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CENTRE NATIONAL D'ÉTUDES SPATIALES

International Doris Service

ACTIVITY REPORT 2015

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IDS

International DORIS Service Activity Report 2015

Edited by Laurent Soudarin and Pascale Ferrage

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Preface

In this volume, the International DORIS Service documents the work of the IDS components between January 2015 and December 2015. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2015 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_2015.pdf

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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.

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

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

Table 2: List of IDS events organized between 2004 and 2015

3. ORGANIZATION

The IDS organization is very similar to the other IAG Services (IGS, ILRS, IVS) and IUGG Service such as IERS (**Figure1**).

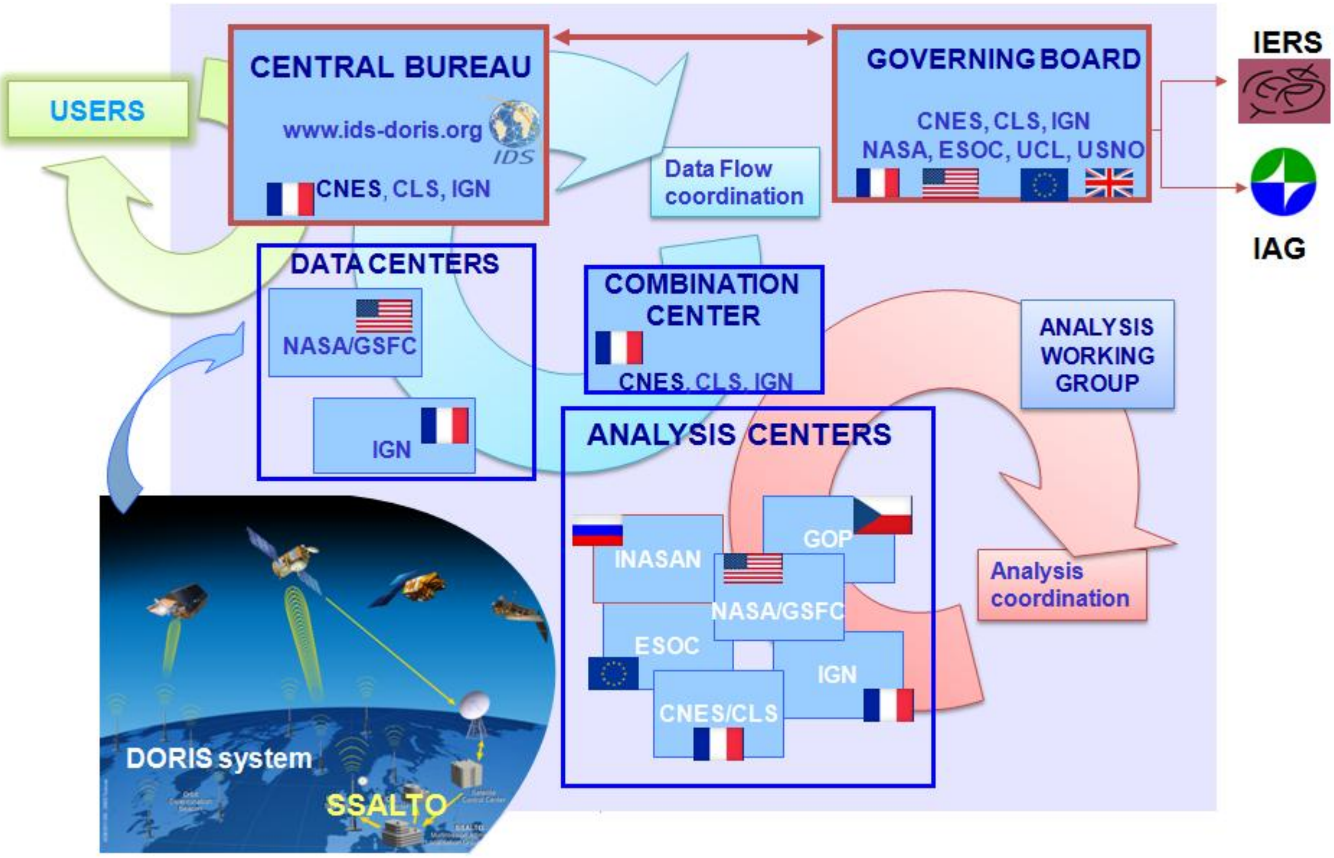


Figure 1: IDS organization

3.1 GOVERNING BOARD

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

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

The elected members have staggered four-year terms, with elections every two years. There is no limit to the number of terms that a person may serve, however he or she may serve only two terms consecutively as an elected member. The Analysis Centers' representative, the Data Centers' representative, and one Member-at-Large are elected during the first two-year election. The Analysis Coordinator and the other Member-at-Large are elected in the second two-year election.

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

3.2 REPRESENTATIVES AND DELEGATES

In 2014, IDS representatives and delegates are:

- IDS representative to the IAG: Pascal Willis
- IDS representatives to the IERS:
    - Analysis Coordinator: Hugues Capdeville (+Jean-Michel Lemoine)
    - Network representative: Jérôme Saunier
- IDS delegate for the GGOS Steering Committee: Pascal Willis (substitute: Frank G. Lemoine)
- IDS representatives to GGOS consortium: Pascal Willis, Laurent Soudarin
- IDS representatives to GGOS Bureau of Networks and Observations: Jérôme Saunier

3.3 CENTRAL BUREAU

In 2015, 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
Analysis coordinator	**2015-2018**	Elected	**Hugues Capdeville** **Jean-Michel Lemoine**	CLS CNES/GRGS	France
	2013-2014	*Ext'd*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2009-2012	*E.b.GB*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2005-2008		*Frank Lemoine (subst.)*	*NASA/GSFC*	*USA*
	2003-2005		*Martine Feissel-Vernier*	*IGN/Paris Observatory*	France
Data Centers' representative	**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	**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	University of Texas/CSR	USA
	2009-2012	E.b.GB	John Ries	University of Texas/CSR	USA
	2003-2008		John Ries	University of Texas/CSR	USA
Member at large	**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	**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	**2013-2016**	App.	**Pascale Ferrage**	CNES	France
IAG representative	**2013-2016**	App.	**Michiel Otten**	ESOC	Germany
	2009-2012	App.	Michiel Otten	ESOC	Germany
	2003-2008		Not designed		
IERS representative	**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

4. THE NETWORK

Jérôme Saunier *(IGN, France)*

4.1 GENERAL STATUS OF THE NETWORK

The DORIS permanent network is made up of 56 stations achieving 90% coverage (for satellites orbiting at 800 km altitude) (**Figure 2**). An additional station is dedicated to experimentation: Grasse (France).

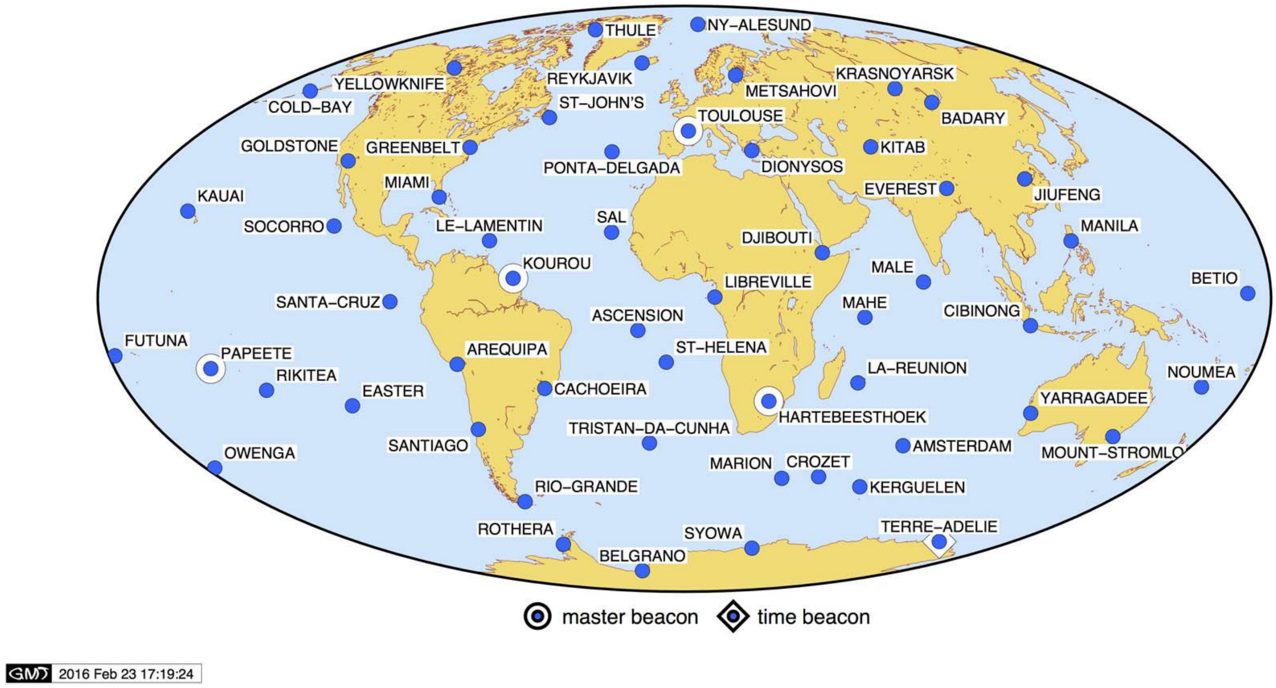


Figure 2: The DORIS permanent network

A new DORIS station, "GONC", was installed this year at the Goldstone Deep Space Communications Complex (GDSCC) in California. DORIS actually occupied this site at Goldstone between 1988 and 2004 but the station was moved 300 km south to Monument Peak (east of San Diego, California) for co-location with the SLR tracking station "7110" and the GNSS station "MONP". Unfortunately, following insoluble conflict at the 2 GHz frequency with a nearby TV microwave relay system, which manifested itself after the US switched to digital television transmissions in 2009, the DORIS station of Monument Peak had to be decommissioned in 2010 after only 4 1/2 years of service. After discussion with NASA, it was determined that the remote location of the GDSCC in the heart of the Mojave Desert was then the best-suited option to ensuring a peaceful and safe environment for the DORIS station.

The return to service of DORIS in California is of great importance for the development of altimetry data products. A gap in coverage leads to degradation in orbit determination, which affects both the real-time orbits computed by the DIODE instrument on-board the DORIS satellites, as well as for the precise orbits that are computed later. This much-awaited station fills a hole in the DORIS data coverage over the northern Pacific Ocean.

Other sites out of order for a long time making gaps in coverage are awaiting solutions: Yuznho-Sakhalinsk (Russia), Santa Cruz (Galapagos, Ecuador), Port-Moresby (Papua New-Guinea) and Santiago (Chili). For most of them, a relocation or/and a host agency change is required.

However, the DORIS network still provided a high level of performance and a reliable service with a network availability maintained over 85% of operating stations since 2012 thanks to the responsiveness and the joint effort of CNES, IGN and all agencies hosting the stations (**Figure 3**).

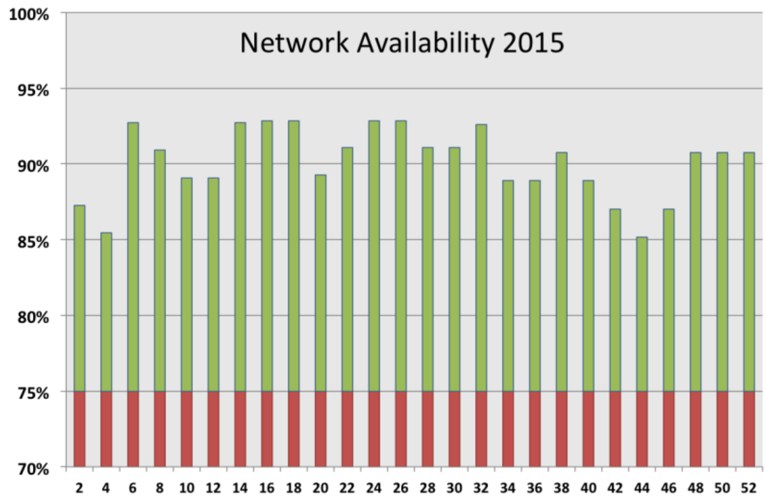


Figure 3: Network availability in 2015

4.2 EVOLUTION AND DEVELOPMENT

The number of maintenance operations is greater since the network equipment is ageing: 9 beacons and 5 antennas required replacements in 2015. The 4th DORIS beacon generation currently under development is the eagerly awaited evolution with the delivery of a prototype in 2017 and the start of the deployment in 2019.

When choosing a new site, co-location with other space geodetic techniques remains a priority goal. We use all opportunities to increase the number of co-located sites with over three-quarters of the DORIS network stations (**Figure 4**).

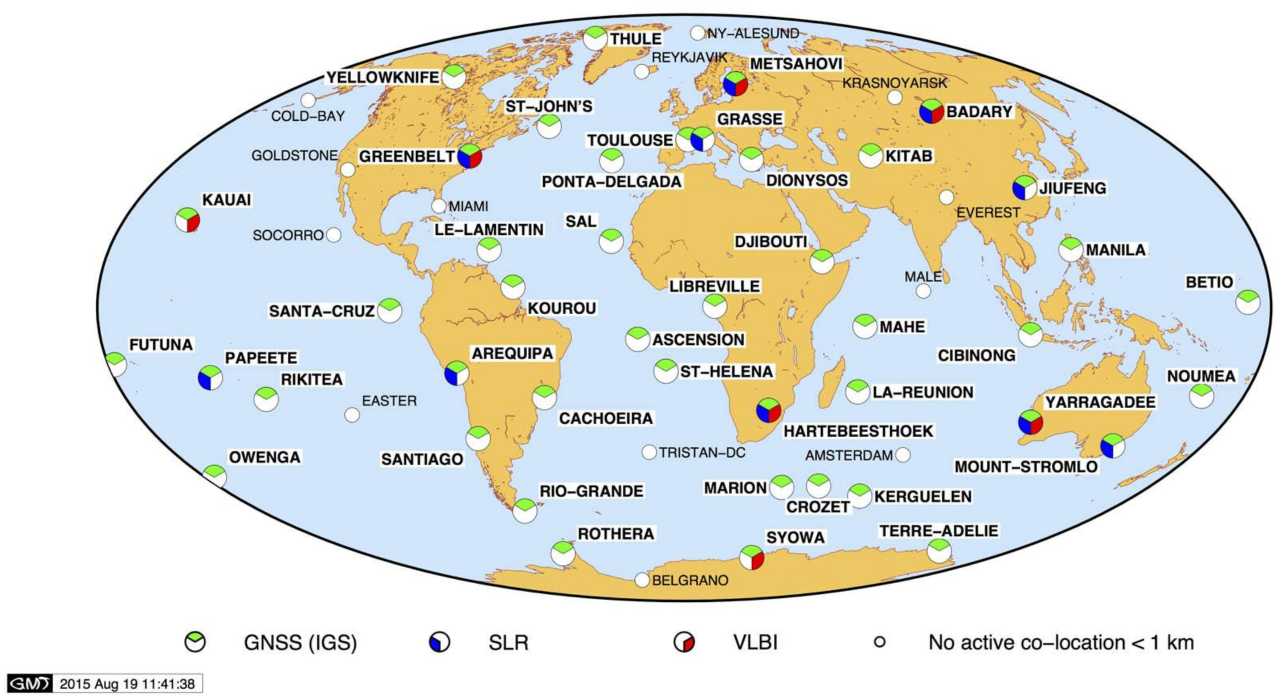


Figure 4: Co-location with other IERS techniques

In 2015 the following sites were visited:

- Goldstone, CA, USA: new site replacing Monument Peak (**Figure 5**).
- Arequipa, Peru: visit
- Kourou, French Guyana: tracking oscillator replacement
- Northern Australia: reconnaissance with a view to installing a new station
- Ny-Ålesund, Spitsbergen, Norway: reconnaissance with a view to move
- Sal, Cape Verde: renovation with a shift of 5 m (**Figure 6**).
- Ponta Delgada, Portuguese island: antenna change

Figure 5: Goldstone, CA, USA

Finally, the overall objectives for the next year are:

- New stations at Managua (Nicaragua), Wettzell (Germany) and San Juan (Argentina)
- Re-location in Kitab (Uzbekistan)
- Restarting at Santa-Cruz (Galapagos, Ecuador)
- Reconnaissance in Mariana Islands (USA), Manchuria (China) and Reykjavik (Iceland)

Figure 6: Sal, Cape Verde

5. THE SATELLITES WITH DORIS RECEIVERS

Pascale Ferrage ***(CNES, France)***

Initially conceived for the TOPEX/Poseidon mission, the first generation receivers were flown on four satellites:

- SPOT-2, a CNES remote sensing satellite which was launched in 1990 with the first DORIS receiver for a 6-month trial experiment. SPOT-2 was de-orbited in June 2009 (maneuvers were performed in order to lower the orbit so that the spacecraft will re-enter the Earth's atmosphere within 25 years). DORIS operated for more than 19 years on-board SPOT-2, far beyond the instrument and spacecraft nominal lifetime.
- TOPEX/Poseidon, a joint venture between CNES and NASA to map ocean surface topography, was launched in 1992. While a 3-year prime mission was planned, with a 5-year store of expendables, TOPEX/Poseidon delivered an astonishing 13+ years of data from orbit: the DORIS mission ended with the second receiver failure in November 2004 whereas the ocean surface topography mapping ended in October 2005,
- SPOT-3 (CNES) was launched in 1993; the spacecraft was lost in November 1996
- SPOT-4 (CNES) was launched in 1998 and featured the first DORIS real time on-board orbit determination (DIODE). After the great success of the mission (15 years) the satellite was decommissioned in June 2013.

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

- Jason-1, the CNES/NASA TOPEX follow-on mission was launched on December 7, 2001 with a miniaturized second generation DORIS receiver. The receiver was switched on December 8. The orbit accuracy of Jason-1 has been demonstrated to be close to one cm in the radial component (Luthcke et al. 2003; Haines et al. 2004). At the present time, Jason-1 DORIS measurements are not used for geodesy, owing to 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). Jason-1 was passivated and decommissioned on July 1st, 2013, terminating the Jason-1 mission after 11.5 years of operations

- Envisat, the ESA mission to ensure the continuity of the data measurements of the ESA ERS satellites was launched on March 1, 2002 with a second generation DORIS receiver. In April 2012, few weeks after celebrating its tenth year of service, Envisat has stopped sending data to Earth. ESA declared the end of mission for Envisat on May 9, 2012.
- SPOT-5 (CNES) was launched on May 4, 2002 with a miniaturized second generation DORIS receiver. After the great success of the mission (13.5 years) the satellite was decommissioned in October 2015.

Then, a new generation DORIS receiver was developed starting in 2005. This receiver called DGXX, 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)

The following satellites have on board a DGXX receiver:

- OSTM/Jason-2 (CNES/NASA/EUMETSAT/NOAA), a TOPEX/Poseidon and Jason-1 follow-on ocean observation mission (same orbit), was launched on June 20, 2008. Jason-2 is based on the same PROTEUS platform as Jason-1.
- Cryosat-2, the ESA mission dedicated to polar observation, was launched on April 10, 2010 with a DGXX DORIS receiver.
- HY-2A, a Chinese satellite (China Academy of Space) was launched on August 15, 2011 with a DGXX receiver.
- SARAL-AltiKA Indian-French satellite (ISRO/CNES) was launched on February 25 2013

Moreover, the satellite STPSAT1 (Plasma Physics and Space Systems Development Divisions, Naval Research Laboratory) with a CITRIS receiver to be used with the DORIS beacon network, was launched on March 9, 2007. This experiment was dedicated to global ionospheric measurements.

Figure 7 gives a summary of the satellites that provide DORIS data to the IDS data centers, as well as the evolution in time of the number of these satellites. 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.

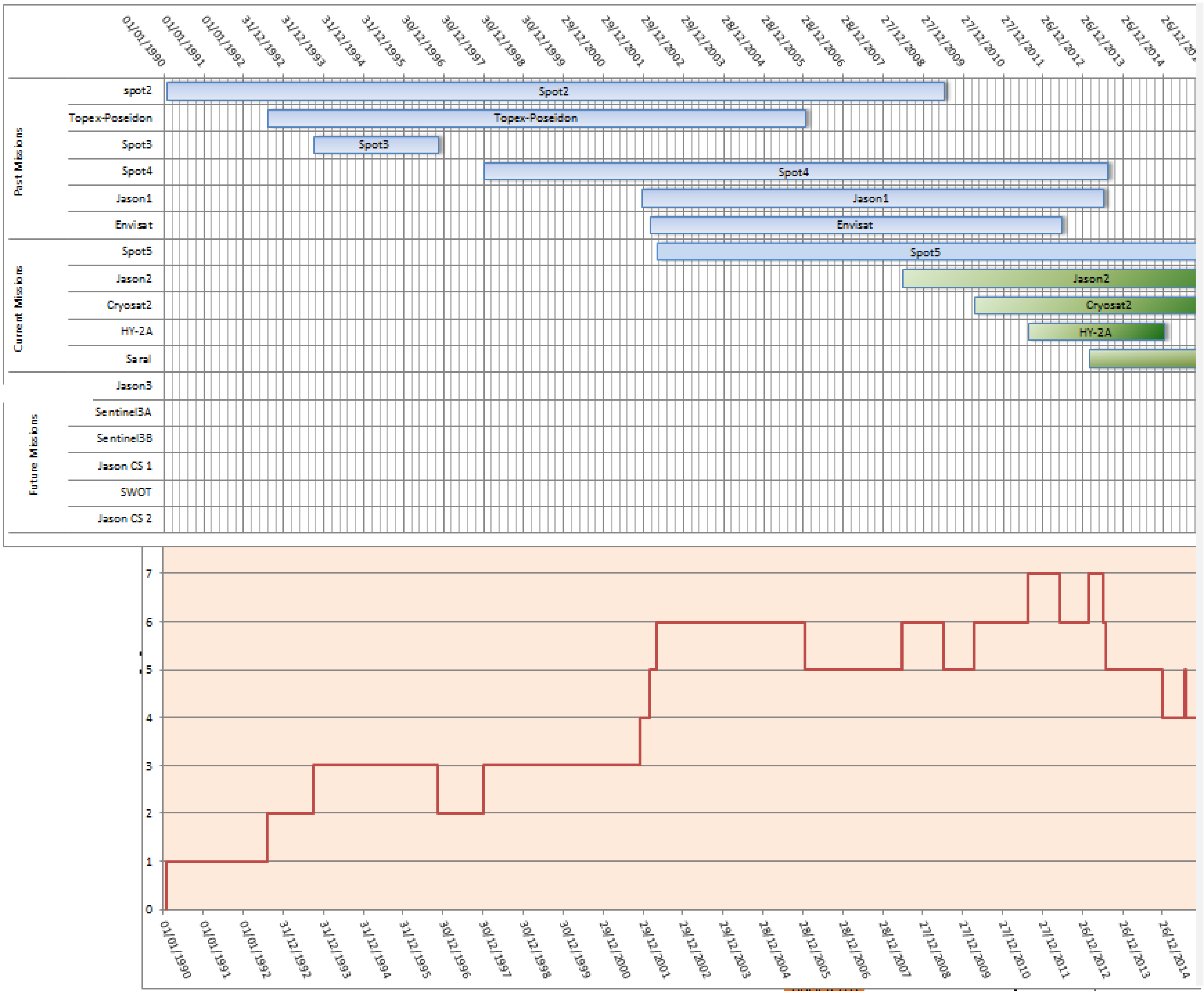


Figure 7: DORIS observations available at the IDS Data Centers (December 2015)

Some other DORIS missions are under development and should guarantee a constellation with at least 4 DORIS contributor satellites through 2032 (**Figure 8**):

- **Jason3** (EUMETSAT/NOAA/CNES) will be launched on January 17, 2016,
- **SENTINEL3A** (GMES/ESA) will be launched on February 16, 2016,
- **SENTINEL 3B** is planned for 2018, then **Sentinel 3C** and **3D** are foreseen for 2020 and 2025.
- **HY-2D & 2E** (China Academy of Space) are foreseen for 2020, 2021
- **Jason CS1/Sentinel6A** (Eumetsat/ESA/CNES) is expected from 2020, and **Jason CS2/Sentinel6B** from 2025,
- **SWOT** is foreseen for late 2020.

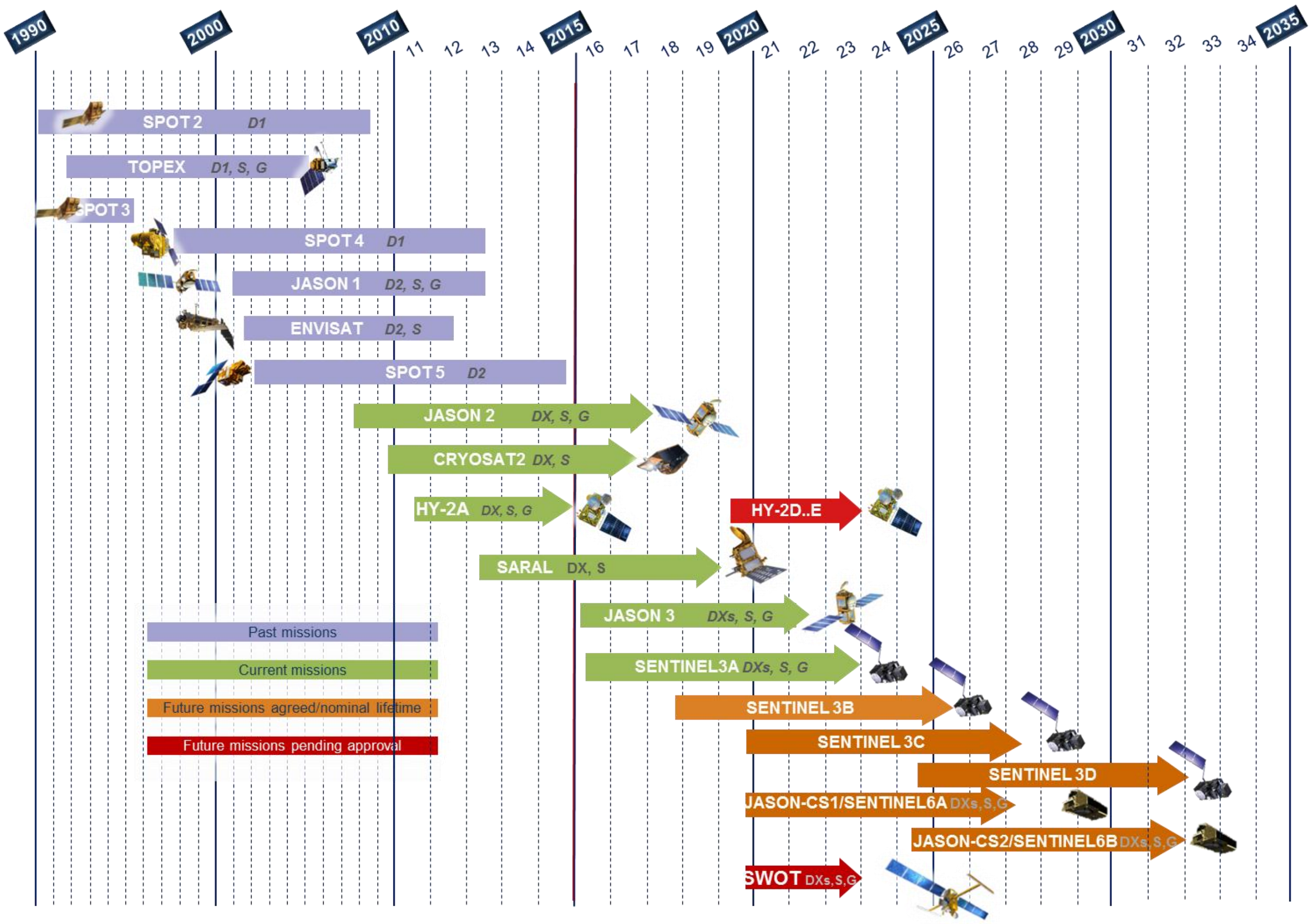


Figure 8: Current and future DORIS

6. THE CENTRAL BUREAU

Laurent Soudarin *(CLS, France)*, Pascale Ferrage *(CNES, France)*

The Central Bureau (CB), funded by CNES and hosted at CLS, is the executive arm of the Governing Board (GB) and as such is responsible for the general management of the IDS consistent with the directives, policies and priorities set by the Governing Board. It brings its supports to the IDS components and operates the information system. This report summarizes the activities of the IDS Central Bureau during the year 2015 and forecasts activities planned for 2016. An overview of the IDS information system is reminded in appendix.

6.1 GENERAL MANAGEMENT

The Central Bureau participated in the organization of the AWG meetings held at CLS in Toulouse on May 28 and 29, and at NASA/Goddard Space Flight Center in Greenbelt, Maryland, on October 15 and 16.It documented the GB meetings held on these occasions. Between the meetings, the CB coordinates the work of the GB.

The CB managed the edition and publication of the IDS Activity Report 2014. In addition, it provided the IDS contributions to IERS Annual report 2014, IAG Travaux 2011-2015, and ICSU World Data System (ICSU-WDS) Biennial Report 2013-2014.

A report of the IDS Workshop 2014 has been written for publication in IAG Newsletter, January 2015 issue. It was initially planned to be included in IAG's page in GIM magazine.

On behalf of the GB, the CB wrote an endorsement letter to the GRASP multi-technique mission concept. The letter has been addressed to Professor Nerem, PI, and joined to the GRASP mission proposal submitted to NASA.

The IDS Terms of Reference (ToR) have been revised by the GB in May 2015, to include the definition of Associate Analysis Center, clarifications of the definition of Analysis Center, amendments to the definition of IDS Associates. The revised version produced by the CB was approved by the IAG Executive Committee at its meeting on June 26, 2015, in Prague, Czech Republic.

A generic mail address was created for the IDS Analysis Coordination team: ids.analysis.organisation@•ids-doris.org

In January, the Central Bureau launched a new survey to hear from the IDS users about the services and ask them to give their feedback by filling a form on the web site.

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

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 2015, this activity focused on:

- the delivery of the CNES orbits in GDR-E standards (file naming, store folders, description files). See [ftp CDDIS or IGN] pub/doris/products/orbits/ssa/README_SP3.txt

- the definition of a new file gathering the initial values of mass and center of gravity coordinates. The goal is to have an independent file containing the values given in the documents “DORIS satellites models implemented in POE processing”.

- the delivery of the reprocessed DORIS/RINEX files with new time tagging (version number of the files = 010)

- consulting the Analysis Centers about the introduction of three-thrust records in maneuver files of SARAL take into account the new strategy defined by ISRO to perform the satellite attitude control

At the AWG meeting in Greenbelt, Ernst Schrama (TU Delft) has offered to provide and maintain a file containing the time window during which Cryosat-2’s yaw-steering is suspended due to orbit correction maneuvers. This file is now accessible via the IDS website: ftp://dutlru2.lr.tudelft.nl/pub/ejo/cryosat2/quaternion/attlaw.d. The description of the file has been added in the descriptive document of Cryosat-2’s quaternions.

6.3 DOR-O-T, THE IDS WEB SERVICE

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

The IDS web service named DOR-O-T for DORis Online Tools (pronounced like the French given name Dorothée) has been upgraded with a new plot tool to visualize the time series of Earth Orientation Parameters from the IDS Combination Center analysis (Xp, Yp, LOD) (http://apps.ids-doris.org/apps/eoptool.html).

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 slight modifications.

In order to help the access to an ever-increasing number of documents on the website, a new page “Documentation” was created in the section “Reports & Mails”. 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

With the aim of giving a broader visibility and making the search easier, the full list of presentations given at DORIS or IDS meetings with the corresponding access links is now available on a unique page “Meeting presentations” in the section “Reports & Mails”. From October 2015, the future pages dedicated to each meeting will no longer contain the list of presentations but a link to this page.
http://ids-doris.org/report/meeting-presentations.html

To give an overview of the DORIS and IDS data and products, a new page “Tables of Data & Products” was created in the section “Data & Products”. It shows in tables the data and product provided by IDS with their main characteristics: latency, sample interval, archive locations, format, missions, content, provider.
http://ids-doris.org/data-products/tables-of-data-products.html

The section “Combination” in the part “Analysis coordination” was restructured. It contains now the two pages: “Contribution ITRF2008” (http://ids-doris.org/combination/contribution-itrf2008.html) and “Contribution ITRF2014” (http://ids-doris.org/combination/contribution-itrf2014.html)

The page with the composition of the Governing Board was revised. A table gives the list of the current and former members with position, term, status, affiliation:
http://ids-doris.org/organization/governing-board.html

A new section « Satellites » in the part “DORIS system” has been open since early 2016: http://ids-doris.org/satellites.html

The main updates of 2015 are reported hereafter.

- The new version of leaflet “DORIS, the space surveyor” can be read from the Outreach section of the page “Documents related to the Analysis”:
  http://ids-doris.org/analysis-documents.html

- The activity reports for 2014 (IDS Activity report, report for IERS) as well as the minutes of the IDS GB meetings held in 2015 (Toulouse, Greenbelt) 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 presentations of the AWG meeting held at CLS in Toulouse on May 28 and 29 were put on line on a dedicated page:
  http://ids-doris.org/report/meeting-presentations/ids-awg-05-2015.html

- The presentations of the IDS Workshop held at NASA/Goddard Space Flight Center in Greenbelt, Maryland, on October 15 and 16 have been made available:
  http://ids-doris.org/report/meeting-presentations/ids-awg-10-2015.html

- The page of Analysis Coordination’s Documents was completed with all the minutes of the Analysis Working Group Meetings
  http://ids-doris.org/report/analysis-coordination.html

- Minutes of the meeting held in Greenbelt, USA (October 16, 2015): http://ids-doris.org/documents/report/GB_Meeting_2015_10_16.pdf

- Minutes of the meeting held in Toulouse, France (May 29, 2015): http://ids-doris.org/documents/report/GB_Meeting_2015_05_29.pdf

- The main events (system, station, data, Earthquake) that occurred on the DORIS space segment and ground segment are regularly updated. They are presented in one single table: http://ids-doris.org/system/table-of-the-events.html

- The list of the peer-reviewed publications related to DORIS has been enriched with 4 new references of articles published in 2015: http://ids-doris.org/report/publications/peer-reviewed-journals.html#2015

- The IDS presentation at IERS Directing Board meeting in December 2015 was put on line on the page of the GB's documents: http://ids-doris.org/report/governing-board.html#presentations

- The page gathering IDS-related presentations was updated with presentations at EGU and AGU 2015: http://ids-doris.org/report/meeting-presentations/ids-related-presentations.html

- Some DORIS-related presentations were added: Ries, 2013; Gerasimenko et al., 2005; Gitton and Kneib, 1990 http://ids-doris.org/report/publications/on-line-publications.html

- A survey form was put online to get feedbacks from the users: http://ids-doris.org/ids-survey.html

- Photos of AWG's dinner (May 2015) and of of the visit at the Goddard Geophysical and Astronomical Observatory (GGAO) added in the gallery: http://ids-doris.org/gallery.html

6.5 IDS FTP SERVER

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

The documents and files put on the IDS ftp site in 2015 are listed hereafter.

New files:

- mass and gravity center initial values recommended by IDS: ftp://ftp.ids-doris.org/pub/ids/satellites/MassCoGInitialValues.txt

- list of the time frames when yaw steering is turned off for Cryosat-2 ftp://ftp.ids-doris.org/pub/ids/ancillary/quaternions/cryosat2_quaternions_TUdelft_description.pdf

- description of mass history files ftp://ftp.ids-doris.org/pub/ids/satellites/mass.readme

- position and velocity discontinuities for DORIS sites used in ITRF2008 ftp://ftp.ids-doris.org/pub/ids/events/DiscontinuitiesITRF2008.txt

- evolution of the DORIS constellation (start and end epochs, number of satellites in operation) ftp://ftp.ids-doris.org/pub/ids/events/EvolutionOfConstellation.txt

- list of Earthquakes with magnitude >6 in the vicinity of geodetic stations (distance < 500 kms) since 1993/01/01
  ftp://ftp.ids-doris.org/pub/ids/events/GeodeticNetworks_Earthquakes_m6d500.txt

Updated files:

- History files of events in ftp://ftp.ids-doris.org/pub/ids/events/
- DORIS internal ties
  ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_int_ties.txt

New documents:

- "Modelling of the ground beacons and ground antennas"
  ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_System_Ground_Segment_Models.pdf

Updated documents:

- description file of Cryosat-2 quaternions
  ftp://ftp.ids-doris.org/pub/ids/ancillary/quaternions/cryosat2_quaternions_TUdelft_description.pdf

- « DORIS satellites models implemented in POE processing » with updated values of Saral's gravity center
  ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf

- « Modelling of the DORIS instruments 1G (Spot-2, -3, -4, Topex) and 2G (Envisat) »; sections about ground beacons and ground antennas removed)
  ftp://ftp.ids-doris.org/pub/ids/satellites/DORIS_instrument_modelling_1G_2G.pdf

- « RINEX DORIS », IDS version
  ftp://ftp.ids-doris.org/pub/ids/data/RINEX_DORIS.pdf

- « System requirements for management of the DORIS station network », IDS version
  ftp://ftp.ids-doris.org/pub/ids/stations/System_Requirements_For_Management_Of_The_DORIS_Station_Network.pdf

6.6 FUTURE PLAN

In 2016, the Central Bureau will participate in the organisation of the Analysis Working group meeting at TU Delft, Netherlands, May 26-27 (http://ids-doris.org/report/meeting-presentations/ids-awg-05-2016.html) and of the IDS Workshop 2016, in La Rochelle, France, on October 31 and November 1 (http://ids-doris.org/report/meeting-presentations/ids-workshop-2016.html).

Data, meta-data and documentation of the two missions Jason-3 and Sentinel 3A launched in early 2016, will be put online the IDS data and information sites as they become available.

2016 is also the year of the launch of the IDS Newsletter and the IDS YouTube channel. The former aims to provide regular information on the DORIS system and the life of IDS to a wide audience, from the host agencies to the other sister services. The latter proposes videos for outreach purposes.

In 2016, the CB will process to the selection of the Combination Center for 2017-2020. A call for participation will be issued in spring. The CB will organize the GB elections to be held in autumn. Three positions are renewed for the term 2017-2020: Data Center representative, Analysis Center representative, one Member at Large.

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

7. IDS DATA FLOW COORDINATION

Carey Noll *(NASA, USA)*

7.1 INTRODUCTION

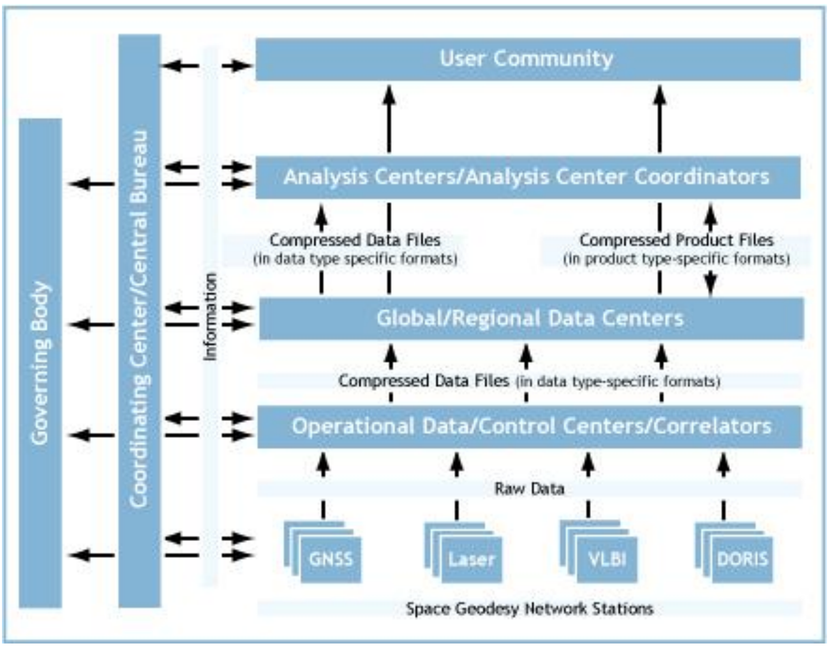
Two data centers support the archiving and access activities for the IDS:

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

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

Governing Body
General oversight of service
Future direction

Fligure 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 4** 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)

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.

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 four operational satellites (CryoSat-2, HY-2A, Jason-2, and SARAL); data from future missions will also be archived within the IDS. Historic data from Envisat, Jason-1, SPOT-2, -3, -4, -5 (mission ended in November 2015), 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 5**. The DORIS data from all 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 2013 of data availability after the last observation day satellite specific are shown in **Table 6**. The delay in data delivery to the data centers (in days by satellite) in 2015 is shown in **Figure 10**.

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*
Product Directories		
/doris/products/2010 campaign/	*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 or SP3c 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*/qbody*YYYYMMDDHHMISS*_*yyyymmddhhmiss*.*LLL*	Spacecraft body quaternions for satellite *sss*, 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*, start date/time *YYYYMMDDHHMISS*, end date/time *yyyymmddhhmiss*, and version number *LLL*
/doris/cb_mirror		Mirror of IDS central bureau files

Table 4: Main Directories for IDS Data, Products, and General Information

Satellite	Time Span
CryoSat-2	30-May-2010 through present
Envisat	13-Jun-2002 through 08-Apr-2012
HY-2A	01-Oct-2011 through present
Jason-1	15-Jan-2002 through 21-Jun-2013
Jason-2	12-Jul-2008 through present
SARAL	14-Mar-2013 through present
SPOT-2	31-Mar through 04-Jul-1990 04-Nov-1992 through 14-Jul-2009
SPOT-3	01-Feb-1994 through 09-Nov-1996
SPOT-4	01-May-1998 through 24-Jun-2013
SPOT-5	11-Jun-2002 through 30-Nov-2015
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004

Table 5: DORIS Data Holdings Summary

Satellite	DORIS-Format Data			RINEX Data
	Number of Days/ Multi-Day File	Average Latency (Days)	Average File Size (Mb)	Average File Size (Mb)
CryoSat-2	8	24	2.8	1.6
HY-2A	8	25	3.4	1.9
Jason-2	11	26	6.8	2.6
SARAL	8	26	3.3	1.8
SPOT-5	10	17	2.5	N/A

Table 6: DORIS Data File Information (2015)

DORIS phase data from Jason-2, CryoSat-2, SARAL, and HY-2A 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 day (typically) following the end of the observation day.

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.gsfc.nasa.gov/doris/campdata/saacorrection/ja1
ftp://cddis.gsfc.nasa.gov/doris/campdata/saacorrection/sp5

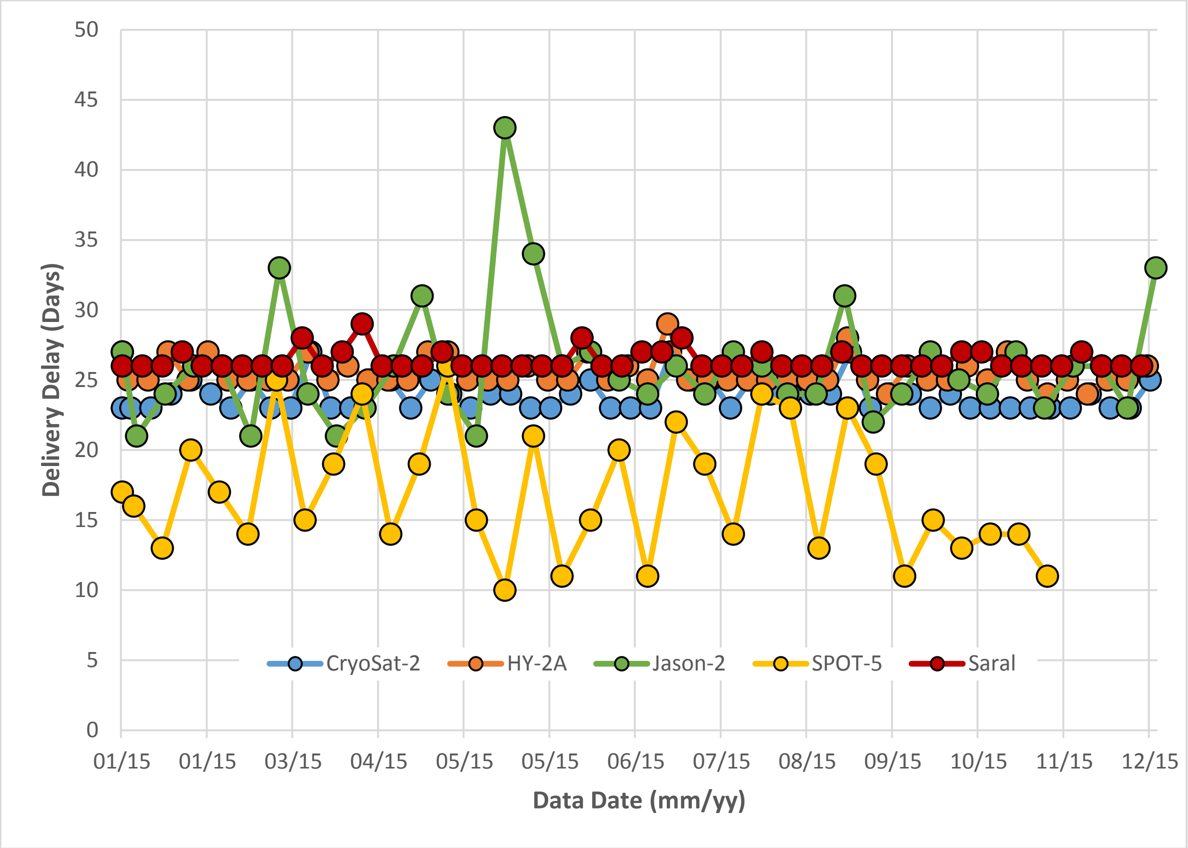


Figure 10: Delay in delivery of DORIS data to the CDDIS (all satellites, 01-12/2015)

In January 2015, SSALTO developed improvements in the time tagging of DORIS measurements in the RINEX format (missions Jason-2, Cryosat-2, HY-2A, and SARAL). Updates were applied to RINEX data starting on January 20, 2015. Older RINEX data were reprocessed and submitted to the data centers in May 2015; these updated data files were named with a new version number to indicate a revised data set.

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 2005-2014 are shown in **Table 7**. This table also includes a list of products under evaluation from several DORIS analysis centers.

Precise satellite orbits provided by SSALTO were updated to new Geophysical Data Record (GDR) standards (GDR-E) starting in April 2015. Orbit files for Jason-1, Jason-2, Cryosat-2, and SARAL were submitted using these standards with new version numbers; older files were archived to subdirectories by GDR designation. Other satellites (e.g., Envisat, HY-2A) will be updated to the GDR-E standards in the future and upcoming missions (e.g., Jason-3) will also utilize the GDR-E standards.

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 SARAL 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.

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

*Note: GAU and SOD historic solutions
**Note: CNES/CLS transitioned their AC acronym from LCA to GRG in 2014.

Table 7: IDS Product Types and Contributing Analysis Centers

8. IDS DATA CENTERS

Carey Noll *(NASA, USA)*, Bruno Garayt *(IGN, France)*

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 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)

8.1.2 OPERATIONAL ACTIVITIES

By the end of 2015, the CDDIS has devoted approximately 90 Gbytes of disk space to the archive of DORIS data, products, and information. During the year, users (640 distinct hosts) downloaded approximately 700 Gbytes (1M files) of DORIS data, products, and information from the CDDIS. On average, over 160 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.gsfc.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.

8.1.3 RECENT ACTIVITIES AND DEVELOPMENTS

The CDDIS developed two applications for querying site information or archive contents.

The **Site Log Viewer** (http://cddis.gsfc.nasa.gov/SLV2/network/QuerySiteLogs.action) 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.

Development of a second application, the **CDDIS Archive Explorer**, was completed in 2015; this application allows users to discover what data are available through the CDDIS. The application (http://cddis.gsfc.nasa.gov/Data_and_Derived_Products/CddisArchiveExplorer.html) allows users, particularly those new to the CDDIS, the ability to specify search criteria based on temporal, spatial, target, site designation, and/or observation parameter in order to identify data and products of interest for download. Results of these queries include a listing of sites and additional metadata satisfying the user input specifications. Such a user interface also aids CDDIS staff in managing the contents of the archive. Future plans for the application include adding a list of data holdings/URLs satisfying the search criteria.

The current CDDIS server configuration consists of multiple incoming and outgoing servers dedicated to specific functions; the system is equipped with 32 Tbytes of online RAID storage. A new virtual-machine based system was installed in 2015; the system is currently under testing with expected operations in spring 2016.

8.1.4 FUTURE PLANS

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

Transition to the new CDDIS server configuration will be completed in early 2016. This new system configuration will provide a more reliable/redundant environment (power, HVAC, 24-hour on-site emergency personnel, etc.) and network connectivity for CDDIS; a disaster recovery system will be installed in a different location on the GSFC campus. The new system location will address the number one operational issue CDDIS has experienced over the past several years, namely, the lack of consistent and redundant power and cooling in its existing computer facility. Multiple redundant 40G network switches will also be 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 will also transition approximately 85% of its operation services over to virtual machine (VM) technology for both multiple instance services in a load balancing configuration which will allow additional instances to be increased or decreased due to demand and will allow maintenance (patching, upgrades, etc.) to proceed without interruption to the user or any downtime. CDDIS will be utilizing 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.

One requirement of the new CDDIS computer system will involve a change to the file upload process. CDDIS has traditionally 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 provides an opportune to update this method to a web-based approach that can utilize a different user sign-on/authentication infrastructure. CDDIS has developed a web-based application to allow users to use existing scripts without significant modification but also tie authentication into the NASA system. Staff will work with groups who submit DORIS data and IDS products to CDDIS on transitioning their procedures to the new file upload system.

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. Additional DOIs are under development and review prior to registering and implementation.

8.1.5 CONTACT

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USA	WWW:	*http://cddis.gsfc.nasa.gov*

8.2 IGN DORIS DATA CENTER

8.2.1 CONTACT

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9. IDS ANALYSIS COORDINATION

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9.1 INTRODUCTION

The activities of all the DORIS analysts of the past year 2015 have been dominated by the IDS contribution to ITRF2014 and its evaluation, and the implementation of the DORIS RINEX data processing. Analysis working group meetings were held in Toulouse (France), May 28-29, 2015 (hosted by Collecte Localisation Satellites) and in Washington DC (USA), October 15-16, 2015 (hosted by NASA Goddard Space Flight Center in Greenbelt, Maryland, USA).

The first period of 2015 was devoted to the processing of the second half of 2014 and to the delivery of that time period to IDS Combination Center (CC) after the extension of ITRF2013 into ITRF2014. An evaluation of the preliminary version of ITRF2014 provided by IERS (Z. Altamimi) has been done by IDS CC, some Analysis Centers (ACs) and one associated AC.

The second major work for the IDS ACs was to implement the RINEX data processing in their software. The Analysis coordinators have proposed to IDS ACs some help to do this job and made available two notes written by Flavien Mercier and Jean-Michel Lemoine (CNES). Some groups have started this work and two ACs have completed.

9.2 ANALYSIS ACTIVITY OVERVIEW

For ITRF2014, the six active analysis centers had agreed to submit new SINEX solutions. In addition, the CNES POD center is lead DORIS analysis center. They do not submit SINEX solutions for the IDS combination, but since they have prime POD responsibility for many of the DORIS satellites, they are the source for much of the spacecraft information needed for processing. In addition, they prepare the DORIS format 2.2 data (the range-rate format) that is used by the IDS ACs. We have also the participation by three other institutions: GFZ, TU/Delft, The University College/London. The GeoForschung Zentrum (GFZ) has participated in several of the IDS meetings, and focused on the POD analysis for altimeter satellites. TU/Delft is analyzing data from Cryosat-2, and has made available the spacecraft quaternions for use by other team members. UCL is interested in working with individual DORIS ACs on the refinement of non-conservative force modeling for DORIS satellites.

So to summarize, the IDS includes six analysis centers and “de facto” three “associate analysis centers” who use seven different software packages, as summarized in **Table 8**. We also note which analysis centers on a routine basis perform POD analyses of DORIS satellites using other geodetic techniques (c.f. Satellite Laser Ranging (SLR), or GNSS). The 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.

9.3 OPEN ISSUES FOLLOWING ITRF2014

Six DORIS Analysis Centers successfully processed 20 years of data to 11 satellites and submitted SINEX files that were combined into an IDS solution for ITRF2014 (Moreaux et al., in press). 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.

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	EPOS-OC	SLR, GNSS
TU Delft		✔	The Netherlands	Ernst Schrama	GEODYN	SLR

Table 8: Summary of IDS Analysis Centers (2015)

9.3.1 JUMP IN DORIS SCALE (2012 AND LATER)

All the DORIS Analysis Centers observe the jump in scale. The scale jump in 2012 is less clear when GRG AC uses DORIS RINEX data. They also showed that there is no scale jump for HY-2A but the scale value is high and increases clearly the multi-satellite scale jump. This issue is still under investigations but an explanation is in discussion with the CNES POD team about a change in the preprocessed DORIS data due to the use of the improved tropospheric correction model (leading to less rejected data in the doris2.2 file).

9.3.2 HY-2A SCALE OFFSET AND TZ

We have to understand what happens with HY-2A high scale (confirmed by SLR) and to decide if we apply a correction of Center of Mass (CoM) value. Since IDS AWG in Toulouse (May, 2015), we have to take into account the discussion about the paper of Gao et al. (2015) which proposes news values of CoM, of 2Ghz DORIS Phase center and of LRA spherical center (different from ILRS recommended values). CNES has to contact Chinese agency to have information in particular for the Center of Phase DORIS position. The goal is to obtain information by showing results of HY-2A of scale factor for example.

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 ERROR IN CENTER OF MASS OF SARAL

Both the CNES POD team and the GSC AC showed that there was a -4 cm error in Z (cross-track) in the CoM of the satellite in the spacecraft frame. The initial CoM position in Z (along cross-track) for Saral was estimated using DORIS data: the pre-launch position in the +Z direction was -0.6583m. The estimated initial position is now -0.6105m. This new value is the one implemented in CNES POE processing since Nov. 6, 2014 and in geometrical correction in the doris2.2 files. The document describing the satellite models implemented in POE processing has been updated (ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf). The Z value of the initial center of gravity in the header of the “mass and center of mass” history file of Saral has also been updated. The re-delivery of the doris2.2 data taking into account the new value of CoM from the beginning of mission to Nov. 6, 2014 by CNES POD team is not urgent, that could be done at the end of Saral mission for example.

Finally, to try to understand the outstanding points following the ITRF reprocessing, IDS Analysis Coordinators ask to IDS ACs (volunteer) to provide a single satellite solution for all satellites to IDS CC over 5 years [2011-2015].

9.4 ITRF2014: IMPLEMENTATION AND EVALUATION

9.4.1 IMPLEMENTATION OF ITRF2014

The geodetic station motion is modeled differently in ITRF2014, compared to previous ITRF realizations. Specifically sites that are known to have earthquakes will include parametric post-seismic models. This offers the POD community more accurate coordinates (for DORIS this would most obviously affect stations such as Fairbanks, Arequipa and Santiago and other stations collocated with GNSS site), but it means four parametric models need to be integrated into each POD software. The implementation and verification of these new models complicates the evaluation of the ITRF2014. The IDS ACs and the Analysis Coordinators need to work closely on validating their implementation of ITRF2014.

Z. Altamimi provided the preliminary version of ITRF2014 (called ITRF2014P) in September 2015 and proposed to some IDS POD groups to evaluate it.

9.4.2 EVALUATION OF ITRF2014P

The candidates to ITRF2014P evaluation were IDS CC, CNES POD team, GSC AC, and GRG AC. GSC has tested ITRF2014P without post-seismic model for Jason-2 from 2008. When they consider the ITRF2014P rather than ITRF2008, the DORIS residuals are lower for all stations except for post-seismic stations (see **Figure 11**). GRG has tested ITRF2014P with post-seismic model applied for 3 satellites from 2012. For Jason-2, CRYOSAT-2, and HY-2A the DORIS residuals are slightly lower with ITRF2014P (see **Figure 12**). CNES POD team has tested ITRF2014P with post-seismic model for Jason-2 from 2012. They observe a very slight improvement in DORIS RMS residuals and the DORIS+SLR orbits closer to GPS-only orbits (see **Figure13**). IDS CC suggests reconsidering velocity constraints in Easter Island and Manila. IDS CC recalls that if you do not use the PSD corrections, you can have centimetric differences even several years after the Earthquake. So, IDS CC proposes to make available to the IDS ACs XYZ and NEU corrections in ASCII file (One file per station and one line per week until 2020.0). IDS CC proposes also to give to ACs the temporal series of stations impacted by post-seismic model.

For ACs and IDS CC, after some minor corrections the ITRF2014P gives good results. If ACs need help to implement in their POD software the post-seismic models they can contact those that have already done (GSC AC, GRG AC, IDS CC, CNES POD team).

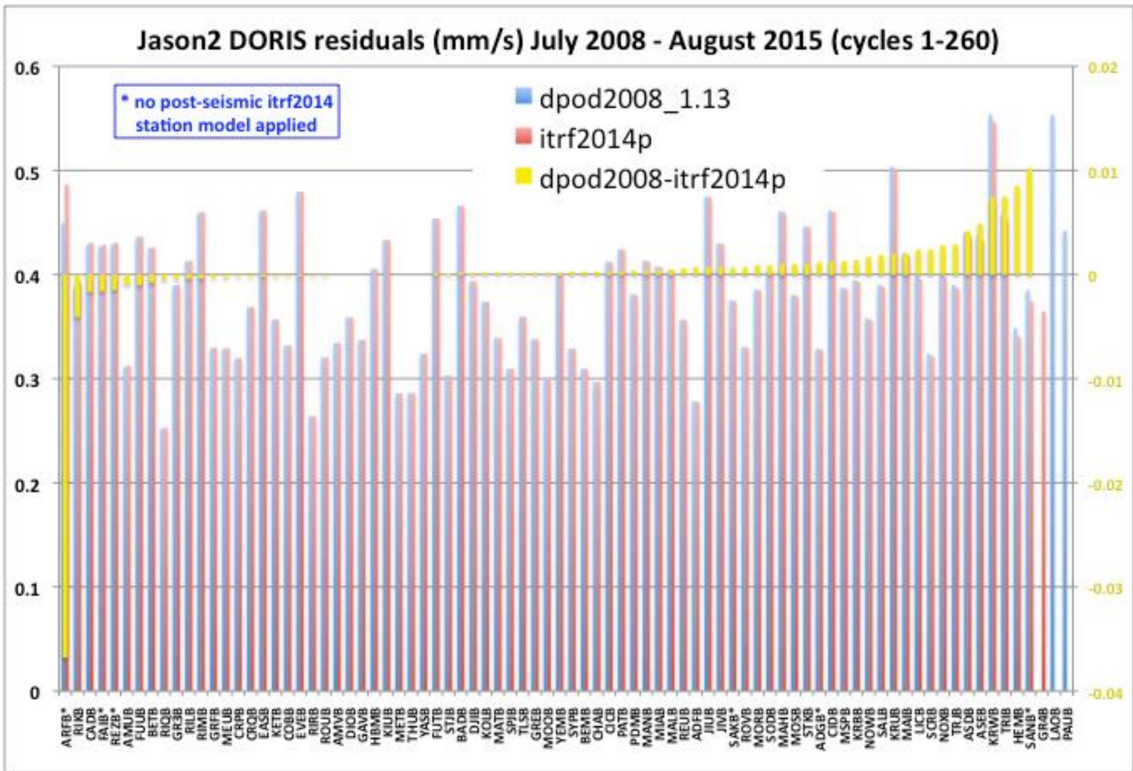

Figure 11: GSC Jason2 DORIS residuals per station

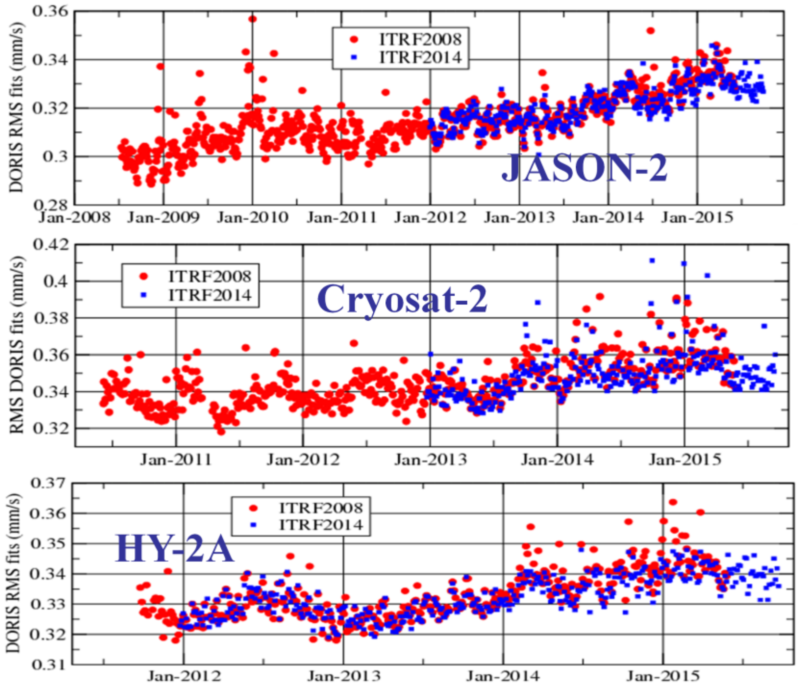

Figure 12: GRG DORIS RMS residuals with ITRF2014P and DPOD2008

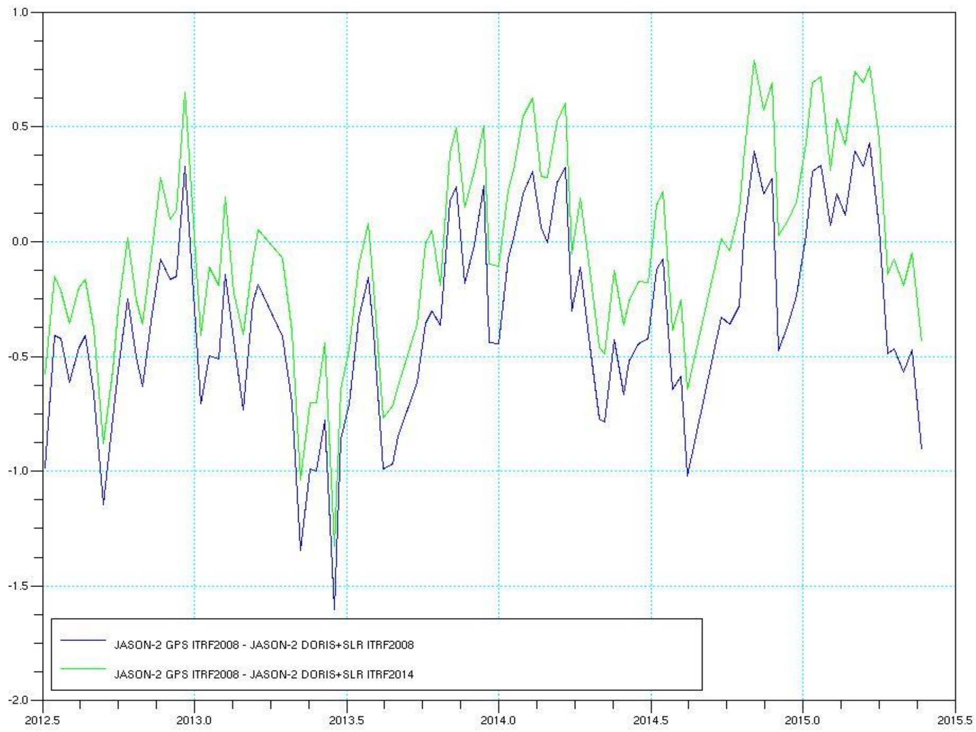

Figure 13: JASON-2 GDR-E DORIS+SLR (ITRF2008 in blue, ITRF2014P in green) vs GPS-based dynamic orbits, mean of Z orbit differences

9.5 DORIS RINEX DATA PROCESSING

Since 2008, starting with Jason-2, the satellites equipped with a DORIS receiver carry the new generation of receivers called DGXX which has seven dual frequency measurement channels, i.e. is able to track up to seven beacons simultaneously. Unlike the previous 1st and 2nd generations, DGXX has new capabilities of measurements. It provides phase and pseudo-range measurements (Auriol and Tourain, 2010). They are distributed in a dedicated format, called RINEX/DORIS 3.0 (Mercier et al., 2010), derived from the RINEX/GPS format. One major advantage of these new measurements is that they are available with a very short latency. They also allow analysis centers to be less dependent on the CNES since the new data format provides the raw information that is necessary for computing the ionospheric delays and the precise time-tagging of the measurements. This was not the case for the former data format where this information was only given in a pre-processed form, following a pre-processing done by the CNES. While CNES supplies data files in doris2.2 and RINEX/DORIS 3.0 formats for the missions equipped with DGXX (Jason-2, Cryosat-2, HY-2A and Saral), only the latter format will be made available for the missions from Sentinel-3A and Jason-3 and following.

In this context, the Analysis Coordinators sent (in March 2015) an email to the IDS community. The aim of this mail was to help the IDS ACs to process the DORIS data in the RINEX format. Compared to the doris2.2 format, in the RINEX format the following corrections (given by measurements) are no longer mentioned:

- the center of mass correction including both effects: satellites and beacons
- the tropospheric refraction correction
- the ionospheric refraction correction
- the measurement doesn’t take into account the best estimate of the actual satellite frequency (long term on-board frequency drift not taken into account)

So, to use the RINEX file data it is necessary:

- to implement the ground antenna geometries in order to be able to position the 400 MHz, 2 GHz and iono-free phase centers with respect to the reference point of the antenna (the middle of the antenna base in the case of the ALCATEL antenna, the 400 MHz phase center in the case of the STAREC antenna)
- to implement the attitude law for each satellite in your software in order to be able to compute the phase-center-to-center-of-mass vector for each measurement
- to use a tropospheric model
- to apply the ionospheric correction by the use of the iono-free combination (IMPORTANT NOTE: the phase center to use is not the 2 GHz phase center any more, but the iono-free phase center)
- to estimate a long term on-board frequency drift

A note written by Flavien Mercier (CNES) which gives the equations to process the DORIS data from RINEX data file and one written by Jean-Michel Lemoine (CNES) which presents how we process RINEX data file in the GINS software are available:

- ftp://ftp.ids-doris.org/pub/ids/data/DORIS_models&solutions_v1.0.pdf
- ftp://ftp.ids-doris.org/pub/ids/data/DORIS_RINEX_implementation_in_GINS.v2.0.pdf

A dedicated web page about DORIS RINEX data was created on the IDS website:
http://ids-doris.org/about-doris-rinex-format.html

9.5.1 RINEX PROCESSING IMPLEMENTATION BY IDS ACS

GRG AC has implemented the processing of RINEX/DORIS data files in the GINS software. In this approach, which consists in converting the phase measurements into Doppler counts, they emphasize that the iono-free phase centers have to be used as the end points of the measurement instead of the 2 GHz phase centers. If omitted, this would lead to a vertical offset of 25 mm when comparing doris2.2 and RINEX/DORIS results. The comparisons between both data formats showed similar results and an identical quality of the orbit (see **Figure 14**) and the station products. However, there are some differences in the scale factor of each single-satellite solution series except for HY-2A. The study of the single-satellite solutions pointed out that Cryosat-2 and Jason-2 are affected by a scale jump in January and June 2012 respectively, only when using the doris2.2 data. This issue is among the ones currently being investigated within the IDS Analysis Working Group. The resulting combined scale factor from the multi-satellite solutions is also clearly increased by HY-2A's contribution. The other issue registered in GRG investigation plan is the along-track bias in the orbit comparisons. They plan to do some tests with the upcoming version of the RINEX/DORIS data which includes an improved time tagging from the PANDOR component. Today, GRG has the capability to process the RINEX/DORIS 3.0 format. This matter is therefore a new crucial project for IDS.

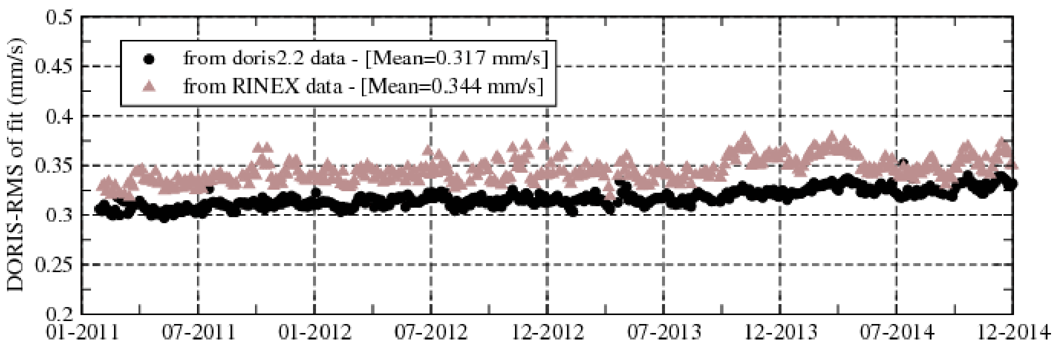

Figure 14: RMS of the Jason-2 DORIS measurement residuals after orbit fit (3.5 day arcs), from doris2.2 data (black circle) and RINEX data (grey triangle)

In 2015, others groups started to implement the RINEX data processing in their software. GSC showed in Washington DC (October 2015) that they obtain encouraging results but some remained to improve. After some exchange with Analysis coordinators they could validate their implementation. For IGN, The DORIS/RINEX reader and phase model and partial derivatives are done. The data filtering is in progress. Note that the data processing and time tagging are done at the same time. For GOP AC the implementation was planned for second half of 2015, in cooperation with the Technical University of Munich (TUM).

9.6 FUTURE PLANS

All ACs have to take the standard routinely processing again by taking into account the news data available of all satellites. They 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). They continue to work on the open points following ITRF reprocessing. Some IDS ACs could contribute to the evaluation of the DORIS versions of the DTRF2014 (DGFI), final ITRF2014 (IGN) and JTRF2014 (JPL) solutions. IDS needs to look how and when to switch to ITRF2014 for operational products. The next IDS Analysis Working Group and Workshop meetings will be held in Delft (Netherlands), May 26-27, 2016 (hosted by TU Delft) and in La Rochelle (France), October 31 November 01, 2016.

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10. IDS COMBINATION CENTER

Guilhem Moreaux *(CLS, France)*

10.1 ACTIVITY SUMMARY

IDS combination activities in 2015 were devoted to the finalization of the IDS contribution to ITRF2014, to the elaboration of the estimation process of a DORIS cumulative solution, to the evaluation of the IGN ITRF2014 solution as well as to communications at EGU and AGU meetings and submission of a paper to the DORIS special issue of Advances in Space Research.

10.2 IDS ROUTINE COMBINATION

Due to the realization of the ITRF2014, the routine combination has been delayed. At the end of 2015, the time span of the SINEX files of the IDS combined solution was 1993.0-2015.5. These files correspond to the IDS 09 series, series which was delivered to the IERS as the IDS contribution to ITRF2014.

10.3 ITRF2014 CONTRIBUTION

The first quarter of 2015 was devoted to the processing of the second half of 2014 and to the delivery of that time period to IERS after the extension of ITRF2013 into ITRF2014. Then, the IDS contribution (series 09) to the 2014 realization of the ITRF was composed by 1140 weekly SINEX solution files from 1993.0 to 2015.0. All the details on the IDS contribution to ITRF2014 can be found in Moreaux et al. (2016).

10.4 IDS CUMULATIVE SOLUTION

As agreed in the IDS AWG held in Toulouse (May 2015), the IDS Combination Center agreed to succeed to P. Willis in the estimation of the ITRF extension for precise orbit determination. The so-called DPOD cumulative position/velocity solutions are computed to include the latest DORIS stations as well as to account for geophysical and/or technical events inducing coordinate and/or velocity changes since the realization of the latest ITRF.

As a preliminary step in the estimation of its first DPOD solution, the IDS Combination Center started to compute a cumulative position/velocity solution from the IDS contribution to ITRF2014. Note that similarly to the evaluation and combination chains, the cumulative chain is based on the CATREF package from IGN. The cumulative chain was designed to be able to make use of the DORIS internal tie vectors from IGN as well as to include velocity constraints. The velocity constraints can be used to either impose the velocity of any station to a given value (from GPS co-located stations or tectonic plate models, for example) or to tightly constrain velocities to the same value over multiple segments unless a velocity discontinuity was observed (for example due to an earthquake). Such velocity constraints make short periods of data before or after a position discontinuity to benefit from the estimated velocity of longer periods at the same site. The cumulative DORIS solution is aligned to a reference datum (ITRF2008, ITRF2014…). The alignment is realized with the network depicted by **Figure 15**. That network was initialized with the stations belonging to the DORIS sites with more than 500 weeks of observations since 1993.0. Then, the network was fine-tuned to improve the homogeneous global distribution with 19 (resp. 18) sites in the northern (resp. southern) hemisphere.

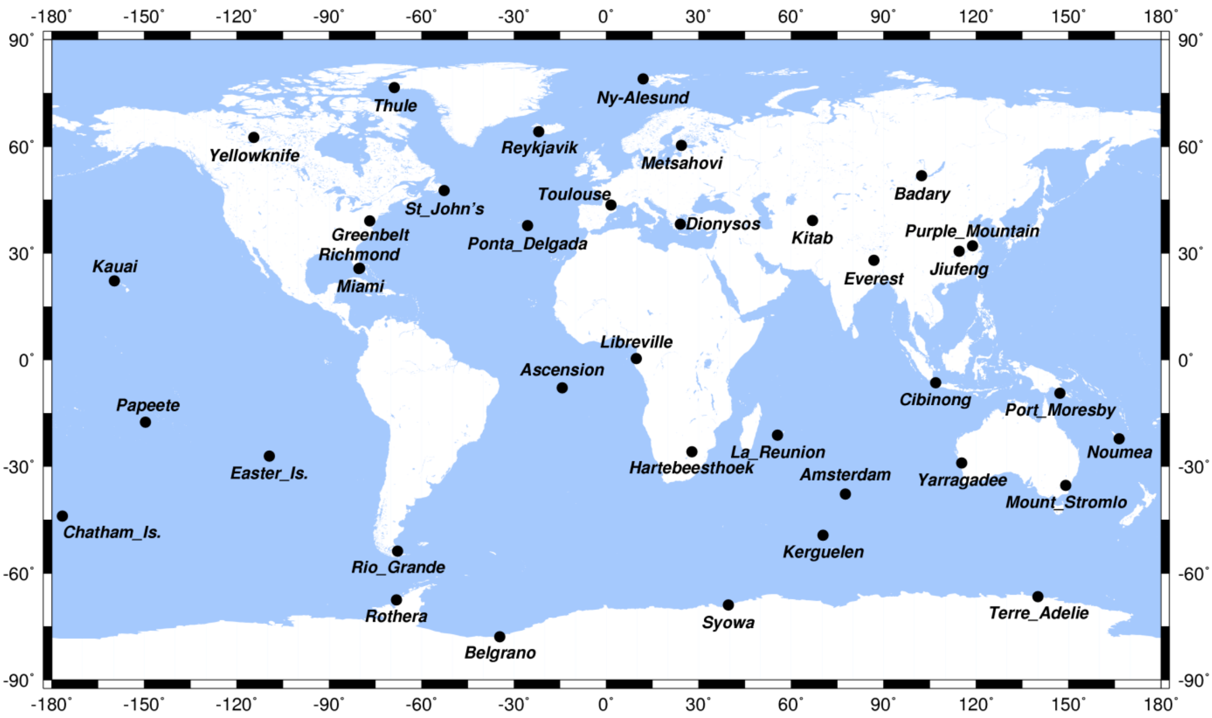

Figure 15: Geographical distribution of the DORIS stations used to align the IDS cumulative solution on either ITRF2008 or ITRF2014

10.5 VALIDATION OF THE IDS CUMULATIVE SOLUTION

To validate the horizontal and vertical velocities from the very first IDS cumulative solution, the Combination Center initialized a study in the second half of 2015. After subtraction of the GIA (Global Isostatic Adjustment) effects from the ICE-6G model to the IDS horizontal velocities, we compared the residual estimations to two global tectonic plate models: GEODVEL and NNR-Morvel-56. The DORIS vertical velocities were compared to the estimations obtained by the La Rochelle University at the co-localized GNSS stations. Sites which show higher differences in either horizontal (ex: Dionysos/Gavdos, Manila) or vertical velocities (ex: Thule, Ny-Ålesund) were of special concern. That study will be the subject of a paper which will be submitted for publication before March 2016.

10.6 COMMUNICATIONS

The IDS Combination Center joined both EGU and AGU fall meetings where it presented one oral presentation and one poster respectively titled “IDS Combined Solution improvements between ITRF2008 and ITRF2014” and “Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with external models”. An abstract on the DORIS evaluation of the DGFI, IGN and JPL realizations of ITRF2014 was also submitted for oral presentation at EGU 2016.

One paper on the IDS contribution to ITRF2014 was submitted and accepted for publication in the DORIS special issue of the journal of Advances in Space Research (see Moreaux et al., 2016). In addition, the IDS Combination Center is co-author of two papers: one on the evaluation of the IDS contribution to ITRF2014 by DGFI-TUM (see Bloßfeld et al., 2016) and one on the elaboration of the STAREC antenna phase law corrections.

10.7 FUTURE PLANS

The first quarter of 2016 will be mainly devoted to the setting up of the estimation process of the DPOD solutions. In parallel, we will evaluate and compare the performances of the three (DGFI, IGN and JPL) realizations of the ITRF2014 solutions. The IDS Combination Center also plans to submit to either Geophysical Journal International or Advances in Space Research the paper titled “Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with external models”. In addition, we have for project to compute the cumulative solution associated to the six IDS AC contributions to ITRF2014 and to derive from it the Fourier analysis of the station coordinate time series.

10.8 REFERENCES

Bloßfeld, M., Seitz, M., Angermann, D., et al., 2016. Quality assessment of IDS contribution to ITRF2014 performed by DGFI-TUM. Adv. Space Res., DOI: 10.1016.j.asr.2015.12.016.

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11. EUROPEAN SPACE OPERATION CENTRE (ESOC)

Michiel Otten, Werner Enderle *(ESOC, Germany)*

11.1 INTRODUCTION

The activities in 2015 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 2015

The upgrades made to the current ESA IDS solution in 2015 were

- Switch to the GRGS EIGEN.GRFS.RL03.v2 model for gravity
- Better handling of the SPOT-5 solar array offset angle
- Switch from NRLMSISE-90 to NRLMSISE-00 model for neutral atmosphere density calculation
- Updated NAPEOS version (3.9)

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 2016 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.

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 AND STANDARDS

All the DORIS data until end of September 2015 were processed and the corresponding SINEX files were delivered to the IDS data centers.

The strategy of the solar radiation pressure (SRP) handling, used in the GOP DORIS data processing, failed when analyzing data from late 2014 and 2015. The processing strategy was based on the iterative process. In the first iteration, the SRP scaling coefficient was adjusted, while the harmonic once per revolution parameters were not estimated. In the second iteration, the SRP scaling coefficient estimate from the first iteration was given as a priori value and strongly constrained (0.0001). The once per revolution parameters in along track direction were adjusted in the second iteration. The failure of this strategy occurred in March-May 2014 (satellites Saral and Cryosat, **Figure 16**) and in March-May 2015 (Saral only, **Figure 17**). The values for the estimated SRP coefficient reached the unrealistic values, while also station coordinates and ERPs were affected. The problem is now fixed changing the processing strategy for Cryosat and Saral, when fixing the long term average value of the SRP coefficient instead of the adjustment.

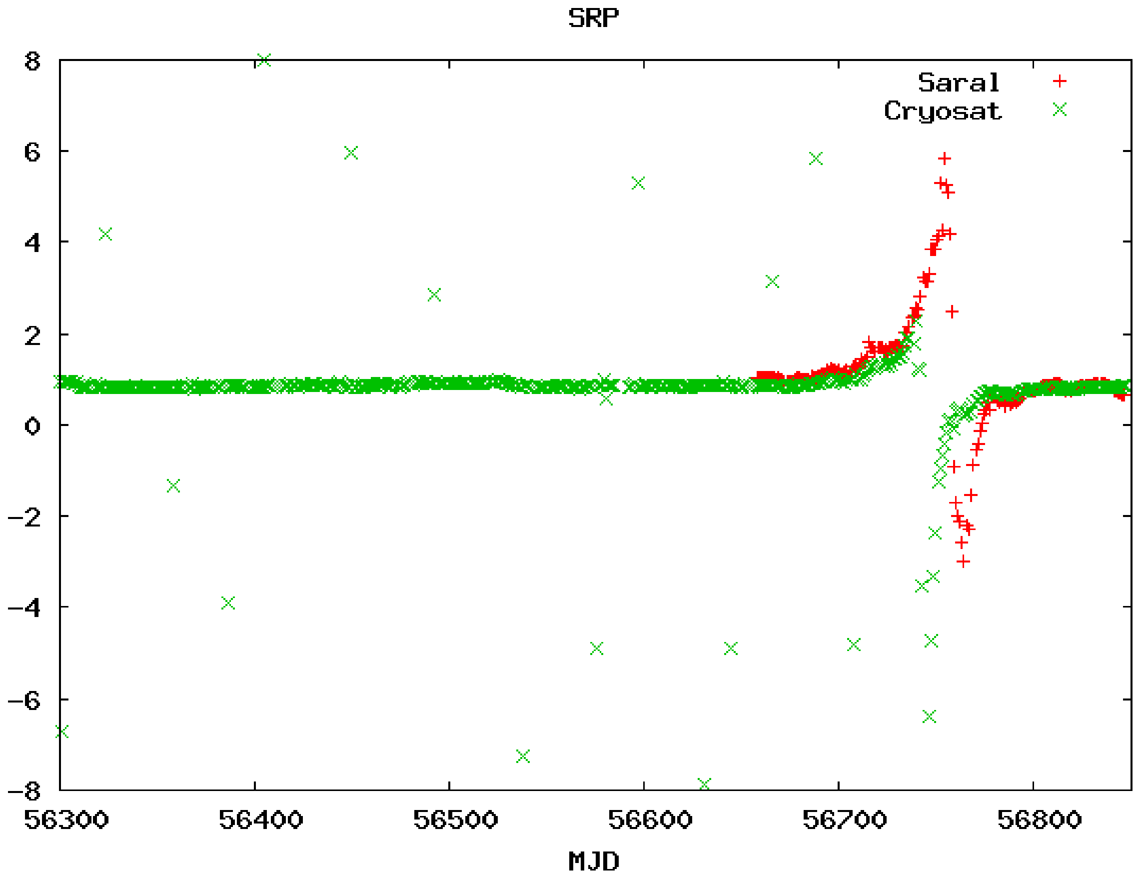

Figure 16: Estimated SRP coefficient abnormality in 2014

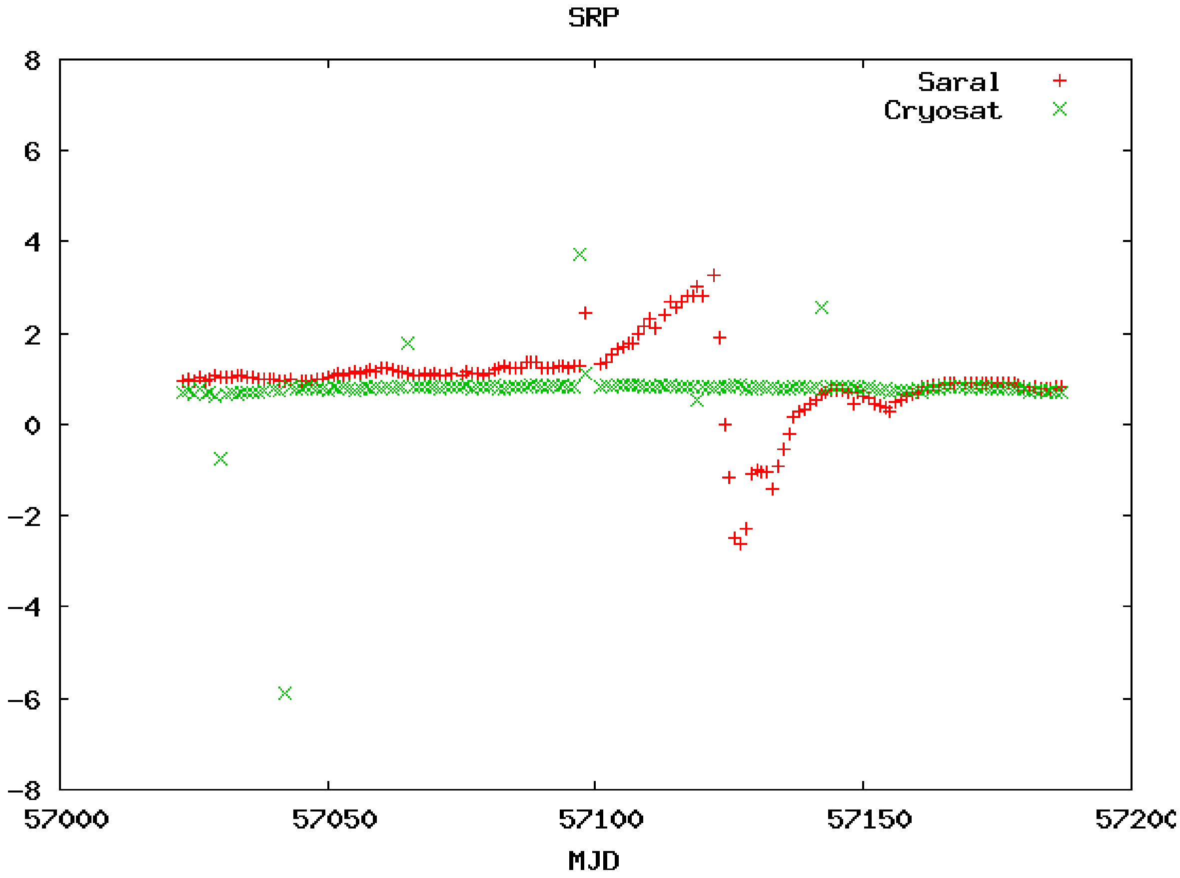

Figure 17: Estimated SRP coefficient abnormality in 2015

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. The only condition is not to adjust cross-track harmonics simultaneously for the reason of very high correlation with LOD. Two years of data were processed (2013.0-2015.0) in the testing campaign, when the Mean difference w.r.t. IERS C04 model was 0.050 ms/day and RMS 0.118 ms/day. The estimated LOD compared to the C04 values is presented in **Figure 18.**

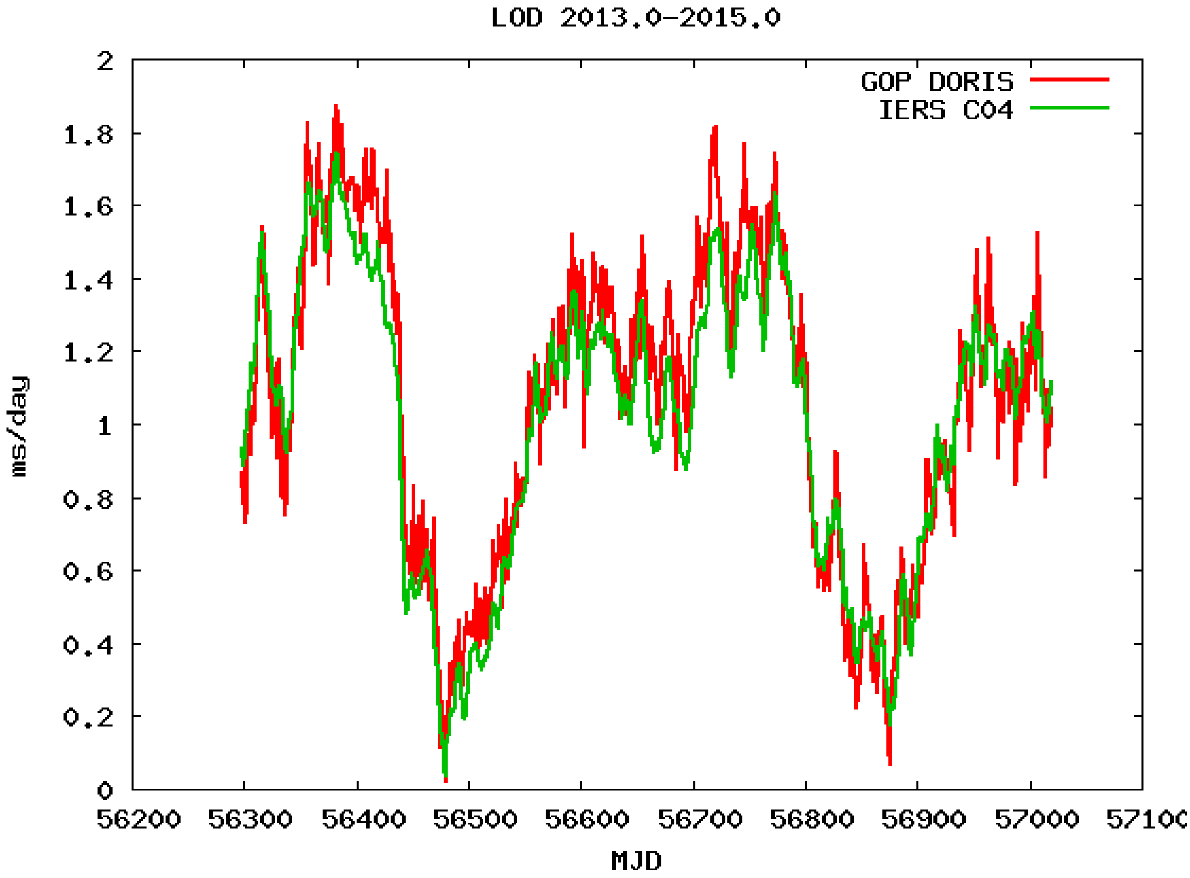

Figure 18: Estimated LOD compared to IERS C04 model

12.3 GRAVITY FIELD AND OCEAN TIDES MODELS APPLICATION

The subject of the study was the impact of a particular setting (maximum degree, time-variable terms) of gravity field and ocean tide models on the quality of the determined orbits. For DORIS satellites SPOT-5 and Jason-2, we optimized the geopotential coefficient truncation degree to meet the limit of 1 mm radial orbit error and 2 mm cross-track and along-track orbit error. A minimum limit for the geopotential coefficient truncation degree is 75 for SPOT-5 and 50 for Jason-2, when using the common dynamic orbit settings and daily orbit arc. The minimum limit for the application of the gravity changes due to the ocean tides is 25 for SPOT-5 and 20 for Jason-2. However, we also demonstrate that these limits depend on an orbit parametrization. Our experiments with SPOT-5 and Cryosat POD show a significant impact of the piecewise linear modeling, applied in the time-varying part of the gravity field model EIGEN-6S2, indicated by the effect on the RMS of the orbit fit. A similar effect of the annual and semiannual gravity terms application on the RMS of the orbit fit was not found, but the arc overlap RMS decreased by 0.6-2 %

13. CNES/CLS ANALYSIS CENTER (GRG, FORMERLY LCA)

Hugues Capdeville, Laurent Soudarin, Adrien Mezerette, Philippe Schaeffer *(CLS, France),* Jean-Michel Lemoine *(CNES/GRGS, France)*

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 2015 was to adapt our POD software to process DORIS RINEX data. We also finalized our contribution to the new release of the International Terrestrial Reference Frame, ITRF2014, and we resumed the standard routine data processing. The attitude of CRYOSAT-2 was analyzed with the quaternions provided by E. Schrama (TU Delft, The Netherlands). In the ITRF2014 context, the SAA corrective models for Jason-1 and for SPOT-5 DORIS data were also assessed.

13.2 STANDARD ROUTINE PROCESSING

To contribute to the new realization of the ITRF (ITRF2014), we completed the processing with the end of the year 2014. This work is described in a paper submitted to ASR revue (DORIS special issue): “Activity of the CNES/CLS Analysis Center for the IDS contribution to ITRF2014”.

The standard routine data processing was resumed by taking into account the data from January 2015 to June 2015. We analyzed the DORIS2.2 data over 3.5-day arcs with a cut-off angle of 12° and applying the ITRF2014 configuration for the following satellites: SPOT-5, JASON-2, CRYOSAT2, HY-2A and SARAL. For each satellite, a single satellite solution was also determined and compared to the DPOD2008.

Table 9 gives the mean values for 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 over the 2015 processing period. The results are at the same level than those obtained for the ITRF2014 realization.

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	2.6	1.5	1.05
JASON-2	0.32 / 1.1	2.6	1.6	0.97
CRYOSAT-2	0.35 / 1.2	3.3	2.4	1.0
HY-2A	0.34 / 1.3	0.5	1.7	0.86
SARAL	0.35 / 1.2	1.6	1.4	1.0

Table 9: Mean DORIS and SLR RMS of fit per arc, OPR amplitude average and Solar radiation coefficient on the entire processing period data processing

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 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.

We evaluate the RINEX/DORIS data processing in comparison with the current processing of the doris2.2 data files. For each satellite, we analyze the impact on the orbit and on the station position estimation. We also address the issue of the scale factor increase from 2012 observed by all the IDS ACs in their solutions produced for ITRF2014. Note that this issue is under investigations within the IDS Analysis Working Group.

The comparisons between both data formats showed similar results and an identical quality of the orbit and the station products (see **Table 10** and **Table 11**). **Table 10** gives the statistics of DORIS and SLR residuals for the Jason-2, Cryosat-2 and HY-2A satellites for the two cases (doris2.2 and RINEX) over the entire period. Even if it not as important as for Jason-2, the DORIS RMS of fit for Cryosat-2 and HY-2A are also slightly higher in the case of DORIS RINEX data. This discrepancy can be fully explained by two factors: the data editing is different between the two sets of data. The rest of the difference comes from a high frequency noise originating from the PANDOR time tagging used in the RINEX files.

For each solution, **Table 11** gives the average of the weekly comparisons over the entire processing period for the translation parameters, the scale factor and the WRMS of the station coordinate differences. In most cases the solutions determined from both types of data sets are very close. We note also a good agreement between the two multi-satellite solutions (combination of Jason-2, Cryosat2 and HY-2A from Oct. 2011 to Dec. 2014) for all parameters.

There are some differences in the scale factor of each single-satellite solution series except for HY-2A (see **Figure 19**). We can note:
a) a discontinuity in the series for Jason-2 in January 2012 with the doris2.2 only;
b) a discontinuity in the series for Cryosat-2 in July 2012 with the doris2.2 only;
c) the series of HY-2A is stable but strongly biased compared to the two other satellites (around 30 mm) with the both sets of data.
This observation aids interpreting the pattern of the scale derived from the combined multi-satellite solutions. The jump observed in the case of the RINEX data is only due to the contribution of HY-2A, while it is a consequence of the inputs of the three satellites in the case of the doris2.2 data. A likely explanation of the discontinuities in January 2012 for Jason-2 and in July 2012 for Cryosat-2 when using doris2.2 data could be linked to the change of tropospheric model used by CNES in its POD processing for the two satellites at those dates respectively (Alexandre Couhert from CNES, personal communication). Indeed, the adoption of a more recent model has induced a reduction of the amount of data marked as rejected in the doris2.2 file, and then, an increase of the data used in our own analysis which is based only on the measurements 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. This assumption is among the ones currently being investigated within the IDS Analysis Working Group.
The other issue registered in our investigation plan is the along-track bias in the orbit comparisons. We plan to do some tests with the upcoming version of the RINEX/DORIS including an improved time tagging from PANDOR component.

This work allowed us to write a paper submitted in the ASR revue (DORIS special issue) “Precise orbit determination and station position estimation using DORIS RINEX data”.

Satellite	***doris2.2***	***RINEX***	***doris2.2***	***RINEX***	***doris2.2***	***RINEX***
Jason-2	0.317	0.344	54850	54130	1.34	1.40
Cryosat-2	0.353	0.367	26990	27620	1.05	1.07
HY-2A	0.332	0.343	35930	34840	1.23	1.23

Table 10: Mean DORIS and SLR RMS of fit per arc on the entire processing period

	Single Jason-2		Single Cryosat-2		Single HY-2A		Multi-satellite	
	DORIS2.2	*RINEX*	*DORIS2.2*	*RINEX*	*DORIS2.2*	*RINEX*	*DORIS2.2*	*RINEX*
TX	-6.0 ±7.5	-7.1 ±8.6	-7.1 ±7.1	-6.5 ±7.1	-5.5 ±4.6	-6.3 ±5.3	-5.7 ±4.6	-6.9 ±5.5
TY	-10.8 ±7.2	-10.2 ±7.3	-2.9 ±6.6	-1.1 ±6.5	0.9 ±4.7	1.3±4.9	-4.2 ±4.1	-4.1 ±4.3
TZ	3.3 ±21.4	10.1 ±19.2	-6.9 ±22.4	-6.9 ±24.2	-92.3 ±19.9	-71.6 ±21.9	-13.8 ±21.1	-5.3 ±15.3
Scale	12.8 ±5.8	13.8 ±5.2	17.2 ±5.5	14.9 ±3.4	31.6 ±2.9	32.2 ±2.8	18.7 ±6.1	19.5 ±5.1
WRMS	22.1	22.7	20.8	19.8	17.7	18.2	14.9	16.1
WRMS North	21.5	22.6	16.8	17.0	15.9	16.4	13.2	14.5
WRMS East	21.8	22.4	25.5	24.3	19.8	20.8	17.1	18.5
WRMS Up	22.8	23.0	18.9	17.0	16.6	16.7	13.9	14.7

Table 11: Results of the comparisons of the single-satellite and multi-satellite solutions to ITRF2008 (units: mm)

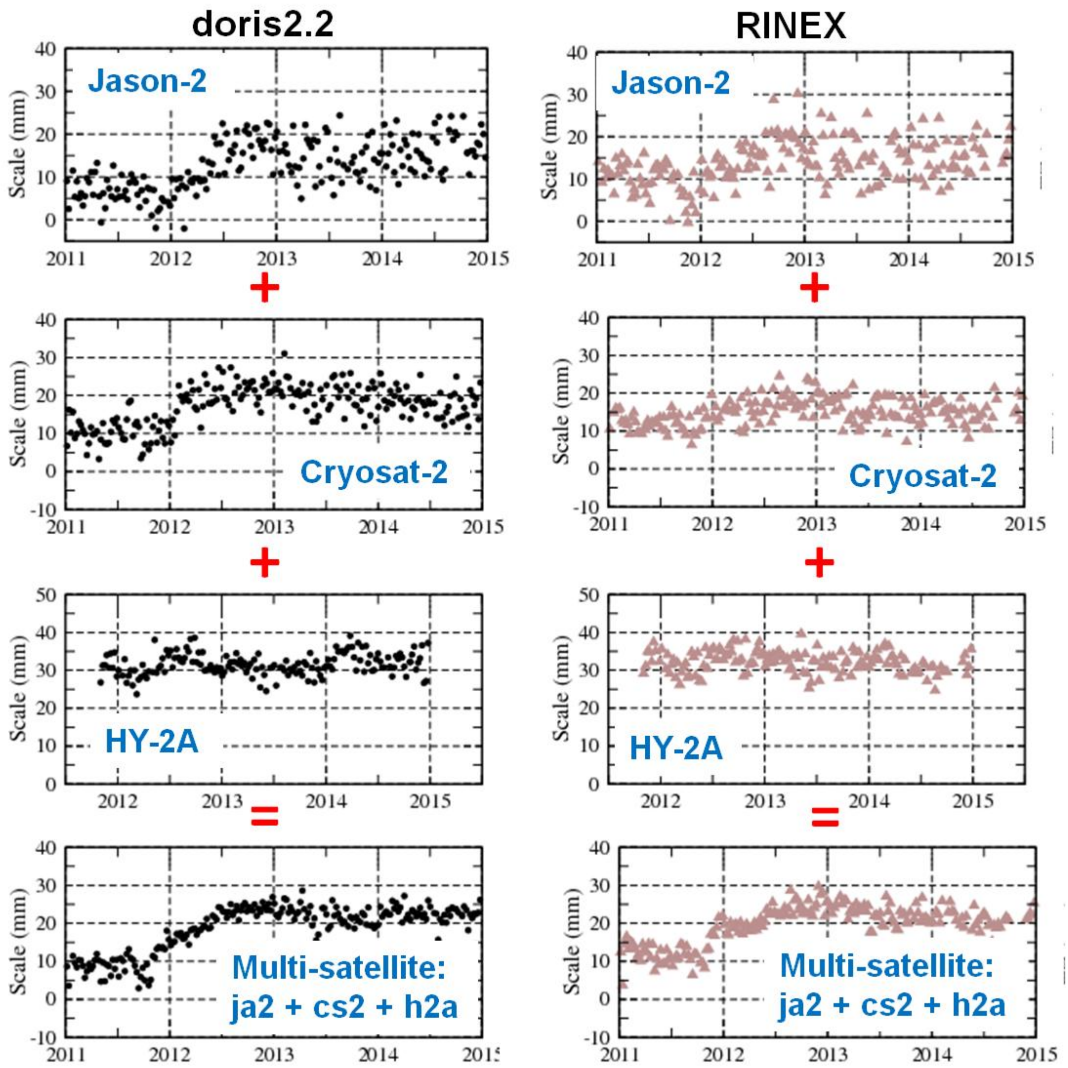

Figure 19: Scale factor for Jason-2, Cryosat-2, HY-2A and the multi-satellite solutions from doris2.2 data on the left (black circles) and RINEX data on the right (grey triangles)

13.4 ANALYSIS OF CRYOSAT-2

We analyzed doris2.2 data with 3.5-day arcs and a cut-off angle of 12° from January 2014 to June 2015 by using the nominal attitude law and the quaternion attitude from E. Schrama (including the 6° pitch in GINS software). In **Table 12** we give DORIS and SLR RMS of fit of the orbit determination and the comparison of the orbit obtained from the two sets. The results are very similar validating the implementation of the nominal attitude in the GINS software. We have also compared the single satellite solution to the ITRF2014 with CATREF software. **Table 13** giving the Helmert parameters (scale and geocenter), and Weighted RMS, shows also identical results.

Attitude	RMS DORIS / SLR (mm/s) / (cm)	OPR amplitude average (10^{-9} m/s^2)		Orbit differences RMS3D
		Along-track	Cross-track	
Nominal	0.352 / 1.25	3.2	2.4	< 1mm
Quaternion	0.356 / 1.26	3.3	2.3	

Table 12: Mean DORIS and SLR RMS of fit per arc, OPR amplitude average and RMS3D orbit differences on the entire processing period

Helmert parameters	Single Cryosat-2	
	Nominal	***Quaternion***
TX (mm)	**-6.1** ± 6.4	**-6.5** ± 6.3
TY (mm)	**-1.9** ± 6.6	**-2.2** ± 6.5
TZ (mm)	**-2.2** ±22.4	**-3.2** ±21.2
Scale (mm)	**11.6** ± 3.3	**12.4** ± 3.6
WRMS (mm)	21.9	22.0

Table 13: Helmert parameters of CRYOSAT2 Single satellite Solution compared to ITRF2014 computed by CATREF: Scale and Geocenter, and Weighted RMS

13.5 SAA CORRECTIVE MODELS

The CNES/CLS AC regularly updates and improves the SAA corrective models for Jason-1 and Spot-5. The GRG AC provided the corrected measurements by the SAA corrective models for Jason-1 and Spot-5 to the IDS data Centers.

In the context of the ITRF2014, the CNES/CLS AC evaluated these corrective models. Based on this work, we write a paper with P. Štěpánek (Geodetic Observatory Pecný, GOP AC): “Update of the corrective model for Jason-1 DORIS data in relation to the South Atlantic Anomaly and a corrective model for SPOT-5” (in press in ASR revue).

13.5.1 EVALUATION OF THE JASON1 SAA CORRECTIVE MODEL

We wanted to show the interest of adding the Jason-1 SAA-corrected solution to the multi-satellite solution. The best time to include Jason-1 SAA-corrected data seems to be the period from the end of TOPEX (November 2004) to the start of Jason-2 (July 2008) in order to fill the gap in the data for the orbits of inclination 66°.

We determine Jason-1 precise orbits by applying the SAA DORIS data correction model and the DORIS stations in the vicinity of the SAA are downweighted. Before combining Jason-1 solution to the other single satellite solutions, parameters of the stations affected by the SAA (positions and troposphere) are renamed in the normal equation systems of Jason-1 (equivalent to a reduction) so that they cannot be combined with the equivalent parameters from the other satellites. We computed a weekly multi-satellite solution with and without Jason-1 from July 2004 to December 2010. Then, we compare these weekly solutions to the ITRF2008 using the CATREF which estimates the Helmert transformation parameters between the free network solutions and the reference set (in this case ITRF2008). Results are shown on **Figure 20** (black curve and grey curve for the multi-satellite solution without and with Jason-1 respectively). The plots show the Helmert translation parameters in X (TX), Y (TY) and Z (TZ) on the right and the scale on the bottom left. The upper-left plot gives the number of stations used for CATREF processing and the number of stations in the SINEX files. The plot on the middle-left gives the weighted RMS of fit obtained by least-square adjustment of CATREF.

The weighted RMS of fit of station positions is at the same level of 13.3 mm for the two solutions. The scale, TX and TY parameters exhibit the same behavior and are at the same level for the solutions with and without Jason-1. When the Jason-1 satellite is added to the multi-satellite solution, the stability of the geocenter TZ is improved (Standard deviation of 11.5 mm vs. 16.5 mm). This improvement during the period from the end of TOPEX (November 2004) to the start of Jason-2 (July 2008) could be explained by the contribution of orbit of inclination 66° due to Jason-1.

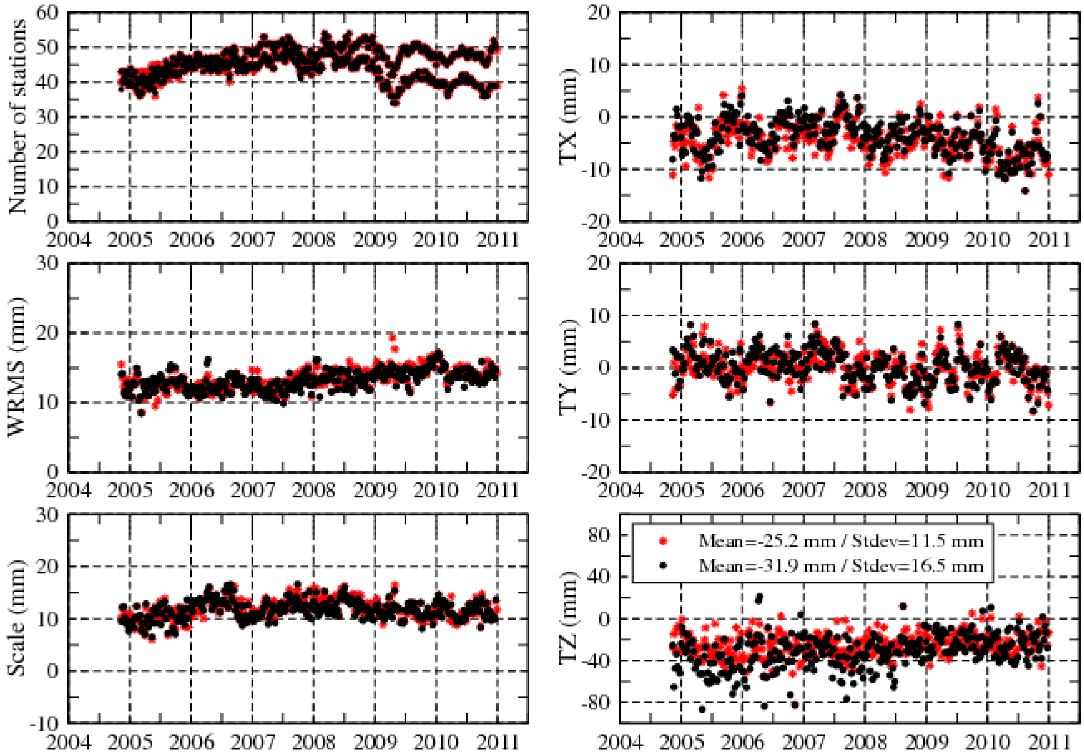

Figure 20: Multi-satellite solution with and without Jason-1 compared to ITRF2008 computed by CATREF. Helmert parameters: Scale and geocenter, in black without Jason-1 and in grey with Jason-1

13.5.2 EVALUATION OF THE SPOT-5 SAA CORRECTIVE MODEL

The SPOT-5 data corrective model significantly improves the POD (RMS of the fit, arc overlap RMS) and the overall statistics of the station position estimation (repeatability, geocenter variations) (see **Figure 21** and **Table 14**). When processing the uncorrected data, the estimated coordinates from the SAA region are biased in all three components, the vertical bias being the highest. It is apparent that the SPOT-5 USO sensitivity to the SAA grows with time. The estimated value of the bias is not the same for the GOP and GRG solutions and there is no clear explanation for this finding. Nevertheless, the application of the data corrective model strongly reduces individual station biases in the North component for all the SAA stations and the height bias for the most affected SAA stations. The East bias is, however, not reduced by this corrective model. The imperfection of the data corrective model is also documented by increased observation residuals in time (for the SAA stations), even in solutions using corrected observations.

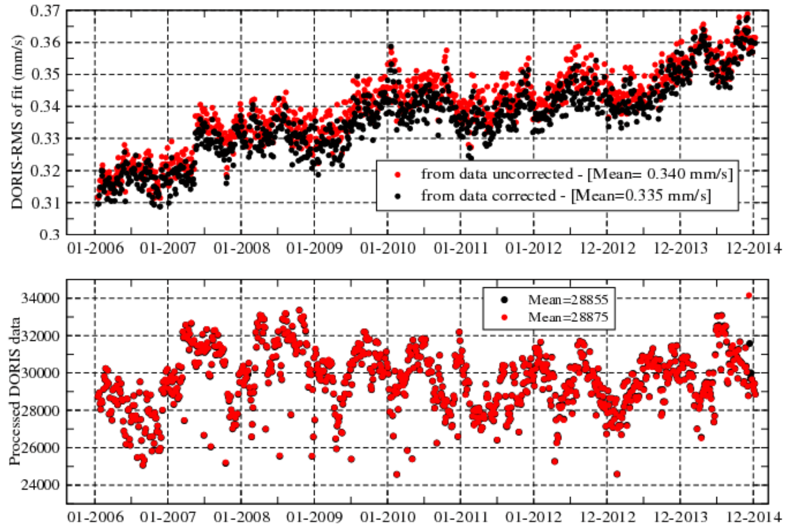

Figure 21: RMS of the orbit fit by arc (3.5 days) – GRG solution. Uncorrected: grey, corrected: black

Solution	Bias/absolute value of bias	No corrections (mm)			Corrected (mm)		
		North	East	Up	North	East	Up
GOP	bias	8.2	-0.4	-56.8	8.1	6.3	1.5
	absolute value of bias	46.2	49.1	74.4	11.8	54.8	11.4
GRG	bias	14.9	1.4	-26.7	12.6	2.0	1.2
	absolute value of bias	25.0	26.8	46.4	13.4	27.6	11.9

Table 14: Average bias and average absolute bias for SAA stations

13.5.3 DELIVERING SAA MEASUREMENTS 2.2 CORRECTED

The Jason-1 doris2.2 data files corrected by the SAA model from cycle number 104 to 241 (from 2004/11/01 to 2008/07/31) are available on the ftp data centers:
ftp://cddis.gsfc.nasa.gov/pub/doris/campdata/saacorrection/ja1
ftp://doris.ign.fr/pub/doris/campdata/saacorrection/ja1 (alternative site: ftp://doris.ensg.eu)

The file name is ja1dataCCC.saa.Z (CCC for the cycle number).

The Spot-5 doris2.2 data files corrected by the SAA model from cycle number 138 to 501 (from December 27, 2005 to November 30, 2015) are available on the ftp data centers:
ftp://cddis.gsfc.nasa.gov/pub/doris/campdata/saacorrection/sp5/
ftp://doris.ign.fr/pub/doris/campdata/saacorrection/sp5 (alternative site: ftp://doris.ensg.eu)

The file name is sp5dataCCC.saa.Z (CCC for the Arc (cycle) number).

13.6 CONTRIBUTION TO IDS MEETINGS

The Analysis Center's representatives participated in 2015 to the AWG meeting in Toulouse and in Greenbelt. They also participate to the OSTST in Reston. They presented the following works:

AWG Toulouse

- GRG ITRF2014 feedback
  http://ids-doris.org/images/documents/report/AWG201505/IDSAWG201505-Capdeville-GRGreport.pdf

- DORIS RINEX data processing at CNES/CLS AC
  http://ids-doris.org/images/documents/report/AWG201505/IDSAWG201505-Lemoine-RINEXprocessingGRG.pdf

- Testing of SPOT-5 SAA data corrective model using long time data series (with and by Petr Stepanek)
  http://ids-doris.org/images/documents/report/AWG201505/IDSAWG201505-Stepanek-SPOT-5SAAmodelTesting.pdf

AWG Greenbelt

- CNES/CLS AC status
  http://ids-doris.org/images/documents/report/AWG201510/IDSAWG201510-Capdeville-GRG_StatusReport.pdf

- ITRF2014P Evaluation by GRG AC
  http://ids-doris.org/images/documents/report/AWG201510/IDSAWG201510-Capdeville-GRG_ITRF2014Pevaluation.pdf

- Explanation of the difference in RMS residuals between DORIS-2.2 and RINEX-PANDOR data
  http://ids-doris.org/images/documents/report/AWG201510/IDSAWG201510-JMLemoine-ExplanationRMSdifferenceDORIS2.2RINEXPANDOR.pdf

OSTST Reston

- Update of the South-Atlantic Anomaly corrective model for JASON-1 DORIS data using the maps of energetic particles from the CARMEN dosimeter onboard JASON-2
  http://meetings.aviso.altimetry.fr/fileadmin/user_upload/tx_ausyclsseminar/files/OSTST2015/POD-08-Capdeville_OSTST_2015_SAA_HC.pptx.pdf

13.7 PUBLICATIONS IN PEER-REVIEWED JOURNALS

In 2015, we have submitted three papers in the ASR revue (DORIS special issue).

Capdeville, H.; Štěpánek, P.; Hecker, L.; Lemoine, J.M., in press. 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, DOI: 10.1016/j.asr.2016.02.009

Lemoine, J.M.; Capdeville, H.; Soudarin, L., in press. Precise orbit determination and station position estimation using DORIS RINEX data, ADVANCES IN SPACE RESEARCH, DOI: 10.1016/j.asr.2016.06.024

Soudarin, L.; Capdeville, H.; Lemoine, J.M., submitted. Activity of the CNES/CLS Analysis Center for the IDS contribution to ITRF2014, ADVANCES IN SPACE RESEARCH

14. GSFC/NASA ANALYSIS CENTER (GSC)

Frank G. Lemoine *(NASA, USA)*
Douglas S. Chinn, Nikita P. Zelensky *(SGT/NASA, USA)*
Karine Le Bail *(NVI Inc-NASA, USA)*

The GSC analysis center focused on the following activities in 2015.

(一). Preparation and delivery of the final SINEX files for the gscwd25, gscwd26 series delivered for ITRF2014.

(二). Preparation of journal papers to document the GSC DORIS contribution to ITRF2014, and contributions to the joint paper discussing the combined DORIS technique submission to ITRF2014.

(三). Analysis of SARAL Satellite Laser Ranging (SLR) & DORIS data and preparation of a journal paper describing these analyses.

(四). Development of test solutions for the radial offset of HY-2A.

(五). Analysis of the Jason-2 DORIS RINEX data, design of the GSFC software and procedures to use these data, in preparation for the launch of Jason-3.

14.1 SINEX DELIVERIES FOR ITRF2014:

The NASA GSFC DORIS analysis center processed data from January 1993 to December 2014 and provided 1141 weekly solutions in the form of normal equations for incorporation into the DORIS solution for ITRF2014. These were delivered to the NASA CDDIS and to the IDS Combination Center. We prepared two solutions for delivery: gscwd25, and gscwd26. The gscwd25 series included the detailed modeling of time-variable gravity using a weekly time series of spherical harmonic coefficients derived from up to 20 SLR+DORIS tracked satellites. The gscwd26 series differed in two ways from the gscwd25 series: (1) The cross-track empirical once-per-rev (OPR) accelerations were adjusted once per arc, rather than once per day; (2) The nominal attitude law instead of the GEODYN-implemented use of the Cryosat-2 quaternions was used to model the attitude and the measurement model corrections for Cryosat-2. In **Table 15**, we provide a summary of the recent DORIS data, where we have extended the processing in 2015.

In addition to looking at the RMS of fit, we have looked closely at the time history of the empirical accelerations, in order to diagnose any problems with the orbit modeling. Occasionally problem arcs will have higher empirical accelerations than the adjacent arcs – so this is an important diagnostic for POD. In addition, large periodic patterns can be indicative of the need to tune the macromodel parameters. We summarize in **Table 16** the median of the amplitude of the along-track and cross-track OPR's, and the median value of the along-track constant acceleration, which is adjusted only for HY-2A.

Of the satellites in the Table, Cryosat-2 manifested periodic patterns but these did not seem correlated with the beta-prime period of the satellite. The signals on HY-2A look periodic, and it would be beneficial in the future to attempt to tune (or retune) the macromodel. A peculiarity of HY-2A is that we must solve for an empirical along-track constant acceleration. This ranges in value from -0.9 nm/s2 at the start of the mission to about -2.0 nm/s2 at the end of the time period shown above. We have no explanation as to why the satellite experiences this variable along-track thrust!

Satellite	Time Span	Narcs	Avg. Nobs	Avg. Fit (mm/s)
Cryosat-2	2010/06 – 2015/06	337	48659	0.4023
HY-2A	2011/11 – 2015/06	225	61462	0.3990
Jason-2	2008/07 – 2015/06	377	109563	0.3832
SARAL	2013/03 – 2015/06	149	52244	0.3968
SPOT-5	2008/07 – 2015/03	387	55003	0.4073
Jason-2 time period only; Use SAA-corrected data.				

Table 15: Summary of RMS of fit for Recent DORIS data processed using the gscwd26 standards

Satellite	Time Span	Narcs	Along-track OPR (median, nm/s2)	Along-track constant (median, nm/s2)	Cross-track OPR (median, nm/s2)
Cryosat-2	2010/06 – 2015/06	1835	2.49	-	1.98
HY-2A	2011/11 – 2015/06	1248	2.75	-1.64	2.39
Jason-2	2008/07 – 2015/06	2472	1.24	-	2.42
SARAL	2013/03 – 2015/06	149	1.40	-	1.42
SPOT-5	2008/07 – 2015/03	387	0.86	-	0.76
Jason-2 time period only; Use SAA-corrected data.					

Table 16: Summary of Daily Amplitudes for Empirical Accelerations for Recent Data Arcs

14.2 SUBMISSION OF JOURNAL PAPERS:

The GSC analysis center prepared or participated in three peer-reviewed articles for the DORIS special issue in the journal Adv. Space Research. We list these papers in **Table 17.**

Lemoine, F.G., D.S. Chinn, N.P. Zelensky, J.W. Beall, K. Le Bail, "The Development of the GSFC DORIS Contribution to ITRF2014", Adv. Space Res., doi:10.1016/j.asr.2015.12.043. (In Press, Available online 12 January 2016).
Zelensky, N.P., F.G. Lemoine, D.S. Chinn, B.D. Beckley, O. Bordyugov, X. Yang, J. Wimert, D. Pavlis, "Towards the 1-cm SARAL orbit", Adv. Space Res., doi:10.1016/j.asr.2015.12.011. (In Press, Available online 19 December 2015).
Moreaux, G., F.G. Lemoine, H. Capdeville, S. Kuzin, M. Otten, P. Stepanek, P. Willis, P. Ferrage, "The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame", Adv. Space Res., doi:10.1016/j.asr.2015.12.021. (In Press, Available online 24 December 2015)

Table 17: DORIS-related Journal papers submitted in 2015 by the GSC Analysis Center

14.3 ANALYSIS OF SARAL DATA:

We did not include SARAL in our ITRF2014 processing, because we felt that the modeling and data processing had not been totally validated. As summarized in Zelensky et al. (2016) (see**Table 17**) we discuss the tests and analysis that we applied to the orbit modeling for SARAL. The most important conclusions are the following:

(1) Separate analysis of the SLR and DORIS data reveals that the a priori Center-of-mass position in the spacecraft frame is in error. The Z coordinate must be corrected by -4.5 cm. In addition we also tuned the SLR and DORIS offset positions. As per Table 3.1 of Zelensky et al. (2016) we recommend use of the following offsets for SARAL (see **Table 18**). We recommend adoption of these updated values for orbit determination on SARAL and we intend to adopt these in our future work.

	X (m), nadir	Y(m), along-track	Z(m), cross-track
Satellite Tracking Point Offsets			
DORIS	0.0031	0.0000	-0.0406
SLR	0.0158	0.0000	-0.0456
Satellite Center-of-mass coordinates			
A priori	-0.0012	-0.0067	-0.6583
Updated	-0.0012	-0.0067	-0.6152

Table 18: Updated Tracking Point and Center-of-mass offsets for SARAL

(2) Analysis of the high-elevation SLR residuals suggests that the orbit accuracy for the SARAL DORIS-only orbits is between 10-15 mm. We compared our NASA GSFC orbits with the SARAL GDR-D orbits of the CNES from March 2013 to August 2014, and we found that the radial orbit differences were ~10 mm RMS, but with a strongly geographically correlated component. It seemed that the variabilities in the modeling of time-variable gravity between the analysis centers strongly contributed to these orbit differences.

(3) SARAL is in a sun-synchronous, near-full-Sun orbit. Nonetheless, the satellite does experience a limited eclipse period in December, where the percentage of the orbit in eclipse reaches 16%. It is in this time period that the cross-track empirical accelerations become as high as 2-5 nm/s2, whereas for the rest of the year they average ~1 nm/s2 in amplitude. It seems clear that thermal effects (i.e. unmodeled thermal accelerations such as anisotropic thermal emission) are responsible for these effects.

14.4 ADJUSTMENT OF HY-2A RADIAL OFFSET:

With respect to HY-2A, now is the winter of our discontent. We have made an attempt to elucidate the scale offset issue on HY-2A. As discussed in IDS AWG meetings, the HY-2A single-satellite scale in the Helmert transformations with respect to ITRF2008 are biased high with respect to the other satellites. We summarize in **Table 19** the mean scales (w.r.t. ITRF2008) that we find for the gscwd26 SINEX solution and for the single-satellite SINEX solutions in 2012-2014. Here, we show the mean and the standard deviation of the scales of the weekly solutions (smoothed with a five week running mean). We see immediately that HY-2A is biased with respect to gscwd26 by about +12.7 mm, and with respect to Jason-2 and Cryosat-2 by approximately +16 mm. It is interesting that the Jason-2 and Cryosat-2 scales agree with each so closely.

Solution	(smoothed) Scale (mm) w.r.t. ITRF2008
gscwd26	19.27 ± 1.55
Cryosat-2	15.98 ± 2.15
Jason-2	16.16 ± 2.04
SPOT-5	19.33 ± 1.84
HY-2A	32.08 ± 2.36

Table 19: Scales of gscwd26 and single-satellite solutions for 2012-2014

We conducted some preliminary tests to see if an adjustment of the radial offset could somehow accommodate the scale offset on HY-2A, adjusting a Z-offset for the DORIS-only arcs, and an SLR offset for the DORIS+SLR arcs. The DORIS-only adjustment seemed larger than expected, and somewhat unrealistic (a priori Z=1.3060 m, adjusted Z=1.3558 m), whereas the SLR offset adjustment was much smaller (a priori Z=0.9944 m, adjusted Z=0.9823 m). In any event, we did not observe the same phenomenon as on SARAL, where both the SLR and DORIS offsets adjusted by ~4.5 cm in the same direction. For SARAL, the similarity in the SLR & DORIS adjustments was diagnostic of an error in the a priori center-of-mass information, however, we can say we do not see such evidence for HY-2A. We will continue to investigate the potential causes of the scale offset on HY-2A in the coming year.

14.5 ANALYSIS OF DORIS/RINEX DATA WITH JASON-2:

In preparation for the launch of Jason-3, we started to look at the processing of RINEX data for Jason-2, following carefully the presentations made by J.M. Lemoine and F. Mercier at earlier IDS AWG meetings. We analyzed all available data for Jason-2, and compared the RINEX processing with the standard processing using the DORIS version 2.2 format data. Our RINEX processing included the following: (1) We determine a USO frequency offset from the RINEX data by taking the provided values and doing a fit (second order polynomial) over a full cycle; (2) As recommended by J.M Lemoine (2015), we apply the periodic correction to the DORIS satellite clock that includes the effect of the Earth J2. We find RMS of fit per data arc that is slightly higher than with DORIS format 2.2 data, by about 0.02 mm/s RMS on average. On the other hand, whereas with the DORIS format 2.2 data we find a mean DORIS time bias (w.r.t. SLR) of -1.15 µsecs, but with the DORIS/RINEX data we find a mean DORIS time bias of -0.05 µsecs. We observe a mean RMS radial difference in the orbits computed from RINEX data compared to those computed with the DORIS V2.2 format of ~2 mm. The RMS SLR residuals for the DORIS-only Jason-2 orbits are comparable for both the RINEX processing and DORIS v2.2 data: ~1.7 cm RMS. We originally observed some anomalies in the DORIS processing with the RINEX data starting in late 2013. After the IDS AWG meeting in Greenbelt, this problem was traced to using a station set that omitted the most recent DORIS stations. When we updated to a newer DORIS station complement (DPOD2008v15 vs. DPOD2008v13), this anomaly disappeared. As a result, we can conclude we are operationally ready to process DORIS/RINEX data for Jason-3 and the other DORIS satellites, with the caveat that the cause of the slightly higher RMS of fit remains to be elucidated.

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 2015, IGN used the most recent versions (GOA 6.2 and successive development versions). This software package is installed on both sites at IGN in Saint-Mandé and at IPGP in Tolbiac. In 2015, 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 2015, the continuation of the solution submitted for the ITRF2014 contribution (ignwd15) was performed.

15.2 PRODUCTS DELIVERED IN 2015

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. 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.

As no ITRF solution was available in 2015 (see **Table 20**), only free-network solutions were submitted. Other products will soon be submitted as a new ITRF2014 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.

Some preliminary results were also obtained for tropospheric estimation to investigate the impact of the phase law corrections.

In 2015, some limited work was conducted toward the realization of a new DPOD2008 solution (terrestrial reference frame for precise orbit determination derived from ITRF2008), for which several updates were delivered and are still available at the following Web site : http://www.ipgp.fr/~willis/DPOD2008/. Version 1.14 is available at the end of 2013, including all possible DORIS stations (Willis et al., in press). This activity is now managed by Guilhem Moreaux.

Product	Latest version	Update	Data span	Number of files
Weekly SINEX free-network	ignwd15	Weekly	1993.0-2016.0	1199
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 20: IGN products delivered at the IDS data centers until the end 2015. As of March 8, 2016

15.3 MAJOR IMPROVEMENTS IN 2015

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 the implementation of the phase law correction in the GIPSY-OASIS II software package.

Recent results obtained in 2015 also show a possible (minor) sensitivity of the Jason-2/DORIS oscillator to radiations over the South Atlantic Anomaly (SAA), see Willis et al. (submitted).

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/Eratosthene proposals to NASA and ESA.

A few papers were submitted to the DORIS Special Issue in preparation in Advances in Space Research and some are still under review.

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Pascal Willis, Michael B. Heflin, Bruce J. Haines, Yoaz E. Bar-Sever, Willy B. Bertiger, Mioara Mandea, Is the Jason2 DORIS oscillator still affected by the South Atlantic Anomaly?, ADVANCES IN SPACE RESEARCH, submitted.

16. INASAN ANALYSIS CENTER (INA)

Sergey Kuzin *(INASAN, Russia)*

16.1 INTRODUCTION

In 2015, INASAN (ina) DORIS Analysis Center reprocessed all DORIS data for 1993.0 - 2016.0 time period with the applying phase center correction law for the ground antennas (inawd10 series). INASAN used the latest version of GIPSY- OASIS II software package (v. 6.3, developed by JPL) for the data reprocessing. **Table 21** shows current products delivered by INASAN to the IDS. Inawd08 free-network weekly time series are the INA AC contribution to IDS ITRF2014 realization. Inawd09 time series are the solutions including satellites (HY2A and SARAL). Inawd10 SINEX series are the current solutions including HY2A and SARAL satellites and phase law correction.

Product	Version	Span
Sinex weekly free-network solutions	inawd08 (contribution to ITRF2014, completed)	**1993.0 – 2015.0**
	inawd09 (inawd08+HY2A+SARAL, completed)	**2011.8 - 2014.6**
	inawd10 **(current series: inawd08+HY2A+SARAL+phase law)**	**1993.0 – 2016.0**

Table 21: INASAN SINEX series delivered to the IDS (February 2016)

16.2 MAJOR IMPROVEMENTS IN 2015

The main improvements in the current inawd10 solutions as compare with the previous ones connected with the use of:

- phase law corrections
- new satellites for the processing (HY2A and SARAL).

16.3 ANALYSIS RESULTS DESCRIPTION

16.3.1 MAIN SCIENTIFIC RESULTS OBTAINED FOR THE ITRF2014 REALIZATION

Figure 22 illustrates per weekly comparison of the INASAN inawd07 (submitted for ITRF2008 realization) and inawd08 solutions with the respect to ITRF2008 (from the ids09 cumulative solution submitted to IERS). The graph shows the variations of the scale parameter and the weighted RMS of station positions. The vertical lines on the graphs divide the time periods by the different number of observing satellites in the comparison procedure.

Comparing the plots of the inawd08 solutions with the inawd07 ones (**Figure 22**) we can see that the weighted RMS shows obviously marked jump after 2002. The level of residuals drops from 20 mm till 10 mm. Generally speaking, the WRMS correlates with the number of DORIS satellites in operation. This jump can be explained by the increasing of the number of satellites in 2002 from 3 to 5. The scale is rather stable during the period 1993.0 till mid 2012 and depends on the geometry of the system. At the same time we can see scale rise at the around mid 2012. The reason of that scale increase is not clear and is currently under investigation within the IDS Analysis Centers.

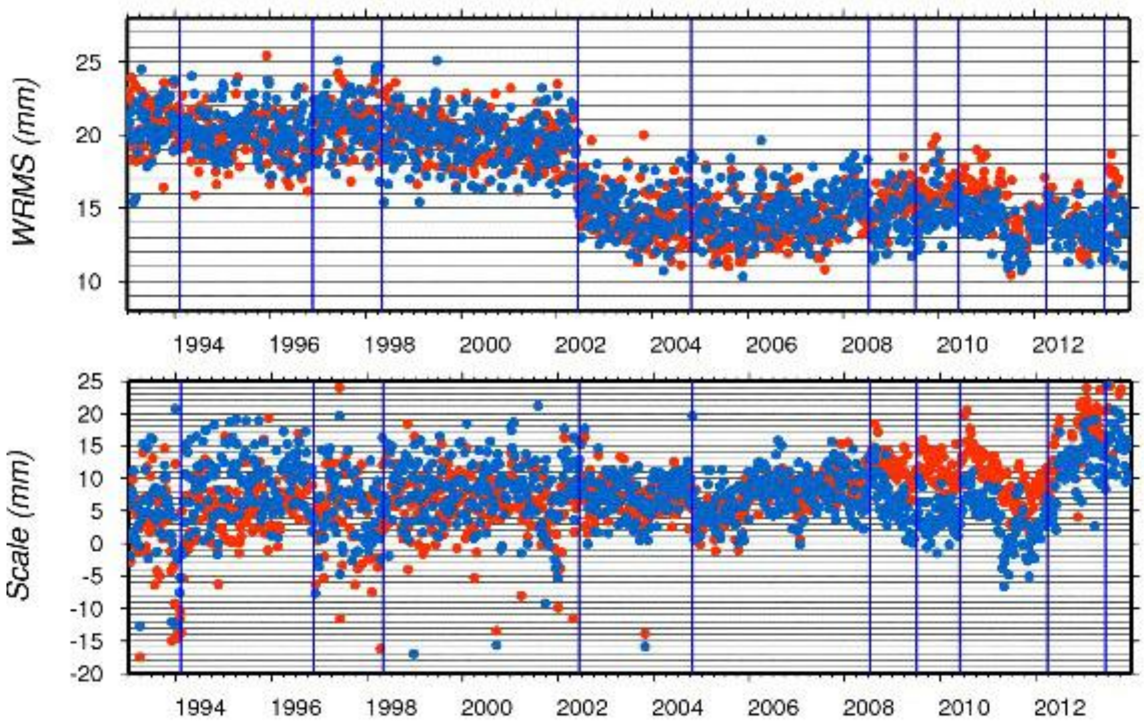

Figure 22: Weekly comparison of the 3D WRMS station positions and scale for the INASAN inawd07 and inawd08 solutions with the respect to ITRF2008 solution (inawd08 solution – blue color, inawd07 solution – red color)

AC series (time interval)	WRMS (mm)	Scale (mm)	TX (mm)	TY (mm)	TZ (mm)	Scale (mm/yr)	TX (mm/yr)	TY (mm/yr)	TZ (mm/yr)
idswd09 (1993.0-2015.0)	16.05 ±3.40	13.23 ±4.01	-4.45 ±4.92	-3.45 ±5.45	-13.02 ±17.86	0.32 ±0.02	-0.17 ±0.02	-0.21 ±0.03	0.05 ±0.08
inawd08 (1993.0-2015.0)	21.38 ±4.41	9.10 ±5.60	-4.82 ±6.95	-7.66 ±8.39	-12.56 ±23.53	0.18 ±0.03	-0.13 ±0.03	-0.36 ±0.04	1.31 ±0.11
inawd07 (1993.0-2013.8)	17.09 ±2.14	7.71 ±5.55	-3.80 ±7.81	-5.07 ±8.83	-6.06 ±24.82	0.52 ±0.03	0.04 ±0.04	-0.44 ±0.05	2.46 ±0.13

Table 22: Comparative statistical characteristics (mean values) of the INA analysis center contribution to ITRF2008 (inawd07), ITRF2014 (inawd08) and IDS combined solution submitted for ITRF2014 realization (idswd09). The reference frame for comparison is ITRF2008 for all time series

Table 22 gives statistical information of the INASAN contributions to ITRF2008 and ITRF2014 and corresponding IDS combined solution ids09 submitted for the ITRF2014 realization. The epoch for the comparison is the mean value over the whole time period.

As we can see from the **Table 22** WRMS, scale coefficient and two translation parameters (Tx, Ty) values are a little bit higher from the inawd08 solution as compare with the inawd07 one. Tz translation component considerably increased (for two times), what can be possibly explained by the increasing of the scale in the mid of 2012 detected by all Analytical Centers. We can see accuracy degradation of the geocenter determination for inawd08 series compare with the inawd07series, but geocenter drift is smaller for the latest inawd08 solution. The Z-geocenter drift component is considerably higher for both INA solutions (inawd08 and inadw07) with the respect to X and Y-geocenter components. This effect can be explained the fact that the estimated Z-geocenter component for DORIS measurements is usually affected by large systematic errors of unknown cause (Gobinddass et al., 2009b). It is expected that the combined solution should be better than any individual solution and one can see from the **Table 22** that values for the Helmert transformation parameters of the idswd09 solution are lower or comparable with the those ones of inawd08. Although it is not exactly correct to compare inawd08 and inawd07 series with the idswd09 solution as the latter used phase center corrections for the DORIS ground antennas.

Figure 23 shows differences of X-pole and Y-pole components, estimated by the inawd08 and inawd07 solutions, with respect to IERS C04 solution.

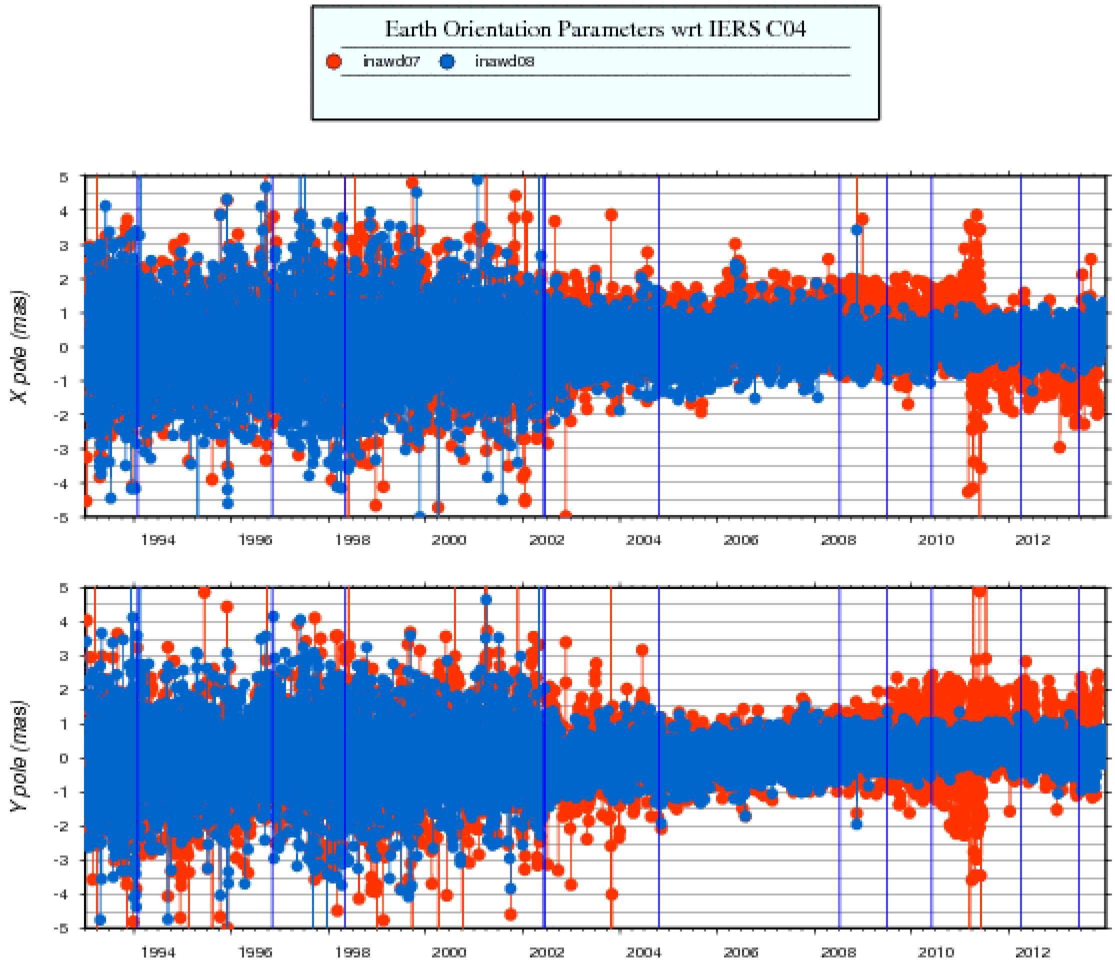

Figure 23: Differences of X-pole and Y-pole components of the inawd08 and inawd07 time series with respect to IERS C04 solution

From these plots we clearly observe an improvement of inawd08 EOP series components compare to inawd07 ones. This evident improvement connected with the fact that polar motion rate was estimated in the daily DORIS computations for inawd07 series and not estimated in inawd08 ones (Willis et al., 2010a). The standard deviation (std) drops from 1.186 and 1.226 mas for X-pole and Y-pole components of inawd07 EOP series to 0.941 and 0.852 mas for inawd08 EOP series. Thus, the agreement with the IERS C04 solution is now better than 0.1 mas (in mean) with a dispersion of about 1 mas. The significant precision improvement of the X and Y pole components after 2002 connected with the changing of the satellites constellation. For that period the number of satellites jumps from 3 to 5 satellites. Each time when a new satellite is added the quality of the EOP series becomes better due to the increase of DORIS data. **Table 23** displays the statistical information about INA EOP time series.

It should be mentioned that **Figure 22** and **Figure 23** as well as numbers in the **Table 22** and **Table 23** were obtained by Dr. G. Moreaux (IDS combination Center) using CATREF software package.

Series	**Period days**	**X pole (mas)**		**Y pole (mas)**	
		mean	std	mean	std
inawd07	7519	0.198	1.186	0.034	1.226
inawd08	7637	0.062	0.941	0.065	0.852

Table 23: INA AC Earth Orientation Parameters Residuals wrt IERS C04

16.3.2 IMPACT OF APPLYING GROUND ANTENNAS PHASE LAW ON DORIS-DERIVED TRF SCALE

After delivery of the INA AC solution (inawd08 series) to the ITRF2014 realization, the PCV corrections (Tourain et al., submitted) for the DORIS ground antennas were included in GIPSY-OASIS II software. All DORIS data for 1993.0 - 2015.0 time interval were reprocessed with the same models and strategies as for ITRF2014 processing taking into account phase law corrections. This new weekly SINEX time series (inawd10) was sent to IDS for validation. After transforming inawd10 time series into DPOD2008 (v.1.13) we can compare effect of PCV corrections for ground antennas on scale Helmert transformation parameter. The results of this comparison are given on **Figure 24**. The mean scale factor values for inawd08 and inawd10 time series are 1.34 ± 0.79 ppb and 2.58 ± 0.82 ppb, respectively. As one can see, the effect of applying PCV correction model for ground DORIS antennas offsets the mean scale factor for about 1.24 ppb (~ 8 mm) with respect to processing without PCV correction. It should be mentioned here as we are used DPOD2008 (v.1.13) for comparison, it will favor solutions without phase law corrections, while comparing with the new IDS combined solution will favor DORIS solutions with phase law corrections. Thus the current results may show a degradation, which depends on the chosen reference system.

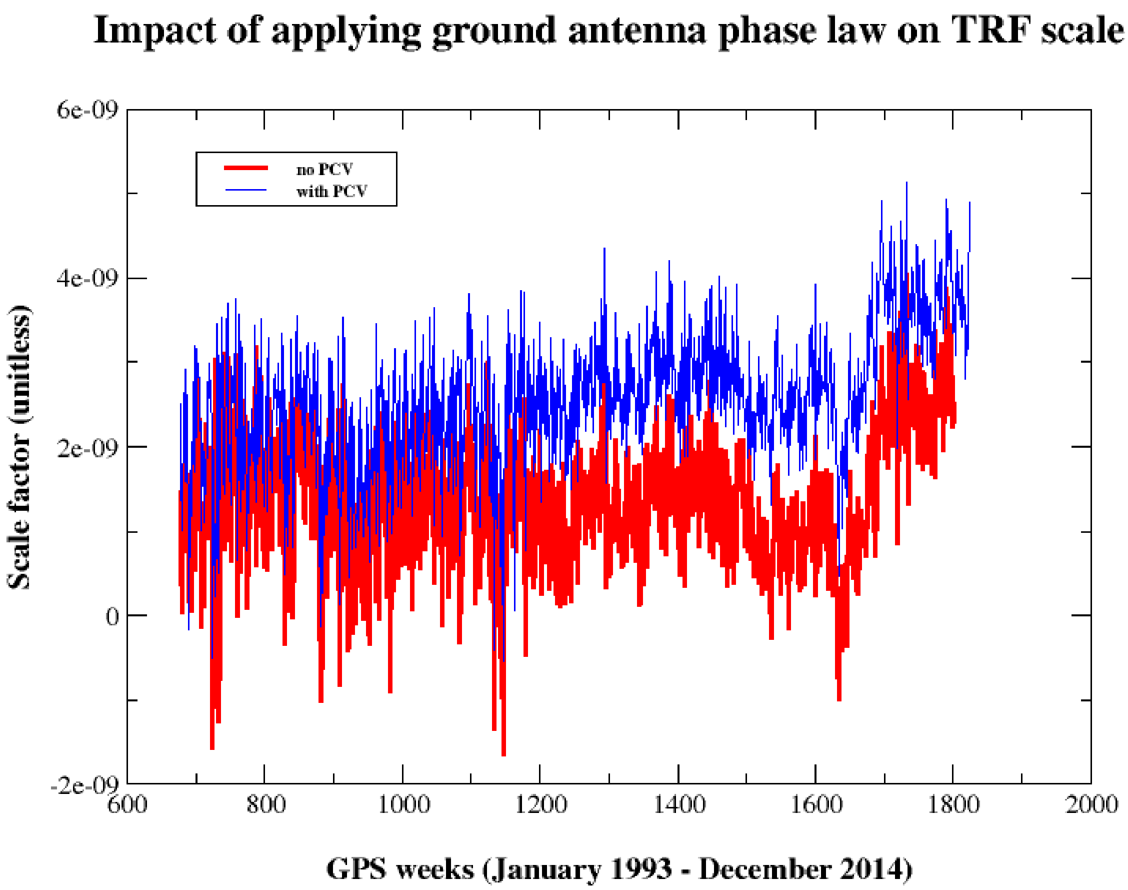

Figure 24: Comparison of scale factor variations for two weekly INA time series with respect to DPOD2008 (v.1.13): inawd08 (lower line, no PCV corrections) and inawd10 (upper line, with PCV corrections)

16.4 REFERENCES

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Moreaux, G., Lemoine, F.G., Capdeville, H., et al., The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame, DOI: 10.1016/j.asr.2015.12.021. In press ASR, 2016.

Tourain, C., Moreaux, G., Auriol, A., DORIS STAREC ground antennas characterization, impact on localization. Submitted to ASR, 2016.

17. REPORT OF THE GFZ ASSOCIATED ANALYSIS CENTER

Sergei Rudenko, Karl-Hans Neumayer *(GFZ, Germany)*

17.1 INTRODUCTION

The activities performed at GFZ in 2015 related to DORIS data processing included further updates of GFZ's “Earth Parameter and Orbit System - Orbit Computation (EPOS-OC)” software used for Precise Orbit Determination (POD) of DORIS satellites, in particular, for Jason-1 and Jason-2, implementation and tests of new models, such as EIGEN-GRGS.RL03-v2.MEAN-FIELD time variable geopotential model, reprocessed GFZ Atmospheric and Oceanic De-aliasing Level-1B (AOD1B) REL05 product, EOT11a ocean tide model, Jason-1 and Jason-2 true attitude in the quaternion form, updated macro-models of TOPEX/Poseidon, Envisat, Jason-1 and Jason-2, computation and detailed analysis of TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2015) VER11 orbits derived in the same ITRF realization (ITRF2008, Altamimi et al., 2011) using consistent, improved models for precise orbit determination for all four missions at the time intervals specified.

17.2 SOFTWARE UPDATES AND TESTS OF NEW MODELS IN 2015

The following updates of the EPOS-OC software and models used for precise orbit determination of DORIS satellites were performed.

Jason-2 satellite, its macro-model and other satellite-related information were included in the EPOS-OC software. Eleven orbit versions (VER01-VER11) were computed at the time interval from July 5, 2008 till April 6, 2015 using various models. The VER01 orbit was derived using EIGEN-GL04S (Lemoine et al., 2007) geopotential model, whereas VER11 orbit was computed using the improvements described below.

Jason-1 orbit was derived using Satellite Laser Ranging (SLR) and DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data corrected for the South Atlantic Anomaly (SAA) also for years 2012-2013. SAA-corrected DORIS data were already used for years 2002-2011.

Using true attitude in the quaternion form instead of models was implemented for Jason-1 and Jason-2.

TOPEX/Poseidon, Envisat, Jason-1 and Jason-2 macro-models were updated and improved according to Cerri et al. (2015) and "Jason Post-launch Satellite Characteristics for POD activities".

A station file used for altimetry satellite POD was updated with the information on 27 DORIS and 12 SLR stations: new occupations, antenna change, corrections of some errors. This brought more DORIS and SLR data used for POD.

Updated versions of the atmospheric loading ERA-INTERIM files and ocean loading files were used for station coordinates for all satellites.

A new time variable geopotential model EIGEN-GRGS.RL03-v2.MEAN-FIELD (http://grgs.obs-mip.fr/grace/variable-models-grace-lageos/mean_fields) was implemented and tested, as compared to EIGEN-6S2.extended.v2 geopotential model.

EOT11a ocean tide model was implemented and tested, as compared to EOT10a model.

17.3 TESTS OF ATMOSPHERIC AND OCEANIC DE-ALIASING LEVEL-1B (AOD1B) PRODUCTS FOR PRECISE ORBIT DETERMINATION OF DORIS SATELLITES

Detailed tests on using reprocessed GFZ Atmospheric and Oceanic De-aliasing Level-1B (AOD1B) REL05 product for precise orbit determination of TOPEX/Poseidon (1992-2005), Envisat (2002-2012) and Jason-1 (2002-2012) were performed at the time intervals given, as compared to using AOD1B REL04 product and no AOD data. The results have been published in Rudenko et al., 2016.

17.4 NEW PRECISE ORBITS OF DORIS SATELLITES

Based on the results of numerous tests new GFZ VER11 orbits of TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013), Jason-2 (2008-2015) were derived using SLR and DORIS data and the best models from the tests performed. Typical arc length is 7 days for Envisat and 12 days for other satellites. Two-day arc overlaps were used at the orbital arcs containing no manoeuvres.

The mean value of the SLR RMS fits for TOPEX/Poseidon reduced from 2.022 to 1.963 cm, i.e. by 0.059 cm (about 2.9%) for VER11 orbit, as compared to VER06 orbit (Rudenko et al., 2014). The mean value of the DORIS RMS fits reduced from 0.4797 mm/s to 0.4778 mm/s, i.e. by 0.0019 mm/s (about 0.4%) for VER11 orbit, as compared to VER06 orbit. Internal orbit consistency provided by the mean values of the arc overlap changed reduced from 1.023 to 0.890 cm, i.e. by 0.133 cm (about 13.0%), for VER11 orbit, as compared to GFZ VER06 orbit. The cross-track arc overlaps reduced from 6.535 to 6.491 cm, i.e. by 0.044 cm (about 0.7%), along-track – from 3.593 to 3.476 cm, i.e. by 0.117 cm (about 3.3%).

The mean value of the SLR RMS fits for Envisat reduced from 1.302 to 1.272 cm, i.e. by 0.03 cm (about 2.3%) for VER11 orbit, as compared to GFZ VER06 orbit. The mean value of the DORIS RMS fits reduced from 0.4314 mm/s to 0.4214 mm/s, i.e. by 0.0100 mm/s (about 2.3%) for VER11 orbit, as compared to VER06 orbit. The mean value of radial arc overlaps changed from 0.517 (VER06 orbit) to 0.534 cm (VER11 orbit), i.e. by +0.017 cm (about 3.2%). Cross-track arc overlaps improved from 2.089 to 1.982 cm, i.e. by 0.107 cm (about 5.1%), and along-track arc overlaps reduced from 2.140 to 1.933 cm, i.e. by 0.207 cm (about 9.7%).

The mean value of the SLR RMS fits for Jason-1 (2002-2013) reduced from 1.633 to 1.185 cm, i.e. by 0.448 cm (about 27.4%) for VER11 orbit, as compared to VER08=CCI10 orbit (Rudenko, 2015). The mean value of the DORIS RMS fits reduced from 0.3633 mm/s to 0.3532 mm/s, i.e. by 0.0101 mm/s (about 2.8%) for VER11 orbit, as compared to VER08 orbit. The reduction of the mean values of the arc overlap of VER11 orbit, as compared to VER08 orbit is following: radial – from 0.979 to 0.785 cm, i.e. by 0.194 cm (about 19.8%), cross-track – from 6.206 to 4.172 cm, i.e. by 2.034 cm (about 32.8%), along-track – from 4.580 to 2.482 cm, i.e. by 2.098 cm (about 45.8%).

The mean value of the SLR RMS fits for Jason-2 reduced from 1.663 to 1.229 cm, i.e. by 0.434 cm (about 26.1%) for VER11 orbit, as compared to VER01 orbit. The mean value of the DORIS RMS fits reduced from 0.3582 mm/s to 0.3490 mm/s, i.e. by 0.0092 mm/s (about 2.6%) for VER11 orbit, as compared to VER01 orbit (**Figure 25**). Reduction of the mean values of the arc overlap of VER11 orbit, as compared to VER01 orbit is as follows: radial – from 0.782 to 0.558 cm, i.e. by 0.224 cm (about 28.6%), cross-track – from 4.545 to 3.344 cm, i.e. by 1.201 cm (about 26.4%), along-track – from 3.657 to 1.456 cm, i.e. by 2.201 cm (about 60.2%). DORIS RMS fits of Jason-2 show increase after 2012. A paper with the details on the orbit improvements for these satellites is under preparation.

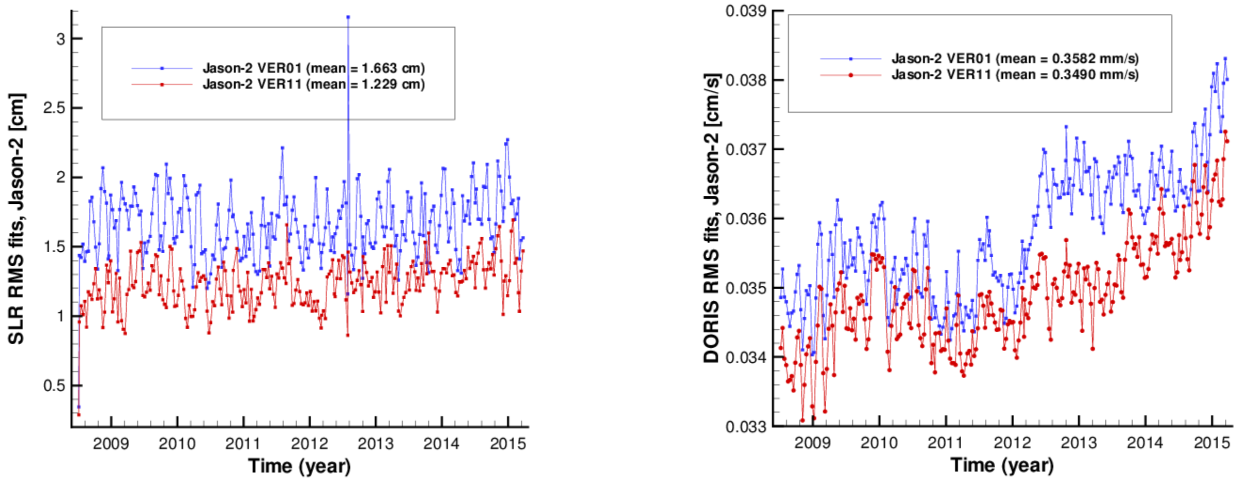

Figure 25: The RMS fits of SLR (left) and DORIS (right) observations per orbital arc obtained in GFZ VER01 (blue) and VER11 (read) orbit solutions for Jason-2

17.5 OTHER ACTIVITIES

New VER11 orbits of TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2015) derived using SLR and DORIS measurements were provided for the use in the European Space Agency Climate Change Initiative Sea Level Project (Ablain et al., 2015), the project “Consistent Estimate of Ultra-High resolution Earth Surface Gravity Data (UHR-GravDat)” funded by the German Research Foundation (DFG), as well as for studying the impact of time variable gravity on annual sea level variability (Esselborn et al., 2015). The orbits will be made available for a wide user community soon.

17.6 FUTURE ACTIVITIES

It is planned to implement ITRF2014 (http://itrf.ign.fr/ITRF_solutions/2014/) reference frame and some new models, implement satellite-specific models for Cryosat-2, SARAL/Altika, Jason-3 and Sentinel-3 missions and compute precise orbits of DORIS satellites.

17.7 PRESENTATIONS

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Förste, C., Bruinsma, S., Rudenko, S., Abrikosov, O., Lemoine, J.-M., Marty, J.-C., Neumayer, H., Biancale, R. EIGEN-6S4: A time-variable satellite-only gravity field model to d/o 300 based on LAGEOS, GRACE and GOCE data from the collaboration of GFZ Potsdam and GRGS Toulouse, European Geosciences Union General Assembly 2015, Vienna, Austria, 14.04.2015. http://meetingorganizer.copernicus.org/EGU2015/EGU2015-3608-1.pdf

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17.10 ACKNOWLEDGMENTS

These activities were partly supported by the European Space Agency within the Climate Change Initiative Sea Level Project and by the German Research Foundation (DFG) within the project "Consistent Estimate of Ultra-High Resolution Earth Surface Gravity Data (UHR-GravDat)".

18. DORIS-RELATED ACTIVITIES AT CNES

Alexandre Couhert, **Sabine Houry**, **Eva Jalabert**, **Flavien Mercier**, **John Moyard** ***(CNES/CST, France)***
Silvia Rios Bergantinos ***(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 REPROCESSING ORBITS WITH GDR-E STANDARDS

On an ongoing basis, new time series are calculated, validated and delivered using updated dynamic/measurement models and improved parameterization. Precise orbits for Jason-1, CryoSat-2, Saral/AltiKa, Jason-2, were reprocessed and presented at the last IDS and OSTST meetings (Couhert et al. 2015; Jalabert et al. 2015). GDR-E orbits for Envisat and HY-2A will be available in 2016. A summary of the adopted new models is given below:

- Updated geopotential model accounting for interannual variability,
- Orbits better referenced to the center-of-mass of the total Earth system,
- New calibrated Solar Radiation Pressure models (available for the IDS community),
- Improved reduced-dynamic parameterization,
- DORIS-only (Saral/AltiKa, CryoSat-2) or GPS+DORIS orbits (Jason-1, Jason-2),

=> SLR is now used independently to evaluate precision and stability.

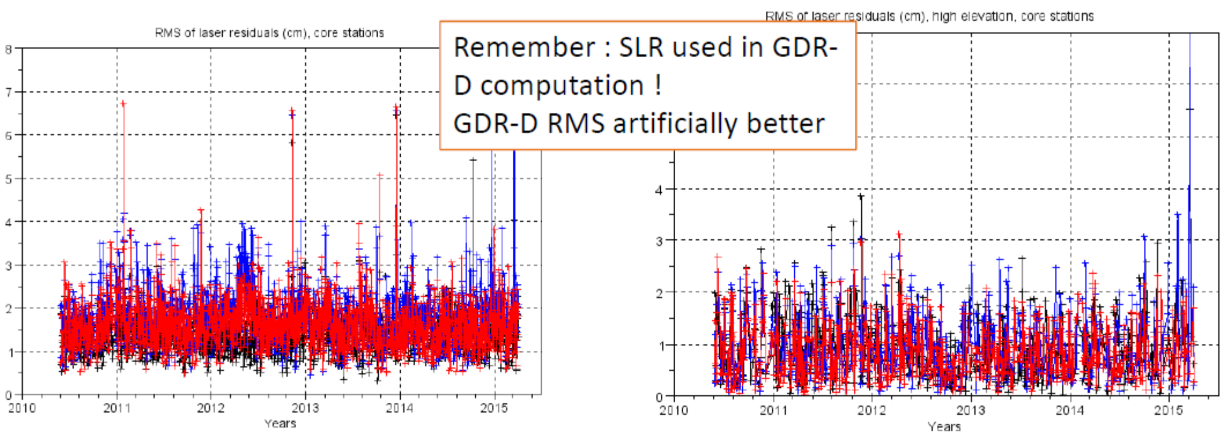
As shown by the SLR residuals with high-elevation passes, the radial orbit accuracy of the CryoSat-2 DORIS-only GDR-E orbit is ~8 mm RMS (**Figure 26**).

18.3 EVALUATION OF ITRF2014P

This test of the ITRF2014P solution concerns the preliminary version released by IGN in September 2015. Moyard et al. 2015 focused on estimating how the ITRF2014P affects Jason-2 GDR-E dynamic orbits, computed with SLR, DORIS data from cycle 147 to 253 (June 29, 2012 to Mai 24, 2015).

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 (**Figure 27**). Both post-fit DORIS and independent SLR residuals show a small improvement.

Core network RMS SLR residuals	GDR-D : Doris + SLR, Stochastic orbit	GDR-E : Doris, Dynamic orbit	GDR-E : Doris, Reduced dynamic orbit
All elevation	1,3 cm	1,7 cm	1,6 cm
High elevation	0,9 cm	0,9 cm	0,8 cm



Core network : L7090 L7105 L7810 L7839 L7840 L7941

Figure 26: Independent "core network" RMS SLR residuals (all/high elevations) for CryoSat-2 GDR-E DORIS-only orbit

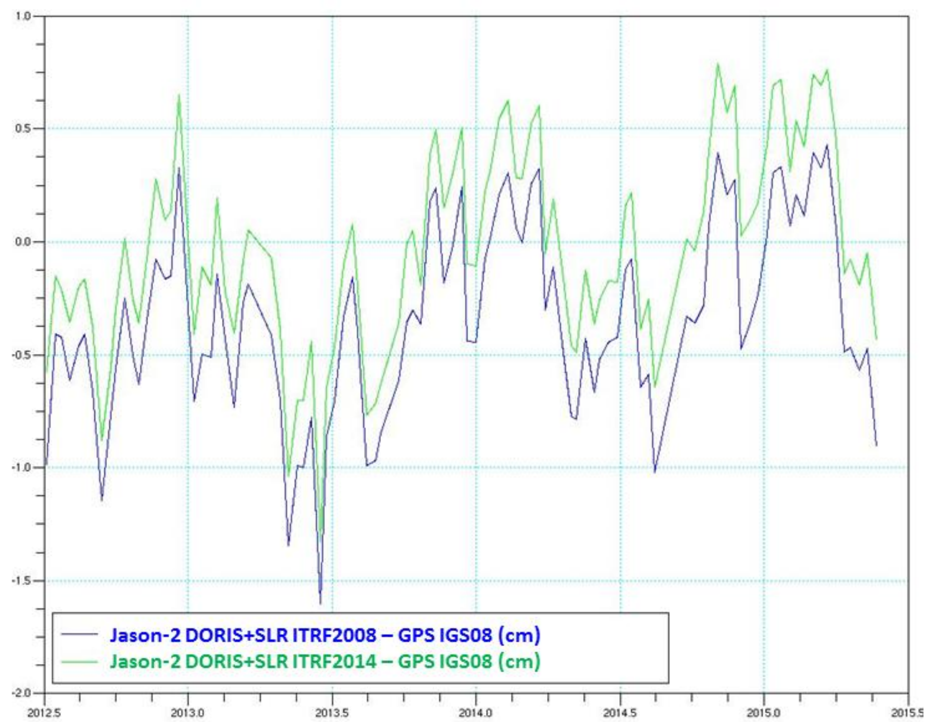


Figure 27: Jason-2 GDR-E DORIS+SLR vs GPS-based dynamic orbits mean of Z orbit differences

18.4 DORIS RINEX PROCESSING FORMULATIONS

For the new DORIS missions including Jason-3 and Sentinel-3, the measurements will be provided only in RINEX format. This means that the analysis centers have to modify their processing, mainly to be able to process the measurement synchronisation and receiver oscillator contribution (this was removed by the POD processing before delivery for the previous measurement definition, so the measurements were not fully independent from the initial POD processing). Now, using the Rinex data, the analysis centers solutions are completely independent from the CNES POD solution results.

A technical document has been written for IDS DORIS users, describing the different possible solutions and parameterizations needed to process the RINEX measurements (carrier phase, or carrier phase and pseudo-range). The formulations are also detailed for the receiver relativity effects which were neglected in the preceding solutions and for the shifted frequeny beacons. The document is available at: ftp://ftp.ids-doris.org/pub/ids/data/DORIS_models&solutions_v1.0.pdf.

18.5 IMPROVEMENT OF DORIS-ONLY ORBIT CENTERING

Examining strategies to mitigate sensitivity to miscentering effects on the orbit coming from the DORIS tracking measurements, Couhert and Mercier (2015) estimated the vertical displacement of each DORIS station, while adjusting the translational motion of the network with Jason-2 DORIS-only orbit. Additionally solving for vertical displacements improves the SLR residuals with respect to only solving for the global translation network motion. Besides, a small crossover variance reduction (positive values mean improvement w.r.t. using SLR-only CoM model) is found when computing Jason-2 DORIS-only orbits with the network shift seen by DORIS and even slightly better with the vertical displacements additionally estimated (**Table 24**).

	SLR (cm)		Crossover	
	high el.	All	mm	mm^2
No CoM	1.09	1.99	5.1	-0.2
COM	**1.07**	1.95	5.2	0.
3 trans.	1.11	2.06	5.8	1.5
3 trans. + vert.	**1.09**	**1.91**	5.6	1.8

Table 24: Independent SLR and altimeter crossover residuals statistics for different orbit solutions

18.6 REFERENCES

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Jalabert, E., Couhert, A., Moyard, J., Mercier, F., Houry, S., Rios-Bergantinos, S., 2015. Jason-2, Saral and CryoSat-2 Status. In: Ocean Surface Topography Science Team Meeting 2015, Reston, Virginia, USA, 20–23 October, 2015.

Moyard, J., Couhert, A., Mercier, F., Jalabert, E., Houry, S., 2015. ITRF2014 Evaluation of Preliminary Version. In: DORIS Analysis Working Group meeting, Greenbelt, Maryland, USA, 15–16 October, 2015.

19. APPENDIX 1: 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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20. APPENDIX 2: 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 modelling, 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, DORISstations or IDS.analysis.forum. 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.

IDS ANALYSIS FORUM

e-mail : ids.analysis.forum@ids-doris.org

In order to share in the present, and secure for the future, information, questions and answers on the problems encountered in the DORIS data analysis, the Analysis Coordinator with the support of the Central Bureau initiated the IDS Analysis Forum. This a list for discussion of DORIS data analysis topics (stations, satellites, DORIS instruments, data, analysis, orbits, EOP, products) moderated by the Analysis Coordination.

The messages are all archived on the mailing list server of CLS at the following address:
http://lists.ids-doris.org/sympa/arc/ids.analysis.forum

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

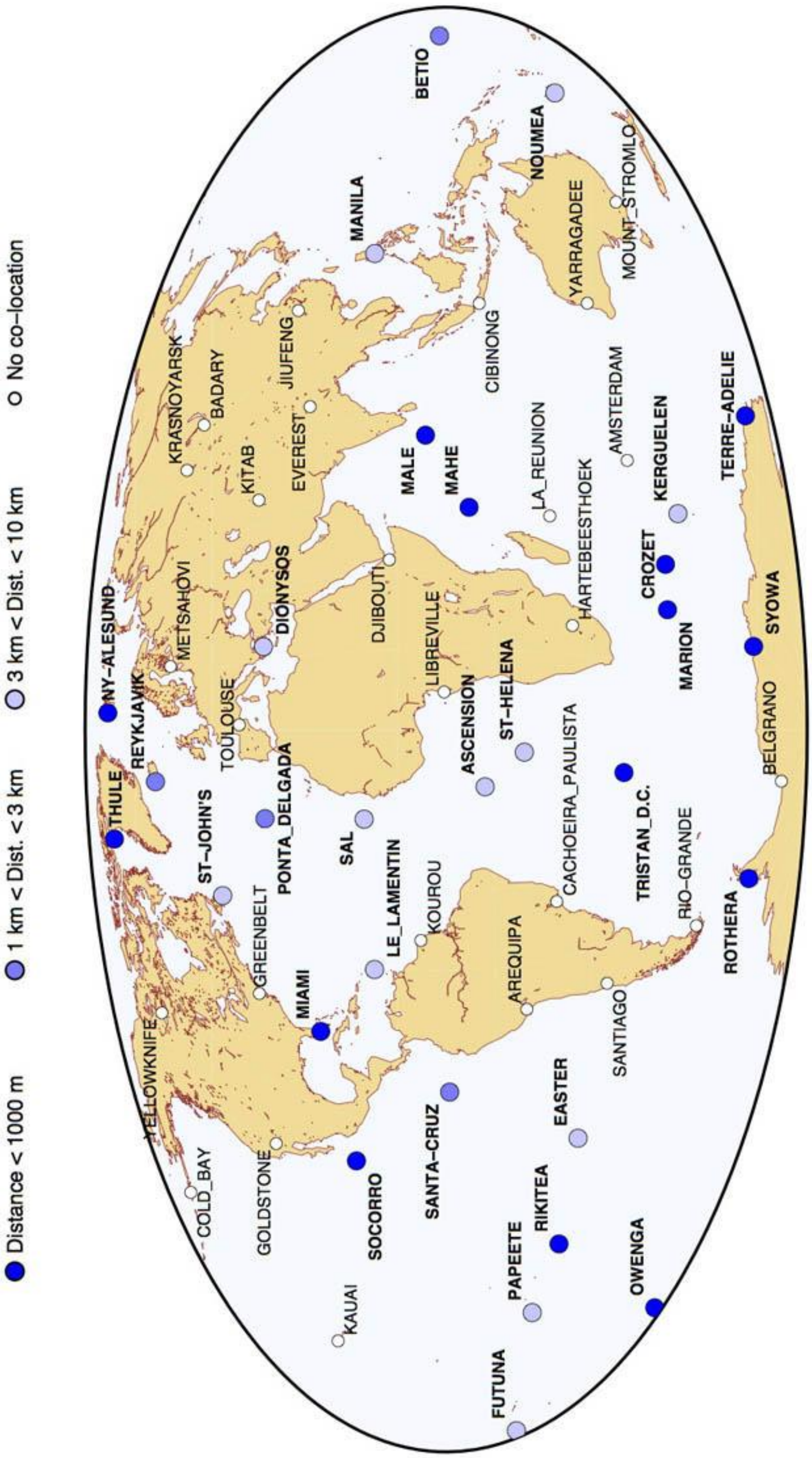
e-mail : ids.central.bureau@ids-doris.org

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.

21. APPENDIX 3: 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	Longitude	Latitude	Country	Start date	Distance (m)	GLOSS id	PSMSL id
ASCENSION	-14.33	-7.92	UK	28/02/1997	6500	263	402001
BETIO	172.92	1.35	KIRIBATI	22/10/2006	1600	113	730009
CROZET ISLAND	51.85	-46.43	FRANCE	21/12/1903	850	21	433001
EASTER ISLAND	-109.38	-27.15	CHILI	17/11/1988	7000	137	810003
FUTUNA	-178.12	-14.31	FRANCE (POLYNESIA)	18/10/2011	4400		
KERGUELEN	70.26	-49.35	FRANCE	28/01/1987	3300	23	434001
LE LAMENTIN	-61.00	14.60	FRANCE (MARTINIQUE)	29/06/2013	7000	338	1942
MAHE	55.53	-4.68	SEYCHELLES	20/06/2001	300	273	442007
MALE	73.53	4.20	MALDIVES	15/01/2005	500	28	454011
MANILA	121.03	14.53	PHILIPPINE	26/02/2003	9700	73	145
MARION ISL.	37.86	-46.88	SOUTH AFRICA	15/05/1987	1000	20	------
MIAMI	-80.17	25.73	USA	10/02/2005	180	---	960001
NOUMEA	166.41	-22.27	FRANCE (CALEDONIA)	20/10/1987	3600	123	740001
NY-ALESUND	11.93	78.93	NORWAY (SPITZBERG)	13/09/1987	600	345	1421
OWENGA	-176.37	-44.03	NEW ZEALAND	17/12/2007	100	---	------
PAPEETE	-149.61	-17.58	FRANCE (POLYNESIA)	27/07/1995	7000	140	780011
PONTA DELGADA	-25.66	37.75	PORTUGAL (AZORES)	02/11/1998	1500	245	36002
REYKJAVIK	-21.99	64.15	ICELAND	04/07/1990	2500	229	10001
RIKITEA	-134.97	-23.13	FRANCE (POLYNESIA)	23/09/2006	800	138	808001
ROTHERA	-68.1	-67.6	UK (ANTARCTICA)	01/03/2005	100	342	1931
SAL	-22.98	16.78	CAPE VERDE	15/12/2002	7000	329	380021
SANTA CRUZ	-90.30	-0.75	ECUADOR	01/04/2005	1600		845031
SOCORRO	-110.95	18.73	MEXICO	09/06/1989	400	162	830062
ST-HELENA	-5.67	-15.94	UK	01/06/1989	4000	264	425001
ST. JOHN'S	-52.68	47.40	CANADA	27/09/1999	4000	223	970121
SYOWA	39.58	-69.01	JAPAN (ANTARCTICA)	10/02/1993	1000	95	A--041
TERRE ADELIE	140.00	-66.67	FRANCE (ANTARCTICA)	05/02/1987	500	131	------
THULE	-68.83	76.54	DENMARK (GREENLAND)	28/09/2002	300	---	------
TRISTAN DA CUNHA	-12.31	-37.07	UK	10/06/1986	2000	266	------



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

22. APPENDIX 4: 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.
	US Coast Guard Navigation Center (NAVCEN)	Alexandria, Virginia, 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
Easter Island	SSC Chile S.A.	Santiago, CHILI
Everest	Comitato Ev-K2-CNR	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.
Hartebeesthoek	HartRAO, South African National Space Agency (SANSA)	Hartebeesthoek, SOUTH AFRICA

Station name	Host agency	City, Country
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
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 (UPF)	Fa'a, Tahiti, Polynésie Française, FRANCE
Ponta Delgada	Universidade dos Açores	Ponta Delgada, Azores, PORTUGAL
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

Station name	Host agency	City, Country
Rothera	British Antarctic Survey (BAS)	Rothera Research Station, Adelaide Island, Antarctica, UK
Sal	Instituto Nacional de Meteorologia e Geofisica (INMG)	Sal Island, CAPE VERDE
Santiago	Santiago Satellite Station SSC Chile S.A.	Peldehue, Colina, CHILI
Santa Cruz	Charles Darwin Foundation (AISBL)	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
Yarragadee	MOBLAS 5 SLR Station, Geoscience Australia (GA)	Yarragadee, AUSTRALIA
Yellowknife	Natural Resources Canada (NR Can)	Yellowknife, CANADA

23. APPENDIX 5: 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

International Doris Service

ACTIVITY REPORT 2015

www.ids-doris.org

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