cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

IGN
INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

IDS

ACTIVITY REPORT 2023

INTERNATIONAL DORIS SERVICE

International DORIS Service Activity Report 2023

Edited by Laurent Soudarin and Claude Boniface

DOI: 10.24400/312072/i02-2024.002

International DORIS Service

Central Bureau

e-mail: ids.central.bureau@ids-doris.org

URL: www.ids-doris.org

20th

IDS Anniversary

Preface

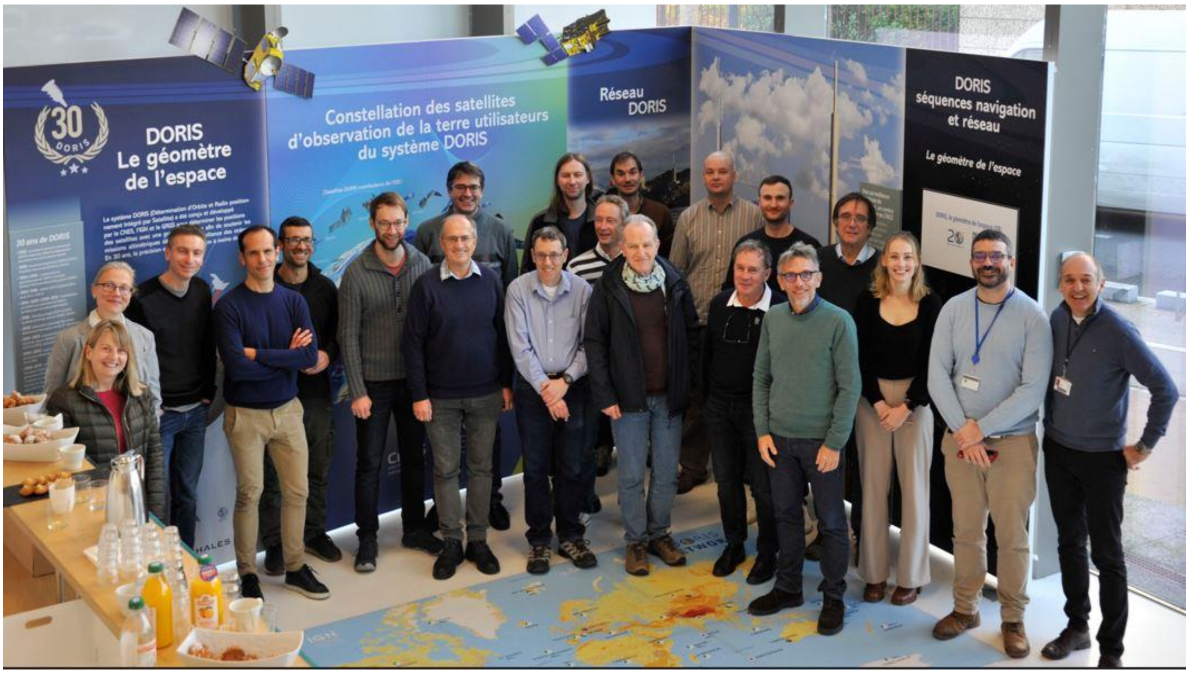
In this volume, the International DORIS Service (IDS) documents the work of the IDS components between January 2023 and December 2023. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2023 Report describes the history, changes, activities and the progress of the IDS. The Governing Board and Central Bureau kindly thank all IDS team members who contributed to this report.

The IDS takes advantage of this publication to relay the thanks of the CNES and the IGN to all the host agencies for their essential contribution to the operation of the DORIS system. The list of the host agencies is given in the appendix of this Report.

The entire contents of this Report also appear on the IDS website at

https://ids-doris.org/documents/report/IDS_Report_2023.pdf



Group photo of the participants at the IDS Analysis Working Group meeting in Saint-Mandé (France), November 28-29, 2023, co-organized by the IGN-IPGP/JPL analysis center and the SGM of IGN.

Main contributors

Claude Boniface	*CNES, 18 Avenue Edouard Belin, 31401 Toulouse Cedex 9, FRANCE*
Hugues Capdeville	*CLS, 11, rue Hermès, 31520 Ramonville Saint-Agne, FRANCE*
Denise Dettmering	*DGFI-TUM, Arcisstrasse 21, 80333 München, GERMANY*
Sergey Kuzin	*Institute of Astronomy, Russian Academy of Sciences, 48, Pyatnitskaya St., Moscow 119017, RUSSIA*
Frank Lemoine	*NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA*
Guilhem Moreaux	*CLS, 11, rue Hermès, 31520 Ramonville Saint-Agne, FRANCE*
Samuel Nahmani & Arnaud Pollet	*Université de Paris, Institut de physique du globe de Paris, CNRS, IGN, 75005 Paris, FRANCE / Univ. Gustave Eiffel, ENSG, IGN, 77454 Marne-la-Vallée, FRANCE*
Jérôme Saunier	*Institut National de l'Information Géographique et Forestière, Service de Géodésie et Nivellement, 73, avenue de Paris, 94165 Saint-Mandé Cedex, FRANCE*
Ernst Schrama	*Section of Astrodynamics and Space missions, Faculty of Aerospace Engineering at the Delft University of Technology, Kluyverweg 1, 2629HS Delft, THE NETHERLANDS*
Patrick Schreiner	*Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Location Oberpfaffenhofen, Building 401/1st floor, Claude-Dornier-Strasse 1, 82234 Wessling, GERMANY*
Laurent Soudarin	*CLS, 11, rue Hermès, 31520 Ramonville Saint-Agne, FRANCE*
Petr Štěpánek	*Geodesy Observatory Pecný, Research Institute of Geodesy, Topography and Cartography, Ondrejov 244, 25165 Prague-East, CZECH REPUBLIC*
Taylor Yates	*SSAI INC / NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA*
Julian Zeitlhöfler	*DGFI-TUM, Arcisstrasse 21, 80333 München, GERMANY*

Table of Contents

ABOUT IDS

INTRODUCTION

The International DORIS Service (IDS) was created in 2003 as an IAG service to federate the research and developments related to the DORIS technique, to organize the expected DORIS contribution to IERS and GGOS, and to foster a larger international cooperation on this topic.

To date, some 80 groups from 51 different countries have participated in IDS at various levels, including over 60 organizations hosting DORIS stations in 40 countries worldwide.

IDS's first contribution to the realization of the ITRF was the provision of individual solutions for ITRF2005 by two analysis centers. In 2006, there were four analysis centers supplying results to IDS. Since 2008, eight analysis groups have provided results, such as orbit solutions, weekly or monthly station coordinates, geocenter variations or Earth polar motion, that are used to generate IDS combined products for geodesy or geodynamics. All these centers have provided SINEX solutions for inclusion in the IDS combined solution that was submitted in 2009 to the IERS for ITRF2008. In 2009, the first IDS combined solution was realized using DORIS solutions from 7 Analysis Groups for weekly station positions and daily Earth orientation parameters. In 2012, 6 analysis centers (ACs) provided operational products, which were combined in a routine DORIS combination by the IDS Combination Center in Toulouse. In 2013, several inter-comparisons between ACs were performed (orbit comparisons, single-satellite SINEX solutions for station coordinates). In 2013 and 2014, the Analysis Centers and the Combination Center hardly worked on preparing the DORIS contribution for the new realization of the ITRF. All the DORIS data (since 1993) were processed by the six Analysis Centers. They submitted sets of weekly SINEX solutions to the Combination Center to generate the combined products. Thanks to the numerous exchanges between the groups to address the issues identified, several iterations were performed. The final version of the IDS contribution was submitted to the IERS in 2015. It was then included in the solutions produced by the IERS Production Centers at IGN, DGFI and JPL. The activities of the DORIS analysts in 2016 and 2017 were dominated by the evaluation of these three independent realizations (ITRF2014, DTRF2014, and JTRF2014), and the computation of DPOD2014, which is the DORIS extension of the ITRF for Precise Orbit Determination. They also focused on analyzing the data of the last DORIS satellites Jason-3 and Sentinel-3A, then Sentinel-3B in 2018, defining a strategy to minimize the impact of the sensitivity to the South Atlantic Anomaly effect of their Ultra Stable Oscillator and resolving the scale factor jump of the IDS solution. The years 2019 and 2020 were devoted to preparing and then carrying out the reprocessing of the DORIS data for the ITRF2020. Thanks to the efforts of the Analysis Centers whose activities were deeply affected by the COVID pandemic for two years, the Combination Centre delivered in 2021 the combined DORIS solution contributing to the ITRF2020 realization published in 2022. In 2023, processing of the 2020.0-2023.0 data was carried out to generate a DORIS contribution to the ITRF2020 extension. In addition, the Combination Centre produced two versions of the DORIS extension to ITRF2020 (DPOD2020), the second version including the estimation of annual and semi-annual signals as well as some post-seismic corrections.

This report summarizes the current structure of the IDS, the activities of the Central Bureau, provides an overview of the DORIS network, describes the IDS data centers, summarizes the DORIS satellite constellation, and includes reports from the individual DORIS ACs and AACs.

1 HISTORY

The DORIS system was designed and developed by CNES, the French space agency, jointly with IGN, the French mapping and survey agency, and GRGS the space geodesy research group, for precise orbit determination of altimeter missions and consequently also for geodetic ground station positioning.

DORIS joined the GPS, SLR and VLBI techniques as a contributor to the IERS for ITRF94. In order to collect, merge, analyze, archive and distribute observation data sets and products, the IGS was established and recognized as a scientific service of the IAG in 1994, followed by the ILRS in 1998 and the IVS in 1999. It is clear that DORIS has benefited from the experience gained by these earlier services. There was an increasing demand in the late nineties among the international scientific community, particularly the IAG and the IERS, for a similar service dedicated to the DORIS technique.

On the occasion of the CSTG (Coordination of Space Technique in Geodesy) and IERS Directing Board meetings, held during the IUGG General Assembly in Birmingham in July 1999, it was decided to initiate a DORIS Pilot Experiment that could lead on the long term to the establishment of such an International DORIS Service. A joint CSTG/IERS Call for Participation in the DORIS Pilot Experiment was issued on 10 September 1999. An international network of 54 tracking stations was then contributing to the system and 11 proposals for new DORIS stations were submitted. Ten proposals were submitted for Analysis Centers (ACs). Two Global Data Centers (NASA/CDDIS in USA and IGN/LAREG in France) already archived DORIS measurements and were ready to archive IDS products. The Central Bureau was established at the CNES Toulouse Center, as a joint initiative between CNES, CLS and IGN. The IDS Central Bureau and the Analysis Coordinator initiated several Analysis Campaigns. Several meetings were organized as part of the DORIS Pilot Experiment (**Table 1**).

The IDS was officially inaugurated on July 1, 2003, as an IAG Service after the approval of the IAG Executive Committee at the IUGG General Assembly in Sapporo. The first IDS Governing Board meeting was held on November 18, 2003, in Arles, France. Since then, each year, several IDS meetings were held (**Table 2**).

In 2023, two meetings of the Analysis Working Group were organized. The first one was held online on April 18. The second took place in Saint-Mandé, France, on November 28 and 29, co-organized by IGN analysis center and IGN Geodesy and Metrology Department (SGM). It was the first in-person meeting of the AWG after a 4-year period due to health crisis.

On 1 July 2023, the IDS turned 20 years old. To celebrate this anniversary, a special event was organized during the general assembly of the International Union of Geodesy and Geophysics in Berlin in July. A second celebration was held with the IDS community in Saint-Mandé in November. AS an introduction to the AWG meeting, representatives from CNES and IGN praised the active role played by IDS in improving and promoting the DORIS system.

On the same date, a new DORIS special issue “New Results from DORIS for Science and Society “was published in Advances in Space Research (Elsevier). Ernst Schrama and Denise Dettmering are the Guest Editors.

Date	Event	Location
2000	DORIS Days https://ids-doris.org/ids/reports-mails/meeting-presentations/doris-days-2000.html	Toulouse France
2002	IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2002.html	Biarritz France
2003	IDS Analysis Workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2003.html	Marne La Vallée France

Table 1. *List of meetings organized as part of the DORIS Pilot Experiment.*

Date	Event	Location
2004	Plenary meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-plenary-meeting-2004.html	Paris France
2006	IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2006.html	Venice Italy
2008	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-03-2008.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-06-2008.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2008.html	Paris France Paris France Nice France
2009	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-03-2009.html	Paris France
2010	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2010.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-10-2010.html IDS workshop & 20th anniversary of the DORIS system https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2010.html	Darmstadt Germany Lisbon Portugal Lisbon Portugal
2011	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2011.html	Paris France
2012	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2012.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-09-2012.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2012.html	Prague Czech Republic Venice Italy Venice Italy
2013	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2013.html	Toulouse France

Date	Event	Location
2013	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-10-2013.html	Washington USA
2014	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-03-2014.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2014.html	Paris France Konstanz Germany
2015	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2015.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-10-2015.html	Toulouse France Greenbelt USA
2016	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2016.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2016.html	Delft The Netherlands La Rochelle France
2017	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2017.html	London United Kingdom
2018	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-06-2018.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2018.html	Toulouse France Ponta Delgada Portugal
2019	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2019.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-09-2019.html	Munich Germany Paris France
2021	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2021.html DORIS days 2021 https://ids-doris.org/ids/reports-mails/meeting-presentations/doris-day-2021.html	online online
2022	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-06-2022.html IDS workshop https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2022.html	online Venice Italy
2023	Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2023.html Analysis Working Group Meeting https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-11-2023.html	online Saint-Mandé France

Table 2. *List of IDS events organized between 2004 and 2023.*

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) (**Figure 1**).

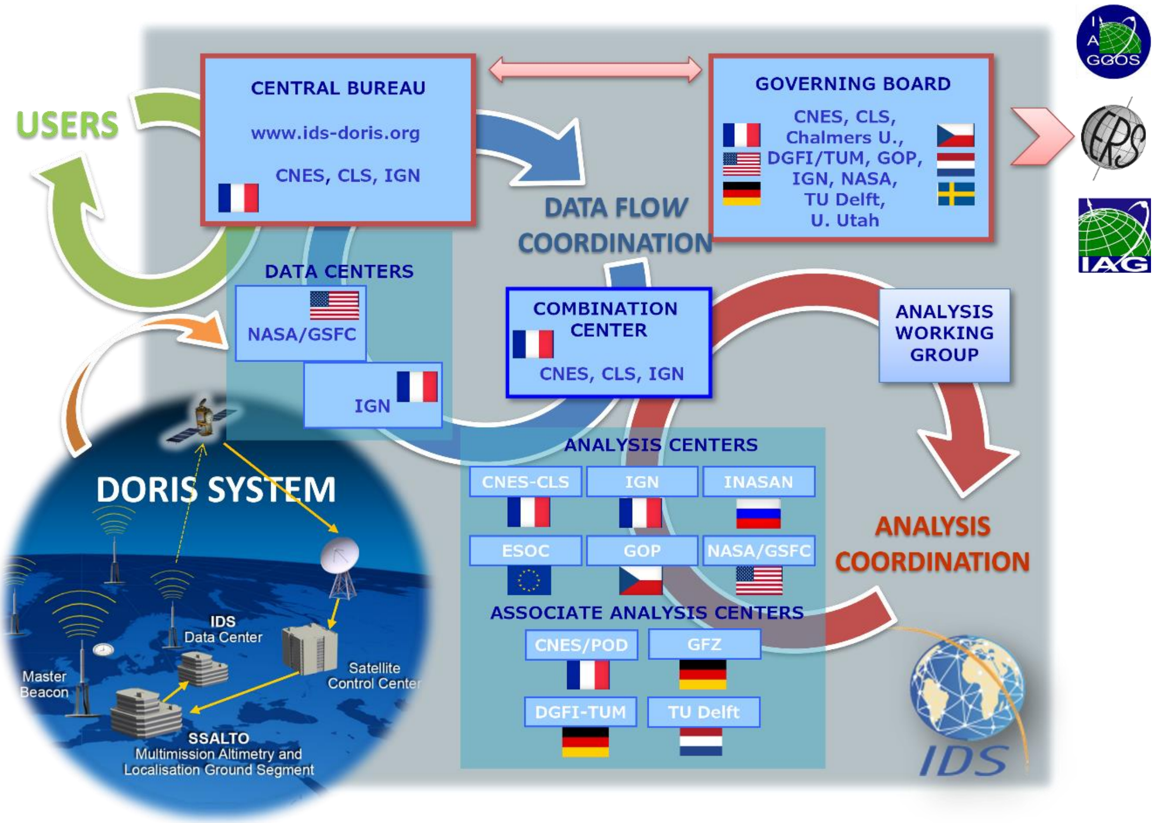


Figure 1. *IDS organization.*

2.1 GOVERNING BOARD

The principal role of the Governing Board (GB) is to set policy and to exercise broad oversight of all IDS functions and components. It also controls general activities of the Service, including restructuring, when appropriate, to maintain Service efficiency and reliability.

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.

In accordance with the Terms of Reference of the IDS, the GB was partially renewed in January 2023. The new members elected to serve for 2023-2026 are:

- Petr Štěpánek (Geodetic Observatory Pecný, Czech Republic) as Analysis coordinator
- Laura Sanchez (DGFI/TUM, Germany) as a Member at large

Table 3 gives the list of the GB's members in office on January 1st, 2022. Denise Dettmering is an ex officio member of the IDS GB, in the role of Chair of the IDS Working Group on Near Real Time Data.

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 Sanchez**	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	**Claude Boniface**	CNES	France
IAG representative	**2023-2027**	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-Nov. 2023**	Ex-officio (non voting member)	**Denise Dettmering**	DGFI/TUM	Germany

Table 3. *List of IDS GB members in office on December 31st, 2023.*

2.2 REPRESENTATIVES AND DELEGATES

In 2023, IDS representatives and delegates are:

- IDS representatives to the IERS:
  - Analysis Coordinator: Petr Štěpánek
  - Network representative: Jérôme Saunier
- IDS representatives to GGOS consortium: Frank G. Lemoine, Laurent Soudarin
- IDS representative to GGOS Bureau of Networks and Observations: Jérôme Saunier
- IDS representatives to GGOS Bureau of Products and Standards: Petr Štěpánek
- IDS representative to GGOS Governing Board: Karine Le Bail (from September 2023)

2.3 CENTRAL BUREAU

In 2023, the IDS Central Bureau is organized as follows:

- Laurent Soudarin CLS (Director)
- Claude Boniface CNES
- Jérôme Saunier IGN
- Guilhem Moreaux CLS

DORIS SYSTEM

3 THE NETWORK

Jérôme Saunier / IGN, France

3.1 GENERAL STATUS AND OPERATION

2023 was a very busy year for the DORIS network's field operations. A number of projects that had been put on hold during the Covid period have come to fruition. Two new sites were added, bringing the total number of stations to 60, a record in the network's history. The densification of the network, which was recommended in the IDS strategic plan established in 2019, has begun!

The network's main event was the commissioning of a new DORIS station at Hanga Roa on Easter Island, in April, which was eagerly awaited for the coverage of the South Pacific. The return of Santa Cruz, Galápagos Islands, in June, after 2y-outage, also contributed to improve the coverage over the Pacific Ocean.

In September, the sixtieth station was installed in Gavdos Island in Greece at the new ESA Permanent Facility for altimetry calibration that is located under a triple crossover of Sentinel 3 and Sentinel 6. This station is co-located with tide gauge and a GNSS real-time station (GVDG) that will be part of the IGS network.

The map of the DORIS network shows an even distribution including 4 master beacons (Toulouse, Greenbelt, Hartebeesthoek, Kourou), 1 time beacon (Terre-Adelie) and 2 experimental beacons for scientific purposes (Wettzell and Gavdos) (see **Figure 2**).

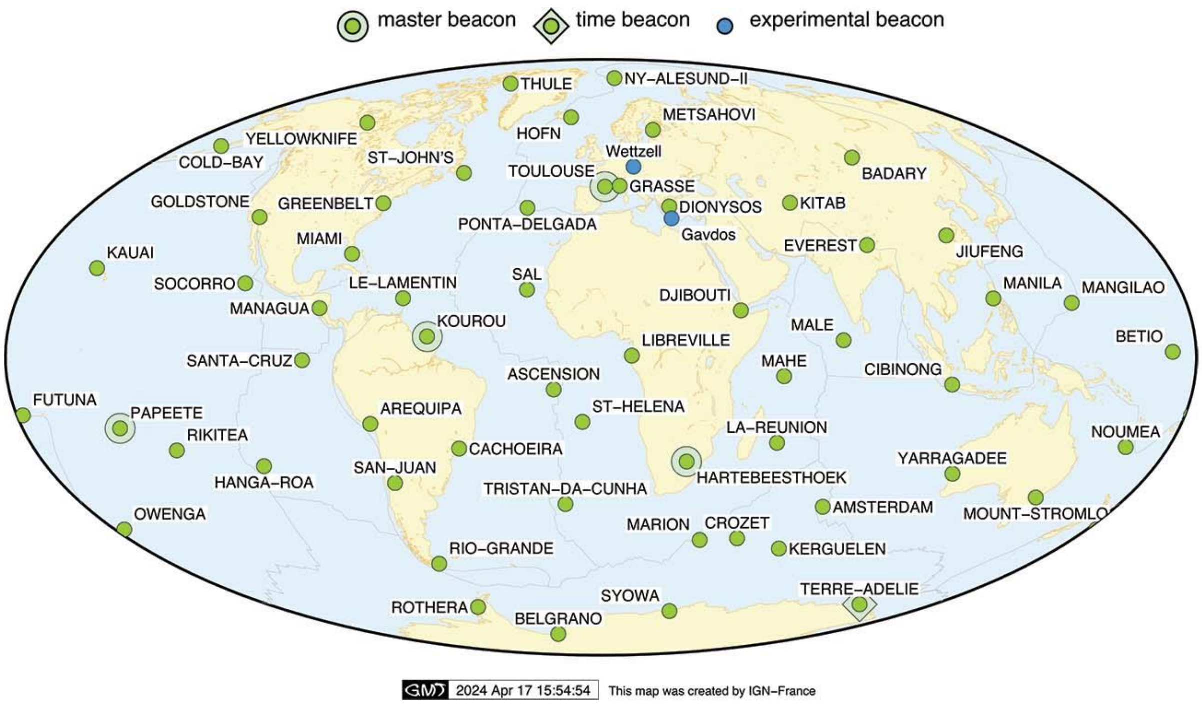


Figure 2. *The DORIS Network: 60 stations.*

This year again, the network provided a high level of service with an annual average of 89% of stations in operation, thanks to efficient maintenance. However, a number of stations are experiencing complications in getting back into service and several successive breakdowns occurred in the last quarter, requiring a change of equipment. (see **Figure 3** and **Figure 4**).

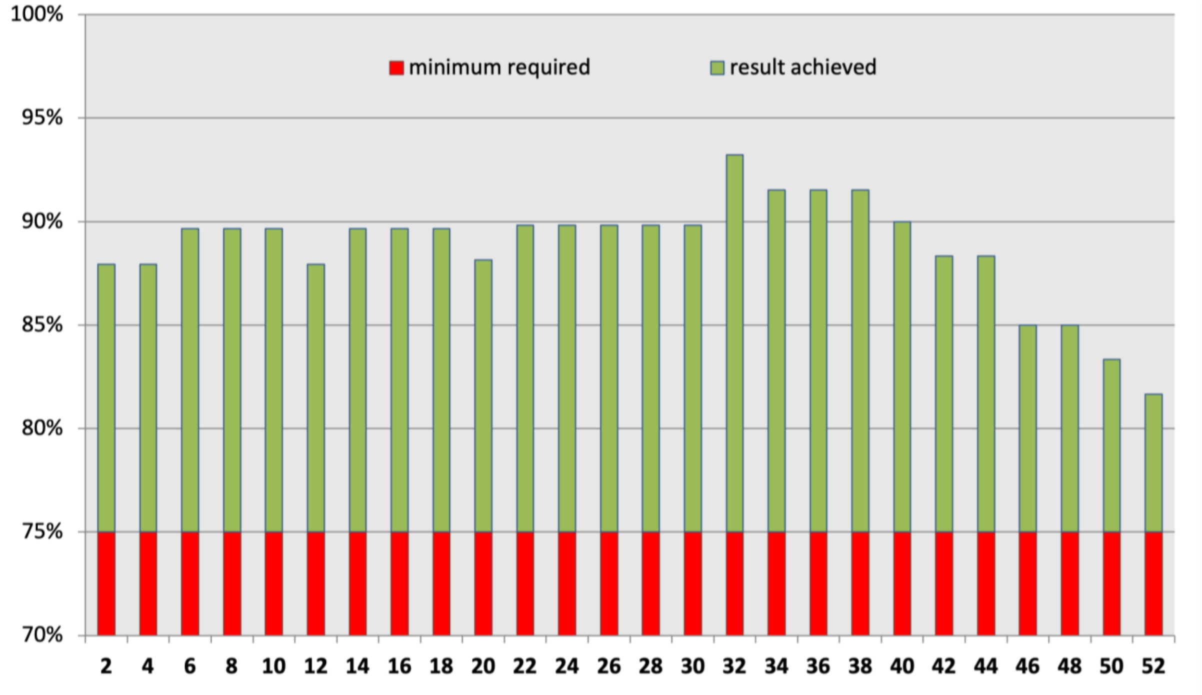


Figure 3. *Network availability 2023: Rate of stations in operation (fortnightly statement).*

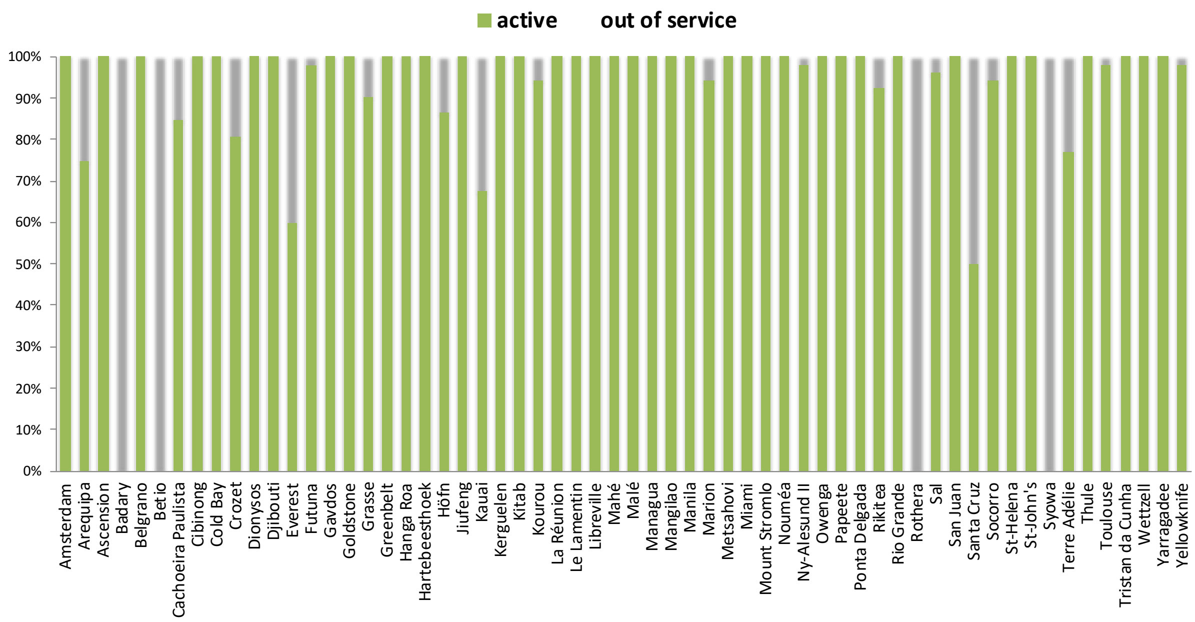


Figure 4. *Network stations activity 2023.*

3.2 EVOLUTION AND DEVELOPMENT

In terms of ground equipment, we have continued the gradual deployment of new antennas (Starec-C from 2014) and new beacons (4th generation from 2019) to replace ageing stations equipment and improve network robustness. At the end of 2023, 62% of the network stations are equipped with the 4th generation beacon and 47% with Starec-C antenna.

In 2023 the following DORIS sites were visited:

- Installation of new DORIS site in Hanga Roa (Easter Island, Chile)
- B4G installing at Kauai (Hawaii, USA)
- Equipment replacement at Santa Cruz (Galapagos, Ecuador)
- Reconnaissance at Ulaanbaatar (Mongolia) with a view to installing new station
- Installation of new DORIS site in Gavdos Island (Crete, Greece)
- B4G installing at Yellowknife (Canada)
- B4G installing at Djibouti (Djibouti)
- Reconnaissance at Kanpur (India) with a view to installing new station
- Major renovation at Rikitea (French Polynesia)

In 2024, the overall objectives are:

- Continuation of the deployment of the 4th generation beacon
- Installation of new DORIS site at Katherine (Australia)
- Installation of new DORIS site at Ulaanbaatar (Mongolia)
- Reconnaissance in South Korea with a view to installing new station
- Station renovation at Cachoeira Paulista (Brazil)
- Station renovation at Everest (Nepal)
- Installation of new DORIS site at Kanpur (India)
- Renovation at Le Lamentin (Martinique, French Indies)

The DORIS network includes a large number of stations co-located with other IERS techniques - GNSS (50), SLR (10), VLBI (8), thanks to an ongoing effort during network development to select sites with a view to contribute to the construction of the ITRF (see **Figure 5**). Co-location surveys are carried out at each DORIS co-located site by IGN following installation or maintenance operations, or with the help of other local survey teams, providing the ITRF product center with essential tie vectors for combining the independent reference frames of each technique: https://ids-doris.org/documents/BC/stations/DORIS_ext_ties.txt.

Co-location with tide gauges is another feature of the DORIS network: around half (29) of the current stations are located on islands or in coastal areas close to tide gauges, to help estimate vertical land motion and monitor sea level (see **Figure 5** and Appendix).

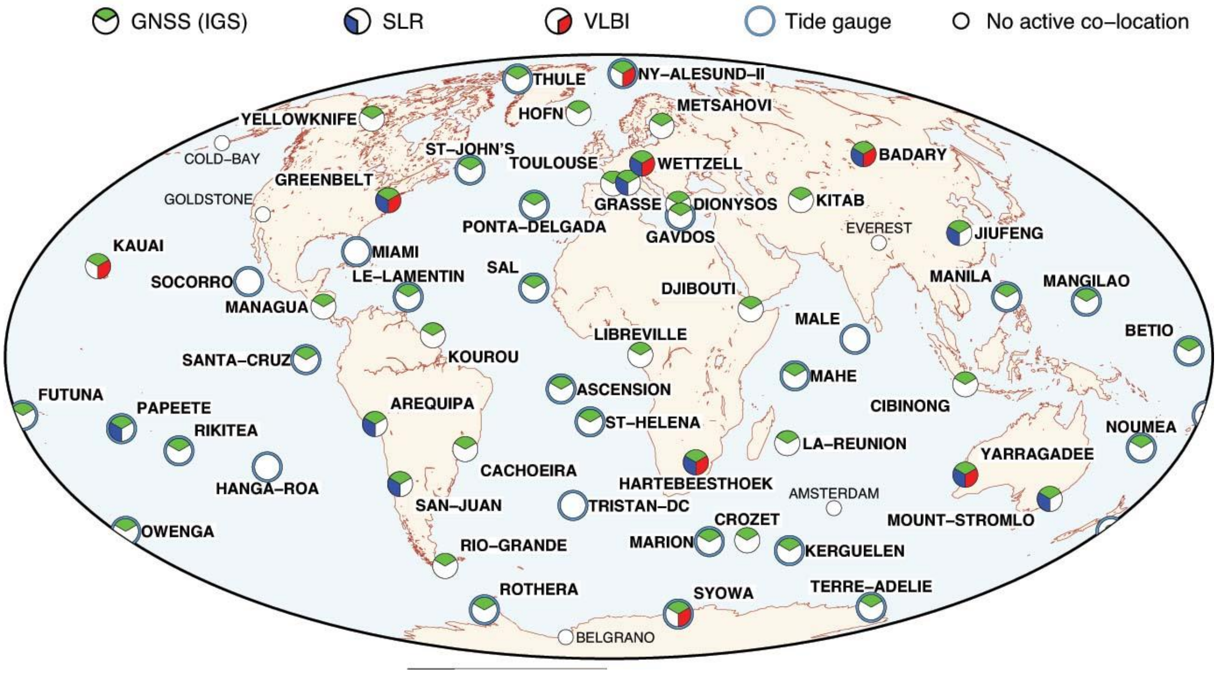


Figure 5. *DORIS stations co-located with other IERS techniques and tide gauges.*

4 THE SATELLITES WITH DORIS RECEIVERS

Claude Boniface / CNES, France

4.1 CURRENT STATUS

As described in **Table 4**, December 2022 marked a significant milestone with the launch of a new DORIS-equipped satellite. This satellite, SWOT (Surface Water and Ocean Topography), represents an innovative collaboration between NASA, CNES, CSA, and UKSA, designed for the global survey of Earth's surface water. While SWOT was launched in late 2022, it became fully operational in 2023, joining the active DORIS constellation. With this addition, the DORIS constellation now comprises 9 operational satellites. Each of these satellites is equipped with the advanced 7-channel DGXX-S DORIS on-board receiver. They orbit at altitudes ranging from 720 to 1336 km, following either near-polar orbits or TOPEX-like inclinations of 66 degrees.

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	-	ESA	Altimetry, ice caps
HY-2A	1-OCT-2011	14-SEP-2020	CNSA, NSOAS	Altimetry
SARAL	14-MAR-2013	-	CNES/ISRO	Altimetry
Jason -3	19-JAN-2016	-	NASA/CNES/NOAA/ Eumetsat	Altimetry
Sentinel-3A	23-FEB-2016	-	GMES/ESA	Altimetry
Sentinel-3B	25-APR-2018	-	GMES/ESA	Altimetry
HY-2C	21-SEP-2020	-	CNSA, NSOAS	Altimetry
Sentinel-6A	21-NOV-2020	-	NASA/CNES/NOAA/ Eumetsat/ESA	Altimetry
HY-2D	19-MAY-2021	-	CNSA, NSOAS	Altimetry
SWOT	16-DEC-2022	-	NASA/CNES/ CSA/UKSA	Interferometric altimetry

Table 4. *DORIS data availability at IDS data centers, as of December 2022.*

4.2 FUTURE PROSPECTS

The DORIS system's future looks promising, with several missions planned in the coming years and beyond, offering long-term visibility for the constellation's evolution:

Near-term missions (next 5 years)

- Sentinel-3C: part of the Copernicus program, continuing the Sentinel-3 series for ocean and land observation.
- Sentinel-3D: the follow-up to Sentinel-3C, ensuring continuity of critical Earth observation data.
- HY-2E: the next in China's HY-2 series of ocean observation and monitoring satellites.
- Sentinel-6B: also known as Jason-CS2, continuing the high-precision ocean altimetry mission.

Mid-term confirmed missions

- GENESIS: an ESA scientific geodesy mission scheduled for launch in 2028. It will carry four techniques, including DORIS (using the latest model of the previous generation, DGXX-S).
- Sentinel-6C: an ESA altimetry mission, continuing the legacy of Jason/Sentinel-6 reference missions, with a planned launch in 2030.

Long-term potential missions:

- Sentinel-3 NG Topo: two ESA satellites, successors to the Sentinel-3 series, awaiting confirmation. Launch is tentatively set for 2032, potentially carrying DORIS instruments provided by CNES.
- Sentinel-6 NG: ensuring continuity of reference missions, with a projected launch in 2035.
- HY-2F/G/H: future iterations of China's HY-2 series, dates to be confirmed.

This pipeline of missions provides visibility into the DORIS constellation's evolution well into the 2030s. The mix of confirmed and potential missions across various space agencies (ESA, CNES, CNSA, NASA, etc.) demonstrates the ongoing international commitment to the DORIS system and its critical role in Earth observation, oceanography, and geodesy.

4.3 HISTORICAL PERSPECTIVE AND CURRENT ACHIEVEMENT

Figure 6 and **Figure 7** offer a comprehensive overview of the DORIS constellation's evolution, tracing its history from the launch of SPOT-2 in 1990 to the present day, and including future planned satellites. Over three decades, from the inaugural SPOT-2 mission in 1990 to the conclusion of the HY-2A mission in 2020, nine distinct missions have utilized DORIS technology.
As of now, nine DORIS instruments are simultaneously operational, all belonging to the same DGXX generation. These instruments are aboard satellites launched between 2010 (CryoSat-2) and 2022 (SWOT). This current configuration represents an unprecedented availability of DORIS instruments, offering IDS users access to more simultaneous data sources than ever before.

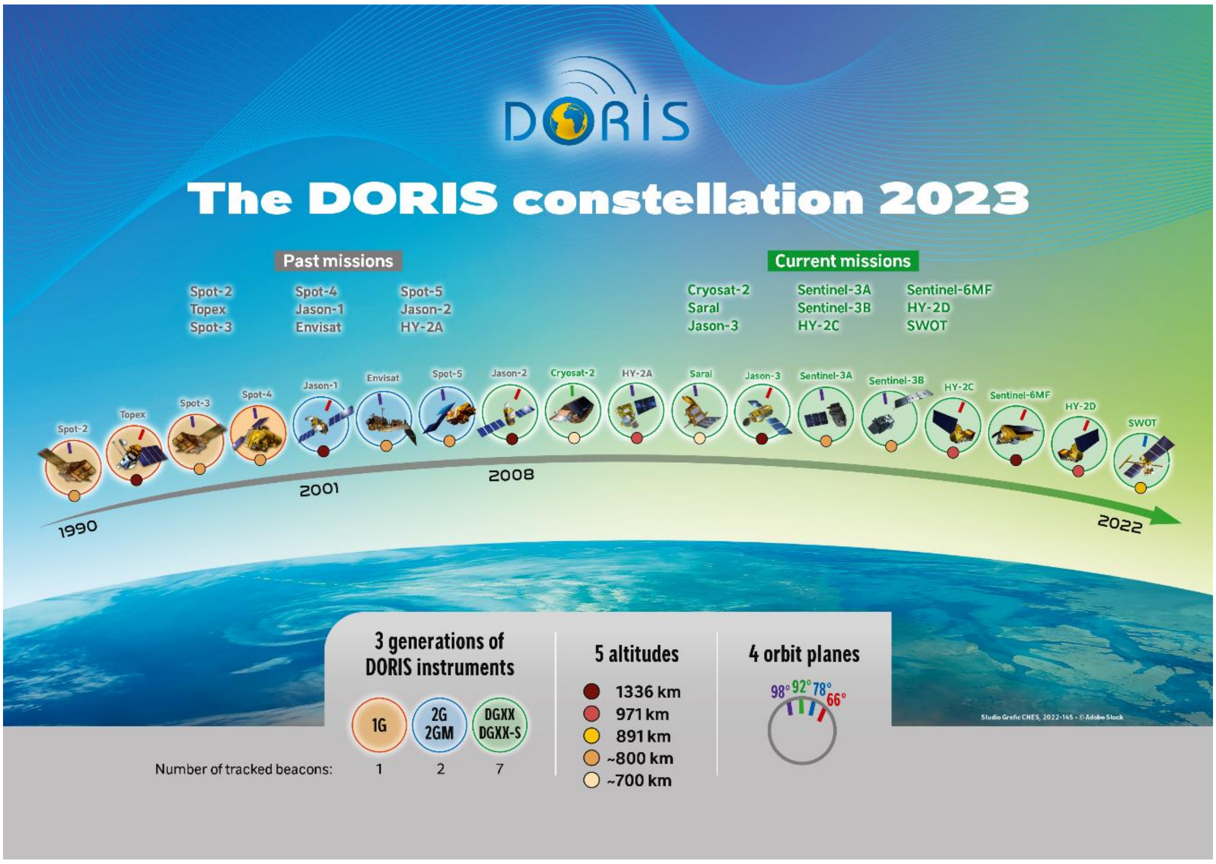


Figure 6. *DORIS satellite constellation and evolution. As of December 2023.*

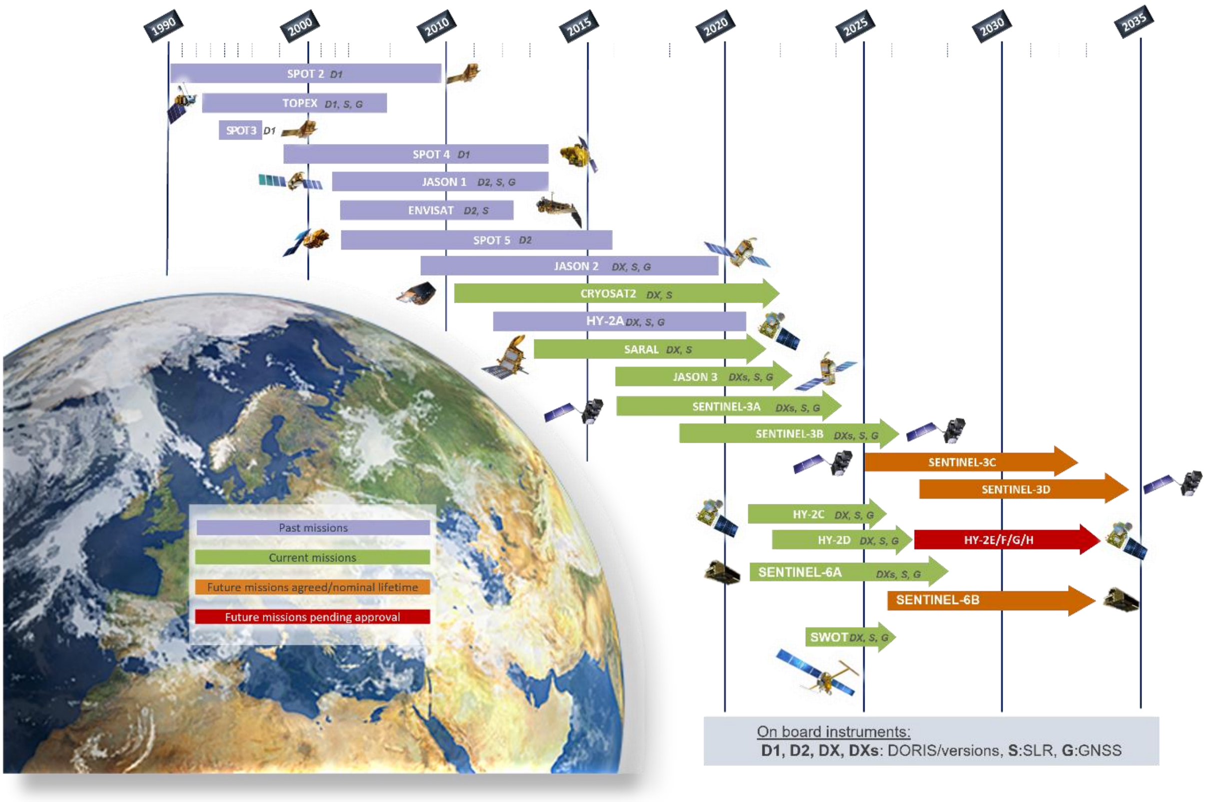


Figure 7. *Past, current and future missions with DORIS. As of December 2023.*

USER SERVICE

5 CENTRAL BUREAU

Laurent Soudarin [1], Claude Boniface [2]
[1] CLS, France / [2] CNES, France

The Central Bureau (CB), 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. This report summarizes the activities of the IDS Central Bureau during the year 2023. An overview of the IDS information system is reminded in appendix.

5.1 CALL FOR HOSTING ONE IDS STATION

In 2022, the IDS launched a call for proposals for an IDS station. The purpose of this call was to describe how institutions and host agencies can express their interest in hosting a DORIS or “IDS Station”. An “IDS station” is distinct from the general network dedicated to orbit determination and may have a specific scientific focus. Of the 8 proposals received, an initial analysis led to the selection of two: La Plata (Argentina) and Kânpur (India). Following discussions with Argentina's National Council for Scientific and Technological Research (CONICET) and the Indian Institute of Technology in Kânpur (IITK) in March 2023, the evaluation committee (J. Saunier, F. Lemoine, G. Moreaux) chose the Kânpur site in India as the future 4-technique geodetic observatory. This choice was validated by the Governing Board of IDS on April 19, 2023, then presented to CNES on June 15, 2023. Kânpur better met IDS's objectives (strategic plan resulting from the IDS Retreat 2018): to expand the DORIS community, develop DORIS community and develop scientific collaborations with host organizations. The great motivation of the IITK team and the fact that one of their students is already working on a thesis on DORIS attracted IDS.
For this operation, the Central Bureau provided support by organizing the special Governing Board meeting and sending decision letters to the finalists.

5.2 MEETINGS

The Central Bureau participated in the organization of the AWG meeting held online on April 18 and offered support for the AWG meeting co-organized by IGN analysis center and IGN Geodesy and Metrology Department (SGM) in Saint-Mandé on November 28 and 29.

It documented the regular GB meetings held online on February 13 and in Saint-Mandé on November 29. It also organized the extraordinary meeting of the GB on 19 April for the final selection of the proposal to host an IDS station.

The Central Bureau also helped to organize IDS's 20th anniversary celebrations at the IUGG general assembly in Berlin, and at the AWG meeting. A room was reserved and a buffet ordered for the special event organized in Berlin on the occasion of the general assembly of the International Union of Geodesy and Geophysics (IUGG; 11-20 July 2023, https://www.iugg2023berlin.org/). A second celebration was held with the IDS community in Saint-Mandé, France, in November. As an introduction to the AWG meeting, representatives from CNES and IGN praised the active role played by IDS in improving and promoting the DORIS system.

5.3 DATA DISSEMINATION

The Central Bureau works with the SSALTO multi-mission ground segment and the Data centers to coordinate the data and products archiving and the dissemination of the related information. Data, metadata, and documentation from the SWOT mission were put online the IDS data and information sites as they become available. In addition, the CB and CNES have started to prepare the release of NRT data (RINEX/DORIS and DIODE sp3 orbits) for the operating missions, in addition to Jason-3.

5.4 NEWSLETTERS

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).
IDS Newsletter # 10 was published in April 2023. It is available on the website at:
https://ids-doris.org/images/documents/newsletters/IDS-Newsletter10.pdf
It contains the following articles:

- DORIS is on SWOT
- Using Near-Real-Time DORIS data for validating real-time GNSS ionospheric maps (D. Dettmering, DGFI-TUM, N. Wang, AIR-CAS)
- IDS contribution to the 2020 realization of the International Terrestrial Reference Frame (G. Moreaux, CLS)
- Höfn, new DORIS site in Iceland (J. Saunier, IGN)
- The host agency in short: Höfn (G.H. Kristinsson, LMI)
- IDS life
- The DORIS constellation 2023

The published newsletters and their contents are listed in Appendix (**Newsletters**).

5.5 OUTREACH PUBLICATIONS AND SERVICE ‘S REPRESENTATIONS

The Central Bureau contributed to the following IAG and GGOS outreach actions:

- French version of the GGOS video “Terrestrial Reference Frames - Connecting the World through Geodesy”;
- Writing of an IDS/DORIS article for the Encyclopedia of Geodesy.

It also published the IDS annual activity report 2021 and assigned it the following DOI: https://doi.org/10.24400/312072/i02-2023.002
It presented the recent achievements made by IDS and its components, and the future plans of the service in the GGOS oral session at EGU General Assembly 2023 (https://ids-doris.org/images/documents/report/meetings/EGU2023-IDS20years.pdf)

5.6 DOCUMENTATION

Documents and static files available on the ftp server in the directory "ftp://ftp.ids-doris.org/pub/ids/" and its sub-directories have been copied to the web server in the directory "https://ids-doris.org/documents/BC/" with the same sub-directories to facilitate access by a web browser, as the ftp protocol is no longer supported by recent browser versions.

The documents and files put on the IDS ftp site in 2023 are listed hereafter with their https access.

Updated document:

- « Sentinel-6A POD context »

https://ids-doris.org/documents/BC/satellites/Sentinel6A_PODcontext.pdf

- DORIS satellites models implemented in POE processing (added SWOT)

https://ids-doris.org/documents/BC/satellites/DORISSatelliteModels.pdf

- Frequency shift mode of the 3rd and 4th generation beacons (previously Frequency shift mode of the 3rd generation beacon)

https://ids-doris.org/documents/BC/stations/3rdAnd4thGeneration_FrequencyShift.pdf

New documents:

- SWOT characteristics for POD processing

https://ids-doris.org/documents/BC/satellites/Swot_CharacteristicsForPODprocessing.pdf

- Description of the theoretical attitude laws for the satellites Sentinel-6 and SWOT

https://ids-doris.org/documents/BC/satellites/SwotAndSentinel6AttitudeLaws.pdf

- Description of the quaternion files for SWOT

https://ids-doris.org/documents/BC/ancillary/quaternions/swot_quaternions_CNES_product_description.pdf

Updates files:

- DORIS ties with other IERS techniques

https://ids-doris.org/documents/BC/stations/DORIS_ext_ties.txt

- Station frequency shift (added GAVC)

https://ids-doris.org/documents/BC/stations/events/station_frequency_shift.txt

- Mass and center of Mass initial values

https://ids-doris.org/documents/BC/satellites/MassCoGInitialValues.txt

6 IDS DATA FLOW COORDINATION

Taylor Yates / SSAI INC, USA

6.1 INTRODUCTION

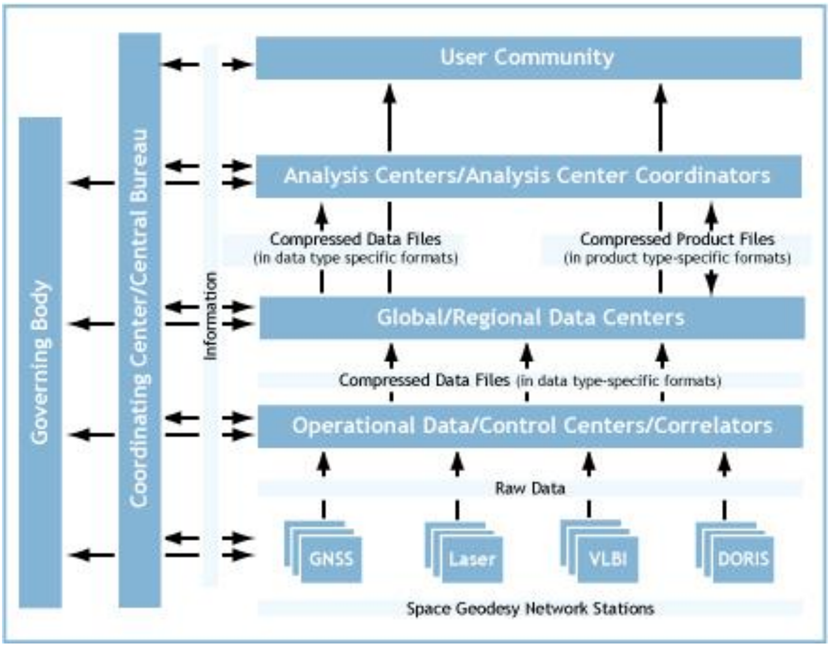
Two data centers support the archiving and access activities for the IDS:

- Crustal Dynamics Data Information System (CDDIS), NASA GSFC, Greenbelt, MD USA
- l'Institut National de l'Information Géographique et Forestière (IGN), Marne la Vallée, France

These institutions have archived DORIS data since the launch of TOPEX/Poseidon in 1992.

6.2 FLOW OF IDS DATA AND PRODUCTS

The flow of data, products, and information within the IDS is similar to what is utilized in the other IAG geometric services (IGS, ILRS, IVS) and is shown in **Figure 8**. IDS data and products are transmitted from their sources to the IDS data centers. DORIS data are downloaded from the satellite at the DORIS control and processing center, SSALTO (Segment Sol multi-missions d'ALTimétrie, d'Orbitographie et de localisation précise) in Toulouse, France. After validation, SSALTO transmits the data to the IDS data centers. IDS analysis centers, as well as other users, retrieve these data files from the data centers and produce products, which in turn are transmitted to the IDS data centers.



Network Stations
Continuously operational
Timely flow of data

Data Centers
Interface to network stations
Perform QC and data conversion activities
Archive data for access to analysis centers and users

Analysis Centers
Provide products to users (e.g., station coordinates, precise satellite orbits, Earth orientation parameters, atmospheric products, etc.)

Central Bureau / Coordinating Center
Management of service
Facilitate communications
Coordinate activities

Governing Body
General oversight of service
Future direction

Figure 8. *Routine flow of data and information for the IAG Geodetic Services.*

Directory	File Name	Description
Data Directories		
/doris/data/*sss*	*sss*data*MMM.LLL*.Z *sss*.files	DORIS data for satellite *sss*, cycle number *MMM*, and version *LLL* File containing multi-day cycle filenames versus time span for satellite *sss*
/doris/data/*sss*/sum	*sss*data*MMM.LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
/doris/data/*sss*/yyyy	*sss*rx*YYDDD.LLL*.Z	DORIS data (RINEX format) for satellite sss, date YYDDD, version number *LLL*
/doris/data/*sss*/yyyy/sum	*sss*rx*YYDDD.LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
/doris/data/yyyy	*yyddd*.status	Summary file of all RINEX data holdings for year *yy* and day of year *ddd*
Product Directories		
/doris/products/2010campaign/	*ccc/cccYYDDDtuVV.sss*.Z	Time series SINEX solutions for analysis center *ccc*, starting on year *YY* and day of year *DDD*, type *t* (m=monthly, w=weekly, d=daily) solution, content *u* (d=DORIS, c=multi-technique), and solution version *VV* for satellite *sss*
/doris/products/dpod/	*dpodYYYY/dpodYYYY_VV.snx*.Z *dpodYYYY/dpodYYYY_ VV.txt*.Z	DPOD solutions (DORIS extension of the ITRF for Precise Orbit Determination) for year *YYYY (2000, 2005, 2008, 2014)* and solution version *VV* in sinex (*snx*) or text (*txt*) format.
/doris/products/eop/	*cccWWtuVV*.eop.Z	Earth orientation parameter solutions for analysis center *ccc*, for year *WW*, type *t* (m=monthly, w=weekly, d=daily), content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/geoc/	*cccWWtuVV*.geoc.Z	TRF origin (geocenter) solutions for analysis center *ccc*, for year *WW*, type *t* (m=monthly, w=weekly, d=daily), content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/iono/	*sss/cccsssVV.YYDDD*.iono.Z	Ionosphere products for analysis center *ccc*, satellite *sss*, solution version *VV*, and starting on year *YY* and day of year *DDD*
/doris/products/orbits/	*ccc/cccsssVV.bXXDDD.eYYEEE*.sp1.*LLL*.Z	Satellite orbits in SP1 format from analysis center *ccc*, satellite *sss*, solution version *VV*, start date year *XX* and day *DDD*, end date year *YY* and day *EEE*, and file version number *LLL*
/doris/products/sinex_global/	*cccWWuVV*.snx.Z	Global SINEX solutions of station coordinates for analysis center *ccc*, year *WW*, content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/sinex_series/	*ccc/cccYYDDDtuVV*.snx.Z	Time series SINEX solutions for analysis center *ccc*, starting on year *YY* and day of year *DDD*, type *t* (m=monthly, w=weekly, d=daily) solution, content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/stcd/	*cccWWtu/cccWWtuVV*.stcd.*aaaa*.Z	Station coordinate time series SINEX solutions for analysis center *ccc*, for year *WW*, type *t* (m=monthly, w=weekly, d=daily), content *u* (d=DORIS, c=multi-technique), solution version *VV*, for station *aaaa*
Information Directories		
/doris/ancillary/quaternions	*sss/yyyy/*qbody*YYYYMMDDHHMISS_yyyymmddhhmiss.LLL* *sss/*qsolp*YYYYMMDDHHMISS_yyyymmddhhmiss.LLL*	Spacecraft body quaternions for satellite *sss*, year *yyyy*, start date/time *YYYYMMDDHHMISS*, end date/time *yyyymmddhhmiss*, and version number *LLL* Spacecraft solar panel angular positions for satellite *sss*, year *yyyy*, start date/time *YYYYMMDDHHMISS*, end date/time *yyyymmddhhmiss*, and version number *LLL*
/doris/cb_mirror		Mirror of IDS central bureau files

Table 5. *Main Directories for IDS Data, Products, and General Information.*

The IDS data centers use a common structure for directories and filenames that was implemented in January 2003. This structure is shown in **Table 5** and fully described on the IDS website at *https://ids-doris.org/struct-dc.html*. The main directories are:

- */doris/data* (for all data) with subdirectories by satellite code
- */doris/products* (for all products) with subdirectories by product type and analysis center
- */doris/ancillary* (for supplemental information) with subdirectories by information type
- */doris/campdata* (for SAA-corrected data) with subdirectories by satellite code
- */doris/cb_mirror* (duplicate of the IDS Central Bureau ftp site) with general information and data and product documentation (maintained by the IDS Central Bureau)
- */doris/general* (for miscellaneous information and summary files)

The DORIS mission support ground segment group, SSALTO, and the analysis centers deliver data and products to both IDS data centers (CDDIS and IGN) to ensure redundancy in data delivery in the event one data center is unavailable. The general information available through the IDS Central Bureau ftp site is mirrored by the IDS data centers thus providing users with secondary locations for these files as well.

6.3 DORIS DATA

SSALTO deposits DORIS data to the CDDIS and IGN servers. Software at the data centers scans these incoming data areas for new files and automatically archives the files to public disk areas using the directory structure and filenames specified by the IDS. Today, the IDS data centers archive DORIS data from nine operational satellites (CryoSat-2, HY-2A, Jason-2, Jason-3, SARAL, Sentinel-3A, Sentinel-3B, Sentinel-6A, and SWOT); data from future missions will also be archived within the IDS. Historic data from Envisat, Jason-1, SPOT-2, -3, -4, -5, and TOPEX/Poseidon, are also available at the data centers. A summary of DORIS data holdings at the IDS data centers is shown in **Table 6.** The DORIS data from select satellites are archived in multi-day (satellite dependent) files using the DORIS data format 2.1 (since January 15, 2002). This format for DORIS data files is on average two Mbytes in size (using UNIX compression). SSALTO issues an email notification through DORISreport once data are delivered to the IDS data centers.

DORIS phase data from CryoSat-2, HY-2A, HY-2C, HY-2D, Jason-2, Jason-3, SARAL, Sentinel 3A and -3B, Sentinel-6A and SWOT are also available in the format developed for GNSS data, RINEX (Receiver Independent Exchange Format), version 3.0. These satellites have the newer, next generation DORIS instrumentation on board, which is capable of generating DORIS data compatible with the RINEX format; future satellites will also utilize this type of DORIS receiver. These data are forwarded to the IDS data centers in daily files prior to orbit processing within one-two days (typically) following the end of the observation day. Data from Jason-3, Sentinel 3A and -3B, Sentinel-6A and SWOT are only available in the RINEX format.

In the fall of 2012, the IDS Analysis Working Group requested a test data set where data from stations in the South Atlantic Anomaly (SAA) were reprocessed by applying corrective models. Data in DORIS V2.2 format from the Jason-1 satellite (cycles 104 through 536, Jan. 2002 through Jun. 2013) have been submitted to the IDS data centers; a set of SPOT-5 data (cycles 138 through 501, Dec. 2005 through Nov. 2015) have also been submitted and archived. These files are archived at the IDS data centers in campaign directories, e.g., at CDDIS:

ftps://gdc.cddis.eosdis.nasa.gov/doris/campdata/saacorrection/ja1 .and */sp5*
https://cddis.nasa.gov/archive/doris/campdata/saacorrection/ja1 .and */sp5*

Satellite	Time Span	Data Type
CryoSat-2	30-May-2010 through present	Multi-day, RINEX
Envisat	13-Jun-2002 through 08-Apr-2012	Multi-day
HY-2A	01-Oct-2011 through 11-Sep-2020	Multi-day, RINEX
HY-2C	11-Sep-2020 through present	RINEX
HY-2D	15-May-2021 through present	RINEX
Jason-1	15-Jan-2002 through 21-Jun-2013	Multi-day
Jason-2	12-Jul-2008 through 10-Oct-2019	Multi-day, RINEX
Jason-3	17-Feb-2016 through present	RINEX
SARAL	14-Mar-2013 through present	Multi-day, RINEX
Sentinel-3A	23-Feb-2016 through present	RINEX
Sentinel-3B	01-May-2018 through present	RINEX
Sentinel-6A	17-Dec-2020 through present	RINEX
SPOT-2	31-Mar-1990 through 04-Jul-1990 04-Nov-1992 through 14-Jul-2009	Multi-day
SPOT-3	01-Feb-1994 through 09-Nov-1996	Multi-day
SPOT-4	01-May-1998 through 24-Jun-2013	Multi-day
SPOT-5	11-Jun-2002 through 30-Nov-2015	Multi-day
SWOT	12-Jan-2023 through present	RINEX
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004	Multi-day

Table 6. *DORIS Data Holdings Summary.*

6.4 DORIS PRODUCTS

IDS analysis centers utilize similar procedures by putting products to the CDDIS and IGN servers. Automated software detects any incoming product files and archives them to the appropriate product-specific directory. The following analysis centers (ACs) have submitted products on an operational basis to the IDS; their AC code is listed in ():

- European Space Agency (esa), Germany
- Geoscience Australia (gau) (historic AC)
- Geodetic Observatory Pecny (gop), Czech Republic
- NASA Goddard Space Flight Center (gsc) USA
- Institut Géographique National/JPL (ign) France
- INASAN (ina) Russia
- CNES/CLS (lca historically, grg starting in 2014) France
- CNES/SOD (sod) France (historic AC)
- SSALTO (ssa) France

Type of Product	ACs/Products										
	ESA	GAU *	GOP	GRG **	GSC	IDS	IGN	INA	LCA **	SOD *	SSA
Time series of SINEX solutions (*sinex_series*)	X	X	X	X	X	X	X	X	X	X	X
Global SINEX solutions (*sinex_global*)				X			X		X		
Geocenter time series (*geoc*)							X	X	X		
Orbits/satellite (orbits)				X	X				X		X
Ionosphere products/satellite (*iono*)											X
Time series of EOP (*eop*)							X	X			
Time series of station coordinates (*stcd*)	X		X	X	X	X	X	X	X		X
Time series of SINEX solutions (*2010campaign*)		X	X		X		X	X	X		

*Note: GAU and SOD historic solutions

**Note: CNES/CLS transitioned their AC acronym from LCA to GRG in 2014.

Table 7. *IDS Product Types and Contributing Analysis Centers.*

A solution (designated "ids") produced by the IDS combination center from the individual IDS AC solutions started production in 2012. IDS products are archived by type of solution and analysis center. The types and sources of products available through the IDS data centers in 2005-2023 are shown in **Table 7**. This table also includes a list of products under evaluation from several DORIS analysis centers.

6.5 SUPPLEMENTARY DORIS INFORMATION

In 2009 an additional directory structure was installed at the IDS data centers containing ancillary information for DORIS data and product usage. Files of Jason-1, -2, and -3 satellite attitude information were made available through the IDS data centers. Two types of files are available for each satellite: attitude quaternions for the body of the spacecraft and solar panel angular positions. The files are delivered daily and contain 28 hours of data, with 2 hours overlapping between consecutive files. Analysts can use these files in processing DORIS data to determine satellite orientation and attitude information.

6.6 FUTURE PLANS

The CDDIS and IGN provide reports that list holdings of DORIS data in the DORIS format. The IDS data centers will also investigate procedures to regularly compare holdings of data and products to ensure that the archives are truly identical.

7 IDS DATA CENTERS

7.1 CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)

Taylor Yates / SSAI INC, USA

7.1.1 INTRODUCTION

The CDDIS is a dedicated data center supporting the international space geodesy community since 1982. The CDDIS serves as one of the primary data centers for the following IAG services, projects and international groups:

- International DORIS Service (IDS)
- International GNSS Service (IGS)
- International Laser Ranging Service (ILRS)
- International VLBI Service for Geodesy and Astrometry (IVS)
- International Earth Rotation and Reference Frame Service (IERS)
- Global Geodetic Observing System (GGOS)

The CDDIS is one of NASA's Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs); EOSDIS data centers serve a diverse user community and are tasked to provide facilities to search and access science data and products. The CDDIS is also a regular member of the International Council for Science (ICSU) World Data System (WDS).

7.1.2 OPERATIONAL ACTIVITIES

At the end of 2023, the CDDIS has devoted 155 GB of disk space (89GB or ~57% for DORIS data, 40GB or ~26% for DORIS products, and 26GB or ~17% for DORIS ancillary data and information) to the archive of DORIS data, products, and information (**Figure 9**). During the past year, users downloaded 2006 GBytes (846,518 files) of DORIS data, products, and information from the CDDIS (**Figure 10**).

The CDDIS provides a file that summarizes the RINEX-formatted data holdings each day. Information provided in the status file includes satellite, start and end date/time, receiver/satellite configuration information, number of stations tracking, and observation types. These files are accessible in yearly sub-directories within the DORIS data subdirectory on CDDIS, *ftps://gdc.cddis.eosdis.nasa.gov/doris/data* or *https://cddis.nasa.gov/archive/doris/data*.

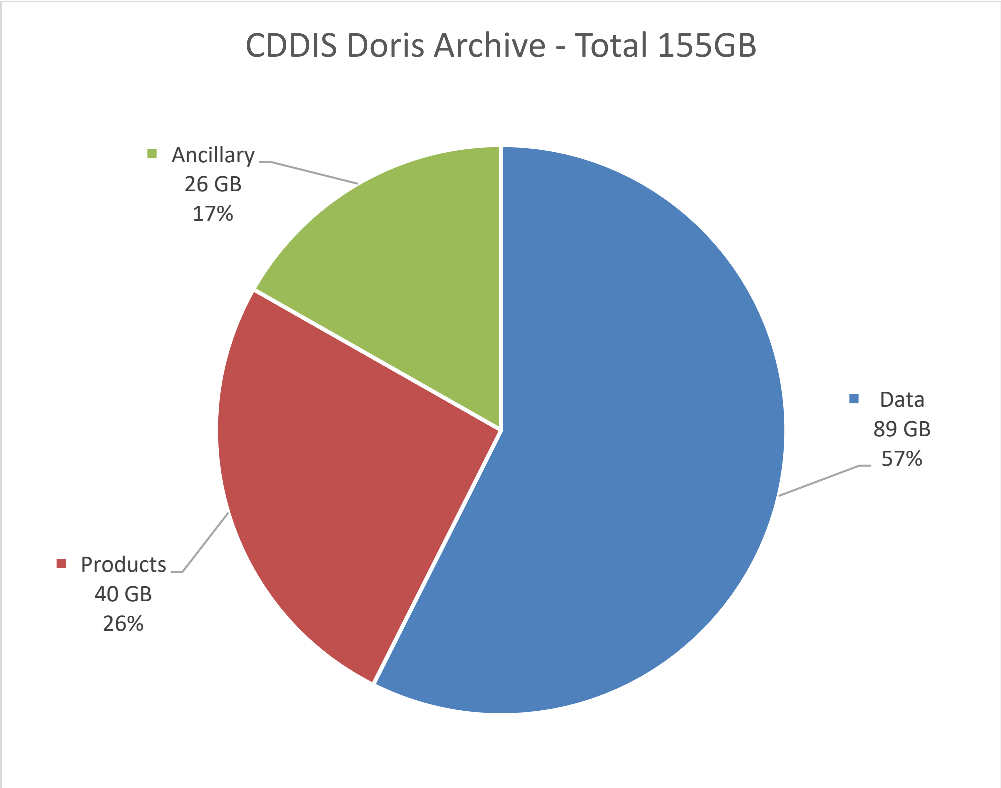


Figure 9. *CDDIS DORIS archive (2023).*

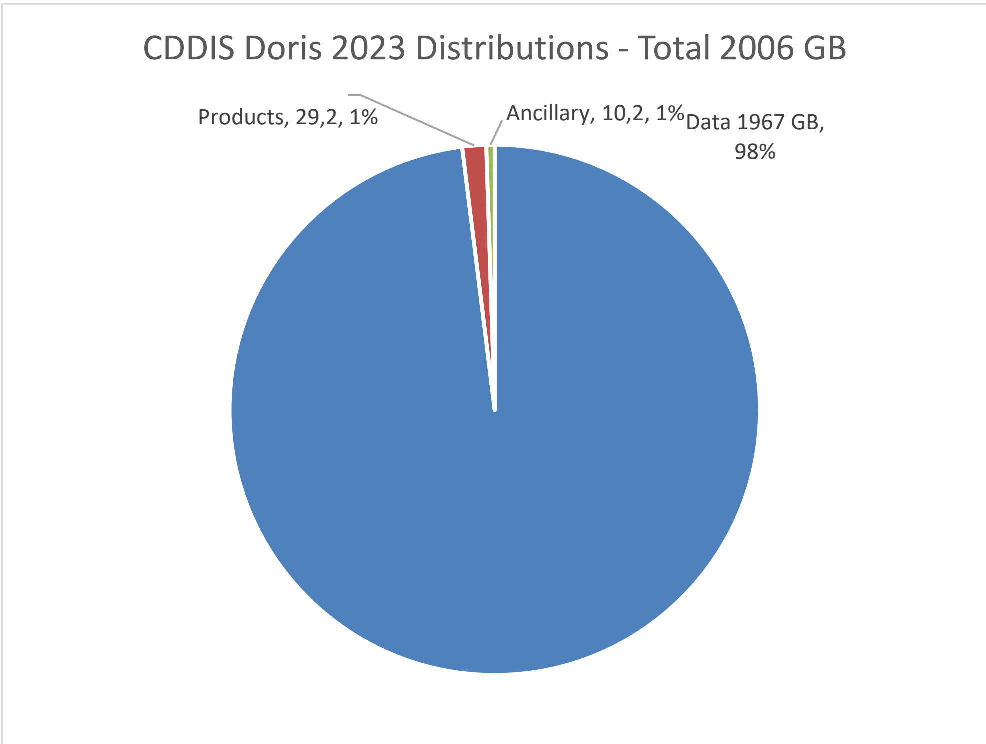


Figure 10. *CDDIS DORIS 2023 distributions.*

7.1.3 RECENT ACTIVITIES AND DEVELOPMENTS

No major recent activities were completed in 2023.

7.1.4 FUTURE PLANS

The CDDIS staff will continue to interface with the IDS Central Bureau (CB), SSALTO, and the IDS analysis centers to ensure reliable flow of DORIS data, products, and information. Enhancements and modifications to the data center will be made in coordination with the IDS CB.

The CDDIS has established Digital Object Identifiers (DOIs) for several of its GNSS data sets; website "landing" pages have been established for these published DOIs. DOIs for additional items, including DORIS data and products, are under development and review prior to registering and implementation.

The CDDIS continues to review and update its ingest procedures to both decrease latency of file delivery to the public archive and to continually improve quality control checks to all incoming data and products. In addition, CDDIS has made its archive fully available through https.

In response to increased Information Technology (IT) security requirements from both the U.S. Government and NASA, CDDIS was forced to remove unencrypted anonymous ftp access to its archive in the fall of 2020 and in its place put in encrypted ftp or what is commonly called ftp over SSL/TLS. The entire archive with the same directory structure is available using ftp-ssl at gdc.cddis.eosdis.nasa.gov.

7.1.5 CONTACT

Taylor Yates, Software Engineer
SSAI, INC
NASA GSFC
Code 61A
Greenbelt, MD 20771
USA

Email: Taylor.A.Yates@nasa.gov

WWW: https://cddis.nasa.gov
Archive access: ftps://gdc.cddis.eosdis.nasa.gov/doris
https://cddis.nasa.gov/archive/doris
Technical support: support-cddis@earthdata.nasa.gov

7.2 IGN DORIS DATA CENTER

Jérôme Saunier / IGN, France

The IGN Data Center hosts and distributes data from the following international services: EUREF, SONEL, IGS, and IDS. The IGN Data Center has been operational since 2006. Today the IGN Data Center serves as:

- IGS Global Data Center: igs.ign.fr
- IGS Terrestrial Frame Combination Center: webigs-rf.ign.fr
- **IDS Data Center**: doris.ign.fr
- EUREF Permanent GNSS Network Local Data Center: rgpdata.ign.fr
- REGINA Data Center
- SONEL Data Center

7.2.1 ARCHITECTURE AND DATA ACCESS

The IGN Data Center offers:

- FTP deposit server for data and analysis centers uploads, requiring special authentication
- Free FTP anonymous access to observations data and products
- Internet link: ftp://doris.ign.fr

An identical infrastructure and configuration had been set up at ENSG (IGN School) to ensure continuity of service thanks to independent access (ftp://doris.ensg.eu) but this backup site is currently experiencing maintenance difficulties.

7.2.2 OPERATIONAL ACTIVITIES

The IGN Data Center stores about 150 Go for DORIS and the IDS, including data, products, metadata and information. In 2023, regarding the IDS section, the number of visits to the data center is stable compared to last year, reaching 5829 visits, with 562 Go (1 431 252 files) of DORIS data downloaded by the users.

The data center operated normally throughout the year with continuous service and very little maintenance for full availability of new IDS data and products.

The interface with the IDS Central Bureau, Combination Center and Analysis Centers enabled reliable provision of data and products. The CNES tool scanning the whole tree structure checked the SSALTO data deliveries (orbits, RINEX, quaternions) regularly to detect missing files and anomalies, and remedial actions were carried out forthwith.

7.2.3 MAINTENANCE AND DEVELOPMENT

The delivery of Near-Real-Time DORIS data and products was implemented at the beginning of 2021 at IGN Data Center: Jason-3 RINEX data and Diode orbits are distributed with a latency of about 2-3 hours. This enables contributing to the ultra-rapid ionosphere VTEC modeling. More NRT DORIS Data from other missions with different orbits (altitude, inclination) should be implemented within the next two years as requested by the IDS WG "NRT DORIS Data".

The DORIS data from the new satellite SWOT was implemented in the third quarter of the year.

Regarding hardware enhancement, the IGN Data Center planned the separation of servers' infrastructure between GNSS data and DORIS data to have full projects independence and avoid mutual interferences.

7.2.4 CONTACT

For technical support, please use our generic email address: ids.data.center@ign.fr

ANALYSIS ACTIVITIES

8 ANALYSIS COORDINATION

Petr Štěpánek / Geodetic Observatory Pecný, VÚGTK, Czech Republic

8.1 INTRODUCTION

This section summarizes the activities of all the DORIS Analysis Working Group (AWG) in 2023 and report status of IDS analytical and associated analytical centers. Two Analysis Working Group meetings were held in 2023. One Analysis Working Group meeting was held online on 18th April. A hybrid meeting with most of participant onsite followed on 28th and 29th November in Saint Mande (France).

8.2 ANALYSIS WORKING GROUP MEETINGS

AWG meeting on 18 April 2023

22 participants from 9 countries attended the virtual AWG meeting on April 18, 2023. The meeting started by welcoming the participants. Then 11 presentations followed, and the meeting was closed by discussions. This meeting was devoted to the data analysis and investigation of the ACs and AACs and most of the presentations were ACs, AACs and combination center status reports. SWOT news was presented by the CNES POD Team. Other topics included CryoSat-2 orbit determination and CNES/GRGS time variable gravity field models.

Presentations from the AWG meeting are available on the IDS website at

https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-04-2023.html

AWG meeting on 28-29 November 2023

21 onsite and 14 online participants from 9 countries attended the hybrid meeting on November 28-29 in Saint Mandé. 23 presentations were divided into two sessions. Session I "IDS, DORIS System and IDS centers reports" started with IDS news, DORIS System News, DORIS system status and outlook. Reports and statuses of Analysis centers, Associated analysis centers, combination center and data center. Session II "POD and other DORIS applications" includes POD presentations focusing on Jason-3, CryoSat-2 and Sentinel satellites and a study analyzing impact of 2-per-rev harmonics. The ionosphere was another topic. Other presentations were devoted to the concept of DORIS on Galileo and the monthly gravity generation field using DORIS and SLR.

Presentations from the AWG meeting are available on the IDS website at

https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-11-2023.html

8.3 ANALYSIS CENTERS AND COMBINATION CENTER

The IDS covers six Analysis Centers (AC) and four Associate Analysis Centers (AAC) who use eight different software packages, as summarized in **Table 8**. Some analysis centers perform POD analyses of DORIS satellites on a routine basis using other geodetic techniques (SLR and GNSS).

Four ACs fully participate in operational solutions (ESA, GSC, GRG, GOP). The IGN center has been restarted routine solution delivery after the retirement of its long-time responsible Pascal Willis and its representatives are active and working on a return to operational status. The INA center has problems with the new software package development. The Associate Analysis centers (AACs) GFZ and DGFI-TUM are active in specific DORIS tasks, while evaluation process to update GFZ from AAC to AC has been started. CNES AAC continues with the POD solutions, including new satellite SWOT.
The combination center (CC) provides routine weekly IDS SINEX series each 3 months and analyses special campaigns. In 2023 a processing of data 2020.0-2023.0 has been performed to generate a DORIS contribution to ITRF2020 extension.

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	Samuel Nahmani Arnaud Pollet	GIPSY	
INA (Inasan)	AC	Russia	Sergei Kuzin	GIPSY/own development	
CNES	AAC	France	Alexandre Couhert	Zoom	SLR, GNSS
GFZ	AAC	Germany	Patrick Schreiner	EPOS-OC	SLR, GNSS
TU Delft	AAC	Netherlands	Ernst Schrama	GEODYN	SLR
DGFI-TUM	AAC	Germany	Mathis Bloßfeld Sergei Rudenko	DOGS	SLR

***Table 8**. Summary of IDS Analysis Centers (AC) and Associate Analysis Centers (AAC).*

9 COMBINATION CENTER

Guilhem Moreaux / CLS, France

9.1 ACTIVITY SUMMARY

In addition to the routine evaluation and combination of the IDS AC solutions, 2023 was mostly devoted to the computation of the second version of the DORIS extension of the ITRF2020 for Precise Orbit Determination (DPOD2020). The CC also performed some analysis on single satellite solutions.

9.2 IDS ROUTINE EVALUATION AND COMBINATION

At the end of 2023, the time span of the SINEX files of the IDS combined solution was 1993.0-2023.5. They correspond to the IDS series 19 and 20 (since 2021.0), extension of the IDS contribution to the ITRF2020 (IDS 16). IDS 20 differs from IDS 19 by the addition of the ESA 15/16 weekly solution.

9.3 DORIS STATION RANKING FROM POSITION RESIDUALS

From the position and velocity cumulative solution based on the IDS 20 series between 1993.0 and 2023.0, the IDS CC estimated the annual ranking of the DORIS stations from the position residuals (differences between the observations and the linear model). If all the technical and geophysical position and/or velocity discontinuities were identified and taken into account during the stacking process, the station position residuals may reflect the quality of the observations.

From **Figure 11**, which displays the 2022 3D RMS of the position residuals, we can easily see that while the largest RMS are associated with sites (Arequipa, Ascension, Cachoeira, Kourou, Le Lamentin, San Juan, St-Helena, Tristan Da Cunha) located in the area of the South Atlantic Anomaly, the smallest RMS are for sites are located closed to the North and South pole regions: Belgrano, Ny-Ålesund II, Rothera, Syowa. This observation is more visible on the map of the 3D RMS of the station position residuals depicted by **Figure 12**. Furthermore, we noticed large RMS values for the sites of Socorro Island, Futuna and Papeete. Looking at the time evolution of the East, North and Up RMS station position residuals, we observed that the residuals of Socorro Island were dominated by the East component and that the East residuals were increasing since 2021. Even if a M6.0 earthquake at 409 km from Socorro was reported on 2021/12/22, no impact was observed on the coordinate time series. In the case of Futuna, the time evolution of the 3D RMS of the station position residuals showed that the large value for 2022 was mainly due to the up-component and that the 2022 RMS of the up residuals were about two times larger than the 2019 ones. Note that a new station FUUC was installed in 2022/09/16 so we only had ten weeks of observations for FUUC in 2022. No position residual was obtained for 2020 and 2021 due to a data gap for FUUB between late 2019 and mid-2022. Even if the site of Papeete is still one with largest residuals, we observe a decrease in 2022 (mainly in the East direction) while neither a technical nor a geophysical event was reported for that site over the last two years.

Unfortunately, so far, we were not able to point out any reason which could explain the large values of the last three sites (Socorro, Futuna and Papeete). However, the extension of such a study over the 2023 ranking will tell us if these patterns are still observable.

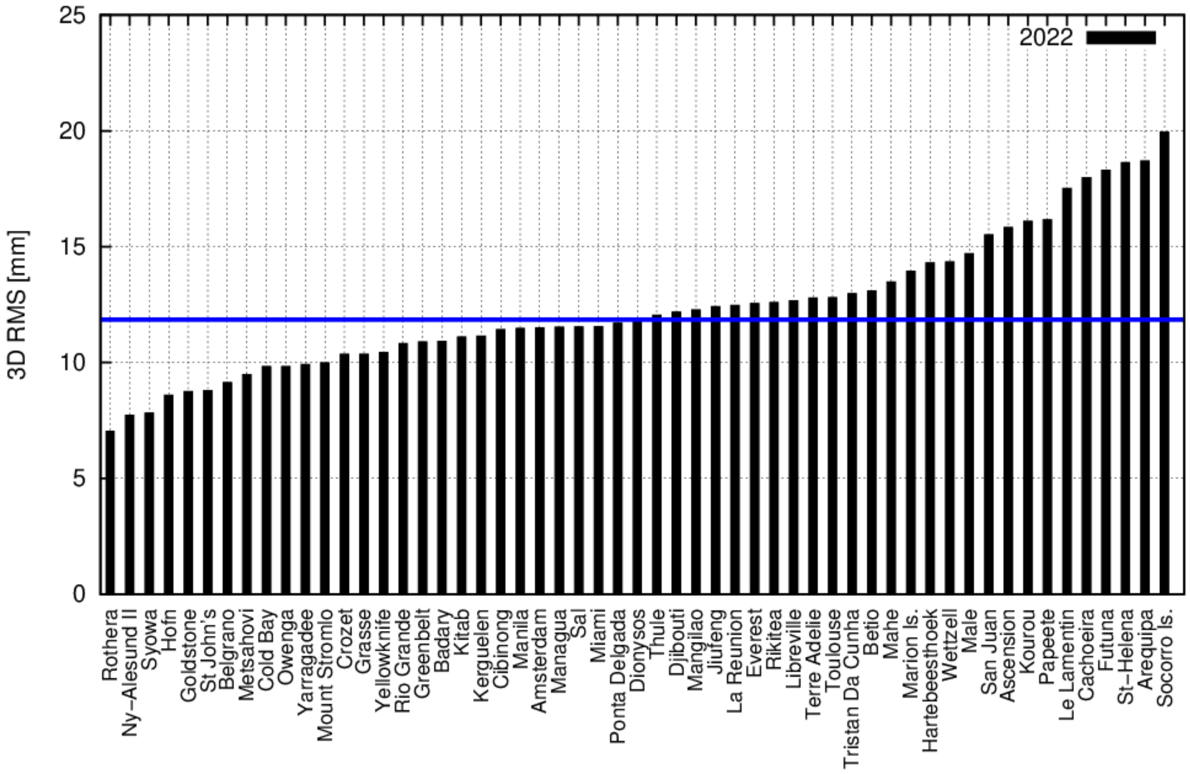


Figure 11. *2022 ranking of the DORIS stations from the 3D RMS of the weekly station position residuals. Blue horizontal line indicates the median value (12.06 mm).*

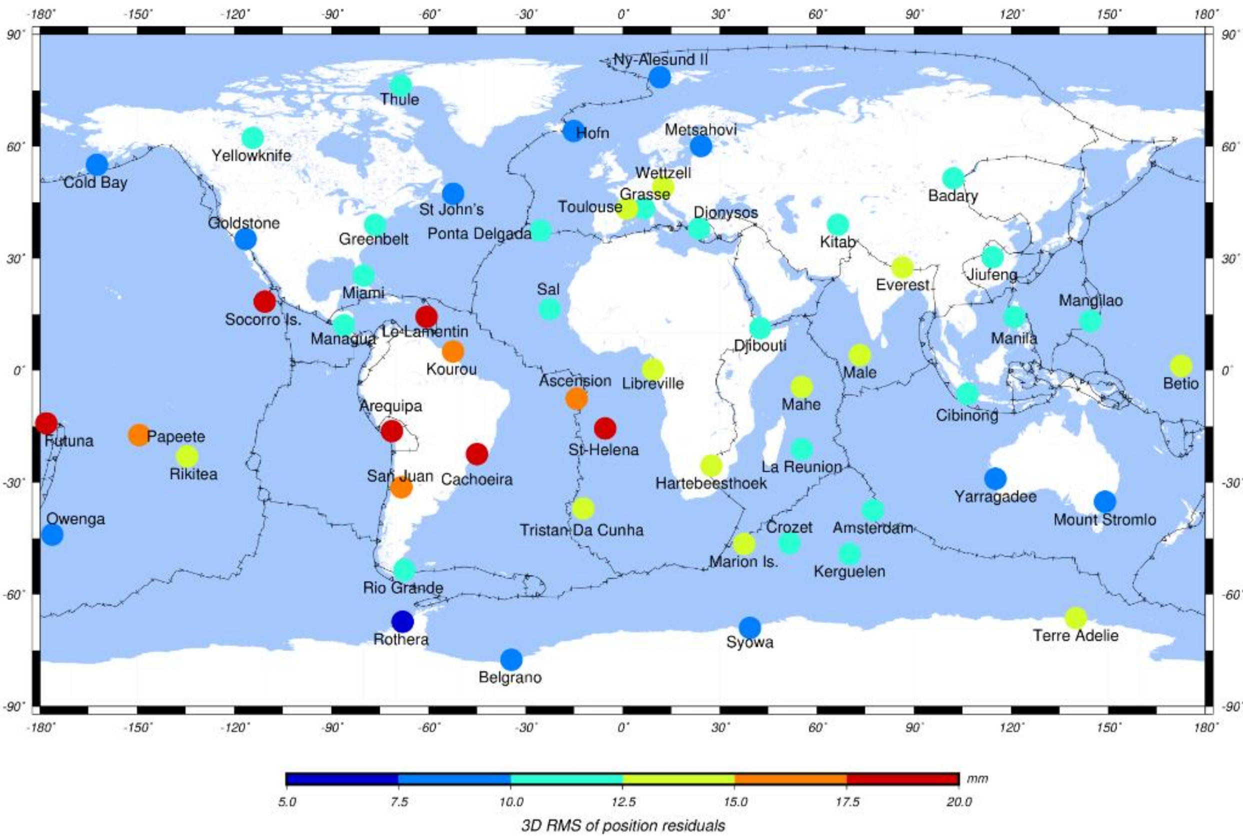


Figure 12. *3D RMS of the DORIS station position residuals for 2022.*

9.4 COORDINATE TIME SERIES OF STATIONS IN THE SOUTH ATLANTIC ANOMALY

In line with delivery early 2022 by the IDS AC GRG and GSC of two combined solutions including a SAA (South Atlantic Anomaly) mitigation strategy for the HY-2A mission, the IDS CC decided to revisit from the beginning of HY-2A in October 2011, the time evolution of the coordinate series of the DORIS stations located in the SAA region: Arequipa, Cachoeira, Hartebeesthoek, Kourou, Le Lamentin, Libreville, Saint-Hélène et Tristan Da Cunha.

The analysis of the coordinate time series (aligned on DPOD2014 v5.7) showed that:

- the GRG and GSC multi-satellite solutions including the HY-2A SAA mitigation strategies drastically reduced the impact of the end of that mission on the time series (see case of Arequipa for GRG on **Figure 13**);
- the coordinate time series of Cachoeira depicts a jump while SPOT-5 ends at the end of 2015 (see case of Cachoeira for GRG on **Figure 14**) and whereas the IDS ACs use the SAA corrected data for that mission;
- the GSC coordinate time series of Arequipa and Cachoeira display position discontinuities while Jason-2 is not present in the multi-satellite solution (see case of Cachoeira for GSC on **Figure 15**).

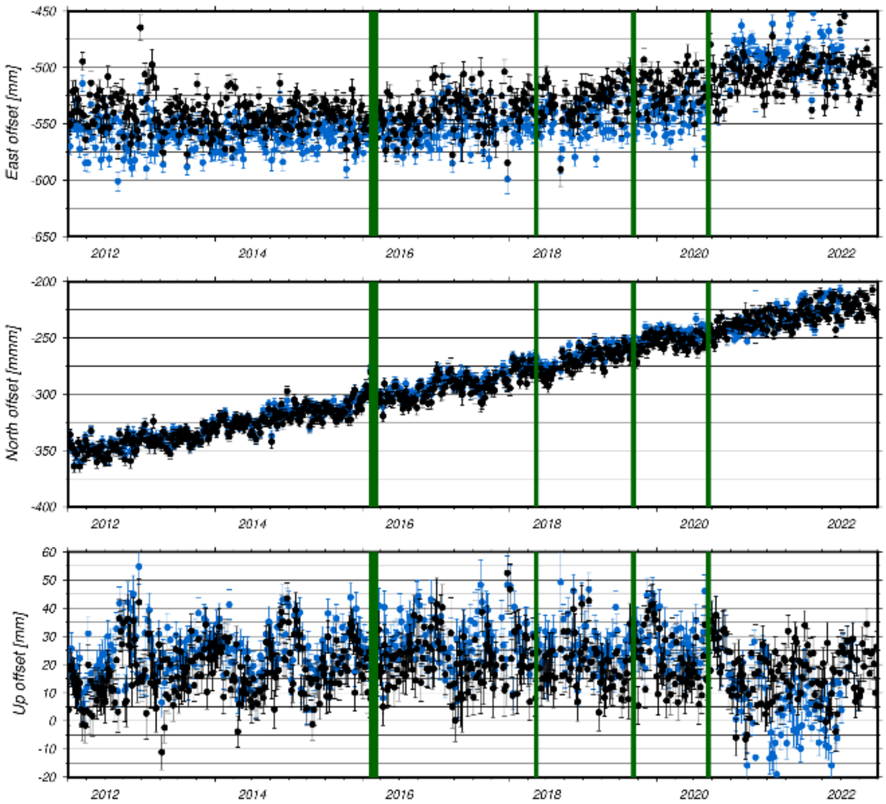


Figure 13. *Coordinate time series of Arequipa from the GRG multi-satellite solutions with (black) and without (blue) the HY-2A SAA mitigation strategy.*

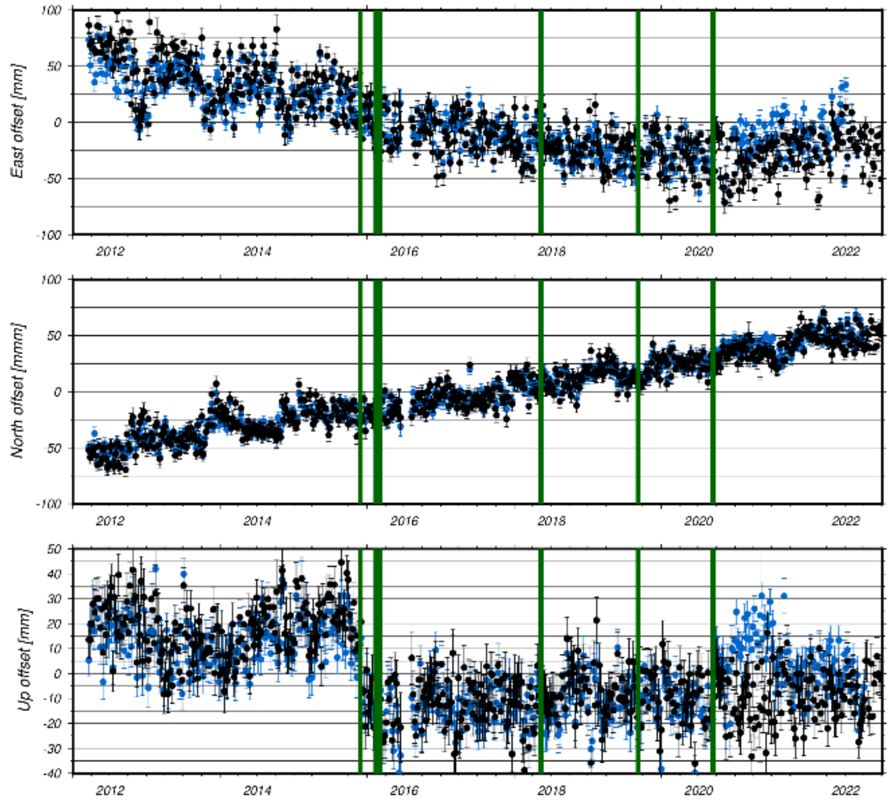


Figure 14. *Coordinate time series of Cachoeira (CADB) from the GRG multi-satellite solutions with (black) and without (blue) the HY-2A SAA mitigation strategy.*

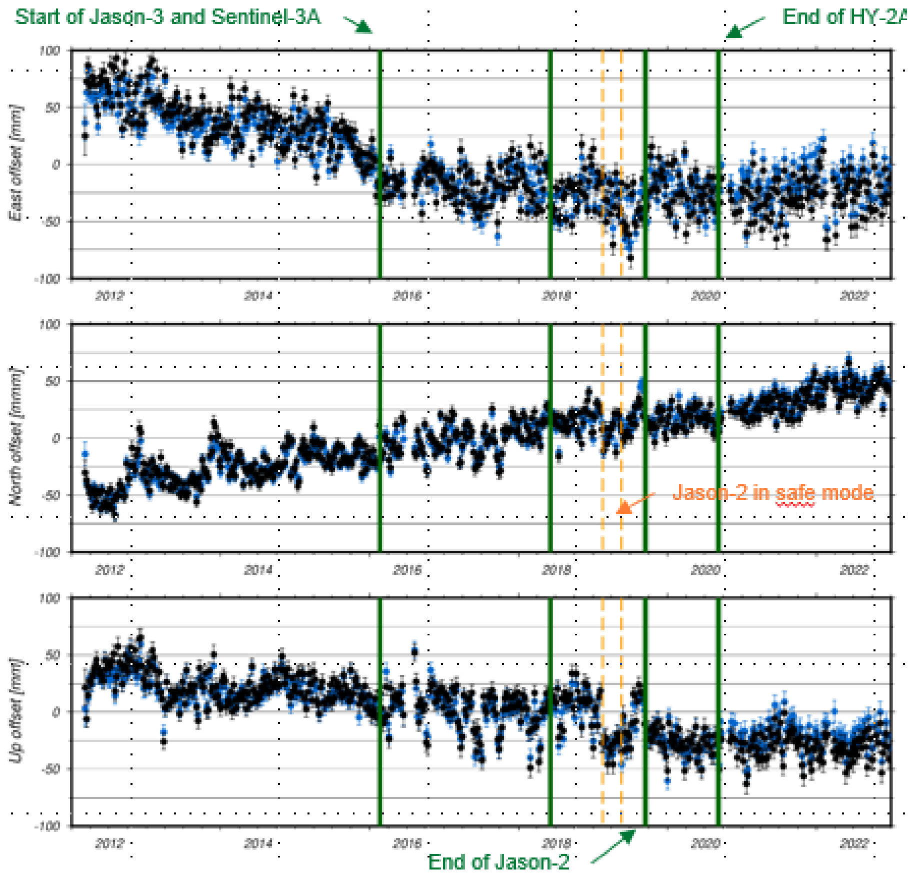


Figure 15. *Coordinate time series of Cachoeira (CADB) from the GSC multi-satellite solutions with (black) and without (blue) the HY-2A SAA mitigation strategy.*

9.5 DORIS EVALUATION OF THE ITRF2020 AND DTRF2020 SOLUTIONS

Once the DTRF2020 solution has been released by the DGFI, the IDS CC realized a comparative study between the DORIS versions of DTRF2020 and ITRF2020 (from IGN).

We started the analysis by looking at the DORIS stations and sites included in both solutions according to the SITE/ID blocks of the SINEX files. Thus, we noticed that while ITRF2020 includes 201 stations at 87 sites, DGFI2020 gives access to mean positions and velocities of 192 stations at 78 sites (see **Figure 16**). The differences are explained by the fact that, in contrary to IGN, DGFI rejected the DORIS stations located at sites with less than 2.5 years of observation: Ajaccio, Flores, Huahine, Iquique, Lifou, Ny-Ålesund II, Paramushir, San Juan and Tana.

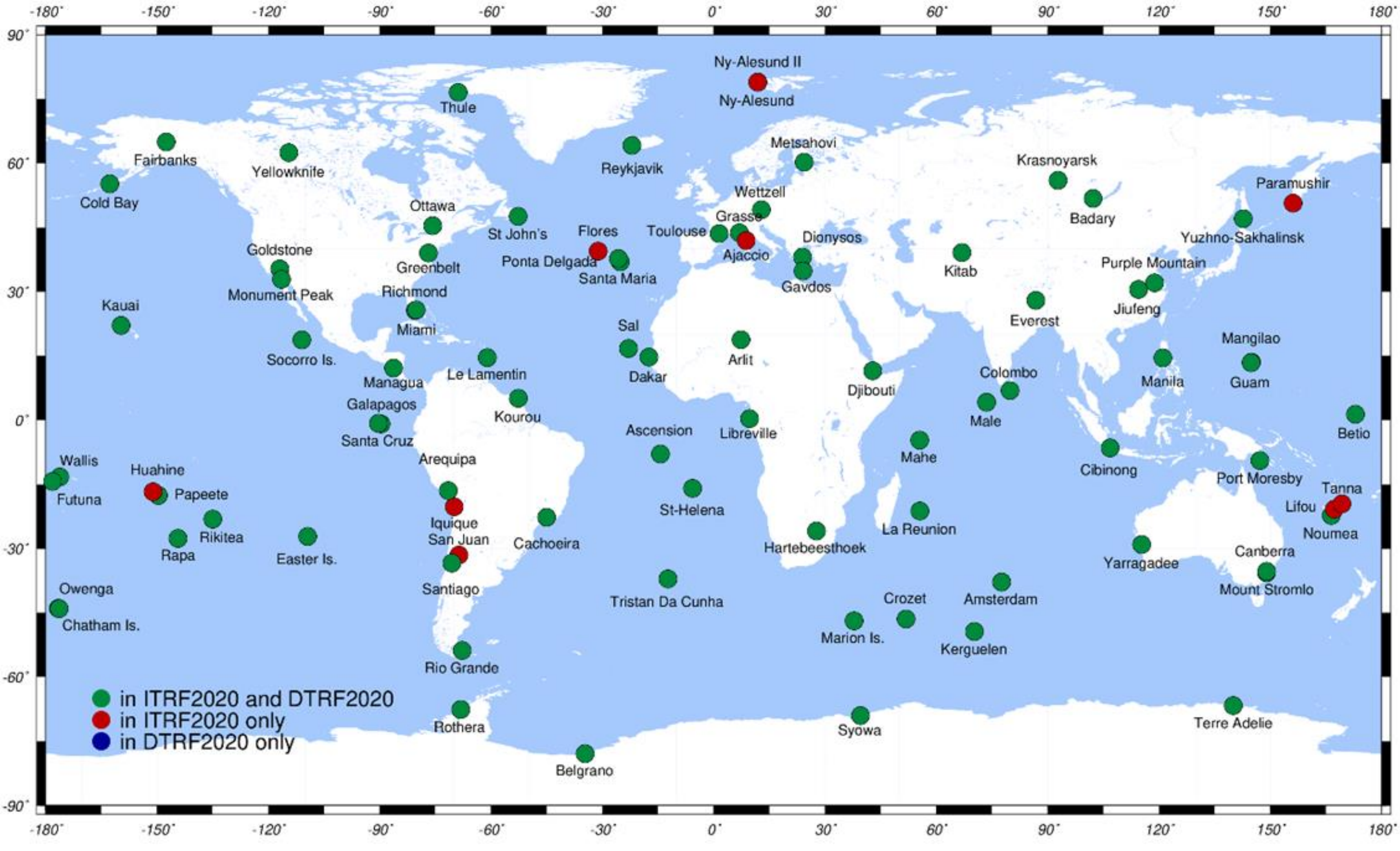


Figure 16. DORIS network of the DTRF2020 and ITRF2020 solutions. Green: sites in both DTRF2020 and ITRF2020; Red: sites in ITRF2020 only; Blue: sites in DTRF2020 only.

Furthermore, we noticed that DGFI did not provide mean positions and velocities for twelve-time segments associated with nine stations (Arequipa, Ascension, Colombo, Easter-Island, Everest, Goldstone, Krasnoyarsk, Ny-Ålesund and Santiago) while these time segments are listed in the SOLUTION/EPOCHS block of the DTRF2020 SINEX file.

Then, we computed the scale and translation Helmert parameters of the IDS 20 weekly combined series (time extension of the IDS contribution to the ITRF2020) with respect to both ITRF2020 and DTRF2020 from 1993.0 to 2022.75. For both TRF2020 solutions, we included post-seismic deformation corrections and no seasonal correction. From **Table 9** and **Figure 17**, we first observe scale differences between DTRF2020 and ITRF2020. These differences must be explained by differences in the definition of the DPOD2020 and ITRF2020 scale: while the DTRF2020 scale is based on the VLBI and GNSS techniques, the ITRF2020 one is obtained from the VLBI (up to 2013.75) and SLR (since 1997.7) techniques. We also observe larger trends of the scale and X-translation differences of IDS 20 wrt DTRF2020 than IDS 20 wrt ITRF2020 up to 2005.0. Since the origins of both DTRF2020 and ITRF2020 are based on the SLR solution, we suppose that these differences in scale and Tx may be related to handling of the DORIS stations equipped with Alcatel antennas. With both DTRF2020 and ITRF2020 we can see higher amplitudes of the 118-day (1st draconitic of Jason satellites) on the z-translation after early 2016 while Jason-3 was included in the multi-satellite solutions.

	Time period	DTRF2020	ITRF2020
Scale	1993.0-2002.5	-3.17 ± 3.90 (0.51)	5.43 ± 3.85 (-0.21)
	2002.5-2008.5	0.69 ± 1.72 (0.27)	6.87 ± 1.75 (0.43)
	2008.5-2022.75	2.15 ± 1.58 (0.25)	8.22 ± 1.73 (0.26)
Tx	1993.0-2002.5	2.01 ± 4.42 (-0.58)	-3.58 ± 4.41 (0.08)
	2002.5-2008.5	-1.00 ± 3.01 (-0.06)	-3.16 ± 3.03 (0.09)
	2008.5-2022.75	-1.85 ± 2.24 (0.18)	-3.20 ± 2.55 (0.26)
Ty	1993.0-2002.5	-4.47 ± 4.71 (-0.67)	-1.86 ± 4.72 (-0.28)
	2002.5-2008.5	-4.00 ± 3.47 (0.93)	1.10 ± 3.57 (0.92)
	2008.5-2022.75	-2.41 ± 2.72 (0.44)	1.07 ± 2.92 (0.27)
Tz	1993.0-2002.5	-5.83 ± 21.81 (2.82)	0.17 ± 21.80 (2.67)
	2002.5-2008.5	-21.85 ± 12.39 (-3.75)	-17.42 ± 12.31 (-3.78)
	2008.5-2022.75	-5.87 ± 9.19 (1.58)	-2.45 ± 9.20 (1.48)

Table 9. *Main statistics (mean and std in mm, trend -into brackets- in mm/yr) of the scale and translation Helmert parameters of the IDS 20 series with respect to ITRF2020 (red) and DTRF2020 (blue) from 1993.0 to 2022.75.*

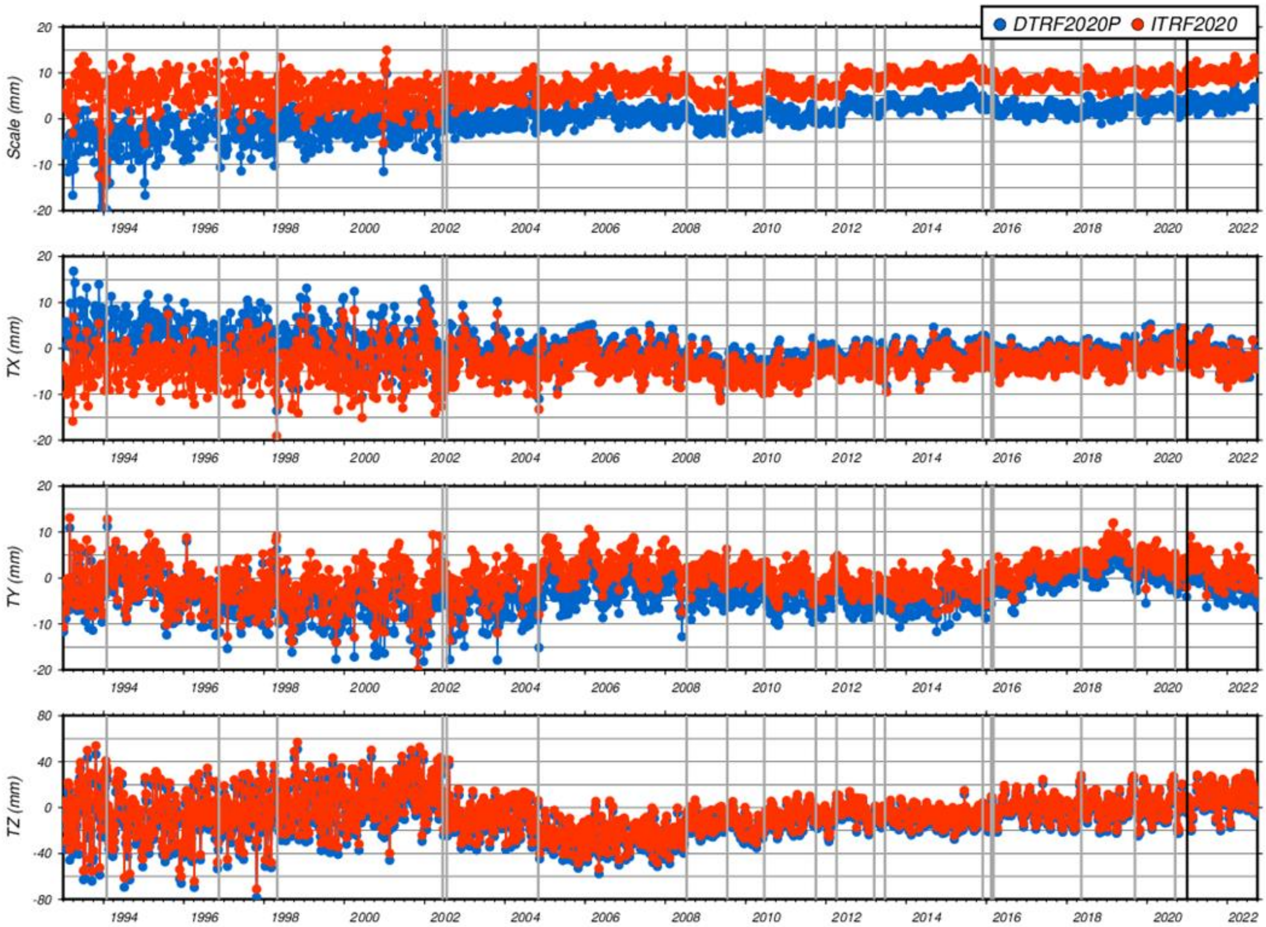


Figure 17. *Scale and translation Helmert parameters of the IDS 20 series with respect to ITRF2020 (red) and DTRF2020 (blue) from 1993.0 to 2022.75.*

Last but not least, the IDS CC estimated the station position residuals of the IDS 20 series with respect to both DTRF2020 and ITRF2020 from 1993.0 to 2022.75. Let us remind you that for both TRF2020 solutions, we included post-seismic deformation corrections and no seasonal correction. From both **Figure 18** and **Table 10**, we almost observe no significant differences between the results with the two TRF2020 solutions. As usual, we clearly see the impact of the time evolution of the DORIS constellation and the impact of the generation of DORIS receiver (i.e. impact of total number of stations simultaneously received onboard: 1993.0-2002.5, 2002.5-2008.5, post-2008.5). We also observe a slight degradation of the residuals in the three directions after 2021.0. This degradation may be explained by the time aging of both DTF2020 and ITRF2020 due to the time evolution of the DORIS network.

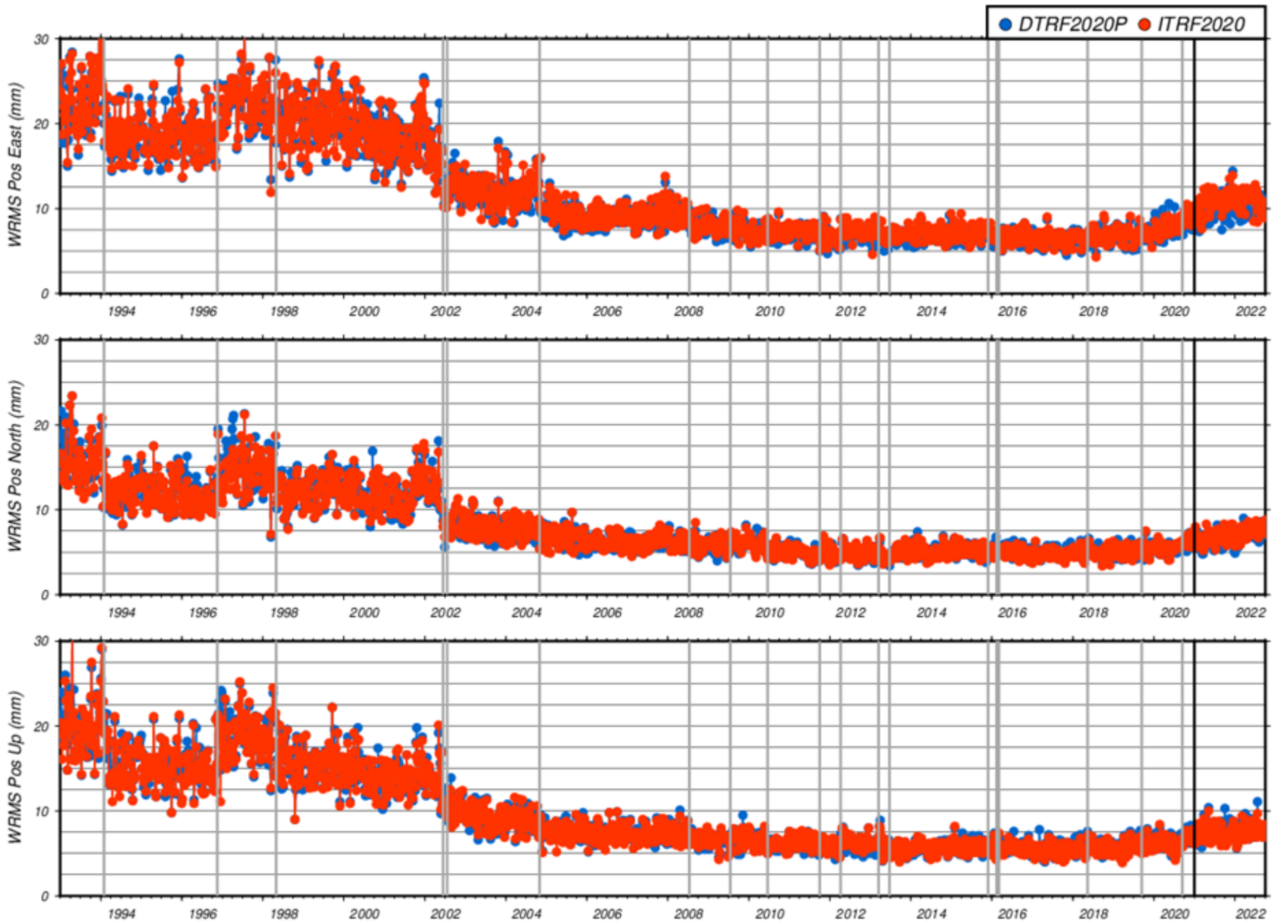


Figure 18. *Weighted RMS of the station position residuals of the IDS 20 series with respect to ITRF2020 (red) and DTRF2020 (blue) from 1993.0 to 2022.75.*

	Time period	DTRF2020	ITRF2020
East	1993.0-2002.5	19.88 ± 3.29	19.94 ± 3.37
	2002.5-2008.5	10.35± 2.00	10.46 ± 1.95
	2008.5-2021.0	6.95 ± 0.97	7.20 ± 0.96
	2021.0-2022.75	10.09 ± 1.25	10.81 ± 1.19
North	1993.0-2002.5	13.06 ± 2.68	12.81 ± 2.49
	2002.5-2008.5	6.97 ± 1.32	7.02 ± 1.31
	2008.5-2021.0	5.24 ± 0.75	5.22 ± 0.77
	2021.0-2022.75	6.68 ± 0.90	7.09 ± 0.87
Up	1993.0-2002.5	16.28 ± 3.31	16.11 ± 3.21
	2002.5-2008.5	8.25 ± 1.46	8.17 ± 1.47
	2008.5-2021.0	6.00 ± 0.82	5.98 ± 0.82
	2021.0-2022.75	7.80 ± 1.02	7.56 ± 0.92

Table 10. *Main statistics (mean and std in mm) of the weighted RMS of the station position residuals of the IDS 20 series with respect to ITRF2020 (red) and DTRF2020 (blue) from 1993.0 to 2022.75.*

9.6 DPOD2020 VERSION 2.0

After the first version elaborated in 2022, the IDS CC initialized mid-2023 the realization of the second version of the DPDO2020. In addition to the extension of the time span (1993.0-2023.0), that second version differs from the first one by the estimation of periodic (annual, semi-annual, first two draconitics of Jason satellites) signals and by the computation of DORIS-only post-seismic deformation corrections for the first DORIS station at Socorro Island (SODA).

The elaboration of DPOD2020 v2.0 started with the computation of a DORIS station position and velocity cumulative solution (aligned to the ITRF2020) from the IDS 19/20 series over the time span 1993.0-2023.0. In overall, from 1993.0 to 2023.0, as depicted by **Figure 19**, the DORIS ground network includes 216 stations at 89 sites. Since the end of ITRF2020 time span, i.e. 2021.0, 14 stations and 2 sites were introduced in the DORIS ground network.

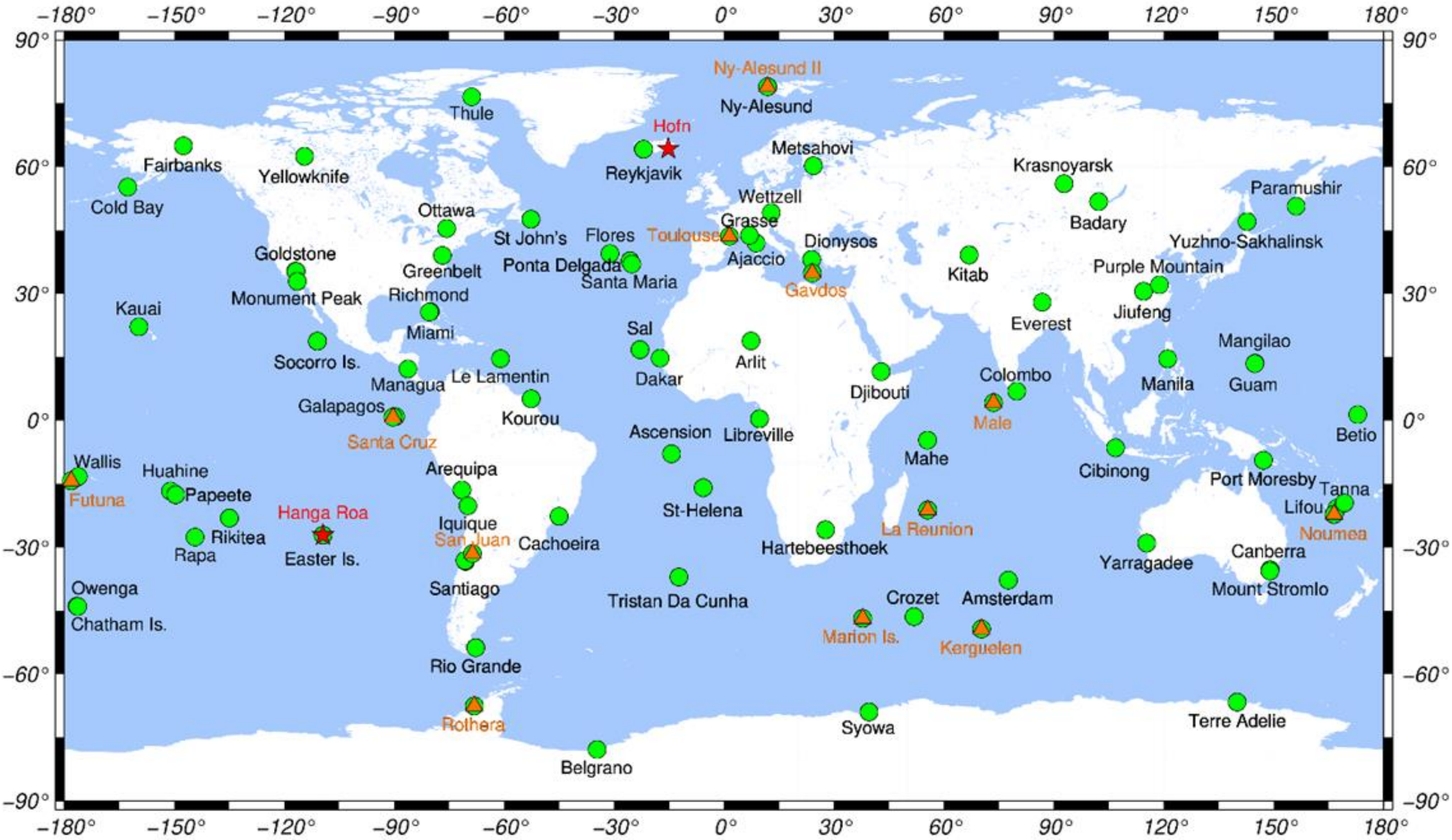


__Figure 19.__ DPOD2020 version 2.0 ground network. Green: sites with no new station since ITRF2020. Orange: sites with new station(s) since ITRF2020. Red: new sites since iTRF2020.

As usual, the discontinuity and velocity constraints were deduced from the analysis of the coordinate time series of all the DORIS stations over the entire time span. The velocity constraints consist in forcing the nearby stations or multiple segments of the same station to have the same velocity unless a velocity discontinuity was observed (e.g. due to an earthquake). On the model of the ITRF2020, we introduced constraints on the frequency coefficients to get a unique couple (cosine and sinus) of coefficients by DORIS site (i.e. all the time segments of all the stations at one site have the same coefficients). Periodic signals were only estimated for sites with more than 2.5 years of observation. Such constraints on the periodic signals follow the assumption that the physical and geophysical processes are locally time invariant. In addition to the above-mentioned velocity and frequency constraints, the DORIS-to-DORIS surveyed ties were used as constraints in the stacking of the IDS weekly solutions. From the analysis of the IDS 19/20 coordinate time series, we ended up with 112 discontinuities at 44 of the 89 DORIS sites between 1993.0 and 2023.0 (see **Figure 20**). Note that nearly half (55) of these discontinuities have a seismic or a geophysical origin, 21 are associated with technical events (such as an antenna change, beacon or USO change), while nearly one-third (36) have an unknown origin.

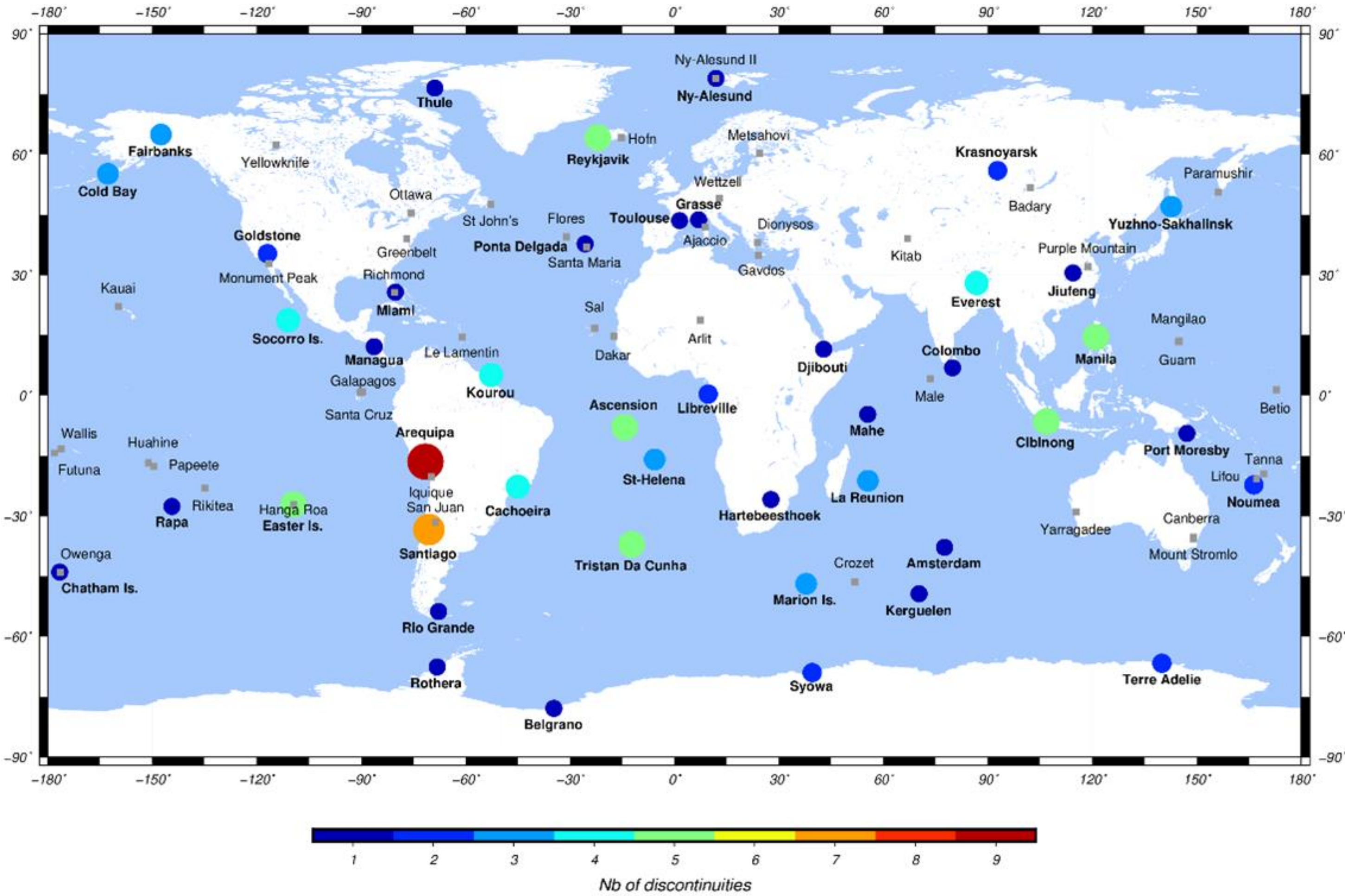


Figure 20. *Total number of discontinuities for all the DORIS sites included in DPOD2020 version 2.0. Grey squares indicate sites with no discontinuity.*

As early mentioned, that second version of the DPOD2020 is associated with DORIS-only post-seismic corrections for the SODA station at Socorro Island. According to Siebe et al. (1995), a submarine eruption happened on 1993/01/29 at 4 km from Socorro Island. That eruption may explain the non-linear motion we observe on the North, East and Up coordinate time series of SODA from the IDS 19 weekly solutions aligned on ITRF2020 (see blue points on **Figure 21**). Then, the IDS CC estimated correction terms which added to the classical linear motion would give better approximation of the IDS 19 weekly estimations. These so-called post-seismic deformation corrections were obtained by exponential and logarithmic functions. The SODA post-seismic deformation corrections are delivered as XYZ corrections to be added to the linear model expressed in the DPDO2020 version 2 SINEX file and are stored in a text ASCII file.

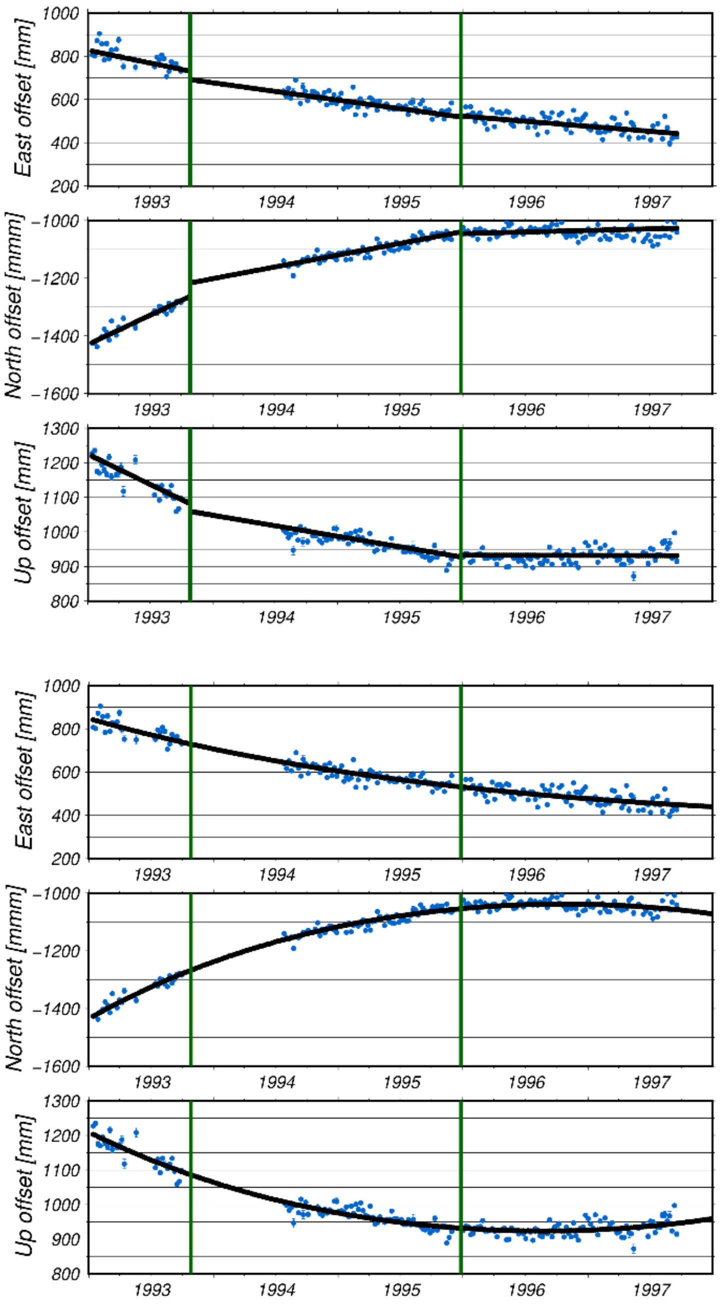


Figure 21. *Coordinate time series of the DORIS station SODA at Socorro Island. Top: IDS 19 series in blue and linear model in black. Bottom: IDS 19 series in blue and linear model with post-seismic corrections in black.*

Then, we started the validation of the second version of the DPOD2020 by computing the weekly coordinate differences with ITRF2020 (including PSD and seasonal corrections), DPOD2020 v1.0 and a version of the DPOD2020 v2 without estimation of the periodic corrections (denoted v2.X) from 1993.0 to 2023.0. As indicated in **Table 11**, the median values of the 3D weekly differences between DPOD2020 v2.0 and either DPOD2020 v1.0, DPOD2020 v2.X and ITRF2020 are smaller than five millimeters. Furthermore, as expected, the largest differences occur at sites with either strong annual and semi-annual corrections in DPOD2020 v2.0 (Canberra), or very short time span (Iquique, Paramushir), or differences in the discontinuities (Marion Island). We also observed large differences between DPOD2020 v2.0 and ITRF2020 for the SODA and CRQC stations at Socorro Island and Crozet respectively. For SODA, our investigations showed that the differences appear because ITRF2020, contrary to DPOD2020, imposes the same velocity over all the time segments of all the stations at Socorro Island, even if DPOD2020 v2.0 and ITRF2020 share the same discontinuity dates. For CRQC, we noticed that DPOD2020 v2.0 gives a smaller DORIS-to-DORIS tie residual (differences between the estimated and measured tie vectors) for CRQC-CRQB than ITRF2020: 4.1 mm vs 28.5 mm.

Then, the IDS CC estimated the DORIS-to-DORIS tie vector residuals (i.e. differences between the estimated and measured ties) and compared them with the ones obtained with ITRF2020. From **Table 12**, we can see that the DPOD2020 version 2.0 and ITRF2020 give similar DORIS-to-DORIS tie residuals. In addition, we observed that eighty percent of the DORIS-to-DORIS tie residuals were smaller than 20 mm and that the largest residuals were associated with stations in the SAA region.

Precise Orbit Determination (POD) tests were also performed by the POD validation group (Frank Lemoine, Nikita Zelensky, Alexandre Couhert, John Moyard and Hugues Capdeville). Results of these POD tests are available in the AGU 2023 Fall meeting presentation given by the IDS CC.

Unit = mm	DPOD2020 v2.0 vs v2.X	DPOD2020 v2.0 vs ITRF2020	DPOD2020 v2.0 vs v1.0.
Maximum	31.8	65.1	125.9
Mean	3.4	4.4	5.5
STD	2.0	2.9	4.5
RMS	4.0	5.3	7.1
Median	3.0	3.8	4.4

Table 11. *Statistics of the weekly station coordinate differences between DPOD2020 v2.0 vs DPOD2020 v2.X, ITRF2020 and DPOD2020 v1.0.*

Unit = mm	DPDO2020 v2.0	ITRF2020
Number of ties	114	105
Number of sites	58	55
Maximum	46.18	49.16
Mean	13.77	13.49
STD	9.04	9.70
RMS	16.45	16.59
Median	11.58	11.36

Table 12. *Main statistics of the DORIS-to-DORIS tie residuals from DPOD2020 version 2.0 and ITRF2020.*

9.7 COMMUNICATIONS

In 2023, the IDS Combination Center joined the EGU where it had a poster titled "IDS evaluation of the DORIS versions of the DGFI and IGN TRF2020 solutions". The IDS CC also attended IUGG2023 and joined the AGU Fall meeting where it had an oral presentation on the second version of the DPOD2020 solution. Last but not least, the IDS CC contributed to the following paper as first author:

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

9.8 FUTURE PLANS

In 2024, in parallel to the routine delivery of the IDS weekly combined solution and its associated products (coordinate time series of the DORIS stations, EOP time series), the IDS Combination Center plans to work on the first update of the ITRF2020 as well as on the third version of the DPOD2020. In addition, the IDS CC will support the IDS ACs in improving the mitigation of the South Atlantic Anomaly on the new missions.

9.9 REFERENCES

Siebe C., J-C Komorowski, C. Navaro et al. (1995) Submarine eruption near Socorro Island, Mexico: Geochemistry and scanning electron microscopy studies of floating scoria and reticulite. *Journal Of Volcanology and Geothermal Research*, 68(4):239-271, DOI: 10.1016/0377-0273(95)00029-1

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

10 ANALYSIS CENTER OF THE GEODETIC OBSERVATORY PECNY (GOP)

Petr Štěpánek / Geodetic Observatory Pecný, Czech Republic

10.1 GENERAL DESCRIPTION

DORIS data have been routinely processed since day 270 of 2023. The standard of wd68 has been applied in operational solutions, differing from the previous standard wd67 by adding satellites Sentinel-6A, HY-2C and HY-2D. For Sentinel-6A, the measured attitude has been applied, for HY-2C/D satellites the nominal attitude model has been implemented. The South Atlantic Anomaly (SAA) mitigation strategy has been applied for satellites Jason-3, Sentinel-6A and HY-2C. As a major part of this strategy, some stations we used only for orbit determination for these satellites. This approach has been implemented by using satellite-specific alias names for the SAA stations.

10.2 ITRF2020 UPDATE REPROCESSING

Three years of data 2021.0-2024.0 were processed using standard wd68. Wd68 differs from wd67 using different time variable gravity field model, i.e., GRGS RL05 instead of EIGEN RL04. The usage of the time variable gravity field model generated from more recent data results in slight solution improvement. The post-fit observation residuals reduced only slightly, but for all observed DORIS satellites (**Table 13**). Improvement has been achieved also in the rotation pole estimation, with the reduction of Y-Pole bias and both X-pole and Y-pole RMS, demonstrated in **Table 14**.

Satellite	Residual reduction (%)
CryoSat-2	0.06
Saral	0.10
Jason-3	0.04
Sentinel-3A	0.04
Sentinel-3B	0.04
Sentinel-6A	0.08
HY-2C	0.03
HY-2D	0.09

Table 13. *Reduction of the post-fit observation residuals when applying GRGS RL05 gravity field model instead of EIGEN RL04.*

Gravity model	X-Pole Mean (µas)	X-Pole Std. dev. (µas)	Y-Pole Mean (µas)	Y-Pole Std. dev. (µas)
EIGEN RL04	-187	438	112	383
GRGS RL05	-179	417	61	375

Table 14. *Comparison of the estimated pole coordinates with IERS C04 model.*

10.3 COMPARISON OF WD67 AND WD69 SOLUTIONS

Figure 22 includes a comparison of the transformation parameters w.r.t. ITRF2020 for the GOP solutions wd67 and wd69. Wd69 includes satellites HY-2C/D and Sentinel-6A. These satellites are not included in the solution wd67. Also, the GRGS RL05 time variable gravity field model is applied in the wd69 solution, while the EIGEN RL04 is employed in the wd67 solution. The solution wd69 shows higher scale and better centered Ty values.

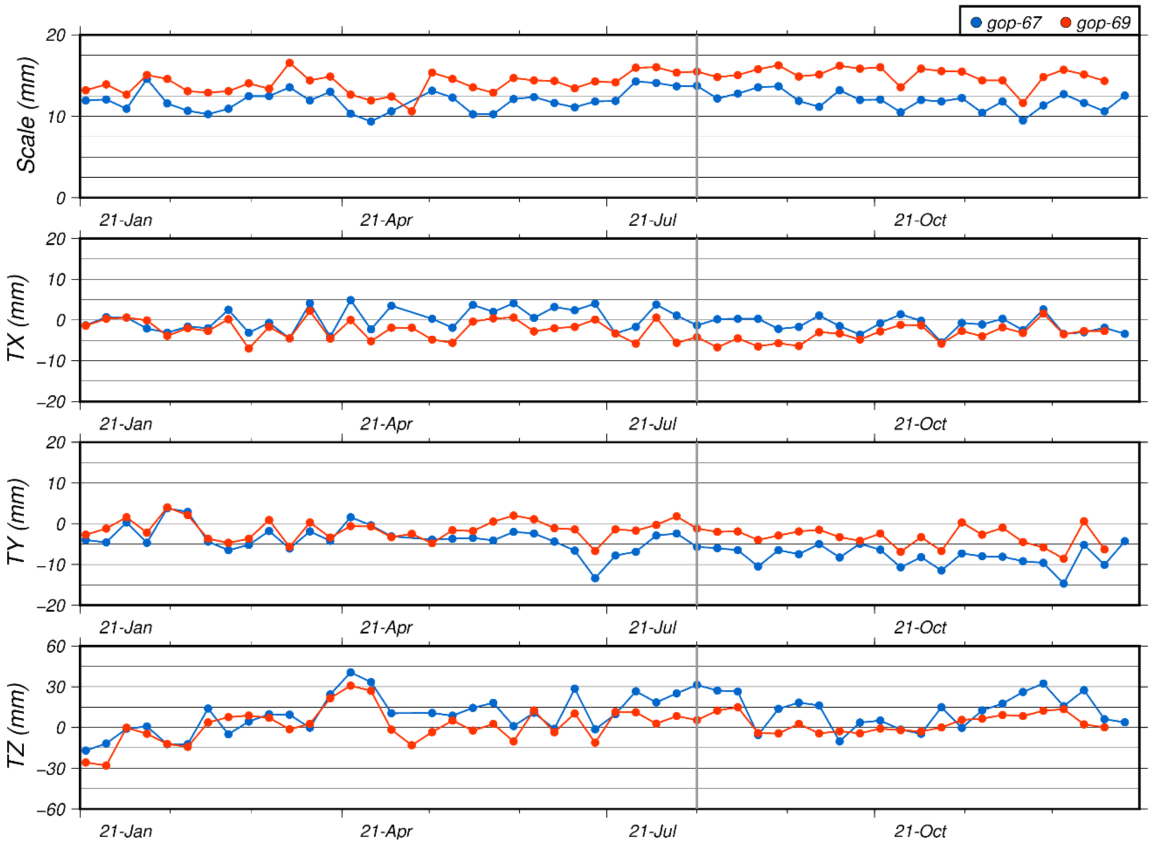


Figure 22. *Transformation parameters w.r.t. ITRF2020 for the GOP solutions wd67 and wd69. Figure by Guilhem Moreaux (IDS combination center)*

10.4 FUTURE PROSPECTS

- LOD estimation campaign using DORIS RINEX data
- Merge DORIS development version of Bernese software with new GNSS version
- Weekly single satellite solutions at routine level
- Project with Technical University Munich to extend our previous cooperation on DORIS USO behavior estimation by GNSS observation, profiting from unique architecture of Sentinel satellites (from October 2024)
- SWOT processing

11 CNES/CLS ANALYSIS CENTER (GRG)

Hugues Capdeville [(1)], Adrien Mezerette [(1)], Jean-Michel Lemoine [(2)]
[(1)] CLS, France / [(2)] CNES/GRGS, France

11.1 INTRODUCTION

The CNES and CLS participate jointly in the IDS as an Analysis Center. The processing of the DORIS data is performed using the GINS/DYNAMO software package developed by the GRGS. We continued the standard routine processing. We analyzed the DORIS data with 3.5-day arcs for the following satellites: CryoSat-2, Saral, Jason-3, Sentinel-3A, Sentinel-3B, Sentinel-6A, HY-2C and HY-2D. The AC also provides routinely the Sentinel orbits to the Sentinel Copernicus POD Quality Working Group (QWG). The main activities in 2023 were to consider the new GRGS Time Variable Gravity field in our DORIS data processing and to look at the impact of the increasing solar activity.

11.2 EVALUATION OF THE NEW GRGS TIME VARIABLE GRAVITY FIELD

Jean-Michel Lemoine (CNES) made available the new CNES GRGS model of the Earth's gravity field (CNES_GRGS.RL05MF_combined_GRACE_SLR_DORIS.DORIS) determined from DORIS, SLR, GRACE and GOCE data at: https://grace.obs-mip.fr/variable-models-grace-lageos/mean-fields/release-05/
DORIS data have been processed with GINS/DYNAMO software considering IERS conventions and IDS recommendations for ITRF2020. We used the previous release 4 (RL04) and the new release 5 (RL05). For the evaluation, DORIS data of TOPEX, Jason-2, CryoSat-2, Saral, Jason-3 and of Sentinel-6A are used. We thus cover the entire active period of the DORIS satellites from 1993 to the end of 2022.
First, the two releases are evaluated using the results of the POD. **Table 15** gives in the first column the means of DORIS RMS on overall of the processing period of the DORIS satellites. The DORIS RMS have the same values, we do not observe a significant impact on the DORIS residuals of the gravity field. We compare also our orbits to the CNES POD team orbit, POE-F. The last three columns give the means of the RMS of the orbit differences in the radial, cross-track and along-track component, in millimeter. The difference between POE-F orbit and our GRG orbit is determined with RL04 (left value) and with RL05 (right value). For the radial component, the agreement between GRG and POE-F orbit is better with the new gravity field for active missions, CryoSat-2, Saral, Jason-3 and Sentinel-6A. For cross-track, there is no significant impact. For along-track, the agreement is also better with the new gravity field RL05.
We also calculated the temporal evolution of the RMS and the mean of the orbit differences in radial component between GRG orbit and POE-F, and the mean of the RMS differences on the overall processing period of the geographically correlated radial differences.
For TOPEX, there is a good agreement between GRG and POE-F orbits but an East/West patch for radial geographical systematic differences vanishes with RL05.
For Jason-2, there is no significant impact of the gravity field. For Saral, the agreement between GRG and POE-F orbit is better with the new gravity field, the mean value is reduced by 1 mm (see **Figure 23**). As shown in **Figure 24**, an East/West patch for radial geographical systematic differences vanishes with RL05.

Satellite	Time period	DORIS RMS (mm/s) RL04 | RL05	GRG – POE-F RMS orbit difference (mm)		
			Radial RL04 | RL05	Cross-track RL04 | RL05	Along-track RL04 | RL05
TOPEX	1993/01 to 2004/10	0.477 | 0.477	12.6 | 12.3	78.1 | 77.1	48.2 | 46.1
Jason-2	2008/07 to 2016/04	0.322 | 0.322	7.64 | 7.45	18.7 | 18.6	23.4 | 22.4
CryoSat-2	2014/12 to 2022/12	0.361 | 0.361	6.74 | 6.32	14.2 | 14.2	16.3 | 16.1
Saral	2014/12 to 2022/12	0.342 | 0.342	7.07 | 5.96	13.3 | 13.3	17.7 | 15.2
Jason-3	2016/03 to 2022/12	0.364 | 0.364	7.72 | 7.03	26.3 | 26.4	25.2 | 22.7
Sentinel-6A	2020/12 to 2022/12	0.367 | 0.367	8.53 | 7.02	26.9 | 27.1	26.2 | 22.8

Table 15. *DORIS RMS of fit (mm/s) and comparison to external orbit POE-F.*

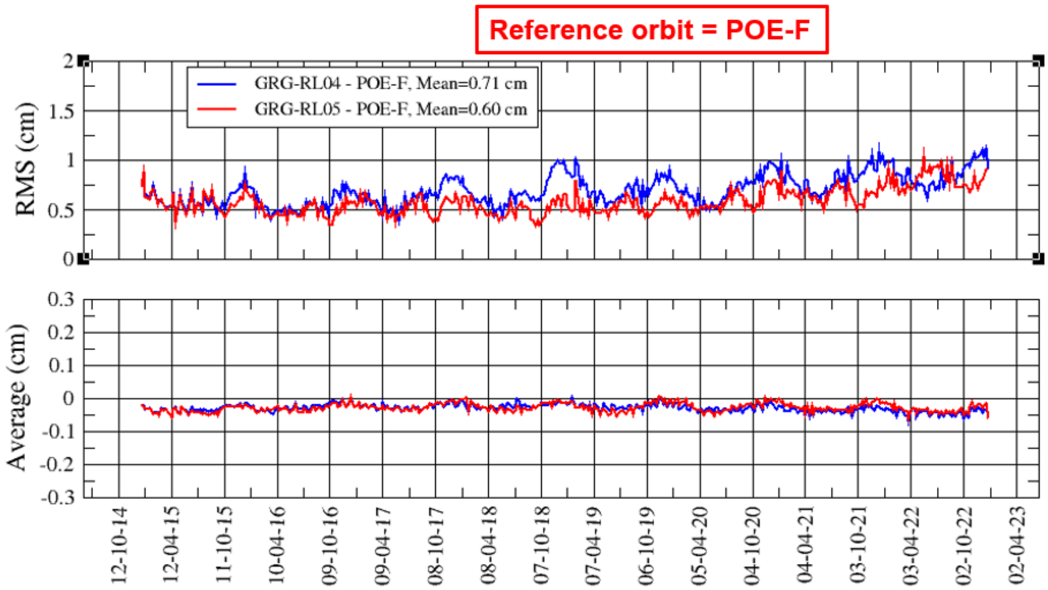


Figure 23. *Weekly RMS and Average Radial orbit differences (in cm) between GRG and POE-F orbits for Saral (in blue GRG orbit determined with RL04 and in red with RL05).*

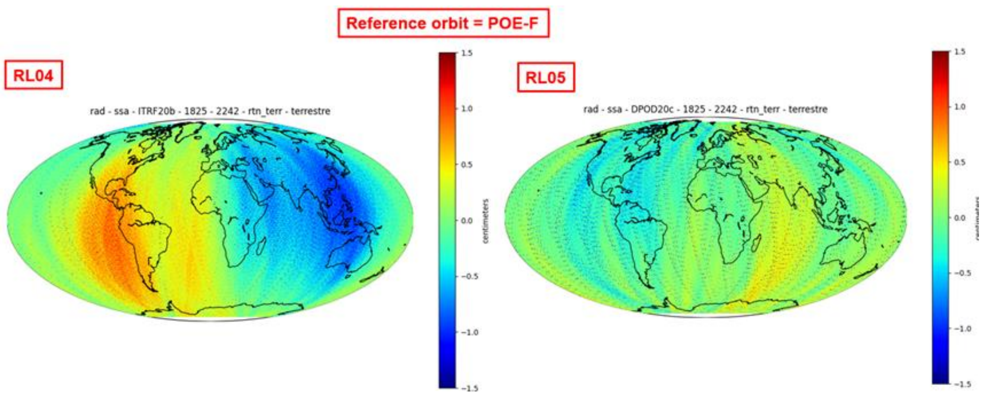


Figure 24. *Geographically correlated radial differences (in cm) for Saral.*

For Jason-3, the agreement between GRG and POE-F orbit is better with the new gravity field. An East/West patch for radial geographical systematic differences is reduced with RL05.

And finally, for Sentinel-6A, the agreement between GRG and POE-F orbit is better with the new gravity field, the mean value is reduced by 1.5 mm (see **Figure 25**). An East/West patch for radial geographical systematic differences is reduced with RL05 (see **Figure 26**). Note, as for Jason-3 there is a 59-day periodic signal in the radial component, probably due to the use of a different solar radiation pressure model.

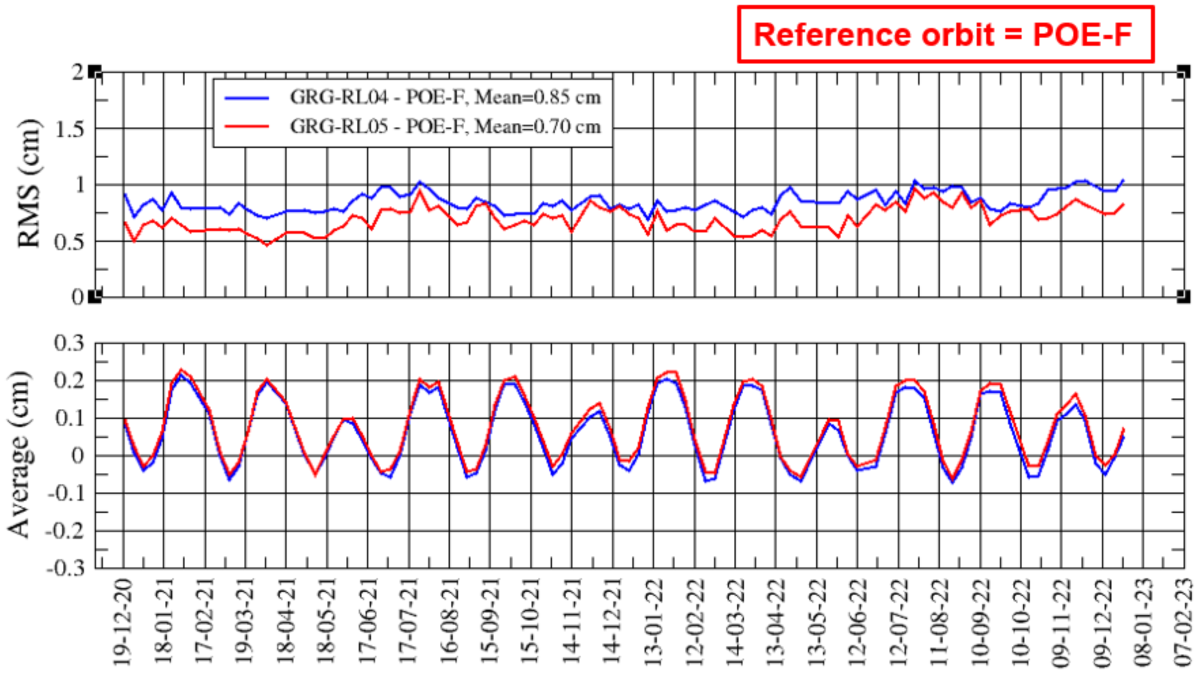


__Figure 25.__ Weekly RMS and Average Radial orbit differences (in cm) between GRG and POE-F orbits for Sentinel-6A (in blue GRG orbit determined with RL04 and in red with RL05).

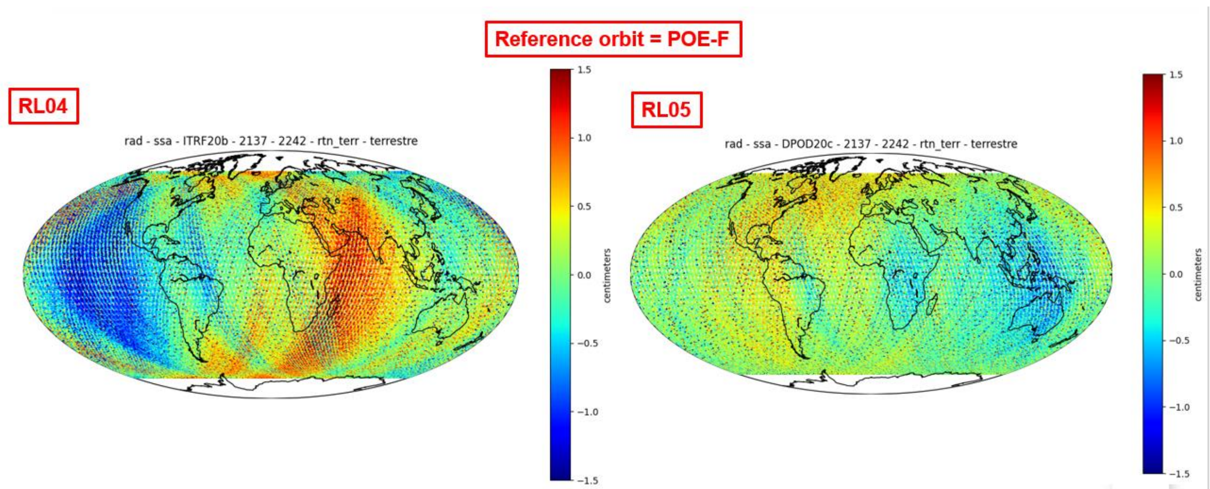


__Figure 26.__ Geographically correlated radial differences (in cm) for Sentinel-6A.

To estimate the impact of the gravity field releases on the DORIS solution in terms of Helmert parameters, individual satellite solutions are determined using RL04 and RL05 and compared to DPOD2014. Because the DORIS scale factor and geocenter are the combination of each single satellite solution, it is important indeed to analyze those obtained from the single satellite solutions to improve the combined solution. TX, TY and TZ translations from single satellite solutions obtained with RL04 and RL05 are shown on **Figure 27**, **Figure 28** and **Figure 29** respectively. It can be seen that RL05 improves TX and TY of Jason-3 and Sentinel-6A, which have a different altitude and inclination to the other satellites, but it has no impact on TZ. The new TVG RL05 is now being used in our DORIS data processing to compute multi-satellite solutions.

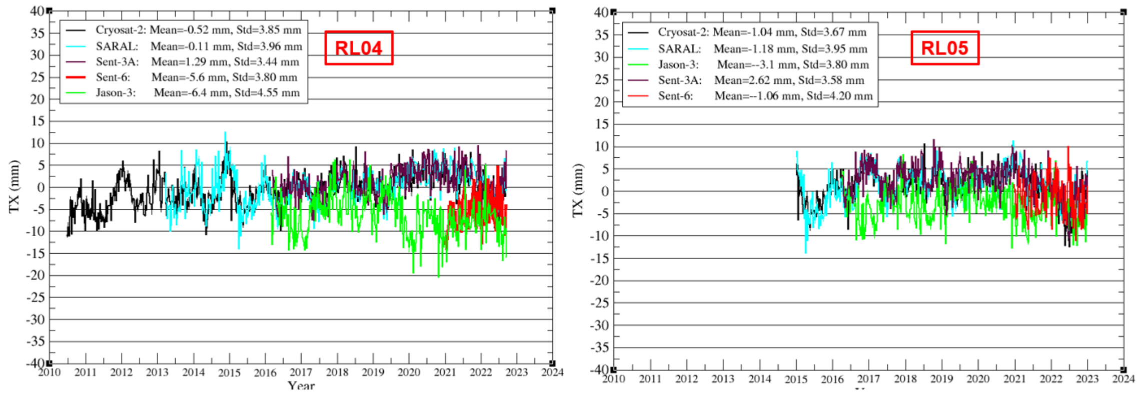


Figure 27. *TX from single satellite solutions obtained with RL04 (left) and RL05 (right).*

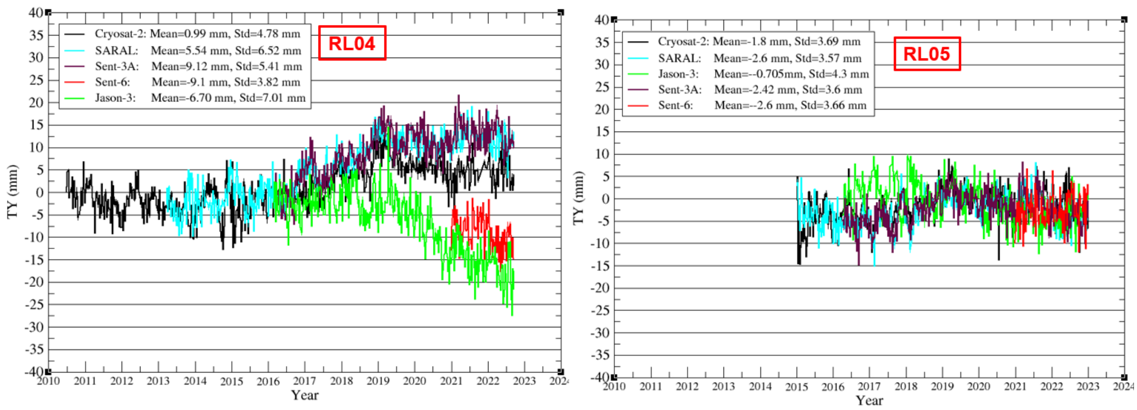


Figure 28. *TY from single satellite solutions obtained with RL04 (left) and RL05 (right).*

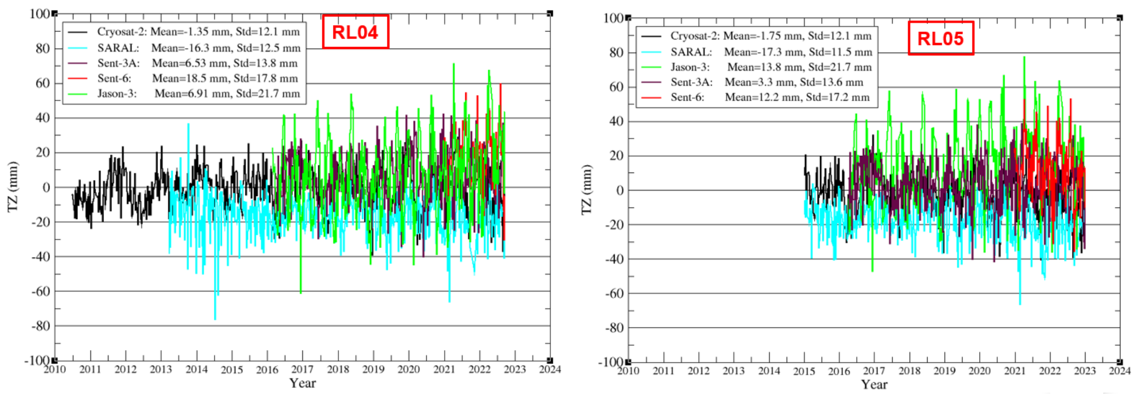


Figure 29. *TZ from single satellites.*

11.3 IMPACT OF INCREASED SOLAR ACTIVITY ON POD

Now, we will look at the impact of increased solar activity on the Precise Orbit Determination. Since the beginning of 2022, the solar activity has increased in particular the solar flux F10.7 as showed in **Figure 30** in red. The DORIS residuals for Sentinel-3A (in blue) increase significantly from early 2023 like the solar flux. Sentinel-3A and Sentinel-6A do not have the same inclination and altitude. The altitude of Sentinel 3A is around 800 km and the one of Sentinel-6A is 1300 km. **Figure 31** gives the One Per Rev acceleration amplitude in the along-track direction. For Sentinel-3A on the left, there is a degradation in the along-track amplitude from early 2023 as the solar flux increases. On the right, we see no impact for Sentinel-6A which has a higher amplitude.

Now, we compare our DORIS-only orbits to external orbits: POE-F from CNES POD team, and to the combined orbit from Copernicus POD Service. **Figure 32** gives the RMS of the orbit differences in radial component, in centimeter. In blue the difference with POE-F and in green the difference with CPOD orbit. For Sentinel-3A, the agreement between GRG orbit and external orbits deteriorates as the solar flux increases. For Sentinel-6A, the agreement between GRG orbit and external orbits is similar over the entire period (~0.7 cm RMS), even when the solar flux is higher.

We therefore plan to define a strategy to mitigate the impact of solar activity on low altitude DORIS satellites (all except Jason-3 and Sentinel-6A).

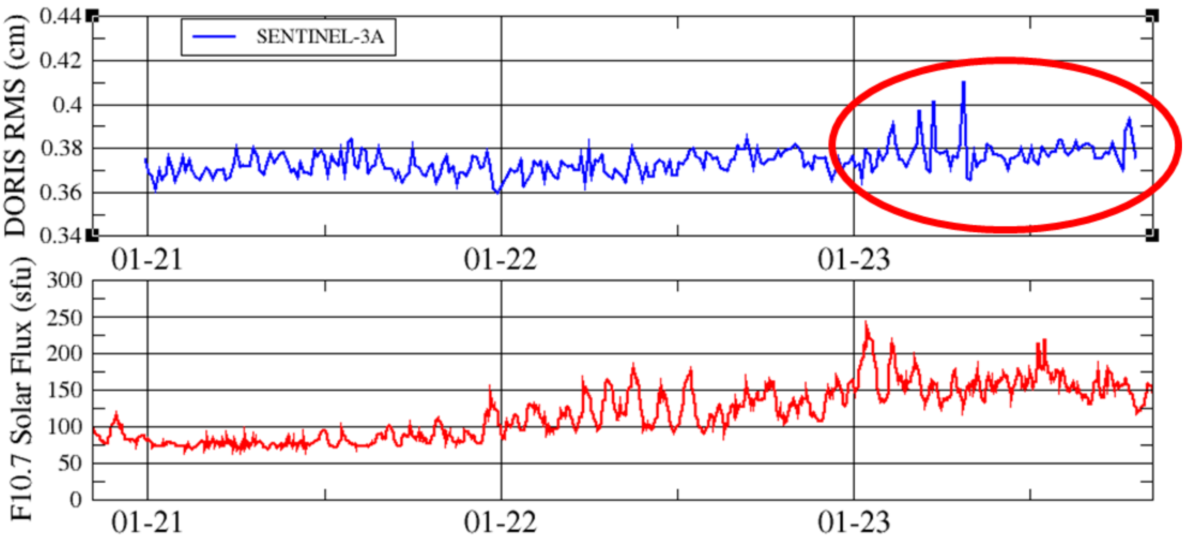


Figure 30. *DORIS RMS of fit (mm/s) for Sentinel-3A (in blue) and the solar flux F10.7 (in red).*

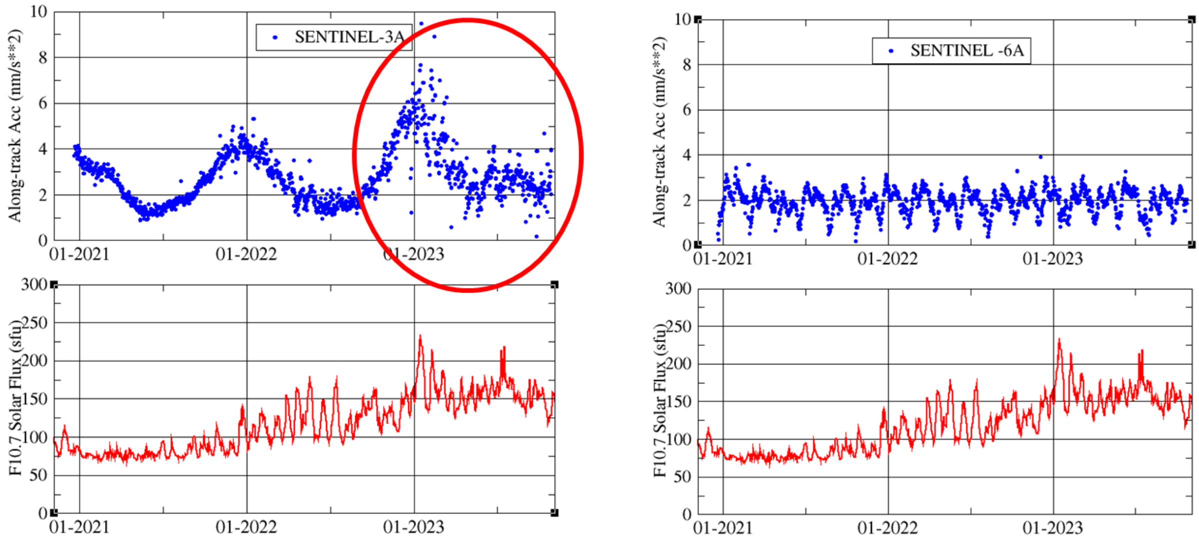


Figure 31. *OPR acceleration amplitude in the along-track direction for Sentinel-3A and Sentinel-6A and the solar flux F10.7 (in red).*

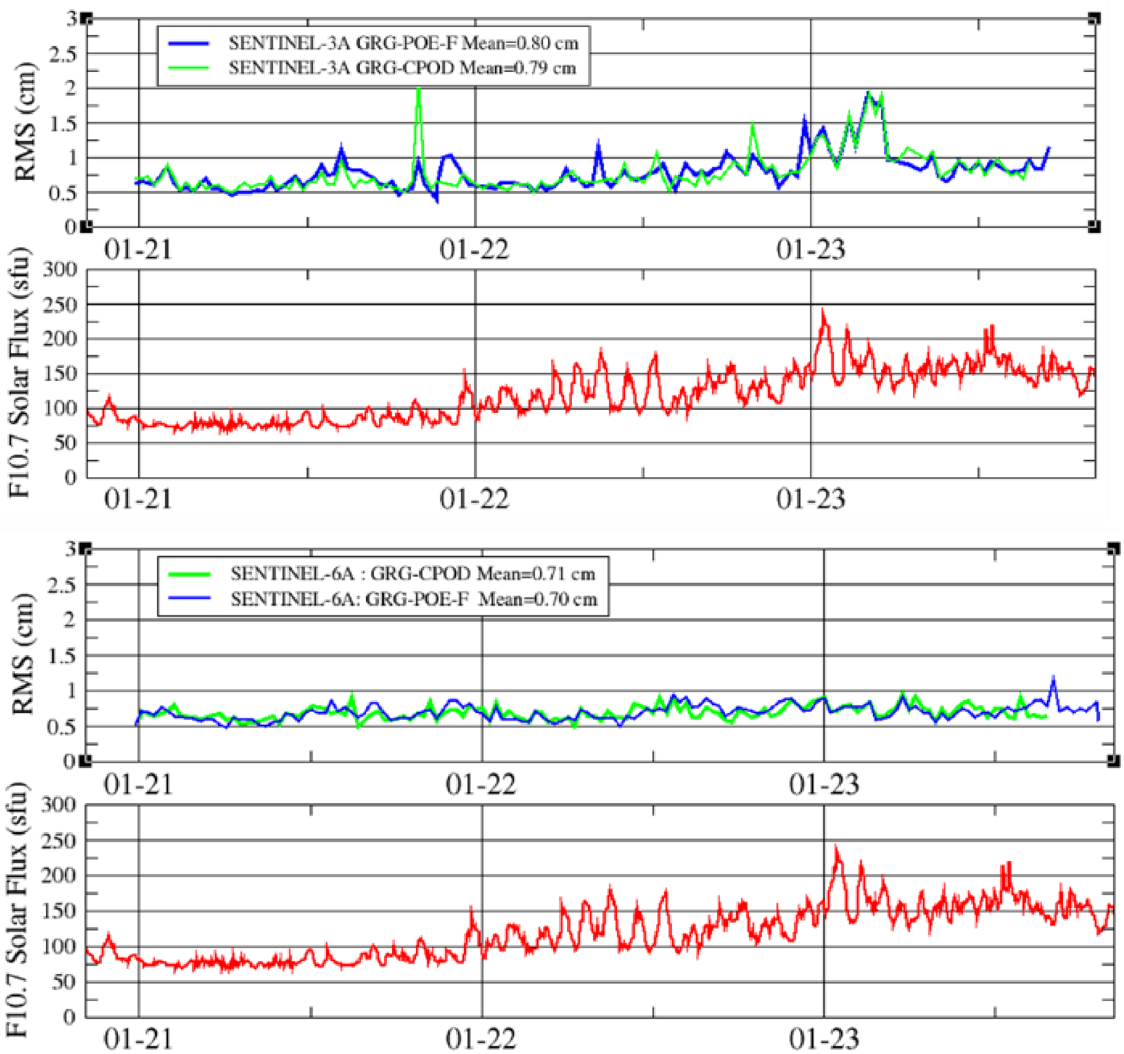


Figure 32. *Weekly RMS and Average Radial orbit differences (in cm) between GRG and external orbits for Sentinel-3A and Sentinel-6A and the solar flux F10.7 (in red).*

11.4 CONTRIBUTION TO IDS MEETINGS

The Analysis Center's representatives participated in 2023 at the AWG virtual meeting in April and in November. We presented the following works:

- "The current status and future plans of GRG AC"
  https://ids-doris.org/images/documents/report/AWG202304/IDSAWG202304-Capdeville-GRG_GravityEvaluation.pdf

- "GRG AC status"
  https://ids-doris.org/images/documents/report/AWG202311/IDSAWG202311-Capdeville-GRGstatus.pdf

12 GSFC/NASA ANALYSIS CENTER (GSC)

F.G. Lemoine [(1)], D.S. Chinn [(2)], N.P. Zelensky [(3)], X. Yang [(2)]
[(1)] Geodesy & Geophysics Laboratory, NASA GSFC, Greenbelt, Maryland, U.S.A.
[(2)] KBR Inc., Greenbelt, Maryland, U.S.A.
[(3)] Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, U.S.A.

12.1 STATUS OF POD AND CURRENT OPERATIONAL SERIES

For the year 2023, we continued our operational processing and implemented upgrades in view of the analysis for delivering the SINEX files for the ITRF2020 extension. We implemented two changes to the gscwd52 series. First, we removed Arequipa, Kourou, Cachoeira, Santiago from the HY-2A normal equations before combination. This was recommended after the IDS Workshop 2022. In addition, we reprocessed the data starting from 20160101, replacing the background static and time-variable gravity model with GRGS_RL05. GRGS_RL05 is a static and time-variable gravity model defined from 1993 to 2022 based on SLR/DORIS, GRACE, GRACE-FO and GOCE data (see **Table 16**). Thus, the new operational series as of the end of 2023 was the gscwd54 series. This series would be the template for the GSC contribution to the ITRF2020 extension (consisting of SINEX normal equations from 2021-2023).

We summarize the RMS of fit for the reprocessed arcs in **Table 17**. We saw a small but clear improvement in the overall average SLR RMS of fit when we adopted the new gravity model. The average SLR RMS of fit for CryoSat-2 decreased from 0.979 to 0.890 cm; the average SLR RMS of fit for Sentinel-3A decreased from 0.766 to 0.712 cm; the average SLR RMS of fit for Jason-3 decreased from 0.779 to 0.684 cm.

As a further means of validation, we examined the single satellite SINEX solutions for each of the satellites, comparing the wd53 (old gravity model) and wd54 (grgs_rl05 gravity model). We saw a consistent improvement in the WRMS (w.r.t. dpod2014_v5.5) for using the new gravity model (See **Table 18**). The improvement was generally a few tenths of a mm but reached 1 mm for HY-2A.

Series	Description	Comment
gscwd52	gscwd51 + Sentinel-3B starting 180610	Deliveries started 2021-10-18 to the NASA CDDIS.
gscwd53	gscwd52 + downweight SAA stations on HY2A by 3X; Remove Arequipa, Kourou, Cacheoira, Santiago, San Juan from HY-2A normal equation before combination.	Deliveries started 2023-04-25
gscwd54	gscwd53 + replace GOCO05s/SLR+DORIS 4x4 solutions with **CNES_GRGS.RL05MF_COMBINED_GRACE_SLR_DORIS** gravity model and resubmit SINEX files from 20160101 for the preparation of the ITRF2020 extension.	Deliveries started 2023-11-08 (Delivered to 2023-DOY260).

Table 16. *Status of GSC DORIS SINEX solutions for 2023*

Satellite	First Arc	Last Arc	No of Arcs	Avg. No. SLR obs. per arc	Avg. No. DORIS obs. per arc	Avg. SLR fit per arc (cm)	Avg. DORIS fit per arc (WRMS, mm/s)
CryoSat-2 (V2)	160103	230917	492	964	61,996	0.890	0.4043
HY-2A (V2)	160103	200906	268	612	82,561	0.901	0.3784
Jason-2 (V2)	160103	190908	164	2536	127,160	0.808	0.3607
Jason-3	160223	230917	426	2545	134,790	0.684	0.3887
Saral (V2)	160103	230917	409	1057	82,188	0.777	0.3862
Sentinel-3A (α)	160508	230917	458	929	76,334	0.712	0.4002
Sentinel-3B (β)	180606	230917	343	833	74,127	0.727	0.4121
(α) No SLR data for Sentinel-3A from 2016-0306 to week of 2016-0508. Sentinel-3A still included in SINEX solution gscwd51 starting on 160302. (β) Sentinel-3B not included in the ITRF2020 submission, but is now part of the operational series, gscwd54.							

Table 17. *POD Summary for DORIS Satellites using SLR+DORIS data (using GRGS_RL05)*

Satellite	WD53, GOCO5s & SLR/DORIS 4x4	WD54, GRGS_RL05
CryoSat-2 (V2)	12.29	12.06
HY-2A (V2)	10.86	9.84
Jason-2 (V2)	16.95	16.11
Jason-3	16.84	16.54
Saral (V2)	10.81	10.28
Sentinel-3A	14.11	13.64
Sentinel-3B	15.74	15.26

Table 18. *WRMS of weekly solutions wr.t. dpod2014_v5.5 (wd53 vs wd54, mm)*

12.2 TESTING OF THE SENTINEL-6A MACROMODEL

As a prelude to including Sentinel-6A in the operational series, we tested the use of a new macromodel developed by Conrad et al. (2023). The new macromodel was developed using GPS data, and has 12-plates, compared to the a priori macromodel which has only six plates. While the new and old macromodels produce comparable magnitudes for the amplitudes of the along-track once-per-rev (OPR) accelerations, the adjusted solar radiation reflectivity coefficient (Cr) is much closer to unity and shows fewer variations than the a priori macromodel (see **Figure 33**).

We also evaluated the POD performance using dynamic orbits from SLR and DORIS from 201218 to 231004. The new macromodel reduces the average SLR fit from 6.19 mm to 5.99 mm. In addition, the mean radial difference to the CNES POE-F (reduced-dynamic orbits based on DORIS and GNSS data) from 6.7 to 6.5 mm. We also find that the amplitude of the 59-day signal in the orbit differences with the reduced-dynamic orbits is reduced with the new macromodel. Hence, we plan to use the new macromodel in our Sentinel-6A processing and in the combined solution that we will submit for the ITRF2020 extension.

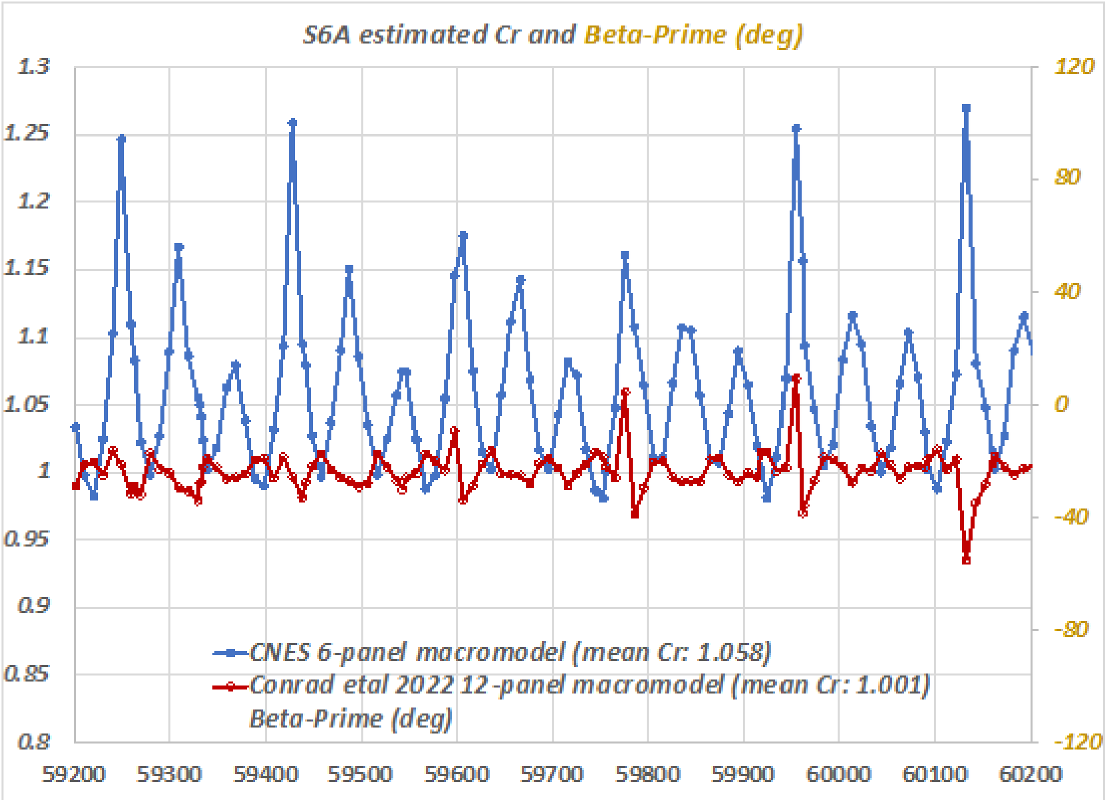


Figure 33. *Sentinel-6A Estimated Cr for the new (Conrad et al., 2023) and the a priori macromodel vs. Beta Prime for Sentinel-6A.*

12.3 SUMMARY

For the GSC DORIS contribution to the ITRF2020 extension we have reconverged all DORIS satellite orbits from 160101 using the grgs_rl05 gravity model. We see small but consistent improvements in the SLR RMS of fit, for SLR+DORIS orbit determination. The single-satellite solutions show a consistent reduction in the WRMS of the weekly solutions w.r.t. dpod2014_v5.5. There is no impact on the scale; there is a minor impact in the Helmert parameters, Tx, Ty, Tz. Therefore, our contribution for the IDS combination for the ITRF2020-extension will be the gscwd54 solution which has two improvements w.r.t. ITRF2020: (a) downweighting of SAA stations in POD, and removal of 5 SAA stations in the HY-2A contribution to the combination; (b) application of the grgs-rl05 gravity model (2016 – 2023). We will endeavor to include Sentinel-6A in a new combined SINEX solution early in 2024 using the new macromodel from Conrad et al. (2023).

12.4 REFERENCES

Conrad A., Desai S., Haines B. et al. (2023) Extending the GPS IIIA antenna calibration for precise orbit determination of low Earth orbit satellites. *Journal of Geodesy*, 97, 35, DOI: 10.1007/s00190-023-01718-0

13 IGN-IPGP/JPL ANALYSIS CENTER (IGN)

***Samuel Nahmani* [1, 2]*, Arnaud Pollet* [1, 2]**

[1] *Université de Paris, Institut de physique du globe de Paris, CNRS, IGN, F-75005 Paris, France.*

[2] *Université Gustave Eiffel, ENSG, IGN, F-77454 Marne-la-Vallée, France*

13.1 REACTIVATION AND FINALIZATION OF THE DORIS DATA PROCESSING CHAIN

Until 2019, the Institut national de l'information géographique et forestière (IGN) utilized the GIPSY/OASIS software package (developed by the Jet Propulsion Laboratory, Caltech, USA) to generate all DORIS products for geodetic and geophysical applications. However, this software is no longer supported by JPL as it has been superseded by the RTGx/GipsyX software. Moreover, with Pascal Willis' retirement in 2020 and the prevailing health crisis (COVID-19), the analysis center's operations could not be resumed normally by Samuel Nahmani and Arnaud Pollet. Indeed, at the time of his departure, RTGx/GipsyX was not yet operational for processing DORIS measurements. Only tests related to the processing of RINEX measurements on the Jason-2 satellite had been conducted.

In 2022, the operations of the IGN Analysis Center (AC) aligned with the schedule of the International DORIS Service. The primary objective of the data produced was to contribute to the combination center for generating DPOD solutions (DORIS extension of the ITRF for Precise Orbit Determination). Our foremost priority was to ensure that the AC becomes operational as swiftly as possible, thereby fully participating in this activity and contributing its products to the data and service hubs.

Since the end of 2023, the DORIS data processing chain using the JPL GipsyX software has been fully finalized. This advancement now allows us to process daily arcs from most DORIS satellites and produce weekly single-satellite or multi-satellite solutions. The combination of single-satellite daily solutions to generate single or multi-satellite weekly solutions is carried out using the PyTRF software, maintained by Paul Rebischung. This has enabled us to contribute to the combined IDS solution for the ITRF2020 update by providing weekly solutions that integrate the CryoSat-2, Jason-3, Sentinel-3A/B, Sentinel-6A, and Saral satellites over the 2021-2023 period to the IDS combination center.

13.2 CONTRIBUTION TO THE ITRF2020-U2023 REALIZATION

At the beginning of October 2023, the first IGN solutions were submitted to the IDS for evaluation. The weekly single-satellite solutions were calculated for CryoSat-2, Jason-3, Saral, Sentinel-3A, Sentinel-3B, and Sentinel-6A. The weekly multi-satellite solutions were calculated by combining the single-satellite solutions from these satellites. An alternative version of the weekly multi-satellite solutions, excluding Saral, was also produced to assess the impact of this satellite's exclusion on the overall performance. This allowed for a more focused evaluation of the contribution of the remaining satellites to the combined solution.

The evaluation of the first IGN solutions highlighted several notable biases and signals in the analyzed parameters, including a draconitic signal of 118 days affecting certain satellites.

- Regarding scale, a draconitic signal of 118 days was detected in the IGN solutions for both Jason-3 and Sentinel-6A, with amplitudes of nearly 20 mm and 18 mm, respectively. For Saral, the IGN solutions showed a better-centered scale compared to GRG, with a mean bias of 2.8 mm compared to 8.7 mm.
- As for translations, the Tz parameter in the IGN solutions exhibited a significant draconitic signal of 118 days, with an amplitude of 32 mm for Jason-3, compared to 20 mm in the GRG solutions. Saral showed a large mean bias on Tz, around 135 mm, in the IGN solutions. Sentinel-3A and Sentinel-3B also presented mean biases on Tz, with values of 94.2 mm for Sentinel-3A and 48.7 mm for Sentinel-3B. Additionally, the inclusion of Saral in the multi-satellite solutions degraded the centering of Ty and Tz, even though it reduced the standard deviation of the scale and translations.
- The WRMS of station positions showed consistent differences between the IGN and GRG solutions. The IGN solutions for CryoSat-2, Jason-3, Saral, Sentinel-3A, Sentinel-3B, and Sentinel-6A exhibited higher WRMS values, particularly in the North and Up directions. In the case of the multi-satellite solutions, the addition of Saral did not significantly affect the WRMS of station positions, although the WRMS for the IGN solutions remained higher, with differences ranging from 2.8 to 4.4 mm compared to GRG.

Finally, the 118-day draconitic signal, corresponding to the draconitic period of Jason-3 and Sentinel-6A, was also observed in the IGN multi-satellite solutions, affecting both the scale and the translations. The origin of the draconitic signal affecting the scale and Tz was identified. It resulted from an error in the initial modeling of satellite clocks, where a Bias + Drift + Acceleration model (deg 2 model) was used instead of Bias + Drift only (deg 1 model) (see **Figure 34**). This led to errors because the a priori acceleration cannot be reliably re-estimated in the processing. This error has been corrected, which successfully eliminated the draconitic signals affecting Jason-3 and Sentinel-6A. For Saral, applying the center of mass correction provided by CNES resolved the observed biases in the translations. Similarly, for Sentinel-3A and 3B, adopting the antenna positions proposed by CNES improved the solutions and reduced the biases observed in the initial solutions (Nahmani and Pollet, 2023b).

With all the corrections made, new solutions were submitted to the IDS for evaluation on December 17th. These solutions covered CryoSat-2, Jason-3, Saral, Sentinel-3A/B, Sentinel-6A, and a combined solution including CryoSat-2, Jason-3, Sentinel-3A, Sentinel-3B, Sentinel-6A, and Saral. The period processed by IGN spanned from 2021.0 to 2023.75.

The evaluation concluded that there were clear improvements compared to the initial submission. In terms of Helmert parameters, there was overall good agreement between the IGN solutions and the GSC 54 single satellite and combined solutions. However, station position residuals remained larger for IGN, particularly in the East direction for CryoSat-2 and in the Up direction for Jason-3. As for the Earth Orientation Parameters (EOPs), the evaluation showed higher differences for IGN, although the rotations seemed to be correct. Further investigation will be needed to address these discrepancies.

As a result, the IGN analysis center has regained its status as an associate analysis center within the IDS, with solutions that can now contribute to the IDS solution for the ITRF2020 update.

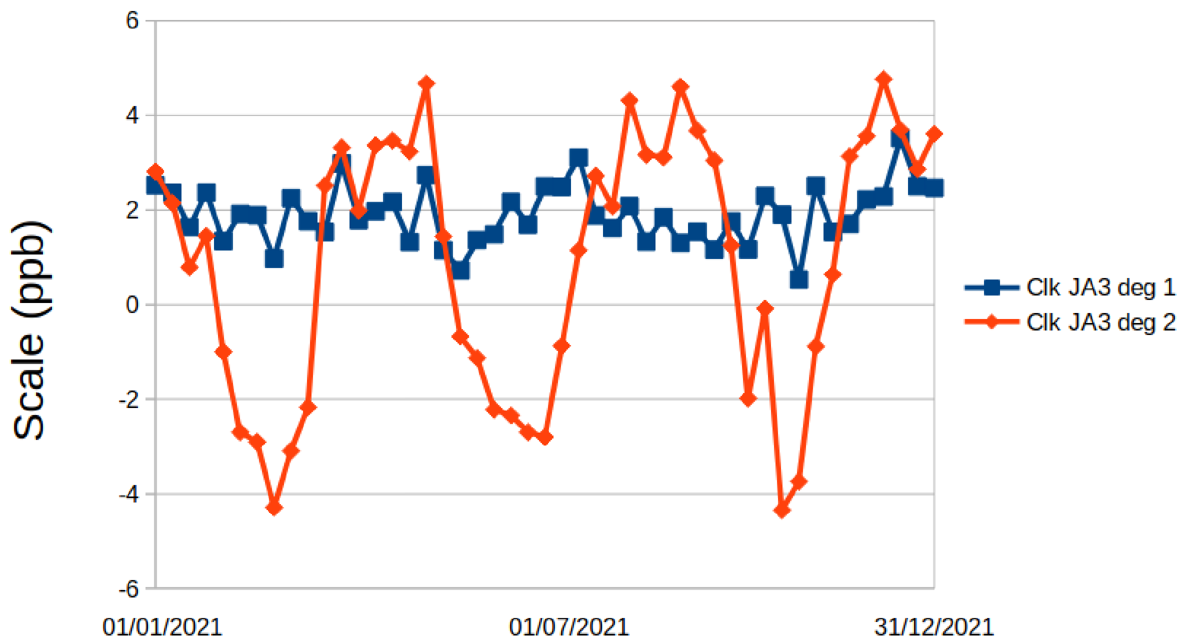


Figure 34. *Comparison of the scale parameter (in ppb) over time for Jason-3 clock models. The blue line represents the results using the Bias + Drift model (deg 1), while the red line represents the results using the Bias + Drift + Acceleration model (deg 2). The significant fluctuations in the deg 2 model are caused by the inability to re-estimate the a priori acceleration during the DORIS data processing, leading to the appearance of the draconitic signal. In contrast, the degree 1 model shows more stable behavior.*

13.3 NEW DEVELOPMENTS OR STUDIES

We conducted an evaluation to determine the extent to which DORIS data processing is affected by multicollinearity effects. We analyzed the estimated parameters for single-satellite computations across different satellites, as well as multi-satellite computations, to mathematically assess the reasonableness of the parameter estimates. In particular, we focused on the frame parameters, such as the origin and scale of the Terrestrial Reference Frame (TRF).

Our analysis revealed that the estimation of Tz in single-satellite solutions from polar-orbiting satellites was particularly affected by multicollinearity, whereas satellites like Jason-3, with an orbital inclination of 66°, were less impacted. However, due to the underrepresentation of satellites with lower orbital inclinations compared to polar satellites, the estimation of Tz in the multi-satellite solutions was also affected by multicollinearity. These findings were presented at the 28th IUGG General Assembly in Berlin (Nahmani, S., Pollet, A., Rebischung, P., 2023). Further studies are planned to address this issue and find a solution to mitigate the impact of multicollinearity in DORIS data processing.

13.4 FUTURE DEVELOPMENTS OR STUDIES

As part of the ongoing efforts to improve the accuracy and robustness of DORIS data processing, several future studies and developments are being considered.

Weighting of DORIS observations: A study on the weighting of DORIS observations during processing is planned. Various weighting strategies are currently employed within IDS and for Precise Orbit Determination (POD). The goal is to identify whether an optimal weighting strategy exists and how to detect it. Thorough investigations will be necessary to define a weighting approach that guarantees optimal results.

Daily multi-satellite processing: Currently, the analysis center processes daily DORIS data for each satellite independently. A future development involves using GipsyX to process daily data from all DORIS-equipped satellites simultaneously. This approach would allow for joint estimation of certain parameters, such as frequency biases and tropospheric parameters, which could improve the coherence of the solutions.

Weekly multi-satellite processing: Weekly multi-satellite solutions are currently produced by combining single-satellite weekly solutions. If the daily multi-satellite processing with GipsyX proves successful, it would be possible to easily combine the daily multi-satellite solutions using PyTRF to produce weekly solutions ready for submission to IDS. Since GipsyX is based on an SRIF filter, it could also be possible to directly generate weekly multi-satellite solutions, bypassing the need to combine daily solutions.

Shared parameters with GNSS: Some DORIS transmitting stations are colocated with GNSS stations on the ground, and some DORIS receiving antennas are deployed alongside GNSS antennas on low-Earth orbit satellites. In some cases, these instruments can share a common atomic clock. This shared clock could be leveraged to improve DORIS solutions, particularly in terms of synchronization and parameter accuracy. Additionally, tropospheric parameters estimated at colocated DORIS/GNSS sites could further enhance estimation precision.

Study on improving Tz estimation: Following the study on multicollinearity effects, a strategy could be developed to improve Tz estimation, focusing on satellites with different orbital inclinations, such as Jason-3, which appear to be less affected by this phenomenon.

13.5 INTERNATIONAL COLLABORATIONS

In 2023, the IGN analysis center strengthened its partnership with Maria Tsakiri's team at the National Technical University of Athens (NTUA), with the medium-term goal of establishing this team as an IDS associate analysis center, and potentially an operational IDS analysis center in the future. This objective includes the development of dedicated software, initiated by Xanthos Papanikolaou as part of his doctoral work on DORIS data processing.

The successful defense of Xanthos Papanikolaou's dissertation, *"Methodology for Orbit Determination Using DORIS RINEX Data,"* further solidified this collaboration. As part of this effort, Maria Tsakiri and her team also play a key role in the CORSAIR project, submitted under the Horizon Europe program, which aims to establish a Center of Excellence for Space Geodesy in Greece. These initiatives reflect the long-term commitment of the various partners involved in this project to strengthen their research capacities in space geodesy.

The CORSAIR project, submitted in 2023 under the Horizon Europe program (Call: HORIZON-WIDERA-2023-ACCESS-02), is led by the NTUA team and focuses on strengthening Greece's research capacities in space geodesy through European collaboration. The IGN-IPGP/JPL analysis center is a project partner, alongside Chalmers University of Technology (Sweden), Collecte Localisation Satellites - CLS (France), and the Helmholtz Centre Potsdam - GFZ (Germany).

The European Commission gave the project a positive evaluation, awarding it a score of 12.50, which exceeds the threshold of 10. The evaluation highlighted the clarity of the project's objectives, a solid scientific strategy, and the potential to enhance research capacities, particularly through the development of open-source software and training programs. The project is expected to significantly contribute to research excellence, national capacity building, and European cooperation in space geodesy.

However, the evaluation also noted some minor weaknesses, such as the incomplete description of certain key performance indicators (KPIs) and the lack of clear references to research ethics, inclusivity, and environmental sustainability. Additionally, uncertainties regarding the development of software tools were identified as a potential risk.

Overall, the CORSAIR project highlights the IGN analysis center's commitment to advancing DORIS-related research, while positioning Maria Tsakiri's NTUA team as a future key player within the IDS community.

13.6 CONTRIBUTION TO MEETINGS

In 2023, the IGN analysis center participated in several key events.

On April 18, 2023, the analysis center presented its progress during the online meeting of the IDS Analysis Working Group (AWG), discussing the restart of the analysis center and future research perspectives (Nahmani and Pollet, 2023a).

In July 2023, the center also took part in the IUGG General Assembly in Berlin, where a presentation was given on the effects of multicollinearity in DORIS data processing (Nahmani, Pollet, Rebischung, 2023).

Finally, on November 28-29, 2023, the analysis center co-organized the IDS AWG meeting in Saint-Mandé with the SGM of IGN and co-financed the event.

13.7 REFERENCES

Nahmani S., Pollet A. (2023a) Progress of the restart of our analysis center and the IGN/IPGP research perspectives for the DORIS technique. Presentation at the IDS Analysis Working Group meeting, April 18, 2023, online.
https://ids-doris.org/images/documents/report/AWG202304/IDSAWG202304-Pollet-IGNactivities.pdf

Nahmani S., Pollet A. (2023b) Status of the DORIS analysis center at IGN-IPGP in the context of the extension of the ITRF2020. Presentation at the DORIS Analysis Working Group Meeting, November 28-29, 2023, Saint-Mandé, France.
https://ids-doris.org/images/documents/report/AWG202311/IDSAWG202311-Pollet_Nahmani-IGNstatus.pdf

Nahmani S., Pollet A., Rebischung P. (2023) Is the processing of DORIS measurements affected by multicollinearity effects? Poster G01p-202, 28th IUGG General Assembly, July 11-20 2023, CityCube Berlin, Berlin, Germany.

14 INASAN ANALYSIS CENTER (INA)

Sergey Kuzin / Institute of Astronomy RAS, Russia

14.1 MAIN ACTIVITIES

In 2023, INASAN (ina) DORIS Analysis Center (AC) performed the activities listed hereafter:

- Daily single-satellite solutions post fit residuals have been investigated;
- De-aliasing model AOD1B RL06 by GFZ has been implemented in DORIS/RINEX data processing;
- The impact of using the AOD1B model on the accuracy of the solution has been evaluated for all available satellites;
- Quaternions have been applied in DORIS/RINEX data processing;
- The impact of application quaternions on the accuracy of the solution has been evaluated for Jason2 and Jason3 satellites;
- DPOD2020 coordinate system was used as a priori;
- Multi-satellite solutions (for 8 satellites) have been obtained and sent to IDS for validation.

14.2 SINGLE-SATELLITE PROCESSING

DORIS data have been routinely processed from the beginning of each mission till the end of the mission for HY-2A and Jason-2 satellites and from the beginning of each mission till the end of 2022.0 for Saral, HY-2C, HY-2D, CryoSat-2, Sentinel-3A, Sentinel-3A, Sentinel-6A and Jason-3 satellites. Depending on the view of the residuals, all satellites can be divided into two groups. The first group consists of HY-2A, Jason-2, CryoSat-2, Saral, Sentinel-3A and Sentinel-3B satellites. Post-fit residuals for this group are given in **Figure 35**. The RMS error curves of these satellites are quite smooth. The second group includes HY-2C, HY-2D, Jason-3 and Sentinel-6A satellites. **Figure 36** shows RMS of fit for these satellites. Here we see periodic jumps of the residuals with a period of about 2 months. The reason for these jumps is not clear. One possible reason could be related to the inclination of the satellites' orbit. One can see satellites orbit inclination on **Table 19** and **Table 20**. The first group of satellites have an inclination of about 98 degrees (except Jason-2 satellite). The second group of satellites have an inclination of 66 degrees. **Table 21** summarizes the single-satellites processing results.

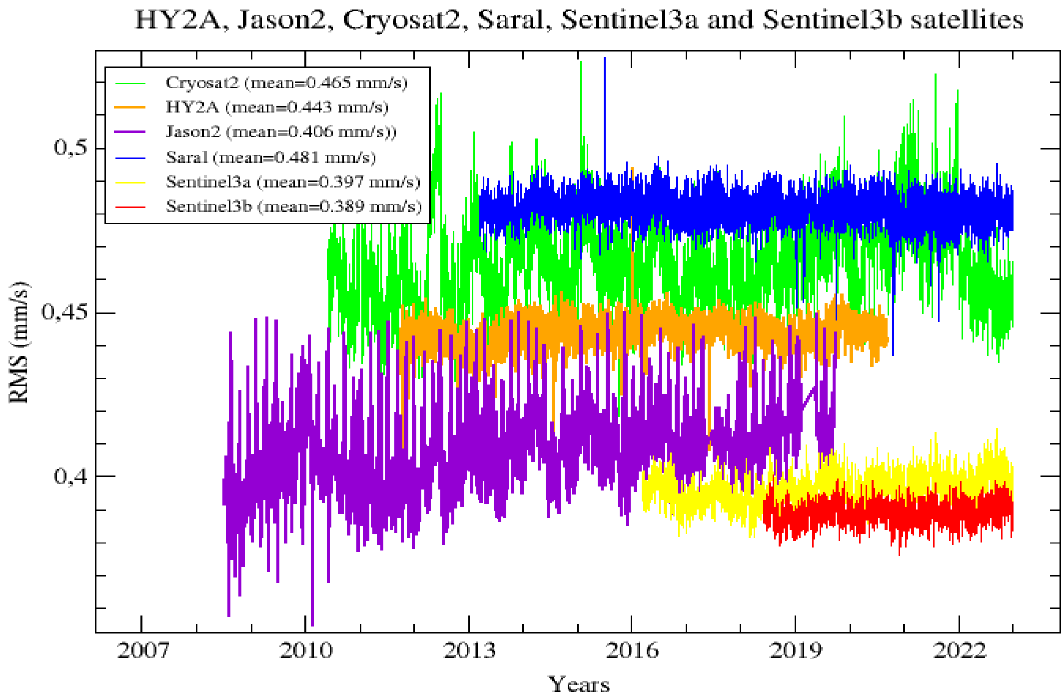


Figure 35. *DORIS RMS of fit for HY-2A, Jason-2, CryoSat-2, Saral, Sentinel-3A and Sentinel-3B satellites.*

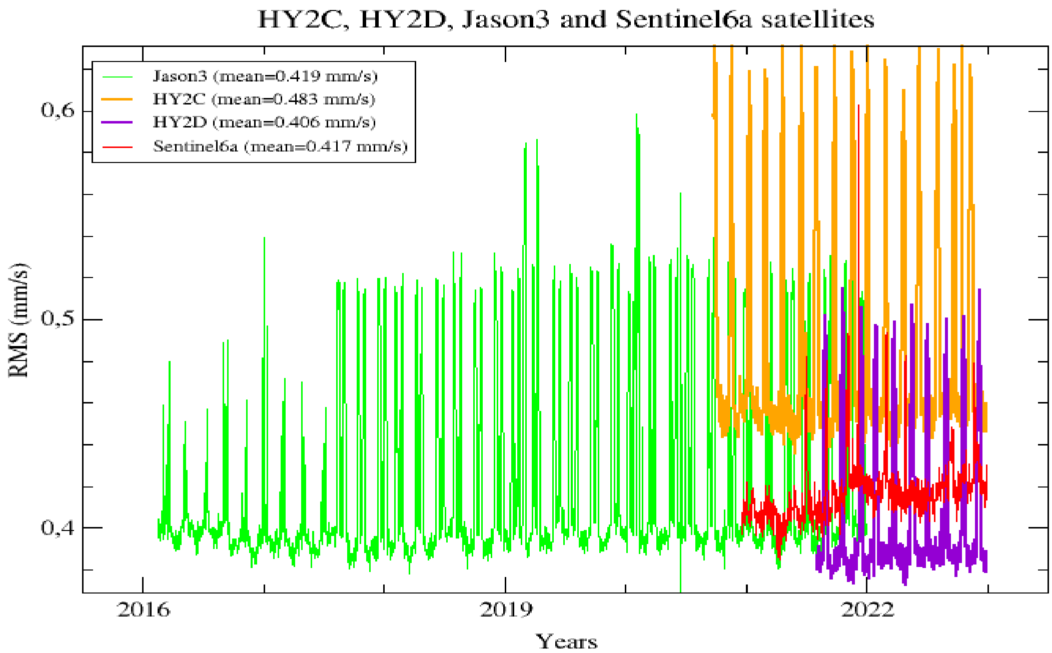


Figure 36. *DORIS RMS of fit for HY-2C, HY-2D, Jason-3 and Sentinel-6A satellites.*

Satellite	Inclination (degree)	Altitude (km)
CryoSat-2	92	717
HY-2A	99.4	963
Jason-2	66	1336
Saral	98.65	800
Sentinel-3A	98.65	814
Sentinel-3B	98.65	814

Table 19. *Orbits inclination for the first group of satellites.*

Satellite	Inclination (degree)	Altitude (km)
Jason-3	66.04	1336
HY-2C	66	957
HY-2D	66	957
Sentinel-6A	66.04	1336

Table 20. *Orbits inclination for the second group of satellites.*

Satellite	Processing period	Mean post-fit RMS (mm/s)	Mean number of daily deleted points (%)
CryoSat-2	2010.4-2023.0	0.465	1-2
HY-2A	2011.8– 2020.7	0.443	6-10
HY-2C	2020.7– 2023.0	0.483	3-8
HY-2D	2021.6– 2023.0	0.406	3-10
Jason-2	2008.5– 2019.8	0.406	1-2
Jason-3	2016.0– 2023.0	0.419	2-5
Saral	2013.2– 2023.0	0.481	10--12
Sentinel-3A	2016.0– 2023.0	0.397	3-5
Sentinel-3B	2018.4– 2023.0	0.389	4-6
Sentinel-6A	2020.9– 2023.0	0.417	2-4

Table 21. *Single-satellite processing results.*

14.3 EXPLORING THE APPLICATION OF THE AOD1B MODEL

The effect of using AOD1B model on the accuracy of the solution has been investigated. AOD1B model was applied to all DORIS/RINEX satellites. The results applying the AOD1B model are given in **Table 22**. We see a slight RMS of fit improvements for all satellites, but these improvements are negligible.

Satellite	Time period	Mean post fit RMS (mm/s)	
		AOD1B	No AOD1B
CryoSat-2	2010.4 – 2023.0	0.465164	0.465685
HY-2A	2011.8– 2020.7	0.443554	0.443642
HY-2C	2020.7– 2023.0	0.482860	0.482895
HY-2D	2021.6– 2023.0	0.405610	0.405667
Jason-2	2008.5– 2019.8	0.405667	0.406870
Jason-3	2016.0– 2023.0	0.419131	0.419579
Saral	2013.2– 2023.0	0.481804	0.481844
Sentinel-3A	2016.0– 2023.0	0.396506	0.396813
Sentinel-3B	2018.4– 2023.0	0.389076	0.389333
Sentinel-6A	2020.9– 2023.0	0.417302	0.417378

Table 22. *Single-satellite processing results with using AOD1B model.*

14.4 EXPLORING THE APPLICATION OF QUATERNIONS

Our next study was related to the effect of using quaternions on the accuracy of the solution. We applied quaternions for Jason-2 and Jason-3 satellites. The results applying of quaternions are given in **Table 23**. We see a slight RMS of fit improvements, but these improvements are negligible.

Satellite	Time period	Mean post fit RMS (mm/s)	
		Quaternions	Attitude files
Jason-2	2008.5 – 2019.8	0.408500	0.408597
Jason-3	2016.0 – 2023.0	0.398219	0.400276

Table 23. *Single-satellite processing results with using quaternions.*

14.5 MULTI-SATELLITE SOLUTIONS

The first multi-satellite solutions were obtained and sent to IDS for evaluation. Unfortunately, the results are unsatisfactory.

14.6 FUTURE ACTIVITIES

In 2024, the INASAN DORIS Analysis Center plans to work on:

- To receive robust multi-satellite solution;
- To use new gravitational field model;
- Processing SWOT satellite data;
- To use CryoSat-2, Sentinel-3A, Sentinel-3B and Sentinel-6A quaternions.

15 DGFI-TUM ASSOCIATE ANALYSIS CENTER

Julian Zeitlhöfler, Mathis Bloßfeld and Sergei Rudenko / Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM)

15.1 INTRODUCTION

The activities of the DGFI-TUM Associate Analysis Center (ACC) of the International DORIS Service (IDS) included in 2023:

- Further enhancement of DOGS-OC (DGFI-TUM Orbit and Geodetic parameter estimation Software – Orbit Computation) used for precise orbit determination (POD) with SLR and DORIS observations,
- Computation of improved orbits of satellite missions equipped with DORIS receivers,
- Quality check of the attitude implementation of TOPEX/Poseidon,
- Validation of the ITRS2020 realizations including the DPOD2020,
- Assessment of different orbit interpolation methods used for reliable orbit comparisons.

15.2 FURTHER DEVELOPMENT OF THE DOGS-OC LIBRARY

In 2023, the use of the following models and improvements were carried out in DOGS-OC:

- Capability of using TOPEX/Poseidon attitude quaternion data (Zeitlhöfler et al., 2024; Zelensky et al. 2024),
- Capability of using and processing DORIS RINEX data,
- Elevation-dependent weighting of DORIS observations,
- Improved bias estimation related to DORIS observations,
- Implementation of Sentinel-6A,
- New representation of ocean tides models based on the ICGEM format (cf. Kehm et al., 2023),
- Implementation of CNES_GRGS.RL05MF_combined_GRACE_SLR_DORIS and COST-G deterministic Earth's time-variable gravity field models,
- Implementation of the most recent non-tidal loading corrections for gravity and station coordinates.

15.3 DESCRIPTION OF MAIN SOFTWARE IMPROVEMENTS

As listed above, we made several important implementations in the DGFI-TUM POD software DOGS-OC in 2023 to improve the processing of DORIS observations and the quality of orbits.
Since DOGS-OC was primarily designed for the processing of SLR observations, where only two bias types are involved (range and time biases), the software was limited in bias estimation in the case of DORIS POD. Thus, we modified the software to estimate more than two bias types per observation

technique for the analysis of DORIS observations which requires to compensate for frequency drifts and offsets and to account for tropospheric scaling at each of the currently 60 beacons.

As in the case of other IDS-related centers, DOGS-OC is now also capable of applying an elevation-dependent observation weighting. This is of special interest in the processing of DORIS observations, since the beacon-emitted signals are influenced on their way through the atmosphere. Furthermore, both DORIS observation formats (IDS2.2 and RINEX/DORIS) can be used for POD now. This enables processing observations of contemporary satellites like Jason-3.

The software improvements mentioned above result in enhanced orbit quality. **Figure 37** shows the arc-wise RMS of DORIS *residuals* for Jason-3 before and after the implementations made in 2023. The average RMS reduces from 0.67 to 0.40 mm/s, which indicates better agreement of the observations to the modelled orbit for the latter solution. A previously prominent seasonal signal is resolved, and the scattering of the values is decreased. The biases estimated in the solution of 2023 are frequency bias (per pass), frequency drift (per station), and tropospheric scale factor (per pass).

Figure 38 shows the biases time series estimated of station Kourou (KOUR; master beacon) for the POD solution derived in 2023 covering the period between 2016 and 2019. The top panel shows the frequency bias which is quite stable at about -0.89 Hz. The second panel provides the frequency drift (mainly between -2 and -1 Hz/day), and the third panel shows the tropospheric refraction. The bottom panel indicates the number of observations used for the estimation of the parameters above. The analysis of each beacon’s biases time series enables the detection of systematics and further improvement of the software.

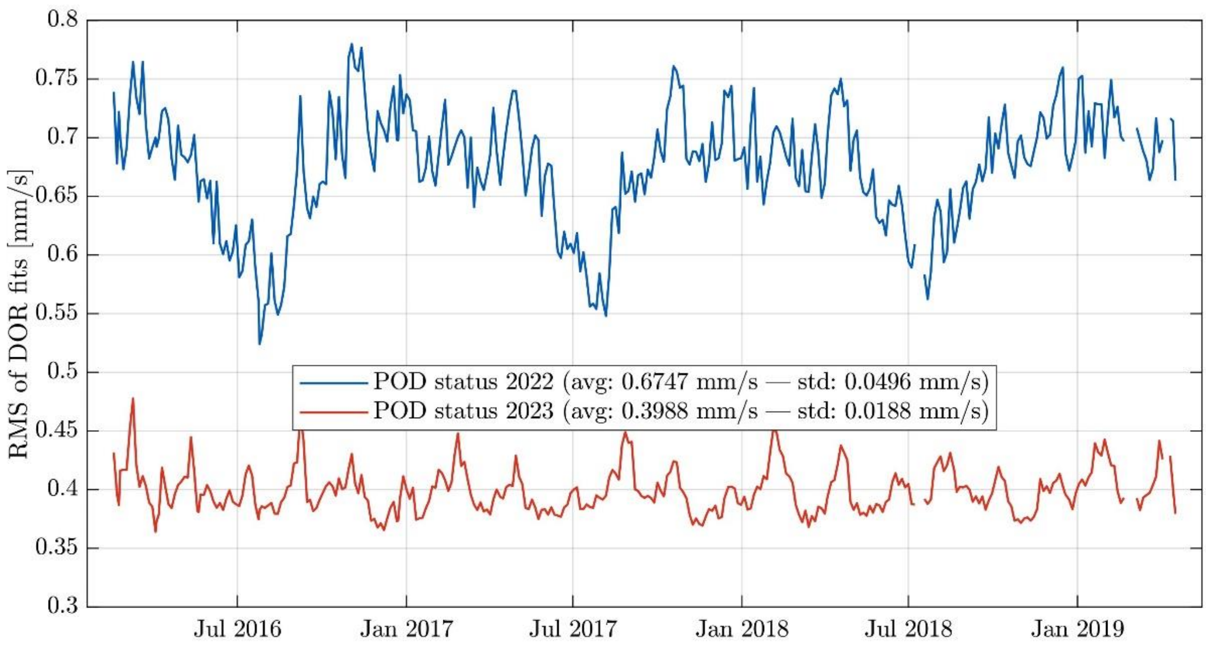


Figure 37. *Arc-wise RMS values of DORIS observation residuals for Jason-3 before and after the implementations made in 2023.*

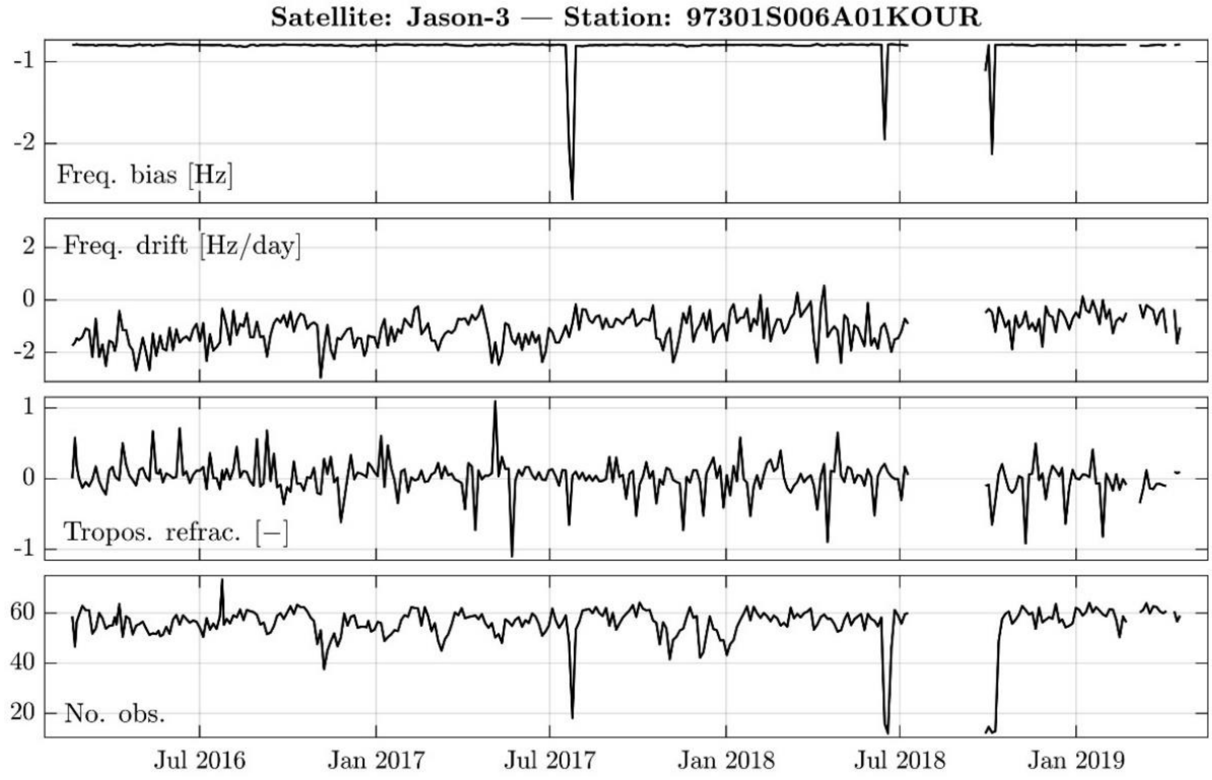


Figure 38*. Bias time series of DORIS station Kourou (KOUR).*

15.4 COMPARISON OF NOMINAL AND OBSERVED ATTITUDE OF TOPEX/POSEIDON

The TOPEX/Poseidon mission is the predecessor of the Jason satellites and thus of major importance for continuous sea level monitoring. In a study carried out in 2023, scientists at DGFI-TUM validated the spacecraft's nominal attitude model by comparing the modelled with the observed attitude (Zeitlhöfler et al. 2024; Zelensky et al., 2024). The latter is realized using quaternion data which is, in the case of the TOPEX/Poseidon mission, only available for a very limited number of weeks.

The investigations of nine intervals prove agreement between both attitude approaches. The orientation of the spacecraft bus differs between both approaches by up to 0.31° on average and the solar panel orientation differs by 0.19° on average. **Figure 39** shows the angular differences between both attitude approaches of three out of nine investigation intervals analyzed in the study. The intervals colored blue indicate periods in which the satellite is in sinusoidal yaw and fixed yaw is colored red. For more information, please see Zeitlhöfler et al. (2024).

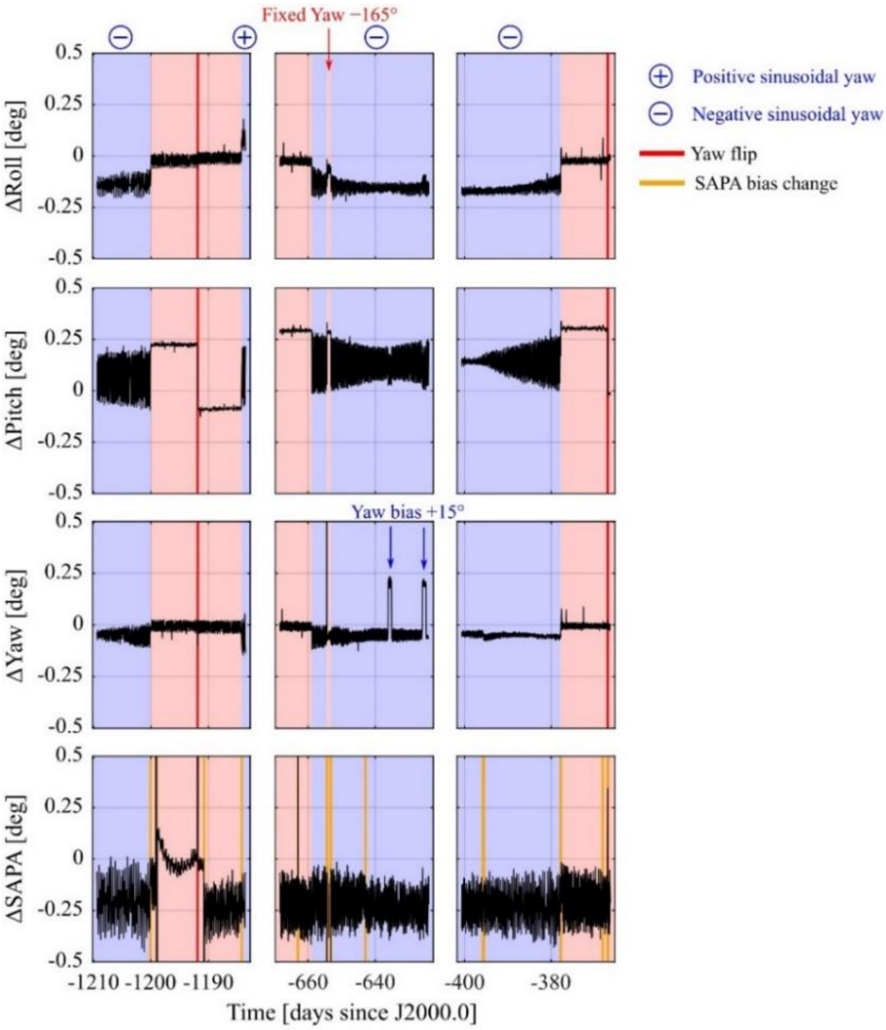


Figure 39. *Angular orientation differences (nominal minus quaternion-based) of the TOPEX/Poseidon spacecraft (Zeitlhöfler et al., 2024).*

15.5 COMPARISON OF STATION COORDINATE TIME SERIES

Besides the recent realizations (xTRF2020) of the International Terrestrial Reference System (ITRS), which comprise all four space-geodetic techniques, technique-specific reference frames are computed. The DPOD2020 (Moreaux et al., 2023) is the most recent version of a DORIS-specific reference frame. Since these frames are used, among other applications, also as a priori station positions for POD, we analyzed the differences between the xTRF2020 and DPOD2020 (as well as different versions of it) using the DORIS beacon Socorro, Mexico (DOMES number 40503S003). **Figure 40** shows the differences in the station's North, East, and Up components between 1993 and 1998. Besides the official ITRS realization (ITRF2020, International Terrestrial Reference Frame), the realizations of the DGFI-TUM (DTRF2020) and JPL (JTRF2020) as well as the DPOD2020 v1.5 and v2.1 are shown. For best comparability between the station positions, similar settings are used for the generation of each coordinate time series. The station positions based on the DTRF comprise offsets and velocities given at a reference epoch together with discrete post-seismic deformations (dPSD), non-tidal loading (NTL) effects referring to the Earth's center of mass (CM), and additional SLR-monitored geocenter variations (GCV). The ITRF comprises station offsets and velocities at its reference epoch as well as post-seismic deformation (PSD) functions and (semi-)annual periodic corrections (PER) referring to CM. The JTRF is used as it is. DPOD version 2.1 accounts, compared to its previous version, for post-seismic deformation and periodic corrections. The latter are referred to the Earth's center of figure (CF). As the beacon is located on Socorro Island, a volcanic island in the Pacific Ocean lying approximately 600 km off Mexico's western coast, its position is affected by volcanic and seismic activities. Thus, the time series contains discontinuities after large earthquakes. However, not all realizations inserted discontinuity at the same epoch. This factor and different treatment of seismic deformation effects result in position differences at the decimeter level.

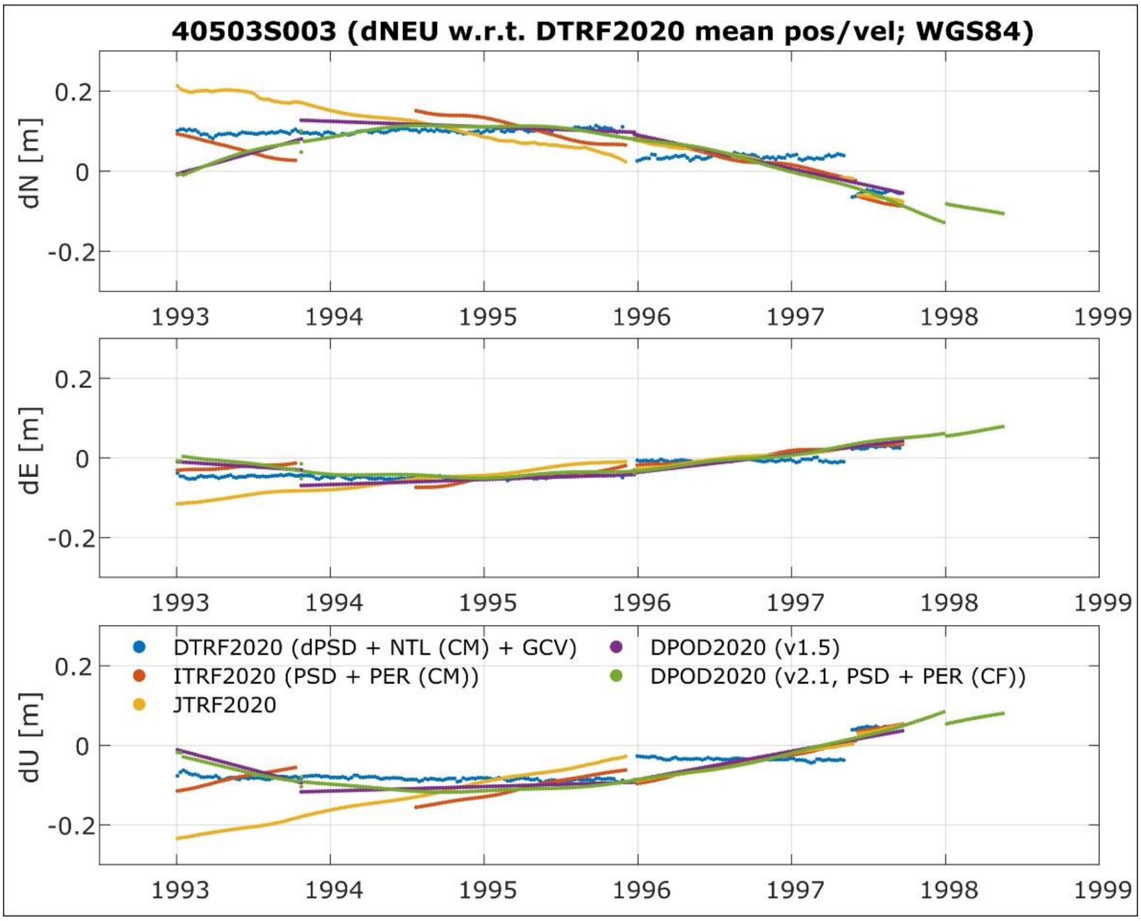


Figure 40. *Time series of station coordinate differences of IDS station Socorro (SODA) based on different realizations of the latest ITRS.*

15.6 PRESENTATIONS

More results can be found in the following presentations:

Bloßfeld M., Seitz M., Zeitlhöfler J., Rudenko S., Glomsda M., Kehm A. (2023) Application of ITRS 2020 realizations for SLR POD. ILRS 2023 Virtual International Workshop on Laser Ranging, International Laser Ranging Service (ILRS), online, https://mediatum.ub.tum.de/?id=1724526

Bloßfeld M., Zeitlhöfler J., Rudenko S. (2023) On the recent activities of the IDS Associate Analysis Center at DGFI-TUM. IDS Analysis Working Group Meeting, online, https://ids-doris.org/images/documents/report/AWG202304/IDSAWG202304-Bloßfeld-DGFIactivities.pdf

Kehm A., Bloßfeld M., Hart-Davis M., Dobslaw H., Mayer-Gürr T. (2023) Towards the Optimisation of Ocean Tides in Orbit and Geodetic Applications. AGU Fall Meeting 2023, American Geophysical Union, San Francisco, CA, USA, https://mediatum.ub.tum.de/?id=1724521

Rudenko S., Alkahal R., Bloßfeld M., Lemoine J.-M. (2023) Results of tests of the Earth's mean time-variable gravity field model CNES_GRGS.RL05MF_combined_GRACE_SLR_DORIS using precise orbit determination of TOPEX/Poseidon and Jason satellites. IDS Analysis Working Group Meeting, online, https://ids-doris.org/images/documents/report/AWG202304/IDSAWG202304-Rudenko-TestTimeVariableGravityField.pdf

Rudenko S., Bloßfeld M., Dettmering D., Zeitlhöfler J. (2023) Evaluation of ITRS 2020 realizations for precise orbit determination of altimetry satellites. IDS Analysis Working Group Meeting, Saint-Mandé, Paris, France, https://ids-doris.org/images/documents/report/AWG202311/IDSAWG202311-Rudenko-ITRF2020evaluations.pdf

Zeitlhöfler J., Bloßfeld M., Rudenko S. (2023) Current status of DORIS POD at DGFI-TUM. IDS Analysis Working Group Meeting 2023, Saint-Mandé, France and online, https://ids-doris.org/images/documents/report/AWG202311/IDSAWG202311-Zeitlhoefler-DGFIstatus.pdf

15.7 REFERENCES

Moreaux G., Lemoine F. G., Zelensky N. P., Moyard J., Couhert A. (2023) DPOD2020: a DORIS extension of the ITRF2020 for Precise Orbit Determination. *Advances in Space Research*, 72(11): 4625-4650, DOI: 10.1016/j.asr.2023.10.006

Zeitlhöfler J., Bloßfeld M., Lemoine F. G., Seitz F. (2024) Quality assessment of the nominal attitude model of TOPEX/Poseidon using quaternion data. *Advances in Space Research*, 73(12):5757-5768, DOI: 10.1016/j.asr.2024.03.031

Zelensky N. P., Lemoine F. G., Zeitlhöfler J., Bloßfeld M., Yang X. (2024) TOPEX/Poseidon spacecraft body and solar array quaternions, version 01A (data). *Zenodo*, DOI: 10.5281/zenodo.10795817

16 GFZ ASSOCIATE ANALYSIS CENTER

Patrick Schreiner, Anton Reinhold, Karl Hans Neumayer / Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Oberpfaffenhofen, Germany

16.1 INTRODUCTION

In 2023, the Associate Analysis Center (AAC) at the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences (GFZ) continued to enhance its ambitions to become an International DORIS Service (IDS) analysis center (AC). This year marked a significant milestone with the launch of the SWOT satellite, which we have implemented in our EPOS-OC (Neumayer et al., 2024) software, further extending our satellite portfolio.

Significant improvements were made to the satellite macro models for CryoSat-2 and SARAL, which have successfully reduced periodic signals in estimated parameters and enhanced orbit accuracy. Furthermore, efforts were made to address and mitigate the West-East patterns observed in previous orbit comparisons between DORIS-derived orbits and reduced dynamic GPS orbits. This issue was tackled through rigorous testing and methodological adjustments, which have shown promising results in improving orbit consistency and reliability.

With the release of the DPOD2020, an extensive analysis was conducted to evaluate the impacts of updating our systems to the DPOD2020 and ITRF2020 standards. This analysis is crucial for ensuring that our data remains robust and relevant in the context of global geodetic parameter estimation. The findings from this comprehensive study have been compiled and submitted for publication (Reinhold et al., 2024).

These advancements underscore our ongoing commitment to refining our technological approaches and analytical methods at the GFZ AAC, driving forward the accuracy and applicability of global satellite data processing.

16.2 PRECISE ORBIT DETERMINATION

We have continued to expand our portfolio of DORIS satellites. Most recently, we added the SWOT satellite to our processing capabilities as soon as the data became available. For SWOT, we have generated orbits using various methodologies: GPS-based, DORIS, DORIS+SLR, and a combination of DORIS, GPS and SLR. This diverse approach helps us identify and address remaining systematic errors in the satellite eccentricities and POD setup. Looking ahead, the integration of the SPOT satellites and the HY-2 series satellites, both equipped with DORIS receivers, is further planned.

16.3 OPTIMIZATION OF POD PRODUCTS

In 2022, we expanded our processing capabilities to include the CryoSat-2 and SARAL satellites. Given the complex shape of CryoSat-2 and self-shadowing effects associated with SARAL, we recognized the need to improve the macro models of these two satellites. By fully redeveloping new macro models for each satellite, we were able to significantly reduce the unmodeled forces in empirically estimated parameters and minimize remaining signal errors.

Furthermore, as reported in Schreiner et al. (2023d), we observed systematic radial orbit differences in DORIS-based orbits when compared to the Copernicus POD (CPOD) quality working group combined orbit solution (GMV, 2022). Efforts to identify the cause of this pattern revealed that switching the Earth's gravity field model from GOCO06s (see **Figure 41**) to the COST-G model (see **Figure 42**) resulted in a substantial reduction of this discrepancy. These findings were also presented at the DORIS AWG meeting (Schreiner and Reinhold, 2023c).

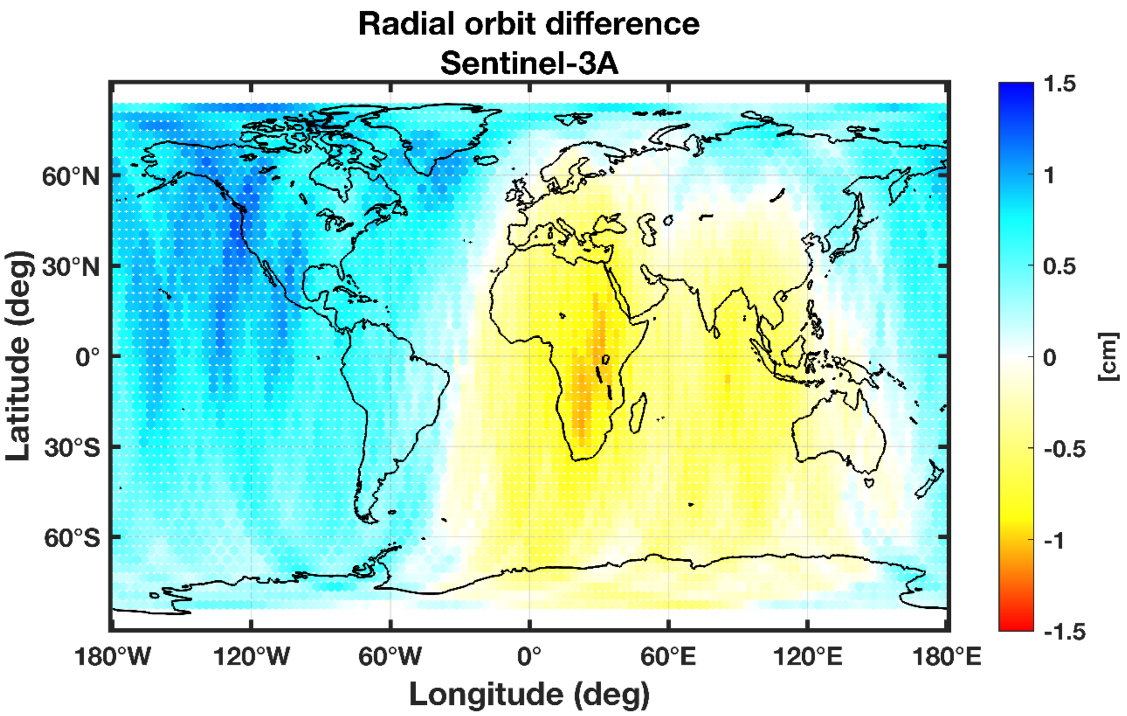


***Figure 41.** Radial orbit differences for the Sentinel-3A solution based on GOCO06s gravity field model in comparison to the CPOD combined orbit solution.*

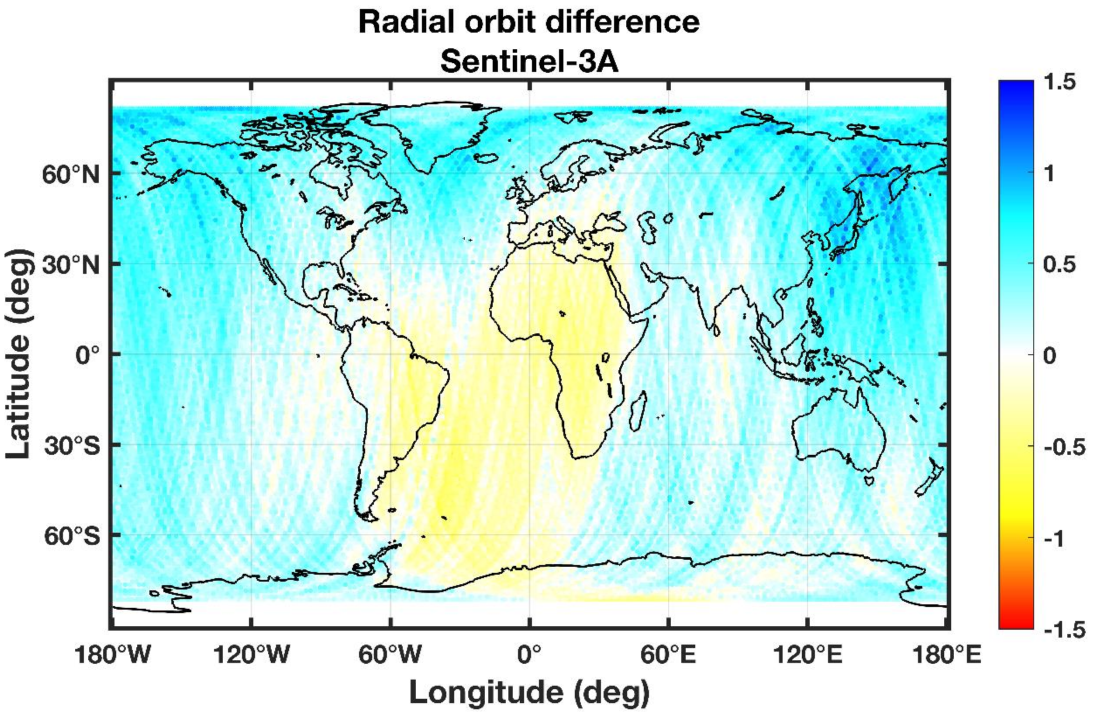


Figure 41. *Radial orbit differences for the Sentinel-3A solution based on COST-G gravity field models in comparison to the CPOD combined orbit solution.*

16.4 REFERENCE FRAME DETERMINATION

The latest version of the DORIS extension to ITRF2020, designated DPOD2020, was released at the end of 2022. To evaluate this new release, our study compares its performance with that of its predecessor, DPOD2014. Our analysis incorporated data from ten prominent altimetry missions — CryoSat-2, Envisat, Jason-1,-2,-3, Saral/AltiKa, Sentinel-3A,-3B,-6A (MF), TOPEX/Poseidon — spanning three decades from 1993 to 2023. We performed Precise Orbit Determination (POD) and evaluated the internal differences, focusing on orbital fit and cross-orbit comparisons. The RMS values for Satellite Laser Ranging (SLR) observations are generally close to 1 cm for most missions, while DORIS observations show RMS values of typically 0.4 mm/s. In case of the orbit comparison between DPOD2020 and DPOD2014 based solutions, the mean values for the radial component are close to zero while the RMS values are in single-digit range and amount to 1-2 mm which indicate good agreement between both orbit solutions with no systematic bias.

For additional external validation of orbit quality, we compared our results with CNES-SSALTO POE-F orbits, observing typical RMS values of about 1 cm in the radial components, which further affirm the high quality of the orbits.

Moreover, we computed weekly local Terrestrial Reference Frames (TRFs) for each satellite and a combined solution to evaluate the impact on derived station coordinates and Earth Rotation Parameters (ERPs). These TRFs were evaluated against the a priori TRF concerning the reference frame defining parameters, i.e. origin, scale, and orientation, along with comparisons between

DPOD2014 and DPOD2020 solutions. The local TRF's show overall good agreement between the DPOD2020 and DPOD2014 solutions with no systematic bias.

The results of this study have been documented and submitted for publication to the proceedings of the IAG Symposia at IUGG Berlin (Reinhold et al, 2024).

16.5 PRESENTATIONS

Schreiner P., Reinhold A. (2023a) Status report of the IDS Associate Analysis Center at GFZ. *DORIS Analysis Working Group Virtual Meeting*, 18 April 2023

Schreiner P., Reinhold A., Neumayer K.H., Koenig R. (2023b) Sentinel POD based on DORIS, GPS and SLR and subsequent reference frame determination based on DORIS-only. *EGU General Assembly 2023*, Vienna, Austria, 24–28 Apr 2023, EGU23-6489, https://doi.org/10.5194/egusphere-egu23-6489

Reinhold A., Schreiner P., König R., Neumayer K.H. (2023a) DORIS based precise orbit and reference frame determination using multiple altimetry satellite missions. *EGU General Assembly 2023*, Vienna, Austria, 24–28 Apr 2023, EGU23-14501, https://doi.org/10.5194/egusphere-egu23-14501

Reinhold A., Schreiner P., König R., Neumayer K.H. (2023b) On DORIS Precise orbit and reference frame determination based on the ITRF2020 using multiple altimetry satellite missions. *IUGG 2023*, Berlin.

Schreiner P., Reinhold A. (2023c) Status report of the IDS Associate Analysis Center at GFZ. *DORIS Analysis Working Group*, Saint-Mandé, France, 28-29 November 2023

16.6 REFERENCES

GMV (2022). Copernicus POD Regular Service Review Jan. – Dec. 2021. https://sentinels.copernicus.eu/documents/247904/4599719/GMV-CPOD-RSR-0023_v1.1_Copernicus_POD_Regular_Service_Review_Jan_Dec_2021.pdf

Neumayer K.H., Schreiner P., König R., Dahle C., Glaser S., Mammadaliyev N., Flechtner F. (2024) EPOS-OC, a universal software tool for satellite geodesy at GFZ. *International Association of Geodesy Symposia*

Reinhold A., Schreiner P., Neumayer K.H. (2024) On DORIS Precise orbit and reference frame determination based on the ITRF2020 using multiple altimetry satellite missions. Submitted to: *International Association of Geodesy Symposia*. Under revision.

Schreiner P., König R., Neumayer K.H., Reinhold A. (2023d) 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. *Advances in Space Research*, 72(1):47-64, DOI: 10.1016/j.asr.2023.04.002

17 TU DELFT ASSOCIATE ANALYSIS CENTER

Ernst J.O. Schrama, Section of Astrodynamics and Space missions / Faculty of Aerospace Engineering at the Delft University of Technology, The Netherlands

17.1 INTRODUCTION

In the reporting period we focused on CryoSat-2 precision orbit determination where we finalized a part of the research on modelling time variable gravity. The question was whether there is an optimal strategy for handling temporal gravity modelling in the transition phase between GRACE and GRACE-FO, this has resulted in a new paper in AISR, see reference [2].

Other aspects we investigated concern the transition from DPOD2014 to ITRF2020 and later DPOD2020, updates in the way IERS EOP data are used in the orbit determination software. A further interpretation of the solved for empirical accelerations, first recognized in [1] and further detailed in [2] including a better interpretation of the observation residuals. To our surprise there was a remnant effect of an error in the tide model setup which was recognized during the review of [2]. Also, we worked on an update of the data weighting and data editing strategy.

More recently the CryoSat-2 POD problem was extended with arcs until the end of 2023, this was because of a request of ESA related to an update of the reaction control system of CryoSat-2 which did not affect the empirical biases that we solve for during POD.

17.2 TEMPORAL GRAVITY

A significant update applied during the POD of CryoSat-2 concerns an extension of the a-priori temporal gravity model (TVG model). Monthly gravity field variations as obtained from the GRACE mission have been used in [1] before the GRACE mission was decommissioned in Oct 2017. Since GRACE there is a significant transition gap to GRACE follow-on which was launched in late 2018 while the first monthly solutions became available in 2019.

GRACE-FO is somewhat noisier than GRACE due to an accelerometer failure on one of the GRACE-FO satellites, also, temporal gravity as seen by CryoSat-2 is modelled partially by the AOD1B model to describe atmospheric and oceanic signals. The interruption between both gravity missions means that one needs to rely on an approximation method which only concerns temporal gravity signal caused by the cryosphere and terrestrial water storage.

The TVG model maximum spherical harmonic degree and order is 60 and its source comes from the Center of Space Research (CSR) release 6 and release 6/1 GSM solutions. To be able to apply the information contained in the GSM coefficients from GRACE and GRACE-FO during POD we approximate spherical harmonics contained in the GSM coefficients and we evaluate criteria to find an optimal approximation that can be used for precision orbit determination of the CryoSat-2 mission. Details are discussed in [2], in essence we looked at the consequences of model updates for SLR and DORIS residuals, and the magnitude of the empirical accelerations that appear during POD.

The conclusion is that TVG modelling including GRACE-FO leads to a somewhat improved POD result, the bigger effect comes from updating our tides setup, and the implementation of AOD1B from weekly averages down to three hourly interpolation of the provided fields. The conclusion is also that noisy GRACE GRACE-FO fields can deteriorate a POD solution, so careful filtering is a must.

17.3 MAINTENANCE OF OUR INFRASTRUCTURE

Retrieval procedures of Earth Orientation Parameters (EOP), solar flux data and geomagnetic data that we need for POD requires access to public archives maintained for instance by the CDDIS, the IGN and the GFZ. Since 2020, FTP access has stopped to several services and this required a review of data retrieval procedures and protocols. Our quaternion archive of CryoSat-2 has been operational during the pandemic, albeit that we had to switch from server within the campus due to hardware failure. Also, the retrieval of quaternion data from ESA had various changes, rather than getting the data from the calval server by FTP an alternative mechanism via FTPS was implemented.

17.4 REFERENCES

[1] Schrama, E.J.O. (2017) Precision orbit determination performance for CryoSat-2. *Advances in Space Research*, 61(1):235-247, DOI: 10.1016/j.asr.2017.11.001

[2] Schrama, E.J.O., Visser, P.N.A.M. (2024) Choices for temporal gravity field modeling for precision orbit determination of CryoSat-2. *Advances in Space Research*, 73(1):31-41, DOI: 10.1016/j.asr.2023.11.034.

18 WORKING GROUP "NRT DORIS DATA"

Denise Dettmering / DGFI-TUM, Germany
Ningbo Wang / AIR-CAS, China

During the last few years, the working group has assessed the requirements, benefits, and prospects of DORIS data with improved data latency. Currently, near real-time (NRT) data is available within about three hours after acquisition. Since the data has to be downlinked from the satellite to be made available, much faster dissemination is impossible.

The working group has defined data format and access, and the effective latency has been evaluated (see previous annual reports). After that, the value of NRT DORIS data for ionospheric applications was demonstrated. This work focused mainly on using DORIS NRT as external validation data since, until the end of 2023, only one satellite mission was providing data to be used.

A main focus of the WG in 2023 was on using DORIS NRT data of the Jason-3 mission to help with the combination of GNSS-based ionospheric maps, i.e. by providing weighting factors for the maps of different analysis centers. Compared to the standard combination approach, this method allows for a weighting based on independent observation data (see IDS Newsletter #10). The independent DORIS NRT data shall play an indispensable role in the combination of global ionospheric maps provided by the International GNSS Service (IGS).

Since all goals described in the current terms of reference (ToR) of the WG are now fulfilled and the dissemination of NRT data from more satellite missions will start in 2024, the WG will enter a new phase with a new focus on the application of NRT DORIS data for ionosphere modelling. This will be accompanied by a change of the chairperson of the WG. In its governing board meeting in November 2023, the IDS agreed on Ningbo Wang as the new chair of the WG. The new ToR will be distributed in the near future, and new members are welcome to join the group.

APPENDIX

19 IDS AND DORIS QUICK REFERENCE LIST

1. **IDS website**
   https://ids-doris.org/

2. **Contacts**
   Central Bureau ids.central.bureau@ids-doris.org
   Governing Board ids.governing.board@ids-doris.org

3. **Data Centers**
   CDDIS: https://cddis.nasa.gov/archive/doris/ and ftps://gdc.cddis.eosdis.nasa.gov/doris/data
   IGN: ftp://doris.ign.fr (back-up ftp://doris.ensg.eu)

4. **Tables of Data and Products**
   https://ids-doris.org/ids/data-products/tables-of-data-products.html

5. **IDS web service**
   https://ids-doris.org/webservice
   DOR-O-T for DORis Online Tools (pronounced in French like the given name Dorothée) is the IDS web service developed to promote the use of the DORIS products. The current version of the service provides tools to browse time series in an interactive and intuitive way, and a network viewer.

6. **Citation**
   The following article is suggested for citation in papers and presentations that rely on DORIS data and results:

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

7. **DORISmail**
   The DORIS mail service is used to send information of general interest to the DORIS community. To send a DORISmail, use the following address: dorismail@ids-doris.org

8. **List of the documentation**
   It gives a table compiling links to the various pages providing documents, grouped in four categories: DORIS system components; IDS information system; Publications, presentations; Documents.
   https://ids-doris.org/ids/reports-mails/documentation.html

9. **List of presentations given at DORIS or IDS meetings**
   Full list of presentations given at DORIS or IDS meetings with the corresponding access links

https://ids-doris.org/ids/reports-mails/meeting-presentations.html

10. List of documents and links to discover the DORIS system
https://ids-doris.org/analysis-coordination/documents-related-to-data-analysis.html

11. List of DORIS publications in international peer-reviewed journals
https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html

12. Overview of the DORIS system
https://www.aviso.altimetry.fr/en/techniques/doris.html

13. Overview of the DORIS satellite constellation
https://ids-doris.org/doris-system/satellites.html

14. Site logs
DORIS stations description forms and pictures from the DORIS installation and maintenance department: https://ids-doris.org/doris-system/tracking-network/site-logs.html

15. Virtual tour of the DORIS network with Google Earth
Download the file at https://ids-doris.org/doris-system/tracking-network/network-on-google-earth.html and visit the DORIS sites all around the world.

16. IDS video channel
Videos of the DORIS-equipped satellites in orbit
https://www.youtube.com/@internationaldorisservice-7170

17. IDS Newsletters
Find all the issues published in color with live links on the IDS website
https://ids-doris.org/ids/reports-mails/newsletter.html

18. Photo Gallery
https://ids-doris.org/ids/gallery.html

19. More contacts
For particular requests, you may also contact the following people:

Governing Board

Frank Lemoine (chairman)
NASA Goddard Space Flight Center
Code 61A, Geodesy and Geophysics Laboratory
Greenbelt, Maryland 20771 U.S.A.
Phone: +1 (301) 614-6109
E-mail: Frank.G.Lemoine@nasa.gov

Central Bureau

Laurent Soudarin (director)
CLS
11 rue Hermes
Parc Technologique du Canal
31520 Ramonville Saint-Agne
France
Phone: +33 (0)5 61 39 48 49 / 5 61 39 47 90
E-mail: lsoudarin@groupcls.com

DORIS System

Claude Boniface
CNES
18, avenue Edouard Belin
31401 Toulouse Cedex 9
France
Phone: +33 (0)5 61 27 42 44
E-mail: claude.boniface@cnes.fr

Network

Jérôme Saunier
Institut National de l'Information Géographique et Forestière
73, avenue de Paris,
94165 Saint-Mandé Cedex
France
Phone: +33 (0)1 43 98 83 63
E-mail: jerome.saunier@ign.fr

Analysis Coordination

Petr Štěpánek
Geodetic Observatory Pecný, Research Institute of Geodesy
Topography and Cartography, Ondrejov 244
25165 Prague-East
Czech Republic
Phone: +420-323-649235

Combination Center

Guilhem Moreaux
CLS
11 rue Hermes
Parc Technologique du Canal
31520 Ramonville Saint-Agne
France
Phone: +33 (0)5 61 39 48 47 / 5 61 39 47 90
E-mail: gmoreaux@groupcls.com

CDDIS Data Center

Patrick Michael
NASA Goddard Space Flight Center
Code 690, Solar System Exploration Division
Greenbelt, Maryland 20771
USA
Phone: +1 (301) 614-5370
E-mail: Patrick.Michael@nasa.gov

IGN Data Center

Jérôme Saunier
Institut National de l'Information Géographique et Forestière
73, avenue de Paris,
94165 Saint-Mandé Cedex
France
Phone: +33 (0)1 43 98 81 97
E-mail: jerome.saunier@ign.fr

20 IDS INFORMATION SYSTEM

20.1 WHAT AND WHERE

IDS has three data/information centers:

- CB: the Central Bureau web and ftp sites at CLS
- DC: the Data Center(s): * CDDIS: web and ftp sites * IGN: ftp sites
- AC: the Analysis Coordination webpages on the CB web site

The baseline storage rules are as follows:

- CB produces/stores/maintains basic information on the DORIS system, including various standard models (satellites, receivers, signal, reference frames, etc.).
- DC store observational data, products, and ancillary information required for the use of these data and products + formats and analysis descriptions.
- AC refers to CB and DC information on the data and modeling and generates/stores analyses of the products.

Two criteria are considered for deciding where files are stored/maintained:

1. the responsibility for their content and update,
2. the ease of user access.

To avoid information inconsistencies, duplication is minimized. Logical links and cross-referencing between the three types of information centers are systematically used.
Products are deposited in ad hoc DCs areas. The analysis centers need to have an account at both DCs.

A description of the data structure and formats is available at:
https://ids-doris.org/ids/data-products/data-structure-and-formats.html

20.2 WEB AND FTP SITES

20.2.1 IDS WEB SITE

address: https://ids-doris.org (or https://www.ids-doris.org)

The IDS web site gives general information on the Service, provides access to the DORIS system pages on the AVISO web site, and hosts the Analysis Coordination pages.

It is composed of four parts:

- "IDS" describes the organization of the service and includes documents, access to the data and products, event announcements, contacts and links.
- "DORIS System" allows to access general description of the system and gives information about the system monitoring and the tracking network.

- “Analysis Coordination” provides information and discussion areas about the analysis strategies and models used in the IDS products. It is maintained by the Analysis Coordinator with the support of the Central Bureau.
- "Web service" gives access to DOR-O-T, the IDS Web service that proposes a family of plot tools to visualize time series of DORIS-related products and a network viewer to select sites.

It is supplemented by a site map, a glossary, FAQs, a history of site updates, news on the IDS and news on DORIS.

The main headings of the “IDS” parts are:

- Organization: structure of the service, terms of reference, components
- Data & Products: tables of data and products, information and data center organization, data structure and formats, access information to the IDS Data Centers and to the Central Bureau ftp site.
- Documentation: synthetic table of the documentation available, newsletters, documents of the IDS components, DORIS bibliography including DORIS-related peer-reviewed publications and citation rules, meeting presentations, mail system messages, etc.
- Meetings: calendars of the meetings organized by IDS or relevant for IDS, as well as links to calendars of other international services and organizations.
- Contacts and links: IDS contacts, directory, list of websites related to IDS activities
- Gallery: photo albums for the DORIS stations (local teams, equipment, obstruction views) and IDS meetings.

The headings of the “DORIS system” part are:

- The DORIS technique (a link to the official DORIS website): a description of the DORIS system on the AVISO web site.
- Tracking network: Site logs, station coordinate time series, maps, network on Google Earth, station management.
- Satellites: information on the DORIS missions.
- System monitoring: table of events that occurred on the DORIS space segment and ground segment, classified into 4 categories ("Station", "System", "Earthquake", "Data"), station performance plots from the CNES MOE and POE processing.

The headings of the “Analysis Coordination” part are:

- Presentation: a brief description of this section
- Combination Center: information about the activity and products, cumulative solution, DPOD, contributions to ITRF2008, ITRF2014 (list of standards used by IDS Analysis Centers) and next ITRF2020
- Documents for the data analysis: about the DORIS system’s components (space segment, ground segment, stations, observations), the models used for the analysis, the products and their availability.
- About DORIS/RINEX format: all the material related to the DORIS/RINEX gathered on one page.
- DORIS related events: history of the workshops, meetings, analysis campaigns...
- Discussion: archive of the discussions before the opening of the forum.

DORIS and IDS news as well as site updates are accessible from the Home page. Important news is displayed in the box “Highlights”. The lists of news about the DORIS system and IDS activities (also widely distributed through the DORISmails) are resumed respectively in the two headings "What's new on DORIS" (https://ids-doris.org/doris-news.html) and "What's new on IDS" (https://ids-doris.org/ids-news.html). The history of the updates of the website is given in "Site updates" (https://ids-doris.org/site-updates.html).

The IDS web site is maintained by the Central Bureau.

20.2.2 IDS WEB SERVICE

address: https://ids-doris.org/webservice (or https://apps.ids-doris.org/apps/)

DOR-O-T for DORis Online Tools (pronounced in French like the given name Dorothée) is the IDS web service developed to promote the use of DORIS products. The current version of the service provides tools to browse time series in an interactive and intuitive way. Besides products provided by the CNES Orbitography Team and the IDS components (Analysis Centers and Combination Center), this service allows comparing time evolutions of coordinates for DORIS and GNSS stations in co-location, thanks to a collaboration with the IGS Terrestrial Frame Combination Center.

The tools proposed by this web service are:

- a NETWORK VIEWER to select sites
- a family of PLOT TOOLS to visualize the following time series:
  - **Station position** differences at observation epochs relative to a reference position: North, East and Up trended time series.
  - **Orbit residuals** and amount of station measurements from CNES Precise Orbit Ephemeris processing: RMS of post-fit orbit residuals, total and validated number of DORIS measurements per arc.
  - **Combination parameters** i.e. outputs of the IDS Combination Center analysis: WRMS of station position residuals, scale and translation parameters, number of stations used in the analysis.
  - **Earth Orientation Parameters** from the IDS Combination Center analysis (Xp, Yp, LOD).
  - **Position residuals** of the cumulative solution from the IDS Combination Center analysis (North, East, Up)

20.2.3 IDS FTP SERVER

address: ftp://ftp.ids-doris.org/pub/ids

The IDS ftp server gives information on the DORIS system and provides analysis results from the Analysis Coordination's combination center.

The main directories are :

- ancillary: documents about the DORIS ancillary data *(such as bus quaternions and solar panel angles of Jason-1 and Jason-2)*

- centers: documents for the analysis centers
- combination_center: products and reports of the combination center
- combinations: working directory of the combination center
- data: documents about the DORIS data *(format description 1.0, 2.1, 2.2, and RINEX, POE configurations for GDRB, GDRC, …)*
- dorismail: archive of the mails of DORISmail mailing list
- dorisreport: archive of the mails of DORISreport mailing list
- dorisstations: archive of the mails of DORISstations mailing list
- events: lists of events occurring on the DORIS system
- ids.analysis.forum: archive of the mails of ids.analysis.forum mailing list
- products: format descriptions of the products *(eop, geoc, iono, snx, sp1, sp3, stcd)*
- satellites: documents and data related to the satellites *(macromodels, nominal attitude model, center of mass and center of gravity history, maneuver history, instrument modelling, corrective model of DORIS/Jason-1 USO frequency, …)*
- stations: documents and data related to the stations *(sitelogs, ties, antennas phase laws, …)*

The contain is described in the document "IDS data structure and formats" (https://ids-doris.org/ids/data-products/data-structure-and-formats.html).

The IDS ftp site is maintained by the Central Bureau. There is a mirror site at CDDIS: ftp://cddis.gsfc.nasa.gov/pub/doris/cb_mirror/ and at IGN: ftp://doris.ign.fr/pub/doris/cb_mirror/

20.2.4 DORIS WEB SITE

Address: https://www.aviso.altimetry.fr/en/techniques/doris.html

The official DORIS web site is hosted by the Aviso website which is dedicated to altimetry, orbitography and precise location missions. The DORIS pages present the principle of the system, its description (instruments onboard, ground beacons, control and processing center, system evolutions, Diode navigator), the applications and the missions. The site is maintained by the Aviso webmaster with the support of the IDS Central Bureau.

20.2.5 DATA CENTERS' FTP AND WEB SITES

Data and products, formats and analysis descriptions are stored at the CDDIS and IGN Data Centers. A detailed description is given in the report of the Data flow Coordinator.

The contain stored on the ftp sites is also described in the document "IDS data structure and formats" (https://ids-doris.org/ids/data-products/data-structure-and-formats.html).

Address of the CDDIS web site:
https://cddis.nasa.gov/Data_and_Derived_Products/DORIS/DORIS_data_and_product_archive.html

Address of the CDDIS data sites:
ftps://gdc.cddis.eosdis.nasa.gov/doris/data and *https://cddis.nasa.gov/archive/doris/data*.

Address of the IGN ftp site: ftp://doris.ign.fr/pub/doris/

20.3 THE MAIL SYSTEM

The mail system of the IDS is one of its main communication tools. Depending on the kind of the information, mails are distributed through the DORISmail, DORISreport or DORISstations. The mails of these four lists are all archived on the mailing list server of CLS. Back-up archives of the text files are also available on the Central Bureau ftp server for the DORISmails and the DORISreports.

A description of the mailing lists can be found on the IDS web site on the page: https://ids-doris.org/report/mails.html

Dedicated mailing lists were also created for the Central Bureau, the Governing Board and the Analysis Working Group, but without archive system.

20.3.1 DORISMAIL

e-mail: dorismail@ids-doris.org

The DORISmails are used to distribute messages of general interest to the users' community (subscribers). The messages concern:

- Network evolution: installation, renovation…
- Data delivery: lack of data, maneuver files
- Satellite status
- Status of the Data Centers
- Meeting announcements
- Calls for participation
- Delivery by Analysis Centers
- etc.…

The messages are moderated by the Central Bureau.

They are all archived on the mailing list server of CLS at the following address:
https://lists.ids-doris.org/sympa/arc/dorismail

They are also available in text format on the IDS ftp site: ftp://ftp.ids-doris.org/pub/ids/dorismail/

20.3.2 DORISREPORT

e-mail : dorisreport@ids-doris.org

This list is used for regular reports from Analysis Centers, from the Analysis coordination and from the CNES POD team. The DORISreport distribution list is composed by Analysis Centers, Data Centers, IDS Governing Board and Central Bureau, CNES POD people delivering data to the Data Centers (subscribers). They are all archived on the mailing list server of CLS at the following address: https://lists.ids-doris.org/sympa/arc/dorisreport

They are also available in text format on the IDS ftp site: ftp://ftp.ids-doris.org/pub/ids/dorisreport/

The list is moderated by the Central Bureau and the CNES POD staff.

20.3.3 DORISSTATIONS

e-mail : dorisstations@ids-doris.org

This mailing list has been opened to distribute information about station events (data gap, positioning discontinuities). The messages are archived on the mailing list server of CLS at the following address: https://lists.ids-doris.org/sympa/arc/dorisstations.

They are also available in text format on the IDS ftp site: ftp://ftp.ids-doris.org/pub/ids/dorisstations/

The archive contains also the mails distributed on the analysis forum before the creation of the dedicated list.

20.3.4 OTHER MAILING LISTS

ids.central.bureau@ids-doris.org: list of the Central Bureau

ids.governing.board@ids-doris.org: list of the Governing Board

ids.cbgb@ids-doris.org: private common list for the Central Bureau and the Governing Board.

ids.awg@ids-doris.org: list of people who attend the AWG, and/or analysis center representatives.

ids.analysis.coordination@ids-doris.org: list of the Analysis Coordination

20.4 HELP TO THE USERS

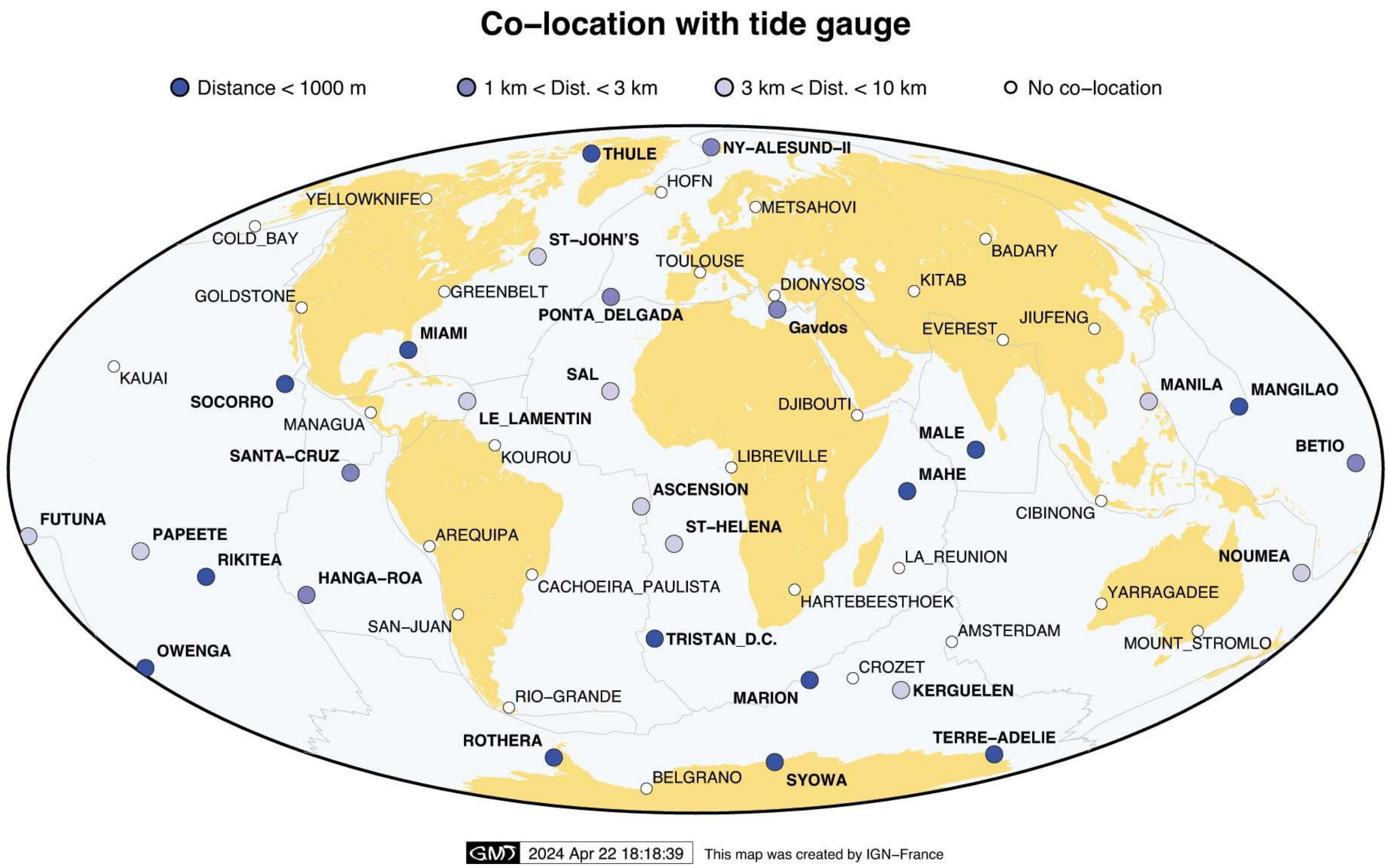
e-mail : ids.central.bureau@ids-doris.org

The contact point for every information requirement is the Central Bureau. It will find a solution to respond to user’s need. A list of contact points has been defined for internal use depending on the kind of questions.

21 DORIS STATIONS / CO-LOCATION WITH TIDE GAUGES

The table and the figure below are managed by IGN and the University of La Rochelle within the framework of their collaboration on « Système d'Observation du Niveau des Eaux Littorales » (SONEL, https://www.sonel.org). 29 DORIS stations are co-located with tide gauge:

DORIS Name	Long	Lat	Country	Start date	Distance (m)	GLOSS id	PSMSL id
ASCENSION	-14.33	-7.92	UK (SOUTH ATLANTIC)	28/02/1997	6500	263	1831
BETIO	172.92	1.35	KIRIBATI	22/10/2006	1600	113	1804
FUTUNA	-178.12	-14.31	FRANCE (POLYNESIA)	18/10/2011	4400	353	2244
GAVDOS	24.11	34.84	GREECE (CRETE)	25/09/23	2000	------	------
HANGA ROA	-109.43	-27.16	CHILE (EASTER ISLAND)	13/04/23	2580	137	1272
KERGUELEN	70.26	-49.35	FRANCE (TAAF)	05/04/1993	3300	23	1849
LE LAMENTIN	-61.00	14.60	FRANCE (MARTINIQUE)	29/06/2013	7000	338	1942
MAHE	55.53	-4.68	SEYCHELLES	20/06/2001	300	339	1846
MALE	73.53	4.20	MALDIVES	15/01/2005	500	28	1753
MANILA	121.03	14.53	PHILIPPINES	26/02/2003	9700	73	145
MANGILAO	144.80	13.43	USA (GUAM IS.)	12/04/2018	830	------	2130
MARION ISLAND	37.86	-46.88	SOUTH AFRICA	01/01/1990	410	20	------
MIAMI	-80.17	25.73	USA (FLORIDA)	10/02/2005	180	332	1858
NOUMEA	166.42	-22.24	FRANCE (CALEDONIA)	27/01/2005	7000	123	2134
NY-ALESUND II	11.83	78.93	NORWAY (SVALBARD)	19/10/2018	2500	345	1421
OWENGA	-176.37	-44.02	NEW ZEALAND (CHATHAM IS.)	20/01/2014	80	------	------
PAPEETE	-149.61	-17.58	FRANCE (POLYNESIA)	27/07/1995	7000	140	1397
PONTA DELGADA	-25.66	37.75	PORTUGAL (AZORES)	02/11/1998	1500	245	258
RIKITEA	-134.97	-23.13	FRANCE (POLYNESIA)	23/09/2006	800	138	1253
ROTHERA	-68.13	-67.57	UK (ANTARCTICA)	01/03/2003	170	342	1931
SAL	-22.98	16.78	CAPE VERDE	15/12/2002	5700	329	1914
SANTA CRUZ	-90.30	-0.75	ECUADOR	01/04/2005	1600	------	1472
SOCORRO	-110.95	18.73	MEXICO	09/06/1989	580	162	1821
ST-HELENA	-5.67	-15.94	UK (SOUTH ATLANTIC)	01/06/1989	5900	264	1845
ST. JOHN'S	-52.68	47.40	CANADA (TERRE-NEUVE)	27/09/1999	3600	223	393
SYOWA	39.58	-69.01	JAPAN (ANTARCTICA)	10/02/1993	1000	95	1396
TERRE ADELIE	140.00	-66.67	FRANCE (ANTARCTICA)	01/02/1997	500	131	2231
THULE	-68.83	76.54	DENMARK (GREENLAND)	28/09/2002	450	343	------
TRISTAN DA CUNHA	-12.31	-37.07	UK (SOUTH ATLANTIC)	10/06/1986	120	266	------


Co–location with tide gauge
Distance < 1000 m
1 km < Dist. < 3 km
3 km < Dist. < 10 km
No co–location
THULE
NY–ALESUND–II
HOFN
YELLOWKNIFE
METSAHOVI
COLD_BAY
ST–JOHN'S
BADARY
TOULOUSE
GOLDSTONE
GREENBELT
DIONYSOS
KITAB
PONTA_DELGADA
JIUFENG
MIAMI
Gavdos
EVEREST
KAUAI
SAL
MANILA
MANGILAO
SOCORRO
LE_LAMENTIN
DJIBOUTI
MANAGUA
MALE
BETIO
SANTA–CRUZ
KOUROU
LIBREVILLE
MAHE
ASCENSION
CIBINONG
FUTUNA
PAPEETE
ST–HELENA
AREQUIPA
RIKITEA
LA_REUNION
NOUMEA
HANGA–ROA
CACHOEIRA_PAULISTA
YARRAGADEE
HARTEBEESTHOEK
SAN–JUAN
AMSTERDAM
TRISTAN_D.C.
MOUNT_STROMLO
OWENGA
CROZET
MARION
KERGUELEN
RIO–GRANDE
ROTHERA
TERRE–ADELIE
BELGRANO
SYOWA
2024 Apr 22 18:18:39
This map was created by IGN–France

22 DORIS STATIONS / HOST AGENCIES

The local teams who look after the DORIS stations make a major contribution to the high quality of the DORIS network constantly improving its robustness and reliability.

The following table gives the list of the organizations involved as host agencies of the DORIS stations.

Station name	Host agency	City, Country
Amsterdam	Institut Polaire Paul Emile Victor (IPEV)	Base Martin-de-Viviès, île Amsterdam, Sub-Antarctica, FRANCE
Arequipa	Instituto Astronómico y Aeroespacial P. Paulet Universidad Nacional de San Agustin (UNSA)	Observatorio de Characato, Arequipa, PERU
Ascension	ESA Telemetry & Tracking Station	Ascension Island, South Atlantic Ocean, UK
Badary	Badary Radio Astronomical Observatory (BdRAO, Institute of Applied Astronomy)	Republic of Buryatia, RUSSIA
Belgrano	Instituto Antártico Argentino (DNA)	Buenos Aires, ARGENTINA
Betio	Kiribati Meteorological Service	Tarawa Island, Republic of KIRIBATI
Cachoeira Paulista	Instituto Nacional de Pesquisas Espaciais (INPE)	Cachoeira Paulista, BRAZIL
Cibinong	Badan Informasi Geospatial (BIG)	Cibinong, INDONESIA
Cold Bay	National Weather Service (NOAA)	Cold Bay, Alaska, U.S.A.
Crozet	Institut Polaire Paul Emile Victor (IPEV)	Base Alfred Faure, archipel de Crozet, Sub-Antarctica, FRANCE
Dionysos	National Technical University of Athens (NTUA)	Zografou, GREECE
Djibouti	Observatoire Géophysique d'Arta (CERD)	Arta, Republic of DJIBOUTI
Everest	Ev-K2-CNR Association	Bergamo, ITALY
Futuna	Météo-France	Wallis-et-Futuna, FRANCE
Gavdos	Technical University of Crete (TUC)	Chania, Crete, GREECE
Goldstone	NASA / GDSCC	Fort Irwin, California, U.S.A.
Grasse	Observatoire de la Côte d'Azur (OCA)	Grasse, FRANCE
Greenbelt	NASA / GSFC / GGAO	Greenbelt, Maryland, U.S.A.

Station name	Host agency	City, Country
Hanga Roa	Universidad de Chile (UdC)	Santiago, CHILE
Hartebeesthoek	HartRAO, South African National Space Agency (SANSA)	Hartebeesthoek, SOUTH AFRICA
Höfn	National Land Survey of Iceland Landmælingar Islands (LMI)	Akranes, ICELAND
Jiufeng	Innovation Academy for Precision Measurement Science and Technology (APM)	Wuhan, CHINA
Kauai	Kokee Park Geophysical Observatory (KPGO)	Kauai Island, Hawaii, U.S.A.
Kerguelen	Institut Polaire Paul Emile Victor (IPEV)	Base de Port-aux-Français, archipel de Kerguelen, Sub-Antarctica, FRANCE
Kitab	Ulugh Beg Astronomical Institute (UBAI)	Kitab, UZBEKISTAN
Kourou	Centre Spatial Guyanais (CSG)	Kourou, FRENCH GUYANA
La Réunion	Observatoire Volcanologique du Piton de La Fournaise (IPGP)	Ile de la Réunion, FRANCE
Le Lamentin	Météo-France	Martinique, French West Indies, FRANCE
Libreville	ESA Tracking Station	N'Koltang, GABON
Mahé	Seychelles Meteorological Authority	Mahé Island, Republic of SEYCHELLES
Male'	Maldives Meteorological Service (MMS)	Male, Republic of MALDIVES
Managua	Instituto Nicaragüense de Estudios Territoriales (INETER)	Managua, NICARAGUA
Mangilao	University of Guam (UoG)	Guam Island, USA
Manila	National Mapping and Ressource Information Authority (NAMRIA)	Taguig, Republic of the PHILIPPINES
Marion	Antartica & Islands Department of Environmental Affairs (DEA)	Marion Island Base, SOUTH AFRICA
Metsähovi	Finnish Geospatial Research Institute National Land Survey (NLS)	Masala, FINLAND
Miami	Rosenstiel School of Marine and Atmospheric Science (RSMAS)	Miami, Florida, U.S.A.
Mount Stromlo	Mount Stromlo Observatory, Geoscience Australia (GA)	Mount Stromlo, Canberra, AUSTRALIA
Nouméa	Direction des Infrastructures, de la Topographie et des Transports Terrestres	Nouméa, New Caledonia, FRANCE
Ny-Ålesund II	Institut Polaire Paul Emile Victor (IPEV) Kartverket (Norwegian Mapping Authority)	Ny-Ålesund, Svalbard, NORWAY
Owenga	Land Information New Zealand (LINZ)	Chatham Island, NEW ZEALAND

Station name	Host agency	City, Country
Papeete	Observatoire Géodésique de Tahiti, Université de la Polynésie Française (UPF)	Fa'a, Tahiti, Polynésie Française, FRANCE
Ponta Delgada	CIVISA / IVAR Universidade dos Açores	Ponta Delgada, Azores, PORTUGAL
Rikitea	Météo-France	Archipel des Gambier, Polynésie Française, FRANCE
Rio Grande	Estación Astronómica de Rio Grande (EARG), Universidad Nacional de la Plata (UNLP)	Rio Grande, ARGENTINA
Rothera	British Antarctic Survey (BAS)	Rothera Research Station, Adelaide Island, Antarctica, UK
Sal	Instituto Nacional de Meteorologia e Geofisica (INMG)	Sal Island, CAPE VERDE
San Juan	Observatorio Astronómico Félix Aguilar Universidad Nacional de San Juan (UNSJ)	San Juan, ARGENTINA
Santa Cruz	Fundación Charles Darwin (FCD)	Santa Cruz Island, Galápagos, ECUADOR
Socorro	Instituto Nacional de Estadística y Geografía (INEGI) Secretaría de Marina Armada (SEMAR)	Aguascalientes, MEXICO Socorro Island, MEXICO
St John's	Geomagnetic Observatory, Natural Resources Canada (NRCan)	St. John's, CANADA
St-Helena	Met Office Saint-Helena Government	Longwood, St Helena Island, South Atlantic, UK
Syowa	National Institute of Polar Research (NIPR)	Syowa Base, Antarctica, JAPAN
Terre Adélie	Institut Polaire Paul Emile Victor (IPEV)	Base de Dumont d'Urville, Terre-Adélie, Antarctica, FRANCE
Thule	National Space Institute at the Technical University of Denmark (DTU Space)	Kgs. Lyngby, DENMARK
Toulouse	Collecte Localisation Satellites (CLS)	Ramonville, FRANCE
Tristan da Cunha	Communications Department of TDC	Tristan da Cunha Island, South Atlantic, UK
Wettzell	Geodetic Observatory Wettzell (BKG)	Bad Kötzting, GERMANY
Yarragadee	Yarragadee Geodetic Observatory, Geoscience Australia (GA)	Yarragadee, AUSTRALIA
Yellowknife	Natural Resources Canada (NRCan)	Yellowknife, CANADA

23 BIBLIOGRAPHY

A fourth special issue on DORIS (after 2006, 2010, and 2016) was published in 2023 in Advances in Space Research (Elsevier) dedicated to new advances in terms of measurement techniques and applications. Ernst Schrama and Denise Dettmering are the Guest Editors. There are eight papers covering the DORIS ground network and equipment, precise orbit determination, DORIS contributions to references frames, in particular to ITRF2020, and the application to ionospheric modelling and validation. The special issue appears in Volume 72, Issue 1 of the journal. The reference is:

> New Results from DORIS for Science and Society, E.J.O. Schrama and D. Dettmerig (Eds.), *ADVANCES IN SPACE RESEARCH*, 72(1):1-128 (1 July 2023)
> https://www.sciencedirect.com/journal/advances-in-space-research/vol/72/issue/1

A full list of articles related to DORIS published in international peer-reviewed journals since 1985 is available on the IDS website at https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html (follow IDS > Reports & Mails > DORIS bibliography > Peer-reviewed journals)

The following list compiles the articles published in 2023:

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

Chen, J.; Ren, X.; Yang, P.; Xu, G.; Huang, L.; Xiong, S.; Zhang, X., 2023. Global Ionosphere Modeling Based on GNSS, Satellite Altimetry, Radio Occultation, and DORIS Data Considering Ionospheric Variation, *JOURNAL OF GEOPHYSICAL RESEARCH-SPACE PHYSICS*, 128(10), DOI: 10.1029/2023JA031514

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

Moreaux, G.; Lemoine, F.G.; Zelensky, N.P.; Moyard, J.; Couhert, A., 2023. DPOD2020: a DORIS extension of the ITRF2020 for Precise Orbit Determination, *ADVANCES IN SPACE RESEARCH*, 72(11):4625-4650, DOI: 10.1016/j.asr.2023.10.006 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 OPEN ACCESS

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

24 NEWSLETTERS

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 electronically. They can also be downloaded from the IDS website at https://ids-doris.org/ids/reports-mails/newsletter.html (follow IDS > Documentation > Newsletter)

To subscribe to the newsletter, please send an e-mail to ids.central.bureau@ids-doris.org, with "Subscribe Newsletter" in the subject.

The following list gives the content of the newsletters issued from #1.

IDS Newsletter #10 (April 2023)

DORIS is on SWOT

Using Near-Real-Time DORIS data for validating real-time GNSS ionospheric maps (D. Dettmering, DGFI-TUM, N. Wang, AIR-CAS)

IDS contribution to the 2020 realization of the International Terrestrial Reference Frame (G. Moreaux, CLS)

Höfn, new DORIS site in Iceland (J. Saunier, IGN)

The host agency in short: Höfn (G.H. Kristinsson, LMI)

IDS life

The DORIS constellation 2023

IDS Newsletter #9 (September 2021)

A new method for monitoring the geocenter motion using DORIS observations (A. Couhert, CNES)

Doppler crossings on-board DORIS receiver carrier satellites (C. Jayles, CNES, J.P. Chauveau, CLS, P. Yaya, CLS)

Major renovation at Réunion Island (J. Saunier, IGN)

La Réunion: the host agency in short (P. Kowalski, OVPF)

The 4th generation of DORIS beacon (J. Saunier, IGN)

IDS life

HY-2D, a new DORIS carrier satellite

IDS Newsletter #8 (December 2020)

2020 celebrates 30 years of the DORIS system

2020, two new missions have joined the DORIS constellation

IDS and DORIS milestones

IDS life

Pascal Willis retires

IDS Newsletter #7 (January 2020)

DORIS in Latin America: more sun, more warmth, and more rythm (J. Saunier, IGN)

The host agencies in short: San Juan (R. C. Podestá, OAFA) and Santa Cruz (J. Carrión, CDF)

IDS life

IDS & DORIS quick reference list

IDS Newsletter #6 (February 2019)

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)

IDS life

IDS Newsletter #5 (September 2018)

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)

IDS life

IDS Newsletter #4 (November 2017)

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)

IDS life

IDS Newsletter #3 (December 2016)

IDS held its Workshop 2016 in La Rochelle (L. Soudarin, CLS)

Looking back over 30 years of DORIS network development (J. Saunier, IGN)

Six DORIS receivers operating in orbit and several more to come (P. Ferrage, CNES)

IDS life

IDS Newsletter #2 (July 2016)

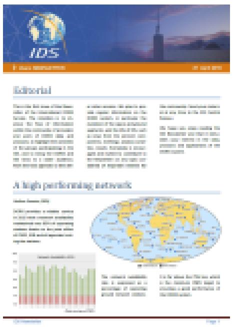
2015 Nepal Earthquakes moved the DORIS station on Everest by a few centimeters (G. Moreaux, CLS)

DORIS-VLBI compatibility tests at the Geodetic Observatory Wettzell (T. Klügel, BKG)

DORIS in Managua (J. Saunier, IGN)

IDS life

IDS Newsletter #1 (April 2016)



A high performing network (J. Saunier, IGN)

Two new DORIS instruments in orbit

(P. Ferrage and C. Manfredi, CNES)

DORIS back in Goldstone (J. Saunier, IGN)

DORIS contributes to the International Terrestrial Reference Frame (G. Moreaux, CLS)

IDS life

25 GLOSSARY

AAC

Associate Analysis Center

AC

Analysis Center

AGU

American Geophysical Union.

AVISO

Archiving, Validation and Interpretation of Satellite Oceanographic data. AVISO distributes satellite altimetry data from TOPEX/Poseidon, Jason-1, Jason-2, ERS-1 and ERS-2, and Envisat, and DORIS precise orbit determination and positioning products.

AWG

Analysis Working Group

CB

Central Bureau

CDDIS

Crustal Dynamics Data Information System

CLS

Collecte Localisation Satellites. Founded in 1986, CLS is a subsidiary of CNES and Ifremer, specializes in satellite-based data collection, location and ocean observations by satellite.

CNES

Centre National d'Etudes Spatiales. The Centre National d'Etudes Spatiales is the French national space agency, founded in 1961.

CNRS

Centre National de la Recherche Scientifique. The Centre National de la Recherche Scientifique is the leading research organization in France covering all the scientific, technological and societal fields

CryoSat-2

Altimetry satellite built by the European Space Agency launched on April 8 2010. The mission will determine the variations in the thickness of the Earth's continental ice sheets and marine ice cover.

CSR

Center for Space Research, the University of Texas

CSTG

Coordination of Space Technique in Geodesy

DC

Data Center

DGXX

DORIS receiver name (3rd Generation)

DIODE

Détermination Immédiate d'Orbite par DORIS Embarqué. Real-time onboard DORIS system used for orbit determination.

DORIS

Doppler Orbitography and Radiopositioning Integrated by Satellite. Precise orbit determination and location system using Doppler shift measurement techniques. A global network of orbitography beacons has been deployed. DORIS was developed by CNES, the French space agency, and is operated by CLS.

DPOD

DORIS extension of the ITRF for Precise Orbit Determination. The so-called DPOD product is a set of coordinates and velocities of all the DORIS tracking stations for Precise Orbit Determination (POD) applications.

ECMWF

European Centre for Medium-range Weather Forecasting

EGU

European Geosciences Union

EOP

Earth Orientation Parameters

Envisat

ENVIronmental SATellite Earth-observing satellite (ESA)

ESA

European Space Agency. The European Space Agency is a space agency founded in 1975. It is responsible of space projects for 17 European countries.

ESA, esa

acronyms for *ESA/ESOC* Analysis Center, Germany

ESOC

European Space Operations Centre (ESA, Germany)

EUMETSAT

EUropean organisation for the exploitation of METeorological SATellites

GAU, gau

acronyms for the *Geoscience Australia* Analysis Center, Australia

GB

Governing Board

GDR-B, GDR-C, GDR-D, GDR-E

Versions B, C, D, and E of **Geophysical Data Record**

geoc

Specific format for geodetic product: time series files of coordinates of the terrestrial reference frame origin (geocenter)

eop

Specific format for geodetic product: time series files of Earth orientation parameters (EOP)

GFZ

GeoForschungsZentrum, German Research Centre for Geosciences

GGOS

Global Geodetic Observing System

GNSS

Global Navigation Satellite System

GLONASS

Global Navigation Satellite System (Russian system)

GOP, gop

acronyms for the *Geodetic Observatory of Pecný* Analysis Center, Czech Republic

GRG, grg

Acronyms for the CNES/CLS Analysis Center, France (see also LCA))

GRGS

Groupe de Recherche de Géodésie Spatiale

GSC, gsc

acronyms for the *NASA*/*GSFC* Analysis Center, USA

GSFC

Goddard Space Flight Center (NASA).

HY-2

HY (for **HaiYang** that means 'ocean' in Chinese) is a marine remote sensing satellite series planned by China (HY-2A (2011), HY-2B (2012), HY-2C (2015), HY-2D (2019))

IAG

International Association of Geodesy

IDS

International DORIS Service

IERS

International Earth rotation and Reference systems Service

IGN

Institut national de l'information géographique et forestière, French National Geographical Institute (formerly Institut Géographique National)

IGN, ign

acronyms for *IGN/IPGP* Analysis Center, France

IGS
International GNSS Service

ILRS
International Laser Ranging Service

INA, ina
acronyms for the *INASAN* Analysis Center, Russia

INASAN
Institute of Astronomy, Russian Academy of Sciences

IPGP
Institut de Physique du Globe de Paris

ISRO
Indian Space Research Organization

ITRF
International Terrestrial Reference Frame

IUGG
International Union of Geodesy and Geophysics

IVS
International VLBI Service for Geodesy and Astrometry

Jason
Altimetric missions (CNES/NASA), follow-on of TOPEX/Poseidon. Jason-1 was launched on December 7, 2001, Jason-2 on June 20, 2008, and Jason-3 on January 17, 2016.

JOG
Journal Of Geodesy

JASR
Journal of Advances in Space Research

LCA, lca
Former acronyms for the CNES/CLS Analysis Center, France (previously LEGOS/CLS Analysis Center)

LEGOS
Laboratoire d'Etudes en Géodésie et Océanographie Spatiales, France

LRA
Laser Retroreflector Array. One of three positioning systems on TOPEX/Poseidon and Jason. The LRA uses a laser beam to determine the satellite's position by measuring the round-trip time between the satellite and Earth to calculate the range.

MOE
Medium Orbit Ephemeris.

NASA

National Aeronautics and Space Administration. The National Aeronautics and Space Administration is the space agency of the United States, established in 1958.

NCEP

National Center for Environmental Prediction (NOAA).

NLC, ncl

Acronyms for *University of Newcastle* Analysis Center, UK

NOAA

National Oceanic and Atmospheric Administration. The National Oceanic and Atmospheric Administration (NOAA) is a scientific agency of the United States Department of Commerce focused on the studies of the oceans and the atmosphere.

OSTST

Ocean Surface Topography Science Team

POD

Precise Orbit Determination

POE

Precise Orbit Ephemeris

Poseidon

One of the two altimeters onboard TOPEX/Poseidon (CNES); Poseidon-2 is the Jason-1 altimeter.

RINEX/DORIS

Receiver INdependent EXchange. Specific format for DORIS raw data files, based on the GPS-dedicated format

SAA

South Atlantic Anomaly

SARAL

Satellite with ARgos and Altika

Sentinel-3

The Sentinel-3 satellites fit into the Copernicus program, a joint project between Esa and European Union. They are dedicated to Earth monitoring and operational oceanography. Sentinel-3A was launched on February 16, 2016, and Sentinel -3B on April 25, 2018.

Sentinel-6

The Sentinel-6 mission is part of the Copernicus program and is a result of international cooperation between Esa, Eumetsat, European Union, Noaa, Cnes and Nasa/JPL. Sentinel-6 Michael Freilich (also named Jason-CS / Sentinel-6A) is the follow-on to Jason-3. It carries a radar altimeter to measure global sea-surface height, primarily for operational oceanography and for climate studies.

SINEX

Solution (software/technique) Independent Exchange. Specific format for files of geodetic products

SIRS

Service d'Installation et de Renovation des Balises (IGN). This service is in charge of all the relevant geodetic activities for the maintenance of the DORIS network.

SLR

Satellite Laser Ranging

SMOS

Service de Maintenance Opérationnelle des Stations (CNES). This service is responsible for the operational issues of the DORIS stations

snx see SINEX

SOD

Service d'Orbitographie DORIS, CNES DORIS orbitography service

SPOT

Système Pour l'Observation de la Terre. Series of photographic remote-sensing satellites launched by CNES.

sp1, sp3

Specific format for orbit ephemeris files

SSALTO

Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation precise. The SSALTO multi-mission ground segment encompasses ground support facilities for controlling the DORIS and Poseidon instruments, for processing data from DORIS and the TOPEX/Poseidon, Jason-1, Jason-2 and Envisat-1 altimeters, and for providing user services and expert altimetry support.

STCD

STation Coordinates Difference. Specific format for time series files of station coordinates (geodetic product)

STPSAT

US Air Force **Space Test Program SATellite.** The first satellite **STPSAT1** was launched in 2007 with a new DORIS receiver called CITRIS. This experiment is dedicated to global ionospheric measurements.

SWOT

Surface Water Ocean Topography. Swot is a joint project including Nasa, Cnes, the Canadian Space Agency and the UK Space Agency. The goal is to join both land hydrology and oceanography communities in a single satellite. The technology for Swot is a Ka-band Radar Interferometer (KaRIn, 0.86 cm wavelength).

TOPEX/Poseidon

Altimetric satellite (NASA/CNES).

USO

Ultra-Stable Oscillator

UTC

Coordinated Universal Time. Timekeeping system that relies on atomic clocks to provide accurate measurements of the second, while remaining coordinated with the Earth's rotation, which is much more irregular. To stay synchronized, UTC has to be adjusted every so often by adding one second to the day, called a leap second, usually between June 30 and July 1, or between December 31 and January 1. This is achieved by counting 23h59'59", 23h59'60" then 00h00'00". This correction means that the Sun is always at its zenith at noon exactly (accurate to the second).

VLBI

Very Long Baseline Interferometry.

WG

Working Group

ZTD

Zenith Tropospheric Delay

CONTACTS

Chairperson
Frank Lemoine (NASA/GSFC)
frank.g.lemoine@nasa.gov

Central Bureau
Laurent Soudarin (CLS)
lsoudarin@groupcls.com

DORIS System
Claude Boniface (CNES)
claude.boniface@cnes.fr

DORIS Network
Jérôme Saunier (IGN)
jerome.saunier@ign.fr

Data flow coordinator
Patrick Michael (NASA/GSFC)
benjamin.p.michael@nasa.gov

Analysis Coordination
Petr Štěpánek
(Geodetic Observatory Pecný)
ids.analysis.coordination@ids-doris.org

Combination Center
Guilhem Moreaux (CLS)
gmoreaux@groupcls.com

www.ids-doris.org

The IDS is a service of the International Association of Geodesy **(IAG)**. It contributes to the International Earth rotation and Reference frames Service **(IERS)** and the Global Geodetic Observing System **(GGOS)**.
It is a network member of the International Science Council World Data System **(WDS)**.