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IDS

ACTIVITY REPORT 2017

International Doris Service

International DORIS Service Activity Report 2017

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International DORIS Service

Central Bureau

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Preface

In this volume, the International DORIS Service documents the work of the IDS components between January 2017 and December 2017. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2017 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 of 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

http://ids-doris.org/documents/report/IDS_Report_2017.pdf

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ABOUT IDS

1 INTRODUCTION

As other space-techniques had already organized into services - the International GNSS Service (IGS) for GPS, GLONASS and, in the future, Galileo (*Beutler et al. 1999*), the International Laser Ranging Service (ILRS) for both satellite laser ranging and lunar laser ranging (*Pearlman et al. 2002*) and the International VLBI Service for Geodesy and Astrometry (IVS) for geodetic radio-interferometry (*Schlueter et al. 2002*) -, the 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 (*Rummel et al. 2005*; *Willis et al. 2005*), and to foster a larger international cooperation on this topic.

At present, more than 60 groups from 38 different countries participate in the IDS at various levels, including 50 groups hosting DORIS stations in 35 countries all around the globe.

Two analysis centers contributed as individual DORIS solutions to ITRF2005 and in 2006 four analysis centers provided results for 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, a first IDS combined solution (*Valette et al., 2010*) 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 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, 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.

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.

2 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 (*Tavernier et al. 2003*).

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 (*Tavernier et al. 2002*) 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 2017, IDS organized a meeting of the Analysis Working Group on May 22-24 at University College London (UK).

In 2018, three events are scheduled:

- a meeting of the Analysis Working Group is scheduled in Toulouse (France) on June 11;
- the retreat IDS in Caussens (France) and a Governing Board meeting on June 13-15;
- the IDS workshop 2018 in Ponta Delgada (Azores Archipelago), Portugal, on September 24-26, as part of the 25 Years of Progress in Radar Altimetry Symposium with the Ocean Surface Topography Science Team (OSTST) meeting.

Date	Event	Location
2000	DORIS Days http://ids-doris.org/report/meeting-presentations/doris-days-2000.html	Toulouse France
2002	IDS workshop http://ids-doris.org/report/meeting-presentations/ids-workshop-2002.html	Biarritz France
2003	IDS Analysis Workshop http://ids-doris.org/report/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 http://ids-doris.org/report/meeting-presentations/ids-plenary-meeting-2004.html	Paris France
2006	IDS workshop http://ids-doris.org/report/meeting-presentations/ids-workshop-2006.html	Venice Italy
2008	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-03-2008.html Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-06-2008.html IDS workshop http://ids-doris.org/report/meeting-presentations/ids-workshop-2008.html	Paris France Paris France Nice France
2009	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-03-2009.html	Paris France
2010	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-03-2009.html IDS workshop & 20th anniversary of the DORIS system http://ids-doris.org/report/meeting-presentations/ids-workshop-2010.html	Darmstadt Germany Lisbon Portugal

Date	Event	Location
2011	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-05-2011.html	Paris France
2012	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-05-2012.html IDS workshop http://ids-doris.org/report/meeting-presentations/ids-workshop-2012.html	Prague Czech Republic Venice Italy
2013	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-04-2013.html Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-10-2013.html	Toulouse France Washington USA
2014	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-03-2014.html IDS workshop http://ids-doris.org/report/meeting-presentations/ids-workshop-2014.html	Paris France Konstanz Germany
2015	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-05-2015.html Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-10-2015.html	Toulouse France Greenbelt USA
2016	Analysis Working Group Meeting http://ids-doris.org/report/meeting-presentations/ids-awg-05-2016.html IDS workshop http://ids-doris.org/report/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

Table 2. List of IDS events organized between 2004 and 2017

3 ORGANIZATION

The IDS organization is very similar to the other IAG Services (IGS, ILRS, IVS) and IUGG Service such as IERS (**Figure 1**).

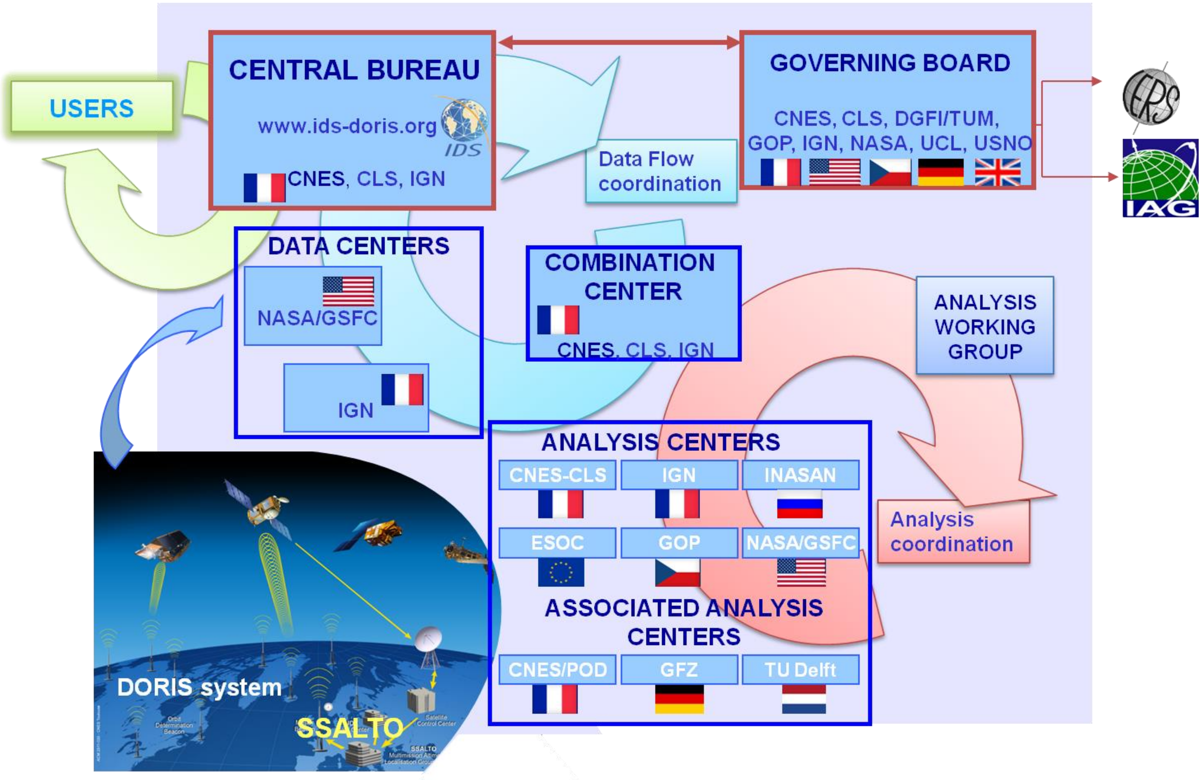


Figure 1. IDS organization

3.1 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 a number of nonvoting members. The membership is chosen to try to strike the right balance between project specialists and the general community.

The elected members have staggered four-year terms, with elections every two years. There is no limit to the number of terms that a person may serve, however he or she may serve only two terms consecutively as an elected member. 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.

Table 3 gives the list of GB's members since 2003, the members in office for 2017 and 2018 are indicated in bold.

Position	Term	Status	Name	Affiliation	Country
Analysis coordinator	**2015-2018**	**Elected**	**Hugues Capdeville** **Jean-Michel Lemoine**	**CLS** **CNES/GRGS**	**France**
	2013-2014	*Ext'd*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2009-2012	*E.b.GB*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2005-2008		*Frank Lemoine (subst.)*	*NASA/GSFC*	*USA*
	2003-2005		*Martine Feissel-Vernier*	*IGN/Paris Obs.*	France
Data Centers' representative	**2017-2020**	**Elected**	**Patrick Michael**	**NASA/GSFC**	**USA**
	2013-2016	*Elected*	*Carey Noll*	*NASA/GSFC*	*USA*
	2009-2012	*Elected*	*Carey Noll*	*NASA/GSFC*	*USA*
	2003-2008		Carey Noll	NASA/GSFC	USA
Analysis Centers' representative	**2017-2020**	**Elected**	**Frank Lemoine (chair)**	**NASA/GSFC**	**USA**
	2013-2016	*Elected*	*Pascal Willis (chair)*	*IGN+IPGP*	*France*
	2009-2012	*Elected*	*Pascal Willis (chair)*	*IGN+IPGP*	*France*
	2003-2008		*Pascal Willis*	*IGN+IPGP*	*France*
Member at large	**2015-2018**	**Elected**	**Marek Ziebart**	**UCL**	**UK**
	2013-2014	*Ext'd*	*John Ries*	*Univ. Texas/CSR*	*USA*
	2009-2012	*E.b.GB*	*John Ries*	*Univ. Texas/CSR*	*USA*
	2003-2008		*John Ries*	*Univ. Texas/CSR*	*USA*
Member at large	**2017-2020**	**Elected**	**Denise Dettmering**	**DGFI/TUM**	**Germany**
	2013-2016	*Elected*	*Richard Biancale*	*CNES/GRGS*	*France*
	2009-2012	*E.b.GB*	*Pascale Ferrage*	*CNES*	*France*
	2003-2008		*Gilles Tavernier (chair)*	*CNES*	*France*
Director of the Central Bureau	**Since 2003**	**App.**	**Laurent Soudarin**	**CLS**	**France**
Combination Center representative	**Since 2013**	**App.**	**Guilhem Moreaux**	**CLS**	**France**
Network representative	**2017-2020**	**App.**	**Jérôme Saunier**	**IGN**	**France**
	2013-2016	*App.*	*Jérôme Saunier*	*IGN*	*France*
	2010-2012		*Bruno Garayt (subst.)*	*IGN*	*France*
	2009	*E.b.GB*	*Hervé Fagard*	*IGN*	*France*
	2003-2008		*Hervé Fagard*	*IGN*	*France*
DORIS system representative	**2017-2020**	**App.**	**Pascale Ferrage**	**CNES**	**France**
	2013-2016	*App.*	*Pascale Ferrage*	*CNES*	*France*
IAG representative	**2017-2020**	**App.**	**Petr Štěpánek**	**Geodetic Obs. Pecny**	**Czech Republic**
	2013-2016	*App.*	*Michiel Otten*	*ESOC*	*Germany*
	2009-2012	*App.*	*Michiel Otten*	*ESOC*	*Germany*
	2003-2008		*Not designed*		
IERS representative	**2017-2020**	**App.**	**Brian Luzum**	**USNO**	**USA**
	2013-2016	*App.*	*Brian Luzum*	*USNO*	*USA*
	2009-2012	*App.*	*Chopo Ma*	*NASA/GSFC*	*USA*
	2003-2008		*Ron Noomen*	*TU Delft*	*Netherlands*

App. = Appointed; Elected = Elected by IDS Associates; E.b.GB = Elected by the previous Governing Board; Ext'd = Extended term for two years linked to the set-up of the partial renewal process

Table 3. Composition of the IDS Governing Board since 2003

3.2 REPRESENTATIVES AND DELEGATES

IDS representatives and delegates are:

IDS representatives to the IERS:

Analysis Coordinator: Hugues Capdeville (+Jean-Michel Lemoine)
Network representative: Jérôme Saunier

IDS representatives to GGOS consortium: Frank Lemoine, Laurent Soudarin

IDS representative to GGOS Bureau of Networks and Observations: Jérôme Saunier

3.3 CENTRAL BUREAU

In 2017, the IDS Central Bureau is organized as follow:

- Laurent Soudarin CLS (Director)
- Pascale Ferrage CNES
- Jérôme Saunier IGN
- Guilhem Moreaux CLS
- Pascal Willis IGN/IPGP

DORIS SYSTEM

4 THE NETWORK

Jérôme Saunier / IGN, France

4.1 GENERAL STATUS OF THE NETWORK

The DORIS ground network is made up of 56 permanent stations (including 4 master beacons and 1 time beacon) well distributed over the Earth's land surface for the purposes of orbitography and altimetry (**Figure 2**). Two additional DORIS stations are used for other scientific applications: Grasse (France) and Wettzell (Germany).

Despite the extensive outage of 4 stations (Santa-Cruz, Easter, Mahé, and Cibinong), the DORIS network provided a reliable service in 2017 with an annual mean of 89% of active sites thanks to the responsiveness and the combined efforts of CNES, IGN and all agencies hosting the stations: 6 failed beacons and 2 failed antennas were replaced (**Figure 3**, **Figure 4**).

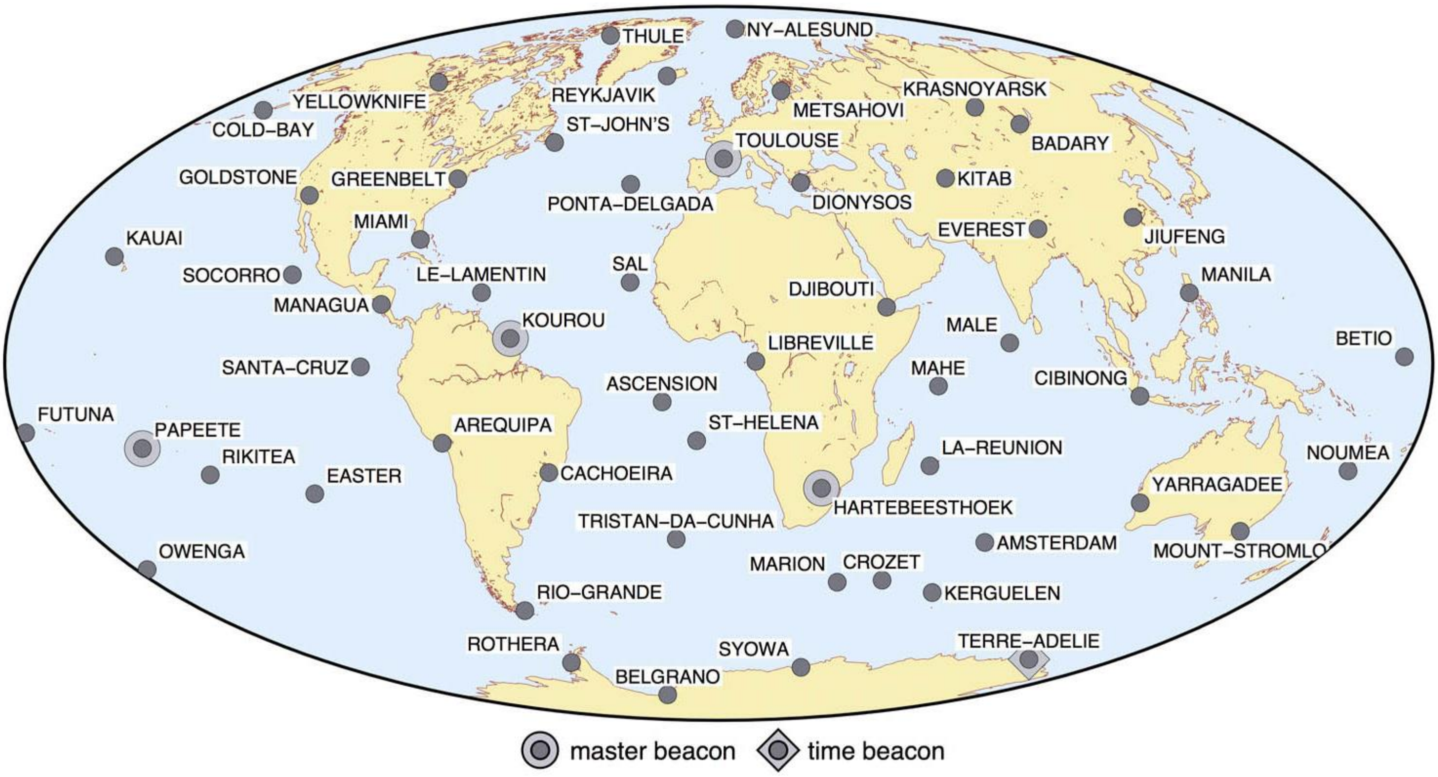


Figure 2. The DORIS permanent network

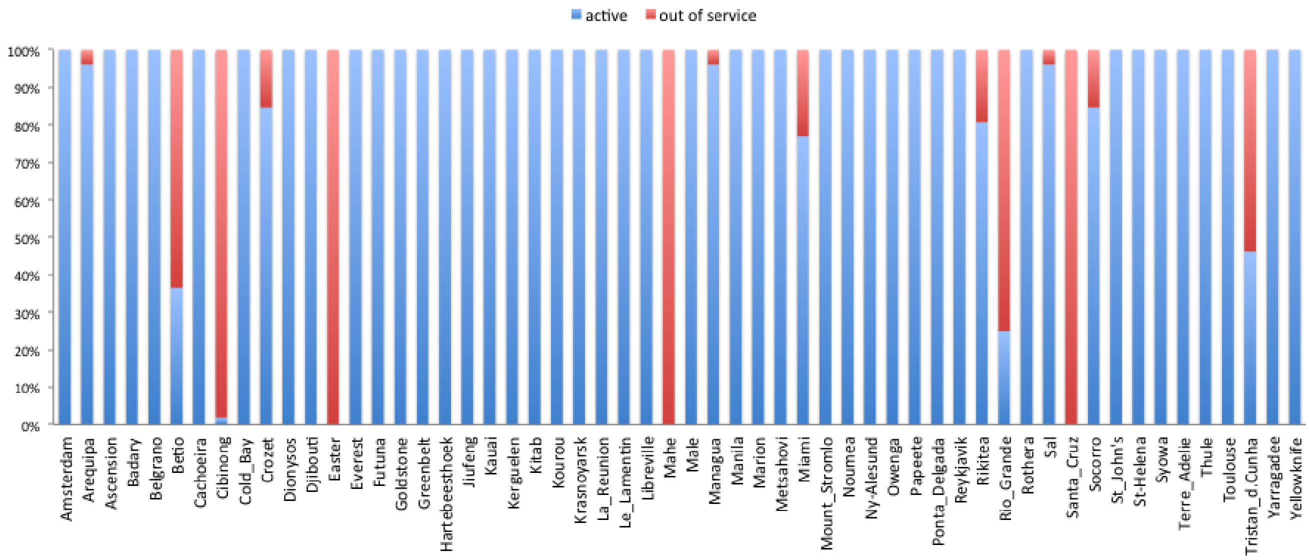


Figure 3. Network activity 2017

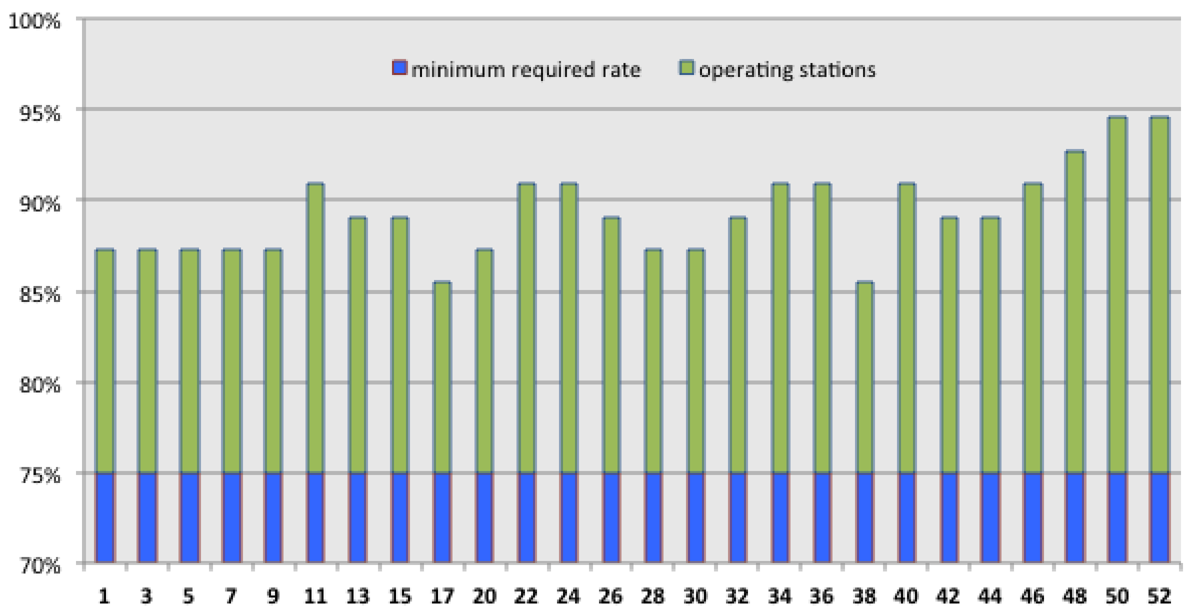


Figure 4. Network availability 2017

4.2 EVOLUTION AND DEVELOPMENT

2017 was a transition year with the CNES internal reorganization that has led to focus on emergency management (operational maintenance) at the expense of the network evolution. Unfortunately, none of the plans to install new DORIS stations was brought to completion due to delays in shipping equipment, custom clearances or other administrative procedures.

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

The tie vectors between successive DORIS antenna locations on the same site were reassessed and made available on the IDS data centers: internal ties file "DORIS_int_ties.txt".

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

Co-location with other space geodetic techniques and with tide gauges remains a major objective for the DORIS network (**Figure 5**). After the DORIS station installation at the geodetic observatory Wettzell in 2016, the IDS plans to install in April 2018 a DORIS station in Guam Island (co-location with IGS station "GUUG" and tide gauge of Pago Bay PSMSL 2130). This new site is also particularly interesting in that it offers coverage of the western North Pacific Ocean over the Micronesia and the Mariana Trench.

In 2017 the following sites were visited:

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

In 2018, the overall objectives are:

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

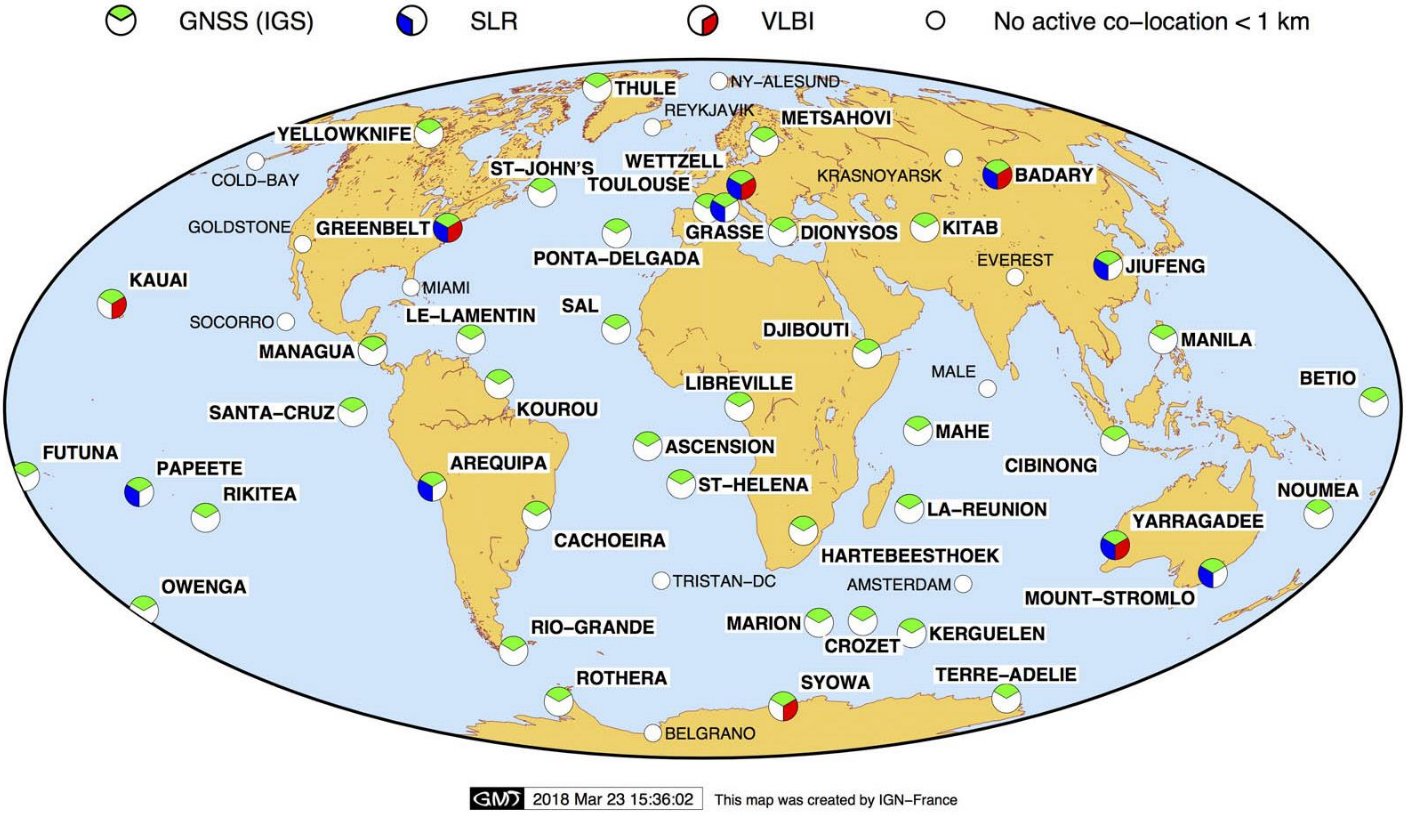


Figure 5. DORIS stations co-located with other IERS techniques

5 THE SATELLITES WITH DORIS RECEIVERS

Pascale Ferrage / CNES, France

5.1 CURRENT MISSIONS

The DORIS system was 27 years old in 2017 and its performance remains unbeatable thanks to permanent enhancements to the system and its components. Thirteen DORIS receivers have flown on various Earth observation and altimetry missions since 1990, and many future missions currently under preparation should guarantee a constellation of DORIS contributor satellites up to 2030 and beyond.

The DORIS constellation includes currently six satellites at altitudes of 720 and 1300 km, with almost polar or TOPEX-like inclination (66 deg.).

Some of the early SPOT-2 data could not be recovered between 1990 and 1992, due to computer and data format limitations. Except for this time period, all DORIS-equipped satellites have provided continuous data to the IDS data centers. Please note the large increase in the number of DORIS satellites around mid-2002 (**Figure 6**).

Another satellite named STPSAT1 (Plasma Physics and Space Systems Development Divisions, Naval Research Laboratory) launched in March 2007 was equipped with a CITRIS receiver of the DORIS signal. This experiment was dedicated to global ionospheric measurements. Unfortunately, the CITRIS data are not available on IDS Data Centers.

Table 4 gives the list of DORIS mission contributing to IDS, and the data availability.

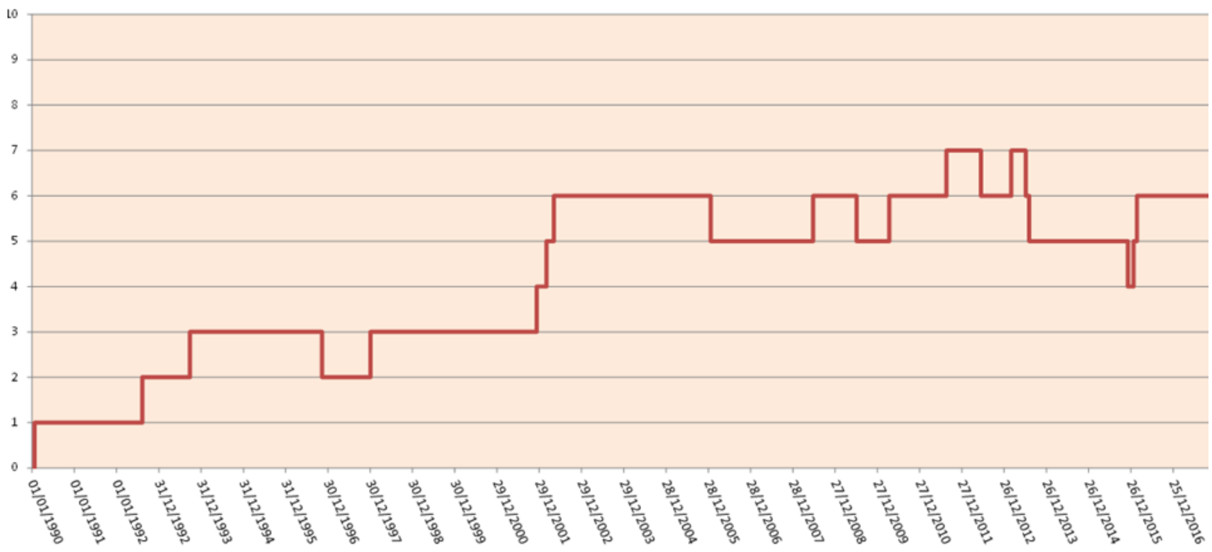


Figure 6. Number of DORIS missions contributing to IDS (December 2016)

Satellite	Start	End	Space Agency	Type	instruments
SPOT-2	31-MAR-1990 04-NOV-1992	04-JUL-1990 15-JUL-2009	CNES	Remote sensing	DG1[1]
TOPEX/Poseidon	25-SEP-1992	01-NOV-2004	NASA/CNES	Altimetry	DG1, SLR, GNSS
SPOT-3	01-FEB-1994	09-NOV-1996	CNES	Remote sensing	DG1
SPOT-4	01-MAY-1998	24-JUN-2013	CNES	Remote sensing	DG1
JASON-1[3]	15-JAN-2002	21-JUN-2013	NASA/CNES	Altimetry	DG2[2], SLR, GNSS
SPOT-5	11-JUN-2002	01-DEC-2015	CNES	Remote sensing	DG2
ENVISAT	13-JUN-2002	08-APR-2012	ESA	Altimetry, Environment	DG2, SLR
JASON-2	12-JUL-2008	PRESENT	NASA/CNES	Altimetry	DGXX[4], SLR, GNSS
CRYOSAT-2	30-MAY-2010	PRESENT	ESA	Altimetry, ice caps	DGXX, SLR
HY-2A	1-OCT-2011	PRESENT	CNSA, NSOAS	Altimetry	DGXX, SLR, GNSS
SARAL/ALTIKA	14-MAR-2013	PRESENT	CNES/ISRO	Altimetry	DGXX, SLR, GNSS
JASON-3	19-JAN-2016	PRESENT	NASA/CNES/NOAA	Altimetry	DGXX, SLR, GNSS
SENTINEL-3A	23-FEV-2016	PRESENT	GMES/ESA	Altimetry	DGXX, SLR, GNSS

Table 4. DORIS missions and data available at IDS data centers (December 2016)

(1) DG1: first DORIS receiver

(2) DG2: In the mid-nineties, CNES developed a second-generation dual channel DORIS receiver that was subsequently miniaturized:

(3) Jason-1 DORIS measurements are affected by the South Atlantic Anomaly (SAA) effect on the on-board Ultra Stable Oscillator (USO) (Willis et al. 2004), however a correction model has been developed (Lemoine and Capdeville 2006).

(4) DGXX: this new generation of DORIS receiver. It was developed starting in 2005. This receiver includes the following main new features:

1. *The simultaneous tracking capability was increased to seven beacons (from only two in the previous generation of receivers)*
2. *The new generation USO design provides better frequency stability while crossing SAA and a better quality of MOE useful for beacon location determination.*
3. *New DIODE navigation software (improved accuracy)*

5.2 FUTURE DORIS MISSIONS

With many future missions lined up, DORIS will continue contributing up to 2030 and beyond (**Figure 7**).

• **Sentinel 3B** (ESA/Copernicus) is to be launched by end of April 2018

Sentinel 3C and **3D** (ESA/Copernicus) are under development, and expected for end 2017, 2020 and 2025.

• **SWOT** (Surface Water Ocean Topography) a joint project involving **NASA**, **CNES**, the **Canadian Space Agency** and the **UK Space Agency**, is planned for 2021.

• **Jason-CS** will ensure continuity from Jason-3 with a first launch in 2020 (Jason-CS1/ Sentinel-6A) and 2025 (Jason-CS2 / Sentinel-6B). The Jason-CS / Sentinel satellites are part of the Copernicus program and are the result of international cooperation between **ESA**, **Eumetsat**, the **European Union**, **NOAA**, **CNES** and **NASA/JPL**.

• **HY2-C**, **HY-2D (CNSA/NSOAS)** two Chinese missions flying DORIS are planned for 2019 and 2020 respectively.

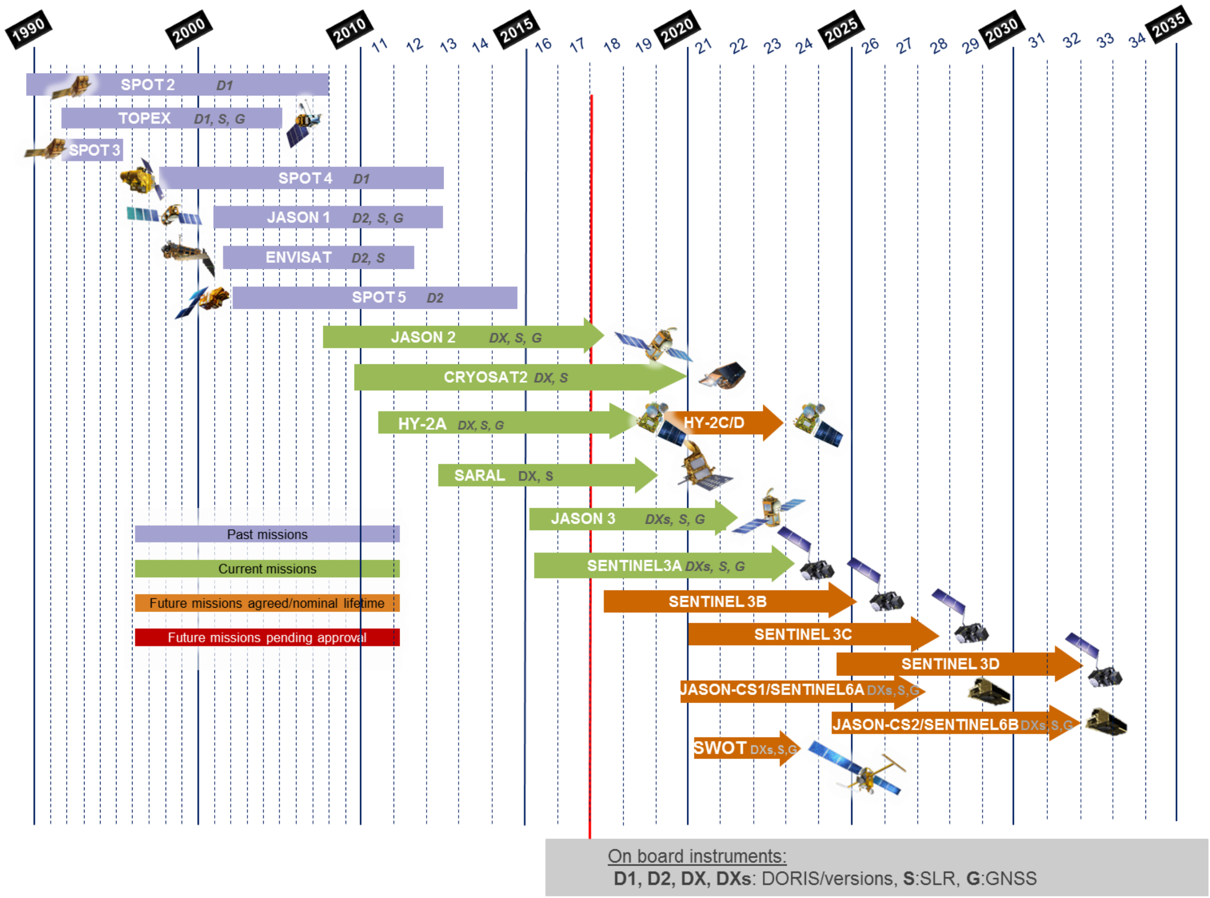


Figure 7. Current and future DORIS missions

USER SERVICE

6 CENTRAL BUREAU

Laurent Soudarin (1), Pascale Ferrage (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 (GB) 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 supports to the IDS components and operates the information system. This report summarizes the activities of the IDS Central Bureau during the year 2017 and forecasts activities planned for 2018. An overview of the IDS information system is reminded in appendix.

6.1 GENERAL ACTIVITIES

6.1.1 SUPPORT TO THE GOVERNING BOARD

The CB prepared several documents for the Governing Board:

- endorsement letter to the E-GRASP/Erastosthenes multi-technique mission concept. The letter has been addressed to Doctor Biancale, PI, and joined to the 2017 E-GRASP mission proposal submitted to ESA;
- thank-you letter to Professor Marek Ziebart for hosting the AWG meeting and the GB meeting at University College London;
- agreement on research cooperation between IDS and Research Institute of Geodesy, Topography and Cartography (VUGTK);

A survey form has been set up and put on the website to collect inputs from both inside and outside the IDS community in preparation for the IDS retreat scheduled in 2018 to define the activities of the service for the next 5-10 years.

6.1.2 SERVICE DESK

Questions from users concerning IDS data and products were answered or forwarded to experts.

6.1.3 REPORTS

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

6.1.4 MEETINGS

The Central Bureau participated in the organization of the AWG meeting held at University College London in London, UK, on May 22 and 23. It documented the GB meetings held on these occasions. Between the meetings, the CB coordinates the work of the GB.

6.1.5 COMMUNICATION

The CB promoted the use of IDS data and products with presentations in the following meetings:

- EGU, Vienna, April: “The International DORIS Service: Current Status and Future Plans” (Soudarin, Ferrage, Saunier).
  https://ids-doris.org/images/documents/report/meetings/EGU2017_IDS_CurrentStatusAndFuturePlan.pdf (poster)
- Unified Analysis Workshop, Paris, July: “IDS services for sharing DORIS data and products” (Soudarin, Mezerette, Ferrage).
  https://ids-doris.org/images/documents/report/meetings/UAW2017-IDSmetadata-Soudarin.pdf (slides)
- IAG/IASPEI Joint Scientific Assembly, Kobe, July: “The International DORIS Service: Current Status and Future Plans” (Soudarin, Ferrage, Saunier, Lemoine). Oral by F. Lemoine
  https://ids-doris.org/documents/report/meetings/IAG2017_IDScurrentAndfuture.pdf (slides)
- AGU, San Francisco, December: “Interoperable webservices for sharing data and products of the International DORIS service” (Soudarin, Ferrage)
  https://ids-doris.org/documents/report/meetings/AGU2017_IDS_InteroperableWebservices.pdf (poster)

6.1.6 NEWSLETTERS

IDS Newsletter #4 was published in November 2017. It contains the following article:

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

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

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

6.2 DATA INFORMATION SERVICE

The Central Bureau works with the SSALTO multi-mission ground segment and the Data centers to coordinate the data and products archiving and the dissemination of the related information.

In 2017, this activity focused on:

- the delivery of the CNES orbits for HY-2A in GDR-E standards (file naming, store folders, description files)
  See [ftp CDDIS or IGN] pub/doris/products/orbits/ssa/README_SP3.txt
- the update of the antex files giving the phase law to apply in DORIS processing for the ground antennas (format of the antex files revised and corrected to be in agreement with the format description; new characterization of the ALCATEL antenna based on 5 antennas)
  See ftp://ftp.ids-doris.org/pub/ids/stations/doris_phase_law_antex_readme.txt

- the change in the delivery of the DORIS/RINEX files in January: (re-)start delivering RINEX with DIODE time tagging with a latency of 1 day (instead of 3 days with SSALTO/PANDOR time tagging) and completion of missing periods (version number of the files: 001)
  See for instance [ftp CDDIS or IGN] pub/doris/data/ja2/README_JASON2_data.txt

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

6.3 DOR-O-T, THE IDS WEB SERVICE

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

A new version of the IDS web service was proposed in early 2017. It is based on the latest Highcharts/Highstock library, and a new version of the network viewer. Improvements were brought to make the service more ergonomic, simpler and more practical, especially on mobile devices.

The webservice is now accessed using the secure HTTPS protocol.

6.4 IDS WEBSITE

Address: https://ids-doris.org

A new version of the IDS website was proposed in early 2017 with an updated design and structure. The website is now accessed using the secure HTTPS protocol.

Pages of the website are regularly updated, and new documents added:

- The presentations of the AWG meeting held at UCL in London on May 22 and 23 were put on line. See:
  https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2017.html

The page of Analysis Coordination's Documents was completed with the minutes of the Analysis Working Group Meeting in London
http://ids-doris.org/report/analysis-coordination.html

- The activity reports for 2016 (IDS Activity report, report for IERS) as well as the minutes of the IDS GB meeting held in 2017 (London) and several presentations in meetings (IERS DB, GGOS, ...) were added on the page of the Governing Board's documents:
http://ids-doris.org/report/governing-board.html

- 33 updated sitelogs of current and former sites have been posted.
http://ids-doris.org/network/sitelogs.html

- The list of the peer-reviewed publications related to DORIS has been enriched with new references of articles published in 2017:
http://ids-doris.org/report/publications/peer-reviewed-journals.html#2017

Besides, the website was enriched with new pages and received some changes. The main updates of 2017 are reported hereafter.

- Two new sections added in the Gallery for the DORIS station: equipment and obstruction views.
https://ids-doris.org/ids/gallery/category/4-stations.html

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

- A new page Working Groups (AWG, WG NRT DORIS data) is available here:
https://ids-doris.org/ids/organization/working-groups.html

- The document « IDS data structure and formats » has been reviewed and completed. It is now available as a PDF file encapsulated in the webpage.
https://ids-doris.org/ids/data-products/data-structure-and-formats.html

- The presentation of the products table and the documentation table has been improved.
https://ids-doris.org/ids/data-products/tables-of-data-products.html
https://ids-doris.org/ids/reports-mails/documentation.html

- The Newsletter articles are accessible separately for online reading
https://ids-doris.org/ids/reports-mails/newsletter.html

- The IDS activity reports are accessible via a click on an image of the cover
https://ids-doris.org/ids/reports-mails/governing-board.html#activity

- The survey set up for the preparation of the retreat is online
https://ids-doris.org/ids-survey.html (with link on the home page)

6.5 IDS FTP SERVER

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

The documents and files put on the IDS ftp site in 2017 are listed hereafter.

New files:

- New characterization of the ALCATEL antenna based on 5 antennas
  ftp://ftp.ids-doris.org/pub/ids/stations/doris_phase_law_antex_alcatel17.txt

Updated files:

- History files of events in ftp://ftp.ids-doris.org/pub/ids/events/

- DORIS internal ties
  ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_int_ties.txt

Updated documents:

- « DORIS satellites models implemented in POE processing » with update on HY-2A DORIS Center of Phase location
  ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf

6.6 FUTURE PLAN

In 2018, the Central Bureau will participate in the organization of the Analysis Working group meeting at CNES, Toulouse, France, on June 11 (https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-06-2018.html), the IDS retreat, and the IDS Workshop in Ponta Delgada (Azores Archipelago), Portugal, on September 24 to 26 (https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2018.html), as part of the 25 Years of Progress in Radar Altimetry Symposium with the Ocean Surface Topography Science Team (OSTST). The Central Bureau will also organize the meetings of the Governing Board scheduled in 2018.

Data, meta-data and documentation of the mission Sentinel 3B scheduled to be launched in Spring 2018 will be put online the IDS data and information sites as they become available.

New evolutions of the IDS web service will be proposed, and two IDS Newsletters will be issued in 2018.

In 2018, the CB will organize the GB elections to be held in autumn. Two positions are renewed for the term 2019-2022: Analysis Coordinator, and one Member at Large.

The Central Bureau will continue to guide any new users who want to get involved in DORIS activities.

7 IDS DATA FLOW COORDINATION

Patrick Michael / NASA GSFC, USA

7.1 INTRODUCTION

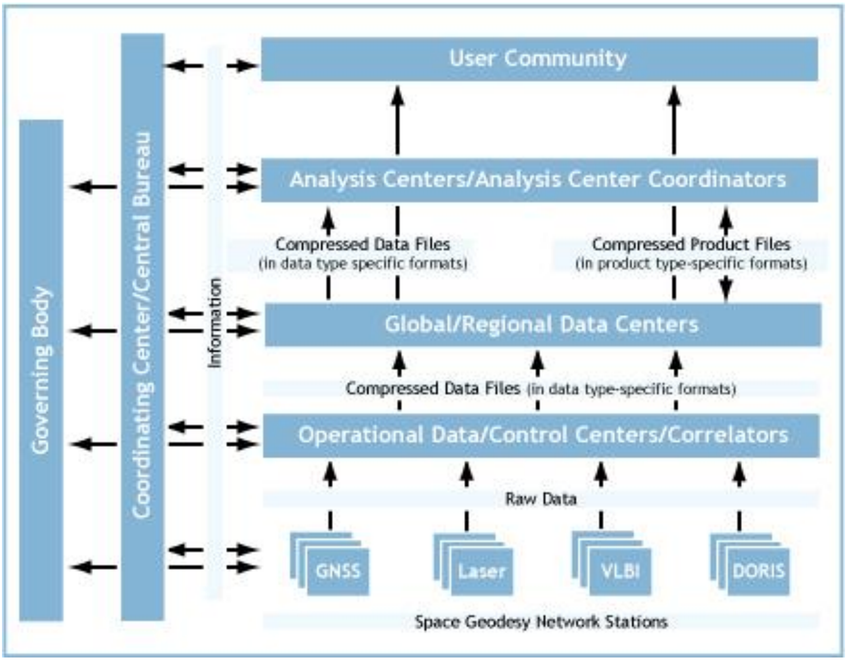
Two data centers support the archiving and access activities for the IDS:

- 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.

7.2 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, atmos. 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

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/products* (for all products) with subdirectories by product type and analysis center
- */doris/data* (for all data) with subdirectories by satellite code
- */doris/ancillary* (for supplemental information) with subdirectories by information type
- */doris/campdata* (for campaign data) with subdirectories by campaign and satellite code
- */doris/general* (for miscellaneous information and summary files)
- */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)

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 are mirrored by the IDS data centers thus providing users secondary locations for these files as well.

Directory	File Name	Description
Data Directories		
/doris/data/*sss*	*sss*data*MMM*.*LLL*.Z	DORIS data for satellite *sss*, cycle number *MMM*, and version *LLL*
	sss.files	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/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*	Spacecraft body quaternions for satellite *sss*, year *yyyy*, start date/time *YYYYMMDDHHMISS*, end date/time *yyyymmddhhmiss*, and version number *LLL*
	sss/qsolp*YYYYMMDDHHMISS*_*yyyymmddhhmiss*.*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

7.3 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 six operational satellites (CryoSat-2, HY-2A, Jason-2, Jason-3, SARAL, and Sentinel-3A); 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.

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 present	Multi-day, RINEX
Jason-1	15-Jan-2002 through 21-Jun-2013	Multi-day
Jason-2	12-Jul-2008 through present	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
SPOT-2	31-Mar through 04-Jul-1990	Multi-day
	04-Nov-1992 through 14-Jul-2009	
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
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004	Multi-day

Table 6. DORIS Data Holdings Summary

DORIS phase data from CryoSat-2, HY-2A, Jason-2, Jason-3, SARAL, and Sentinel-3A 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 and Sentinel-3A 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:

ftp://cddis.nasa.gov/doris/campdata/saacorrection/ja1

ftp://cddis.nasa.gov/doris/campdata/saacorrection/sp5

7.4 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

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 2005-2017 are shown in **Table 7**. This table also includes a list of products under evaluation from several DORIS analysis centers.

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

7.5 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.

7.6 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.

8 IDS DATA CENTERS

8.1 CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)

Patrick Michael, Carey Noll / NASA GSFC, USA

8.1.1 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).

8.1.2 OPERATIONAL ACTIVITIES

By the end of 2017, the CDDIS has devoted nearly 115 Gbytes of disk space (53% for DORIS data, 27% for DORIS products, and 20% for DORIS ancillary data and information) to the archive of DORIS data, products, and information. During the year, users downloaded approximately 1400 Gbytes (2.5M files) of DORIS data, products, and information from the CDDIS. On average, approximately 191 distinct hosts downloaded DORIS-related files from the CDDIS each month.

In 2017, CDDIS developed all new software to automate the ingest of data submitted by SSALTO. This new software is a significant improvement over the previous process and performs a full range of quality-checks and metadata extraction. The software uses these new checks and metadata to generate a summary file for each data file. All incoming DORIS data have its metadata extracted and stored in a local database. These metadata, which includes satellite, time span, station, and number of observations per pass, and are utilized to generate data holding reports on a daily basis.

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, ftp://cddis.nasa.gov/doris/data.

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

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

8.1.3 RECENT ACTIVITIES AND DEVELOPMENTS

During 2017, the CDDIS developed all new software to handle the ingest of GNSS, SLR, and DORIS data. This new software allows for more automated operation, much improved quality-checks, and a new metadata extraction process and storage method all leading to improved efficiency in processing incoming data. CDDIS's goal is that all incoming files are quality-checked, metadata extracted, and processed into the archive within 30 seconds of being received. A schematic diagram of the current CDDIS architecture is shown in **Figure 9**.

8.1.4 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 plans to make several changes to its operation in 2018. Ingest software for DORIS products will be updated to use the new DORIS data processing software that was described under recent developments. Secondly, CDDIS will be expanding access to the archive with both ftp-ssl and https along with its current ftp offerings.

8.1.5 CONTACT

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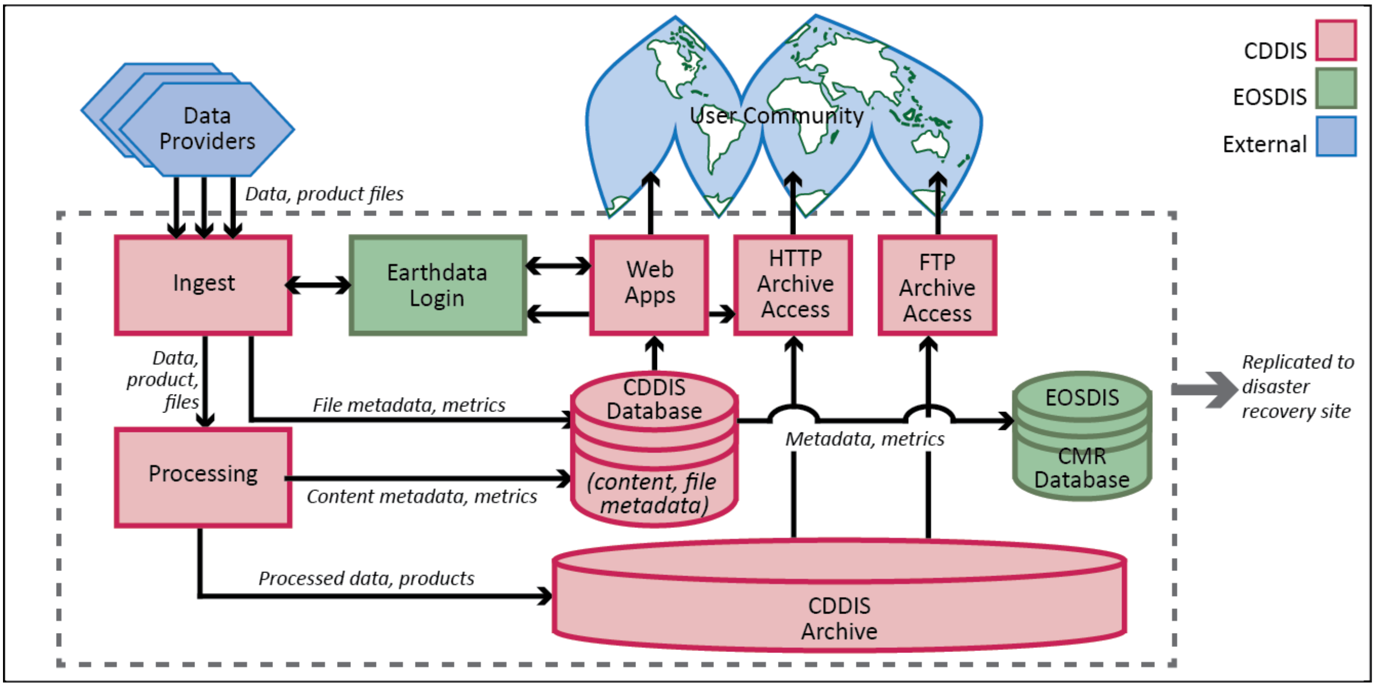

Figure 9. System architecture overview diagram for the new CDDIS facility installation within the EOSDIS infrastructure

8.2 IGN DORIS DATA CENTER

Bruno Garayt / IGN, France

To ensure a more reliable data flow and a better availability of the service, two identical layouts have been setup in two different locations at the IGN: (1) Marne-la-Vallée and (2) Saint-Mandé. Each site has:

- a FTP deposit server for data and analysis centers uploads, requiring special authentication
- a free FTP anonymous access to the observations and products
- an independent Internet links.

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

- ftp://doris.ensg.eu for the Marne-la-Vallée site
- ftp://doris.ign.fr for the Saint-Mandé site

8.2.1 CONTACT

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ANALYSIS ACTIVITIES

9 ANALYSIS COORDINATION

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9.1 INTRODUCTION

The activities of all the DORIS analysts of the past year 2017 have been dominated by the evaluation of the three TRFs 2014 solutions and the DPOD2014, taking into account the last DORIS satellites Jason-3 and Sentinel-3A which DORIS data are only available in RINEX format, defining a strategy to minimize the impact of the sensitivity to the South Atlantic Anomaly (SAA) effect of their Ultra Stable Oscillator (USO) and resolving the scale factor jump of the IDS solution.

The last International DORIS Service Analysis Working Group (IDS-AWG), from May 22 to May 23, 2017, was hosted in London at the University College of London.

9.2 ANALYSIS ACTIVITY OVERVIEW

All the IDS Analysis Centers (AC) continue the standard routinely processing by taking into account the last DORIS data available. The IDS includes six ACs and “de facto” three “associate analysis centers” who use seven different software packages, as summarized in **Table 8**. We also note which analysis centers on a routine basis perform POD analyses of DORIS satellites using other geodetic techniques (c.f. Satellite Laser Ranging (SLR), or GNSS). The multi-technique analyses are useful since they can provide an independent assessment of DORIS system performance and allow us to validate more easily model changes and the implementation of attitude laws for the different spacecraft, in the event spacecraft external attitude information (in the form of spacecraft quaternions) is not available. The participation of the Norwegian Mapping Authority (NMA, represented by Geir Arne Hjelle) and other potential IDS ACs should continue to be encouraged.

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

Table 8 . Summary of IDS Analysis Centers

9.3 IDS SCALE JUMP

An increase in the IDS scale factor was identified in 2012. This increase is mainly due to the introduction of the HY-2A satellite into the combined solution, which has a high scale factor. The increase also comes from DORIS2.2 data processing for the Jason-2 and Cryosat-2 satellites. For this part, the jump observed in the scale factor is due to the change of tropospheric model in the POD processing of the CNES team. It was then recommended to the IDS ACs to consider all the measurements in the DORIS2.2 file, even those rejected by the CNES POD team preprocessing, and therefore to do their own preprocessing.

In November 2017, a new initial position of the HY-2A satellite center of mass (CoM) in the satellite reference frame was delivered to CNES by the Chinese Mission Center. The CNES/CLS AC considered this new value and determined a HY-2A single-satellite solution over several months. From this solution, CNES/CLS AC calculated the HY-2A scale factor. **Figure 10**, giving the scale factor obtained from the old and new CoM position, shows that the new position greatly reduces the HY-2A scale factor. This new position is thus validated, the IDS Analysis coordinators recommend to IDS ACs to use this new value.

CNES/CLS AC determined a multi-satellite solution by taking into account all the DORIS data in the DORIS2.2 measurement file, even those rejected by the pre-processing made by the CNES POD team. **Figure 11** shows in red the scale factor of the combined solution provided to the IDS combination center for CNES/CLS AC contribution to the ITRF2014. In this figure (in red) we can clearly see the jump of the scale factor in 2012 due to the high scale factor HY-2A and the use of preprocessing by the CNES POD team. As shown in **Figure 11** (in black), the new position of the CoM HY-2A and our preprocessing remove this jump.

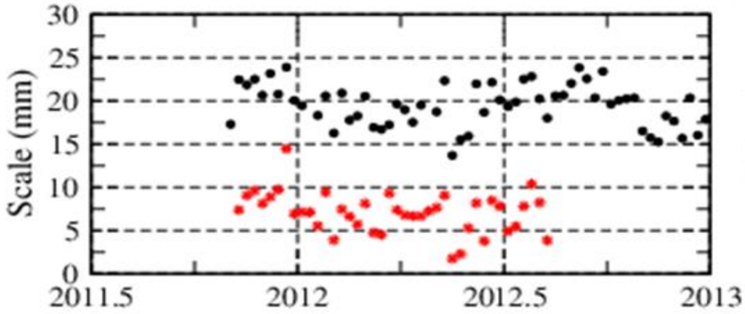

Figure 10. HY-2A scale factor

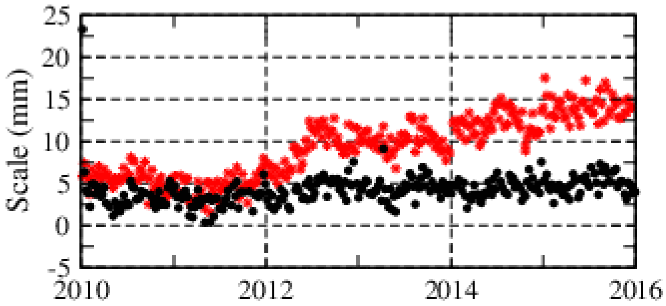

Figure 11. Multi-satellite scale factor

9.4 EVALUATION OF THE THREE TRF2014 SOLUTIONS AND DPOD2014

IDS did an assessment of the three realizations of the Terrestrial Reference Frame which are the outcome of the “ITRF2014 effort”: the ITRF2014 (IGN), DTRF2014 (DGFI) and JTRF2014 (JPL). While ITRF2014 and DTRF2014 are formally similar, differing mainly by the Post Seismic Deformation model (PSD) which has been introduced in the IGN solution, the JPL solution is quite different, being a time series of weekly solutions obtained through a Kalman filter process. Due to a more aggressive data editing, the JPL solution contains less stations at a given time than the two others, particularly at the beginning of the processed period in 1993. The three TRF realizations have been evaluated in terms of DORIS and SLR observation residuals, orbit overlaps and transformation parameters of the DORIS network. All the TRF realizations represent a clear improvement post-2008 over the previous realization ITRF2008 (see **Figure 12**). Based on the different criteria used for the evaluation, it has been shown that it is the ITRF2014 which presents the best overall performances. It is this model that will serve as a basis for the operational processing of the future IDS products.

For that purpose, the ITRF2014 needs to be supplemented (new DORIS stations not present in the ITRF2014 solutions, if necessary correction of the position and velocity for the stations which had a short observation interval in the ITRF2014). The extension of the ITRF2014 for the DORIS network, called DPOD2014, consists in an update of the position/velocity of all the DORIS stations and aligned to the ITRF2014, leading to possible minor adjustment of older stations (see **Figure 13**). The DPOD2014 built by the IDS CC (G. Moreaux) was validated by a POD group (P. Willis, F. Lemoine, A. Couhert, N. Zelensky and Ait Lakbir Hanane). The DPOD2014 solution will be updated twice a year. Some IDS ACs have switched to ITRF2014 by using the DPOD2014 solution for their IDS operational products at the end of 2017 and others will plan to do that in 2018.

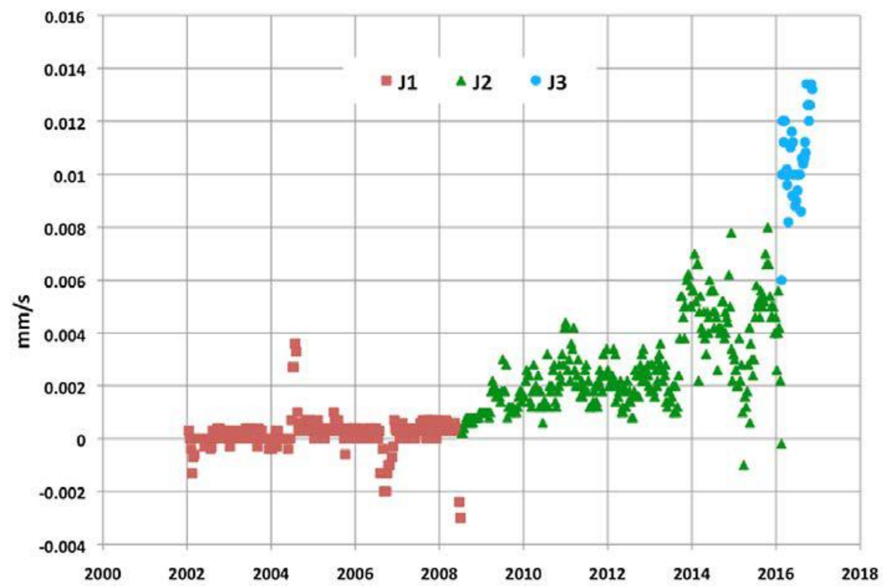

Figure 12. GSFC AC result for DORIS residuals: ITRF2014 vs. DPOD2008

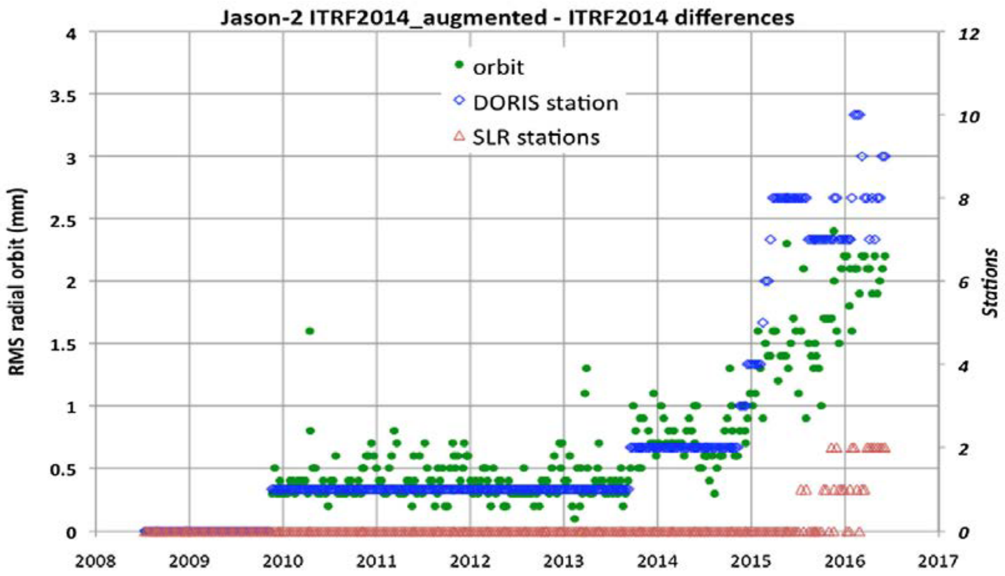

Figure 13. GSFC result: Jason-2: ITRF2014 & DPOD2014: Radial Orbit differences vs. no. of “missing” stations

9.5 SENSITIVITY TO THE SAA EFFECT OF DORIS USO

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

Thanks to the extremely precise time-tagging of the T2L2 experiment on-board Jason-2, A. Belli and the GEOAZUR team showed that the DORIS on-board Ultra Stable Oscillator (USO) of Jason-2 is approximately 10 times less sensitive to the SAA than the one of Jason-1. Taking into account the temperature of the DORIS USO and the radiations received, they managed to draw up a model that accurately represents the variations of Jason-2 USO's frequency (enabling time transfer by laser link between SLR stations that are not in common view) (see **Figure 14**). They provided one year (2013) of DORIS data corrected by their model in DORIS2.2 format. To evaluate the Belli model, the CNES/CLS AC processed the DORIS2.2 data corrected and uncorrected. The DORIS residuals are reduced by the use of the model for SAA stations but there are no significant orbit differences. As shown in **Table 9** the use of the corrective model improves slightly the single satellite station position estimation.

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

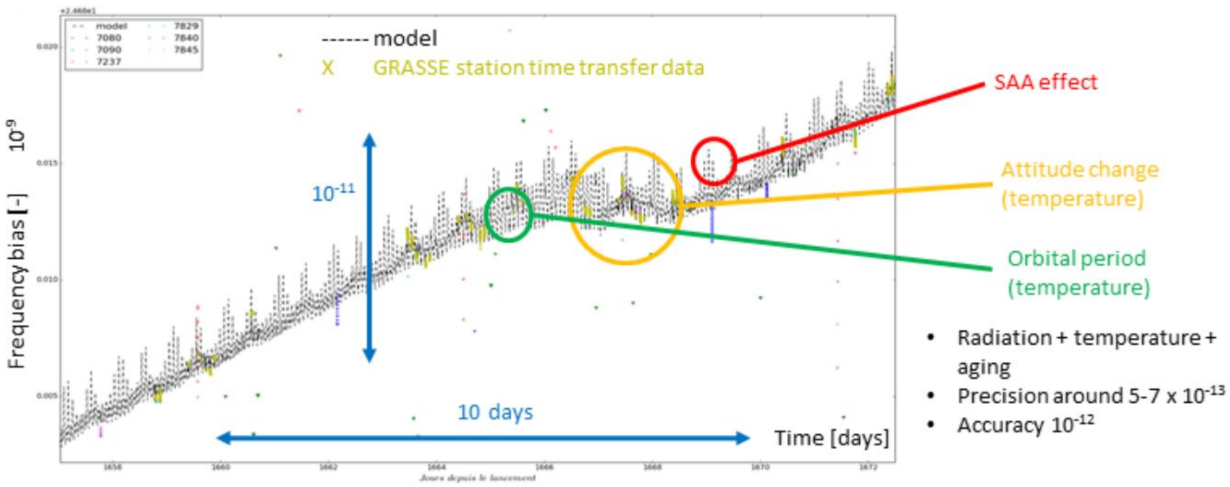

Figure 14. Jason-2 USO model of Belli et al. (Adv. Space Res. 2016)

Station	Jason-2 (in cm)			Jason-2 corrected (in cm)		
	North	East	Up	North	East	Up
Cachoeira	4.3	2.2	**7.4**	2.8	3.3	4.1
Arequipa	-2.0	2.4	**8.8**	-1.6	1.9	3.4
Santiago	**8.2**	-0.3	1.8	**6.1**	0.2	-0.7
Ascension	0.7	-1.7	**5.3**	-0.1	-0.4	3.2
Saint Helene	**5.2**	0.3	2.9	3.9	0.5	1.2
Libreville	-2.7	-1.0	2.9	-2.1	-0.6	1.4
Kourou	-2.2	-0.4	1.9	-1.4	-0.7	0.9
Yarragadee	*0.3*	*-0.8*	*0.5*	*0.1*	*-0.8*	*0.6*
Thule	*-0.3*	*-0.9*	*-2.0*	*-0.4*	*-1.1*	*-1.8*

Table 9. Differences between the Jason-2 corrected and uncorrected and Cryosat-2 solutions in NEU, average over 52 weeks (year 2013)

9.6 OTHER WORK EFFORTS

9.6.1 IMPROVEMENT OF THE NON-CONSERVATIVE FORCE MODELLING FOR DORIS SATELLITES

The analyses associated with ITRF2014 as well as subsequent work have demonstrated that the DORIS products contain signals at distinct tidal, TOPEX/Jason-draconitic, semi-annual, and annual periods. These signals point to potential problems in force and measurement modeling, potentially associated with the tidal EOP modelling and with the modeling of non-conservative forces on some satellites. ACs have to improve SRP modelling to reduce draconitics, in particular for Topex/Jasons satellites by using solar angle panels as done and showed by the GSFC AC.

9.6.2 DORIS RINEX DATA PROCESSING AND INTRODUCTION OF THE NEW SATELLITES

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

9.6.3 SCALE ISSUES ON SPOT-5 (SAWTOOTH PATTERN) / SPOT ATTITUDE

The SPOT-5-only scale clearly showed a sawtooth pattern with breaks. The discontinuities are of the order of -20 mm, so they are significant. Although no obvious cause has been found, efforts to understand these variations should continue, in particular to understand if something intrinsic to the SPOT-5 DORIS USO might be the cause.

9.6.4 ESTIMATION OF THE POLE BY USING DORIS DATA

The POD CNES team showed that it is possible to estimate the pole in short delay using only DORIS measurements as also presented by C. Jayles (CNES) previously with DIODE software. The IERS prediction for pole values can sometimes be quite far from the actual values, and this impacts the orbit determination. It can thus be useful to estimate the polar motion using orbit determination data, and then use this estimated pole in the actual orbit determination. When combining data from several satellites, the precision of the pole estimation is around 0,5 milliarcsecond (1,5 cm). The estimated pole can compensate for the poor IERS predictions. Outside of these poor prediction periods: the impact of estimating a DORIS pole shows a small but consistent improvement on SLR residuals and on orbit comparison.

9.6.5 ESTIMATION OF THE GEOCENTER MOTIONS BY USING DORIS DATA

The POD CNES team is working on the DORIS-Derived Geocenter Motion for Precise Orbit Determination of Altimetry Satellites. They used Jason satellites (with draconitic period not close to one solar year) and they plan to benefit from combining other satellites. The future consecutive launches of Jason-CS/Sentiel-6 and SWOT (inclination of 78°, draconitic period of 78.5 days) will make possible this combination.

They also tested an approach that enables the GPS products to be referenced w.r.t. the CM of the Earth, instead of the CF (at least for the annual part). The observation of the Geocenter motion with GPS and the Jason-2 LEO satellite seems possible based on these results. Further progress could be performed using IGS14 orbit and clock products and fixing ambiguities with Jason-3, in order to also have access to the pluri-annual variations of the Geocenter motion with GPS (not only the seasonal signal).

9.7 FUTURE PLANS

In preparation to the next ITRF, scheduled in 2019 or in 2020, IDS ACs should have:

- to complete their DORIS/RINEX data processing implementation in order to take into account the data from Jason-3 and Sentinel-3A (available first quarter of 2016)
- to improve SRP modelling to reduce draconitics, in particular for Topex/Jasons satellites by using solar angle panels
- to apply a strategy to minimize the SAA effect
- to take into account the new position of the HY-2A satellite center of mass (CoM) in the satellite reference frame proposed by the Chinese Mission Center
- to do their own pre-processing when using the DORIS2.2 data
- to take into account the phase law for ground antennas
- to take into account new standards proposed by IERS as the linear mean pole model
- …

The next IDS Analysis Working Group will be held in Toulouse (France), on Monday June 11, 2018 (hosted by CNES) followed by the Copernicus Quality Working Group Meeting on Tuesday June 12 to which IDS AWG members are invited.

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

10 COMBINATION CENTER

Guilhem Moreaux / CLS, France

10.1 ACTIVITY SUMMARY

In addition to the routine evaluation and combination of the IDS AC solutions, in 2017, the IDS Combination Center worked on the first two releases of the IDS cumulative position and velocity and DPOD2014 solutions.

10.2 IDS ROUTINE EVALUATION AND COMBINATION

At the end of 2017, the time span of the SINEX files of the IDS combined solution was 1993.0-2017.5. These files correspond to the IDS series 12.

The evaluation of the AC individual series showed a scale increase for the GOP, IGN and INA contributions (**Figure 15**). The investigations pointed out a possible link with the upgrade of the CNES standards from GDR-D to GDR-E for the Cryosat-2, Jason-2 and Saral missions.

10.3 IDS CUMULATIVE SOLUTION

In 2017, the IDS Combination Center started to build and make available (through the IDS Data Centers) its DORIS cumulative position and velocity solution. That solution is obtained by the stacking of the latest IDS combined solution from 1993.0 to the last week of the combined solution. Therefore, the cumulative solution contains only the mean positions and velocities (**Figure 16**) of the DORIS stations included in the IDS combined solution. That solution is updated twice a year. All the solutions are available in SINEX format and can be freely downloaded from the subdirectory "products/sinex_global/ids/" from the IDS Data Centers (CDDIS and IGN). Note that the IDS CC added into the SINEX files two unofficial blocks: one to list the station position discontinuities with indication of the origin (ex: earthquake, antenna move…) and one to indicate for each station the periods of time the station was not included in the combination due, for example, to corrupted data. Note that the IDS cumulative solutions are aligned to the current ITRF by no net rotation and not net translation conditions. Furthermore, the motions of the DORIS stations are modelized by linear functions. In addition to the realization of the cumulative solution, the IDS CC realizes some validation tests including comparison of the station position and velocities to the ITRF2014 ones.

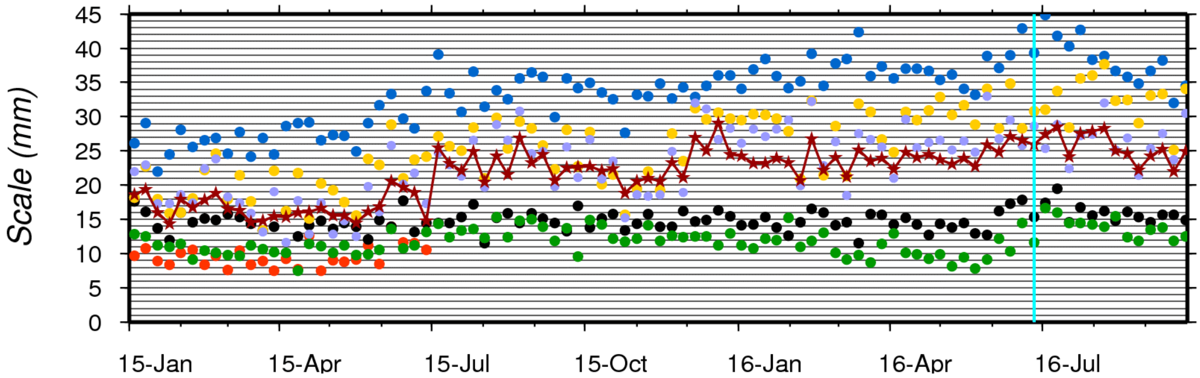

Figure 15. Scale of the IDS AC (red: ESA; dark blue: GOP; black: GRG; green: GSC; yellow: IGN; light blue: INA) and CC (brown) solutions

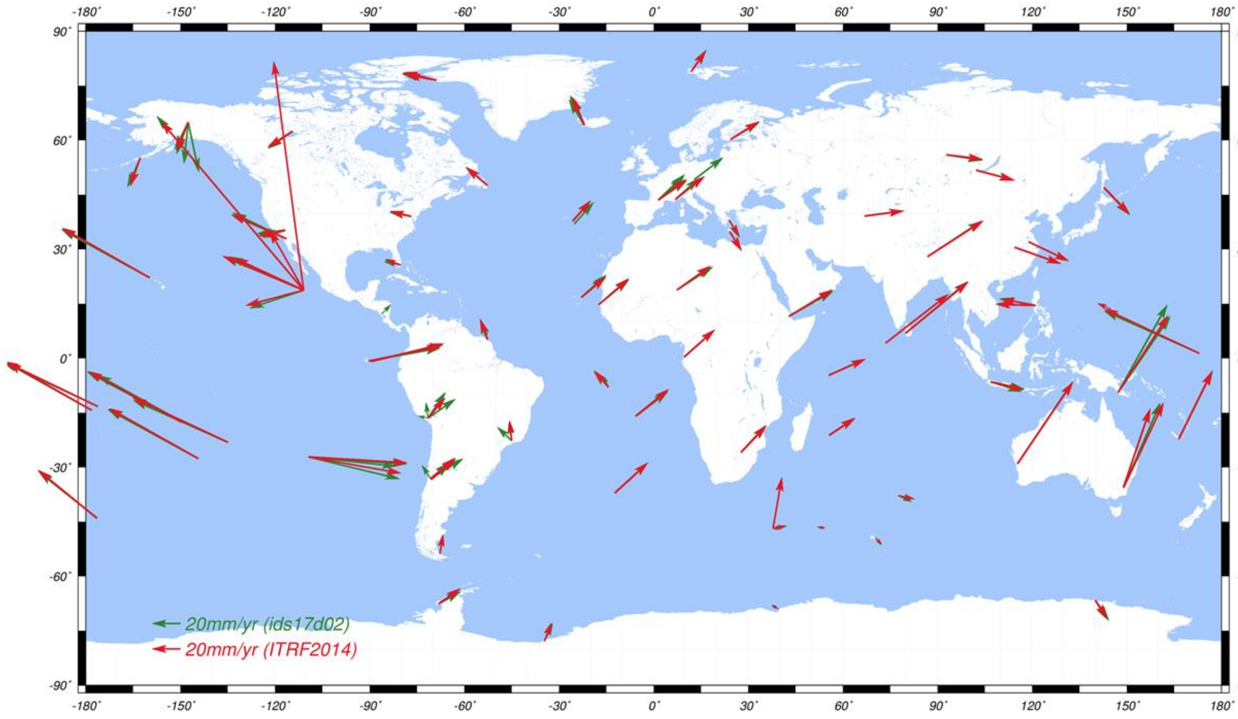

Figure 16. IDS cumulative solution version 2 vs ITRF2014 horizontal velocities

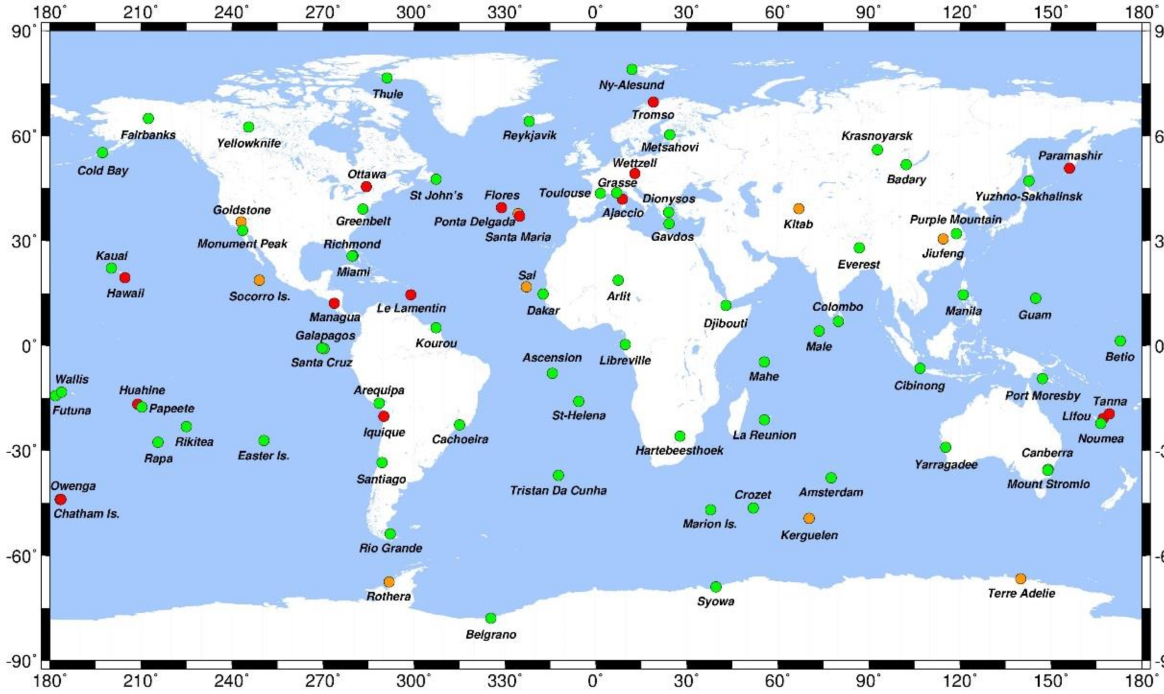

Figure 17. Map of the DORIS sites included in the DPOD2014 version 2.0. Green: ITRF2014 sites. Orange: ITRF2014 sites with new station(s) since ITRF2014. Red: sites not included in the ITRF2014

10.4 DPOD2014

Following the activities initiated during the second part of 2017, the IDS CC dedicated part of the last year on the realization, validation and delivery of the two first versions of the DPOD2014. The DPOD2014 solutions are based on the latest IDS cumulative position and velocity realizations (see previous section) and are augmented or the stations observed before 1993 and turned on after the ending date of the stacking (**Figure 17**). The DPOD2014 solution is updated twice a year and is available for download from the IDS Data Centers through the subdirectory "products/dpod/dpod2014/" in both SINEX and text formats. Moreover, to facilitate operational applications of the DPOD solutions, one SINEX and one text file named dpod2014_current.snx.Z and dpod2014_current.txt.Z are also available in the subdirectory "products/dpod/". These files will always contain the latest DPOD solution in SINEX and text format, respectively. In 2017, two versions of the DPOD2014 solution were realized corresponding to two time periods of stacking: 1993.0-2016.0 and 1993.0-2017.0. As agreed in 2016, before publication, these solutions were validated by the POD validation group.

10.5 IDS WEB SITE

To provide information about the activity and products of the Combination Center, the IDS CC created some web pages which were added to the analysis coordination corner of the IDS web site (see https://ids-doris.org/analysis-coordination/combination/activity-products.html). In addition to a general web pages on the activity and products of the Combination Center, we putted on line one page dedicated to the IDS cumulative position and velocity solutions and one page on the DPOD2014. These two pages briefly describe how the solution are realized and make available the technical reports of each release. These technical reports show the main differences to the previous release and display the results of some of the validation tests performed by the IDS Combination Center.

10.6 COMMUNICATIONS

The IDS Combination Center joined both EGU and AGU fall meetings where it presented one poster and one oral presentation respectively titled “Analysis of the signal content in the coordinate time series of the DORIS stations” and “Analysis of the DORIS, GNSS, SLR, VLBI and gravimetric time series at the GGOS core sites”. An abstract on the analysis of the DORIS, GNSS, SLT and VLBI coordinate time series at co-located sites (continuation of AGU 2017 study) was also submitted for oral presentation at EGU 2018. The IDS CC is also co-author of the abstract titled “Improvement in the DORIS position time series through years: reaching velocity error of 0.5 mm/yr” submitted by Anna Klos.

In 2017, the IDS Combination Center was co-author of the paper:

Klos, A.; Bogusz, J.; Moreaux, G., 2017. Stochastic models in the DORIS position time series: estimates for IDS contribution to ITRF2014. Journal of Geodesy, doi: 10.1007/s00190-017-1092-0

10.7 FUTURE PLANS

As in 2017, next year, we plan to deliver two new versions of the DPOD2014 solution. We hope that these two updates will be based on a new version of the IDS combined solution thanks to new AC series free of scale increases in 2011 and 2015. Taking benefits of a dedicated processing to minimize the SAA effect on Jason-2, Jason-3 and Sentinel3-A at the AC level, the coordinate time series of the stations located in the SAA region must not be impacted by the adding of these missions in the IDS combined series. The IDS CC plans to continue in 2018 the multi-technique study initialized last year. In line with some DORIS user requests, the IDS CC will initiate a new product with the generation of a so-called SINEX master file from the SITE/ID and ANTENNA blocks of the DPOD2014 solutions. We also plan to submit our joined paper on the evaluation of the DTRF2014, ITRF2014 and ITRF2014 solutions to Advances in Space Research. In parallel, we will also submit to the same journal a paper on the elaboration and validation of the DPOD2014 solution.

11 ANALYSIS CENTER AT EUROPEAN SPACE OPERATION CENTRE (ESOC)

Michiel Otten, Werner Enderle / ESOC, Germany

11.1 INTRODUCTION

The activities in 2017 of the European Space Operation Centre as an IDS analysis center were limited due to time constrains. As a result, the time that was available has been used to migrate from the old DORIS data format to start using the DORIS RINEX files. A first internal test solution based on DORIS RINEX data has been generated. It is expected that routine delivery to the IDS combination centre will restart in Q2 of 2018.

11.2 CHANGES MADE TO THE ESAWD10 SOLUTION IN 2017

The upgrades made to the current ESA IDS solution in 2017 were

- Updated the atmospheric gravity modeling to the GFZ AOD1B rl06 series
- Switch to the DORIS RINEX files for the newer DGXX satellites
- Updated NAPEOS version (4.1)

This current solution does not yet cover the entire IDS period from 1993 onwards but it is foreseen to deliver a fully reprocessed series before the Workshop in September 2018.

11.3 FUTURE ACTIVITIES

The Navigation Support Office plans for 2018 to include in the processing Sentinel-3B which is planned to be launched in April of 2018. Furthermore, we plan to perform a complete reprocessing of the older data with the inclusion of the newer satellites to provide again a complete homogeneous solution from 1993 onwards.

We will also restart the quarterly routine delivery of the ESA products to the IDS combination centre.

For the COL activities we plan to extend the ESA solution beyond the current period and will evaluate to possibility to complement our technique specific solutions with this combined solution.

12 ANALYSIS CENTER OF THE GEODETIC OBSERVATORY PECNY (GOP)

Petr Štěpánek / Geodetic Observatory Pecný, Czech Republic

12.1 INTRODUCTION

Besides the routine DORIS data processing, the research activities of GOP focused on two different issues. The first issue is the estimation of the true length of the day (LOD) including the spectral analysis and the investigation of the effect on other estimated parameters. Detailed results and discussions are summarized in Štěpánek et al. (submitted). The second subject of interest is the scale inconsistency in DORIS time-series. We analyzed the effect of the application of additional data from observation files as well as the elevation dependent downweighting effect and explained all the significant inconsistencies in 2011-2016. The results are summarized in Štěpánek and Filler (submitted).

12.2 STANDARD ROUTINE PROCESSING

The data until the day 270, 2017 were processed and the corresponding weekly SINEX files of the standard solution wd50 were delivered to the data center. Solution wd43 using older standard is no more supported. The combination center analysis pointed out anomaly of X-pole series, derived from GOP solutions, with possible seasonal character. The origin of this problem is not yet clear, but we plan a testing campaign to analyze the possible relation between the signal and cross track harmonics adjustment/constraints in the GOP DORIS solutions.

12.3 LOD ESTIMATION

We demonstrated that estimation of LOD using DORIS observations with accuracy relevant for the space geodesy is feasible. The condition is that no unconstrained or weakly constrained orbit cross-track harmonics are adjusted in the same solution. Formal precision of the LOD estimation is around 40 µs for the last years of the testing campaign (2012.0-2015.0). The mean difference with respect to the reference IERS C04 model reaches a few tens µs with a standard deviation around 120 µs. The satellite-specific bias can be partially eliminated by applying the long-term averages of the pre-estimated sine amplitude of the cross-track harmonic empirical acceleration on cost of a decreased level of DORIS solution independency. The power spectrum of the difference between estimated LOD and reference IERS C04 shows signals with several periods (**Figure 18**). An annual signal with highest amplitude 43 µs relates to the sun-synchronous satellites. There is also signal with amplitudes under 20 µs related to the draconitic periods of Cryosat-2 and Jason-2. High frequency signal at 14.2 days with amplitude 32 µs could be related to a mismodeling of tidal effects, including the imperfection of IERS 2010 ERP sub-daily tidal model, in according to Griffiths and Ray (2013).

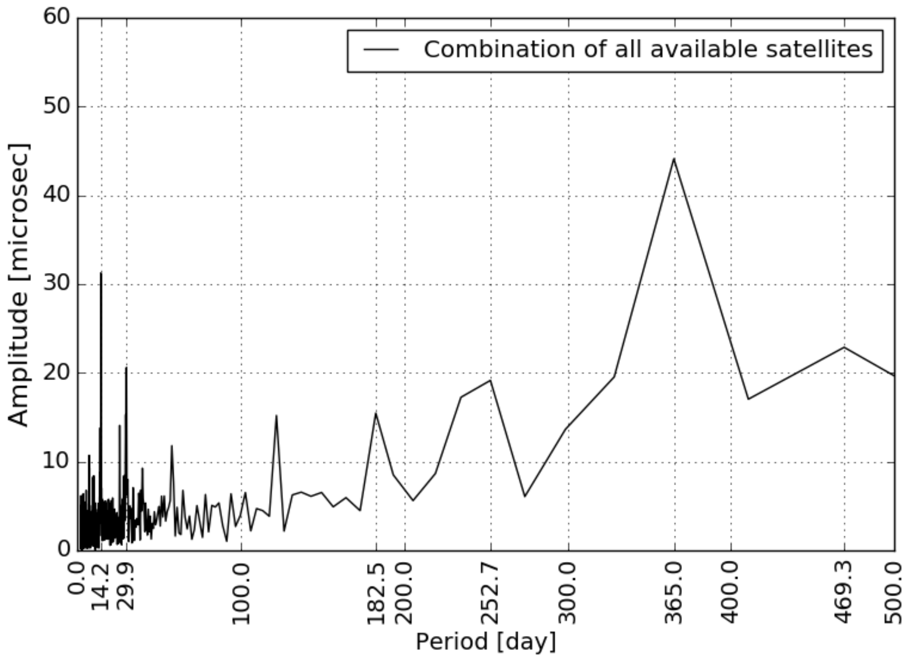

Figure 18. Periodogram for the difference between LOD from IERS C04 and from DORIS combination of all available satellites for a time interval of 9 years

The achieved standard deviation with respect to IERS C04 model is about 2 times higher than for SLR LOD estimation from the satellite combination including Lageos satellites, but comparable to the accuracy of the SLR solution from LEO satellites (Sośnica, 2014). The most critical point for DORIS LOD series is the mean difference w.r.t. IERS C04 model. When the mean difference achieves the value of tens µs, we get one order of magnitude worse result than for SLR and GNSS. In addition, the mean difference shows long-term instability. We encourage DORIS research community to discuss the possibility of LOD adjustment in the operational IDS solutions. The LOD adjustment has only a minor or even negligible effect on the estimates of the pole coordinates and station positions. The necessary condition is a proper orbit modeling and handling of the highly correlated cross-track harmonic empirical accelerations. Note that our solutions are based on daily orbit arcs processing. Even if our previous work confirmed the redundancy of daily cross track harmonics in DORIS geodetic solutions (Štěpánek et al., 2014), additional testing on more recent data, mainly around solar activity maximum and for long arcs, is required.

12.4 SCALE CAMPAIGN

It is obvious, that the explanation of the differences between the DORIS solutions carried out by different analysis centers could be problematic, when always affected by many incompatibilities in modeling, strategy, processing options and software issues. To understand the scale inconsistencies and other related issues, our analysis profited from 4 different strategies (V1-V4) based only on GOP analysis center solution (**Table 10**).

Solution	Observation downweighting	Validity indicator	Antenna–Ref point correction
V1	No	Yes	Yes
V2	Sin *E*	Yes	Yes
V3	Sin *E*	No	Yes
V4	Sin *E*	No	No

Table 10. Solution differences

A difference in the sequence of the solutions directly corresponded to one of the changes in the solution settings: data elevation dependent weighting (sin *E*), application of data validity indicators and application of phase center - reference point correction. We processed multi-satellite and single-satellite solutions for time period 2011.0 - 2017.0. Our results explained the scale inconsistency issues in 2011/2012 and in 2015. The origin of both issues is not the same. 2011/2012 scale increment is a concurrence of changes in satellite constellation (termination of Envisat data and beginning of Hy-2A data) and change in the provider data validity standards for Cryosat-2 and Jason-2. The scale increment in 2015 is the effect of change in the standards for phase center - reference center corrections for Saral, Jason-2 and Cryosat-2. For 2011/2012 scale increment, our investigation almost confirmed previously performed testing, while for 2015 scale increment we offer to DORIS research community a new piece of knowledge. **Figure 19** displays scale time-series for all the solutions V1-V4.

Moreover, comparing the solutions with and without data downweighting but both with the same elevation cut off (10 degrees), we found a significant reduction of scale bias together with the reduction of scale variation applying data downweighting. It is not only the scale, but also the station positioning repeatability, which is significantly better when applying the data elevation downweighting law.

The solution, which is completely free from the additional data associated with observations and applies the data downweighting law (V4) eventuates in a consistent scale time series with the lowest offset w.r.t. DPOD 2014 (12.7±2.3 mm for 2011.0 - 2017.0). The absence of inconsistencies in this series is confirmed by analysis of individual satellite solution scale. The only remaining scale issue is the part of 2011/2012 increment of the size around 5 mm, due to the changes in the satellite constellation.

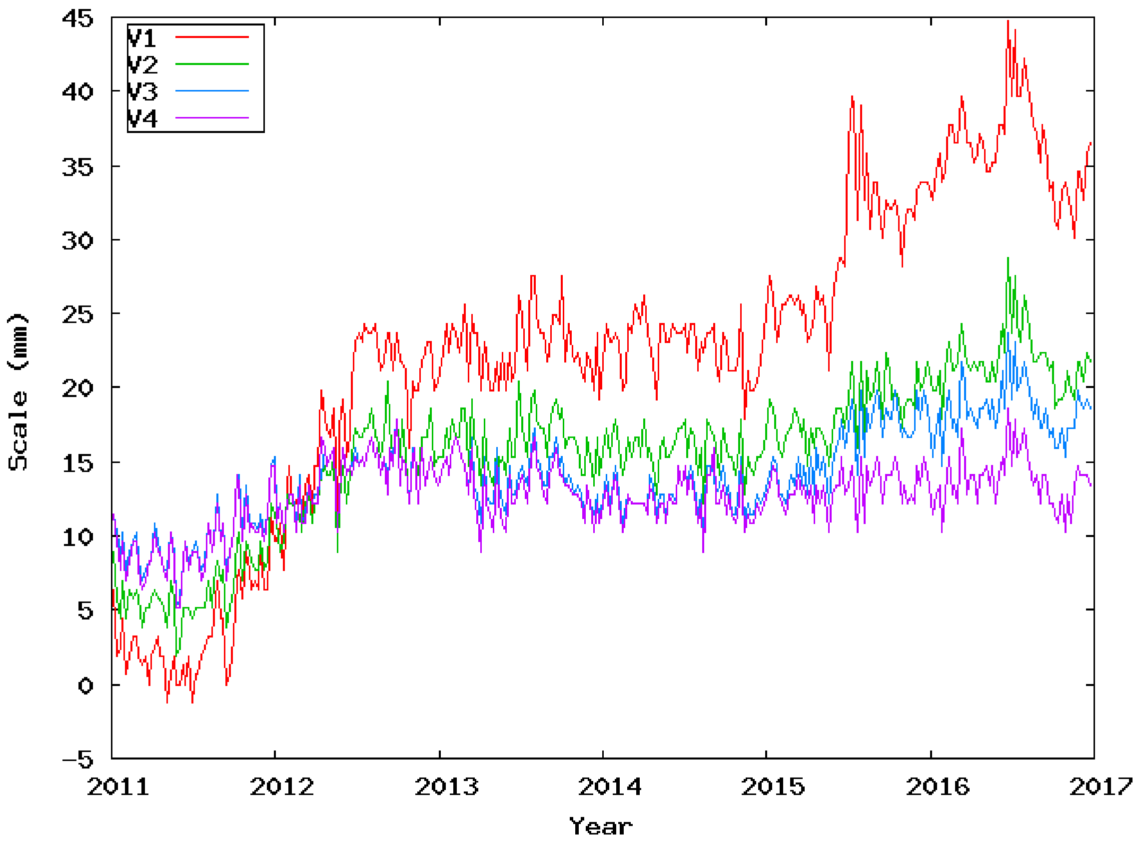

Figure 19. Scale w.r.t. DPOD 2014 for multi-satellite DORIS solutions V1, V2, V3 and V4

12.5 REFERENCES

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13 CNES/CLS ANALYSIS CENTER (GRG)

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13.1 INTRODUCTION

The CNES and CLS participate jointly to the International DORIS Service (IDS) as an Analysis Center. The processing of the DORIS data is performed using the GINS/DYNAMO software package developed by the GRGS.

The main activity during 2017 was to process the Jason-3 and Sentinel-3A DORIS data which are only available in RINEX format. An evaluation of the TRFs 2014 solutions has also been done. We have also analyzed the sensitivity to the South Atlantic Anomaly (SAA) effect of the Jason2&3 Ultra Stable Oscillators (USO) and propose some strategies to minimize its impact on the orbit and on the station position estimation.

13.2 STANDARD ROUTINE PROCESSING

We continued the standard routinely processing by taking into account the data until October 2017. We analyzed the DORIS2.2 data with 3.5-day arcs and a cut-off angle of 12° by using the ITRF2014 configuration for the following satellites: JASON-2, CRYOSAT2, HY-2A and SARAL.

We give in the **Table 11** the mean over the 2017 processing period of the DORIS and SLR RMS of fit of the orbit determination, the OPR Acceleration Amplitude (Along-track and Cross-track) and the radiation pressure coefficient. The results are at the same level than those obtained for the ITRF2014 realization.

For each satellite, we determine also a single satellite solution that we compare to the DPOD2014.

Satellite	DORIS RMS (mm/s)	OPR amplitude average (10^{-9} m/s^2)		Solar radiation coefficient
		Along-track	Cross-track	
JASON-2	0.33	2.6	1.9	0.97
CRYOSAT-2	0.35	3.1	2.3	1.0
HY-2A	0.34	0.5	1.9	0.86
SARAL	0.33	1.6	2.1	1.0

Table 11. Mean DORIS and SLR RMS of fit per arc, OPR amplitude average and solar radiation coefficient on the entire data processing period

13.3 JASON-3 AND SENTINEL-3A POD STATUS

The Jason-3 and Sentinel-3A satellites were added in the DORIS processing chain of the CNES/CLS Analysis Center. A POD status for the two new missions has been done by analyzing the orbit results obtained on the time span processing of 72 weeks (from April 2016 to August 2017). We took into account the standards and models used for our contribution to the realization of the ITRF2014, the IERS conventions and the IDS recommendations. We give in **Table 12** the average per arc of the amplitudes of empirical acceleration in tangential and normal, DORIS and SLR RMS of the orbit residuals. For both directions (tangential and normal), the average amplitude of the empirical accelerations is less than 4.10^{-9} m/s^2, showing that the modeling of the macromodel and attitude laws is correct.

Satellite	DORIS RMS (mm/s)	SLR RMS (cm)	OPR amplitude average (10^{-9} m/s^2)		Solar radiation coefficient
			Along-track	Cross-track	
JASON-3	0.358	1.8	1.3	2.5	0.99
SENTINEL-3A	0.365	1.3	2.2	1.9	1.00

Table 12. Average of DORIS and SLR RMS of fit per arc, OPR amplitude average and Solar radiation coefficient on the entire processing period data processing

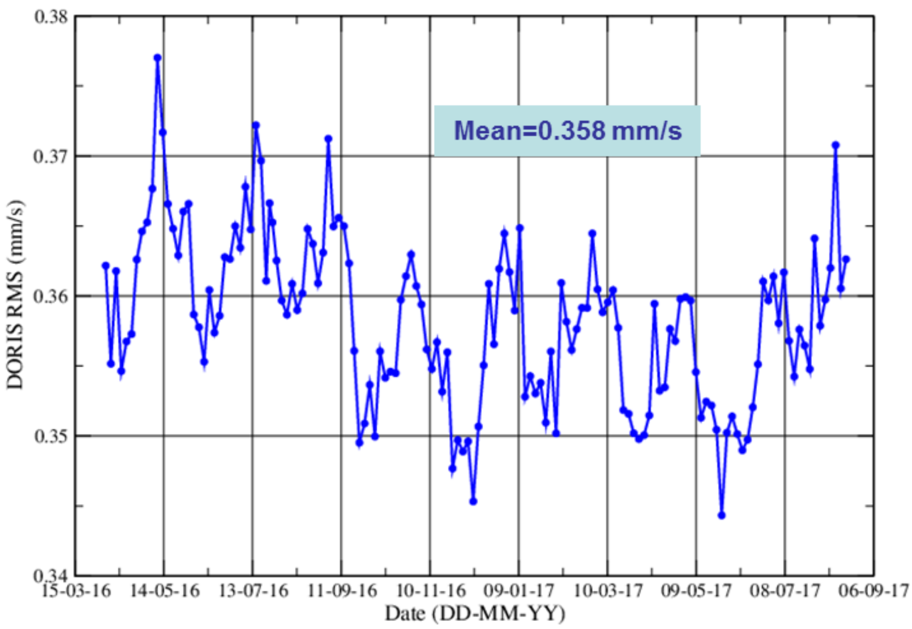

Figure 20. Jason-3 DORIS RMS of fit

The orbit residuals level of the Jason-3 shown in **Figure 20** (0.36 mm/s on average) and Sentinel-3A (0.36 mm/s), are slightly higher than Jason-2 (0.33 mm/s). For Jason-3, it can be explained by a higher sensitivity to SAA than other satellites. For Jason-3, there is also a 60-day signal in the DORIS residuals. The DORIS-only orbits have also been evaluated by an independent SLR measurements processing. SLR residuals on DORIS-only orbits are of a good level for Jason-3 and Sentinel-3A (**Figure 21**). The level is comparable to the other orbits evaluated, precise orbit DORIS+GPS of CNES POD team (for Jason-3 and Sentinel-3A) and GPS-only orbit of ESA (for Sentinel -3A).

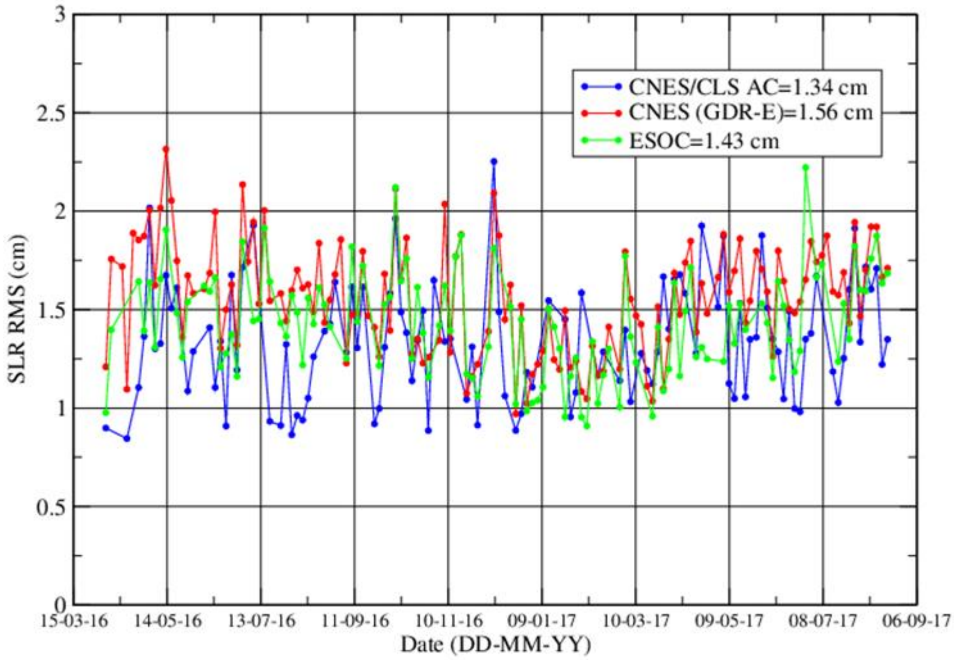

Figure 21. Independent SLR RMS of fit on Sentinel-3A orbits, DORIS-only orbit for CNES/CLS AC et (GPS+DORIS) orbit for POD CNES team (GDR-E) and GPS-only for ESA

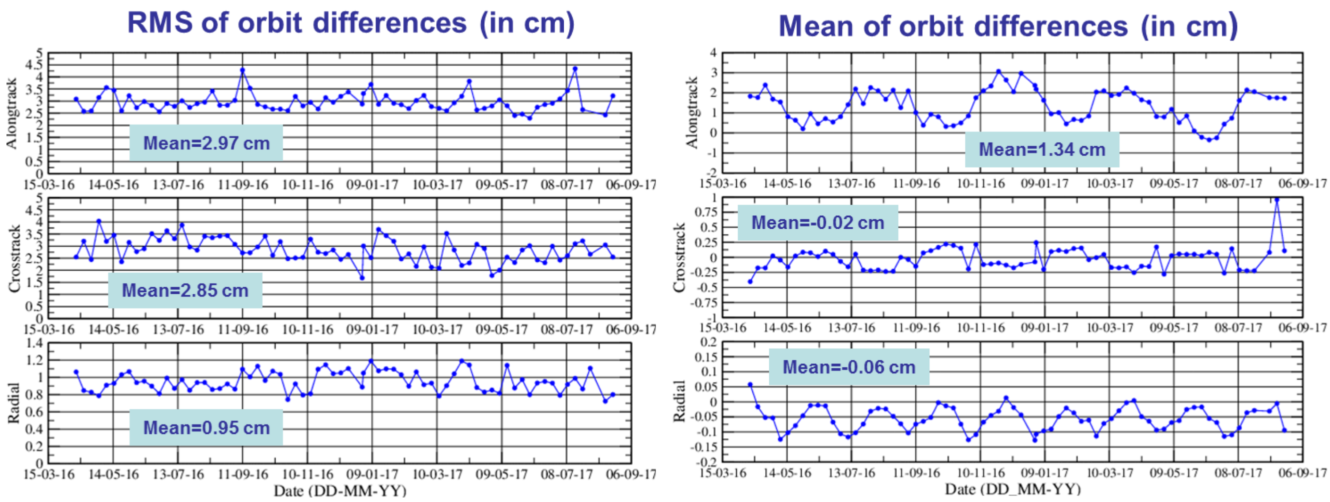

Figure 22. Jason-3 orbit differences between CNES/CLS AC and CNES POD team

We compared the Jason-3 and Sentinel-3A orbits with those of the CNES POD team and ESA's Analysis Center (shown in **Figure 22** for Jason-3 and in **Figure 23** for Sentinel-3A). For Jason-3, there is a good agreement between the 2 orbits but there is a tangential bias of ~ 1.3 cm which could be explained by a difference in the time tagging of the measurements. There is also a signal at 60 days in the average of the radial component that could come from the fact that we use the nominal attitude, unlike the CNES POD team that uses measured quaternions (BUS + solar panels angles). For Sentinel-3A, the agreement between the 2 orbits is better but there remains a tangential bias of ~ 0.6 cm certainly correlated to the time tagging of the measurements. From **Figure 23** ESA's precise orbit comparison shows better results except for the normal component with a 1.1 cm bias.

The CNES/CLS AC applied to join the Sentinel-3A Quality Working Group (QWG). After being accepted, he provided his precise orbits in sp3 format and was able to participate in the last QWG evaluation campaign. We present here one result from the evaluation made by GMV (**Figure 24**). These results show that the DORIS-only orbit calculated with GINS is at the same level as the other orbits which are all determined from GPS measurements.

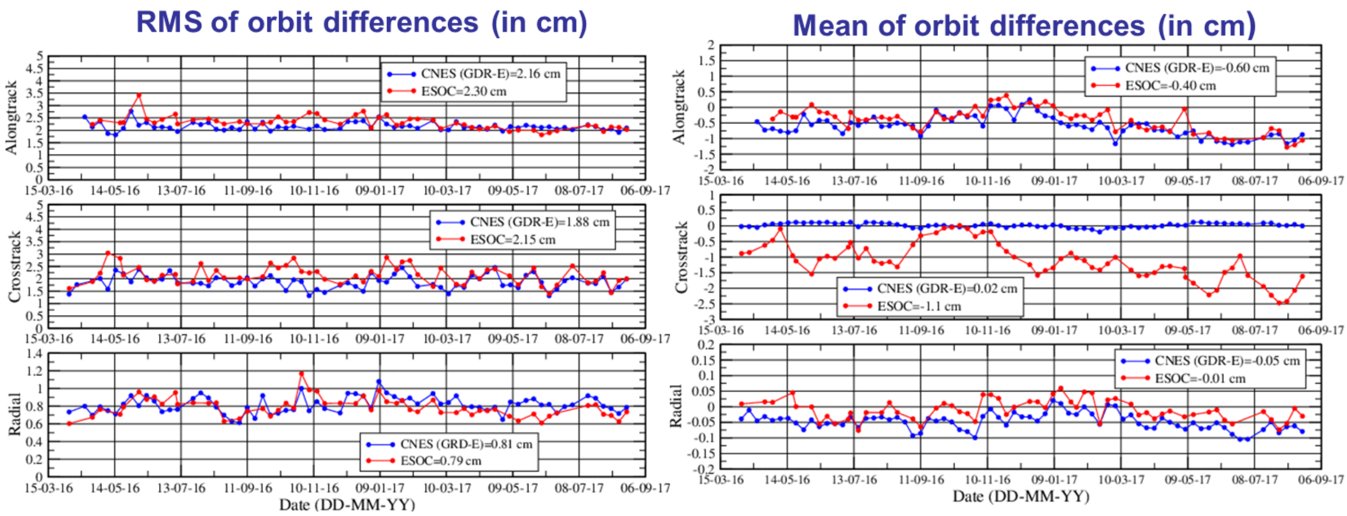

Figure 23. Sentinel-3A orbit differences between CNES/CLS AC and CNES POD team (in blue), CNES/CLS AC and ESOC (in red)

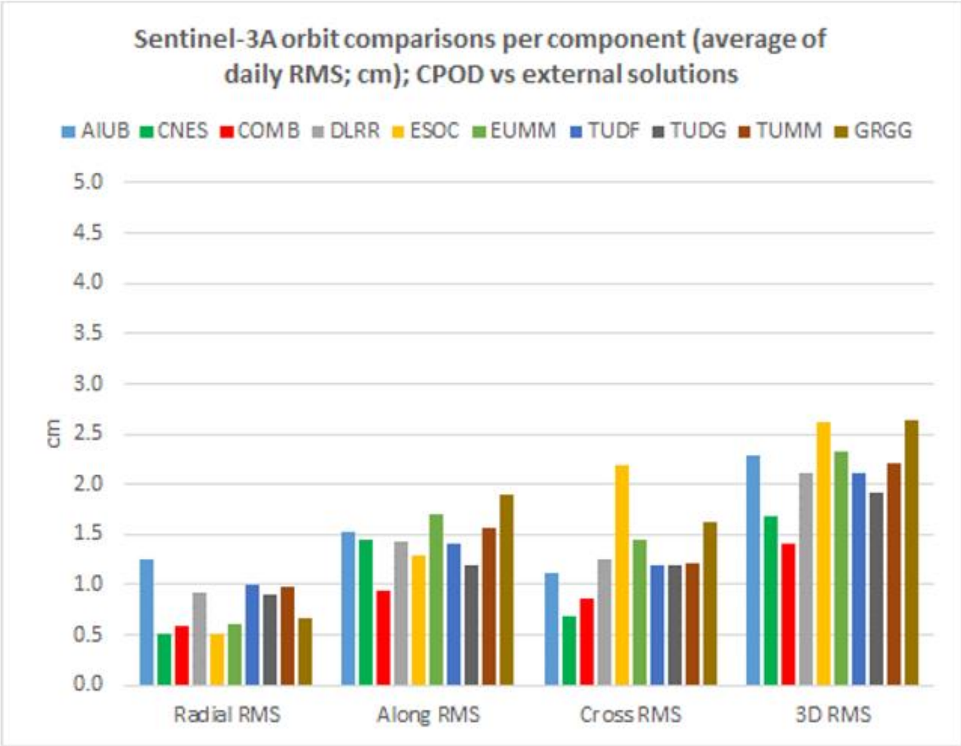

Figure 24. Sentinel-3A orbit comparisons per component (average of daily RMS; cm); CPOD vs. external solutions (source GMV)

13.4 EVALUATION OF TRF SOLUTIONS IN PRECISE ORBIT DETERMINATION BY CNES/CLS IDS ANALYSIS CENTER

The three realizations (ITRF2014/IGN, DTRF2014/DGFI and JTRF2014/JPL) are evaluated by DORIS and SLR data processing for TOPEX, Jason-1, and Jason-2 satellites to explore the whole period of the DORIS observations.

We give here the orbit results obtained on the time span processing from January 3, 1993 to December 27, 2014 of TOPEX, Jason-1 and Jason-2 satellites for the three 2014 TRF realizations and we compared to the ITRF2014 solution the other two solutions. The **Table 13** gives the average per arc of the DORIS station number, the overall number of DORIS and SLR observations, as well as the DORIS and SLR RMS residuals.

Due to the editing criteria of the JPL solution, the JTRF2014 contains fewer stations at a given time than both DTRF2014 and ITRF2014 due to a more aggressive data editing, particularly at the beginning of the processed period, in 1993 and it stops end 2014. After the end of 2014 there are fewer stations for the ITRF2014 and DTRF2014 solutions because the new stations are not in the solutions. So, we decided to make the comparison until the end of 2014.

Satellite	TRF Solutions	Average DORIS stations number	Average DORIS points	Average SLR points	Average RMS residuals	
					DORIS (mm/s)	SLR (cm)
TOPEX 3 Jan. 1993 To 17 Jun. 2004	ITRF2014	39.8	18718	1662	0.455	4.58
	DTRF2014	39.8	18765	1663	0.456	4.58
	JTRF2014	35.3	17226	1665	0.452	4.69
JASON-1 18 Jul. 2004 To 12 Jul. 2008	ITRF2014	43.9	36270	1463	0.307	2.52
	DTRF2014	43.8	36106	1463	0.307	2.51
	JTRF2014	43.2	35913	1464	0.307	2.53
JASON-2 13 Jul. 2008 To 27 Dec. 2014	ITRF2014	46.3	50934	1646	0.313	2.15
	DTRF2014	45.9	50498	1645	0.313	2.17
	JTRF2014	45.7	50458	1648	0.312	2.15

Table 13. Summary of POD results

The differences between the three 2014 TRF realizations are at a very low level in particular for the Jason-1 and Jason-2 results. For the ITRF2014 and DTRF2014 solutions, the most significant improvements are obtained for years from 1992 to 1998 and from 2010 to 2014, probably due to the improvement of the estimation of the station velocities compared to those estimated in the DPOD2008 solution realization. We have also evaluated the ITRF2014 solution with annual and semi-annual signals on the station coordinates and the DTRF2014 solution with loading adding atmospheric and hydrologic non-tidal loading. The impact of these solutions on the POD is not significant. Based on the different criteria used for evaluation, it has been shown this is the ITRF2014 solution which presents the best overall performance. This realization will be used for the DPOD2014 solution which will be used for the operational processing of DORIS data.

13.5 SENSITIVITY OF DORIS USO TO THE SAA EFFECT

All the Ultra Stable Oscillators (USO) of DORIS satellites are more or less sensitive to the South Atlantic Anomaly (SAA) effect. For Jason-1 and SPOT-5 satellites, a corrective model has been developed and used for the realization of the ITRF2014. However, Jason-2 is also impacted, not at the same level as Jason-1 but strong enough to worsen the multi-satellite solution provided for ITRF2014 for the SAA stations. The last DORIS satellites are also impacted by the SAA effect, in particular Jason-3. While awaiting a DORIS data corrective model for the other satellites Jason-3 and Sentinel-3A, we propose here different strategies to minimize the SAA effect on the orbit and also and in particular on the station position estimation.

13.5.1 SAA IMPACT ON THE PRECISE ORBIT AND ON THE STATION POSITION ESTIMATION

To conduct this study, we processed the DORIS RINEX data from April 2016 to August 2017 (72 weeks) for the Jason-2, Cryosat-2, Jason-3 and Sentinel-3A satellites. On **Figure 25** which gives the SAA map at the altitude of Jason satellites, we can find the stations in the heart of the SAA area: Arequipa, Ascension, Cachoeira, Kourou, Le Lamentin, Libreville et Sainte-Helene. We are looking at the adjusted parameters in GINS processing. The Frequency bias of Kourou (master beacon) for Jason-3 is larger than those obtained for Jason-2 and Sentinel-3A (see **Figure 26**). The DORIS residuals for Jason-3 (0.36 mm/s) are also larger than those obtained for Jason-2 (0.33 mm/s) certainly due to the SAA effect.

We determined the single satellite solution from DORIS data of Jason-2, Jason-3, Sentinel-3A et Cryosat-2 from April 2016 August 2017 and we compared to DPOD2014 (computed by CATREF). As the Cryosat-2 USO is not affected by SAA, we use the Cryosat-2 single satellite solution as a reference. The **Table 14** gives the differences between the Jason-2/Jason-3/Sentinel-3A and Cryosat-2 solutions in North East Up (NEU) components (Mean of 72 weeks). Jason-3 USO is more sensitive to the SAA than Jason-2. The Jason-3 solution gives a bias in at least one of the NEU components for the SAA stations. The sensitivity of the Sentinel-3A USO is not strong enough to affect the station position estimation.

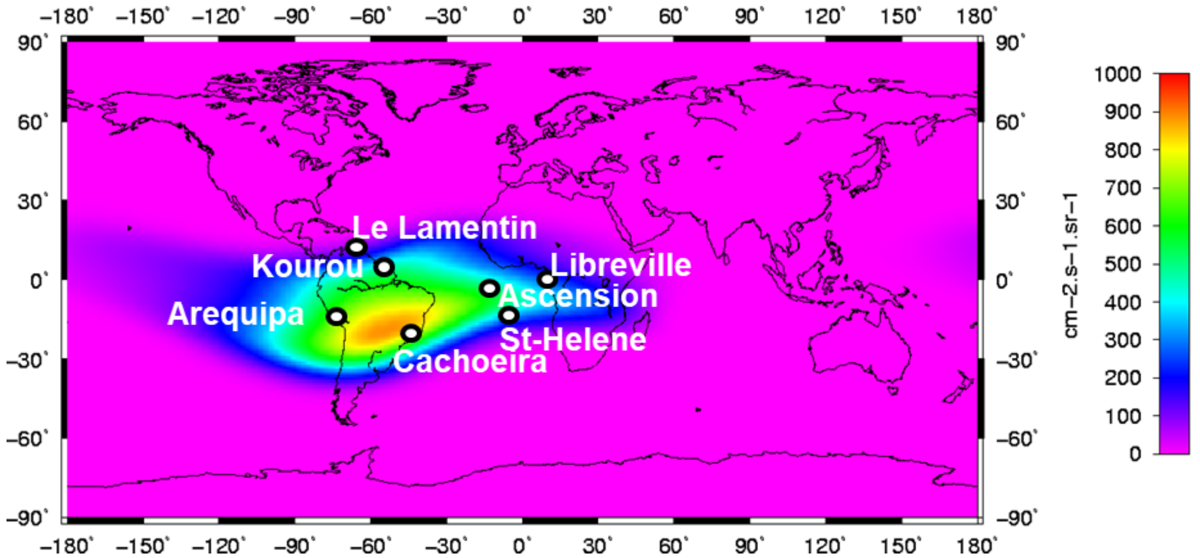

Figure 25. SAA map from Jason-2 CARMEN data and the SAA stations (>87 MeV integrated proton flux map (2009-2011 average))

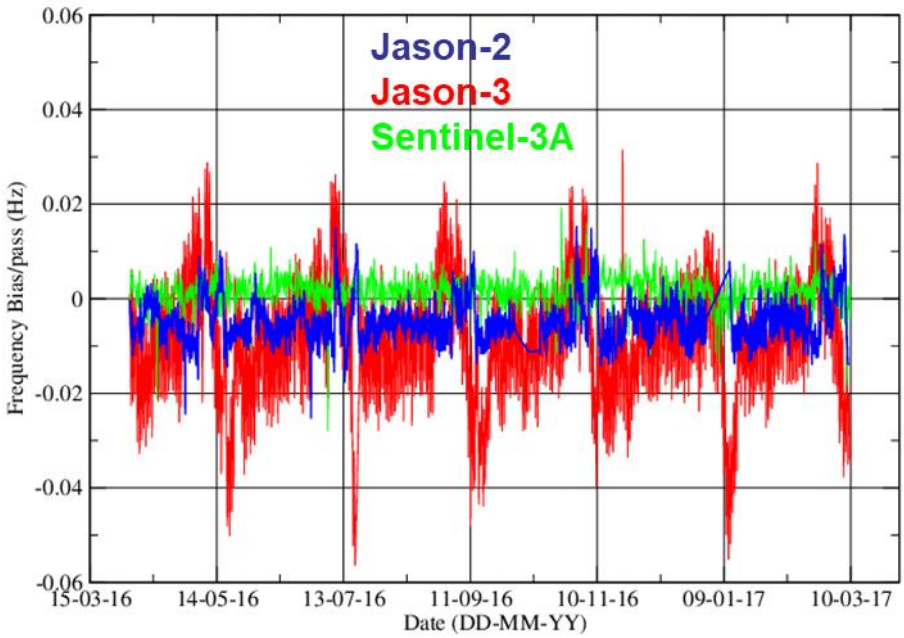

Figure 26. Kourou Frequency bias adjusted per pass

Station	**Jason-2** (in cm)			**Jason-3** (in cm)			**Sentinel-3A** (in cm)		
	North	**East**	**Up**	**North**	**East**	**Up**	**North**	**East**	**Up**
Cachoeira	4.4	4.5	**8.9**	**6.8**	2.6	**20.0**	0.3	-0.6	0.1
Arequipa	-1.6	4.2	**8.8**	-1.7	**10.8**	**20.1**	0.4	-0.7	1.9
Kourou	-2.0	-1.1	0.8	**-6.0**	1.3	3.5	0.8	1.3	0.4
Ascension	1.4	-3.9	**6.1**	2.1	-0.2	**14.8**	1.5	-0.5	-0.2
Saint Helene	**5.0**	-1.6	2.4	**9.5**	-3.2	**9.3**	0.3	-0.7	-1.5
Le Lamentin	-0.6	-0.2	-3.6	-1.8	-2.1	**-5.6**	1.2	0.4	-0.8
Libreville	-3.9	-0.4	2.9	**-6.1**	1.1	**8.3**	1.1	0.3	0.4
Yarragadee	*-1.1*	*-0.1*	*0.2*	*-0.2*	*0.9*	*-0.4*	*0.8*	*0.2*	*0.5*
Thule	*0.2*	*-0.6*	*-0.4*	*1.2*	*-0.7*	*-1.1*	*-0.4*	*0.9*	*-1.6*

Table 14. Differences between the Jason-2/Jason-3/Sentinel-3A and Cryosat-2 solutions in NEU, average over 72 weeks (from April 2016 to August 2017)

13.5.2 STRATEGY TO MINIMIZE THE SAA EFFECT

While awaiting a DORIS data corrective model for the satellites Jason-2&3, we propose here different strategies to minimize the SAA effect on the orbit and also and in particular on the station position estimation.

For each satellite Jason-2&3 we did two processing, one classical with one frequency bias adjusted per pass for all the DORIS stations and one other with frequency polynomial (degree 4) adjusted per pass for SAA stations (Arequipa, Cachoeira, Sainte-Helene, Libreville, Ascension, Hartebeesthoek, Kourou, Tristan, Le Lamentin). The DORIS residuals are lower when we apply the strategy of polynomial adjusting frequency per pass for SAA stations. The impact is significant for SAA stations as shown in **Figure 27** for Jason-3. The global RMS is reduced by 0.002 mm/s for Jason-2 and by 0.004 mm/s for Jason-3.

Jason-2 and Jason-3 single satellite solutions have been determined in the classical case and in the polynomial case. As the Cryosat-2 USO is not affected by SAA, we use the Cryosat-2 single satellite solution as a reference and we calculated the differences between the Jasons and Cryosat-2 solutions in NEU. As shown in **Table 15** for Jason-3, the strategy of polynomial adjustment brings an improvement in the station position estimation for the SAA stations, especially for the vertical component.

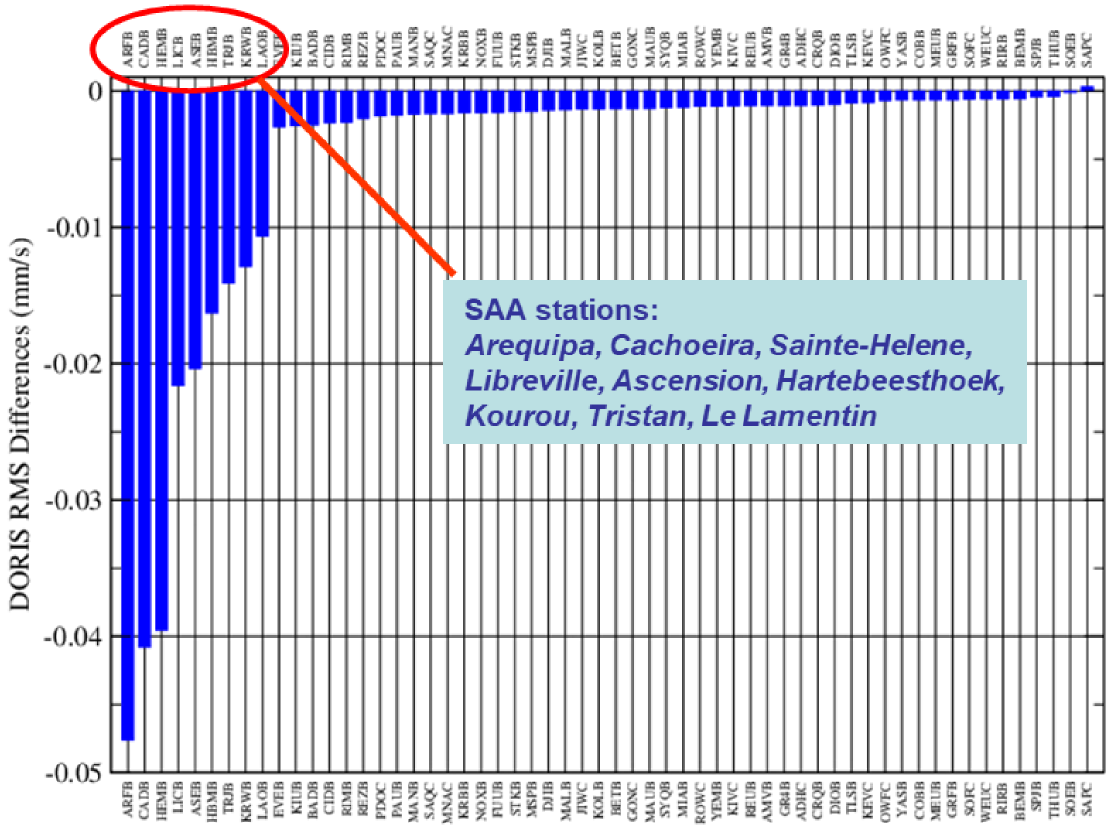

Figure 27. DORIS RMS of fit differences per station for Jason-3 case with strategy – classical case

Station	Jason-3 (in cm)			Jason-3 with strategy (in cm)		
	North	East	Up	North	East	Up
Cachoeira	**6.8**	2.6	**20.0**	**4.9**	**6.2**	**5.2**
Arequipa	-1.7	**10.8**	**20.1**	-0.2	4.6	3.5
Kourou	**-6.0**	1.3	3.5	-3.5	0.4	0.8
Ascension	2.1	-0.2	**14.8**	-1.0	1.1	**5.2**
Saint Helene	**9.5**	-3.2	**9.3**	**4.9**	-3.3	1.7
Le Lamentin	-1.8	-2.1	**-5.6**	-0.6	-1.1	-0.6
Libreville	**-6.1**	1.1	**8.3**	**-3.1**	1.7	2.3
Yarragadee	*-0.2*	*0.9*	*-0.4*	*-1.1*	*0.1*	*0.1*
Thule	*1.2*	*-0.7*	*-1.1*	*0.9*	*-0.2*	*-1.8*

Table 15. Differences between the Jason with and without strategy and Cryosat-2 solutions in NEU, average over 72 weeks (from April 2016 to August 2017)

13.5.3 STRATEGY TO ADD SINGLE SATELLITE SOLUTION AFFECTED BY THE SAA IN THE MULTI-SATELLITE SOLUTION

For Jason-1, we developed a method to add the single satellite solution Jason-1 affected by the SAA in the multi-satellite solution. Before combining Jason-1 solution to the other single satellite solutions, we rename the SAA stations (and all their adjusted parameters). So, these SAA stations from Jason-1 do not contribute to the realization of the combined solution.

We computed 3 weekly multi-satellite solutions from 2010 to August 2017 (8,5 years):

- One Solution of reference REF which combines the solutions of satellites:
  Envisat + Spot4 + Spot5 + Cryosat-2 + HY-2A + Saral + Sentinel-3A

- And two solutions with the single satellite solution Jason-2 and Jason-3 affected by SAA:
  Solution 1: REF + Jason-2 + Jason-3
  Solution 2: REF + Jason-2 SMS + Jason-3 SMS
  with SMS = SAA Mitigation Strategy: Renaming + (Polynomial adjusting)

The **Table 16** gives the differences between the solutions 1&2 with the solution of reference REF. The strategy brings an improvement in the station position estimation for the SAA stations, especially for the vertical component. We can also remark that the IDS solution provided for the ITRF2014 was worsened by the Jason-2 solution for the SAA stations.

Station	Solution 1 (in cm)			Solution 2 (in cm)		
	North	East	Up	North	East	Up
Cachoeira	0.9	-0.2	2.2	0.3	0.2	0.7
Arequipa	-0.5	1.1	2.3	0.0	0.3	0.4
Kourou	-0.4	0.1	0.2	-0.2	0.06	0.04
Ascension	0.1	-0.5	2.0	0.1	-0.1	0.5
Saint Helene	1.4	-0.4	1.6	0.5	-0.2	0.4
Le Lamentin	-0.1	-0.3	-1.1	0.0	-0.1	-0.2
Libreville	-1.0	-0.3	1.1	-0.02	-0.06	0.2
Yarragadee	*0.1*	*-0.1*	*0.06*	*0.1*	*-0.1*	*0.07*

Table 16. Differences between the solutions with Jason-2&3 and the solution of reference REF in NEU, average over 8.5 years

13.6 CONTRIBUTION TO IDS MEETINGS

The Analysis Center's representatives participated in 2017 to the AWG meeting in London. They also participate to the OSTST in Miami, EGU in Vienna and AGU in New Orleans. They presented the following works:

AWG London

- GRG status report
  https://ids-doris.org/images/documents/report/AWG201705/IDSAWG201705-Capdeville-GRG_StatusReport.pdf
- Evaluation of TRF2014 solutions by CNES/CLS AC:
  https://ids-doris.org/images/documents/report/AWG201705/IDSAWG201705-Capdeville-GRGevaluationTRF2014.pdf
- Evaluation of the DPOD2014 :
  https://ids-doris.org/images/documents/report/AWG201705/IDSAWG201705-Capdeville-GRGevaluationDPOD2014.pdf

OSTST Miami

- Strategy to minimize the impact of the South Atlantic Anomaly effect on the Jason-3 and Sentinel-3A POD and on the station position estimation

And contribute to Alexandre Belli study:

- The T2L2 contribution to precise orbit determination and positioning

EGU Vienna

- Evaluation of ITRF2014/DTRF2014/JTRF2014 solutions in precise orbit determination by CNES/CLS IDS Analysis Center
  https://ids-doris.org/images/documents/report/publications/EGU2017_GRG_EvaluationsDTRF_ITRF_JTRF2014.pdf

AGU New Orleans

- Strategy to minimize the impact of the South Atlantic Anomaly effect on the DORIS station position estimation
  https://ids-doris.org/documents/report/publications/AGU2017-StrategyMinimizeSAAonPosition-Capdeville.pdf

14 GSFC/NASA ANALYSIS CENTER (GSC)

F.G. Lemoine [(1)], D.S. Chinn [(2)], N.P. Zelensky [(2)], Karine Le Bail [(3)]
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The GSC Analysis Center carried out the following activities in 2017:

(1) Corrected an error in the end-of-mission processing for SPOT-5, where we had not applied the modified solar array pitch bias that the spacecraft had actually used.

(2) Delivered new SINEX files that used DPOD2014 and included Jason-3 data.

(3) Tested the three ITRS realizations produced by the ITRS product centers: IGN, DGFI, and JPL: ITRF2014/IGN, DTRF2014, and JTRF2014 as they applied to altimeter satellite orbit determination.

14.1 CORRECTION OF SPOT-5 PROCESSING

A review of the empirical accelerations for SPOT-5 showed that an input error after MJD=56700 had resulted in the solar array pitch bias not being applied. We corrected this error in the SINEX gscwd29 and later. This error affected the SPOT-5 orbits for approximately the last two years of the mission. It caused the empirical along-track acceleration amplitudes to increase by factors of five to ten (to as high as 10 nm/s^2), as we showed at the Analysis Working Group meeting in London in May 2017. We corrected this input error and show the updated once-per-revolution empirical acceleration history for SPOT-5 in **Figure 28**. The corrected SPOT5 (gscwd29) mean and median values of the empirical accelerations are summarized in **Table 17.** The mean and median were computed using 2830 daily acceleration values over the entire span of the SPOT-5 mission.

Parameter	**Mean** (nm/s^2)	**Median** (nm/s^2)
Along-track	0.974	1.21
Cross-track	0.790	1.11

Table 17. Statistics of SPOT-5 empirical accelerations for gscwd29

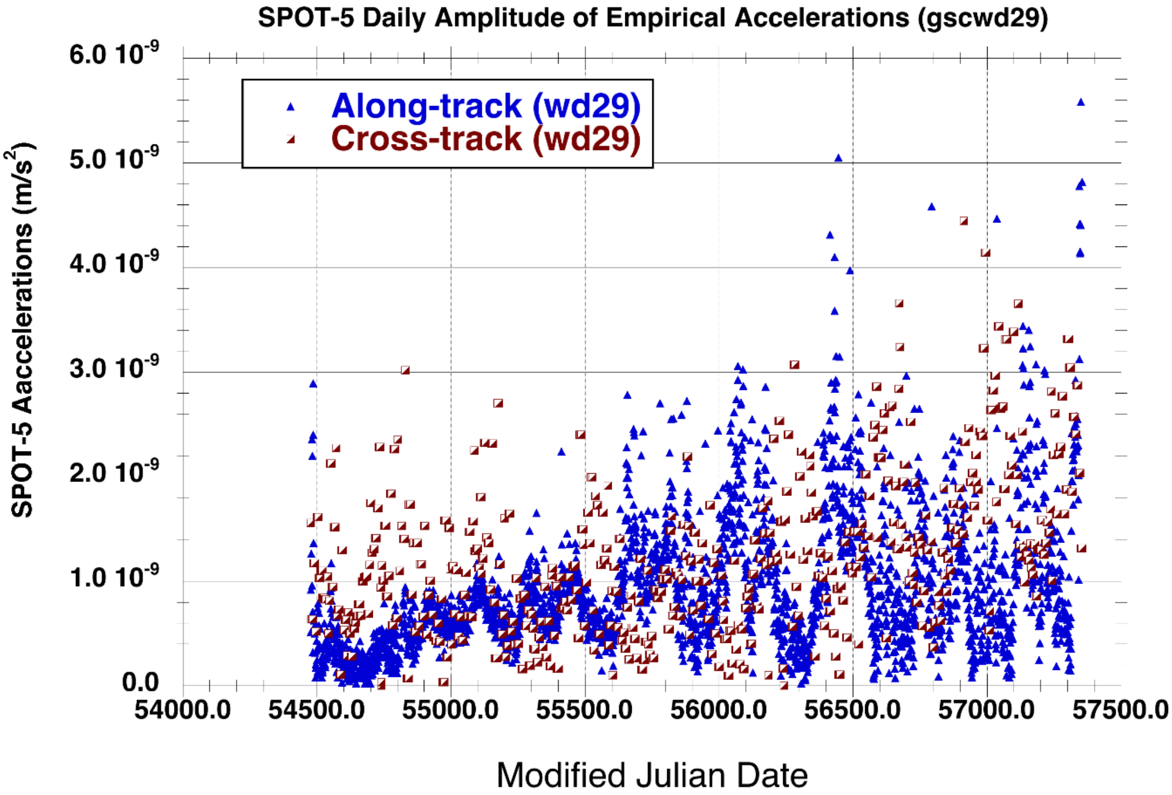

Figure 28. SPOT-5 Daily amplitude of empirical accelerations, along-track and cross-track from the gscwd29 SINEX series

14.2 SINEX DELIVERIES

(a) gscwd29 series. This series was developed after the Analysis Working Group meeting in London, in May 2017. We reprocessed all the DORIS data using DPOD2014 as a priori. One of the benefits of this was to ensure that we had updated coordinates for all the stations, especially the newest stations. We made two deliveries of the gscwd29 series to the IDS data centers at the IGN and the NASA CDDIS *(initially documented in DORISREPORT 4328, 16-June-2017)*. The time series on the CDDIS starts in 2008 (DOY 020) and is complete through 2017 (DOY 176).

(b) gscwd30 & gscwd31 series. These series were developed to test the addition of Jason-3. Jason-3 involves the processing of RINEX data which we treat as Doppler data, after appropriate preprocessing. As noted by Jean-Michel Lemoine et al. (Adv. Space Res., 2016) in their paper on RINEX processing, it is important to account for the offset from the 2GHz phase center that we normally assume with the V2.2 data. We tested two methods of handling the SAA stations: in wd30, there was no SAA strategy; in gscwd31, the SAA stations for Jason-3 were adjusted locally on the Jason-3 matrix and thus did not contribute to the combination solution. The gscwd30 series covers 2016 and 2017 from 2016-DOY 010 to 2017-DOY176. The gscwd series cover 2016 and 2017 from 2016-DOY003 to 2017-DOY267 (end of the third quarter 2017).

Series	Description	Comment
gscwd26	series delivered for ITRF2014	Ends 2016-DOY269.
gscwd27	gscwd26 + SARAL (**Test Series only**)	2013-DOY006 to 2016-DOY178
gscwd28	gscwd27 + use solar array quaternions on Jason-2 instead of nominal attitude model.	2008-DOY195 to 2016-DOY360
The following updated series were delivered in 2017.		
gscwd29	gscwd28 but use DPOD2014 instead of DPOD2008	2008-DOY020 to 2017-DOY176
gscwd30	Add Jason-3 starting in 2016, no strategy for SAA stations (**Test Series only**).	2016-DOY010 to 2017-DOY176
gscwd31	Add Jason-3 starting in 2016, with strategy for SAA stations (**New Operational Series**).	2016-DOY003 to 2017-DOY267
All series (gscwd26-gscwd31) use quaternions to orient the body of Jason-2.		

Table 18. Description of GSC SINEX Series

G. Moreaux *(personal communication, December 5, 2017)* of the IDS Combination Center made the following remarks concerning the two new series:

(a) gscwd31 showed smaller scale values than gscwd29 and gscwd30. The mean values over the time period 2016.0-2017.5 were: 11.3 ± 1.8mm for gscwd29, 8.8 ± 2.3mm for gscwd30 and 5.9 ± 2.9mm for gscwd31.

(b) adding Jason-3 reduced the standard deviation of the translation parameters, mainly in Tz (from 14.8 mm for gscwd29 to 11.8 mm for gscwd30 and to 11.6 mm for gscwd31). In terms of EOP differences w.r.t IERS C04 series, the addition of Jason-3 caused a slight degradation of in the standard deviations of the differences w.r.t. IERSC04 for both Xp and Yp.

For completeness, we summarize in **Table 18** the description of the different SINEX series we have delivered, and how they are related to the series that we delivered for ITRF2014, that is documented in Lemoine et al. (2016, Adv. Space Res.)

14.3 TESTING OF ITRS REALIZATIONS

We extensively tested the three ITRS realizations as well as DPOD2014 and applied them to SLR and DORIS orbit determination for TOPEX/Poseidon, Jason-1, Jason-2, and Jason-3. We looked carefully at the change in RMS of fit (both with time and for individual stations). We looked at the change in the orbits, estimated the amplitude of the radial orbit drift of the orbit differences. We also computed the DORIS residuals from different complements w.r.t. the GPS-reduced dynamic orbits of JPL. These results are discussed and presented in detail in the following paper which was submitted and eventually published online late in 2017:

Zelensky, N.P., F.G. Lemoine, B.D. Beckley, D.S. Chinn and D.E. Pavlis (2018), "Impact of ITRS 2014 realizations on altimeter satellite precise orbit determination", Adv. Space Res., 61(1), 45–73, doi: 10.1016/j.asr.2017.07.044.

We summarize the salient conclusions from the paper:

(1) Following 2009, the ITRF2008 DORIS & SLR station position extrapolation error dominates with the comparison with the ITRF2014 stations and orbits. SLR RMS of fit improves by 1-2 mm between 2011 and 2016; DORIS RMS of fit improves by as much as 0.012 mm/s in 2016.

(2) The altimeter crossovers show a statistically significant improvement in accuracy for all ITRF2014 –based orbits starting in 2002 and increasing with time.

(3) Beginning in 2016 (with Jason-3), statistically significant improvement is only seen for DPOD2014, which has the most complete station set.

(4) Station complements that are routinely updated are essential to POD.

(5) The JTRF2014 series accurately represents non-tidal station loading and geocenter motion. These effects impact the Jason-2 orbit with a 15 mm peak-to-peak annual variation in Z, and is important to POD.

(6) The ITRF2008 to ITRF2014(IGN) DORIS network drift in Z as computed arc-by-arc with Helmert transformation of only those stations used in the POD is -0.23 mm/yr.

(7) The ITRF2008 to ITRF2014 (IGN) radial orbit drift amounts to only 0.028 mm/yr between 1993 and 2016, however we still observe regional rates of up to ±0.20 mm/yr at the higher latitudes.

15 IGN/JPL ANALYSIS CENTER (IGN)

Pascal Willis [1,2]
[1] *IGN, France* / [2] *IPGP, France*

15.1 CONTEXT

The Institut Géographique National uses the GIPSY/OASIS software package (developed by the Jet Propulsion Laboratory, Caltech, USA) to generate all DORIS products for geodetic and geophysical applications. In 2017, IGN used the most recent versions (GOA 6.3 and successive development versions). This software package is installed on both sites at IGN in Saint-Mandé and at IPGP in Tolbiac. While data are processed on a regular basis, DORIS results were only submitted at specific intervals (every 3 months, as requested by the IDS Analysis Coordinator). New solutions are submitted simultaneously to both IGN and NASA/CDDIS data centers. In 2017, the continuation of the solution submitted for the ITRF2014 contribution (ignwd15) was performed. In parallel, early developments were done with the new GipsyX software package from JPL for processing DORIS Doppler and RINEX data.

15.2 PRODUCTS DELIVERED IN 2017

The latest delivered IGN weekly time series is still ignwd15 (in free-network) (**Table 19**). This solution is used by the IDS combination center to derive the IDS combined products. The ignwd15 solution is the one used by the IDS Combination Center in preparation of ITRF2014 (same analysis options). Doppler data from all DORIS satellites were used, except for Jason-1 because of the South Atlantic Anomaly effect. For SPOT5, corrected data were used, as provided by Hughes Capdeville. Following problems found when trying to process the DORIS data expressed in the new RINEX format (providing pseudoranges and phases instead of integrated Doppler), the newest satellites Jason-3 and Sentinel-3 could not be used in the IGN solution in 2017.

As the DPOD2014 solution was not available in 2016, only free-network solutions were submitted since then. As the IDS combination can now provide the IGN solution after projection and transformation into ITRF2014, as well as all derived geodetic products, only the DORIS free-network solution is now provided to IDS. Due to the lack of time, no new combined IGN solution was computed, as we plan to use the future regular DPOD2014 realizations to transform and align our weekly solution with the future GipsyX software package, still under development.

In early 2017, the problem related to the change in procedure for the CDDIS data center encountered at the end of 2016 was solved.

Product	Latest version	Update	Data span	Number of files
Weekly SINEX - free-network	ignwd15	Weekly	1993.0-2017.7	1292
STCD	none	Weekly	1993.0-2014.7	0
Geocenter	none	Weekly	1993.0-2014.7	0
EOPs	none	Weekly	1993.0-2014.7	0

Table 19. IGN products delivered at the IDS data centers until the end 2017. As of March 20, 2018.

In 2017, the new DPOD2014 solutions are now generated by Guilhem Moreaux (CLS). We set up a validation group to perform some basic verifications (availability of results for all stations, tests of performances for POD applications, comparisons with previous solutions, ...). This evaluation group includes: Hanane Ait Lakbir (CNES), Alexandre Couhert (CNES), Frank Lemoine (NASA/GSFC), Guilhem Moreaux (CLS), Pascal Willis (IGN-IPGP, chair), Nikita Zelensky (SGT). In 2017, two official new releases of DPOD2014 were validated and then released through a DORISMail.

15.3 MAJOR IMPROVEMENTS IN 2017

Major difference from previous ignwd15 weekly solution concerns:

- the use of phase law correction (however, the correction for the Alcatel antennas is only based on data provided by the manufacturer and not yet data from anechoid chamber observations),
- the use of the GRGS gravity field model (EIGEN-6S, using 2 successive realization) including time variations,
- use of VMF-1 mapping function and,
- only at the end of the time series, estimation of horizontal tropospheric gradients (since January 2014).

15.4 NEW DEVELOPMENTS

New developments are mostly related to modification of the GIPSY-OASIS II software package to allow processing of the new DORIS satellites (jason3 and sentinel3A), which now only provide data in the DORIS/RINEX data. For test purposes, several days were processed with GIPSY/OASIS II for the Jason2 satellite, as CNES provide both the Doppler data and the RINEX data for this satellite, allowing possible verification. Some early results were obtained in 2017, showing degradation when using the RINEX data. Data were processed either transforming the RINEX data into integrated Doppler data and also directly using RINEX data for phase and pseudo-ranges. Current results in early 2018 show that the problem may be link to an improper interpretation of the DORIS time tagging information provided in the RINEX files (clock model for the satellite on-board oscillator). Some discussions were initiated with other groups to solve this problem: NASA/CDDIS (Frank Lemoine, Nikita Zelensky), CNES (Flavien Mercier, Jean-Michel Lemoine).

In parallel, major developments were made at JPL on the new GipsyX software package for GNSS data processing, for which IGN obtained a license in 2017. As the older GIPSY/OASIS II software is not maintained any more, it was decided to start extending the data processing capabilities of GipsyX to include DORIS measurements. Some early tests were made in 2017 at JPL with Willy Bertiger, processing DORIS data (Doppler, or pseudo-range and phase) to be able to process the oldest and the newest DORIS satellite, in view of a future complete DORIS data reprocessing. Similar problems, as found with GIPSY/OASIS II, were found and are still under investigation.

15.5 REFERENCES

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16 INASAN ANALYSIS CENTER (INA)

Sergey Kuzin / INASAN, Russia

16.1 INTRODUCTION

In 2017, INASAN (ina) DORIS Analysis Center (AC) continued routine processing DORIS data using GIPSY-OASIS II software package (v. 6.4, developed by JPL). The processing strategy and the used models stayed the same as for the ITRF2014 preparation. There were no done any strategy, software package and models modifications during 2017. Currently INA AC processes DORIS data in DORIS 2.2 format for CRYOSAT2, HY2A, JASON2 and SARAL satellites. **Table 20** shows current products delivered by INASAN to the IDS.

Product	Latest version	Span
Weekly SINEX (free-network solutions)	inawd10	1993.0 – 2017.8
Geocenter time series	ina17wd01	1993.0 - 2017.8
EOP time series	ina17wd01	1993.0 - 2017.8

Table 20. INASAN SINEX series delivered to the IDS (February 2018).

16.2 ANALYSIS RESULTS DESCRIPTION OF THE MAIN SCIENTIFIC RESULTS OBTAINED IN 2017

Table 21 gives statistical information of the current INASAN (inawd10) and IDS combined solution (idswd12) contribution to IDS. The epoch for the comparison is the mean value over the whole time period. From the Analysis Coordinator graphs (https://apps.ids-doris.org/apps/7ptool.html) we can see continuous slow scale rise beginning from the mid 2012 for INA, IGN, GOP and IDS Analysis Centers. While for the GRG and GSC AC centers the scale parameter stays rather stable, it is biased compared to previous analysis centers. This scale increase is currently under investigation within the IDS Analysis Centers.

Table 22 displays the statistical information about inawd10 and idswd12 EOP time series. The standard deviation (std) for the X-pole and Y-pole components of the current INA eop series has about the same values (0.54 and 0.51 mas, respectively).

It should be mentioned that numbers in **Table 21** and **Table 22** were obtained by Dr. G.Moreaux using CATREF software package (https://ids-doris.org/webservice).

Table 23 represents amplitudes and phases for the annual components of the geocenter motion for the 1993.0-2017.8 time period obtained from the transformation free-network inawd10 series to ITRF2008. In order to estimate amplitudes, periods and phases of geocenter variations with a least square estimation procedure we used CNES software package FAMOUS (Frequency Analysis Mapping On Unusual Sampling) developed by F. Mignard, OCA/CNRS (Obs. de la Cote dAzur Cassiop/Centre National de la Recherche Scientifique, ftp://ftp.obs-nice.fr/pub/mignard/Famous). The amplitudes A and phases ϕ are modeled by Acos(ωt + ϕ), ω – angular frequency. The evaluated amplitudes of the annual oscillations are 3.1±0.1 mm and 4.2±0.1 mm for X and Y components, respectively, and 3.4±0.7 mm for Z component. The phase estimates of the annual signal relative to January 1 for ina17wd geocenter time series are 359±6 and 224±5 degrees for X and Y components, respectively, and 342±28 degrees for Z component.

AC series (time interval)	**WRMS** (mm)	**Scale** (mm)	**Tx** (mm)	**Ty** (mm)	**Tz** (mm)	**Scale rate** (mm/yr)	**Tx rate** (mm/yr)	**Ty rate** (mm/yr)	**Tz rate** (mm/yr)
idswd12 (1993.0 - 2017.8)	13.97 ±3.75	10.33 ±4.64	-1.73 ±4.51	-0.93 ±4.87	-10.54 ±18.18	0.43	-0.06	0.04	-0.46
inawd10 (1993.0 - 2017.8)	19.03 ±4.68	12.95 ±5.50	-1.96 ±6.58	-5.38 ±7.88	-10.4 9±24.5 6	0.44	0.02	-0.13	0.28

Table 21. Comparative statistical characteristics (mean values) of the INA analysis center (inawd10) and IDS combined solution (idswd12) contribution to IDS wrt ITRF2014

Solution	**Span**	**X-pole**			**X-pole**			**LOD**		
		mean (mas)	std (mas)	trend (mas/y)	mean (mas)	std (mas)	trend (mas/y)	mean (mas)	std (mas)	trend (mas/y)
idswd12	1993.0-2017.8	0.02	0.42	0.00	0.00	0.40	-0.00	-	-	-
Inawd10	1993.0-2017.8	-0.02	0.54	0.01	-0.01	0.51	-0.01	-0.02	0.34	-0.00

Table 22. INA AC and combined idswd12 Earth Orientation Parameters Residuals wrt IERS C04.

Solution	**X-component**		**Y-component**		**Z-component**		**Span**
	A, mm	φ, deg.	A, mm	φ, deg.	A, mm	φ, deg.	
inawd10	3.1±0.1	359±6	4.2±0.1	224±5	3.4±0.7	342±28	1993.0 - 2017.8

Table 23. Annual geocenter motion estimations from weekly ina17wd time series wrt ITRF2008

17 GFZ ASSOCIATED ANALYSIS CENTER

Rolf König, Henryk Dobslaw, Susanne Glaser / Helmholtz Centre Potsdam - GFZ, Potsdam, Germany

17.1 INTRODUCTION

The activities performed at GFZ in 2017 comprised firstly the validation of a new GRACE Atmosphere and Ocean De-aliasing level 1B (AOD1B) product release via precise orbit determination (POD) of DORIS and altimetry satellites, namely, ENVISAT, TOPEX/POSEIDON, JASON-1, JASON-2, ERS-1 and ERS-2. Secondly, within the project GGOS-SIM (Simulation of the Global Geodetic Observing System) real DORIS data to ENVISAT and JASON-1/-2 were evaluated for their characteristics for the use in simulations to generate global Terrestrial Reference Frames (TRFs).

17.2 VALIDATION OF THE AOD1B RL06 BY POD OF DORIS SATELLITES

GFZ provides a new release, RL06, of the AOD1B product (Dobslaw et al., 2017). Its impact on POD was evaluated by adopting it to POD of the ENVISAT satellite with SLR and DORIS observations over the years 2003 to 2012, and of the JASON-1 satellite over the years 2002 to 2012. The results were compiled in terms of orbital fits and compared to a solution with the precursor versions RL04 and RL05, and to one without AOD at all. It turns out that this test shows small but significant improvements in orbit accuracy by adopting AOD1B. However, the test gets less significant when looking at the improvements during the transition of the AOD1B product from RL04 to RL05 to RL06. Indeed, the DORIS orbital fits are visually not distinguishable between the various releases as displayed in **Figure 29** for JASON-1. The improvements in SLR fits are at the order of sub-millimeters, those in DORIS fits at sub-micrometer per second level. The analysis was published in Dobslaw et al., 2017, extended to the TOPEX mission for the years 1992 to 2005 with SLR and DORIS observations, and to the ERS-1 and -2 missions over the years 1991 to 1996 and 1995 to 2006 respectively with SLR and altimetry cross-over observations and PRARE observations, respectively. We arrived at similar findings for SLR observations, sub-millimeter differences, this also for altimetry cross-overs and PRARE ranges, and sub-micrometer level for DORIS observations and micrometer level in PRARE range-rate observations. The differences in orbital fits do always show an improvement when using AOD instead of not using it. However, the differences when comparing the different AOD releases mostly point to an improvement from one release to the next, but not in all cases, indicating that this test becomes increasingly less sensitive for new AOD releases.

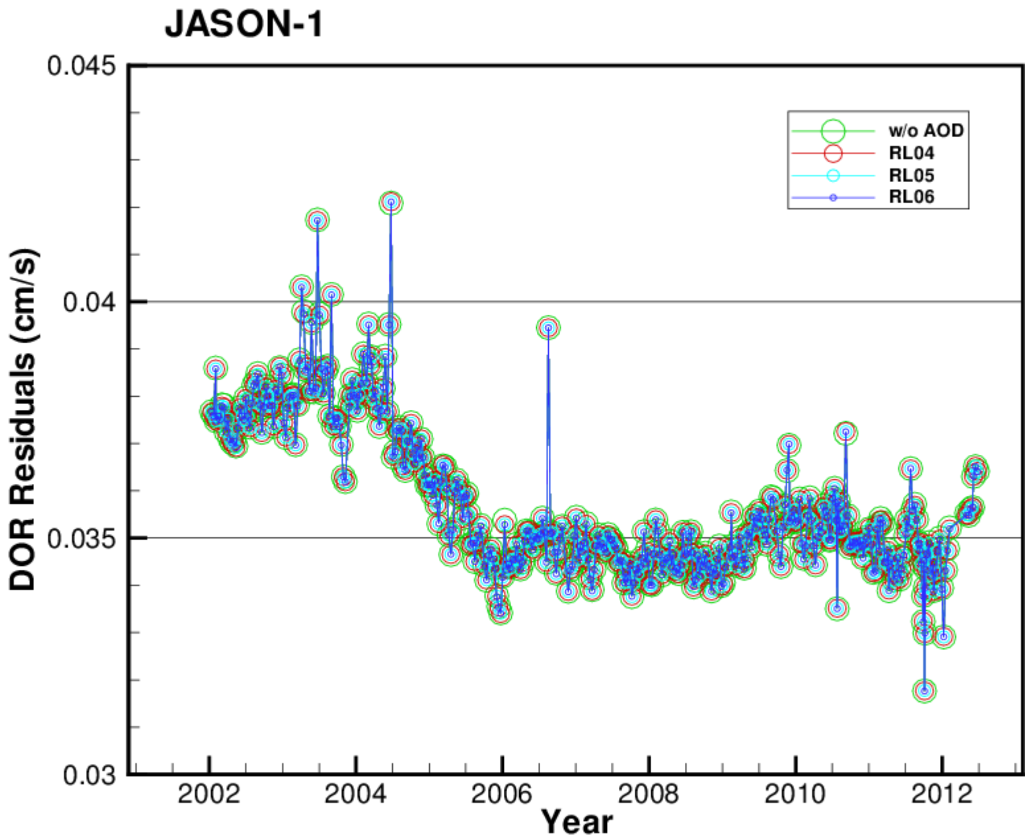

Figure 29. Jason-1 DORIS residuals for various releases

17.3 POD OF DORIS AND ALTIMETRY SATELLITES FOR GGOS-SIM

The German project GGOS-SIM (Schuh et al., 2016) aims at simulating all space-geodetic observation types including DORIS for generating the global TRF with the GGOS objectives of 1 mm accuracy and 0.1 mm/year long-term stability. Particular attention is given to scenarios close to reality in terms of distribution of the observations in time and space and in terms of their stochastic properties. For the DORIS part we selected the missions ENVISAT, JASON-1 and JASON-2 within the years 2008 to 2014 as available and a ground station network of 62 sites. POD was done based on a combination of DORIS, SLR, and altimetry cross-over observations on one hand and based purely on DORIS observations on the other hand. In both cases it turns out that the mean noise level for DORIS observations from ENVISAT can be set to 0.042 cm/s and from JASON-1 and -2 to 0.035 cm/s. The DORIS orbital fits per satellite and per arc for a total of about 87,000,000 observations are shown in **Figure 30**. This number of observations needs to be simulated for GGOS-SIM.

17.4 PRESENTATIONS

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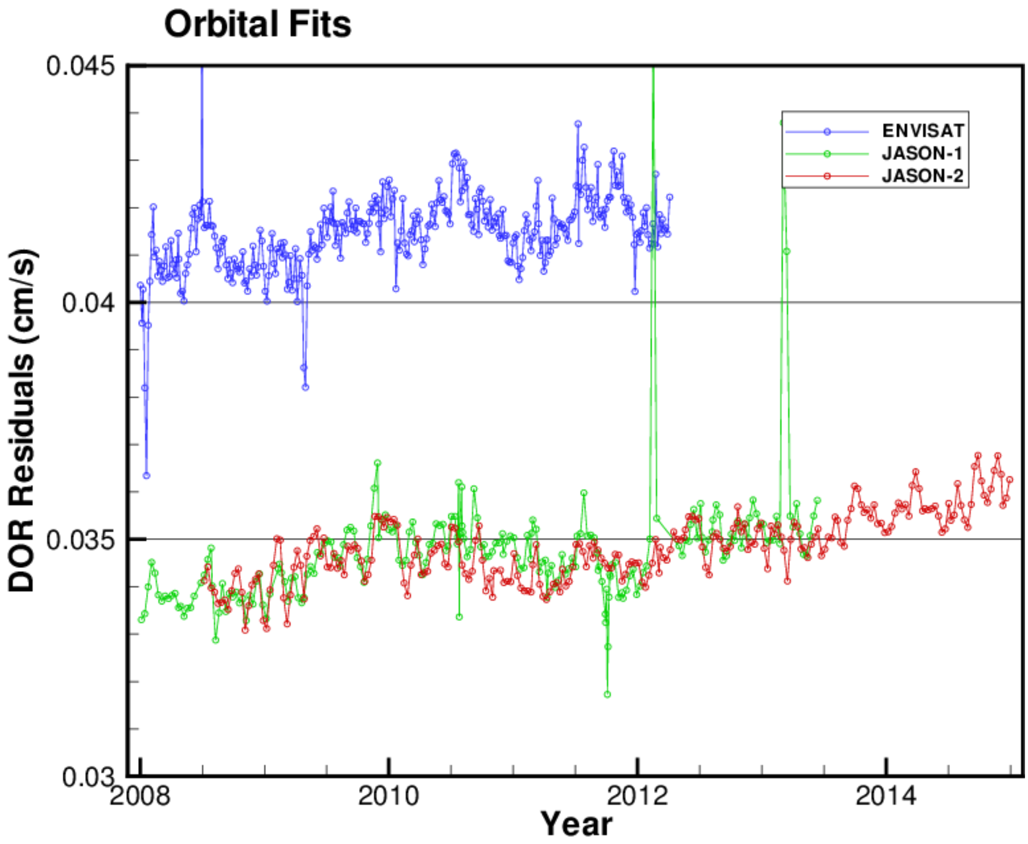

Figure 30. DORIS orbital fits per satellite and per arc

17.5 REFERENCES

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17.6 ACKNOWLEDGMENTS

These activities were partly supported by the German Research Foundation (DFG) within the project "GGOS-SIM: Simulation of the Global Geodetic Observing System".

18 CNES/SOD ASSOCIATED ANALYSIS CENTER

Alexandre Couhert (1), Hanane Ait-Lakbir (2), Sabine Houry (1), Eva Jalabert (1), Flavien Mercier (1), John Moyard (1)

(1) CNES, France / (2) CS SI, France

18.1 INTRODUCTION

The Precision Orbit Determination (POD) group at CNES produces the precise orbits that are used on the currently flying altimeter mission Geophysical Data Records (GDRs), with a state of the art set of geophysical standards. Periodically an updated set of orbits and geophysical standards is defined, to address short-term and long-term orbit errors impacting mean sea level change estimates. The ZOOM orbit determination and geodetic parameter estimation software, developed by CNES, is used for precise satellite orbit computation.

18.2 COMPARISON/EVALUATION OF DIFFERENT ATMOSPHERE/OCEAN DE-ALIASING PRODUCTS USING ALTIMETER MISSIONS

The current CNES Geophysical Data Records (GDR) version E standards rely on the inverted barometer approximation, using atmospheric gravity 6-hr NCEP pressure fields with S1 and S2 radiational tides from the Biancale-Bode model. The major drawback of this hypothesis is that high frequency atmospheric signals such as wind effects are not taken into account. More accurate de-aliasing products are now available with update delays compatible with CNES operational orbits. An evaluation of several atmospheric/ocean de-aliasing products has been done. Based on the analysis from *Moyard et al. (2017)* [1], the GFZ AOD1B RL06 products are planned to be used in the future CNES GDR version F standards.

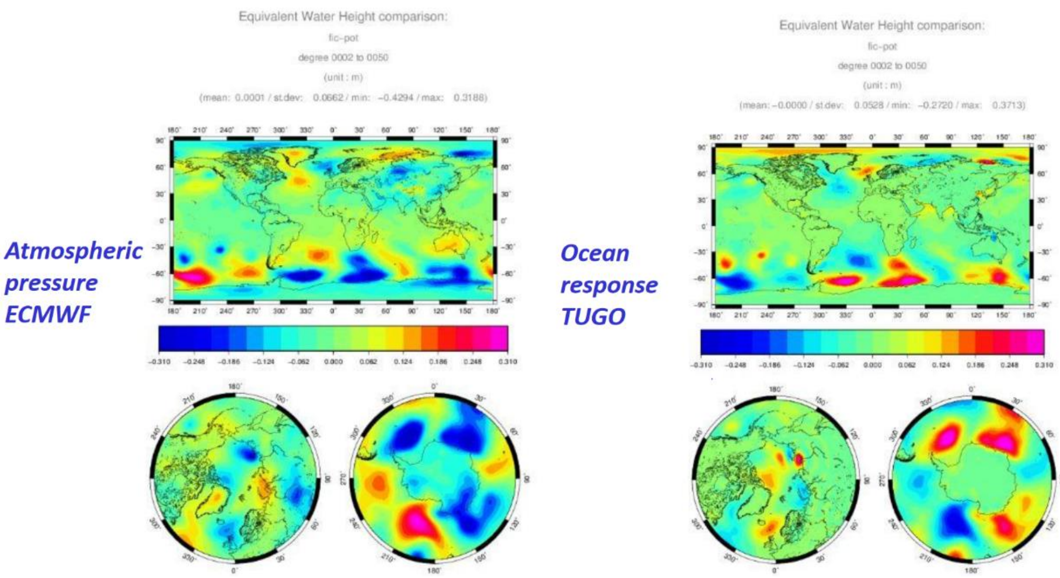

Figure 31. Time-variable atmosphere and ocean gravitational potential from P. Gégout (GET/CNRS)

18.3 DORIS-BASED POLAR MOTION DETERMINATION FOR THE MOE ORBIT SOLUTIONS

When computing MOE orbit solutions, the polar motion is given by IERS predictions since the pole values are usually not stabilized. Yet, these predictions can sometimes provide erroneous values, which may impact the precise orbit performances. It can thus be useful to estimate the polar motion based on orbit determination data, and then use this estimated pole in the actual orbit determination. The main conclusions from the study of *Jalabert et al. (2017)* [2] were the following:

- When combining data from several satellites, the precision of the DORIS-derived pole estimation is around 0,5 milliarcsecond (1,5 cm).
- The estimated pole can compensate for erroneous IERS predictions.

Outside of these poor prediction periods: the impact of estimating a DORIS pole shows a small but consistent improvement on SLR residuals and on orbit comparisons.

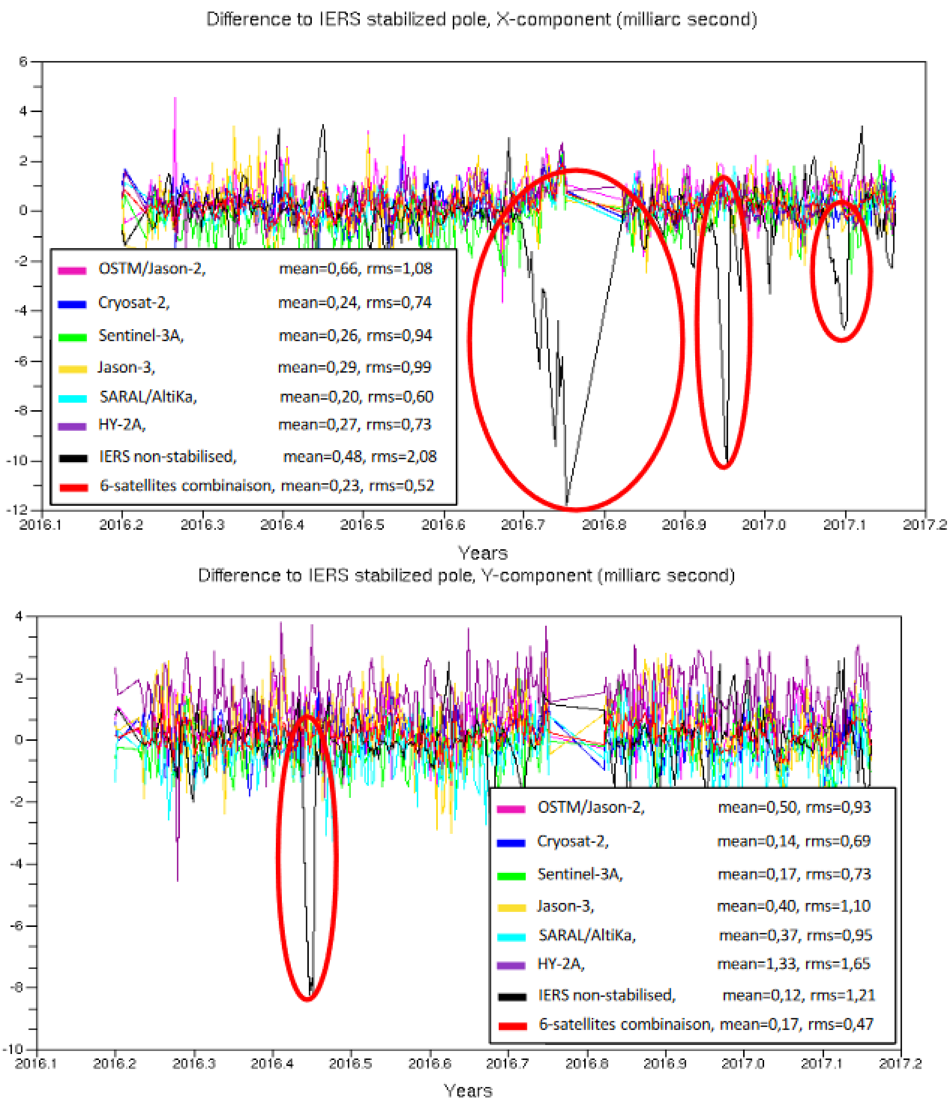

Figure 32. Independent polar motion estimates w.r.t IERS stabilized pole: X-component (top), Y-component (bottom)

18.4 ESTIMATION OF THE DORIS PHASE CENTER LOCATIONS FOR THE CURRENTLY FLYING ALTIMETER MISSIONS

The purposes of this study were firstly to estimate the offsets between the DORIS receiver phase center and the satellite center of mass in the radial, along-track and cross-track directions, and secondly to check how consistent the DORIS system is with respect to the other tracking systems (GPS and SLR). To this end, the DORIS, GPS and SLR offsets were independently estimated in the radial and cross-track directions as well as the relative along-track offsets between two instruments. The analysis of *Lakbir et al. (2017)* [3] exhibited a -2.5 cm DORIS radial offset common to all altimeter missions, and for HY-2A, a radial offset of -4.7 cm. These biases may affect the scale factor and the estimated heights of the DORIS stations. As for the along-track direction, the DORIS system shows a good consistency with GPS and SLR. Finally, there is no noticeable cross-track offset except for Sentinel-3A. The 3 tracking systems observe biases between 1.2 cm and 2.8 cm which could be explained by errors either in the model of solar radiation pressure, either in the cross-track location of the center of mass.

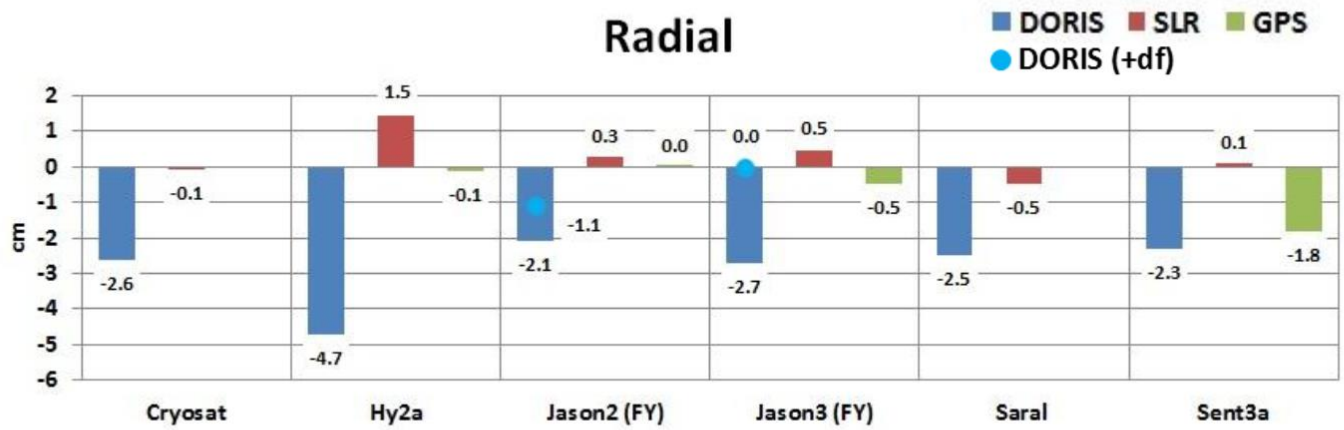

Figure 33. Radial offsets of the POD tracking instruments for the six current altimeter missions

18.5 EVOLUTION OF THE MEAN POLE MODEL

The use of the IERS 2010 standards formulas for the rotational deformation due to polar motion is discussed. The mean pole to be used in the formulas must remove the frequencies outside the annual Chandler frequency band. It is shown that moving averages are sufficient for this objective. Such a filtered value is available at IERS. However, there is still an unmodeled response which is the earth response to the remaining pluriannual signal present in the mean pole (*Mercier and Couhert, 2017)* [4]. The amplitude of this response has to be studied, and can reach millimeters values in the vertical direction. For the earth potential, the situation is different because we use now variable potential for LEO orbits computations, so it is only necessary to correct the C21/S21 values with exactly the mean pole model used for the potential identification.

A linear model for the mean pole was suggested at UAW 2017 (Paris) to better compute the rotational deformation due to the pole tide. Orbit solutions were also computed using this model and compared to the cubic-linear model of the IERS Conventions (2010) on the contemporary missions, with the same ITRF realization coordinates. The improvement was validated in *Lakbir et al. (2017)* [5] by looking at SLR residuals and geographically correlated orbit differences.

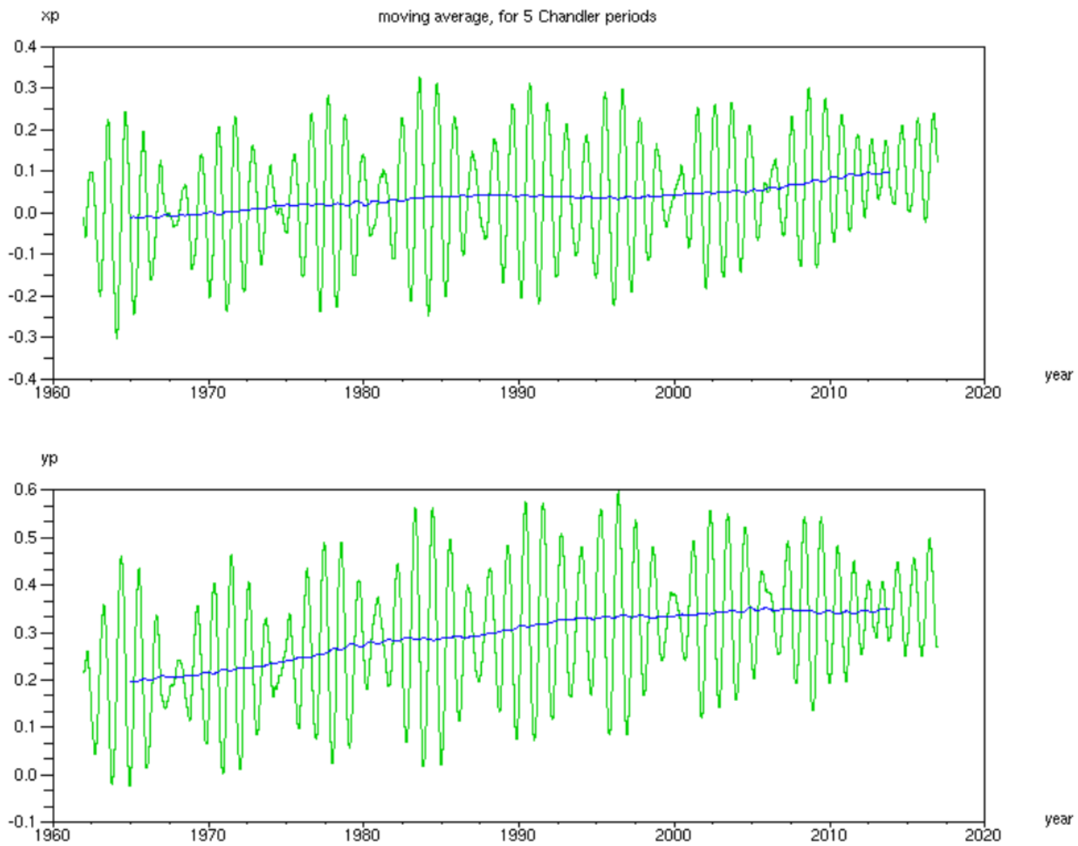

Figure 34. Polar motion (green) and signal characteristics outside the annual band (blue).

18.6 DORIS-DERIVED NON-TIDAL GEOCENTER MOTION

The geocenter vector measured by Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) so far ended with a lesser precision, as was to be expected given the less accurate positioning information, and the significant challenges to precise orbit determination (modeling of the non-gravitational forces) presented by the satellites tracked. However, the DORIS (and Global Navigation Satellite System, GNSS) tracking network is uniquely well distributed geographically. Likewise, as a microwave tracking system, DORIS (and GNSS) observations are not limited to cloudless weather, which can adversely create systematic effects in SLR-based estimations. Thus, DORIS contribution to geocenter motion determination may also play a role. While obtaining independent DORIS-based geocenter time series, *Couhert et al. (2017)* [6] [7] showed how DORIS observations can contribute to allow insight into model and geodetic technique errors, and provide an independent assessment of the ITRF origin stability.

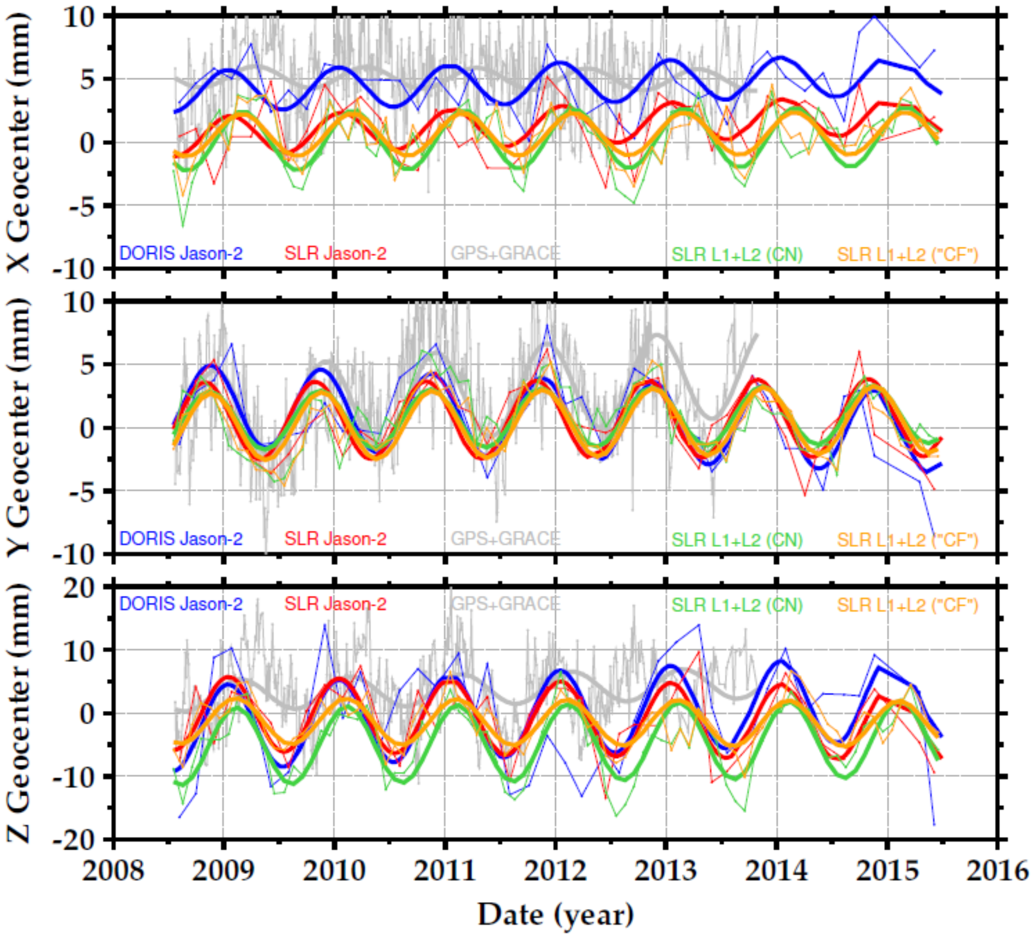

Figure 35. Different estimates of geocenter coordinates: GPS+GRACE (gray), SLR LAGEOS-1+LAGEOS-2 (green and orange), Jason-2 DORIS (blue) and SLR (red).

18.7 NEXT GDR-F POD STANDARDS

The given presentation, *Couhert et al. (2017)* [8], provided an insight into the next GDR-F POD standards, where efforts have been made to better model orbits at the center of mass of the whole Earth system. To this end, a DORIS-based geocenter motion model was derived and will be applied in the following standards. Additionally, the station positions will be referenced in the last ITRF2014 reference frame, while updating (when necessary) on-board instrument phase center locations. Low-elevation DORIS data (below 10°) will be used, owing to the up-to-date troposphere correction model GPT2/VMF1, the definition of a weighting law, and the adjustment of horizontal tropospheric gradients. Data-screening of GPS data will be improved, especially to let the possibility of fixing ambiguities on Jason-3 and Sentinel-3 missions. Geopotential models (mean TVG model and atmospheric gravity) will be updated as well.

18.8 RELATED PRESENTATIONS

[1] *Moyard, J., Couhert, A., Jalabert, E., Mercier, F., Houry, S., Ait-Lakbir, H., 2017. Comparison/evaluation of different atmosphere/ocean de-aliasing products using altimeter missions. In: IDS Working Group Meeting, London, United-Kingdom, 22–24 May, 2017*

[2] *Jalabert, E., Moyard, J., Couhert A., Mercier, F., 2017. Polar motion using DORIS measurements. In: IDS Analysis Working Group Meeting, London, United-Kingdom, 22–24 May, 2017.*

[3] *Ait-Lakbir, H., Couhert, A., Mercier, F., Moyard, J., Jalabert, E., Houry, S., 2017. Estimation of the DORIS phase center locations for the currently flying altimeter missions. In: IDS Analysis Working Group Meeting, London, United-Kingdom, 22–24 May, 2017.*

[4] *Mercier, F. and Couhert, A., 2017. Discussion for the mean pole. In: International DORIS Service Analysis Working Group Meeting, London, United-Kingdom, 22–24 May, 2017.*

[5] *Ait-Lakbir, H., Couhert, A., Mercier, F., Houry, S., Jalabert, E., Moyard, J., 2017. Impact of the next foreseen mean pole model (linear) on altimeter satellite precise orbits, and validation of updated measurement models. In: Ocean Surface Topography Science Team Meeting 2017, Miami, USA, 23–27 October, 2017.*

[6] *Couhert, A., Zelensky, N., Lemoine, F., 2017. Geocenter & TVG modeling for satellite altimetry POD. In: Unified Analysis Workshop, Paris, France, 10–12 July, 2017.*

[7] *Couhert, A., Mercier, F., Moyard, J., Biancale, R., 2017. Independent geocenter determination with DORIS: disentangling analysis and modeling effects in the realization of the ITRF origin. In: International workshop on the inter-comparison of space and ground gravity and geometric spatial measurements, Strasbourg, France, 16–18 October, 2017.*

[8] *Couhert, A., Ait-Lakbir, H., Houry, S., Jalabert, E., Mercier, F., Moyard, J., 2017. Brief presentation of the next GDR-F POD standards. In: International DORIS Service Analysis Working Group Meeting, London, United-Kingdom, 22–24 May, 2017.*

19 TU DELFT ASSOCIATED ANALYSIS CENTER

Ernst J.O. Schrama / Delft University of Technology, The Netherlands

19.1 INTRODUCTION

In 2017 we concentrated our efforts on CryoSat-2 precision orbit determination, we summarized all the POD details in a paper which was accepted in Advances in Space Research, *Schrama (2017)* [1]. We announced in the 2016 annual report a number of items that we would concentrate on, namely the implementation of ITRF2014 coordinates from DORIS and SLR, but also an improved temporal gravity model. An unexpected finding in [1] is the visibility of the South Atlantic Anomaly in the DORIS residuals, CryoSat-2 is well below the T/P Jason altitude where this effect is clearly seen, but unexpected is that the DGXX DORIS receiver on CryoSat-2 flying at a lower attitude is also affected by the SAA effect.

19.2 ITRF2014

Before 2017 we used the DPOD2008 and SLRF2008 reference systems which were established several years before the start of the CryoSat-2 mission. The DPOD series dates back to DPOD2000, its definition is related to ITRF2000, the DPOD system defines the core network coordinates and velocities to use for the DORIS beacons. A similar situation is in effect for SLRF2008, this reference system is also related to ITRF2008; however, the SLRF2008 system provides coordinates and velocities of the SLR tracking stations coordinates. Since Nov 2016 we decide to switch to the ITRF2014 reference system for the nominal station coordinates and velocities that are the result of a combination of different geodetic techniques. ITRF2014 was consistently implemented for DORIS and SLR. Details on how we treat ITRF2014 coordinates for are described in [1] where we combined several SINEX files that contain the required additional eccentricity and post seismic deformation data. The solution strategies described in [1] explain how we deal with the DORIS beacon and SLR tracking stations that are not in ITRF2014

19.3 TEMPORAL GRAVITY

A significant update that we applied during the POD of CryoSat-2 concerns an extension of the a-priori temporal gravity model. Prior to [1] we used estimates that are based on monthly GRACE solutions that were converted into surface mass loss over ice sheets and variations in land surface water. The mascon model is an important part of the temporal gravity signature that affects the POD of CryoSat-2, however, during the preprocessing we removed the effect of the oceans and the atmosphere which is provided in the form of a GAC file by the GRACE analysis centers. A better approach is to retain the signal in the GAC de-aliasing product within the temporal gravity model, since this is a signal that will affect the orbit of a low earth orbiting satellite such as CryoSat-2. A regression analysis on annual and semi-annual frequencies including a linear trend for spherical harmonics up to degree and order 36 provides the required information to apply during POD. This model can be extended beyond the lifespan of the GRACE mission, albeit that the harmonic fit of the GSM+GAC GRACE coefficients is only valid in the GRACE window. The further we extend, the worse the situation will become, the more POD accuracy of CryoSat-2 will deteriorate because we miss the possibility to model a part of the temporal gravity signal.

19.4 RESULTS

We re-processed the CryoSat-2 orbits between June-2010 and April-2017, five versions are now available, they are labeled V41 to V45.

- V41 is the former processing scheme, so it is based on DPOD2008/SLRF2008 and the mascon based temporal gravity model, no coordinates are adjusted.
- V42 is the new processing scheme, ITRF2014 is used for both IDS and SLR, and an updated temporal gravity model, no coordinates are adjusted, that is missing stations in ITRF2014 were not used or substituted.
- V43 is similar to V42, but now we adjust the IDS beacon positions that are not in ITRF2014 where surveyed coordinates of beacons are taken as a prior guess, however, SLR station positions that are not in ITRF2014 are ignored.
- V44 is similar to V43, but now without the SLR tracking data.
- V45 is similar to uses the mascon model and the ITRF2014 reference system.

Table 24 summarizes the main results of all five solutions that were computed. **Table 25** lists the crossover difference statistics of solution V42 compared to other solutions, the RADS database was used for the generation of the crossover differences

Solution	DORIS mm/s	SLR cm	Along nm/s^2	Cross nm/s^2	NAV cm	MOE cm	POE cm
V41	0.3980	1.666	3.94	12.78	3.50	1.68	1.70
V42	0.3887	1.393	3.16	10.67	3.27	1.35	1.28
V43	0.3933	1.417	3.14	10.22	3.26	1.33	1.25
V44	0.3942		3.13	10.78	3.26	1.33	1.25
V45	0.3974	1.601	3.97	13.07	3.50	1.69	1.71

Table 24. Solution characteristics, DORIS and SLR fits, level of empirical accelerations in along-track and cross-track direction, differences of our solution compared to navigator (NAV), MOE and POE orbits provided by the CNES. The NAV, POE and MOE statistics

V43	NAV	MOE	POE
4.61	7.29	4.71	4.55

Table 25. CS2 Crossover difference standard deviation of orbit solution V42 compared to three external orbits. All units are in cm, for details see [1].

A significant improvement in precision orbit processing is due to the application of the new temporal gravity model for CryoSat-2. Also we conclude that the adjustment of the IDS beacon coordinates slightly helps to improve the external comparisons, this slightly increases the IDS residuals because we analyze data from beacons that are not in ITRF2014 mostly because they could not be unified in a multi system inversion, details are described in [1].

19.5 IS THERE AN SAA EFFECT IN THE DORIS RESIDUALS?

We mapped the DORIS tracking residuals on a global 1 by 1 degree grid and inspected the statistical median (not the mean) and the standard deviation for each grid cell to trace systematic patterns. We were able to demonstrate that the standard deviation map (**Figure 36** hereafter) does indicate an increase towards the horizon of a beacon visibility circle. The most likely explanation is that there are tropospheric refraction errors at low elevation angles. The second plot (**Figure 37** hereafter) appears more challenging to interpret, in this case we strongly suspect that the South Atlantic Anomaly is visible in a couple of beacon residuals, in particular over South America. The SAA effect remains when we map the DORIS residuals with another station coordinate set such as DPOD2008, which excludes the possibility that the results for the South American stations were caused by for instance an earthquake or a post seismic signal.

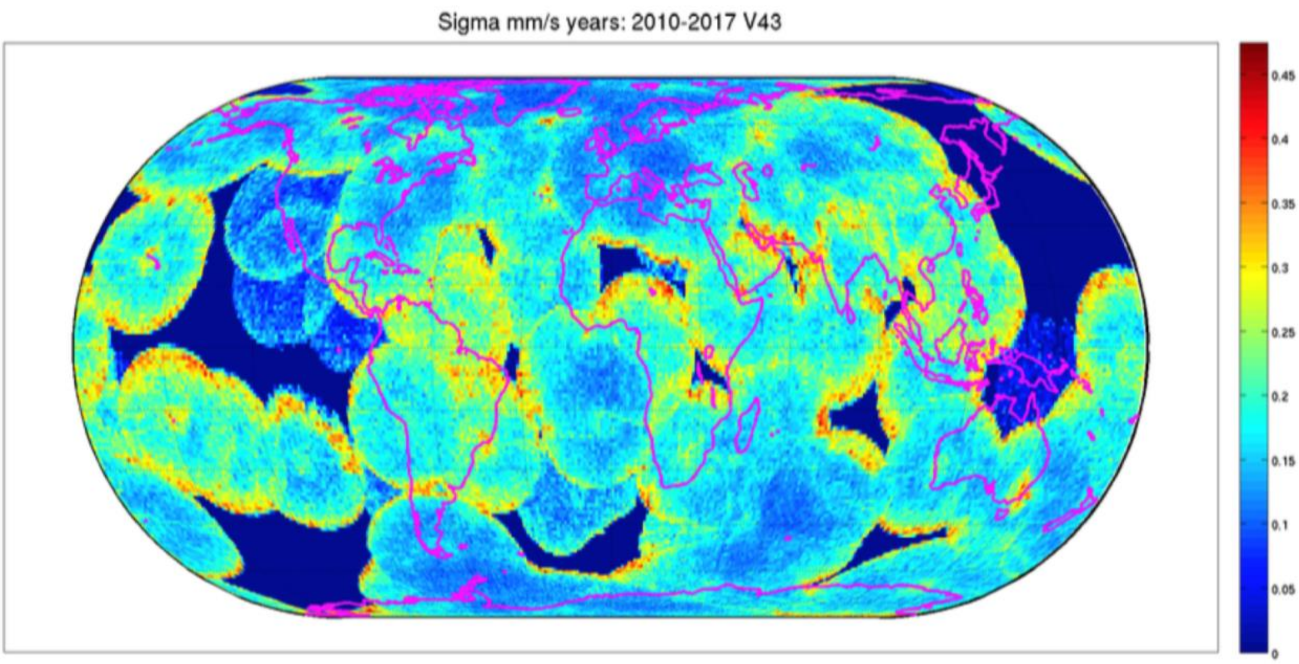

Figure 36. Binned r.m.s. values of the DORIS data residuals, units in mm/s, solution V43. This analysis shows that the tracking data residuals become noisier at lower elevation angles, our suggestion is that this is due to the wet tropospheric refraction effect

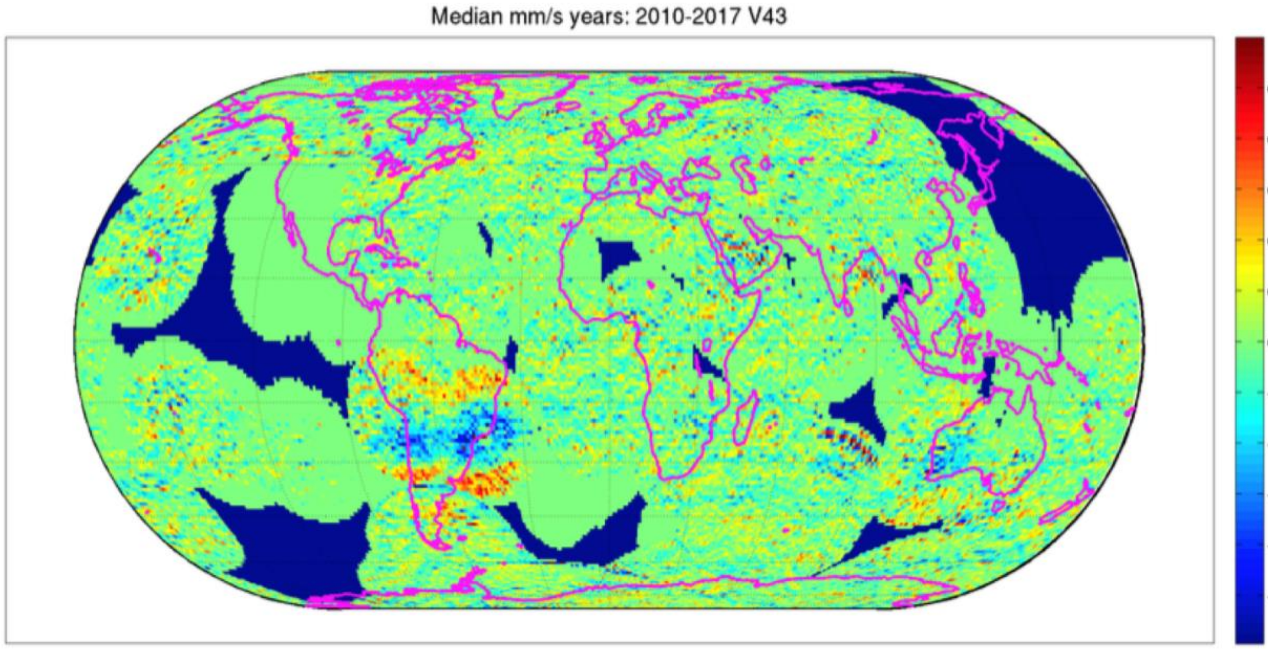

Figure 37. Median of the DORIS data residuals, units in mm/s, this is solution V43. In this case we suggest that the feature over south America is a remnant of the SSA effect

19.6 REFERENCES

[1] Ernst Schrama (2017) Precision orbit determination performance for CryoSat-2, Advances in Space Research, Volume 61, Issue 1, 1 Jan 2018, pp. 235-247 doi: 10.1016/j.asr.2017.11.001

20 WORKING GROUP "NRT DORIS DATA"

Denise Dettmering / DGFI-TUM, Germany

Following user requests for rapid dissemination of DORIS data for assimilation in ionospheric models, the IDS Governing Board created a Working Group (WG) dealing with near real-time (NRT) DORIS data, on November, 1st, 2017, and appointed Denise Dettemering (DGFI-TUM) as chair.

20.1 TERMS OF REFERENCE

The general objective of this working group is a thorough assessment on applications, benefits, requirements and prospects of DORIS data with improved data latency. Currently, data is available as daily RINEX files with a latency of about one day. Thus, DORIS real-time and near real-time (NRT) applications of any kind are currently only possible on board of the satellite.

Most of the other geodetic space-techniques provide their data to the users with lower latencies. The IGS disseminates its terrestrial GNSS data as hourly RINEX files and via real-time Ntrip streams. The ILRS asks its stations to provide SLR data within two hours after measurements. For data collected on board of satellites (as it is the case for DORIS) the minimum latency is restricted by the data downlink, usually performed within one to two hours after acquisition. Data sets from GPS radio occultations and satellite altimetry are available with one to three hours latency. In principle, it is also possible to provide the DORIS data with a latency of a few hours. However, this would require significant changes in operations of tools and procedures at the DORIS mission center.

DORIS NRT data sets would be useful for different applications, one of them is the modelling of the Earth's ionosphere. Using DORIS in combination with GNSS (and additional techniques) helps to improve the accuracy and reliability of ionospheric maps, especially in ocean regions with poor GNSS coverage. This has been proved for post-processing applications but will probably also hold for NRT.

The following, non-restrictive list of goals for the WG is proposed (TBD in the WG):

- definition of detailed NRT DORIS data requirements (latency, formats, ...)
- conduction of simulations and/or a short-term test campaign in order to investigate the potential of DORIS NRT in ionospheric applications
- definition of objectives and possible additional applications of NRT DORIS data,
- investigation of possible ionospheric applications for on-board computations and telemetry downlinking (as currently done for pole coordinate estimation)
- identification of potential users

Based on the results of the Working Group CNES may evaluate the possibility to establish a new NRT DORIS data production chain.

20.2 MEMBERS

- Denise Dettmering (DGFI-TUM, Germany) (chair)
- Nicolas Bergeot (ROB, Belgium)
- Vince Eccles (Utah State University, USA)
- Eren Erdogan (DGFI-TUM, Germany)
- Zishen Li (CAS, China)
- Michael Schmidt (DGFI-TUM, Germany)
- Ningbo Wang (CAS, China)
- Volker Wilken (DLR, Germany)

APPENDIX

21 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: ftp://cddis.gsfc.nasa.gov/doris/
   IGN: ftp://doris.ensg.eu and ftp://doris.ign.fr

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., Fagard H., Ferrage P., Lemoine F.G., Noll C.E., Noomen R., Otten M., Ries J.C., Rothacher M., Soudarin L., Tavernier G., Valette J.J. (2010), The International DORIS Service, Toward maturity, Advances in Space Research, 45(12):1408-1420, DOI: 10.1016/j.asr.2009.11.018

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
   http://ids-doris.org/report/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/channel/UCiz6QkabRioCP6uEjkKtMKg

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 persons:

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22 IDS INFORMATION SYSTEM

22.1 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 site
- AC: the Analysis Coordination webpages on the CB web site

The baseline storage rules are as follows:

DC store observational data and products + formats and analysis descriptions.

CB produces/stores/maintains basic information on the DORIS system, including various standard models (satellites, receivers, signal, reference frames, etc).

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 on their content and updating,
2. the easiness of user access.

Data-directed software is stored and maintained at the CB, analysis-directed software is stored/maintained, or made accessible through the AC webpages.

To avoid information inconsistencies, duplication is minimized. Logical links and cross referencing between the three types of information centers is systematically used.

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

22.2 WEB AND FTP SITES

22.2.1 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 and Products: information and data center organization, tables of data and products, access information to the IDS Data Centers and to the Central Bureau ftp site.
- Meetings: calendars of the meetings organized by IDS or relevant for IDS, as well as links to calendars of other international services and organizations.
- Reports and Mails: 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.
- 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 processings.

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 and ITRF2014 (list of standards used by IDS Analysis Centers)
- Documents for the analysts: 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.

22.2.2 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)

22.2.3 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.ensg.eu/pub/doris/cb_mirror/

22.2.4 DORIS WEB SITE

Address: http://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.

22.2.5 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: http://cddis.gsfc.nasa.gov/doris_summary.html
Address of the CDDIS ftp site: ftp://cddis.gsfc.nasa.gov/pub/doris/
Address of the IGN ftp site: ftp://doris.ensg.eu/pub/doris/ (or ftp://doris.ign.fr/pub/doris/)

22.3 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: http://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.

22.3.1 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:
http://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/

22.3.2 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:
http://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.

22.3.3 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: http://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.

22.3.4 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

22.4 HELP TO THE USERS

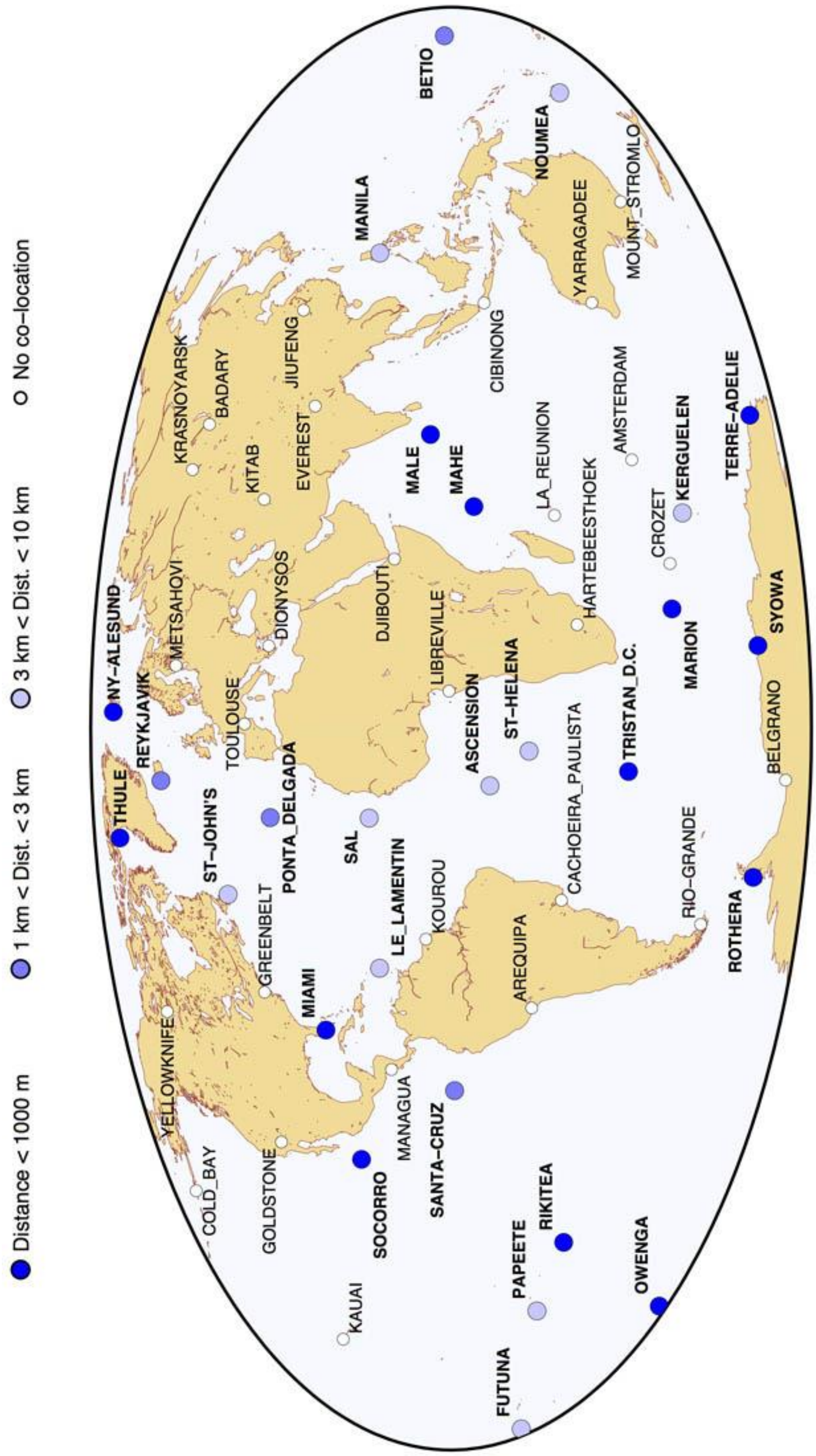
e-mail : ids.central.bureau@ids-doris.org

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.

23 DORIS STATIONS / COLOCATION 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, http://www.sonel.org).

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		2244
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
MARION ISLAND	37.86	-46.88	SOUTH AFRICA	01/01/1990	1000	20	------
MIAMI	-80.17	25.73	USA	10/02/2005	180	332	1858
NOUMEA	166.42	-22.24	FRANCE (CALEDONIA)	27/01/05	7000	123	2134
NY-ALESUND	11.93	78.93	NORWAY (SPITZBERG)	13/09/1987	600	345	1421
OWENGA	-176.37	-44.02	NEW ZEALAND (CHATHAM	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
REYKJAVIK	-21.99	64.15	ICELAND	04/07/1990	2500	229	638
RIKITEA	-134.97	-23.13	FRANCE (POLYNESIA)	23/09/2006	800	138	1253
ROTHERA	-68.1	-67.6	UK (ANTARCTICA)	01/03/2003	100	342	1931
SAL	-22.98	16.78	CAPE VERDE	15/12/2002	7000	329	1914
SANTA CRUZ	-90.30	-0.75	ECUADOR	01/04/2005	1600		1472
SOCORRO	-110.95	18.73	MEXICO	09/06/1989	400	162	1821
ST-HELENA	-5.67	-15.94	UK (SOUTH ATLANTIC)	01/06/1989	4000	264	1845
ST. JOHN'S	-52.68	47.40	CANADA	27/09/1999	4000	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	------
THULE	-68.83	76.54	DENMARK (GREENLAND)	28/09/2002	300	---	------
TRISTAN DA CUNHA	-12.31	-37.07	UK (SOUTH ATLANTIC)	10/06/1986	120	266	------


Distance < 1000 m
1 km < Dist. < 3 km
3 km < Dist. < 10 km
No co-location
BETIO
NOUMEA
MOUNT_STROMLO
YARRAGADEE
MANILA
CIBINONG
KRASNOYARSK
BADARY
JIUFENG
KITAB
EVEREST
MALE
MAHE
LA_REUNION
AMSTERDAM
KERGUELEN
CROZET
TERRE-ADELIE
HARTEBEESTHOEK
SYOWA
MARION
NY-ALESUND
METSAHOVI
DIONYSOS
DJIBOUTI
LIBREVILLE
ST-HELENA
TRISTAN_D.C.
REYKJAVIK
TOULOUSE
ASCENSION
BELGRANO
THULE
PONTA_DELGADA
CACHOEIRA_PAULISTA
ST-JOHN'S
SAL
LE_LAMENTIN
RIO-GRANDE
ROTHERA
GREENBELT
KOUROU
AREQUIPA
YELLOWKNIFE
MIAMI
MANAGUA
COLD_BAY
GOLDSTONE
SOCORRO
SANTA-CRUZ
KAUAI
PAPEETE
RIKITEA
OWENGA
FUTUNA

24 DORIS STATIONS / HOST AGENCIES

The local teams that take care of the DORIS stations contribute in large part with skill and efficiency to the high quality of the DORIS network improving continuously 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	Universidad Nacional de San Agustin (UNSA)	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	BAKOSURTANAL	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	Malae, Wallis-et-Futuna, FRANCE
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
Hartebeesthoek	HartRAO, South African National Space Agency (SANSA)	Hartebeesthoek, SOUTH AFRICA
Jiufeng	Institute of Geodesy and Geophysics (IGG)	Wuhan, CHINA
Kauai	Kokee Park Geophysical Observatory (KPGO)	Kauai Island, Hawaï, 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
Krasnoyarsk	Siberian Federal University (SibFU)	Krasnoyarsk, RUSSIA
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 Department of Meteorology	Male, Republic of MALDIVES
Managua	Instituto Nicaragüense de Estudios Territoriales (INETER)	Managua, NICARAGUA
Manila	National Mapping and Ressource Information Authority (NAMRIA)	Manila, Republic of the PHILIPPINES
Marion	Antartica & Islands Department of Environmental Affairs(DEA)	Marion Island Base, SOUTH AFRICA
Metsähovi	Finnish Geospatial Research Institute (FGI)	Masala, FINLAND
Miami	Rosenstiel School of Marine and Atmospheric Science (RSMAS)	Rickenbacker Causeway, 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
Ny-Ålesund	Base arctique AWIPEV Institut Polaire Paul Emile Victor (IPEV)	Ny-Ålesund, Spitzberg, NORWAY
Owenga	Land Information New Zealand (LINZ)	Chatham Island, NEW ZEALAND
Papeete	Observatoire Géodésique de Tahiti, Université de la Polynésie Française (UPF)	Fa'a, Tahiti, Polynésie Française, FRANCE
Ponta Delgada	Universidade dos Açores	Ponta Delgada, Azores, PORTUGAL

Station name	Host agency	City, Country
Reykjavik	Landmælingar Islands (LMI)	Reykjavik, ICELAND
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
Santa Cruz	Charles Darwin Foundation (CDF)	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	US Air Force Base National Survey and Cadastre (KMS)	Pituffik, Greenland, DENMARK Copenhagen, DENMARK
Toulouse	Collecte Localisation Satellites (CLS)	Ramonville, FRANCE
Tristan da Cunha	Telecommunications 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 (NR Can)	Yellowknife, CANADA

25 GLOSSARY

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.

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.

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. Name of a future CNES/NASA satellite mission.

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.

ZTD

Zenith Tropospheric Delay

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The following list compiles articles related to DORIS published in 2017 in international peer-reviewed journals

The full list since 1985 is available on the IDS website at http://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html (follow IDS > Reports & Mails > DORIS bibliography > Peer-reviewed journals)

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