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 enhanced continuously. Four scientific geodetic groups have processed the whole data set since 1993: INASAN (GPSPV software), Geoscience Australia (GEOYVN software), IGN/JPL (GPSPV software), LEGOS/CLS (GPSPV software). Most of them have provided monthly and/ or weekly series of station coordinates in IGST 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.

DORIS data

Spot 2 : 1993...
Tipes : 1992/08-2004/11
Spot 4 : 1995-2002
Enviroment : 2002/01
Spot 5 : 2002/05

IDS Data Centers: CBDBS and LAREG

Solution naming:
igs for IGN/LAREG
ina for LEGOS/CLS
ign for INASAN
gic for NASA/GSFC

The AC’s have processed the whole DORIS data set with the same strategy. Each one provided a description of its processing strategy (see file).

Data modelling and analysis

For a given Analysis Center, the input is a time series of station positions and associated variance-covariance matrixes: \( \Sigma_i \). The general combination model is based on the following equation:

\[
X_i = \mathbf{X}^c + (\mathbf{X}^c - \mathbf{X}_0) + T_i \mathbf{X}^c + B_i \mathbf{X}^c + R_i \mathbf{X}^c
\]

Where \( \mathbf{X}_0 \) is the epoch of station \( i \) available in solution \( c \) and is chosen to be the median epoch of the incorporated solution. \( T_i, B_i, R_i \) are estimated translation, scale factor and rotation, where \( i \) is the frame associated to the solution, \( \mathbf{X}^c \) : combined solution at \( \mathbf{X}_0 \).

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:

\[
\left( \mathbf{A}^T \mathbf{A} \right)^{-1} \mathbf{A}^T \mathbf{X} - \mathbf{X}_0 = 0
\]

where \( \mathbf{X}^c \) is the vector of estimated station positions and velocities, \( \mathbf{A} \) is the reference solution containing a selected set of stations and \( B \) 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).

TRF analysis of weekly solutions

The weighted rms (wrms) of the weekly combinations clearly show the sensitivity to the number of satellites. From 20 to 30 m 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 hereafter. The TX component shows the highest coherency between the series (except for gic, discussed further). It ranges from \(- 20 \) mm to \(+ 20 \) mm with a strong annual signal after 1997.

The TX component is more scattered from \(- 10 \) mm up to \(+ 30 \) mm. A bias of about 15 mm is observed between ign and lca series.

The TZ component is the most spread from \(- 150 \) mm to \(+ 150 \) mm at the maximum and reduced to \(- 50 \) to \(+ 70 \) mm during the 5 satellites period (2003). After 2003, 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 gc solution. This point is not yet understood.

References


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


Future

The solutions from Geoscience Australia are to be included in the processing. The Czech Geodetic Observatory of Prague (Beneš 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 provide possible conclusions of the mean trend.