

3.4 Technique Centres

3.4.1 International DORIS Service (IDS)

Overview The International DORIS Service was established in 2003 with the primary mission to provide a service to support geodetic and geophysical research activities through DORIS data and derived products. The current report summarizes the different activities held in 2019 by the IDS components. More detailed information can be found in the IDS Report 2019–2020 available for download from the IDS website at <https://ids-doris.org/ids/reports-mails/governing-board.html#activity> (to be published in 2021).

DORIS system

Satellites During this report period (2019), the number of DORIS satellites has decreased to six (see Table 1).

Table 1: *DORIS data available at IDS Data Centers. As of December 2019*

Satellite	Start	End	Mission
SPOT-2	31-MAR-90 04-NOV-92	04-JUL-90 15-JUL-09	Remote sensing
TOPEX/Poseidon	25-SEP-92	01-NOV-04	Altimetry
SPOT-3	01-FEB-94	09-NOV-96	Remote sensing
SPOT-4	01-MAY-98	24-JUN-13	Remote sensing
SPOT-5	11-JUN-02	11-DEC-15	Remote sensing
Jason-1	15-JAN-02	21-JUN-13	Altimetry
ENVISAT	13-JUN-02	08-APR-12	Altimetry, Environment
Jason-2	12-JUL-08	10-OCT-19	Altimetry
Cryosat-2	30-MAY-10	-	Altimetry
HY-2A	1-OCT-11	-	Altimetry
SARAL	14-MAR-13	-	Altimetry
Jason-3	17-JUN-16	-	Altimetry
SENTINEL-3A	16-FEB-16	-	Altimetry
SENTINEL-3B	25-APR-18	-	Altimetry

After more than 11 years in orbit, the Ocean Surface Topography Mission (OSTM) on Jason-2 permanently ceased acquisition of scientific data on October 10, 2019.

Many future missions will guarantee a constellation of DORIS contributor satellites up to 2030 and beyond:

- HY2-C, HY-2D (CNSA/NSOAS) are two Chinese missions flying DORIS, the first launched in September 2020, the second planned for 2021.
- Jason-CS will ensure continuity from Jason-3. Jason-CSA / Sentinel-6A was launched in November 2020; Jason-CSB / Sentinel-6B is planned for 2025. The Jason-CS / Sentinel satellites are part of the Copernicus program and are the result of international cooperation between ESA, Eumetsat, the European Union, NOAA, CNES and NASA/JPL.
- Sentinel-3C and -3D (ESA/Copernicus) are under development and expected for 2024 and 2025.
- SWOT (Surface Water Ocean Topography), a joint project involving NASA, CNES, the Canadian Space Agency and the UK Space Agency, is planned for 2021.

Network The current DORIS network consists of 59 stations including 4 master beacons (Toulouse, Greenbelt, Hartebeesthoek, Kourou), 1 time beacon (Terre-Adelie) and 1 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. (Figure 1)

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+ and the addition of a signal amplifier at the foot of the antenna will allow a larger distance between beacon and antenna (50m instead of only 15m) providing better options to satisfy the sky-clearance criterion for new or renovated DORIS sites.

The B4G deployment started from mid-2019 at St-John's, Canada. The deployment strategy consists in replacing gradually the aging equipment and renovating sites for which the relocation of the antenna will enhance the station performance. Four sites were equipped with B4G in 2019: Grasse, St-John's, Ponta-Delgada, and Saint Helena.

Furthermore, we continued deploying the new generation of ground antennae (Starec C type) for which standard uncertainty of the 2GHz phase center in the vertical direction was significantly reduced to im-

prove measurements accuracy. We achieved an antenna replacement of 30% of the network (18 sites) at the end of 2019.

Throughout the network development there has been a continuing effort to co-locate DORIS with other space geodetic techniques and with tide gauges. 48 DORIS stations out of 59 are co-located with at least one other IERS technique: GNSS, SLR, and/or VLBI (Figure 1). All tie vectors at co-located sites with DORIS are available in a maintained file “DORIS_ext_ties.txt” on IDS web and data centers.

In 2019 the following DORIS sites were visited:

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

In 2020, the overall objectives are:

- Continuation of the deployment of the 4th generation beacon
- Renovation of the DORIS station at La Réunion (France)
- Restarting at Badary and Krasnoyarsk (Russia)
- Relocation of the Icelandic DORIS station in Höfn
- Antenna relocation at Malé (Maldives)
- Installation of new DORIS site at Changchun (China)
- Relocation of the DORIS station at Easter Island (Chile)
- Relocation of the DORIS Greek station

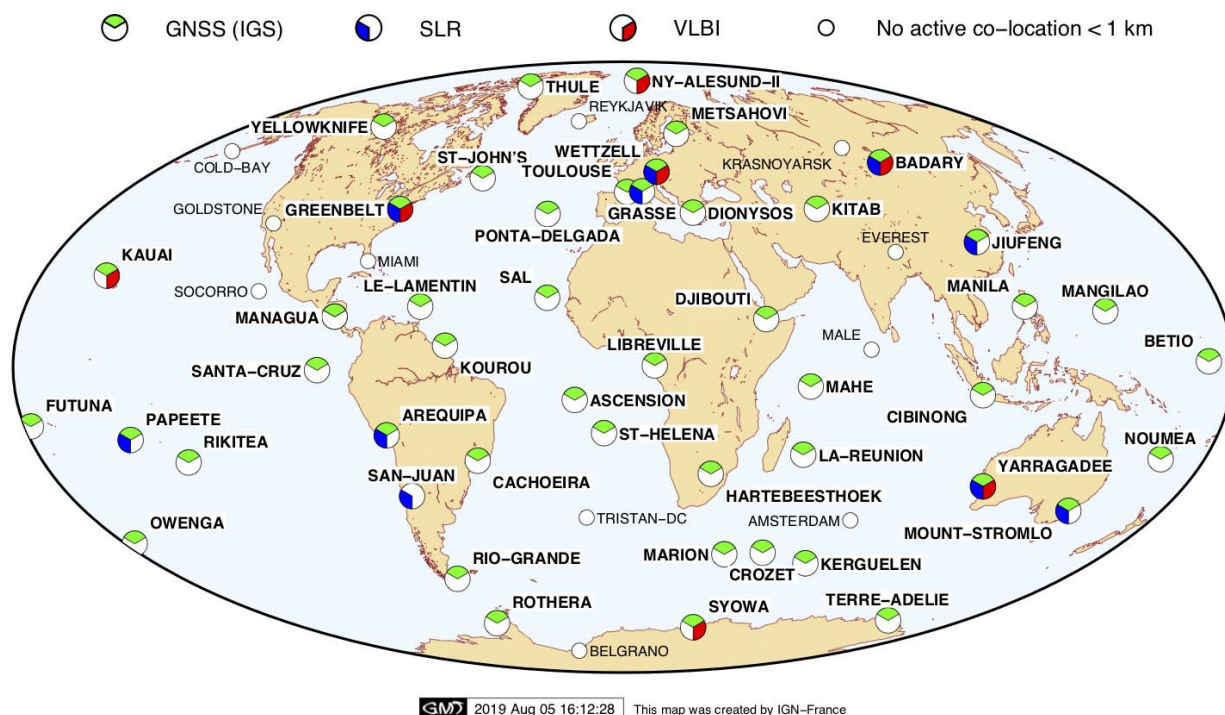


Fig. 1: The permanent DORIS network and co-location with other IERS techniques (as of August 2019).

IDS organization and activities

Governing Board

New members have joined the Governing Board (GB) to serve for the period 2019–2022:

- Hugues Capdeville (CLS, France) and Petr Štěpánek (Geodetic Observatory Pecný, Czech Republic) as the new tandem for the Analysis Coordination, elected by the IDS Associates;
- Claudio Abbondanza (NASA/JPL, USA) as a Member-at-Large, elected by the IDS Associates;
- Ernst Schrama (TU Delft, The Netherlands) appointed by IAG Executive Committee in July 2019 to serve as the new IAG representative.

The current list of members can be seen at the web page <https://ids-doris.org/ids/organization/governing-board.html>.

Meetings

In 2019, IDS organized two meetings of the Analysis Working Group, first on April 4 at DGFI-TUM in Munich (Germany), then at CNES in Paris (France) on September 30 and October 1. All the presentations from these meetings are made available by the Central Bureau on the IDS website at:

<https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2019.html>

<https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-09-2019.html>

These meetings were also an opportunity for the Governing Board to meet.

Associated Analysis Centers

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 1, 2019. In addition to the six regular Analysis Centers, four Associate Analysis Centers now contribute to the IDS analysis activities.

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. The main lines of the plan were presented to CNES and IGN in November 2019. In the coming years, IDS will focus on growing the community, extending the DORIS applications, and improving the technology, the infrastructure and the processing.

IDS at GGRF Workshop

Frank Lemoine (chair of the GB) and Laurent Soudarin (director of the Central Bureau) 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.

The presentations given by IDS during this workshop are available on the IDS website:

- Presentation of the DORIS system and the International DORIS Service

<https://ids-doris.org/documents/report/meetings/GGRFworkshop2019-DORISandIDS-Soudarin.pdf>

- The science contributions of DORIS and synergy with other space geodetic techniques

<https://ids-doris.org/documents/report/meetings/GGRFworkshop2019-ScienceContributionDORIS-Lemoine.pdf>

**Unified Analysis Workshop
(October 2–4, Paris)**

Several IDS/DORIS-related presentations were given for the Unified Analysis Workshop held at IPGP in Paris from October 2 to 4:

- Session "DORIS Systematic Errors and Biases":
 - “South Atlantic Anomaly compensation”
 - “DORIS scale”
 - “Non-conservative force modeling”
- Session “Global Space Geodesy Infrastructure”:
 - “The DORIS Ground Network, Current Status and Future Prospects”
- Session “Reference Systems and Frames”:
 - “Limiting Error Sources Affecting the Geocenter Motion & GM Estimation”
- Session “Site Survey and Co-location”:
 - “IGN Recent and Planned Local Site Survey Activities & Contribution to the EURAMET GeoMetre Project”

The presentations are available on GGOS website (<https://ggos.org/event/uaw-unified-analysis-workshop-2019/>).

**User Service
Data information service**

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.

In 2019, the Central Bureau made an inventory of the archived data at CDDIS and IGN in order to ensure the completeness of the datasets required for the DORIS contribution to ITRF2020. It led to the delivery of missing files and the correction of nomenclature anomalies and archiving errors.

The Central Bureau also interfaced with the Combination Center for making available several products:

- DPOD2014 version 4 and new combined solution;
- time series for the webservice;
- new version of the DORIS SINEX master file that contains for each DORIS station geographic positions, station IDs, type and eccentricity of the antennas. See <ftp://ftp.ids-doris.org/pub/ids/stations/ids.snx>

Web and ftp sites Address: <https://ids-doris.org>

In 2019, an improvement has been made to the display tool of the main events that occurred on the DORIS space segment and ground segment (<https://ids-doris.org/doris-system/system-monitoring/table-of-all-events.html>). Sort filters have been added and it is now possible to export the displayed results in CSV format. A tutorial on how to use the tool has also been created.

DOR-O-T, the IDS Webservice Address: <https://ids-doris.org/webservice>

In 2019, a new feature was 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 ILRS and IVS co-located stations.

Newsletter IDS Newsletter #6 was published in February 2019. It contains the following articles:

- The synergy of SLR and DORIS as geodetic techniques (F. Lemoine, A. Belli, C. Noll, NASA GSFC)
- The Azores: a key location occupied by DORIS for three decades (J. Saunier, IGN, C. Jayles, CNES, G. Moreaux, CLS, P. Yaya, CLS)
- Ponta Delgada: the host agency in short (R. TF. Marques, CIVISA)
- Tribute to Richard Biancale (F. Lemoine, NASA, L. Soudarin, CLS, JM. Lemoine, CNES, P. Ferrage, CNES, JP. Boy, EOST)

The issues are distributed via email and are also available at <https://ids-doris.org/ids/reports-mails/newsletter.html>.

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

- Crustal Dynamics Data Information System (CDDIS), funded by NASA and located in Greenbelt, Maryland, USA (<ftp://cddis.nasa.gov>)
- l'Institut National de l'Information Géographique et Forestière (IGN) in Marne la Vallée, France (<ftp://doris.ign.fr>) and (<ftp://doris.ensg.eu>)

In 2019, CDDIS warned the user community of the scheduled end of anonymous ftp to CDDIS archives, and strongly recommended to start the transition to the use of https as the preferred method.

Analysis Centers and Coordination

The activities of all the DORIS analysts of the past year 2019 have been dominated by preparation of ITRF2020 reprocessing. Two Analysis Working Group meetings (AWG) were realized, in April (TUM, Munich, Germany) and in September/October (CNES, Paris, France). As the major topics we can highlight ITRF reprocessing schedule and standards, South Atlantic Anomaly (SAA) mitigation, Satellite attitude/orbit modeling and stability of the scale.

All the IDS Analysis Centers (AC) continue the standard routinely processing by taking into account the last DORIS data available. The IDS includes six ACs and four “associate analysis centers (AAC)”, who use eight different software packages. For ITRF 2020 reprocessing, the analysis centers ESA, GOP, GRG and GSC promised full participation, while INA plans a limited contribution processing pure DORIS RINEX data. All other ACs and AACs are encouraged to participate partially. A Geocenter working group was established including ACs (AACs) CNES, GOP, GRG and DGFI-TUM.

IDS standards/recommendations for ITRF2020 reprocessing were defined. The list of major updates with respect to the standards used for ITRF 2014 reprocessing are as follows:

- New satellites Saral, Sentinel-3A and Sentinel-3B involved
- Elevation-dependent observation weighting recommended
- Usage of the measured satellite attitude (quaternions), if available, is strongly recommended
- Up-to-date external models/standards (time-variable gravity field + secular pole, ocean tides, sub-daily pole model)
- Combination of advanced strategies for SAA mitigation
- Avoid a usage of data accessories from the IDS Doppler exchange format, as the center of mass corrections and the observation validity indicator. Use own data preprocessing and satellite attitude modeling instead
- Use DORIS data in the RINEX format, at least for the Sentinels where old Doppler data format is not supported
- Apply updated phase law model for ground antenna Alcatel-type

The ITRF reprocessing schedule has been defined to process the data from 1993.0 to 2021.0 according to the following schedule:

- 2020, March 30: AC delivery of 1993.0–2002.3 (until start of Envisat First DORIS 2G receiver)
- 2020, June 30: AC delivery of 2002.3–2011.8 (until start of HY-2A).

- 2020, Sept. 30: AC delivery 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: AC delivery of 2020
- 2021, Mar. 15: Complete delivery to the IERS of the IDS combined solution (1993.0–2021.0)

Combination Center

In 2019, in addition to the routine evaluation and combination of the IDS AC solutions, the IDS Combination Center delivered to the IDS Data Centers its fourth version of the DPOD2014 (DORIS extension of the ITRF2014 for Precise Orbit Determination) based on the fourth version of the DORIS cumulative position and velocity solutions. The IDS CC conducted also several analyses related to the ITRF2020 and analyzed the ITRF2014 DORIS-to-DORIS tie vector residuals.

Publications

IDS published the 2018 activity report that was broadly distributed to all DORIS participants and relevant services (see <https://ids-doris.org/ids/reports-mails/governing-board.html#activity>).

All DORIS related articles published in international peer-reviewed journals are available on the IDS Web site <https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html>.

Conclusions

The DORIS constellation lost Jason-2 in 2019, but two new satellites join it in 2020, HY-2C and Sentinel-6A. The year was marked by the start of the deployment of 4th generation DORIS beacon (B4G), a much-awaited development, providing better options to satisfy the sky-clearance criterion for new or renovated DORIS sites.

The composition of the GB has slightly evolved with the departure of some members whom we thank warmly for their involvement and their replacement by new colleagues whom we welcome.

In 2019, DGFI-TUM (Munich, Germany) became the fourth Associate Analysis Center. The group has been contributing for several years to AWG studies and analyses. It thus confirms its participation in IDS.

The year was devoted to the preparation of DORIS data reprocessing for ITRF2020. The Analysis Coordination with the Analysis Centers defined the reprocessing schedule, and a list of recommended standards has been established. Besides, an inventory of the archived data at the Data Centers was performed to ensure the completeness of the datasets.

IDS continues to evolve. In the coming years, the Service will focus on growing the community, extending the DORIS applications, and improving the technology, the infrastructure and the processing.

*Laurent Soudarin, Pascale Ferrage, Jérôme Saunier,
Hugues Capdeville, Guilhem Moreaux*