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GSFC/NASA DORIS-only Contribution to ITRF2008 and determination of the Geocenter motion with DORIS

K. Le Bail, NVI Inc - GSFC/NASA, Greenbelt, MD, USA
F. G. Lemoine, Goddard Space Flight Center/NASA, Greenbelt, MD, USA
D. S. Chinn, SGT Inc - GSFC/NASA, Greenbelt, MD, USA

Contacts: Karine.Lebail@nasa.gov; Frank.G.Lemoine@nasa.gov

Abstract

For the development of the new realization of the terrestrial reference frame, ITRF2008, the Goddard Space Flight Center reprocessed the DORIS data from six satellites (TOPEX/Poseidon, SPOT-2, SPOT-3, Envisat, SPOT-4 and SPOT-5) from 1992 to 2009. The reprocessing followed the modelling standards and analysis strategies recommended by the International DORIS Service Analysis Working Group (IDS AWG).

This study describes the details of the processing, pointing to two significant conclusions:
(1)The impact of the meteorological data used (modelling of Temperature and Pressure of DORIS stations compared to in-situ data) and the use of mapping function for troposphere correction,
(2)The effect of satellite-specific parameters (macromodel & nonconservative force model).

Herein we also compare our estimate of the geocenter motion, determined dynamically via the degree one coefficients C11, S11 and C10, with the geometrical determination via the Helmert parameters processed by IDS combination center.

Data processed

The NASA GSFC DORIS analysis center has processed DORIS data within the period November 1992 to January 2009 of six DORIS satellites. Table 1 gives the periods of processed observations for these satellites. Weekly solutions (839 SINEX files) of stations positions and Earth Orientation Parameters were provided to the International DORIS Service (IDS) for combination with six other DORIS Analysis Centers (**see Poster G11C-0655 by Valette et al., Session G11C, Terrestrial Reference Systems**).

Table 1- DORIS satellites processed and observation period.

Satellite	Processed observation period
Envisat	June 2002 – January 2009
SPOT-2	November 1992 – January 2009
SPOT-3	February 1994 – November 1996
SPOT-4	January 1999 – January 2009
SPOT-5	June 2002 – January 2009
TOPEX/Poseidon	November 1992 – November 2004

Analysis strategy

Table 2 gives the standard models used in the GSFC processing, as recommended by the IDS AWG.

Table 2- GSFC Analysis DORIS data processing standard for ITRF2008.

Atmospheric gravity	ECMWF-6hr
Ocean tides	GOT4.7
Ocean loading	GOT4.7
Station coordinates	DPOP2005 Center of mass/Antenna offset applied from the DORIS data
Elevation cutoff	10°
Static gravity	EIGEN-GL04S1 (120x120)
C21/S21	IERS Standards
Drag parameterization	Cd/2-hrs (sigma=1.0) Envisat and SPOTs Cd/8-hrs TOPEX/Poseidon Cd/1-hr within 2001-2002
A priori Met. Data	GPT Boehm et al. (2007)
Mapping function	Niell (1996)

The data were processed in arcs of approximately seven days, except for periods when there were data gaps or maneuvers.

To improve the quality of the solution, we conducted different modelling tests, including modelling of the troposphere (see section in this poster). We also estimated tuned values of the Cr as well as new values for parameters of the DORIS satellite macromodels. The different updates on SRP parameters applied for the GSFC solution are given in Table 3.

Table 3- Update on SRP parameters for each satellite used applied for GSFC solution.

Satellite	Macromodel	Period	Cr used in the processing	Panels adjusted
TOPEX/Poseidon	Marshall et al. (1995) Updated	Nov. 1992-Nov. 2004	Cr=1	No
Envisat	UCL model Ziebart et al. (2005)	June 2002-Dec 2008	Cr=1	No
SPOT-2	GSFC model (tuned)	Nov. 1992-Dec 2002	Cr=1.0386	No
	GSFC model (tuned)	Jan 2003-Dec 2008	Cr=1.0716	No
SPOT-3	GSFC model (tuned)	Feb 1994-Nov 1996	Cr=1	Yes
SPOT-4	CNES model (adjusted)	Jan 1999-Dec 2008	Cr=1	Yes
SPOT-5	CNES model (adjusted)	June 2002-27 Jan. 2008	Cr=1	Yes
	CNES model (adjusted)	27 Jan 2008-Dec 2008	Cr=0.8208	Yes

References

Boehm, J., Heinkelmann, R., Schuh, H., Short Note: A global model of pressure and temperature for geodetic applications, J. Geod., 81, 679-683, 2007.
Goad, C.C., Goodman, L., A modified Hopfield tropospheric refraction correction model, Fall Meeting of the American Geophysical Union, San Francisco, CA, Dec. 12-17, 1974.
Marshall, J.A., Zelensky, N.P., Klosko, S.M., et al., The temporal and spatial characteristics of TOPEX/Poseidon radial orbit error, J. Goephys. Res., 100(C12), 25331-25352, Luthcke, S.B., R et al., 1995.
Niell, A.E., Global mapping functions for the atmosphere delay at radio wavelengths, J. Geophys. Res., 101(B2), 3227-3246, 1996.
Ziebart, M., Adhya, S., Sibthorpe, A., Combined radiation pressure and thermal modelling of complex satellites: Algorithms and on-orbit tests, Adv. Space Res, 36(3), 424-430, 2005.

Troposphere modelling

To test the impact of troposphere modelling in the DORIS processing, we used different analysis strategies given in Table 4.

Table 4 - Troposphere modelling effect on DORIS scale. The values in the column on the right are the estimated GM value minus the IERS value of $3.986004415.10^{14}$ m^3/s^2.

	Meteorological data	Troposphere model	Scale Factor Adjustment	Mapping function	GM diff (10^5)
gscwd06	DORIS	Hopfield	Wet + dry	Goad and Goodman (1974)	**-67**
Test 1	GPT	Hopfield	Wet + dry	Goad and Goodman (1974)	**-63**
Test 2	GPT	Hopfield	Wet + dry	CFA2.2	**-44**
Test 3	GPT	Hopfield	Wet only	CFA2.2	**-34**
Test 4	GPT	Hopfield	Wet only	Niell	**+33**
				Envisat	**+14**
				SPOT-2	*+40*
				SPOT-4	**+22**
				SPOT-5	**+18**
				TOPEX/Poseidon	**+14**

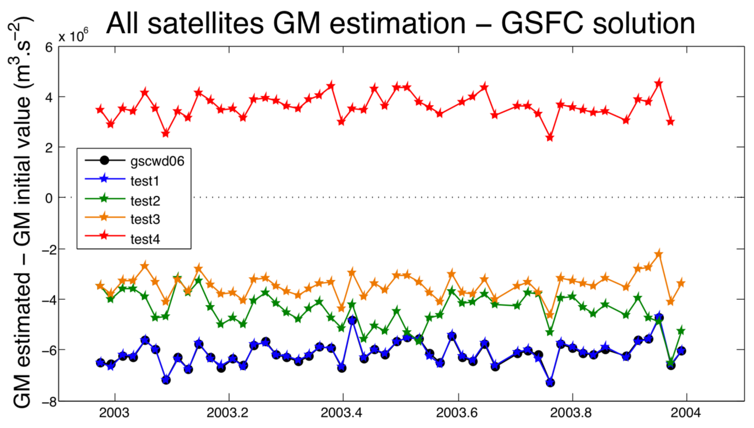
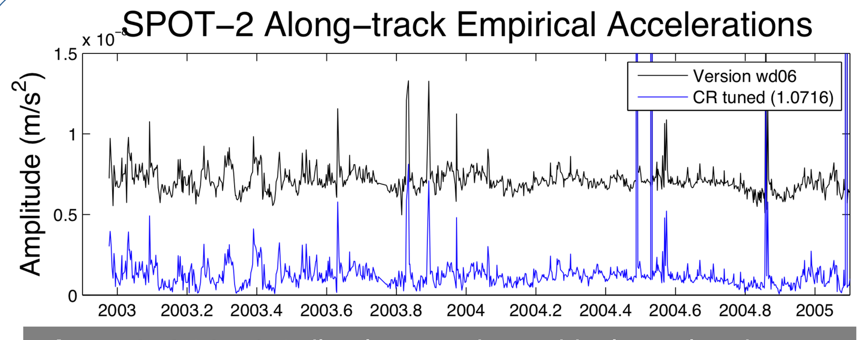


Figure 1– Effect of the Troposphere Mapping Functions on the DORIS estimate of GM, as a proxy for the scale of the coordinate solutions.

We saw an improvement using the Niell (1996) mapping function, but we expect that use of the more modern models GMF (Boehm et al., 2006) or VMF would lead to a more stable scale for DORIS.

Parameters specific to the satellite

We experimented with adjusting the reflectivity coefficient Cr, which scales the entire macromodel, as well as the adjustment of individual macromodel parameters.



Cr test – Example of SPOT-2

Figure 2- SPOT-2 Daily Along-track Empirical Acceleration Amplitudes using Cr=1, and the tuned value of Cr=1.0716.

Macromodel test – Example of SPOT-4

Table 5 - Parameters for SPOT-4 Macromodel: Panel area, Specular reflectivity (σ), Diffuse reflectivity (δ).

Panel	Area (m^2)	Nominal (σ,δ)	Test 1 (σ,δ)	Test 2 (σ,δ)	Test 3 (σ,δ)
+X	3.5	(0.54,0.07)	-	-	-
-X	3.5	(0.63,0.81)	-	-	-
+Y	7.7	(0.54,0.50)	-	(0.21,0.50)	(0.14,0.50)
-Y	7.7	(0.56,0.38)	-	-	(0.56,0.30)
+Z	9.0	(0.47,0.11)	-	-	-
-Z	9.0	(0.47,0.25)	-	-	-
Sol. Array - front	24.8	(0.10,0.15)	(0.32,0.15)	(0.34,0.15)	(0.35,0.15)
Sol. Array – back	24.8	(0.24,0.24)	-	-	-
Along-Track $10^{-9}m/s^2$ Mean Acceleration		9.45	0.96	0.78	8.50
Cross-Track $10^{-9}m/s^2$ Mean Acceleration		3.74	3.88	3.93	3.42

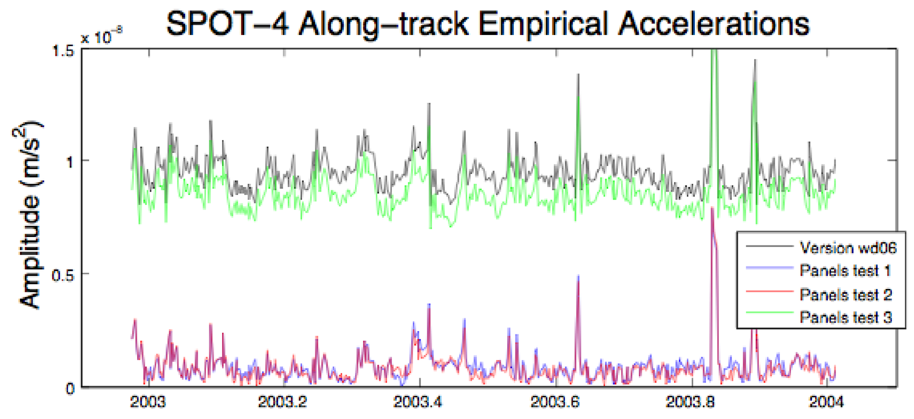
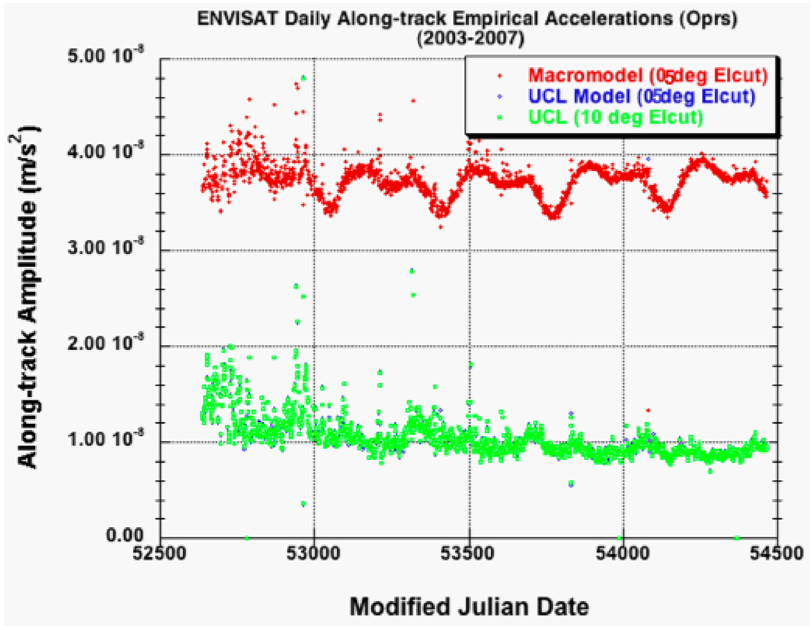


Figure 3- Comparison of the panel parameter adjustments for SPOT-4. The amplitude of the recovered daily empirical along-track accelerations is shown after applying the estimated panel parameters in the new orbit



UCL model test – Example of Envisat

Figure 4 - Comparison between the UCL model and the GSFC macromodel on Envisat. Along-track component of the empirical accelerations.

DORIS determination of the geocenter

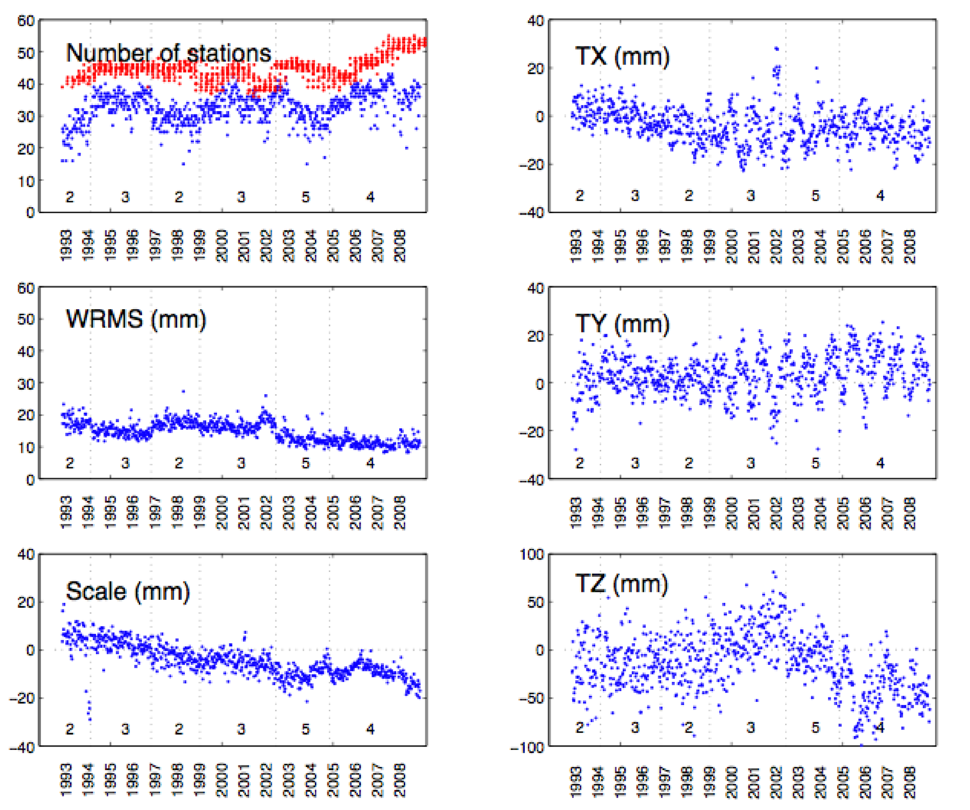


Figure 5- Cumulative GSFC solution computed by CATREF. The number of satellites per period is given as an indication. For the Number of Stations, we give in red the number of stations in the SINEX files (normal equations) provided in the gscwd10 solution. Data provided by Jean-Jacques Valette.

The GSFC DORIS solution has been combined by the IDS Combination Center (IDS CC) using CATREF. The results in terms of Helmert parameters are given in Figure 5. We indicated the number of stations in the SINEX files in red: stations are removed by IDS CC during the combination step.

We estimated these parameters dynamically (estimating degree one Stokes coefficients) and compared them to the geometric method (CATREF). TX and TY series are similar. The TZ difference can be explained by the number of stations that differs in the two methods. Comparing with geophysical models, we noticed that the DORIS determination of the geocenter is in agreement concerning the annual terms, but with an amplitude larger than the geophysical determination, especially in TZ.

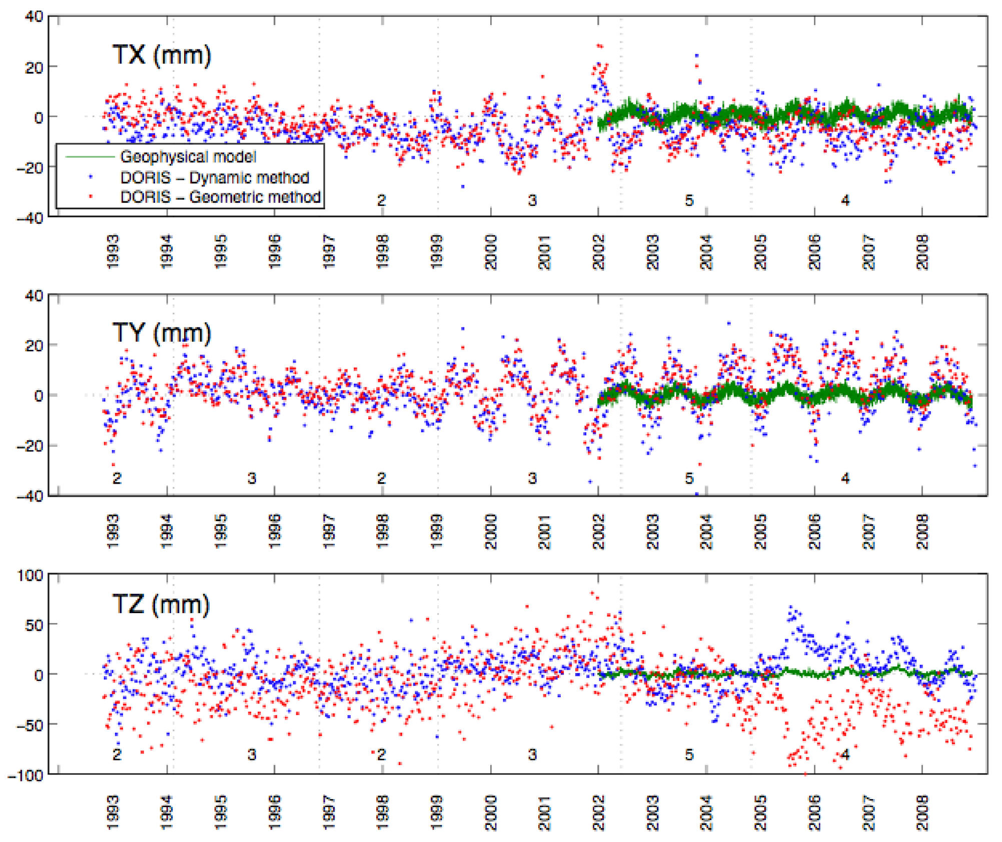


Figure 6- Geocenter retrieved from DORIS analyses (dynamic method – this study – and geometric method) compared to geophysical models. Data provided by Jean-Paul Boy.

Conclusions

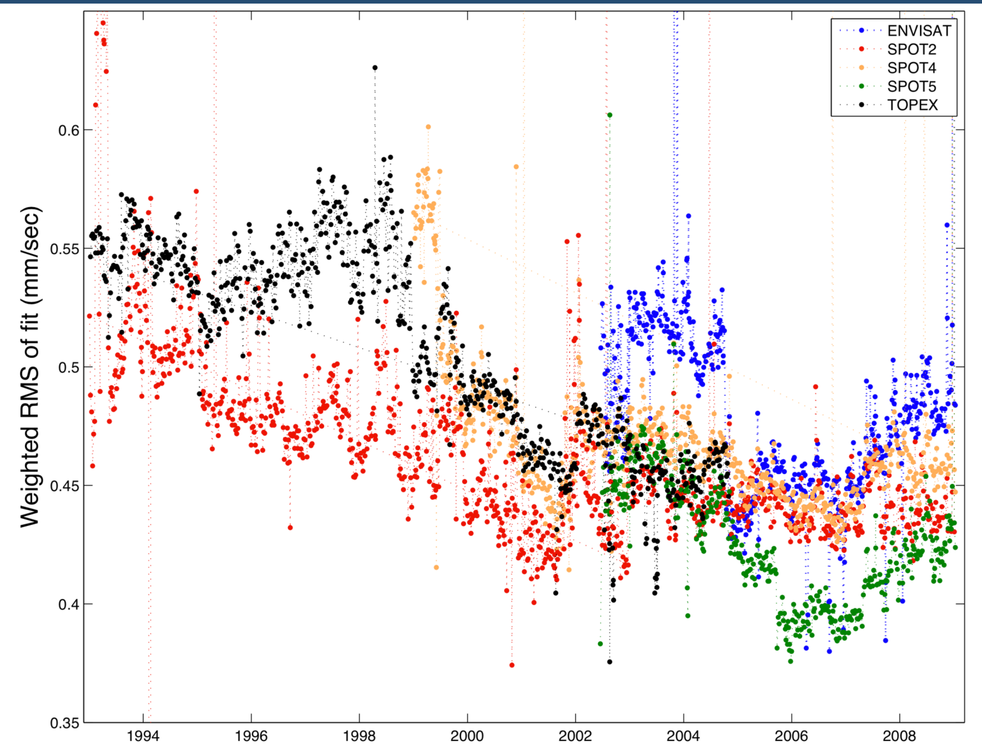


Figure 7- DORIS RMS of fit of the orbit determination for each satellite used in the GSFC solution.

Figure 7 gives the final weighted RMS of fit of the orbits obtained for the GSFC DORIS solutions by satellite.

1.The RMS of fit of SPOT-2 is systematically better than for TOPEX/Poseidon;
2.The improvements in RMS for SPOT-2 and TOPEX/Poseidon (1998-2002) reflect the improvement in the DORIS network;
3.The change in RMS of fit for Envisat is due to change in the count interval;
4.Change in software for SPOT-5 and Envisat are visible and impact the RMS of fit.

In the future we look forward to the challenges of working with the new DORIS satellites such as Jason-2 and future missions such as Cryosat-2.

GSFC DORIS Analysis Center intends to continue processing DORIS data and delivering regularly SINEX files to IDS, as well as experimenting new models and updating more in details individual satellite macromodels.