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IDS

International Doris Service

ACTIVITY REPORT 2016

International DORIS Service Activity Report 2016

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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 2016 and December 2016. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2016 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_2016.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 in order 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 were dominated by the evaluation of these three independent realizations (ITRF2014, DTRF2014, and JTRF2014).

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 2016, IDS organized a meeting of the Analysis Working Group on May 26-27 at TU Delft (Netherlands) and a Workshop in La Rochelle (France), on October 31 and November 1.

In 2017, a meeting of the Analysis Working Group is scheduled in London (UK) on May 22-24.

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

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
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 Rep. 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 Netherlands La Rochelle France

Table 2: List of IDS events organized between 2004 and 2016

3. ORGANIZATION

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

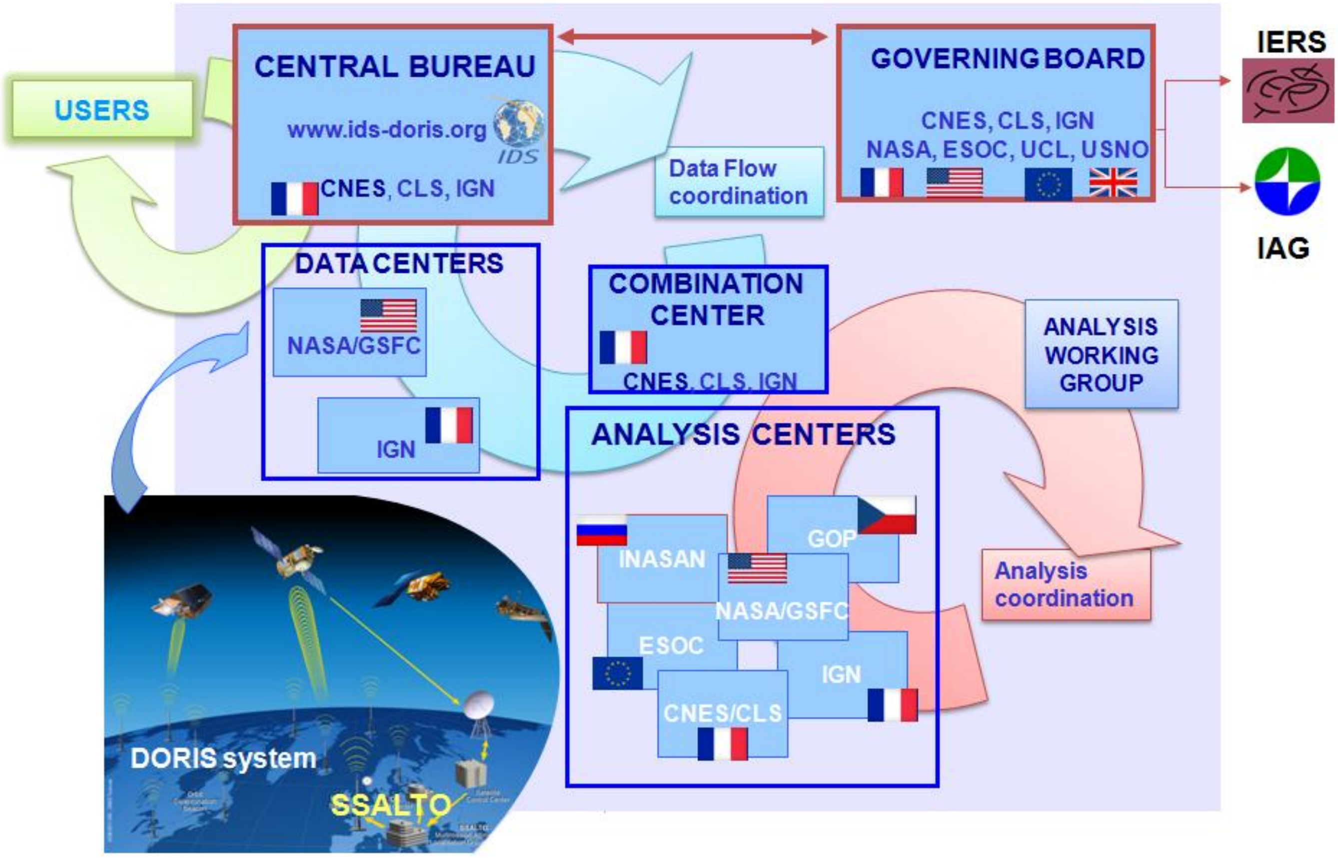

Figure 1: IDS organization

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.

The term of three posts expired at the end of 2016. The holders of these posts are: Carey Noll as the Data Center representative, Pascal Willis as the Analysis Center representative, and Richard Biancale as one of the Members at Large. After the elections organized in fall 2016, the new members elected by the IDS Associates are:

Frank Lemoine as the Analysis Center Representative,

Patrick Michael as the Data Center Representative,

Denise Dettmering as a Member-at-Large.

In addition, the IAG nominated Petr Stepanek as its representative to the IDS GB. Petr succeeds Michiel Otten who held that post for 8 years.

In November, the Board elected Frank Lemoine as the new Chairman from Jan. 1st, 2017.

The IDS congratulates the new members and warmly thanks Carey, Pascal, Michiel and Richard for their valuable contribution to the IDS.

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

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: Pascal Willis (then Frank Lemoine from Jan. 1st, 2017), Laurent Soudarin

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

3.3 CENTRAL BUREAU

In 2016, 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

Position	Term	Status	Name	Affiliation	Country
	2015-2018	**Elected**	**Hugues Capdeville Jean-Michel Lemoine**	**CLS CNES/GRGS**	**France**
Analysis coordinator	*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

DORIS SYSTEM

4. THE NETWORK

Jérôme Saunier / IGN, France

4.1 GENERAL STATUS OF THE NETWORK

DORIS has a globally distributed network of 56 permanent stations dedicated for orbitography and altimetry. Two additional DORIS stations are used for other scientific purposes: Grasse (France) and Wettzell (Germany).

The new DORIS station at the Geodetic Observatory Wettzell started work on September 27, 2016 with shifted frequencies to avoid internal jamming with the nearby stations of the permanent network. The most challenging requirement was to manage interferences with VLBI. After some months of intensive tests carried out on site, a compromise to minimize the constraints for both systems has been found. Greenbelt and Wettzell are now two examples of core sites complying with the GGOS requirements with the four space geodetic techniques (co-located DORIS/GNSS/SLR/VLBI).

Another main event of 2016 is the newly installed DORIS station at Managua, Nicaragua. Fully integrated within the data coverage map, this new station is also well located to provide reliable information on the Caribbean tectonic plate motion when combined with the DORIS station data of “Le Lamentin”.

This new DORIS site compensates for the decommissioning of Santiago with regard to the number of beacons of the permanent network, remained stable: 56 including 4 master beacons and 1 time beacon (**Figure 2**).

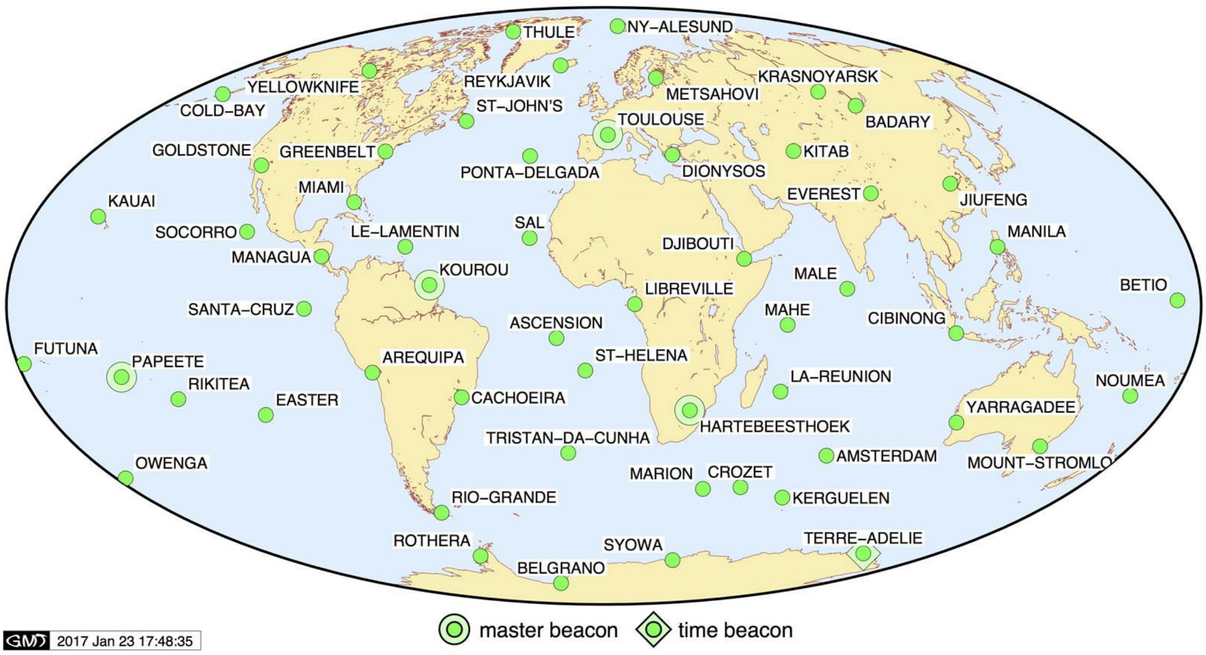

Figure 2: The DORIS permanent network

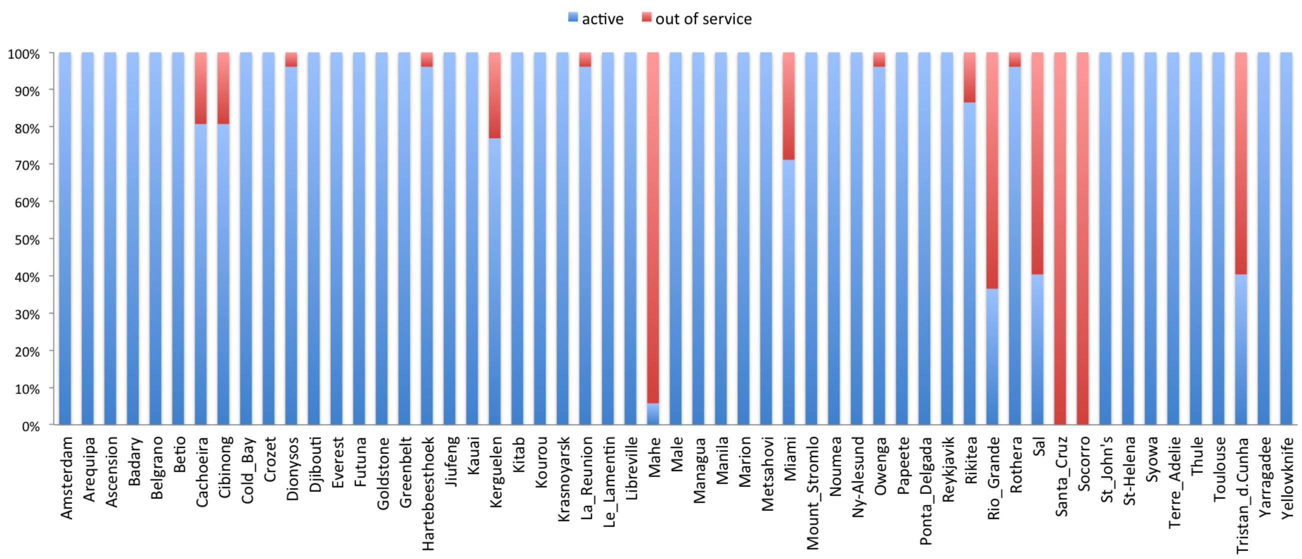

Figure 3: Network activity 2016

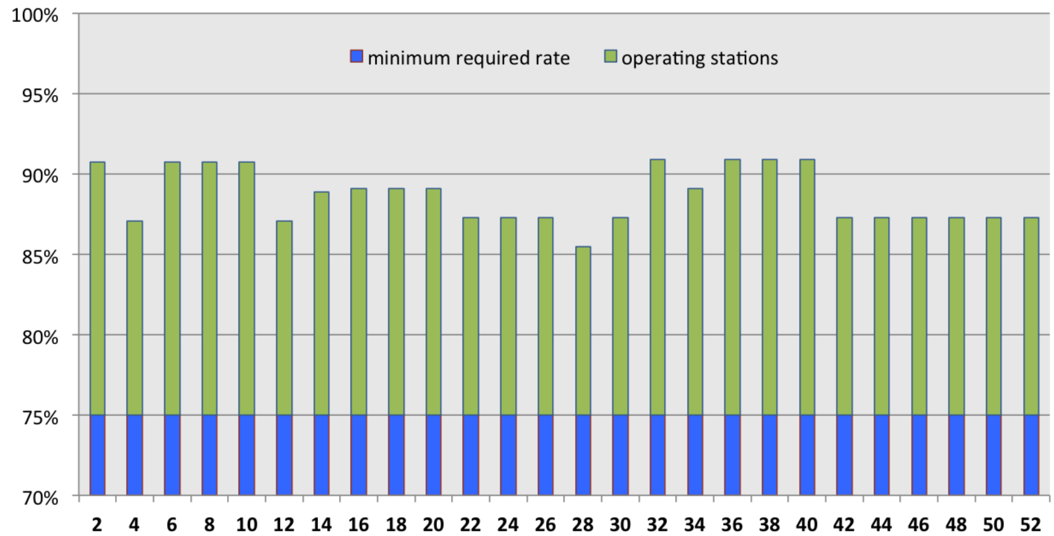

Figure 4: Network availability 2016

The extensive outage of 3 stations is to be noticed: Mahé, Santa-Cruz and Socorro. Nevertheless, the DORIS network provided a very reliable service (**Figure 3** and **Figure 4**) 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: 8 failed beacons and 1 failed antenna were replaced and 2 antennas were relocated.

4.2 EVOLUTION AND DEVELOPMENT

The development of the 4th DORIS beacon generation continued with the preliminary design review in July and everything is going according to the provisional schedule: detailed design review and manufacturing of a prototype in 2017, technical appraisal and testing in 2018 and start of the deployment in 2019.

The network monumentation was the subject of a global assessment in the JASR DORIS Special Issue performed by Saunier (2016) and based on three methods: mechanical laboratory study to see the behavior of the metallic structures, field measurements on the existing monuments, evaluation chart in order to have a grading and scoring of each monument. Elastics deformations for the standard monuments are less than one millimeter when undergoing extreme climatic conditions. Two thirds of the network monuments are compliant with standards. The field checks conducted in the last 15 years showed that 80% of the monuments are stable within a millimeter.

In reviewing the history of the network, four main phases can be distinguished (**Figure 5**): setting-up the network (1986-1992), densification (1992-1999), renovation (2000-2009), modernization (2010-today).

Co-location has always been a major objective for the DORIS network. We continuously increased the number of stations co-located with other space geodetic techniques and with tide gauges throughout the various phases in the network evolution (**Figure 6**).

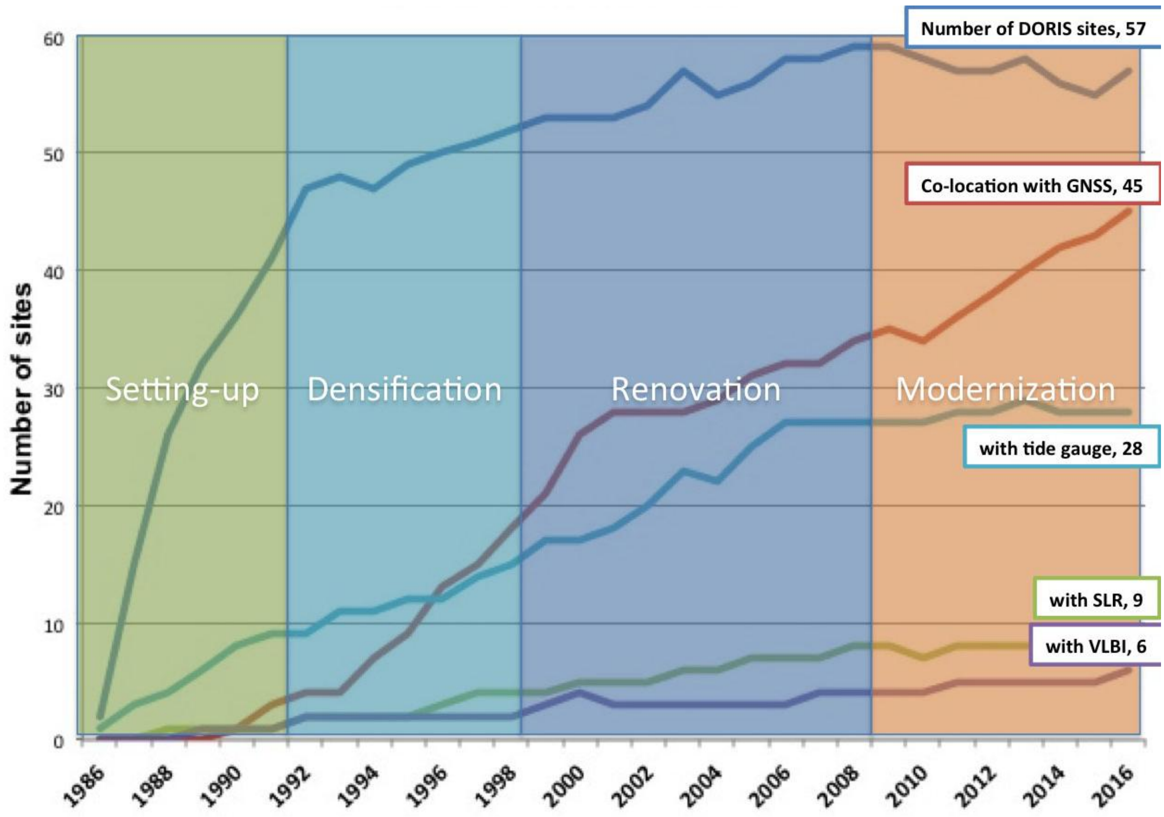

Figure 5: DORIS Network Evolution

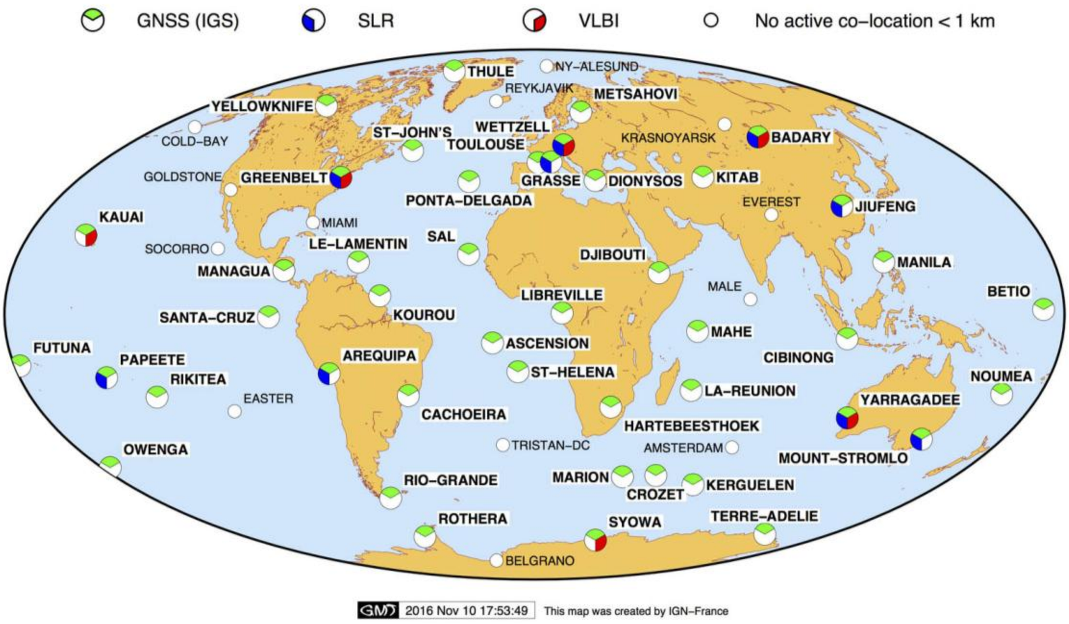

Figure 6: DORIS stations co-located with other IERS techniques

In 2016 the following sites were visited:

- Managua, Nicaragua: new site
- Mariana Islands, USA: reconnaissance with a view to installing a new station
- Kitab, Uzbekistan: station re-location (200m South)
- Hartebeesthoek, South Africa: tracking oscillator replacement
- Wettzell, Germany: new site (IDS station)

Finally, the overall objectives for the next year are:

- Restarting at Socorro (Mexico) and Santa-Cruz (Galapagos, Ecuador)
- New stations at San Juan (Argentina) and Guam Island (USA)
- Re-location in Easter Island (Chile)
- Reconnaissance in Papenoo (French Polynesia), Manchuria (China) and Reykjavik (Iceland)

5. THE SATELLITES WITH DORIS RECEIVERS

Pascale Ferrage / CNES, France

The DORIS system was 26 years old in 2016 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.

Two new satellites were launched in early 2016: Jason-3 and Sentinel-3A, both using the new 7-channel DG-XXS DORIS receiver on-board the satellite. The DORIS constellation then steadily increased, including 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. With the exception of 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 7**).

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.

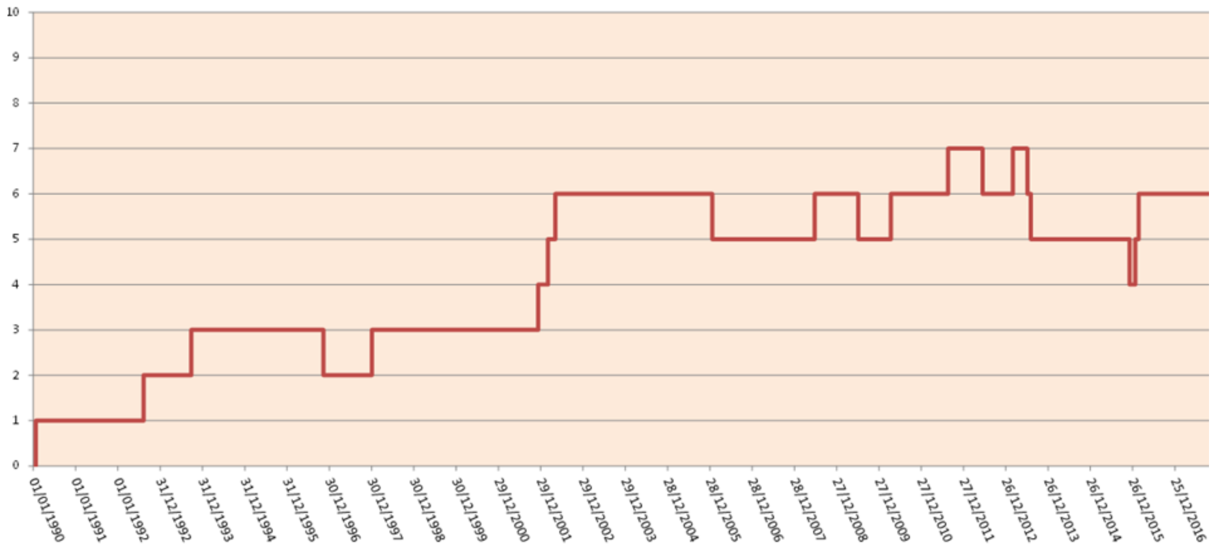

Figure 7: Number of DORIS missions contributing to IDS (December 2016).

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-3	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/	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)

5.1 FUTURE DORIS MISSIONS

With many future missions lined up, DORIS will continue contributing up to 2030 and beyond (**Figure 8**).

- **Sentinel 3B**, **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. A further four missions (HY2-E, -F, -G and -H) are pending approval and planned from 2024.
- **Dedicated geodetic mission projects**

Aiming at improving the TRF to a precision of 1 mm and a stability of .1 mm/yr and homogenizing TRF/CRF/EOP, the **GRASP** and **E-GRASP/Eratosthenes** mission proposals were not selected in the NASA/Earth Venture Mission-2 and ESA/Earth Explorer-9 calls respectively in late 2016. However and because ESA did select no mission at all, an improved version of the E-GRASP/Eratosthenes proposal will be submitted to the new ESA/EE9 call in 2017.

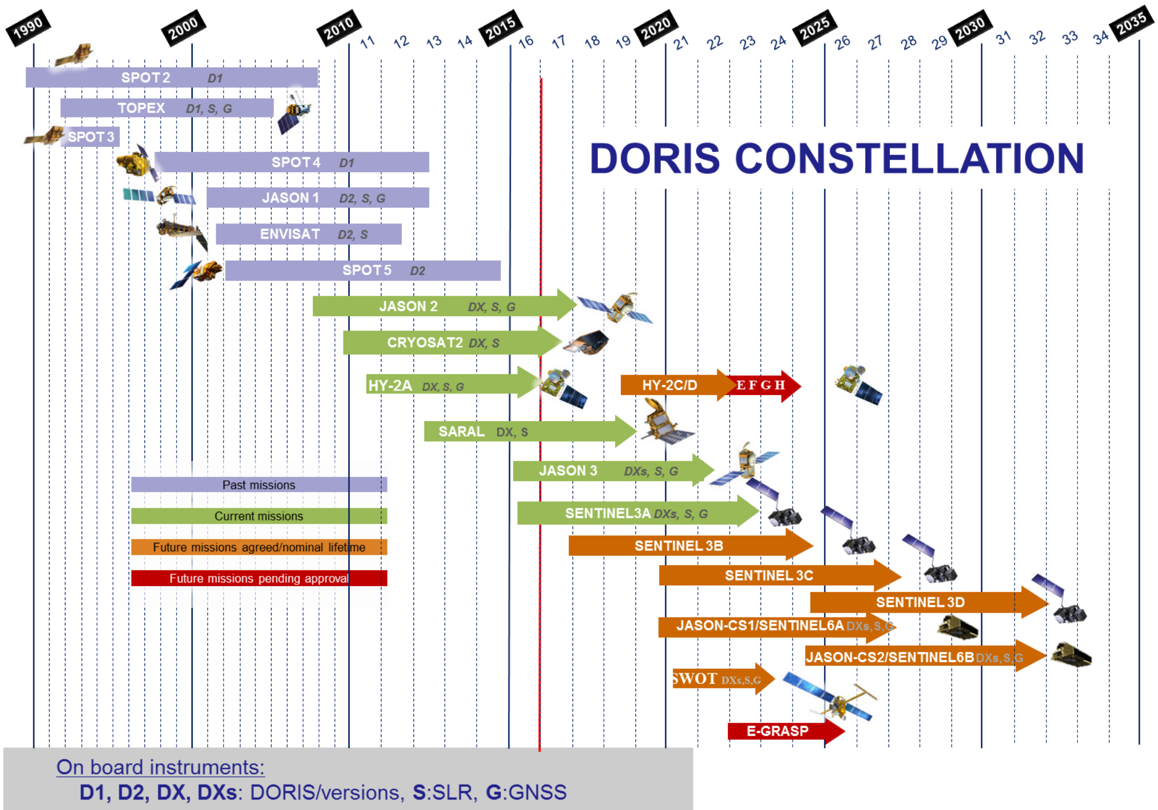

Figure 8: Current and future DORIS missions

USER SERVICE

6. THE CENTRAL BUREAU

Laurent Soudarin [1], Pascale Ferrage [2]
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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 2016 and forecasts activities planned for 2017. An overview of the IDS information system is reminded in appendix.

6.1 GENERAL ACTIVITIES

6.1.1 SUPPORT TO THE GOVERNING BOARD

On behalf of the GB, the CB wrote an endorsement letter to the E-GRASP/Erastosthenes multi-technique mission concept. The letter has been addressed to Doctor Biancale, PI, and joined to the E-GRASP mission proposal submitted to ESA.

The CB also prepared the decision letter confirming that the GB accepts GFZ as an Associated Analysis Center.

6.1.2 ELECTIONS FOR THE GOVERNING BOARD

In accordance with the Terms of Reference of the IDS, several positions within the Governing Board became vacant at the end of 2016. They concerned three members elected by IDS Associates (the representative of the Data centers, the representative of the analysis Center, one member at large) and four representatives appointed respectively by CNES (DORIS system), IGN (network), IAG and IERS. The CB managed the actions related to the renewal of these members for the next 4-year term 2017-2020. On one hand, the CB contacted the relevant organizations to appoint their representatives; on the other hand the CB organized the elections for the three open positions by the IDS Associates, and in a second step for the new chair of the GB by its members.

The members who were elected or appointed are:

- Frank Lemoine as Analysis Center Representative,
- Patrick Michael as Data Center Representative,
- Denise Dettmering as Member-at-Large,
- Pascale Ferrage, reappointed by CNES as the DORIS system representative,
- Jérôme Saunier, reappointed by IGN as the Network representative.
- Brian Luzum, reappointed by IERS as the IERS representative.

Petr Stepanek was nominated by IAG Executive Committee in February 2017 as the IAG representative to replace Michiel Otten who served two terms.

The new Governing Board has designated Frank Lemoine as the new Chairperson of the IDS Governing Board for 2017-2010.

In addition, the CB carried out the selection of the Combination Center for 2017-2020. The call for proposals for the successor to the current Combination Center closed on October 15. Only one proposal was submitted, that of CNES/CLS who applies to continue the activities of the Combination Center. The GB accepts the application and selects it as the IDS Combination Center for a new period of four years, starting on January 1, 2017. Guilhem Moreaux (CLS) remains the representative of the Combination Center within the GB.

6.1.3 SERVICE DESK

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

6.1.4 REPORTS

The CB managed the edition and publication of the IDS Activity Report 2015. It also produced the IDS contributions to IERS Annual report 2015, and to the Geodesist's Handbook of the IAG.

6.1.5 MEETINGS

The Central Bureau participated in the organization of the AWG meeting held at the Faculty of Aerospace Engineering in Delft, Netherlands, on May 26 and 27, and of the IDS Workshop in La Rochelle, from October 31 to November 1st. It documented the GB meetings held on these occasions. Between the meetings, the CB coordinates the work of the GB.

6.1.6 COMMUNICATION

On demand of Richard Gross, chair of the GGOS session, the Central Bureau joined the AGU fall meeting and made an oral presentation titled ""The International DORIS Service: Current Status and Future Plans".

In addition, it provided materials for the July 2016 issue of the IAG Newsletter to announce the elections, the call for participation for the Combination Center, the Workshop in La Rochelle and the issue number 2 of the IDS Newsletter.

6.1.7 NEWSLETTERS

At its meeting in Washington in October 2015, the Governing Board asked the Central Bureau to consider the publication of a newsletter. The intention is to improve the flow of information within the community of providers and users of DORIS data and products, to highlight the activities of the groups participating in the IDS, and to bring the DORIS and IDS news to a wider audience, from the host agencies to the other sister services. A draft was proposed in March 2016 by the Central Bureau to the Governing Board who accepted the concept. So, the IDS Newsletter is born. Three issues were published in 2016, #1 in April 2016, #2 in July, and #3 in December. The issues are distributed via email to the subscribers to the DORISmail and a number of identified managers and decision-makers. They are also available for downloading on the IDS website.

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 2016, this activity focused on:

- the delivery of Jason-3 data, auxiliary data and information related to this new mission.
- the delivery of Sentinel-3A data, auxiliary data and information related to this new mission.
- the delivery of the CNES orbits for Saral in GDR-E standards (file naming, store folders, description files).

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

The Central Bureau also interfaced with the CDDIS staff, SSALTO, and the IDS components during the transition phase to the new file upload system at CDDIS.

6.3 DOR-O-T, THE IDS WEB SERVICE

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

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

6.4 IDS WEBSITE

Address: http://ids-doris.org

Besides the regular updates of pages and additions of documents, the website was enriched with new pages and received some changes. The main new features of 2016 are the Youtube IDS channel and the upgrade of the website.

The IDS video channel has been created on Youtube to host a set of existing videos for outreach. New videos were included too. They show DORIS-equipped satellites in orbit. These videos have been produced with the Visualization Tool for Space Data (VTS) free software from CNES.

https://www.youtube.com/channel/UCiz6QkabRioCP6uEjkKtMKg

A new "Satellites" page has been added on the website. It provides access to a summary table of DORIS missions and satellite pages giving attributes, links to data files and VTS videos. The page also provides access to the VTS tool and predefined scenarios for DORIS missions, as well as directories of orbit files and quaternions.

http://ids-doris.org/satellites.html

A dedicated Newsletters page has been created. It contains the IDS Newsletters since April 2016.

http://ids-doris.org/report/newsletter.html

The main updates of 2016 are reported hereafter.

- The DORIS newsletters published between 1990 and 1993 were digitized by CNES and put online on the Documents page.
  http://ids-doris.org/analysis-documents.html

- The event table has been improved by adding a color code by event type and a timeline to display events between two dates.
  http://ids-doris.org/system/table-of-the -events.html

- Sitelogs of a number of ancient and temporary sites have been posted.
  http://ids-doris.org/network/sitelogs.html

- The presentations of the AWG meeting held at TU Delft in Delft on May 26 and 27 were put on line. See:
  http://ids-doris.org/ids/reports-mails/meeting-presentations/ids-awg-05-2016.html

- The presentations of IDS Workshop held in La Rochelle on October 31 and November 1st were put on line. See:
  http://ids-doris.org/ids/reports-mails/meeting-presentations/ids-workshop-2016.html

- The activity reports for 2015 (IDS Activity report, report for IERS) as well as the minutes of the IDS GB meetings held in 2016 (Delft, La Rochelle) 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

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

- The minutes of the Governing Board meetings held Delft and La Rochelle are available:
  http://ids-doris.org/ids/reports-mails/governing-board.html#minutes

- The list of the peer-reviewed publications related to DORIS has been enriched with new references of articles published in 2016:
  http://ids-doris.org/report/publications/peer-reviewed-journals.html#2016

6.5 IDS FTP SERVER

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

The documents and files put on the IDS ftp site in 2016 are listed hereafter.

New files:

- New files ja3att.txt, ja3man.txt, ja3mass.txt, s3aman.txt, s3amass.txt in ftp://ftp.ids-doris.org/pub/ids/satellites/
- New file of ties between DORIS to other techniques ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_ext_ties.txt

Updated files:

- History files of events in ftp://ftp.ids-doris.org/pub/ids/events/
- Added values for Jason-3 and Sentinel-3A in ftp://ftp.ids-doris.org/pub/ids/satellites/MassCoGInitialValues.txt
- 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 Jason-3 and Sentinel-3A ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf

6.6 FUTURE PLAN

In 2017, the Central Bureau will participate in the organization of the Analysis Working group meeting at University College London, UK, May 26-27 (http://ids-doris.org/report/meeting-presentations/ids-awg-05-2017.html) and other IDS events not scheduled yet.

A new version of the IDS web service will be proposed in early 2017. New materials will be made available on the website, in particular, the DPOD2014 and the cumulative solution produced by the Combination Center. Two IDS Newsletters will be issued in 2017.

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

7. IDS DATA FLOW COORDINATION

Carey Noll / NASA GSFC, USA

7.1 INTRODUCTION

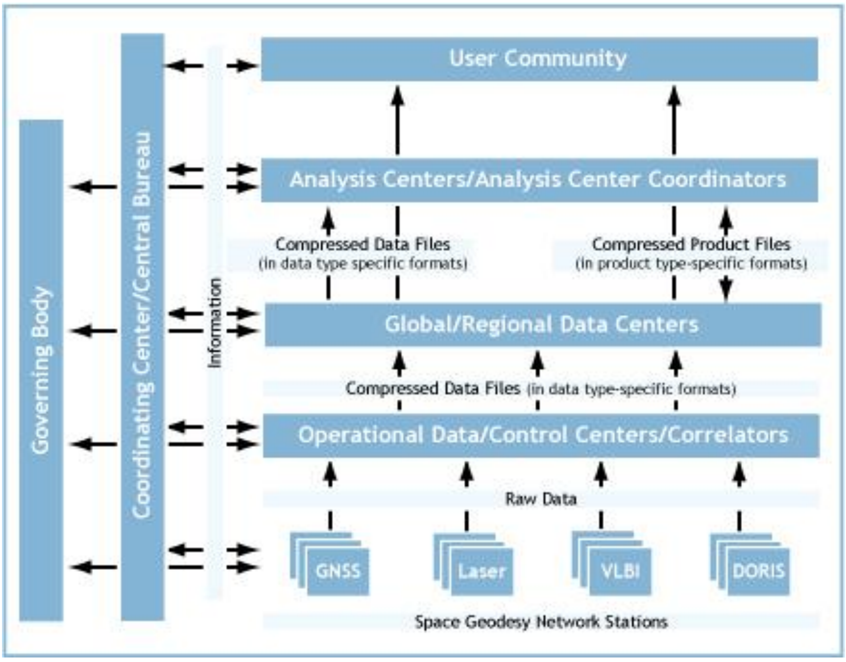
Two data centers support the archiving and access activities for the IDS:

- Crustal Dynamics Data Information System (CDDIS), NASA GSFC, Greenbelt, MD USA
- 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 9**. 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.)

CentralBureau/Coordinating Center
Management of service
Facilitate communications
Coordinate activities

Governing Body
General oversight of service
Future direction

Figure 9: 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:

http://ids-doris.org/analysis-documents/45-analysis-coordination/analysis-documents/55-struct-dc.html.

The main directories are:

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

The DORIS mission support ground segment group, SSALTO, and the analysis centers deliver data and products to both IDS data centers (CDDIS and IGN) to ensure redundancy in data delivery in the event one data center is unavailable. The general information available through the IDS Central Bureau ftp site 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. The number of days per file and average latency in 2016 of data availability after the last observation day satellite specific are shown in **Table 7**.

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
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-Format Data				RINEX Data		
Satellite	**Number of Days/ Multi-Day File**	**Average Latency (Days)**	**Average File Size (Mb)**	**Number of Daily Files**	**Average Latency (Days)**	**Average File Size (Mb)**
CryoSat-2	8	24	2.9	364	3.9	1.6
HY-2A	8	25	3.2	349	3.9	1.9
Jason-2	11	26	6.5	364	3.9	2.6
Jason-3	N/A	N/A	N/A	314	3.2	2.6
SARAL	8	26	3.2	354	3.9	1.8
Sentinel-3A	N/A	N/A	N/A	221*	4*	1.8

**Note: Over 200 Sentinel-3A files were delivered to the DCs in early 2017; latency figure does not include these new files.*

Table 7: DORIS Data File Information (2016)

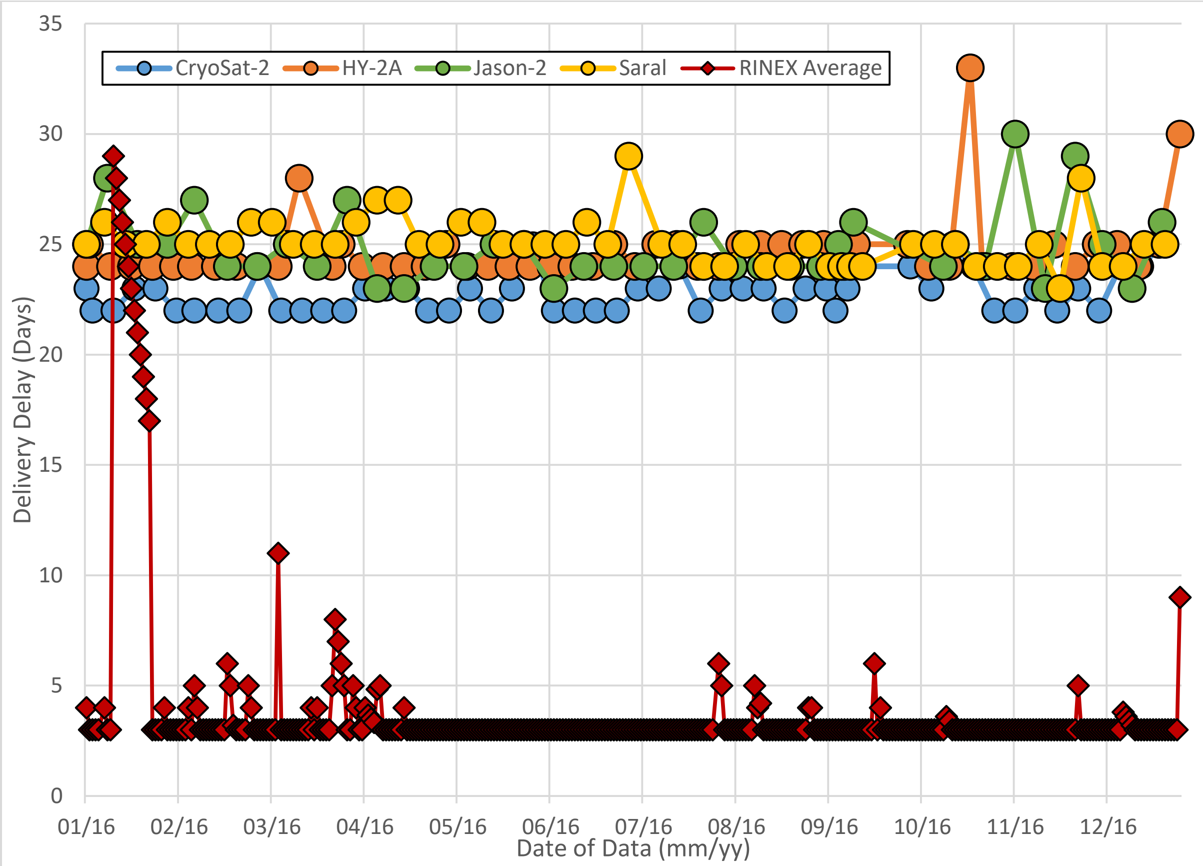


Figure 10: Delay in delivery of DORIS data to the CDDIS (all satellites, 01-12/2016; both multi-day and daily RINEX files)

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.

The delay in data delivery to the data centers (in days by satellite) in 2016 is shown in **Figure 10**. This figure includes an average latency across all satellites providing data in daily files in 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 2005-2016 are shown in **Table 8**. 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 8 : 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

Carey Noll / NASA GSFC, USA

8.1 CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)

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 2016, the CDDIS has devoted nearly 100 Gbytes of disk space (47% for DORIS data, 29% for DORIS products, and 23% for DORIS ancillary data and information) to the archive of DORIS data, products, and information. During the year, users downloaded approximately 550 Gbytes (805K files) of DORIS data, products, and information from the CDDIS. On average, approximately 200 distinct hosts downloaded DORIS-related files from the CDDIS each month.

The CDDIS automated software archives data submitted by SSALTO and performs minimal quality-checks (e.g., file readability, format compliance) resulting in a summary file for each data file. Software extracts metadata from all incoming DORIS data. These metadata include satellite, time span, station, and number of observations per pass. The metadata are loaded into a database and 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 provided special, limited access space in its archive for IDS Analysis Working Group (AWG) test solutions. This area allowed AWG members to exchange SINEX and orbit files for analysis development and testing.

The CDDIS provides access to two applications for querying site information or archive contents. The Site Log Viewer (accessible on the CDDIS website at URL *https://cddis.nasa.gov/Data_and_Derived_Products/SiteLogViewer/index.html*) 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 CDDIS Archive Explorer application (accessible on the CDDIS website at URL *https://cddis.nasa.gov/Data_and_Derived_Products/CddisArchiveExplorer.html*) 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.

8.1.3 RECENT ACTIVITIES AND DEVELOPMENTS

Transition to the new CDDIS computer hardware was completed in late November 2016. This new system configuration now provides a more reliable/redundant environment (power, HVAC, 24-hour on-site emergency personnel, etc.) and network connectivity for CDDIS; a disaster recovery system is installed in a different location on the GSFC campus. The new system location addresses a long-time concern for the CDDIS, namely, the lack of consistent and redundant power and cooling in its existing computer facility. Multiple redundant 40G network switches are utilized to take full advantage of a high-performance network infrastructure by utilizing fully redundant network paths for all outgoing and incoming streams along with dedicated 10G network connections between its primary operations and its backup operations. The CDDIS transitioned the majority of its operation services to virtual machine (VM) technology for both multiple instance services in a load balancing configuration which allows additional instances to be increased or decreased due to demand and allows maintenance (patching, upgrades, etc.) to proceed without interruption to the user or any downtime. CDDIS now utilizes a unified storage system (100 Tbytes in size) to easily accommodate future growth of the archive and facilitate near real-time replication between its production and disaster recovery sites. A schematic diagram of the new CDDIS architecture is shown in **Figure 11**.

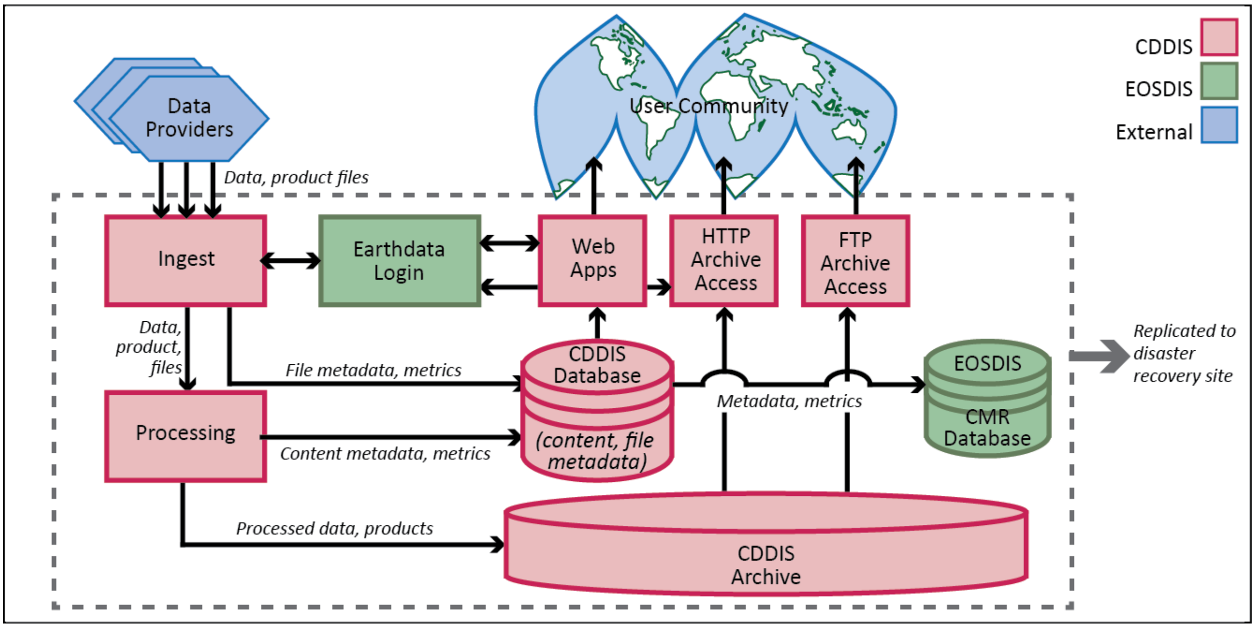


Figure 11: System architecture overview diagram for the new CDDIS facility installation within the EOSDIS infrastructure

One requirement of the new CDDIS computer system involved a change to the file upload process. In the old system, CDDIS used ftp for delivery of data for the archive from both data centers and analysis centers. While this has worked well over the years, transition to the new system provided an opportunity to update this method to a web-based approach that can utilize a different user sign-on/authentication infrastructure. CDDIS developed a web-based application that allows users to use existing scripts without significant modification but also tie authentication into the NASA system. Staff worked with the groups who submit DORIS data and IDS products to CDDIS to transition their procedures to the new file upload system.

CDDIS performed complete rewrite of its file ingest processing software in 2016. This rewrite incorporated numerous disparate programs developed over the years into a single, easily maintained software base which incorporates all the CDDIS requirements for data ingest while also allowing additional flexibility in meeting future metadata requirements. The software was initially modified for incoming GNSS files but will be extended to all incoming files, including DORIS data and products, in the near future.

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 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.

8.1.5 CONTACT

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WWW: https://cddis.nasa.gov

8.2 IGN DORIS DATA CENTER

8.2.1 CONTACT

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ANALYSIS ACTIVITIES

9. DORIS ANALYSIS COORDINATION

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

9.1 INTRODUCTION

The activities of all the DORIS analysts of the past year 2016 have been dominated by the evaluation of the ITRF2014, taking into account the last DORIS satellites Jason-3 and Sentinel-3A which DORIS data are only available in RINEX format and the analyzing of the sensitivity to the South Atlantic Anomaly (SAA) effect of their Ultra Stable Oscillator (USO).

IDS meetings were held in Delft (The Netherlands) for an Analysis Working Group, May 26-27, 2016, hosted by Technical University, and in La Rochelle (France) for an IDS Workshop, October 31 and November 1, 2016.

9.2 ANALYSIS ACTIVITY OVERVIEW

All the IDS ACs have to take the standard routinely processing again by taking into account the news data available of all satellites. The IDS includes six ACs and “de facto” three “associate analysis centers” that use seven different software packages, as summarized in **Table 9**. 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 multitechnique 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. We note that a representative of the Norwegian Mapping Authority (NMA) expressed in an interest in analysis of DORIS data, and also in multi-technique analyses. The participation of the NMA (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	Sergei Rudenko Rolf Koenig	EPOS-OC	SLR, GNSS
TU Delft*		✔	The Netherlands	Ernst Schrama	GEODYN	SLR

Table 9: Summary of IDS Analysis Centers

**CNES POD group and TU Delft were recognized as AACs by the IDS GB in May 2017*

9.3 OPEN ISSUES FOLLOWING ITRF2014

Following the DORIS processing for the realization of the ITRF2014, there are still many substantive issues that remain to be addressed, even with the current data already processed. Some issues where work or investigations are in progress are listed below.

9.3.1 JUMP IN DORIS SCALE (2012 AND LATER)

The IDS scale jump in 2012 seems fully explained by a variation in the number of low-elevation measurement included in the processing. Indeed, the increase of the scale factor for Jason-2 and Cryosat-2 is linked to the change of tropospheric model used by CNES in its POD processing (GDR standards): from CNET (GDR-C) to GPT/GMF (GRD-D). It causes a reduction of the amount of data marked as rejected in the doris2.2 file (input doris data file) and then, an increase of the data used considered to be good in CNES pre-processing. The larger number of data, especially at low elevation, could thus be the cause of the change we observe in the scale factor. The date of change is mission dependent. The scale increase of the multi-satellite solutions is due to the jump not at the same time of the Jason-2 and Cryosat-2 solutions but also of the HY-2A high scale. So, IDS ACs need to do their own pre-processing

The IDS Combination Center has to confirm by analyzing all the AC contributions that only AC not using the flagged data in the doris2.2 file (from CNES pre-processing) are impacted. ACs could provide a Jason-2 single satellite solution obtained from processing using homogeneous editing criteria since 2011 (i.e. not relying on the CNES editing flags in the doris2.2 file). Then, if the problem is solved for Jason-2, it has been decided to reprocess all data using these homogeneous editing criteria for the whole period of each satellite having data in 2012.

9.3.2 HY-2A ZOFFSET AND HY-2A TZ

The high scale level of HY-2A has been mentioned and an action has been decided to solve this problem: GSFC, CNES-POD, GRG, INA and IGN have agreed to make a multi-year determination of the HY-2A radial offset. Some groups have also a high Tz value (~70 mm for GRG). To see which AC is impacted, Analysis Coordinators propose to ACs to provide a HY-2A single satellite solution to IDS CC at least one year (5 years [2011-2015] in the best case).

9.3.3 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. There is an action in progress for ACs: plot histogram of residuals for SPOT-4/5, JASON-2 and CRYOSAT-2 to see if the center moves according to the elevation.

9.3.4 INCREASE OF DORIS RMS OF FIT OF THE ORBIT DETERMINATION

There is an apparent correlation of the recent years increase in the DORIS measurement residuals, which cannot be attributed only to the uncertainty of DPOD2008 in extrapolation mode, with the solar activity (Solar flux at F10.7). On this point, the Analysis Coordinators require the ACs who are willing to participate to provide their time series of satellite measurement residuals.

9.4 EVALUATION OF ITRF2014/DTRF2014/JTRF2014 SOLUTIONS

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 only 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 editing criteria the JPL solutions contains fewer 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 observation residuals, orbit overlaps and transformation parameters of the DORIS network. All TRF realizations represent a clear improvement over the previous realization, ITRF2008 (see an example of GSC result in **Figure 12**). Based on the different criteria used for evaluation, it has been shown this is the ITRF2014 which presents the best overall performance. It is this model that will serve as a basis for the operational processing of future DORIS data. 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). This extension of ITRF2014 for the DORIS network is called DPOD2014: an update the position/velocity of all stations is performed and aligned on the ITRF2014, leading to possible minor adjustment of older stations. A version of the DPOD2014 will be submitted by IDS Combination Center (G. Moreaux) to the evaluation of the users at the beginning of 2017.

9.5 DORIS RINEX DATA PROCESSING AND INTRODUCTION OF THE NEW SATELLITES

Some recommendations on the practical implementation of the RINEX measurements in the POD software have been given at the last AWGs in 2016. A bug in time tagging from PANDOR process inferred a high frequency noise in RINEW files. Another problem coming from DIODE was as well removed. The relativistic propagation correction should include not only GM but also the J2 effect. The ionospheric correction has to be computed from RINEX file. ACs should take care that the iono-free phase center is shifted from the 2 GHz phase center by 6 mm on board and 19 mm on ground, so 25 mm at all. Values of CoP-CoM vector and beacon phase center height are newly given for RINEX in an IDS available document. All differences between 2.2 and RINEX data are now explained and the necessary corrections have been applied.

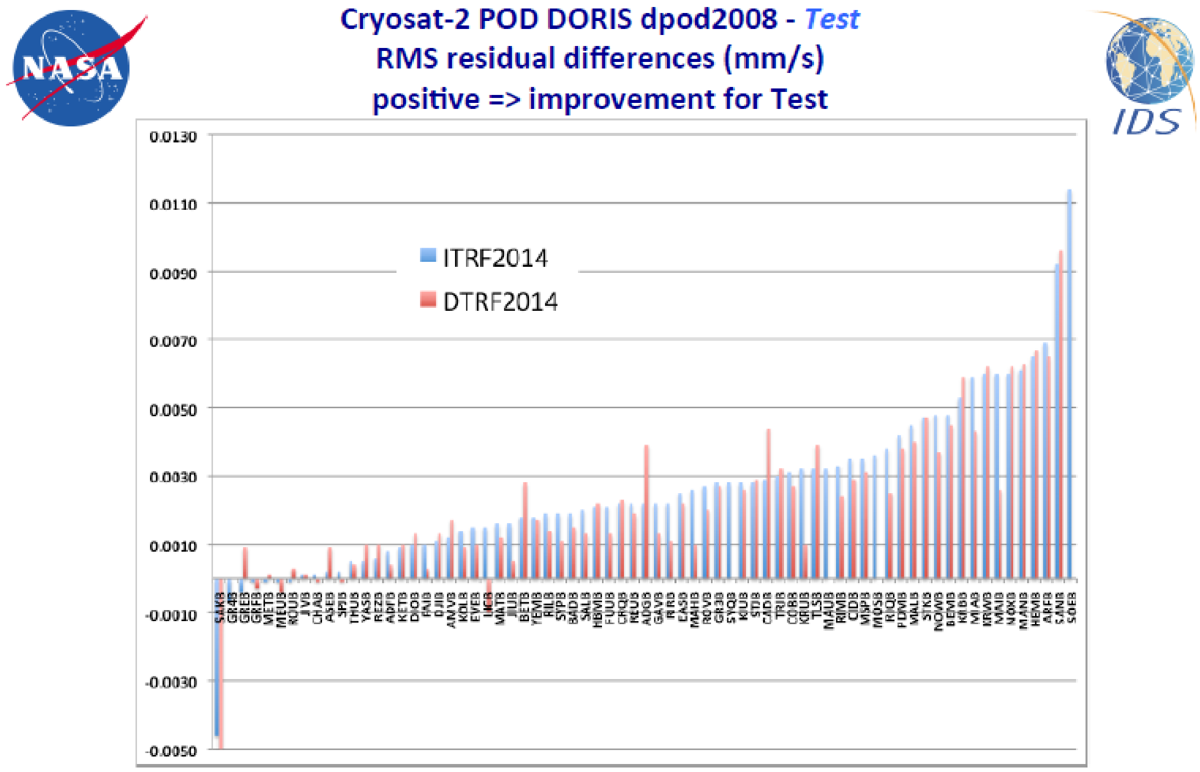

Figure 12: GSC Cryosat-2 RMS residual differences (DPOD2008-test)

A study has been done to see the impact of the time-tagging (stability/accuracy) on the orbit determination and the positioning performance. The objective was to assess the actual improvement in the DORIS products of the “new” RINEX-DORIS data (using the PANDOR component) and to compare to the “old” RINEX-DORIS data (using DIODE time-tagging). As the PANDOR RINEX-DORIS data present some disadvantages in operation (as latency of 3 days, longer data-gaps, cost of maintenance, reprocessing of all missions and period are required in case of anomaly…) this study could make take a decision to continue the dissemination of these RINEX data or to provide the RINEX-DORIS data using DIODE time-tagging. Based on test results done by GRG and GSC ACs, CNES decides to switch back to DIODE time tagging.

The Jason-3 and Sentinel-3A satellites were added in the DORIS processing chain of some ACs which can process RINEX data format (as GSC and GRG AC).

9.6 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. 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 13**). This model is available for test within the IDS at GEOAZUR's ftp site.

IGN AC has shown, thanks to the "DORIS PPP method" on uncorrected Jason-2 DORIS data, that the positioning error due to the SAA can reach up to 10 cm for some stations with this satellite. GRG AC and C. Jayles from CNES both showed that Jason-3 is also sensitive to the SAA, at a level which is lower than that of Jason-1, but still 4 to 5 times higher than that of Jason-2. The CNES POD team has shown that Sentinel-3A is also sensitive to the SAA. They, using an original method based on the clock determination of the GNSS receiver on-board Sentinel-3A, showed that it is possible with this method to obtain an accurate and continuous observation of the satellite's USO frequency excursions (see **Figure 14**).

One of the conclusions of these studies was that, while no noticeable effect of the SAA influence has been shown on POD or reference frame transformation parameters, there is an important impact on the station position estimation for some stations in the vicinity of the SAA area. Building accurate models of frequency variations in response to the temperature and to the SAA radiations for each DORIS USO is therefore a task that is encouraged by the IDS community for the accurate position estimation of all DORIS stations.

The model of A. Belli et al. for Jason-2 was evaluated by analyzing its impact on the position estimation of the SAA stations by GRG and GSC ACs. The model leads to improve the positioning in the SAA area.

While awaiting a more precise DORIS data corrective model, a solution was proposed to minimize the SAA effect on the orbit and also and in particular on the station position estimation. Before combining the solution disturbed by the SAA effect to the others single satellite solutions, we rename the SAA stations (and all their adjusted parameters). Thus, these SAA stations from solution disturbed by the SAA do not contribute to the realization of the combined solution. The strategy (applied to Jason-2 and Jason-3 solutions) brings an improvement in the station position estimation for the SAA station, in particular for the Cachoeira station. When the strategy is applied, the differences to the reference solution are in the same level as the one obtained for station outside the SAA area (< 1 cm for all components).

9.7 FUTURE PLANS

ACs have to complete their DORIS/RINEX data processing implementation in order to consider the data from Jason-3 and Sentinel-3A (available first quarter of 2016). IDS will switch to ITRF2014 for operational products when the DPOD2014 will be available. The next IDS Analysis working group and Workshop meetings will be held in London (Netherlands), May 22-24, 2017 (*hosted by University College London*).

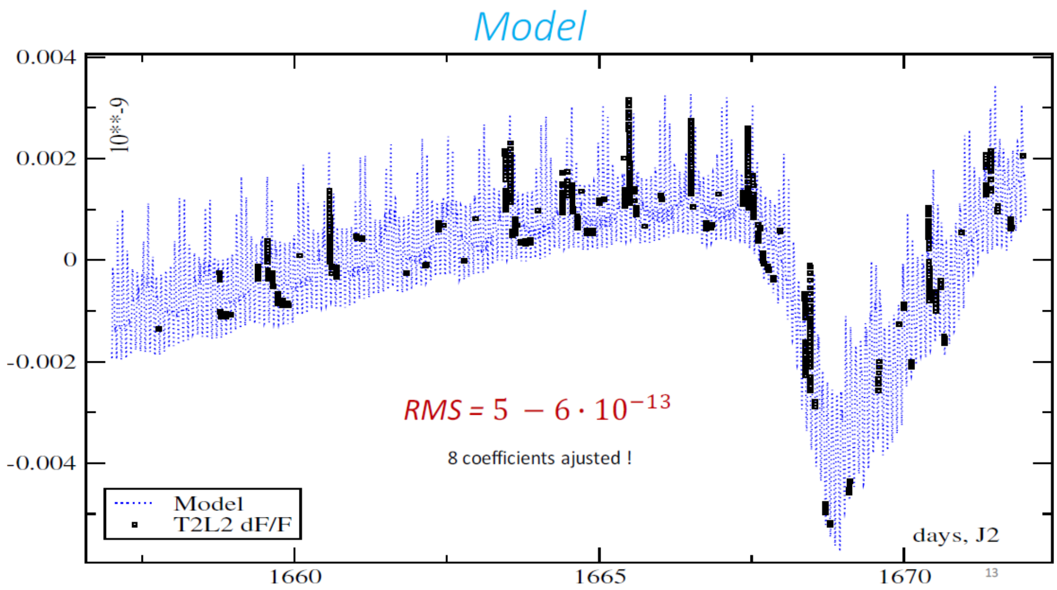

Figure 13: Variations of Jason-2 USO's frequency

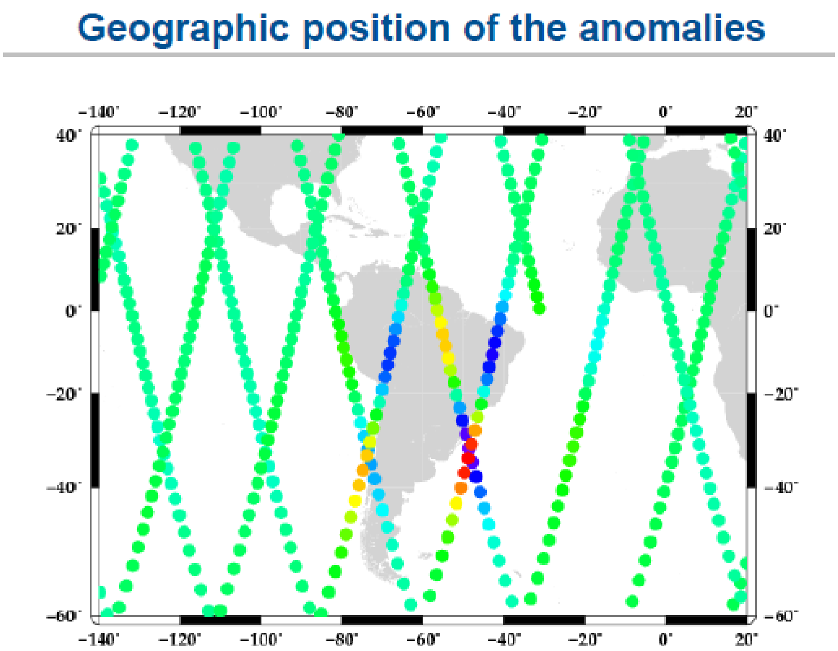

Figure 14: Estimation of the residuals curvature

10. IDS COMBINATION CENTER

Guilhem Moreaux / CLS, France

10.1 ACTIVITY SUMMARY

In 2016, in addition to the routine evaluation and combination of the IDS AC solutions, the IDS Combination Center mainly worked on the DPOD2014 solution as well as on the DORIS evaluation of the DGFI, IGN and JPL ITRF2014 realizations.

10.2 IDS ROUTINE COMBINATION

At the end of 2015, the time span of the SINEX files of the IDS combined solution was 1993.0-2016.5. These files correspond to the IDS series 09, 11 and 12. The IDS 09 series was realized for the ITRF2014. The IDS 11 differs from IDS 09 by the including of the INA 10 series (in place of INA 08), so all the IDS AC contributions make use of the DORIS ground beacon phase laws. The IDS 12 series was developed for the DPOD2014 realization.

10.3 DPOD2014

In 2016, the IDS Combination Center continued the DPOD activities started in 2015 after P. Willis decided to hand over the DPOD realization. In line with the delivery of a new INA series including DORIS PCVs, we initialized a new combined series (IDS 11) and estimated a first preliminary version of the DPOD2014 with observations from 1993.0 to 2016.0. To show the stability of the mean positions and velocities of the oldest stations with respect to the DPOD observation time span, we also computed two solutions: one with data from 1993.0 to 2009.0 and one with data from 1993.0 to 2015.0. As presented during the IDS AWG in Delft, the maximum of the 3D position differences between the two solutions 1993.0-2009.0 and 1993.0-2016.0 is around 16 mm. Early June 2016, a first DPOD meeting was organized at CNES in Toulouse with CNES, IGN and CLS people to clarify the goals of the DPOD solution. As a result of that meeting, a validation group was created. That group, lead by P. Willis, is especially in charge of the POD validation of all the coming DPOD solutions from the IDS Combination Center. As the DPOD solution must contain position and velocities of all the DORIS stations, the Combination Center had to adapt the combination criterion associated to the minimum number of AC solutions per station. That criterion moved from 3 to 2 and a new combined solution was created (IDS 12) with more stations and without significant change in the position and velocity of the stations contained in the cumulative solution from the IDS 11 series. Note that before sending its solution to the validation group, the Combination Center do some internal validation tests. These tests include the estimation of the position and velocity differences with the ITRF2014, the analysis of the DORIS-to-DORIS tie vector residuals and the comparison of the DORIS-to-GNSS, DORIS-to-SLR and DORIS-to-VLBI ties with the surveyed ones (**Figure 15**) and while the GNSS, VLBI and SLR positions are extracted from the ITRF2014.

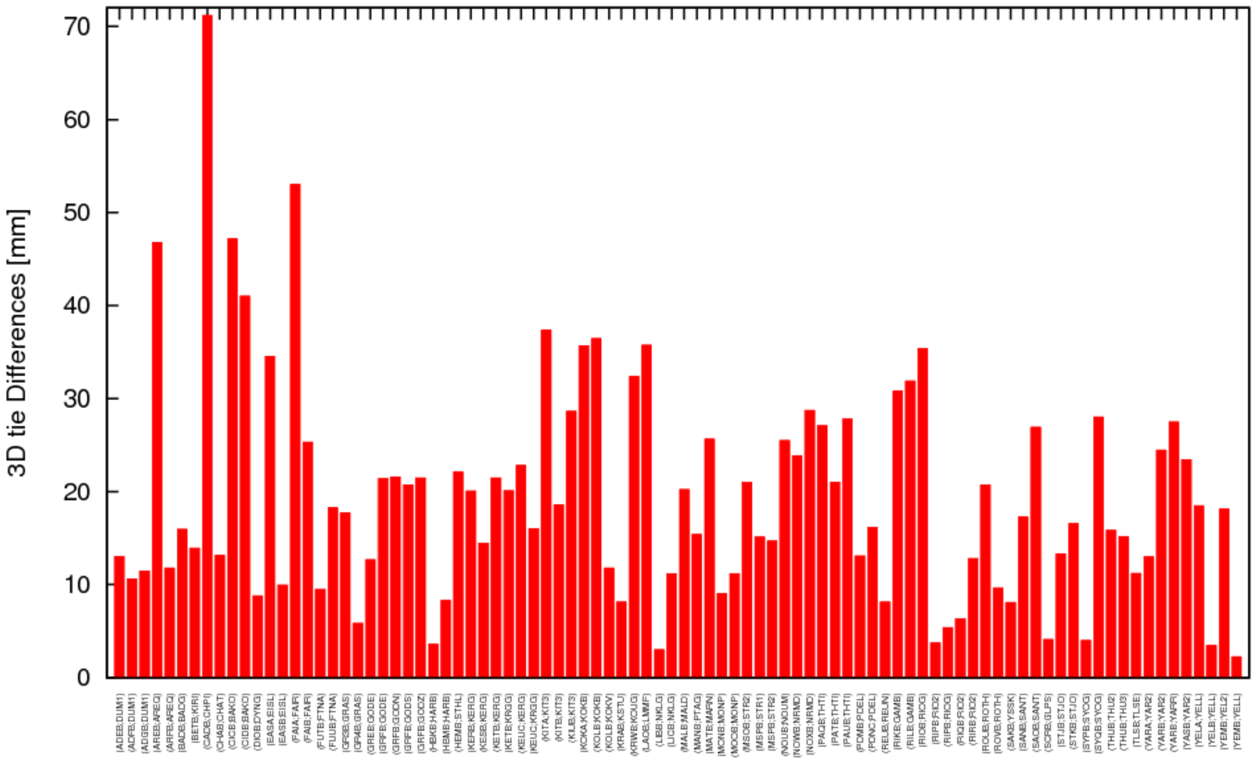

Figure 15: 3D differences between the DORIS-to-GNSS ties from DPOD2014 v0.3 with the surveyed ties

In line with the second DPOD meeting organized with the validation group during the IDS Workshop in La Rochelle, to include the stations with observations before 1993.0, we decided to ask the IDS ACs to treat these stations. In the meantime, the position and velocity of these stations will be deduced from the latest DPOD2008 from P. Willis. We also agreed to write a dedicated paper to present the new DPOD2014 solution. The objectives are to get a version 1.0 of the DPOD2014 by February 2017 and to submit a paper by the end of the first half of 2017.

10.4 DTRF2014, ITRF2014 AND JTRF2014 DORIS EVALUATION

Early 2016, in cooperation with the IDS Analysis Coordinators (Hugues Capdeville and Jean-Michel Lemoine), the IDS Combination Center started a first analysis of the three ITRF2014 realizations from DGFI, IGN and JPL. The results of that first study were presented at the EGU 2016. That study was divided in two parts: i) analysis of the results (Helmert parameters, station positioning performances) of the IDS 09 series with respect to the three solutions (**Figure 16**) and, ii) impact of these three ITRF2014 solutions on DORIS orbit determination.

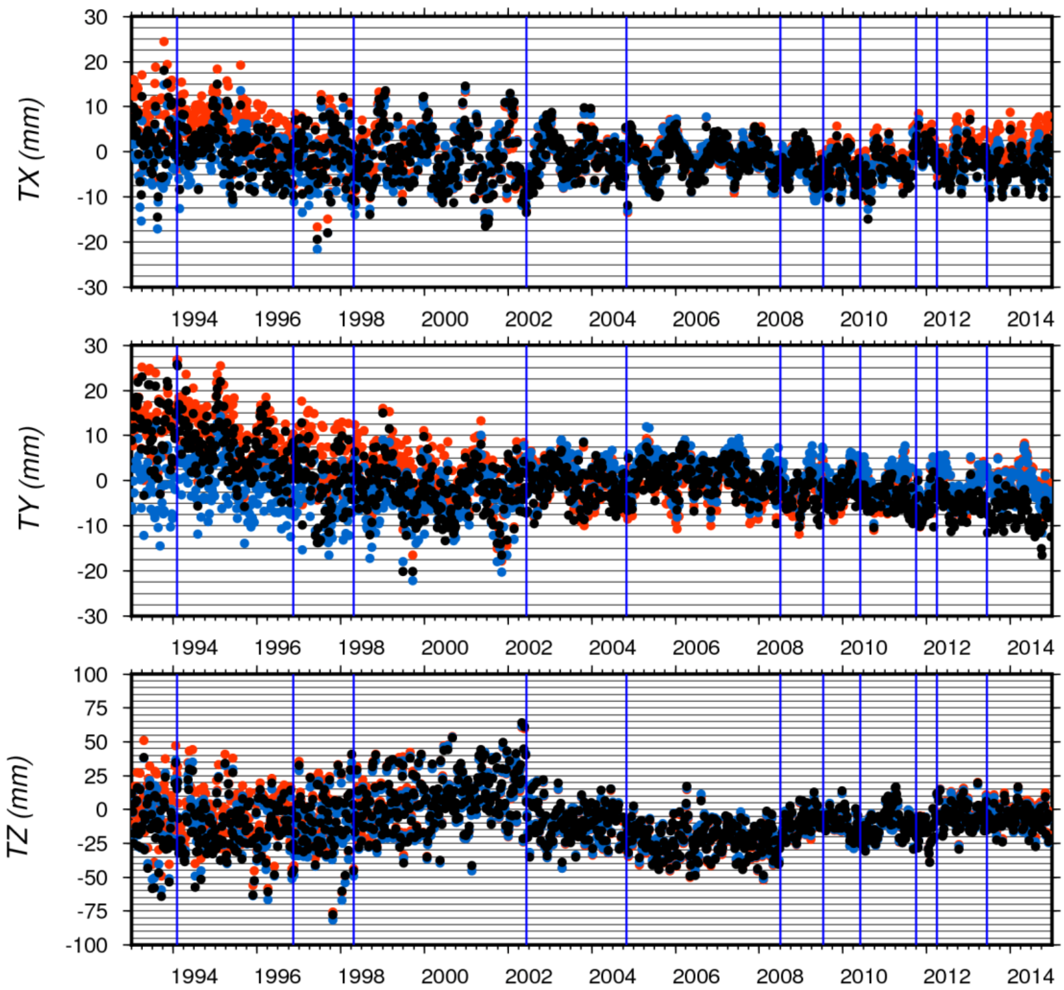

Figure 16: Translations of IDS 09 with respect to DTRF2014 (red), ITRF2014 (blue) and JTRF2014 (black). Vertical lines correspond to the DORIS satellite constellation changes

Then, later on, the IDS CC asked Claudio Abbondanza (JPL) and Mathis Bloßfeld (DGFI) to join us to complete that study with the objective to submit a paper on that subject. Compared to the results presented in Vienna, the paper will address the analysis of the scale and geocenter differences, the review of the DORIS-to-DORIS tie vector residuals as well as the estimation of DORIS station position differences. In addition, the paper will include the testing of two new solutions: the DTRF2014 plus the atmospheric and hydrologic non-tidal loading corrections and the ITRF2014 plus the annual and semi-annual coordinate time series (personal communication from Z. Altamimi).

10.5 COMMUNICATIONS

The IDS Combination Center joined both EGU and AGU fall meetings where it presented one oral presentation and one poster respectively titled “IDS evaluation of the DORIS versions of the DGFI, IGN and JPL ITRF2014 solutions” and “DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination”. An abstract on the spectral analysis of the DORIS station coordinate time series was also submitted for oral presentation at EGU 2017.

In 2016, six papers with the contribution of the IDS Combination Center were published:

Bloßfeld, M.; Seitz, M.; Angermann, D.; Moreaux, G., 2016. Quality assessment of IDS contribution to ITRF2014 performed by DGFI-TUM, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2505-2519, DOI: 10.1016/j.asr.2015.12.016

Moreaux, G.; Lemoine, F.G.; Argus, D.F.; Santamaría-Gómez, A.; Willis, P.; Soudarin, L.; Gravelle, M.; Ferrage, P., 2016. Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with geophysical models, GEOPHYSICAL JOURNAL INTERNATIONAL, 207(1), 209-227, DOI: 10.1093/gji/ggw265

Moreaux, G.; Lemoine, F.G.; Capdeville, H.; Kuzin, S.; Otten, M.; Štěpánek, P.; Willis, P.; Ferrage, P., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2479-2504, DOI: 10.1016/j.asr.2015.12.021

Tourain, C.; Moreaux, G.; Auriol, A.; Saunier, J., 2016. Doris starec ground antenna characterization and impact on positioning, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2707-2716, DOI: 10.1016/j.asr. 2016.05.013

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

Willis, P.; Zelensky, N.P.; Ries, J.; Soudarin, L.; Cerri, L.; Moreaux, G.; Lemoine, F.G.; Otten, M.; Argus, D.F.; Heflin, M.B., 2016. DPOD2008, a DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, IAG SYMPOSIA SERIES, 143, 175-181, DOI: 10.1007/1345_2015_125

10.6 FUTURE PLANS

The first quarter of 2017 will be devoted to the finalization of the first version of the DPOD2014 as well as to the spectral analysis of the DORIS station coordinate time series. We also plan to achieve the writing of CLS, CNES, DGFI, JPL joined paper on the DORIS evaluation of the DGFI, IGN and JPL ITRF2014 realizations. That paper must be submitted to Advances in Space Research by May-June 2017. In addition, a second paper on the DPOD2014 realization may be also submitted to Advances in Space Research by the end of the first half of 2017. In the meantime, the IDS Combination Center must have dedicated web pages on the IDS web site to present and give access to the DPOD2014.

11. ANALYSIS CENTER AT EUROPEAN SPACE OPERATION CENTRE (ESOC)

Michiel Otten, Werner Enderle / ESOC, Germany

11.1 INTRODUCTION

The activities in 2016 of the European Space Operation Centre as an IDS analysis center were limited due to severe time constrains. As a result, the time that was available has been used to maintain and perform minor upgrades to the current ESA IDS solution (esawd10).

11.2 CHANGES MADE TO THE ESAWD10 SOLUTION IN 2016

The upgrades made to the current ESA IDS solution in 2016 were:

- Updated GRGS EIGEN.GRFS.RL03.v2 model for gravity
- Changed atmospheric gravity model to (GEOS-FPIT) from massloading.net also updated S1/S2 contribution of the atmospheric contribution to the gravity field
- Updated NAPEOS version (4.0); this current solution covers the entire IDS processing period from 1993 until 2016 and has been delivered to the combination centre.

11.3 FUTURE ACTIVITIES

The Navigation Support Office plans for 2017 to include in the processing SARAL/ALTIKA, Jason-3 and Sentinel-3A. The last mission will mean that we will start using the DORIS RINEX data for all available missions (Jason-2, Cryosat-2, HY-2A and Sentinel-3A) instead of the older DORIS Data Exchange Format. 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 GEODETICAL OBSERVATORY PECNY (GOP)

Petr Štěpánek / Geodetic Observatory Pecný, Czech Republic

12.1 ROUTINE PROCESSING

The data until the day 270, 2016 were processed and the corresponding weekly SINEX files of the standard solution wd43 were delivered to the data center. The combination center consequently pointed out some discontinuities in the Geocenter coordinates in GOP solutions. The origin of this problem was found and thus the re-delivery of the corrected SINEX files for the period 270/1015-270/2016 is planned in early 2017. In addition, GOP AC started to produce a new solution wd50 (see §12.5). So far the corresponding SINEX files have been created for 270/2015 – 270/2016 and the official delivery is planned for early 2017.

12.2 LOD ESTIMATION

Our experiment with estimation of the Length of the Day (LOD) from DORIS data proved the possibility to estimate the quantity from pure DORIS data with geodetic accuracy. In 2016 we extended the time span of the processed data from period 2013.0-2015.0 to 2006.0-2015.0. The results confirm RMS w.r.t. IERS C04 model being close to 0.10 msec/day. However, the bias w.r.t. IERS04 is varying with the changes in the satellite constellation at the level of tenths msec/day. The major periodical signal in LOD series corresponds to the semiannual and to the annual period. While the semiannual signal has very similar amplitude in DORIS LOD series and in the IERS04 series, the annual amplitude is by about 20% higher for DORIS LOD estimates, which corresponds to the annual signal of the amplitude about 0.08 msec/day w.r.t. IERS C04 model – see **Figure 17** and **Figure 18**.

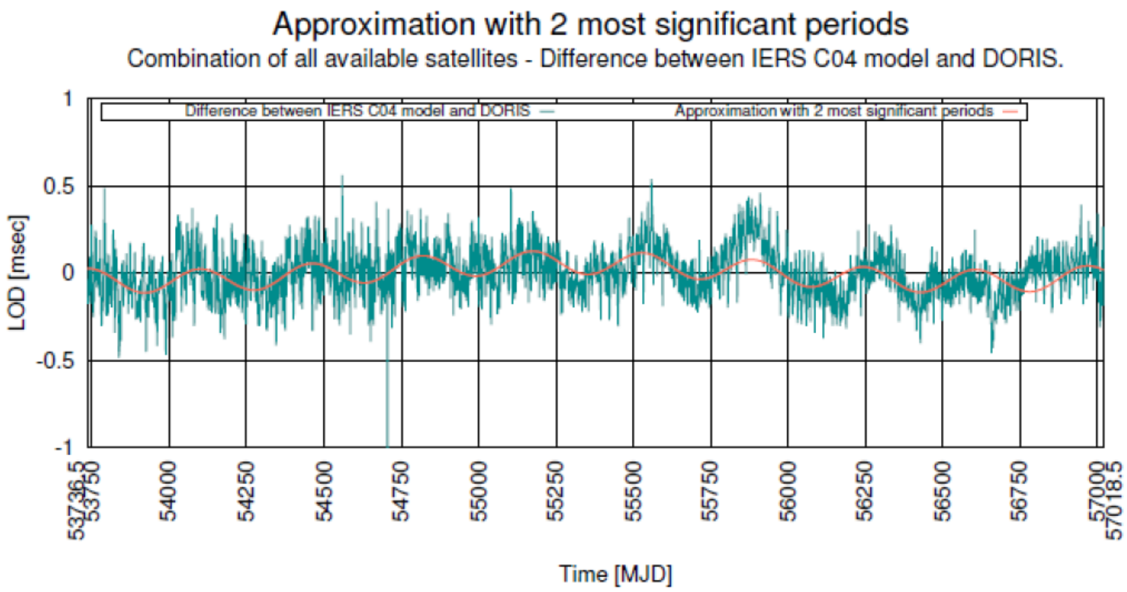

Figure 17: Difference between IERS C04 model and DORIS LOD estimates

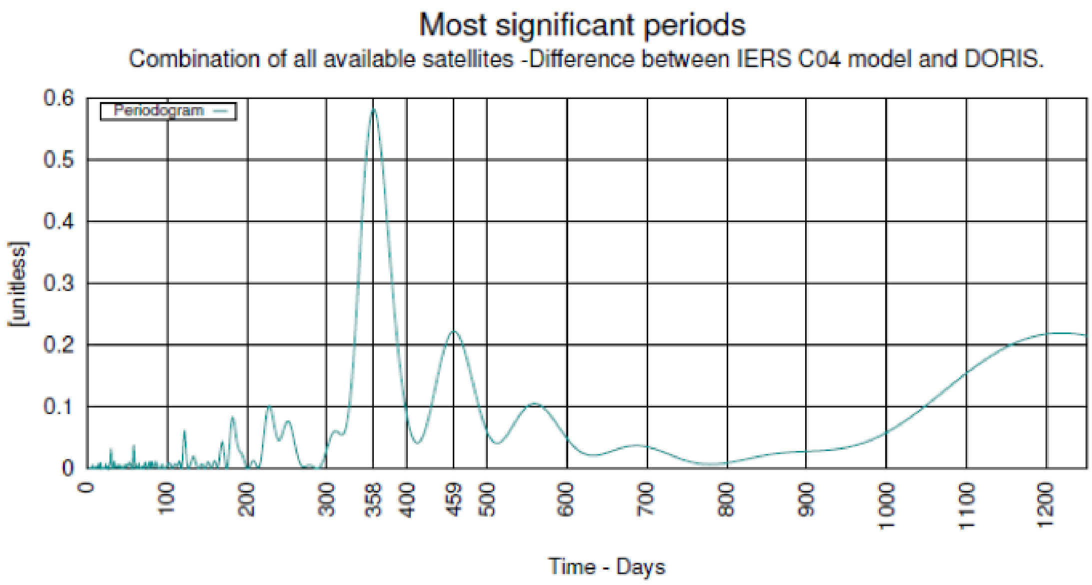

Figure 18: Periodogram of the difference between IERS C04 model and DORIS LOD estimates

12.3 SOFTWARE UPDATE

The data processing software was updated from Bernese 5.0 to Bernese 5.2. In standard operational processing, the version Bernese 5.0 is still in use. The updated software enables e.g. the application of quaternions (measured attitude) or SINEX creation in two forms, covariance matrix and normal equations matrix.

12.4 MEASURED ATTITUDE FOR JASON-2

The tools for application of the Jason-2 measured attitude were implemented in the data processing software. The test was based on the three different solutions employing a specific modeling of the center of the satellite mass. First, we used the correction from the data file, second, we applied the nominal model and third, we used the measured attitude data. The testing proved the highest accuracy of the solutions with measured satellite altitude, particularly with respect to the nominal attitude.

12.5 PREPROCESSING AND DATA DOWNWEIGHTING

In the standard solution (wd43), we apply the observation quality indicator in the data files and we do not apply any observation weighting. Experimentally, we processed the data from the period 270/1015-366/2016 with different standards, i.e., not employing the observation quality indicator and applying the observation weighting function Cos (Z), where Z is the zenith angle. The new strategy significantly improved the (unweighted) weekly station repeatability (15.7 mm vs. 18.0 mm) and reduced the scale w.r.t. ITRF/DPOD 2008 (4.7 ppb vs. 7.9 ppb). For the reason of this significant improvement, we decided to include the settings in the alternative solution wd50, processed in parallel with solution wd43.

13. CNES/CLS ANALYSIS CENTER (GRG)

Hugues Capdeville [(1)], Adrien Mezerette [(1)], Soudarin Laurent [(1)], Jean-Michel Lemoine [(2)]
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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 2016 was to introduce in our processing chain the new satellites Jason-3 and Sentinel-3A, the DORIS data of which are only available in RINEX format. We have also analyzed the sensitivity to the South Atlantic Anomaly (SAA) effect of their Ultra Stable Oscillator (USO). We evaluated the Jason-2 SAA corrective model of Belli & al. A study on the impact of the low elevations measurements has also been done.

13.2 STANDARD ROUTINE PROCESSING

We restarted the standard routine processing by taking into account the data from June 2015 to June 2016. 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: SPOT-5, JASON-2, CRYOSAT2, HY-2A and SARAL.

Table 10 gives the mean over the 2016 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 and we compared to the DPOD2008.

Satellite	RMS DORIS / SLR (mm/s) / (cm)	OPR amplitude average (10^{-9} m/s^2)		Solar radiation coefficient
		Along-track	Cross-track	
SPOT-5	0.35	2.8	1.8	1.05
JASON-2	0.33 / 1.1	2.5	1.9	0.97
CRYOSAT-2	0.35 / 1.2	3.0	2.4	1.0
HY-2A	0.34 / 1.3	0.7	3.0	0.86
SARAL	0.34 / 1.2	1.3	1.7	1.0

Table 10: Mean DORIS and SLR RMS of fit per arc, OPR amplitude average and solar radiation coefficient on the entire data processing period.

13.3 DORIS RINEX DATA PROCESSING

A strategy was developed for the processing of the measurements of the DGXX instruments in RINEX/DORIS format, as it will be the only type of DORIS format made available by CNES starting as from the Jason-3 and Sentinel-3A missions, launched at the beginning of the year 2016. The method was implemented in the CNES/CLS Analysis Center orbit computation software GINS to process RINEX/DORIS data files. Phase measurements are converted into Doppler counts and then into relative satellite-to-beacon velocities. In this approach, the iono-free phase centers have to be used as the end points of the measurement instead of the 2 GHz phase centers.
Some comparison tests between doris2.2 and RINEX data have been achieved for Jason-2, Cryosat-2 and HY-2A on 4 years time span (2011 to 2014). The results are given in a paper about the RINEX/DORIS processing at GRG and published in Advances in Space Research (Lemoine et al., 2016; see §13.7).

A study has been done to see the impact of the time-tagging (stability/accuracy) on the orbit determination and the positioning performance. The objective was to assess the actual improvement in the DORIS products of the “new” RINEX/DORIS data (using the PANDOR component) and to compare to the “old” RINEX/DORIS data (using DIODE time-tagging). As the PANDOR RINEX-DORIS data present some disadvantages in operation (as latency of 3 days, longer data-gaps, cost of maintenance, reprocessing of all missions and period are required in case of anomaly …) this study could make take a decision to continue the dissemination of these RINEX data or to provide the RINEX-DORIS data using DIODE time-tagging.
Analyses and comparisons on Jason-2 were performed by GRG AC from 6 months of data (from March, 27 2016 to September, 3 2016) with different formats:

- Doris2.2 (V2) : ftp://cddis.gsfc.nasa.gov/doris/data/ja2/ja2data${cycle}
- RINEX PANDOR (RINEX_P): ftp://cddis.gsfc.nasa.gov/doris/data/ja2/2016 (a correction in the PANDOR software has been done on June, 2 2016**)**
- RINEX SPA (Datation Diode) (RINEX_S):

For each data set, we analyzed the temporal evolution of the DORIS RMS of fit of the orbit determination and the measurements number (**Figure 19**). We compared the two RINEX orbits to those obtained from doris2.2 data. And an evaluation of the positioning was done by the comparison to the DPOD2008 of the 3 single satellite solutions Jason-2 obtained from the 3 different data sets.
Starting from the correction made in the PANDOR software in June 2016, the DORIS RMS residuals are at the same level for DORIS2.2 (V2) data and the two sets of RINEX data (PANDOR and SPARINEX). The Jason-2 DORIS-only orbit independent SLR RMS residuals are at the same level for the 3 sets of data. Jason-2 orbit comparison (RINEX data compared to DORIS2.2 data). The orbits are very close but there is an offset < 0.2 cm in the STD radial orbit differences, there is an offset of 0.4 cm in the Along-track orbit differences for RINEX PANDOR and there is an offset of 0.6 cm in the Along-track orbit differences for RINEX SPA.
As shown at the AWG in Toulouse in May 2015, the quality with DORIS RINEX data is at the same level than DORIS 2.2 data. For GRG AC, the Precise Orbit Determination (POD) and the station position estimation obtained from RINEX PANDOR and SPARINEX (DIODE time-tagging) are the same quality.

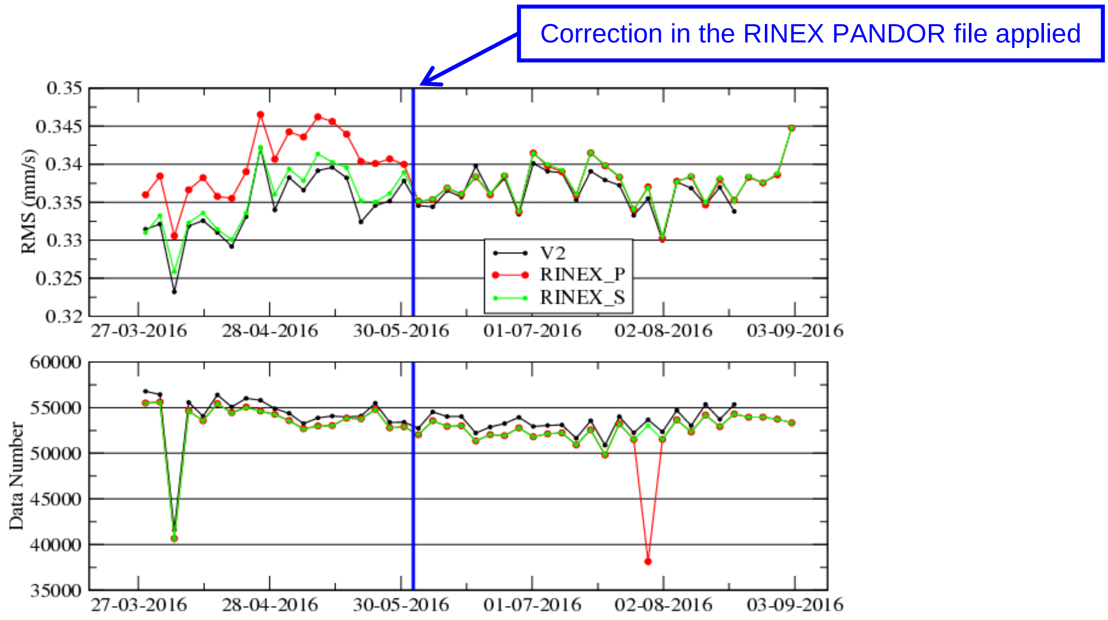

Figure 19: DORIS RMS of fit of the orbit determination and measurement number, from Doris2.2 in black, RINEX_PANDOR in red and RINEX_SPA in green

13.4 ADDING JASON-3 AND SENTINEL-3A

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 is presented through statistical results such as one per revolution (OPR) empirical acceleration amplitudes and orbit residuals. We give also some comparisons to the CNES precise orbit used for altimetry (GDR-E).

The first step was to determine the radiation pressure coefficient for Jason-3 and Sentinel-3A by adjusting over a sufficient long period (we obtained 0.99 for Jason-3 and 1.0 for Sentinel-3A). We analyzed the orbit results obtained on the time span processing of 30 weeks: 21 February to 24 September 2016. We looked the OPR empirical acceleration amplitude in the Along-track and Cross-track directions, the temporal evolution of the DORIS RMS of fit of the orbit determination and the measurements number for each satellite. We focus on the DORIS RMS for the stations in the SAA area. The DORIS-only orbits were evaluated by independent SLR data processing. Then, a comparison to the CNES precise orbit used for altimetry (GDR-E) was done.

The POD results are of good quality but the DORIS RMS are still higher than the other DORIS satellites (**Figure 20**). For Jason-3, that could be explained by the SAA effect. The CNES/CLS orbits are very close to the CNES precise orbit used for altimetry (GDR-E) but there is an offset in the Along-track orbit differences (~2 cm for Jason-3 and ~5 mm for Sentinel-3A). The SAA effect can be neglected for the POD but for the station position estimation it must be taken into account.

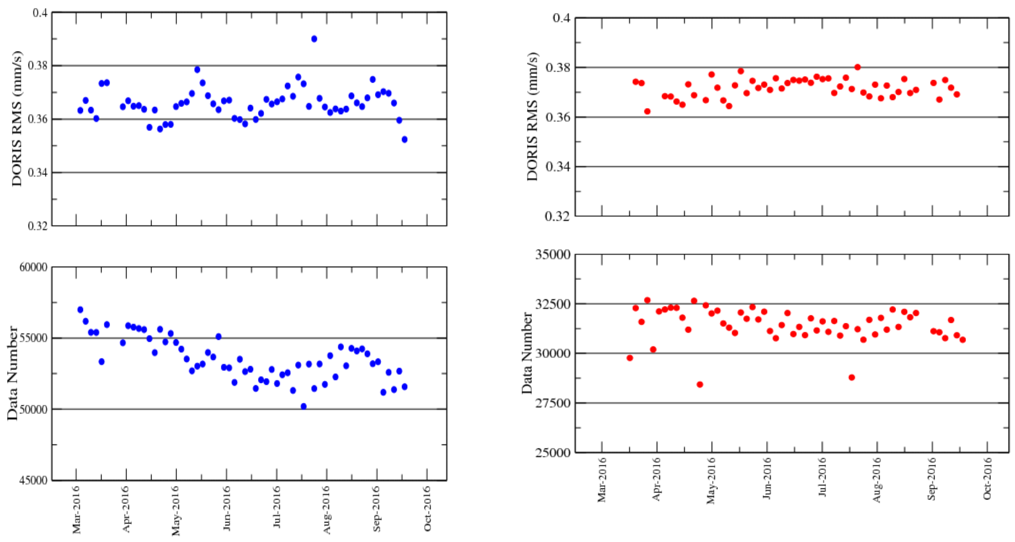

Figure 20: DORIS RMS residuals and measurements number, in blue for Jason-3 and in red for Sentinel-3A

13.5 SENSITIVITY OF DORIS USO TO THE SAA EFFECT

The DORIS Ultra Stable Oscillators for Jason-3 and Sentinel-3A DORIS satellites are sensitive to the SAA effect at a level which is lower than that of Jason-1, but for Jason-3 still 4 to 5 times higher than that of Jason-2. So, for the POD, the SAA effect can be neglected but for the station position estimation, it must be taken into account. Indeed, we show here the impact on the station position estimation for some stations in the vicinity of the SAA area (see **Figure 21**) by comparison of the single satellite solutions.

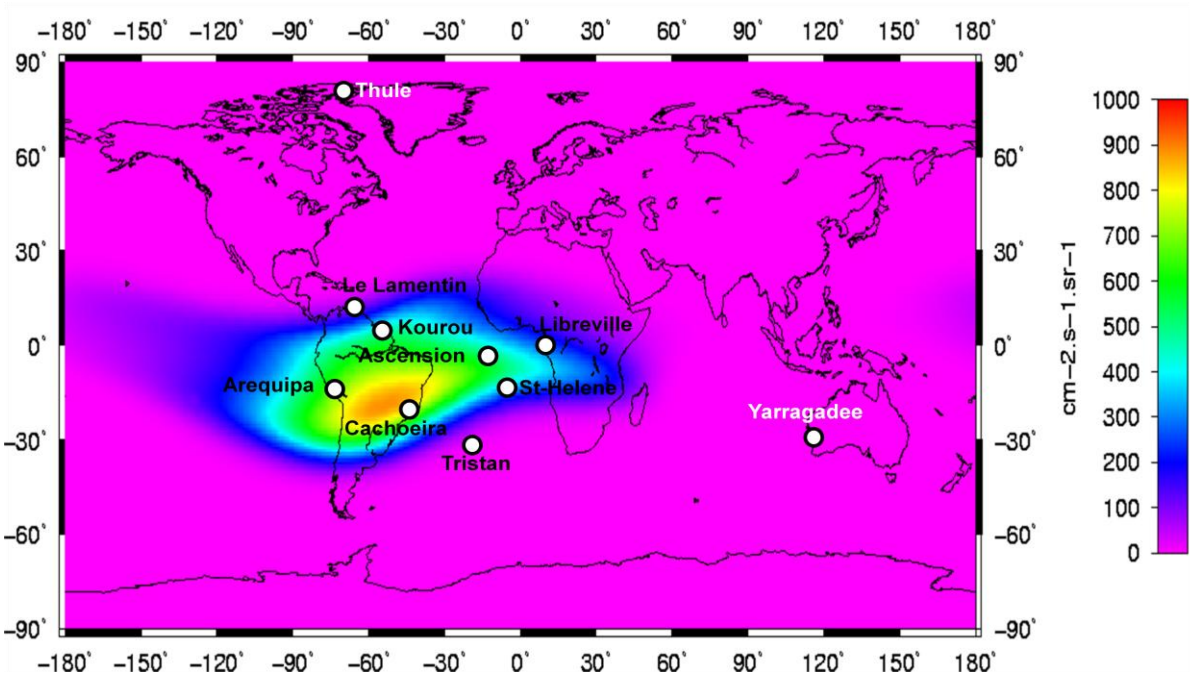

Figure 21: SAA map from Jason-2 CARMEN data and the SAA stations (>87 MeV integrated proton flux map; 2009-2011 average)

We computed weekly single satellite solutions for Jason-2, Jason-3, Sentinel-3A and Cryosat-2 from 21 February to 24 September 2016. Comparisons of these weekly solutions to DPOD2008 are performed with the CATREF (Combination and Analysis of Terrestrial Reference Frames) package.

Table 11 gives the differences between the Jason-2/Jason-3/Sentinel-3A and Cryosat-2 (used as reference) solutions for the North, East, and Up (NEU) components for the eight SAA stations (see **Figure 21**) and two stations outside the SAA area (Yarragadee and Thule).

Some previous results show that Jason-2 USO is sensitive to the SAA but not at the same level as Jason-1 and SPOT-5. The effect is not strong enough to be observed clearly on the DORIS residuals of the SAA stations. As the Cryosat-2 USO is not affected by SAA, we use the Cryosat-2 single satellite solution as a reference. Compared to Cryosat-2 solution, the Jason-2 single satellite solution has an important bias (higher than 4 cm) in at least one of the NEU components for the following SAA stations: Cachoeira, Arequipa, Ascension, Saint-Helene and Le Lamentin. As a consequence, the multi-satellite solution provided for ITRF2014 contribution can be impacted by the Jason-2 solution for the SAA stations.

These results also show that Jason-3 USO is more sensitive to the SAA than Jason-2. The effect is strong enough to be observed on the DORIS residuals of the SAA stations. Compared to Cryosat-2 solution, the Jason-3 solution gives a bias in at least one of the NEU components for the SAA stations. Furthermore, these biases are higher than those obtained with Jason-2 for Cachoeira, Arequipa, Ascension, Saint-Helene and Le Lamentin. And Kourou, Tristan and Libreville are also impacted.

The differences between the single satellite solutions for Sentinel-3A and Cryosat-2 are low enough (under 2 cm) for the SAA stations to conclude that the sensitivity of the Sentinel-3A USO is not strong enough to affect the station position estimation. Indeed, the differences between the two solutions are at the same level than those obtained for the stations outside the SAA area (Yarragadee and Thule).

Station	**Jason-2 (in cm)**			**Jason-3 (in cm)**			**Sentinel-3A (in cm)**		
	North	**East**	**Up**	**North**	**East**	**Up**	**North**	**East**	**Up**
Cachoeira	3.9	4.5	8.2	7.2	3.2	21	1.4	-1.8	0.2
Arequipa	-1.6	4.2	8.5	-2.4	10.7	19.1	1.2	-1.1	1.4
Kourou	-2.4	-1.3	0.3	-6.8	0.6	4.0	0.8	1.1	0.1
Ascension	0.8	-6.0	5.6	1.7	-2.2	14.4	1.2	-0.6	-0.2
Saint Helene	5.1	-1.8	1.9	9.9	-6.5	9.7	0.2	-0.9	-2.2
Tristan	-2.3	0.2	-2.1	-2.9	-0.1	-5.3	-0.2	-2.0	1.3
Le Lamentin	-0.7	-0.4	-4.2	-2.8	-1.9	-6.2	1.2	0.3	-1.0
Libreville	-3.8	-1.1	2.7	-7.2	0.4	9.2	1.0	0.5	0.1
Yarragadee	*-1.5*	*-0.4*	*0.3*	*-1.4*	*0.4*	*-0.3*	*0.9*	*0.3*	*1.0*
Thule	*1.6*	*-0.5*	*-0.1*	*2.8*	*-1.1*	*-1.2*	*-0.2*	*1.2*	*-1.5*

Table 11: Differences between the Jason-2/Jason-3/Sentinel-3A and Cryosat-2 solutions in the NEU components for eight stations in SAA area and two stations (*bold italic*) outside the SAA area. Mean of 30 weeks (from 21 February to 24 September 2016)

13.5.1 TEST OF THE BELLI & AL. SAA CORRECTIVE MODEL FOR JASON-2 DORIS DATA

Thanks to the extremely precise time-tagging of the T2L2 experiment on-board Jason-2, A. Belli and the GEOAZUR team managed to draw up a model that accurately represents the variations of Jason-2 USO's frequency (http://www.geoazur.fr/t2l2/en/data/v4/). This model is evaluated by analyzing its impact on the position estimation of the SAA stations. For that we corrected the doris2.2 data with this model.

We processed the doris2.2 data and corrected doris2.2 data from 6 January to 23 March 2013. The DORIS and SLR RMS residuals are slightly reduced when the model is applied but not systemically. The orbits obtained from the two data sets are not significantly different. We computed weekly single satellite solutions for Jason-2 which are compared to DPOD2008 with the CATREF package. **Table 12** gives the differences between the Jason-2 and Cryosat-2 (used as reference) solutions in the NEU component for the SAA stations and two stations outside the SAA area (Yarragadee and Thule). The model leads to reduce the difference to the Cryosat-2 solution and then to improve the positioning in the SAA area.

Station	**Jason-2 (in cm)**			**Jason-2 corrected (in cm)**		
	North	**East**	**Up**	**North**	**East**	**Up**
Cachoeira	4.2	3.6	5.3	3.2	3.5	3.4
Arequipa	-1.8	1.9	6.8	-1.1	1.2	3.2
Santiago	8.2	-0.2	1.8	6.8	-0.8	1.0
Ascension	-0.2	-1.4	4.4	-0.1	-0.9	2.6
Saint Helene	4.2	0.5	1.3	3.3	0.5	0.2
Yarragadee	*1.2*	*-0.3*	*1.2*	*0.4*	*-0.2*	*0.2*
Thule	*-0.9*	*-0.8*	*-2.0*	*-0.8*	*-0.4*	*-1.6*

Table 12: Differences between the Jason-2/Jason-2 corrected and Cryosat-2 solutions in NEU. Mean of 10 weeks (from 6 January to 23 March 2013)

13.5.2 STRATEGY TO MINIMIZE THE SAA IMPACT ON THE POSITIONING

While awaiting a DORIS data corrective model, a solution will be proposed to minimize the SAA effect on the orbit and also and in particular on the station position estimation. For Jason-1, we have developed a strategy to add the Jason-1 solution to the multi-satellite solution. Before combining Jason-1 solution to the others single satellite solutions, we rename the SAA stations (and all their adjusted parameters). Thus, these SAA stations from Jason-1 do not contribute to the realization of the combined solution.

We computed weekly multi-satellite solutions from 21 February to 24 September 2016 (30 weeks). Comparisons of these weekly solutions to DPOD2008 are performed with the CATREF package. We provided 3 solutions:

- Solution of reference: combination of Cryosat-2+HY-2A+Saral+Sentinel-3A

- Solutions with satellites (Jason-2 and Jason-3) impacted by the SAA:
  Solution 1: combination of Cryosat-2+HY-2A+Saral+Sentinel-3A+Jason-2+Jason-3
  Solution 2: combination of Cryosat-2+HY-2A+Saral+Sentinel-3A+Jason-2+Jason-3 with strategy applied

These weekly solutions are compared to DPOD2008 with CATREF. **Table 13** gives the differences in NEU between the two solutions with Jason-2 and Jason-3 (solution 1 and 2) and the reference solution for the SAA stations and one station outside the SAA area. The strategy brings an improvement in the station position estimation for the SAA station, in particular for the Cachoeira station (from 4 cm to 0.7 cm of difference for north component). When the strategy is applied, the differences to the reference solution are in the same level as the one obtained for station outside the SAA area (< 1 cm for all components).

Station	Solution 1 (in cm)			Solution 2 (in cm)		
	North	East	Up	North	East	Up
Cachoeira	4.0	-0.6	4.0	0.7	-1.0	0.8
Arequipa	-0.5	2.5	4.4	-0.1	0.7	0.9
Kourou	1.0	-0.1	0.6	-0.2	0.1	-0.2
Ascension	0.1	-1.5	3.8	0.1	-0.1	0.9
Saint Helene	2.1	-1.4	2.3	0.4	-0.2	0.7
Tristan	-0.3	0.9	-1.0	0.0	0.4	-0.1
Le Lamentin	-0.5	-0.4	-1.6	-0.1	-0.1	-0.3
Libreville	1.8	-0.3	1.8	-0.2	0.1	0.8
Yarragadee	*-0.2*	*-0.1*	*-0.2*	*-0.3*	*-0.2*	*-0.1*

Table 13: Differences between the solutions with Jason-2 & Jason-3 and the solution of reference in NEU. Mean of 30 weeks (from 21 February to 24 September 2016)

13.6 CONTRIBUTION TO IDS MEETINGS

The Analysis Center's representatives participated in 2016 to the AWG meeting in Delft. They also participate to the IDS WORKSHOP and OSTST in La Rochelle. They presented the following works:

AWG Delft

- GRG status report
  http://ids-doris.org/images/documents/report/AWG201605/IDSAWG201605-Capdeville-GRG_StatusReport.pdf

- Evaluation of TRF2014: Comparison of DPOD2008, ITRF2014 and DTRF2014
  http://ids-doris.org/images/documents/report/AWG201605/IDSAWG201605-Capdeville-GRG_TRF2014evaluation.pdf

- Are the Jason-2 and Jason-3 USO sensitive to the SAA? http://ids-doris.org/images/documents/report/AWG201605/IDSAWG201605-Capdeville-SAA_Jason2&3.pdf

IDS Workshop La Rochelle

- Which datation method for DORIS-RINEX data? http://ids-doris.org/images/documents/report/ids_workshop_2016/IDS16_s2_LemoineJM-WhichDatationMethodForDORISRINEXdata.pdf

- Impact of the low elevation measurements on the DORIS scale factor http://ids-doris.org/images/documents/report/ids_workshop_2016/IDS16_s3_Capdeville_ImpactLowElevationDataOnScaleFactor.pdf

- Impact of the South Atlantic Anomaly effect on the position station estimation of the last DORIS satellites http://ids-doris.org/images/documents/report/ids_workshop_2016/IDS16_s4_Capdeville_ImpactSAAonStationPosition.pdf

OSTST La Rochelle

- Precise orbit determination and station position estimation status on Jason-3 and Sentinel-3A by CNES/CLS IDS Analysis Center

13.7 PUBLICATIONS IN PEER-REVIEWED JOURNALS

In 2016, three papers have been published in the ASR revue (DORIS special issue).

Capdeville, H., Stepanek, P., Hecker, L., Lemoine, J.-M, 2016. Update of the corrective model for Jason-1 DORIS data in relation to the South Atlantic Anomaly and a corrective model for SPOT-5. ADVANCES IN SPACE RESEARCH. http://dx.doi.org/10.1016/j.asr.2016.02.009

Lemoine, J.-M., Capdeville, H., Soudarin, L, 2016. Precise orbit determination and station position estimation using DORIS RINEX data. ADVANCES IN SPACE RESEARCH. http://dx.doi.org/10.1016/j.asr.2016.06.024

Soudarin, L., Capdeville, H., Lemoine, J.M, 2016. Activity of the CNES/CLS analysis center for the IDS contribution to ITRF2014. ADVANCES IN SPACE RESEARCH. http://dx.doi.org/10.1016/j.asr.2016.08.006

14. GSFC/NASA ANALYSIS CENTER (GSC)

F.G. Lemoine (1), D.S. Chinn, N.P. Zelensky (2), Karine Le Bail (3)
(1) NASA, USA / (2) SGT/NASA GSFC, USA / (2) NVI Inc./NASA, USA

The GSC analysis center focused on the following activities in 2016:

- Preparation and delivery of an updated SINEX series, GSCWD28, an update of the GSCWD26 series that includes (1) addition of SARAL; (2) Modification of the modeling for the Jason-2 solar array to include the solar array quaternions in order to properly model the satellite orientation.

- Testing of the ITRF2014 SLR and DORIS realizations (ITRF2014/IGN, DTRF2014, JTRF2014).

- Testing the RINEX processing for DORIS data for Jason-2, Jason-3, Cryosat-2, and SARAL.

- Testing and implementing the new CDDIS upload procedures.

14.1 SINEX DELIVERIES

14.1.1 REDELIVERY OF SINEX FILES (SEPTEMBER 2013 TO SEPTEMBER 2015) FOR THE SERIES GSCWD26.

Analysis of the SINEX series associated with our ITRF2014 delivery by G. Moreaux (IDS Combination Center) showed that our solution was missing the latest DORIS stations. Accordingly, the 13 new DORIS stations were added by switching from the default (configuration-controlled) station coordinate set, DPOD2008v13, to DPOD2008v15. This added the following stations: ADHC, GONC, GR4B, KEUC, LAOB, MAOB, OWEC, PDNC, ROWC, SOEB, STKB and TRJB. As documented in DORISREPORT No. 4000 (13-Jan-2016 00:46:16), 156 weekly files were redelivered.

14.1.2 DELIVERY OF THE GSCWD27 SERIES, INCLUDING SARAL.

We formally delivered the updated series including SARAL on March 1, 2016, as documented in DORISREPORT 4027 (01-Mar-2016 23:09:28). The delivery consisted of the gscwd27 files (solution with SARAL) from 2013 (DOY 076) to 2015 (DOY361). In addition the GSCWD26 solution was extended to the end of 2015 to allow a complete comparison between the two series and evaluate the contribution of the new satellite. As documented in DORISREPORT 4092 (15-Jun-2016 20:44:20), the two series, gscwd26 & gscwd27 were extended to 2016-DOY087.

14.1.3 DELIVERY OF THE GSCWD28 SERIES, AS THE NEW OPERATIONAL SERIES.

For this series we reprocessed Jason-2 in order to include direct modeling of the Jason-2 solar array orientation from quaternions, rather than relying on the default attitude model. On November 23, 2016 we delivered 416 files from the start of the Jason-2 mission, 2008 (DOY195) to 2016 (DOY171).

We make the following observations concerning the modeling of the Jason-2 solar arrays using quaternion information:

- In tests that compare the dynamic SLR+DORIS orbits with the JPL reduced dynamic orbits, the orbit differences are reduced. In particular, we reduce the amplitude of the 117-day radial signal in the orbit differences from ~2.9 mm to ~2.0 mm.

- The mean and the median of amplitude for the daily along-track empirical accelerations are only slightly reduced by including the solar array quaternions. However, we note that extreme values in s small percentage of arcs is reduced from levels of 5-10 nm/s^2 to more normal levels of 1-3 nm/s^2.

- For SLR+DORIS orbits, the use of the Jason-2 solar array quaternions only slightly improves the SLR RMS of fit (1.13 to 1.08 cm), as evaluated over 297 cycles. However, we note that for a small percentage (~4%) of the arcs, the improvement in SLR RMS of fit is 0.5 to 1.7 cm.

- We note a reduction in the amplitude of the 117-day signals for the Tx, and Ty components of geocenter. The Tz component is largely unaffected.

The addition of SARAL seems to improve the determination of EOP from DORIS data. The standard deviation of the differences with the IERSC04 series is reduced from levels of 337-341 µas to 302-317 µas, or an improvement of about 9 percent. We note that some of the scatter in the EOP differences with IERSC04 is also visibly reduced.

14.2 PRELIMINARY TESTS WITH ITRF2014

We evaluated two ITRF2014 station complements, ITRF2014 (IGN) and DPOD2014, compared to DPOD2008.v15. For the ITRF2014 (IGN) complement, we added 32 stations from DPOD2008.v15 using a 14-parameter transformation. This version of the DPOD2014 was missing five stations: JIWC, PDOC, SAPC, KEV, MNAC, so it included only 91 stations over the Jason-2 test period (080712 to 160831), compared to 96 stations for the other complements.

We present a brief summary of the results.

- For DPOD2014 and ITRF2014 (IGN-augmented), we see an across-the-board improvement in the DORIS RMS of fit - averaging 0.001 mm/s. The improvement is larger in 2015 and 2016 (improvement of 0.0014 to 0.0015 mm/s).

- We tested the DORIS station complements by holding the orbits fixed to the JPL reduced dynamic orbits (orbit series jpl14a), and looking at the individual station performance. For Jason-2: SAKB and RIKB showed substantial degradation (0.003 to 0.005 mm/s) with DPOD2014 and ITRF2014 (IGN). We see improvements of 0.005 to 0.015 mm/s in the RMS of fit for the following stations (SANB, HEMB, ARFB, TRIB, CADB), indicating that the modeling for these stations has dramatically improved.

We also computed TOPEX orbits using the different DORIS complements and make the following observations:

- Concentrating on DPOD2014, about ½ of the stations show an improvement greater than 0.0002 mm/s. The stations showing the most improvement (> 0.0015 mm/s) include YARB, KITB, REUB, SPIB, MSOB, SAOB, RIOB, ASDB and STJB.

- About ¼ of the DORIS stations show no change in the DORIS RMS of fit with DPOD2014.

- About ¼ of the DORIS stations show minor degradations in the RMS of fit (0.0001 to 0.0003 mm/s); One station, SANB show substantial degradation (0.0012- 0.0013 mm/s) with DPOD2014 and ITRF2014; Station SANA shows a substantial degradation with ITRF2014 (> 0.002 mm/s) but not with DPOD2014 (no visible change in the RMS of fit).

14.3 RINEX PROCESSING TESTING

We processed RINEX data (created using the PANDOR processor) for the following satellites:

• Jason-2 (to Sept. 2016)

• Jason-3 (to Sept. 2016)

• SARAL (to Jan. 2016)

• Cryosat-2 (to Jan. 2016)

• HY-2A (to Jan. 2016)

We also tested improvements to the DORIS RINEX processing including

- Application of the Belli et al. (2016) Jason-2 USO frequency corrections (derived from T2L2 and detailed modeling of the DORIS USO).

- Application of the periodic relativity corrections (described by J.M. Lemoine et al. (2016)) in the standard RINEX processing.

We present a summary of the RINEX-processing results.

- The DORIS RINEX orbits are quite close to the DORIS-V2 orbits for Jason-2. They differ by on average 2 mm radial RMS (between July 2008 and Sept. 2016). The differences between the RINEX-derived orbits or the DORIS-V2 orbits and the independent JPL reduced-dynamic orbits are between 6-8 mm, radial RMS. In terms of altimeter crossovers over cycles 1-297, the standard V2 processing yields an average altimeter crossover RMS of 5.325 cm, compared to 5.322 cm for the DORIS/RINEX orbits.

- For SARAL, Cryosat-2 and HY-2A we observe a slightly higher RMS of fit on the DORIS/RINEX data (by 0.02 mm/s) and mean RMS radial orbit differences of 2.0, 3.6 and 2.6 mm for SARAL, Cryosat-2 and HY-2A respectively.

- We observe that the editing of the DORIS/RINEX data is much more difficult than with the DORIS/V2 data. Indeed the rate of convergence is much slower, and it is possible on occasion for DORIS/RINEX-only orbits to converge to an orbit worse than that obtained with the DORIS/V2 data.

- In the normal course of processing we fit a second order polynomial to the DORIS/RINEX-provided frequency offset estimates. For Jason-2 and Jason-3 this fit is performed per cycle (every ten days). We tested the DORIS-USO frequency models provided by Alexandre Belli and the Grasse T2L2 team (Belli et al., 2016). They provide two models for the Jason-2 DORIS USO: an hourly model and a 1-minute model. We looked at the data from January 3- March 23, 2013 (cycles 166-173). For cycles 166-169 and cycles 173 we observe an improvement in the overall RMS of fit (0.001 mm/s). The data for the other cycles seem corrupted by excursions in the USO frequency model over two separate cycles. It would seem that the USO frequency model cannot be used “as-is”, but requires screening in order to remove spurious solutions. These results were shared with Belli et al., and we hope that the Jason-2 USO model can be further improved to remove these anomalous values.

- J.M. Lemoine et al. (2016) derived the expressions for the DORIS range-rate relativity correction for the satellite clock. These corrections are periodic and depend also on J_2. We note a small but consistent improvement in the RMS of fit to the DORIS/RINEX data. It is important to note that since we apply this correction in the pre-processing, it must not be applied by GEODYN in the POD analysis.

14.4 TESTING OF THE NEW CDDIS UPLOAD PROCEDURES

On June 17, 2016, the Crustal Dynamics Data Information System (CDDIS) notified the IDS analysis centers that the CDDIS would be implementing a change to its upload procedures via ftp. The users were notified that they would need to transition to an https-based solution with both a command line option and a web interface. The messages outlined a series of steps to complete so that data could continue to be uploaded to the CDDIS. The final deadline for the transition was November 30, 2016. The GSC analysis center successfully completed these tests and has routinely been making deliveries using the new system. In addition as part of the verification of the procedures, we noted that our IDS products were available in totality only from the CDDIS data center. Per current procedures it is the responsibility of the DORIS analysis center to deliver to both the IGN and CDDIS data centers. We have updated our procedures to routinely upload data to both data centers. We thank the IDS Combination Center (G. Moreaux) for providing us with a convenient script to check the SINEX file holdings at the two data centers.

14.5 DORIS-RELATED PUBLICATIONS IN 2016 INVOLVING GSC PERSONNEL

Lemoine, F.G. and Schrama, E.J.O., 2016. Preface, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12), 2477–2478, DOI: 10.1016/j.asr.2016.11.002.

Lemoine, F.G.; Chinn, D.S.; Zelensky, N.P.; Beall, J.W.; Le Bail, K., 2016. The Development of the GSFC DORIS Contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2520-2542, DOI: 10.1016/j.asr.2015.12.043

Zelensky, N.P.; Lemoine, F.G.; Chinn, D.S.; Beckley, B.D.; Bordyugov, O.; Yang, X.; Wimert, J.; Pavli, D., 2016. Towards the 1-cm SARAL orbit, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2651-2676, DOI: 10.1016/j.asr.2015.12.011

Moreaux, G.; Lemoine, F.G.; Capdeville, H.; Kuzin, S.; Otten, M.; Štěpánek, P.; Willis, P.; Ferrage, P., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2479-2504, DOI: 10.1016/j.asr.2015.12.021

Zawadzki, L., M. Ablain, L. Carrère, R.D. Ray, N.P. Zelensky, F. Lyard, A. Guillot, N. Picot, 2016. Reduction of the 59-day error signal in the Mean Sea Level derived from TOPEX/Poseidon, Jason-1 and Jason-2 data with the latest FES and GOT ocean tide models, OCEAN SCIENCE Discussion, DOI: 10.5194/os-2016-19.

15. IGN/JPL ANALYSIS CENTER (IGN)

Pascal Willis / IGN/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 2016, 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. In 2016, all DORIS results were generated to IDS by the IPGP site using the new 64-bit computer (doris). 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 2016, the continuation of the solution submitted for the ITRF2014 contribution (ignwd15) was performed.

15.2 PRODUCTS DELIVERED IN 2016

The latest delivered IGN weekly time series is still ignwd15 (in free-network). As the ITRF2014 was only available in early 2016, a companion series was not computed but will soon be submitted as before, expressed in the latest ITRF using a proper DPOD solution. The ignwd15 solution is the one used by the IDS Combination Center in preparation of ITRF2014 (same analysis options). 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. The newer satellites (jason2 and sentinel-3a) are not yet used as they only provide data in the DORIS/RINEX format.

As the DPOD2014 solution was not available in 2016 (see **Table 14**), only free-network solutions were submitted. Other products will soon be submitted as a new DPOD2014 solution is available and as a new internal long-term solution (positions and velocities estimated using the full DORIS data set) can now be derived to generate such results.

Product	Latest version	Update	Data span	Number Number of files
Weekly SINEX - free-network	ignwd15	Weekly	1993.0-2016.7	1239
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 14: IGN products delivered at the IDS data centers until the end 2016. As of January 18, 2017

At the end of 2016, the new DORIS SINEX solutions are only submitted to the IGN, and not anymore at the CDDIS data center, following a change in procedure for the CDDIS data center. This technical problem should be solved in 2017.

In 2016, some limited work was conducted in the validation of the new DPOD2014 solutions, now generated by Guilhem Moreaux (CLS).

15.3 MAJOR IMPROVEMENTS IN 2016

Major difference from previous ign weekly solution concerns:

- the use of phase law correction,

- 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. In parallel, new developments are also made in the new GIPSY-X software package to allow DORIS data processing. Major problems were encountered in 2016 when trying to process the DORIS phase and pseudo range now available in the DORIS/RINEX format.

Recent results obtained in 2015 and 2016 showed a minor sensitivity of the Jason-2/DORIS oscillator to radiations over the South Atlantic Anomaly (SAA); see Willis et al. (2016).

Some early study, done with CNES (Alexandre Couhert) may show that some physical models of the HY2A satellite may need to be modified (radial component of the vector between the antenna phase center and the origin of the satellite frame). Such a modification could potentially improve the stability of the DORIS-derived scale of the terrestrial reference frame.

Finally, the IGN Analysis Center was associated with the US GRASP proposal (Geodetic Reference Antenna in Space) as well as with the European e-GRASP/Eratosthenes proposals to NASA and ESA. Unfortunately, none of these missions were selected.

15.5 REFERENCES

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Willis, P.; Zelensky, N.P.; Ries, J.; Soudarin, L.; Cerri, L.; Moreaux, G.; Lemoine, F.G.; Otten, M.; Argus, D.F.; Heflin, M.B., 2016. DPOD2008, a DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, IAG SYMPOSIA SERIES,143, 175-181, DOI: 10.1007/1345_2015_125

16. INASAN ANALYSIS CENTER (INA)

Sergey Kuzin / INASAN, Russia

16.1 INTRODUCTION

In 2016, INASAN (ina) DORIS Analysis Center (AC) continued routine processing DORIS data using the latest version of 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. **Table 15** shows current products delivered by INASAN to the IDS.

Product	Latest version	Span
Weekly SINEX (free-network solutions)	inawd10	1993.0 – 2017.0
Geocenter time series	ina16wd01	1993.0 - 2017.0
EOP time series	ina16wd01	1993.0 - 2017.0

Table 15: INASAN SINEX series delivered to the IDS (February 2017).

16.2 ANALYSIS RESULTS DESCRIPTION

16.2.1 THE MAIN SCIENTIFIC RESULTS OBTAINED IN 2016

Table 16 gives statistical information of the current INASAN and IDS combined solution (idswd12) contribution to IDS. The epoch for the comparison is the mean value over the whole time period. As it was noted in the latest INA IDS report (http://ids-doris.org/documents/report/IDS_Report_2015.pdf) we could see scale rise at the around mid 2012. Unfortunately up to now this scale increase is continued and is currently under investigation within the IDS Analysis Centers.

A priori the combined solution should be better than any individual solution and one can see from the **Table 16** that precision for the Helmert transformation parameters of the idswd12 solution are lower or comparable with the those ones of inawd10.

Table 17 displays the statistical information about INA and idswd12 EOP time series. The standard deviation (std) of the current INA eop series has a smaller values 0.89 and 0.82 mas for X-pole and Y-pole components as compared with the results of our previous report (0.94 and 0.85 mas, correspondently).

It should be mentioned that numbers in **Table 16** and **Table 17** were obtained by Dr. G.Moreaux using CATREF software package (https://ids-doris.org/webservice).

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 (1993.0-2016.75)	14.03 ±3.51	9.91 ±4.58	-1.70 ±4.56	-0.93 ±4.91	-9.68 ±17.86	0.38 ±0.02	-0.06 ±0.02	0.05 ±0.02	-0.3 ±0.07
inawd10 (1993.0-2016.75)	19.13 ±4.39	12.46 ±5.29	-1.97 ±6.61	-5.16 ±7.86	-9.38 ±23.65	0.37 ±0.02	0.02 ±0.03	-0.09 ±0.03	0.61 ±0.10

Table 16: Comparative statistical characteristics (mean values) of the INA analysis center (inawd10) and IDS combined solution (idswd12) contribution to IDS wrt ITRF2014

Series	**Period**	**X pole (mas)**		**Y pole (mas)**		**LOD(msec)**	
		mean	**std**	**mean**	**std**	**mean**	**std**
idswd12	1993/1/3-2016/10/2	0.03	0.49	0.01	0.45	-	-
inawd10	1993/1/3-2016/10/2	-0.03	0.89	0.02	0.82	-0.02	0.34

Table 17: INA AC and combined idswd12 Earth Orientation Parameters Residuals wrt IERS C04.

We estimated amplitudes and phases for the annual components of the geocenter motion for the 1993.0 - 2017.0 period getting from the transformation free-network inawd10 series to ITRF2008.

The evaluated amplitudes of the annual oscillations are 3.3±0.4 mm and 4.4±0.5 mm for X and Y components, respectively, and 2.9±0.8 mm for Z component.

The phase estimates of the annual signal relative to January 1 for ina16wd geocenter time series are 208±7 and 73±7 degrees for X and Y components, respectively, and 210±30 degrees for Z component. Cosine approximation was used for this evaluation.

16.3 CONTRIBUTION TO IDS MEETINGS

IDS Workshop, La Rochelle

- The main results of the DORIS data processing in the INASAN Analysis Center for the ITRF2014
  http://ids-doris.org/images/documents/report/ids_workshop_2016/IDS16_s3_Kuzin_INASANmainResultsForITRF2014.pdf

16.4 PUBLICATIONS IN PEER-REVIEWED JOURNALS

Kuzin, S.; Tatevian, S., 2016. DORIS data processing in the INASAN Analysis Center and the contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2561-2571, DOI: 10.1016/j.asr.2016.07.010

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17. GFZ ASSOCIATED ANALYSIS CENTER

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17.1 INTRODUCTION

The activities performed at GFZ in 2016 related to DORIS data processing comprise the release of new precise orbits of DORIS altimetry satellites in version VER11 featuring improved models, and further on included the test of the new ITRF2014 realization of the International Terrestrial Reference System for precise orbit determination (POD) of DORIS and altimetry satellites, namely, Envisat, TOPEX/Poseidon, Jason-1, Jason-2, ERS-1 and ERS-2, as compared to the previous ITRF2008 realization. The major improvement of the orbit quality is obtained, as expected, for the recent years 2010-2015. Additionally, tests of daily time variable Earth's gravity field solutions based on GFZ GRACE RL05 monthly and GFZ radial basis function (RBF) daily solutions for Envisat, Jason-1 and Jason-2 POD using SLR and DORIS observations were performed, as compared to using a global EIGEN-6S4 Earth gravity field model. Also in 2016, we started the GGOS-SIM (Simulation of the Global Geodetic Observing System) project which aims at simulating realistically all the space-geodetic observations including DORIS for the purpose of assessing certain impacts on the accuracy and stability of Terrestrial Reference Frames (TRFs).

17.2 NEW PRECISE ORBITS OF DORIS AND ALTIMETRY SATELLITES

GFZ VER11 orbits of Envisat (2002-2012), TOPEX/Poseidon (1992-2005), Jason-1 (2002-2013) and Jason-2 (2008-2015) derived using SLR and DORIS observations, as well as ERS-1 (1991-1996) and ERS-2 (1995-2006) derived using SLR, single-satellite altimetry crossover and PRARE (in case of ERS-2) data, were released on May 13, 2016, via anonymous ftp. The orbits are derived in the ITRF2008 (Altamimi et al., 2011) using improved POD models (Rudenko et al., 2017). The description of how to access the orbits is given in the file

ftp://ftp.gfz-potsdam.de/pub/home/kg/orbit/SLCCI/Readme_GFZ_VER11_SLCCI_orbits.

17.3 TESTS OF DAILY TIME VARIABLE EARTH'S GRAVITY FIELD SOLUTIONS FOR PRECISE ORBIT DETERMINATION OF DORIS AND ALTIMETRY SATELLITES

We made use of current GFZ GRACE RL05a monthly and daily gravity field products from 2002 to 2014 based on radial basis functions (RBF), as compared to using a global Earth's time variable gravity field model EIGEN-6S4, in POD of altimetry satellites. The advantage of using daily or monthly time variable Earth's gravity field solutions is that they are available with a delay of some weeks or months, while the time variable part in models like EIGEN-6S4 is updated once a year or at longer intervals, if so ever. Since some monthly solutions are missing in the GFZ GRACE RL05a solution and in order to reach a better quality for precise orbit determination, daily interpolated solutions were used in case of gaps. In case of the RBF solutions, the coefficients of low degrees were co-estimated by using apriori SLR-derived values up to degree and order 4.

Precise orbits for the altimetry satellites Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2014) have then been computed over the given time intervals by employing this approach using SLR and DORIS observations and were compared with the orbits obtained when using the Earth's gravity field model EIGEN-6S4 (Förste et al. 2016). As from the second half of the year 2012 onward, the yaw steering of Jason-1 became unreliable until the end of the mission, attitude quaternions were used instead of nominal attitude models for both satellites, Jason-1 and Jason-2. This lead to an improvement of some 10% of the SLR fits in the case of Jason-1 and of around 1% in the case of Jason-2 (Rudenko et al., 2017).

We obtained rather comparable quality of the orbits derived using EIGEN-6S4 model, GFZ RL05a and GFZ RBF solutions for both Jason satellites: the differences of the RMS fits of SLR and DORIS observations is less than 0.8 and 0.2%, accordingly, when using any of these representations of the Earth's gravity. Internal consistency of Jason-2 orbits in the radial direction is the same (0.56 cm) for all three representations, while GFZ RBF solutions provide smaller radial arc overlaps (0.77 cm), as compared to EIGEN-6S4 model and GFZ RL05a solutions (0.79 cm for both) for Jason-1. In case of Envisat, we found comparable and even better performance of the RMS values of the SLR observation fits from 2002 until the middle of 2008 for the orbit based on the GFZ RBF solution, as compared to those derived using EIGEN-6S4 model, whereas EIGEN-6S4 model performs better than GFZ RBF solutions from 2008 onwards. The smallest radial arc overlaps for Envisat (0.53 cm) were obtained using EIGEN-6S4 model followed by GFZ RBF solutions (0.57 cm) and GFZ RL05a solutions (0.60 cm). Some results of this study were presented at the European Geosciences Union General Assembly 2016. Details of this study are given in Gruber et al., submitted.

17.4 AN ASSESSMENT OF ITRF2014 FOR PRECISE ORBIT DETERMINATION OF DORIS AND ALTIMETRY SATELLITES

A TRF is the basis for POD of Earth orbiting satellites. Three new TRF realizations became recently available. These are ITRF2014 (Altamimi et al., 2016), DTRF2014 (Seitz et al., 2016) and JTRF2014 (Wu et al., 2015). We have assessed one of them, namely, ITRF2014 for precise orbit determination of altimetry satellites ERS-1 (1991-1996), ERS-2 (1995-2003), TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2015) at the time intervals given, as compared to the previous (ITRF2008) realization. For this purpose, we have computed GFZ VER13 orbits of these satellites using the ITRF2014 reference frame and analyze them, as compared to the GFZ VER11 orbits (Rudenko et al., 2017) of the same satellites derived using the ITRF2008 reference frame (Altamimi et al., 2011).

The impact of using ITRF2014 instead of ITRF2008 for precise orbit determination of the satellites of question is as follows. The major improvement of the orbit quality is obtained for years 2010-2015 (**Figure 22**, **Figure 23**). The mean values of the RMS fits of SLR observations improved by 1.8, 3.1, 2.4 and 8.8% for ERS-2, Envisat, Jason-1 and Jason-2, respectively, and are almost not impacted for ERS-1 and TOPEX/Poseidon. An improvement of Jason-2 DORIS RMS fits of 0.3-1% was found for 2012-2015. Two-day arc overlaps in the radial direction improved by 0.4, 0.6, 2.4, 5.1 and 7.1% for ERS-2, ERS-1, Jason-1, Jason-2 and TOPEX/Poseidon, but slightly (by 0.7%) degraded for Envisat. Some results of this study were presented at the DORIS Analysis Working Group meeting (AWG) of the International DORIS Service in Delft in May 2016, at the 2016 IDS Workshop and 2016 Ocean Surface Topography Science Team Meeting in La Rochelle, France in October/November 2016. A paper with the results of this study is under preparation.

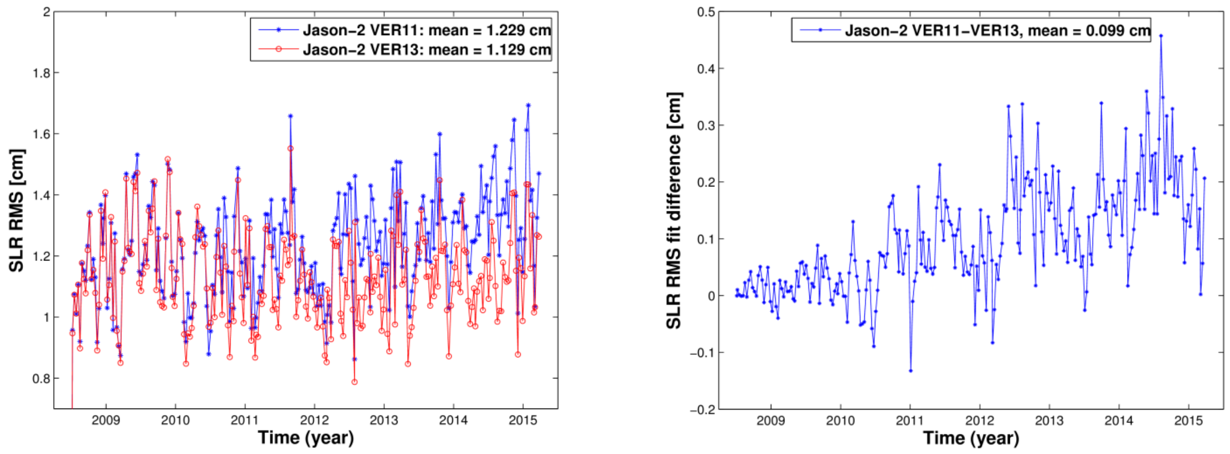

Figure 22: SLR RMS fits (left) of Jason-2 (July 2008 – April 2015) VER13 (ITRF2014) orbit (red) versus VER11 (ITRF2008) orbit (blue) and their differences (right).

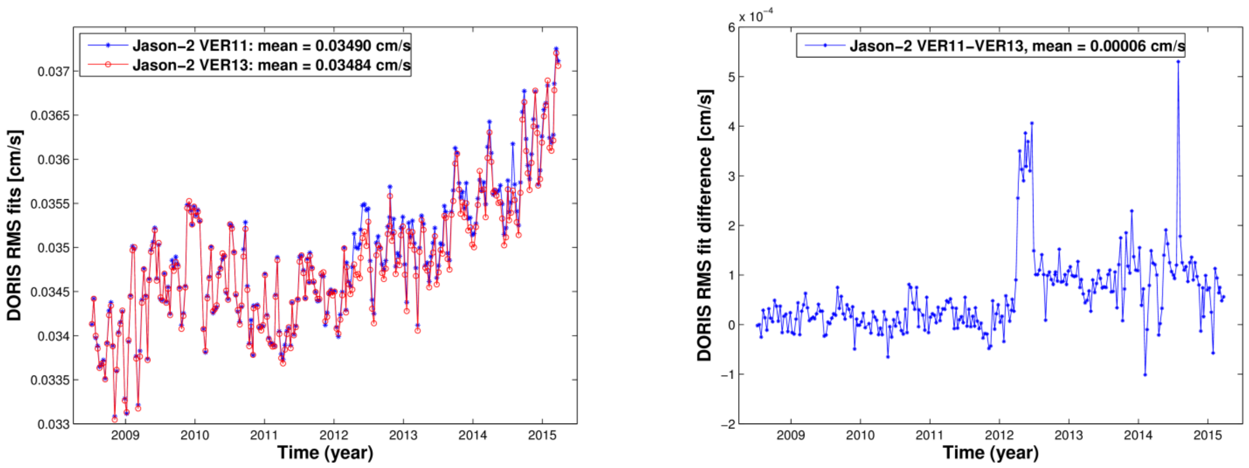

Figure 23: DORIS RMS fits (left) of Jason-2 (July 2008 – April 2015) VER13 (ITRF2014) orbit (red) versus VER11 (ITRF2008) orbit (blue) and their differences (right).

17.5 SIMULATION OF DORIS OBSERVATIONS FOR TRF DETERMINATION IN VIEW OF GGOS

The German project GGOS-SIM (Schuh et al., 2016) aims at simulating all space-geodetic observation types including DORIS for generating the global TRF. Particular attention is given to scenarios close to reality of these days in terms of distribution of the observations in time and space and in terms of their stochastic properties. Final objective of the project is to create a tool that easily can answer questions like what is the benefit of a new station for the quality of the TRF in view of the requirements imposed by GGOS (1 mm and 1 mm/a resp.) or in general, how can we meet the GGOS goals. For the time being the analysis is restricted to the seven years 2008 to 2014. In case of DORIS we selected as an initial representative scenario the missions Jason-1, Jason-2, and Envisat and a ground station set of about 60 stations.

17.6 PRESENTATIONS

Rudenko S., Esselborn S., Schöne T., Dettmering D., Neumayer K.-H.: Assessment of ITRF2014 for precise orbit determination of altimetry satellites. 2016 IDS Workshop, La Rochelle, France, 2016.

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17.8 ACKNOWLEDGMENTS

These activities were partly supported by the European Space Agency within the Climate Change Initiative Sea Level Phase II Project and by the German Research Foundation (DFG) within the projects “Consistent dynamic satellite reference frames and terrestrial geodetic datum parameters” and “GGOS-SIM: Simulation of the Global Geodetic Observing System”.

18. DORIS-RELATED ACTIVITIES AT CNES

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

[(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 TOPEX/POSEIDON ORBITS REPROCESSING WITH THE GDR-E STANDARDS

During the reprocessing, the focus was given to the measurements used and the lack of GRACE time-varying gravity (TVG) observations (between 1992 and 2002). DORIS-only (vs. DORIS+SLR) solutions were computed and two approaches were investigated to model TVG: solving for the degree 3 order 1 spherical harmonic (which the T/P orbit is most sensitive to) in dynamic orbits and computing reduced-dynamic solutions. The obtained solutions were then validated with independent altimeter crossover residuals, and by comparisons to the external GSFC STD1504 DORIS+SLR dynamic orbits, exhibiting their good agreement (from 1.0 to 1.5 cm RMS in the radial direction).

The geographically correlated radial orbit difference drifts between the different solutions are found below 1 mm/y and only 4-5 mm annual signatures over the North Pacific and South Atlantic coming from orbit centering differences (in X and Z axes) are visible. The DORIS residuals are between 0.5 mm/s and 0.6 mm/s RMS, and the independent high-elevation SLR residuals are of about 2.7 cm RMS (**Figure 24**). The preliminary version of the TOPEX/Poseidon GDR-E solution computed over the full life time of the satellite was presented at the last OSTST meeting.

Related presentation:

Ait-Lakbir, H., Couhert, A., Houry, S., Jalabert, E., Mercier, F., Moyard, J., 2016. Reprocessing TOPEX/Poseidon precise orbits in the GDRE standards. In: Ocean Surface Topography Science Team Meeting 2016, La Rochelle, France, 1–4 November, 2016

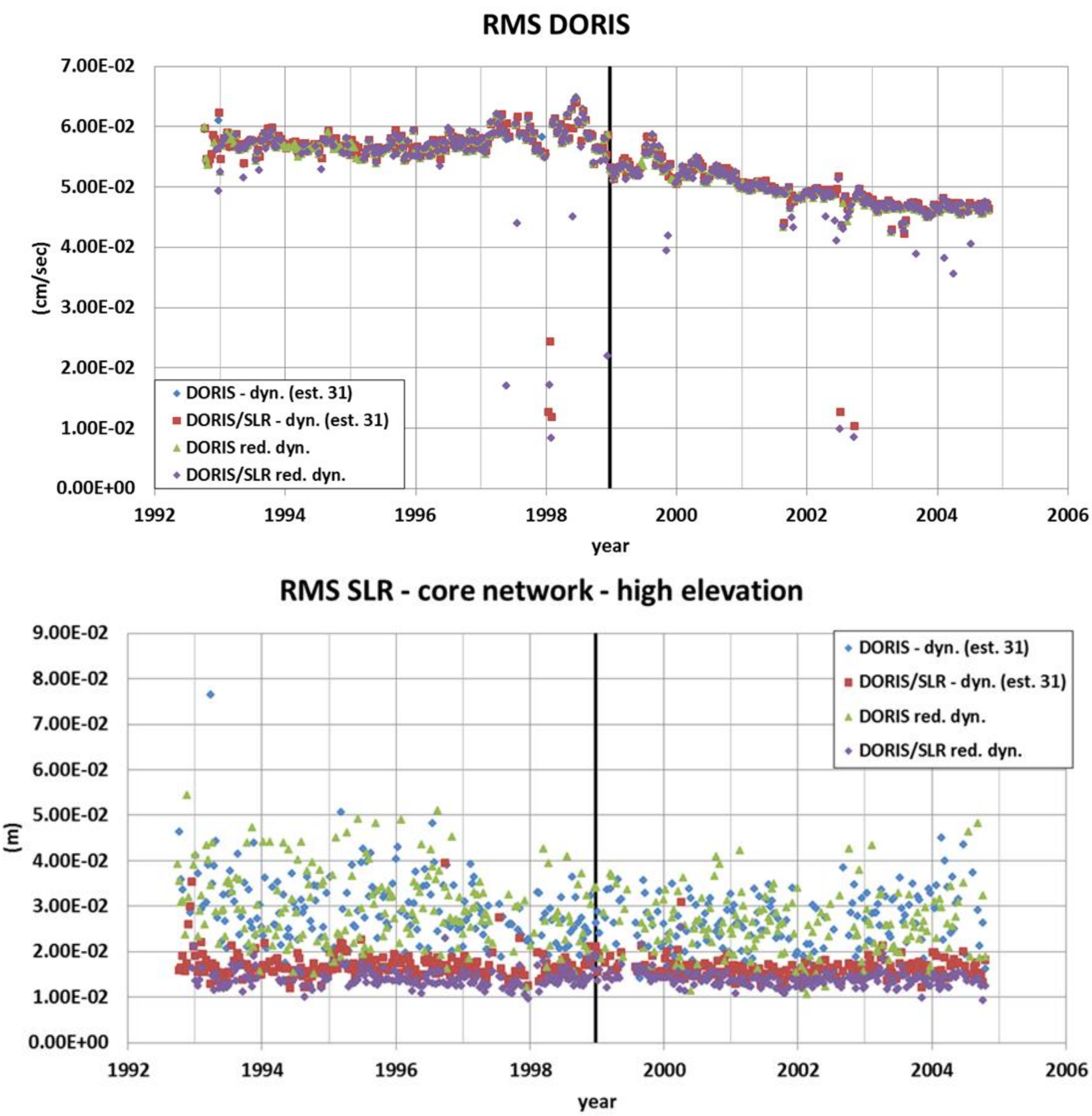

Figure 24: RMS DORIS and SLR residuals of the computed T/P reprocessed solutions.

18.3 ITRF2014/JTRF2014/DTRF2014 EVALUATIONS

Three new Terrestrial Reference Frames (TRF) have been evaluated: ITRF2014 (IGN) JTRF2014 (JPL) and DTRF2014 (DGFI). The main conclusion of the study is that using any new TRF has a small but consistent impact of the different metrics evaluated, i.e. a small improvement has been observed w.r.t. using the previous IRTF2008, although orbit differences are very small:

- All the new TRF improve SLR residuals. The impact of the different new TRF is virtually the same.

- Concerning DORIS residuals, a small improvement is observed when a new TRF is used on Jason2. For Jason1, a small improvement is also observed, apart from the period prior to June 24, 2004 (switch to backup DORIS oscillator) where degradation is observed regardless of the new TRF used.

- The impact of using a new TRF is very small on crossover variances (virtually no change when using DTRF2014 and ITRF2014, around 1mm² improvements when using JTRF2014).

The performance of the three new TRF being very similar, the choice of which TRF to implement was made considering the number of station and the post seismic deformations. JTRF2014 contains fewer stations than the other TRF; therefore it won't be used in the next GDR standard. DTRF2014 doesn't take into account post seismic deformation whereas ITRF2014 provides a model to take them into account.

It has been decided that ITRF2014 will be implemented in the future GDR-F standard. Over this time span, the orbit change remains below 3 mm radial RMS, with a small but noticeable Z-shift that brings DORIS/SLR orbits closer to GPS-only orbits. Both post-fit DORIS and independent SLR residuals show a small improvement.

Related presentations:

Jalabert, E., Couhert A., Moyard, J., Mercier, F., Houry, S., 2016. Evaluation of ITRF2014/DTRF2014/JTRF2014 solutions in Jason precision orbit determination. In: International DORIS Service Analysis Working Group Meeting, Delft, Netherlands, 26–26 May, 2016.

Lemoine, F.G., Zelensky, N.P., Beckley, B.D., Couhert A., Jalabert, E., 2016. The Evaluation of ITRF2014 w.r.t Altimeter Satellite Precise Orbit Determination. In: 2016 AGU Fall Meeting, San Francisco, California, 12–16 December, 2016.

18.4 ANALYSES OF SENTINEL-3A DORIS USO

The South Atlantic Anomaly (SAA) is known to degrade the performance of Doris measurements, due to the sensitivity of the on board oscillator to radiations. The Doris measurement modeling relies on a precise model of the oscillator which is not valid when the satellite passes through SAA. But on Sentinel3A, the GPS receiver and the DORIS receiver use the same Ultra Stable Oscillator provided by the Doris instrument (DORIS USO) and *Jalabert et al. (2016)* have shown that the average oscillator frequency over 10 s can be well observed using GPS measurements. The SAA impacted area has been precisely determined. It contains two DORIS stations: Arequipa and Cachoeira (see **Figure 25**).

Using the GPS-observed oscillator in the Doris computation (instead of the classical model) enables to correct Arequipa and Cachoeira SAA-impacted passes. The vertical positioning of these two stations is also improved.

Related presentation:

Jalabert, E., Mercier, F., Couhert, A., Moyard, J., Houry, S., 2016. Sentinel-3A USO observed through GNSS measurements. In: International DORIS Service Workshop, La Rochelle, France, 31 October–1 November, 2016.

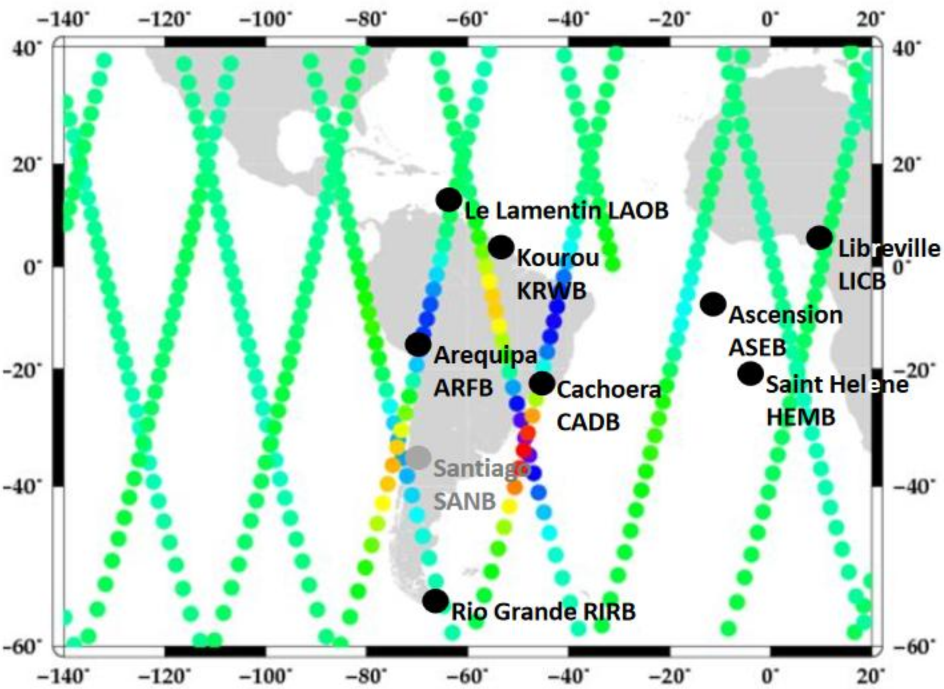

Figure 25: Geographic location of the anomalies

18.5 DORIS MASCON SOLUTIONS

Moyard et al. (2016) investigated un-modeled hydrological loading effects in the Yarragadee SLR station position (e.g., from the Yarragadee Aquifer) to explain the degradation of residuals observed between 2010 and 2013 (compatible with a vertical bias of ~-1 cm in the station position). To this end, local mass variations were derived from all available DORIS altimeter satellites (Jason-1, OSTM/Jason-2, Envisat, CryoSat-2), to benefit from the diverse inclinations of the missions, where an improved observability in the East-West direction is expected over polar-only orbits. The corresponding normal equations were stacked over 6-month intervals. Despite the similarity between CNES DORIS-only and GSFC GRACE-based mascon solutions at continental scales, the separation between the three basins (Eastern, Center, and Western Australian basins) is more challenging, when comparing to GRACE-derived results, especially over the Western Australian region (see **Figure 26**).

The subsequent inclusion of GPS observations (from the Jason-1 and Jason-2 satellites) may be useful as an additional validation of these DORIS-only preliminary results.

Related presentation:

Moyard, J., Couhert, A., Mercier, F., Jalabert, E., Houry, S., 2016. Using 'mascons' to analyze SLR station biases. In: Ocean Surface Topography Science Team Meeting 2016, La Rochelle, France, 1–4 November, 2016.

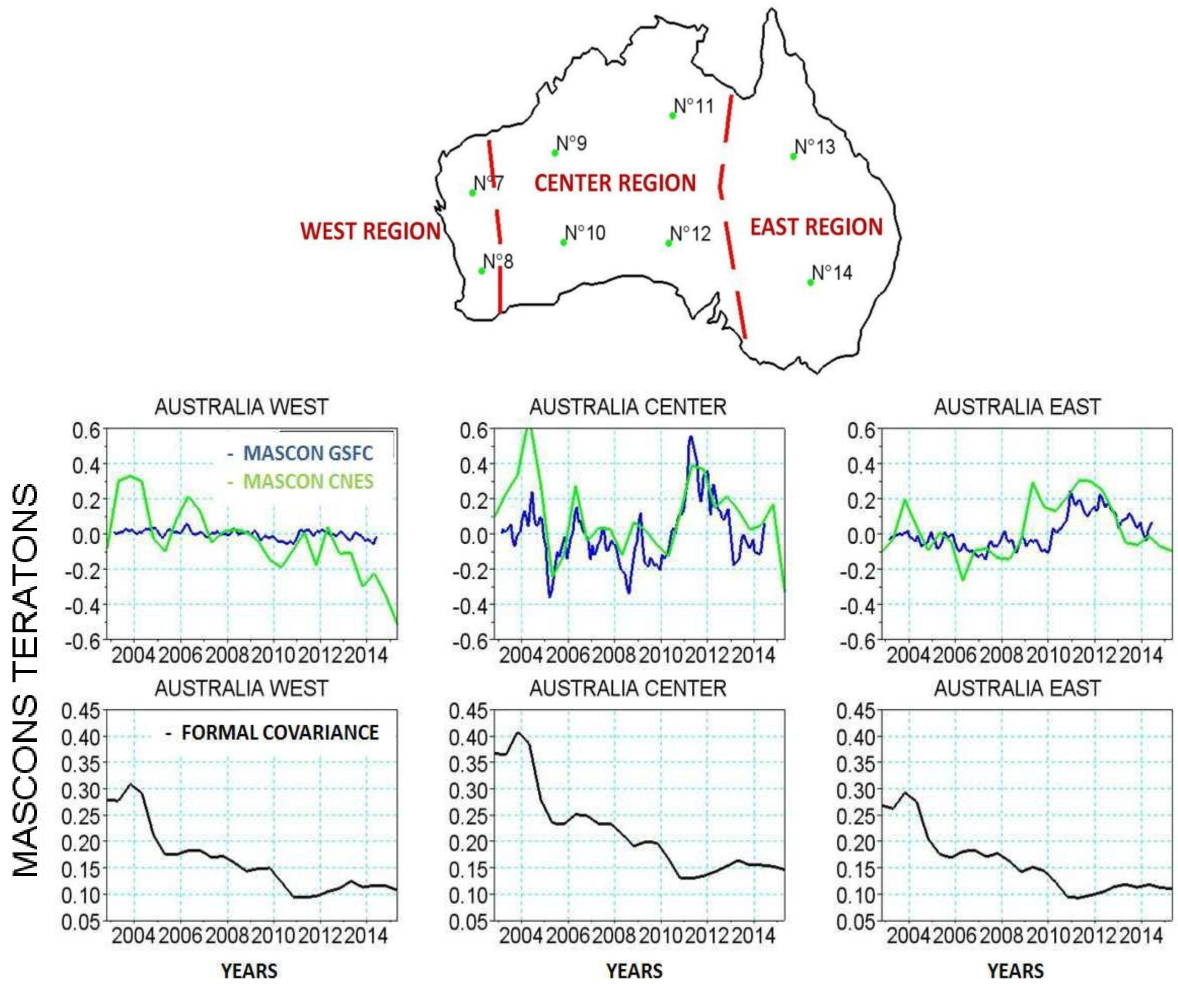

Figure 26: Regional comparisons between CNES DORIS-only and GSFC GRACE-derived mascon solutions over Australian basins.

18.6 LOW-ELEVATION DORIS MEASUREMENTS

Studies dealing with station positioning, geocenter motion, or reference frame scale factor should make use of low-elevation measurements. Thus a new DORIS preprocessing dealing with measurements below ten degree elevations has been developed by *Moyard et al. (2016)*, based on DORIS residual adjustments on troposphere mapping functions.

In order to take into account low elevation measurements, the additional use of a weighting function is needed, because these specific data are especially more sensitive to multipath effects in the direction of the satellite velocity. This weighting function takes into account two components, the propagation delay and the antenna gain. These new processing of the low-elevation DORIS data has been validated and tested on several altimeter missions (see **Figure 27**).

Related presentations:

Moyard, J., Mercier, F., Couhert, A., Jalabert, E., Houry, S., 2016. Preprocessing considerations and use of low-elevation DORIS measurements. In: International DORIS Service Analysis Working Group Meeting, Delft, Netherlands, 26–26 May, 2016.

Moyard, J., Mercier, F., Couhert, A., Jalabert, E., Houry, S., 2016. DORIS preprocessing and weighting function for Jason-1 and Jason-2/OSTM. In: International DORIS Service Workshop, La Rochelle, France, 31 October–1 November, 2016.

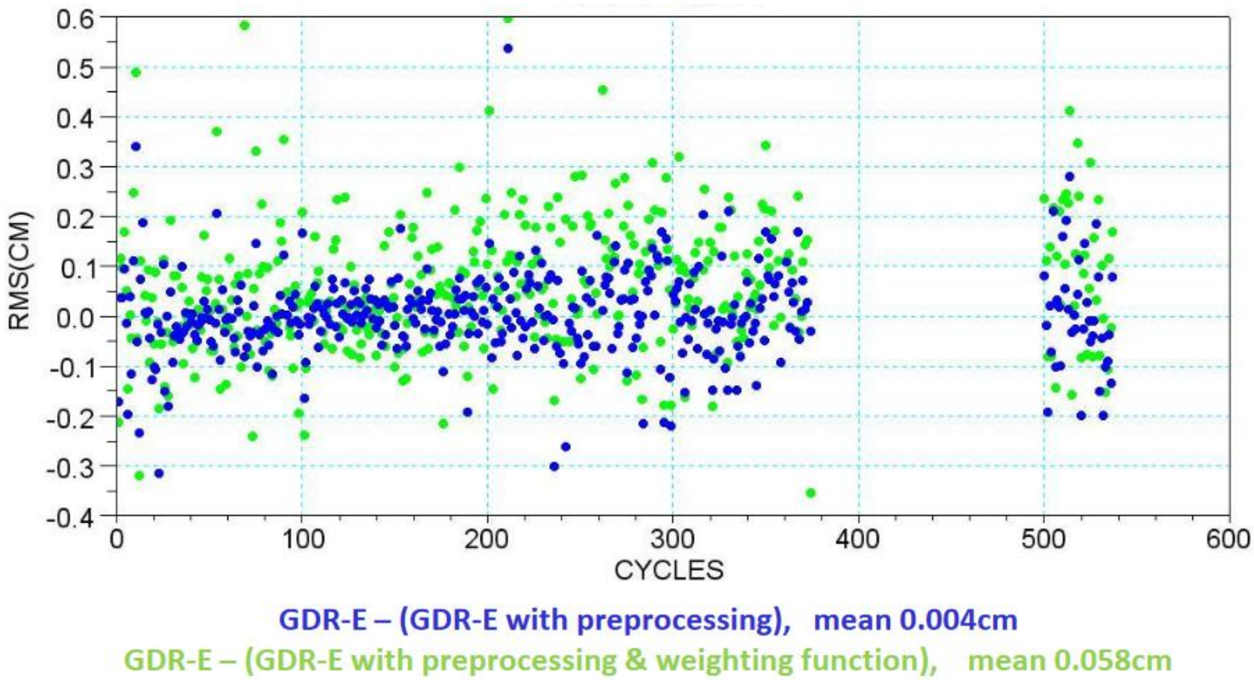

Figure 27: Jason-1 high-elevation RMS SLR residuals

18.7 DORIS-DERIVED NON-TIDAL GEOCENTER MOTION

The currently delivered CNES (GDR-E) orbits apply an annual geocenter model (Ries 2013), derived from LAGEOS-1 & LAGEOS-2 SLR data. The geocenter model corrects the DORIS and SLR station positions so that they are properly referenced to the true center of mass of the Earth. However for several reasons, the CNES POD analysis centers have tried to refine the modeling of the geocenter variations based on DORIS data:

- Annual signatures change in amplitude and phase over time, thus an annual geocenter model may not be sufficiently precise for an accurate determination of the mean sea level (MSL) rise,

- Independently determined geocenter time series are necessary to validate the accuracy of the CM motion observability.

Couhert et al. (2016) presented mitigation strategies to yield competitive DORIS-based geocenter variations from the Jason-2 satellite, while taking benefit from the more numerous and better uniformly distributed DORIS stations across the globe. The agreement, in term of amplitude and phase of the seasonal signal, between the DORIS-derived and independent (SLR-based and GPS-derived) estimates of the CM motion is shown below (**Figure 28**).

- 1 : GPS JPL IGS products, 1-day estimates
- 2 : SLR (L1-L2) Cheng et al., 2013 ITRF2005, 60-day estimates
- 3 : SLR (L1-L2) Ries, 2016 ITRF2014, 60-day estimates
- 4 : SLR (5 sat) Cheng et al., 2013 ITRF2005, monthly estimates
- 5 : GPS Global Inversion Wu and Heflin, 2014
- 6 : DORIS Jason-2 this study, 10-day estimates
- 7 : SLR Jason-2 this study, 10-day estimates

Solution	X (amp)	X (ph)	Y (amp)	Y (ph)	Z (amp)	Z (ph)
1	2.0	53	3.4	305	1.6	60
2	1.9	59	2.6	320	3.8	36
3	2.4	55	2.5	321	6.1	31
4	3.7	38	2.1	323	4.7	31
5	1.9	25	3.3	330	3.7	21
6	1.7	24	3.5	313	8.2	5
7	1.8	59	4.1	324	8.9	5

cnes

Figure 28: CNES Jason-2 DORIS-only (green) compared to independent geocenter estimates

Related presentations:

Couhert, A., Mercier, F., Moyard, J., Biancale, R., 2016. Systematic Error Mitigation in DORIS Derived Geocenter Motion. In: 2016 AGU Fall Meeting, San Francisco, California, 12–16 December, 2016.

Couhert, A., Mercier, F., Geeraert, J., Moyard, J., Jalabert, E., Biancale, R., Bruinsma, S., 2016. Doris-derived geocenter motion for precise orbit determination of altimetry satellites. In: Ocean Surface Topography Science Team Meeting 2016, La Rochelle, France, 1–4 November, 2016.

19. DORIS-RELATED ACTIVITIES AT TU DELFT

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

19.1 INTRODUCTION

In 2017 we organized an IDS analysis working group at the TU Delft. The meeting was attended by approximately 25 persons and it took place on 26 and 27 May 2016. Furthermore we are involved in POD activities for CryoSat-2 which take place within the scope of a calibration / validation study contract between the TU Delft and ESA that considers both the orbits and the altimeter performance over the oceans, see [1]. This report will focus on two changes that we have implemented in 2016. Since the beginning of our CS-2 POD project we assumed that the ground-station coordinates come from the website of Pascal Willis [2], the reference system is therefore the DPOD2008 system. Since Nov 2016 we have implemented ITRF2014 in our POD processing. A second improvement concerns an update of the temporal gravity model. Both aspects are discussed in this report.

19.2 ITRF2014

DPOD2008 was established several years before the start of the CryoSat-2 mission, and the station coordinates of the beacons have been updated since. In combination to that we used up to 2016 the ILRS tracking station coordinates from SL2F2008, see also the ILRS website [3]. 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 SLR and the IDS coordinates whereby several sinex files were combined. For the SLR coordinates the eccentricity information must be considered on top of the ITRF2014 positions, the reason is that the ITRF2014 solutions refer to benchmarks at SLR observatories and that a tracking station is put somewhere at the observatory but not per se at the benchmark. The sinex files with the eccentricity information is the result of a local site survey, and the information is obtained from CDDIS [4]. We found a few SLR tracking stations that were not in ITRF2014, we have decided so far to ignore these stations. For IDS beacon position in ITRF2014 there are no eccentricity vectors and the beacon position and velocity is used as is. A handful of IDS stations do not appear in ITRF2016, in this case we decide to adjust the station coordinates where the apriori is obtained from DPOD2008. For both IDS and SLR information in ITRF2014 where is a second source of information that should be used, and this is the post seismic deformation (PSD) model that is provided as a separate sinex file. The PSD sinex files are obtained from the IERS website [5]. In the end we therefore rely on several sinex files, and their information content for the stations that we encounter in the observation data should be combined when we process the POD data.

19.3 TEMPORAL GRAVITY

A second significant update that we applied concerns an extension of the a-priori temporal gravity model, so far we have used estimates from GRACE based on the observed mass loss over ice sheets and continental hydrology. The new version of the temporal gravity model also considers the effect of the atmosphere and oceans the way it is implemented in the GAC and the GAD de-aliasing files. Within this context we reprocessed 151 monthly GRACE solution files, back-substituted the GAC and the GAD dealiasing files, and performed a regression analysis on annual and semi-annual frequencies including a linear trend for spherical harmonics up to degree and order 36.

19.4 RESULTS

We re-processed the CryoSat-2 orbits from 1-June-2010 to 31-Jan-2017, four versions are now available, they are labeled V41 to V44.

- V41 is the former processing scheme based on DPOD2008/SLRF2008 and our previous temporal gravity model
- V42 is the new processing scheme, ITRF2014 for both IDS and SLR, and an updated temporal gravity model
- V43 is similar to V42, but now we adjust the IDS beacon positions that are not in ITRF2014, SLR station positions that are not in ITRF2014 are ignored.
- V44 is similar to V43, but now without the SLR tracking data.

Table 18 summarizes the main characteristics of all four solutions that we have computed. **Table 19** lists the crossover difference statistics of solution V42 compared to other solutions, the RADS database was used for the generation of the crossover difference.

Solution	DORIS mm/s	SLR cm	Along nm/s^2	Cross nm/s^2	NAV cm	MOE cm	POE cm
V41	0.3975	1.334	3.56	12.77	3.45	1.63	1.65
V42	0.3893	0.959	2.78	10.58	3.27	1.35	1.28
V43	0.3936	0.959	2.77	10.13	3.27	1.33	1.25
V44	0.3950		2.77	10.65	3.26	1.33	1.25

Table 18: Solution characteristics, DORIS and SLR fits, level of empirical accelerations in along track and cross-track direction, differences of our solution compared to navigator, MOE and POE orbits provided by the CNES. The NAV, POE and MOE statistics concern

V42 solution	NAV	MOE	POE
4.6049	7.2880	4.7134	4.5463

Table 19: CS2 Crossover difference standard deviation of orbit solution V42 compared to three external orbits

The most 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 slightly helps to improve the external comparisons, the adjustment slightly increases the IDS residuals because we analyze data from beacons that are not in ITRF2014 mostly because they could not be unified, see the description on [5] for more details.

19.5 REFERENCES

[1] Schrama E, Naeije M, Y. Yi, P. Visser and C.K. Shum, CryoSat-2 precise orbit determination and indirect calibration of SIRAL. Third progress report, 4-April-2014, ESA contract 18196/04/NL/GS

[2] Willis P., Zelensky N.P., Ries J.C., Soudarin L., Cerri L., Moreaux G., Lemoine F.G., Otten M., Argus D.F., Heflin M.B., DPOD2008, A DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, IAG SYMPOSIA SERIES, 143, in press.

[3] ILRS website documenting the SLRF tracking station coordinates: https://ilrs.cddis.eosdis.nasa.gov/science/awg/SLRF2008.html

[4] Eccentricity vectors for ILRS: ftp://cddis.gsfc.nasa.gov/slr/slrocc/ecc_xyz.snx

[5] IERS website for ITRF2014: http://itrf.ign.fr/ITRF_solutions/2014/ITRF2014_files.php

APPENDIX

20. IDS AND DORIS QUICK REFERENCE LIST

1. **IDS website**
   http://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**
   http://ids-doris.org/data-products/tables-of-data-products.html

5. **IDS web service**
   http://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.

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
http://ids-doris.org/report/meeting-presentations.html

10. List of documents and links to discover the DORIS system

http://ids-doris.org/analysis-documents.html

11. List of DORIS publications in international peer-reviewed journals

http://ids-doris.org/report/publications/peer-reviewed-journals.html

12. Overview of the DORIS satellite constellation

http://www.aviso.altimetry.fr/en/techniques/doris/doris-applications.html

13. Site logs

DORIS stations description forms and pictures from the DORIS installation and maintenance department: http://ids-doris.org/network/sitelogs.html

14. Virtual tour of the DORIS network with Google Earth

Download the file at http://ids-doris.org/network/googleearth.html and visit the DORIS sites all around the world.

15. IDS video channel

Videos of the DORIS-equipped satellites in orbit
https://www.youtube.com/channel/UCiz6QkabRioCP6uEjkKtMKg

16. IDS Newsletters

Find all the issues published in color with live links on the IDS website
http://ids-doris.org/report/newsletter.html

17. More contacts

For particular requests, you may also contact the following persons:

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21. THE IDS INFORMATION SYSTEM

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 Coordinator 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:
http://www.ids-doris.org/analysis-documents/struct-dc.html

WEB AND FTP SITES

IDS WEB SITE

address: http://ids-doris.org (or http://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 from local teams 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
- Network: Site logs, station coordinate time series, maps, network on Google Earth.
- Satellites: information on the DORIS missions
- System monitoring: DORIS system events file, station events file, station performance plots from the CNES MOE and POE processings, list of events impacting the data, list of earthquakes close to DORIS sites.

The headings of the “Analysis Coordination” part are:

- Presentation: a brief description of this section
- Combination: contribution ITRF2008 and contribution ITRF2013 (list of standards used by IDS Analysis Centers)
- Documents: about the DORIS system’s components (space segment, ground segment, stations, observations), the models used for the analysis, the products and their availability. A direct access to this regularly-visited page is also given in the “IDS” part.
- DORIS related events: history of the workshops, meetings, analysis campaigns...
- Discussion: archive of the discussions before the opening of the forum.
- Software: a couple of software provided by the Analysis Coordinator.
- About DORIS/RINEX format: all the material related to the DORIS/RINEX gathered on one page.

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” (http://ids-doris.org/doris-news.html) and “What’s new on IDS" (http://ids-doris.org/ids-news.html). The history of the updates of the website is given in "Site updates" (http://ids-doris.org/site-updates.html).

The IDS web site is maintained by the Central Bureau.

IDS WEB SERVICE

address: http://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 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).

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 documents available concern:

- the centers: presentation and analysis strategy of the ACs;
- the DORIS data: format description 1.0,2.1, 2.2, and RINEX, POE configuration for GDRB and GDRC altimetry products from Jason-1 and Envisat, on-board programming and POE pre-processing history;
- the dorimails and dorisreports: archive of the messages in text format, and indexes;
- the products: format of eop, geoc, iono, snx, sp1, sp3, stcd;
- the satellites: macromodels, nominal attitude model, center of mass and center of gravity history, maneuver history (including burn values), instrument modelling, corrective model of DORIS/Jason-1 USO frequency, plots of POE statistics of all stations for each satellite;

- the stations: sitelogs, ties, seismic events around the DORIS station network, ITRF2000, antennas description, beacon RF characteristics, information about the frequency shifts of the 3rd generation beacon, IDS recommendations for ITRF2005, Jason and Spot-4 visibility, station events, plots of the POE statistics of all the satellites for each station, document about the interface specification between the DORIS Network beacons and the onboard instrument;
- the combinations: analysis results from Analysis Coordination's combination center (internal validation of each individual Analysis Center time series, weekly combination), IDS combination for the DORIS contribution to ITRF2008.
- ancillary data such as bus quaternions and solar panel angles of Jason-1 and Jason-2

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.ign.fr/pub/doris/cb_mirror/

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.

DATA CENTERS' 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.

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.ign.fr/pub/doris/

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.

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/

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 people.

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.

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

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

HELP TO THE USERS

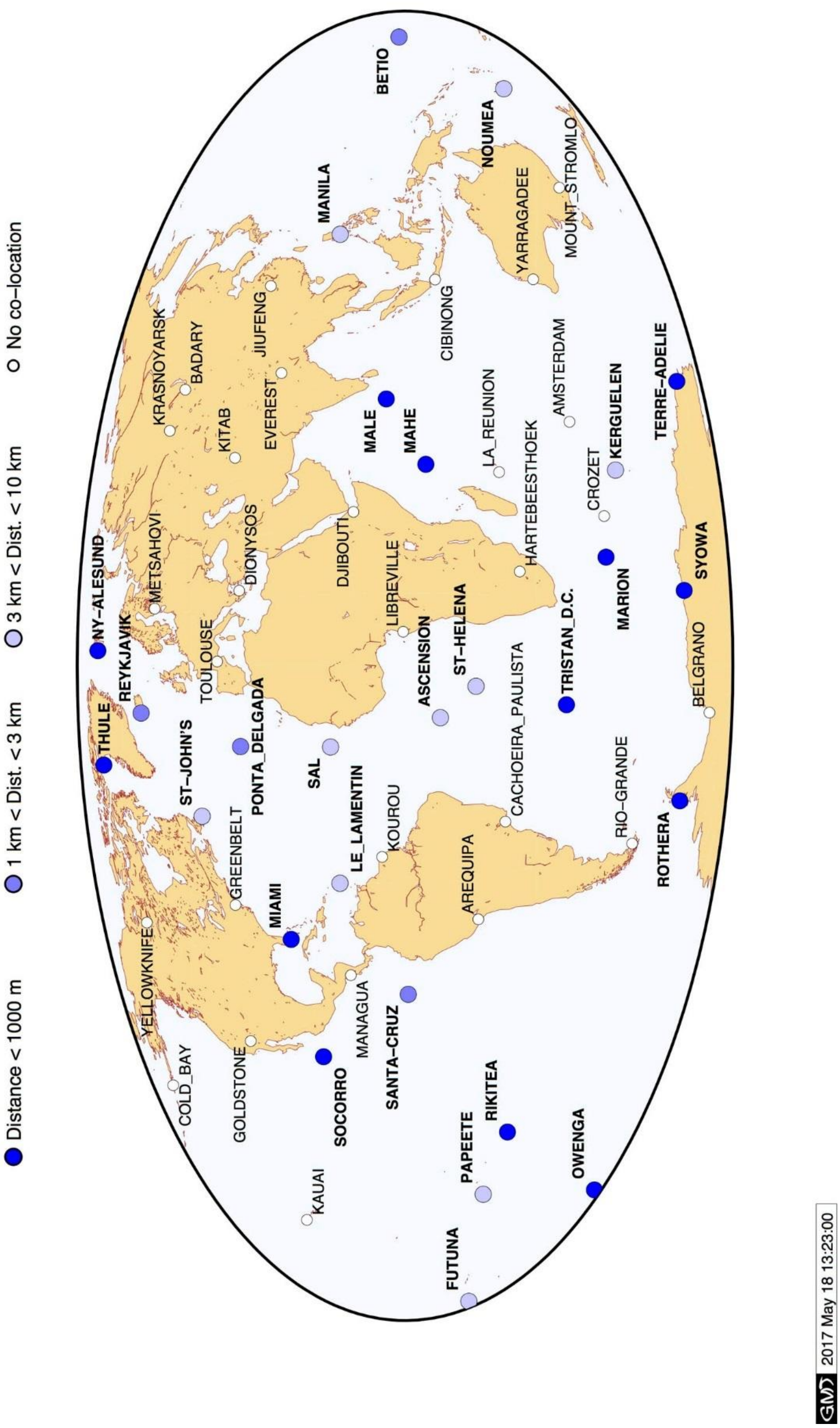
e-mail : ids.central.bureau@ids-doris.org

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.

22. 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
NY–ALESUND
REYKJAVIK
THULE
METSAHOVI
KRASNOYARSK
BADARY
KITAB
EVEREST
JIUFENG
DIONYSOS
TOULOUSE
ST–JOHN'S
PONTA_DELGADA
GREENBELT
YELLOWKNIFE
COLD_BAY
GOLDSTONE
MIAMI
SAL
LE_LAMENTIN
KOUROU
MANAGUA
SOCORRO
SANTA–CRUZ
KAUAI
PAPEETE
RIKITEA
FUTUNA
OWENGA
AREQUIPA
CACHOEIRA_PAULISTA
RIO–GRANDE
ROTHERA
BELGRANO
TRISTAN_D.C.
ASCENSION
ST–HELENA
LIBREVILLE
DJIBOUTI
HARTEBEESTHOEK
MARION
SYOWA
CROZET
KERGUELEN
AMSTERDAM
LA_REUNION
MALE
MAHE
TERRE–ADELIE
CIBINONG
MANILA
YARRAGADEE
MOUNT_STROMLO
NOUMEA
BETIO
2017 May 18 13:23:00

23. 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, FRANCE
Libreville	ESA Tracking Station	N'Koltang, GABON
Mahé	Seychelles National Meteorological Services	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	SLR Observatory, Geoscience Australia (GA)	Mount Stromlo, 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)	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	Meteorological Station	St Helena Island, South Atlantic Ocean, 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 Ocean, UK
Wettzell	Geodetic Observatory Wettzell (BKG)	Bad Kötzting, GERMANY
Yarragadee	MOBLAS 5 SLR Station, Geoscience Australia (GA)	Yarragadee, AUSTRALIA
Yellowknife	Natural Resources Canada (NR Can)	Yellowknife, CANADA

24. 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 and Jason-2 was launched on June 20, 2008.

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

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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