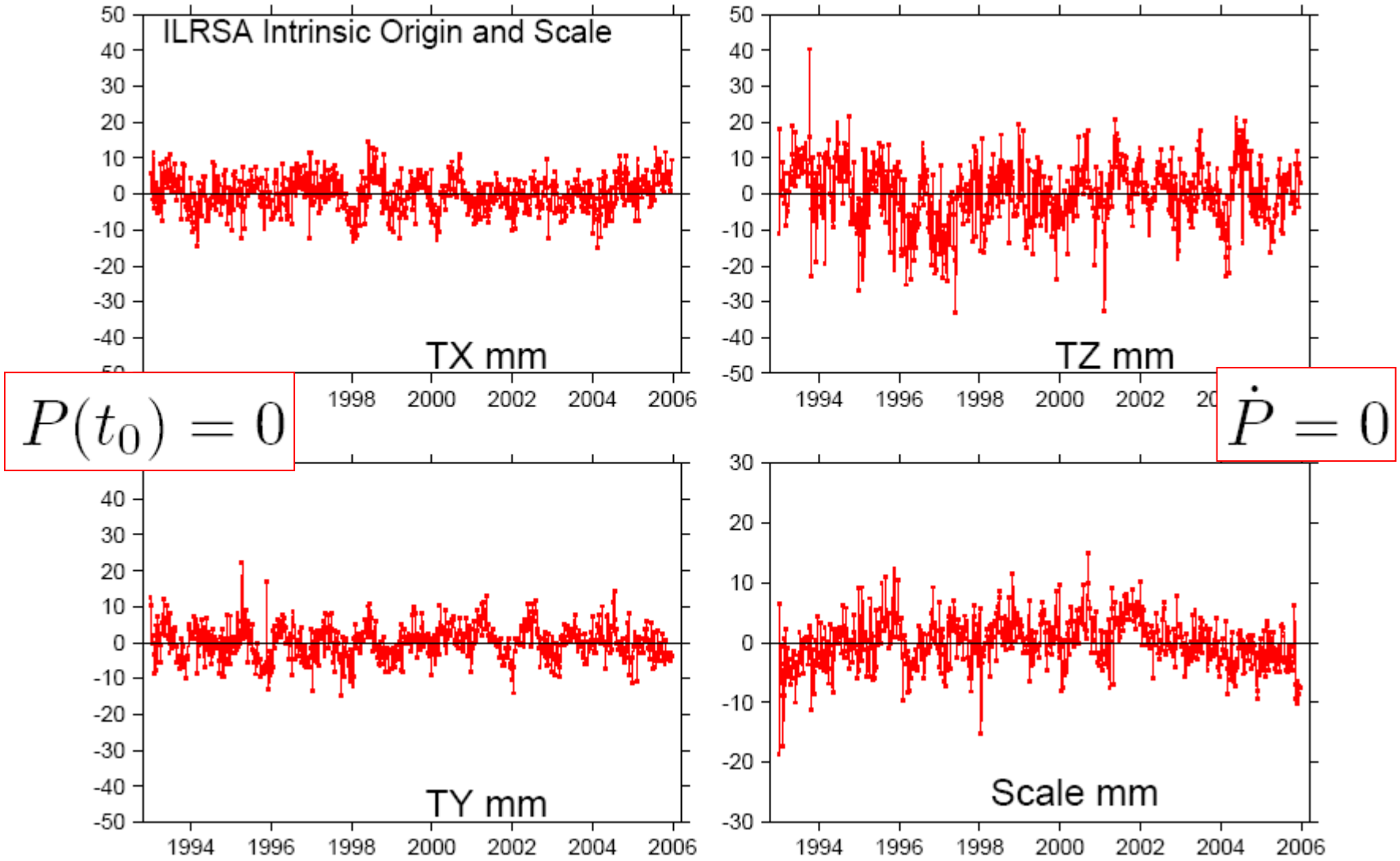
$P(t_0) = 0$ **and** $\dot{P} = 0$ **or**

$$\begin{cases} \sum_{k \in K} P(t_k) & = & 0 \\ \sum_{k \in K} \frac{P(t_k)}{t_k - t_0} & = & 0 \end{cases}$$

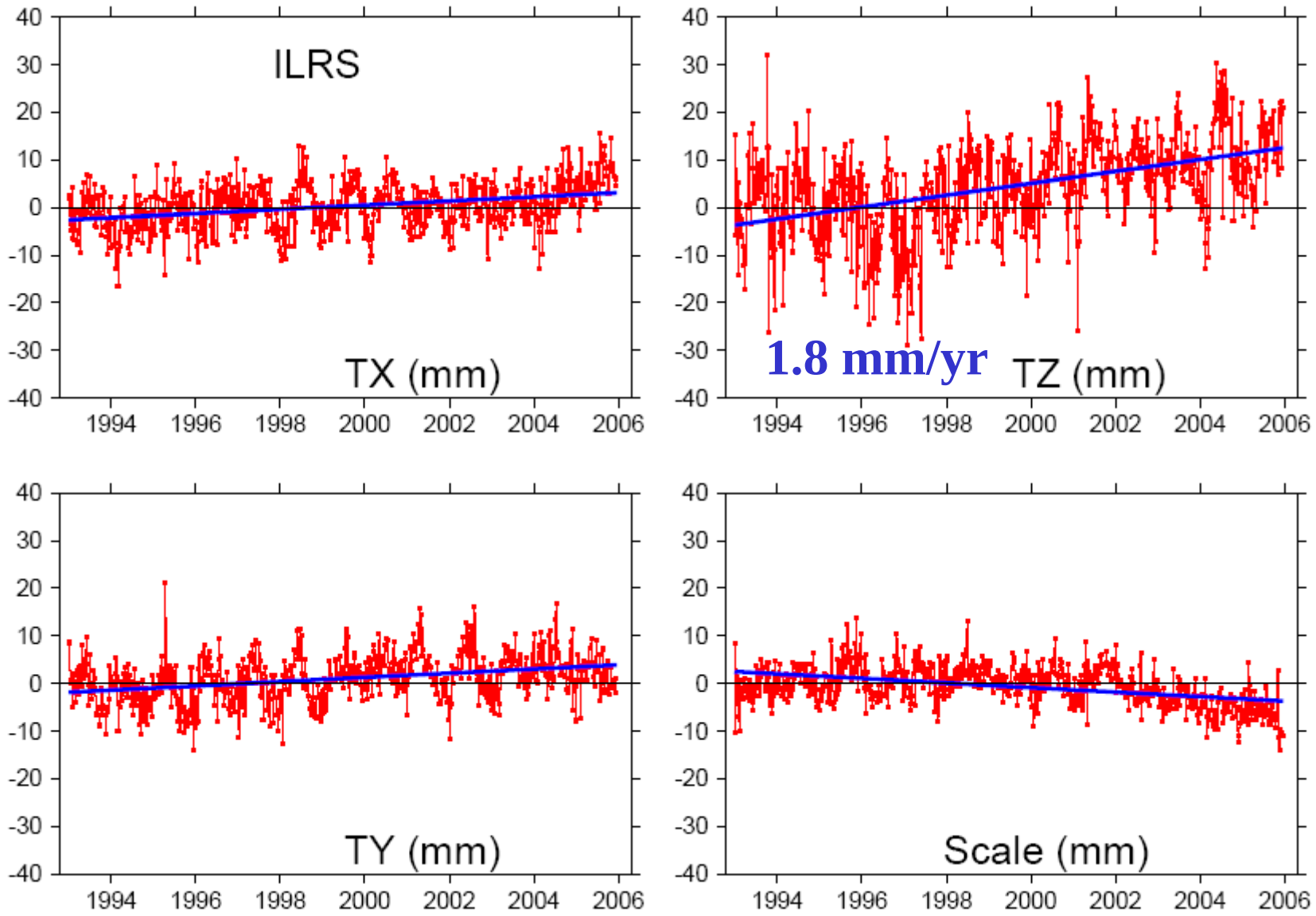
Intrinsic VLBI Scale



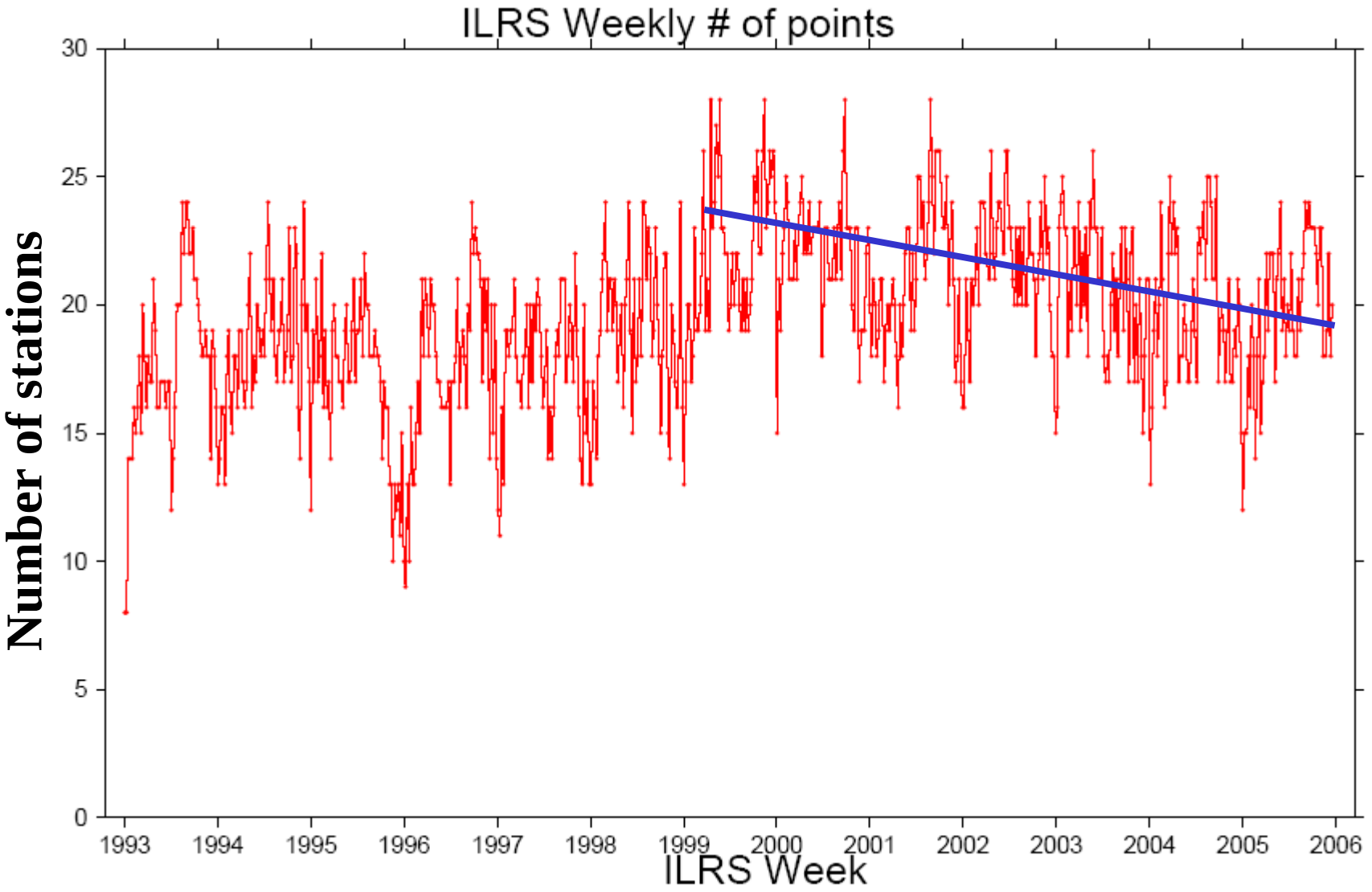
Intrinsic SLR Origin and Scale Variations



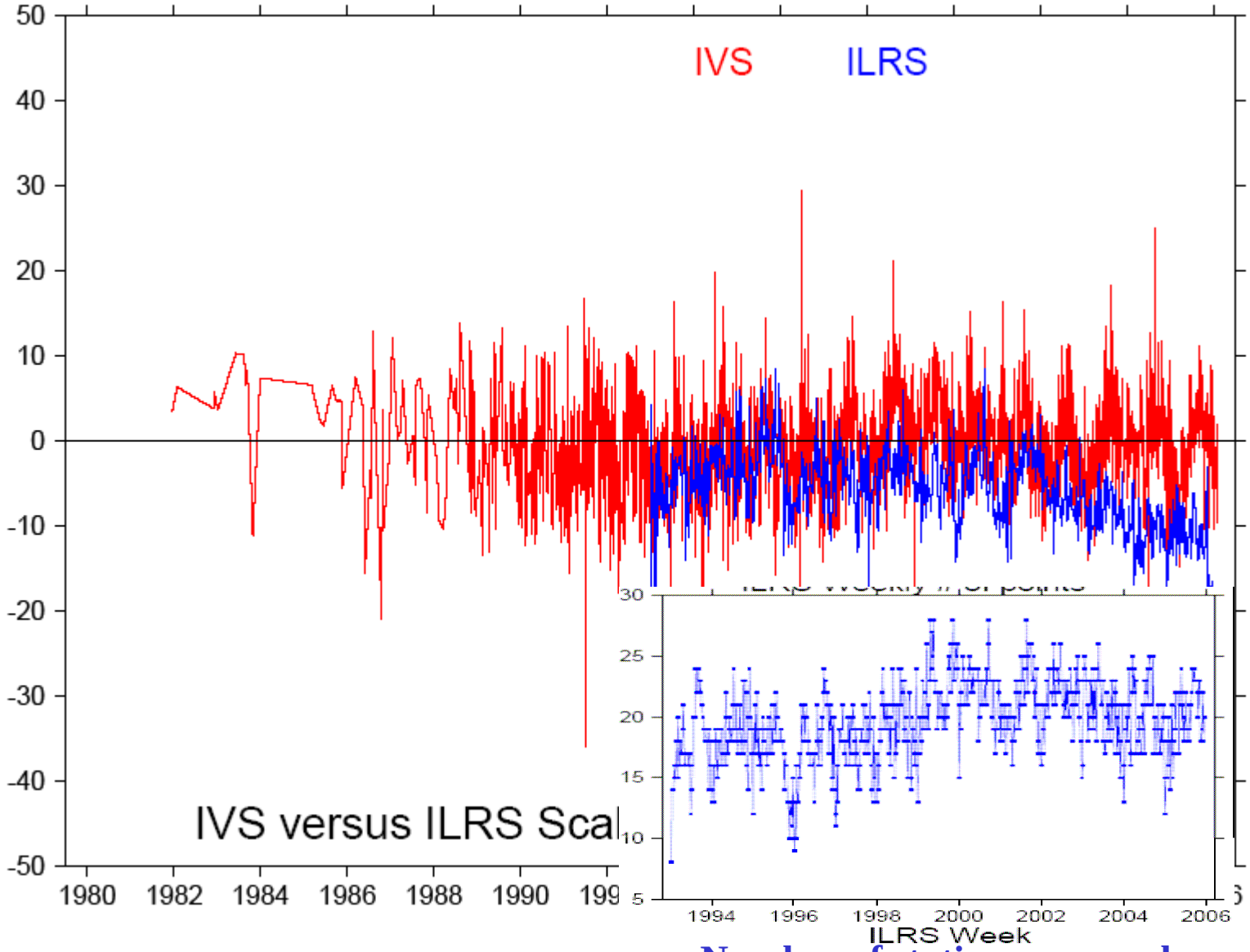
SLR Origin and Scale Variations WRT ITRF2000



ILRS Network

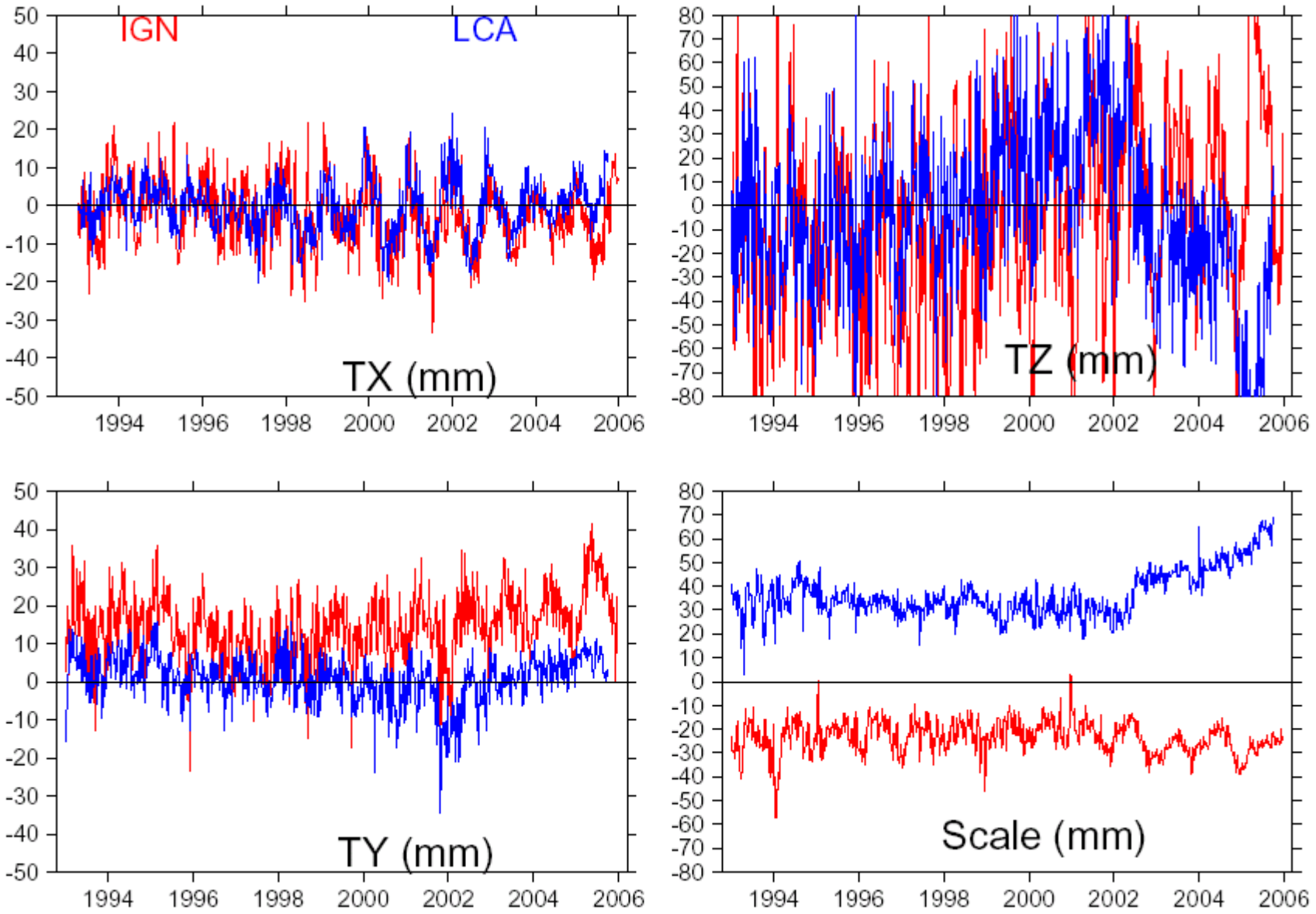


VLBI vs SLR Scale wrt ITRF2005



Number of stations per week

DORIS Origin and Scale Variations WRT ITRF2000



ITRF2005 Datum definition

- **Orgin:** **ZERO translations/rates btw ITRF2005 and ILRS time series**

- **Scale:** **ZERO scale/rate btw ITRF2005 and IVS time series**

- **Orientation:** **ZERO rotations/rates btw ITRF2005 and ITRF2000**

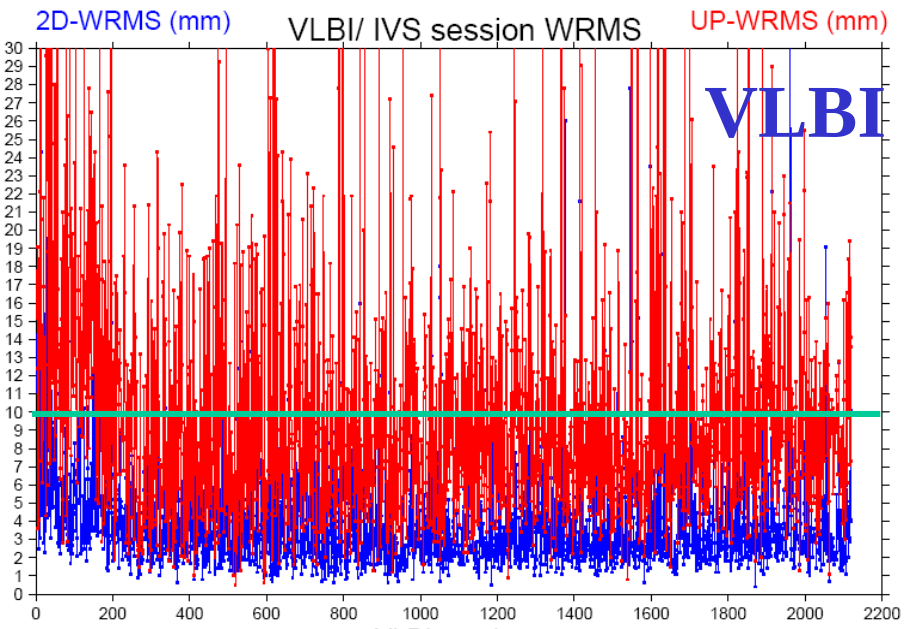
ITRF2005 to ITRF2000

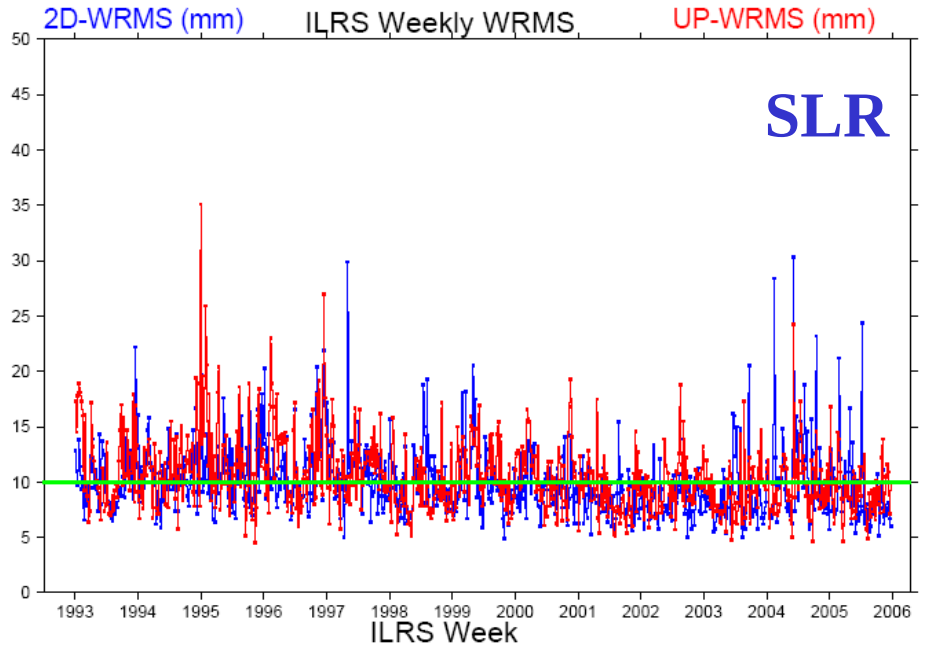
	TX mm mm/y	TY mm mm/y	TZ mm mm/y	Scale ppb ppb/y
Offset At 2000.0	0.1	-0.8	-5.8	0.40
Drift	-0.2	0.1	-1.8	0.08

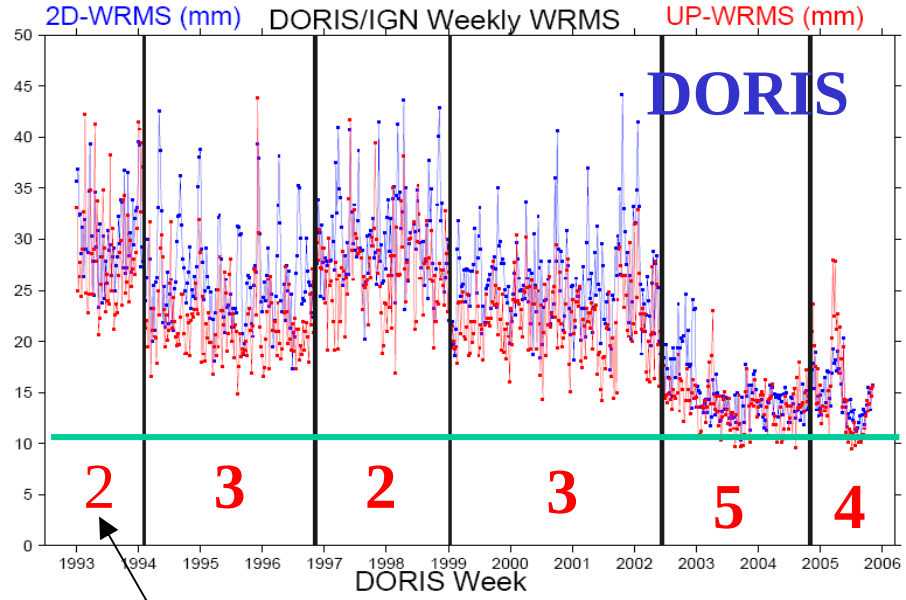
ITRF2005
Accuracy of the datum definition

	at epoch 2000.0 (mm)	Rate mm/yr
Origin	5	2
Scale	6.3	0.6
NNR		2

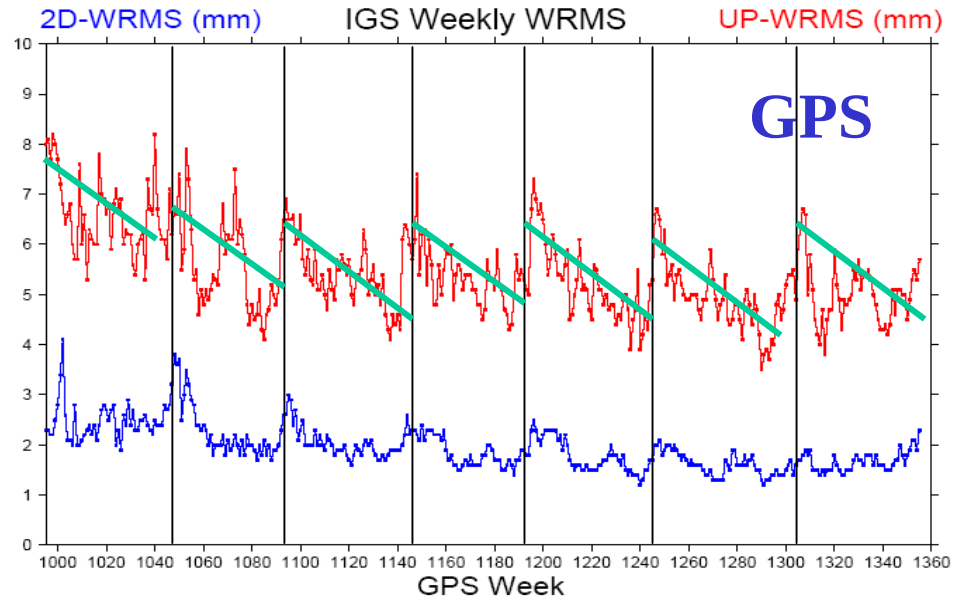
Positioning Performance from ITRF2005 Experience







Number of satellites used



Positioning Performance

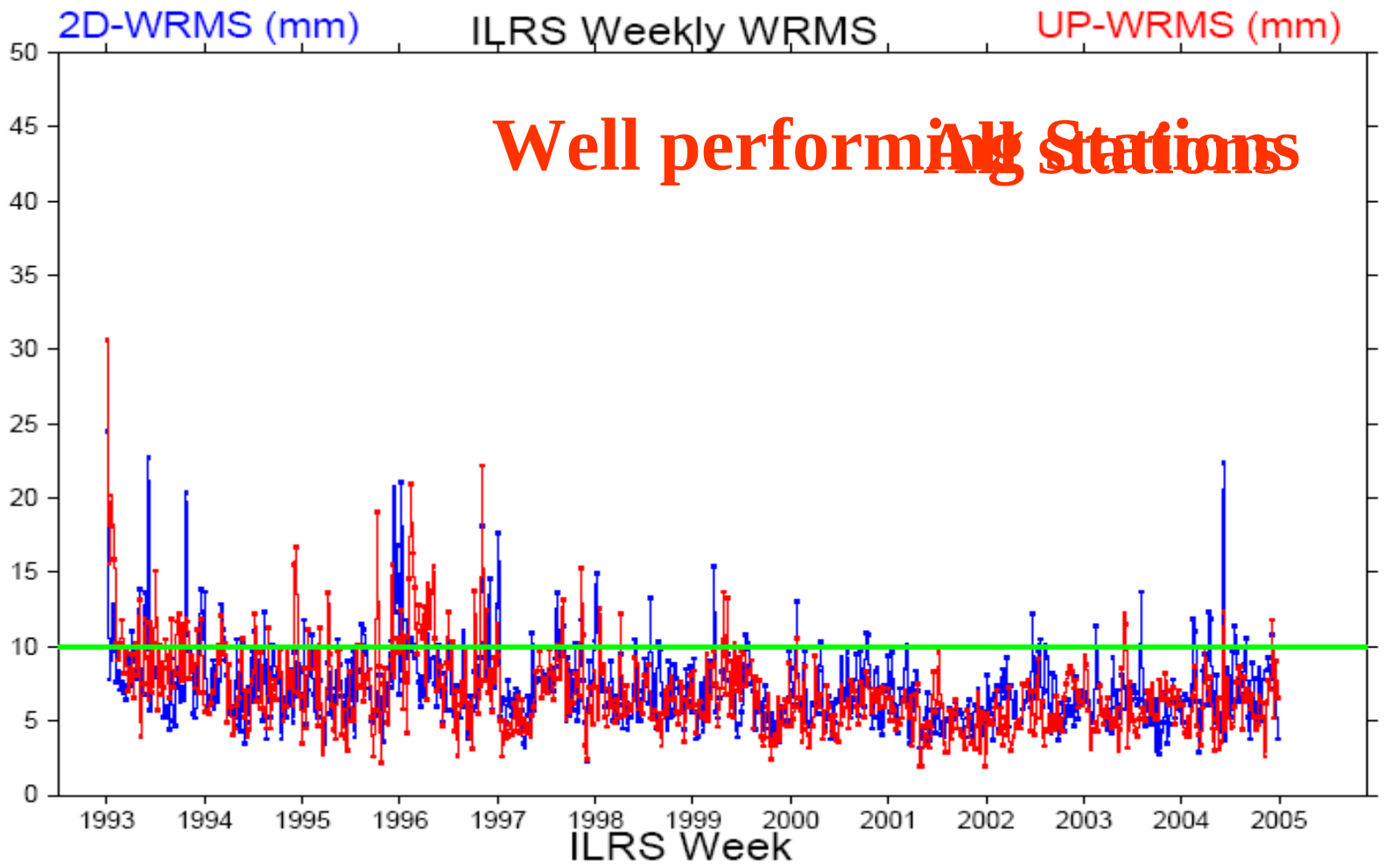
WRMS range per technique

(Internal Precision – Repeatability)

Solution	2-D WRMS mm	Up WRMS mm
VLBI	2-3	5-7
SLR	5-10	5-10
GPS	2-3	5-6
DORIS	12-25	10-25

WARNING! These are indicative numbers and are station dependant

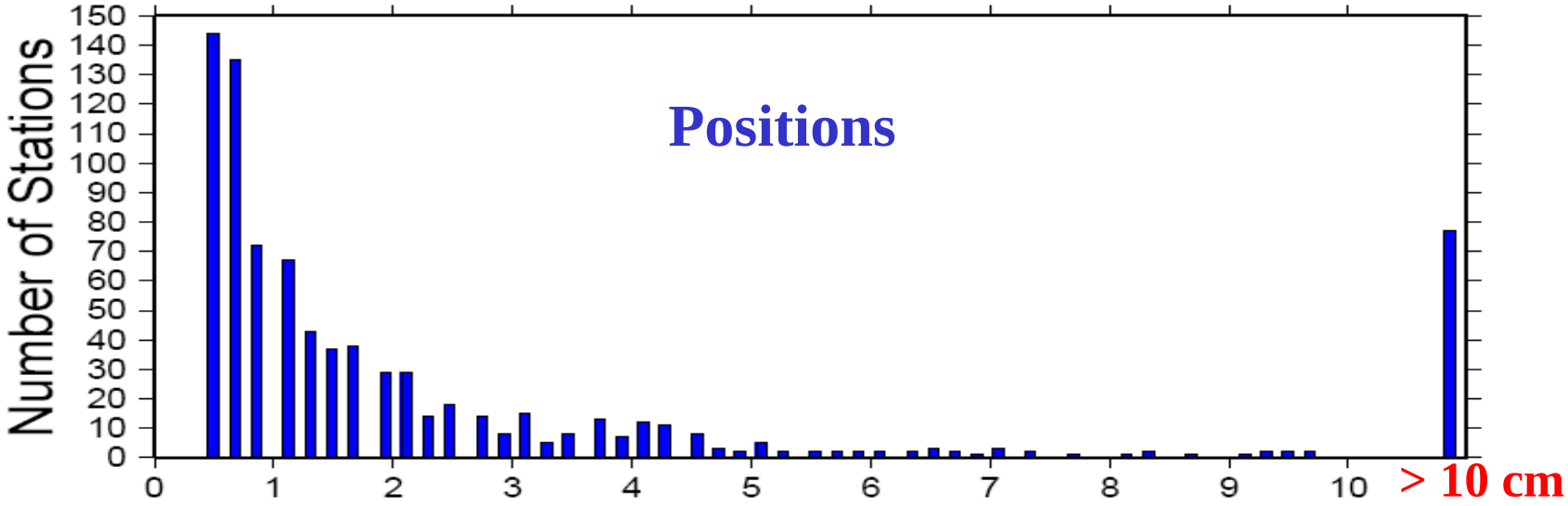
SLR station Performance !

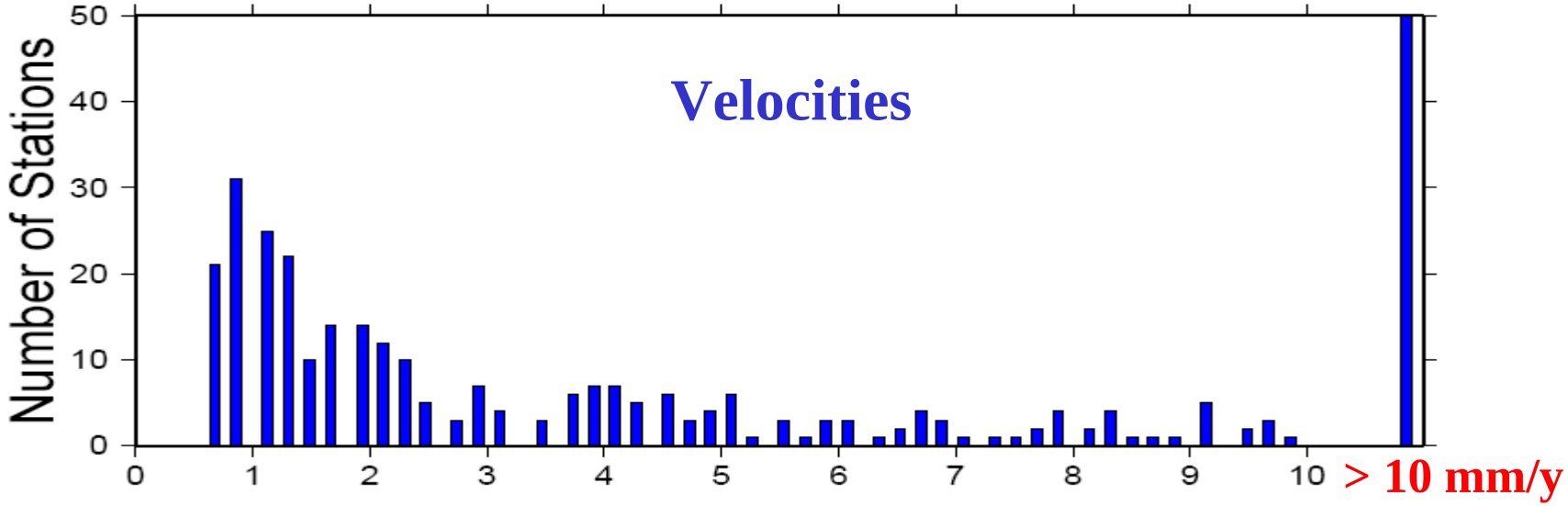


Well performing Stations

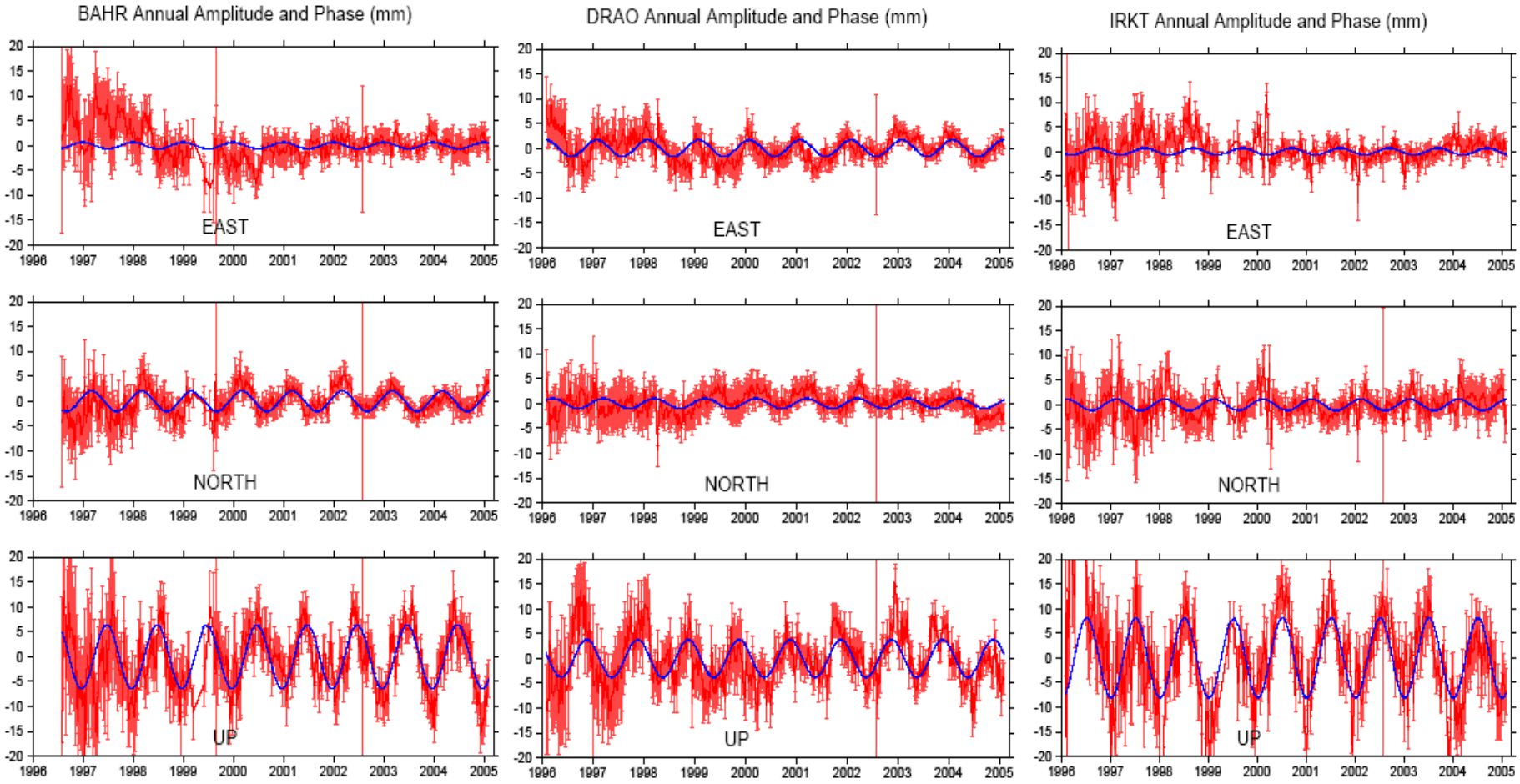
All stations

ITRF2005 Position & Velocity Spherical Errors



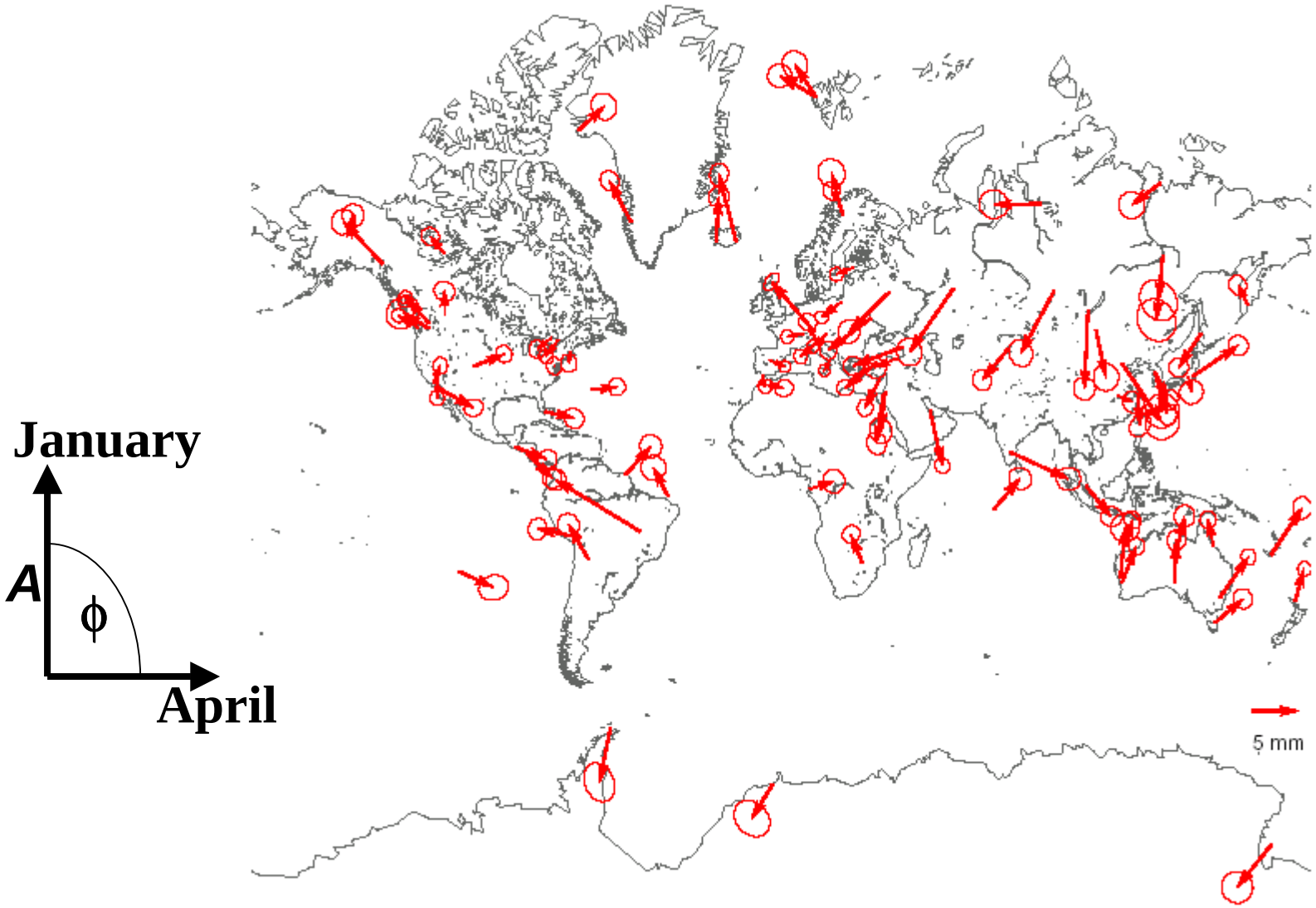


Seasonal Variations GPS/IGS Sites

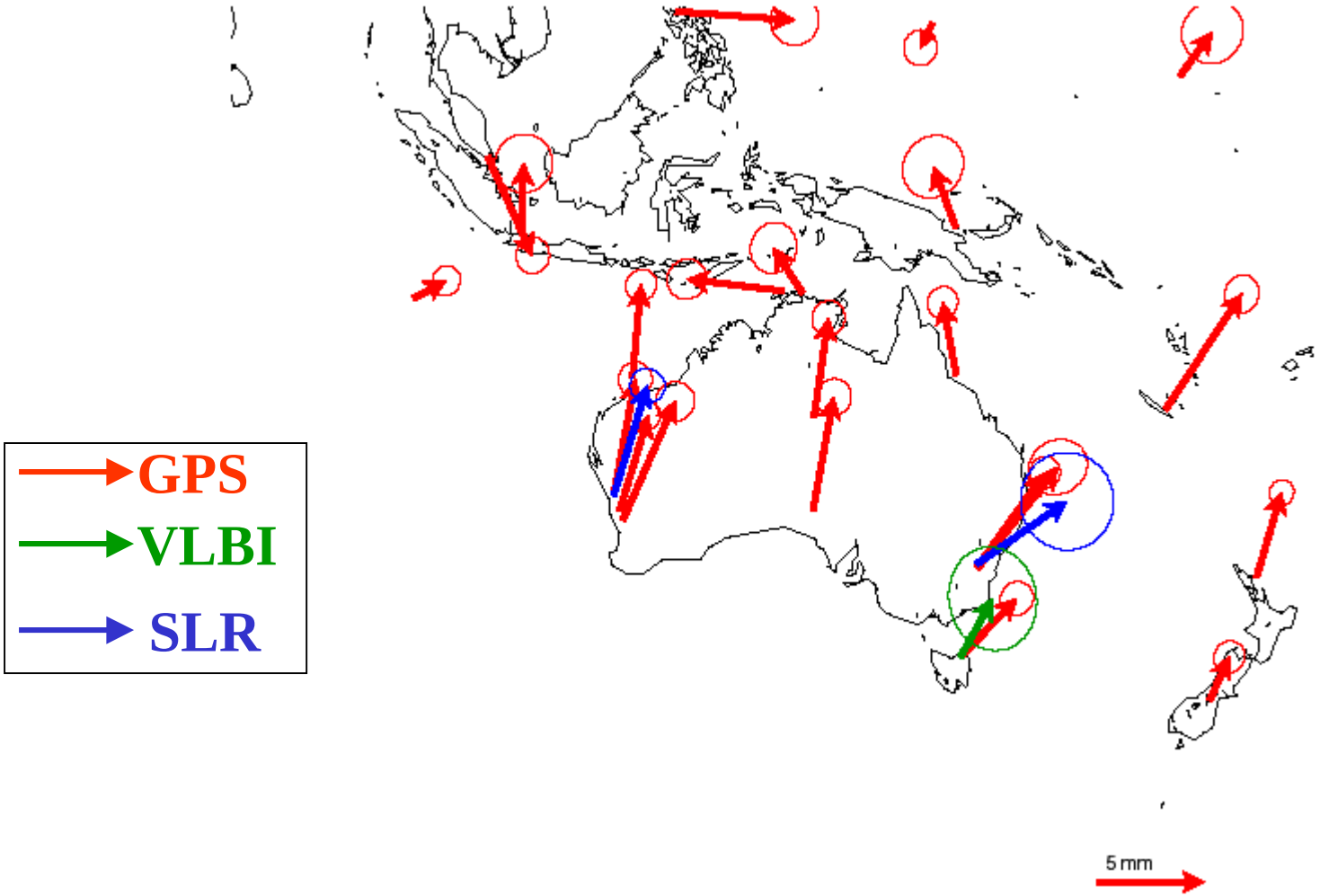


BAHR **DRAO** **IRKT**

GPS Annual Vertical Amplitude & Phase



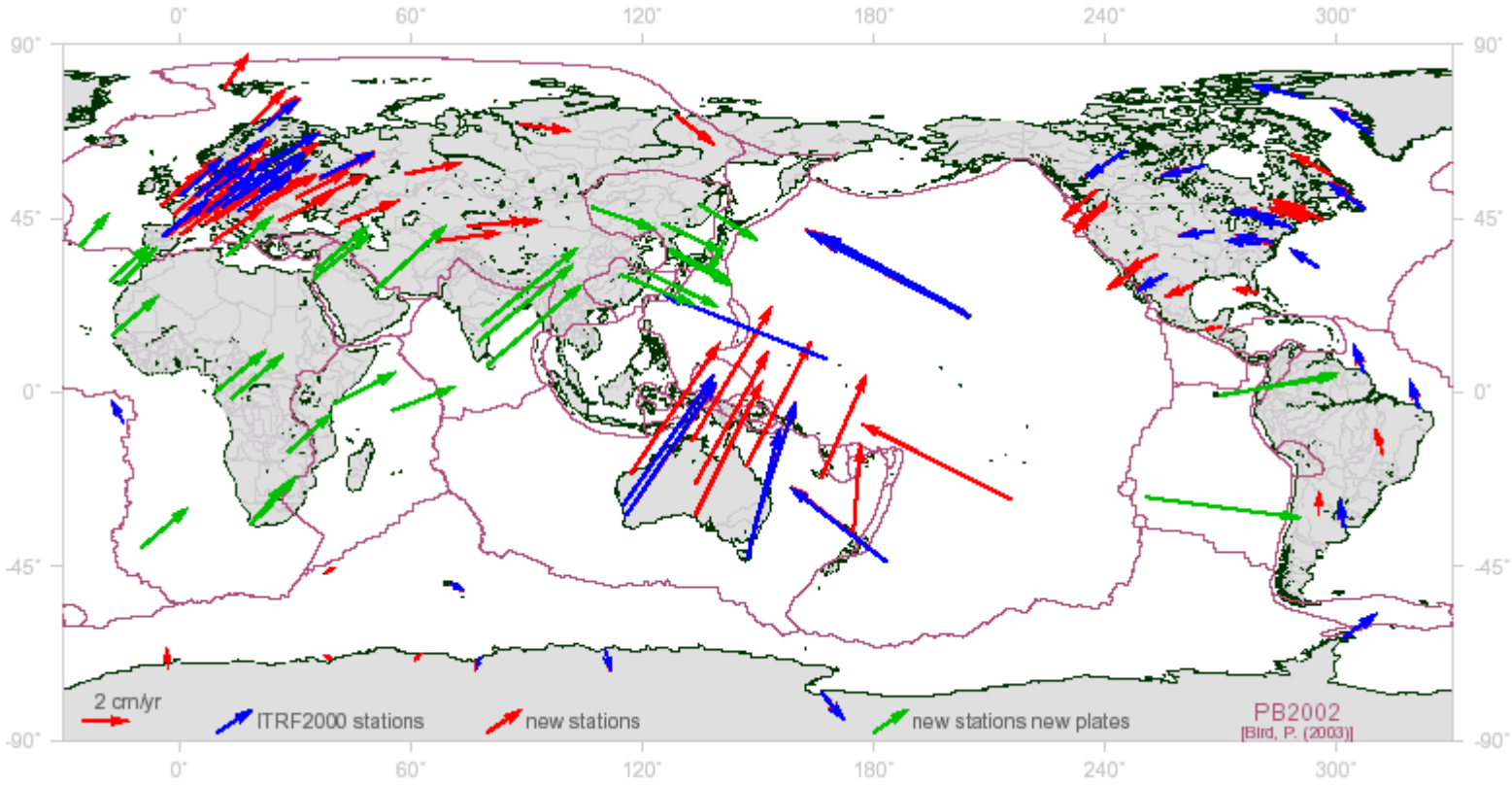
Annual Vertical Amplitude & Phase
Australia Case



Example of selected sites for plate angular velocities estimation

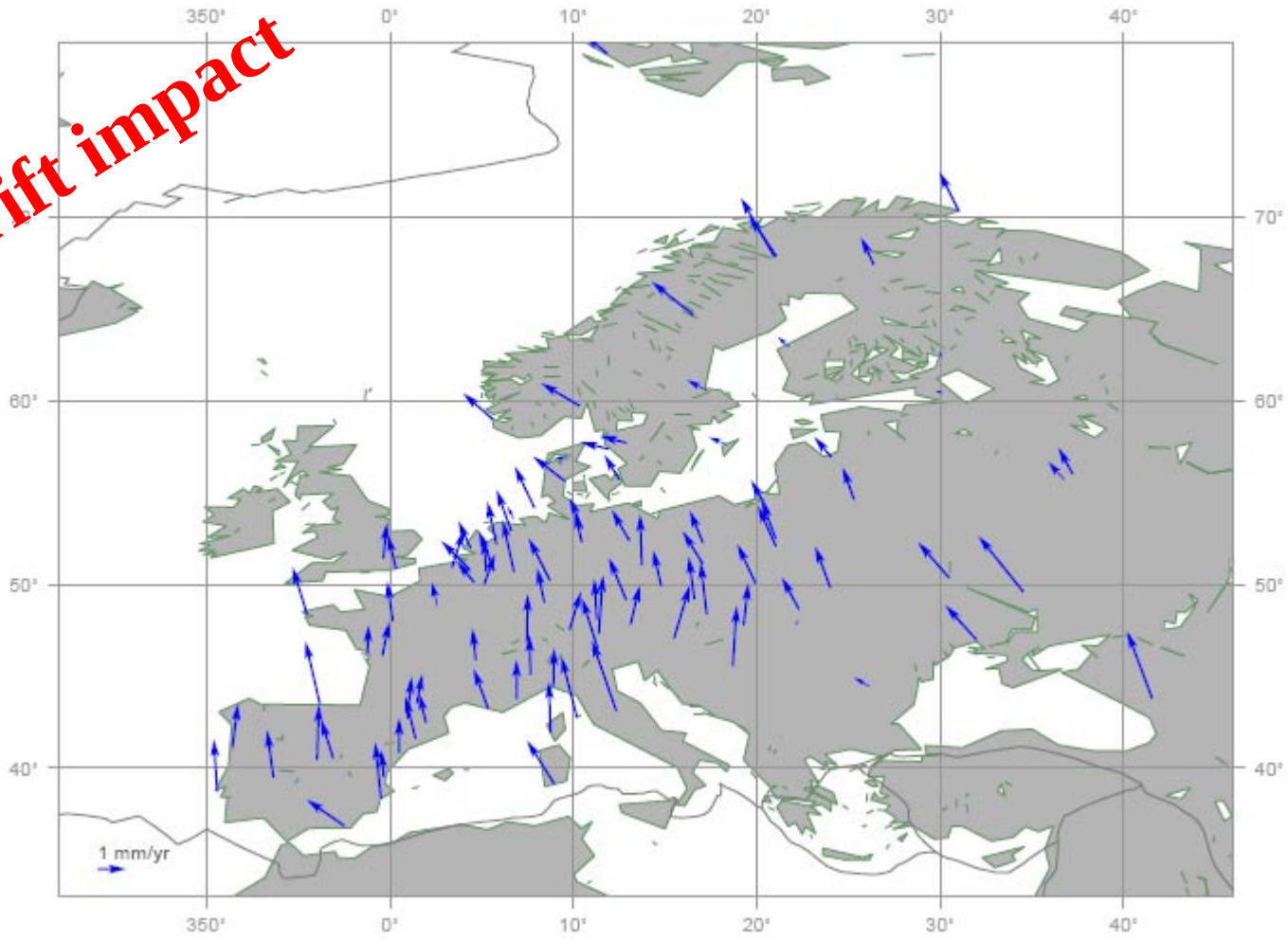
Using PB 2002 Plate boundaries (Bird, 2003)

Pacific
Africa
Amur
Antarctica
Arabia
Australia
Caribbean
Eurasia
India
North America
Nazca
Okhotsk
South America
Somalia
Yangtze



Velocity differences between ITRF2005 and ITRF2000 An example over Europe

TZ drift impact



Limitations & Improvements (1/2)

- Poor SLR & VLBI networks and their co-location
- Improve analysis
  - Systematic errors
  - Include more satellites for SLR ? (see DORIS experience)
  - GM, Satellite CoMs ?
  - Correction models consistency
    - Troposphere
    - Relativity
    - Others
  - More TRF VLBI sessions
  - Process ALL SLR data
- Improve GPS equipments : discontinuity problem, antenna settings,… !
- Improve DORIS scale and Z-component (how ?)

Limitations & Improvements (2/2)

- **Improve Co-locations :**
  - **Re-Survey dubious Co-location sites (International effort needed)**
  - **Re-compute all old ties ==> Full SINEX files**
  - **More Co-locations with better distribution : SLR & VLBI !!!**
- **Monitor the ITRF frame parameters (Scale & Origin)**
  - **Regular time series analysis**
  - **Need IAG services commitment to continue providing weekly (daily) solutions**
- **Monitor ITRF/EOPs consistency on a regular basis**
  - **Coordination between ITRF and EOP PCs**

Conclusions

- **Origin:**
  - **Significant drift / ITRF2000 in TZ : 1.8 mm/y**
  - **Consider Impact on ITRF2005 velocity field**

    (ITRF2005 velocities are 1.8 mm/yr larger than ITRF2000)
- **Scale:**
  - **~ 1 ppb bias btw solutions from VLBI and SLR**
- **NNR Condition: Still at the level of 2 mm/yr**
- **Still too many issues to improve …**

We are indebted to the many contributors to ITRF2005