Analyse of the ancillary results obtained from the DORIS data processing with the GINS/DYNAMO software

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Purpose

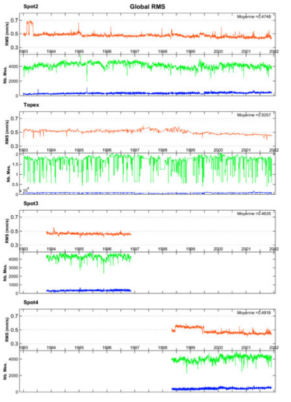
In 2001, the LEGOS/CLS Analysis Center for the International DORIS Service (IDS) has processed all the DORIS data available since January 1993 with a new computation modeling based on the ITRF-2000 coordinates and velocities as a priori values, and the GRIM5-C1 gravity model, among others. The data set analyzed until now represents 25 years (1993/01 – 2001/12) of radial velocity measurements done between the permanent emitting ground stations and the on-board instruments on the SPOT-2, -3, -4, and Topex/Poseidon satellites. In addition to the geodetic parameters (station positions and velocities, Earth Orientation Parameters), dynamical (drag, solar pressure…) and propagation (tropospheric zenithal bias) parameters are estimated. We dispose also of several processing results (orbit residuals, number of data…) and ancillary data (meteorological observations). Time series of most of these coefficients and information were plotted. It concerns information per satellite or per station. We look also at solar events, orbit maneuvers, beacon replacements… Our main objective is to point out correlation between these series and station coordinate time series in order to identify the origin of spurious values, steps or other anomalies that are observed in the latter. The second objective is to constitute a set of ancillary results that could be used as well by the other Analysis Centers for comparison and investigations.

Orbit residuals

Orbit computations are performed on a daily basis for SPOT-2, SPOT-3 and SPOT-4, and on 1-day to 3-day arcs (nominally) for TOPEX/Poseidon. Opposite plots show for each arc the number of measurements treated (green line), the number of measurements rejected (blue line) and the orbit residuals' root-mean-squares (red line).

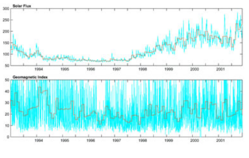
We can note the reduction of the residuals on TOPEX after the switch on the redundant receiver in early 1999. The variations of the residuals during the first year following the launch of SPOT-4 are due to the alternance between the chained and unchained modes.

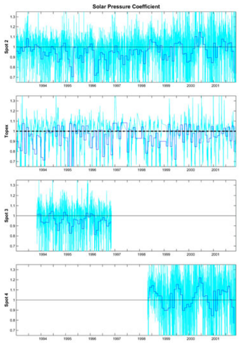
For SPOT-2, the step in January 1995 follows a time-tagging correction in the CNES data pre-processing. We don't know the reason of the variations occurring during the first half-day of 1993.

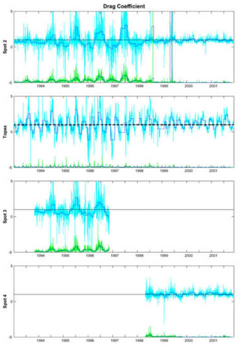


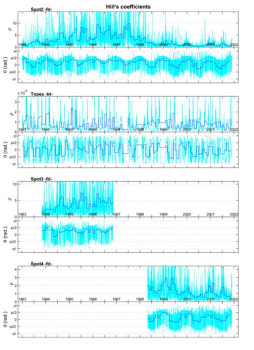
Solar pressure and drag coefficients, Hill's parameters

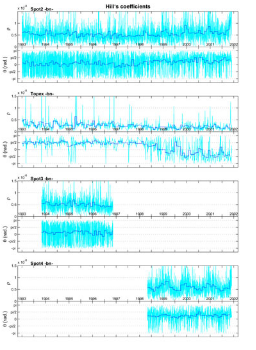
We plot the following dynamical parameters with monthly averages superimposed.
Atmospheric drag coefficients (and standard deviations (in green))
1 constant / 5 hours and 2 at orbital period for Spots
1 constant / 0.5 day for Topex
Solar pressure coefficients :
1 constant / arc for Spots and Topex
Hill's coefficients (amplitude (ρ) and phase (θ)) :
2 at orbital period in normal direction for Spots (*fd*) and Topex (*bn*)
2 at orbital period in tangential direction for Topex (*bt*)
Below are plotted the daily solar flux (10.7 cm) and the daily planetary geomagnetic index (Ap)











A periodic signal of about 120 days can be seen in the drag coefficient series of Topex. It is linked to the attitude mode change (dates of attitude maneuvers are indicated on the axis), showing a mismodeling of the satellite's attitude.

We can note that the drag force (and then the atmospheric density) is better determined (coefficients close to 1, low standard deviations (green line)) during high-activity solar periods (see time series of the daily solar flux). Opposite phenomenon but with lower amplitude for the solar pressure coefficients.

Meteorological data and tropospheric zenithal delay estimation

These plots (right) show from bottom to top for every satellite pass superimposed with monthly averages:

-ground pressure (mb), surface temperature (°C), and relative humidity (%) measured in-situ, or provided by CNES from a basic model when the data are missing or spurious;

-dry and wet components (m) of the zenithal delay from the CNET1 tropospheric model;

-the zenithal bias (m) estimated over each satellite pass;

-the tropospheric zenithal delay from the model (dry + wet; red line; monthly averages only) and the estimated delay (dry + wet +bias; green and blue lines) (m).

The examples presented here illustrate several important issues:

-the estimated bias fluctuations are of the same magnitude than the dry and wet components (10-20 cm);

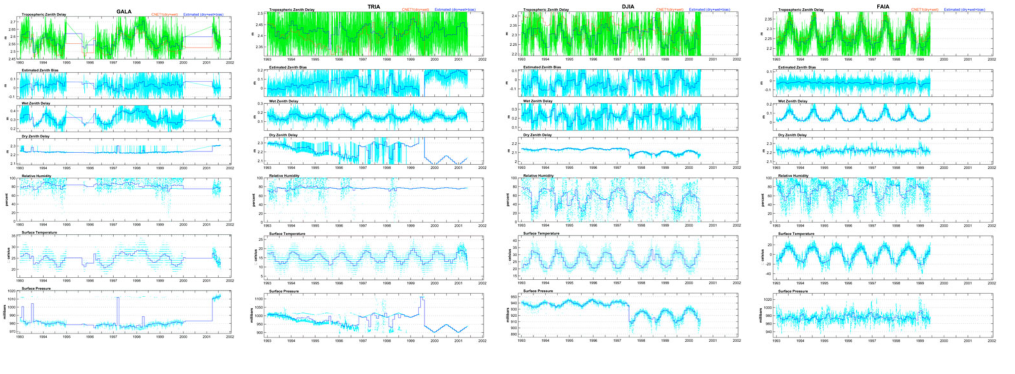
-the meteorological sensors are quite often failing (humidity TRIA) or show ageing signs (pressure TRIA);

-the values by default are not always realistic: in the case of the pressure of TRIA, the values by default have been change to correspond to the last measurements which were unfortunately erroneous. This unrealistic change of 100 mb lead to estimated bias of 20 cm and to an artificial variation of the vertical component of 2 cm.

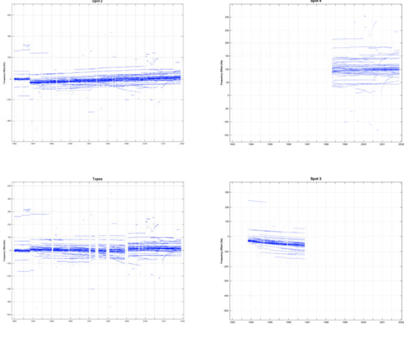
-the tropospheric model is not really satisfying (see the systematic –5cm estimated bias for FAIA)

-the meteorological instruments are not always calibrated: problem with the first generation beacons which include a electronic card which is coupled with the meteorological sensors; no problem with the 2 second generation beacons which transmit directly the meteorological measurements . As an example, the 1.0 beacon (and the sensors) of GALA has been replaced by a 2.0 one in January 2001. And so, the measured pressures rise of 30 mb from 980 to 1010 mb, which seems to be the real mean pressure. Note that for this station, the values by default were always around 1010 mb.

A large part of these errors are absorbed by the estimated tropospheric bias, but an other one can be found in the positions.



On-board oscillators' drift



These four plots (left) show for Topex and the Spot satellites the additional frequency estimated per beacon and per pass over the 1993-2001 period. It is a combination of the offsets relative to the nominal ground and onboard frequencies. The estimated values do not differ significantly from the initial ones. The main signal we see on these plots is the drift of the on-board oscillator. For Topex, the break in late 1998 is due to the switch to the redundant instrument. We see that the oscillator stabilization periods can last several months.

Beacon frequency offset
Impact on vertical position determination

The time series of the beacon frequency offsets allowed to point out a strong correlation with vertical position.

In our Doppler equation, we use the nominal frequency of the beacons instead of the real emitted one. But this error is not negligible and has an impact on the vertical position determination. A 100-Hz variation of the frequency leads to a 5-cm variation on the vertical. Such variations occur when the beacon is replaced or when the oscillator drifts.

The plots beside illustrate this effect. The blue curve of the top plots gives the vertical monthly position as we determined in our routine computation. The red curve is obtained after removing the effect induced by the beacon frequency offset plotted below (monthly average).

For SAKA, the first step of +15 cm (following the beacon's replacement in March 1995) is strongly reduced, the second one of -5 cm (replacement in April 1996) disappears. The spurious dot is due to a low number of data.

For YARA, the beacon has been replaced in early 1996. The first data were collected during the first days of emission during the heating period of the oscillator. We observe however that it did not stabilize and drifted during more than 3 years. These variations had a strong impact on our computation of the station vertical component, introducing a slope that we removed using the empirical law that we made.