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CENTRE NATIONAL
D'ÉTUDES SPATIALES

International Doris Service
Activity Report **2014**

IGN
INSTITUT NATIONAL
DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE

IDS

International DORIS Service Activity Report 2014

Edited by Laurent Soudarin and Pascale Ferrage

International DORIS Service

Central Bureau

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Preface

In this volume, the International DORIS Service documents the work of the IDS components between January 2014 and December 2014. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2014 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_2014.pdf

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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. **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

5. **IDS Analysis forum**
   The IDS Analysis Forum is a list for discussion of DORIS data analysis topics. To start a discussion on a specific topic, use the following address: ids.analysis.forum@ids-doris.org

6. **List of documents and links to discover the DORIS system**
   http://ids-doris.org/analysis-documents.html

7. **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

8. **List of DORIS publications in international peer-reviewed journals**
   http://ids-doris.org/report/publications/peer-reviewed-journals.html

9. **Overview of the DORIS satellite constellation**
   http://www.aviso.altimetry.fr/en/techniques/doris/doris-applications.html

10. Site logs

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

11. 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.

12. 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.

13. More contacts

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

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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

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 will be 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**, **Table 3**).

In 2015, two DORIS Analysis Working Group meetings will take place: in May, in Toulouse (France), then in October, in Washington (USA).

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

Table 2. List of IDS events organized between 2004 and 2009

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

Table 3. List of IDS events organized between 2010 and 2014

3 ORGANIZATION

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

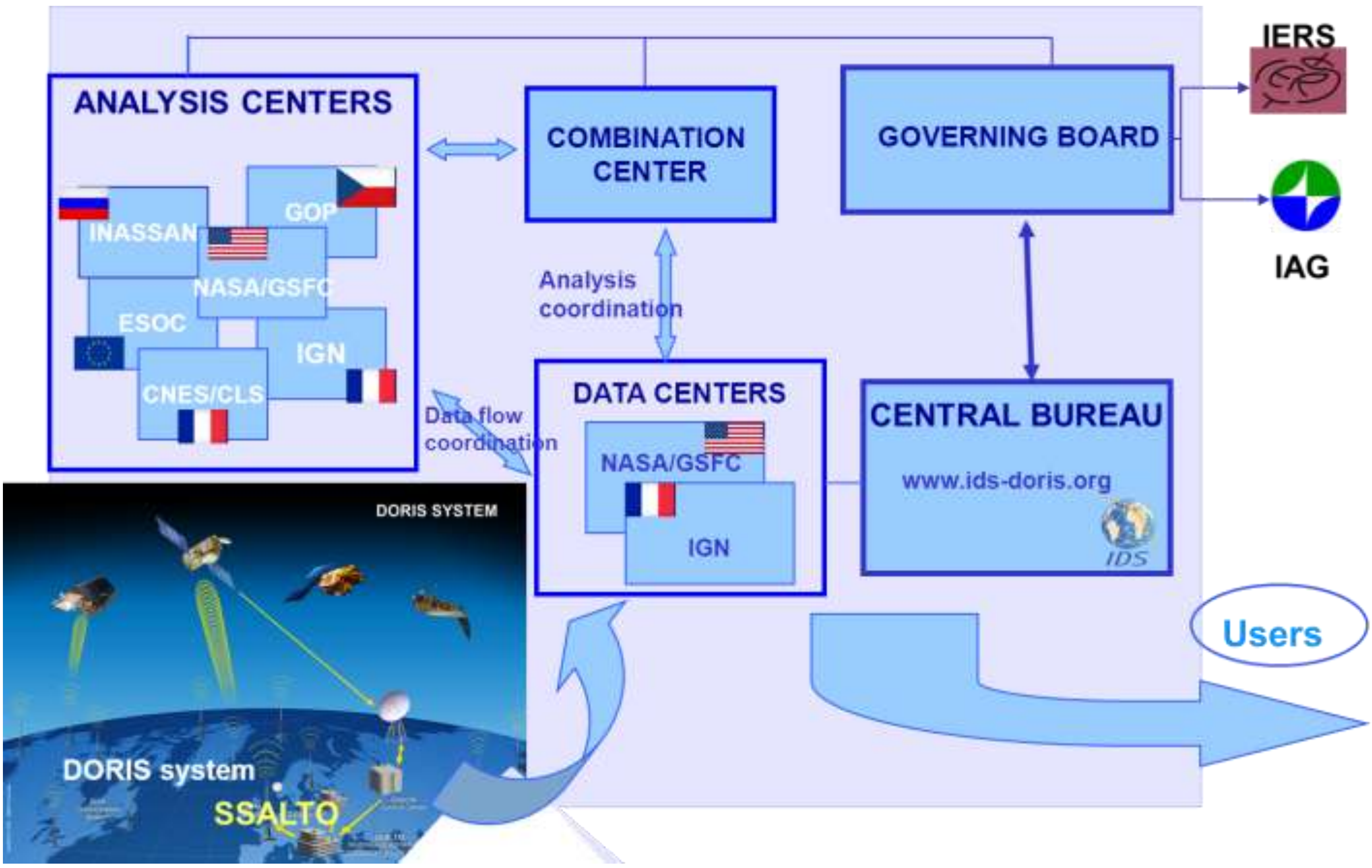


Figure 1. IDS organization

3.1 GOVERNING BOARD

In accordance with the Terms of Reference of the IDS, two positions within the Governing Board became vacant at the end of 2014: the position of Frank Lemoine as the Analysis Coordinator, and the position of John Ries as one of the Members at Large. Both have served for two terms consecutively, and therefore cannot be a candidate to a seat for another term. After the elections organized in Fall 2014, the new members elected by the IDS Associates to serve for the next four-year term 2015-2018 are:

- Hugues Capdeville (CLS)/Jean-Michel Lemoine (CNES) as Analysis Coordinator,
- Marek Ziebart (UCL) as a Member at Large.

It is important to note that Hugues Capdeville and Jean-Michel Lemoine will share together the responsibility and the work of the Analysis Coordination. From January 1st 2015, the tandem can be contact at ids.analysis.coordination@ids-doris.org

The Governing Board and Central Bureau would like to friendly and warmly thanks Frank and John for their valuable contribution to the IDS.

The 2013-2014 IDS Governing Board is:

Elected Members:

Elected by the associate members

- Pascal WILLIS (IGN/IPGP) **Chairperson** Analysis Centers' representative
- Carey NOLL (NASA/GSFC) Data Centers' representative
- Richard BIANCALE (CNES/GRGS) Member at large

Elected by the previous Governing Board

- Frank G. LEMOINE (NASA/GSFC) Analysis Coordinator
- John RIES (University of Texas/CSR) Member at large

Appointed members:

- Pascale FERRAGE (CNES) DORIS System representative
- Jérôme SAUNIER (IGN) Network representative
- Laurent SOUDARIN (CLS) Director of the Central Bureau
- Guilhem MOREAUX (CLS) Combination Center representative
- Michiel OTTEN (ESA/ESOC) Representative of the IAG
- Brian LUZUM (USNO) Representative of the IERS

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: Frank G. 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

3.3 CENTRAL BUREAU

In 2014, 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

4 THE CENTRAL BUREAU

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

The Central Bureau is the executive arm of the Governing Board and as such is responsible for the general management of the IDS consistent with the directives, policies and priorities set by the Governing Board. It brings its supports to the IDS components and operates the information system. This report summarizes the activities of the IDS Central Bureau during the year 2014 and forecasts activities planned for 2015. An overview of the IDS information system is reminded in appendix.

4.1 SUPPORT TO THE IDS COMPONENTS

4.1.1 ELECTION OF THE GOVERNING BOARD

In accordance with the Terms of Reference of the IDS, two positions within the Governing Board became vacant at the end of 2014: the position of Frank Lemoine as the Analysis Coordinator, and the position of John Ries as one of the Members at Large. Both have served for two terms consecutively, and therefore cannot be a candidate to a seat for the following term (2015-2018).

For the election, the Central Bureau led the following actions:

- define the agenda and the list of actions;
- create the appropriate mailing lists (associates, nominating committee, ballots);
- update the list of the IDS Associates and make it public on the website of the IDS (http://ids-doris.org/organization/associate-members.html) after approval by the GB;
- invite the Associates to submit names of candidates for each of the two positions open for election. A Call for Nominations was send on June 20. Propositions were collected by the nominating committee (Frank Lemoine (NASA), chairman, John Ries (CSR) and Laurent Soudarin (CLS)) which also contacted the proposed candidates to obtain their application (CV and agreement) and establish a list of candidates to be presented to the GB;
- put on the IDS web site the list of candidates with their statements and CVs
- invite the Associates to vote by email before Oct. 22. The Call for vote was send on Oct. 10. The Associates were invited to send their ballots at ids.elections @ ids-doris.org.
- announce results of the vote
- update the GB page on the IDS web site with the names of the new elected members (http://ids-doris.org/organization/governing-board.html)

4.1.2 PROMOTION OF THE IDS

The Central Bureau participated in the organization of the AWG meeting in Paris and IDS Workshop in Konstanz.

The IDS workshop and the start of the IDS web service were announced in IAG newsletters.

A leaflet presenting the DOR-O-T, the IDS web service, has been distributed to the participants of the Workshop.

The Central Bureau prepared a tutorial about the use of DORIS data in RINEX-like format. It brings together existing elements (data archive, file naming convention, description, publications, and presentations). It includes the document prepared by CNES "Introduction to RINEX DORIS". This tutorial is available on the IDS website at http://ids-doris.org/about-doris-rinex-format.html

In 2014, the Central Bureau invited the DORIS community to participate to a survey about the IDS services. Users are invited to give their satisfaction level by filling a form on the IDS web site at http://ids-doris.org/ids-survey.html

4.2 DOR-O-T, THE IDS WEB SERVICE

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

In September, the Central Bureau announces the launch of the IDS web service named DOR-O-T for DORis Online Tools (pronounced like the French given name Dorothée). The current version provides tools to browse time series in an interactive and intuitive way. It includes a network viewer to select sites and a family of plot tools to visualize the following time series: (1) station position differences at observation epochs relative to a reference position; (2) DORIS data residuals and the amount of available station observations as deduced from the CNES Precise Orbit Ephemeris processing, (3) outputs of the IDS Combination Center analysis, such as the Helmert parameters, and the WRMS. In addition to visualizing DORIS station coordinate time series, the web service also incorporates the time evolution of GNSS stations that are in co-location with DORIS, thanks to collaboration with the IGS Terrestrial Reference Frame Combination Center.

4.3 IDS WEBSITE

Address: http://ids-doris.org

The content management system has been upgraded in November. The most visible change due to this new version is the style of the menu. A database including station information used on many pages and data of the web service was also set up to make easier updating the website and data access for the plot tools.

The main updates of 2014 are reported hereafter.

- The presentations of the AWG meeting held in Paris, France, March 26-27, were put on line on a dedicated page:
  http://ids-doris.org/report/meeting-presentations/ids-awg-03-2014.html

- The presentations of the IDS Workshop held in Konstanz, Germany, October 27-28, have been made available:
  http://ids-doris.org/report/meeting-presentations/ids-workshop-2014.html

- The data analysis summary of the DORIS weekly SINEX series submitted by the Analysis Centers and used for the DORIS contribution to ITRF 2014 is shown in a table:
  http://ids-doris.org/contribution-itrf2013.html

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

- All the documents and files related to the DORIS/RINEX format is now gathered on a new page in the Analysis Coordination section:
  http://ids-doris.org/about-doris-rinex-format.html

- The list of the peer-reviewed publications related to DORIS has been enriched with 10 new references of articles published in 2014:
  http://ids-doris.org/report/publications/peer-reviewed-journals.html#2014

- The activity reports for 2013 (IDS Activity report, report for IERS) as well as the minutes of the IDS GB meetings held in 2014 (Paris, Konstanz) and several presentations in meetings (IERS DB, GGOS, ...) were added on the page of the Governing Board's documents:
  http://ids-doris.org/report/governing-board.html

- The page gathering IDS-related presentations was updated with several presentations:
  http://ids-doris.org/report/meeting-presentations/ids-related-presentations.html

- Some DORIS-related presentations were added:
  http://ids-doris.org/report/publications/on-line-publications.html

4.4 IDS FTP SERVER

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

The documents and files put on the IDS ftp site in 2014 are listed hereafter:

- "DORIS site standard configuration" is a new document describing the standard configurations compliant with the DORIS system requirements applicable to the management of the DORIS station network:
  ftp://ftp.ids-doris.org/pub/ids/stations/DORIS_Site_Standard_Configurations.pdf

- "Introduction to DORIS RINEX" gives a quick description of the DORIS/RINEX format. The principle chosen in this document is to take an example of RINEX content and describe the main parameters.
  ftp://ftp.ids-doris.org/pub/ids/data/IntroductionToDORISRINEX.pdf

- Routines to read DORIS/RINEX files. The "tar file" contains the Fortran90 subroutines used in GINS to read the RINEX files (courtesy by Jean-michel Lemoine, CNES).
  ftp://ftp.ids-doris.org/pub/ids/data/DORIS_RINEX_subroutines_from_GINS.tar

- Version #6 of the document describing the DORIS satellite models implemented in CNES POE processing. It includes updates on SPOT-5 solar panel offsets.
  ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf

- Updated version of the mass and center of mass history file for Jason-1. The X value of the initial Center of Gravity was increased by 2 cm to +0.955 m to agree with the value recommended by CNES/SOD and given in the document describing the DORIS satellite models implemented in CNES POE processing.
  ftp://ftp.ids-doris.org/pub/ids/satellites/ja1mass.txt

- Leaflet presenting the IDS web service DOR-O-T:
  ftp://ftp.ids-doris.org/pub/ids/DOR-O-T_Webservice_2014.pdf

4.5 FUTURE PLAN

In 2015, the Central Bureau will participate to the organisation of the AWG meetings. The first one will be held at CLS, Ramonville Saint-Agne, France, May 28-29 (http://ids-doris.org/report/meeting-presentations/ids-awg-05-2015.html). The second one is planned in October in Washington, USA, before the OSTST meeting. Data, meta-data and documentation of Jason-3 and Sentinel 3A whose launches are scheduled in 2015, will be put online the IDS data and information sites as they become available. Time series of EOP from the DORIS solutions will be made accessible on the web service. The Central Bureau will continue to guide any new users who want to get involved in DORIS activities.

5 THE NETWORK

Jérôme Saunier *(IGN, France)*

5.1 GENERAL STATUS OF THE NETWORK

At the end of 2014, the DORIS permanent network (**Figure 2**) is made up of 55 stations and an additional station is dedicated to experimentation: Grasse (France).

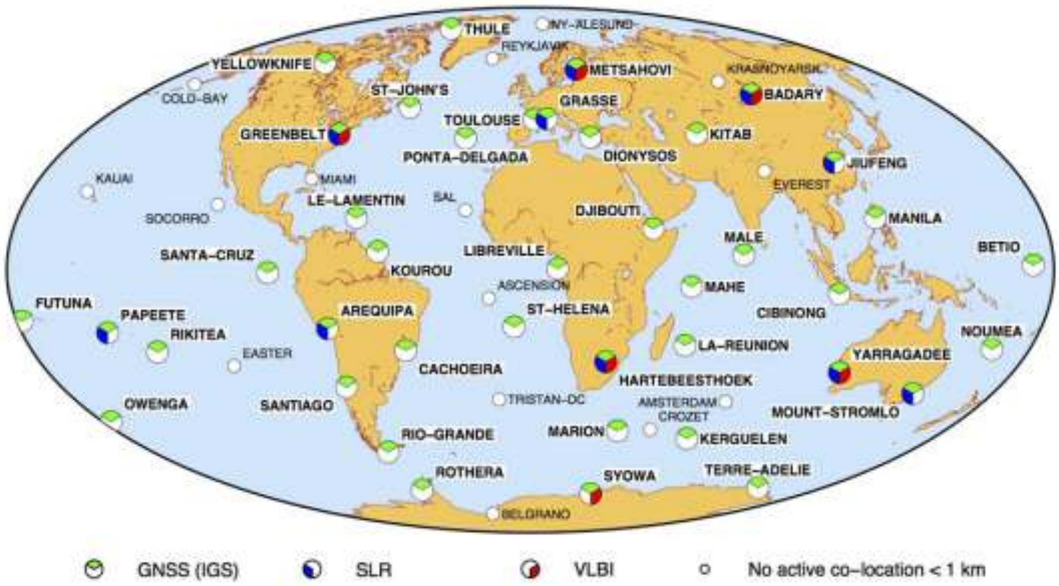


Figure 2. The DORIS network – Co-location with other IERS techniques

Due to recurring maintenance issues, two stations have been decommissioned this year: Gavdos (Greek island part of Crete) in March 2014 and Port-Moresby (Papua New Guinea) in May 2014.

As a reminder, two stations had been decommissioned in the past years: Yuzhno-Sakhalinsk (at the far east of Russia) and Monument Peak (CA, USA).

Two stations are out of order for over a year: Santa Cruz (since 06/2009) and Santiago (05/2013).

Nevertheless, thanks to its very good geographical distribution, the DORIS network maintained a high level of performance. The return to service of Socorro, eagerly awaited and back to operation in April 2014, brought a lot in the North Pacific region.

At the same time, throughout the year, many prompt and effective maintenance operations (equipment replacement) made it possible to keep up the network availability rate with of a 91% annual mean of operating stations (**Figure 3**).

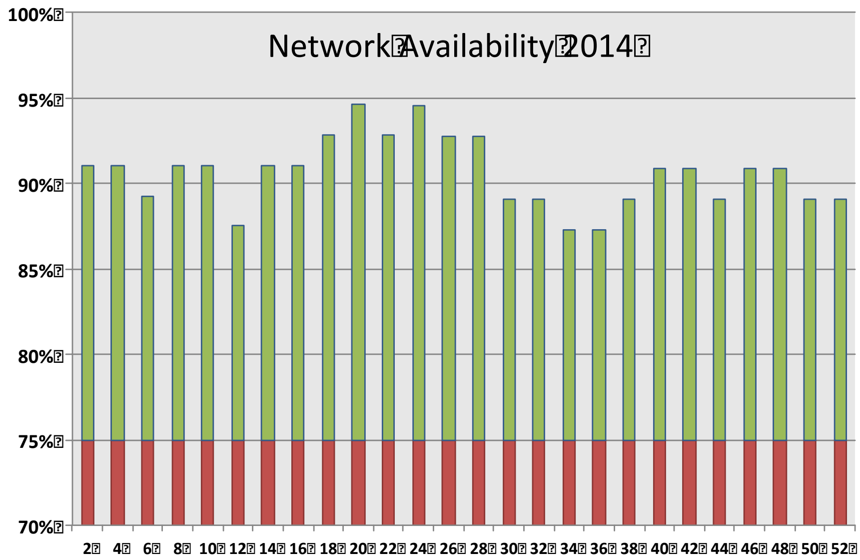


Figure 3. Network availability in 2014

5.2 EVOLUTION AND DEVELOPMENT

As regards the ground equipment, the deployment of the remote control system allowing more rapid reaction to hardware failure is mostly complete (only 6 sites remain to be equipped). All the four master beacons are now equipped with model 3.1 (see IDS Activity Report 2011 about the network) and six additional orbitography beacons has been upgraded to version 3.1 with ultra-stable oscillator. A new antenna type begins to roll out across the network. The letter “C” appears at the end of acronyms when this antenna type is used. This antenna is the same as the former one but the manufacturing process has been consolidated with more stringent specifications in order to better characterize the relative position of all the characteristic points of the antenna and draw up a more realistic error budget.

In terms of network distribution, no tangible evolution occurred during that year. However there are a number of further projects in the pipeline. Unfortunately, unforeseen events (such as sites closures or moving) and difficulties affected our program. The general context is not very favorable whether from the economic, political or legal angle. Moreover the network equipment is getting old: 40% of beacons reached the age limit stipulated by the manufacturer (10 years). And maintenance operations remain the priority.

Efforts continued in the field to improve the monument stability at any new installation and to carry out high precision local tie surveys.

In 2014 the following sites were visited:

- Syowa, Antarctica: antenna change (performed by GSI, Japan)
- Easter island, Chile: reconnaissance with a view to move within the island
- Santiago, Chile: reconnaissance with a view to move within a 500km radius
- Hartebeesthoek, South Africa: local tie survey in the framework of ITRS new realization
- Marion island, South Indian Ocean: antenna change (performed by HartRAO, South Africa)
- Socorro, Mexican island: major renovation with a shift of 260m (**Figure 4**)
- Ponta Delgada, Portuguese island: renovation with antenna change
- Owenga, NZ Chatham island: new site replacing Chatham (**Figure 5**)
- Wettzell, Germany: reconnaissance with a view to have a 4 techniques fundamental GGOS station

Figure 4. Socorro, Mexico

Figure 5. Owenga, New Zealand

With regard to the off-network stations dedicated to IDS for scientific purposes, objectives and priorities have been redefined at the beginning of that year as follows:

- Wettzell, Germany: 4 techniques GGOS site; DORIS station installation planned in 2015
- Guam island, North Pacific Ocean: IGS “GUUC” + tide gauge co-location
- Sejong, Korea: future 4 techniques GGOS site

Finally, the overall objectives for the next year are:

- New stations at Goldstone (in place of Monument Peak), Wettzell, and Managua (Nicaragua)
- Re-location in Easter island and Kitab
- Reconnaissance in Northern Australia to find a new site in place of Port-Moresby

6 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 01 July 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 9th, 2012.
- SPOT-5 (CNES) was launched on May 4, 2002 with a miniaturized second generation DORIS receiver.

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, but carries the DGXX DORIS.
- 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 6 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.

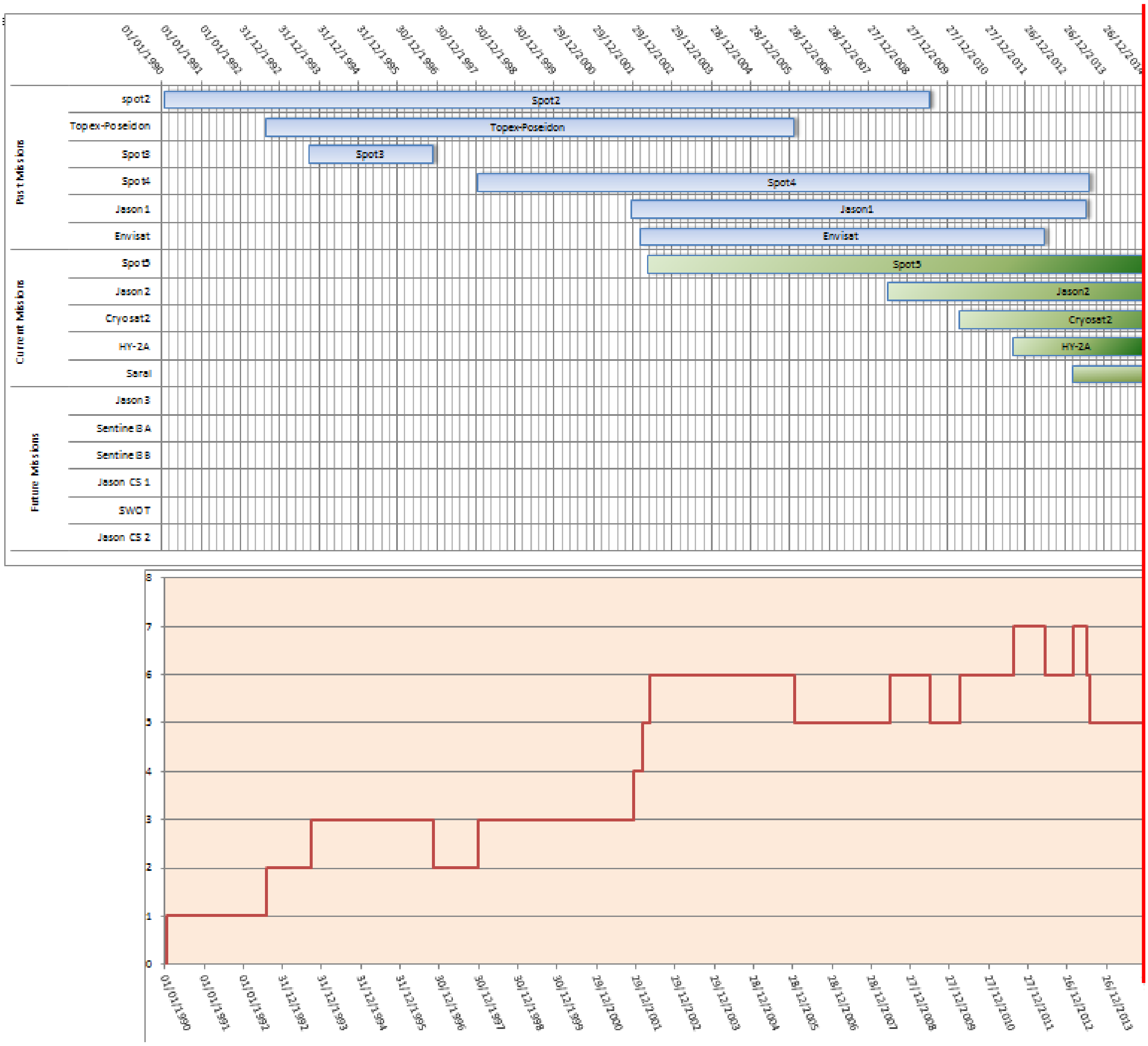


Figure 6. DORIS observations available at the IDS Data Centers (December 2014)

Some other DORIS missions are under development and should guarantee a constellation with at least 4 DORIS contributor satellites through 2030 (**Figure 7**):

- Jason3 (EUMETSAT/NOAA/CNES) is ready for launch in July 2015
- SENTINEL3A (GMES/ESA) is planned for end 2015, then SENTINEL 3B 12 to 30 months later.
- Jason CS1 (Eumetsat/ESA/CNES) is expected from 2020, and Jason CS2 from 2025,
- SWOT is foreseen for 2020.

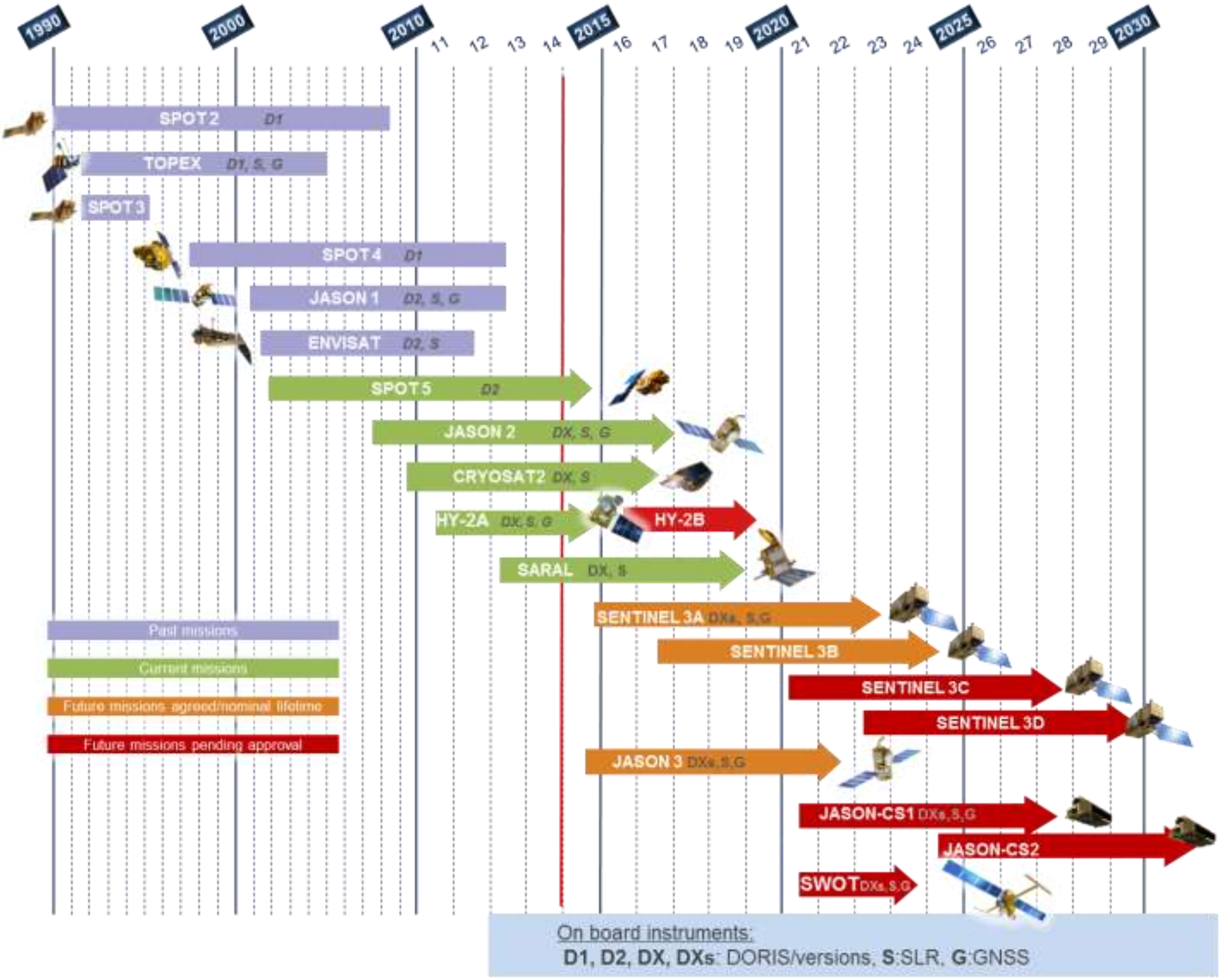


Figure 7. Current and future DORIS constellation (December 2014)

7 IDS DATA FLOW COORDINATION (2014)

Carey Noll *(NASA, USA)*

7.1 INTRODUCTION

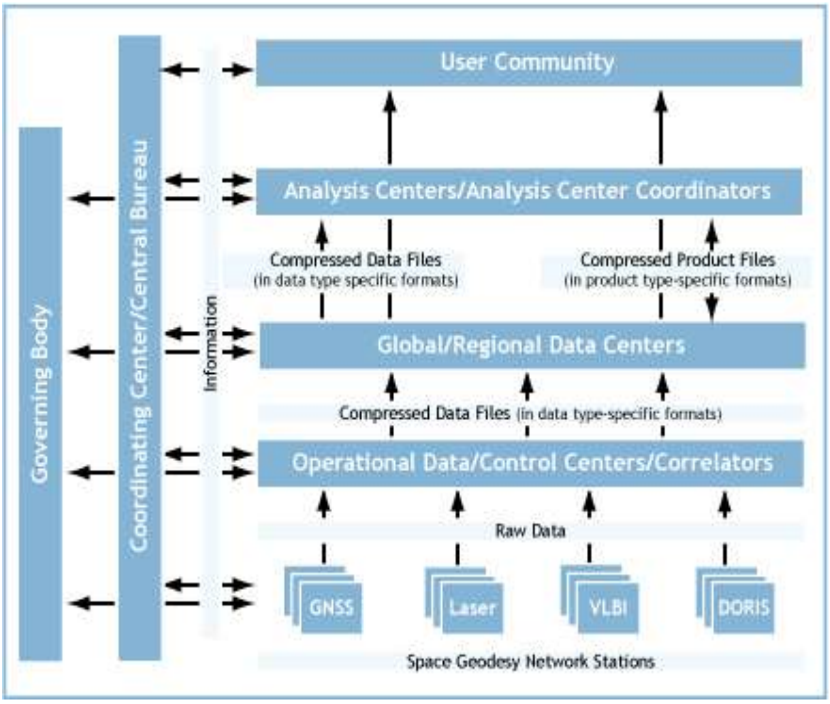
Two data centers support the archiving and access activities for the IDS:

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

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

7.2 FLOW OF IDS DATA AND PRODUCTS

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



Network Stations
Continuously operational
Timely flow of data

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

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

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

Governing Body
General oversight of service
Future direction

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

The IDS data centers use a common structure for directories and filenames that was implemented in January 2003. This structure is shown in **Table 4** and fully described on the IDS Central Bureau website at *http://ids-doris.org/struct-dc.html*. The main directories are:

- */pub/doris/data* (for all data) with subdirectories by satellite code
- */pub/doris/products* (for all products) with subdirectories by product type and analysis center
- */pub/doris/ancillary* (for supplemental information) with subdirectories by information type
- */pub/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 (Segment Sol multimissions d' ALTimétrie, d'Orbitographie et de localisation précise), and the analysis centers deliver data and products to both IDS data centers (CDDIS and IGN) to ensure redundancy in data delivery in the event one data center is unavailable. The general information available through the IDS Central Bureau ftp site are mirrored by the IDS data centers thus providing users secondary locations for these files as well.

Directory	File Name	Description
Data Directories		
/doris/data/*sss*	*sss*data*MMM*.*LLL*.Z	DORIS data for satellite *sss*, cycle number *MMM*, and version *LLL*
	sss.files	File containing multi-day cycle filenames versus time span for satellite *sss*
/doris/data/*sss*/sum	*sss*data*MMM*.*LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
/doris/data/*sss*/yyyy	*sss*rx*YYDDD*.*LLL*.Z	DORIS data (RINEX format) for satellite sss, date YYDDD, version number *LLL*
/doris/data/*sss*/yyyy/sum	*sss*rx*YYDDD*.*LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
Product Directories		
/doris/products/2010campaign/	*ccc*/*cccYYDDDtuVV*.*sss*.Z	Time series SINEX solutions for analysis center *ccc*, starting on year *YY* and day of year *DDD*, type *t* (m=monthly, w=weekly, d=daily) solution, content *u* (d=DORIS, c=multi-technique), and solution version *VV* for satellite *sss*
/doris/products/eop/	*cccWWtuVV*.eop.Z	Earth orientation parameter solutions for analysis center *ccc*, for year *WW*, type *t* (m=monthly, w=weekly, d=daily), content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/geoc/	*cccWWtuVV*.geoc.Z	TRF origin (geocenter) solutions for analysis center *ccc*, for year *WW*, type *t* (m=monthly, w=weekly, d=daily), content *u* (d=DORIS, c=multi-technique), and solution version *VV*
/doris/products/iono/	*sss*/*cccsssVV*.*YYDDD*.iono.Z	Ionosphere products for analysis center *ccc*, satellite *sss*, solution version *VV*, and starting on year *YY* and day of year *DDD*
/doris/products/orbits/	*ccc*/*cccsssVV*.*bXXDDD*.*eYYEEE*.sp1.*LLL*.Z	Satellite orbits in SP1 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

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 five operational satellites (CryoSat-2, HY-2A, Jason-2, SARAL, and SPOT-5); data from future missions will also be archived within the IDS. Historic data from Envisat, Jason-1, SPOT-2, -3, -4, 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 2014 is shown in **Figure 9**.

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 present
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004

Table 5. DORIS Data Holdings Summary

Satellite	DORIS-Format Data Number of Days/ Multi-Day File	DORIS-Format Data Average Latency (Days)	DORIS-Format Data Average File Size (Mb)	RINEX Data Average File Size (Mb)
CryoSat-2	8	23	2.9	1.7
HY-2A	8	25	3.3	1.9
Jason-2	11	26	6.8	2.6
SARAL	8	26	3.2	1.8
SPOT-5	10	17	2.6	N/A

Table 6. DORIS Data File Information (2014)

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 in 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 from 2011 in DORIS V2.2 format from the Jason-1 satellite (cycles 104 through 368) were submitted to the IDS data centers in late 2012 and 2013; a set of SPOT-5 data (cycles 138 through 456, 2006 through Sept. 2014) were provided in 2013 and 2014. These files were submitted to the IDS data centers and archived in dedicated directories, e.g., at CDDIS:

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

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

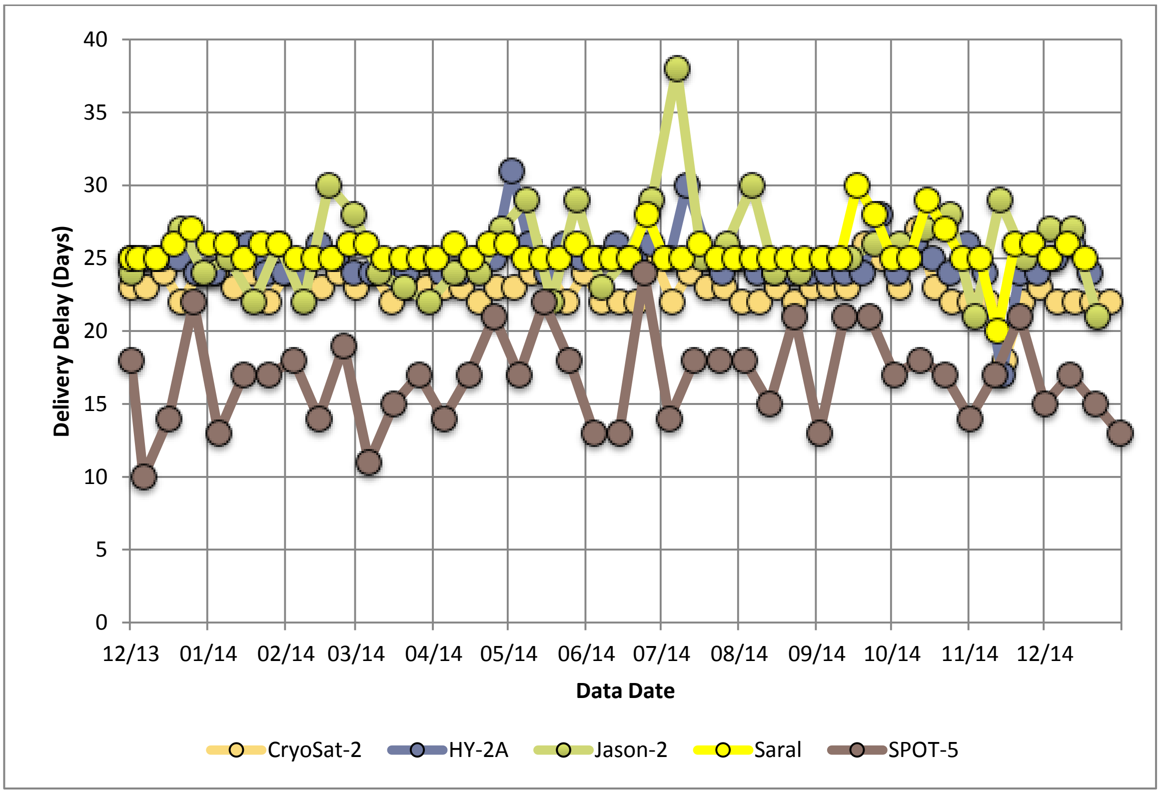


Figure 9. Delay in delivery of DORIS data to the CDDIS (all satellites, 01-12/2014)

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.

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
Time series of SINEX solutions (2010 campaign)		X	X		X		X	X	X		

*Note: GAU and SOD historic solutions

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

Table 7. IDS Product Types and Contributing Analysis Centers

7.5 SUPPLEMENTARY DORIS INFORMATION

In 2009 an additional directory structure was installed at the IDS data centers containing ancillary information for DORIS data and product usage. Files of Jason-1, -2, and 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.

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 RECENT ACTIVITIES AND DEVELOPMENTS

By the end of 2014, the CDDIS has devoted approximately 72 Gbytes of disk space to the archive of DORIS data, products, and information. During the year, users downloaded approximately 1.1 Tbytes (905K files) of DORIS data, products, and information from the CDDIS. On average, over 16K 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 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.

Work on an update of the CDDIS website was completed in early 2014. In addition to a refresh of the appearance of the website, the content was reviewed and updated. An application for the enhanced display and comparison of the contents of IGS, ILRS, and IDS site logs was completed in 2014. Through this Site Log Viewer application, users can display a complete site log, section by section, display contents of one section for all site logs, and search the contents of one section of a site log for a specified parameter value. Thus, users can survey the entire collection of site logs for systems having particular equipment or characteristics. The application points users to the approved archive of site logs to ensure the latest and official copy of the log is available to the user. Lastly, the CDDIS developed an http interface to the data archive (in addition to the operational ftp data retrieval protocol); testing continues.

8.1.3 FUTURE PLANS

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

Funding was identified in 2013 to procure a computer system refresh for the CDDIS. Hardware was purchased in mid-2014 with installation beginning in late 2014 and scheduled for completion and testing in early 2015. The system will be installed within a new computer facility at GSFC that will provide a more reliable/redundant environment and network connectivity; 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. CDDIS will be utilizing a large storage system to easily accommodate future growth of the archive.

A second web-based application, the CDDIS Archive Explorer, is currently under development to aid in discovering data available through the CDDIS. The application will allow 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 will include a listing of sites (or other metadata) or data holdings satisfying the user input specifications.

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.

8.1.4 CONTACT

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

8.2 IGN DORIS DATA CENTER

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

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

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

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

8.2.1 CONTACT

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9 IDS ANALYSIS COORDINATION

Frank Lemoine *(NASA, USA)*

9.1 INTRODUCTION

The activities of the past two years (2013-2014) have been dominated by the efforts of all the DORIS analysts to implement improvements in their processing, and to reprocess all the DORIS data, and prepare weekly SINEX files from 1993 to 2014 for the development of the IDS contribution to ITRF2013. Analysis working group meetings were held in Toulouse (France), April 4-5, 2013 (*hosted by Collecte Localisation Satellites*), Washington DC (USA), October 15-16, 2013 (*hosted by Stinger Ghaffarian Technologies in Greenbelt, Maryland, USA*), Paris (France), March 26-27, 2014 (*hosted by the CNES*). The bi-annual IDS workshop was held in association with the Ocean Surface Topography Science Team (OSTST) meeting in Konstanz, Germany, October 27-28, 2014 (1).

The face-to-face meetings at the different AWG meetings were supplemented at various times by telecons that involved the DORIS analysis centers and the IDS Combination Center (G. Moreaux, CLS). The purpose of these supplementary meetings was to try and maintain the pace of progress in assessing the model improvements, and to resolve issues associated with the reprocessing of the DORIS data. The IDS endeavored to meet the original objective of delivering a combination to the IERS by April 2014 (based on data processed through the end of 2013). It met its objective, but as it became clear that the other geodetic techniques were considerably delayed in their submissions, it allowed some updating of the submissions on the part of the ACs, and refinement of the IDS combination by the Combination Center. Near the end of the year 2014, the IERS requested that IDS process data through 2014 and submit these data by February 2015. Because of data latencies, the IDS replied that its ACs would only supply SINEX files through the end of the week of August 31, 2014. Thus ITRF2013 officially became ITRF2014.

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 note that in the past year we have had participation by three other institutions: GFZ, TU/Delft, The University College/London.

(1) We note the AWG meeting in October 2013 was originally scheduled to be held at the NASA Goddard Space Flight Center (Greenbelt, Maryland), but due to the shutdown of the U.S. Government in October 2013 due to the temporary lack of national budget for the fiscal year 2014, NASA GSFC was closed and the NASA hosts (IDS GB members C. Noll and F. Lemoine) were not allowed to attend the AWG meeting.

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. While the GFZ has requested a status as an “associate analysis center”, presently the IDS Terms of Reference (ToR) do not allow for this possibility. At the IDS Governing Board (GB) meeting in Konstanz (Germany), October 28, 2014, the GB agreed to modify the ToR. This modification is an involved procedure that must be coordinated with the IAG (International Association of Geodesy).

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) also attended the IDS Workshop in Konstanz (Oct. 2014), and expressed in an interest in analysis of DORIS data, and also in multi-technique analyses. In the future, the participation of the NMA (Geir Arne Hjelle) and other potential IDS ACs should continue to be encouraged. Finally at the IDS Governing Board meeting in Konstanz in October 2014, approved the application of the “LCA” analysis center to change its name to “GRG” at the IDS Workshop in Konstanz. The name change was requested so that research group’s submissions regarding processing of space geodetic data (SLR, DORIS, GNSS) would have a consistent name for each of the geodetic services.

The major efforts over the last two years focused on the development of the processing standards for ITRF2013(4). The details in the modeling for the ITRF-related time series submitted by the different analysis centers are reported on the IDS website at the URL: http://ids-doris.org/contribution-itrf2013.html. The major changes that were validated in 2013-2014, included the following:

(1) The implementation and validation of the phase law for the DORIS antennae in the software of the different IDS Analysis Centers;

(2) The introduction of new satellites into the DORIS weekly solutions;

(3) The improvement in the troposphere modeling by some of the different IDS Analysis Centers;

(4) The testing of improved gravity models, and associated models for atmospheric and ocean de-aliasing;

(5) The identification of discrepancies in the processing for different analysis centers through comparison of the time series of empirical accelerations.

Name	AC	AAC	Location	Contact	Software	Multi-technique
ESA	✔		Germany	Michiel Otten	NAPEOS	SLR, GNSS
GOP	✔		Czech Republic	Petr Stepanek	Bernese	
GRG	✔		France	Laurent Soudarin, Hugues Capdeville, Jean-Michel Lemoine	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 (2013-2014)

9.3 ANTENNA PHASE LAW

Following the IDS AWG meeting in Toulouse (April 2013), Cédric Tourain (CNES) provided a version of the phase law for the Starec and Alcatel antennae in ANTEX format. The Starec phase law was based on actual measurements of sample antennae in an anechoic chamber at the CNES. The Alcatel antenna phase law was based on manufacturer specifications, as a sufficient number of working Alcatel antennae were no longer available. C. Tourain and A. Auriol (AWG Toulouse, 2013) and C. Tourain (AWG Paris, 2014) presented the Starec anechoic chamber test results to the IDS AWG. Initially, all the AC's were asked to test two years: 1995 to test primarily the implementation of the Alcatel phase law, and 2011 to test the implementation of primarily the Starec phase law. To validate the phase law implementation, two tests were applied: (1) Testing the RMS of fit – the implementation of the phase law should result in a reduction in the RMS of fit when tested over many arcs; (2) The change in scale of the weekly coordinate solutions due to the application of the phase law should be in the same direction, and approximately of the same magnitude for all the AC's. By the time of the AWG meeting in Paris (March 2014), all the AC's except INA had delivered a time series that included the phase law, and some ACs computed entire time series with only the application of the phase law as the only change applied. An example of the scale change observed by an individual AC is shown in **Figure 10** for the GOP submission, comparing an amalgamation of series without the phase law (gopwd3X) to one that included it (gopwd43). The change in scale ranges from about +5 mm in the Alcatel era to about +10 mm in the Starec era. **Figure 10** also illustrates another conundrum, namely that all the AC's observed an increase in scale starting in 2012. Despite many discussions and suggestions, we have not found an explanation for the increase in DORIS scale – although from single-satellite SINEX solutions, it seems related to scale changes observed on individual satellites, such as Cryosat-2, HY-2A, and Jason-2.

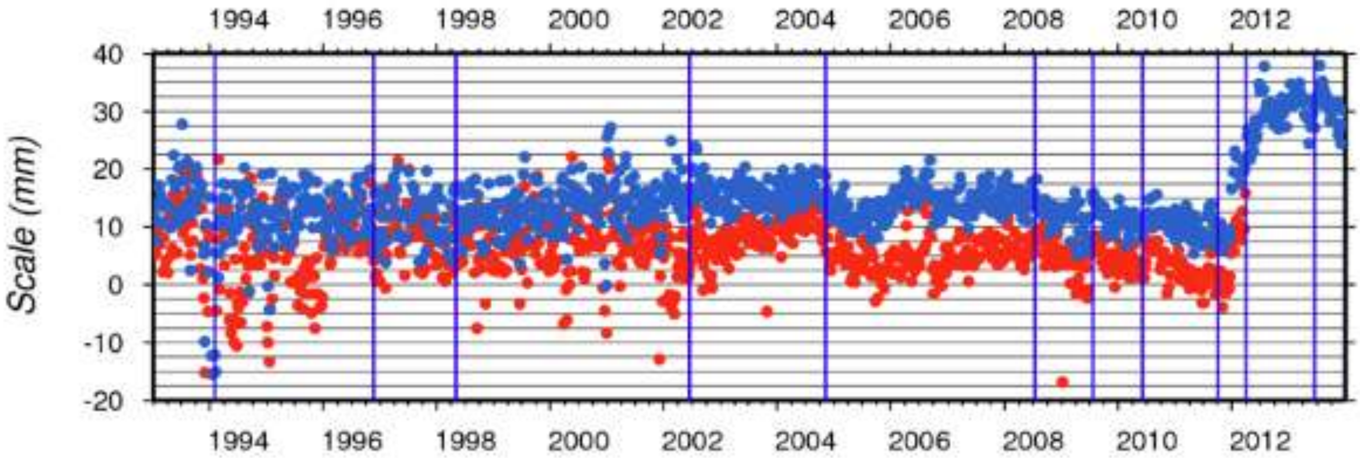

Figure 10. Scale change for GOP SINEX series submitted for ITRF2013 (gopwd3X in red, vs. gopwd43 in blue)

In conclusion, although there were some ambiguities about the convention of the phase law definition (*The IDS AC's eventually had to apply the negative of the supplied correction in order to obtain an improvement in the residual RMS of fit, and a change in the scale in the desired direction*), the application of the phase law was successful. However the preliminary results from the ITRF combination analyses (Altamimi et al., Fall AGU 2014) are that the new DORIS scale moves <u>away</u> from the other techniques (SLR and VLBI) producing a larger inter-technique discrepancy in the ITRF scale. Unlike GPS, no phase law was applied for the satellite receivers, as we had no information available.

9.4 TIME VARIABLE GRAVITY

One of the major concerns for the DORIS modeling for the development of the contribution to ITRF2013 was how to model time-variable gravity. It was clear that the ITRF2008-vintage models (e.g. EIGEN-GL04S; GGM01C, GGM02C as listed in Valette et al., 2008) would no longer be adequate for the periods following 2008, particularly in light of the POD results already demonstrated by the POD team for Jason-2. DORIS satellites by virtue of their lower altitude (especially Cryosat2, ENVISAT and the SPOT satellites) are more sensitive to modeling of time variable gravity. The DORIS ACs chose two approaches: (1) Use the GRGS-provided model, EIGEN6-S2; (2) Use a time-series of 5x5 weekly solutions developed from analysis of data to SLR+DORIS satellites from 1993 – 2013 (only GSC).

The EIGEN6S2 solution is a tailored solution (GRACE+GOCE+LAGEOS) with a background static model, and time-varying coefficients that are fit year-by-year and by design are piecewise continuous. The GRGS provided a model for use by the DORIS ACs to forward model the atmosphere and ocean mass variations. The EIGEN6S2 solution is propagated backward in time by using the annual variations from the GRACE time period (post-2003), and considering epoch-wise solutions only for C_{20}. In contrast the GSC approach provided a solution over the entire time period (1993-2013), but not all the coefficients are properly resolved (such as C_{31} and C_{50}). GSC used the ECMWF-6hrly fields to model atmospheric gravity. Jean-Paul Boy (University of Strasbourg, France) provided these ECMWF “AOD” de-aliasing files. The INA analysis center used a composite model based on the background GOCO02s model, and modeled low degree variations (using harmonic terms and secular rates) derived from an earlier SLR+DORIS time-variable gravity time series solution from GSC. In early April 2014, Jean-Michael Lemoine (CNES) made a late re-delivery of the portion of the EIGEN-6S2 solution for 2012 onwards, which necessitated a recalculation of the SINEX solutions in the final year of the submissions by some of the IDS ACs. ESA used the EIGEN-6C4 (Förste et al., 2014) solution from the GFZ/GRGS for some of the intermediate processing before the delivery of the final series for ITRF2014, esawd10. Of the six ACs, two ACs (the two GIPSY analysis centers, IGN & INA) did not apply models of atmospheric gravity or oceanic mass variations. The versions of GIPSY used by the DORIS analysis centers had bugs in the application of atmosphere-ocean dealiasing (AOD) models that were only fixed late in 2014 (Shailen Desai (JPL), Personal Communication).

We can characterize the change in the Helmert parameters between a series that includes the newer time-variable gravity models, and one that does not. The application of time-variable gravity reduced the amplitude of the annual terms in Tx and Ty, and also reduced the slope in the these parameters for the period after ~2005 as shown when we consider the examples for gscwd20 (earlier model of static and time-variable gravity, a effectively slight update of EIGEN-GL04S) and gscwd25 (using a newer model of time-variable gravity time-variable gravity described above). For Tx the amplitude of the annual terms is reduced from 3.16 mm with gscwd20 to 1.70 mm with gscwd25. For Ty the slope is reduced from -2.02 mm/yr to 1.51 mm/yr, where the fit was made from 2005 to 2014.

9.5 TROPOSPHERE MODELING

IDS AC	ITRF2008 (1)	ITRF2014		
	Troposphere Model + Meteorological data + Mapping function		Estimate gradients	Elevation cutoff
ESA	GMF + GPT + GMF	Saastamoinen + GPT + GMF	Yes (3)	7° (a)
GAU	Hopfield + GPT + Niell	-----	---	---
GOP	GMF + GPT + GMF	Saastamoinen + GPT + GMF	No	10° (b)
GRG	(2)	GPT2/VMF1	Yes (3)	12° (b)
GSC	Hopfield + GPT + Niell	Saastamoinen + GPT + GMF	No	10° (b)
IGN	GMF + formula + GMF	VMF1	No	7° (a)
INA	Lanyi + formula + Lanyi	?? + ?? + GMF	No	12° (a)

(1) - From Valette et al. (2010).
(2) - After 2002, dry and wet interpolated from ECMWF grids. Before 2002, use DORIS Met. Data. Mapping function Guo and Langley (2003).
(3) – Estimate north and east troposphere gradient daily per station.
(a) – Change from ITRF2008 (lower elevation data included).
(b) – Same Elevation cutoff as in ITRF2008.

Table 9. Summary of Troposphere modeling for IDS ACs

The DORIS ACs improved their troposphere modeling for ITRF2014. All the ACs used either GMF or VMF1 for the troposphere mapping function. IGN and GRG (LCA) applied VMF1. Two of the ACs (ESA and GRG) estimated atmospheric gradients for the SINEX time series. ESA reported (Otten, IDS Workshop 2014) that the estimation of horizontal gradients was aided by the more abundant low elevation data from the DGXX-equipped satellites, after the launch of Jason-2. ESA reported an improvement of 3-5 mm in the WRMS. For the up coordinate, applying the deweighting function, while including the lower elevation data (to 7 degrees), helped to decorrelate the troposphere correction from the station coordinate height estimation. This has also been observed in the analysis of VLBI data, and is the reason VLBI data is included (if possible) down to elevations lower than ten degrees. They did not notice an improvement in the coordinate estimation with the application of gradients prior to 2002 (before the inclusion of data from SPOT-5 and ENVISAT). Willis et al. (2012, IAG Symposia series, doi: 10.1007/978-3-642-20338-1_127) tested the application of gradients on DORIS data in 2007, however IGN only estimated gradients for the last few months of the SINEX series submitted for ITRF2014.

In summary, nearly all the IDS ACs have improved or updated their troposphere modeling, either by adopting new models or mapping functions, and/or by including lower elevation data. It is fair to say that for ITRF2014, the troposphere modeling for the DORIS ACs is much more up-to-date and consistent with the state-of-the art employed by the other radio techniques (GPS & VLBI) than was the case for ITRF2008. We summarize the IDS AC troposphere modeling in **Table 9**.

9.6 INCLUSION OF NEW SATELLITE DATA

In the broadest sense, the new data processed by the IDS ACs for ITRF2014 included the following:

(1) New DGXX-equipped satellites (Jason-2, Cryosat-2, HY-2A, SARAL);
(2) Corrections to data submitted for earlier years;
- New data for ENVISAT (2002-2006); cf. DORISMAIL 0823, 16-May-2012).
- New data for SPOT-4 (1998-1999); cf. DORISMAIL 0701, 22-Sept-2010).
- Corrected data for stations GR3B & GAVB for Cryosat-2 and Jason-2, (cf. DORISMAIL 0750,17-May-2011).

(3) Inclusion of Jason-1 (November 2004 to July 2008);
(4) Processing of the SAA-corrected data for SPOT-5, from 2006 onwards.

The ACs were not generally encouraged to process SARAL as the launch of that satellite in only March 2013, meant there would not be sufficient time to validate the models and sort out any potential issues with that satellite. The purpose of including Jason-1 was to add satellite coverage at the inclination of 66° between the end of the availability of DORIS data on TOPEX (November 2004) and the launch of Jason-2 (July 2008). This inclination complements the polar-orbiting satellites in the DORIS constellation strengthening the estimation of DORIS station coordinates. This period coincided with the use of the second DORIS USO on Jason-1, which was more stable than the first DORIS USO. The first DORIS USO on Jason-1 was used from the launch of the satellite through cycle 90 (~June 14, 2004). Three ACs processed data from Jason-1: ESA, GRG, and GSC. The ACs were asked to apply a strategy to deweight or exclude the Jason-1 SAA-affected stations, and minimize or eliminate their contributions to the combined weekly solutions. G. Moreaux evaluated the test series that included Jason-1 data and presented the results at the IDS AWG in Washington (Fall 2013). Regarding the Jason-1, the salient conclusions were: (1) All of the Helmert parameters show reduced standard deviations (smaller scatter) with the addition of Jason-1; (2) The week-to-week repeatability in the station positions was improved; (3) There was little impact on the EOP parameters; (4) It appeared a 120-day periodic signal was introduced into the Helmert parameters in the comparisons of the solutions from some of the ACs. In summary the addition of Jason-1 for ITRF2014 was successful. The ACs that did not process Jason-1 should be encouraged to process the data from this satellite and have their contributions validated – so as to be 'prepared' for the data processing associated with the next ITRF realization in four-five years (2018 or 2019).

9.7 **OPEN ISSUES AND RECOMMENDATIONS**

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. The IDS Community should not rest on its laurels, as there are still many substantive issues that remain to be addressed, even with the current data already processed. These issues where future work or investigations will be required are listed below.

(1) Jump in DORIS scale, 2012: All the DORIS Analysis Centers observe the jump in scale. Presently the only substantive clues are that the jump seems more prominent for the DORIS analysis centers that use the data-supplied corrections and that although Cryosat-2, Jason-2 and HY-2A seem implicated, it is HY-2A that seems to cause the largest jump in scale.

(2) Scale issues on SPOT-5: At the AWG meeting in Washington DC (October 2013), G. Moreaux presented an analysis of the scale of SPOT-5 single-satellite SINEX solutions submitted by three ACs (ESA, GRG, GSC). All three ACs applied the SPOT satellite attitude law in their software and the tracking point offsets and center of mass as specified in the CNES documentation. The SPOT-5-only scale clearly showed a saw tooth pattern with breaks at or near the following dates: (a) 2004/11/22; (b) 2006/09/18; (c) 2008/08/28; (d) 2011/04/11. 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.

(3) Degradation in solutions near the Solar Maximum (2001-2002): The IDS Combination solution presents a degradation in WRMS of about 5 mm in late 2001 to early 2002. This corresponds to the period of most intense solar activity associated the maximum of solar cycle 23. A similar degradation appears not to have been observed near the maximum of solar cycle 24 for two reasons: (1) the peak of solar cycle 24 has not been as intense as that of solar cycle 23; (2) the SPOT-2 and SPOT-4 satellites were retired by the peak of solar cycle 24, and in addition more data was available from DGXX-equipped satellites, strengthening the station position determinations. While not a major issue, the degradation in 2001-2002 should be amenable to improvement. It appears that the efforts by the IDS ACs to estimate drag coefficients more frequently did not completely resolve the problem.

(4) Error in center of mass of SARAL: Both the CNES POD team and the GSC analysis center (see poster by N. Zelensky at the IDS Workshop in Konstanz, October 2014) showed that there was a -4 cm error in Z (cross-track) in the Center of Mass of the satellite in the spacecraft frame. The IDS needs to agree on a corrected value for the Center of Mass, assure that the DORIS format 2.2 data are reprocessed to this new standard, and then verify that all the ACs (especially those that apply the tracking point offsets themselves in their respective orbit determination programs) use these updated values.

(5) Error in data corrections for ENVISAT (2003-2004): When the GSC analysis center applied the DORIS antenna phase correction, because of the requirements of the GEODYN software it had to apply the tracking point corrections inside of GEODYN. The antecedent solutions had used the DORIS data-supplied corrections. GSC noticed that in 2003 through the third quarter of 2004 (possibly also 2002) that with gscwd21, the ENVISAT DORIS RMS of fit was dramatically improved, from 0.75 to 0.55 mm/s in cases (see **Figure 11**). Although a small improvement is expected when the phase law is applied, the large improvement was obviously independent of any application of the phase law. It implies the data-supplied tracking point corrections for ENVISAT are in error in this time period for at least some of the data. Therefore, the IDS AWG should request that the CNES POD center review their processing of ENVISAT data, and possibly submit corrected ENVISAT data files to the IDS data centers for at least this time period.

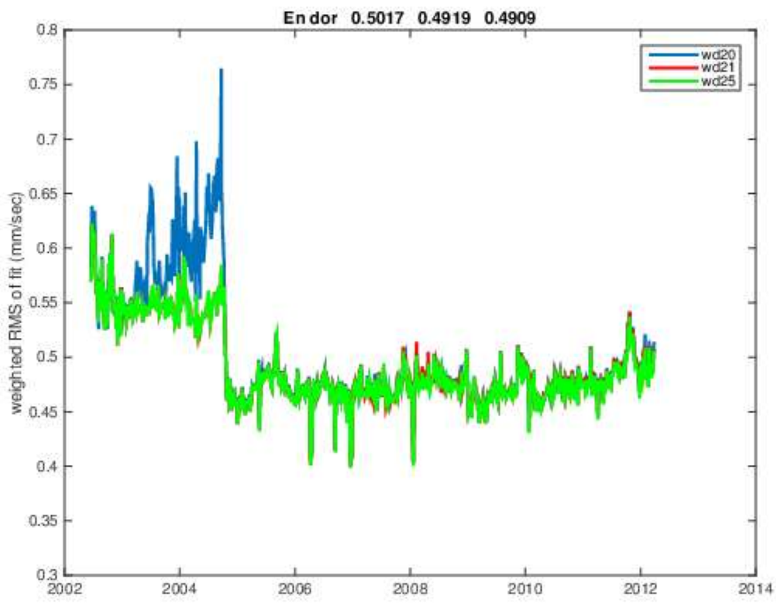

Figure 11. ENVISAT RMS of fit for three SINEX series: GSCWD20 (use data-supplied tracking point corrections, no phase law); GSCWD21 (use GEODYN-computed tracking point corrections, and apply phase law); GSCWD25 (GSCWD21 + apply improved model for time-variable gravity

(6) Validation of macromodel performance: A particularly successful aspect of the work performed by the IDS ACs for ITRF2014, was the inter-comparison of the performance of the residual accelerations between the different ACs. It was possible to ascertain with these comparisons that each AC had a macromodel or attitude modeling issue with at least one satellite. This comparison was particularly helpful in identifying satellite-specific anomalies in the modeling of the non-conservative forces. It is highly recommended that these inter-comparisons continue to be made, especially for new satellites, or if an AC changes its background models. This intercomparison is an important part of the performance validation for the routine combination as well as for the individual AC. A close inspection of the history of empirical accelerations, particularly on a day-by-day or week-by-week basis could also identify aberrant arcs for any particular analysis center. The inter-comparisons were not pushed to this level for ITRF2014, but might be considered for the routine operational processing.

(7) Quaternion Availability: For ITRF2014 the IDS ACs mostly used the nominal attitude laws to orient the spacecraft body and any articulating appendages (such as solar arrays). Only the GSC analysis center used the body quaternions from Jason-1, Jason-2, Cryosat-2 and occasionally for TOPEX (*only for off-nominal cycles*). The assumption has been that the nominal attitude law was adequate for most of the DORIS satellites. This might be true for the satellites without articulating solar arrays, but Cerri et al. (2010) noted that the solar array orientations can deviate from the nominal (see Cerri et al., 2010, Marine Geodesy). Given that the geophysical products (especially the Earth orientation parameters) are known to contain the 118-day (Jason-related) solar beta-prime signal, it may be useful to implement an analysis campaign to test direct use of the quaternions in the force and measurement models to see if the amplitude of these signals can be reduced. Not all IDS ACs can fully handle the use of spacecraft quaternions to model spacecraft attitude. The status of the IDS ACs in this respect is summarized in **Table 10**.

AC	**Software**	**Handle Quaternions.**
ESA	NAPEOS	At present body quaternions only.
GOP	Bernese	Software not yet capable.
GRG	GINS	Yes.
GSC	GEODYN	Body and solar array quaternions.
IGN & INA	GIPSY	Handle quaternions in single-satellite, but not multi-satellite mode.

Table 10. Summary of External Attitude (Quaternion) modeling for IDS ACs

Presently quaternions (external attitude) information is not available for HY-2A and SARAL, so we cannot make an assessment with those satellites the extent to which a slightly off-nominal attitude might affect the recovery of geophysical parameters. For missions such as Sentinel-3A/B, Jason-3, every effort should be made to make sure the spacecraft quaternions (including those of the solar array) are routinely made available and archived in the IDS data centers. For these satellites, this information is pertinent not only to the force model, but also to the measurement modeling and data reduction for GPS and SLR as well as DORIS.

(8) Atmospheric gravity: As previously mentioned all ACs except the GIPSY analysis centers used external information to forward model atmospheric and oceanic mass variations. These "Atmosphere-Ocean-Dealiasing" products are used in the reduction of the GRACE, GOCE and LAGEOS data – so the geopotential modeling is incomplete for example for EIGEN6S2 if this information is not used. The GIPSY analysis centers should be encouraged to upgrade their version of GIPSY and include these forward models, as failing to model these mass variations can induce annual radial orbit errors of up to 5 mm on the Jason orbit (see Lemoine et al., 2010, Adv. Space Res), and probably higher signals on the lower orbiting DORIS satellites. The IDS Analysis Coordinators should identify sources of this AOD information with sufficient latency for use by the IDS ACs. Three possibilities are: (1) the AGRA files from NCEP (available from http://gemini.gsfc.nasa.gov/agra); (2) ECMWF 6-hrly or 3-hrly files supplied by Jean-Paul Boy (University of Strasbourg) on a best-efforts basis; (3) The AOD files supplied by the GRGS.

(9) Implementation of ITRF2014: Altamimi et al. (2014, IDS Workshop, http://ids-doris.org/images/documents/report/ids_workshop_2014/IDS14_s1_Altamimi_IDScontributionITRF2013.pdf**,** pp. 15-18) have already announced that the geodetic station motion will be 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 – but other stations could also be affected), but it means four parametric models will need to be integrated into each POD software. The implementation and verification of these new models will of necessity complicate the evaluation of the ITRF2014. The IDS ACs and the Analysis Coordinators will need to work closely on validating their implementation of ITRF2014.

(10) Augmentation of the DORIS constellation: It is becoming extremely popular to propose low-cost "mini-satellite" missions. These are nano-satellites, that can carry only a targeted scientific instrument and a miniaturized components on small satellite bus. The nanosatellites can be of the Cubesat 1U (10 cm) or 3U (30 cm) variety. It might be useful to encourage studies to see how (and whether) DORIS could participate in nano-satellite initiative – as it would be a convenient method to diversify the DORIS satellite constellation from the point of view of orbit inclination and altitude.

(11) SPOT-2 Pre-1992 Analysis Campaign: The contribution of DORIS to the IERS reference frame starts in January 1993. We all know that the SPOT-2 spacecraft was launched on January 22, 1990. Three months of pre-1990 data were provided by the CNES to NASA as preparation for the TOPEX/Poseidon in 1992. These data were eventually incorporated into the pre-launch gravity models for TOPEX/Poseidon (e.g., see Nerem et al., JGR, 1994). It has always been an assumption that the mono-satellite solutions for coordinates and EOP are not very useful. However, the ILRS also relies on only one satellite prior to the launch of Lageos-2 and the Etalon satellites. So in a combination solution for the reference frame, DORIS might contribute to a solution for EOP even from SPOT-2 alone from 1990 to 1992. In addition, the extra two years could be useful for constraining the velocity of some DORIS stations, particularly those of island sites with tide gauges. It might be useful to initiate an analysis campaign for the three months of SPOT-2 data 1990 that are extant at the IDS Data Centers. If these campaigns are promising, then the CNES might be encouraged to translate the remaining 1990-1992 SPOT-2 data into a usable format (i.e. DORIS format 2.2). We note that the IGN analysis center has already processed and conducted preliminary studies using these 1990 from SPOT-2.

10 IDS COMBINATION CENTER

Guilhem Moreaux *(CLS, France)*

10.1 ACTIVITY SUMMARY

IDS combination activities in 2014 were devoted to the elaboration of the IDS contribution to ITRF2013 as well as to communications at EGU and AGU meetings.

10.2 IDS ROUTINE COMBINATION

Due to the ITRF2013, the routine combination has been suspended in 2014.

10.3 ITRF2013 CONTRIBUTION

From April 17th to December 5th, the IDS Combination Center delivered 5 versions of the IDS weekly combined solution to IERS in the framework of the ITRF2013 realization.

The first IDS combined solution, which was delivered mid April, was denoted as preliminary version since GOP contribution was not available for the time period 1993-2004 and since ESA series was excluded to the scale estimation between 2002 and 2004 due to Jason-1 including. Excepted INA, the other 5 single AC series took into account DORIS ground antennae (Alcatel and Starec) phase laws. Therefore, as agreed during the AWG meeting which took place in October 2013 in Washington, INA does not contribute to the combined scale. Moreover, as ESA EOPs showed larger differences with IERS C04 series than the other ACs, ESA was not included in the X- and Y-pole estimates. Note than since less than 3 ACs estimate LOD, the combined solution does not include LOD values.

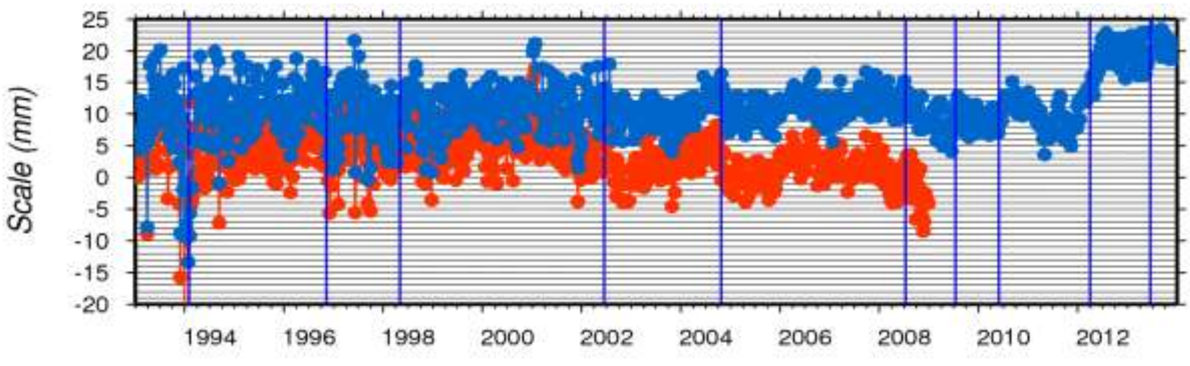

Figure 12. Scale values of IDS combined solutions (red= IDS contribution to ITRF2008; blue = IDS preliminary contribution to ITRF2013) wrt ITRF2008.

As depicted by **Figure 12**, compared to the IDS contribution to ITRF2008, the scale of that preliminary IDS contribution to ITRF2014 shows no more discontinuity early 2002 thanks to implementation of beacon frequency offset estimation by all the ACs. Both IDS contribution to ITRF2008 and preliminary contribution to ITRF2013 present high absolute values early 1994. Further investigations revealed that these values were due to SPOT2 so, different strategies were proposed to minimize such scale outliers. From **Figure 12**, we also observe that adding Jason-1 between end of TOPEX (late 2004) and Jason-2 start (mid 2008) improves scale stability. Moreover, scale of the new combined solution shows high increase since mid 2012.

Taking into account IDS feedbacks from the evaluation of the preliminary version of the IDS contribution to ITRF2013 as well as availability of GOP contribution from 1993 to 2004, very early August, the IDS CC made available to IERS a second version of the IDS combined solution. That new solution also took benefit of EIGEN6-S2 time variable gravity field update for post 2012 drift coefficients. Moreover, that update version uses new version of ESA series which does not anymore includes Jason-1 between 2002 and 2004.

In response to a DGFI request to add a SOLUTION/STATISTICS block (including number of observations, number of unknowns, number of degrees of freedom and matrix scaling factor) in the combined SINEX files, late September 2014, the IDS CC redelivered to IERS the 1093 SINEX files sent early August including the new block.

While doing some new validations of the IDS combined solution delivered to IERS for ITRF2013, I realized that four stations (JIVB - Jiufeng, KRWB - Kourou, MAIB – Mahé - and SODB - Socorro) were rejected for bad reasons. As at that time, not all the geodetic techniques have submitted to IERS their contribution to ITRF213, I asked IERS to deliver for November 14th an updated version of the IDS contribution including the four missing stations.

Finally, in line with a remark from Zuheir Altamimi on the lack of AREB (Arequipa) in the latest IDS contribution, I decided to do another processing. That IDS combined solution (series 07), which was delivered to IERS on December 5th, also differs from the previous one with a new strategy for the estimation of the combined scale after 2012 doy 092. Evaluations of the single AC solutions pointed out that, even if all the series showed scale increases, half of the ACs had much larger increases than the others. Therefore, to minimize the increase of the combined scale, in addition to INA, IGN and GOP series will not contribute to the combined scale after 2012 doy 092. Then, we end up with a IDS-ITRF2014 network (see **Figure 13**) of 156 stations located at 71 sites with 38 sites located in the northern hemisphere and 33 in the southern hemisphere. Compared to the IDS contribution to ITRF2008, there are five new sites are: Betio, Cold Bay, Grasse, Socorro in the northern hemisphere and Rikitea in the southern hemisphere.

Furthermore, as depicted by **Figure 14**, half of the sites have been observed 665 weeks (nearly 13 years) with a maximum (resp. minimum) of 1093 (resp. 159) weeks. Note than 9 of the sites have more than 1.000 weeks of observations, i.e. are almost continuously operational since the early beginning of the DORIS system.

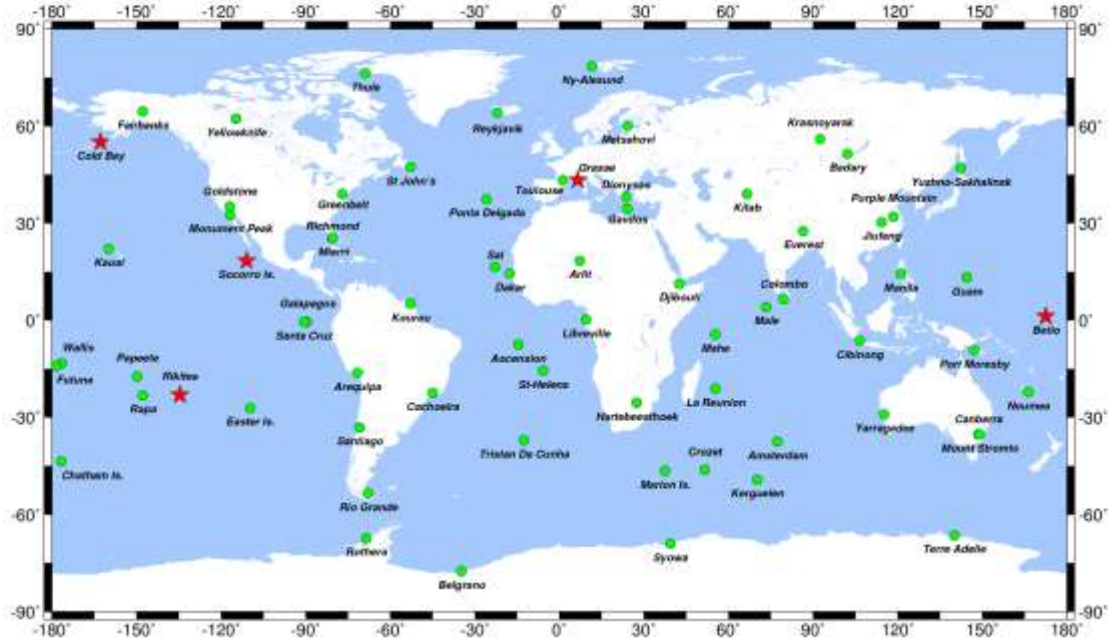

Figure 13. Geographical distribution of the DORIS stations included in the IDS contribution to ITRF2013 (red stars indicate new sites compared to IDS contribution to ITRF2008).

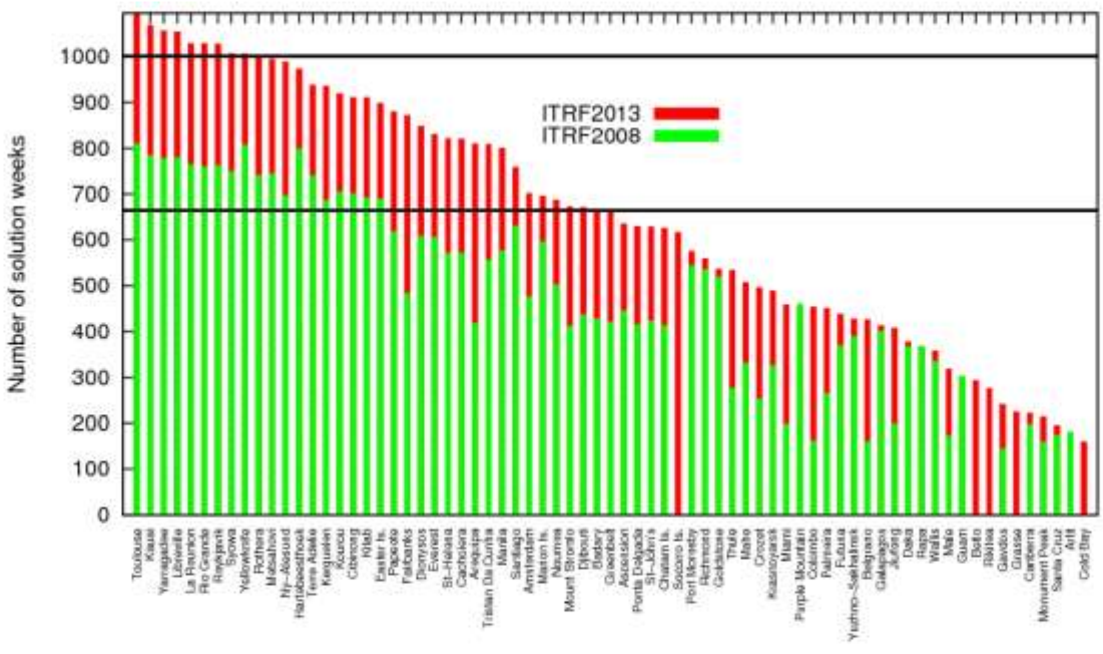

Figure 14. Number of weeks of station position in IDS contribution to both ITRF2013 and ITRF2008.

Evaluation of the IDS contribution to ITRF2008 (series 01) and to ITRF2013 (series 07) with respect to ITRF2008 (see **Figure 15**) showed:

- Improvements of Tx, Ty and Tz after 2002 (lower STDs, less annual signal) thanks to time variable gravity fields use in the ITRF2013 contribution.
- Scale offset (between the IDS contributions to the 2 ITRF) due to beacons PCVs in ITRF2013 processing.
- Less scale spurious values early 1994 (SPOT2 is no more included in the combined scale) in IDS series 07.
- No more scale factor discontinuity in 2002 thanks to beacon frequency offset estimations.
- Improvement of scale stability between end of TOPEX (late 2004) and Jason-2 start (mid 2008) thanks to Jason-1 including.
- Scale factor increase mid 2012.
- Better week-to-week repeatability of Helmert parameters of ids 07 (solution more consistent).

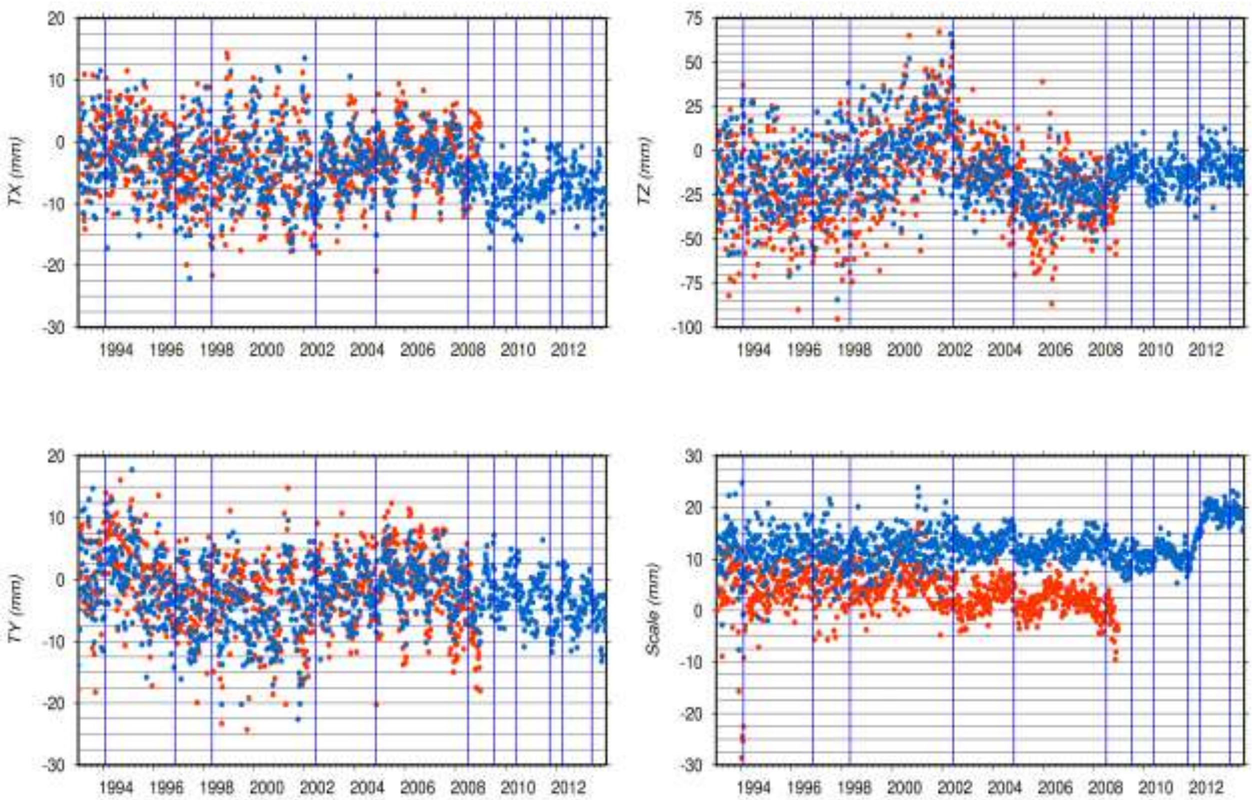

Figure 15. Helmert parameters (translations and scale of the IDS contributions to ITRF2008 (red) and ITRF2013 (bkue) with respect to ITRF2008.

In addition, the evaluation process also pointed out that the IDS contribution to ITRF2013 gives higher differences of mainly X-pole estimates with the IERS C04 than the IDS contribution to ITRF2008 series (see **Figure 16**). The explanation of that substantial degradation could be that the new solution uses 2 ACs less than the previous one.

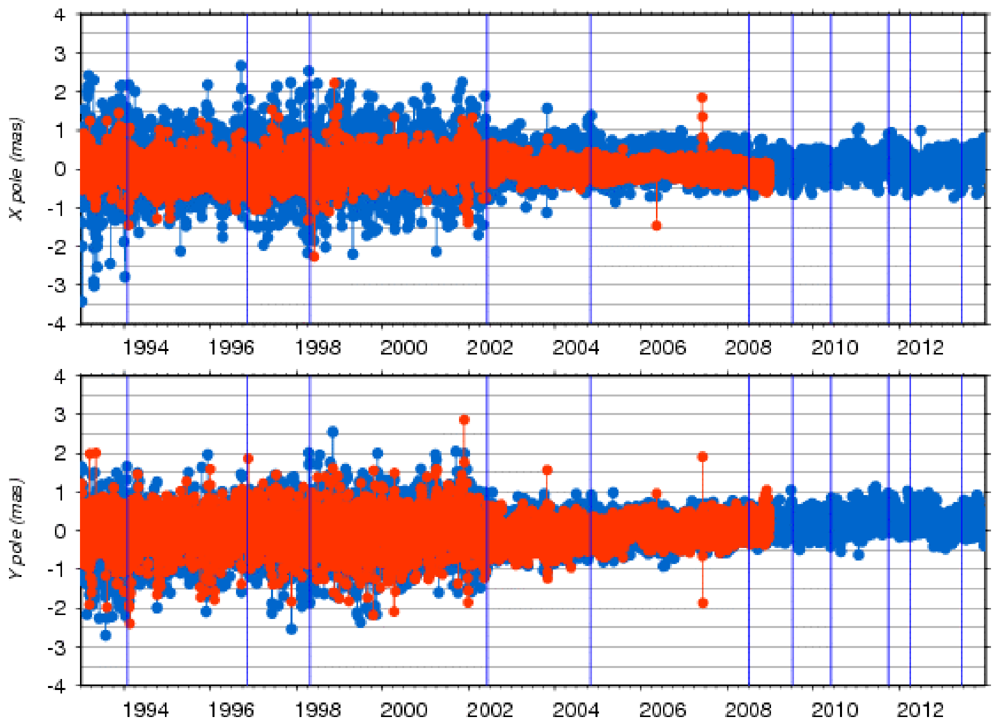

Figure 16. EOPs differences between IDS contribution to ITRF2008 (red) and ITRF2013 (blue) with respect to IERS C04 series.

10.4 COMMUNICATIONS

The IDS Combination Center joined both EGU and AGU fall meetings where it presented two oral presentations respectively titled “IDS contribution to ITRF2013” and “IDS and ITRF2013: Contribution and Evaluation”. An abstract on the DORIS contribution to ITRF2014 was also submitted for oral presentation at EGU 2015 and a paper on the IDS contribution to ITRF2014 for the DORIS special issue of the journal of Advances in Space Research has been initiated.

10.5 FUTURE PLANS

Due to the transformation of ITRF2013 into ITRF2014, during the first two months of 2015, the IDS Combination Center will finalize the IDS contribution to ITRF2014. Then, the IDS Combination Center will address the elaboration of a stacking chain to compute a cumulative

DORIS position and velocity solution. The objective is to routinely update that cumulative solution from the output of the routine combination process. In parallel and in collaboration with the IDS Analysis Coordinators and IDS Analysis Centers, the IDS Combination Center would like to go further in the explanation of both the scale increase mid 2012 and scale pattern of SPOT5 mission. Last but not least, the IDS CC plans to finalize its paper on the IDS contribution to ITRF2014 and to submit it to the DORIS special issue of the journal of Advances in Space Research.

11 REPORT OF THE EUROPEAN SPACE OPERATION CENTRE (ESA)

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

11.1 INTRODUCTION

The activities in 2014 of the European Space Operation Centre focused on the generation and extension of the ESA IDS contribution to ITRF2014. As a result of various test performed throughout the last and this year we have generated a new ESA IDS solution (esawd10). This solution has been made available to the combination centre and after the finalization of the ITRF2014 activities will be made available on CDDIS. Further this solution will also become the new ESA routine solution for 2015 onwards.

11.2 TESTING FOR ITRF2013 AND THE NEW ESAWD10 SOLUTION

The esawd07 solution released in 2012 contained major improvements to our modeling and was our first solution covering the period from 1993 until 2012. In 2013 and 2014 we have generated several further test solutions that accumulated into the final esawd10 solution. Many minor changes were made but some of the major differences came from the following changes:

- Starec and Alcatel phase law correction applied
- Inclusion of Jason-1 from 2002 until launch of Jason-2
- New SAA corrected data for Jason-1 and Spot-5 (>2006)
- Switch to EIGEN-6S2.5 model for gravity
- Switch to the EOT11a ocean tide model and inclusion of the atmospheric tides (Ray-Ponte 2003)
- Proper handling of the TOPEX and SPOT-5 solar array offset angle
- Retuning of Solar radiation coefficients for all satellites based on each mission entire duration instead of selected period as done before
- Switch from NRLMSISE-90 to NRLMSISE-00 model for neutral atmosphere density calculation

This updated solution covers the entire IDS processing period from 1993 until mid 2014 and has been delivered to the combination centre and after the closure of the ITRF2014 activities will be made available on CDDIS.

Figure 17 shows the weekly statistics from the ESAwd10 solution against one of the earlier combined IDS ITRF2014 solution.

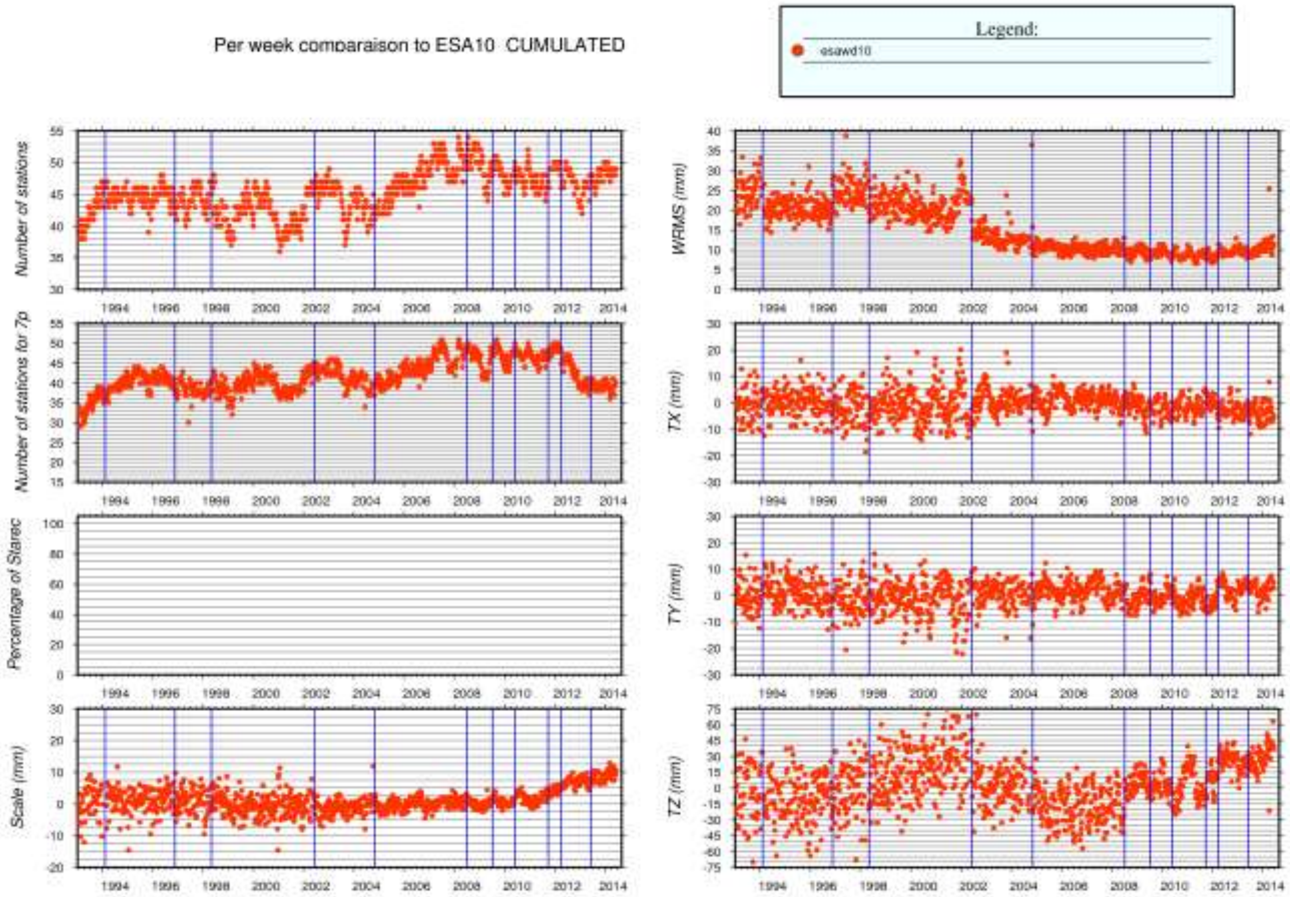

Figure 17. Weekly statistics from the ESAwd10 solution

11.3 FUTURE ACTIVITIES

The Navigation Support Office plans for 2015 to switch to processing the DORIS RINEX data for Jason-2, Cryosat-2 and HY-2A instead of the older DORIS Data Exchange Format.

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 REPORT OF THE GEODETICAL OBSERVATORY PECNY ANALYSIS CENTER (GOP)

Petr Štěpánek ***(Geodetic Observatory Pecný, Czech Republic)***

12.1 DATA RE-PROCESSING FOR NEW ITRF

Activities of GOP analysis center in 2014 were mainly focused on the ITRF data re-processing. The data from all the DORIS satellites from 1993.0 to 2014.0 except Jason-1 were processed with the newly defined standards, while the changes from the previous DORIS data processing are following:

- Dynamical orbit modeling instead of empirical-stochastic approach
- Corrected software minor error in ocean tides model application (gravity)
- Ground antenna phase center law application (Alcatel and Starec)
- Compatibility to IERS 2010 conventions
- Time-varying gravity field model EIGEN-6S2 after 2002.0
- SPOT-5 SAA corrected data

The improvement was achieved in: reduction of the station WRMS, reduction of Tx, Ty variations and the elimination of the high frequency signal in the series, reduction of Tz dependence on the Solar activity and reduction of the estimated polar coordinates RMS w.r.t. IERS C04 model, demonstrated by **Figure 18**.

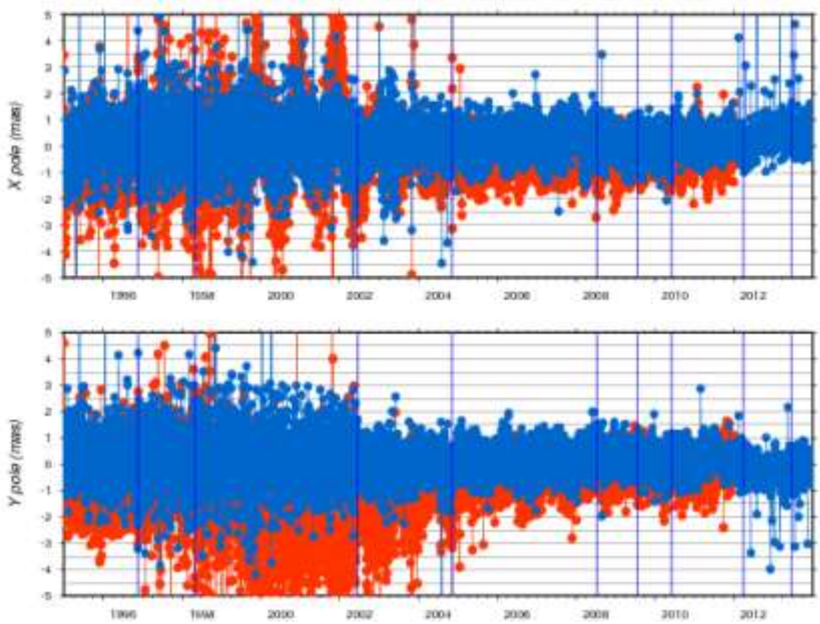

Figure 18. Xp, Yp bias relative to IERS C04 model: (red) old processing standards, (blue) recent processing standards (by Guilhem Moreaux)

12.2 GRAVITY FIELD APPLICATION STUDY

The study analyzing the gravity force impact was performed at GOP (Štěpánek et al., in preparation). Our study is different from those published in the past, e.g., Rudenko et al. 2014. We are not searching an optimum gravity field model, all our results were obtained applying the EIGEN-6S2 model with differing restrictions. We want to understand how precisely we need to apply a given gravity field model, i.e. what is the limit for the degree of model geopotential coefficients to meet an accuracy required. Moreover, we want better understand the effect of the time dependent terms, periodical and piecewise linear. Our interest is to determine the size of their impact on the estimated orbit ephemerides and a possible POD improvement reached by using these terms. In addition, we performed a similar study for the gravity variations due to the ocean tides, applying the FES 2004 model with differing restrictions. The main goal is to provide background information for future considerations of the gravity force modeling for POD, particularly for corresponding application to DORIS data.

12.3 VERIFICATION OF CNES/CLS SPOT-5 DATA CORRECTIVE MODEL

CNES/CLS data corrective model is recently used as the IDS standard for compensation of the SPOT-5 onboard DORIS oscillator instability due to the South Atlantic Anomaly (Capdeville et al., in preparation). We performed thcomplex testing of the data corrective model, using the data span 2006.0 – 2014.0. Our testing confirmed the improvement of the POD and RMS of the fit. For station coordinates estimation, the data corrective model eliminates the bias in station Latitude and Height. However, the bias in longitude is neither eliminated nor reduced. **Table 11** includes the summary of the station coordinates bias (SPOT-5 single satellite solution relative to the multi-satellite solution without SPOT-5).

12.4 REFERENCES

Capdeville H., et al.: 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 preparation

Rudenko, S., Dettmering, D., Esselborn, S., Schöne, T., Förste, Ch., Lemoine, J.-M., Ablain, M., Alexandre, D., Neumayer, K.-H.: Influence of time variable geopotential models on precise orbits of altimetry satellites, global and regional mean sea level trends, Advances in Space Research", 54(1): 92-118, 10.1016/j.asr.2014.03.010, 2014

Štěpánek P, Bezděk A, Kostelecký J, Filler V: Gravity field modeling application for DORIS precise orbit determination, in preparation.

Station coordinates bias (SPOT-5 single satellite solution relative to the multi-satellite solution without SPOT-5). All the stations with bias over 30 mm in any coordinate are included. SAA stations are highlighted by yellow.

Station	Latitude	Longitude	Region	No corrections (mm)			Corrected (mm)		
				Latitude	Longitude	Height	Latitude	Longitude	Height
ADGB	-66.5	140	Antarctica	9.3	7.9	**-35.0**	-3.6	14.4	**-30.7**
ARFB	-16.4	288.5	Peru	**-89.7**	**56.9**	**128.7**	-25.5	**-57.6**	1.9
ASEB	-7.9	345.7	South Atlantic	**-52.8**	**-36.9**	**44.5**	-11.9	**60.6**	-5.5
BEMB	-77.8	325.4	Antarctica	-13.5	3.1	**-44.0**	-5.8	3.2	**-37.1**
CADB	-22.5	315	Brasil	29.6	**-123.1**	**248.1**	-3.7	**-126.7**	-19.0
CRQB	-46.2	51.8	S-W Indian Ocean	1.7	16.5	**-35.7**	-2.7	10.6	**-34.4**
HEMB	-15.8	354.3	South Atlantic	-2.3	**-44.0**	17.7	8.8	-6.0	11.6
KRVB	5.1	307.4	Guiana	**-71.1**	**31.2**	-2.0	-15.3	**60.7**	8.7
KRWB	5.1	307.4	Guiana	**-110.5**	**75.0**	21.4	-4.6	**117.6**	**33.7**
MATB	-46.7	37.8	S-W Indian Ocean	-2.0	9.4	**-33.4**	-3.4	2.8	-28.8
MOSB	-9.4	147.2	Papua New Guinea	-20.2	**-40.3**	20.2	-23.2	**-38.7**	14.1
RIQB	-53.6	292.3	Argentina	14.9	**36.5**	**-37.0**	-12.0	**61.3**	-4.3
RIRB	-53.6	292.3	Argentina	**35.8**	**52.4**	**-49.1**	-3.9	**71.7**	-3.0
ROVB	-67.4	291.9	Antarctica	-0.8	14.6	**-47.2**	5.8	16.5	-29.6
SANB	-33	289.4	Chille	**102.2**	**55.3**	**89.0**	5.8	**-53.9**	7.5
SYPB	-68.8	39.6	Antarctica	-2.4	18.0	**-37.9**	-3.6	11.1	**-33.5**
TRJB	-36.9	347.7	South Atlantic	21.3	18.2	**-46.8**	-20.9	33.8	**-46.6**

Table 11. Station coordinates bias (SPOT-5 single satellite solution relative to the multi-satellite solution without SPOT-5). All the stations with bias over 30 mm in any coordinate are included. SAA stations are highlighted by yellow.

13 REPORT OF THE CNES/CLS ANALYSIS CENTER (GRG, FORMERLY LCA)

Hugues Capdeville, Laurent Soudarin, 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 2014 was to finalize our contribution to the next release of the International Terrestrial Reference Frame planned in 2015 (ITRF2014). We give here a review of our ITRF reprocessing. In 2014, we also worked on the SAA corrective model for Jason-1 by using CARMEN (dosimeter onboard of Jason-2) map and provided the SPOT-5 DORIS data corrected by the SAA model.

13.2 DATA PROCESSING AND PRODUCTS DELIVERED TO IDS

Note the acronym of the IDS CNES/CLS AC products has been changed to GRG instead of LCA to be coherent with the products of the IGS CNES/CLS AC. GRG is indeed the acronym chosen by the CNES team involved in both Analysis Centers as it is part of the GRGS.

13.2.1 ITRF REPROCESSING REVIEW AND STANDARD ROUTINELY PROCESSING

For our contribution to the new realization of the ITRF, we processed DORIS data from January 3, 1993 to September 4, 2014. Indeed, it was asked to ACs of the different techniques to complete their contribution with the year 2014. However, because of the late request and the availability times of the data, it was decided to provide SINEX files only for the eight first months of the year. We took this opportunity to add SARAL in our multi-satellite solution. So, for 2014, the corresponding products are obtained from the routine processing set up after the dedicated reprocessing for the ITRF. The series of multi-satellite solutions in SINEX format was delivered to the IDS Combination Center with the label grgwd40. Orbit files in sp3c format were supplied to the IDS Data Centers for each DORIS mission from its beginning, including Jason-1. These are DORIS+SLR mixed orbits for ENVISAT, TOPEX, CRYOSAT-2, HY-2A, SARAL and the two JASON satellites, and DORIS-only orbits for the SPOT satellites. The generic name of these series is grg03.sp3.

Coordinates time series of each station expressed in ITRF2008 can be displayed on the IDS website with the visualization tools at http://ids-doris.org/webservice. They are updated approximately every 3 months. Description files can be found at CDDIS (ftp://cddis.gsfc.nasa.gov/) and IGN (ftp://doris.ensg.ign.fr/).

Table 12 gives the DORIS data used and the satellite combination for the different periods. For all missions, the elevation cut-off is 12° and a down-weighting law is applied for elevation angles under 20°. Note that for Jason-1 we used the new data set including SAA model corrections for the time range between the end of TOPEX (Nov. 2004) and the beginning of Jason-2 (July 2008). For SPOT-5, the new data set including SAA model corrections is considered from 2006 onwards.

Period	Satellite_combination
1993/01-1994/01	s2t
1994/02-1996/10	s2s3t
1996/11-1998/04	s2t
1998/05-2002/06	s2s4t
2002/06-2002/07	s2s4s5t
2002/07-2004/10	s2s4s5te
2004/10-2008/06	s2s4s5ej
2008/07-2009/07	s2s4s5eJ
2009/07-2010/05	s4s5eJ
2010/05-2011/10	s4s5eJc
2011/11-2012/04	s4s5eJch
2012/04-2013/03	s4s5Jch
2013/03-2013/06	s4s5JchS
2013/06-2014/09	s5JchS

Table 12. Multi-satellite combination used for IDS solutions (s2/3/4/5 = SPOT-2/3/4/5, t = Topex, e = Envisat, J = Jason-2, c = Cryosat-2, j = Jason-1, h=Hy-2a, S=Saral)

In **Table 13**, we summarize the results of our reprocessing for the ITRF. For each satellite, we give the processing period, the solar radiation coefficient, the RMS of the orbit residuals, the One Per Revolution (OPR) mean amplitudes (along-track and cross-track) over the processing period. The solar radiation coefficients have been estimated over a sufficient long period and the obtained mean values are kept fixed in the data processing. The level of DORIS and SLR orbit residuals are good. The mean OPR acceleration amplitudes are < 4 nm/s^2. Note, that high amplitudes (>10 nm/s^2) can be the fact of a problem in the macro-model or in the attitude law implementation.

Satellite	Period	Solar radiation coefficient	RMS DORIS - LASER mm/s - cm	OPR Amplitude Along_Track/Cross_Track average in nm/s2	
SPOT-2	01/1993-07/2009	1.07	0.41	1.7	1.6
SPOT-3	02/1994-11/1996	1.07	0.43	0.9	1.2
SPOT-4	05/1998-06/2013	1.16	0.39	1.3	1.1
SPOT-5	06/2002-09/2014	1.05	0.34	1.6	1.2
TOPEX	01/1993-10/2004	1.03	0.45	1.7	1.2
ENVISAT	07/2002-04/2012	1.05	0.39 - 0.97	1.1	1.1
JASON-1	11/2004-07/2008	0.94	0.31 - 1.2	1.9	1.1
JASON-2	07/2008-09/2014	0.97	0.31 - 1.2	2.6	1.5
CRYOSAT-2	06/2010-09/2014	1.0	0.34 - 0.94	3.3	2.3
HY-2A	11/2011-09/2014	0.86	0.33 – 1.15	0.5	1.8
SARAL	03/2013-09/2014	1.0	0.35 - 0.9	1.3	1.3

Table 13. Results of the CNES/CLS AC (GRG) reprocessing

The IDS Combination Center has done the first analysis of our multi-satellite solution grgwd40. **Figure 19** presents the results of the comparison to the ITRF 2008 obtained with CATREF software for the grgwd40 series and our previous solution lcawd30. In addition to the usual results (WRMS, scale, Translations Tx, Ty, Tz, …) the percentage of STAREC antennae in the sub-network selected to calculate the 7 Helmert parameters is given. It is used by the IDS CC to look at the correlations between the evolution of the network and the improvements of the results. The first interesting result we can note for the grgwd40 solution (in blue) is the larger bias on the scale which is explained by the application of the phase law. Contrary to the grgwd40 solution, the phase law was not applied for the lcawd30 solution. Still regarding the scale factor, a jump is observed mid-2012, essentially due to HY-2A data and seen by all the IDS ACs.

The periodic long term signal of 18,6 years on the translations Tx and Tz is clearly reduced with the grgwd40 solution.

On **Figure 19**, we also see the different time periods corresponding to the change of satellite number in the constellation (vertical blue lines), in particular the two periods, before and after 2002 (introduction of the 2G instruments with Spot-5, Envisat and Jason-1, and increasing number of satellites from 3 to 5).

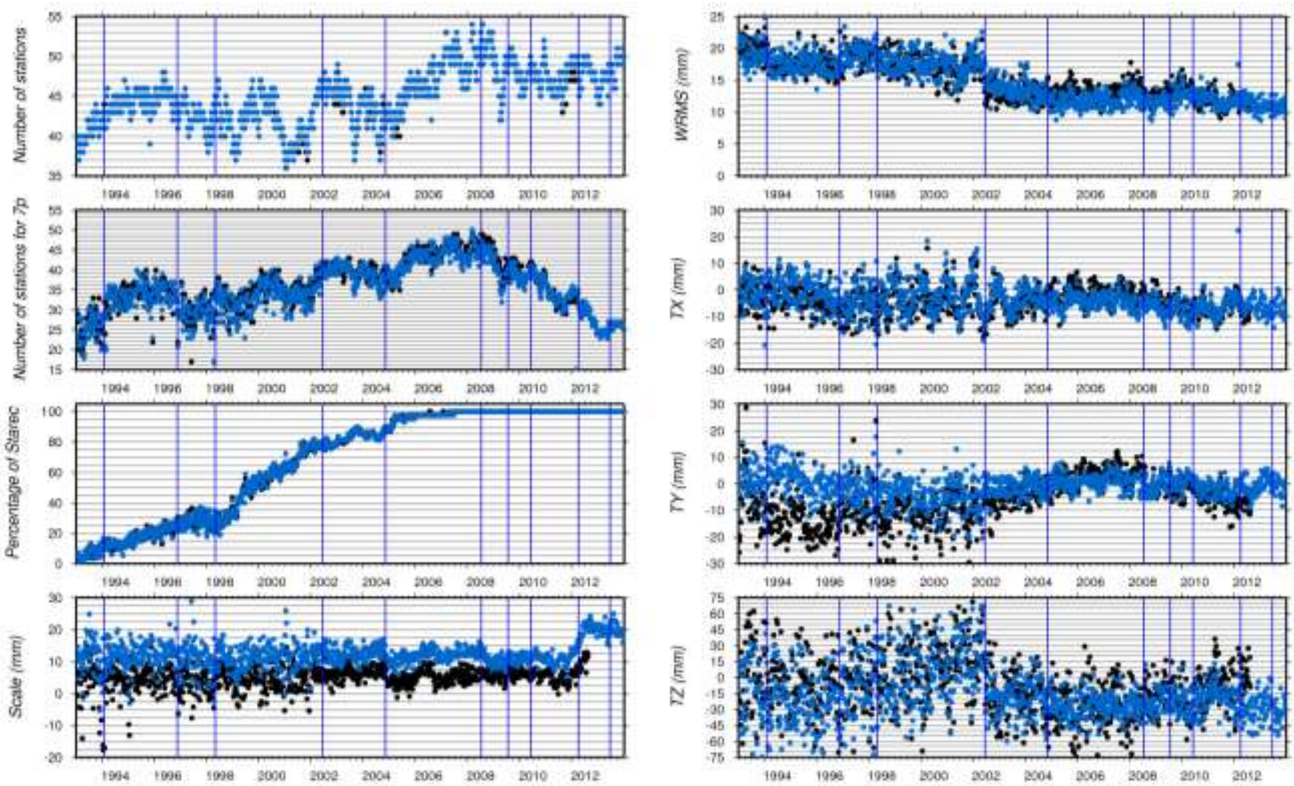

Figure 19. 7 Helmert parameters (Geocenter and Scale) estimated by the IDS Combination Center with GRG (formerly LCA) solution grgwd40 in blue and lcawd30 in black

Figure 20, which gives the EOP differences between the GRG solutions (grwd40 in blue and lcawd30 in black) and the C04 IERS series, shows that the grgwd40 solution is better, especially after 2008.

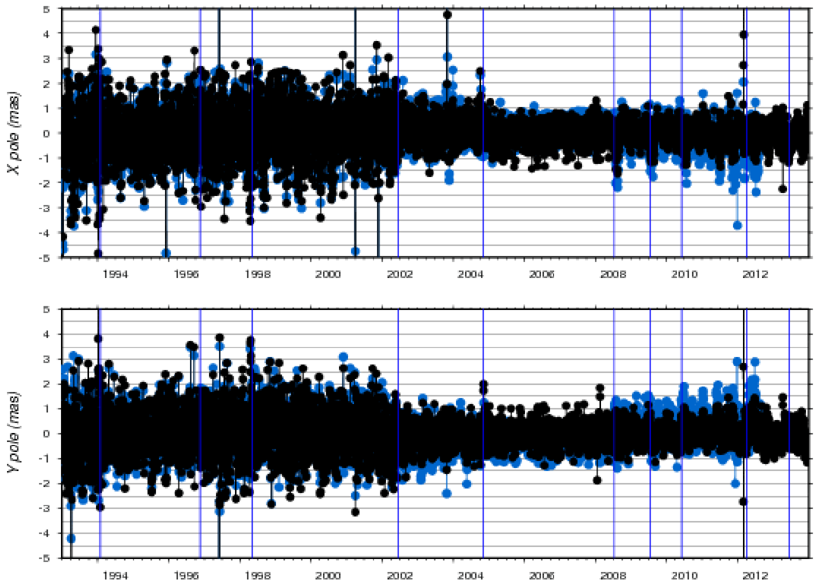

Figure 20. EOP differences between GRG (formerly LCA) solutions and IERS C04 series (grgwd40 in blue and lcawd30 in black)

13.3 COMPARISON TO THE CNES-GDR-D PRECISE ORBITS

We compared CNES GDR-D precise orbits (calculated with ZOOM software) to GRG precise orbits (calculated with GINS software) obtained in the frame of the new realization of ITRF. The main differences in the POD configuration between CNES GDR-D and GRG AC are presented in **Table 14**. Note that the GPS data are included in CNES POD when they are available. For the gravity field, GRG AC uses a more recent version of the EIGEN model (called EIGEN-6S2.v2.extended) with the associated dealiasing products.

For each satellite, the orbit differences are performed and the discrepancies are given as the average and the standard deviation per week for the along-track, cross-track and radial components. To look for potential geographical systematic differences, we have also calculated the average of radial discrepancies in 2° boxes.

We present here the results obtained for Jason-2. **Figure 21**, which gives the orbits differences in the three components, shows a good agreement between CNRS GDR-D and GRG orbits, especially in radial. On **Figure 22**, we represent on a map the mean radial orbit differences calculated over 6 months in 2° boxes. Radial geographical systematic differences are observed, mainly a patch in the South Atlantic (North/South).

POD Configuration	GRG Analysis Center	CNES GDR-D
Arc length **Data processed**	3.5 days DORIS +SLR	10 days or 7 days DORIS + SLR and +GPS (for satellites with GPS receiver onboard)
Gravity model	EIGEN-6S2.v2.extended up to degree 95 including time variable terms up to degree 50 (bias & drift per yr from 2002 to 2012, periodic 18.6, 1, 0.5yrs) Solid Earth Tides: from IERS2010 Ocean tides FES2012 Atmospheric gravity : 3hr ERA-interim / ECMWF up to degree 50 Non tidal oceanic gravity: TUGO R12 up to degree 50	EIGEN-RGS_RL02bis_MEAN-FIELD(2011) Non-tidal TVG : Annual, Semi-annual, and drifts up to deg/ord 50 Solid Earth Tides: from IERS2003 Ocean tides FES2004 Atmospheric gravity : 6hr NCEP pressure fields + tides from Biancale-Bode model
Surfaces Forces	Radiation Pressure model: tuned for Jason-2 Earth Radiation : Albedo and IR pressure values interpolated from ECMWF 6hr grids	Radiation Pressure model: the same except for Jason-2 Earth Radiation : Knocke-Ries albedo and IR satellite model
Satellite reference	Attitude Model : nominal attitude law for all satellites	Attitude Model : nominal attitude law except for Jason-1 and Jason-2 : Quaternions
Displacement of reference points	Earth tides: IERS2010 conventions Ocean Loading: FES2012	Earth tides: IERS2003 conventions Ocean Loading: FES2004

Table 14. Main differences in the POD configuration between CNES GDR-D and GRG AC

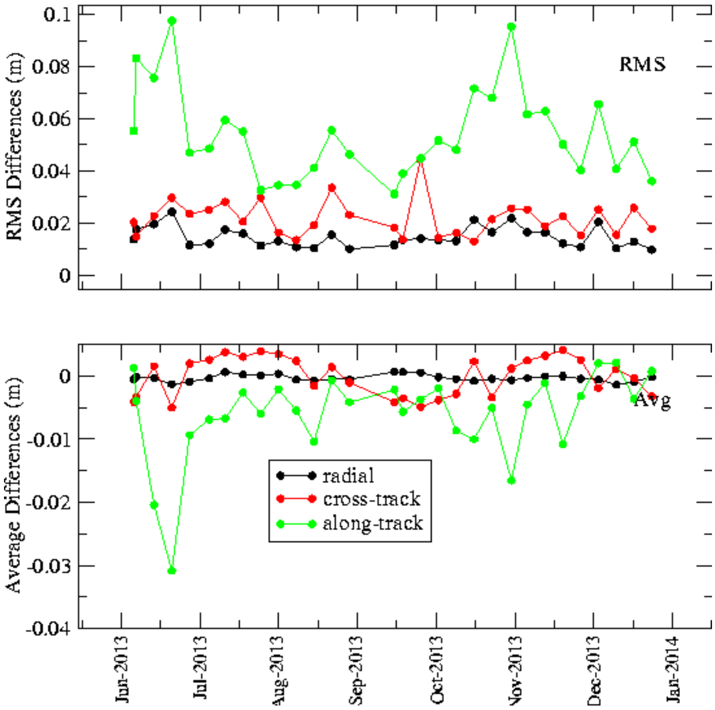

Figure 21. Jason-2 Radial/Cross-track /Along-track Orbit differences GRG vs CNES GDR-D (6 months, June - December 2013)

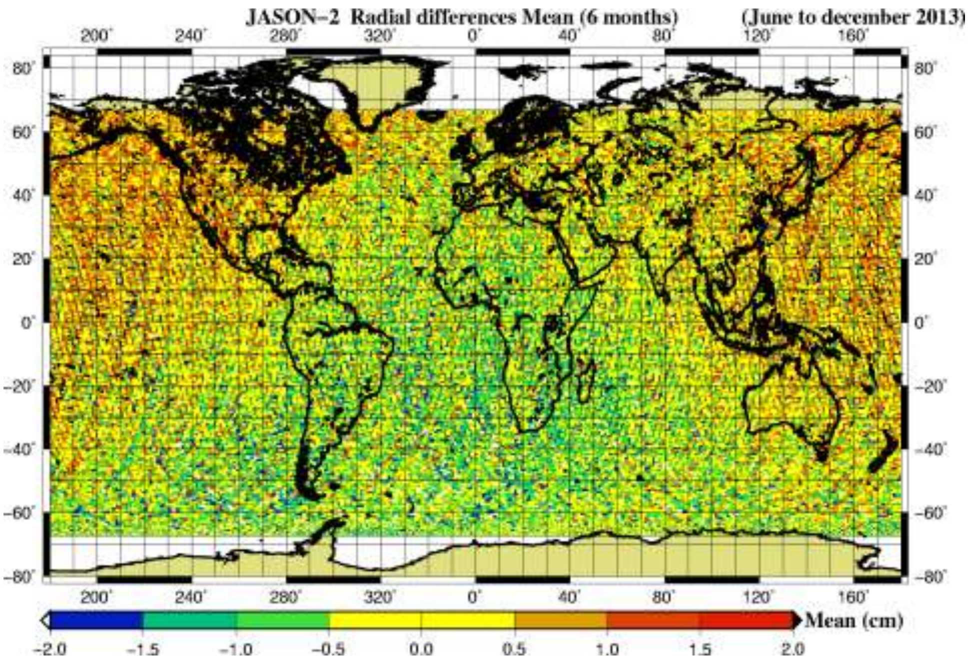

Figure 22. Average of Jason-2 radial orbit differences GRG vs CNES GDR-D (6 months, June - December 2013)

13.4 SAA CORRECTIVE MODELS

In the context of the forthcoming ITRF 2014, the GRG AC was in charge to deliver the measurements corrected with the SAA models for Jason-1 and Spot-5 for the periods defined at the AWG in 2013.

13.4.1 JASON-1 SAA MODEL

In 2013, the use of maps of energetic particles obtained by the dosimeter CARMEN on-board of Jason-2 has been investigated to improve the SAA model. The first work was to define the energy band the most correlate with the one of SAA Jason-1. In 2014, we used this map to determine the model parameters. The new model based on the CARMEN map didn't improve significantly the Jason-1 orbit and the station positioning. We concluded that the SAA map determined from DORIS data has of a good level of quality.

13.4.2 SPOT-5 SAA MODEL

In 2014, an update of the SPOT-5 SAA model has been performed by using the last DORIS data. Then, we continued to provide the SPOT-5 DORIS corrected data to the Data Centers.

13.4.3 DELIVERING SAA CORRECTED MEASUREMENTS 2.2

First, we remind that the corrective model for Jason-1 DORIS Doppler data is available on the CB ftp site under: ftp://ftp.ids-doris.org/pub/ids/satellites/CORRECTIVE_MODEL_JASON1

The Jason-1 doris2.2 data files including corrections from the SAA model are available for cycles number 104 to 241 (from 2004/11/01 to 2008/07/31) on the Data Centers' ftp sites:

ftp://cddis.gsfc.nasa.gov/pub/doris/campdata/saacorrection/ja1
ftp://doris.ign.fr/pub/doris/campdata/saacorrection/ja1, as well as
ftp://doris.ensg.eu/pub/doris/campdata/saacorrection/ja1

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

The Spot-5 doris2.2 data files including corrections from the SAA model are available for cycles number 138 to 469 (from 2005/12/27 to 2015/01/15) on the Data Centers' ftp sites:

ftp://cddis.gsfc.nasa.gov/pub/doris/campdata/saacorrection/sp5/
ftp://doris.ign.fr/pub/doris/campdata/saacorrection/sp5, as well as
ftp://doris.ensg.eu/pub/doris/campdata/saacorrection/sp5

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

13.5 CONTRIBUTION TO IDS MEETINGS

The Analysis Center's representatives participated in 2014 to the AWG meeting in Paris, and to the IDS Workshop and the OSTST meetingin Konstanz. They presented the following works:

AWG Paris

Analyses Center status ITRF2013 Reprocessing Status from CNES/CLS Analysis Center
http://ids-doris.org/images/documents/report/AWG201403/IDSAWG1403-Capdeville-LCAStatusReport.pdf

IDS WS Konstanz

Reprocessing from CNES/CLS IDS Analysis Center for the contribution to the ITRF2013 GRG (formerly LCA) Analyses Center status
http://ids-doris.org/images/documents/report/AWG201403/IDSAWG1403-Capdeville-LCAStatusReport.pdf

Update of the SAA JASON-1 corrective model by the use of the maps of energetic particles obtained by the dosimeter CARMEN onboard of JASON-2
http://ids-doris.cls.fr/images/documents/report/ids_workshop_2014/IDS14_s4_Capdeville_Jason1SAACorrectiveModelWithCarmenMaps.pdf

Use of DORIS RINEX Doppler measurement with the GINS software
http://ids-doris.cls.fr/images/documents/report/ids_workshop_2014/IDS14_s4_Soudarin_UsingRINEXDORISdopplerMeasurementsWithGINS.pdf

OSTST Konstanz

Precise Orbit Determination by CNES/CLS IDS Analysis Center in the framework of ITRF2013
http://ids-doris.org/images/documents/report/publications/OSTST2014-PODatCNESCLSAnalysisCenterforIDS.pdf

14 REPORT OF GSFC/NASA ANALYSIS CENTER (GSC)

Frank G. Lemoine *(NASA, USA)*
Douglas S. Chinn, Nikita P. Zelensky *(SGT/NASA, USA)*
Jennifer W. Beall *(Mission Operations and Service-NASA, USA)*
Karine Le Bail *(NVI Inc-NASA, USA)*

14.1 1. NEW SINEX SERIES

In 2014, the GSC analysis center reprocessed all the available DORIS data (1993.0 - 2014.0) and submitted two SINEX series, gscwd25, and gscwd26 as its contribution to the new realization of the ITRF2013 (which has since become ITRF2014). We had previously implemented an extensive series of improvements and changes with respect to the GSC contribution to ITRF2008 (Le Bail et al., 2010), which have been discussed in the 2013 Report of the International DORIS Service. We summarize the series produced and the changes implemented in **Table 15**. In the series earlier than gscwd18, the changes in the frequency of the beacon from the nominal value were not correctly handled. This caused spurious jumps in the height time series for some stations. This change was handled in GEODYN by modifying the partial derivatives used for range-bias estimation to accommodate the (potential) frequency change.

Series	Description
gscwd12	Previous operational series (continuation of ITRF2008)
gscwd13	Test series in response to IERS call to test application of atmospheric loading
gscwd15	New time series (1992-2012): updates and data cleanups.
gscwd17	Test macromodel-related changes (SPOT-2, SPOT-3, Envisat)
gscwd18	gscwd17+implement modeling for DORIS station frequency changes.
gscwd20	Implementation of IERS2010 (wrt. pole modeling) Changes to drag modeling as recommended by the IDS AWG (Toulouse, April 2013).
gscwd21	Test implementation of phase law for Starec and Alcatel antennae. Also used GEODYN-attitude modules to compute tracking point (measurement model) corrections, rather than using those on the DORIS data.
gscwd25	**New time series (1992-2013). Use GSFC-derived time-variable gravity solution (weekly smoothed time series); Add Jason-1 and HY-2A.**
gscwd26	**As gscwd25, but adjust cross-track opr per arc instead of per day. Along-track opr parameterization is unchanged.**

Table 15. Summary of GSC SINEX series developed since ITRF2008

As part of the validation for the implementation of the phase law for the Starec and Alcatel antennae, first we verified during two test periods (1995 and 2011) that the change in the RMS of fit for each satellite was either neutral or showed an improvement. Second, we supplied to the IDS Combination Center (G. Moreaux) two test series, with and without the implementation of the phase law. The Combination Center verified that the change in scale was of the right sign and in the same direction for all the IDS Analysis Centers. It is important to note that the implementation of the phase law in GEODYN required that we compute and apply internally the tracking point (measurement model) corrections using either an attitude model or quaternions. For series gscwd20 and earlier, we had used the DORIS-data supplied tracking point (measurement model) corrections. The gscwd25 and gscwd26 series represent the series that were delivered for ITRF2013, and included the improvements tested in the antecedent series.

In **Table 16** we summarize the POD RMS of fit for the DORIS satellites for the different series. As a matter of course we always computed the SLR+DORIS combined orbits in addition to the DORIS-only orbits. The SLR data give a precise measure of the orbit quality, and allow us to verify more quickly that the attitude of the spacecraft has been modeled correctly. Of the satellites listed below, Envisat, SARAL, HY-2A, and the SPOT satellites all used an internal attitude law, as specified in the documentation supplied by the CNES (cf. document number blah-blah-blah). The attitude law or quaternions come into play in two ways: (1) in the measurement model for the calculation of the tracking point corrections on the spacecraft; (2) in the force model for the computation of the non-conservative forces. For TOPEX we ordinarily used the satellite attitude law, but used quaternions for the cycles where the orientation was off-nominal. For Jason-1 and Jason-2, we used the project supplied quaternions, but only for the spacecraft body. For Cryosat-2, we used the internal attitude law for series wd12 to wd20, but used the quaternions supplied by E.J.O. Schrama (TU Delft) for the wd25 and wd26 series.

The Envisat DORIS data show a dramatic improvement in the RMS of fit in the period 2003 to 2004, especially with the new series gscwd25. The data-supplied corrections for Envisat appear to be erroneous in this time period. This is apparent when we apply the attitude law beginning with the series wd21. Hence the improvement in the SLR RMS of fit for Envisat from 1.29 to 1.04 cm is due to both the improvement in the attitude modeling (especially over 2003-2004) and the better modeling of time-variable gravity over the entire time period.

In **Figure 23**, we show the recovered scale from the series wd20, wd25, and wd26. The application of the phase law cases a net increase in the DORIS scale, as shown in the difference between the wd20 and wd25 series. It is interesting that restricting the adjustment of the cross-track accelerations to once/arc, alters the scale of the wd26 series, after the inclusion of Cryosat-2. There was no sensible change in the WRMS between the wd25 and the wd26 series.

Satellite and Data	wd12	wd15	wd20	wd25
Envisat (SLR) (DORIS)	1.272 0.494	1.289 0.492	1.126 0.491	1.039 0.491
TOPEX (SLR) (DORIS)	1.701 0.513	1.679 0.514	1.668 0.513	1.701 0.512
Jason1 (SLR) (DORIS)	------	------	1.318 0.324	1.276 0.324
Jason2 (SLR) (DORIS)	1.215 0.361	1.165 0.376	1.172 0.379	1.118 0.379
Cryosat2 (SLR) (DORIS)	2.131 0.437	1.850 0.445	1.304 0.402	1.134 0.400
HY-2A (SLR) (DORIS)	------	------	1.506 0.411	1.335 0.409
SARAL (SLR) (DORIS)	------	-----	1.621 0.399	1.405 0.392
SARAL is independent. Not included in the ITRF2013 submission.				

Table 16. POD RMS of fit Summary (cm for SLR (in green); mm/s for DORIS (in blue))

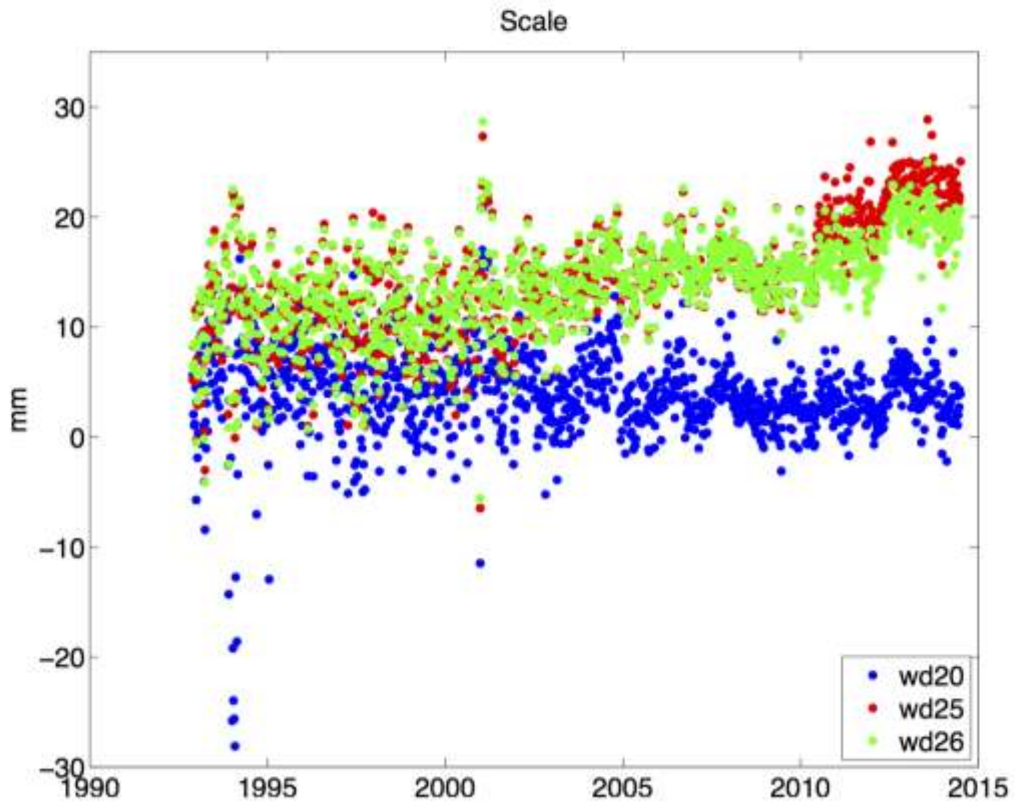

Figure 23. Scale from GSC DORIS Sinex solution series wd20, wd25, wd26

14.2 2. ANALYSIS OF SARAL

In preparation for the future analysis of SARAL altimeter data at NASA GSFC, and in order to evaluate the contribution of the DORIS data to the weekly combination, we analyzed SLR and DORIS data to this newest DORIS satellite. We found that both the SLR and DORIS offsets adjusted by -0.0456 cm and -0.0406 cm in Z respectively. We believe the SARAL Center of mass specification is in error by 4 cm in the Z (cross-track) direction. Whereas the a priori CoM was (-0.011, -0.0067, -0.6573) m, we have now adopted the value (-0.0112, -0.0067, -0.6152) m for the new nominal position of the spacecraft center of mass. We subsequently adjusted the X SLR offset (nadir direction) by +1.57 cm, while using a mean range correction for the SARAL laser retroreflector array of -3.748 cm. We show in **Figure 24** the recovered empirical accelerations for SARAL from March 25, 2013 to August 31, 2014, where we used the macromodel specified in the CNES documentation ("DORISSatelliteModels.pdf"). The empirical accelerations along-track and cross-track, peak towards the end of the year in 2013. The SARAL spacecraft is located in a near-full Sun orbit that is also sun-synchronous, but experiences eclipses only towards the end of calendar year (Nov.-Dec. 2013). The OPR's peak when SARAL experiences eclipses, indicating the macromodel does not accommodate properly the eclipse effects in the solar radiation pressure model.

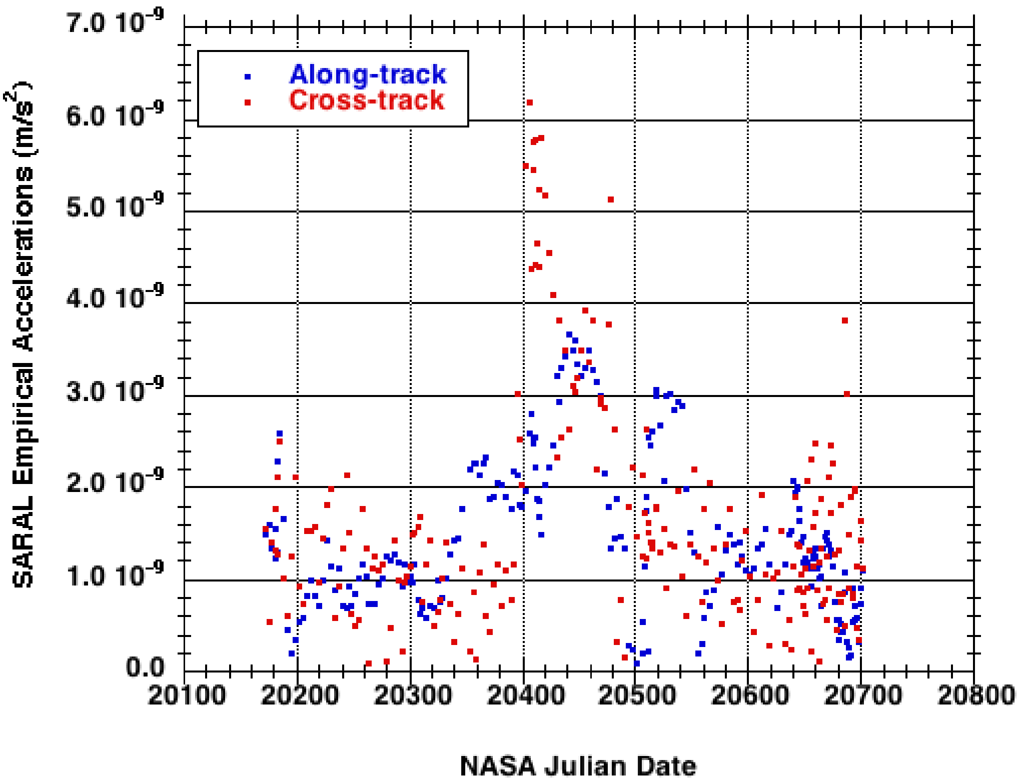

Figure 24. Daily Empirical Acceleration Amplitude for SARAL from March 25, 2013 to August 31, 2014.

We evaluated the SARAL data by progressively testing different model improvements, including the application of the Vienna Mapping Function (VMF1), the DORIS antenna phase map, and by subsequently retuning the DORIS and SLR offsets. In these tests we obtain average altimeter crossover fits of 5.86-5.88 cm RMS, and a final SLR fit of 1.34 cm RMS for the arcs tested, as summarized in **Table 17**.

	Average RMS Residuals		
Models Tested	**DORIS (mm/s)**	**SLR (cm)**	**Crossover (cm)**
(1) Nominal. GMF/GPT	0.4110	1.498	5.869
(2) + VMF1	0.4109	1.498	5.870
(3) + DORIS beacon phase map	0.4102	1.467	5.880
(4) (Combined)	0.4101	1.468	5.881
(5) Retune offsets with phase map.	0.4089	1.338	5.883

Table 17. SARAL POD Tests (March 2013 – February 2014)

14.3 3. TIME-VARIABLE GRAVITY DEVELOPMENTS

As part of the work to support the DORIS reference frame, we developed a times series of spherical harmonic solutions to represent the time-variable gravity (TVG) field of the Earth from 1992 to 2014. These solutions were to degree five in spherical harmonics, although C_{50} was not adjusted because it could not be separated with the available data from C_{30} SLR and DORIS tracking data from 18 SLR and DORIS satellites were processed. The satellites whose tracking data contributed to the TVG solutions included the available SLR “cannonball” satellites, SLR+DORIS satellites (TOPEX, Envisat, Cryosat-2, Jason-2), and the SPOT satellites, although SPOT-5 did not contribute until 2013 after the end of mission of SPOT-4. Normal equations were stacked weekly. The solutions were smoothed using a running five-week running window. We reported on the preliminary results with this time series at the Spring EGU in 2014 in the paper “Time-Variable Gravity Solutions from 1993-2013 from SLR and DORIS data”, F.G. Lemoine, D.S. Chinn, N.P. Zelensky, J.W. Beall, S. Melachroinos, Abstract EGU2014-13971. As an example of the time series to resolve the low-degree harmonics, we illustrate in **Figure 25**, the recovered time series for C22, compared to the GRGS RL02b time series, independently determined from GRACE and LAGEOS data.

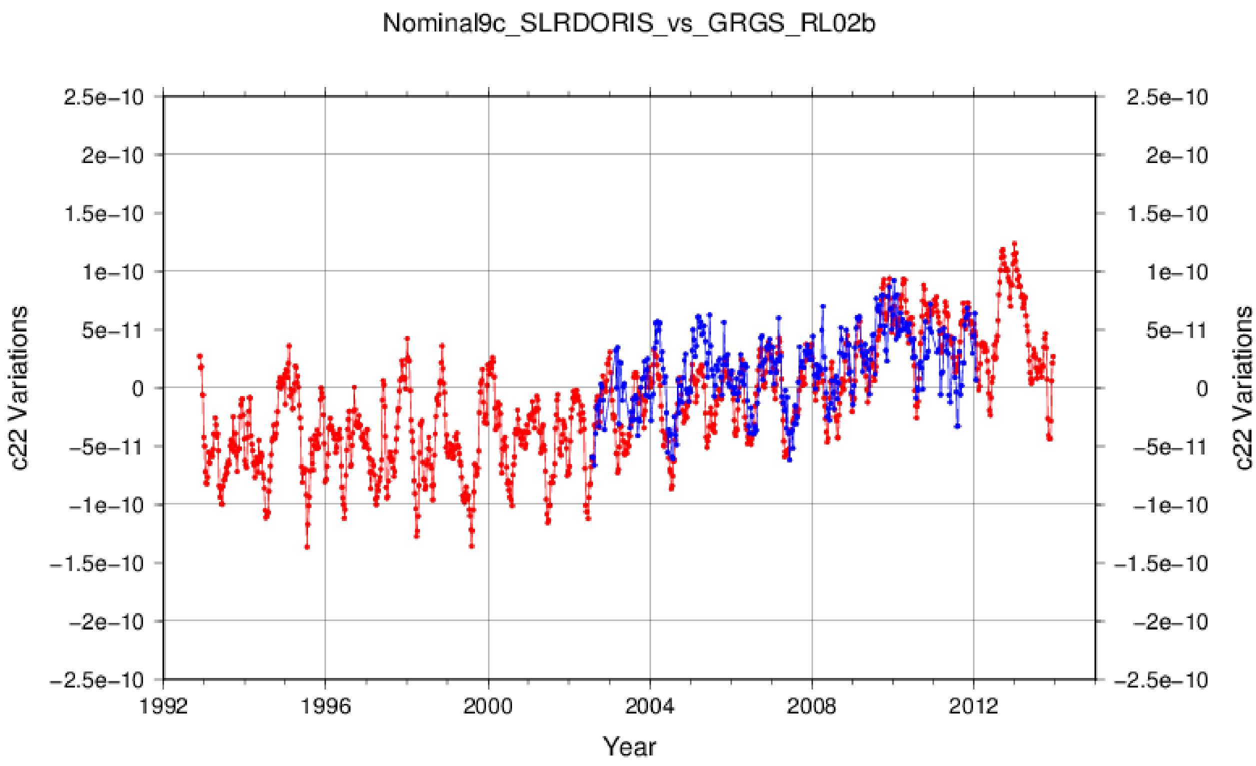

Figure 25. Comparison of C22 between the GSFC SLR+DORIS time series, and the GRACE+LAGEOS-derived GRGS RL02b series.

15 REPORT OF THE 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 2014, 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 2014, all DORIS results were generated to IDS by the IPGP site using the new 64-bit computer. While data are processed on a regular basis, DORIS results were only submitted at specific intervals (when a new gravity field was provided by the GRGS group). New solutions were submitted simultaneously to both IGN and NASA/CDDIS data centers. In 2014, a complete reprocessing of the data was done in view of ITRF2013/2014, including DORIS data since January 1993 until early September 2014.

15.2 PRODUCTS DELIVERED IN 2014

The latest delivered IGN weekly time series is still ignwd15 (in free-network). This time, as ITRF2013/2014 was not available, no companion series was submitted as before, expressed in ITRF. The ignwd15 solution was used by the IDS Combination Center in preparation of ITRF2013/2014. 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 no ITRF solution was available in 2014 (see above), only free-network solutions were submitted (**Table 18**). Other products will only be submitted when a new ITRF2013/2014 is available and when a new internal long-term solution (positions and velocities estimated using the full DORIS data set) is derived.

Some test solutions were also provided to the IDS Combination Center, in particular a complete time series before the phase law (ground antenna phase center) correction was implemented in the GIPSY-OASIS software package.

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

In 2014, 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 website: http://www.ipgp.fr/~willis/DPOD2008/. Version 1.13 is available at the end of 2013, including all possible DORIS stations (Willis et al., in press).

Product	Latest version	Update	Data span	Number of files
Weekly SINEX - free-network	ignwd15	Weekly	1993.0-2014.7	1132
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 18. IGN products delivered at the IDS data centers in 2014. As of February 22, 2015.

15.3 MAJOR IMPROVEMENTS IN 2013

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.

15.4 NEW DEVELOPMENTS

New developments are mostly related to the implementation of the phase law correction in the GIPSY-OASIS II software package.

15.5 REFERENCES

Bock O., Willis P., Wang, J., Mears C. (2014), A high-quality, homogenized, global, long-term (1993-2008) DORIS precipitable water dataset for climate monitoring and model verification, Journal of Geophysical Research, Atmospheres, 119(12), 7209-7230, DOI: 10.1002/2013JD021124.

Willis P., Bock O., Bar-Sever Y.E. (2014), DORIS tropospheric estimation at IGN : Current strategies, GPS intercomparisons and perspectives, IAG Symposia Series, 139, 11-18, DOI: 10.1007/978-3-642-37222-3_2.

Willis P., Lemoine F.G., Moreaux G., Soudarin L., Ferrage P., Ries J.C., Otten M., Saunier J., Noll C.E., Biancale R., Luzum B., The International DORIS Service (IDS), Recent developments in preparation of ITRF2013, IAG Symposia Series, 143, in press.

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

16 REPORT OF THE INASAN ANALYSIS CENTER (INA)

Sergey Kuzin, Suriya Tatevian *(INASAN, Russia)*

16.1 INTRODUCTION

In 2014, INASAN (ina) DORIS Analysis Center mainly concentrated its attention for reprocessing all DORIS data for 1993.0- 2014.8 time period to prepare INA contribution to the IDS combination for ITRF2013. INASAN used the latest version of GIPSY- OASIS II software (v. 6.3) for the data reprocessing. **Table 19** shows current products delivered by INASAN to the IDS. Inawd08 free-network weekly time series are the INA AC contribution to IDS ITRF2013 realization. Inawd09 time series are the test solutions including the recent launched satellites (HY2A and SARAL), which were sent for IDS validation. Geocenter, EOP and STCD time series are by-products of the inawd08 weekly solutions.

Product	Latest version	Span
Sinex weekly free-network solutions	inawd08 inawd09	1993.0 – 2014.8 2011.8 – 2014.6
Geocenter time series	ina10wd01	1993.0 - 2013.8
EOP time series	ina10wd01	1993.0 - 2013.8
STCD time series	ina14wd08	1993.0 - 2014.0

Table 19. INASAN products delivered to the IDS (February 2015).

16.2 MAJOR IMPROVEMENTS IN 2014

The main results obtained in 2014 were connected with reprocessing all DORIS data for time period 1993.0 – 2014.8 for ITRF2013/2014 realization. For the first time we have used 64-bit Linux version of GIPSY-OASIS software compare with the previous 32-bit platform solutions.

The main recent improvements in the inawd08 solutions, submitted to IDS ITRF2013 validation, compare to the previous ones (inawd07 series submitted for ITRF2008 realization), connected with the use of:

- a new gravity field model; now INA uses the GOCO02S satellite-only global gravity field model, all types of tides correspond to the IERS2010 Conventions;

- polar motion and UT1 values, taken from the IERS bulletin A instead of the IERS bulletin B applied for ITRF2008 realization. DORIS coordinates were expressed in DPOD2008_1.13 reference frame;

- models of the instruments reference points displacements corresponding to the IERS2010 Conventions;

- a priori atmospheric density model DTM2000 , instead of DTM94 for the ITRF2008 submission;

- better troposphere mapping function, GMF model, instead of previous NMF model;

- elevation angle cutoff = 12 degrees, instead of 15 degrees for the ITRF2008 contribution;

- corrected data of SPOT5 SAA (South Atlantic Anomaly) for data processing since the beginning 2006.0 onward;

- different weights for combination of the single satellite solutions: 0.51 mm/s for SPOT2, SPOT3, SPOT4, TOPEX, ENVISAT, CRYOSAT2; 0.4 mm/s for SPOT5, JASON2.

It should be noted that unlike the other Analysis Centers, INA AC didn't apply phase center correction laws for the ground antennas, so the combined IDS solution submitted to IERS for ITRF2013 realization don't include INA scale factor estimations. At the same time during the preparation of the current report INA AC has applied phase center correction laws for the present-day routine processing and planning to submit the first results to IDS Combination Center for validation.

16.3 ANALYSIS RESULTS DESCRIPTION

The results of the above-mentioned improvements one can see from the cumulative IDS solution coming from the Combination Center analysis using CATREF software (http://apps.ids-doris.org/apps/7ptool.html). The WRMS and scale coefficient transformation parameters of the inawd08 solutions wrt ITRF2008 gives values 16.95±1.93 mm and 7.44±5.41 mm, respectively, that is a little bit less as compare with the inawd07 series. At the same time the translation parameters in X (-4.92±6.99 mm), Y (-6.58±8.39 mm) and Z (-12.24±23.23) directions slightly increased, especially Z component (for two times), what can be possibly explained by the increasing of the scale in the mid of 2012 detected by all Analytical Centers. This scale jump still needs to be explained.

Comparative analysis of the Helmert transformation parameters of the INASAN solution (inawd08) with those of the others analysis centers gives almost the same results except of a little lower scale parameter and a gently higher Ty translation component.

For the EOP parameters we clearly observe an improvement of inawd08 EOP series components compare to inawd07 ones. 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.

We also estimated amplitudes and phases of the annual and semiannual variations of the geocenter components dX, dY, dZ getting from the transformation free-network inawd08 series to ITRF2008.

The evaluated amplitudes of annual oscillations are of the order of 4.06±0.48 mm and 4.11±0.15 for X and Y components, respectively, and 0.53±0.19 mm for Z component. Semiannual amplitudes are also noticeable in all components (6-9 mm for X, Y and Z components).

During the ITRF2013 preparation the scale, estimated by the combined IDS solution sent to IERS, has an evident increasing in the mid of 2012. To investigate the reason of that jump the special single satellite campaign for 2011-2013 was announced by IDS Analysis Coordinator. Data of 5 satellites (SPOT4, SPOT5, ENVISAT, JASON2, CRYOSAT2) were processed by INA and other ACs for this time period, but unfortunately the results of this single satellite campaign didn't explain the scale rising in the mid of 2012 for the IDS combined solution.

The second single satellite campaign was connected with the scale rising in the combined IDS solution at the beginning of 1994. Only 2 satellites (SPOT2 and TOPEX) were in operation for that time. It was decided to exclude SPOT2 satellite for processing for 8 weeks 1994 (weeks 94002-94058). As a result, no scale jump in the IDS combined time series was detected, although the WRMS of the transformation to ITRF2008 slightly degrades due to the availability of only one operational satellite for this time interval. In terms of EOP, excluding of the SPOT2, has a small impact that is characterized by a small increasing of standard deviations of the differences wrt IERS C04 series.

The results of the last inawd08 time series analysis made by the IDS Combination Center, show better statistical characteristics compare to the previous inawd07 series both for Helmert transformation parameters wrt ITRF2008 and for EOP.

17 DORIS-RELATED ACTIVITIES AT CNES

Alexandre Couhert, **Sabine Houry**, **Eva Jalabert**, **Flavien Mercier**, **John Moyard** ***(CNES/CST, France)***
Silvia Rios Bergantinos *(CS SI, France)*

17.1 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 are 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.

17.2 ORBIT ERROR BUDGET FOR THE JASON SERIES GDR-D SOLUTIONS

The current precise orbit ephemerides on the Jason series GDRs are included in the version 'D' orbit standards. A long-term (seasonal to decal time scales) radial orbit error budget of the orbit time series was constructed in the Jason POD Team paper (*Couhert et al., 2015 [a]*) and summarized in **Table 20**:

Error source	Time scale	Global	Regional	Rationale
Tracking Data Residual Consistency	Seasonal		3–8 mm	SLR v. GPS/DORIS orbits
	Interannual		3 mm/y	
	Decadal		2 mm/y	
Reference frame	Seasonal		8 mm	GPS v. SLR + DORIS, ITRF08 v. 05
	Interannual	0.03 mm/y	1 mm/y	
	Decadal	0.05 mm/y	0.3 mm/y	
Time Variable Gravity	Seasonal		4 mm	Mean field v. 10-day series and external orbits
	Interannual	0.1 mm	2 mm/y	
	Decadal	0.1 mm/y	1.5 mm/y	

Table 20. Upper born estimates of GDR-D radial orbit error budget for the Jason series.

An outcome of the paper is that solving for the $C_{3,1}$ and $S_{3,1}$ terms of the GDR-D mean gravity field model (similar to EIGEN-6S2, adopted for ITRF2014 processing) can accurately estimate unmodeled TVG effects, especially outside of its 8-year adjustment period (before 2003 and after 2010). **Figure 26** shows the adjusted $S_{3,1}$ coefficient allowed to adjust freely over the 1-cycle orbital arc length using Jason-1 and Jason-2 data. The tracking data used to estimate the geopotential coefficient are GPS + DORIS + SLR, except for Jason-1 which are only DORIS + SLR after August 2006 (with failure of GPS receivers).

The solved-for gravity coefficients compare better with the GSFC “fit” model (with a high correlation coefficient of 0.7) than to the GRACE-based corresponding harmonics, in term of tendency over the Jason-1 and Jason-2 periods.

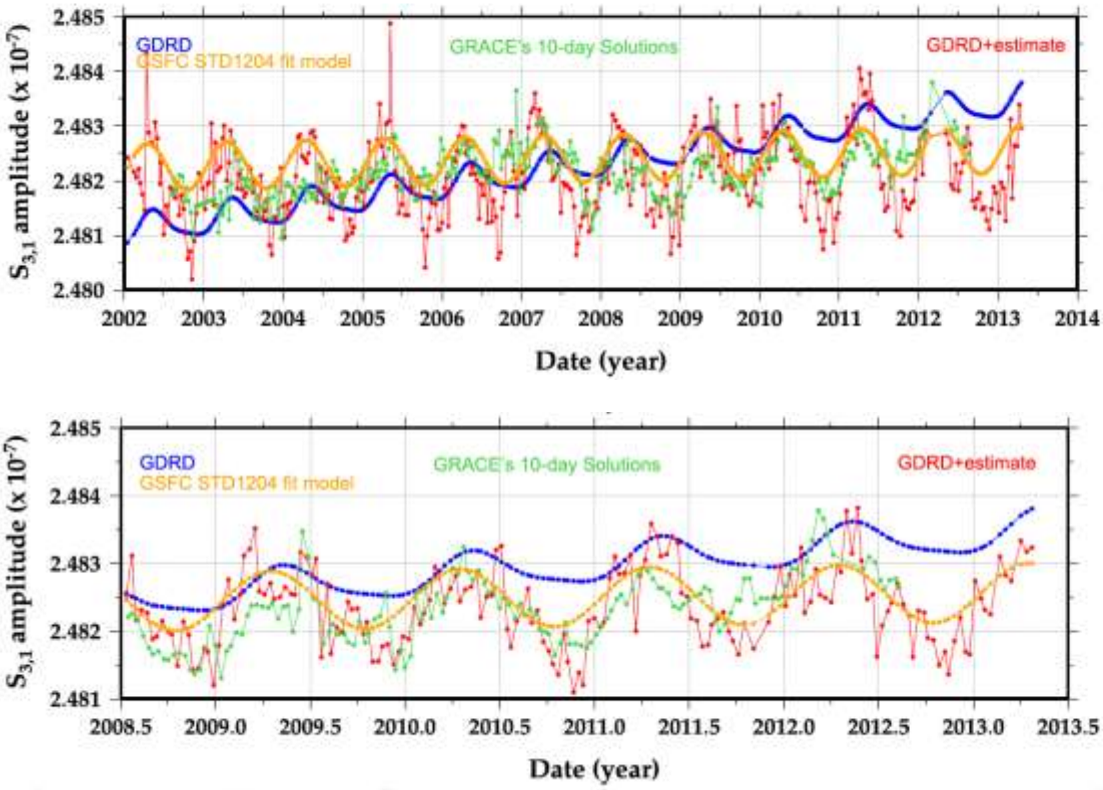

Figure 26. S3, 1 coefficient of the spherical harmonic expansion of the GDR-D mean gravity field model, GSFC std1204 “fit” model of time-variable corrections, 10-day gravity field time series and estimates for Jason-1 (top) and Jason-2 (bottom).

17.3 VALIDATION OF THE DORIS ANTENNA PHASE LAW

The analysis of the phase residual mean signatures for historically well performing DORIS beacons (see **Figure 27**) shows that the phase map only is not sufficient to explain the residual signature (*Mercier and Couhert, 2014 [f]*):

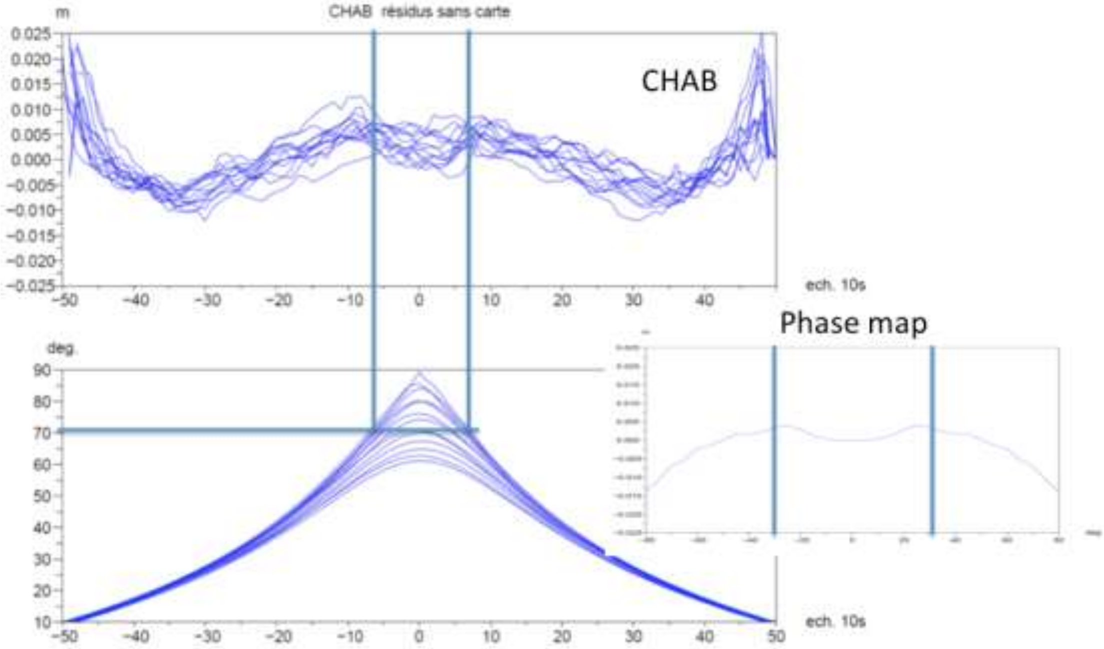

Figure 27. The mean signature visible in DORIS beacon phase residuals (CHAB), when no phase map is applied, reflects the shape of the ground antenna phase map itself (especially above 70 degree elevation).

Yet, the use of the phase map helps stabilizing the adjusted vertical position of the DORIS stations (see **Figure 28**). Its effect on orbit radial performance is negligible (< 1 mm RMS), but additionally solving for the vertical position of the DORIS beacons on average seems to improve by ~2 mm RMS the radial component of the DORIS-only orbits, as validated externally by SLR residuals (*Couhert and Mercier, 2014 [c]*):

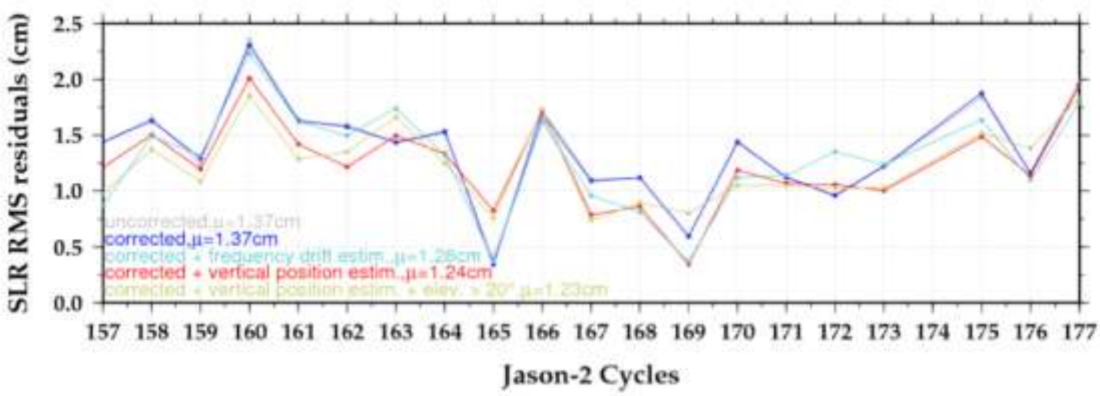

Figure 28. High elevation (above 70°) SLR core network residuals on independent DORIS-only orbits.

17.4 PREPARATION OF THE NEXT POD STANDARDS

New time series were tested using updated dynamic/measurement models and improved parameterization. Preliminary GDR-E orbits were computed for Jason-2 and presented at the last OSTST meeting (*Moyard et al., 2014 [h]*). A summary of the proposed new models is given in **Table 21**.

The major updates include the implementation of a reduced-dynamic parameterization and improved Solar Radiation Pressure (SRP) models. *Mercier et al. (2014) [g]* developed a calibrated SRP model for Jason-2, by adjusting the solar array optical properties, and by estimating a harmonic model for the central box function of the satellite angular position with respect to the subsolar point (see **Figure 29**)

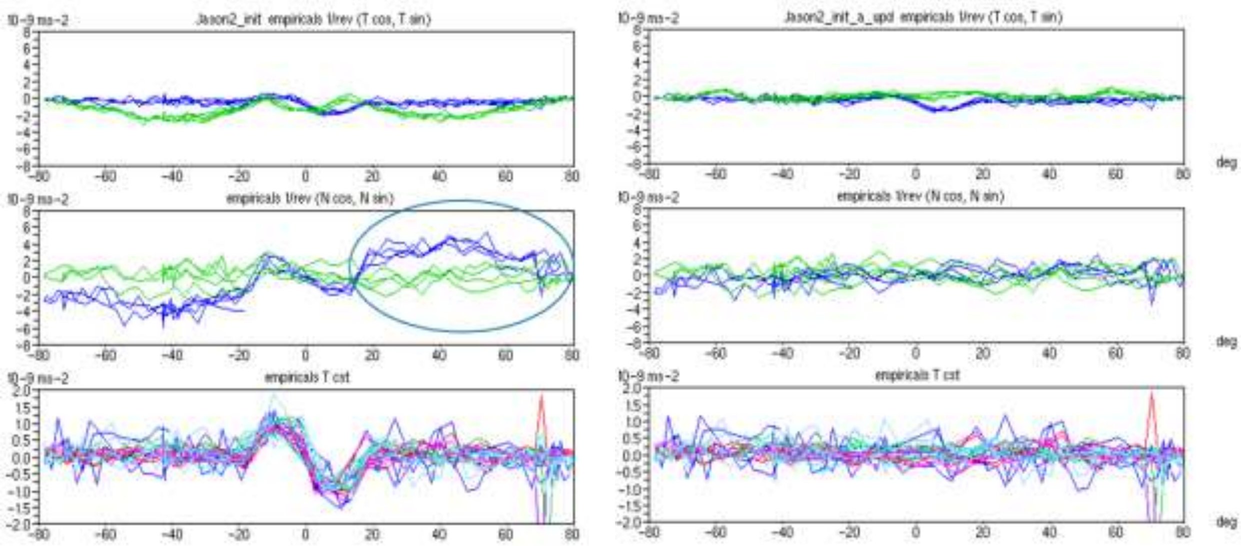

Figure 29. Estimated empirical accelerations when using the standard GDR-D configuration for Jason-2 (left) and when using the new calibrated SRP model (right).

The other altimeter missions could also benefit from similar calibrated semi-empirical SRP models, aimed at reducing the estimated once-per-revolution accelerations (*Jalabert et al., 2014 [e]*).

Simultaneously, the new release of the thermosphere model DTM2013 was thoroughly tested, and the sensitivity of the altimeter missions to dispersion in GRACE TVG solutions was gauged. Alongside, the initial center of mass position of Jason-1 was re-assessed (*Couhert and Jalabert, 2014 [b]*).

	GDR-D	GDR-E
Gravity model		
Static	EIGEN-GRGS_RL02bis_MEAN-FIELD	EIGEN-GRGS.RL03-v2.MEAN-FIELD
Non-tidal TVG	annual, semi-annual, and drift up to deg/ord 50	one annual, one semi-annual, one bias and one drift terms for each year up to deg/ord 80; C21/S21 modeled according to IERS2010 conventions; C31/S31 estimation by arc if necessary
Solid Earth tides	from IERS2003 conventions	Unchanged
Ocean tides	FES2004	FES2012
Atmospheric gravity	6hr NCEP pressure fields (20x20) + tides from Biancale-Bode model	6hr NCEP pressure fields (70x70) + tides from Biancale-Bode model
Pole tide	solid Earth and ocean from IERS2010 conventions	Unchanged
Third bodies	Sun, Moon, Venus, Mars and Jupiter	Unchanged
Surface forces		
Radiation pressure model	thermo-optical coefficient from pre-launch box and wing model, with smoothed Earth shadow model	calibrated semi-empirical solar radiation pressure model
Earth radiation	Knocke-Ries albedo and IR satellite model	Unchanged
Atmospheric density model	DTM-94 for Jason satellites, and MSIS-86 for other satellites	DTM-13 for Jason satellites, HY-2A, and MSIS-86 for other satellites
Estimated dynamical parameters	Drag coefficient every 2 or 3 revolutions Along-track and cross-track 1/rev per day or every 12 hours	Improved stochastic solutions
Satellite reference		
Mass and center of gravity	post-launch values + variations generated by Control Center	Unchanged
Attitude model	For Jason satellites: quaternions and solar panel orientation from control center, completed by nominal yaw steering law when necessary Other satellites: nominal attitude law	
Displacement of reference points		
Earth tides	IERS2003 conventions	Unchanged
Ocean loading	FES2004	FES2012
Pole tide	solid earth pole tides	solid earth pole tides and ocean pole tides (Desai, 2002) S1-S2 atmospheric pressure loading, implementation of Ray & Ponte (2003) by

Reference GPS constellation	JPL solution at IGS (orbits and clocks) – fully consistent with IGS08	van Dam JPL solution in "native" format (orbits and clocks), referenced to the CoM of the solid Earth/Ocean system – fully consistent with IGS08
Geocenter variations	None	Tidal: ocean loading and S1-S2 atmospheric pressure loading Non-tidal: seasonal model from J. Ries
Terrestrial reference frame	Extended ITRF2008 (SLRF/ITRF2008, DPOD2008, IGS08)	Unchanged
Earth orientation	Consistent with IERS2010 conventions and ITRF2008	Unchanged
Propagation delays *SLR troposphere correction* *SLR range correction* *DORIS troposphere correction* *GPS*	 Mendes-Pavlis constant 5.0 cm range correction for Envisat, elevation dependent range correction for Jason GPT/GMF model PCO/PCV (emitter and receiver) consistent with constellation orbits and clocks (IGS08 ANTEX) phase wind-up correction	 Unchanged Unchanged Unchanged DORIS beacons phase center correction Unchanged Unchanged
Estimated measurement parameters	DORIS: one frequency bias per pass, one troposphere zenith bias per pass SLR: bias per arc solved for a few stations, bias per pass for a few stations GPS: floating ambiguity per pass, receiver clock adjusted per epoch	Unchanged Data used for orbit validation Unchanged
Tracking data corrections	Jason-1 Doris data: South Atlantic Anomaly model (J.-M. Lemoine et al.) applied before and after DORIS instrument change DORIS time-tagging bias for Envisat and Jason aligned with SLR before and after instrument change	Jason-1 Doris data: updated South Atlantic Anomaly model (J.-M. Lemoine et al.) applied before and after DORIS instrument change Unchanged
DORIS weight	1.5 mm/s (1.5 cm over 10 sec) For Jason-1, DORIS weight is reduced by a factor 10 before DORIS instrument change	Unchanged For Jason-1, SAA DORIS beacons weight is reduced by a factor 10 before DORIS instrument change
SLR weight	15 cm	Data used for orbit validation
GPS weight	2 cm (phase) / 2 m (code)	Unchanged

Table 21. Definition of the GDR-E POD standards

17.5 NON-TIDAL GEOCENTER CORRECTION

The use of a seasonal non-tidal geocenter correction ("Climatological model" SLR-only; from CSR) clearly improves DORIS-only solutions consistency with GPS-based orbits (see **Figure 30**) and will thus be included for the first time in the next POD standards.

When the annual components of the global translation vector for the DORIS stations network is determined simultaneously with Jason-2 GDR-D-like DORIS-only orbit, only the X and Y components exhibit stable and consistent results with the CSR SLR-only CM correction model (*Couhert et al., 2014 [d]*) (see **Figure 31**).

The reason for the odd behavior of the Z component estimates (affected by the elevation cut-off angle) - from DORIS measurements but also noticed with GPS measurements - remains to be determined.

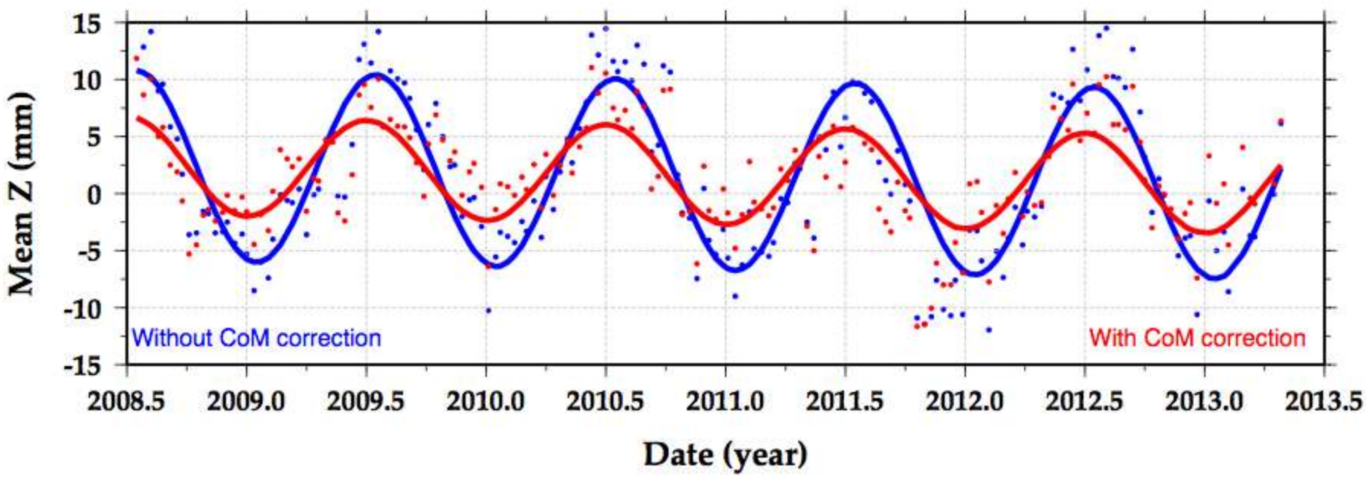

Figure 30. Jason-2 orbit mean Z differences: GDR-D-like DORIS-only solution, applying or not the CSR SLR CoM correction model, w.r.t. GPS-derived orbit. The solid curve is the result of the least squares fit to the orbit mean Z differences of a bias, drift and and annual periods.

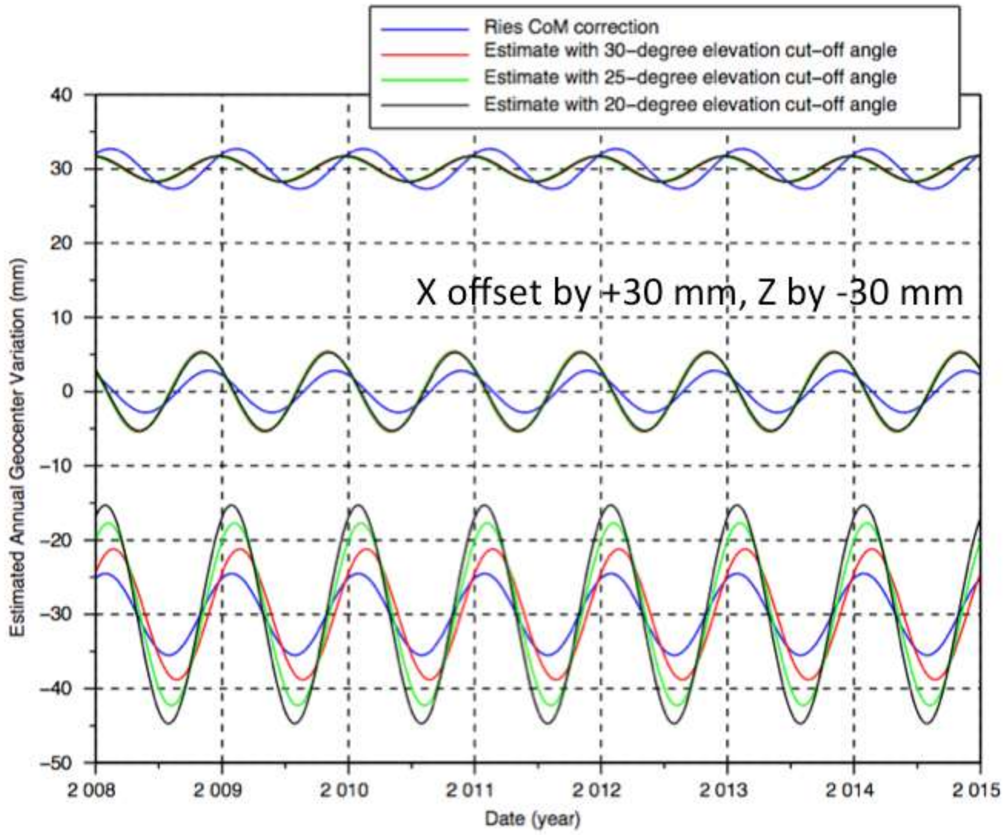

Figure 31. Components of the CSR SLR CoM correction model (blue), the estimated annual components of the translation vector for the DORIS stations network determined simultaneously with Jason-2 GDR- D-like DORIS-only orbit with different elevation cut-off angles (30°: blue; 25°: green; 20°: black)

17.6 REFERENCES

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[b] Couhert, A., Jalabert, E., 2014. CNES Reprocessing Plans for the Next POD Standards. In: DORIS Analysis Working Group meeting, Paris, France, 26–27 March, 2014.

[c] Couhert, A., Mercier, F., 2014. New DORIS Doppler Parameterization Inferred from Phase Measurement Analyses. In: IDS Workshop, Lake Constance, Germany, 27–28 October, 2014.

[d] Couhert, A., Mercier, F., Jalabert, E., et al., 2014. Long-term Analysis of Possible Remaining Sources of Orbit Error. In: Ocean Surface Topography Science Team Meeting 2014, Lake Constance, Germany, 28–31 October, 2014.

[e] Jalabert, E., Mercier, F., Couhert, A., 2014. Solar Radiation Pressure Model for Altimeter Satellites. In: IDS Workshop, Lake Constance, Germany, 27–28 October, 2014.

[f] Mercier, F., Couhert, A., 2014. Analysis of DORIS map correction using phase measurements. In: DORIS Analysis Working Group meeting, Paris, France, 26–27 March, 2014.

[g] Mercier, F., Jalabert, E., Couhert, A. et al., 2014. Jason-1 and 2 Solar Radiation Pressure Models. In: Ocean Surface Topography Science Team Meeting 2014, Lake Constance, Germany, 28–31 October, 2014.

[h] Moyard, J., Jalabert, E., Couhert, A. et al., 2014. Jason-2 POD Status. In: Ocean Surface Topography Science Team Meeting 2014, Lake Constance, Germany, 28–31 October, 2014.

18 DORIS-RELATED ACTIVITIES AT GFZ

Sergei Rudenko ***(GFZ, Germany)***

18.1 INTRODUCTION

The activities performed at GFZ in 2014 related to DORIS data processing included further updates of GFZ's EPOS-OC software used for Precise Orbit Determination (POD) of DORIS satellites, in particular, for Jason-1 orbit computation, tests of new time variable Earth's gravity field solutions developed by GFZ and CNES/GRGS, tests of Atmosphere and Ocean Dealiasing (AOD1B) RL05 Product, seven tropospheric refraction models (Yionoulis and Hopfield, Hopfield, Saastamoinen, Davis, Niell, Global Mapping Function (GMF) and Vienna Mapping Function 1) for the correction of DORIS observations used for precise orbit determination of Envisat, TOPEX/Poseidon and Jason-1, computation and detailed analysis of precise orbits of TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013) at the time intervals given.

18.2 JASON-1 ORBIT MODELING AND COMPUTATION

Following the activities performed in 2013, Jason-1 instrument position data were included in the EPOS-OC software and verified. A time series of the coordinates of the center of mass in the satellite coordinate system was computed for Jason-1 (2001-2013) using the data from CNES. A script to transform Jason-1 mass and center-of-mass corrections from the CNES to the EPOS-OC format was written.

A 2 cm difference in the initial X coordinate of the center of gravity was found for Jason-1 between the values available at a CNES ftp file and in an IDS reference document. A test was performed showing that this discrepancy produces RMS orbit differences up to 4, 16 and 8 mm in radial, cross-track and along-track directions. The initial X coordinate of the center of gravity was set to Xinit= +0.9550 m.

A few orbit solutions were computed for Jason-1 (2002-2013) in the ITRF2008 reference frame by using DORIS and SLR observations and applying background models as given by Rudenko et al., 2014, but various geopotential and some other models and corrections:

- CCI01 orbit solution computed using EIGEN-GL04S geopotential model;

- CCI02 orbit solution derived using EIGEN-6S2 geopotential model;

- CCI06 orbit solution calculated using DORIS data corrected for the South Atlantic Anomaly (SAA);

- CCI07 orbit solution obtained using Vienna Mapping Function 1 as a tropospheric correction model for DORIS observations;

- CCI08 orbit solution computed without taking into account the gravitational field of the atmosphere in order to estimate the magnitude of the effect;

- CCI09 orbit solution calculated using Atmosphere and Ocean Dealiasing Product (AOD1B) RL05 instead of RL04 one;

- CCI10 orbit solution derived using the new models and data from CCI02, CCI06, CCI07 and CCI09 orbit solutions. This solution provides presently the best results among these orbit solutions for Jason-1 computed at GFZ allowing reduction of the mean values of SLR RMS fits from 1.575 to 1.505 cm, i.e. by 0.070 cm (about 4.4%) and those of DORIS RMS fits from 0.3827 to 0.3545 mm/s, i.e. by 0.0282 mm/s (about 7.4%), as compared to the mean values obtained for CCI02 orbit solution (**Figure 32**).

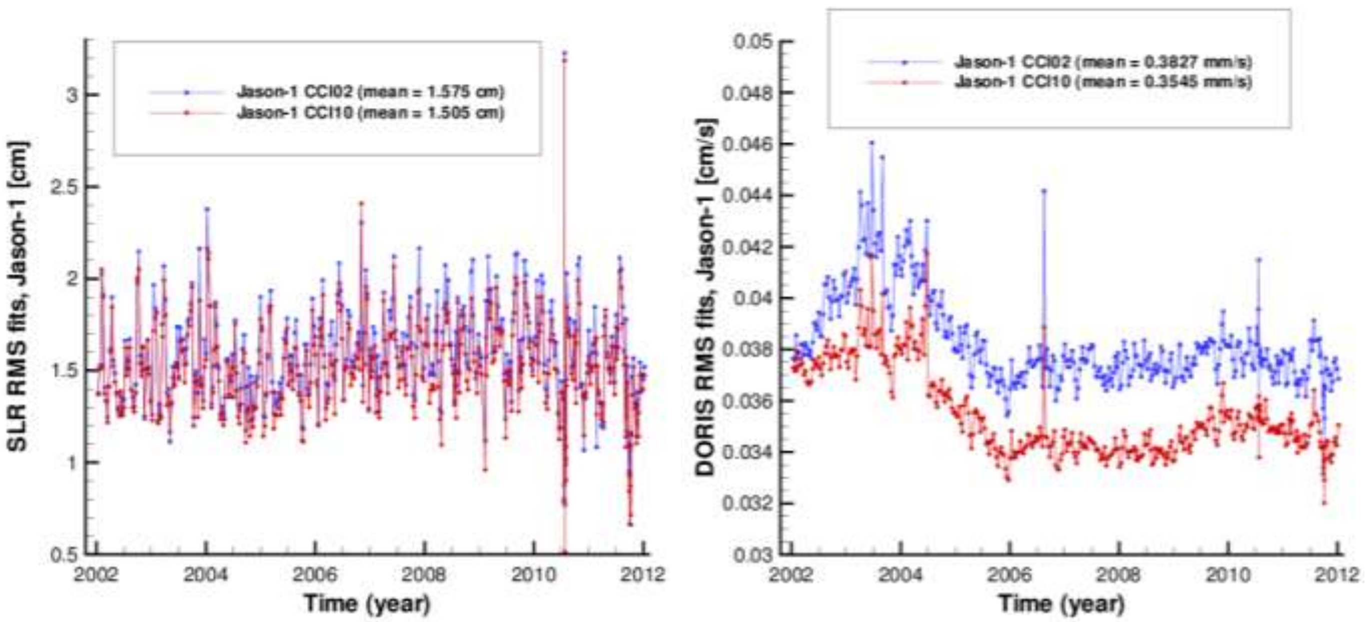

Figure 32. The RMS fits of SLR (left) and DORIS (right) measurements per orbital arc obtained in GFZ CCI02 (blue) and CCI10 (red) orbit solutions for Jason-1.

18.3 PRECISE ORBITS OF DORIS SATELLITES - TESTS OF NEW TIME VARIABLE EARTH'S GRAVITY FIELD SOLUTIONS

Six various geopotential models (EIGEN-GL04, EIGEN-6S_correct, EIGEN-6S_stat, EIGEN-6S2A, EIGEN-6S2B and EIGEN-6S2) were tested for Envisat at the time span from January 1, 2011 till April 8, 2012 (end of the mission). The best results were obtained using EIGEN-6S2 time variable geopotential model (Rudenko et al., 2014). To investigate the influence of annual and semi-annual variations of geopotential coefficients on the Envisat orbit, a test orbit was computed using EIGEN-GL04S geopotential model without use of annual and semi-annual variations of geopotential coefficients. Based on the results of the tests of these geopotential models for ERS-1 (1991-1996), ERS-2 (1995-2006), TOPEX/Poseidon (1992-2005) and Envisat (2002-2012) at the time intervals given, presentations on the impact of recent time variable geopotential models on precise orbits of altimetry satellites, global and regional mean sea level trends were given by S. Rudenko et al. at the DORIS Analysis Working Group meeting of the International DORIS Service, Paris, France, March 27, 2014 and the European Geosciences Union General Assembly 2014 (EGU-2014), Vienna, Austria, May 1, 2014.

A new time variable geopotential model EIGEN-7Sp.33-16-5-8-time-variable.gfc was tested for precise orbit determination of five satellites (ERS-1, ERS-2, TOPEX/Poseidon, Envisat and Jason-1). The model provides further improvements, as compared to the EIGEN-6S2 geopotential model.

A new approach in applying time variable gravity filed solutions was tested for Envisat and Jason-1 at the time span from 2002 until 2012 by using EIGEN-6C static field and daily interpolated time variable gravity field corrections based on two solutions: GRACE time-series of monthly gravity field spherical harmonic solutions generated at GFZ (RL05a) and a regional method based on radial base functions (RBF). Some preliminary results were presented by Gruber et al. at the EGU-2014 and Rudenko et al. at the 2014 Ocean Surface Topography Science Team (OSTST-2014) meeting, October 27-31, 2014, Lake Constance, Germany.

18.4 TESTS OF ATMOSPHERE AND OCEAN DEALIASING (AOD1B) RL05 PRODUCT

A test of the Atmosphere and Ocean Dealiasing Products (AOD1B RL05 versus RL04) computed at GFZ for Envisat orbit (years 2002-2012, 763 orbital arcs) was performed. The test shows reduction of SLR RMS fits on average by 0.7% from 1.302 to 1.293 cm, when RL05 is used instead of RL04. The mean values of the RMS differences of satellite positions are 1.4 mm in radial, 3.5 mm in cross-track and 3.6 mm in along-track directions.

The GFZ AOD1B RL05 products were available until recently only from January 1, 2001 onwards, while the AOD RL04 products are available from January 1, 1976. The GFZ AOD1B RL05 product has been extended backward from 2001 to 1976 at the end of 2014. Detailed tests on using GFZ AOD1B RL05 product instead of AOD1B RL04 one and no AOD product at all for ERS-1 (1991-1996), ERS-2 (1995-2006), TOPEX/Poseidon (1992-2005), Envisat (2002-2012) and Jason-1 (2002-2012) precise orbit determination were performed. The results were presented at the 2014 AGU Fall Meeting in the poster presentation "Backward extension to 1976 of RL05 GRACE Atmosphere and Ocean De-aliasing Level-1B (AOD1B) product and its validation" by E. Fagiolini et al. (2014). A paper on these tests is under preparation.

18.5 A TEST OF TROPOSPHERIC REFRACTION MODELS FOR DORIS OBSERVATIONS

A test of seven tropospheric refraction models (Yionoulis and Hopfield, Hopfield, Saastamoinen, Davis, Niell, Global Mapping Function (GMF) and Vienna Mapping Function 1) for the correction of DORIS observations for Envisat (2002 - 2012), TOPEX/Poseidon (1992-2005) and Jason-1 (2002-2013) precise orbit determination was performed.

The orbit and altimetry crossover analyses show, that the best performance was obtained by using Vienna Mapping Function 1. Some results were presented by Rudenko et al. (2014) at the OSTST-2014 meeting. A paper (Rudenko et al., 2015) on this study is under preparation.

18.6 OTHER ACTIVITIES

Precise orbits of Envisat (2002-2012), TOPEX/Poseidon (1992-2005) and Jason-1 (2002-2013) derived using SLR and DORIS observations were provided for the use for 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 German Research Foundation (DFG), as well as for studying the impact of time variable gravity on annual sea level variability (Esselborn et al., 2015, in press).

18.7 FUTURE ACTIVITIES

It is planned to improve further Jason-1 modeling and implement models for Jason-2, Cryosat-2 and SARAL/Altika missions and compute precise orbits of these satellites.

18.8 PRESENTATIONS

Rudenko, S., Dettmering, D., Esselborn, S., Schöne, T., Förste, C., Lemoine, J.-M., Ablain, M., Alexandre, D., Neumayer, K.-H.: Influence of recent time variable geopotential models on precise orbits of altimetry satellites, global and regional mean sea level trends. Oral presentation. DORIS Analysis Working Group meeting of the International DORIS Service, Paris, France, March 27, 2014, http://ids-doris.org/images/documents/report/AWG201403/IDSAWG1403-Rudenko-GeopotentialTests.pdf

Rudenko, S., Esselborn, S., Schöne, T., Gruber, Ch., Neumayer, K.-H. Investigation of long-term stability of precise orbits of altimetry satellites. Oral presentation. Ocean Surface Topography Science Team (OSTST) Meeting, Lake Constance, Germany, October 29, 2014, http://www.esa-sealevel-cci.org/webfm_send/265

Fagiolini, E., Dobslaw, H., Rudenko, S., Flechtner, F. Backward extension to 1976 of RL05 GRACE Atmosphere and Ocean De-aliasing Level-1B (AOD1B) product and its validation. Poster presentation. 2014 AGU Fall Meeting, San Francisco, USA, December 17, 2014, http://www.esa-sealevel-cci.org/webfm_send/263

18.9 PUBLICATIONS

Ablain, M., Cazenave, A., Larnicol, G., Balmaseda, M., Cipollini, P., Faugere, Y., Fernandes, M. J., Henry, O., Johannessen, J. A., Knudsen, P., Andersen, O., Legeais, J., Meyssignac, B., Picot, N., Roca, M., Rudenko, S., Scharffenberg, M. G., Stammer, D., Timms, G., and Benveniste, J. (2015): Improved sea level record over the satellite altimetry era (1993-2010) from the Climate Change Initiative project, Ocean Sci., 11, 67-82, doi :10.5194/os-11-67-2015 http://dx.doi.org/10.5194/os-11-67-2015.

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Rudenko, S., Dettmering, D., Esselborn, S., Schöne, T., Förste, C., Lemoine, J.-M., Ablain, M., Alexandre, D., Neumayer, K.-H. (2014): Influence of time variable geopotential models on precise orbits of altimetry satellites, global and regional mean sea level trends, Advances in Space Research, 54(1):92-118, doi :10.1016/j.asr.2014.03.010 http://dx.doi.org/10.1016/j.asr.2014.03.010

18.10 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)".

19 DORIS-RELATED ACTIVITIES AT TU DELFT

Ernst J.O. Schrama *(TU Delft, The Netherlands)*

19.1 INTRODUCTION

In 2014 we worked on the validation of Cryosat-2 orbits which are determined by combining 10s range rates observed by the DORIS receiver and a network of SLR stations. These activities take place within the scope of a calibration / validation study contract between the TU Delft and ESA that considers both the orbits and the altimeter performance over the oceans.

Precise orbit determination (POD) is performed with the help of the GEODYN-2 software developed by the Space Geodesy Group at the Goddard Space Flight Center in Greenbelt Md USA. The provided tool is extended with additional capabilities for processing new data types such as PRARE data and altimeter crossover data. We also developed new tools to streamline DORIS satellite tracking data; moreover additional tools were developed by us to update earth orientation parameter (EOP) tables, process magnetic field constants, solar flux data and a variety of other geophysical constants or models.

The ground-station coordinates that we use come from the website of Pascal Willis [2], the reference system is therefore the DPOD2008 system. For CryoSat-2 we implemented attitude modeling based on the quaternions that we receive from ESA, also we implemented solar radiation pressure models for the satellite, and we consider antenna offsets and the changes in the mass of the satellite. All our POD processing steps are documented in an ESA study report [1], in this annual report for the IDS we briefly focus on the main POD results achieved in this study, and we present an outlook for future activities.

19.2 ORBIT ATTITUDE MODELING

As said before, for the POD activities depend on a number of public databases; we retrieve the star tracker quaternions from an ESA ftp server, the quaternions are acquired from all star trackers on the satellite; the star tracker quaternions are defined in the camera frame and we rotate them with the help of a calibration matrix into the spacecraft frame. This allows us to reconstruct the pitch, yaw and roll angles of the satellite so that these angles can be compared to the nominal 4 degree yaw steering mode. Sometimes the satellite leaves the nominal attitude mode, this is due to short or long maintenance maneuvers designed to keep the satellite on a reference track, or, to avoid space debris.

Short maintenance maneuvers usually last up to 2 or 3 orbits. During this maneuver the AOCS will leave the nominal yaw steering mode at the equator, an orbit burn is executed and the yaw steering mode is restored at the earliest possible equator crossing. In this case we would have a short maintenance maneuver and we avoid computing precision orbits during this period. Whereas short maintenance maneuvers take about 2 hours, the long maintenance can last to around 6 hours. In the latter case the AOCS executes a number of commands which include a yaw flip, a burn, followed by a reverse yaw flip to arrive back at the point where the nominal attitude mode is picked up again.

The reality is that short maneuvers occur at a frequency of about once per month while the longer maneuvers were only seen once or twice since the launch of CryoSat-2 in April 2010. In either case we avoid to calculate precision trajectories when the satellite is not in a default attitude law. If there is a need to, and if the altimeter operates at all during such maneuvers, the CNES MOE orbit product may be used. For validation studies we did not think it was necessary or useful to calculate POD orbits during maneuver events. The quaternions and the maneuver windows can be provided upon request by the author.

19.3 DATA HANDLING, UPDATES IN 2014

In 2014 we had a software modification which concerned the access to the ESA ftp server (calval-pds.cryosat.esa.int) where we get star tracker quaternions, MOE and POE ephemeris data, and the DORIS navigator orbits. Geophysical parameters that frequently change such as the A_p and the K_p parameters, but also the solar flux parameters, are retrieved from NGDC although we have added additional access paths to the GFZ who distribute solar flux values more frequently.

Updates in the interface control documents and the access to their servers were reported back to ESA. For the reporting period we had to deal with a change in the allocated IP number of server lrlsase.lr.tudelft.nl within the TU Delft. This affected our ability to communicate with ESOC in Darmstadt so that FOS announcements were not received between 5-Jan-2014 and 20-Feb-2014. The underlying cause for this outage is the method of public key exchange for the sftp protocol.

Access to the IDS and the ILRS data centers did not change in 2014, however there were several IDS station coordinate changes and they were obtained from the website of Pascal Willis (Willis et al., in press) where he stores DPOD2008 coordinates of the IDS beacons. If this website is not updated then station logs at the IDS website are consulted to update our settings.

19.4 MODELLING

During the ESA validation study described in Schrama et al., 2014, it was discovered that modeling of solar radiation pressure on CryoSat-2 may need additional attention. We started with the ESA provided Lambert cosine law parameters of the satellite panels, this includes for each panel: area, orientation in the spacecraft frame, specular reflectivity, diffuse reflectivity and absorptivity. Initially we obtained from ESA for 6 panels the radiation law parameters which are defined in the UV domain.

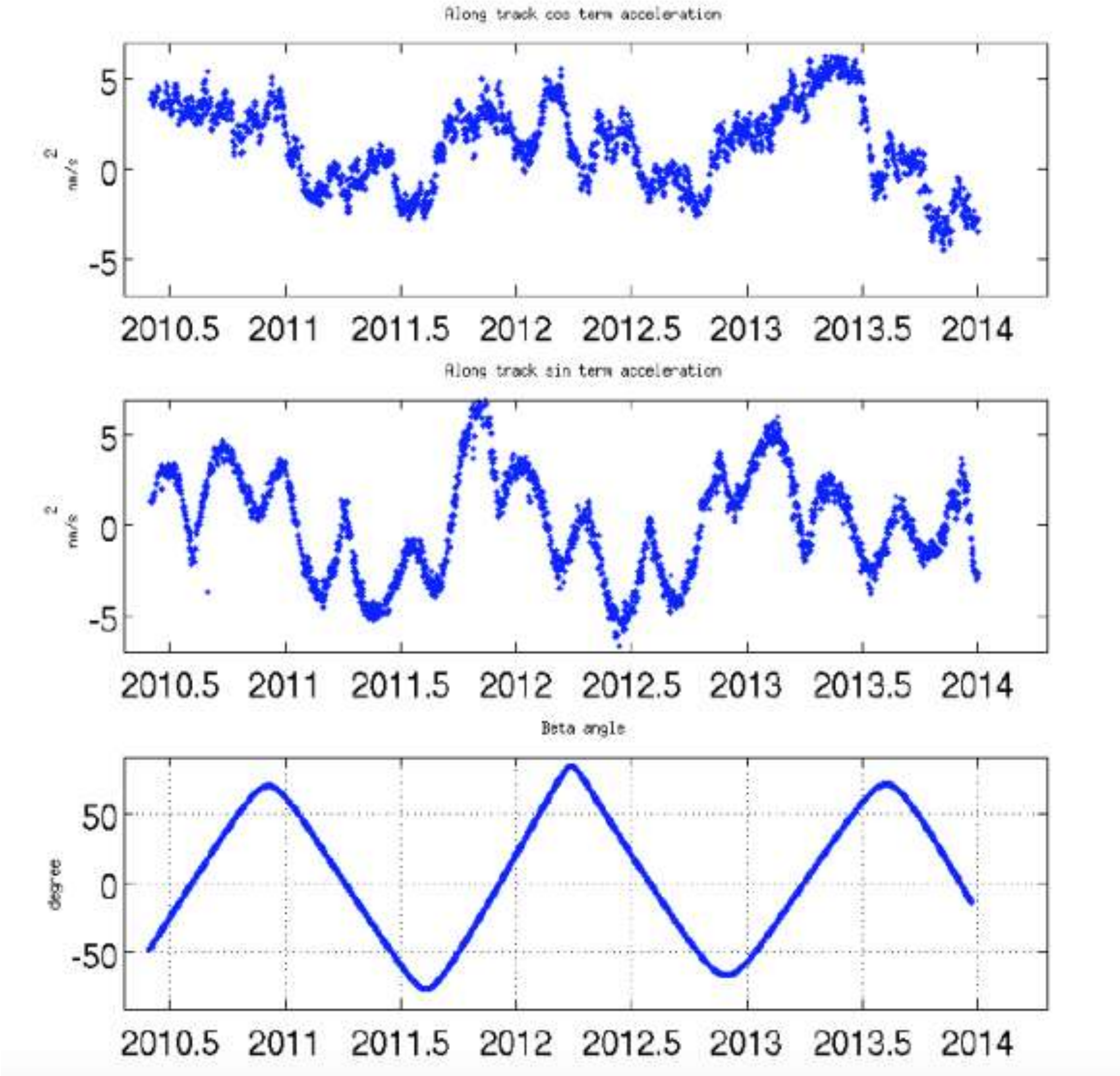


Figure 33. top panel: solved for empirical cosine acceleration term (nm/s2), middle panel: solved for empirical sine acceleration term (nm/s2), bottom panel: beta angle (degree).

During POD we estimate initial state vector elements, DORIS beacon Doppler frequency offsets, 3 hourly drag parameters and we eliminate tropospheric refraction parameters. At the same time we estimate during POD empirical acceleration parameters that model any effect that we miss in solving the equations of motion. Our empirical parameter space considers accelerations in the along- and cross- track direction of the satellite at the once per orbital frequency. The validity interval of the empirical acceleration parameters is 12 hours, while the average arc length is 6 days. The empirical parameters absorb unmodeled solar radiation pressure accelerations, but also any other accelerations that act on the satellite. In the ideal case one would like to see a low random noise level without too much resemblance of a **β** angle signature which would indicate that either the satellite's solar radiation pressure model is not optimally tuned, or that perhaps the satellite is venting volatiles etc.

On **Figure 33** we plot the evolution of the along track empirical acceleration parameters over the entire mission duration. We see that there is a clear signature in the sine along track empirical parameters that some degree of coherency with the **β** regime of the satellite. We see that the along track sine component is showing mirroring effects when there is a **β**=0 transition, thus when the Sun goes through the orbital plane. The figure strongly suggests that the SRP model needs to be tuned and that a sufficient number of **β** cycles has been acquired to accomplish this task.

During the OSTST meeting in Konstanz Germany in 2014 I had a discussion with Flavien Mercier from CNES on this topic, and as a result of this discussion we now reconsider a number of alternative solar radiation pressure models for CryoSat-2. It is expected that the updated modeling will demand less from the empirical force modelling parameterization, and therefore improve the precision orbit determination.

19.5 REFERENCES

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

Willis P., Zelensky N.P., Ries J.C., Soudarin L., Cerri L., Moreaux G., Lemoine F.G., Otten M., Argus D.F., Heflin M.B., DPOD2008, A DORIS-oriented Terrestrial Reference Frame for Precise Orbit

APPENDIX 1: THE IDS INFORMATION SYSTEM

20 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

21 WEB AND FTP SITES

21.1 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, 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: 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.
- 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
- 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.
- Contribution ITRF2013: list of standards used by IDS Analysis Centers for the DORIS contribution to ITRF2013.
- 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 new 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.

21.2 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.

21.3 IDS FTP SERVER

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

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

The 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/

21.4 DORIS WEB SITE

Address: http://www.aviso.altimetry.fr/en/techniques/doris.html (new URL)

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.

21.5 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/

22 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.

22.1 DORISMAIL

e-mail: dorismail@ids-doris.org

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

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

The messages are moderated by the Central Bureau.

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

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

22.2 DORISREPORT

e-mail : dorisreport@ids-doris.org

This list is used for regular reports from Analysis Centers, from the Analysis coordination and from the CNES POD team. The DORISReport distribution list is composed by Analysis Centers, Data Centers, IDS Governing Board and Central Bureau, CNES POD people delivering data to the Data Centers (subscribers).

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

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

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

22.3 DORISSTATIONS

e-mail : dorisstations@ids-doris.org

This mailing list has been opened to distribute information about station events (data gap, positioning discontinuities).

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

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

22.4 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

22.5 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.

23 HELP TO THE USERS

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

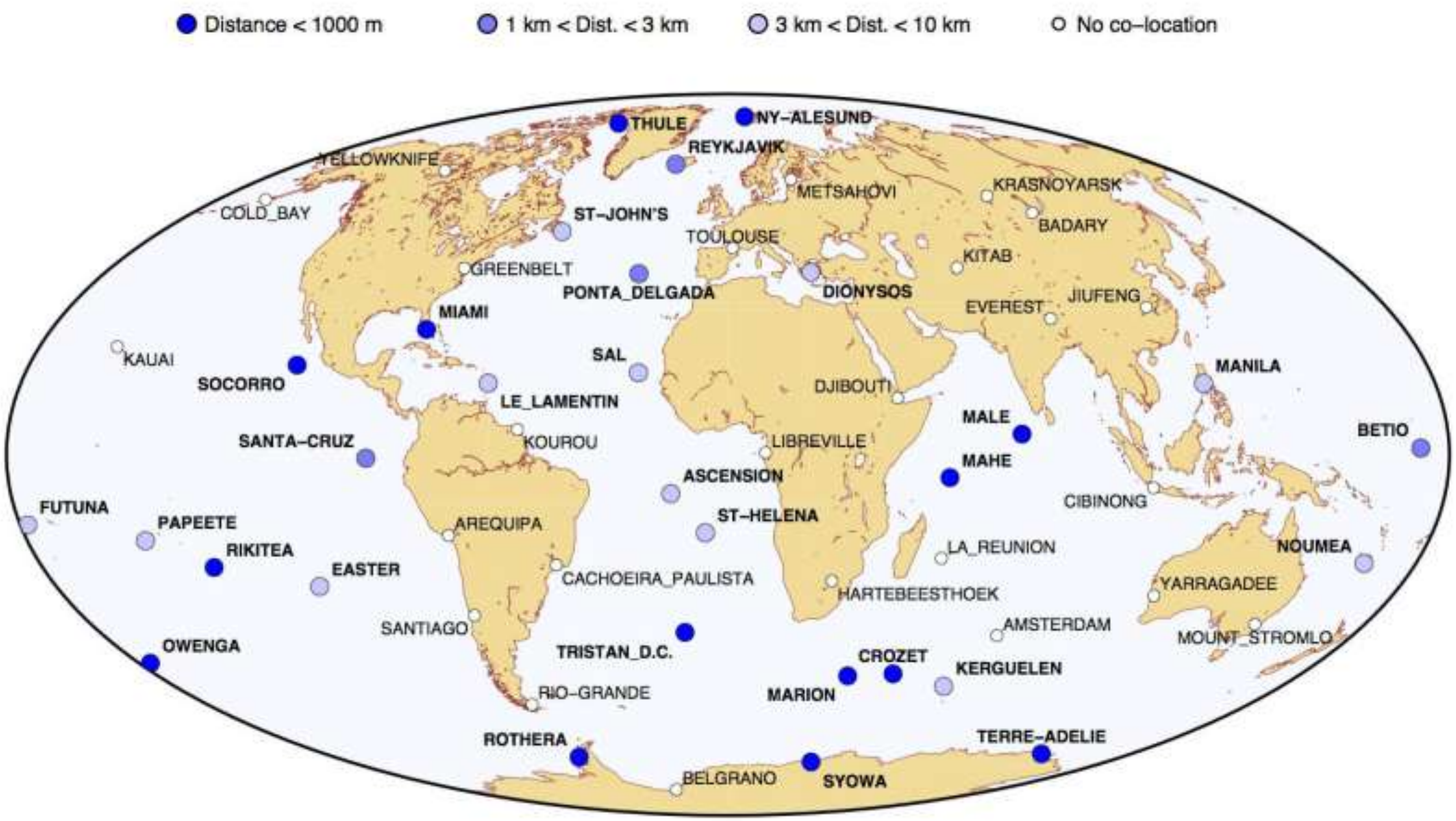
The contact point for every information requirement is the Central Bureau. It will find a solution to respond to user’s need. A list of contact points has been defined for internal use depending on the kind of questions.

APPENDIX 2: 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	28/02/97	6500	263	402001
BETIO	172.92	1.35	KIRIBATI	22/10/06	1600	113	730009
CROZET ISL.	51.85	-46.43	FRANCE	21/12/03	850	21	433001
EASTER ISL.	-109.38	-27.15	CHILI	17/11/88	7000	137	810003
FUTUNA	-178.12	-14.31	FRANCE (POLYNESIA)	18/10/11	4400		
KERGUELEN	70.26	-49.35	FRANCE	28/01/87	3300	23	434001
LE LAMENTIN	-61.00	14.60	FRANCE (MARTINIQUE)	29/06/13	7000	338	1942
MAHE	55.53	-4.68	SEYCHELLES	20/06/01	300	273	442007
MALE	73.53	4.20	MALDIVES	15/01/05	500	28	454011
MANILA	121.03	14.53	PHILIPPINE	26/02/03	9700	73	145
MARION ISL.	37.86	-46.88	SOUTH AFRICA	15/05/87	1000	20	------
MIAMI	-80.17	25.73	USA	10/02/05	180	---	960001
NOUMEA	166.41	-22.27	FRANCE (CALEDONIA)	20/10/87	3600	123	740001
NY-ALESUND	11.93	78.93	NORWAY (SPITZBERG)	13/09/87	600	345	1421
OWENGA	-176.37	-44.03	NEW ZEALAND	17/12/07	100	---	------
PAPEETE	-149.61	-17.58	FRANCE (POLYNESIA)	27/07/95	7000	140	780011
PONTA DELGADA	-25.66	37.75	PORTUGAL (AZORES)	02/11/98	1500	245	36002
REYKJAVIK	-21.99	64.15	ICELAND	04/07/90	2500	229	10001
RIKITEA	-134.97	-23.13	FRANCE (POLYNESIA)	23/09/06	800	138	808001
ROTHERA	-68.1	-67.6	UK (ANTARCTICA)	01/03/05	100	342	1931
SAL	-22.98	16.78	CAPE VERDE	15/12/02	7000	329	380021
SANTA CRUZ	-90.30	-0.75	ECUADOR	01/04/05	1600		845031
SOCORRO	-110.95	18.73	MEXICO	09/06/89	400	162	830062
ST-HELENA	-5.67	-15.94	UK	01/06/89	4000	264	425001
ST. JOHN'S	-52.68	47.40	CANADA	27/09/99	4000	223	970121
SYOWA	39.58	-69.01	JAPAN (ANTARCTICA)	10/02/93	1000	95	A--041
TERRE ADELIE	140.00	-66.67	FRANCE (ANTARCTICA)	05/02/87	500	131	------
THULE	-68.83	76.54	DENMARK (GREENLAND)	28/09/02	300	---	------
TRISTAN DA CUNHA	-12.31	-37.07	UK	10/06/86	2000	266	------

Co–location with tide gauge



APPENDIX 3: 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, USA
	US Coast Guard Navigation Center (NAVCEN)	Alexandria, Virginia, USA
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

Station name	Host agency	City, Country
Gavdos	Technical University of Crete (TUC)	Chania, Crete, GREECE
Grasse	Observatoire de la Côte d'Azur (OCA)	Grasse, FRANCE
Greenbelt	NASA / GSFC / GGAO	Greenbelt, Maryland, USA
Hartebeesthoek	HartRAO, South African National Space Agency (SANSA)	Hartebeesthoek, SOUTH AFRICA
Jiufeng	Institute of Geodesy and Geophysics (IGG)	Wuhan, CHINA
Kauai	Kokee Park Geophysical Observatory (KPGO)	Kauai Island, Hawaï, USA
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, USA
Mount Stromlo	SLR Observatory, Geoscience Australia (GA)	Mount Stromlo, AUSTRALIA
Nouméa	Direction des Infrastructures, de la Topographie et des Transports Terrestres	Nouméa, NEW CALEDONIA

Station name	Host agency	City, Country
Ny-Ålesund	Institut Polaire Paul Emile Victor (IPEV) Geodesiobservatoriet (Statens Kartverk)	Base Charles Rabot, Ny-Ålesund, 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
Port Moresby	National Mapping Bureau (DLPP)	Port-Moresby, PAPUA NEW GUINEA
Reykjavik	Landmælingar Islands (LMI)	Reykjavik, ICELAND
Rikitea	Météo-France	Archipel des Gambier, Polynésie Française, FRANCE
Rio Grande	Estación Astronómica de Rio Grande (EARG)	Rio Grande, ARGENTINA
Rothera	British Antarctic Survey (BAS)	Rothera Research Station, Adelaide Island, Antarctica, UK
Sal	Instituto Nacional de Meteorologia e Geofisica (INMG)	Sal Island, CAPE VERDE
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
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

Station name	Host agency	City, Country
Yellowknife	Natural Resources Canada (NR Can)	Yellowknife, CANADA

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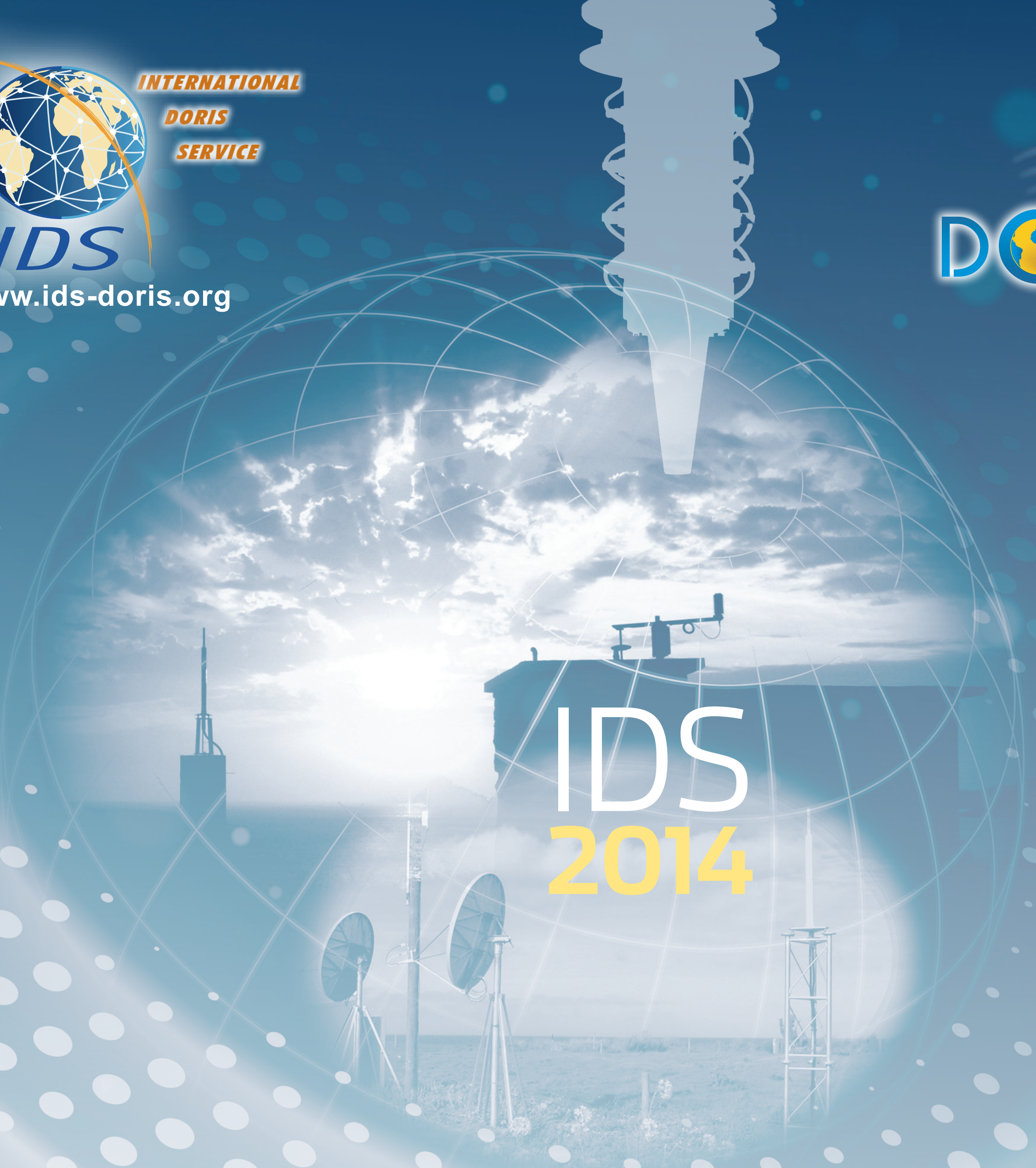

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IPGP INSTITUT DE PHYSIQUE DU GLOBE DE PARIS

CLS COLLECTE LOCALISATION SATELLITES

NASA

IGN INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

cnes

esa

VIGTK

CDDIS Crustal Dynamics Data Information System

INSTITUTE OF ASTRONOMY RUSSIAN ACADEMY OF SCIENCES