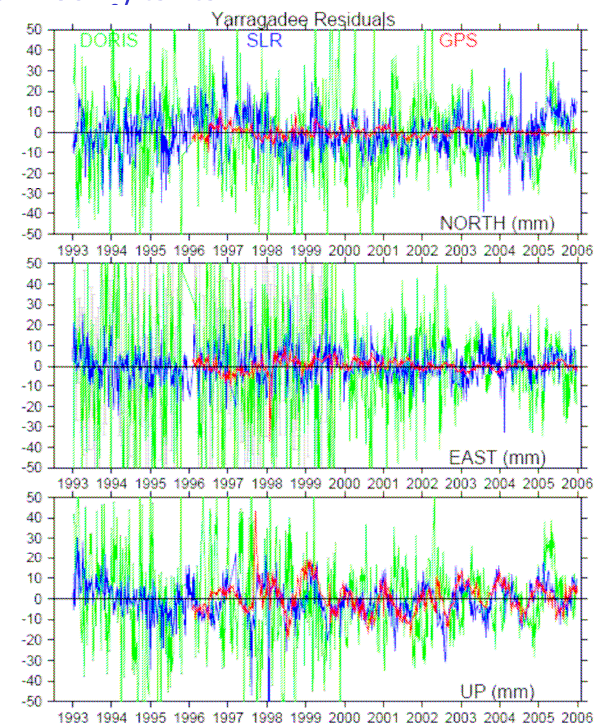
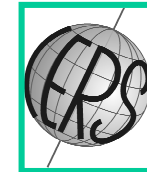


# Time Series Analysis of ILRS SLR Weekly Solutions

- Datum definition for time series analysis
- Seasonal variation of SLR Origin
- Comparison to external models
- Network effect
- Scale issue
- Conclusions



Zuheir Altamimi, Xavier Collilieux  
IGN, France

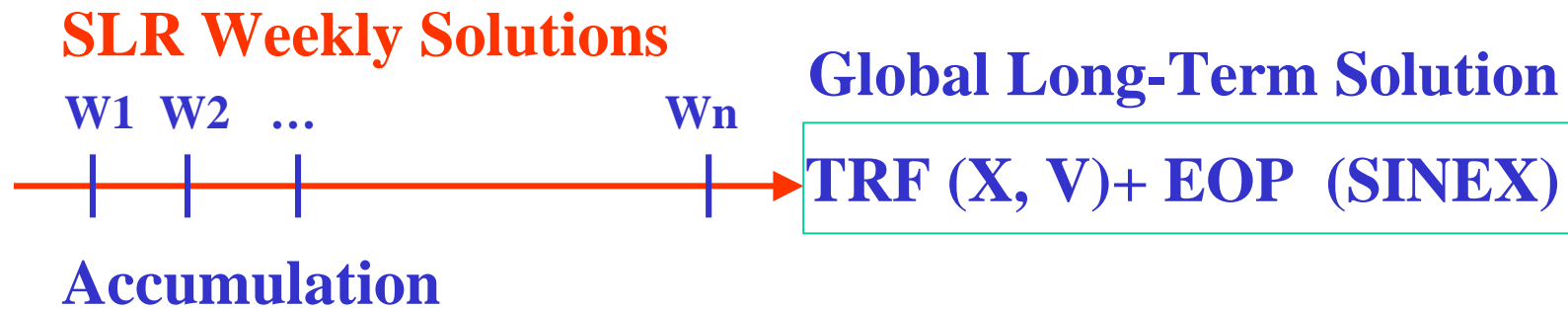


ILRS Workshop, Grasse, France , September, 2007

# Analyzed data and models

- **ILRS SLR weekly solutions (ITRF2005 data)**
- **Test SLR Solutions from**
  - ASI (by C. Luceri)
  - IGN/OCA (by D. Coulot)
- **Displacements models**
  - **GPS+OBP (Wu, 2006): Global inversion of GPS residuals & Ocean bottom pressure variations for loading displacements**
  - **Loading model (van Dam, 2007) : Hydrology + non-tidal Ocean + Atmosphere**

# Time Series Stacking



# Datum Definition for Time Series Stacking

## Minimum Constraints Approach

Select an external frame as a "reference"  
and apply minimum constraints approach:

$$X_R = X_c + A\theta$$

$$\theta = 0$$

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

# Datum Definition for Time Series Stacking Intrinsic Approach

- Estimate time series of Transfo. Param. & long-term solution
- Considering linear transf. parameter  $P$  :

$$P(t) = P(t_0) + \dot{P} \cdot (t - t_0) \quad (1)$$

- Eq. 1 could be solved by linear regression:

$$\begin{pmatrix} K & \sum_{k \in K} (t_k - t_0) \\ \sum_{k \in K} (t_k - t_0) & \sum_{k \in K} (t_k - t_0)^2 \end{pmatrix} \begin{pmatrix} P_k(t_0) \\ \dot{P}_k \end{pmatrix} = \begin{pmatrix} \sum_{k \in K} P_k \\ \sum_{k \in K} (t_k - t_0) P_k \end{pmatrix}$$

**Intrinsic conditions:**

$$P(t_0) = 0 \quad \& \quad \dot{P} = 0 \quad \text{or}$$

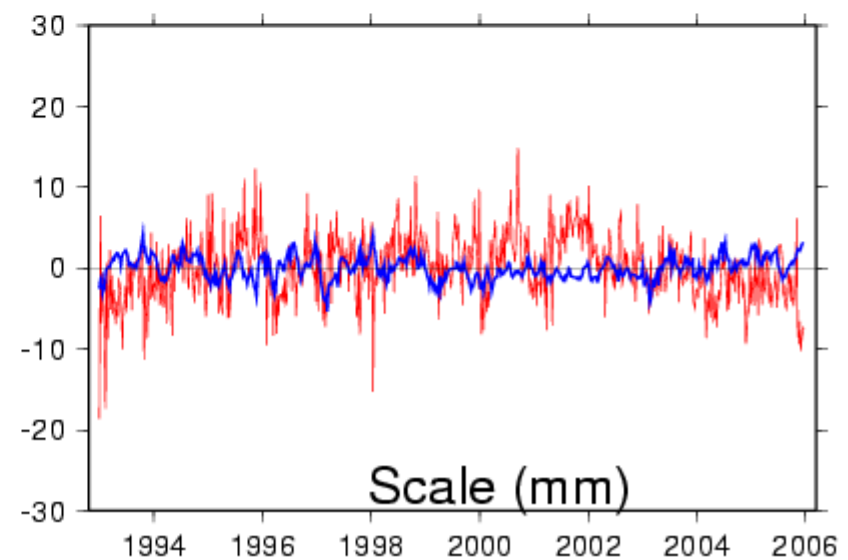
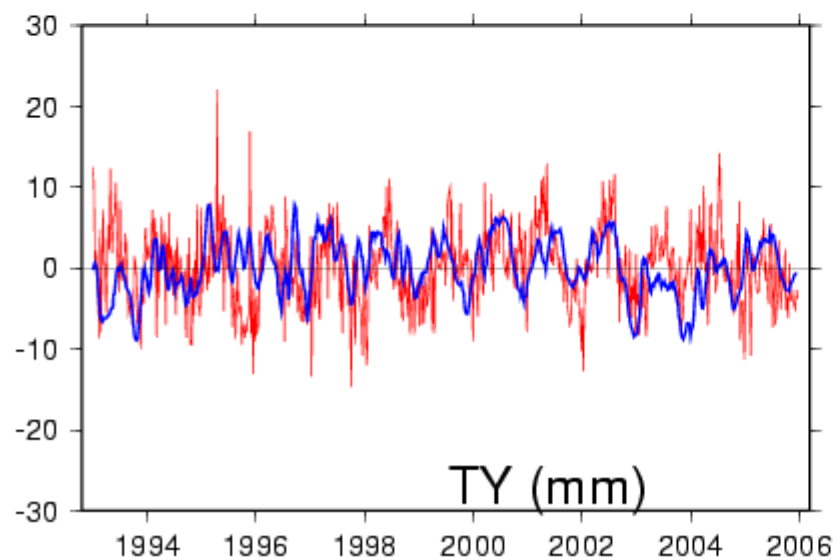
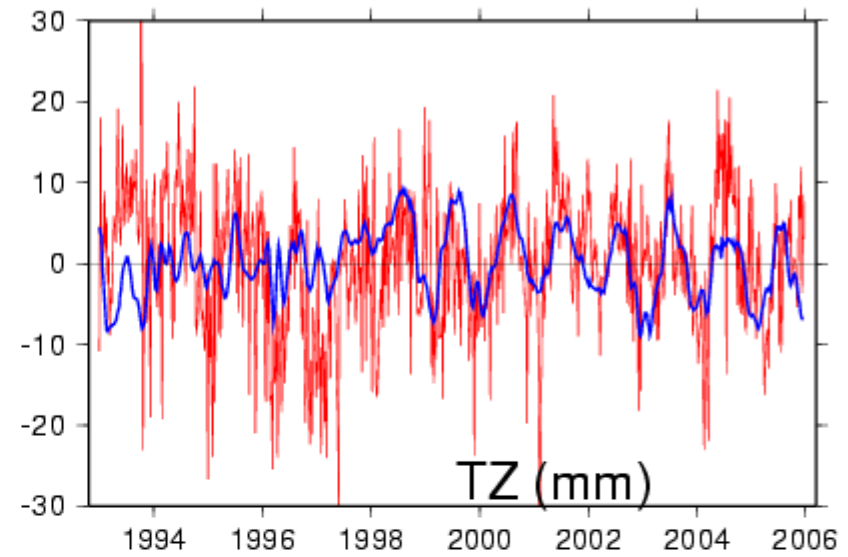
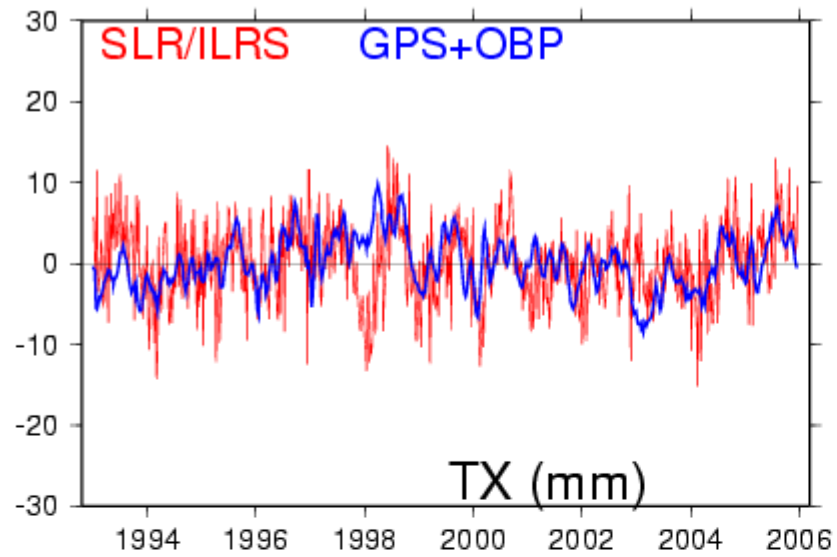
$$\begin{cases} \sum_{k \in K} P_k(t_k) = 0 \\ \sum_{k \in K} \frac{P_k(t_k)}{(t_k - t_0)^{-1}} = 0 \end{cases}$$

# Intrinsic Conditions

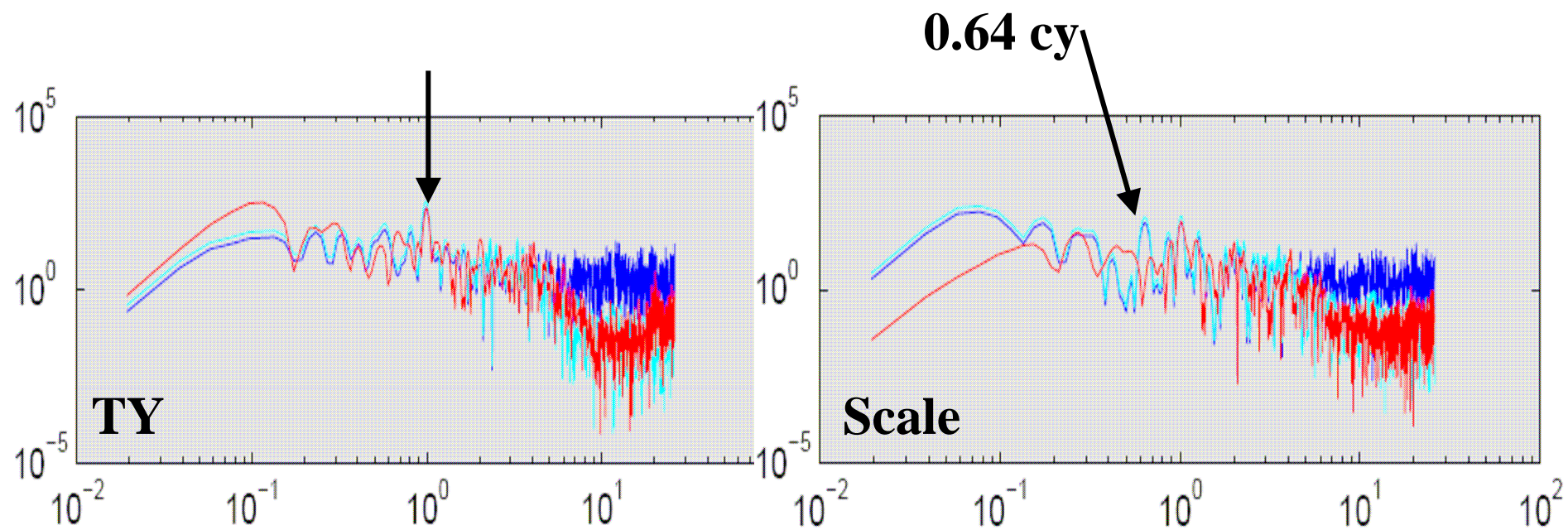
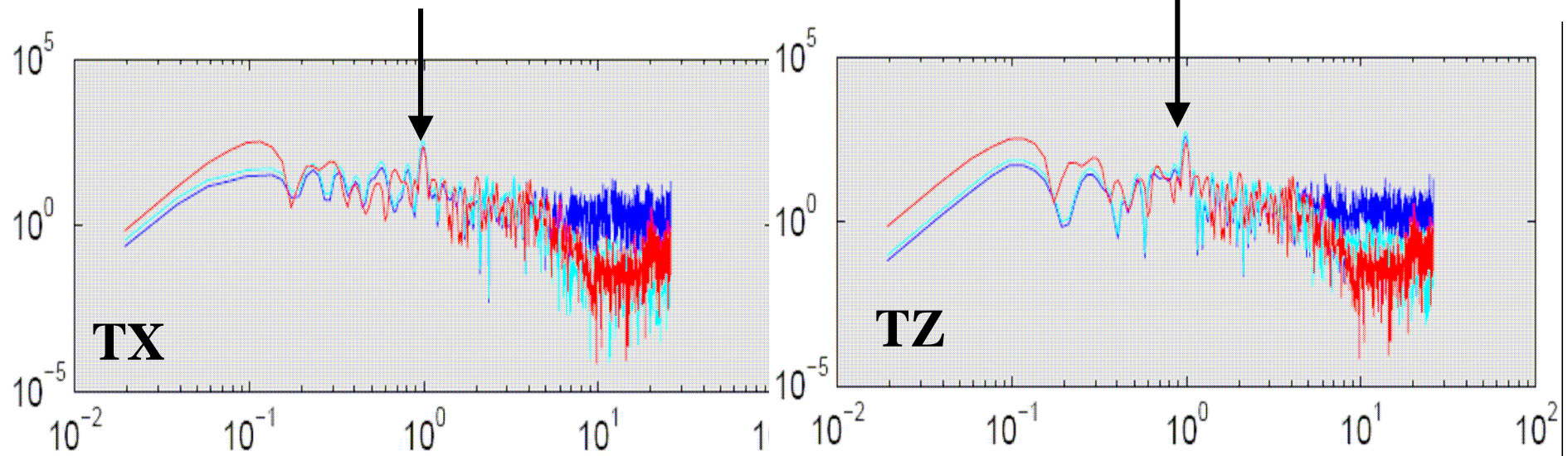
$$\boxed{P(t_0) = 0} \quad \& \quad \boxed{\dot{P} = 0} \quad \left\{ \begin{array}{l} \sum_{k \in K} P_k(t_k) = 0 \\ \sum_{k \in K} \frac{P_k(t_k)}{(t_k - t_0)^{-1}} = 0 \end{array} \right.$$

- **Preserve the intrinsic origin of SLR**
  - Seen as **No-Net-Translation** condition
  - **Preserve/Realize the long-term CoM** as sensed by SLR
- **Preserve the intrinsic scale of SLR & VLBI**

# Geocenter ILRS SLR vs GPS+OBP model

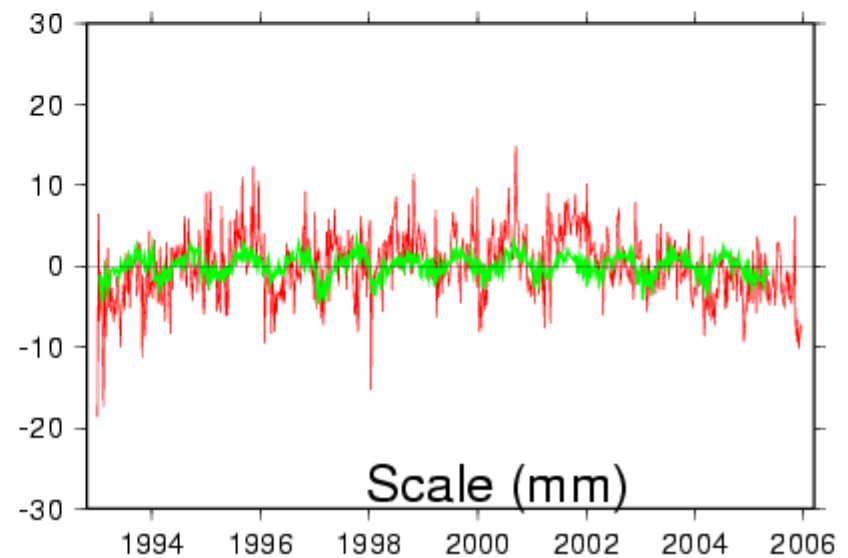
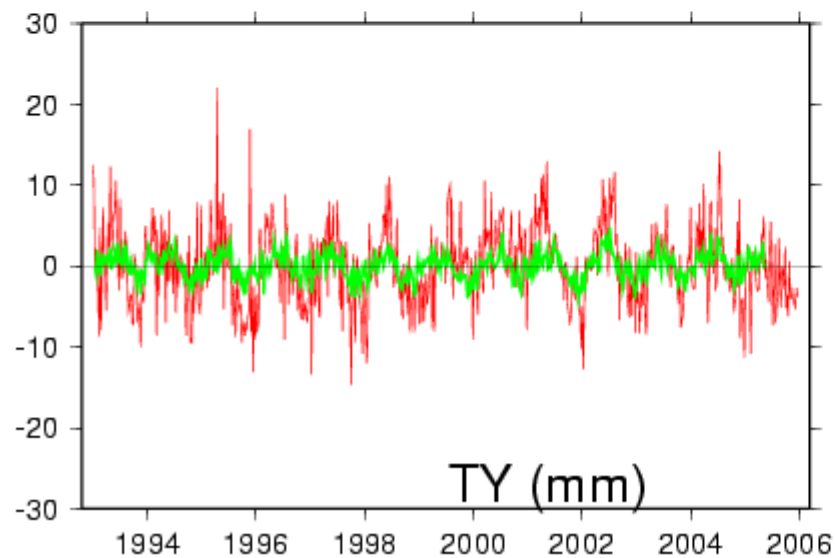
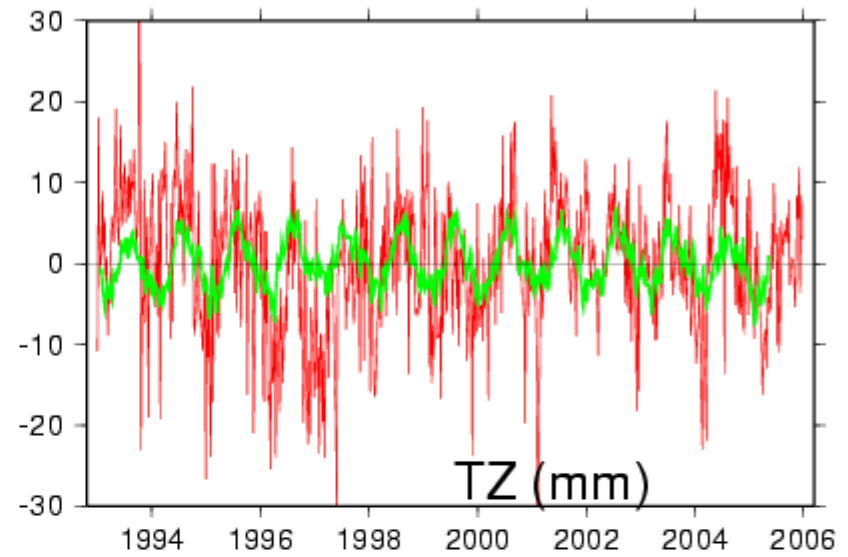
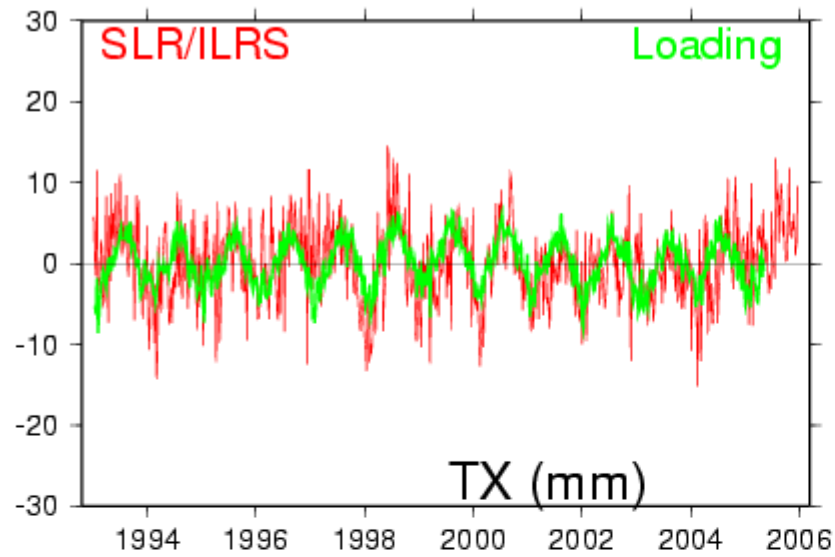


# ILRS SLR & GPS+OBP Power Spectrum

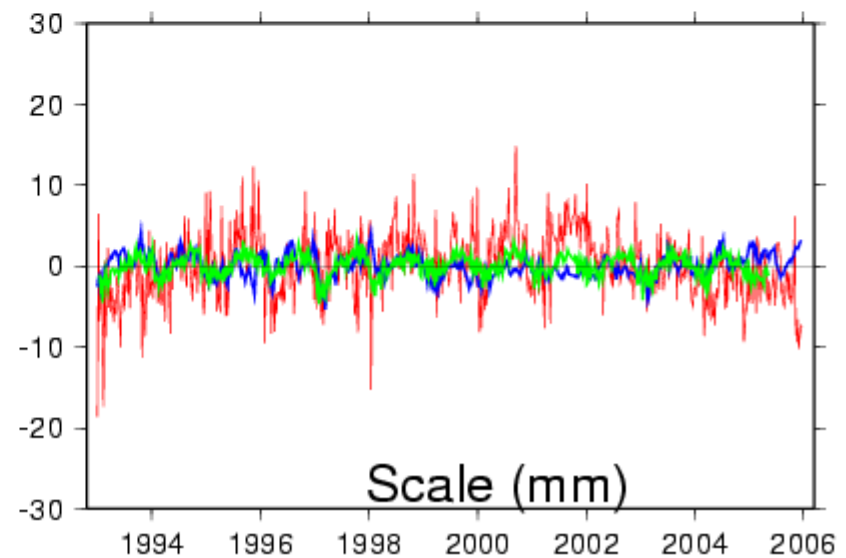
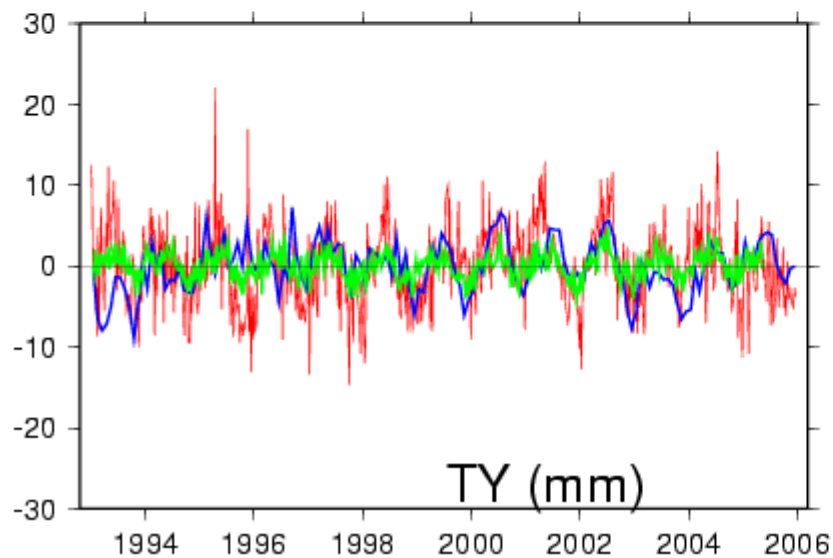
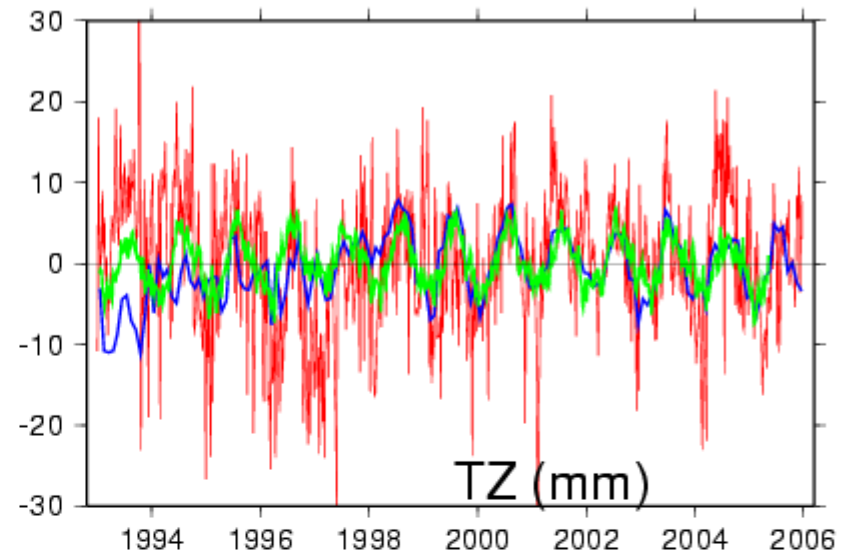
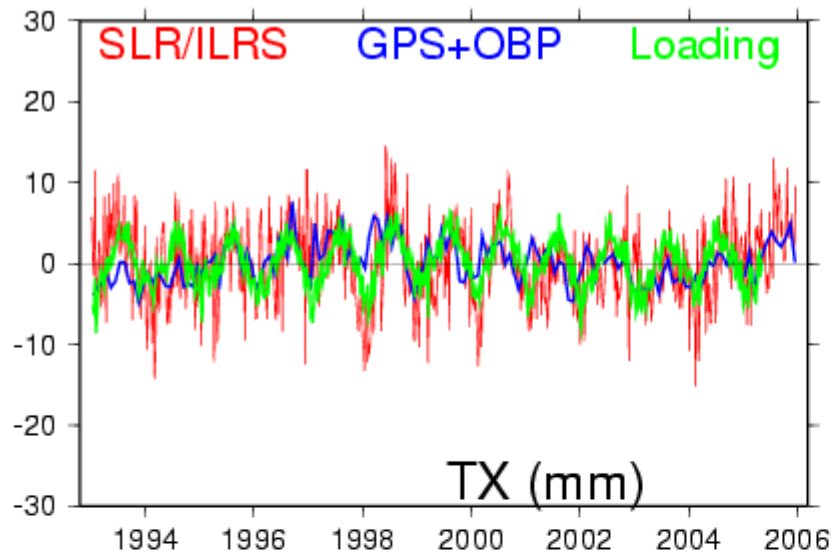




# Geocenter ILRS SLR vs Loading model

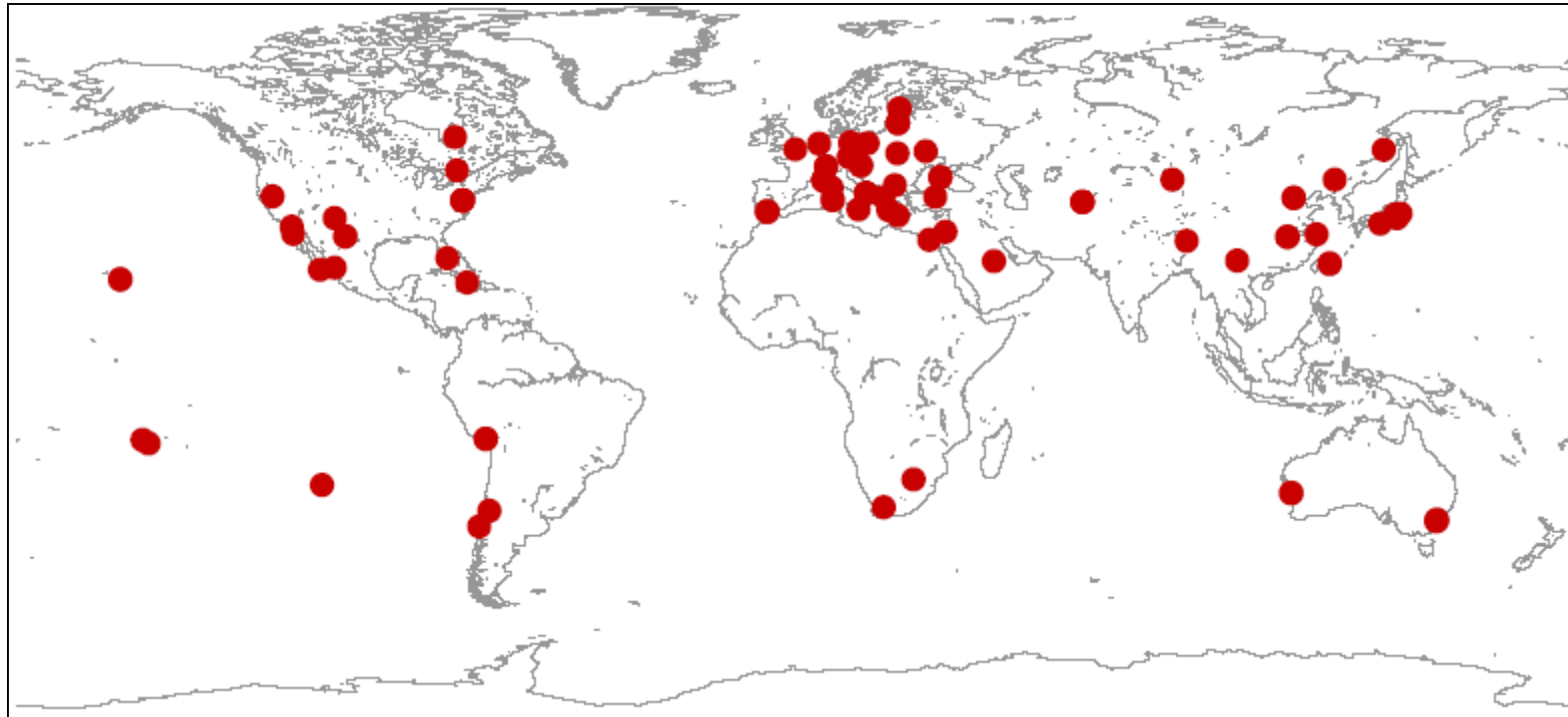


# Geocenter ILRS SLR vs GPS+OBP and Loading models

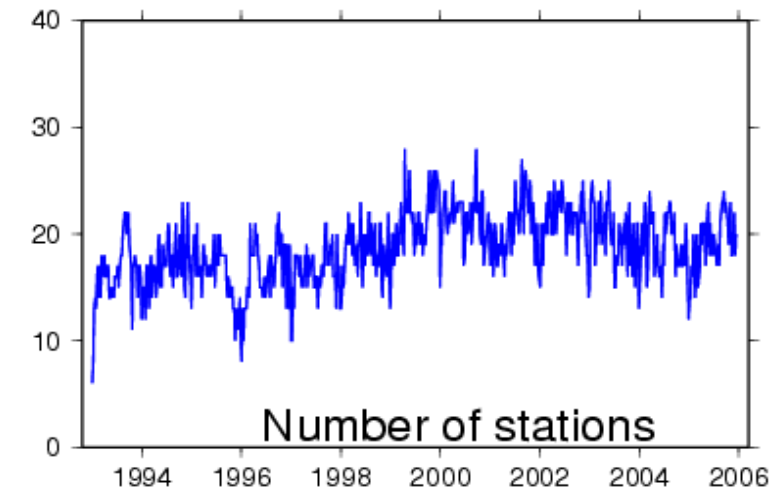
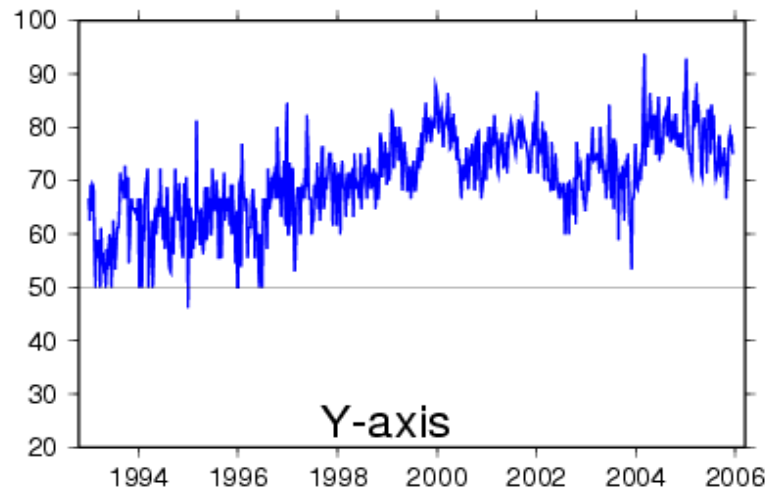
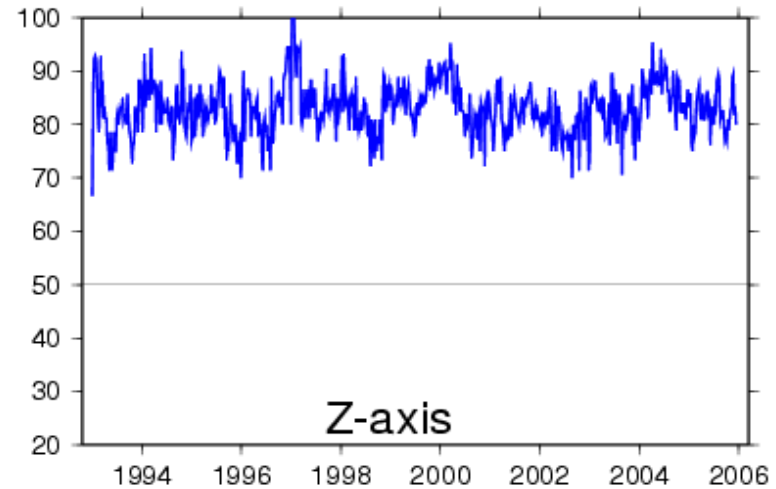
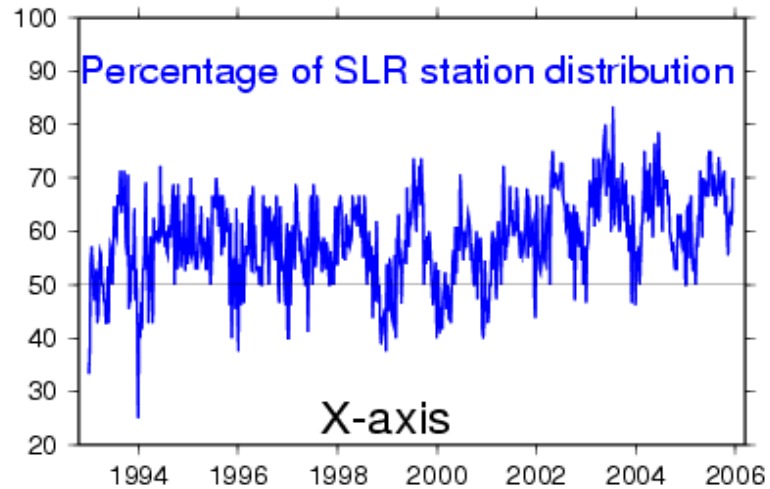


# ITRF2005: ILRS Network

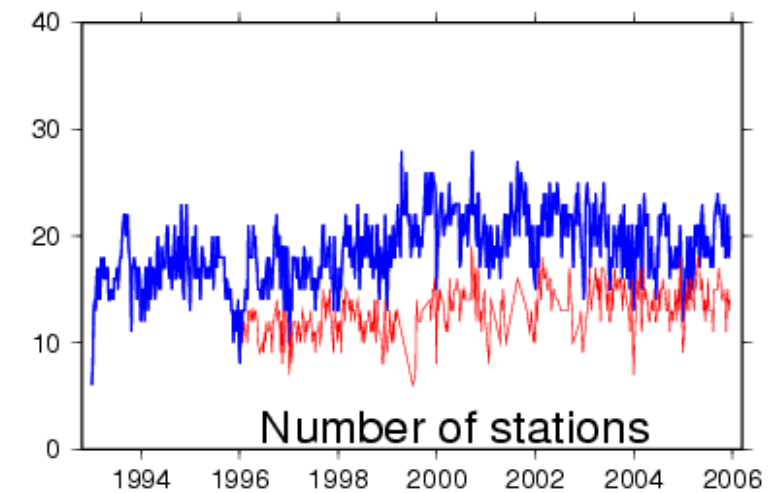
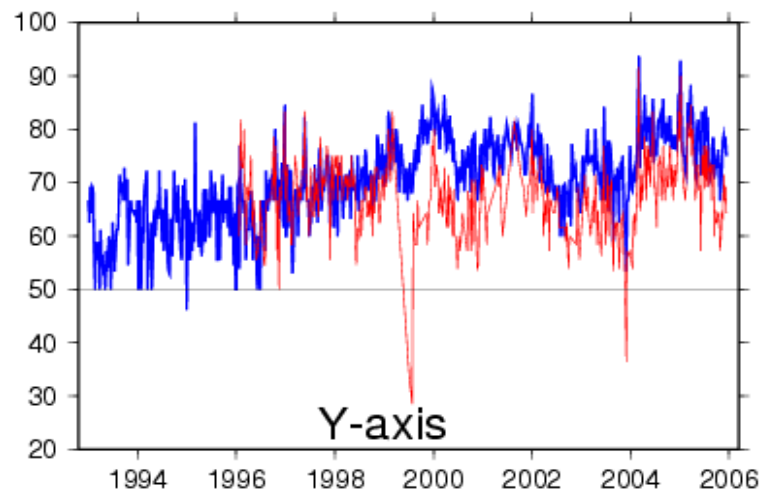
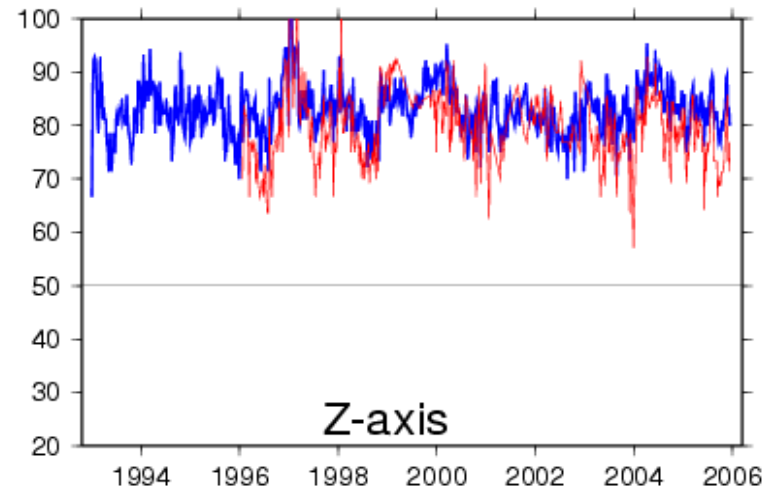
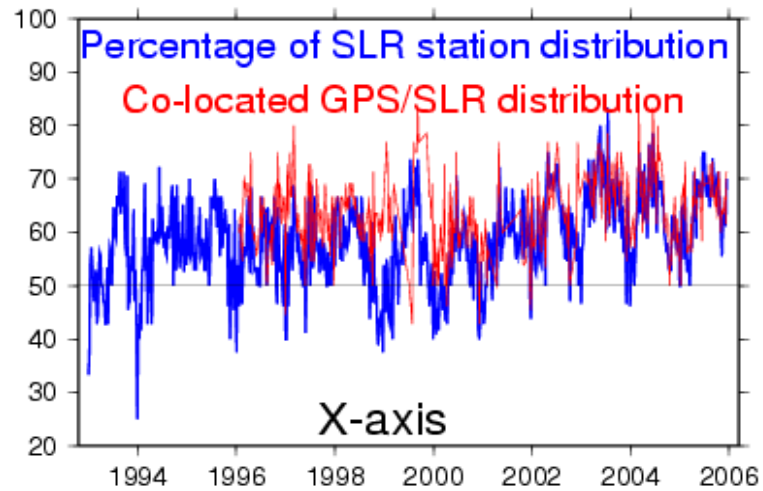
1993.0 – 2006.0



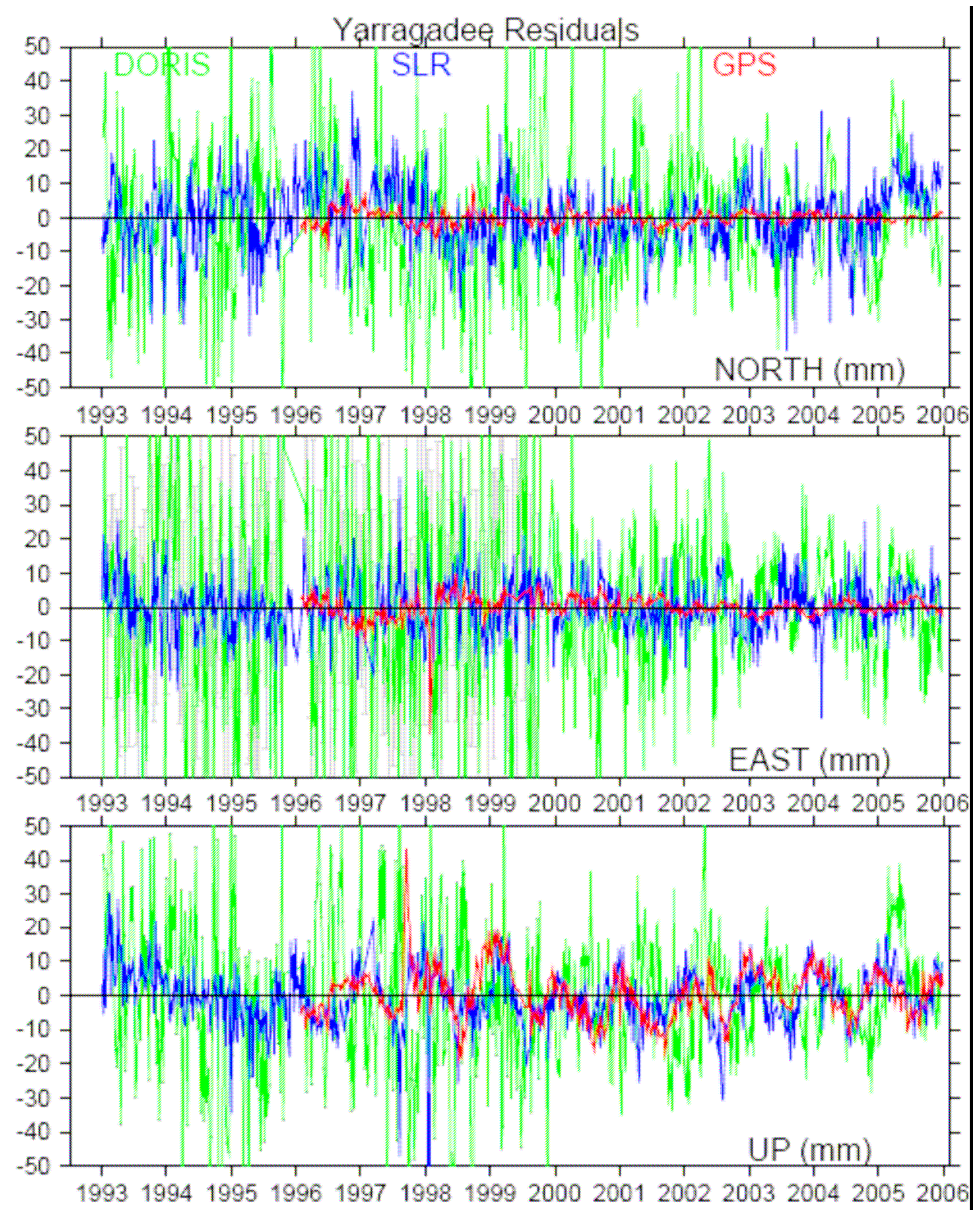
# % of station distribution



# % of station distribution



# ITRF2005: Yarragadee Residuals



# **Network Effect on Origin and Scale**

## Evaluation of the Network Effect on Origin and Scale

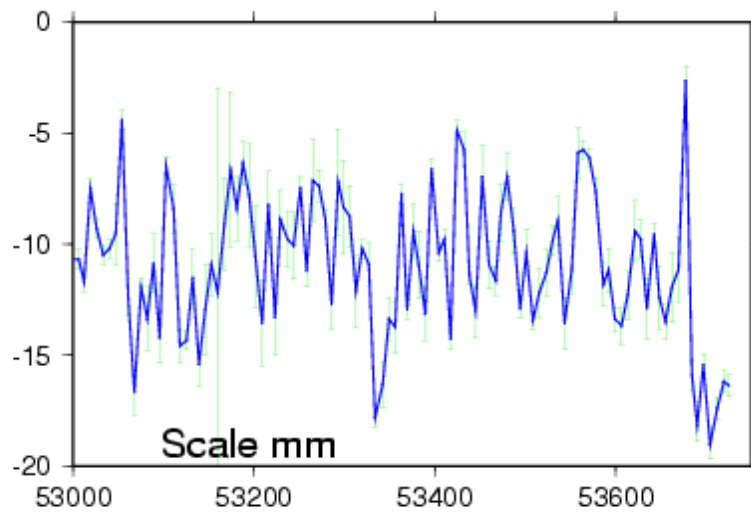
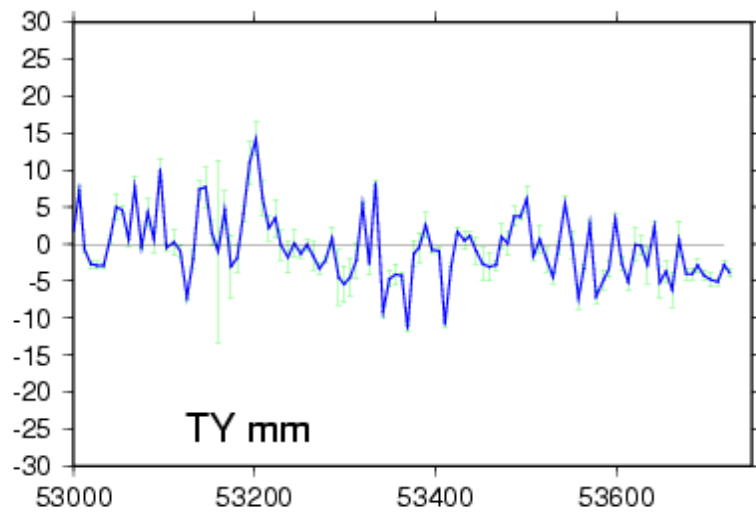
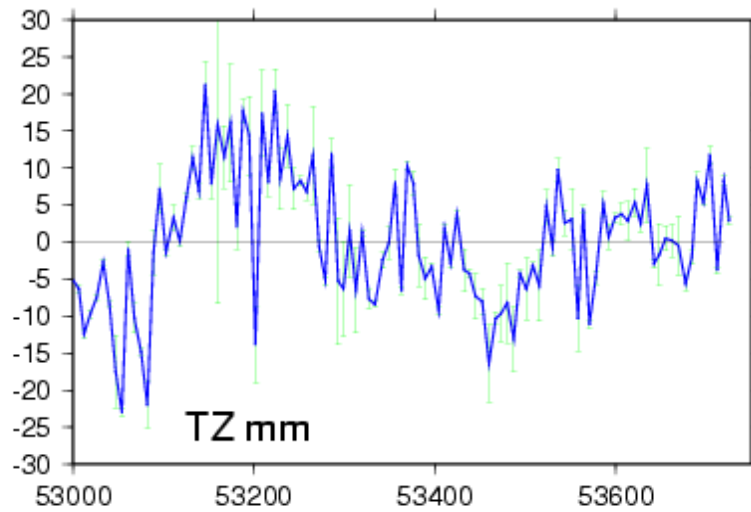
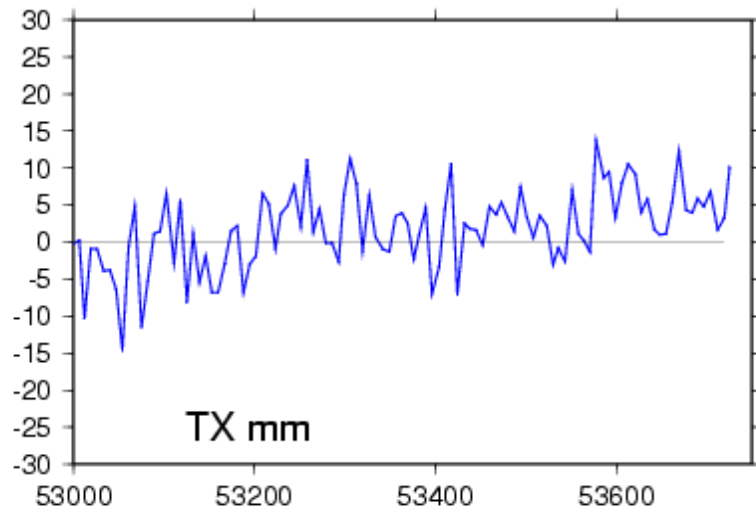
- How to discriminate btw Global Network motion (geocenter motion) and individual station motion ?
- Study the seasonal (not secular) variation
- Modify the 7-parameter model and introduce a station displacement vector  $\Delta\mathbf{X}$

$$\mathbf{X}_s^i = \mathbf{X}_c^i + \mathbf{T} + \mathbf{D} \cdot \mathbf{X}^i + \mathbf{R} \cdot \mathbf{X}^i + \Delta\mathbf{X}^i$$

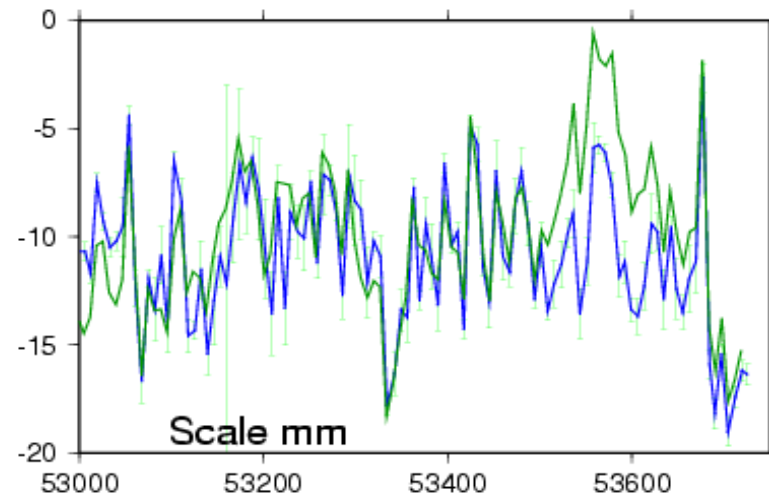
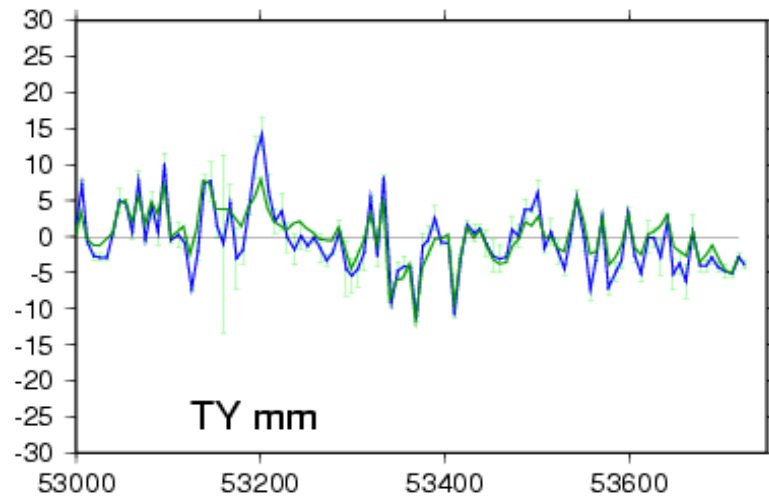
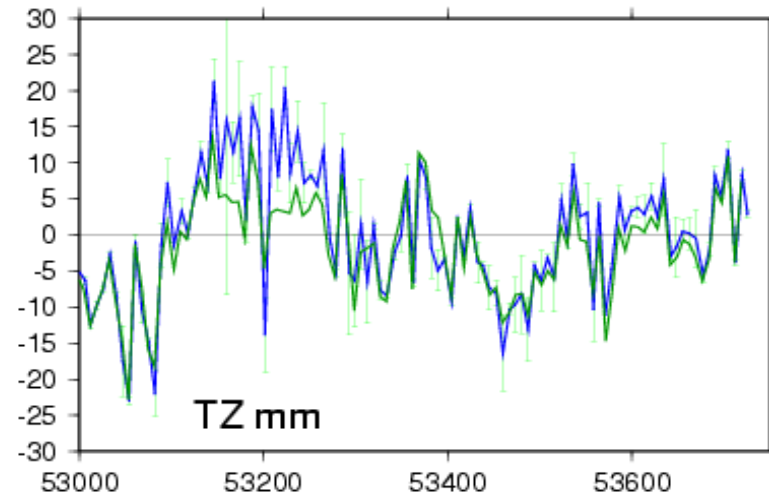
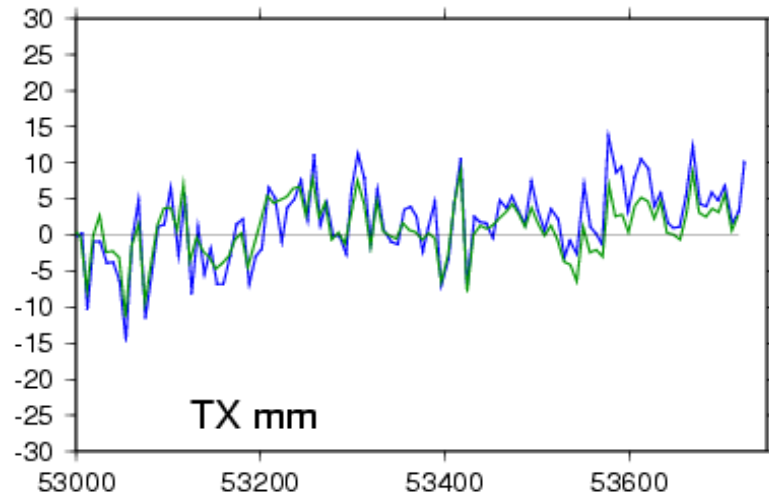
- Use Kalman filter : Two options
  - Stochastic constraints: Random Walk
  - Constraint  $\Delta\mathbf{X}^i$  to GPS non-linear residuals at co-location sites



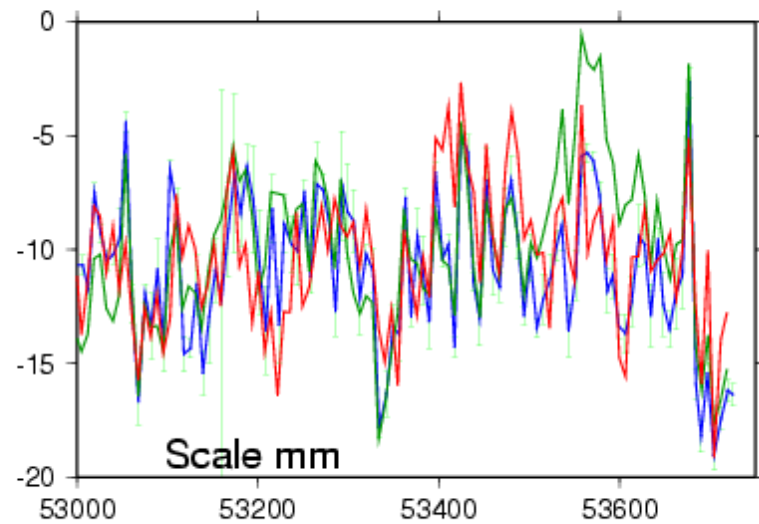
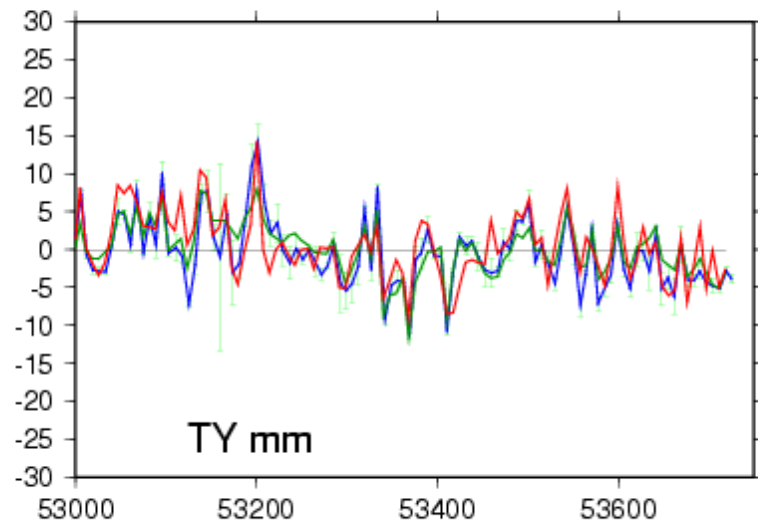
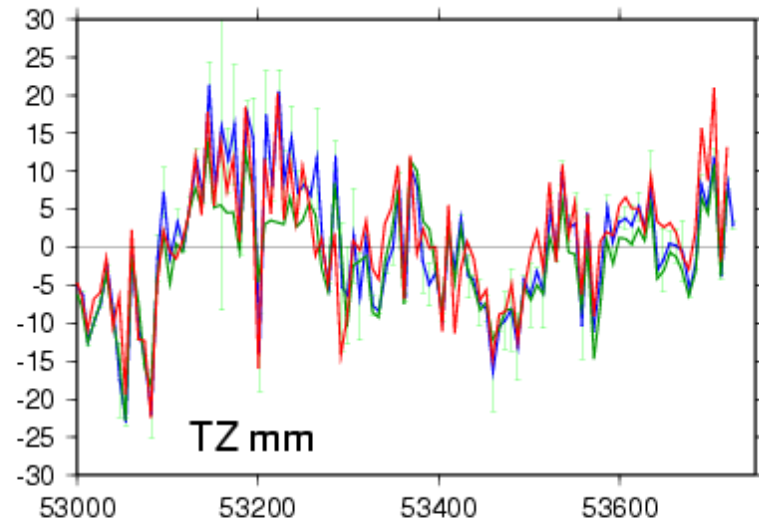
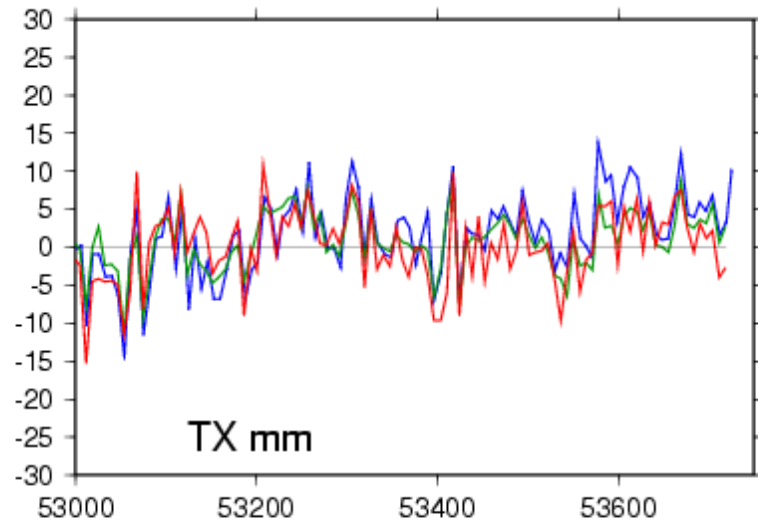
# SLR Origin & Scale (2004.0 – 2006.0)



## SLR Origin & Scale (2004.0 – 2006.0)

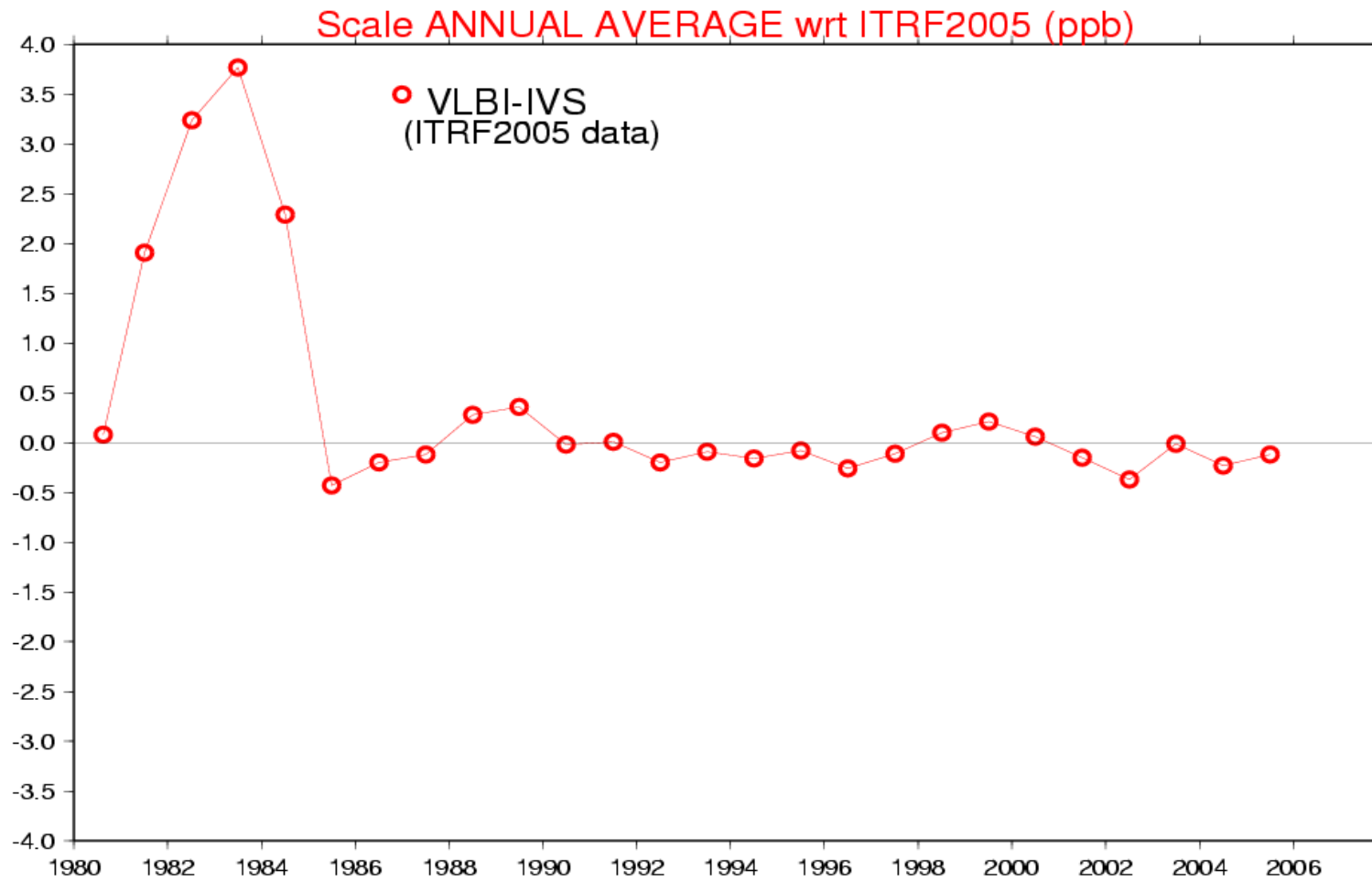


# SLR Origin & Scale (2004.0 – 2006.0)

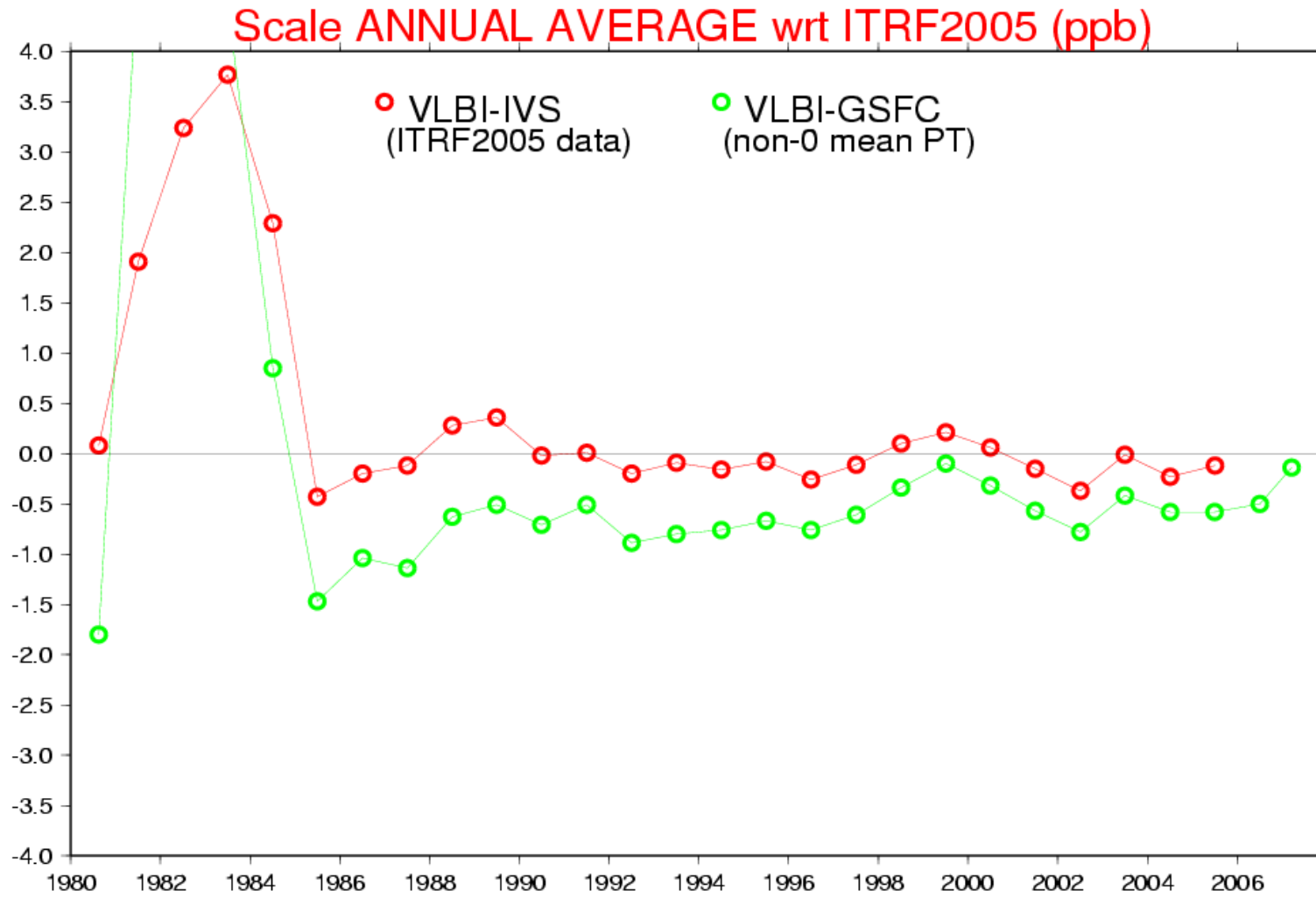


# The Scale Issue

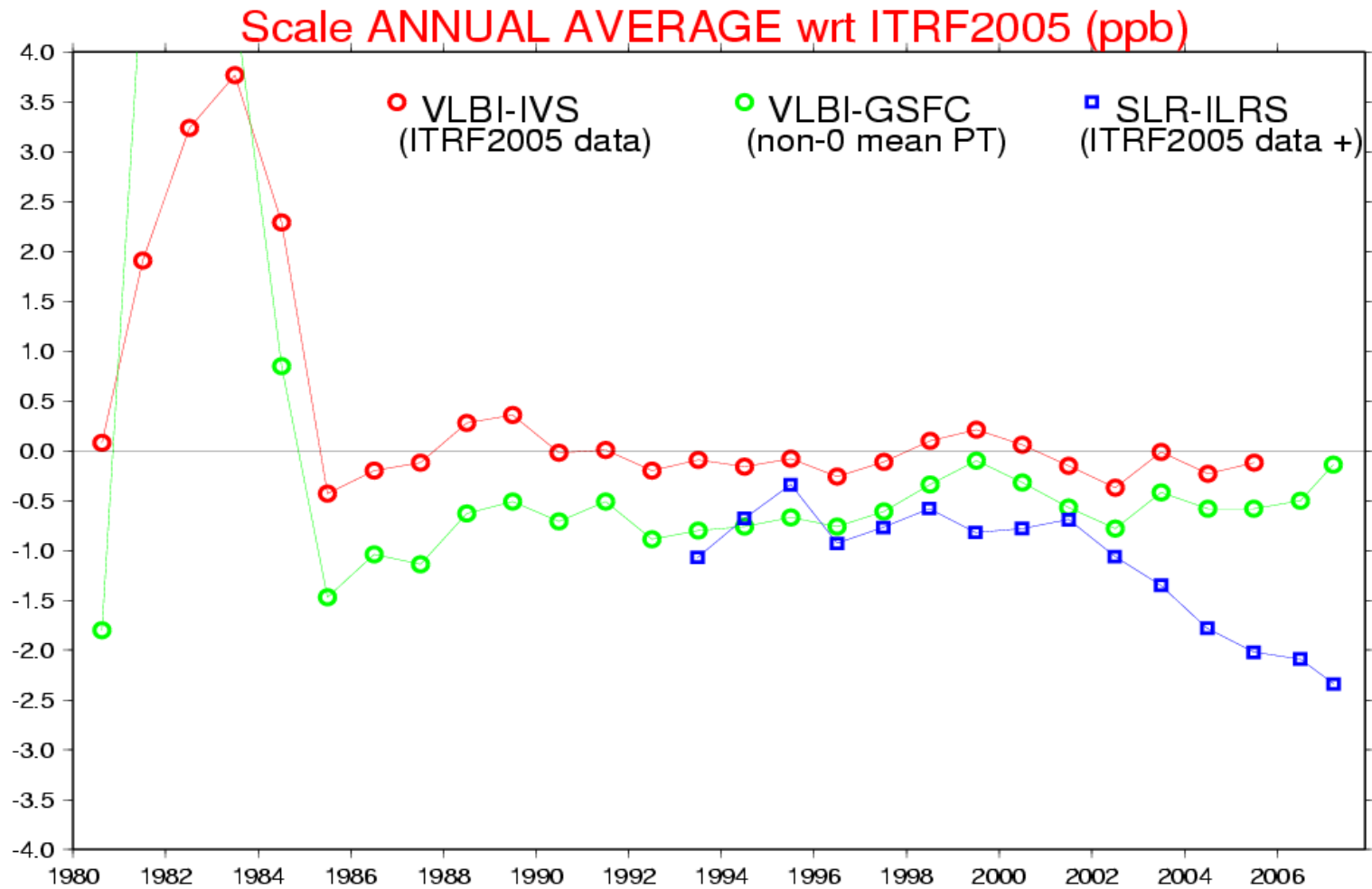
# Scale Annual Average



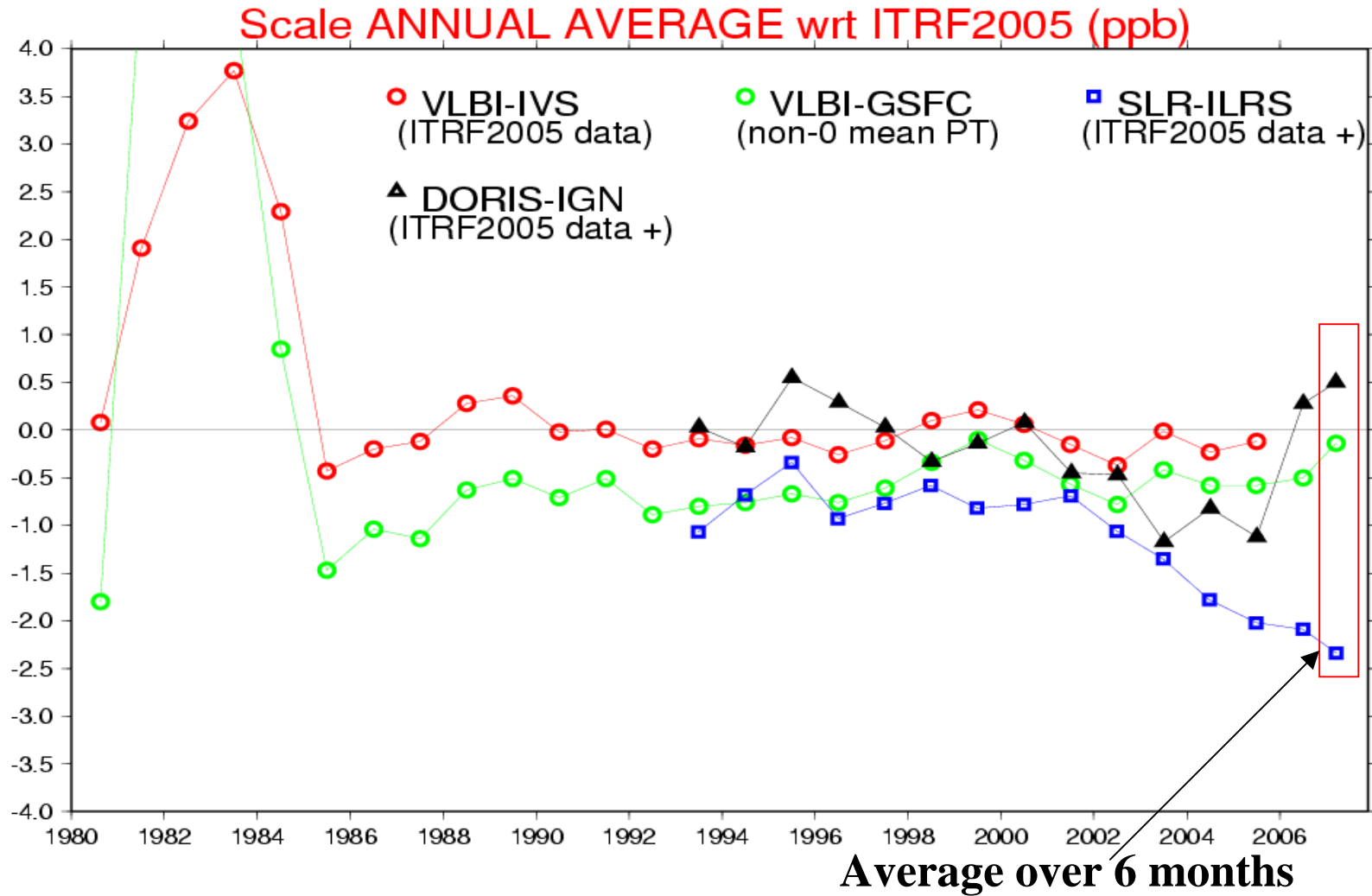
# Scale Annual Average



# Scale Annual Average

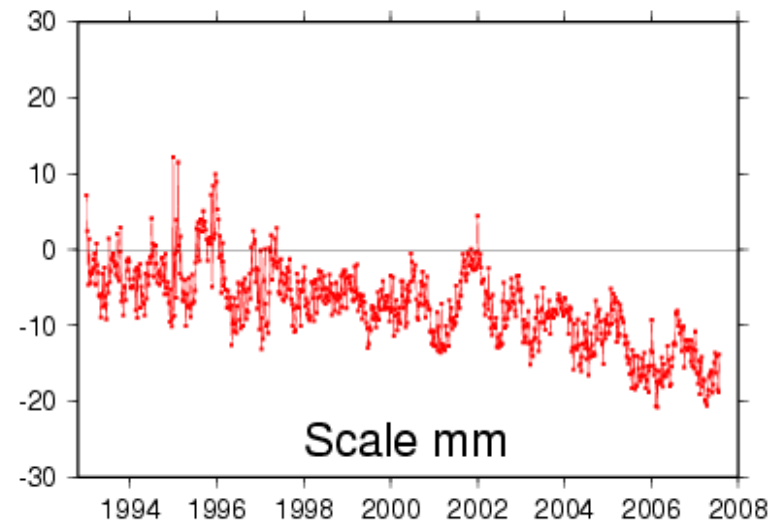
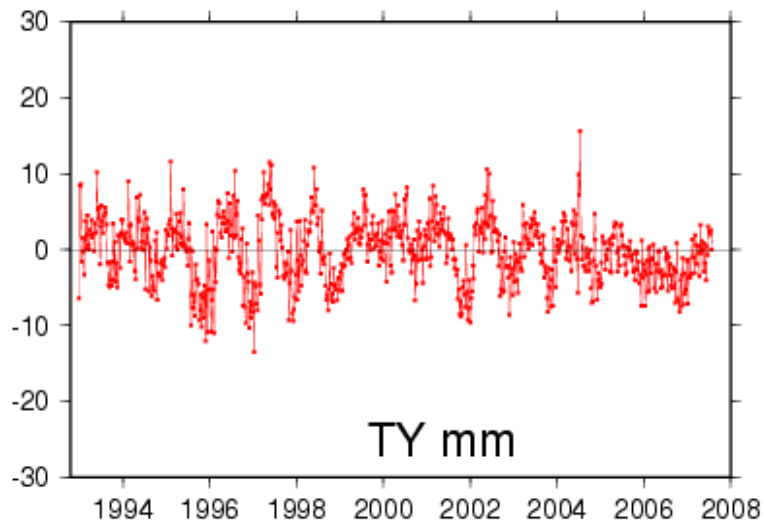
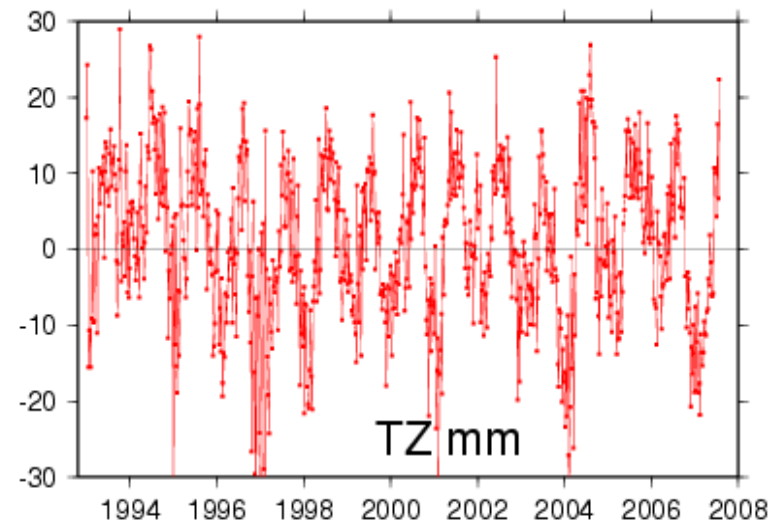
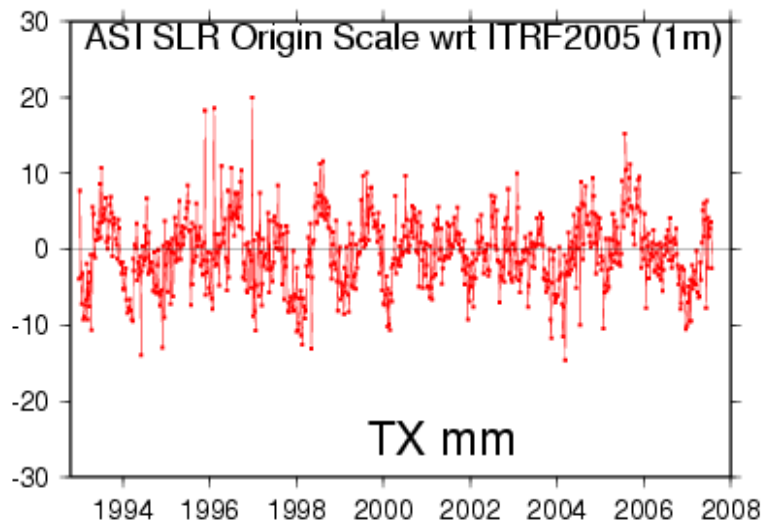


# Scale Annual Average

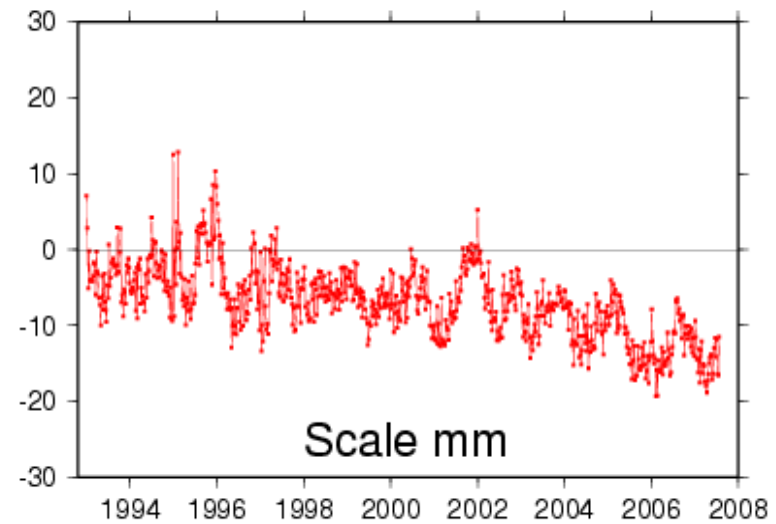
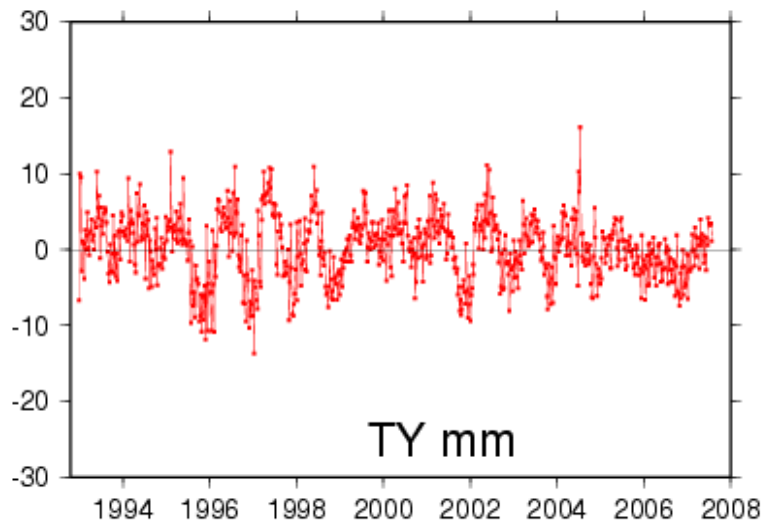
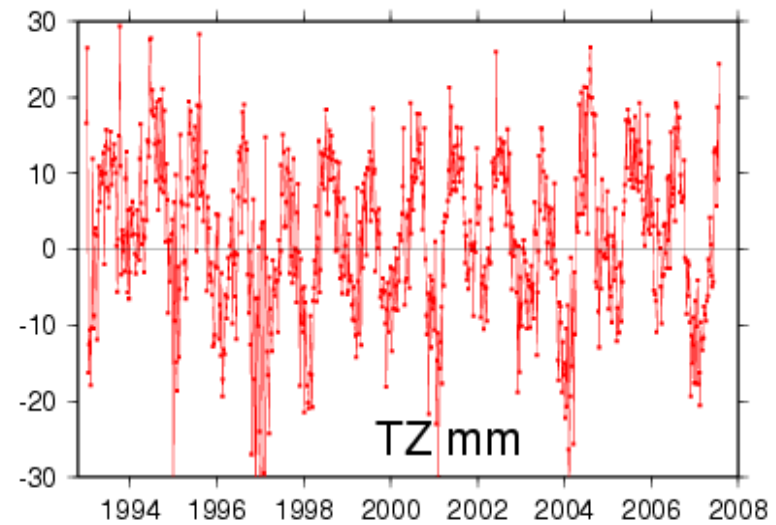
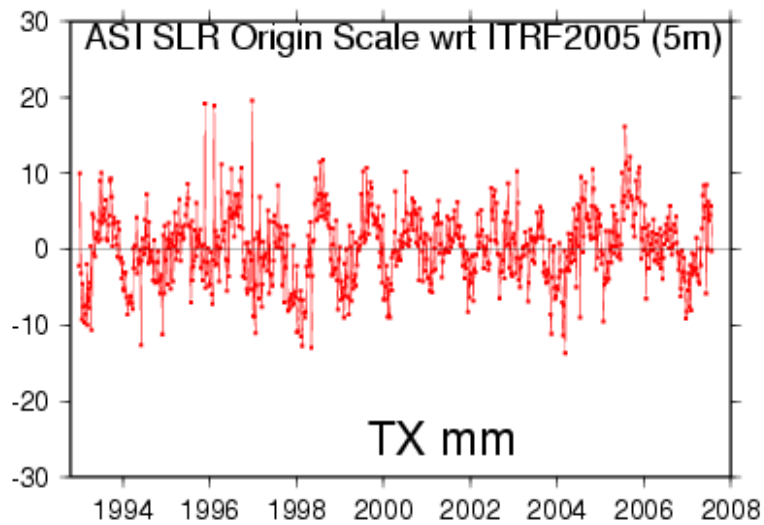




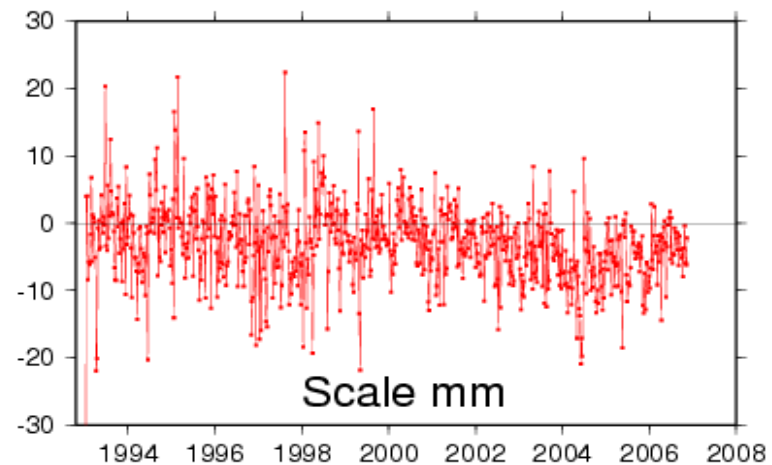
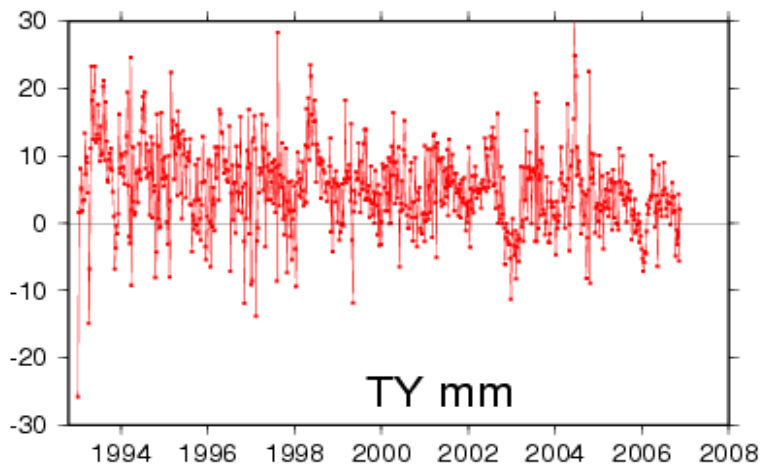
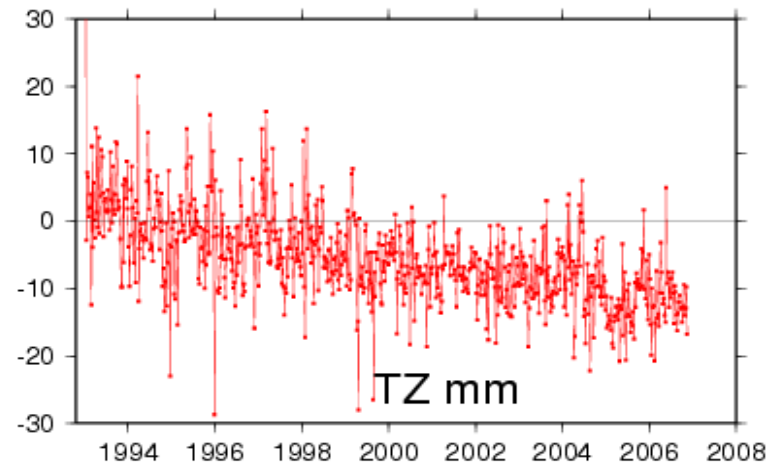
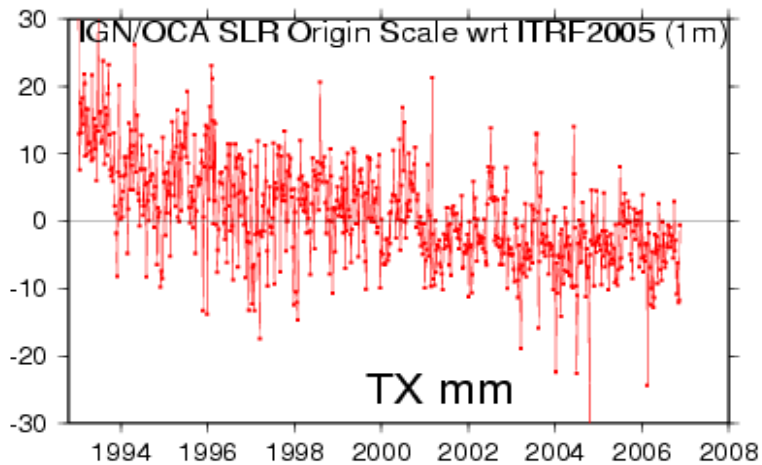
# ASI test solution (1m loose constraints)



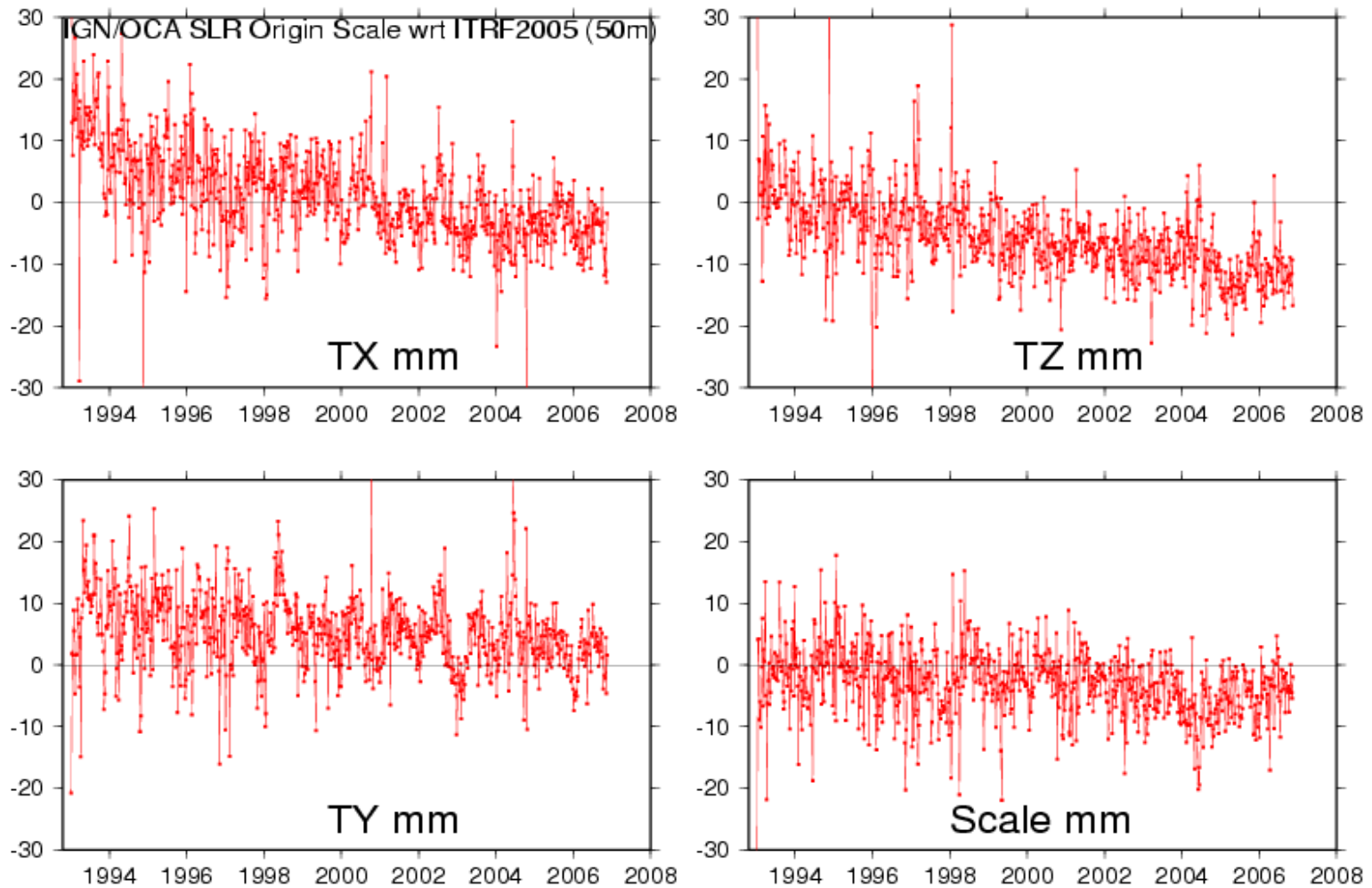
# ASI test solution (~5m loose constraints)



# IGN/OCA test sol. (1m loose constraints)



# IGN/OCA test sol. (50m loose constraints)



## Conclusions

- **Despite its poor network, apparent geocenter motion is embedded in SLR weekly solutions**
  - **Good agreement with GPS+OBP and Loading models**
- **Network impact on origin & scale seasonal variation range between 1 – 2 mm**
- **We explain now 0.5 ppb of the scale discrepancy btw SLR and VLBI solutions**
- **Scale Issue still needs to be investigated**
- **Consider SLR back for the scale definition of the next ITRF solution**