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 2018 by the IDS components. More detailed information can be found in the IDS Annual Report available for download from the IDS website at https://ids-doris.org/ids/reports-mails/governing-board.html#activity .

1 DORIS system

1.1 Satellites

During this report period (2018), the number of DORIS satellites has increased to seven (see Table 1).

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	–	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

Table 1. DORIS data available at IDS Data Centers. As of December 2018

In 2018, a new DORIS instrument came to join its fellows. It operates onboard Sentinel-3B, launched in April 2018. With Jason-2, Cryosat-2, HY-2A, Saral, Jason-3, and Sentinel-3A, there are now seven active DORIS instruments, all the same DGXX generation.

Many future missions currently under preparation should guarantee a constellation of DORIS contributor satellites up to 2030 and beyond:

- HY2-C, HY-2D (CNSA/NSOAS) two Chinese missions flying DORIS are planned for 2019 (or early 2020) and 2020 respectively.
- Jason-CS will ensure continuity from Jason-3 with a first launch in 2020 (Jason-CSA/ Sentinel-6A) and 2025 (Jason-CSB / Sentinel-6B). 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 2023 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.

1.2 Network

With 57 stations (including 4 master beacons and 1 time beacon) that are spatially well distributed over the Earth's land surface, the DORIS permanent network fully meets the orbit determination requirements for satellite altimetry. Two additional DORIS stations are dedicated to IDS for other scientific applications: Wettzell (Germany) and Mangilao (Guam Island, USA). (Figure 1)

Notwithstanding the extensive outage of 2 stations (Santa-Cruz and Betio) and the shutdown of the 2 Russian stations (Badary and Krasnoyarsk) for regulation issues, the DORIS network provided a reliable service in 2018 with an annual mean of 88% of active sites thanks to the resourcefulness and the combined efforts of CNES, IGN and all agencies hosting the stations: 6 failed beacons and 2 failed antennas were replaced, including Mahé restarted in November after 3-yr outage.

There have been many developments and maintenance operations for the ground network in 2018. Early in the year, we moved the station at Rothera about 100 m away because of site refurbishment. In April, a new DORIS site has been set up in Guam Island, at Mangilao, close to the IGS station "GUUG" and the tide-gauge of Pago Bay (PSMSL 2130). This station will provide a significant contribution to the coverage of the western North Pacific Ocean over the Micronesia and the Mariana Trench. Then, two main events occurred in Argentina in the last semester: the restarting at Rio Grande after 2-yr outage and the station installation at San Juan. These two stations were both eagerly 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.
Regarding the network equipment, we continued the gradual replacement of Starec ground antennae B type with C type for which standard uncertainty of the 2GHz phase center in the vertical direction was reduced to 1 mm from 5 mm to improve measurements accuracy. 25% of the network is equipped with such antennae (Starec type C). The 4th DORIS beacon generation is now in its final stage of development. Following the testing of the prototype in 2018, the manufacturer will proceed with the construction of the production models with the first delivery planned in the spring of 2019. Using a signal amplifier at the foot of the antenna, a longer distance between beacon and antenna (up to 50m vs. 15 m before) will make it easier to find suitable environment for the coming antennae installations and give the opportunity to relocate existing antennas to get better visibility.
Co-location with other space geodetic techniques and with tide gauges remains a major objective for the DORIS network. In 2018, we increased the number of co-located DORIS sites with GNSS at Mangilao and Ny-Alesund II, with SLR at San Juan, with VLBI at Ny-Alesund II (Figure 1).
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

In 2018, the following sites were visited:

- Re-location in Rothera (Antarctica)
- New site at Guam Island (USA)
- Reconnaissance in Changchun (China)
- Visit at Ponta-Delgada (Azores, Portugal)
- New site at San Juan (Argentina)
- Re-location in Ny-Ålesund (Svalbard, Norway)
- Restarting at Mahé (Seychelles)

In 2019, the overall objectives are:

- Start of the deployment of the 4th generation beacon
- Equipment replacement and local tie survey at St-John's (Canada)
- Reconnaissance in Iceland
- Restarting at Santa-Cruz (Galapagos, Ecuador)
- Restarting at Badary and Krasnoyarsk (Russia)
- New site in Changchun (China)
- Re-location at Easter Island (Chile)

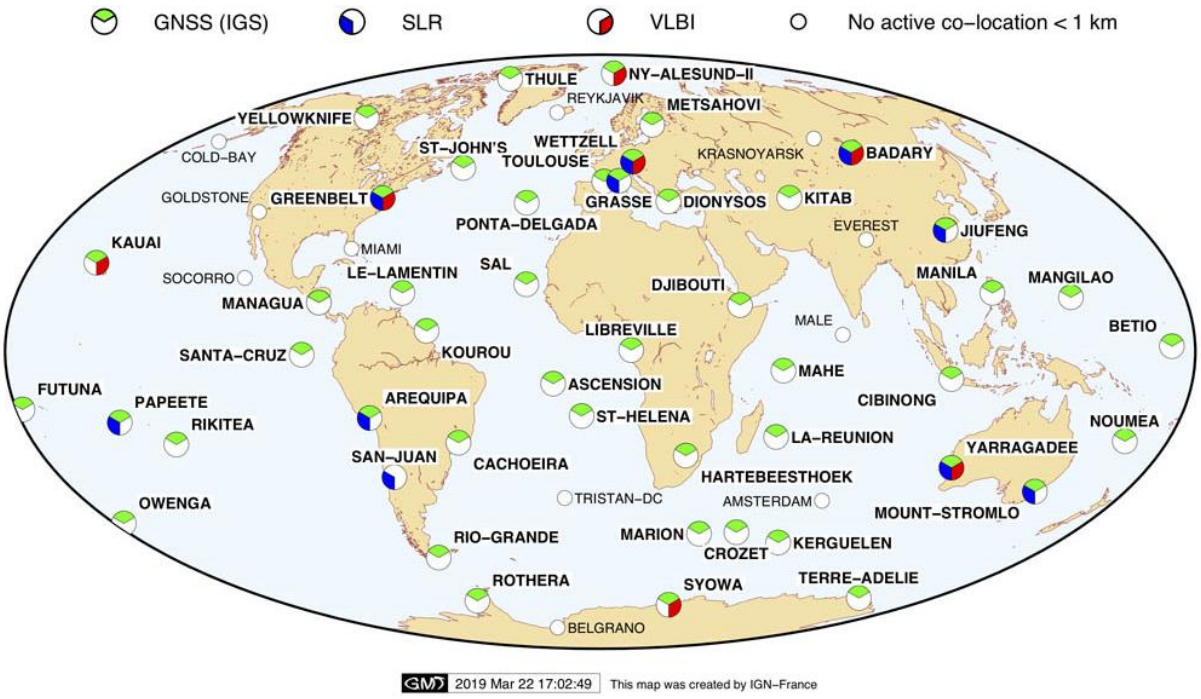

Fig. 1. The permanent DORIS network – 57 stations – and co-location with other IERS techniques (as of March 2019).

2 IDS organization and activities

2.1 Governing Board

In fall 2018, IDS organized elections to renew two posts expiring at the end of 2018. The holders of these posts are: Hugues Capdeville (CLS)/Jean-Michel Lemoine (CNES) as Analysis Coordinator, and Marek Ziebart as one of the Members at Large.

After the elections, the new members elected by the IDS Associates are:

- Hugues Capdeville & Petr Štěpánek as the new tandem for the Analysis Coordination,
- Claudio Abbondanza as a Member-at-Large.

They took up their duties within the Governing Board (GB) on January 1st, 2019 to serve for the period 2019-2022

A new IAG representative (previously Petr Štěpánek who resigned for the Analysis Coordination) will be designed by IAG Executive Committee in July 2019.

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

2.2 Meetings

In 2018, IDS organized a meeting of the Analysis Working Group on June 11 at CNES in Toulouse (France), and a Workshop in Ponta Delgada (Azores Archipelago), Portugal, on 24 to 26 September, as part of the 25 Years of Progress in Radar Altimetry Symposium with the Ocean Surface Topography Science Team (OSTST) 2018.
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-06-2018.html
https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2018.html

In 2019, IDS organizes two meetings of the Analysis Working Group, first in Munich (Germany), on Thursday April 4 (hosted by DGFI-TUM), then in Paris, end of September.

2.3 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.

3 User service

3.1 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 2018, this activity focused on:

- the delivery of Sentinel-3B's DORIS data (first data on IDS DCs in DORIS-RINEX format only with DIODE time tagging on May 1st, 2018)
- the delivery of the CNES orbits in POE-F standards (file naming, store folders, description files)
  See [ftp CDDIS or IGN] pub/doris/products/orbits/ssa/README_SP3.txt

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

3.2 Web and ftp sites

Address: https://ids-doris.org

The main updates of the website, as well as the list of the new documents and files put on the ftp site, can be found in the 2018 IDS Activity Report (https://ids-doris.org/ids/reports-mails/governing-board.html#activity).

3.3 DOR-O-T, the IDS Webservice

Address: https://ids-doris.org/webservice

Several new features were added to the IDS web service in 2018. The main ones have been brought 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.
A new plottool for position residuals was created to plot the position residuals (North, East, Up) of the cumulative solution derived from the routine analysis of the IDS Combination Center (https://apps.ids-doris.org/apps/dpodtool.html).

3.4 Newsletter

IDS Newsletter #5 was published in September 2018. It contains the following article:

- DORIS stations in polar regions, an ongoing challenge for continuous operation (J. Saunier, IGN)
- Focus on Rothera on the Antarctic Peninsula (J. Saunier, IGN)
- Rothera: the host agency in short (D.G. Vaughan, BAS)
- DORIS on Sentinel-3B: and now seven! (CNES)
- Jason-2, ten years after (CNES)
- IDS meetings: a time to remove the nose from the grindstone (G. Moreaux, L. Soudarin, CLS)

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

3.5 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 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.

4 Analysis Centers and Coordination

The activities of all the DORIS analysts of the past year 2018 have been dominated by taking into account the last DORIS satellites Jason-3, Sentinel-3A and Sentinel-3B which DORIS data are only available in RINEX format, 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 starting the preparation of the next ITRF contribution. The last International DORIS Service Analysis Working Group (IDS-AWG) was hosted in CNES on June 11, 2018 in conjunction with Copernicus POD Quality Working Group. The IDS workshop 2018 was held on 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.

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 three "associate analysis centers" who use seven different software packages. 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 multi-technique 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.

The behavior of the various DORIS on-board oscillators in the vicinity of the high radiation area "South Atlantic Anomaly" (SAA) has been studied. It has been shown by different ACs (and associated) that all DORIS receivers are frequency-sensitive to the crossing of the SAA, though at very different levels. For Jason-1 and SPOT-5 satellites, a corrective model has been developed and used for the realization of the ITRF2014. However, Jason-2 is also impacted, not at the same level as Jason-1 but strong enough to worsen the multi-satellite solution provided for ITRF2014 for the SAA stations. The last DORIS satellites are also impacted by the SAA effect, in particular Jason-3. Currently we have several 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. For Jason-2 and Jason-3, ACs can adjust at least a Bias+drift by pass for SAA stations in their POD processing. We can also use the strategy to add single satellite solution affected by the SAA in the multi-satellite solution.

The space-geodetic observation of geocenter motion is still in its infancy. Independent solutions have systematic differences as large as the signal level. The ITRF origin is only sensed by SLR observations of the LAGEOS-1 and 2 satellites. There are other techniques than SLR (DORIS, GPS-LEO satellites). DORIS can play a role because the tracking network is stable and well-distributed (reduces network effects). The collinearity of TZ with residual SRP modeling errors can be mitigated well for Jason-like satellites since their 118-day draconitic period is not close to one solar year. So, the Jason-2/3 satellites are appealing for geodetic DORIS-based geocenter motion determination. The upcoming launches of future DORIS satellites HY-2C (inclination of 66º), Jason-CS/Sentinel-6 (66º), and SWOT (inclination of 78º), should also permit the same

type of geocenter solutions. IDS GB is evaluating formation of Working Group on the Geocenter where non-IDS participation would be encouraged.
The analyses associated with ITRF2014 as well as subsequent work have demonstrated that the DORIS products contain signals at distinct tidal, TOPEX/Jason-draconitic, semi-annual, and annual periods. These signals point to potential problems in force and measurement modeling, potentially associated with the tidal EOP modelling and with the modeling of non-conservative forces on some satellites. ACs have to improve SRP modelling to reduce draconitics, in particular for Topex/Jasons satellites by using solar angle panels, by estimating SRP coefficient, by improving the macromodels, ...
The Jason-3, Sentinel-3A and Sentinel-3B satellites have to be added in the DORIS processing chain of IDS ACs. ACs have to complete their DORIS/RINEX data processing implementation in order to take into account the data from these new satellites.
IDS ACs have to adopt and evaluate the new standards/models recommended by IERS for the next ITRF. ACs have to implement in particular the new linear mean pole model and adopt a Time-Variable Gravity (TVG) model compatible.
The next IDS Analysis Working Group will be held in Munich (Germany) hosted by DGFI, on Thursday April 4, 2019.

5 Combination Center

In 2018, in addition to the routine evaluation and combination of the IDS AC solutions, the IDS Combination Center delivered to the IDS Data Centers its third version of the DPOD2014 (DORIS extension of the ITRF2014 for Precise Orbit Determination) based on the third version of the DORIS cumulative position and velocity solutions. 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.

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

6 Publications

IDS published the 2017 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

2018 has been highlighted by the organization of the first retreat of the IDS, first step for the definition of a strategic plan for the next years.
The IDS Combination Center delivered its third version of the DPOD2014 (DORIS extension of the ITRF2014 for Precise Orbit Determination).
The activities of all the DORIS analysts of the past year 2018 have been dominated by taking into account the last DORIS satellites Jason-3, Sentinel-3A and Sentinel-3B which DORIS data are only available in RINEX format, 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 starting the preparation of the next ITRF contribution.

Laurent Soudarin, Pascale Ferrage, Jérôme Saunier, Patrick Michael, Hugues Capdeville and Guilhem Moreaux.