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 current report presents the different activities held by all the components of the International DORIS Service (IDS) for the period from the middle of 2019 to the middle of 2023.

The main achievements of the IDS over this period are:
(1) analysis, combination and stacking of the contributions from the four IDS Analysis Centers involved in the realization of the IDS contribution to the ITRF2020;
(2) dissemination of the DORIS data of the brand-new missions HY-2C, Sentinel-6A and HY-2D;
(3) dissemination of DORIS NRT data of Jason-3 mission;
(4) renewal of several positions within the Governing Board;
(5) organization of the first "DORIS days" on November 16, 17 and 18, 2021;
(6) organization of the IDS Workshop on October 31 and November 1, 2022;
(7) publication of articles about the DPOD2014 realization and the IDS contribution to ITRF2020 by the Combination Center;
(8) publication of five newsletter.

The IDS has been impacted by the Covid-19 pandemic. The events planned for 2020 could not take place. The IDS workshop planned in Venice in October 2020 was cancelled and was first postponed to 2021. In the Spring of 2021, the IDS Workshop was again postponed to March 2022. It finally took place in Fall 2022 in Venice, in conjunction with the Ocean Surface Topography Science Team. Similarly, the first edition of the DORIS days, planned as a face-to-face event on Saturday 2 May 2020 at the Technical University of Vienna, Austria, prior to the EGU 2020, was finally held remotely in November 2021.

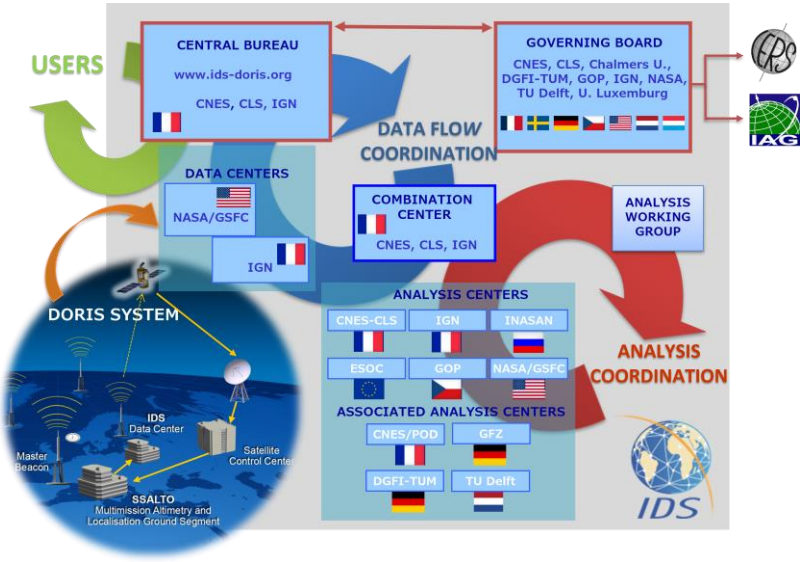
During the period of this report, the DORIS system had its 30th anniversary. The first DORIS measurement was recorded on February 3, 1990, on board SPOT-2.

Note also that on 1 July 2023, the International DORIS Service will celebrate the 20th anniversary of its creation under the umbrella of the International Association of Geodesy.

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**, four new satellites were launched over the report period: HY-2C and Sentinel-6A Michael Freilich in 2020, HY-2D in 2021, and SWOT in late 2022. All use the new 7-channel DGXX-S DORIS on-board receiver. During the same period, two missions were decommissioned: Jason-2 and HY-2A.

There are now nine active on-orbit DORIS receivers. This is the first time we have had so many DORIS receivers in simultaneous operation. From 1990 to now, 18 missions were equipped with 3 generations of DORIS receivers: the 1G with 1 channel, the 2G and 2GM with 2 channels, and the last generation DGXX and DGXX-S with 7 channels, able to track up to 7 DORIS stations simultaneously. These satellites have operated or are operating at five different altitudes, from about 700 km to 1336 km for the TOPEX/Jason series, and in four orbit planes: 66° mainly for the oceanic altimetry missions, 78 ° for SWOT and 92 and 98° for the polar orbits.

Table 1. DORIS data available at IDS data centers, as of June 2023.

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	10-OCT-2019	NASA/CNES	Altimetry
CRYOSAT-2	30-MAY-2010	PRESENT	ESA	Altimetry, ice caps
HY-2A	1-OCT-2011	14-SEP-2020	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
HY-2C	21-SEP-2020	PRESENT	CNSA, NSOAS	Altimetry
SENTINEL-6A	21-NOV-2020	PRESENT	NASA/CNES/NOAA/ Eumetsat/ESA	Altimetry
HY-2D	19-MAY-2021	PRESENT	CNSA, NSOAS	Altimetry
SWOT	16-DEC-2022	PRESENT	NASA/CNES/CSA/ UKSA	Altimetry

In the next few years, more DORIS satellites are planned: (agreed) Sentinel-3C and 3D, Sentinel-6B; (pending approval) Sentinel-6C, HY-2E and F. The GENESIS-1 mission, already approved by the ESA Council of Ministers in November 2022, is in the mission design and implementation phase.

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 since 2002, five or more DORIS satellites have been available to IDS users, which is a key requirement for the precision of the geodetic products.

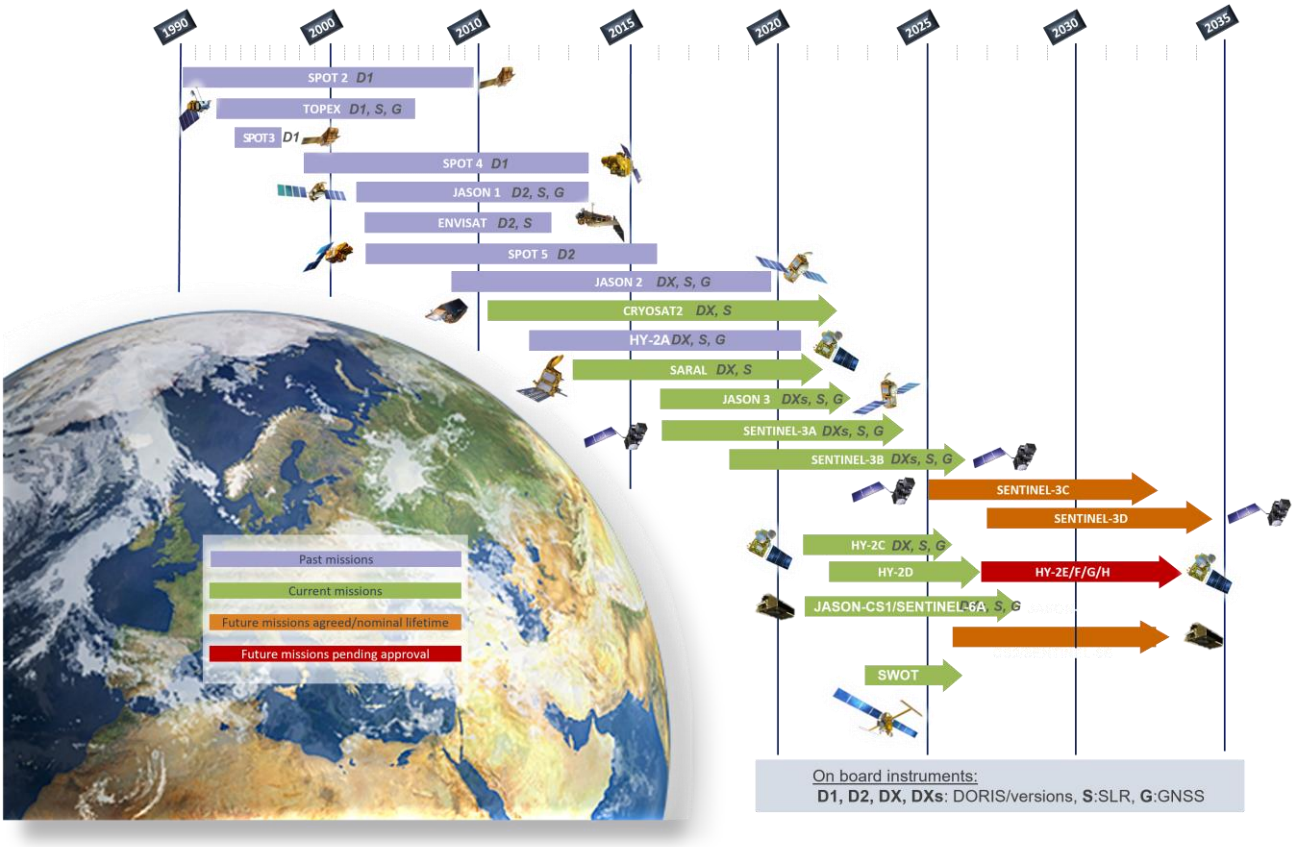


Figure 1. DORIS satellite constellation. As of June 2023.

1.2 DORIS network

General status and operation

DORIS has a globally distributed network of 59 permanent stations dedicated for precise orbit determination and altimetry with four master beacons (Papeete, Hartebeesthoek, Kourou, Toulouse), one time beacon (Terre-Adélie), and one experimental beacon dedicated to IDS for scientific purposes (Wettzell). Mangilao (Guam Island, USA), initially dedicated to IDS, joined the permanent DORIS network in September 2019. In April 2023, the major event on the network was the commissioning of Hanga Roa (Easter Island), which was eagerly awaited for its coverage of the South Pacific.

The map of the DORIS network slightly changed with the new stations and the withdrawal of Krasnoyarsk in Russia which has now been decommissioned. See **Figure 2**.

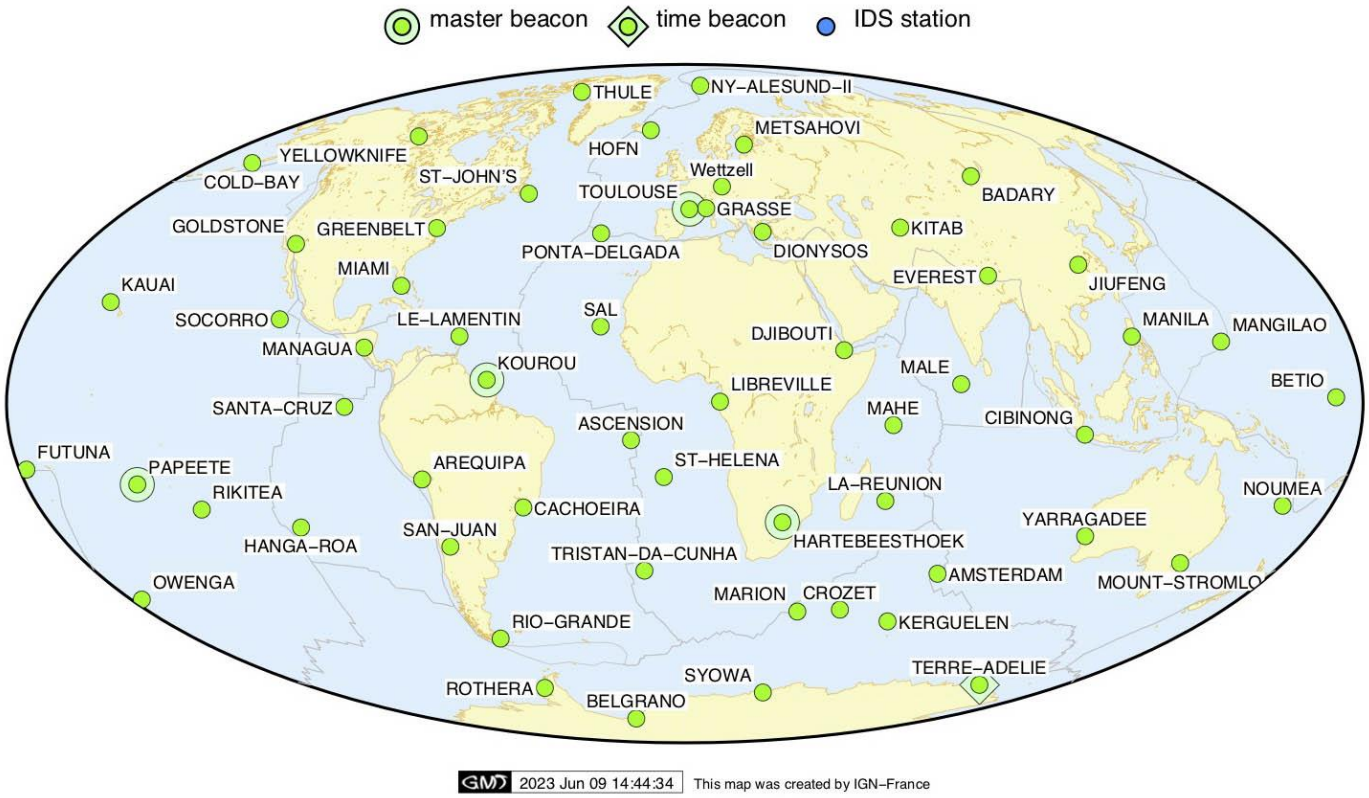


Figure 2. The DORIS permanent network.

As regards maintenance, the good news is that after a very long outage the DORIS station at Santa-Cruz, Galapagos Islands, Ecuador, has been back in operation since December 2019. The station was completely reinstalled, and a new relationship was initiated with the new local staff. In 2020, two stations were fully renovated to enhance performance by changing the antenna environment and upgrading the equipment: an antenna relocation at La Réunion Island (France, Indian Ocean) and a new DORIS site in Höfn (Iceland) in place of Reykjavik. On the other hand, the extensive power outage at Betio has not yet been solved and the two Russian stations (Badary and Krasnoyarsk) are still awaiting authorization from the government authorities for transmission of the DORIS signal.

Notwithstanding those local difficulties and the global health crisis complicating maintenance operations in 2020, the DORIS network provided a reliable service with a mean of 84% of active sites over the two-year period 2019-2020 thanks to the responsiveness of the agencies hosting the stations and an efficient and effective overall management and coordination steered by the CNES and the IGN: 13 failed beacons and 5 failed antennas were replaced.

After the COVID-19 pandemic that considerably complicated field operations and maintenance, 2022 marked the return back to more normal operations. All the projects for the network development that had been put on hold were restarted. On the other hand, the Russo-Ukrainian conflict resulted in the decommissioning of the two Russian DORIS stations (Badary and Krasnoyarsk) after April 2022.

The continuation of the 4th generation beacon deployment, while prioritizing stations out of order or showing signs of a fault, has enabled the network to maintain a high level of service, with a mean of 88% of active sites over the year (see Figure 1). This has been achieved through a strong involvement of the CNES and IGN maintenance teams and the valuable contribution of

the local host agencies. After over a year of outage, Cibinong, San Juan, Ny-Alesund II and Futuna were brought back to operation in 2022 (see **Figure 3**).

Figure 3. Network availability 2022: Rate of stations in operation (fortnightly statement)

Evolution and development

2019 was a year marked by the start of the deployment of 4th generation DORIS beacon (B4G), a much-awaited development. Indeed, a new architecture built with up-to-date electronic technology and advanced components will allow reliable operation through 2030+. Moreover, the addition of a signal amplifier at the foot of the antenna to restore the signal to its nominal power after the signal losses during long cable transfer enables increasing the beacon-to-antenna distance (from 15 to 50 m). This offers better options for placing the antenna in an open environment, a major criterion for obtaining good observations.
Although the installation of a site requires balancing different requirements as well as the specific site and host agency constraints, the goal is to maintain a clear sky visibility down to 10 degrees elevation.
The B4G deployment started from mid-2019 at St-John's (Newfoundland), Canada. The deployment strategy consists of replacing gradually the aging equipment, and renovating sites for which the relocation of the antenna will enhance the station performance. By mid-2023, 33 out of 59 sites (56% of the network) will be equipped with the 4th generation beacon (B4G).
Furthermore, we have continued to deploy the new generation of ground antennae (Starec C type) for which the uncertainty in the location of the 2GHz phase center in the vertical direction was significantly reduced to improve the DORIS measurement accuracy. We achieved the antenna replacement of 42% of the network (25 sites) by mid-2023.

The co-location with other space geodetic techniques is also of great interest for geodesy. 49 DORIS stations out of 59 are co-located with at least one other IERS technique: GNSS, SLR, and/or VLBI. Half of the DORIS stations are also co-located with tide gauges enabling better monitoring of the vertical land movement (see **Figure 4**). IGN systematically carries out local tie surveys on the occasion of installations, renovations or dedicated visits on site to contribute to ITRF realizations. All tie vectors at co-located sites with DORIS are available in a maintained file "DORIS_ext_ties.txt" on IDS web (ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_ext_ties.txt) and

data centers.

It is also worth noting the long-term life of the DORIS stations: At the end of 2021, half of the current network stations are over 27 years old with 20 of them in continuous operation since the beginning of the DORIS system (1990).

The project of network densification to 70 stations is underway with a number of projects near completion. Five additional sites should be operational in the next two years. The aim is to enhance the network reliability and coverage and to better contribute to geodesy.

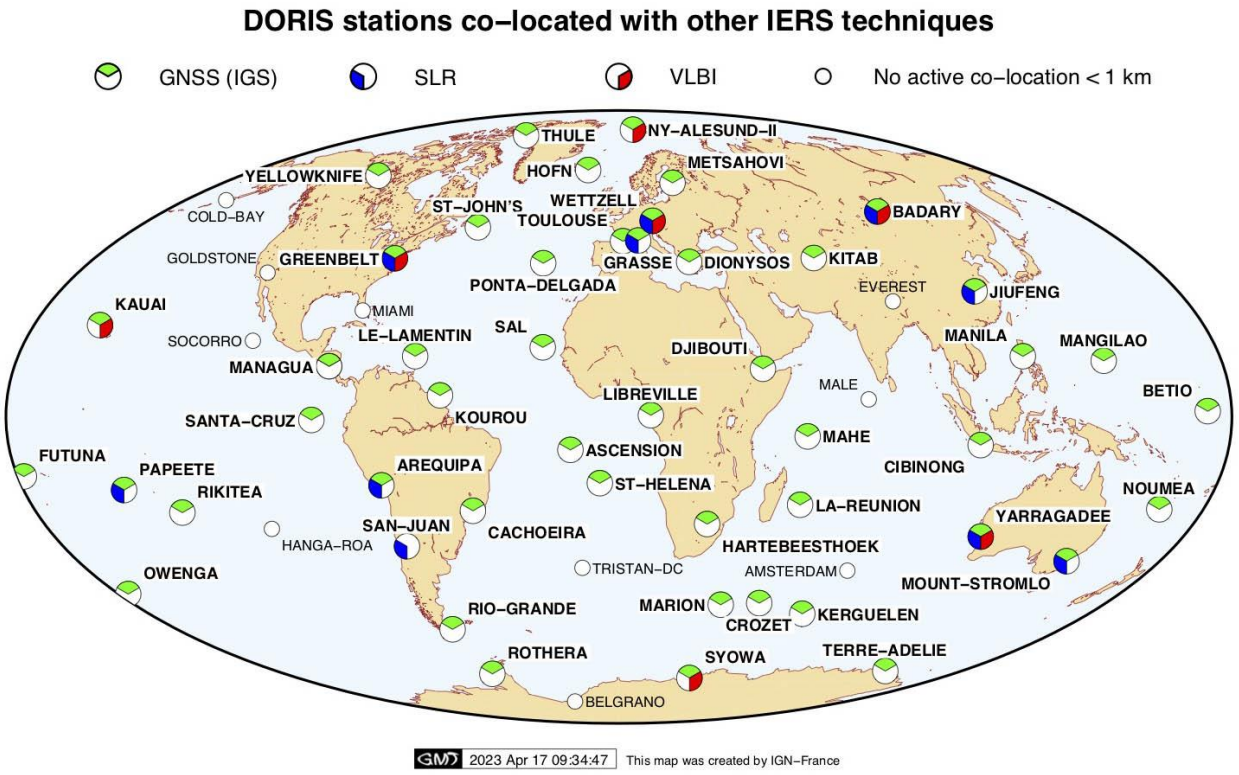


Figure 1. DORIS stations co-located with other IERS techniques and tide gauges

The list of DORIS sites visited during the period covered by this report is as follows:
2019

- B4G testing and site survey at Grasse (France)
- Reconnaissance in Reykjavik and Höfn (Iceland)
- Renovation and site survey at St-John's (Canada)
- B4G installation at Ponta-Delgada (Azores, Portugal)
- Re-installation at Santa-Cruz (Galapagos, Ecuador)
- B4G installing at Saint-Helena (South Atlantic, UK)

2020

- Reconnaissance at Malé (Maldives)
- Renovation of the DORIS station at La Réunion (France)
- B4G installation at Miami (USA)
- Relocation of the Icelandic DORIS station in Höfn
- Reconnaissance in Athens and Crete (Greece)

2021

- Maintenance at La Réunion (France, Western Indian Ocean)
- B4G installation at Metsähovi (Finland)
- Antenna relocation at Malé (Maldives)
- B4G installation at Mahé (Seychelles)

2022

- B4G installation at Kourou (French Guyana)
- B4G installation at Hartebeesthoek (South Africa)
- Reconnaissance at Cachoeira Paulista (Brazil) with a view to relocate the DORIS antenna
- B4G installation at San Juan (Argentina)
- Maintenance at Ny-Ålesund II (Svalbard, Norway)
- B4G installing at Futuna (France)
- B4G installing at Wettzell (Germany)
- B4G installing at Nouméa (New Caledonia, France)
- B4G installing at Owenga (Chatham Island, New Zealand)

In 2023, the overall objectives are:

- Continuation of the deployment of the 4th generation beacon
- Relocation of the DORIS station at Easter Island (Chile)
- Restarting of the DORIS station at Santa-Cruz (Galapagos)
- Installation of a new DORIS site at Gavdos Island (Crete, Greece)
- Station renovation at Everest (Nepal)
- Installation of new DORIS site at Katherine (Australia)
- Renovation at Rikitea (French Polynesia)

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 several 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. Over the period covered by this report, in accordance with the Terms of Reference of the IDS, the membership of the GB was then partially renewed in January 2021 and January 2023 (see **Table2**).

The members who were elected or appointed for the term 2021-2024 are:

- Frank Lemoine (NASA/ GSFC, USA) as Analysis Center Representative,
- Patrick Michael (NASA/GSFC, USA) as Data Center Representative,
- Karine Le Bail (Chalmers University of Technology, Sweden) as Member-at-Large,
- Pascale Ferrage (CNES, France), reappointed by CNES as the DORIS system representative,

- Jérôme Saunier (IGN, France), reappointed by IGN as the Network representative.
- Tonie van Dam (University of Luxembourg, Luxembourg), appointed by IERS as the IERS representative.

The members who were elected or appointed for the term 2023-2025 are:

- Petr Štěpánek (Geodetic Observatory Pecný, Czech Republic) as Analysis Coordinator.
- Laura Sánchez (DGFI-TUM, Germany) as Member-at-large.

In January 2021, the Governing Board re-elected Frank Lemoine as the Chairperson of the IDS Governing Board for 2021-2024.

Denise Dettmering remains an ex officio but non-voting member of the IDS GB, in the role of Chair of the IDS Working Group on Near Real Time Data

Note that Ernst Schrama (TU Delft, The Netherlands) was designated by IAG as its representative within the Governing Board for 2019-2022, to replace Petr Štěpánek (Geodetic Observatory Pecny, Czech Republic), who resigned from this position after he was elected with Hugues Capdeville (CLS, France) to form the Analysis Coordination team for the term 2019-2022.

The IDS GB sincerely thanks the previous members Brian Luzum, Hugues Capdeville and Claudio Abbondanza for serving on the IDS GB for several years.

We would like to say a special thank you to Pascale Ferrage who, after 13 years of involvement in the organization and animation of the IDS, has moved on to other activities in 2022. She is replaced by Arnaud Sellé as CNES/ IDS project manager and representative of the DORIS system within the IDS.

Table 2. Composition of the IDS Governing Board from January 2023.

Position	Term	Status	Name	Affiliation	Country
Analysis coordinator	**2023-2026**	Elected	**Petr Štěpánek**	Geodetic Observatory Pecný	Czech Republic
Data Centers' representative	**2021-2024**	Elected	**Patrick Michael**	NASA/GSFC	USA
Analysis Centers' representative	**2021-2024**	Elected	**Frank Lemoine (chair)**	NASA/GSFC	USA
Member at large	**2023-2026**	Elected	**Laura Sánchez**	DGFI/TUM	Germany
Member at large	**2021-2024**	Elected	**Karine Le Bail**	Chalmers University of Technology	Sweden
Director of the Central Bureau	Since 2003	Appointed	**Laurent Soudarin**	CLS	France
Combination Center representative	Since 2013	Appointed	**Guilhem Moreaux**	CLS	France
Network representative	**2021-2024**	Appointed	**Jérôme Saunier**	IGN	France
DORIS system representative	**2023-2024**	Appointed	**Arnaud Sellé**	CNES	France
IAG representative	**2019-2022**	Appointed	**Ernst Schrama**	TU Delft	The Netherlands
IERS representative	**2021-2024**	Appointed	**Tonie van Dam**	University of Luxembourg	Luxembourg
Chair of WG "NRT DORIS data"	**Nov. 2016-**	Ex-officio (non voting member)	**Denise Dettmering**	DGFI/TUM	Germany

2.2 IDS strategic plan

After the IDS Retreat held in June 2018, the IDS GB worked on the development of a strategic plan for the IDS. In the coming years, IDS will focus on growing the community, extending the DORIS applications, and improving the technology, the infrastructure, and the processing.

2.3 IDS life

The reporting period started sadly because on February 4, 2019, we lost our colleague and friend Richard Biancale, recently retired from the CNES in September 2018, and newly installed at the GFZ (Oberpfaffenhofen) to work with Dr. Frank Flechtner on GRACE Follow-On. A tribute was paid to him in the IDS Newsletter #6:

https://ids-doris.org/images/documents/newsletters/IDS-Newsletter6.pdf#page=5.

IDS also experienced a more joyful departure as in April 2020 Pascal Willis retired from the Institut Géographique National (IGN) after a long and active career promoting analysis and use of DORIS data in geodesy. An article was dedicated to him in the IDS Newsletter #8:

https://ids-doris.org/images/documents/newsletters/IDS-Newsletter8.pdf#page=8.

Arnaud Pollet and Samuel Nahmani will now lead the IGN/DORIS Analysis Center activities following the retirement of Pascal Willis.

The application of the DGFI-TUM (Munich, Germany) to become an Associate Analysis Center was approved by the IDS Governing Board at its meeting on October 1st, 2019. In addition to the six regular Analysis Centers, four Associate Analysis Centers now contribute to the IDS analysis activities.

Frank Lemoine and Laurent Soudarin attended the International Workshop for the Implementation of the Global Geodetic Reference Frame in Latin America held in Buenos Aires, Argentina, from September 16 to 20, 2019. It was the opportunity to meet the friendly colleagues from the agencies hosting DORIS stations in this part of the world.

In 2022, Pascale Ferrage resigned from the IDS GB and was replaced by Arnaud Sellé as CNES/ IDS project manager and representative of the DORIS system within the IDS.

2.4 DORIS days 2021 (November 16, 17 and 18)

The IDS organized online “DORIS Days" on November 16, 17 and 18, 2021. This event was an introductory course to give non-practitioners in DORIS the opportunity to broaden their knowledge of the DORIS technique as well as to provide information on IDS products. Three sessions were given online:

- "Introduction to DORIS and the International DORIS Service" (118 participants)
- "Overview of Products Derived from DORIS" (90 participants)
- "Description DORIS Station Installation and Operations Requirements" (70 participants)

The complete program is available on the IDS website at https://ids-doris.org/ids/reports-mails/meeting-presentations/doris-day-2021.html

This event widely mobilized the members of the Governing Board and the Central Bureau. The organization committee was composed of Pascale Ferrage, Karine Le Bail, Frank Lemoine, Guilhem Moreaux, Jérôme Saunier, Ernst Schrama, Laurent Soudarin. Several external speakers gave presentations in the form of ppt slides or pre-recorded videos.

Prior to the days, the Central Bureau and the organization committee carried out the following actions:

- Preparation of the material: logo mock-up, presentation template, final version of the wallpaper for Teams, pdf of the presentations.
- Communication about the event: dedicated page on the IDS website, announcements on DORISmails and other mailing lists, ...
- Registration management: registration form, follow-up of registrations, sending of confirmation emails
- Management of online meetings with MS Teams: sending invitations, test sessions with speakers, technical support during sessions, retrieving attendance statistics, recording sessions
- Forum management: setting up the https://dorisdays2021.aviso.altimetry.fr/ sub-site, configuration, creation of accounts, uploading of presentations and videos, user support

2.5 DORIS special issue

The journal Advances in Space Research launched in September 2021 a Call for Papers for a Special Topic Issue with the title “New Results from DORIS for Science and Society” and the editors Dr. Ir. Ernst Schrama (TU Delft) and Dr. Ing- Denise Dettmering (DGFI / TU München).

The issue consists of 8 eight papers and is dated 1 July 2023. The list of articles can be found at https://www.sciencedirect.com/journal/advances-in-space-research/vol/72/issue/1.

2.6 IDS call for proposals: hosting a DORIS station

In April 2022, the IDS issued a call for participation with aim at encouraging institutions and agencies involved in geodesy to express their interest in hosting an "IDS Station" and developing scientific collaboration with IDS. An "IDS station" is distinct from the general network dedicated to "orbitography" or "orbit determination" and can have a specific scientific focus.

Eight proposals were submitted. Analysis of the proposals by a committee made up of GB members led to a list of two proposals that best met the selection criteria (location, co-location with other instruments, indoor equipment housing conditions, antenna environment, monument stability, maintenance and security, host agency abilities, scientific collaboration). Remote meetings were organized with each of the two shortlisted groups to meet them and gather additional information. Following these meetings, the GB made its decision and selected the proposal from ITT Kanpur (India). A site reconnaissance will be carried out in order to determine the best suitable location for the antenna with respect to system requirements. The objective is to install the beacon in 2024.

2.7 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 (see **3.1**). 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.

Website

Flash the QR code to visit the IDS website

The Central Bureau maintains the web resources of the IDS. Besides the regular updates of pages and additions of documents, the website (https://ids-doris.org) has been upgraded and was enriched with new information. New features were added to the network viewer (https://apps.ids-doris.org/apps/map.html). IVS and ILRS co-located stations with DORIS sites can now be displayed in addition to the IGS stations. The list of the colocations is based on the file of ties between DORIS and GNSS, VLBI and SLR stations managed (see **Figure 5**). This item completes the list already in place: boundaries of the tectonic plates (Bird, 2003), large Earthquakes (magnitude greater or equal to 6) within a 500 km radius of the DORIS stations (source USGS), horizontal and vertical velocity vectors of the DPOD2014 solution, as well as rates (North, East and Up; in mm/yr) and local events, i.e., the events of the station (dates of installation, change of beacon equipment, Earthquakes in the vicinity).

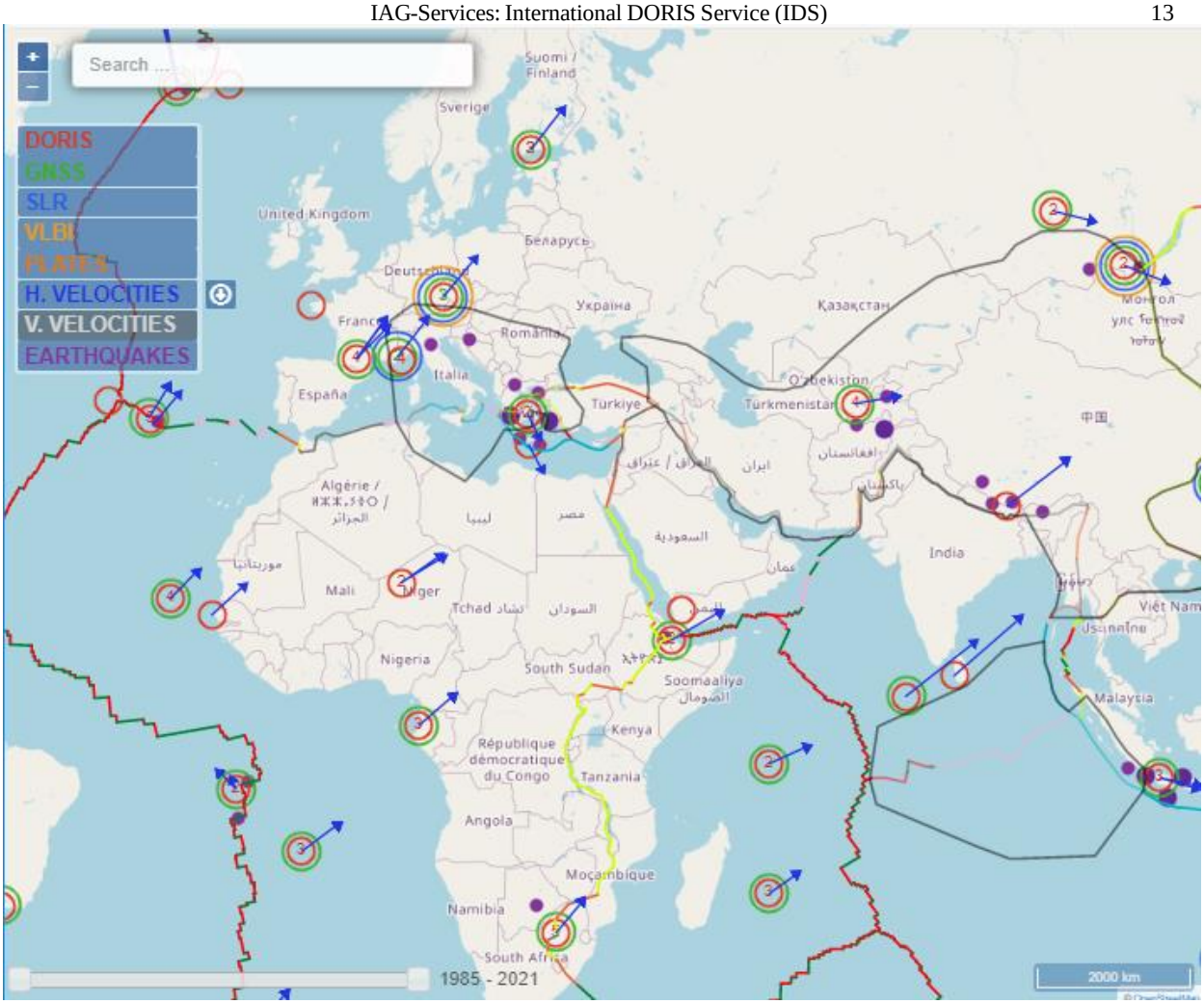


Figure 5. screenshot of the network viewer on the IDS web (https://apps.ids-doris.org/apps/map.html).

Newsletter

Launched in April 2016, the IDS Newsletter aims to provide regular information on the DORIS system and the life of IDS to a wide audience, from the host agencies to the other sister services. The issues are distributed via email to the subscribers to the DORISmail and several identified managers and decision-makers. They are also available from the IDS website (https://ids-doris.org/ids/reports-mails/newsletter.html).

A total of five issues were published in 2019 (#6 in February), 2020 (#7 in January, #8 in December), 2021 (#9 in September), 2023 (#10 in April). A new more dynamic presentation has been adopted since issue #7.

Data dissemination

The Central Bureau works with the SSALTO multi-mission ground segment and the IDS Data Centers (at IGN and the NASA CDDIS) to coordinate the data and products archiving and the dissemination of the related information. Data, metadata, and documentation of the three missions HY-2C, Sentinel-6A and HY-2D were put online the IDS data and information sites as they become available.

Following user requests for rapid dissemination of DORIS data for assimilation in ionospheric models, CNES has been distributing since February 2021 the first DORIS NRT products via the IGN data center. Observation data (RINEX) and orbit information (sp3) for the Jason-3 mission is available with a latency of about three hours. The new products are freely accessible via the following directories:

ftp://doris.ign.fr/pub/doris/data/ja3/NRT/
ftp://doris.ign.fr/pub/doris/products/orbits/ssa/ja3/NRT/
In 2023, the delivery of NRT products will be extended to additional missions.

DORIS-related articles in peer-reviewed journals
A new web-based tool for the management and consultation of the DORIS bibliography has been implemented on the IDS website. All references are stored in a database. The web component of the tool deployed on the https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html page allows dynamic display of the references and offers search functionalities by filter. The administration part of the tool consists of an input interface for ingesting references and a dashboard providing statistics on the content of the database.

DOI assignment
The Central Office now has the possibility of assigning DOIs to IDS documents and products using the CNES DOI service. For instance, a DOI was- assigned to the IDS16 solution contributing to ITRF2020 (10.24400/312072/i01-2021.001) as well as to the IDS activity report 2021 (10.24400/312072/i02-2023.001).
The Central Bureau participates in the meetings of the GGOS DOI Working Group.

2.8 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,
- Institut National de l'Information Géographique et Forestière (IGN) in Marne-la-Vallée France.

Both institutions have archived DORIS data since the launch of TOPEX/Poseidon in 1992. The CDDIS (ftps://gdc.cddis.eosdis.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.

From mid-2019, CNES developed a new tool to control the SSALTO deliveries of DORIS data and products at both IDS Data Centers (CDDIS and IGN). Missing files and anomalies were identified and fixed for the whole sub-tree of both data centers through detailed joint work between the IDS Central Bureau, SSALTO team and the Data Centers teams. This routine maintenance is now regularly carried out to ensure the integrity of SSALTO data and products (orbits, RINEX, quaternions…).

Following the IDS Retreat in 2019, the provision of Near-Real-Time DORIS data and products was decided. A pilot project was set up at the beginning of 2021 with the IGN Data Center: Jason3 RINEX data and DIODE orbits are distributed with a latency of about 3 hours. The first feedback from the WG "NRT DORIS Data" was quite positive: DORIS data latency up to 2-3 hours enables a contribution to the ultra-rapid ionosphere VTEC modeling; files structure improvements were requested but all may not be taken into account because it will impact the logical organization of the directory structure.

CDDIS Data Center

The NASA CDDIS Data Center stopped providing anonymous ftp services as of 1 November 2020. All users are now requested to use https, and a NASA Earthdata login as a method of access to the CDDIS archive. Instructions and example links are available here: https://cddis.nasa.gov/Data_and_Derived_Products/CDDIS_Archive_Access.html
Unencrypted anonymous ftp services are still available at IGN Data Center for the time being.

At the end of 2022, the CDDIS has devoted 146 GB of disk space (83GB or ~57% for DORIS data, 38GB or ~26% for DORIS products, and 25GB or ~17% for DORIS ancillary data and information) to the archive of DORIS data, products, and information. During the past year, users downloaded 1949 Gbytes (1,033,799 files) of DORIS data, products, and information from the CDDIS.

IGN Data Center

To ensure a more reliable data flow and a better availability of the IGN Data Center, two identical infrastructures and configurations have been set up in two different locations at IGN: (1) Saint-Mandé and (2) Marne-la-Vallée.
Each site offers:

- FTP deposit server for data and analysis centers uploads, requiring special authentication
- Free FTP anonymous access to observations data and products
- Independent Internet links

All the DORIS data and products archived and available at IGN DC may be access through:

1. ftp://doris.ign.fr (Saint-Mandé)
2. ftp://doris.ensg.eu (Marne-la-Vallée)

The mirroring applied between both IGN DORIS Data Centers will be consolidated to have exact identical content.
Finally, the IGN Data Center is thinking about possible evolution regarding file access and transfer by implementing the Secure File Transfer Protocol (SFTP).

After more than 12 years of service for the IGN DORIS Data Center, Bruno Garayt handed over to Jérôme Saunier from January 2019. Thank you Bruno!

2.9 Analysis Centers and Analysis Coordination

The activities of all DORIS analysts were dominated by the preparation in 2019, then by the reprocessing of DORIS data for ITRF2020 in 2020 and early 2021. However, they were profoundly affected by the COVID pandemic in 2020 and 2021. In 2020, all meetings of the Analysis Working Group (AWG) and the IDS workshop were cancelled due to the pandemic. The usual face-to-face AWG meetings were held remotely from 2021 onwards.
Two meetings were held in 2019, in Munich (Germany) in April and in Paris (France) in September/October. The only AWG meeting in 2021 was held online on April 6 and 7. The AWG then met online on June 14, 2022, and April 18, 2023. The group will meet again in person in November 2023.

Analysis Working Group (AWG) meetings

The first AWG meeting of 2019 was held in Munich on April 4, thanks to our hosts Denise Dettmering and Mathis Bloßfeld from DGFI-TUM. As usual, the analysis centers and the combination center gave their processing status. New DORIS groups such as DGFI-TUM and Copernicus POD service presented the results of their processing of DORIS satellite data. The CNES POD team presented studies on the update of the HY-2A SRP model, on the progress of CNES mascon solutions and on the pre-processing of DORIS phase data for Doppler solutions. The main objective of this meeting was the IDS contribution to ITRF2020.
The second AWG meeting of 2019 took place at CNES headquarters in Paris on September 30 and

October 1, thanks to our host Pascale Ferrage. The first part of the meeting was devoted to general IDS presentations, while the second part focused on the most important topics relevant to the 2020 ITRF reprocessing.

Meetings resumed in 2021, with an online meeting in April. The analysis centers involved in the ITRF2020 reanalysis also held periodic virtual meetings with the IDS combination center to discuss issues relating to their contributions and the preparation of the IDS combination for ITRF2020.

The online meeting in June 2022 started typically with DORIS system and network status reports. A major part of the meeting was devoted to the post-ITRF reprocessing plans and activities of IDS analysis centers and associated analysis centers. The CNES POD team presented how to profit from the tandem phase of Jason-3/Sentinel-6A and Sentinel-3A/Sentinel-3B. Also, detail analysis of Tristan Da Cunha data was presented.

The April 2023 meeting was also held online. In addition to the reports from the Analysis Centers and Associate Analysis Centers, presentations were given on the latest gravity field New mean gravity field model CNES_GRGS.RL05MF_combined_GRACE_SLR_DORIS from GRGS (JM Lemoine) and its evaluation by DGFI-TUM (S. Rudenko) using precise orbit determination of TOPEX/Poseidon and Jason satellites, as well as the precise determination of CryoSat-2's orbit in ITRF2020 (E. Schrama).

Presentations from the AWG meetings are available on the IDS website at
https://ids-doris.org/ids/reports-mails/meeting-presentations.html

Analysis Centers and Combination Center

The IDS includes six Analysis Centers (AC) and four Associate Analysis Centers (AAC) who use eight different software packages, as summarized in **Table 3**. Some analysis centers perform POD analyses of DORIS satellites on a routine basis using other geodetic techniques (SLR and GNSS). Over the recent years, three ACs have fully participated in operational solutions (GSC, GRG, GOP). The ESA AC also participated in the ITRF reprocessing. The ACs IGN and INA are not delivering operational solutions at the present time. The IGN center has not yet restarted its activities after the retirement of its long- time director, Pascal Willis. The IGN AC is presently implementing DORIS processing with the new GipsyX software. The INA analysis center is presently developing a new software package. The IDS has been in contact with the ACs, but we contain to wait for their return to operational status. The Associate Analysis center (AAC) GFZ contributed to ITRF2020 by testing series processing data from chosen set of satellites. The DGFI-TUM AAC has been active in the satellite attitude modeling and the evaluation of reference frames. The CNES AAC continues to provide POD solutions for operational users, including for the new satellites, Sentinel-6A and HY-2C. The CNES AAC POD solutions are delivered regularly to the IDS Data Centers and are usually multi-technique solutions based on DORIS and GNSS.

A Geocenter Working Group was established including CNES, GOP, GRG, and DGFI-TUM.

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

DGFI-TUM	**AAC**	Germany	Mathis Bloßfeld, Sergei Rudenko	DOGS	SLR

Table 3. Summary of IDS Analysis Centers (AC) and Associate Analysis Centers (AAC)

ITRF2020 reprocessing

Four analysis centers participated in the ITRF 2020 reprocessing: GSC, GRG, GOP, and ESA. GSC, GRG and GOP processed data 1993.0-2020.0. GSC did not include Sentinel-3A and Sentinel-3B data but plans its inclusion in final solution. GOP completely excluded Jason-1 data. The ESA data processing was delayed but with anticipation of full contribution. IGN and INA were not able fully contribute.

The schedule followed by IDS for this reprocessing was as follows:

- 2020, March 30: delivery by ACs of 1993.0 2002.3 (until start of Envisat First DORIS 2G receiver)
- 2020, June 30: delivery by ACs of 2002.3 2011.8 (until start of HY-2A).
- 2020, Sept. 30: delivery by ACs of 2011.8 2020.0.
- 2021, Feb. 10: First delivery of the IDS combined solution to the IERS (1993.0 2020.0).
- 2021, Feb. 14: delivery by ACs of 2020
- 2021, Mar. 15: Complete delivery to the IERS of the IDS combined solution (1993.0-2021.0).

2.10 Combination Center

The IDS Combination Center (CC) performs the routine evaluation and combination of the solutions of the IDS Analysis Centers. In 2019 and 2020, the CC released the two versions of the IDS cumulative position and velocity and DPOD2014 solutions. It also performed some analysis mostly related to the forthcoming realization of the IDS contribution to the ITRF2020 and initialized the analysis and construction of the IDS series for the ITRF2020. In 2021, the CC finalized the IDS contribution to the ITRF2020. Then, it computed and distributed the first version of the DPOD2020.

IDS Routine Evaluation and Combination

At the end of 2020, the time span of the SINEX files of the IDS combined solution was 1993.0-2020.5. These files correspond to the new IDS series 14 which differs from the previous series 13 by a new preprocessing of the inputs, i.e., the weekly SINEX files provided by the Analysis Centers (ACs).

Late 2019, the Combination Center released a new version of the coordinate time series plots which are routinely delivered to the Data Centers. That new version (see **Figure 6**) displays as vertical lines dates of events which may have an impact of the positions and/or velocities. Depending on their origin, three types of events are displayed: seismic, technical (beacon or USO change, antenna displacement…) and unknown.

At the end of the first quarter of 2023, the time span of the SINEX files of the IDS combined solution was 1993.0-2022.0. These files correspond to the new IDS series 20 which can be seen as the time extension of the IDS contribution to the ITRF2020. Note that now the routine evaluation includes the delivery to the IDS Data Centers of the time series of the daily Earth pole coordinate estimations from the IDS ACs and the IDS CC solutions. Over the last two years, the IDS CC also evaluated several single satellite solutions (Jason-3, Sentinle-3A/B, Sentinel-6A mainly) from the IDS ACs as well as from the associated AC GFZ.

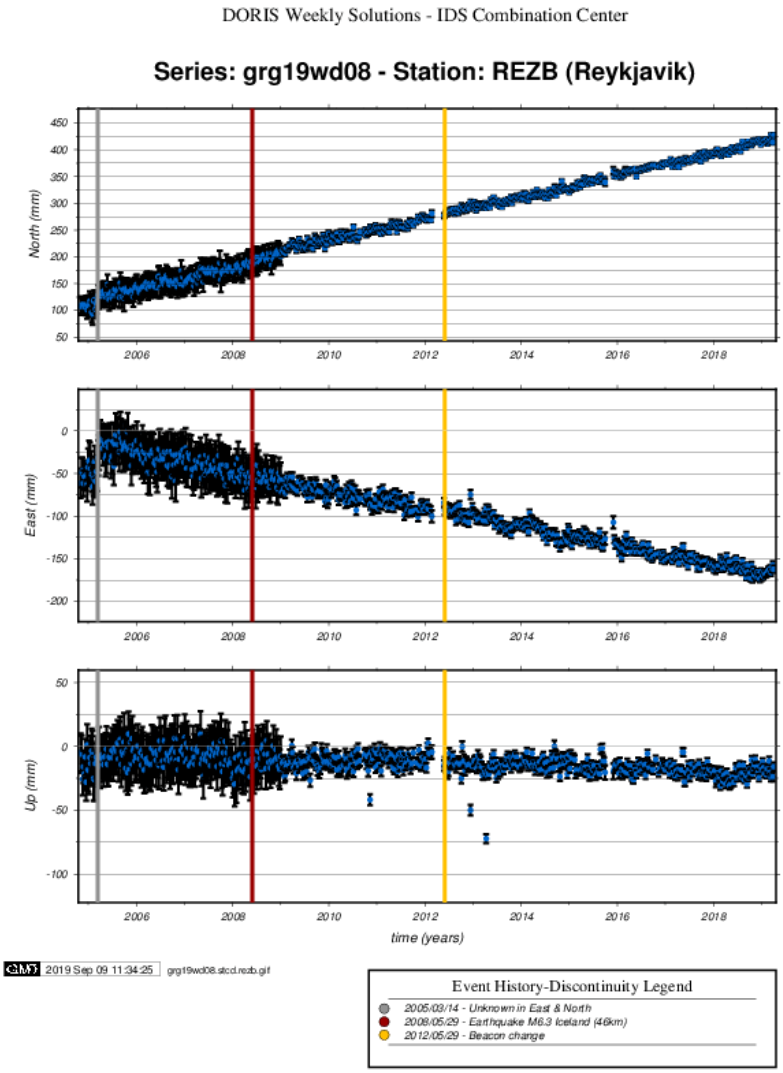


Figure 6. Example of the new version of the coordinate time series plots delivered to the IDS Data Centers for station REZB (Reykjavik).

IDS Cumulative Solution

In 2019, the Combination Center realized and made available (through the IDS Data Centers) the fourth version of the DORIS cumulative solution (ids19d04) which provides the mean positions and velocities of the DORIS stations. That solution is obtained by the stacking of the ids 13 weekly combined solution from 1993.0 to 2019.0. All the cumulative solutions are available in SINEX format at the IDS Data Centers. Internal validation reports as well as plots of the station position residuals (differences between the weekly positions as input and the positions deduced from the mean positions and velocities) are available on the IDS website.

Mid-2020, due to both the evolution of the beacon ground network and of new geophysical events, a new cumulative solution over 1993.0-2020.0 was produced based on the ids13 and ids14 weekly combined solutions.

To better understand the differences between the solutions of the Analysis Centers and their impact on the estimation of the mean positions and velocities, the Combination Center adapted the cumulative processing chain to get position and velocity cumulative solutions for each operational AC. As the IDS cumulative solution, these solutions are also aligned to the ITRF2014 and make use of the same discontinuities.

DPOD2014

In line with the realization of the fourth version of the DORIS cumulative solution, the Combination Center delivered to the IDS community the fourth and fifth versions of the DORIS extension of the ITRF2014, called DPOD2014 (see **Figure 7**). Compared to the cumulative solution, the DPOD2014 contains the stations observed before 1993 as well as the stations turned on after the ending date of the stacking. The DPOD2014 solution is available for download from the IDS Data Centers in both SINEX and text formats.

From the DPOD2014, the Combination Center generates a so-called IDS SINEX Master file containing the names and locations of all the DORIS stations since the start of DORIS. The SINEX Master file is freely available for download from the IDS Central Bureau ftp site at https://ids-doris.org/documents/BC/stations/ids.snx.

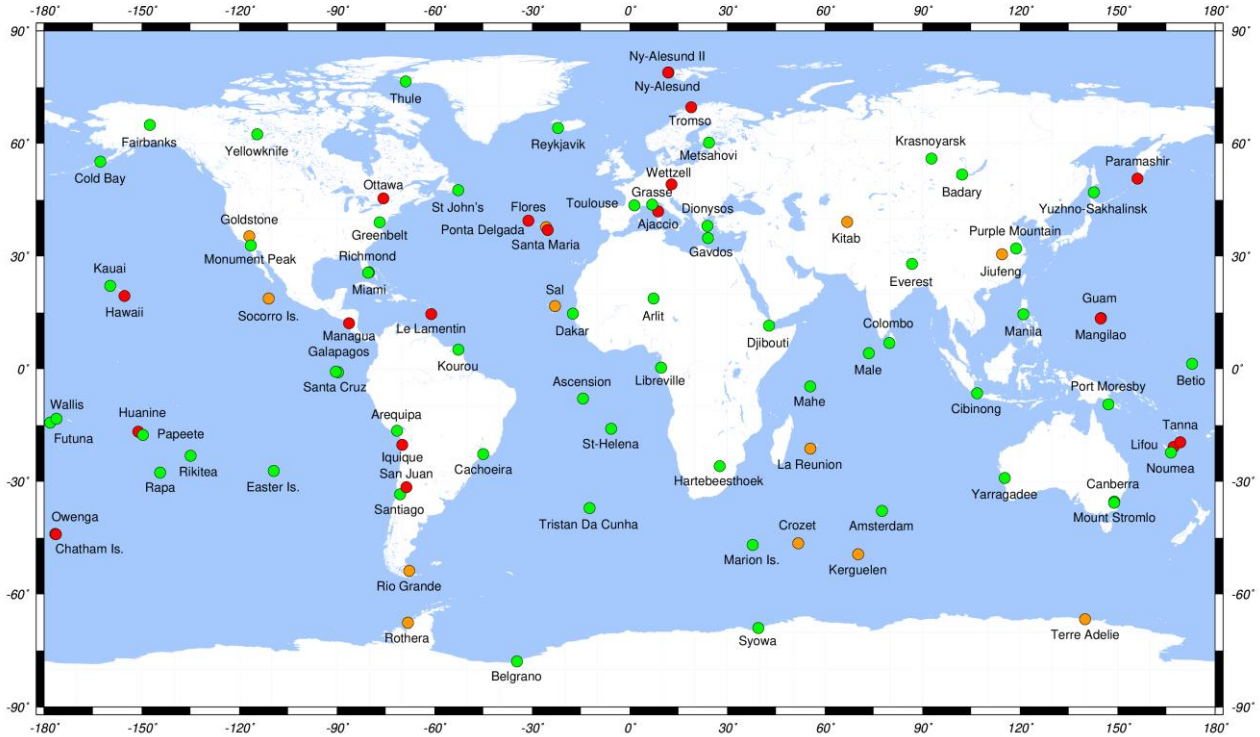


Figure 7. DORIS sites included in the version 5 of the DPOD2014 (i.e., DORIS extension of the ITRF2014). Green: ITRF2014 sites. Orange: ITRF2014 sites with new station(s) since ITRF2014. Red: sites not included in the ITRF2014.

ITRF2020

Nearly fifteen series were delivered by the four IDS ACs (ESA, GOP, GRG and GSC) which agreed to participate to the realization of the DORIS contribution to the ITRF2020. The AC's delivered multiple series to test different models and modes of data processing. The final series delivered for ITRF2020 were fully compliant with the latest IERS standards and recommendations in the ITRF2020 call of participation. The delivery of the ACs was scheduled over time-periods linked with the time evolution of the DORIS satellite constellation: 1993.0-2002.5, 2002.5-2011.7 and 2011.7-2020.0. Due the DORIS data and model latencies, the last year (2020) was delivered by February 2021.

The year 2020 was devoted to evaluating the performance of the received series, analyzing the anomalies, iterating with the Analysis Centers to correct them, improving the combination processing chain, and defining the combination strategy.

Prior to AGU 2020 Fall meeting, the IDS CC made available for evaluation to the IERS combination centers (DGFI, IGN and JPL) a preliminary IDS solution from 1993.0 to 2020.0.

From the contribution of the four IDS ACs (ESA, GOP, GRG and GSC), the IDS CC realized the IDS contribution to the ITRF2020. The final version of the IDS 16 series was delivered to the IERS in July 2021. For all the details of the IDS contribution to the 2020 realization of the ITRF, we refer to the next open access paper:

Moreaux, G., Lemoine, F.G., Capdeville, H., et al., 2023. The International DORIS Service contribution to the 2022 realization of the International Terrestrial Reference Frame. Adv. Space Res., 72(1), 65-91, DOI: 10.1016/j.asr.2022.07.012.

As soon as the ITRF2020, DTRF2020 and JTRF2020 solutions were made available, the IDS CC performed the DORIS evaluation of these solutions and shared the results with the corresponding IERS ITRS centers.

DPOD2020

In 2022, the IDS CC started the realization of the first version of the DPOD2020 (*DORIS extension of the ITRF2020 for Precise Orbit Determination*) based on the IDS 19 weekly combined solution from 1993.0 to 2022.0 (see **Figure 8**). Like with DPOD2014, each DPOD realization relies on the computation of a DORIS position and velocity cumulative solution aligned to the current version of the ITRF and is validated by POD tests performed by GSFC and CNES. The processing strategy and the validation test results of the DPOD2020 version 1.0 were presented at AGU 2022. The DPOD2020 version 1.0 was released to the IDS Data Centers late January 2023 and is available in both text and SINEX formats. Since DPOD2014, the DPOD SINEX files include two new blocks listing the dates and origins of the discontinuities and time periods of some stations which were rejected and may not be used for POD.

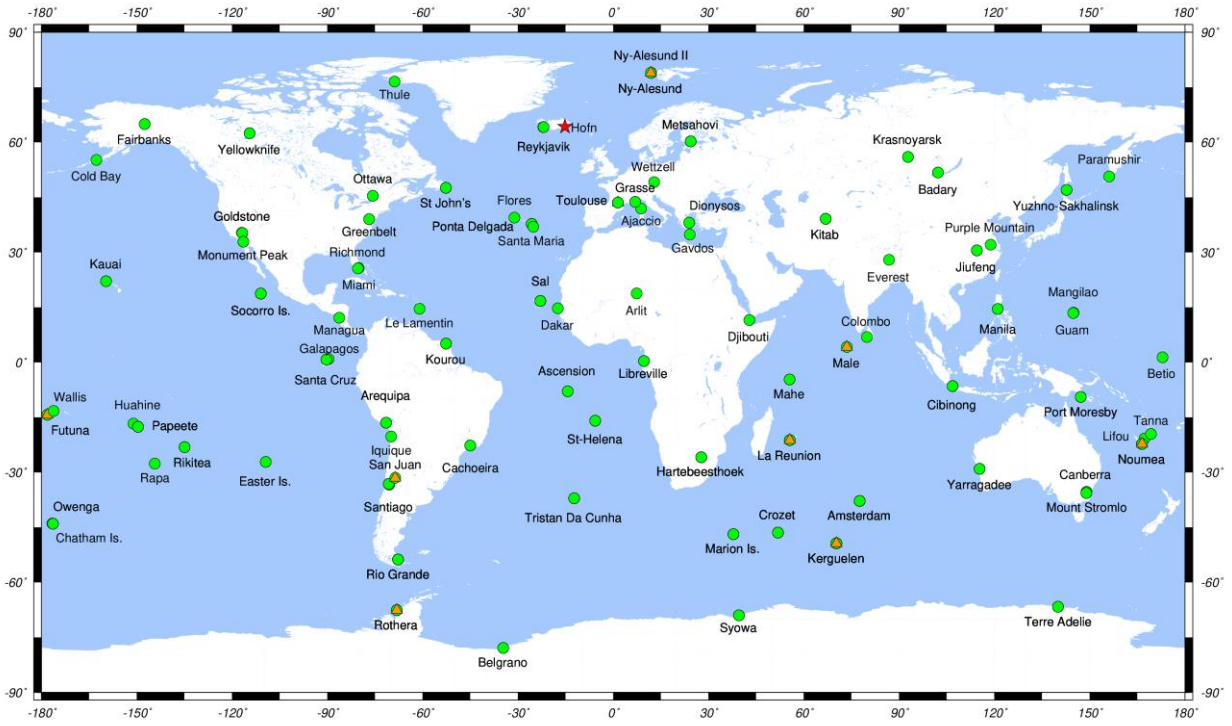


Figure 8. DORIS sites included in the version 1 of the DPOD2020. Green: ITRF2020 sites. Orange: ITRF2020 sites with new station(s) since ITRF2020. Red: sites not included in the ITRF2020.

Since the release of the DPOD2020 version 1.0, the IDS CC initiated some studies on the sensitivity of the HY-2A mission to the South Atlantic Anomaly. From the output of the DORIS position and velocity cumulative solution, the IDS CC also investigated the increase of some

station position residuals since 2018-2019.

2.11 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 Dettmering (DGFI-TUM) as chair.
The general objective of this working group is a thorough assessment on benefits, requirements, and prospects of near real-time (NRT) DORIS data with a focus on applications in ionospheric research.

The main topics addressed by the WG are:

- Development of a DORIS ionospheric product (STEC/VTEC or dSTEC/dVTEC),
- Using DORIS data for global real-time ionospheric modeling,
- Using DORIS data to validate the performance of global ionospheric TEC models,
- Improving ionospheric modelling with focus on the combination of different space-based observation datasets,
- Networking with other IAG working groups: GGOS JWG 3 “Improved understanding of space weather events and their monitoring by satellite missions” and IAG JWG 4.3.1 “Real-time ionosphere monitoring and modelling”.

Since February 2021, the first DORIS NRT products are distributed via the IGN data center. Within the current evaluation period, observation data (RINEX) and orbit information (sp3) for the Jason-3 mission is available with a latency of about three hours. The new products are freely accessible via the following directories:
ftp://doris.ign.fr/pub/doris/data/ja3/NRT/
ftp://doris.ign.fr/pub/doris/products/orbits/ssa/ja3/NRT/

“Since the data from one mission are too few to have a direct influence on ionosphere modelling, there are no NRT ionosphere models with DORIS data yet. However, the data can already be used to validate existing GNSS-based ionosphere models. For this purpose, relative changes in the slant total electron content (dSTEC) derived from two-frequency measurements along the link between the ground station and the satellite, are calculated for individual overflights of the satellite, always related to the highest elevation of the arc. This method has been used for GNSS observations for a long time (Hernández-Pajares et al. 2017). Liu et al (2023) uses this method to validate real-time (RT) GNSS ionospheric models from different IGS analysis centres (namely from CAS, CNES, UPC, WHU; see Liu et al (2023) for more explanations) and finds that this works as well with DORIS data as with GNSS data and is completely independent of the model input data.
In addition to providing an indication of the accuracy of individual RT ionospheric models, the NRT DORIS data can also be used to weight the models of individual data centres for combination. Wang et al (2022) presents first results of such a weighting and shows through a validation with independent altimeter data from the Jason-3 mission that the new combination achieves a better performance than the combination based on classical methods.

It is planned to make NRT DORIS data available for additional satellite missions (Sentinel-3A, Sentinel-3B, Sentinel-6A) and possibly also to further reduce the latency times. This would then result in numerous further applications for ionospheric modelling.” *(source IDS Newsletter #10*

https://ids-doris.org/images/documents/newsletters/IDS-Newsletter10.pdf#page=2)

References

Hernández-Pajares, M., Roma-Dollase, D., Krankowski, A., García-Rigo, A., Orús-Pérez, R. (2017). Methodology and consistency of slant and vertical assessments for ionospheric electron content models. Journal of Geodesy, 91(12). DOI: 10.1007/s00190-017-1032-z

Liu A., Wang N., Dettmering D., Li Z., Schmidt M., Liang W., Yuan H. (2023). Using DORIS Data for Validating Real-Time GNSS Ionosphere Maps. Advances in Space. Research. DOI: 10.1016/ j.asr.2023.01.050

Wang, N., Liu, A., Dettmering, D., Li, Z., Schmidt, M. (2022). Using Near-Real-Time DORIS data for validating real-time GNSS ionospheric maps. Presented at the IDS Workshop 2022. DOI: 10.24400/312072/i03-2022.3612

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.

In addition, for the first time, the IDS organized a special event called “DORIS Days" on November 16, 17 and 18, 2021. This event held online was an introductory course to give non-practitioners in DORIS the opportunity to broaden their knowledge of the DORIS technique as well as to provide information on IDS products.

Table 4 gives the list of the meetings held over the reporting period. Due to the global Covid-19 pandemic, no event was organized in 2020.

Table 4: IDS Meetings and events (2019-2023)

Meeting	Location	Country	Dates
DORIS AWG Meeting	Munich	Germany	4 April 2019
DORIS AWG Meeting	Paris	France	30 September – October 2019
DORIS AWG Meeting	online		6-7 April 2021
DORIS day	online		16-18 November 2021
DORIS AWG Meeting	online		14 June 2022
IDS Workshop	Venice	Italy	31 October - 2 November 2022
DORIS AWG Meeting	online		18 April 2023

3.2 Publications

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

- International DORIS Service (IDS), Report of the International Association of Geodesy 2015-2019, Travaux de l'Association Internationale de Géodésie, Frank Lemoine (chairman of the Governing Board), 2019.
  https://ids-doris.org/documents/report/IDS_Report_mid2015_mid2019_for_IAG.pdf
- International DORIS Service Activity report 2018, Laurent Soudarin and Pascale Ferrage (Eds), 108 pages, 2019.
  https://ids-doris.org/documents/report/IDS_Report_2018.pdf
- International DORIS Service Activity report 2019-2020, Laurent Soudarin and Pascale Ferrage (Eds), 137 pages, 2021
  https://ids-doris.org/documents/report/IDS_Report_2019-2020.pdf
- International DORIS Service Activity report 2021, Laurent Soudarin and Pascale Ferrage (Eds), 105 pages, 2023
  https://doi.org/10.24400/312072/i02-2023.001

3.3 Peer-reviewed publications related to DORIS

IDS 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), including the eight papers of the DORIS special issue "New Results from DORIS for Science and Society" published in Advances in Space Research:

2023

Altamimi, Z.; Rebischung, P.; Collilieux, X.; Métivier, L.; Chanard, K., 2023. ITRF2020: an augmented reference frame refining themodeling of nonlinear station motions, JOURNAL OF GEODESY, 97:47, DOI: 10.1007/s00190-023-01738-w **OPEN ACCESS**

Delva, P.; Altamimi, Z.; Blazquez, A.; Bloßfeld, M.; Böhm, J., 2023. GENESIS: co-location of geodetic techniques in space, EARTH PLANETS AND SPACE, 75:5, DOI: 10.1186/s40623-022-01752-w **OPEN ACCESS**

Herscovici-Schiller, O.; Gachet, F.; Couetdic, J.; Meyer, L.; Reynaud, S., 2023. A simple ionospheric correction method for radar-based space surveillance systems, with performance assessment on GRAVES data, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):108-114, DOI: 10.1016/j.asr.2022.05.036

Kong, Q.; Zhang, L.; Han, J.; Li, C.; Fang, W.; Wang, T., 2023. Analysis of coordinate time series of DORIS stations on Eurasian plate and the plate motion based on SSA and FFT, GEODESY AND GEODYNAMICS, 14(1):90-97, DOI: 10.1016/j.geog.2022.05.001

Liu, A.; Wang, N.; Dettmering, D.; Li, Z.; Schmidt, M.; Wang, L.; Yuan, H., 2023. Using DORIS Data for Validating Real-Time GNSS Ionosphere Maps, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):115-128, DOI: 10.1016/j.asr.2023.01.050

Lösler, M.; Eschelbach, C.; Mähler, S.; Guillory, J.; Truong, D.; Wallerand, J.P., 2023. Operator-software impact in local tie networks, APPLIED GEOMATICS, 15:77-95, DOI: 10.1007/s12518-022-00477-5 OPEN ACCESS

Moreaux, G.; Lemoine, F.G.; Capdeville, H.; Otten, M.; Štěpánek, P.; Saunier, J.; Ferrage, P., 2023. The international DORIS service contribution to ITRF2020, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):65-91, DOI: 10.1016/j.asr.2022.07.012 **OPEN ACCESS**

Pollet, A.; Coulot, D.; Biancale, R.; Perosanz, F.; Loyer, S.; Marty, J.C.; Glaser, S.; Schott-Guilmault, V.; Lemoine, J.M.; Mercier, F.; Nahmani, S.; Mandea, M., 2023. GRGS numerical simulations for a GRASP-like mission – A way to reach the GGOS goal for terrestrial reference frame, JOURNAL OF GEODESY, 97:45, DOI: 10.1007/s00190-023-01730-4

Rudenko, S.; Dettmering, D.; Zeitlhöfler, J.; Alkahal, R.; Upadhyay, D.; Bloßfeld, M., 2023. Radial Orbit Errors of Contemporary Altimetry Satellite Orbits, SURVEYS IN GEOPHYSICS, 44:705-737, DOI: 10.1007/s10712-022-09758-5 **OPEN ACCESS**

Saunier, J., 2023. The DORIS network: Advances achieved in the last fifteen years, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):3-22, DOI: 10.1016/j.asr.2022.07.016

Schreiner, P.; König, R.; Neumayer, K.H.; Reinhold, A., 2023. On precise orbit determination based on DORIS, GPS and SLR using Sentinel-3A/B and -6A and subsequent reference frame determination based on DORIS-only, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):47-64, DOI: 10.1016/j.asr.2023.04.002

Štěpánek, P.; Filler, V., 2023. DORIS Alcatel ground antenna: Evaluation of the phase center variation models, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):23-26, DOI: 10.1016/j.asr.2022.02.024

Štěpánek, P.; Moreaux, G.; Hugentobler, U.; Filler, V., 2023. The GOP Analysis Center: DORIS contribution to ITRF2020, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):92-107, DOI: 10.1016/j.asr.2022.11.038 **OPEN ACCESS**

Zhou, C.; Zhong, S.; Peng, B.; Xiao, C.; Yan, H.; Zhang, J.; Guo, F.; Chen, R., 2023. Analysis of precise orbit determination for maneuvering HY2C and HY2D satellites using DORIS/RINEX data, in New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmering (Eds.), ADVANCES IN SPACE RESEARCH, 72(1):37-46, DOI: 10.1016/j.asr.2022.05.040

2022

Ampatzidis, D.; Thaller, D.; Wang, L., 2022. The Correlations of the Helmert Transformation Parameters as an Additional Auxiliary Diagnostic Tool for Terrestrial Reference Frames Quality Assessment, IAG SYMPOSIA, :, DOI: 10.1007/1345_2022_164 OPEN ACCESS

Seitz, M.; Bloßfeld, M.; Angermann, D.; Seitz, F., 2022. DTRF2014: DGFI-TUM's ITRS realization 2014, ADVANCES IN SPACE RESEARCH, 69(6):2391-2420, DOI: 10.1016/j.asr.2021.12.037

Zeitlhöfler, J.; Bloßfeld, M.; Rudenko, S.; Dettmering, D.; Seitz, F., 2022. Station-dependent satellite laser ranging measurement corrections for TOPEX/Poseidon, ADVANCES IN SPACE RESEARCH, 71(1):975-996, DOI: 10.1016/j.asr.2022.09.002

2021

Belli, A.; Zelensky, N.P.; Lemoine, F.G.; Chinn, D.S., 2021. Impact of Jason-2/T2L2 Ultra-Stable-Oscillator Frequency Model on DORIS stations coordinates and Earth Orientation Parameters, ADVANCES IN SPACE RESEARCH, 67(3):930-944, DOI: 10.1016/j.asr.2020.11.034 OPEN ACCESS

International Altimetry Team, 2021. Altimetry for the future: Building on 25 years of progress, ADVANCES IN SPACE RESEARCH, 68(2):319-363, DOI: 10.1016/j.asr.2021.01.022 OPEN ACCESS

Khelifa, S., 2021. Correlation study of the annual signal in GPS and DORIS station positions with atmospheric and hydrology loading effects, ARABIAN JOURNAL OF GEOSCIENCES, 14:370, DOI: 10.1007/s12517-021-06778-0

König, R.; Reinhold, A.; Dobslaw, H.; Esselborn, S.; Neumayer, K.H.; Dill, R.; Michalak, A., 2021. On the effect of non-tidal atmospheric and oceanic loading on the orbits of the altimetry satellites ENVISAT, Jason-1 and Jason-2, ADVANCES IN SPACE RESEARCH, 68(2):1048-1058, DOI: 10.1016/j.asr.2020.05.047

Mertikas, S.; Donlon, C.; Matsakis, D.; Mavrocordatos, C.; Altamimi, Z.; Kokolakis, C.; Tripolitsiotis, A., 2021. Fiducial reference systems for time and coordinates in satellite altimetry, ADVANCES IN SPACE RESEARCH, 68(2):1140-1160, DOI: 10.1016/j.asr.2020.05.014

Yu, H.; Sośnica, K.; Shen, Y., 2021. Separation of geophysical signals in the LAGEOS geocentre motion based on singular spectrum analysis, GEOPHYSICAL JOURNAL INTERNATIONAL, 225(3):1755–1770, DOI: 10.1093/gji/ggab063

2020

Abbondanza, C.; Chin, T.M.; Gross, R.S.; Heflin, M.B.; Parker, J.W.; Soja, B.; Wu, X., 2020. A sequential estimation approach to terrestrial reference frame determination, ADVANCES IN SPACE RESEARCH, 65(4):1235 - 1249, DOI: 10.1016/j.asr.2019.11.016

Bertiger, W.I.; Bar-Sever, Y.E.; Dorsey, A.; Haines, B.J.; Harvey, N.; Hemberger, D.; Heflin, M.B.; Lu, W.; Miller, M.; Moore, A.W.; Murphy, D.; Ries, P.; Romans, L.J.; Sibois, A.; Sibthorpe, A.; Szilagyi, B.; Vallisneri, M.; Willis, P., 2020. GipsyX/RTGx, A New Tool Set for Space Geodetic Operations and Research, ADVANCES IN SPACE RESEARCH, 66(3):469-489, DOI: 10.1016/j.asr.2020.04.015 OPEN ACCESS

Beutler, G.; Villiger, A.; Dach, R.; Verdun, A.; Jäggi, A., 2020. Long polar motion series: Facts and insights, ADVANCES IN SPACE RESEARCH, 66(11):2487–2515, DOI: 10.1016/j.asr.2020.08.033 OPEN ACCESS

Bloßfeld, M.; Zeitlhöfler, J.; Rudenko, S.; Dettmering, D., 2020. Observation-Based Attitude

Realization for Accurate Jason Satellite Orbits and Its Impact on Geodetic and Altimetry Results, REMOTE SENSING, 12(4):682, DOI: 10.3390/rs12040682 OPEN ACCESS

Hernàndez-Pajares, M.; Lyu, H.; Garcia-Fernandez, M.; Orus-Perez, R., 2020. A new way of improving global ionospheric maps by ionospheric tomography: consistent combination of multi-GNSS and multi-space geodetic dual-frequency measurements gathered from vessel-, LEO- and ground-based receivers, JOURNAL OF GEODESY, 94:73, DOI: 10.1007/s00190-020-01397-1

Jagoda, M.; Rutkowska, M.; Suchocki, C.; Katzer, J., 2020. Determination of the tectonic plates motion parameters based on SLR, DORIS and VLBI stations positions, JOURNAL OF APPLIED GEODESY, 14(2):121-131, DOI: 10.1515/jag-2019-0053

Kong, Q.; Zhang, L.; Han, L.; Guo, J.; Zhang, D.; Fang, W., 2020. Analysis of 25 Years of Polar Motion Derived from the DORIS Space Geodetic Technique Using FFT and SSA Methods, SENSORS, :20(10), DOI: 10.3390/s20102823 OPEN ACCESS

Kosek, W.; Popiński, W.; Wnęk, A.; Sośnica, K.; Zbylut-Górska, M., 2020. Analysis of Systematic Errors in Geocenter Coordinates Determined From GNSS, SLR, DORIS, and GRACE, PURE AND APPLIED GEOPHYSICS, 177(2):867-888, DOI: 10.1007/s00024-019-02355-5 OPEN ACCESS

Štěpánek, P.; Bingbing, D.; Filler, V.; Hugentobler, U., 2020. Inclusion of GPS clock estimates for satellites Sentinel-3A/3B in DORIS geodetic solutions, JOURNAL OF GEODESY, 94:116, DOI: 10.1007/s00190-020-01428-x

Zhou, C.; Zhong, S.; Peng, B.; Ou, J.; Zhang, J.; Chen, R., 2020. Real-time orbit determination of Low Earth orbit satellite based on RINEX/DORIS 3.0 phase data and spaceborne GPS data, ADVANCES IN SPACE RESEARCH, 66(7):1700 - 1712, DOI: 10.1016/j.asr.2020.06.027

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, A. Sevi, J. Neves, H. Zhao (Eds.), SUSTAINABLE CIVIL INFRASTRUCTURES, :126-135, DOI: 10.1007/978-3-319-95645-9_12

Lian, L.; Wang, J.; Huang, C., 2019. Analysis and combination of four technique-individual EOP time series, GEODESY AND GEODYNAMICS, 10(2): 130 - 139, DOI: 10.1016/j.geog.2018.04.005 OPEN ACCESS

Merkowitz, S.M.; Bolotin, S.; Elosegui, P.; Esper, J.; Gipson, J.; Hilliard, L.; Himwich, E.; Hoffman, E.D., 2019. Modernizing and expanding the NASA Space Geodesy Network to meet future geodetic requirements, JOURNAL OF GEODESY, 93(11):2263–2273, DOI: 10.1007/s00190-018-1204-5

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

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