Analysis of DORIS stations coordinates long time series with CATREF software

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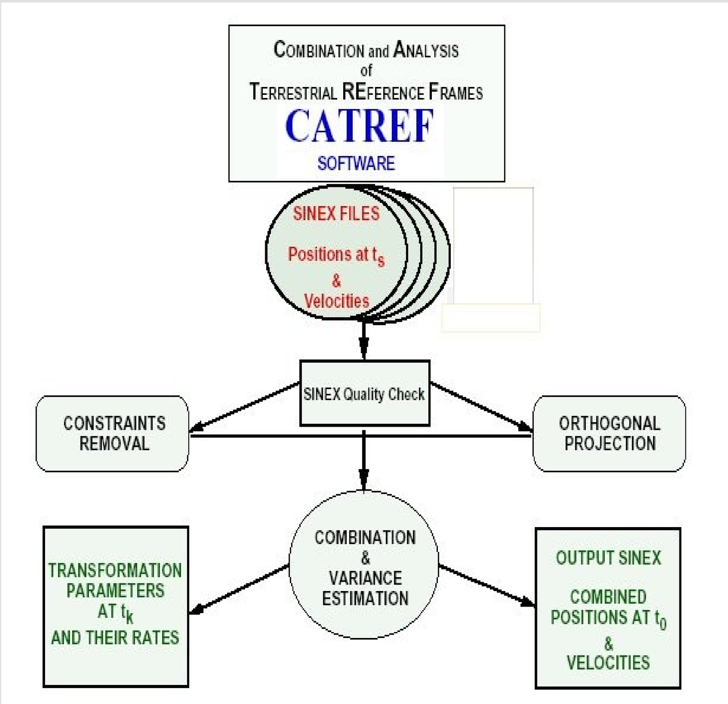
Summary

Since the International DORIS Service started operating in 2003, the processing of DORIS data has been enhancing continuously. Four scientific geodetic groups have processed the whole data set since 1993: INASAN (GIPSY software), Geoscience Australia (GEODYN software), IGN/JPL (GIPSY software), LEGOS/CLS (GINS software). Most of them have provided monthly and/or weekly series of stations coordinates in Sinex format. NASA/GSFC also provided solutions over 2004. The available long time series from the above-mentioned AC's have been processed individually by the Terrestrial Reference Frames (TRF) combination CATREF software developed at IGN/LAREG. We focus here the analysis on the coherency or discrepancy of the weekly TRF parameters.



Data modelling and analysis

For a given Analysis Center, the input is a time series of station positions and associated variance-covariance matrices: X_s^i, Σ_s^i . The general combination model is based on the following equation:

$$X_s^i = X^i + (t_s^i - t_0) \cdot \dot{X}^i + T_k + D_k \cdot X^i + R_k \cdot X^i$$

Where t_s^i is the epoch of station i available in solution s and is chosen to be the median epoch of the incorporated solutions. T_k, D_k, R_k are estimated translation, scale factor and rotation, where k is the frame associated to the solution s. $X^i, \dot{X}^i$: combined solution at t_0.
The normal equation constructed using the above model is singular, having a rank deficiency of 14, corresponding to the datum definition parameters. In order to define the combined frame an equation of minimum constraints is used, given by: $(A^T A)^{-1} A^T (X_R - X_E) = 0$

where *XE* is the vector of estimated station positions and velocities, *XR* is the reference solution containing a selected set of stations and A is the design matrix of partial derivatives. Unlike the classical constraints applied over station coordinates, minimum constraints are applied over the frame parameters, thus allowing to express the combined solution in any external frame (ITRF2000), without altering the quality (or internal consistency) of the estimated solution (Altamimi et al., 2002 and Sillard et al. 2001).

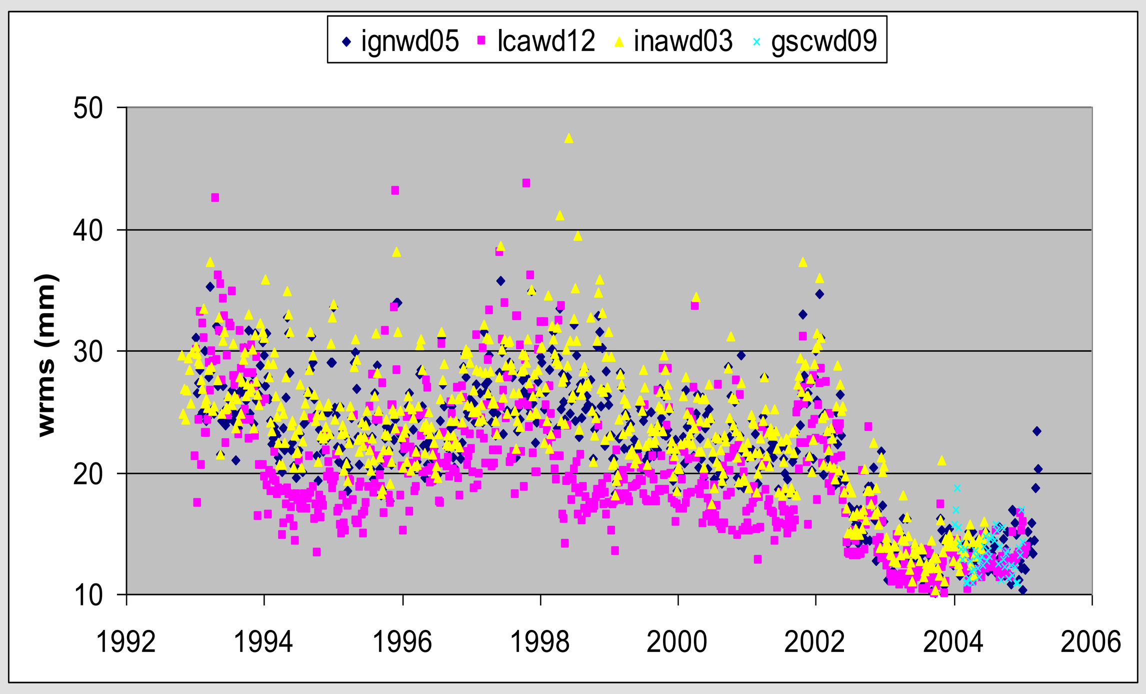
DORIS data

Spot 2 : 1993…
Topex : 1992/08-2004/11
Spot 3 : 1993/11-1996/11
Spot 4 : 1998/03…
Envisat : 2002/01
Spot 5 : 2002/05

IDS Data Centers: CDDIS and LAREG
Weekly sinex at ftp://cddis.gsfc.nasa.gov/pub/doris/products/sinex_series/

The ACs have processed the whole DORIS data set with the same strategy
Each one provided a description of its processing strategy (dsc file).

TRF analysis of weekly solutions



Solution naming:
ign for IGN/LAREG
lca for LEGOS/CLS
ina for INASAN
gsc for NASA/GSFC
wd# is for weekly series number

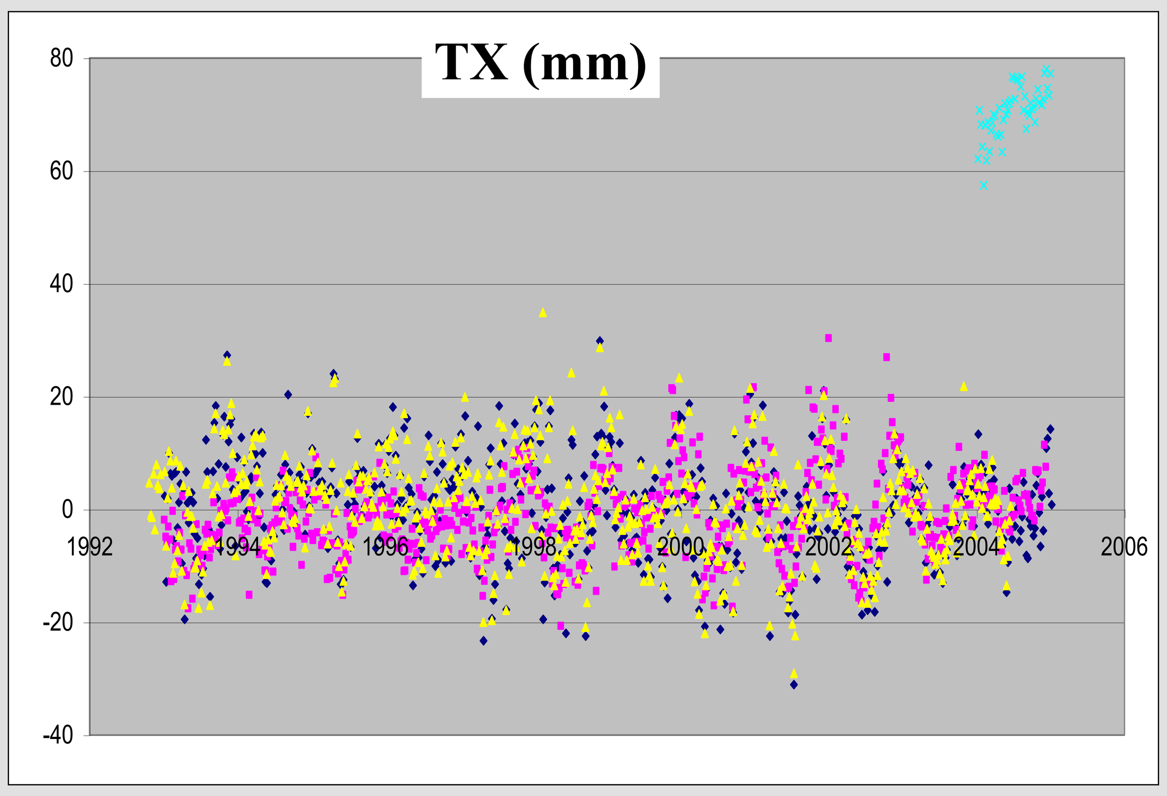
The weighted rms (wrms) of the weekly combinations clearly show the sensitivity to the number of satellites. From 20 to 30 mn in 1997 a period with 2 satellites available, the wrms fall down under 15 mm in 2003, a period with 5 satellites.

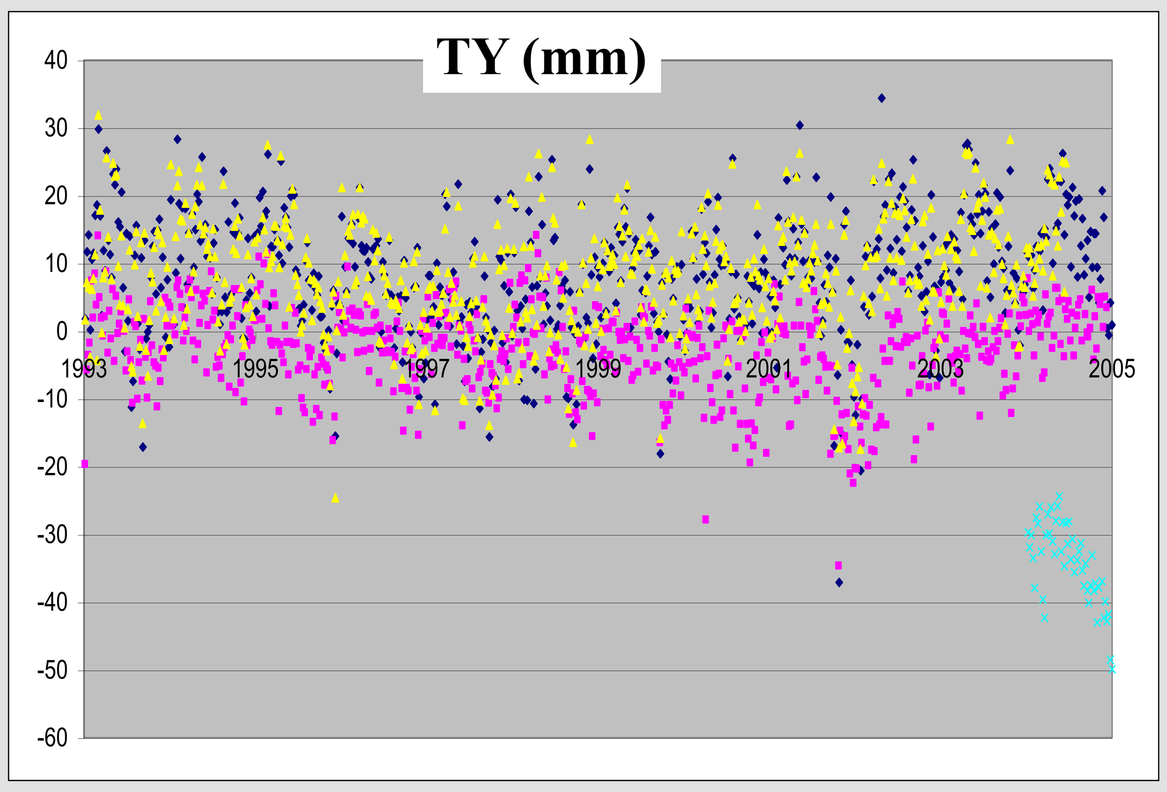
The calculated parameters for the translation of the origin are plotted here after.
The TX component shows the highest coherency between the series (except for gsc, discussed further). It ranges from +/- 20 mm with a strong annual signal after 1997.

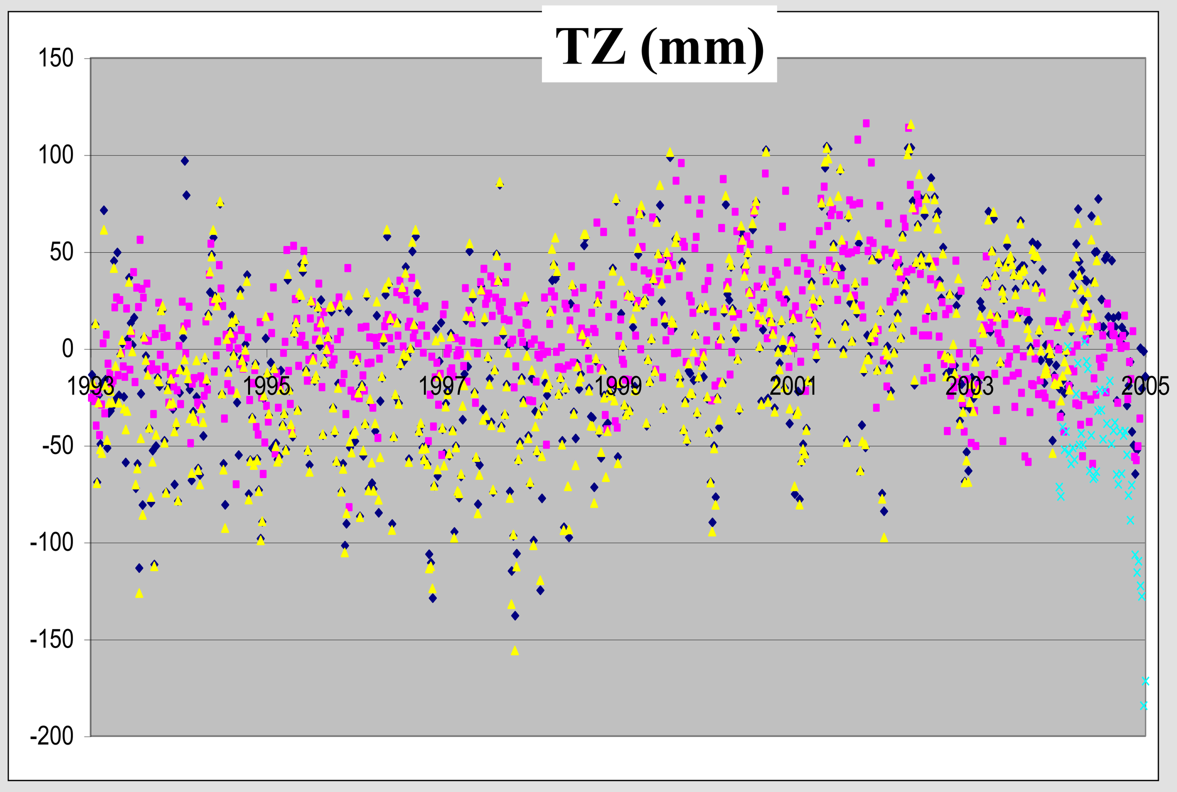
The TY component is more scattered from -20 mn up to 30 mn. A bias of about 15 mn is observed between ina-ign and lca series.

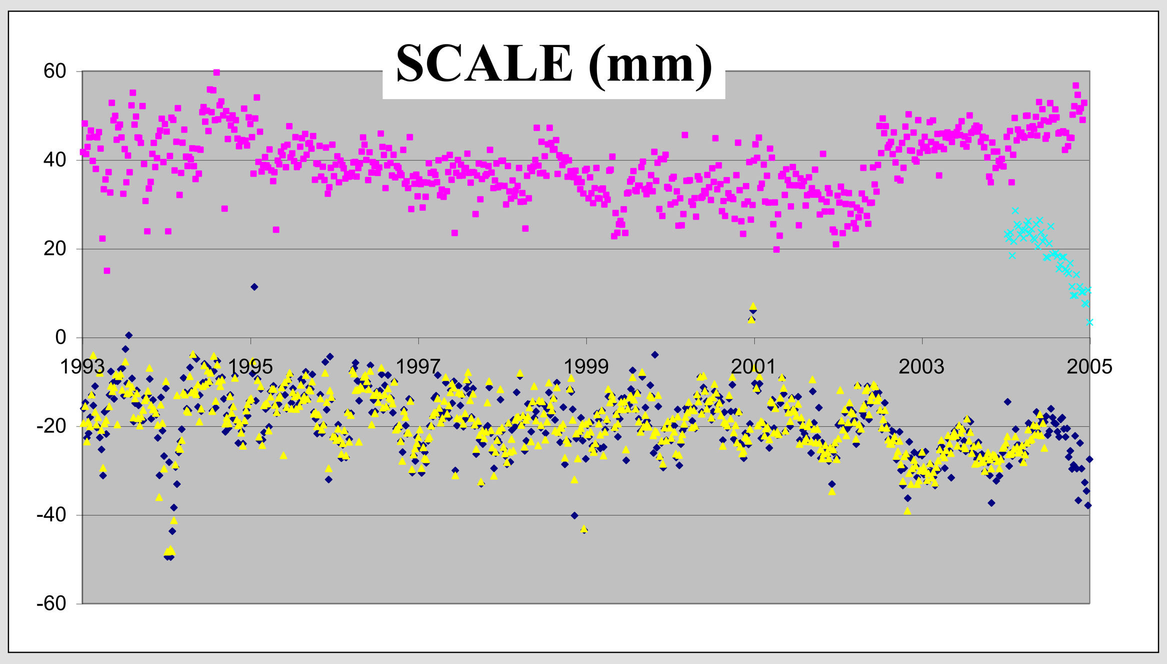
The TZ component is the most spread from -150 mm up to +100 mm at the maximum and reduced to -50 to 70 mm during the 5 satellites period (2003). After 2002, the TZ behaviour changes significantly for lca. After epoch an annual signal affects ign and ina series.

It is noticed that a strong effect of reference system still remains in the gsc solution. This point is not yet understood.









The scale factor is shown in the left plot. The most visible result is the discrepancy between the series lca, resp. gsc have a positive scale factor of 40, resp. 20 mm while ina and ign have a very close and negative one around -25 mm. The discrepancy is about 60 mm i.e. nearly 10 ppb! Once again 2002 is followed by a behaviour change for all of the series. This topic is one of the most serious source of question in the DORIS station coordinates analysis for TRF. See also a complementary analysis on the scale factor in paper No 1, G1 session.

This analysis show incoherencies in the Terrestrial Reference Frame parameters issued from the processing of the same DORIS data by different software. One can suspect that they are probably due to remaining sources of errors in the modeling DORIS data or in the strategy of the estimated parameters (troposphere?). It is also clear that the two Analysis Centers (ina & ign) that run the same software have the closest results, however not strictly identical.

All the results and especially the CATREF residual per station are available at ftp://ftp.cls.fr/pub/ids-cls/ in the corresponding lcwad12, igwd05, inawd03 repertories. The residuals have been analyzed at IGN/LAREG to derive the medium term stability, annual signatures in order to propose a select a core network suitable for achieving long term consistency (see paper No 9, G4 session).

References

Altamimi Z., P. Sillard and C. Boucher, 2002. ITRF2000: a new release of the International Terrestrial Reference Frame for earth science applications, J. Geophys. Res., 107 (B10), 2002.

Sillard P. and C. Boucher – A review of algebraic constraints in terrestrial reference frame datum definition. J. Geodesy 75: 63-73, 2001.

Le Bail K. et al., Long term consistency of multi-technique terrestrial reference frames, a spectral approach. G4 session, paper No 9, IAG meeting, Cairns, Australia, 2005.

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Future

The solutions from Geoscience Australia are to be included in the processing. The Czech Geodetic Observatory of Pecny (Bernese software) and the Russian Institute of Applied Astronomy at St-Petersburg are also working towards the integration of DORIS observations in two other different softwares. A good enough number of DORIS solutions performed by different approaches and tools will then be available to make possible comparative analysis.
The updated CATREF software will also be applied with the estimation of Earth Orientation Parameters.