3.4.4 International DORIS Service (IDS)

General

The present organization of the IDS is similar to that of the other technique-oriented services, and is described at <http://ids.cls.fr/html/organization.html>. The IDS website is <http://ids.cls.fr/>. The IDS Terms of Reference are available at <http://ids.cls.fr/html/organization/tor.html>.

Network

The DORIS permanent network is shown in Figure 1. Site logs are available at <http://ids.cls.fr/html/doris/sitelog.php3>.

The stations rejuvenation program initiated in 2000 is now almost complete, as illustrated in Figure 2. In 2006 only one station was completely renovated in order to improve the long term stability of the antenna support (Dionysos, Greece, DORISMAIL 0452, June 6, 2006) while less of a modification was carried out on the antenna support at Arequipa (Peru) and Hartebeesthoek (South Africa). The station at Arequipa was restored to operation after a long hiatus since 2003. The antenna at Djibouti (DJIB) was replaced following discovery of a tilt due to a corroded base plate (DORISMAIL 0456, July 3, 2006). A tilt was also found in the antenna at Marion Island, MARB (DORISMAIL 0449, May 23, 2006). The MARB antenna was repaired courtesy of assistance from colleagues at HartRAO (Hartebeesthoek Radio Astronomy Observatory) (DORISMAIL 0453, June 8, 2006).

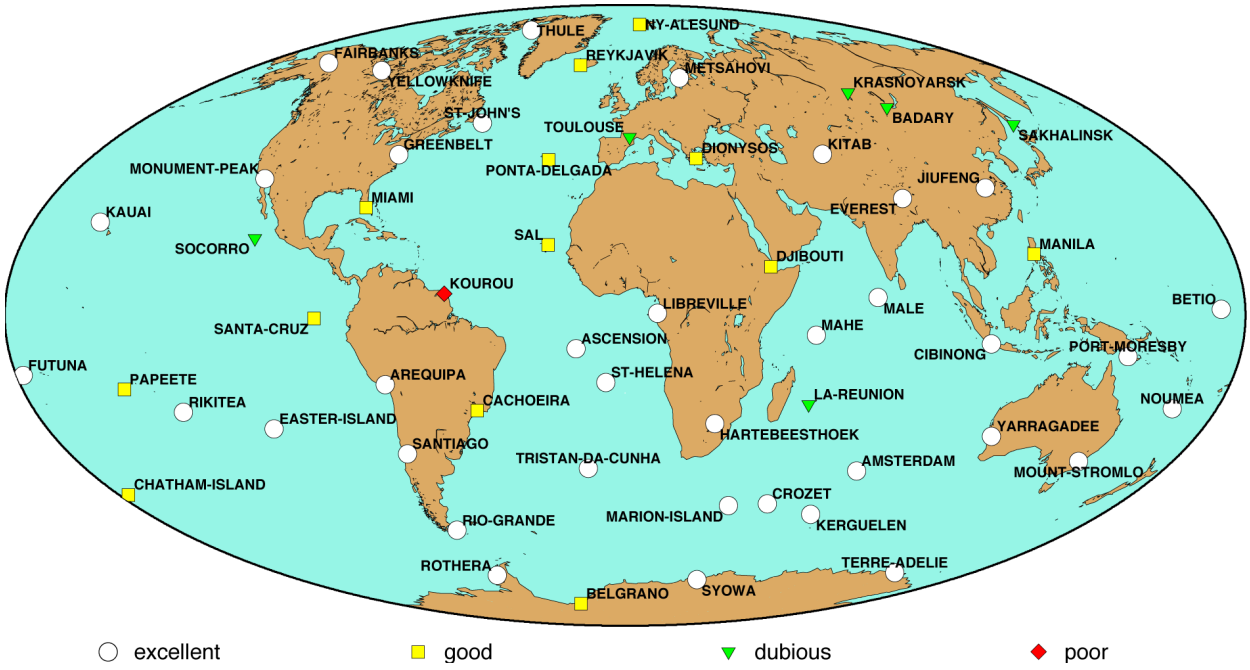

Fig. 1: The DORIS permanent stations and their estimated stability (January 2007)

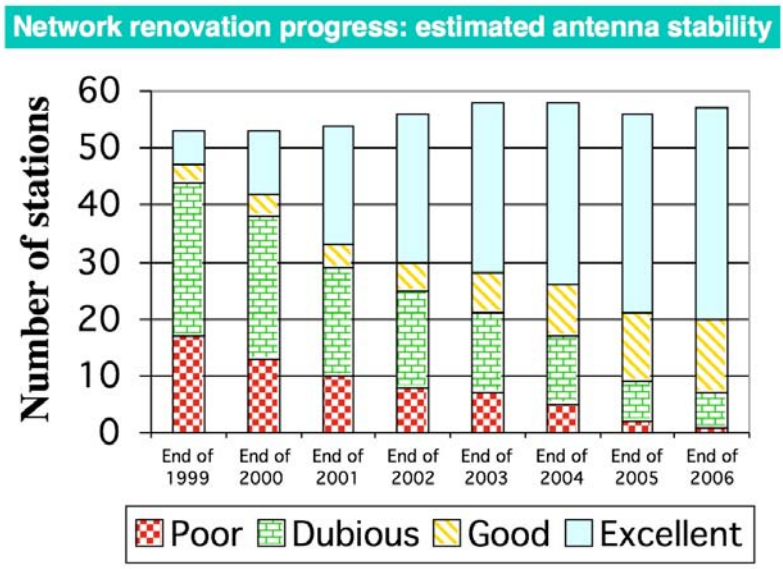

Figure 2: DORIS permanent network renovation

The following new stations were installed:

- Rikitea (French Polynesia), replacing Rapa
- Betio (Tarawa atoll, Republic of Kiribati)

The total number of DORIS stations in the permanent network is now 57, out of which only seven are considered to have dubious or poor stability (see Figures 1 and 2).

The status of co-locations with currently operating stations of the other techniques contributing to IERS (located less than 10 km away from DORIS) is as follows.

- GPS: 37 sites
- SLR: 9 sites
- VLBI: 7 sites

Space Segment

Three new oceanography and cryosphere observation missions will carry DORIS receivers, which will help to ensure continuity of DORIS data. These missions include Jason-2 (NASA/CNES/NOAA/EUMETSAT) scheduled for launch in June 2008, Cryosat 2 (ESA) scheduled for launch in May 2009, and SARAL/Alti-KA (joint with the CNES and ISRO, the Indian Space Research Organization) scheduled for launch in 2009-2010. The current DORIS satellite constellation includes: SPOT-2 (in orbit since 1990), SPOT-4, SPOT-5, ENVISAT, and Jason-1.

Operational Product Delivery

The latency of products delivered by the IDS is controlled in part by the delivery of DORIS tracking data to the IDS data centers (e.g. the NASA CDDIS). We show in Figure 3 the latency of DORIS data delivery typical in 2006 for the different satellites which average at present 20–30 days.

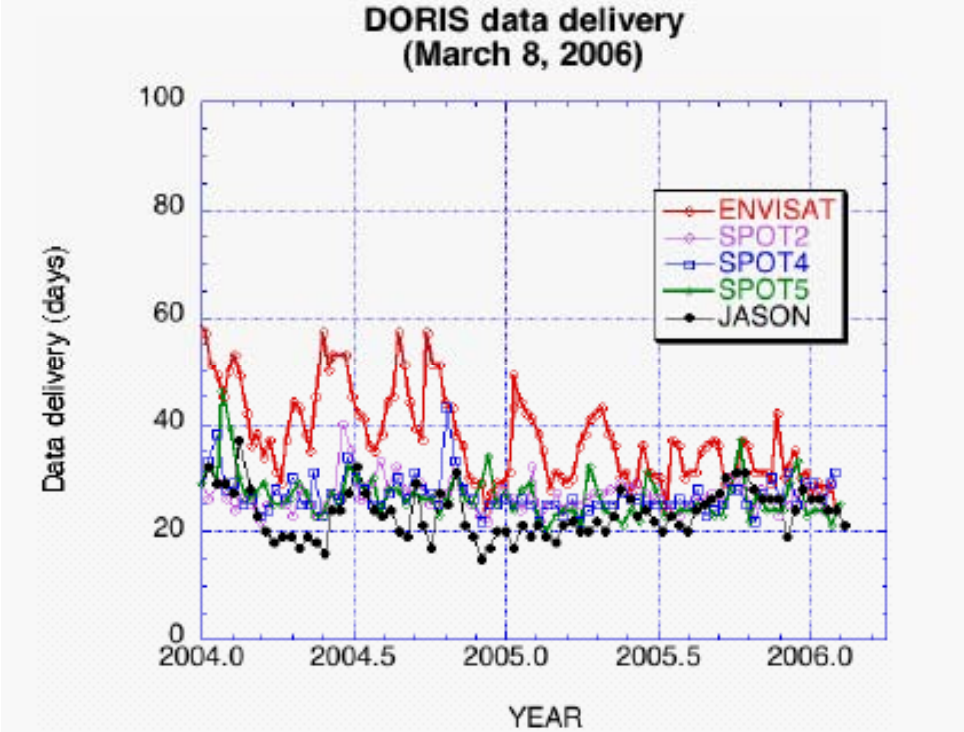

Fig. 3: Latency of DORIS data delivery to the NASA/CDDIS (2004 to March 8, 2006).

IDS Workshop, March 13–15, 2006, Venice, Italy

The International DORIS Service (IDS) workshop was held on March 13–15, 2006, in conjunction with the ESA symposium, "15 years of Progress in Altimetry", and the Ocean Surface Topography Science Team (OSTST) meeting. The purpose of this workshop was to get representatives from all IDS groups together to share information about the network, data, products, developments and results in all aspects of DORIS. The meeting was a platform for discussion and coordination of future activities. The presentations from the meeting are available at <http://ids.cls.fr/html/events/IDS2006/>. A detailed position paper was produced to outline the necessary steps to refine and improve the delivery of IDS products. This position paper is available at <http://ids.cls.fr/documents/events/IDS2006/IDS06_s1_Lemoine_coordination.pdf>.

DORIS special Issue (Journal of Geodesy)

A special issue dedicated to DORIS was published in the Journal of Geodesy (Volume 80(8-11), November 2006. The guest editor was Pascal Willis (IGN/JPL). The issue included four papers on the DORIS system and IDS, three papers on geodynamics, two papers on the ionosphere, five papers on the reference frame and Earth rotation, and three papers on DORIS technical issues. The countries of the authors and co-authors included: France (28); USA (13); UK (1); The Netherlands (1); Czech Republic (1); Switzerland (1); and Nepal (1).

New Citation

As a result of the special issue, we request that users of DORIS data and products use the following new citation:

Tavernier, G., Fagard, H., Feissel-Vernier, M., Le Bail, K., Lemoine, F., Noll, C., Noomen, R.; Ries, J.C., Soudarin, L., Valette, J.J., Willis, P. (2006), The International DORIS Service: genesis and early achievements, *Journal of Geodesy 80(8-11), pp. 403–417, DOI: 10.1007/s00190-006-0082-4*.

ITRF2005 Contributions

Three analysis centers submitted full SINEX file time series (1993–2005) for inclusion in the ITRF2005: IGN/JPL, LEGOS/CLS, and INASAN (Institute of Astronomy, Russian Academy of Sciences). The IGN/JPL and INASAN time series were based on the Gipsy software; the LEGOS/CLS solution was based on the GINS software. All the contributions from the analysis centers were based on DORIS data from SPOT-2, SPOT-3, TOPEX/Poseidon, SPOT-4, SPOT-5 and ENVISAT. Jason-1 DORIS data were not included owing to the perturbing effect of the South Atlantic Anomaly (SAA) on the Jason-1 DORIS Ultrastable Oscillator. No DORIS combination was produced for the IERS, but rather the individual analysis center contributions were directly included in the ITRF2005 solution. A detailed document was written by IDS to provide specification for the ITRF2005 computation (discontinuities, change in velocity, bad data, ...) and is available on <http://ids.cls.fr/documents/report/IDS_for_ITRF2004_v1_0.pdf>.

Tests of ITRF2005

DORIS analysts conducted extensive tests of the ITRF2005, including the preliminary versions released in the summer of 2006 by the IGN and the DGFI (ITRF2005P), and the final version released in October 2006.

Luca Cerri (CNES) analyzed Jason-1 SLR and DORIS data from cycle 110 to 145 (January 1 to December 31, 2005). The tests included pure DORIS-only orbits, and DORIS+SLR orbits, and separately tested the ITRF2000, ITRF2005P (IGN), and ITRF2005P (DGFI) solutions. For ITRF2000, the DPOD2000 corrections of *Willis and Ries* (2005) were used. The DORIS RMS of fit showed a small improvement for ITRF2005. The altimeter crossover RMS of fit for the DORIS-only orbits improved from 5.953 cm (ITRF2000) to 5.906 cm (ITRF2005P, IGN) and 5.905 cm (ITRF2005P, DGFI). As illustrated in Figure 4, the altimeter mean for these orbits shows a significant improvement, indicating the orbits are better centered in ITRF2005 compared to ITRF2000.

The improved centering is also visible in the DORIS+SLR orbits with ITRF2005P. Use the ten core SLR stations (Wettzell, Hertmonceux, Graz, Shanghai, Grasse, Zimmerwald, Monument Peak, Greenbelt, Yarragadee, McDonald) along with the ITRF2005 DORIS complement, Luca Cerri (CNES) found that the RMS of fit

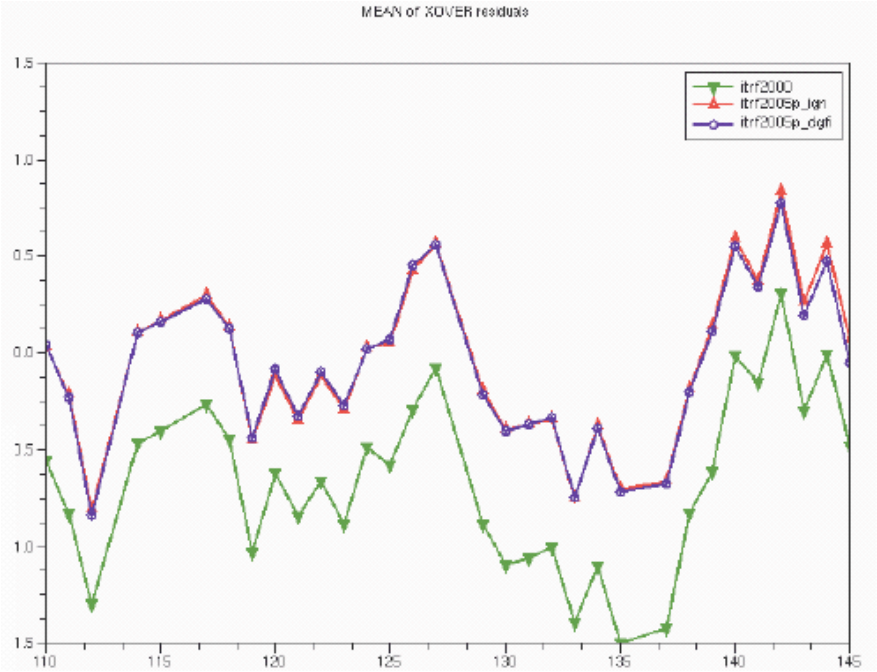

Fig. 4: Mean of Jason-1 Altimeter Crossover Residuals (cm) for DORIS-only orbits computed with ITRF2000 (green line), ITRF2005P-IGN (red line), and ITRF2005P-DGFI (blue line). The vertical scale ranges from –1.5 to +1.5 cm.

was 1.13 cm (ITRF2000), 1.50 cm (ITRF2005P-IGN), and 1.24 cm (ITRF2005P-DGFI). The global mean SLR fit was 0.23 cm (ITRF2000), 0.65 cm (ITRF2005P-IGN), and 0.35 cm (ITRF2005P-DGFI).

The LEGOS/CLS analysis center (Laurent Soudarin) tested ITRF2005P-IGN using data to all DORIS satellites in June 2004. An improvement in the RMS of fit was discerned for all the DORIS satellites except Jason-1 (see Table 1).

Table 1: RMS of fit for DORIS data in June 2004 from LEGOS/CLS analyses

Satellite	**ITRF2000 RMS, mm/s**	**ITRF2005P-IGN RMS, mm/s**
SPOT-2	0.3569	0.3536
SPOT-4	0.4160	0.4115
SPOT-5	0.3951	0.3906
TOPEX/Poseidon	0.4257	0.4244
Jason-1	0.3749	0.3771
ENVISAT	0.4792	0.4752

The NASA/GSFC POD center (Nikita Zelensky, Doug Chinn and Scott Luthcke) analyzed the tracking data for both TOPEX/Poseidon (cycles 1 to 364, 1992 to 2002) and Jason-1 (cycles 1 to 168, 2002

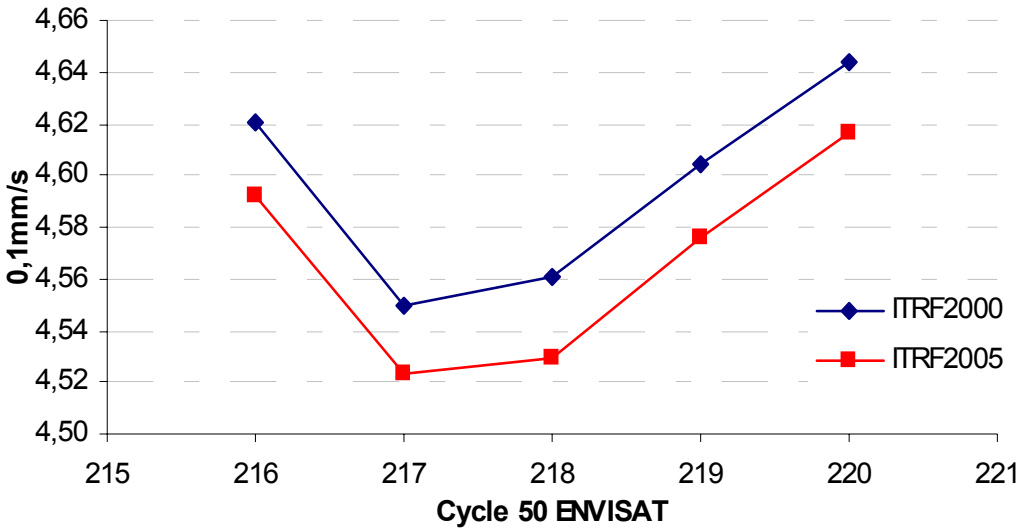

Fig. 5: DORIS fits for ENVISAT orbits based on SLR and DORIS tracking using ITRF2000 (blue line) and ITRF2005 (red line). In these tests by the CNES POD center, the DORIS performance is systematically improved with ITRF2005. The vertical scale ranges from 0.450 to 0.466 mm/s.

to 2006) to test the final ITRF2005 release. This analysis used only the stations that appeared in the ITRF2005 solution, and in particular they applied the correction SLR or DORIS solution by epoch for certain stations with multiple solutions. The GGM02C gravity was used for both TOPEX and Jason-1, and in addition for Jason-1 the South Atlantic Anomaly (SAA) correction model of J.M. Lemoine and H. Capdeville (2006) was applied. As with the CNES analysis center the Willis and Ries (2005) corrections to ITRF2000 (DPOD2000) were used. For TOPEX, while the DORIS fits improved, the SLR fits increased, and there was a slight increase in the altimeter crossover RMS of fit (see Table 2). The SLR fits for both TOPEX/Poseidon and Jason are characterized by an increase in the mean SLR residual. For Jason-1, the RMS of fit improved for the DORIS data, the SLR data, and the altimeter crossovers.

The CNES POD Center analyzed the SLR and DORIS data for ENVISAT cycle 50 (August 1 to September 4, 2006) – thus using data that were not part of the ITRF2005 solution. They showed that the DORIS fits to ITRF2005 are a systematic and consistent improvement compared to ITRF2000 (see Figure 5).

The IGN/JPL analysis center (Pascal Willis) compared the IGN/JPL solution with ITRF2000 and ITRF2005P. The most notable result was the change in the scale of the TRF. For ITRF2000, the IGN/JPL solution had a scale offset of –3.23 ppb (–21 mm), whereas for ITRF2005 the IGN/JPL solution had a scale offset of –0.78 ppb (–5 mm).

Table 2: RMS of fit for TOPEX and Jason-1 SLR and DORIS Orbits with ITRF2000 and ITRF2005

TOPEX orbits: 34 select cycles†	**DORIS RMS, mm/s**	**SLR RMS, cm**	**SLR mean, cm**	**Crossover RMS, cm**
ITRF2000	0.4864	1.805	0.104	5.460
ITRF2005	0.4863	1.846	0.319	5.472
Jason orbits: Cycles 1-168 (edit cycle 137)	**DORIS RMS, mm/s**	**SLR RMS, cm**	**SLR mean, cm**	**Crossover RMS, cm**
ITRF2000	0.3862	1.447	-0.061	5.576
ITRF2005	0.3856	1.420	0.247	5.572
† TOPEX Cycles 13-15, 85-87, 159-161, 239, 241, 308, 311, 344-360, 361-364				

In summary, the ITRF2005 solution is positive for DORIS, and shows improvements compared to ITRF2000, especially for the period after 2000, when the newest stations joined the DORIS network. The DORIS network provides orbit solutions for Jason-1 that are better centered, as shown by the mean crossover fits for both the DORIS-only and the DORIS+SLR orbit solutions. Positioning improvements are expected in the operational weekly SINEX solutions once ITRF2005 is implemented by the analysis centers. The DORIS centers will implement ITRF2005 in their routine operations during 2007, as soon as it is practical for them to do so.

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