Overview

The current report presents the different activities held in 2017 by the components of the International DORIS Service (IDS). In a first step, we give the current status of the DORIS system (satellites and tracking network). In a second step, we provide the latest news of the IDS (Governing Board, Central Bureau, Data Centers). Then we focus on the most recent activities conducted by the Analysis Centers and the Analysis Coordination. The report ends with information about the meetings and the publications.

1 DORIS system

1.1 DORIS satellites

During this report period (2017), the number of DORIS satellites has remained the same as the previous year at six (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

Table 1. DORIS data available at IDS Data Centers. As of December 2017

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:

- Sentinel-3C and -3D (ESA/Copernicus) are under development and expected for 2020 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.
- Jason-CS will ensure continuity from Jason-3 with a first launch in 2020 (Jason-CS1/ Sentinel-6A) and 2025 (Jason-CS2 / 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.
- HY2-C, HY-2D (CNSA/NSOAS) two Chinese missions flying DORIS are planned for 2019 and 2020 respectively.

1.2 DORIS network

The DORIS ground network is made up of 56 permanent stations (including 4 master beacons and 1 time beacon) well distributed over the Earth's land surface for the purposes of orbitography and altimetry. Two additional DORIS stations are used for other scientific applications: Grasse (France) and Wettzell (Germany).

Despite the extensive outage of 4 stations (Santa-Cruz, Easter, Mahé, and Cibinong), the DORIS network provided a reliable service in 2017 with an annual mean of 89% of active sites thanks to the responsiveness and the combined efforts of CNES, IGN and all agencies hosting the stations: 6 failed beacons and 2 failed antennas were replaced.

The development of the 4th DORIS beacon generation has been nominally ongoing according to the provisional schedule: after the detailed design review, a prototype was developed for testing at the end of 2017. The start of the deployment is still scheduled for mid-2019. This development is eagerly waited for the network because that will allow installation of the antenna up to 50 m from the indoor equipment: the maximum cable length currently allowed to the antenna is 15 m which often makes it difficult for the antenna to have a clear view of the sky with the proximity of the building housing the transmitting unit.

The tie vectors between successive DORIS antenna locations on the same site were reassessed and made available on the IDS data centers: ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_int_ties.txt

Specifications for installing nearby DORIS and VLBI were set based on successive RF compatibility tests performed at Greenbelt, MD USA (2014), then at Wettzell, Germany (2015-2016) and lastly at Papenoo, French Polynesia (2017) in the framework of the future geodetic observatory of Tahiti.

Co-location with other space geodetic techniques and with tide gauges remains a major objective for the DORIS network. After the DORIS station installation at the geodetic observatory Wettzell in 2016, the IDS plans to install in April 2018 a DORIS station in Guam Island (co-location with IGS station "GUUG" and tide gauge of Pago Bay PSMSL 2130). This new site is also particularly interesting in that it offers coverage of the western North Pacific Ocean over the Micronesia and the Mariana Trench.

In 2017 the following sites were visited:

- Reconnaissance in Papenoo (French Polynesia)
- Local tie survey at Papeete (French Polynesia) and Sal (Cape Verde)

In 2018, the overall objectives are:

- New stations at Guam Island (USA) and San Juan (Argentina)
- Re-location in Rothera (Antarctica) and Easter Island (Chile)
- Restarting at Santa-Cruz (Galapagos, Ecuador) and Mahé (Seychelles)
- Reconnaissance in China and Iceland

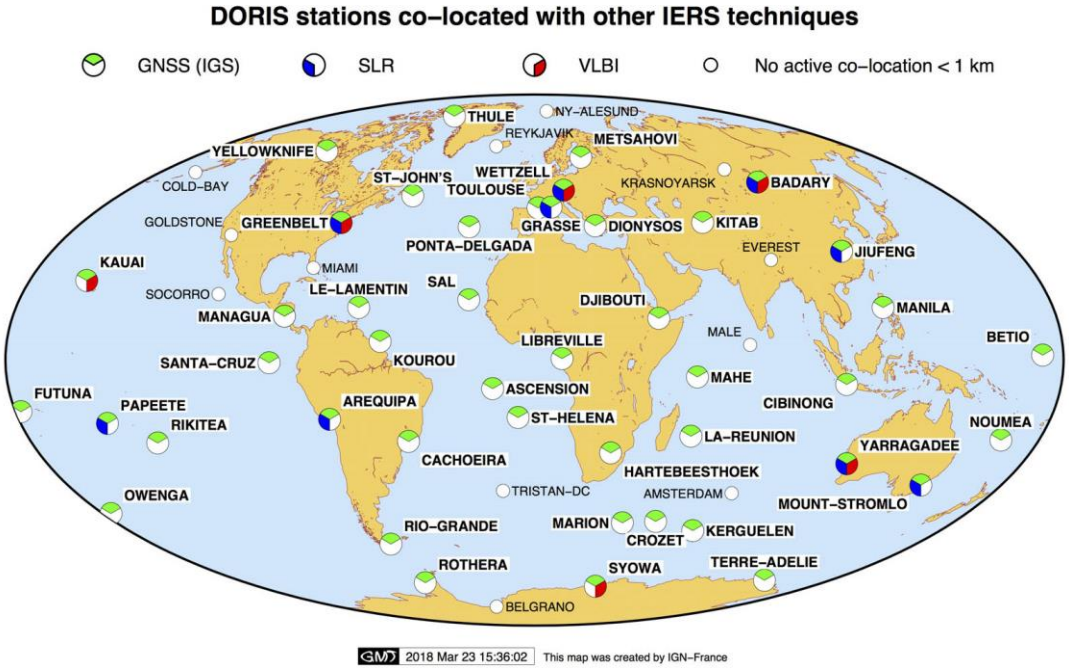

Fig. 1. The permanent DORIS network – 56 stations – and co-location with other IERS techniques (as of March 2018).

2 IDS Governing Board

On January 1st, 2017, new members took up their duties within the Governing Board (GB) to serve for the period 2017-2020:

- Frank Lemoine as the Analysis Center Representative,
- Patrick Michael as the Data Center Representative,
- Denise Dettmering as a Member-at-Large.

In addition, the IAG nominated Petr Stepanek as its representative to the IDS Governing Board (GB). Petr succeeds Michiel Otten who held that post for 8 years.
Guilhem Moreaux (CLS) was confirmed as the representative of the Combination Center (CC) within the GB after CNES/CLS was selected to run the IDS CC for a new period of four years (2017-2020).
In November 2016, the Board elected Frank Lemoine as the new Chairman from January 1st, 2017.
The composition of the new Governing Board is given in Table 2.

At its meeting in May 2017, the GB has accepted TU Delft and the POD team of CNES as Associated Centers.

Following user requests for NRT data for assimilation in ionospheric model, the GB has decided to create a Working Group (WG) “NRT DORIS data” to:

- define the objectives and possible applications,
- identify potential users,
- define the test requirements (time, duration, ..).

The CNES will then study the feasibility and implement this test campaign. Based on the results of the Working Group, in a later stage, the possibility to operationalize this production will be evaluated.
The GB appointed Denise Dettmering as chairman of this WG.

In May 2017, the GB also decided to organize a retreat in 2018 to review the activities, overall scientific direction and future of the service. A key outcome of the meeting will be a set of ideas that can contribute to the development of a strategic plan for the IDS.

A survey form has been set up and put on the website to collect inputs from both inside and outside the IDS community in preparation for the retreat.

Name	Institution	Country	Mandate
Hugues Capdeville Jean-Michel Lemoine	CLS CNES	France	Analysis Coordination
Denise Dettmering	DGFI/TUM	Germany	Member at large
Pascale Ferrage	CNES	France	System representative
Frank Lemoine (chair)	NASA/GSFC	USA	Analysis Center representative
Brian Luzum	GSFC	USA	IERS representative
Guilhem Moreaux	CLS	France	Combination Center representative
Patrick Michael	NASA/GSFC	USA	Data flow Coordinator
Michiel Otten	ESOC	Germany	IAG representative
Jérôme Saunier	IGN	France	Network representative
Laurent Soudarin	CLS	France	Director of Central Bureau
Marek Ziebart	UCL	UK	Member at large

Table 2. Composition of the IDS Governing Board (January 2017 – December 2018)

3 IDS Central Bureau

In 2017, the Central Bureau participated in the organization of the AWG meeting held at University College London in London, UK, on May 22 and 23. The CB documented the GB meeting held on this occasion.

The CB managed the edition and publication of the 2016 IDS Activity Report. It also produced the IDS contribution to the 2016 IERS Annual Report.

At its meeting in Washington in October 2015, the Governing Board asked the Central Bureau to consider the publication of a newsletter. The intention was to improve the flow of information within the community of providers and users of DORIS data and products, to highlight the activities of the groups participating in the IDS, and to bring the DORIS and IDS news to a wider audience, from the host agencies to the other sister services.

Three issues were published in 2016, #1 in April 2016, #2 in July, and #3 in December.
IDS Newsletter #4 was published in November 2017. It contains the following article:

- Station re-location at Kitab (Uzbekistan) to get better visibility (J. Saunier, IGN)
- Kitab: the host agency in short (D. Fazilova and S. Ehgamberdiev, UBAI)
- DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination (G. Moreaux, CLS).

In addition, the section "IDS life" provides information about the service.

The issues are distributed via email to the subscribers to the DORISmail and several identified managers and decision-makers. They are also available on the IDS website for downloading at https://ids-doris.org/ids/reports-mails/newsletter.html.

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 2017, this activity focused on:

- the delivery of the CNES orbits for HY-2A in GDR-E standards (file naming, store folders, description files)

See:
[ftp CDDIS or IGN] pub/doris/products/orbits/ssa/README_SP3.txt

- the update of the antex files giving the phase law to apply in DORIS processing for the ground antennas (format of the antex files revised and corrected to be in agreement with the format description; new characterization of the ALCATEL antenna based on 5 antennas)

See:
ftp://ftp.ids-doris.org/pub/ids/stations/doris_phase_law_antex_readme.txt

- the change in the delivery of the DORIS/RINEX files in January: (re-)start delivering RINEX with DIODE time tagging with a latency of 1 day (instead of 3 days with SSALTO/PANDOR time tagging) and completion of missing periods (version number of the files: 001)

See for instance:
[ftp CDDIS or IGN] pub/doris/data/ja2/README_JASON2_data.txt
The Central Bureau also interfaced with the Data Centers and the Combination Center for making available the DPOD products. See [ftp CDDIS or IGN] pub/doris/products/dpod/dpod.readme

3.2 IDS Web and ftp sites

The IDS Central Bureau (CB) maintains the IDS web (https://ids-doris.org) and ftp (ftp://ftp.ids-doris.org/pub/ids) sites.
A new version of the IDS website was proposed in early 2017 with an updated design and structure. The website is now accessed using the secure HTTPS protocol.

Besides the regular updates of pages and addition of documents, the website was enriched with new pages and received some changes. We can mention among others the following new features:

- The Section "Combination" has been renamed, reorganized and enriched. It is now named "Combination Center" and contains new pages about the Activity and Products of the Combination Center, the cumulative solution and the DPOD in addition to the section dedicated to the contributions to the ITRF. The map of the horizontal displacements of the DORIS stations by Moreaux et al. (2016) can be seen on the page:

https://ids-doris.org/analysis-coordination/combination/activity-products.html

- A new page Working Groups (AWG, WG NRT DORIS data) is available here:

https://ids-doris.org/ids/organization/working-groups.html

- The document « IDS data structure and formats » has been reviewed and completed. It is now available as a PDF file encapsulated in the webpage.

https://ids-doris.org/ids/data-products/data-structure-and-formats.html

- Two new sections added in the Gallery for the DORIS station: equipment and obstruction views.

https://ids-doris.org/ids/gallery/category/4-stations.html

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 2017 IDS Activity Report (https://ids-doris.org/ids/reports-mails/governing-board.html#activity).

3.3 DOR-O-T, the IDS Webservice

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

4 IDS Data Centers

The IDS data flow organization remains the same. It is based on two data centers: one on the East Coast of the U.S. (CDDIS at NASA GSFC) and one in Europe (IGN in France). They are both exact mirrors of each other, and so, are able to continue on an operational basis, even if one of them is inaccessible due to a temporary failure.
These two data centers archive the DORIS data as well as the IDS products (station coordinates and velocity, geocenter motion, earth orientation parameters, ionosphere data, etc.).

During 2017, the CDDIS developed all new software to handle the ingest of GNSS, SLR, and DORIS data. This new software allows for more automated operation, much improved quality-checks, and a new metadata extraction process and storage method all leading to improved efficiency in processing incoming data. CDDIS's goal is that all incoming files are quality-checked, metadata extracted, and processed into the archive within 30 seconds of being received.

The CDDIS provides access to two applications for querying site information or archive contents. The Site Log Viewer is an application for the enhanced display and comparison of the contents IAG service site logs; currently the IGS, ILRS, and IDS site logs are viewable through this application. Through the Site Log Viewer application, users can display a complete site log, section by section, display contents of one section for all site logs, and search the contents of one section of a site log for a specified parameter value. Thus, users can survey the entire collection of site logs for systems having particular equipment or characteristics.
The Site Log Viewer is accessible on the CDDIS website at URL:
https://cddis.nasa.gov/Data_and_Derived_Products/SiteLogViewer/index.html

The CDDIS Archive Explorer application allows users to discover what data are available through the CDDIS. The application allows users, particularly those new to the CDDIS, the ability to specify search criteria based on temporal, spatial, target, site designation, and/or observation parameter in order to identify data and products of interest for download. Results of these queries include a listing of sites and additional metadata satisfying the user input specifications. Such a user interface also aids CDDIS staff in managing the contents of the archive. Future plans for the application include adding a list of data holdings/URLs satisfying the search criteria.
The CDDIS Archive Explorer application is accessible on the CDDIS website at URL:
https://cddis.nasa.gov/Data_and_Derived_Products/CddisArchiveExplorer.html

5 IDS Analysis Centers and IDS Analysis Coordination

The activities of all the DORIS analysts of the past year 2017 have been dominated by the evaluation of the three TRFs 2014 solutions and the DPOD2014, taking into account the last DORIS satellites Jason-3 and Sentinel-3A which DORIS data are only available in RINEX format, defining a strategy to minimize the impact of the sensitivity to the South Atlantic Anomaly (SAA) effect of their Ultra Stable Oscillator (USO) and resolving the scale factor jump of the IDS solution. In 2017, the Analysis Working Group (AWG) met in London at the University College of London, from May 22 to May 23.
All the IDS Analysis Centers (AC) continue the standard routinely processing by considering the last DORIS data available. The IDS includes six ACs and three associate analysis centers who use seven different software packages. Some ACs on a routine basis perform POD analyses of DORIS satellites using other geodetic techniques (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.
An increase in the IDS scale factor was identified in 2012. This increase is mainly due to the introduction of the HY-2A satellite into the combined solution, which has a high scale factor. The increase also comes from DORIS2.2 data processing for the Jason-2 and Cryosat-2 satellites. For this part, the jump observed in the scale factor is due to the change of tropospheric model in the POD processing of the CNES team. It was then recommended to the IDS ACs to consider all the measurements in the DORIS2.2 file, even those rejected by the CNES POD team preprocessing, and therefore to do their own preprocessing. In November 2017, a new initial position of the HY-2A satellite center of mass

(CoM) in the satellite reference frame was delivered to CNES by the Chinese Mission Center. This new position greatly reduces the HY-2A scale factor. The IDS Analysis Coordinators recommend to IDS ACs to use this new position of the CoM HY-2A.

The IDS performed an assessment of the three realizations of the Terrestrial Reference Frame which are the outcome of the "ITRF2014 effort": the ITRF2014 (IGN), DTRF2014 (DGFI) and JTRF2014 (JPL). While ITRF2014 and DTRF2014 are formally similar, differing mainly by the Post Seismic Deformation model (PSD) which has been introduced in the IGN solution, the JPL solution is quite different, being a time series of weekly solutions obtained through a Kalman filter process. Due to a more aggressive data editing, the JPL solution contains less stations at a given time than the two others, particularly at the beginning of the processed period in 1993. The three TRF realizations have been evaluated in terms of DORIS and SLR observation residuals, orbit overlaps and transformation parameters of the DORIS network. All the TRF realizations represent a clear improvement post-2008 over the previous realization ITRF2008. Based on the different criteria used for the evaluation, it has been shown that it is the ITRF2014 which presents the best overall performances. It is this model that will serve as a basis for the operational processing of the future IDS products. The extension of the ITRF2014 for the DORIS network, called DPOD2014, consists in an update of the position/velocity of all the DORIS stations and aligned to the ITRF2014, leading to possible minor adjustment of older stations. Some IDS ACs have switched to ITRF2014 by using the DPOD2014 solution for their IDS operational products at the end of 2017 and others will plan to do that in 2018.

The behavior of the various DORIS on-board oscillators near 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. While awaiting precise DORIS data corrective model for the satellites Jason-2&3, ACs have to adopt a strategy to minimize the SAA effect on the orbit and also and in particular on the station position estimation. This strategy could lead to add the single satellite solutions affected by the SAA in the multi-satellite solution as it was done for the ITRF2014 with Jason-1.

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 as done and showed by the GSFC AC.
The Jason-3 and Sentinel-3A satellites were added in the DORIS processing chain of some ACs which can process RINEX data format. The others ACs have to complete their DORIS/RINEX data processing implementation in order to take into account the data from these new satellites and in preparation to the next ITRF.

6 IDS Combination

In 2017, in addition to the routine evaluation and combination of the IDS AC solutions, the IDS Combination Center delivered to the IDS Data Centers its two first versions of the DPOD2014 (DORIS extension of the ITRF2014 for Precise Orbit Determination). These two solutions are based on the two DORIS cumulative position and velocity solutions of the IDS Combination Center from the IDS combined solution over the time periods 1993.0-2016.0 and 1993.0-2017.0, respectively. Both the IDS cumulative position and velocity solution and the DPOD2014 solution will be updated twice a year and freely available from the IDS Data Centers. More information on these new IDS products are accessible on the Combination Center corner of the IDS website.

7 Meetings

In 2017, IDS organized a meeting of the Analysis Working Group on May 22-23 at University College London (UK).
All the presentations from the meeting are made available by the Central Bureau on the IDS website at:
https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2017.html

In 2018, IDS organizes two events:

- a meeting of the Analysis Working Group in Toulouse (France), on Monday June 11, 2018 (hosted by CNES) followed by the Copernicus Quality Working Group Meeting on Tuesday June 12 to which IDS AWG members are invited.

- the IDS Workshop 2018, in Ponta Delgada (Azores Archipelago) (24 to 26 September 2018), Portugal, as part of the 25 Years of Progress in Radar Altimetry Symposium with the Ocean Surface Topography Science Team (OSTST) 2018.

8 Publications

IDS published the 2016 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

2017 has been highlighted by the arrival of four new members in the Governing Board, and two new Associate Analysis Centers (CNES/POD and TU Delft), the creation of the Working Group “NRT DORIS data” and the decision to organize an IDS retreat to prepare the activities of the Service for the next years.
The IDS Combination Center delivered its two first versions of the DPOD2014 (DORIS extension of the ITRF2014 for Precise Orbit Determination).
The activities of all the DORIS analysts have been dominated by the evaluation of the three TRFs 2014 solutions and the DPOD2014, considering the last DORIS satellites Jason-3 and Sentinel-3A, defining a strategy to minimize the impact of the sensitivity to the South Atlantic Anomaly (SAA) effect of their Ultra Stable Oscillator (USO) and resolving the scale factor jump of the IDS solution.

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