Statistical stability of origin, scale and orientation of space-geodetic terrestrial reference frames

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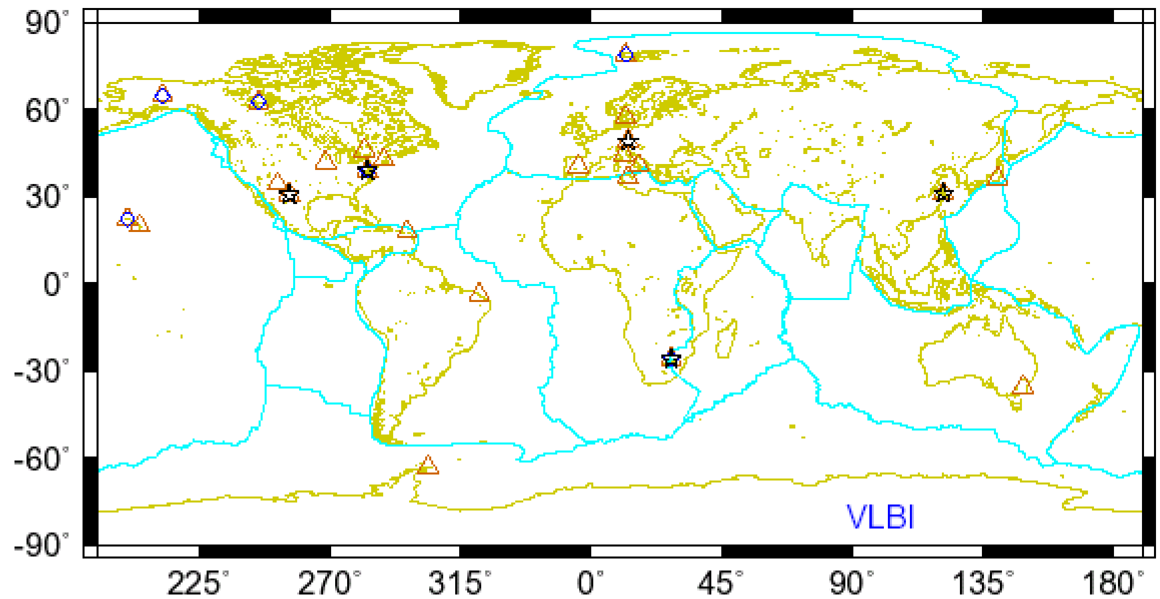
Introduction

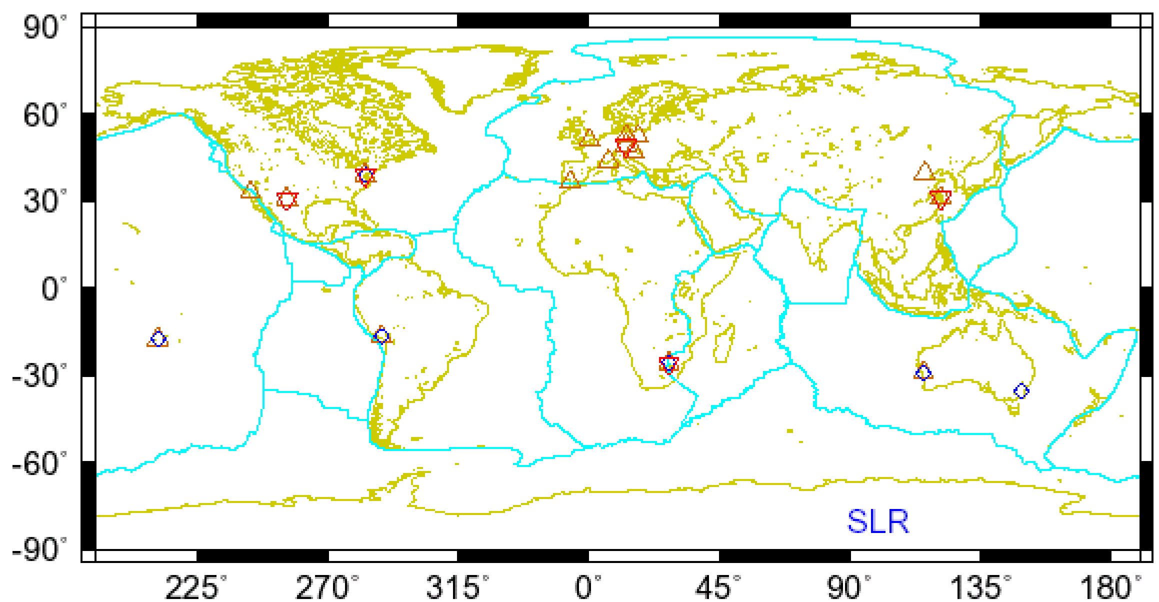
- Study of the colocation sub-networks
  - Geographical distribution
  - Strength of the connection
- Noise in the transformation parameters :
  - Study of colocation sub-networks noise with the Allan variance
  - Tentative determination of the stability per technique by the three-cornered hat method

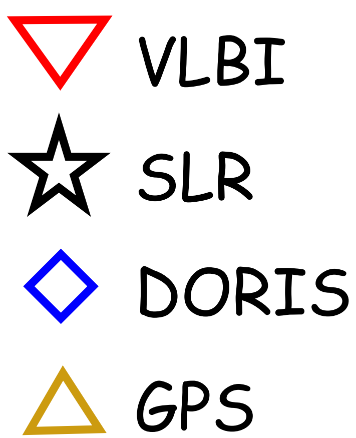
Data

- Time series of coordinate residuals relative to linear motion :
  - VLBI (R) GSFC
  - SLR (L) OCA
  - DORIS (D) LEGOS-CLS
  - DORIS (D) IGN-JPL
  - GPS (P) IGS

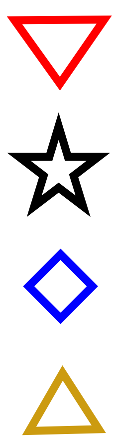
VLBI and SLR colocation sub-networks

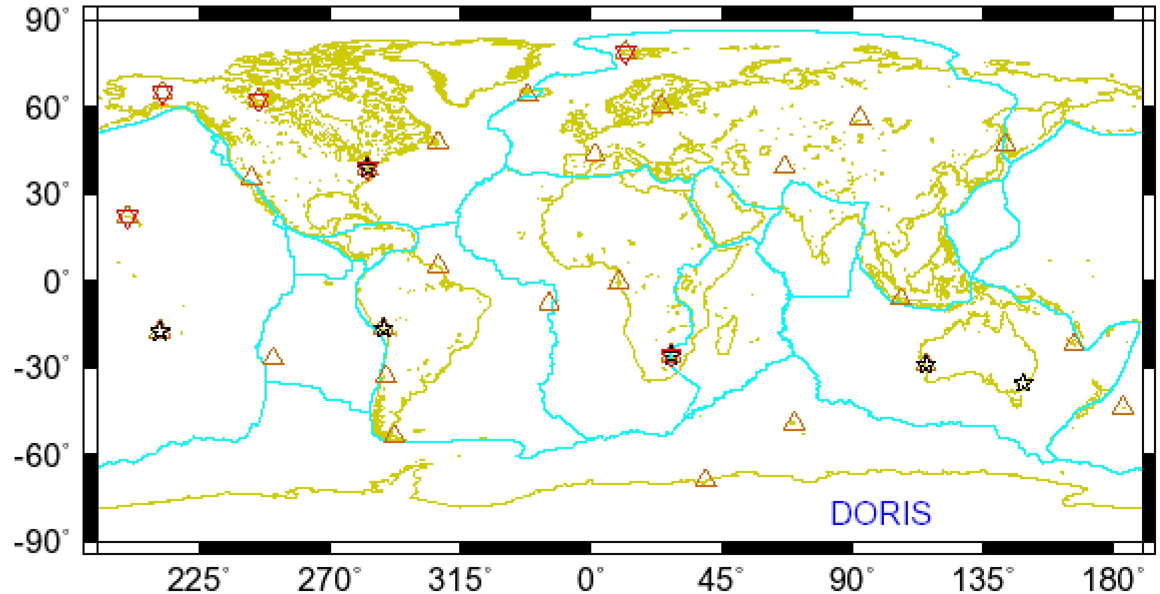


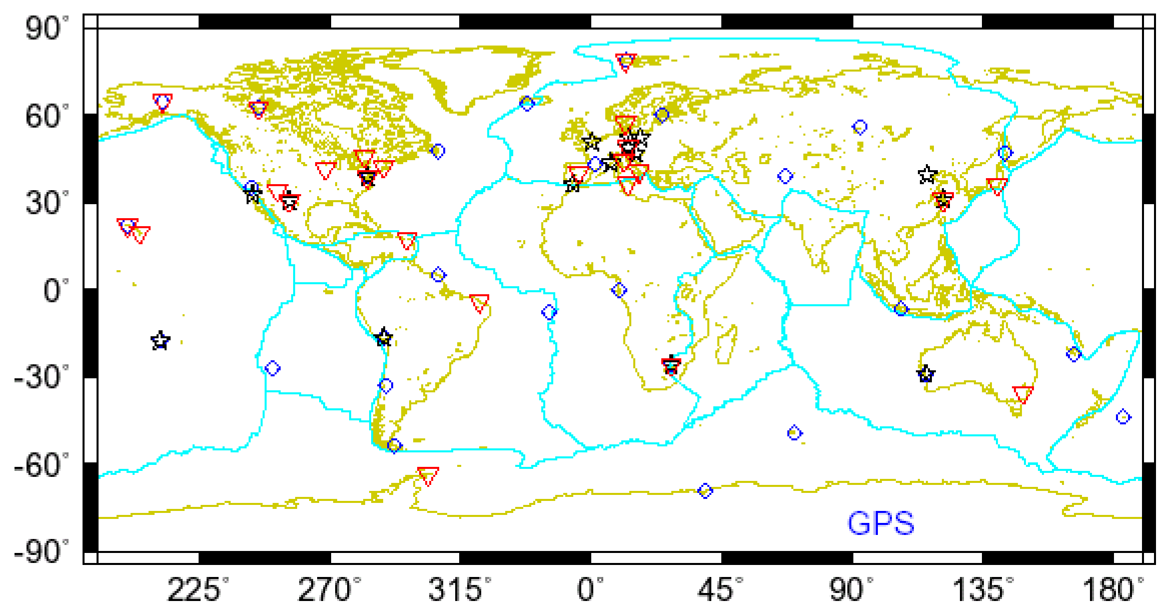




DORIS and GPS colocation sub-networks







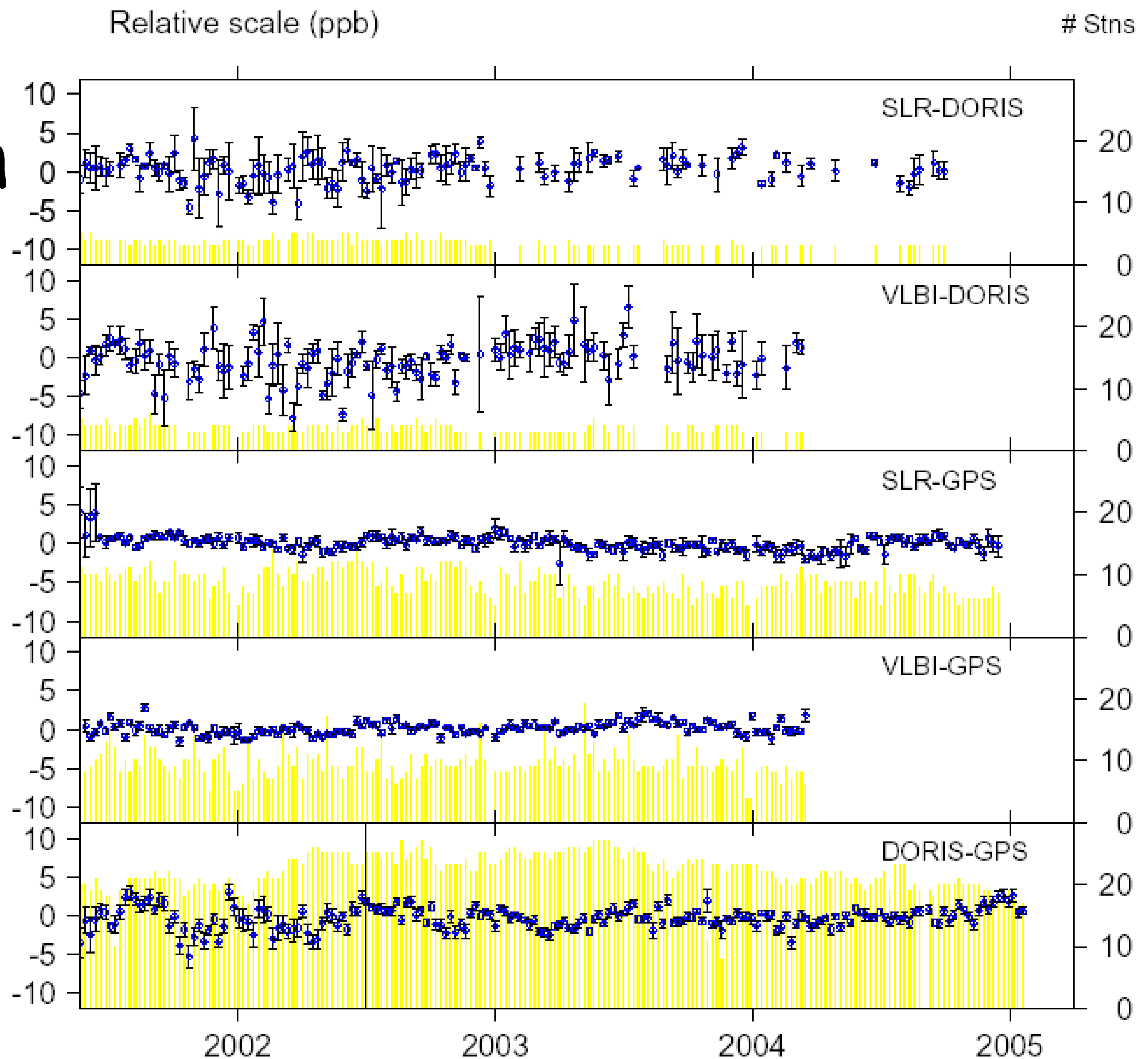
Time series of station coordinates Colocation sub-networks

Tech.	Nsta	Start	End	#weeks	#missing
R-L	5	2001.5	2004.2		
D-R	7	2001.4	2004.2	141	39
D-L	6	2001.5	2004.7	170	56
R-P	26	2001.4	2004.2	147	1
L-P	16	2001.5	2005.0	181	2
D-P	30	2002.5	2005.2	142	2

Noise in the transformation parameters

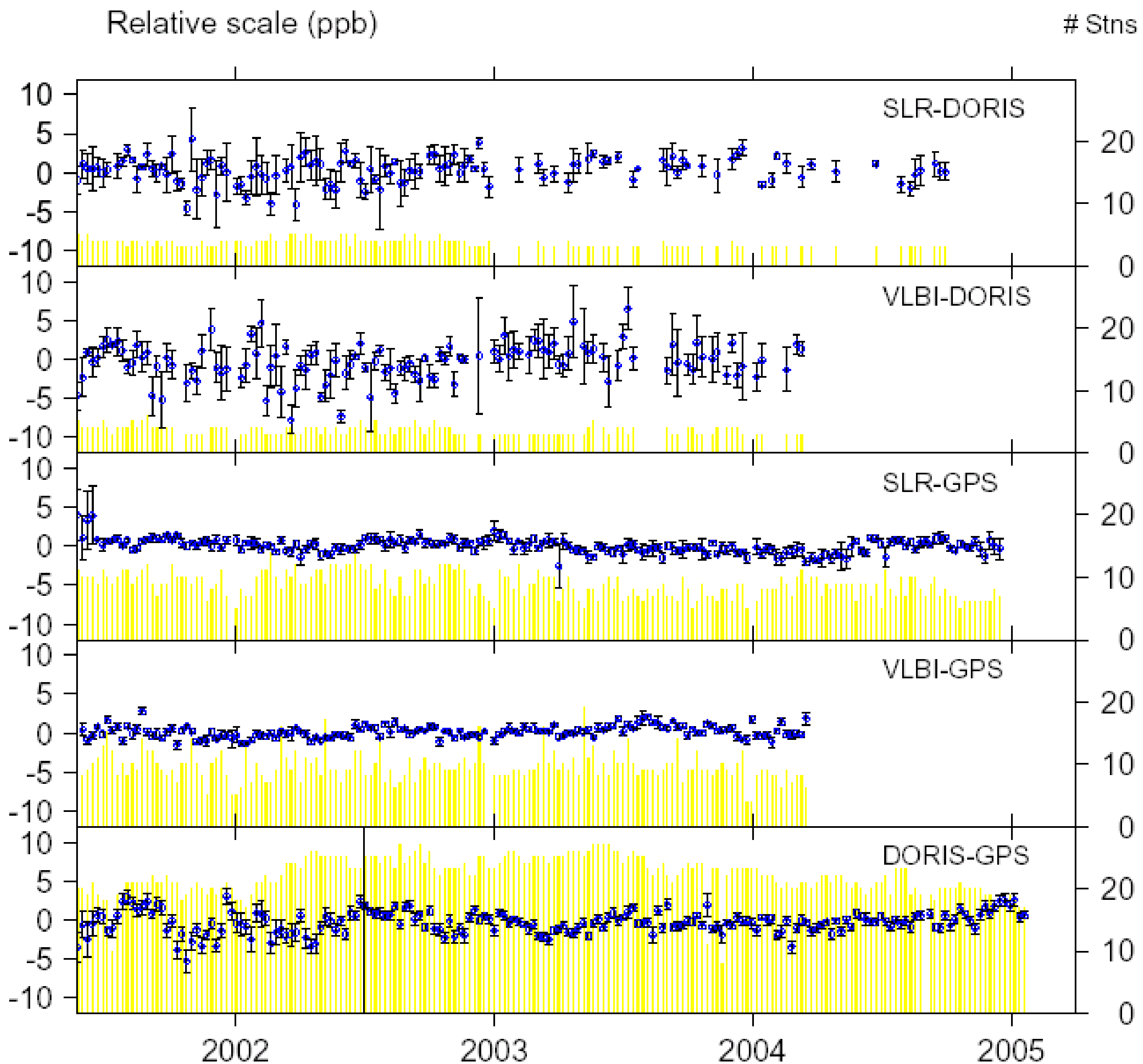
- Approach :
  - propagating the noise in time series of station coordinates into the transformation parameters between pairs of TRF
- ⚠ Study insensitive to :
  - Inhomogeneous velocity
  - Local ties

Time distribution and quality of the colocation time series

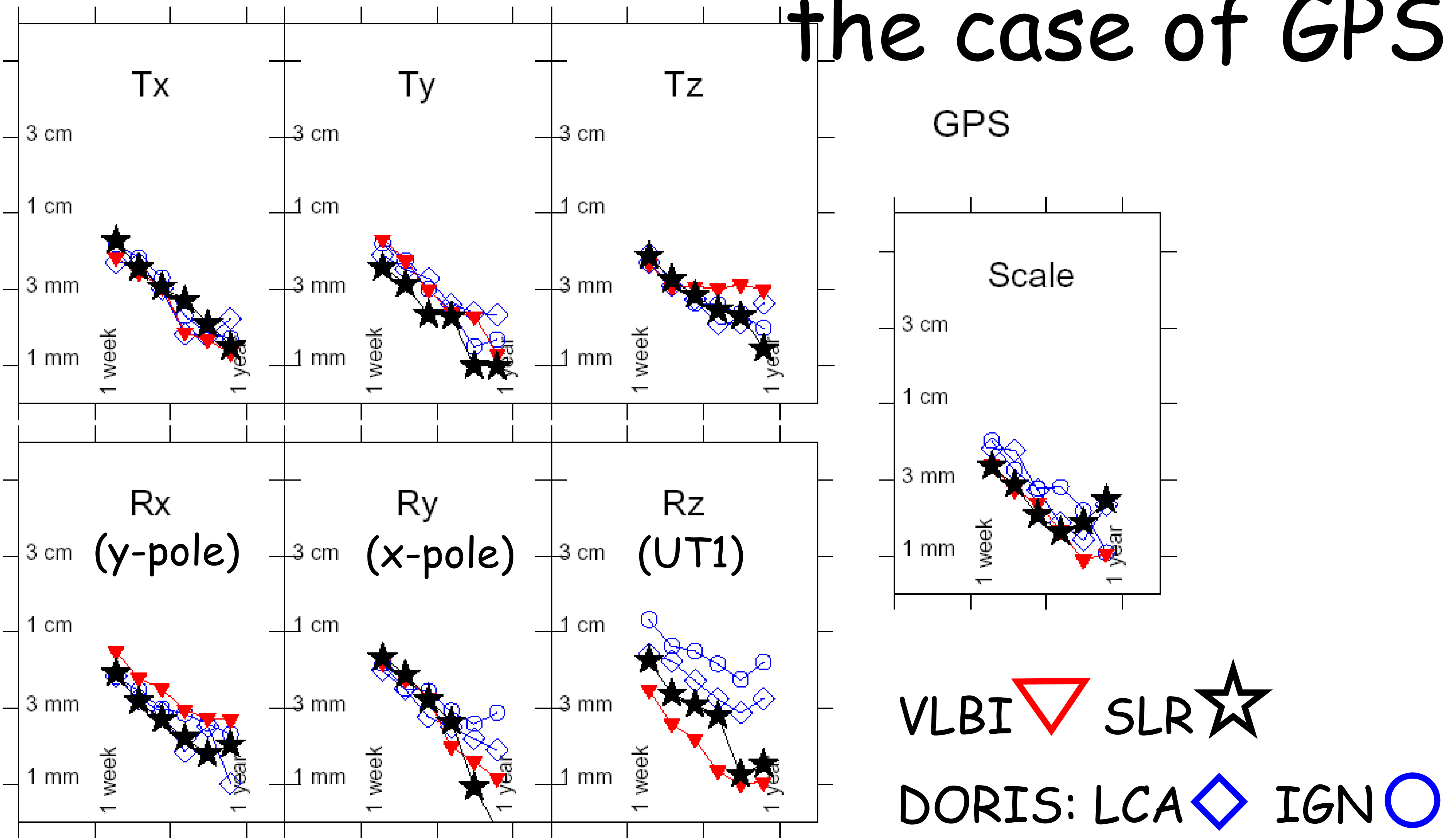


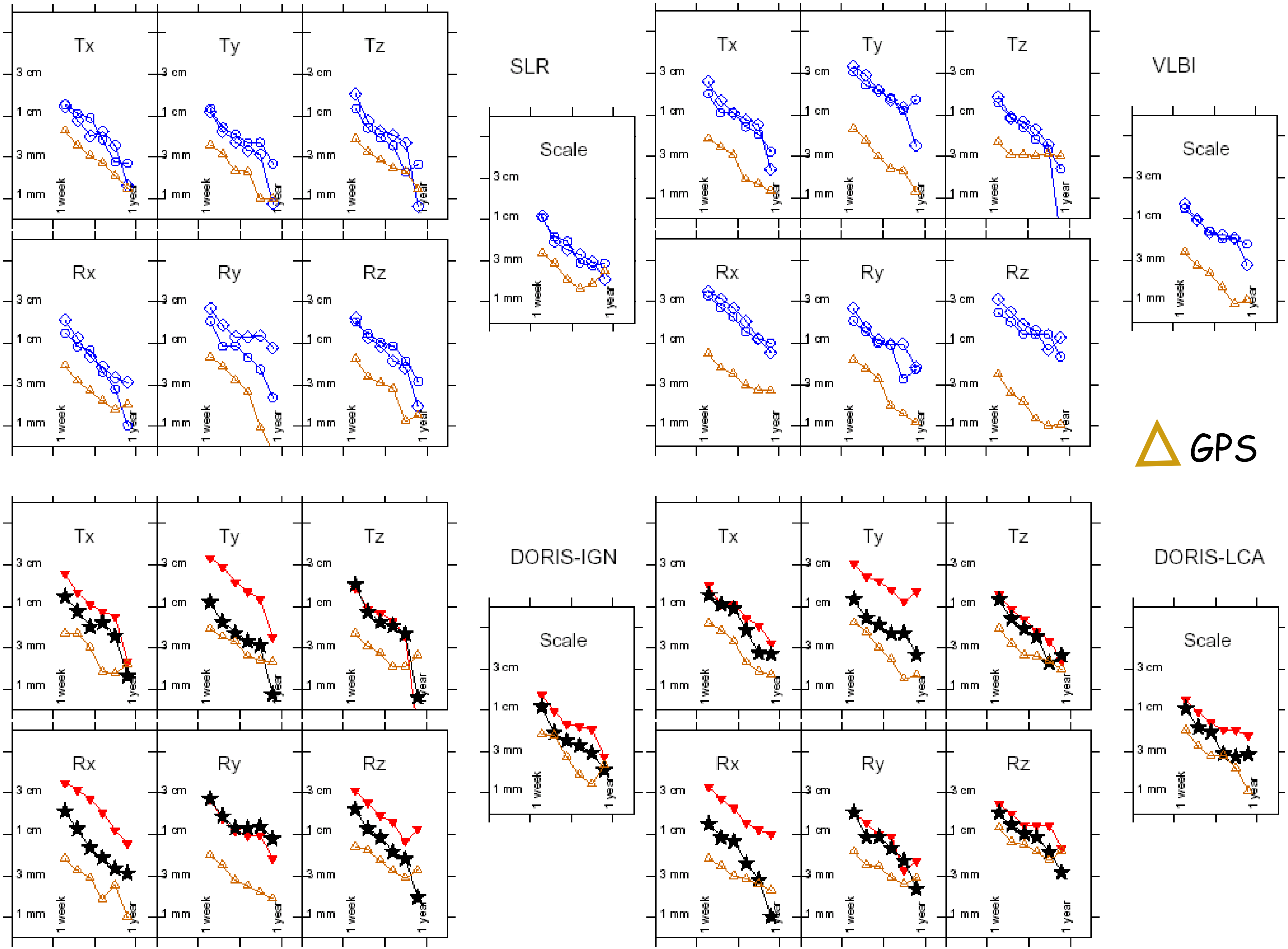
Analysis Tools (1)

- Allan Variance → type and level of noise
  - $\mu = -1$: white noise (spectral density independent of frequency f)
  - $\mu = 0$: flicker noise (spectral density ~ 1/f)


Relative scale (ppb)
Stns
SLR-DORIS
VLBI-DORIS
SLR-GPS
VLBI-GPS
DORIS-GPS
10
5
0
-5
-10
20
10
0
2002
2003
2004
2005

Allan variance of noise in transformation parameters : the case of GPS




SLR
VLBI
DORIS-IGN
DORIS-LCA
GPS
Tx
Ty
Tz
Rx
Ry
Rz
Scale
3 cm
1 cm
3 mm
1 mm
1 week
1 year

Analysis Tools (2)

- Three-cornered hat
  - $x_i = S + \varepsilon_x^i$

    S is the common term and ε_x^i the noise
  - Elimination of the common signal S by means of the differences :

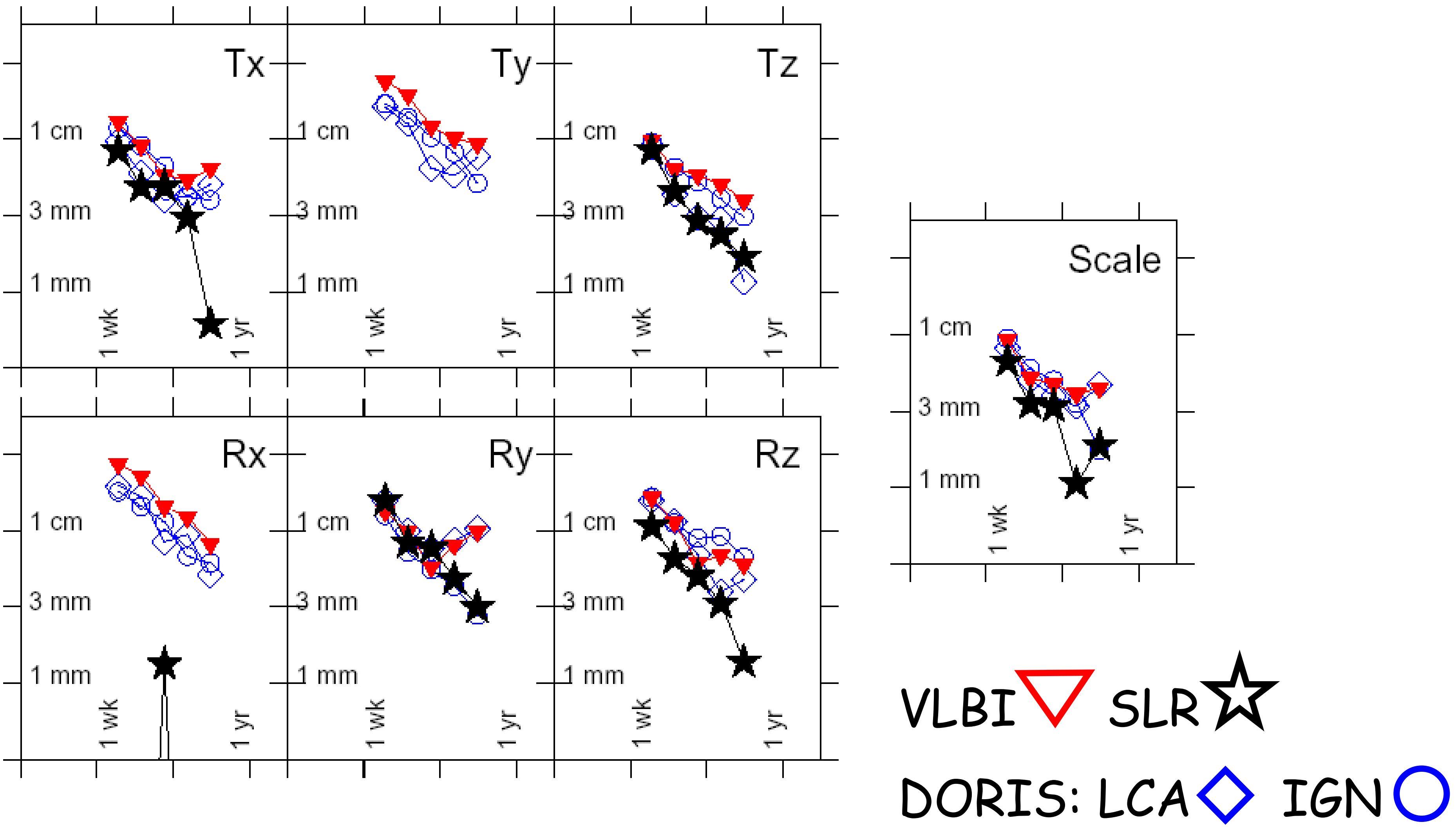
$$\begin{cases} \sigma^2(x-y) = \sigma^2(\varepsilon_x) + \sigma^2(\varepsilon_y) - \cancel{2\operatorname{cov}(\varepsilon_x, \varepsilon_y)} \\ \sigma^2(x-z) = \sigma^2(\varepsilon_x) + \sigma^2(\varepsilon_z) - \cancel{2\operatorname{cov}(\varepsilon_x, \varepsilon_z)} \\ \sigma^2(z-y) = \sigma^2(\varepsilon_z) + \sigma^2(\varepsilon_y) - \cancel{2\operatorname{cov}(\varepsilon_z, \varepsilon_y)} \end{cases}$$

  - Assume statistical independence of error

Analysis Tools (3) : Solving for noise per technique (WIP)

- Few degrees of freedom => least square estimation inappropriate
  - Possibility : L1-norm estimation
- Numerical problems (difference of variance levels) => special estimation technique
  - Possibility : Simplex algorithm with positive constraints (WIP)
- Partial solution : VLBI, SLR, DORIS

Stability per technique (L1-norm)



Discussion

- Quality of colocation sub-networks :
  - SLR/VLBI : too weak for statistics
  - Quality of the GPS colocation sub-networks
  - DORIS-SLR : too sparse but reasonable noise
  - DORIS-VLBI : abnormal noise to be investigating
- Possible signature of analysis problems (RZ, TZ)
- Impact on combination strategies?