DORIS CONTRIBUTION TO THE DETERMINATION OF THE EARTH POLAR MOTION

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ABSTRACT - *DORIS was included in the IERS as the fifth geodetic technique in 1995. The International DORIS Service (IDS) is a project to provide a support to various communities linked to astronomy, geodesy and geophysics. A Technique Center for DORIS is currently being organized as a Pilot Experiment within Commission VIII (CSTG) of the International Association of Geodesy. Although the Earth orientation monitoring is not its primary objective, DORIS can bring information on polar motion.*
However the present accuracy is so far not comparable to those obtained by the other techniques: SLR, VLBI and GPS. Since Spring 1999, the SOD section in Toulouse is sending, on an operational basis, to the Earth Orientation Center of the IERS in Paris the pole components derived from the analyses of the observations of 3 satellites (TOPEX, SPOT2, SPOT4) augmented in February 2002 with JASON. In November 2001, the IDS initiated an analysis Campaign with the original objective of realizing a terrestrial reference frames through the positions of stations in a unified network. In March 2002, this campaign was extended to the determination of polar motion.
We have analyzed various solutions derived from independent institutes and using different packages. Comparisons of these solutions to the IERS C04 solutions were performed.
Depending on the solutions, the accuracy of DORIS solutions are in the range of 0.8-4 mas corresponding to 3-12 cm on the Earth surface. The introduction of Jason data appears to slightly improve the solutions. Further improvements are expected with the progressive introduction of SPOT5 and ENVISAT data.

INTRODUCTION, THE COMBINED IERS SOLUTION EOP(IERS) C04.

The orientation of the Earth with respect to a non-rotating reference frame based on radio-sources positions can be expressed as a product of transformation matrices linked to precession-nutation, polar motion and universal time. Precession and nutation are due to the gravitational torques exerted by the Moon and the Sun on the Earth body. They can be predicted to a fair level of accuracy by an expansion in function of different arguments of the moon and sun motions. On the contrary, polar motion and Universal time fluctuations which are mainly due to a variety of internal and external geophysical phenomena cannot be modeled with accuracy. They have to be permanently monitored. The various techniques allowing this monitoring are complementary and at some extent redundant. The different pole components and Universal time series obtained by the independent techniques are unequal in time length, quality, time resolution, which supports the concept of combined solutions benefiting from the various contributions. The realization of such series must take advantage of the qualities of the independent series at the various time scales. For practical reasons also linked to statistical applications, the combined solution series EOP(IERS) C04 is given at equidistant intervals (1 day). It should contain no jump and negligible systematic errors; at least 3 independent techniques are thus highly desirable for that purpose. Table 1 shows the evolution of the uncertainty of one single value since 1962.

Table 1 - Uncertainty of one daily value of EOP (IERS) C 04.

	1962-1967	1968-1971	1972-1979	1980-1983	1984-1996	1997 --
X (mas)	30	20	15	2	0.5	0.2
Y (mas)	30	20	15	2	0.5	0.2
UT1(0.1ms)	30	20	15	2	0.5	0.2
dPsi (mas)	12	9	5	3	0.5	0.3
dEps(mas)	2	2	2	2	0.5	0.3

Table 2 - Characteristics of the smoothing adopted for EOP(IERS) C 04. Variations with periods smaller than the values are smoothed out.

	1962-1967	1968-1971	1972-1979	1980-1983	1984-1996	1997 --
X	40d	40d	30d	15d	8d	2d
Y	40d	40d	30d	15d	8d	2d
UT1	17d	17d	15d	10d	8d	2d
dPsi					8d	3d
dEps					8d	3d

In order to remove the white noise, the series were smoothed. The filtering characteristics have evolved (Table 2) according to the improvement of the series accuracies and to the temporal resolution. The present cutoff period is smaller than 2 days. The first step in the general procedure for deriving the IERS C04 multi-technique combined solution is the evaluation for each solution of the correction of systematic errors, bias and drift in order to translate it into the IERS system. The formal uncertainties estimated by the analysis centers being an internal consistency value, an external calibration has to be made in order to reflect the real uncertainty of the estimates. This is done using a pair variance analysis. Consequently a scaling factor is given to the series. Weights of the series entering the combined solution are thus estimated.

THE DORIS POLAR MOTION DATA

DORIS is a precise and reliable satellite tracking system. It is characterized by an optimal orbital coverage with beacons well distributed on the globe. DORIS data are also relatively simple to process, and this makes DORIS a good technique for the purpose of determination of both the terrestrial reference frame and the polar motion (figure 1). The main delay involved in data processing is due to the data collection on board the spacecraft, and to the fact that data are downloaded at specific locations.

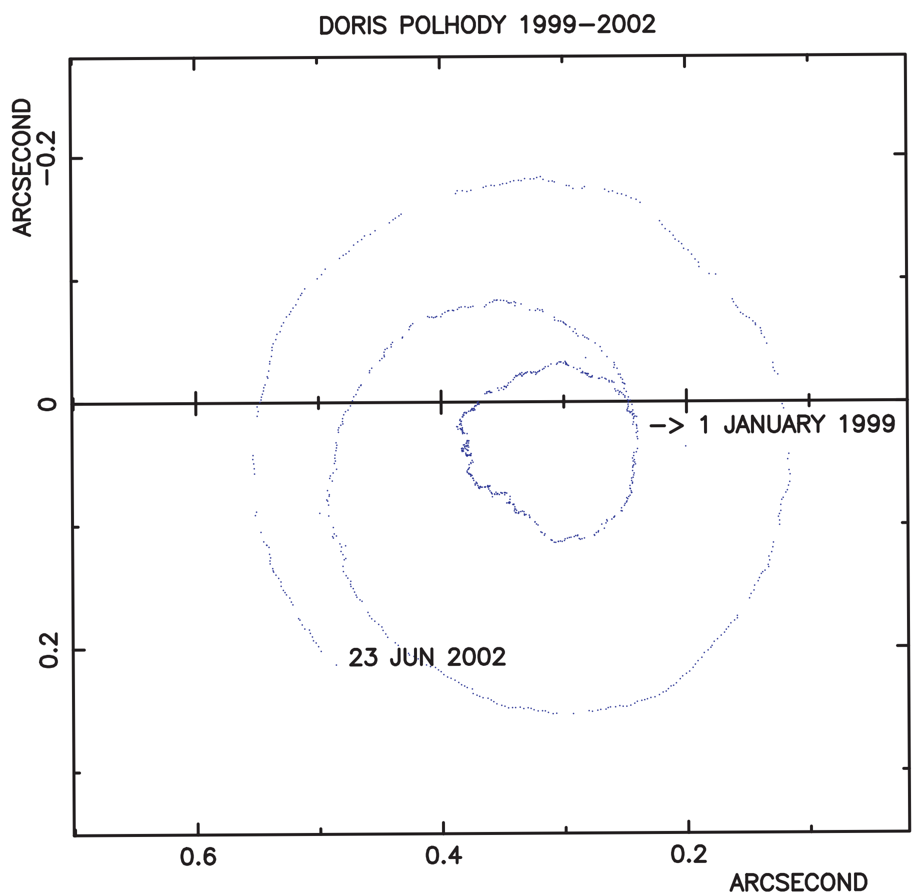

Figure 1 - Polar motion or polhody obtained from the analysis of DORIS observations

ANALYSES

Figure 2 shows for the X-Pole component, the differences between current solutions derived from the various techniques GPS, VLBI, SLR and DORIS and the combined IERS C04 solution used as a reference. Root Mean Square (Rms) of the differences are given on Figure 2. DORIS solution is significantly less consistent than for the other techniques.

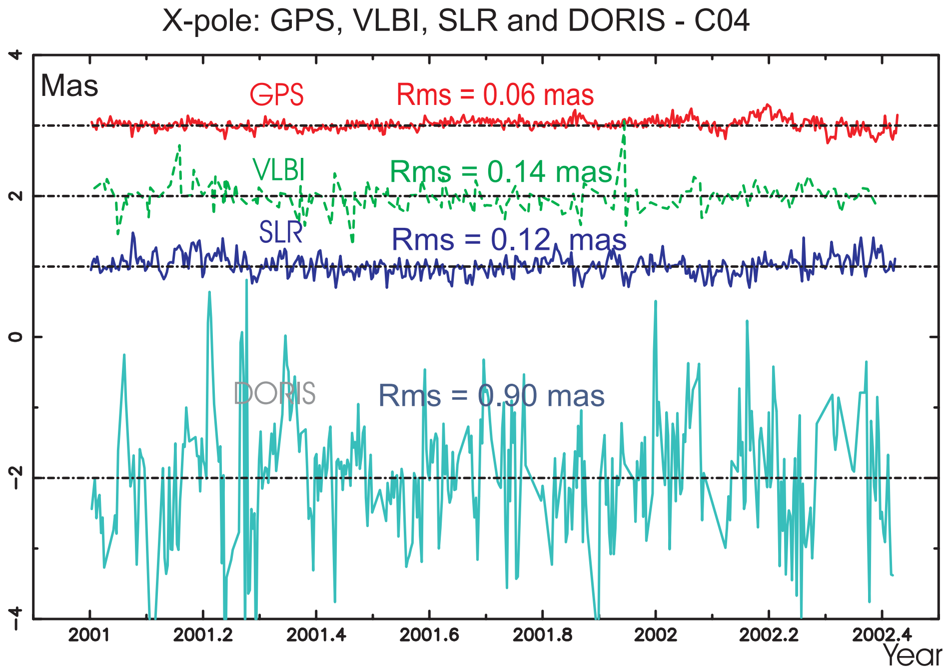

Figure 2 - Differences between the solutions of the various techniques GPS, VLBI, SLR and DORIS solutions and the combined IERS C04 solution used as the reference.

In the frame of the DORIS campaign, various analysis centers provided polar motion components series. The following Table 3 summarizes the characteristics of their processing; More descriptions are available at the EOP Center (http://hpiers.obspm.fr/eop-pc)

ANALYSIS CENTER	SATELLITES	SOFTWARE	DATA INTERVAL
CNES/SOD	SPOT2,SPOT4,TOPEX AND JASON	ZOOM	1999- 2002
OPA-GRGS	SPOT2,SPOT4,TOPEX	GINS/DYNAMO	3 months in 2000
IGN-JPL	SPOT2,SPOT4,TOPEX AND JASON	GYPSY/OASIS	1992 - 2001
LEGOS/CLS	SPOT2,SPOT4,TOPEX	GINS/DYNAMO	1993 - 2001
IGN	SPOT2,SPOT4,TOPEX AND JASON	SINEX COMBINATION	1992 - 2001

Table 3 - Summary of solutions available from the various analysis center for the Doris campaign.

Figure 3 represents for X-pole the differences between the DORIS solutions obtained by the various analysis centers i.e. CNES/SOD , OPA-GRGS, IGN-JPL and LEGOS/CLS. Accuracies are in the range of 1~3 mas. similar estimates are derived for the Y- component.

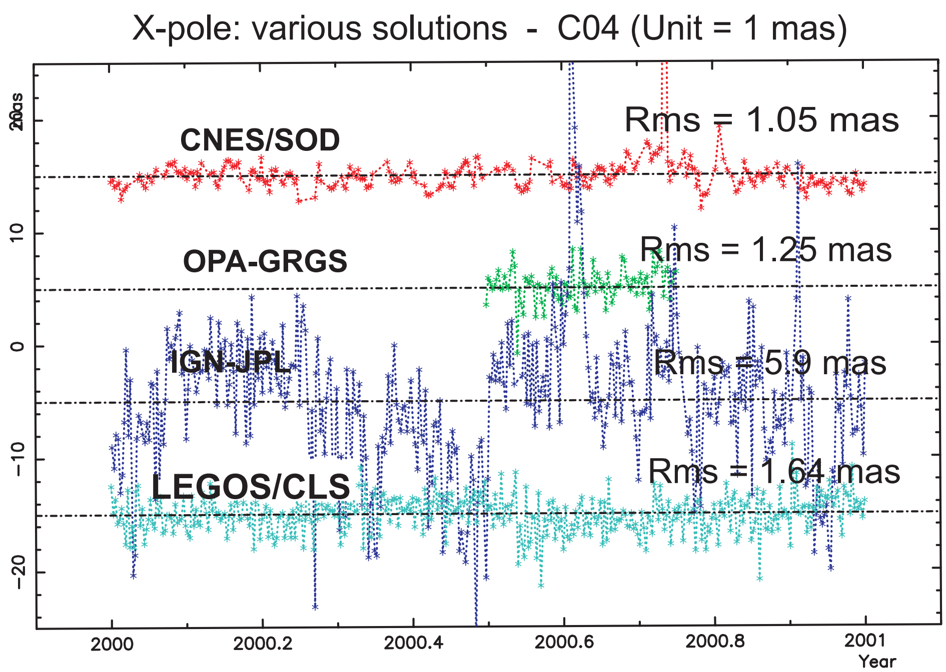

Table 4 gives the weighted rms agreement of the four solutions with respect to the C04 solution used as a reference for X-Pole component. Significant systematic periodic variations appear in some solutions in particular with seasonal signature for IGN-JPL and about 430 days for LEGOS/CLS. These periodic perturbations are the consequence of a mismodeling of the satellite orbits partly due to radiation pressure acceleration. After removal of these systematic variations, the estimated polar components are in the range of 1 to 2 mas.

Analysis Center	x-pole (mas)	y-pole (mas)
CNES/SOD	1.05	1.52
OPA-GRGS	1.25	1.23
IGN-JPL	3.10	1.80
LEGOS/CLS	1.64	1.51

Since March 2002 Jason data are available and processed on an operational basis by CNES/SOD. Figure 4 shows for both pole components the residuals between CNES/SOD solution and IERS C04. The use of 4 satellites including Jason lead to a slight improvement in the accuracy for both components .

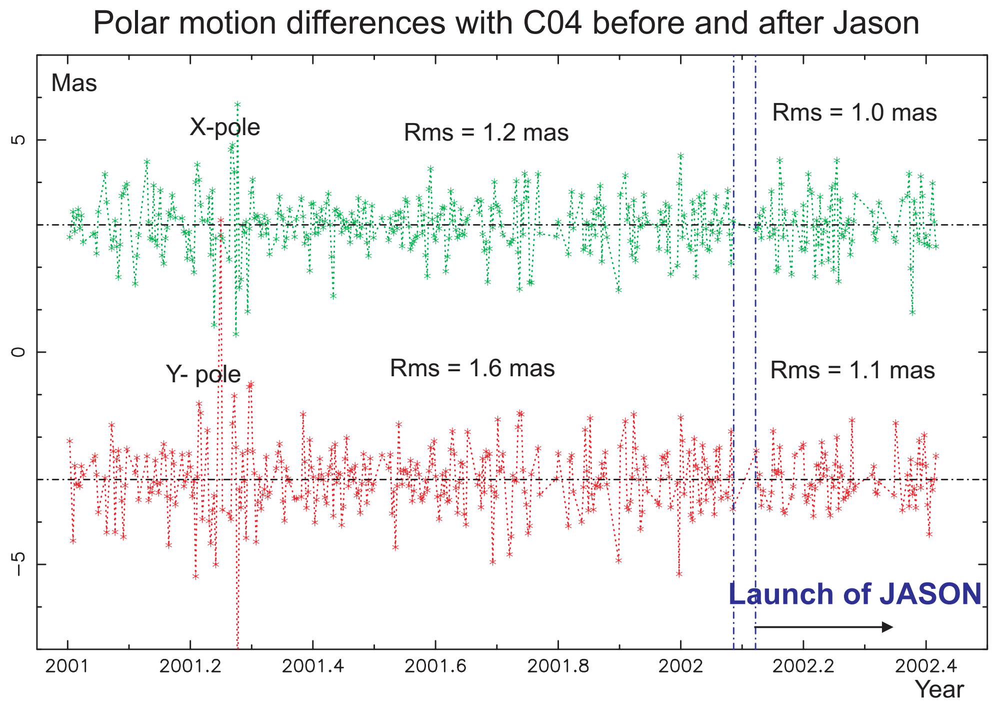

Figure 4 - The introduction of Jason observation in February 2002 brought a slight improvement in the accuracy.

ACKNOWLEDMENTS

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CONCLUSION

To date, various techniques allow the determination of all or a part of the Earth Orientation Parameters: Laser Ranging to the Moon (LLR) and to dedicated artificial satellites (SLR), Very Large Baseline Interferometry on extra-galactic sources (VLBI), Global Positioning System (GPS) and more recently DORIS introduced in the IERS activities in 1995. The payload DORIS system is embarked on various satellites SPOT2, SPOT4 Topex/Poseidon and more recently on Jason satellite which are not really dedicated to geodynamics studies. This system has shown its ability to determine position beacons in an homogeneous terrestrial frame with an accuracy of a few centimeters. So far, the precision on polar motion is in the range of one milliarcsecond. The introduction of Jason observations in the analyses have lead to a slight improvement in the accuracy. Further improvements are expected from the introduction of SPOT5 and ENVISAT equipped with new receivers and which will provide additional coverage and lower measurement noise.