International DORIS Service (IDS)

https://ids-doris.org/

Chairman of the Governing Board: Frank Lemoine (USA)
Director of the Central Bureau: Laurent Soudarin (France)

Overview

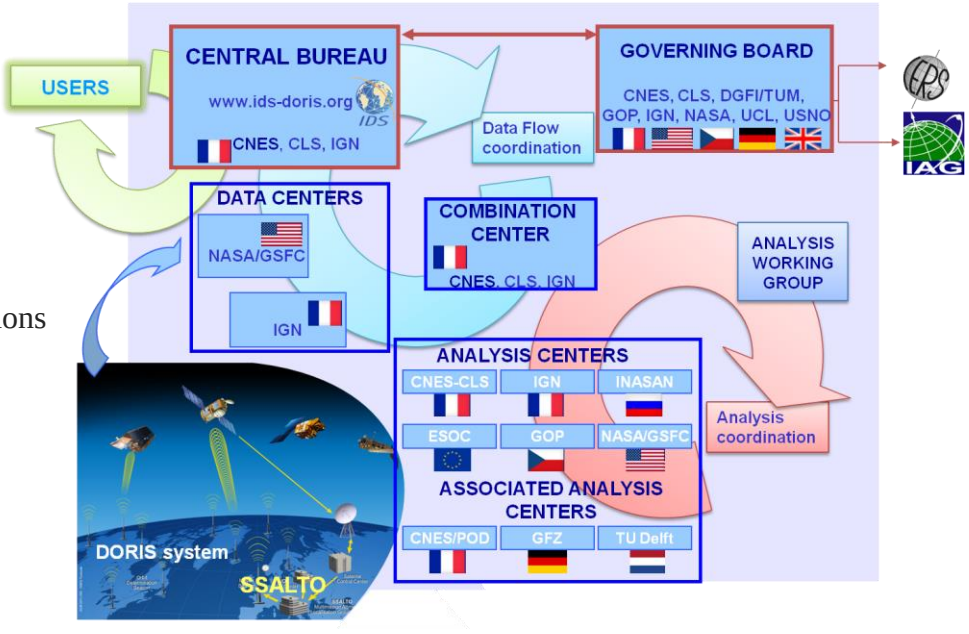
The main achievements of the International DORIS Service (IDS) over the period July 2015-June 2019 were (1) the contribution to ITRF2014, (2) the preparation of articles for the DORIS Special Issue in the journal "Advances in Space Research", and (3) the initiation of a routine operational delivery of an IDS combination on a quarterly basis. Six IDS analysis centers (ACs) used five separate analysis packages to create IDS products as well as to reprocess all DORIS data since 1993 for inclusion in the DORIS combination for ITRF2014. The Combination Center in Toulouse creates the routine combinations in close collaboration with the Analysis Coordinators and the Analysis Centers. The components of the IDS meet regularly primarily during Analysis Working Group (AWG) meetings to discuss progress on current technical questions. The Governing Board of the IDS 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 next months will be focused on the preparation of the next ITRF, the activities are already underway.

The current report presents the different activities held by all the components of the IDS for the period from the middle of 2015 to the middle of 2019.

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**, three new satellites were launched over the report period: Jason-3 and Sentinel-3A, in early 2016, and Sentinel-3B in 2018. They all use the new 7-channel DGXX-S DORIS on-board receiver. The DORIS constellation has steadily increased, and now includes seven satellites at altitudes between 720 and 1336 km, with near-polar or TOPEX-like inclination (66 deg).

Table 1: DORIS data available at IDS data centers, as of June 2019

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	1-DEC-2015	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
JASON-3	19-JAN-2016	PRESENT	NASA/CNES/NOAA/ Eumetsat	Altimetry
SENTINEL-3A	23-FEB-2016	PRESENT	GMES/ESA	Altimetry
SENTINEL-3B	25-APR-2018	PRESENT	GMES/ESA	Altimetry

In the next few years, more DORIS satellites are planned: Sentinel-3C and 3D, HY-2C and 2D, Jason-CS1/SENTINEL-6A and Jason-CS2/SENTINEL-6B, SWOT (Surface Water Ocean Topography). In addition, other missions are under consideration.

Figure 1 summarizes the evolution of the DORIS constellation since the launch of the SPOT-2 satellite in 1990, and includes satellites that are currently planned. It must be noted that in the past last years, four or more DORIS satellites have been available to IDS users, which is a key requirement for the precision of the geodetic products.

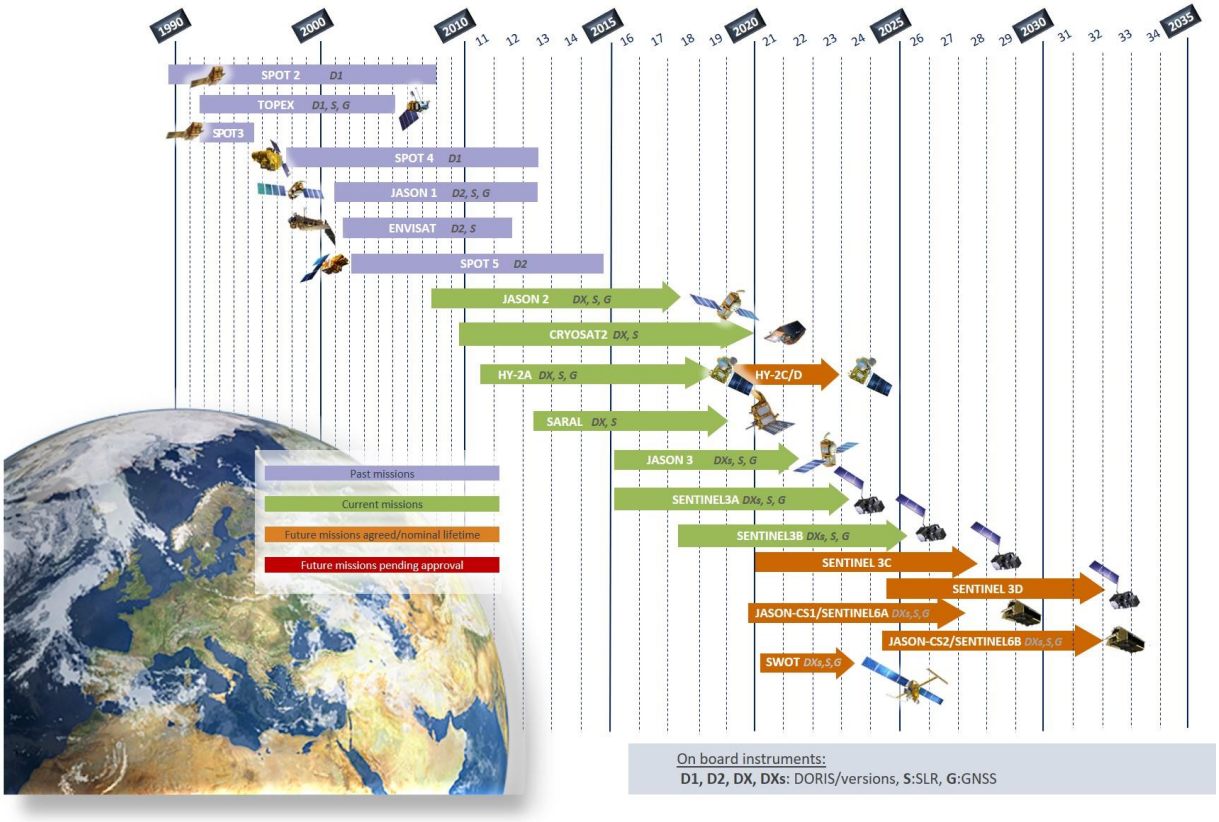


Figure 1: DORIS satellite constellation. As of June 2019.

1.2 DORIS network

DORIS has a globally distributed network of 57 permanent stations dedicated for precise orbit determination and altimetry with four master beacons (Papeete, Hartebeesthoek, Kourou, Toulouse) and one time beacon (Terre-Adélie). Two additional DORIS stations are used for other scientific purposes: Wettzell (Germany) and Mangilao (Guam Island, USA). See **Figure 2**.

There have been many developments and maintenance operations for the ground network during the report period.

In 2015, a new DORIS station, “GONC”, was installed at the Goldstone Deep Space Communications Complex (GDSCC) in California. DORIS occupied this site at Goldstone between 1988 and 2004 but the station was moved 300 km south to Monument Peak (east of San Diego, California) for co-location with the SLR tracking station “7110” and the GNSS station “MONP”. Unfortunately, following insoluble conflict at the 2 GHz frequency with a nearby TV microwave relay system, which manifested itself after the US switched to digital television transmissions in 2009, the DORIS station of Monument Peak had to be decommissioned in 2010 after only four and a half years of service. After discussion with NASA, it was determined that the remote location of the GDSCC in the heart of the Mojave Desert was the best option to ensure a safe and unencumbered environment for the DORIS station. The return to service of DORIS in California is of great importance for the development of altimetry data products. A gap in coverage leads to degradation in orbit determination, which affects both the real-time orbits computed by the DIODE instrument on-board the DORIS satellites, as well as for the precise orbits that are computed later. This much-awaited station fills a hole in the DORIS data coverage over the northern Pacific Ocean.

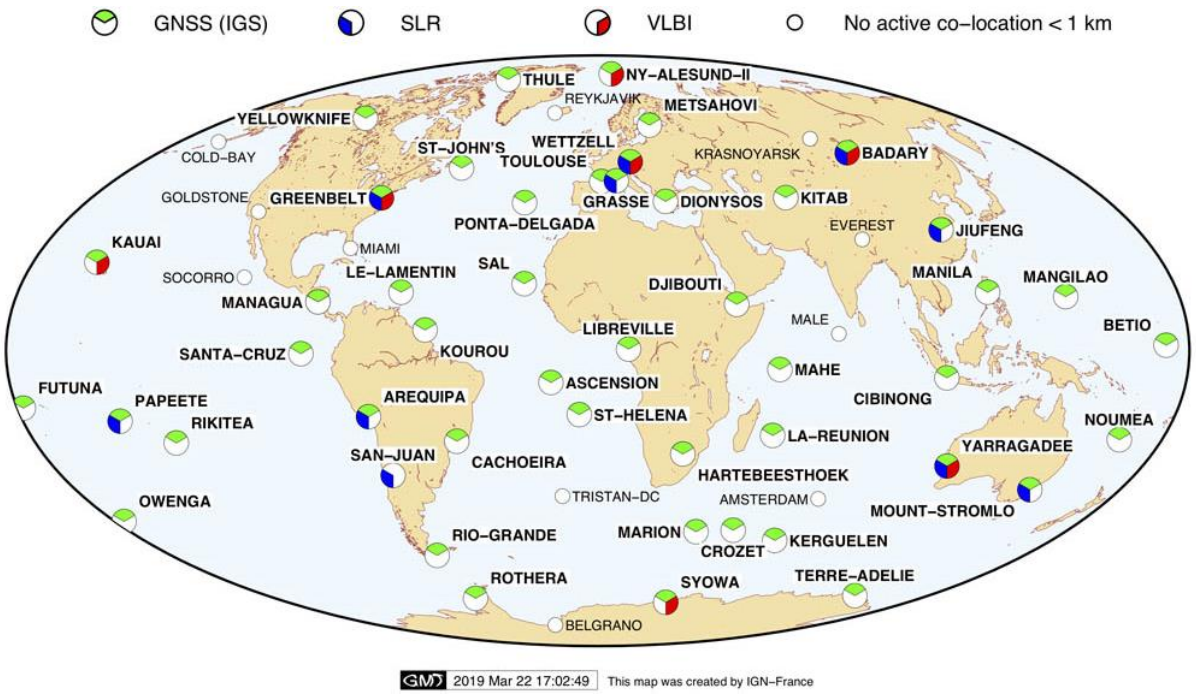


Figure 2: DORIS tracking network. Co-location with other IERS techniques as of March 2019.

On September 27, 2016, the new DORIS station at the Geodetic Observatory Wettzell started work with shifted frequencies to avoid internal jamming with the nearby stations of the permanent network. The most challenging requirement was to manage potential interference with VLBI. After some months of intensive tests carried out on site, a compromise was reached to minimize potential problems for both systems. Greenbelt and Wettzell are now two examples of core sites complying with the GGOS requirements with the four space geodetic techniques (co-located DORIS/GNSS/SLR/VLBI).

Another main event of 2016 was the installation of a new DORIS station in Managua, Nicaragua. Fully integrated within the data coverage map, this new station is also well located to provide reliable information on the Caribbean tectonic plate motion when combined with the DORIS station data of "Le Lamentin", on the island of Martinique in the French West Indies.

In April 2018, a new DORIS site was set up on Guam, at Mangilao, close to the IGS station "GUUG" and the tide-gauge of Pago Bay (PSMSL 2130). This station provides a significant contribution to the coverage of the western North Pacific Ocean over the Micronesia and the Mariana Trench.

Two other main events occurred in 2018, both in Argentina: the restarting of Rio Grande (province of Tierra del Fuego) after a 2-yr outage and the station installation at San Juan (province of San Juan, northwest of Mendoza). These two stations were both expected to fill the coverage gap in this area. Finally, in October, the station in Svalbard was relocated about 3 km away to be part of the new geodetic observatory Ny-Ålesund II. The new twin telescopes of the VLBI Geodetic Observing System at Ny-Ålesund II were dedicated in June 2018.

Since 2015, the DORIS network has provided reliable service with the total number of operating stations approaching an annual average of about 90% of active sites, thanks to the responsiveness and the combined efforts of CNES, IGN and all agencies hosting the stations.

As regards the ground equipment, the 4th beacon generation is under development with a view to starting deployment in 2019. Designed with new electronic components and new architecture, this new beacon model will provide better performance and reliability and will allow the DORIS antenna to be installed up to 50 m from the beacon (the limit is currently 10 m). This will improve options for placement of new stations, while still satisfying the station visibility constraint of minimizing obstructions at low elevation.

Efforts continue towards increasing the number of co-located sites, improving the monument stability at any new installation and carrying out high precision local tie surveys. There are currently several projects under way in North Australia (Katherine), in China and in French Polynesia (Papenoo), in the framework of the future geodetic observatory of Tahiti.

All tie vectors between DORIS and the other techniques are compiled in a maintained file available on the IDS data centers: ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_ext_ties.txt

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

The GB consists of eleven voting members and a number of nonvoting members. The voting membership of the GB is composed of 5 members elected by the IDS Associates, and 6 appointed members. The elected members have staggered four-year terms, with elections every two years. The Analysis Centers' representative, the Data Centers' representative, and one Member-at-Large are elected during the first two-year election. The Analysis Coordinator and the other Member-at-Large are elected in the second two-year election. In accordance with the Terms of Reference of the IDS, the GB was then partially renewed in January 2017 and January 2019 (see **Table2**).

In the Fall 2016, the CB organized the elections for the Analysis Centers' representative, the Data Centers' representative, and one Member-at-Large. In addition, IDS proceeded to the renewal of four representatives appointed respectively by CNES (DORIS system), IGN (network), IAG and IERS. First, the CB contacted the relevant organizations to appoint their representatives; second, the CB organized the elections for the three vacant positions. In a final step for the GB elected its new chairman.

The members who were elected or appointed for the term 2017-2020 are:
- Frank Lemoine (NASA/GSCF) as Analysis Center Representative,
- Patrick Michael (NASA/GSCF) as Data Center Representative,
- Denise Dettmering (DGFI/TUM) as Member-at-Large,
- Pascale Ferrage (CNES), reappointed by CNES as the DORIS system representative,
- Jérôme Saunier (IGN), reappointed by IGN as the Network representative.
- Brian Luzum (USNO), reappointed by IERS as the IERS representative.
- Petr Štěpánek (Geodetic Observatory Pecny), nominated by IAG Executive Committee in February 2017 as the IAG representative to succeed Michiel Otten who served two terms.

The new Governing Board has designated Frank Lemoine as the new Chairperson of the IDS Governing Board for 2017-2020.

In addition, the CB carried out the selection of the Combination Center for 2017-2020. The call for proposals for the successor to the current Combination Center closed on October 15. Only one proposal was submitted, that of CNES/CLS who applies to continue the activities of the Combination Center. The GB accepts the application and selects it as the IDS Combination Center for a new period of four years, starting on January 1, 2017. Guilhem Moreaux (CLS) remains the representative of the Combination Center within the GB.

In the fall 2018, elections were organized for the Analysis Coordinator and the other Member-at-Large. the new members elected by the IDS Associates for the term 2019-2022 are:

- Hugues Capdeville (CLS) and Petr Štěpánek (Geodetic Observatory Pecny) as Analysis Coordinator,
- Claudio Abbondanza (NASA/JPL) as a Member at Large.

It is important to note that Hugues Capdeville and Petr Štěpánek will share the responsibility and the work of the Analysis Coordination. From January 1st, 2019, the IDS Analysis Coordinator team can be contact at ids.analysis.coordination@ids-doris.org.

Because of his new responsibility within the IDS Governing Board, Petr Štěpánek resigned from his position of IAG Representative. Another representative will be designated by IAG for 2019-2020.

2.2 IDS retreat

After 15 years of activity, the IDS organized its first retreat on June 13 and 14 at Château de Mons, near the small town of Caussens, in Gascony, in the Southwest of France (country of the Musketeers and Armagnac). In addition to the members of the IDS Governing Board, eleven people including outside members of IDS such as Christian Bizouard (Observatoire de Paris), Klaus Börger (University of Bonn), Pierre Exertier (OCA), Oliver Montenbruck (DLR), Paul Poli (SHOM) were asked to work on the strengths, weaknesses, opportunities and threats of the IDS. To support the general discussions dealing with how to grow or to increase the visibility of the IDS, five subjects of special interest (possible evolution of the DORIS technology, Precise Orbit Determination, interest in ionospheric-tropospheric derived products, DORIS geocenter and pole estimations, IDS scientific goals and organization) were addressed. From the minutes of all the discussions, the IDS Governing Board will write a preliminary version of the IDS strategic plan. The next step will be consultation with the DORIS system stakeholders. Then, the first IDS strategic plan including both medium and long-term actions will be made available.

2.3 Central Bureau

The Central Bureau, funded by CNES and hosted at CLS, is the executive arm of the Governing Board and as such is responsible for the general management of the IDS consistent with the directives, policies and priorities set by the Governing Board. It brings its support to the IDS components and operates the information system.

The Central Bureau participated in the organization of the AWG meetings and the IDS Workshop held between 2015 and 2019 (see **Table 5**). It documented the Governing Board meetings held on these occasions. The Minutes of the GB meetings are available on the website at https://ids-doris.org/ids/reports-mails/governing-board.html#minutes.

Table 2: IDS GB members since 2003, with members in office on January 1st, 2019, indicated in bold.

Position	Term	Status	Name	Affiliation	Country
Analysis coordinator	**2019-2022**	**Elected**	**Hugues Capdeville** **Petr Štěpánek**	**CLS** **Geodetic Obs. Pecny**	**France** **Czech Republic**
	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*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2005-2008		*Frank Lemoine (subst.)*	*NASA/GSFC*	*USA*
	2003-2005		*Martine Feissel-Vernier*	*IGN/Paris Obs.*	France
Data Centers' representative	**2017-2020**	**Elected**	**Patrick Michael**	**NASA/GSFC**	**USA**
	2013-2016	*Elected*	***Carey Noll***	*NASA/GSFC*	*USA*
	2009-2012	*Elected*	*Carey Noll*	*NASA/GSFC*	*USA*
	2003-2008		Carey Noll	NASA/GSFC	USA
Analysis Centers' representative	**2017-2020**	**Elected**	**Frank Lemoine (chair)**	**NASA/GSFC**	**USA**
	2013-2016	*Elected*	***Pascal Willis (chair)***	*IGN+IPGP*	*France*
	2009-2012	*Elected*	*Pascal Willis (chair)*	*IGN+IPGP*	*France*
	2003-2008		Pascal Willis	IGN+IPGP	France
Member at large	**2019-2022**	**Elected**	**Claudio Abbondanza**	**NASA/JPL**	**USA**
	2015-2018	*Elected*	***Marek Ziebart***	*UCL*	*UK*
	2013-2014	Ext'd	John Ries	Univ. Texas/CSR	USA
	2009-2012	E.b.GB	John Ries	Univ. Texas/CSR	USA
	2003-2008		John Ries	Univ. Texas/CSR	USA
Member at large	**2017-2020**	**Elected**	**Denise Dettmering**	**DGFI/TUM**	**Germany**
	2013-2016	*Elected*	***Richard Biancale***	*CNES/GRGS*	*France*
	2009-2012	E.b.GB	Pascale Ferrage	CNES	France
	2003-2008		Gilles Tavernier (chair)	CNES	France
Director of the Central Bureau	**Since 2003**	**App.**	**Laurent Soudarin**	**CLS**	**France**
Combination Center representative	**Since 2013**	**App.**	**Guilhem Moreaux**	**CLS**	**France**
Network representative	**2017-2020**	**App.**	**Jérôme Saunier**	**IGN**	**France**
	2013-2016	*App.*	***Jérôme Saunier***	*IGN*	*France*
	2010-2012		Bruno Garayt (subst.)	IGN	France
	2009	E.b.GB	Hervé Fagard	IGN	France
	2003-2008		Hervé Fagard	IGN	France
DORIS system representative	**2017-2020**	**App.**	**Pascale Ferrage**	**CNES**	**France**
	2013-2016	*App.*	***Pascale Ferrage***	*CNES*	*France*
IAG representative	**2019-2020**	**App.**	**To be appointed**		
	2017-2018	*App.*	***Petr Štěpánek***	*Geodetic Obs. Pecny*	*Czech Republic*
	2013-2016	*App.*	***Michiel Otten***	*ESOC*	*Germany*
	2009-2012	*App.*	Michiel Otten	ESOC	Germany
	2003-2008		Not designed		
IERS representative	**2017-2020**	**App.**	**Brian Luzum**	**USNO**	**USA**
	2013-2016	*App.*	***Brian Luzum***	*USNO*	*USA*
	2009-2012	*App.*	Chopo Ma	NASA/GSFC	USA
	2003-2008		Ron Noomen	TU Delft	Netherlands

App. = Appointed ; 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

The Central Bureau maintains the web resources of the IDS. A new version of the IDS website was proposed in early 2017 with an updated design and structure. The website is now accessed using the secure HTTPS protocol. Besides the regular updates of pages and additions of documents, the website was upgraded and enriched with new pages. The IDS video channel was created on YouTube (https://www.youtube.com/channel/UCiz6QkabRioCP6uEjkKtMKg) to host a set of existing videos for outreach, and new videos showing the DORIS-equipped satellites in orbit. These videos were produced with the Visualization Tool for Space Data (VTS) free software from CNES.

A new page of outreach material was created. It gathers links to the videos, leaflets and newsletters as well as some material to discover DORIS https://ids-doris.org/ids/reports-mails/outreach-material.html.

A new version of the IDS web service (http://ids-doris.org/webservice) was proposed in early 2017. It is based on the latest Highcharts/Highstock library, and a new version of the network viewer. Improvements were brought to make the service more ergonomic, simpler and more practical, especially on mobile devices. The webservice is now accessed using the secure HTTPS protocol.

It has been upgraded with new plot tools to visualize the time series of Earth Orientation Parameters and the position residuals (North, East, Up) of the cumulative solution derived from the routine analysis of the IDS Combination Center.

Several new features were added to the network viewer (https://apps.ids-doris.org/apps/map.html). In addition to the DORIS network and the IGS co-located stations, it is now possible to display the boundaries of the tectonic plates (Bird, 2003), the large Earthquakes (magnitude greater or equal to 6) within a 500 km radius of the DORIS stations (source USGS), as well as the horizontal and vertical velocity vectors of the DPOD2014 solution. When the velocity vectors are showed, rates are displayed on mouse-over. Rates (North, East and Up; in mm/yr) can also been seen in the list of information linked to each station, obtained by clicking on a station. This list includes now local events, i.e., the events of the station (dates of installation, change of beacon equipment, Earthquakes in the vicinity).

At its meeting in Washington in October 2015, the Governing Board asked the Central Bureau to consider the publication of a newsletter. The intention is to improve the flow of information within the community of providers and users of DORIS data and products, to highlight the activities of the groups participating in the IDS, and to bring the DORIS and IDS news to a wider audience, from the host agencies to the other sister services. In March 2016, the Central Bureau proposed a draft to the Governing Board who approved the concept. So, the IDS Newsletter was created. Three issues were published in 2016 (#1 in April, #2 in July, and #3 in December), one in 2017 (#4 in November), one in 2018 (#5 in September) and one in 2019 (#6 in February). The issues are distributed via email to the subscribers to the DORISmail and a number of identified managers and decision-makers. They are also available from the IDS website (https://ids-doris.org/ids/reports-mails/newsletter.html).

The Central Bureau works with the SSALTO multi-mission ground segment and the Data centers to coordinate the data and products archiving and the dissemination of the related information. Data, meta-data and documentation of the three missions Jason-3, Sentinel-3A and Sentinel-3B, were put online the IDS data and information sites as they become available

During the change to the new file upload system at the CDDIS, the Central Bureau also interacted with the CDDIS staff, SSALTO, and the IDS components in order to ease the transition.

2.4 Data Centers

Two data centers currently support the archiving and distribution of data for the IDS:

- Crustal Dynamics Data Information System (CDDIS), funded by NASA and located in Greenbelt, Maryland USA
- l'Institut National de l'Information Géographique et Forestière (IGN) in Marne la Vallée France

Both of these institutions have archived DORIS data since the launch of TOPEX/Poseidon in 1992. The CDDIS (ftp://cddis.nasa.gov) runs fully redundant systems with both primary and secondary systems at different physical locations with access transparent to the end user. IGN in France uses two sites (ftp://doris.ign.fr) and (ftp://doris.ensg.ign.fr) which are exact mirrors of each other offering continued operations even if one of them is inaccessible due to a temporary failure. The data holdings between CDDIS and IGN are not mirrored between the sites but rely on data providers to upload data and products to both to ensure full coverage at each center.

On 1 December 2016, CDDIS moved its entire operations to new facilities associated with its parent organization the Earth Observing System Data and Information System (EOSDIS). At the same time, it moved away from the old ftp protocol to a https-based upload procedure for data uploads; this new procedure offers both web and command line interfaces. The move to https was necessitated by security and operational concerns. Before the transition all DORIS data and products were supplied by seven individuals/groups. On 1 December 2016, five (5) of the suppliers (GSFC, ESA, SSALTO, INA, IDS ACC) had made the transition to the new procedure with the remaining two groups (GOP, IGN) transitioning to the new procedure in March 2017.

In 2017, CDDIS developed all new software to automate the ingest of data submitted by SSALTO and in 2018 add product ingest as well. This new software is a significant improvement over the previous process and performs a full range of quality-checks and metadata extraction. The software uses these new checks and metadata to generate a summary file for each data file. All incoming DORIS data have its metadata extracted and stored in a local database. These metadata, which includes satellite, time span, station, and number of observations per pass, and are utilized to generate data holding reports on a daily basis.

2.5 Analysis Centers and Analysis Coordination

The activities of all the DORIS analysts over the last four years were dominated by 1) the IDS contribution to ITRF2014, 2) assessing the three TRFs 2014 solutions and the DPOD2014, 3) the implementation of the data processing of DORIS RINEX, 4) considering the last DORIS satellites Jason-3, Sentinel-3A and Sentinel-3B, 5) defining the best strategy to mitigate the impact of the sensitivity to the South Atlantic Anomaly (SAA) effect of DORIS Ultra Stable Oscillator (USO), and 6) starting the preparation of the next ITRF contribution.

Analysis working group met six times, in Toulouse (France), May 28-29, 2015 (*hosted by Collecte Localisation Satellites*), in Greenbelt, Maryland (USA), October 15-16, 2015 (*hosted by NASA Goddard Space Flight Center in Greenbelt, Maryland, USA*), in Delft (The Netherlands), May 26-27, 2016 (hosted by Technical University of Delft), in London (UK), May 22-23, 2017 (hosted at the University College London), in Toulouse (France), June 11,

2018 (*hosted by CNES),* and in Munich (Germany), April 4, 2019 (hosted by DGFI). Two IDS Workshops were organized in 2016 and 2018. The first one was held in La Rochelle (France), October 31 to November 01, 2016, in conjunction with the Ocean Surface Topography Science Team (OSTST) meeting. The second was held from 24 to 26 September 2018 in Ponta Delgada (Azores Archipelago, Portugal), as part of the 25 Years of Progress in Radar Altimetry Symposium with the Ocean Surface Topography Science Team (OSTST) 2018.

For ITRF2014, the six active analysis centers agreed to submit new SINEX solutions. In addition, the CNES POD center is a lead DORIS analysis center. They do not submit SINEX solutions for the IDS combination, but since they have prime POD responsibility for many of the DORIS satellites, they are the source for much of the spacecraft information needed for processing. In addition, they prepare the DORIS format 2.2 data (the range-rate format) that is used by the IDS ACs. We have also the participation by three other institutions: GFZ, TU/Delft, The University College/London. The GeoForschung Zentrum (GFZ) has participated in several of the IDS meetings, and focused on the POD analysis for altimeter satellites. TU/Delft is analyzing data from Cryosat-2, and has made available the spacecraft quaternions for use by other team members. UCL is interested in working with individual DORIS ACs on the refinement of non-conservative force modeling for DORIS satellites. GFZ was recognized by the Governing Board as an Associated Analysis Center (AAC) in October 2015. CNES POD and TU/Delft became AAC in May 2017.

So to summarize, the IDS includes six Analysis Centers and three Associated Analysis Centers who use seven different software packages, as summarized in **Table 3**. We also note which analysis centers on a routine basis perform POD analyses of DORIS satellites using other geodetic techniques (c.f. Satellite Laser Ranging (SLR), or GNSS). The multitechnique analyses are useful since they can provide an independent assessment of DORIS system performance, and allow us to validate more easily model changes and the implementation of attitude laws for the different spacecraft, in the event spacecraft external attitude information (in the form of spacecraft quaternions) is not available.

Several groups expressed interest in the analysis of DORIS data, as well as in multi-technique analyses, such as the Norwegian Mapping Authority (NMA) and the Deutsches Geodaetisches Forschungsinstitut der Technischen Universitaet Muenchen (DGFI-TUM). Their respective representatives, Geir Arne Hjelle and Mathis Blossfeld, have regularly attended the IDS meetings. Their participations and that of other potential IDS ACs are strongly encouraged.

Table 3: Summary of IDS Analysis Centers

Name	AC	AAC	Location	Contact	Software	Multi-technique
ESA	**X**		Germany	Michiel Otten	NAPEOS	SLR, GNSS
GOP	**X**		Czech Republic	Petr Stepanek	Bernese	
GRG	**X**		France	Hugues Capdeville	GINS	SLR, GNSS
GSC¶	**X**		USA	Frank Lemoine	GEODYN	SLR
IGN	**X**		France	Pascal Willis	GIPSY	
INA	**X**		Russia	Sergei Kuzin	GIPSY	
CNES		**X**	France	Alexandre Couhert	Zoom	SLR, GNSS
GFZ		**X**	Germany	Rolf Koenig	EPOS-OC	SLR, GNSS
TU Delft		**X**	The Netherlands	Ernst Schrama	GEODYN	SLR

Following the DORIS processing for the realization of the ITRF2014, there were still many substantive issues that remained to be addressed. Some issues, such as the jump in the DORIS scale (2012 and later) have been analyzed. The IDS scale jump in 2012 is now fully explained by a variation in the number of low-elevation measurements included in the processing. Indeed, the increase of the scale factor for Jason-2 and Cryosat-2 is linked to the change of tropospheric model used by CNES in its POD processing (GDR standards): from CNET (GDR-C) to GPT/GMF (GRD-D). It caused a reduction of the amount of data marked as "rejected" in the doris2.2 file (input DORIS data file) and then, an increase of the data used considered to be good in CNES pre-processing. The larger amount of data, especially at low elevation, could thus be the cause of the change observed in the scale factor. The date of change is mission dependent. The scale increase of the multi-satellite solutions is due to the jump of the scale of the Jason-2 and Cryosat-2 solutions as well as to the high scale of HY-2A, whose DORIS data became available starting in November 2011. So, IDS ACs need to do their own pre-processing. Investigation to solve the large value of the scale observed on HY-2A is still ongoing.

Since 2008, starting with Jason-2, the satellites equipped with a DORIS receiver carry the new generation of receivers called DGXX which provides phase and pseudo-range measurements. They are distributed in a dedicated format, called RINEX/DORIS 3.0 derived from the RINEX/GPS format. One major advantage of these new measurements is that they are available with a very short latency. They also allow analysis centers to be less dependent on the CNES since the new data format provides the raw information that is necessary for computing the ionosphere delays and the precise time-tagging of the measurements. This was not the case for the former data format where this information was only given in a pre-processed form, following a pre-processing done by the CNES. While CNES supplies data files in doris2.2 and RINEX/DORIS 3.0 formats for the missions equipped with DGXX (Jason-2, Cryosat-2, HY-2A and Saral), only the latter format is available for the missions from Sentinel-3A and Jason-3 and following. To help ACs to implement the RINEX data processing in their software a dedicated web page about DORIS RINEX data was created on the IDS website:
https://ids-doris.org/analysis-coordination/about-doris-rinex-format.html

IDS completed an assessment of the three realizations of the Terrestrial Reference Frame which are the outcome of the "ITRF2014 effort": the ITRF2014 (IGN), DTRF2014 (DGFI) and JTRF2014 (JPL). While ITRF2014 and DTRF2014 are qualitatively similar, differing mainly by the Post Seismic Deformation model (PSD), which was introduced into the IGN solution, the JPL solution was quite different, being a time series of weekly solutions obtained through a Kalman filter process. Due to editing criteria the JPL solution contains less stations at a given time than the two other realizations, particularly at the beginning of the DORIS data period, in 1993. The three TRF realizations were evaluated in terms of DORIS observation residuals, orbit overlaps and transformation parameters of the DORIS network. All TRF realizations show a clear improvement over the previous realization, ITRF2008. Based on the different criteria used for evaluation, analysis by IDS components showed that the ITRF2014(IGN) realization provides the best overall performance. It is this realization that will serve as a basis for the operational processing of future DORIS data. For that purpose, the ITRF2014 needs to be augmented (e.g. with new DORIS stations not present in the ITRF2014 solutions, or if necessary, correction of the position and velocity for the stations which had a short observation interval in the ITRF2014). This extension of ITRF2014 for the DORIS network is called DPOD2014: an update of the position/velocity of all stations is performed and aligned on the ITRF2014, leading to possible minor adjustment of older stations. The DPOD2014 built by the IDS CC (G. Moreaux) was validated by a POD group (P. Willis, F. Lemoine, A. Couhert, N. Zelensky and Ait Lakbir Hanane). The DPOD2014 solution will be updated twice a year. Some IDS ACs have switched to ITRF2014 by using the DPOD2014 solution for their IDS

operational products at the end of 2017 and some others in 2018. More information about DPOD2014 is available from the URL:
https://ids-doris.org/analysis-coordination/combination/dpod.html

The behavior of the various DORIS on-board oscillators in the vicinity of the high radiation area "South Atlantic Anomaly" (SAA) was also studied. DORIS ACs showed that all DORIS receivers are sensitive to the crossing of the SAA, though to different degrees. Thanks to the extremely precise time-tagging provided by the T2L2 experiment on-board Jason-2, A. Belli and the GEOAZUR team showed that the Jason-2 DORIS Ultra Stable Oscillator (USO) is approximately 10 times less sensitive to the SAA than that of Jason-1. The IGN AC has shown, thanks to the "DORIS PPP method" on uncorrected Jason-2 DORIS data, that the positioning error due to the SAA can reach up to 10 cm for some stations with this satellite. The GRG AC and C. Jayles from CNES both showed that Jason-3 is also sensitive to the SAA, at a level that is lower than that of Jason-1, but still 4 to 5 times higher than that of Jason-2. The CNES POD team showed that Sentinel-3A is also sensitive to the SAA. Using a novel method based on the clock determination of the GNSS receiver on-board Sentinel-3A, the CNES POD team showed that it is possible to obtain an accurate and continuous observation of the satellite's USO frequency excursions. One of the conclusions of these studies was that, while no noticeable effect of the SAA influence was shown on POD or reference frame transformation parameters, there is an important impact on the station position estimation for some stations in the vicinity of the SAA area. Building accurate models of frequency variations in response to the temperature and to the SAA radiation effects for each DORIS USO is therefore a task that is encouraged by the IDS community for the accurate position estimation of all DORIS stations. Currently we have the following possibilities to mitigate the SAA effect. For SPOT-5 and Jason-1, ACs can use the DORIS2.2 data corrected by the models available at CDDIS and IGN Data Centers. Note, for Jason-1 the corrective model is also available. For Jason-2 and Jason-3, ACs can adjust at least a bias+drift by pass for SAA stations in their POD processing. We could use better corrected frequency model for Jason-2 and Jason-3 USO when Belli et al. will demonstrate their efficiency and will make them available. We can also use the strategy to add single satellite solution affected by the SAA in the multi-satellite solution. This method was tested and adopted for Jason-1 for the ITRF2014. Before combining single satellite solution affected by SAA to the other single satellite solutions, we rename the SAA stations (and all their adjusted parameters) so these SAA stations from this single satellite do not contribute to the realization of the combined solution.

The next months will be focused on the preparation of the next ITRF. ACs must complete the implementation of the DORIS/RINEX data processing in order to be able to process the data of Jason-3, Sentinel-3A and Sentinel-3B, which are only available in this format. They will work on the mitigation of the non-conservative force model error on satellites, the assessment of the new models/standards (TVG, HF-EOP model, ocean tides, …), the mitigation of the SAA effect on DORIS USOs for Spot-5 and Jason series, and the determination of the scale factor (choice of the elevation cut off and the data down-weighting).

The next IDS Analysis working group meeting will be held in Paris (France), on September 30 and October 1, 2019 (*hosted by CNES*). It will be devoted exclusively to the IDS contribution to the next ITRF realization

2.6 Combination Center

In addition to its operational activities of evaluation and combination of all the individual ACs weekly solutions, the IDS Combination Center (CC) has been involved in several studies proposed by the AWG and the Analysis Coordinator such as the scale jump in 2012 and the evaluation of the three 2014 TRF realizations from DGFI, IGN and JPL.

DORIS position and velocity cumulative solution

In line with the successful IDS contribution to the ITRF2014 (see Moreaux et al., 2016a)., the IDS CC initiated the elaboration of a DORIS position and velocity cumulative solution. To validate the stacking procedure and the DORIS mean velocities, the IDS CC compared the DORIS velocities with global tectonic models as well as with GNSS velocities at co-located sites. The analysis of the velocity differences (Moreaux et al., 2016b) validated the new stacking procedure. Then, early in 2017, the IDS CC started to regularly (on a quarterly basis) process and deliver (via the IDS Data Centers) a DORIS position and velocity cumulative solution from the latest IDS combined series. So far, this solution does not include Post-Seismic Deformation corrections; a piecewise linear (position+velocity) model is used to describe the station motions (see **Figure 3**). A dedicated webpage (https://ids-doris.org/analysis-coordination/combination/cumulative-solution.html) was also added to the IDS website to give further information on the IDS cumulative solution (ex: residual time series, DORIS-to-DORIS tie vector residuals, DORIS-to-GNSS tie vector comparisons, position and velocity differences with ITRF2014…).

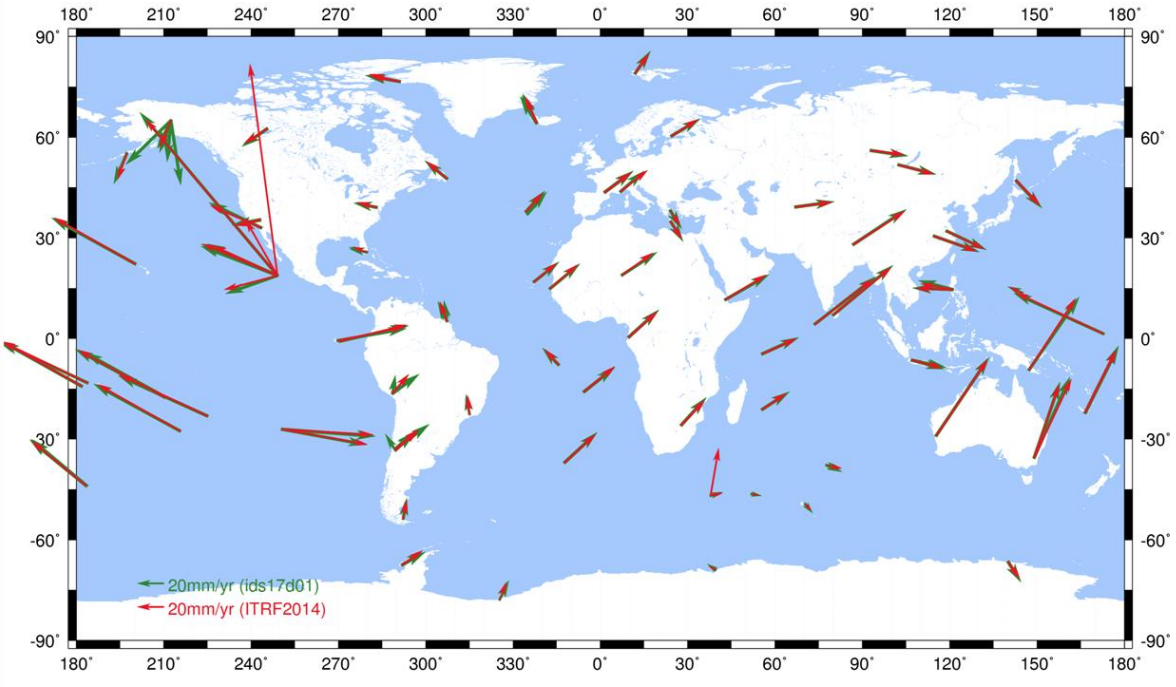


Figure 3: Horizontal velocities of the DORIS sites from ITRF2014 (red) and the first DORIS cumulative solution

DPOD2014

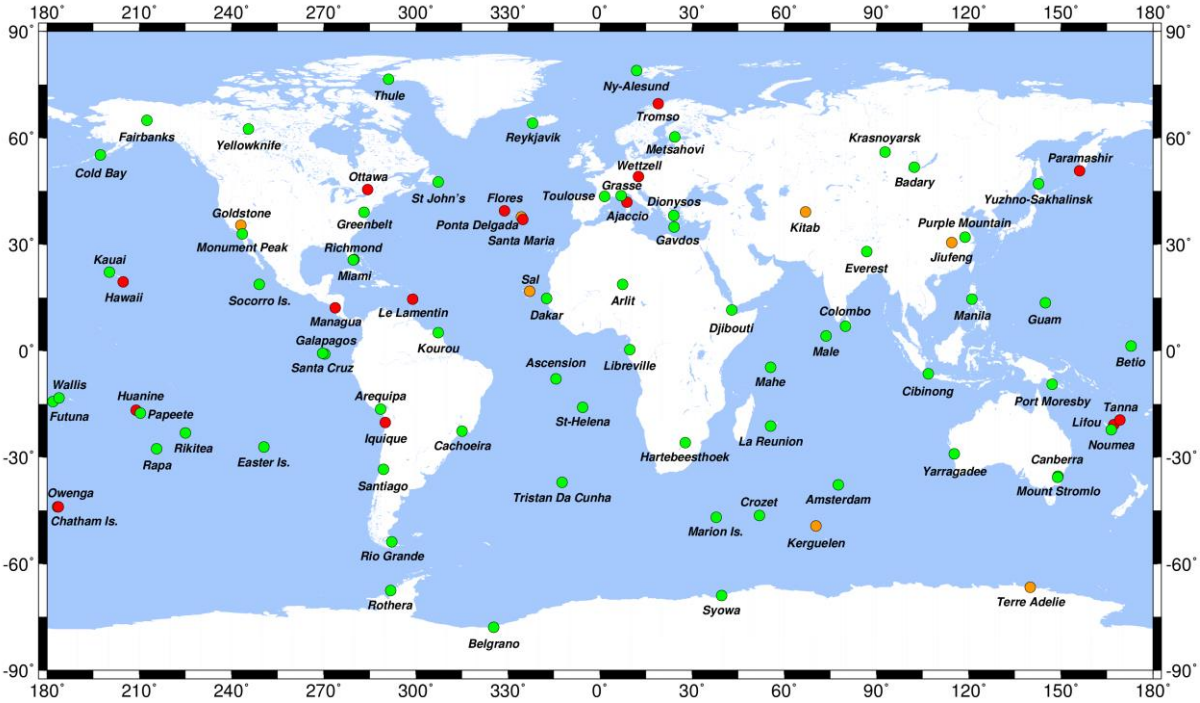


Figure 4: DORIS sites in DPOD2014_v01 produced by the IDS Combination Center; green indicates sites in ITRF2014 and DPOD2014_v01; orange indicates sites in both coordinate sets but updated in DPOD2014_v01; red indicates sites **not** in ITRF2014, but included in DPOD2014_v01.

During the first 2015 IDS AWG held in Toulouse, the IDS CC agreed to take over from P. Willis the routine production of the DPOD: "the DORIS extension of the ITRF for Precise Orbit Determination". The DPOD solutions were initiated to overcome some intrinsic drawbacks of using the latest ITRF: i) some stations are added to the tracking network after the completion of the ITRF; ii) some stations might be affected by coordinate and/or velocity discontinuities that could occur after the realization of the ITRF; iii) the precision of the position and velocities of the stations with few observations at the time of the ITRF can be increased with a longer data span and; iv) some problems in data processing may be found after the computation of the ITRF (e.g. USO sensibility to the SAA). Based on the latest IDS position and velocity cumulative solution, the IDS CC constructs the DPOD2014 solutions aligned to the ITRF2014 (see **Figure 4**). After some IDS CC internal validation tests (including coordinate and velocity differences with the previous DPOD solution and ITRF realization), the IDS POD validation group lead by P. Willis performs some POD tests with many of the DORIS satellites. After approval by the POD validation group, the new version of DPOD2014 solution is released. DPOD2014 is available from the two IDS Data Centers and is added to the dedicated IDS website page (https://ids-doris.org/analysis-coordination/combination/dpod.html). The DPOD2014 will be updated twice a year.

All the details on the realization and validation processes of the DPOD2014 are described in Moreaux et al., 2019 (that paper is in open access until the end of 2019). In preparation to the realization of the IDS contribution to the next ITRF (ITRF2020), the IDS CC started to review the whole combination strategy with the objective of improving the station positioning and EOP performances, mainly over the time period 1993.0-2002.3.

IDS products

Table 4 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 4: Summary of IDS Products.

Type of Products	**Contributing Analysis Centers ¶**							
	ESA	**GOP**	**GRG§**	**GSC**	**IGN**	**INA**	**IDS✚**	**SSA**
Time series of SINEX solutions (***sinex_series***)	X	X	X	X	X	X	X	X
Global SINEX solutions (***sinex_global***)			X		X		X	
Geocenter time series (***geoc***)			X	X				X
Satellite Orbits (*orbits*)			X	X				X
Ionosphere products/sat. (***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		
	✚ Combination Center of the IDS. **§ The GRG analysis center was renamed from the "LCA" analysis center in 2015.** **Previous analysis centers who have contributed products include GAU (Geoscience Australia) and CNES POD team under the ID "SOD"**							

References

Moreaux, G., Lemoine, F.G., Capdeville, H., et al., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame. Adv. Space Res., doi: 10.1016/j.asr.2015.12.021.

Moreaux, G.; Lemoine, F.G.; Argus, D.F.; Santamaría-Gómez, A.; Willis, P.; Soudarin, L.; Gravelle, M.; Ferrage, P., 2016. Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with geophysical models, Geophysical Journal International, 207(1), 209-227, doi: 10.1093/gji/ggw265

Moreaux, G.; Willis, P.; Lemoine, F.G.; Zelensky, N.P.; Couhert, A.; Ait Lakbir, H.; Ferrage, P., 2019. DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination, ADVANCES IN SPACE RESEARCH, 63(1):118-138, DOI: 10.1016/j.asr.2018.08.043

2.7 Working Group "NRT DORIS DATA"
Chair: Denise Dettmering (DGFI-TUM, Germany)

Following user requests for rapid dissemination of DORIS data for assimilation in ionospheric models, the IDS Governing Board created a Working Group (WG) dealing with near real-time (NRT) DORIS data, on November, 1st, 2017, and appointed Denise Dettemering (DGFI-TUM) as chair.

The general objective of this working group is a thorough assessment on benefits, requirements and prospects of DORIS data with improved data latency with a focus on applications in ionospheric research. In 2018, two main topics has been handled by members of the Working Group, namely (1) the validation of real-time global ionospheric maps by DORIS data sets and (2) the usage of DORIS data in near real-time ionospheric modeling. Based on the present experiences and in line with some of the recommendations from the IDS retreat in June 2018, currently, CNES is studying a potential extension of its services in order to allow the ground segment to export the DORIS measurements in near real-time to the users.

3. IDS meetings and publications

3.1 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 focused on technical issues, and usually attended by representatives of Analysis Centers.

Table 5: IDS Meetings (2015-2019)

Meeting	Location	Country	Dates
DORIS AWG Meeting	Toulouse	France	28-29 May 2015
DORIS AWG Meeting	Greenbelt	Maryland, USA	15-16 October 2015
DORIS AWG Meeting	Delft	Netherlands	26-27 May 2016
IDS Workshop	La Rochelle	France	31 October – 1 November 2016
DORIS AWG Meeting	London	UK	22-24 May 2017
DORIS AWG Meeting	Toulouse	France	11 June 2018
IDS Workshop	Ponta Delgada	Portugal	24-26 September 2018
DORIS AWG Meeting	Munich	Germany	4 April 2019

3.2 Publications

During the last four years, IDS published several activity reports:

International DORIS Service (IDS), Report of the International Association of Geodesy 2011-2015, Travaux de l'Association Internationale de Géodésie, Pascal Willis (chairman of the Governing Board), 2015.
https://ids-doris.org/documents/report/IDS_Report_mid2011_mid2015_for_IAG.pdf

International DORIS Service (IDS), Report of the International Association of Geodesy 2015-2017, Travaux de l'Association Internationale de Géodésie, Frank Lemoine (chairman of the Governing Board), 2017.
https://ids-doris.org/documents/report/IDS_Report_mid2015_mid2017_for_IAG.pdf
International DORIS Service Activity report 2014, Laurent Soudarin and Pascale Ferrage (Eds), 122 pages, 2015. https://ids-doris.org/documents/report/IDS_Report_2014.pdf
International DORIS Service Activity report 2015, Laurent Soudarin and Pascale Ferrage (Eds), 99 pages, 2016. https://ids-doris.org/documents/report/IDS_Report_2015.pdf
International DORIS Service Activity report 2016, Laurent Soudarin and Pascale Ferrage (Eds), 120 pages, 2017. https://ids-doris.org/documents/report/IDS_Report_2016.pdf
International DORIS Service Activity report 2017, Laurent Soudarin and Pascale Ferrage (Eds), 118 pages, 2018. https://ids-doris.org/documents/report/IDS_Report_2017.pdf

3.3 Peer-reviewed publications related to DORIS

Following two DORIS Special Issues published in Journal of Geodesy in 2006-2007, and Advances in Space Research in 2010, a third DORIS Special was launched in 2014. A total of 18 manuscripts passed the peer-reviewed process and were published in Advances in Space Research on December 15, 2016, in Volume 58, Number 12. This special issue is entitled "The scientific applications of DORIS in Space Geodesy" and is edited by Frank G. Lemoine and Ernst J.O. Schrama. The papers cover five themes: ITRF2014; DORIS Ultra Stable Oscillator (Jason-2); Precise orbit determination; DORIS System and Network; Intertechnique comparisons of DORIS products.

The list of the DORIS special issues with the direct links to the indexes are given hereafter:

DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2477-2774 (15 December 2016)
https://www.sciencedirect.com/journal/advances-in-space-research/vol/58/issue/12
DORIS Special Issue: Precise Orbit Determination and Applications to Earth Sciences, P. Willis (Ed.), ADVANCES IN SPACE RESEARCH, 46(12):1483-1660 (15 December 2010)
https://www.sciencedirect.com/journal/advances-in-space-research/vol/46/issue/12
DORIS Special Issue: Scientific Applications in Geodesy and Geodynamics, P. Willis (Ed.), ADVANCES IN SPACE RESEARCH, 45(12):1407-1540 (15 June 2010)
https://www.sciencedirect.com/journal/advances-in-space-research/vol/45/issue/12
DORIS Special Issue, P. Willis (Ed.), JOURNAL OF GEODESY, 80(8-11):401-664 (November 2006
https://link.springer.com/journal/190/80/8

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

2019

Kong, Q.; Gao, F.; Guo, J.; Han, L.; Zhang, L.; Shen, Y., 2019. Analysis of precise orbit predictions for a HY-2A satellite with three atmospheric density models based on dynamic method, REMOTE SENSING, 11(1), 40, DOI: 10.3390/rs11010040
Kong, Q.; Guo, J.; Han, L.; Shen, Y., 2019. Performance of three atmospheric density models on precise orbit determination for Haiyang-2A satellite using DORIS data, in Enhancements in Applied Geomechanics, Mining, and Excavation Simulation and Analysis. GeoChina 2018, Sevi A., Neves J., Zhao H. (Eds.), SUSTAINABLE CIVIL INFRASTRUCTURES, 126-135, DOI: 10.1007/978-3-319-95645-9_12

Moreaux, G.; Willis, P.; Lemoine, F.G.; Zelensky, N.P.; Couhert, A.; Ait Lakbir, H.; Ferrage, P., 2019. DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination, ADVANCES IN SPACE RESEARCH, 63(1):118-138, DOI: 10.1016/j.asr.2018.08.043 OPEN ACCESS

Rudenko, S.; Esselborn, S.; Schöne, T.; Dettmering, D., 2019. Impact of terrestrial reference frame realizations on altimetry satellite orbit quality and global and regional sea level trends: a switch from ITRF2008 to ITRF2014, SOLID EARTH, 10(1):293-305, DOI: 10.5194/se-10-293-2019 OPEN ACCESS

2018

Belli, A.; Exertier, P., 2018. Long-Term Behavior of the DORIS Oscillator under Radiation: The Jason-2 case, IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL, 65(10):1965-1976, DOI: 10.1109/TUFFC.2018.2855085

Couhert, A.; Mercier, F.; Moyard, J.; Biancale, R., 2018. Systematic error mitigation in DORIS-derived geocenter motion, JOURNAL OF GEOPHYSICAL RESEARCH: SOLID EARTH, 123(11):10142-10161, DOI: 10.1029/2018JB015453

Esselborn, S.; Rudenko, S.; Schöne, T., 2018. Orbit-related sea level errors for TOPEX altimetry at seasonal to decadal timescales, OCEAN SCIENCE, 14(2):205-223, DOI: 10.5194/os-14-205-2018

Fazilova, D.; Ehgamberdiev, Sh.; Kuzin, S., 2018. Application of time series modeling to a national reference frame realization, GEODESY AND GEODYNAMICS, 9(4):281-287, DOI: 10.1016/j.geog.2018.04.003 OPEN ACCESS

Jalabert, E.; Mercier, F., 2018. Analysis of South Atlantic Anomaly perturbations on Sentinel-3A Ultra Stable Oscillator. Impact on DORIS phase measurement and DORIS station positioning, ADVANCES IN SPACE RESEARCH, 62(1):174-190, DOI: 10.1016/j.asr.2018.04.005

Klos, A.; Bogusz, J.; Moreaux, G., 2018. Stochastic models in the DORIS position time series: estimates for IDS contribution to ITRF2014, JOURNAL OF GEODESY, 92(7):743-763, DOI: 10.1007/s00190-017-1092-0 OPEN ACCESS

Kraszewska, K.; Jagoda, M.; Rutkowska, M., 2018. Tectonic plates parameters estimated in International Terrestrial Reference Frame ITRF2008 based on DORIS stations, ACTA GEOPHYSICA, 66(4):509-521, DOI: 10.1007/s11600-018-0169-3 OPEN ACCESS

Štěpánek, P.; Filler, V., 2018. Cause of scale inconsistencies in DORIS time series, STUDIA GEOPHYSICA ET GEODAETICA, 62(4):562-585, DOI: 10.1007/s11200-018-0406-x

Štěpánek, P.; Hugentobler, U.; Buday, M.; Filler, V., 2018. Estimation of the Length of Day (LOD) from DORIS observations, ADVANCES IN SPACE RESEARCH, 62(2):370-382, DOI: 10.1016/j.asr.2018.04.038

2017

Abbondanza, C.; Chin, T.M.; Gross, R.S.; Heflin, M.B.; Parker, J.W.; Soja, B.S.; vanDam, T.; Wu, X., 2017. JTRF2014, the JPL Kalman filter and smoother realization of the International Terrestrial Reference System, JOURNAL OF GEOPHYSICAL RESEARCH: SOLID EARTH, 122(10):8474-8510, DOI: 10.1002/2017JB014360

Chen, P.; Yao, Y.; Yao, W., 2016. Global ionosphere maps based on GNSS, satellite altimetry, radio occultation and DORIS, GPSSOLUTIONS, 21(2), 639-650, DOI: 10.1007/s10291-016-0554-9

Exertier, P.; Belli, A.; Lemoine, J.M., 2017. Time biases in laser ranging observations: A concerning issue of Space Geodesy, ADVANCES IN SPACE RESEARCH, 60(5), 948-968, DOI: 10.1016/j.asr.2017.05.016

Gu, Y.; Yuan, L.; Fan, D.; You, W.; Su Y., 2017. Seasonal crustal vertical deformation induced by environmental mass loading in mainland China derived from GPS, GRACE and surface loading models, ADVANCES IN SPACE RESEARCH, 59(1), 88-102, DOI: 10.1016/j.asr.2016.09.008

He, B.; Wang, X.-Y.; Hu, X.-G.; Zhao, Q.-H., 2017. Combination of terrestrial reference frames based on space geodetic techniques in SHAO: methodology and main issues, RESEARCH IN ASTRONOMY AND ASTROPHYSICS, 17(9), DOI: 10.1088/1674-4527/17/9/89 http://www.raa-journal.org/docs/papers_accepted/ 0049.pdf

Kong, Q.; Guo, J.; Sun, Y., 2017. Centimeter-level precise orbit determination for the HY-2A satellite using DORIS and SLR tracking data, ACTA GEOPHYSICA, 65(1), 1-12, DOI: 10.1007/s11600-016-0001-x

Rudenko, S.; Neumayer, K.-H.; Dettmering, D.; Esselborn, S.; Schöne, T.; Raimondo, J.-C., 2017. Improvements in precise orbits of altimetry satellites and their impact on mean sea level monitoring, IEEE Transactions on Geoscience and Remote Sensing, 55(6), 3382-3395, DOI: 10.1109/TGRS.2017.2670061

Schrama, E., 2017. Precision orbit determination performance for CryoSat-2, ADVANCES IN SPACE RESEARCH, 61(1), 235-247, DOI: 10.1016/j.asr.2017.11.001

Talpe, M.J.; Nerem, R.S.; Forootan, E.; Schmidt, M.; Lemoine, F.G.; Enderlin, E.M.; Landerer, F.W., 2017. Ice mass change in Greenland and Antarctica between 1993 and 2013 from satellite gravity measurements, JOURNAL OF GEODESY, 91(11), 1283-1298, DOI: 10.1007/s00190-017-1025-y

Zelensky, N.P.; Lemoine, F.G.; Beckley, B.D.; Chinn, D.S.; Pavlis D.E., 2017. Impact of ITRS 2014 realizations on altimeter satellite precise orbit determination, ADVANCES IN SPACE RESEARCH, 61(1), 45-73, DOI: 10.1016/j.asr.2017.07.044

2016

Altamimi, Z.; Rebischung, P.; Métivier, L.; Collilieux, X., 2016. ITRF2014: A new release of the International Terrestrial Reference Frame modeling nonlinear station motions, JOURNAL OF GEOPHYSICAL RESEARCH: Solid Earth, 121(8), 6109-6131, DOI: 10.1002/2016JB013098 OPEN ACCESS

Belli, A.; Exertier, P.; Samain, E.; Courde, C.; Vernotte, F.; Jayles, C.; Auriol, A., 2016. Temperature, radiation and aging analysis of the DORIS Ultra Stable Oscillator by means of the Time Transfer by Laser Link experiment on Jason-2, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2589-2600, DOI: 10.1016/ j.asr.2015.11.025

Bloßfeld, M.; Seitz, M.; Angermann, D.; Moreaux, G., 2016. Quality assessment of IDS contribution to ITRF2014 performed by DGFI-TUM, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2505-2519, DOI: 10.1016/j.asr.2015.12.016

Capdeville, H.; Štěpánek, P.; Hecker, L.; Lemoine, J.M., 2016. Update of the corrective model for Jason-1 DORIS data in relation to the South Atlantic Anomaly and a corrective model for SPOT-5, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2628-2650, DOI: 10.1016/j.asr.2016.02.009

Jayles, C.; Chauveau, J.P.; Didelot, F.; Auriol, A.; Tourain, C., 2016. Doris system and integrity survey, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2691-2706, DOI: 10.1016/j.asr.2016.05.032

Jayles, C.; Exertier, P.; Martin, N.; Chauveau J.P.; Samain E.; Tourain C.; Auriol A.; Guillemot P., 2016. Comparison of the frequency estimation of the DORIS/Jason2 oscillator thanks to the onboard DIODE and Time Transfer by Laser Link experiment, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2601-2616, DOI: 10.1016/j.asr.2015.08.033

Khelifa, S., 2016. Noise in DORIS station position time series provided by IGN-JPL, INASAN and CNES-CLS Analysis Centres for the ITRF2014 realization, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2572-2588, DOI: 10.1016/j.asr.2016.06.004

King, M. A.; Santamaría-Gómez, A., 2016. Ongoing deformation of Antarctica following recent Great Earthquakes, GEOPHYSICAL RESEARCH LETTERS, 43, 1918–1927, DOI: 10.1002/2016GL067773

Kuzin, S.; Tatevian, S., 2016. DORIS data processing in the INASAN Analysis Center and the contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2561-2571, DOI: 10.1016/j.asr.2016.07.010

Heinkelmann, R.; Willis, P.; Deng, Z.; Dick, G.; Nilsson, T.; Soja, B.; Zus, F.; Wickert, J.; Schuh, H., 2016. Multi-technique comparison of atmospheric parameters at the DORIS co-location sites during CONT14, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2758-2773, DOI: 10.1016/j.asr.2016.09.023

Lemoine, F.G.; Chinn, D.S.; Zelensky, N.P.; Beall, J.W.; Le Bail, K., 2016. The Development of the GSFC DORIS Contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2520-2542, DOI: 10.1016/j.asr.2015.12.043 OPEN ACCESS

Lemoine, J.M.; Capdeville, H.; Soudarin, L., 2016. Precise orbit determination and station position estimation using DORIS RINEXdata, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2677-2690, DOI: 10.1016/j.asr.2016.06.024

Moreaux, G.; Lemoine, F.G.; Argus, D.F.; Santamaría-Gómez, A.; Willis, P.; Soudarin, L.; Gravelle, M.; Ferrage, P., 2016. Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with geophysical models, GEOPHYSICAL JOURNAL INTERNATIONAL, 207(1), 209-227, DOI: 10.1093/gji/ggw265

Moreaux, G.; Lemoine, F.G.; Capdeville, H.; Kuzin, S.; Otten, M.; Štěpánek, P.; Willis, P.; Ferrage, P., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2479-2504, DOI: 10.1016/j.asr.2015.12.021

Rudenko, S.; Dettmering, D.; Esselborn, S.; Fagiolini, E.; Schöne, T., 2016. Impact of Atmospheric and Oceanic De-aliasing Level-1B (AOD1B) products on precise orbits of altimetry satellites and altimetry results, GEOPHYSICAL JOURNAL INTERNATIONAL, 204(3), 1695-1702, DOI: 10.1093/gji/ggv545

Saunier, J., 2016. Assessment of the DORIS network monumentation, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2725-2741, DOI: 10.1016/j.asr.2016.02.026

Saunier, J.; Auriol, A.; Tourain, C., 2016. Initiating and error budget of the DORIS ground antenna position Genesis of the Starec antenna type C, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2717-2724, DOI: 10.1016/j.asr.2016.02.013

Soudarin, L.; Capdeville, H.; Lemoine, J.-M., 2016. Activity of the CNES/CLS Analysis Center for the IDS contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2543-2560, DOI: 10.1016/j.asr.2016.08.006

Štěpánek, P.; Bezděk, A.; Kostelecký, J.; Filler, V., 2016. Gravity field and ocean tides modeling for precise orbit determination of DORIS satellites, ACTA GEODYNAMICA ET GEOMATERIALIA, 13(1), 27-40, DOI: 10.13168/AGG.2015.0048 FREE ACCESS

Tourain, C.; Moreaux, G.; Auriol, A.; Saunier, J., 2016. Doris starec ground antenna characterization and impact on positioning, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2707-2716, DOI: 10.1016/j.asr. 2016.05.013

Tornatore, V.; Tanır Kayıkçı, E.; Roggero, M., 2016. Comparison of ITRF2014 station coordinate input time series of DORIS, VLBI and GNSS, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2742-2757, DOI: 10.1016/j.asr.2016.07.016

Willis, P.; Heflin, M. B.; Haines, B. J.; Bar-Sever, Y. E.; Bertiger, W. I.; Mandea, M., 2016. Is the Jason-2 DORIS Oscillator also Affected by the South Atlantic Anomaly?, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2617-2627, DOI: 10.1016/j.asr.2016.09.015

Willis, P.; Lemoine, F.G.; Moreaux, G.; Soudarin, L.; Ferrage, P.; Ries, J.; Otten, M.; Saunier, J.; Noll, C.; Biancale, R.; Luzum, B., 2016. The International DORIS Service (IDS), recent developments in preparation for ITRF2013, IAG SYMPOSIA SERIES, 143, 631-639, DOI : 10.1007/1345_2015_164

Willis, P.; Zelensky, N.P.; Ries, J.; Soudarin, L.; Cerri, L.; Moreaux, G.; Lemoine, F.G.; Otten, M.; Argus, D.F.; Heflin, M.B., 2016. DPOD2008, a DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, IAG SYMPOSIA SERIES,143, 175-181, DOI: 10.1007/1345_2015_125

Zelensky, N.P.; Lemoine, F.G.; Chinn, D.S.; Beckley, B.D.; Bordyugov, O.; Yang, X.; Wimert, J.; Pavli, D., 2016. Towards the 1-cm SARAL orbit, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2651-2676, DOI: 10.1016/j.asr.2015.12.011

Zoulida, M.; Pollet, A.; Coulot, D.; Perosanz, F.; Loyer, S.; Biancale, R.; Rebischung, P., 2016. Multi-technique combination of space geodesy observations: Impact of the Jason-2 satellite on the GPS satellite orbits estimation, ADVANCES IN SPACE RESEARCH, 58(7), 1376-1389, DOI: 10.1016/j.asr.2016.06.019

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), 2-23, DOI : 10.1016/j.asr.2014.06.041

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

Jayles, C.; Chauveau, J.P.; Auriol, A., 2015. DORIS/DIODE : Real-Time Orbit Determination Performance on Board SARAL/AltiKa, MARINE GEODESY, 38 (S1):233-248, DOI: 10.1080/01490419.2015.1015695

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