Impact of Jason-2 and Cryosat-2 on DORIS combination

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DGXX intrument

Summary

For the preparation of ITRF2008, the International DORIS Service (IDS) processed data from 1993 to 2008, including data from TOPEX/Poseidon, the SPOT satellites and Envisat in the weekly solutions. Since the development of ITRF2008, the IDS has been engaged in a number of efforts to try and improve the reference frame solutions. These efforts include assessing the contribution of the first new DORIS generation satellites: Jason-2 and Cryosat-2.

The goal of this paper is to analyze the impact of Jason-2 and Cryosat-2 DORIS data on geocenter and scale solutions of the IDS weekly solutions.

Jason-2 and Cryosat-2 specificities

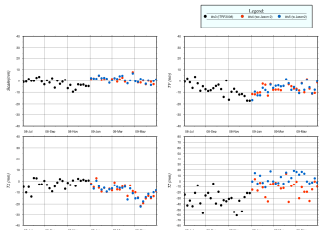
Jason-2 (launched on June 2008 - 1336km - 66°) and Cryosat-2 (launched on April 2010 – 717km – 92°) are the satellites with new DORIS DGXX instrument onboard. This new generation of DORIS receivers can track up to 7 beacons simultaneously, compared to one and two beacons for the first (Spot-2, Spot-3, Spot-4 and Topex) and second (Jason-1, Envisat, Spot-5) generations respectively, increasing dramatically the number of available measurements.

Furthermore, except for Jason-1, which is not included in the DORIS combined solutions due to its USO sensibility to the SAA, Jason-2 is the first DORIS satellite at 66 degrees of inclination since TOPEX.

Jason-2 impact on DORIS combined solutions

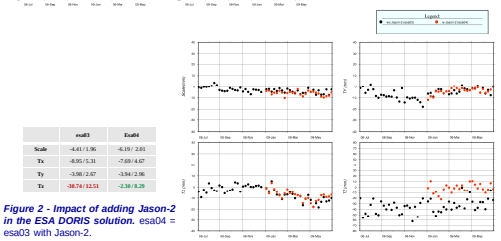
Early 2009, a few weeks after the end of Jason-2 commissioning phase, most of the IDS Analysis Center's (ACs) started to deliver in tandem with their current multi-satellites series (extension to ITRF2008 contribution) new weekly solutions including Jason-2 DORIS data.

Evaluation (estimation of transformation parameters wrt ITRF2008) of these new multi-satellite pointed out that the Tz geocenter component is centered much better with Jason-2 and this benefits the IDS combination (see Figure 1 for the IDS combined –multi ACs – solution and Figure 2 for example from the SINEX series submitted by ESA and Figure 2 for the IDS combined solution)



	ids4	ids5
Scale	1.88 / 2.47	0.42 / 2.40
Tx	-9.25 / 5.28	-9.02 / 5.58
Ty	-6.73 / 4.28	-6.75 / 4.03
Tz	4.21 / 8.77	-12.94 / 12.44

Figure 1 - Impact of adding Jason-2 in the DORIS solution. ids3 = IDS contribution to ITRF2008 (Envisat, Spot-2,-3,-4,-5, Topex) – ids4 = IDS combined solution (Envisat, Spot-2, Spot-4, Spot-5, Jason-2) – ids5 = IDS4 without Jason-2.



	esa03	Exa04
Scale	-4.41 / 1.96	-6.19 / 2.01
Tx	-8.95 / 5.31	-7.69 / 4.67
Ty	-3.98 / 2.67	-3.94 / 2.96
Tz	-10.74 / 12.51	-2.30 / 8.29

Figure 2 - Impact of adding Jason-2 in the ESA DORIS solution. esa04 = esa03 with Jason-2.

Thus, the question was raised as to why Jason2 has such an impact on the Tz geocenter. Is it due to either new capabilities of the DORIS DGXX receiver or is it due to Jason-2 orbit inclination?

To answer to the question and to discriminate between these two possibilities, the IDS analysis coordinator asked all the seven IDS ACs

1) To deliver single satellites (Envisat, Spot-2, Spot-4, Spot-5, Jason-2) solutions over 2009.

2) To use the Jason-1 & 2 tandem period to simulate a Jason-2 Jason-1 like single satellite solution.

Single satellite solutions

Evaluation of the DORIS single satellite solutions from all the ACs has shown that:

1) Tz geocenter components of Spot-4 and Envisat have positive and negative biases, respectively. This indicates a satellite-data-level issue as opposed to a modeling issue, or a common mode modeling issue for all the analysis centers.
2) The Tz components for Spot-5 and Jason-2 were clustered more closely to zero.
3) The Tx and Ty geocenter components exhibit a 120-day oscillation with Jason-2 which could result from problems associated with the radiation force model for Jason-2.
4) Spot-4 and Spot-5 have positive scale whereas Jason-2 and Envisat have negative ones.

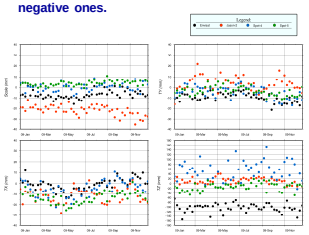


Figure 3 – ESA single satellite solutions.

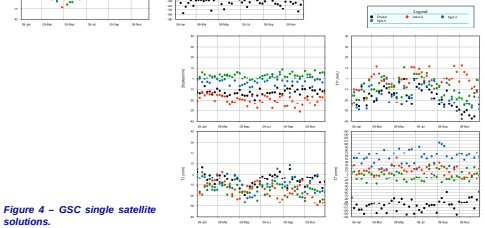


Figure 4 – GSC single satellite solutions.

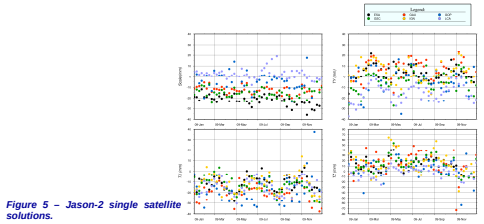


Figure 5 – Jason-2 single satellite solutions.

Analysis of single satellite solutions has also revealed that stations such as Santiago, Arequipa, Cachoeira and Fairbanks and possibly Syowa had systematically high residuals.

Acronym	Analysis Center	Country	Contact	Software Package
ESA	European Space Operation Center	Germany	Michiel Otten	NAPEOS
GAU	Geoscience Australia	Australia	Ramesh Govind	GEODYN
GOP	Geodetic Observatory Pecny	Czech Rep.	Petr Stepanek	Bernese
GSC	Goddard Space Flight Center	USA	Frank Lemoine, Karin Le Bail, Douglas Chinn	GEODYN
IGN	Institut Geographique National	France	Pascal Willis	GIPSY/OASIS
INA	INASAN	Russia	Sergey Kuzin	GIPSY/OASIS
LCA	Centre National d'Etudes Spatiales + Collecte Localisation Satellite	France	Laurent Soudarin, Hugues Capdeville	GINS/DYNAMO

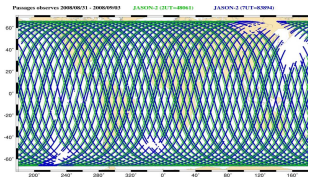
Table 1 – IDS Analysis Centers.

Jason-2 Jason-1 like solution

To better understand the impact of the 7 DORIS frequency channels (DFCs) of the new DORIS DGXX receiver, one AC (lca) used the Jason-1, 2 tandem period (September to December 2008) to

1) Extract list of stations simultaneously tracked onboard Jason-1 2 DFCs and Jason-2 7 DFCs.
2) Compute Jason-2 orbit from observations subset determined in 1)
3) Estimate so-called Jason-2 Jason-1 like solution using 1)

Figure 6 – Data coverage comparison between Jason-2 2DFCs (green) and Jason-2 7DFCs (blue). Notice the positive effect of 7 DFCs in areas with data gap (south atlantic, north pacific and antarctic).



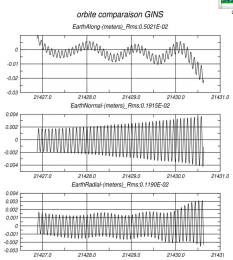
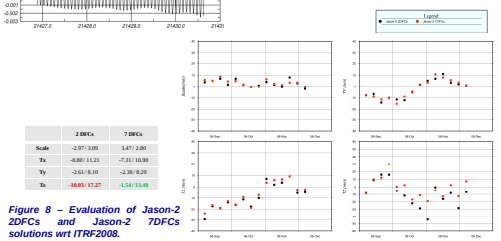


Figure 7 – Orbit comparison between Jason-2 2DFCs and Jason-2 7DFCs.



	2 DFCs	7 DFCs
Scale	-2.97 / 3.09	3.47 / 2.80
Tx	-8.80 / 11.21	-7.31 / 10.90
Ty	-2.61 / 8.10	-2.38 / 8.29
Tz	-10.63 / 17.27	-1.54 / 13.49

Figure 8 – Evaluation of Jason-2 2DFCs and Jason-2 7DFCs solutions wrt ITRF2008.

This comparative study between 2 and 7 DFCs receivers has pointed out

1) Using 7DFCs doubles the number of observations and increases robustness in areas with data gaps.
2) No difference at the orbit level.
3) Tz geocenter is better centred using 7 DFCs.

Cryosat-2 impact

So far, evaluation of first new DORIS solutions including Cryosat-2 has shown no impact on the geocenter. This could be explained by 1) the orbit inclination (92°) which is very close to the inclination of the majority of the DORIS satellites (around 98° for Envisat, Spot-4, 5) and 2) the low altitude which reduce the number of stations that can be simultaneously tracked (up to 5 on Jason-2 and up to 3 on Cryosat-2).

Nonetheless, due to its polar orbit, Cryosat-2 should have a positive effect on polar station coordinate determination.

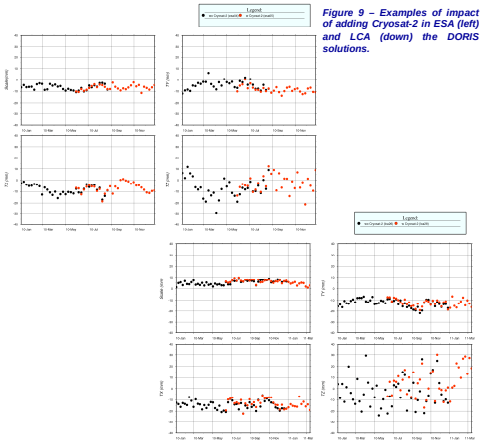


Figure 9 – Examples of impact of adding Cryosat-2 in ESA (left) and LCA (down) the DORIS solutions.

Future DORIS missions

Since Cryosat-2, one more satellite is equipped with the DORIS DGXX receiver: HY-2A (CNSA - August 16th 2011 – 971km – 99.3°). DGXX will also be onboard the forthcoming missions: Saral/Altika (mid 2012), Sentinel-3A (2013).

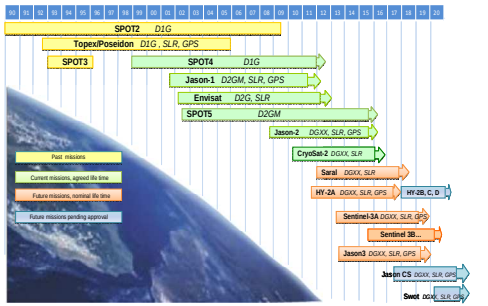


Figure 10 – Status and future DORIS missions.