ITRF2005 and consequences for the ETRS89 realization

- Introduction
- Preliminary ITRF2005 under evaluation
- Results
  - Origin (Geocenter)
  - Scale
  - No Net Rotation Condition
- Consequences for ETRS89 realization
- Conclusions

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ITRF2005

- **For 1st time, use Time Series of Station Positions** :
  - **Daily (VLBI)**
  - **Weekly (GPS, SLR & DORIS)**
- **and Earth Orientation Parameters**:

  Polar Motion (x_p, y_p)

  Universal Time (UT1) (Only from VLBI)

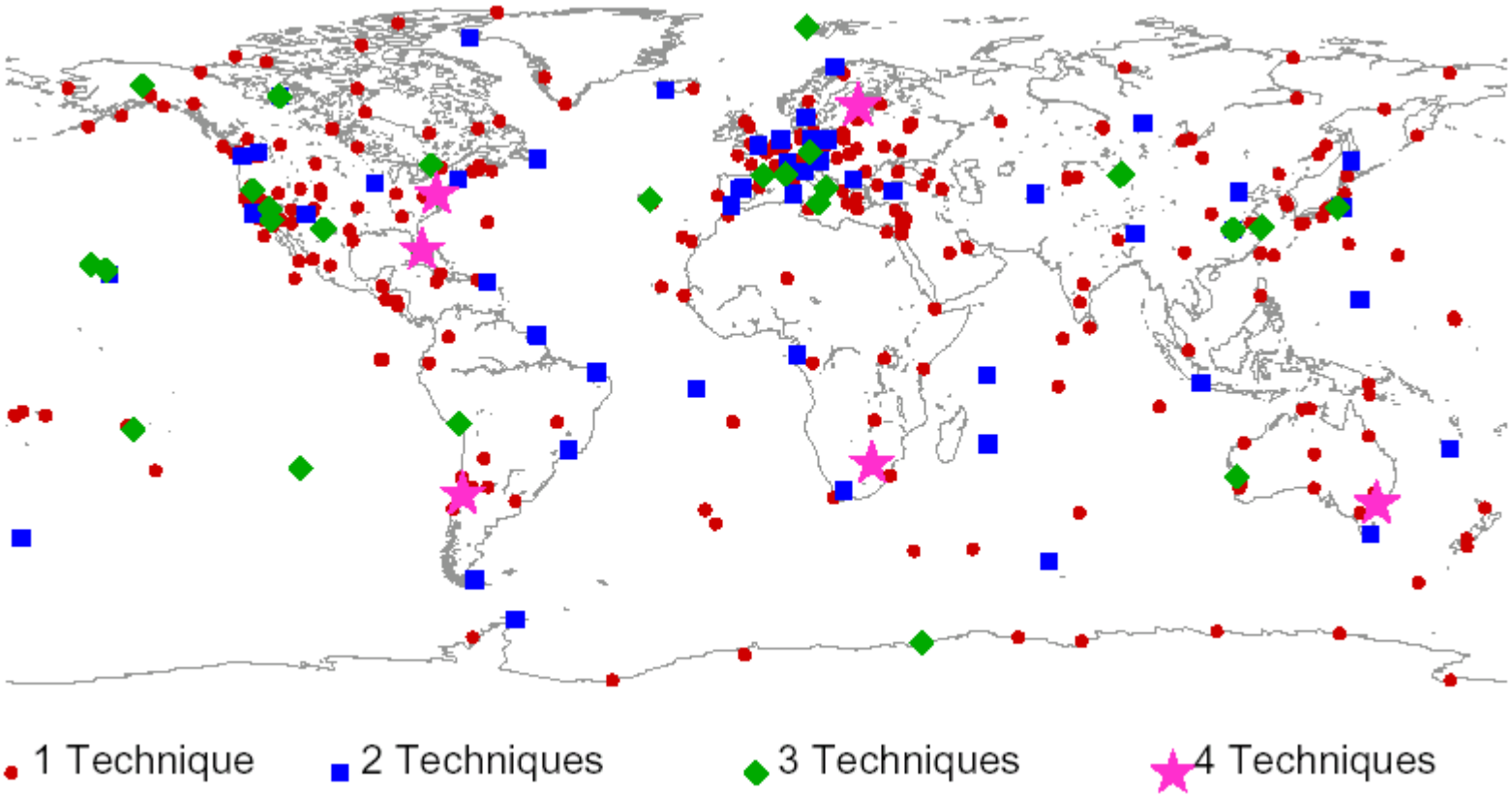
  Length of Day (LOD)

- **3 ITRF CC: NRCan, DGFI, IGN**

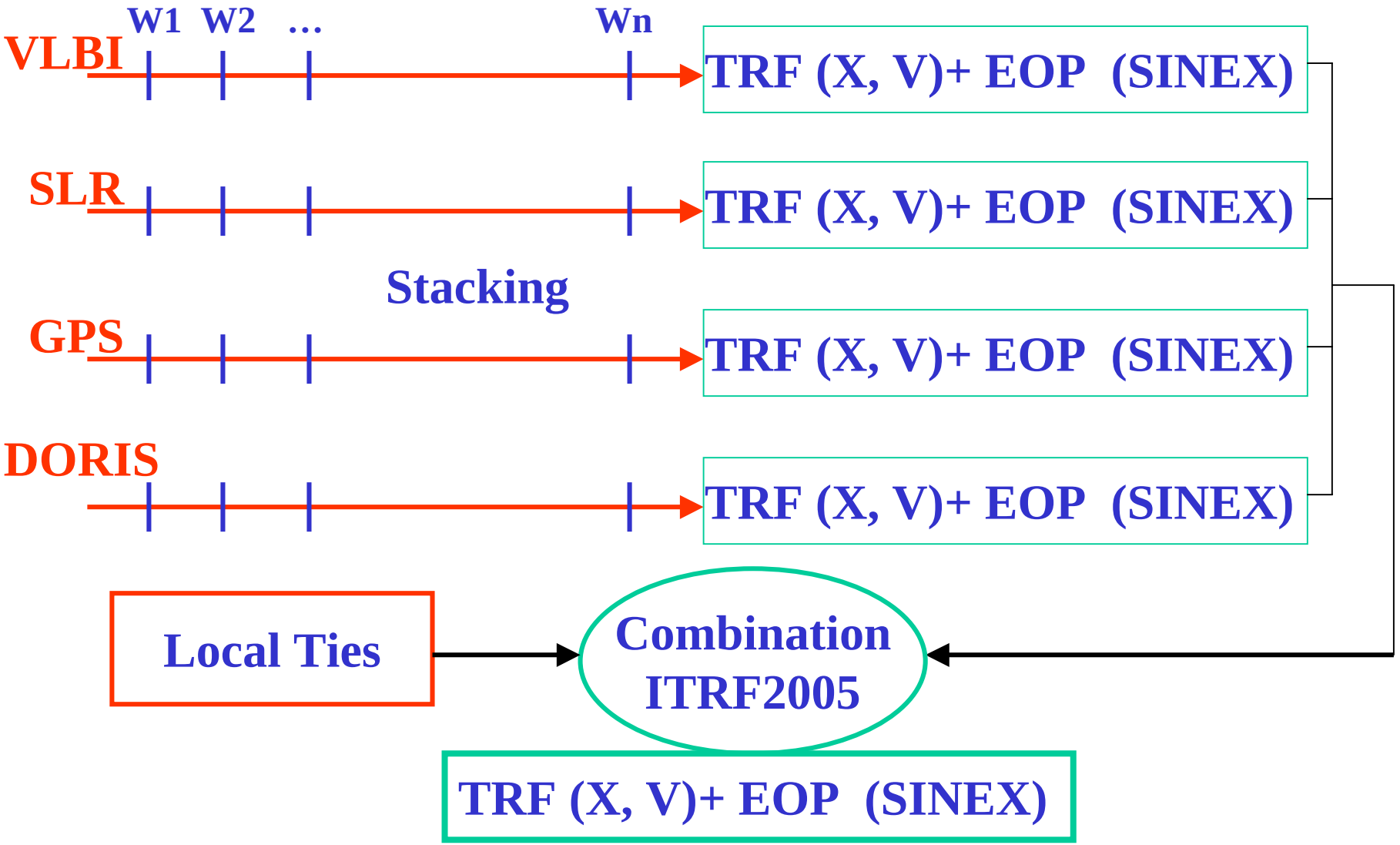
Submitted data

TC - AC	Time-span	Type of constraints/solution	
IVS VLBI	1980.0-2006.0	Normal Equation	Daily
ILRS SLR	1992.9-2005.9	Loose; Var-Covar	Weekly
IGS GPS	1996.0-2006.0	Minimal; Var-Covar	
IDS - IGN DORIS	1993.0-2006.0	Loose; Var-Covar	
IDS -LCA DORIS	1993.0-2005.8	Loose; Var-Covar	

ITRF2005 Co-locations



ITRF2005 Derivation



Time series combination (Rigourosly stacking)

- **Input:**
  - Weekly Station Positions: X(t)
  - Daily Polar motion (& rates), UT1, LOD
- **Output: Long-Term Solution (LTS):**
  - Station positions at a reference epoch t_0
  - Station Velocities
  - Daily EOPs
  - Time series of the transformation parameters between each week and the LTS

Stacking
TRF & EOP time series Combination

CATREF Software

INPUT: $X(t)$, **EOP(t) in daily/weekly/monthly SINEX files**

OUTPUT: $X(t_0)$, $\dot{X}$, **EOP(t),** $(\underbrace{T_x, T_y, T_z}_{\text{Geocenter}}, D, R_x, R_y, R_z)$ **time series**

$$\begin{cases} X_s^i = X_{itrf}^i + (t_s^i - t_0)\dot{X}_{itrf}^i + T_k + D_k X_{itrf}^i + R_k X_{itrf}^i \\ \quad + (t_s^i - t_k)\left[\dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i\right] \\ \dot{X}_s^i = \dot{X}_{itrf}^i + \dot{T}_k + \dot{D}_k X_{itrf}^i + \dot{R}_k X_{itrf}^i \end{cases}$$

$$\begin{cases} x_s^p = x^p + R2_k \\ y_s^p = y^p + R1_k \\ UT_s = UT - \frac{1}{f} R3_k \\ \dot{x}_s^p = \dot{x}^p + \dot{R}2_k \\ \dot{y}_s^p = \dot{y}^p + \dot{R}1_k \\ LOD_s = LOD + \frac{\Lambda_0}{f}\dot{R}3_k \end{cases}$$

Datum Definition with Minimum Constraints Over a Reference Set of stations

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

- **Matching common EOP parameters at UT noon**
- **Propagate at UT noon if rates are available**

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:**

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

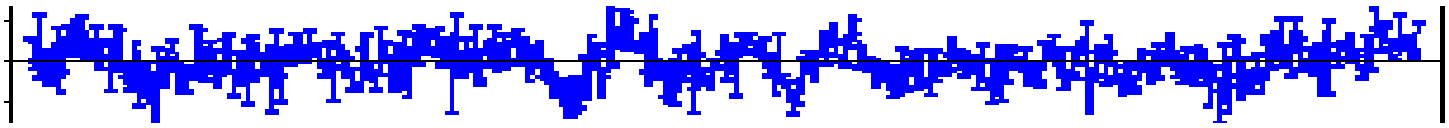
or

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

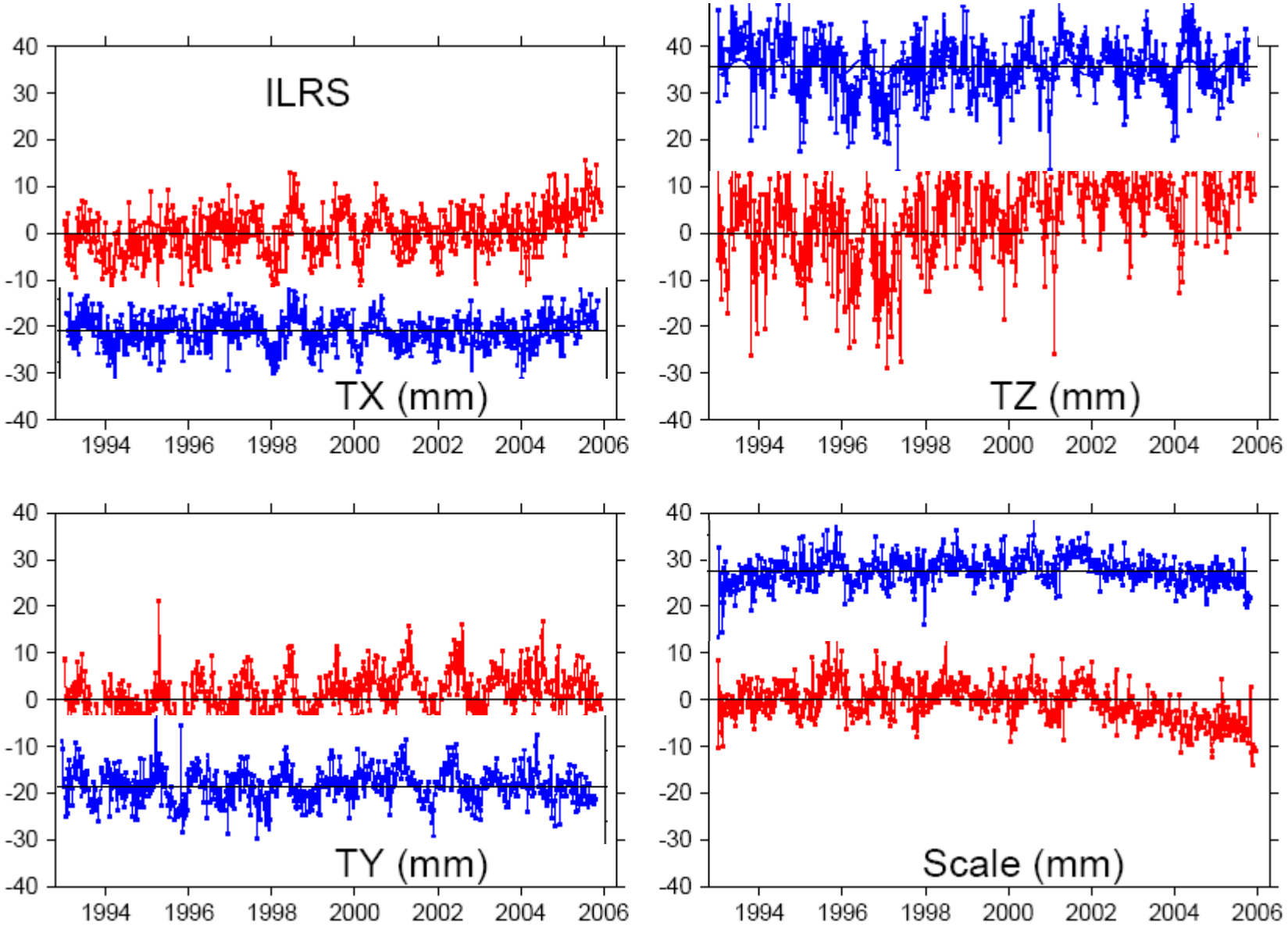
$$P(t) = P(t_0) + \dot{P} \times (t - t_0)$$

apply "inner" conditions:

$$P(t_0) = 0 \quad \textbf{and} \quad \dot{P} = 0$$



SLR Origin and Scale Variations WRT ITRF2000



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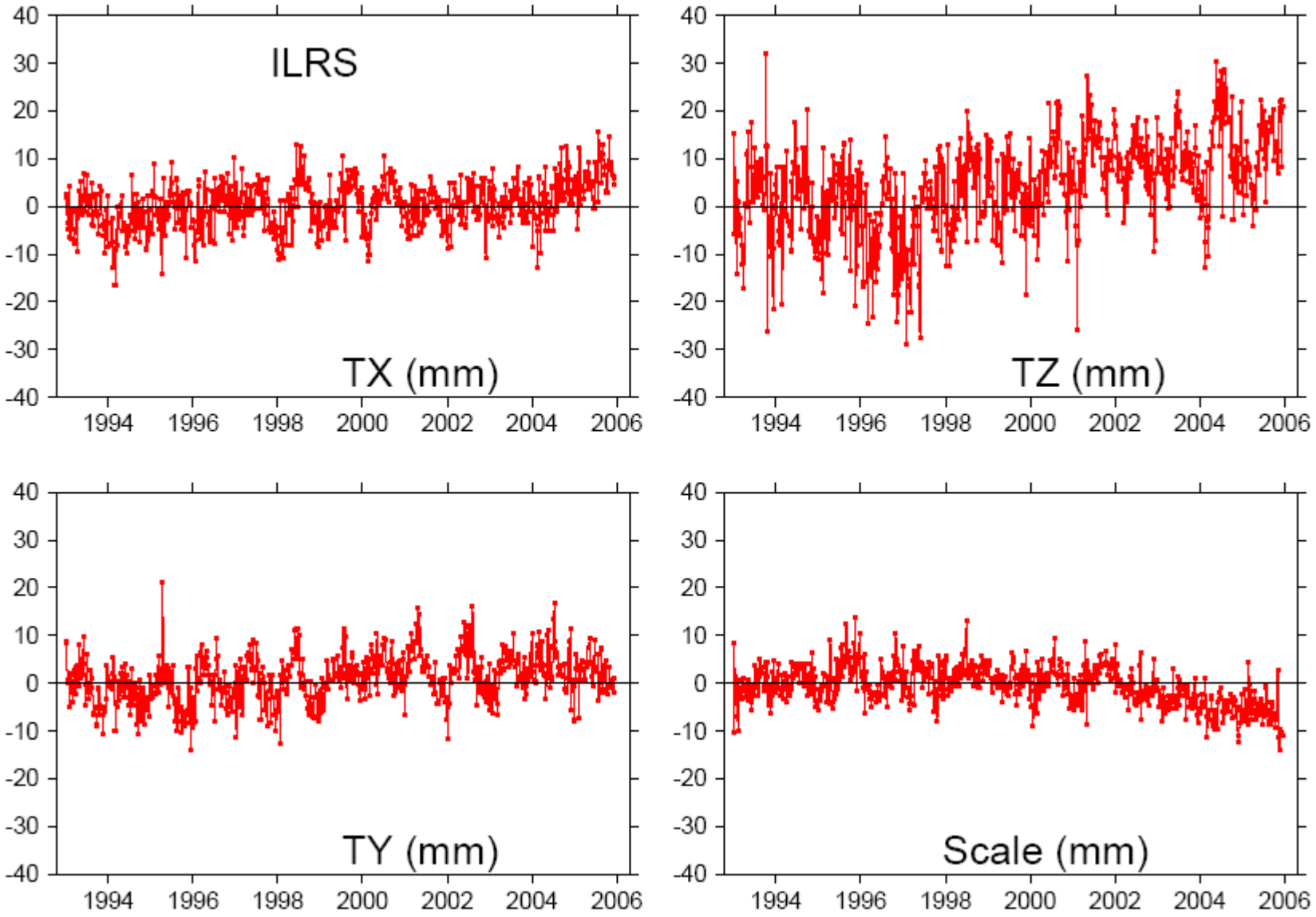
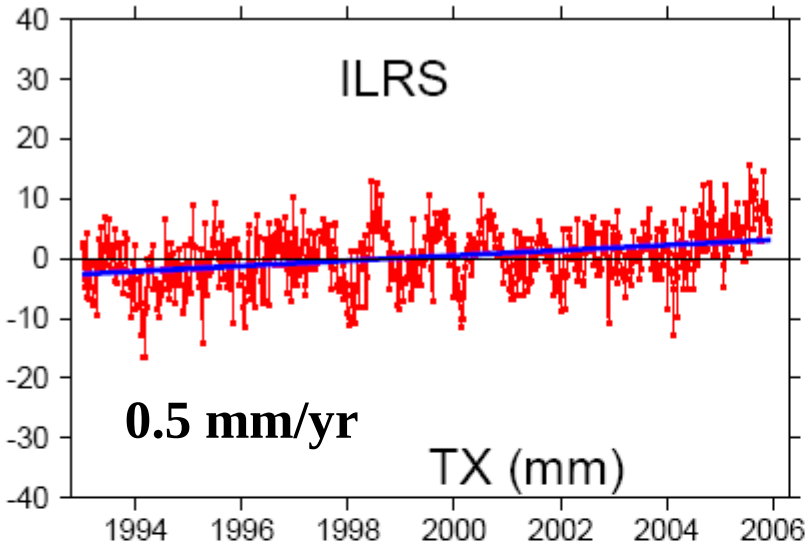
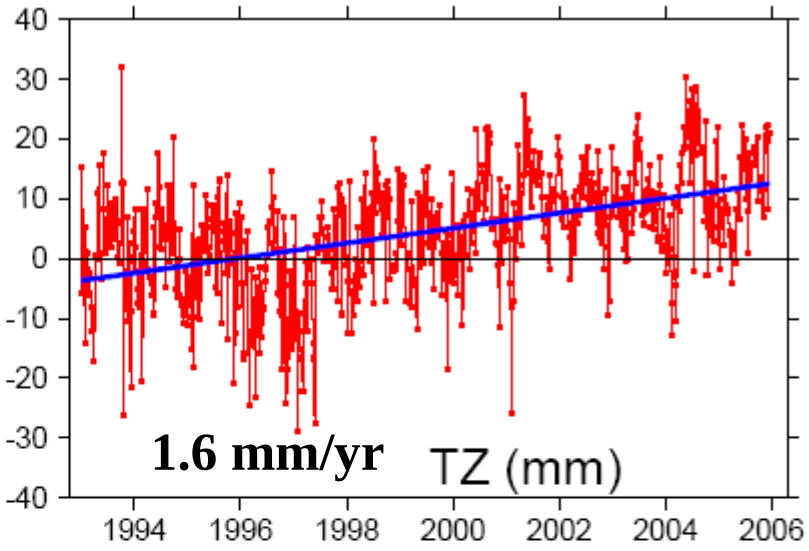
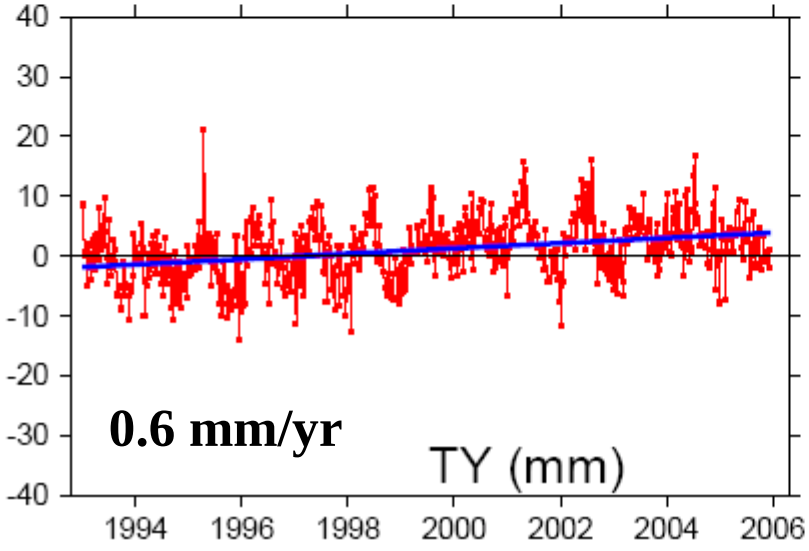
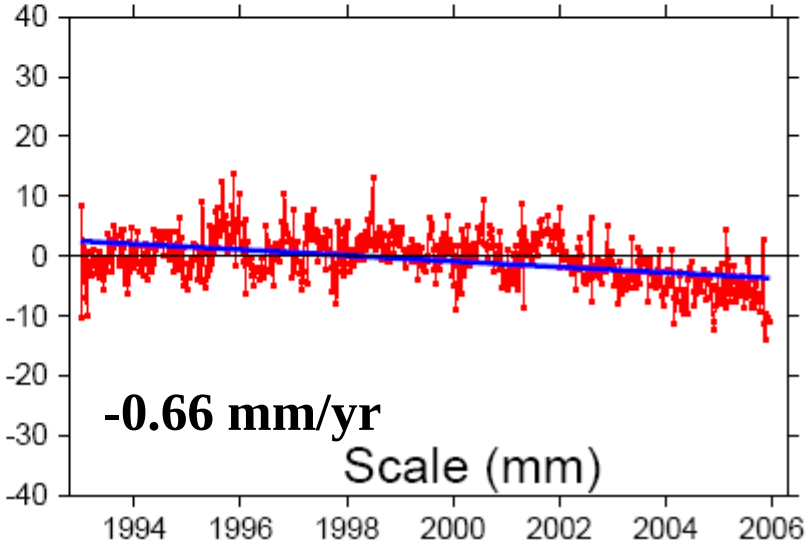


SLR Origin and Scale Variations WRT ITRF2000

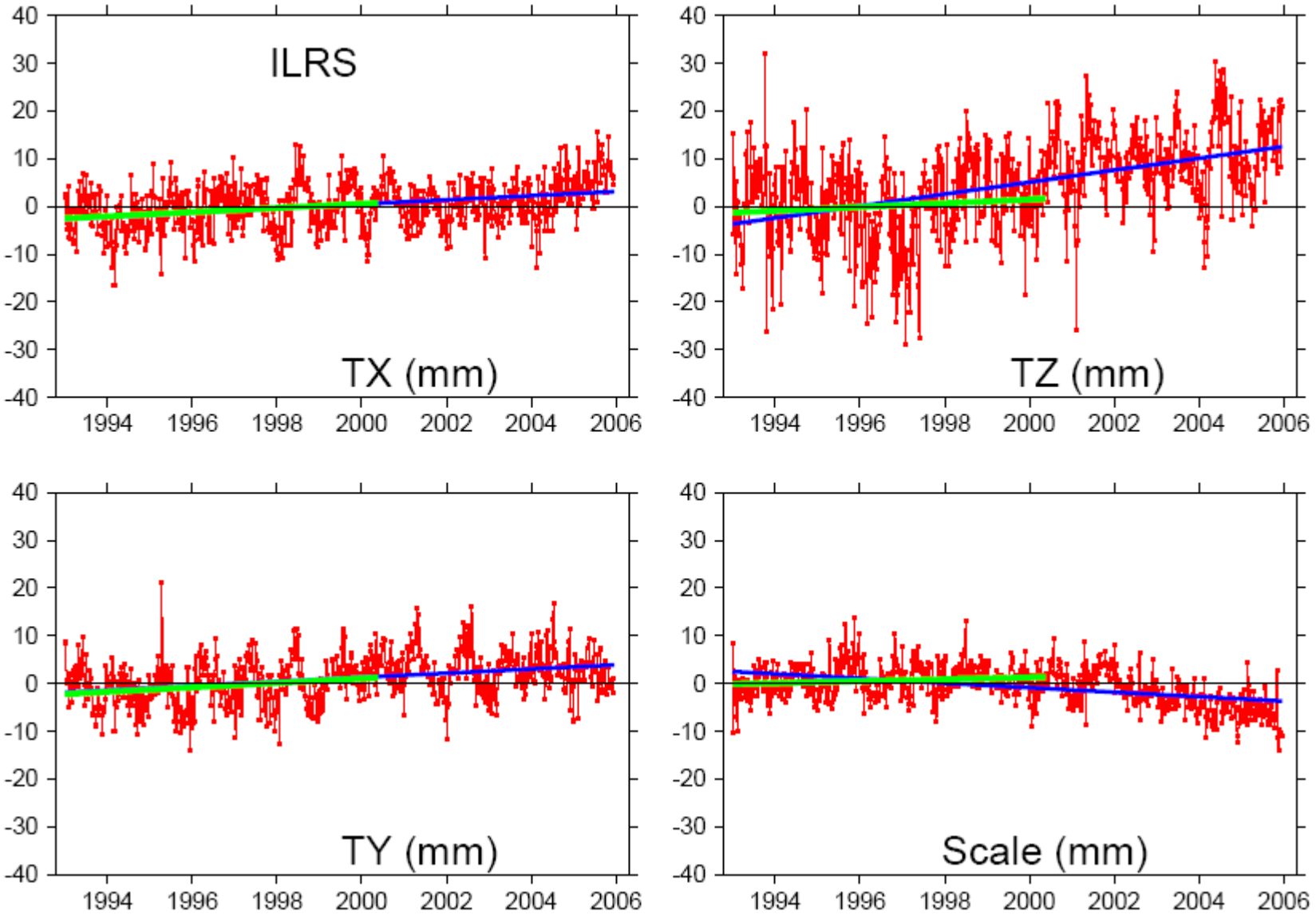




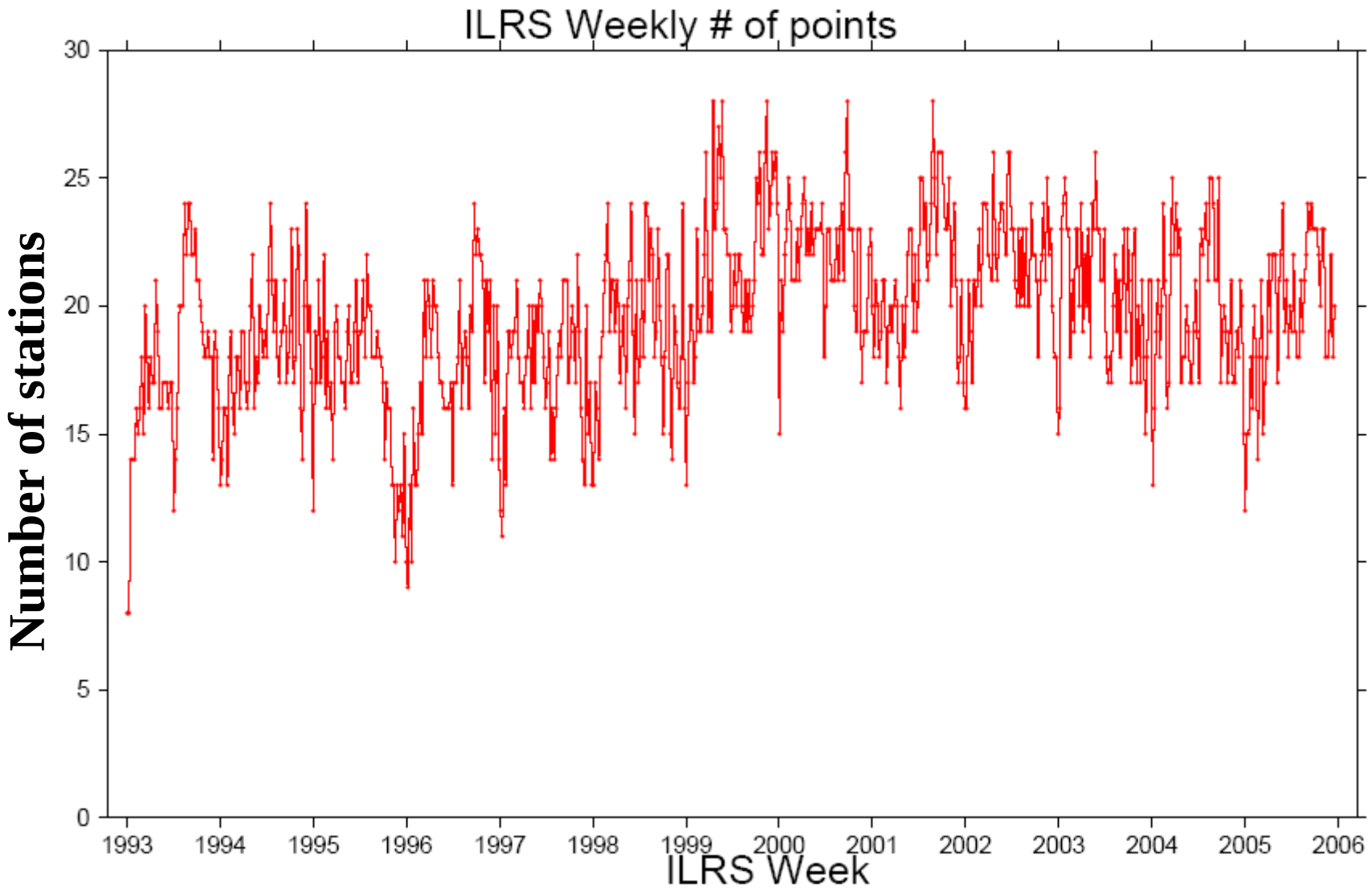




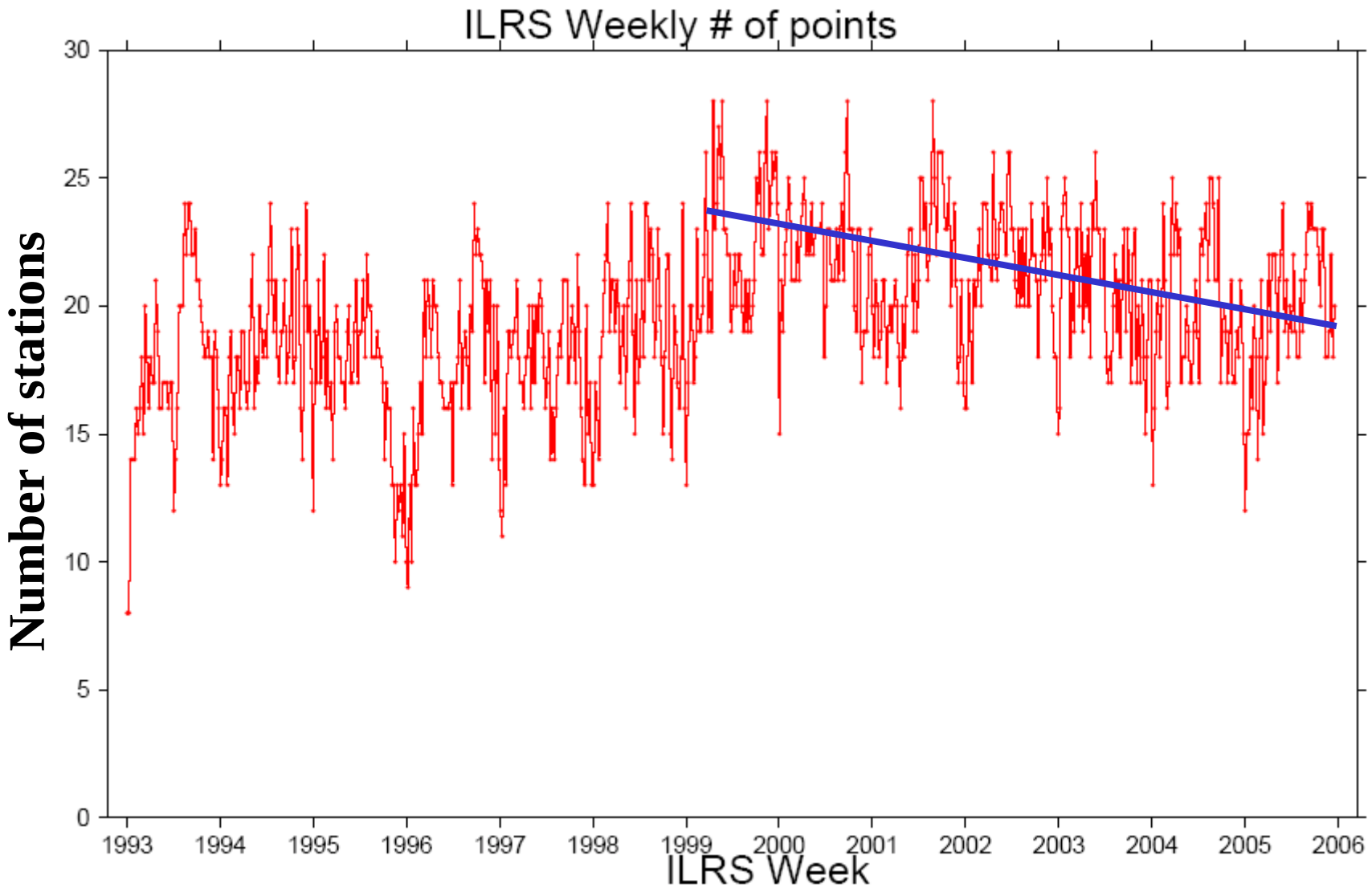
SLR Origin and Scale Variations WRT ITRF2000



ILRS Network

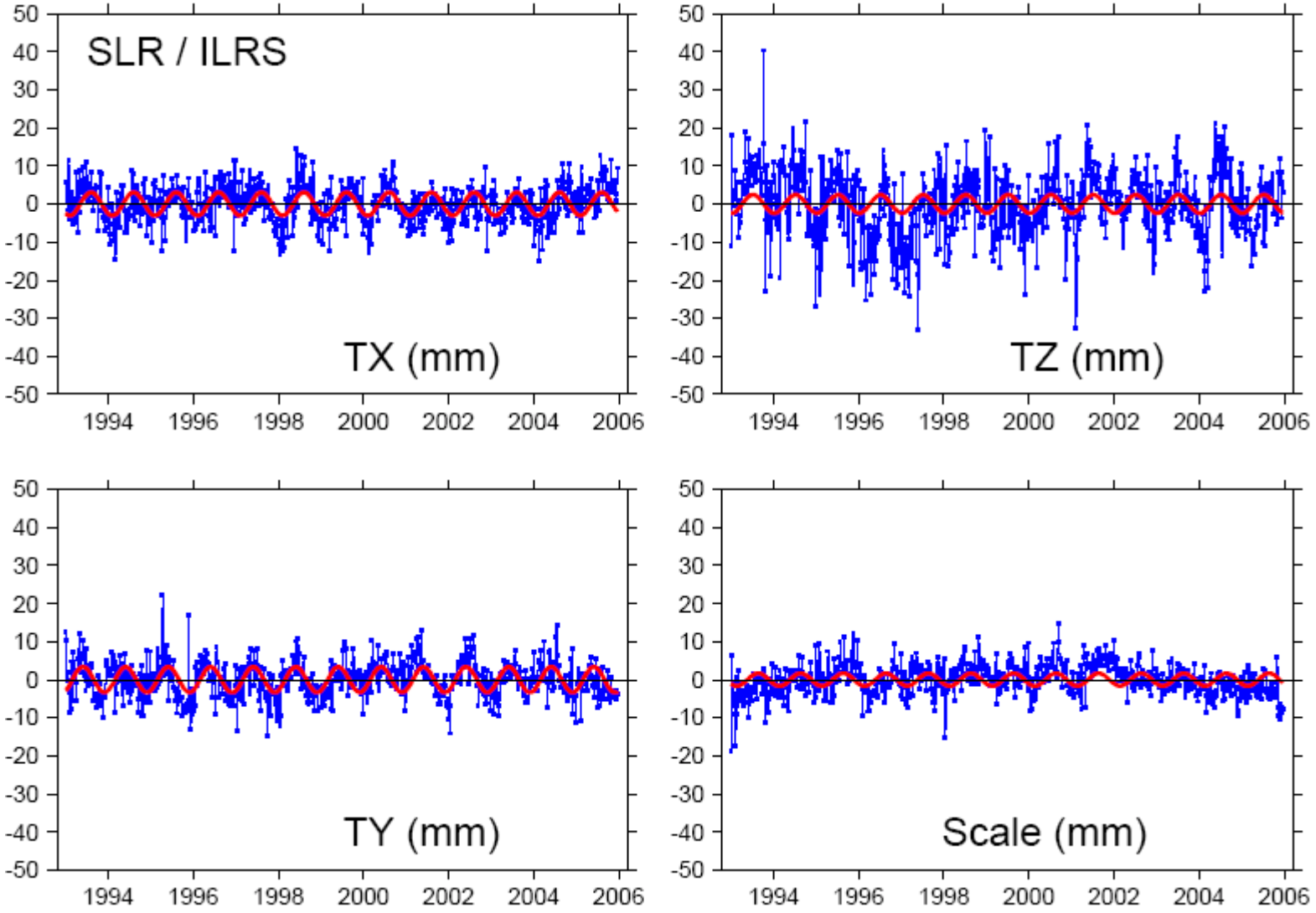


ILRS Network



SLR Origin and Scale Variations

$$TX(t) = A\cos(2\pi t + \varphi)$$

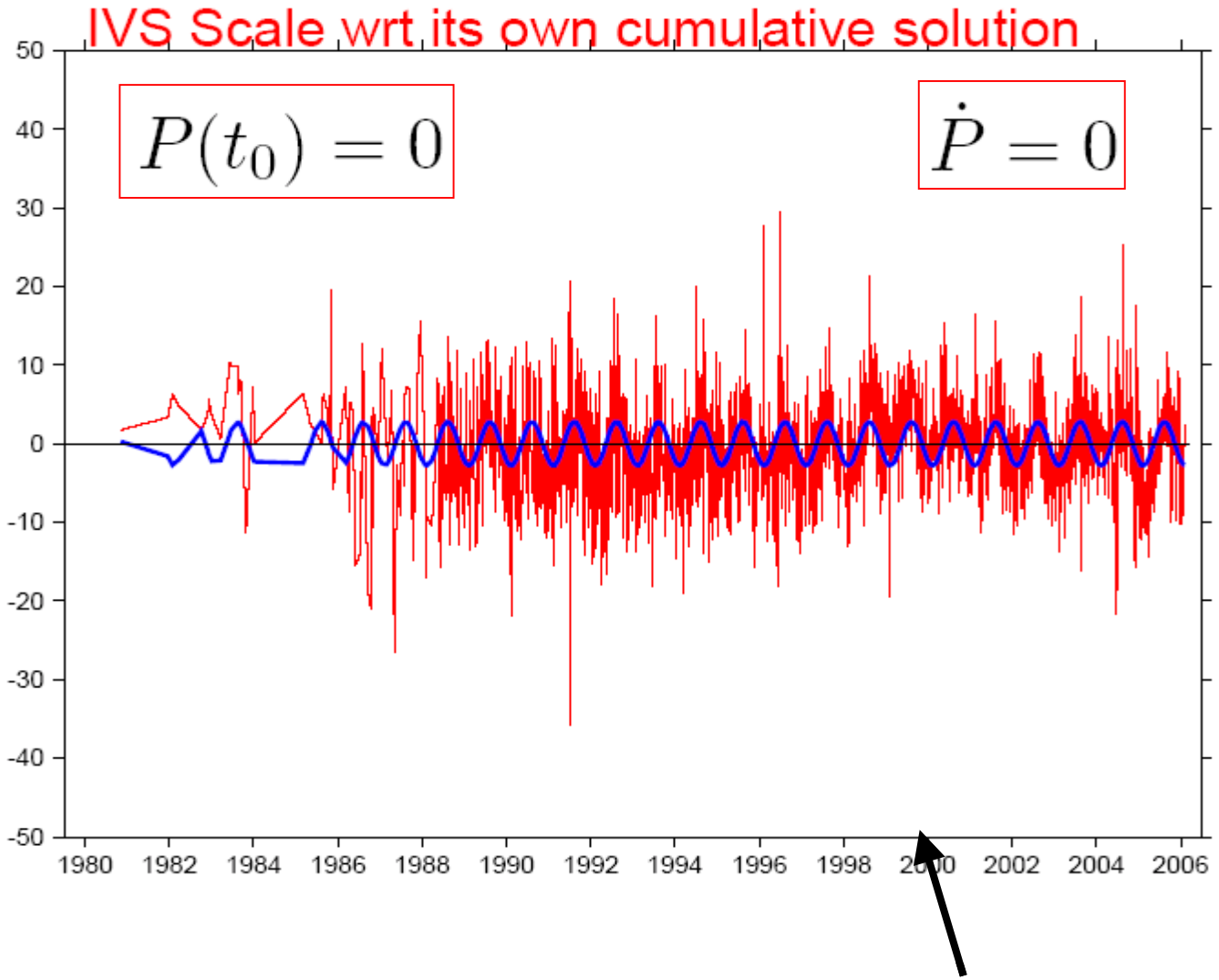


Amplitude and Phase of SLR Origin

	A (mm)	φ (deg)
TX	3.1	144
TY	3.9	211
TZ	2.4	173
Scale	1.6	129

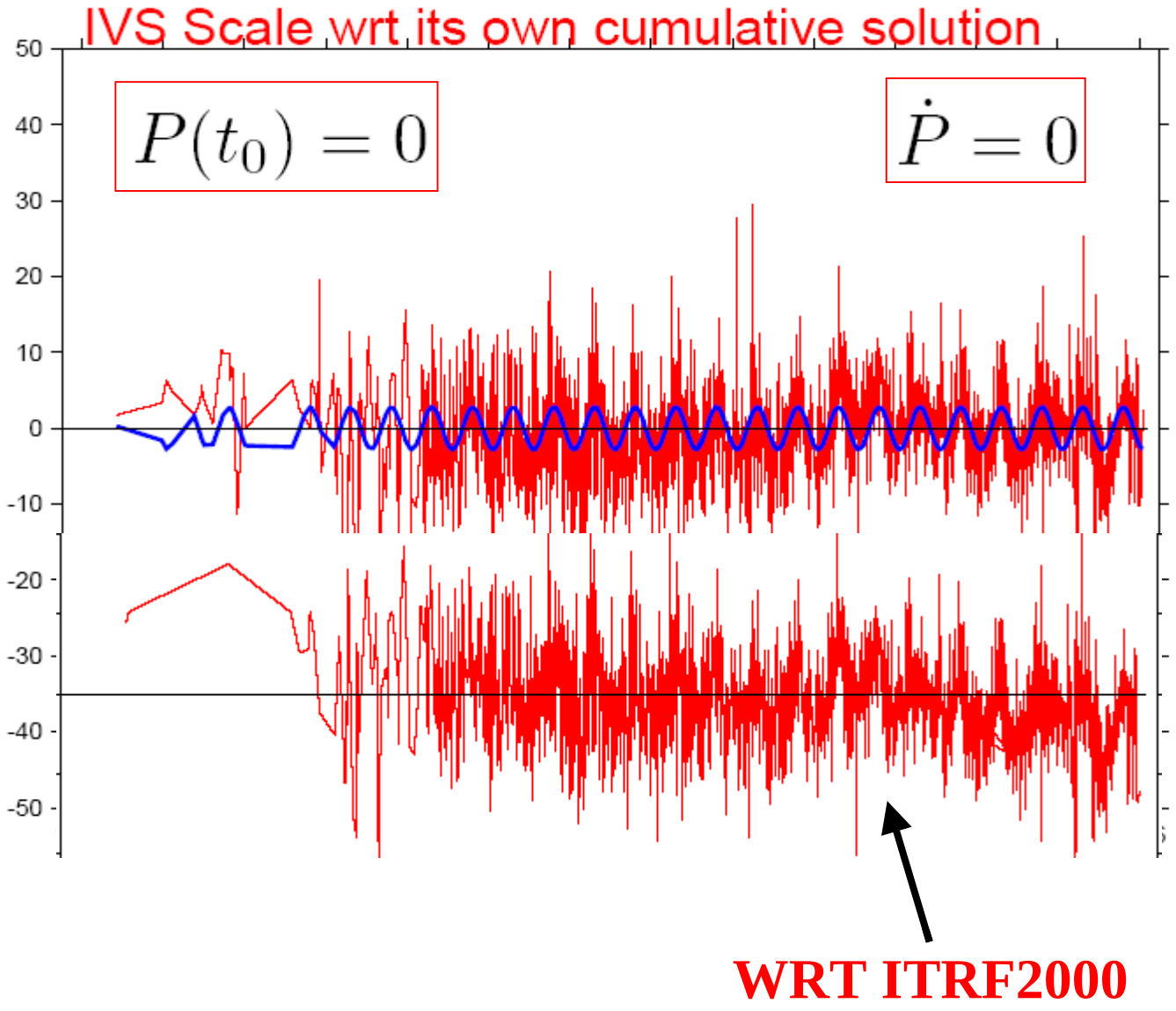
$$TX(t) = A\cos(2\pi t + \varphi)$$

VLBI Scale

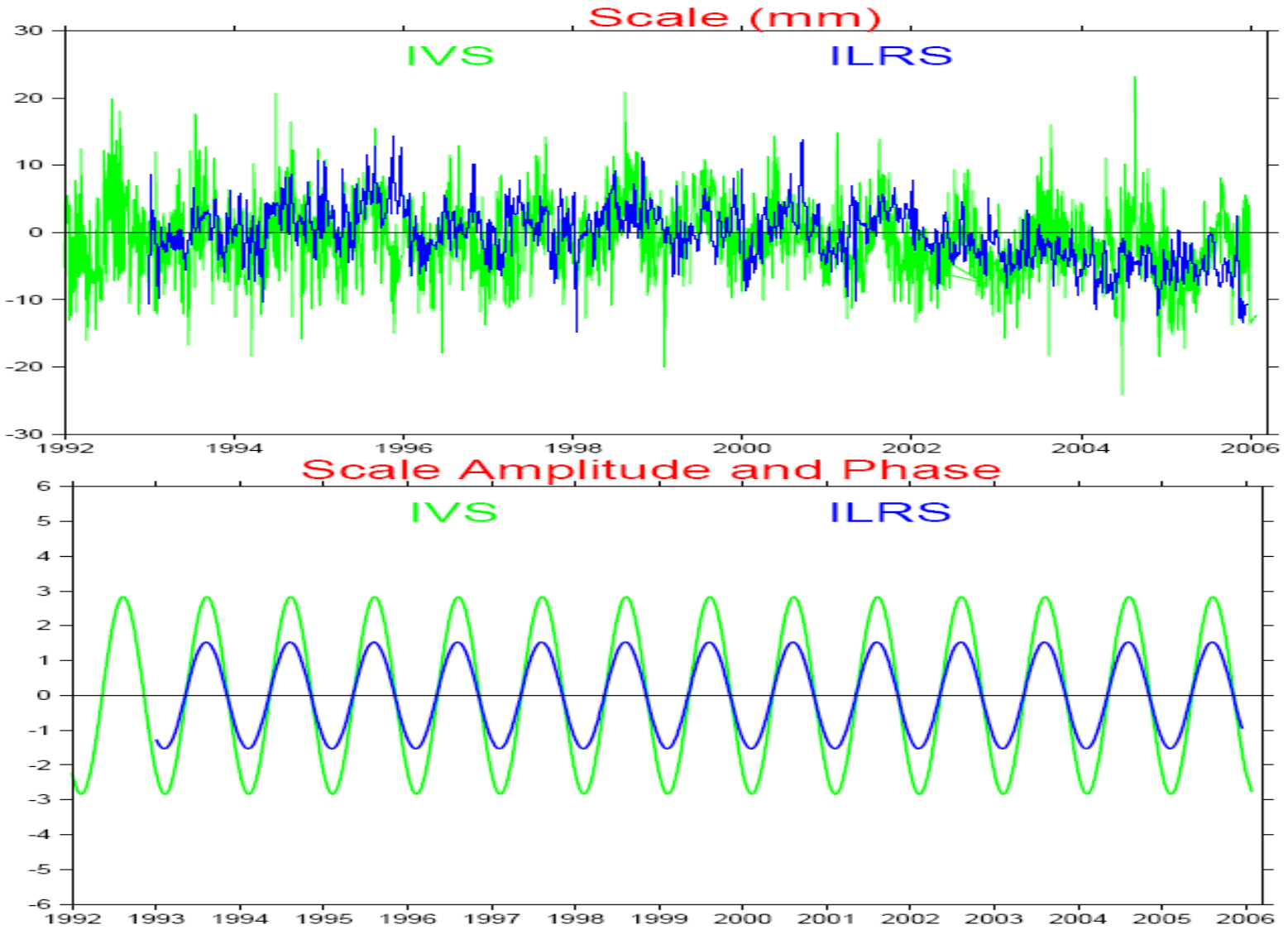


WRT ITRF2000

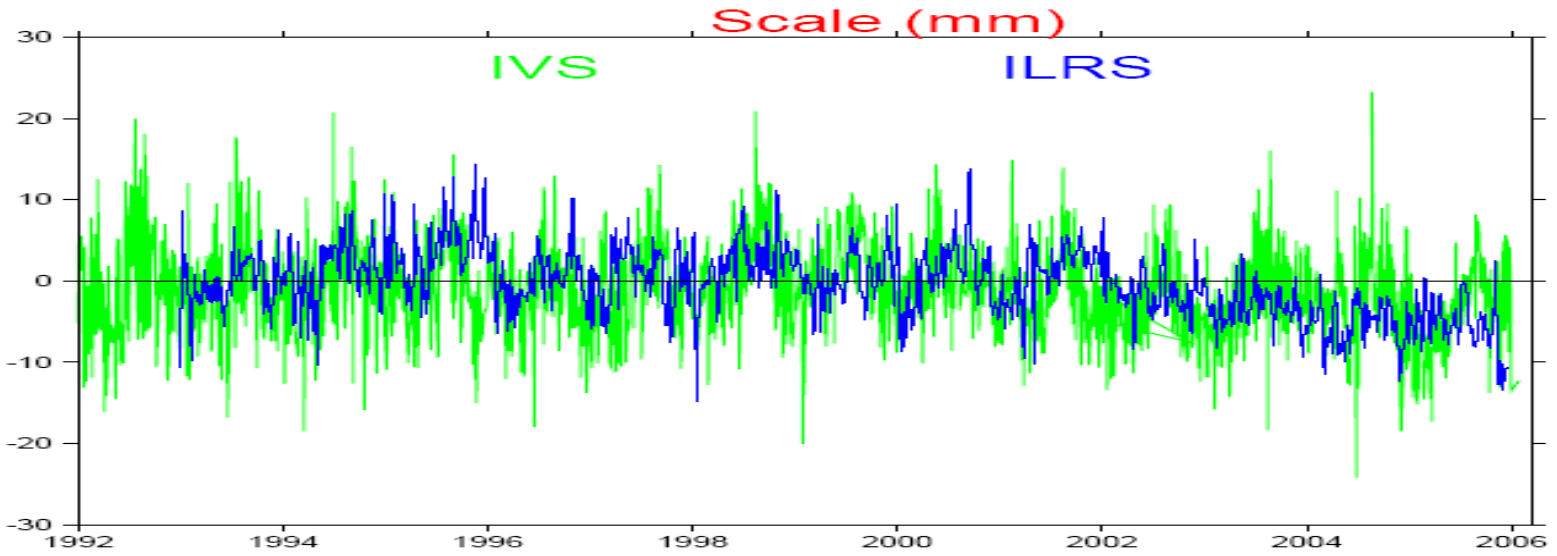
VLBI Scale


IVS Scale wrt its own cumulative solution
$P(t_0) = 0$
$\dot{P} = 0$
50
40
30
20
10
0
-10
-20
-30
-40
-50
WRT ITRF2000

VLBI vs SLR Scale wrt ITRF2000



VLBI vs SLR Scale wrt ITRF2000



	A (mm/y)	*Φ (deg./y)*
SLR	**1.6**	**129**
VLBI	**2.7**	**139**

Consequences for ETRS89 realization

- **Transformation parameters between ITRTF2005 and ITRF2000 have to be taken into account:**
  - **Transltaion & rates**
  - **Scale & rates**
  - **No-Net Rotation Condition**
- **Procedure for ETRS89 realization will be updated**

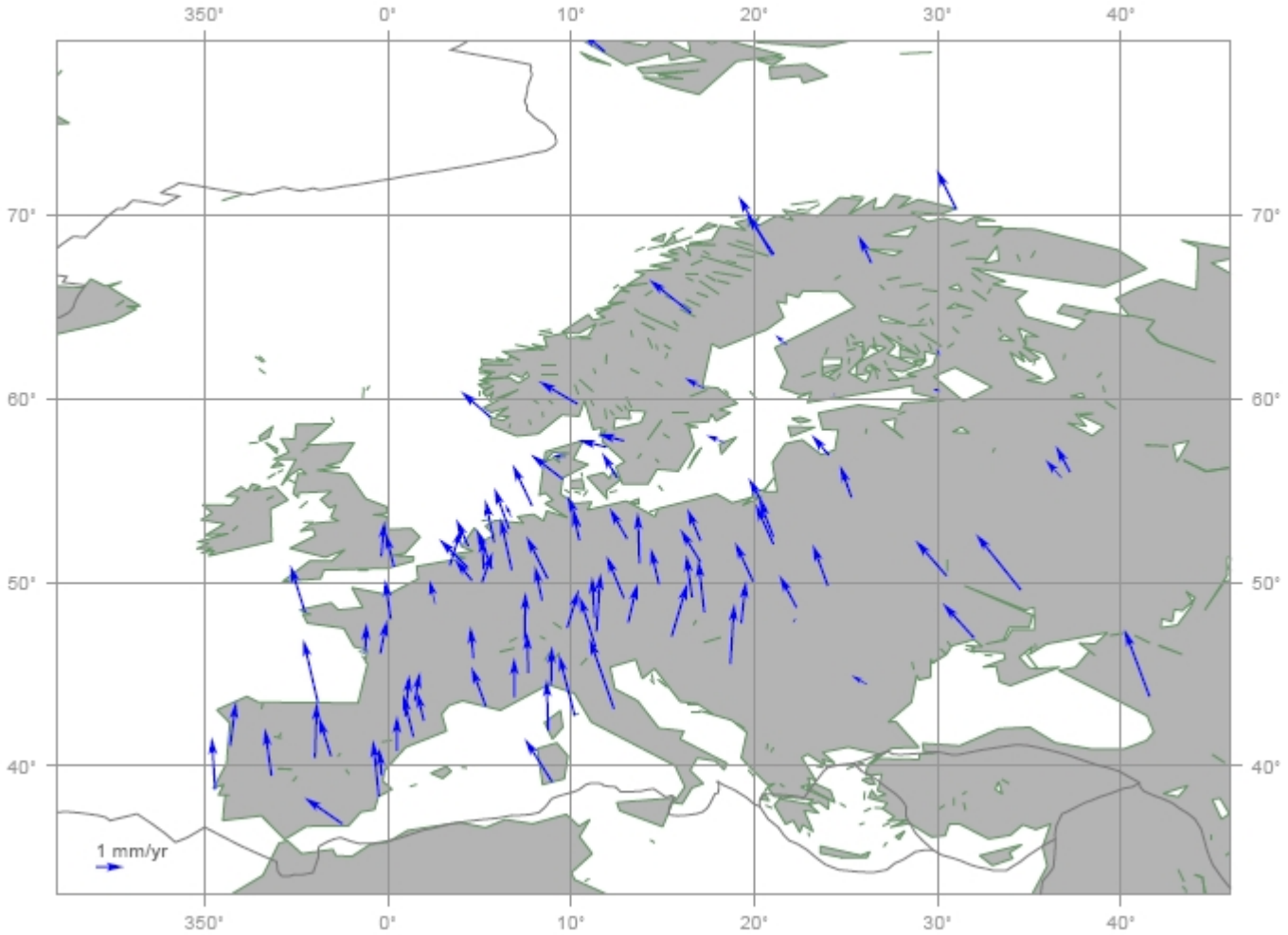
ITRF2005P to ITRF2000

TX mm mm/y	TY mm mm/y	TZ mm mm/y	Scale ppb ppb/y
0.8	-0.9	-5.1	0.24
0.0	0.0	-1.6	0.06

ITRF2005 and the NNR condition

- **Three possibilities are still to be tested/evaluated using:**
  - **ITRF2000**
  - **APKIM 2005**
  - **New NNR model by Kreemer et al.**

Velocity differences btw ITRF2005P ITRF2000



Conclusions

- **Origin:**
  - **‘’Significant’’ SLR Network effect after 2000.x**
  - **Significant drift / ITRF2000 in TZ : 1.6 mm/y**
  - **Consider Impact on ITRF2005 velocity field**
- **Scale:**
  - **VLBI and SLR Scale drift are small**
  - **VLBI and SLR seem to be in phase**
  - **Annual Amplitude of VLBI larger than SLR**

- **NNR Condition: Still to be finalized**