International DORIS Service (IDS)

http://ids-doris.org/

Chairman of the Governing Board: Pascal Willis (France)

Overview

Using the experience gained in the preparation of the ITRF2008, the International DORIS Service (IDS) is now based on a reinforced structure. Six Analysis Centers from five different countries using five different software packages provide regular products to the IDS. The combination of the weekly solutions for the station coordinates and the EOPs is realized by the Combination Center with close collaboration with the Analysis Coordinator and the Analysis Centers. All these components cooperate through the Analysis Working Group (AWG), the meetings of which lead to improvements in DORIS analysis strategies and DORIS-derived geodetic products. Data and products are archived at the two Data Centers. The Governing Board provides long-term direction while the Central Bureau manages the day-to-day activities, brings its supports to the IDS components and operates the information system.

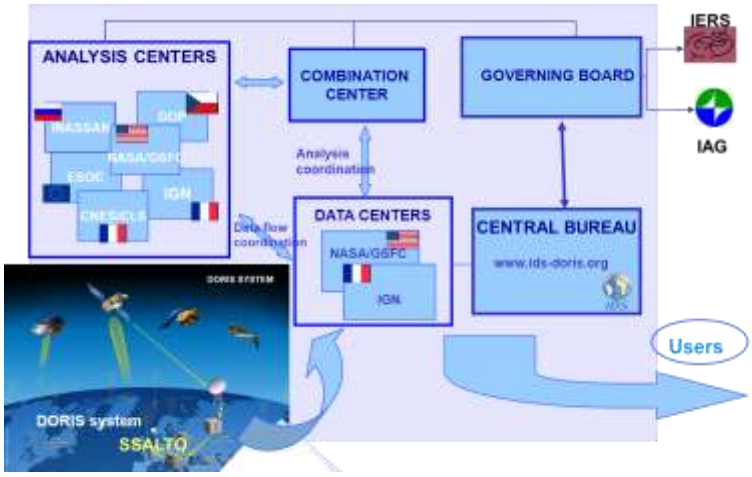
The current report presents the different activities held by all the components of the IDS for the period from the middle of 2011 to the middle of 2015.

Structure

The IDS organization is very similar to the other IAG Services.

The service accomplishes its mission through the following components:

- Satellites carrying a DORIS receiver
- Network of tracking stations
- Data Centers
- Analysis centers and Analysis Coordinator
- Combination Center
- Working Groups
- Central Bureau
- Governing Board



Activities

1. DORIS system

1.1 DORIS satellites

As described in Table 1.1, two new satellites were launched in the last four years: HY-2A and SARAL, both using the new 7-channel DG-XX DORIS receiver on-board the satellite. The DORIS constellation then steadily increased, including currently five satellites at altitudes of 720 and 1300 km, with almost polar or TOPEX-like inclination (66 deg).

Table 1.1: DORIS data available at IDS data centers. As of May 2015

Satellite	Start	End	Space Agency	Type
SPOT-2	31-MAR-1990 04-NOV-1992	04-JUL-1990 15-JUL-2009	CNES	Remote sensing
TOPEX/Poseidon	25-SEP-1992	01-NOV-2004	NASA/CNES	Altimetry
SPOT-3	01-FEB-1994	09-NOV-1996	CNES	Remote sensing
SPOT-4	01-MAY-1998	24-JUN-2013	CNES	Remote sensing
Jason-1	15-JAN-2002	21-JUN-2013	NASA/CNES	Altimetry
SPOT-5	11-JUN-2002	PRESENT	CNES	Remote sensing
Envisat	13-JUN-2002	08-APR-2012	ESA	Altimetry, Environment
Jason-2	12-JUL-2008	PRESENT	NASA/CNES	Altimetry
Cryosat-2	30-MAY-2010	PRESENT	ESA	Altimetry, ice caps
HY-2A	1-OCT-2011	PRESENT	CNSA, NSOAS	Altimetry
SARAL/ALTIKA	14-MAR-2013	PRESENT	CNES/ISRO	Altimetry

In the next few years, more DORIS satellites are foreseen: first Jason-3 (USA) and Sentinel-3A (GMES/ESA) in 2015, then Sentinel-3B 12 to 30 months later. Some missions are announced and pending approval: Sentinel-3C, Sentinel-3D, Jason CS1, Jason CS2, SWOT. The Chinese HY-2A satellite for altimetry could be followed by other satellites of the same type (HY-2B, HY-2C, HY-2D). Furthermore, other missions are in consideration. Of particular interest is GRASP (Geodetic Reference Antenna in Space), providing on board the same spacecraft several well calibrated geodetic systems such as GNSS, DORIS, SLR, and VLBI.

Figure 1.1 summarizes the evolution of the DORIS constellation since the launch of the SPOT-2 satellite in 1990, and includes already foreseen satellites. It must be noted that in the past last years, four or more DORIS satellites were available to IDS users, which is a key requirement for the precision of the geodetic products.

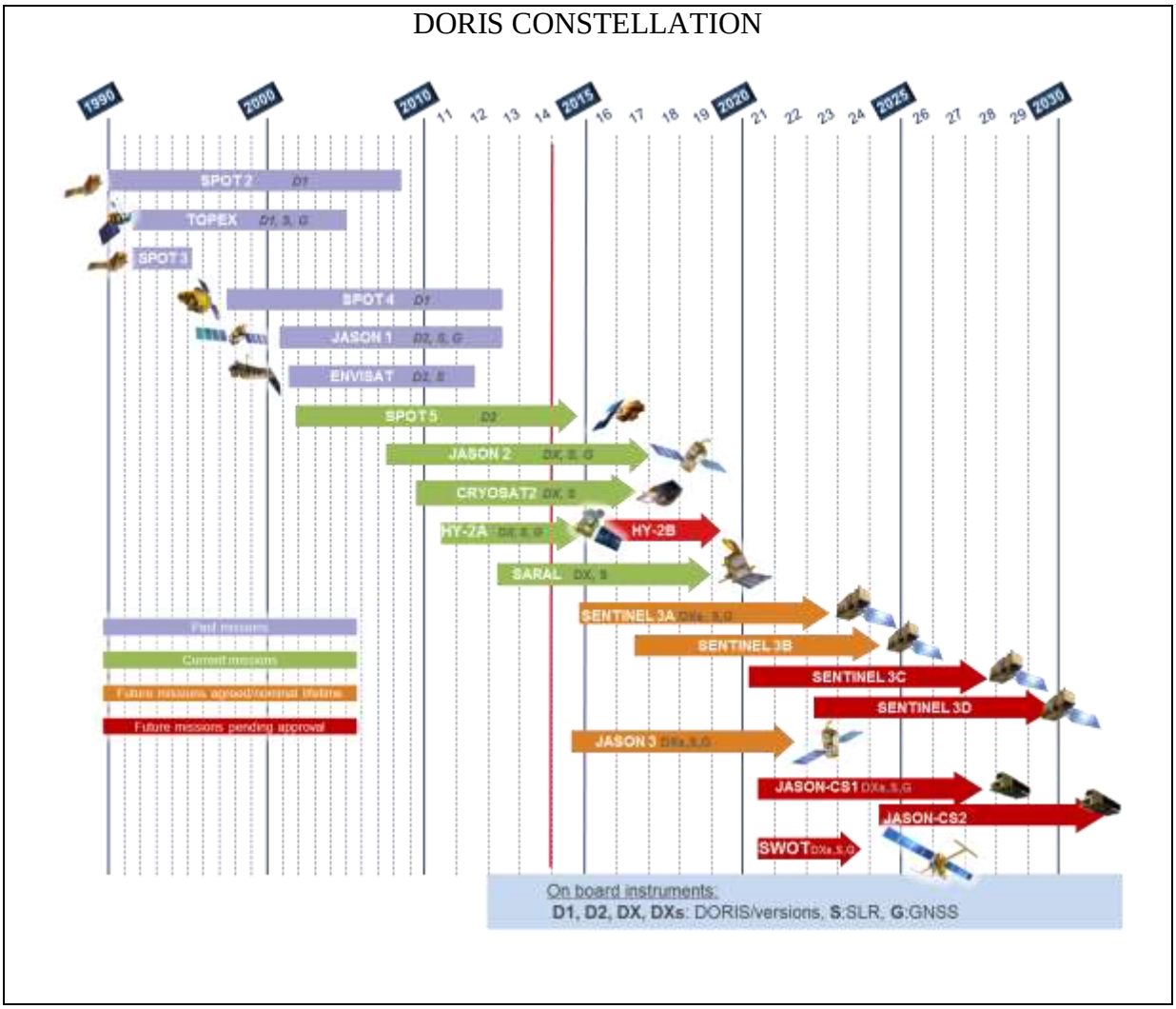


Figure 1.1: DORIS satellite constellation. As of May 2015.

1.1 DORIS network

The DORIS network maintained a high level of performance: many prompt and effective maintenance operations (equipment replacement) and the return to service of Socorro in June 2014 eagerly awaited since several years made it possible to keep up the network availability rate with of a 91% annual mean of operating stations.
At the end of 2014, the DORIS permanent network is made up of 55 stations and an additional station in Grasse, France, is dedicated to experimentation (see Figure 1.2).

With regard to the off-network stations dedicated to IDS for scientific purposes, objectives and priorities have been redefined early 2014 as follows:

Wettzell, Germany: 4 techniques GGOS site; DORIS station installation planned in 2015

Guam island, North Pacific Ocean: IGS "GUUC" + tide gauge co-location

Sejong, Korea: future 4 techniques GGOS site

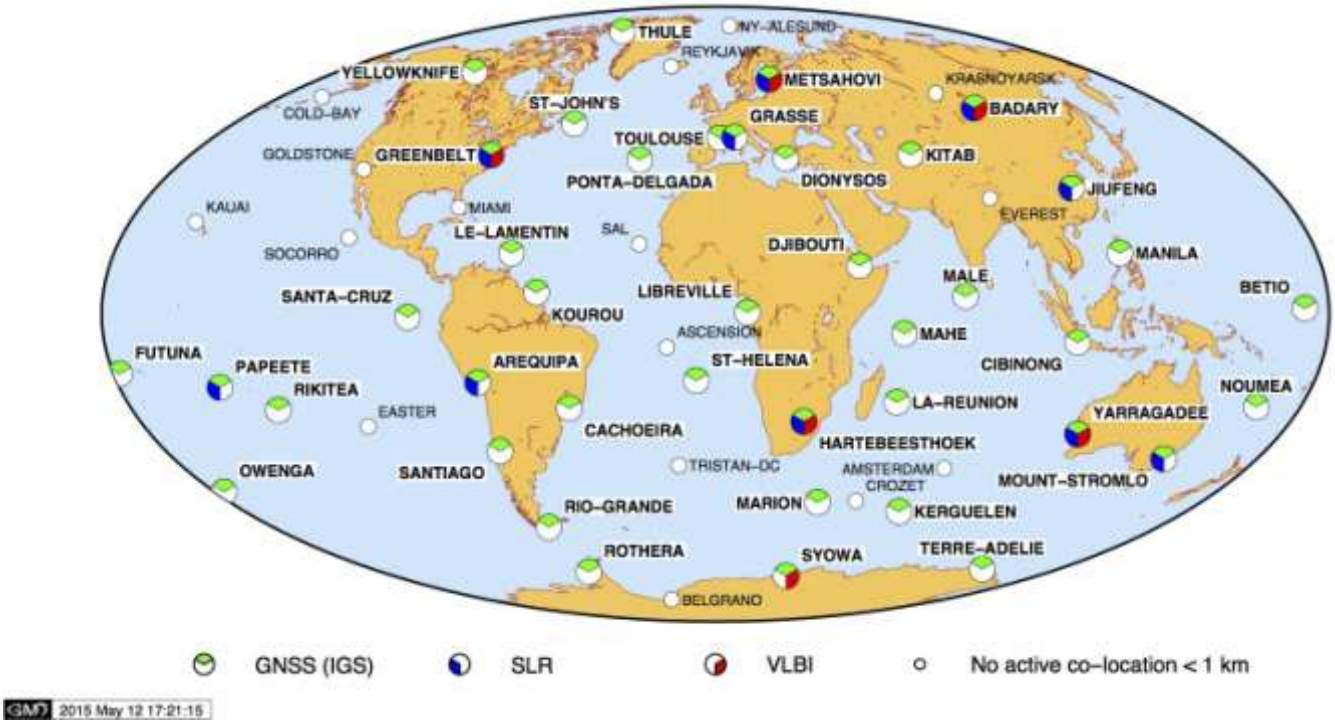


Figure 1.2: DORIS tracking network. Co-location with other IERS techniques As of May 2015.

As regards the ground equipment, the deployment of the remote control system allowing more rapid reaction to hardware failure is mostly complete. A new antenna type begins to roll out across the network. The letter "C" appears at the end of acronyms when this antenna type is used. This antenna is the same as the former one but the manufacturing process has been consolidated with more stringent specifications in order to better characterize the relative position of all the characteristic points of the antenna and draw up a more realistic error budget.

Efforts continued in the field to improve the monument stability at any new installation and to carry out high precision local tie surveys.

2. IDS organization

Like the other IAG Services, an IDS Governing Board (GB), helped by a Central Bureau (CB), organizes the activities done by the Analysis Centers (AC), the Data Centers (DC), and the Combination Center (CC).

2.1 Governing Board

On GB's request, a Working Group was formed on September 2010 to review and update the IDS Terms of Reference. The main evolutions of the text are:

- Revision of the election process of the GB members; the members at large are elected by the Associates Members, and not by the GB.
- Addition of a representative for the Combination Center.
- Addition of a DORIS system representative appointed by CNES
- Appointment of the network representative by IGN

The new Terms of Reference have been applied for the renewal of the GB whose term was ending in December 2012. Elections were held in Fall 2012. Because of the set up of the GB partial renewal process with election every two years, only 3 elected positions were renewed this time for the 4-year term 2013-2016: Analysis Center representative, Data Center representative, 1 member at large. The terms of Frank Lemoine (Analysis Coordinator) and John Ries (Member at large) have been extended for two additional years. Elections were organized in Fall 2014 to renew these two positions. The new members elected by the IDS Associates will serve four years from January 2015 to December 2018. For the first time, a tandem was chosen to occupy the seat of Analysis Coordinator. Hugues Capdeville and Jean-Michel Lemoine share together the responsibility and the work of the Analysis Coordination. From January 1st 2015, they can be contact at ids.analysis.coordination@ids-doris.org

Table 2.1 presents the evolution of the composition of the IDS Governing Board over 2009-2015. Note that since 2013, the GB is composed of eleven members instead of nine previously.

Table 2.1: Composition of the IDS Governing Board (2009 to 2015). Current members are indicated in bold.

Position	Term	Status	Name	Affiliation	Country
Analysis coordinator	**2015-2018**	Elected	**Hugues Capdeville** **Jean-Michel Lemoine**	CLS CNES/GRGS	France
	2013-2014	Ext'd	*Frank Lemoine*	NASA/GSFC	USA
	2009-2012	E.b.GB			
Data Centers' representative	**2013-2016**	Elected	**Carey Noll**	NASA/GSFC	USA
	2009-2012	Elected			
Analysis Centers' representative	**2013-2016**	Elected	**Pascal Willis (chair)**	IGN+IPGP	France
	2009-2012	Elected			
Member at large	**2015-2018**	Elected	**Marek Ziebart**	UCL	UK
	2013-2014	Ext'd	*John Ries*	U. Texas/CSR	USA
	2009-2012	E.b.GB			
Member at large	**2013-2016**	Elected	**Richard Biancale**	CNES/GRGS	France
	2009-2012	E.b.GB	*Pascale Ferrage*	CNES	France
Director of the Central Bureau	**since 2003**	Appointed	**Laurent Soudarin**	CLS	France
Combination Center representative	**since 2013**	Appointed	**Guilhem Moreaux**	CLS	France
Network representative	**2013-2016**	Appointed	**Jérôme Saunier**	IGN	France
	2010-2012	E.b.GB	*Bruno Garayt*	IGN	France
	2009	E.b.GB	*Hervé Fagard*	IGN	France
System representative	**2013-2016**	Appointed	**Pascale Ferrage**	CNES	France
IAG representative	**2013-2016**	Appointed	**Michiel Otten**	ESOC	Germany
	2009-2012	Appointed			
IERS representative	**2013-2016**	Appointed	**Brian Luzum**	USNO	USA
	2009-2012	Appointed	*Chopo Ma*	NASA/GSFC	USA

Elected = Elected by IDS Associates
E.b.GB = Elected by the previous Governing Board
Ext'd = Extended term for two years linked to the set up of the partial renewal process

2.2 Central Bureau

During the last four years, the Central has continued to improve the IDS information system. One of the main events is the launch of the IDS web service (http://ids-doris.org/webservice) named DOR-O-T for DORis Online Tools (pronounced like the French given name Dorothée) in 2014. The current version provides tools to browse time series in an interactive and intuitive way. It includes a network viewer to select sites and a family of plot tools to visualize the following time series: (1) station position differences at observation epochs relative to a reference position; (2) DORIS data residuals and the amount of available station observations as deduced from the CNES Precise Orbit Ephemeris processing, (3) outputs of the IDS Combination Center analysis, such as the Helmert parameters, and the WRMS. In addition to visualizing DORIS station coordinate time series, the web service also incorporates the time evolution of GNSS stations that are in co-location with DORIS, thanks to collaboration with the IGS Terrestrial Reference Frame Combination Center.

The website has been also improved. The content management system was upgraded. The updating of the web pages including station information is now easier since these data are now directly loaded from the database initially installed for the web service.

In 2012, then in 2014, the DORIS users were solicited to give their satisfaction level concerning the services provided by the IDS CB. They were invited to fill in a survey form on the IDS web site. These surveys helped the Central Bureau to improve the web site and the web service.

2.3 Data Centers

Since the beginning of the IDS, two data centers have provided open access to IDS data and products: the CDDIS, located in the U.S. and funded by NASA/GSFC (ftp://cddis.gsfc.nasa.gov) and IGN in France using two mirroring sites (ftp://doris.ign.fr and ftp://doris.ensg.ign.fr). They are both exact mirrors of each other, and so, are able to continue on an operational basis, even if one of them is inaccessible due to a temporary failure.

2.4 Analysis Centers and Analysis Coordination

In the last four years, the number of Analysis Centers slightly changed due to the cessation of the activities of Geoscience Australia as an IDS Analysis Center in December 2012.
There are currently six active Analysis Centers, using five different software packages, as displayed in Table 2.3.

Table 2.3: IDS Analysis centers. As of May 2015.

Acronym	Analysis Center	Country	Software Package
ESA	European Space Operation Center	Germany	NAPEOS
GOP	Geodetic Observatory Pecny	Czech Rep.	Bernese
GSC	Goddard Space Flight Center	USA	GEODYN
IGN	Institut Geographique National	France	GIPSY/OASIS
INA	INASAN	Russia	GIPSY/OASIS
GRG (formerly LCA)	Centre National d'Etudes Spatiales + Collecte Localisation Satellite	France	GINS/DYNAMO

Three other institutions contribute to IDS analysis too: GFZ, TU/Delft, the University College/London. It should also be mentionned that the Norwegian Mapping Authority (NMA) expressed in an interest in analysis of DORIS data, and also in multi-technique analyses. In the future, the participation of the NMA and other potential IDS ACs should continue to be encouraged.
The Analysis Centers and the associate groups works together within the Analysis Working Group (AWG), under the initiative of the IDS Analysis Coordinator (Frank Lemoine, NASA/GSFC), discussed their analysis strategy and provided tests solutions to IDS, as well as operational solutions in view of the ITRF2008 realization.
All the Analysis Centers have a very important commitment in the AWG. With the support of the Combination Center, they made sustained efforts in the last few years to implement improvements in their processing, to reprocess all the DORIS data, and to prepare weekly SINEX files from 1993 to 2014 for the development of the IDS contribution to ITRF2014.
The major changes that were validated in 2013-2014, included the following:
(1) The implementation and validation of the phase law for the DORIS antennae in the software of the different IDS Analysis Centers; (2) The introduction of new satellites into the DORIS weekly solutions; (3) The improvement in the troposphere modeling by some of the different IDS Analysis Centers; (4) The testing of improved gravity models, and associated models for atmospheric and ocean de-aliasing; (5) The identification of discrepancies in the processing for different analysis centers through comparison of the time series of empirical accelerations.
As a conclusion, we may highlight that six DORIS Analysis Centers successfully processed 20 years of data to 11 satellites and submitted SINEX files that were combined into an IDS solution for ITRF2014. The IDS Community should not rest on its laurels, as there are still many substantive issues that remain to be addressed, even with the current data already processed.

2.5 Combination Center

After the successful DORIS contribution to ITRF2008, IDS decided to extend the combination process to an operational service. Every 3 months, Analysis Centers deliver to the DCs 3 months of cumulated weekly SINEX solutions (including all the satellites) with a latency of 3 months.

In addition to its operational activities of evaluation and combination of all the individual ACs weekly solutions, the IDS Combination Center has been involved in several studies proposed by the AWG and the Analysis Coordinator:

- impact of the seven channels of the new DORIS DGXX receiver;

- impact of the properly handling of the beacon frequency offsets between the actual frequency of the transmitted signal at 2GHz by the beacons and its nominal value at 2.03625 GHZ (this correction solved copious amounts of artificial discontinuities and shifts in the vertical position time series);

- assessment of the ground antenna phase laws;

- contribution of each new satellite to the combination.

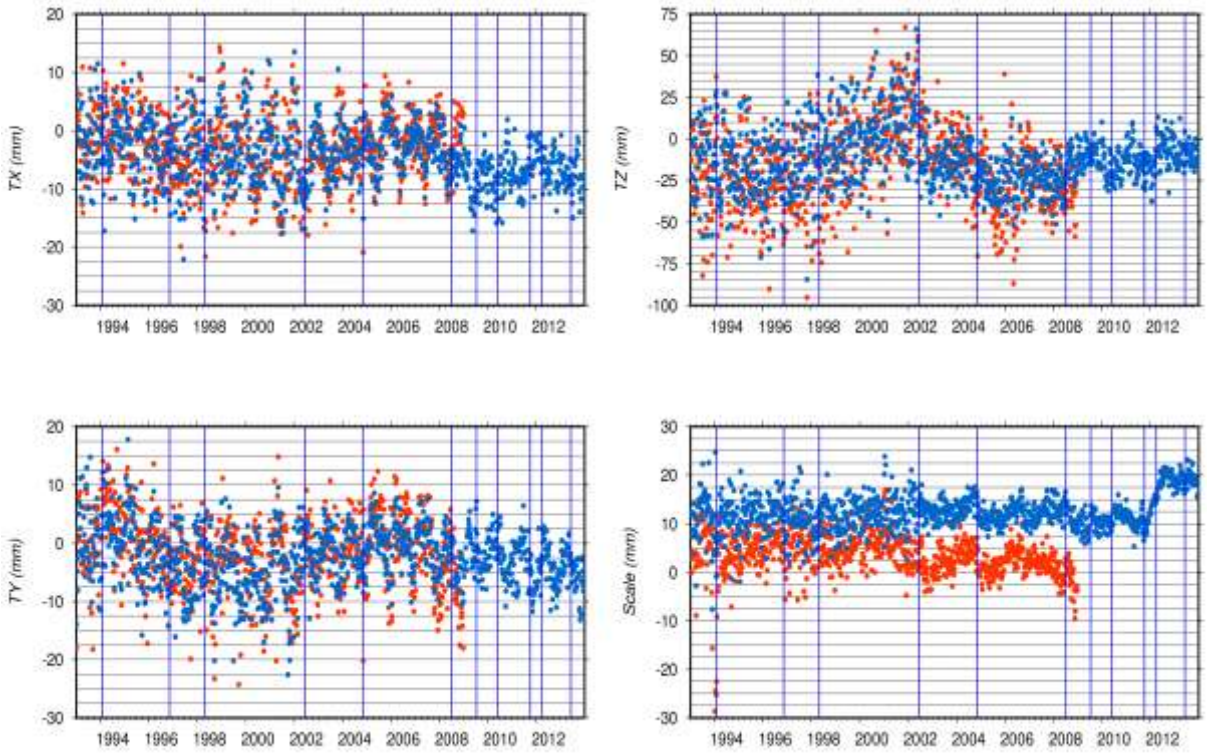


Figure 2.1 - Helmert parameters (translations and scale of the IDS contributions to ITRF2008 (red) and ITRF2014 (blue) with respect to ITRF2008.

From 2012, the activity of the Combination Center has been mainly devoted to the elaboration of the DORIS contribution to the next ITRF. In 2014, it delivered to IERS five versions of the IDS combined SINEX files. Each version is a set of eleven hundreds of weekly SINEX files including station coordinates and earth orientation parameters, covering the time period from 1993 to 2014. These IDS series are the result of the combination of weekly solutions from the six Analysis Centers (ESA, Geodetic Observatory of Pecny, NASA, IGN, INASAN, CNES/CLS). The data comes from three generations of DORIS receivers onboard of eleven satellites (Cryosat-2, Envisat, HY-2A, Jason-1,-2, Saral, SPOT-2,-3,-4,-5 and TOPEX/Poseidon) supported by a beacon network of nearly sixty stations uniformly spread across the globe. Due to Jason-1 and SPOT5 USO's sensitivity to the South Atlantic Anomaly (SAA), for these 2 missions IDS made available SAA corrected data. Evaluation of the IDS contribution to ITRF2008 (series 01) and to ITRF2014 (series 07) with respect to ITRF2008 (see Figure 2.1) showed:

- Improvements of Tx, Ty and Tz after 2002 (lower STDs, less annual signal) thanks to time variable gravity fields use in the ITRF2014 contribution.
- Scale offset (between the IDS contributions to the 2 ITRF) due to phase center's variations of the beacons in ITRF2014 processing.
- Less scale spurious values early 1994 (SPOT2 is no more included in the combined scale) in IDS series 07.
- No more scale factor discontinuity in 2002 thanks to beacon frequency offset estimations.

- Improvement of scale stability between end of TOPEX (late 2004) and Jason-2 start (mid 2008) thanks to Jason-1 including.
- Scale factor increase mid 2012.
- Better week-to-week repeatability of Helmert parameters of IDS series 07 (solution more consistent).

In addition, the evaluation process also pointed out that the IDS contribution to ITRF2013 gives higher differences of mainly X-pole estimates with the IERS C04 than the IDS contribution to ITRF2008 series. The explanation of that substantial degradation could be that the new solution uses 2 ACs less than the previous one.

3. IDS products

Table 3.1 presents the current IDS products available through the two IDS data centers. All Analysis Centers provided at a least a long-term weekly solution of SINEX files.

Table 3.1: IDS Product Types and Contributing Analysis Centers. As of December 2014

	ACs/Products										
Type of Product	**ESA**	**GAU***	**GOP**	**GRG****	**GSC**	**IDS**	**IGN**	**INA**	**LCA****	**SOD***	**SSA**
Time series of SINEX solutions (*sinex_series*)	X	X	X	X	X	X	X	X	X	X	X
Global SINEX solutions (*sinex_global*)				X			X		X		
Geocenter time series (*geoc*)							X	X	X		
Orbits/satellite (*orbits*)				X	X				X		X
Ionosphere products/satellite (*iono*)											X
Time series of EOP (*eop*)							X	X			
Time series of station coordinates (*stcd*)	X				X	X	X	X	X		X
Time series of SINEX solutions (2010campaign)		X	X		X		X	X	X		

*Note: GAU and SOD historic solutions
**Note: CNES/CLS transitioned their AC acronym from LCA to GRG in 2014.

4. IDS meetings and publications

4.1 Meetings

IDS organizes two types of meetings:
- IDS Workshops (every two years), opened to a large public and related to scientific aspects or applications of the DORIS systems
- Analysis Working Group Meetings (AWG) (when needed), more focussed on technical issues, and usually attended by representatives of Analysis Centers.

Table 4.1 summarizes all the IDS meetings held during the last four years.

Table 4.1: IDS meetings (June 2011 – May 2015).

Meeting	Location	Country	Dates
DORIS AWG Meeting	Prague	Czech Republic	31 May-1 June 2012
DORIS AWG Meeting	Venice	Italy	26 September 2012
IDS Workshop	Venice	Italy	25-26 September 2012
DORIS AWG Meeting	Toulouse	France	4-5 April 2013
DORIS AWG Meeting	Washington	USA	15-16 October 2013
DORIS AWG Meeting	Paris	France	26-27 March 2014
IDS Workshop	Konstanz	Germany	27-28 October 2014
DORIS AWG Meeting	Toulouse	France	28-29 May 2014

4.2 Publications

During the last four years, IDS published several annual reports (by chronological order) :

Willis, P., International DORIS Service (IDS), Report of the International Association of Geodesy 2007-2011, Travaux de l'Association Internationale de Geodesie, 2011.
http://ids-doris.org/documents/report/IDS_Report_2007_2011_for_IAG.pdf

Ferrage, P., Garayt, B., Govind, R., Kuzin, S., Lemoine, F., Ma, F., Moreaux, G., Noll, C., Otten, M., Ries, J.C., Saunier, J., Soudarin, L., Stepanek, P., Willis, P. International DORIS Service Activity report 2011, 85 pages, 2012.
http://ids-doris.org/documents/report/IDS_Report_2011.pdf

Ferrage, P., Garayt, B., Kuzin, S., Lemoine, F., Ma, F., Moreaux, G., Noll, C., Otten, M., Ries, J.C., Saunier, J., Soudarin, L., Stepanek, P., Willis, P. International DORIS Service Activity report 2012, 96 pages, 2013.
http://ids-doris.org/documents/report/IDS_Report_2012.pdf

Biancale, B., Capdeville, H., Ferrage, P., Garayt, B., Kuzin, S., Lemoine, F., Luzum, B., Moreaux, G., Noll, C., Otten, M., Ries, J.C., Saunier, J., Soudarin, L., Stepanek, P., Willis, P. International DORIS Service Activity report 2013, 98 pages, 2014.
http://ids-doris.org/documents/report/IDS_Report_2013.pdf

Capdeville, H., Couhert, A., Ferrage, P., Kuzin, S., Lemoine, F., Moreaux, G., Noll, C., Otten, M., Rudenko, S., Saunier, J., Schrama, E., Soudarin, L., Stepanek, P., Willis, P., International DORIS Service Activity report 2014, 120 pages, 2015.
(in preparation)

4.3 Peer-reviewed publications related to DORIS

Following two DORIS Special Issues published in Journal of Geodesy in 2006-2007, and Advances in Space Research (ASR) in 2010, a call for participation was issued by the Guest Editors (Frank Lemoine and Ernst Schrama) for a new DORIS Special Issue in ASR entitled "Scientific Applications of DORIS data in preparation of ITRF2014". The submission deadline for the papers is May 31, 2015.

IDS also maintains on its Web site a complete list of DORIS-related peer-reviewed articles published in international Journals (http://ids-doris.org/report/publications/peer-reviewed-journals.html). In the last five years, the following articles were published (by year):

In press

Jayles, C.; Chauveau, J.P.; Auriol, A., in press. DORIS/DIODE : Real-Time Orbit Determination Performance on Board SARAL/AltiKa, Marine Geodesy, DOI: 10.1080/01490419.2015.1015695

Willis, P.; Lemoine, F.G.; Moreaux, G.; Soudarin, L.; Ferrage, P.; Ries, J.; Otten, M.; Saunier, J.; Noll, C.; Biancale, R.; Luzum, B., in press. The International DORIS Service (IDS), recent developments in preparation for ITRF2013, IAG SYMPOSIA SERIES, 143

Willis, P.; Zelensky, N.P.; Ries, J.; Soudarin, L.; Cerri, L.; Moreaux, G.; Lemoine, F.G.; Otten, M.; Argus, D.F.; Heflin, M.B., in press. DPOD2008, a DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, IAG SYMPOSIA SERIES,143

2015

Couhert, A.; Cerri, L.; Legeais, J.F.; Ablain, M.; Zelensky, N.P.; Haines, B.J.; Lemoine, F.G.; Bertiger, W.I.; Desai, S.D.; Otten, M., 2015. Towards the 1 mm/y Stability of the Radial Orbit Error at Regional Scales, ADVANCES IN SPACE RESEARCH, 55(1), 2-3, DOI : 10.1016/j.asr.2014.06.041 1-year OPEN ACCESS

Gao, F.; Peng, B.; Zhang, Y.; Evariste, N.H.; Liu, J.; Wang, X.; Zhong, M.; Lin, M.; Wang, N.; Chen, R.; Xu H., 2015. Analysis of HY2A Precise Orbit Determination Using DORIS, ADVANCES IN SPACE RESEARCH, 55(5), 1394-1404, DOI : 10.1016/j.asr.2014.11.032

Zishen, L. ; Yunbin, Y.; Ningbo, W.; Hernandez-Pajares, M.; Xingliang, H., 2015. SHPTS: towards a new method for generating precise global ionospheric TEC map based on spherical harmonic and generalized trigonometric series functions, JOURNAL OF GEODESY, 89(4), 331-345, DOI: 10.1007/s00190-014-0778-9

2014

Bock, O.; Willis, P.; Wang, J.; Mears, C., 2014. A high-quality, homogenized, global, long-term (1993-2008) DORIS precipitable water dataset for climate monitoring and model verification, JOURNAL OF GEOPHYSICAL RESEARCH - ATMOSPHERES, DOI: 10.1002/2013JD021124

Dettmering, D.; Limberger, M.; Schmidt, M., 2014. Using DORIS measurements for modeling the vertical total electron content of the Earth's ionosphere, JOURNAL OF GEODESY, 48(12), 1131-1143, DOI : 10.1007/s00190-014-0748-2

Guo, J.; Zhao, Q.; Guo, X.; Liu, X.L.; Liu, J.N.; Zhou, Q., 2014. Quality assessment of onboard GPS receiver and its combination with DORIS and SLR for Haiyang 2A precise orbit determination, SCIENCE CHINA-EARTH SCIENCES, 58(1), 138-150, DOI: 10.1007/s11430-014-4943-z

Kong, Q.; Guo, J.; Hwang, C.; Gao, F.; Lin, H.; Zhao, C., 2014. Precise orbit determination and accuracy analysis of HY-2A satellite using DORIS Doppler data, ACTA GEODAETICA ET GEOPHYSICA, 49(4), 455-470, DOI : 10.1007/s40328-014-0066-4

Kosek, W.; Wnęk, A.; Zbylut-Górska,M.; Popiński, W., 2014. Wavelet analysis of the Earth center of mass time series determined by satellite techniques, JOURNAL OF GEODYNAMICS, DOI: 10.1016/j.jog.2014.02.005

Palanisamy, H.; Cazenave, A.; Meyssignac, B.; Soudarin, L.; Wöppelmann, G.; Becker, M., 2014. Regional sea level variability, total relative sea level rise and its impacts on islands and coastal zones of Indian Ocean over the last sixty years, GLOBAL AND PLANETARY CHANGE, 116:54-67, DOI: 10.1016/j.gloplacha.2014.02.001

Rudenko, S.; Dettmering, D.; Esselborn, S.; Schöne, T.; Förste, C.; Lemoine, J.M.; Ablain, M.; Alexandre, D., Neumayer, K.H., 2014. Influence of time variable geopotential models on precise orbits of altimetry satellites, global and regional mean sea level trend, ADVANCES IN SPACE RESEARCH, 54(1): 92-118, DOI: 10.1016/j.asr.2014.03.010

Stepanek, P.; Rodriguez-Solano, C.J.; Hugentobler, U.; Filler, V., 2014. Impact of orbit modeling on DORIS station position and Earth rotation estimates, ADVANCES IN SPACE RESEARCH, 53(7):1058-1070, DOI: 10.1016/j.asr.2014.01.007

Willis, P.; Bock, O.; Bar-Sever, Y.E., 2014. DORIS Tropospheric Estimation at IGN, Current Strategies, GPS Intercomparisons and Perspectives, IAG SYMPOSIA SERIES, 139:11-18, DOI: 10.1007/978-3-642-37222-3_2

Zhou, Q.; Guo, J.; Zhao, Q., 2014. Precise orbit determination for Haiyang 2A satellite using un-differenced DORIS code and phase measurements, LECTURE NOTES IN ELECTRICAL ENGINEERING, 305(3), 31-39. DOI: 10.1007/978-3-642-54740-9_3

2013

Cerri, L.; Lemoine, J.M.; Mercier, F.; Zelensky, N.P.; Lemoine, F.G., 2013. DORIS-based point mascons for the long term stability of precise orbit solutions, ADVANCES IN SPACE RESEARCH, 52(3):466-476, DOI: 10.1016/j.asr.2013.03.023

Guo, J.; Kong, Q.; Qin, J.; Sun, Y., 2013. On precise orbit determination of HY-2 with space geodetic techniques, ACTA GEOPHYSICA, 61(3):752-772, DOI: 10.2478/s11600-012-0095-8

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