IDS Activity Report 2010

International Doris Service

IDS

IGN INSTITUT GEOGRAPHIQUE NATIONAL

cnes

The International DORIS Service

January 2010 – December 2010 report

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In this volume, the International DORIS Service documents the work of the IDS components between January 2010 and December 2010. The individual reports were contributed by IDS groups in the international geodetic community who make up the permanent components of IDS.

The IDS 2010 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.

IDS benefits from this publication to relay the thanks of CNES and IGN towards the whole of the host agencies for their essential contribution with the operation of the DORIS system. The list of the host agencies is given in appendix.

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

http://ids-doris.org/documents/report/IDS_Report_2010.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.ign.fr/pub/doris/

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.oceanobs.com/en/doris/doris-applications/index.html

10. Sitelogs

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. **More contacts**

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

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GLOSSARY

AC

Analysis Center

AGU

American Geophysical Union. AGU is a scientific society that aims to advance the understanding of Earth and space. AGU conducts meetings and conferences, publishes journals, books and a weekly newspaper, and sponsors a variety of educational and public information programs.

AVISO

Archiving, Validation and Interpretation of Satellite Oceanographic data. AVISO distributes satellite altimetry data from TOPEX/Poseidon, Jason-1, 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 Geophysical 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 projets for 17 european countries.

ESA, esa
acronyms for *ESA/ESOC* Analysis Center, Germany

ESOC
European Space Operation Centre (ESA, Germany)

EU

European Union

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

Versions B and C 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)

GGOS

Global Geodetic Observing System

GMF

Global Mapping Function

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

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

(HaiYang 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 Géographique National, French National Geographical Institute

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

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

RMS
Root Mean Square

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 multimission 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 serie 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 50 groups from 35 different countries participate in the IDS at various levels, including 43 groups hosting DORIS stations in 32 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.

2 DORIS SPECIAL ISSUE IN THE ADVANCES IN SPACE RESEARCH

Pascal Willis (1,2) (Guest Editor)

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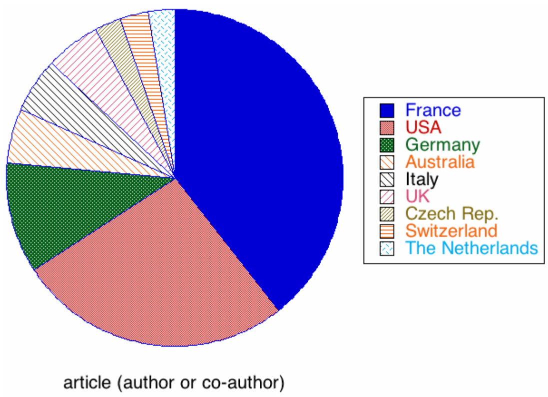
Following a first DORIS Special Issue in Journal of Geodesy (Springer-Verlag, 80(8-11), 406-664, 2006), a second DORIS Special was launched in 2009 in Advances in Space Research (Elsevier). A Call for Participation was broadly distributed through different channels (International DORIS Service, International Association of Geodesy, COSPAR, etc.) and submissions were accepted from April to November, 2009.

Major aspects of the International DORIS Service and of the DORIS system development were addressed: IDS organization, products and data flow, new DORIS technology, precise orbit determination, recent improvement in DORIS data analysis from the seven IDS Analysis Centers (solar radiation pressure and atmospheric drag, geodetic and geophysical applications (station coordinates and velocities, geocenter motion, tide gauge monitoring), detection of effects related to the South Atlantic Anomaly (SAA), comparisons and combination of products in view of the ITRF2008 realization, characterization of clock performances using other systems such as T2L2, atmospheric sciences (ionospheric perturbations and tropospheric correction), characterization of signal and noise in DORIS data measurements and products.



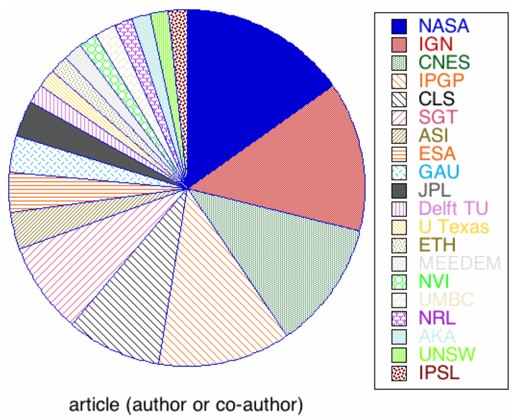


Figure 1 Geographical distribution of authors and co-authors of the DORIS Special Issue in *Advances in Space Research* (45(12) and 46(12)): by country and by institution.

In total, 25 manuscripts were submitted and went through a regular peer-reviewed process, including at least three independent reviewers. Due to the large number of articles, the DORIS Special Issue was published as two separate volumes: Advances in Space Research, 45(12), 1407-1540 published on June 15, 2010 and Advances in Space Research, 46(12), 1483-1660, published on December 15, 2010. All manuscripts can be accessed online at the Journal's Website:

http://www.sciencedirect.com/science/journal/02731177.

A total of 22 manuscripts passed the peer-reviewed process and were published in *Advances in Space Research* in 2010: 10 articles in issue 45(12) and 12 articles in issue 46(12). As displayed in Figure 1, while a large number of articles were written by a French or by a US co-author, this Special Issue included a large number of authors and co-authors from different countries: (alphabetical order) Australia, Czech Republic, France, Germany, Italy, The Netherlands, Switzerland, United Kingdom, USA. It must also be noted that, even if a large number of articles were co-authored by NASA, CNES, IGN, IPGP (see Figure 1), the authors and co-authors belong to a large number of institutions: (alphabetical order) AKA, Agenzia Spaziale Italiana (ASI), Collecte Localisation Satellites (CLS), Centre National d'Etudes Spatiales (CNES), Deutches Geoforschnungs Institut (DGFI), Ecole et Observatoire des Sciences de la Terre (EOST), European Space Agency (ESA), Eidgenössische Technische Hochschule Zürich (ETH Zürich), Geoscience Australia, Geodetic Observatory Pecny (GOP), Institut d'Astrophysique de Paris (IAP), Institut Géographique National (IGN), Institut de Physique du Globe de Paris (IPGP), IPSL, Jet Propulsion Laboratory (JPL), Ministère du Développement durable de l'Ecologie et de la Mer (MEEDEM), National Aeronautics and Space Administration (NASA), NVI, Observatoire de la Cote d'Azur (OCA), SGT, Technical University of Delft (TU Delft), University Paris Sud, University Texas (UT), University College London (UCL), University of Maryland Baltimore County (UMBC), University of New Brunswich (UNSW). Special thanks should also be addressed to the large number of reviewers who were also involved in this Special Issue.

3 HISTORY

The DORIS system was designed and developed by CNES, the French space agency, in partnership with the space geodesy research institute GRGS and France's mapping and survey agency IGN 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 IDS. 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 (Collecte Localisation Satellites) and IGN (Institut Géographique National).

The IDS Central Bureau and the Analysis Coordinator initiated several Analysis Campaigns.

Several meetings were organized as part of the DORIS Pilot Experiment:

DORIS Days were held in Toulouse in May 2000 (see programme and contributions in

http://ids-doris.org/report/meeting-presentations/doris-days-2000.html),

an IDS Workshop was held in Biarritz in June 2002 (see programme and contributions in http://ids-doris.org/report/meeting-presentations/ids-workshop-2002.html),

an IDS Analysis Workshop was held in Marne La Vallée in February 2003 (see programme and contributions in http://ids-doris.org/report/meeting-presentations/ids-workshop-2003.html).

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.

An IDS plenary meeting was held in Paris in May 2004 (see programme and contributions in http://ids-doris.org/report/meeting-presentations/ids-plenary-meeting-2004.html).

An IDS workshop was held in Venice in March 2006 (see http://ids-doris.org/report/meeting-presentations/ids-workshop-2006.html).

Two DORIS Analysis Working Group Meetings were held in Paris in March and June 2008 (see http://ids-doris.org/report/meeting-presentations/ids-awg-03-2008.html and http://ids-doris.org/report/meeting-presentations/ids-awg-06-2008.html).

An IDS workshop was held in Nice in November 2008 (see http://ids-doris.org/report/meeting-presentations/ids-workshop-2008.html).

A DORIS analysis Working Group Meeting was held in Paris in March 2009 (see http://ids-doris.org/report/meeting-presentations/ids-awg-03-2009.html)

In 2010, a DORIS analysis Working Group Meetings was held in Darmstadt at ESOC in May (see http://ids-doris.org/report/meeting-presentations/ids-awg-03-2009.html) and an IDS Workshop was organized on October 21-22, in Lisbon, Portugal (see http://ids-doris.org/report/meeting-presentations/ids-workshop-2010.html), where the 20th anniversary of the DORIS system was celebrated.

In 2011, a DORIS Analysis Working Group meeting will take place in Paris in May.

4 ORGANIZATION

The IDS organization is very similar to the other IAG Services (IGS: International GNSS Service, ILRS: International Laser Ranging Service, IVS: International VLBI Service for Geodesy and Astrometry) and IUGG Service such as IERS (International Earth rotation and Reference system Service).

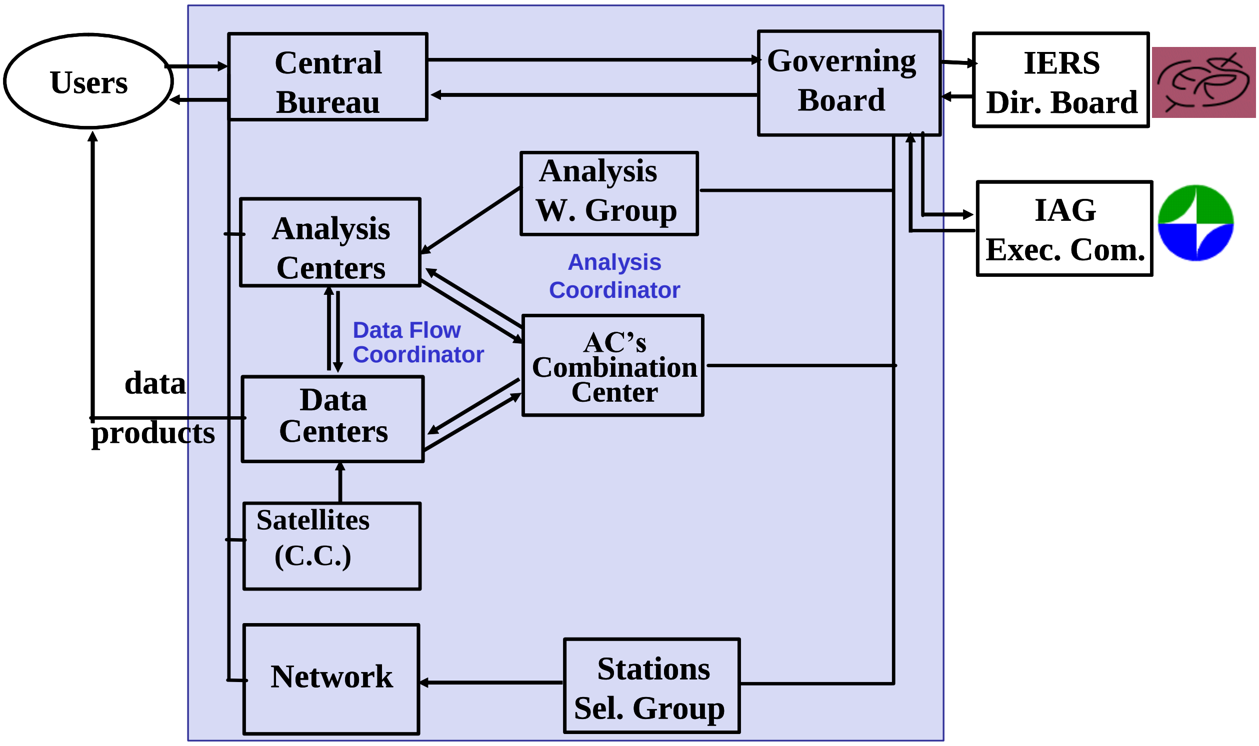


Figure 2 IDS organization

Governing Board

In December 2008, a new Governing board was elected or appointed. In 2010, the Governing Board was:

• Pascal Willis	IGN/IPGP	Analysis Center Representative (Chairperson)
• Pascal Ferrage	CNES	Member at large
• Bruno Garayt	IGN	Network representative
• Frank Lemoine	NASA GSFC	Analysis Coordinator
• Chopo Ma	NASA GSFC	IERS Representative
• Carey Noll	NASA GSFC	Data Flow Coordinator
• Michiel Otten	ESOC	IAG Representative
• John Ries	U. Texas CSR	Member at large
• Laurent Soudarin	CLS	Director of the Central Bureau

Following the change of activities of Herve Fagard in Fall 2009, Bruno Garayt (IGN) was elected in December 2009 as Network representative and will serve until 2012 in the IDS Governing Board as all other members. The IDS Governing Board, Central Bureau and members express their warm thanks to Hervé Fagard for his long-term and efficient involvement in the IDS and in the DORIS network installation and maintenance activity.

Central Bureau

In 2010, the Central Bureau is organized as follows :

• Laurent Soudarin	CLS (Director)
• Jérôme Saunier	IGN
• Pascale Ferrage	CNES
• Jean-Jacques Valette	CLS
• Pascal Willis	IGN/IPGP

5 THE CENTRAL BUREAU: IDS INFORMATION SYSTEM

Laurent Soudarin (1), Pascale Ferrage (2)

(1) CLS, France
(2) CNES, France

Within the IDS, the information is provided through the web and ftp sites of the Central Bureau, the Data Centers and the Analysis Coordination, depending on the kind of information. Day-to-day news of general interest are given to the DORIS community by the DORIS mail service. The DORIS report and the IDS Analysis Forum mailing lists are devoted to the Analysts. This report gives an overview of the IDS information system. Novelties brought to the IDS web and ftp sites in 2010 are also mentioned.

5.1 WHAT AND WHERE

IDS has three data/information centers:

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

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

5.2 WEB AND FTP SITES

5.2.1 IDS WEBSITE

Address : http://ids-doris.org (or http://www.ids-doris.org)

A new version of the site designed and became operational in March 2010. It is developed with a Content Management System (CMS) which offers new capabilities for the management and the update of the site. The structure remains the same but the system address has changed.

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

It is composed of three 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 and the Combination Center with the support of the Central Bureau.

The IDS website 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

The headings of the "DORIS system" part are:

- Official website: a description of the DORIS system on the AVISO website
- 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 processing, list of events impacting the data.

The headings of the "Analysis Coordination" part are:

- 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.

DORIS and IDS news as well as site updates are accessible from the homepage. 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 main updates of 2010 are reported hereafter.

- The list of DORIS publications in international peer-reviewed journals (http://ids-doris.org/report/publications/peer-reviewed-journals.html) is enriched with the articles published in the two volumes of the DORIS special issue in Advances in Space Research.
- The presentations of the 2010 IDS meetings (AWG in Darmstadt and Lisbon, Workshop in Lisbon) are online (see http://ids-doris.org/report/meeting-presentations.html).
- A new page was created to provide information about events occurring on the station network such as new sites, new antennas, removed sites, data gaps, invalidated data... (http://ids-doris.org/system/doris-stations-events.html). It is automatically updated from the DORISstations mails.
- A list was created to resume the main events that occured on each DORIS mission and that may have an impact on the data delivered to the Data Centers (http://ids-doris.org/system/events-impacting-data.html).
- The MOE statistics (daily performance plots from CNES Medium Orbit Ephemeris processing) now include Jason-2 and Cryosat-2 (http://ids-doris.org/system/moe.html).
  The POE statistics (station and satellite performance plots from CNES Precise Orbit Ephemeris processing) also now include Jason-2 and Cryosat-2 (http://ids-doris.org/system/poe.html), and global statistics per satellite were added.

The IDS website is maintained by the Central Bureau.

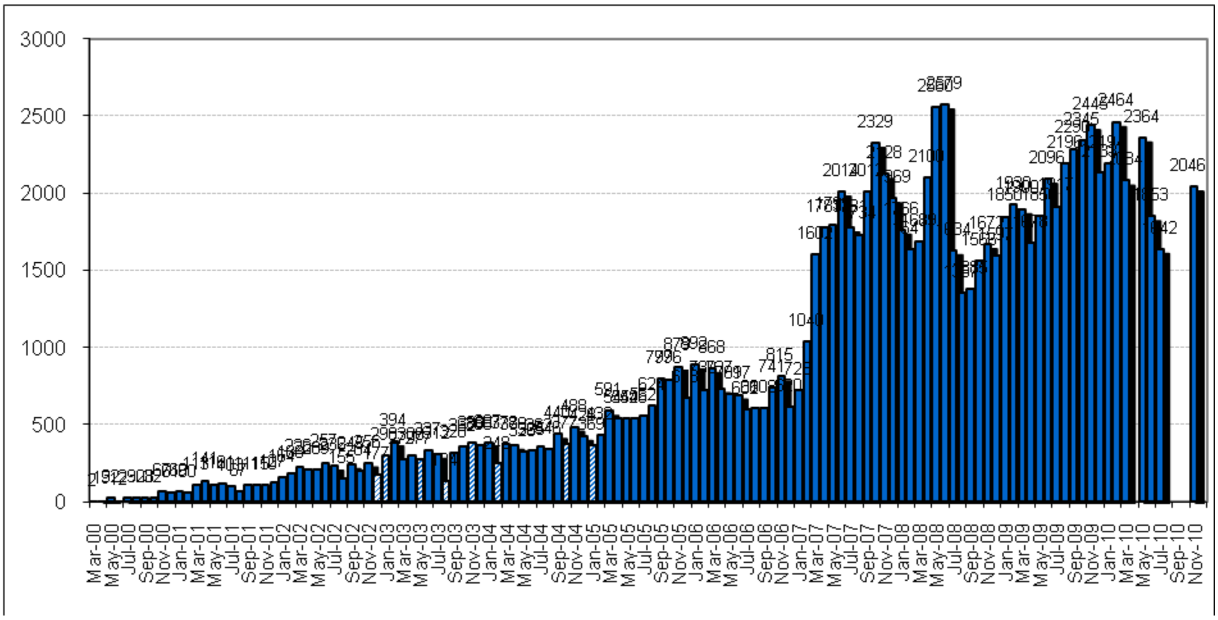


Figure 3 IDS website number of access per month (CNES and CLS excluded). Some values are missing in 2010 due to log loss.

5.2.2 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, attitude maneuvers, 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 the POE statistics of all the stations for each satellite;
- the stations: 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 new documents and files put on the IDS ftp in 2010 are listed hereafter.

- The list of DORIS system events was made available in text format on the ftp site (ftp://ftp.ids-doris.org/pub/ids/data/DORIS_system_events.txt), as well as the brand new file of DORIS station events (ftp://ftp.ids-doris.org/pub/ids/stations/events/StationEventsHistory.txt).
- The history of events impacting the data was created both in pdf (ftp://ftp.ids-doris.org/pub/ids/data/EventsImpactingDataHistory.pdf) and excel formats (ftp://ftp.ids-doris.org/pub/ids/data/EventsImpactingDataHistory.xls).
- Files of maneuvers and mass for Cryosat-2 are now regularly put on the IDS ftp by SSALTO.
- 3 new documents were added: "System requirements for management of the DORIS station network", "Precise orbit context" for Cryosat-2 (ESA) and "Characteristics for DORIS calibration and POD processing" for Cryosat-2 (CNES)
- Updated versions were put online for the document "Characteristics for DORIS calibration and POD processing", the description of the RINEX/DORIS format and the file of DORIS internal ties
- All the macromodel files were removed and replaced with a new document describing the DORIS satellite models implemented in CNES POE processing (ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf).

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/

5.2.3 DORIS WEBSITE

Address: http://www.aviso.oceanobs.com/en/doris/index.html

The official DORIS website 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.

In 2010, a series of videos produced by CNES on the occasion of the 20th anniversary of the DORIS system have been put online (http://www.aviso.oceanobs.com/en/newsstand/altimetry-and-doris-applications-in-videos/index.html).

5.2.4 DATA CENTERS' WEBSITES

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 website: 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/

5.3 THE MAIL SYSTEM

The mail system of the IDS is one of its main communication tools. Depending on the kind of the information, mails are distributed through the DORISmail, DORISreport, 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 website 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.

5.3.1 DORISMAIL

e-mail: dorismail@ids-doris.org

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

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

The messages are moderated by the Central Bureau.

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

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

5.3.2 DORISREPORT

e-mail : dorisreport@ids-doris.org

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

They are all archived on the mailing list server of CLS at the following address:

http://lists.ids-doris.org/sympa/arc/dorisreport

They are also available in text format on the IDS ftp site:

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

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

5.3.3 DORISSTATIONS

E-mail : dorisstations@ids-doris.org

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

The messages are archived on the mailing list server of CLS at the following address:

http://lists.ids-doris.org/sympa/arc/dorisstations.

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

5.3.4 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

Previous to the creation of forum, the Analysis Coordinator has collected 68 messages of conversion between analysts in an archive that can be viewed at http://www.ids-doris.org/analysis-discussion.html

5.3.5 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: common list for the Central Bureau and the Governing Board. This list is private.

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

5.4 HELP TO THE USERS

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

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

5.5 FUTURE PLAN

In 2011, we will work on making available Cryosat-2's quaternion files, elaborated by the CNES/SOD team. Sitelogs will be updated and completed. Additional pictures taken at the DORIS sites will be also put online. Of course, we will take into account the new missions planned to be launched and provide the users with the related DORIS data and documentation as soon as they will be available. A gallery of pictures will be set-up too.

The Central Bureau will continue to support any new ACs as they join the service.

6 THE NETWORK

Jérôme Saunier (1)

(1) IGN, France

6.1 LOOKING BACK OVER 20 YEARS SERVICE

This year we celebrated the twentieth DORIS anniversary. This also means more than twenty years of fruitful collaboration between CNES and IGN. I take the opportunity to look back on the DORIS network past.

DORIS's history began in the early eighties between CNES and IGN. CNES brought its experience in the space and IGN brought its experience on the ground.

Therefore IGN was put in charge of the network deployment just after the first station installation carried out in 1986 at Tristan Da Cunha.

Four years later, 32 DORIS stations were installed and ready to transmit to the first DORIS equipped satellite SPOT 2 launched in January 1990.

The second era of the deployment consisted in making the network denser in order to improve the coverage. This raised the number to more than fifty stations.

At the same time the equipment performance were greatly improved and the positioning accuracy of the DORIS system as well.

The third era (that is to say from 2000 to nowadays) focused on the stability and the environment of the antenna. During these last ten years, IGN carried out a major renovation effort on each of the DORIS stations.

Today, nearly sixty stations make up DORIS network. These are well distributed geographically worldwide. This distinctive feature is unique in the world of space geodesy and we are very proud of that.

Another result of great importance for us geodesists: DORIS system is not simply a precise orbit determination system. It is also a highly accurate positioning system. Therefore DORIS network has become a geodetic network recognized by all the scientific community and contributes significantly to the realization of the International Terrestrial Reference System. This engagement gives to DORIS network new objectives with the prospect of GGOS 2020, the future Global Geodetic Observing System.

So, our efforts in the years to come will be aimed towards finding co-location sites with other space geodetic techniques becoming essential in this GGOS 2020 aim.

DORIS network is evolving continuously and will go ahead with the objective of better service to the system, improving its accuracy and its reliability. We hope that we will all carry on the good work and the collaborative spirit. Partnership played a full role in DORIS network, thanks to all partners: science institutes, national mapping agencies, space agencies, meteorological stations, telecommunication stations, universities, research centers and others who kindly host and preserve DORIS stations.

6.2 2010 NETWORK EVENTS

This year starts with unexpected events but we carried out most of planned operations.

- Monument Peak: final shutdown due to conflict in frequency with a TV relay station
- Santiago: coordinates updating following earthquake
- Libreville: local tie survey after new GNSS station installation
- Santa-Helena: local tie survey after new GNSS station installation
- Ascension: major renovation (35-m antenna shifting)
- Kourou: beacon upgrading conforming to standards
- Fairbanks: taking down
- Cold Bay: new station installation (in place of Fairbanks)
- Chichijima Island (Japan) : reconnaissance with a view to install a new station

In order to facilitate maintenance and reduce time to re-activate the beacon in case of break, a remote management system began to be deployed on 18 stations this year.

For now on, all beacons in the network are third generation ones, except Socorro (1st generation) and Futuna (2nd generation).

Finally, our plans for the next year: new stations in Riyadh, Goldstone (in place of Monument Peak) and maybe Chichijima, and major renovations in Socorro, Tristan Da Cunha and Futuna.

7 THE SATELLITES WITH DORIS RECEIVERS

Pascale Ferrage (1)

(1) 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 has been functioning 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) which was launched in 1998 and featured the first DORIS real time on-board orbit determination (DIODE).

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 recently been developed (*Lemoine and Capdeville 2006*),

- 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

- 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

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 is dedicated to global ionospheric measurements, it is planned to have the corresponding data available at IDS Data Centers .

Figure 4 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.

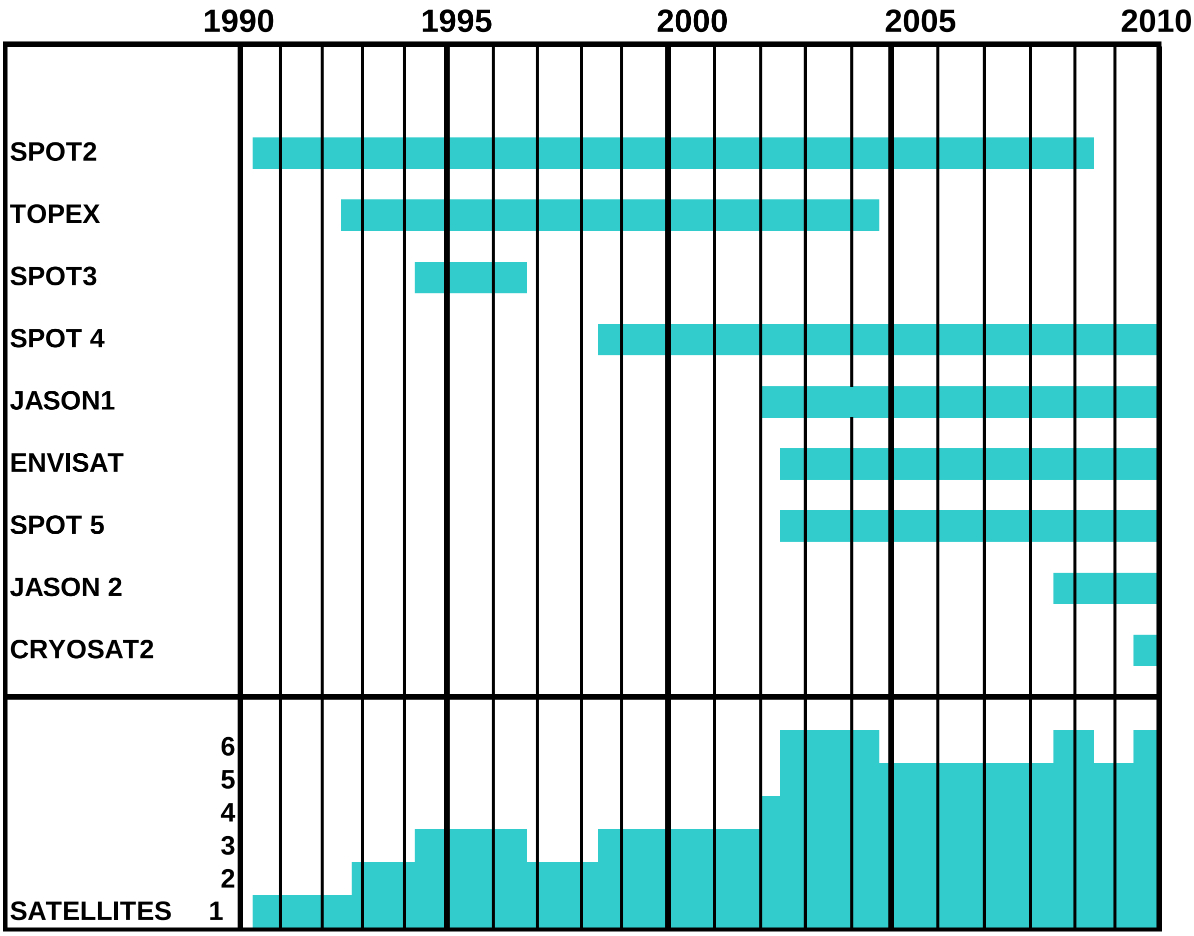


Figure 4 DORIS observations available at the IDS Data Centers (December 2010).

The future DORIS mission are numerous and should guarantee a constellation with at least 4 DORIS contributor satellites through 2025:

- **HY2A** (China Academy of Space), is to be launched in July 2011
- **SARAL/ALTIKA** (ISRO/CNES) is to be launched in 2012
- **SENTINEL3A** (GMES/ESA) is planned for April 2013, then **SENTINEL 3B** 12 to 30 months later
- **Jason3** (EUMETSAT/NOAA/CNES) is foreseen from mid 2013
- **Jason CS (**Eumetsat/ESA/CNES**)** is expected for 2017
- **SWOT** is foreseen for 2020

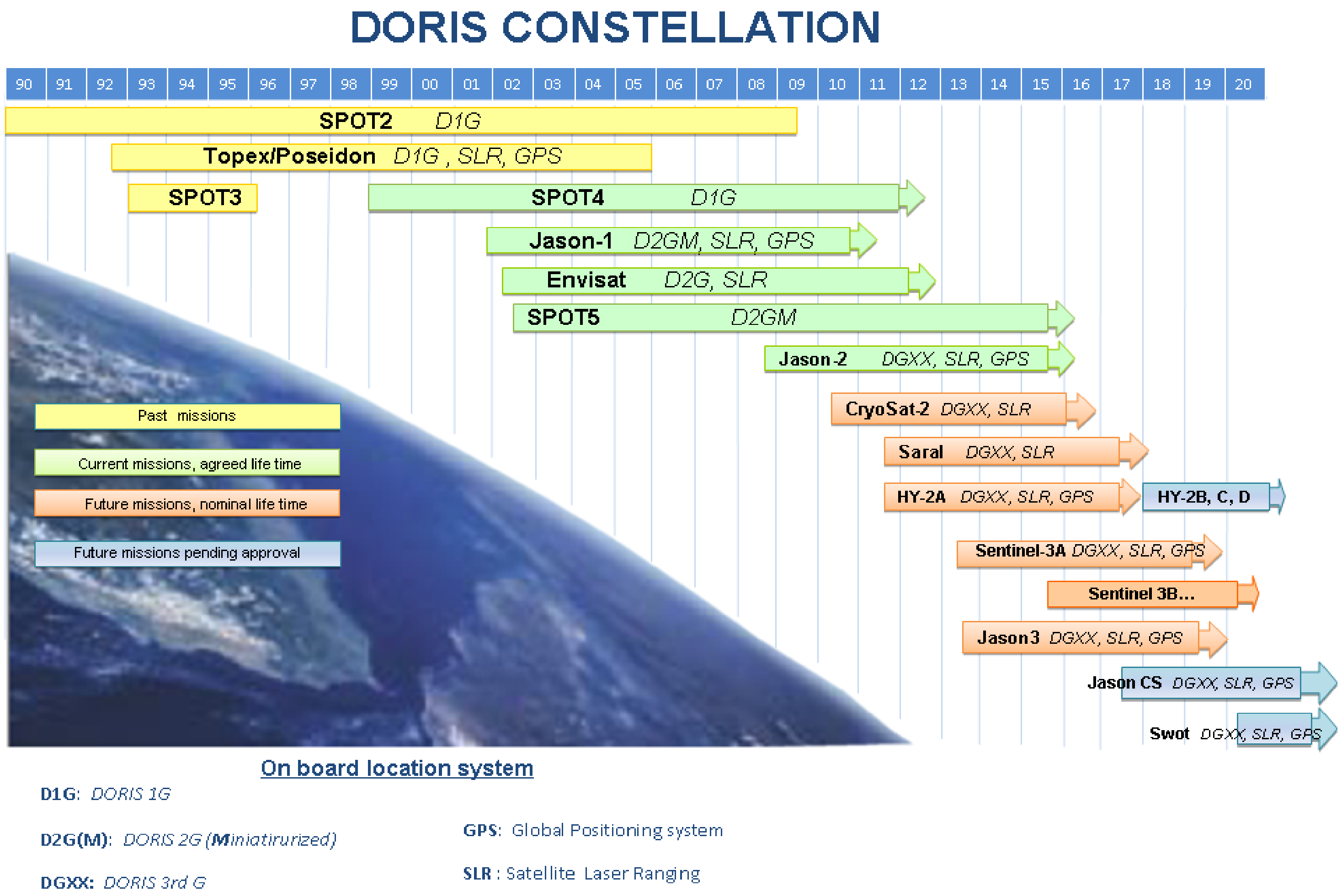


Figure 5 Current and future DORIS constellation (December 2009).

8 IDS DATA FLOW COORDINATION

Carey Noll (1)

(1) NASA/GSFC, USA

8.1 INTRODUCTION

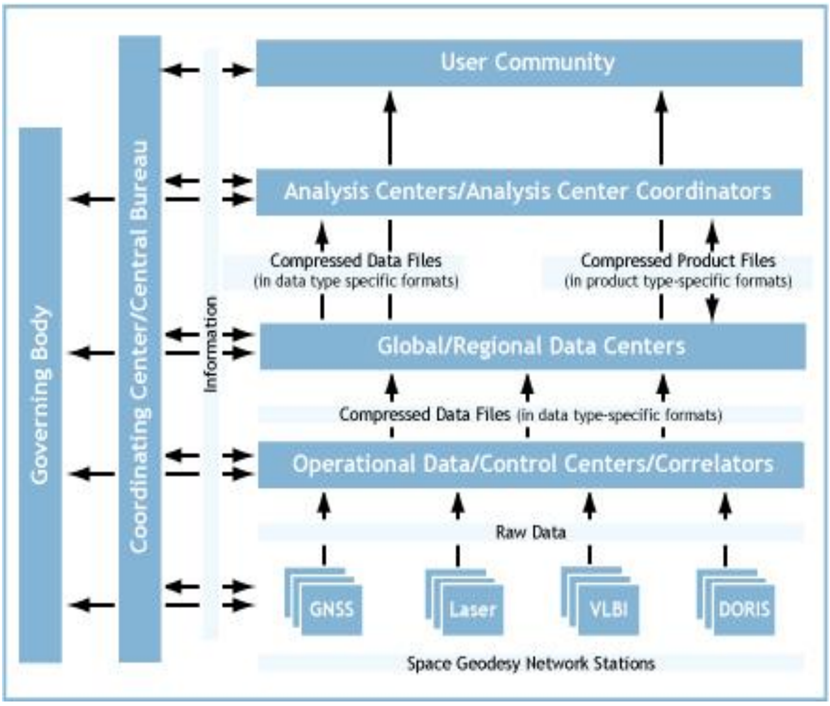
Two data centers currently support the archiving and access activities for the IDS:

- Crustal Dynamics Data Information System (CDDIS), NASA GSFC, Greenbelt, MD USA
- Institut Géographique National (IGN), Saint Mandé France

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

8.2 FLOW OF IDS DATA AND PRODUCTS

The flow of data, products, and information within the IDS is analogous to what is utilized in the other IAG geometric services (IGS, ILRS, IVS) and is shown in Figure 6. 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 6 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 1 and fully described on the IDS Central Bureau website at *http://ids-doris.org/analysis-documents/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 CB ftp site) with general information and data and product documentation (maintained by the IDS Central Bureau)

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

Directory	**File Name**	Description
Data Directories		
/doris/data/*sss*	*sss*data*MMM*.*LLL*.Z	DORIS data for satellite *sss*, cycle number *MMM*, and version *LLL*
	sss.files	File containing multi-day cycle filenames versus time span for satellite *sss*
/doris/data/*sss*/sum	*sss*data*MMM*.*LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
/doris/data/*sss*/yyyy	*sss*rx*YYDDD*.*LLL*.Z	DORIS data (RINEX format) for satellite sss, date YYDDD, version number *LLL*
/doris/data/*sss*/yyyy/sum	*sss*rx*YYDDD*.*LLL*.sum.Z	Summary of contents of DORIS data file for satellite *sss*, cycle number *MMM*, and file version number *LLL*
Product Directories		
/doris/products/orbits/	*ccc*/*cccsssVV*.*bXXDDD*.*eYYEEE*.sp1.*LLL*.Z *ccc*/*cccsssVV*.*bXXDDD*.*eYYEEE*.sp3.*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*
/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/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/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/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*
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 1 Main Directories for IDS Data, Products, and General Information

8.3 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. The IDS data centers currently archive DORIS data from six operational satellites (SPOT-4, -5, Jason-1, -2, Envisat, and CryoSat-2); data from future missions (e.g., SARAL, etc.) will also be archived within the IDS. Historic data from SPOT-2 (operations ceased in July 2009), SPOT-3, 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 2. The DORIS data from all satellites are archived in multi-day (satellite dependent) files using the DORIS data format 2.2 (since June, 2008). The DORIS data files are 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 2010 of data availability after the last observation day satellite specific are shown in Table 3. The delay in data delivery to the data centers (in days by satellite) in 2010 is shown in **Figure 7**.

Satellite	Time Span
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004
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 present
SPOT-5	11-Jun-2002 through present
Jason-1	15-Jan-2002 through present
Jason-2	12-Jul-2008 through present
CryoSat-2	30-May-2010 through present
Envisat	13-Jun-2002 through present

Table 2 DORIS Data Holdings

Satellite	Number of Days/ Multi-Day File	Average Latency (Days)
CryoSat-2	6	36
Envisat	6	27
Jason-1	10	33
Jason-2	10	40
SPOT-4, -5	9	32

Table 3 DORIS Data File Information

DORIS phase data from Jason-2 and CryoSat-2 are also available in RINEX (Receiver Independent Exchange Format), version 3.0 (see ftp://ftp.ids-doris.org/pub/ids/data/RINEX_DORIS.pdf). These satellite houses the newer, next generation DORIS instrumentation (DGXX) capable of generating these 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.

8.4 DORIS PRODUCTS

IDS analysis centers use 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, M. Otten
- Geoscience Australia (gau), R. Govind
- Geodetic Observatory Pecny (gop), Czech Republic, P. Stepanek
- NASA Goddard Space Flight Center (gsc) USA, F. Lemoine
- Institut Géographique National/JPL (ign) France, P. Willis
- INASAN (ina) Russia, S. Kuzin
- CNES/CLS (lca) France, L. Soudarin
- CNES/SOD (sod) France, L. Cerri
- SSALTO (ssa) France, L. Cerri

IDS products are archived by type of solution and analysis center. The types and sources of products available through the IDS data centers in 2005-2009 are shown in Table 4. This table also includes a list of products under evaluation from several DORIS analysis centers.

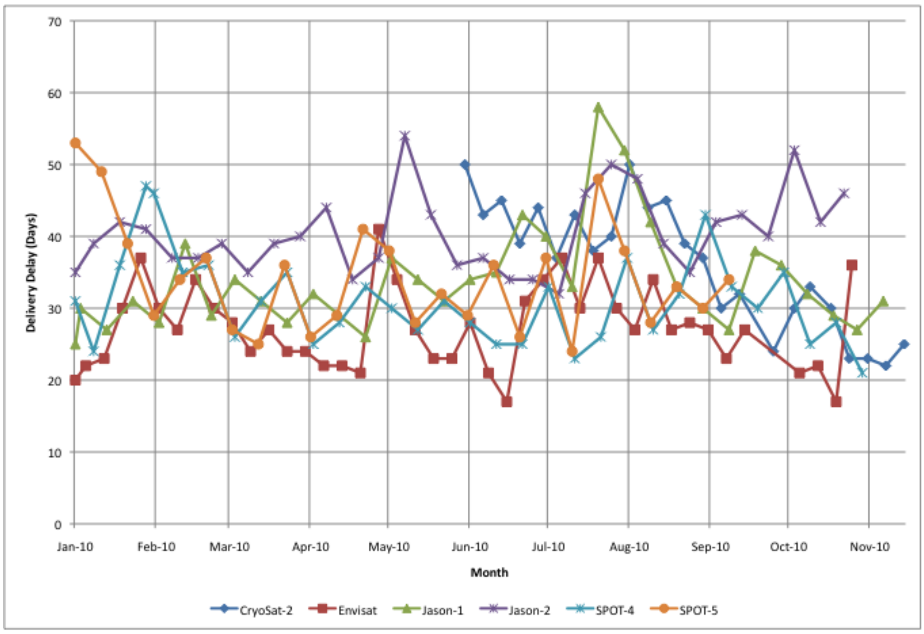


Figure 7. Latency in delivery of DORIS data to the CDDIS (all satellites, 01-12/2010)

The IDS Analysis Working Group proposed to conduct a special analysis campaign to isolate the differences between AC solutions found during the creation of the IDS combined solution. For this study, several AC submitted single-satellite SINEX files for 2009. These files were archived at the IDS data centers in subdirectories by AC.

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

Notes: W=weekly solution, M=monthly solution

Table 4 IDS Product Types and Contributing Analysis Centers

8.5 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 and -2 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.

8.6 FUTURE PLANS

The IDS data centers will investigate procedures to regularly compare holdings of data and products to ensure that the archives are truly identical.

9 IDS DATA CENTERS

Carey Noll (1), B. Garayt (2)

(1) NASA/GSFC, USA

(2) IGN, France

9.1 CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)

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:

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

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. Approximately 45 Gbytes of CDDIS disk space is devoted to the archive of DORIS data, products, and information.

In June 2010 the CDDIS transitioned operations to a new distributed server environment. Users continued to access the CDDIS as before; however, suppliers of data and product files were required to use a new server dedicated to incoming file processing. The structure of the DORIS data and product archive remained unchanged in this new system configuration.

During 2010, user groups in over 50 countries downloaded approximately 260 Gbytes (250K files) of DORIS data, products, and information from the CDDIS.

9.1.1 CDDIS FUTURE PLANS

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

9.1.2 CDDIS CONTACT

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

9.2 IGN DORIS DATA CENTER

The IGN data center is handled by the geodetic and leveling department (SGN).

During 2009, the international network and services operational activities at IGN have been reorganized. The IGS (global data center, Reference Frame coordination from 01/2010), the IDS (data center and analysis, operated by IGN/SGN in cooperation with P. Willis IGN/DT), the ITRF database management and local tie survey, the EUREF analysis center and the IGN DORIS network activities have been merged into a unit (International Network and Services) within the Geodetic and Levelling department. This reorganization was motivated by the search of a valuable synergy between different techniques at different level of activities (from the network to the analysis) which might be benefit to the IDS, working closely with the analysis centers, and contributing to the setting up by the international community of a geodetic infrastructure of the highest quality in terms of monuments, observation conditions, enhanced with the collocation with other fundamental geodetic space techniques as required by IAG for GGOS.

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

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

All the data and products archived and available at IGN Global Data Center may be access through:

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

The IGN plans to develop a dedicated website for the IDS Data Center.

9.2.1 CONTACT

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10 IDS ANALYSIS COORDINATION

Frank G. Lemoine (1)

(1) NASA/GSFC, USA

The DORIS community had a productive year in 2010. The activities consisted of: (1) follow-up activities related to the development of ITRF2008, including the extension of the data processing to include data in 2009; (2) the development of satellite-only time series of SINEX solutions as part of an analysis campaign to try and ascertain the causes of scale and Tz variations in IDS solutions; (3) the evaluation of the IDS3 solution with respect to ITRF2008 and the EOP performance for the cumulative solution and per Analysis Center (AC); (4) the assessment of the Jason-2 contribution to the IDS combination (Jason2 was not included in the IDS combination solution created for ITRF2008); (5) the first assessment of the Cryosat2 DORIS data; (6) the evaluation of the DORIS and SLR complements of the ITRF2008 solution using POD and other tests. In support of these activities, the IDS Analysis Working Group conducted two meetings: (1) Darmstadt, Germany, May 26-27, 2010, hosted by ESOC; (2) Lisbon, Portugal, October 21-22, 2010 in conjunction with Ocean Surface Topography Science Team Meeting. Two team papers were presented at the IAG Symposium on Reference Frames for Applications in the Geosciences (REFAG), October 4-8, 2010, in Marne-la-Vallée, France: “IDS Evaluation of ITRF2008,” F. Lemoine, N. Zelensky, A. Couhert, L. Cerri, L. Soudarin, P. Willis, K. Le Bail; “A Review of IDS Processing for ITRF2008 and Avenues for Future Improvements,” F. Lemoine, J.J. Valette, G. Moreaux, P. Willis, L. Soudarin, P. Stepanek and M. Otten.

Seven analysis centers routinely participated in the analysis activities in 2010. All seven analysis centers that participated in ITRF2008 continue to remain active, participating in the IDS activities. The .seven analysis centers include the European Space Operations Center (ESOC/ESA), the Geodetic Observatory Pecny (GOP), Geoscience Australia (GAU), the NASA Goddard Space Flight Center (named as GSC), the Institut Géographique National (IGN), the Institute of Astronomy, Russian Academy of Sciences (INASAN, named as INA), and CNES/CLS (named as LCA). In addition TU Delft (E. Schrama) participated in the IDS AWG in 2010 with his evaluation of the POD performance of Cryosat2 with SLR and DORIS data. The CNES POD center (L. Cerri, A. Couhert) was also an active IDS participant in all POD analyses, including the ITRF2008 station coordinate evaluation. We note that G. Moreaux (CLS) has assumed the role of leader for the IDS Combination Center.

For the purpose of extending the IDS combination to include 2009, the AC’s were asked to continue their operational series in so far as was possible to be consistent with their ITRF2008 submissions. In addition a preliminary evaluation of the EOP performance by AC was performed for the time series submitted for ITRF2008. The major lessons learned were as follows: The IDS-3 EOP after 2002.4 (when 4 satellites are available) differ in a RMS sense from IERS05-C04 by 0.16 mas for Xp and 0.26 mas for Yp. The origin of the lower precision for Yp polar motion is not understood. The second conclusion was that the EOP precision was highly variable between the different ACs, and that it was the ESA EOP precision that controlled that of the final IDS-3 solution. The other conclusion from these tests with the 2009 SINEX files, was that the 2009 IDS combination was coherent in scale, geocenter parameters with the early time series, validating the approach to extend operationally the IDS Combination.

The IDS Combination conducted the first evaluations of the Jason-2 contribution to the IDS combination and reports were presented at both the Darmstadt and Lisbon meetings. There were two important conclusions: (1) The Tz geocenter component is centered much better with Jason-2 and this benefits the IDS combination (see Figure 1 for example from the SINEX series submitted by ESA); (2) The Tx and Ty geocenter components exhibit a 120-day oscillation with Jason-2, indicative of problems associated with the radiation force model for Jason2. A question was raised as to why Jason2 had more deleted stations in the satellite-only SINEX solutions than the other satellites. Overall the contribution of Jason-2 is seen as beneficial with the caveat that the IDS must continue to work to improve the radiation pressure modeling for this satellite.

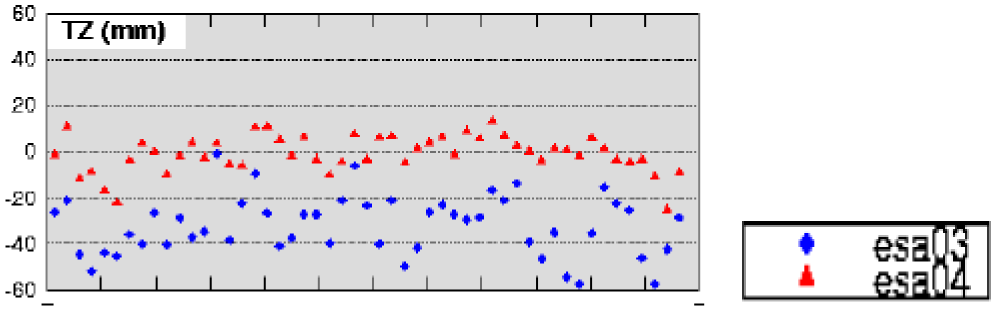

Figure 8. Comparisons of the ESA SINEX series for 2009 in the Tz geocenter component toward ITRF2008 with esa03 (without Jason-2) and esa04 (with Jason-2). The combination solution with Jason-2 is centered much better. This was seen with all of the satellite-only SINEX solutions submitted by the different ACs

For the Lisbon meeting, the IDS ACs were asked to submit single satellite SINEX solutions for 2009. These were analyzed to try and identify systematic patterns and sources of error. The most surprising result was as follows: When the satellite-only SINEX solutions were compared towards ITRF2008, all the ACs had a positive Tz bias for SPOT4 (52-102 mm) and a negative Tz bias for Envisat (-50 to -175 mm) (see Figure 2 for example from GSC). This indicates a satellite-data-level issue as opposed to a modeling issue, or a common mode modeling issue for all the analysis centers. In contrast the Tz components for SPOT5 and Jason2 were clustered more closely to zero. For the scale, there were seen to be two families of solutions: SPOT4/SPOT5 (zero to positive) vs Jason2/Envisat (negative). The significance of this observation is unknown. Finally the 2009 analysis showed stations that had systematically high residuals: These included Santiago, Arequipa, Cachoiera and Fairbanks and possibly Syowa.

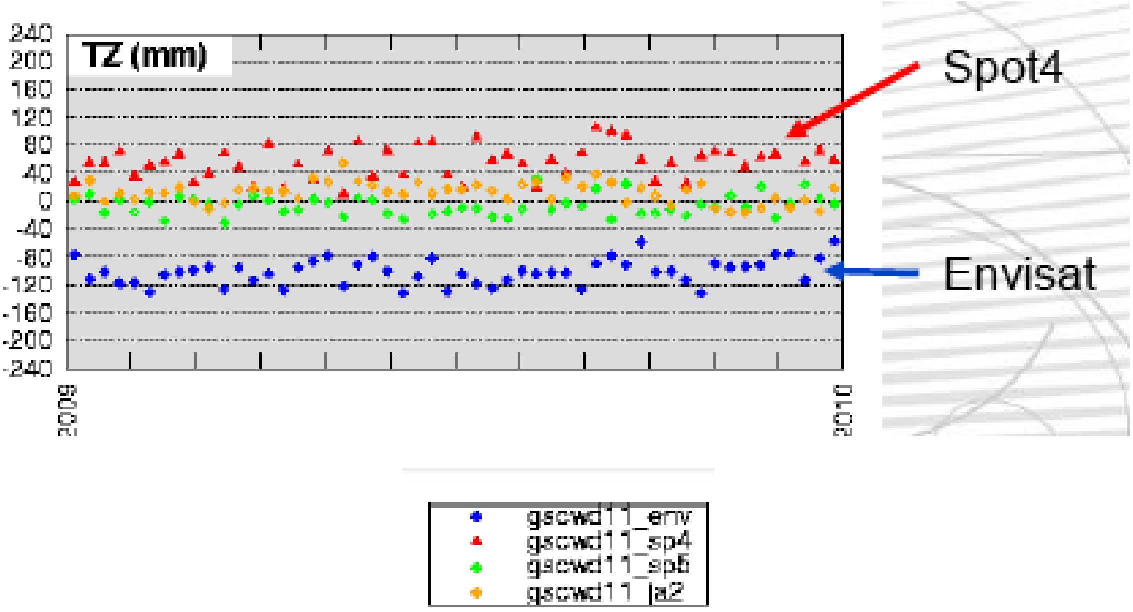

Figure 9.GSC satellite-only SINEX solutions for 2009 compared towards ITRF2008 for the Tz geocenter component. The Envisat and SPOT4 satellites produce distinctly different Tz offsets and this is seen in all the AC results.

IDS members (N. Zelensky, GSC; A. Couhert, L. Cerri, CNES; L. Soudarin, LCA) analyzed the performance of the ITRF2008 solution. The analysis included POD tests on altimeter satellites (TOPEX/Poseidon, Jason2) for select periods from 1993 to 2010. In addition the horizontal and vertical station velocities were reviewed for ITRF2008 and ITRF2005. The evaluation included the final ITRF2008 as well as the ITRF combination submitted by the DGFI (ITRF2008d). For the DORIS complement, the ITRF2008 appears to be an improvement over ITRF2005 (DPOD2005, Willis et al., 2009) for many stations (see Figure 3). When the DORIS station data RMS of fit is analyzed individually, we see that for the 1993 test period (Sept. 1992 to April 1993), only 4 stations out 43 had a degradation in RMS of fit of greater than 0.0008 mm/s with ITRF2008: COLA, DIOA, CACB, RIDA. Over the Jason-2 test period (July 2008 – January 2010), five stations have a noticeable degradation with respect to ITRF2005 (DPOD2005): CADB, SANB, ASDB, REZB, and SCRB. The degradation for CADB (Cachoeira Paulista, Brazil) is particularly significant (0.008 mm/s) and could be an indication that the potential SAA problem on SPOT5 identified by Stepanek et al. (2010) is contaminating the position and velocity solution for this station (especially as this station is located so close to the geographic location of the South Atlantic Anomaly).

When ITRF2008d is compared to ITRF2008, the DORIS fits are degraded – and this may be related to the velocity discrepancies for successive DORIS occupations at the same site in the ITRF2008d solution. For the SLR complement, ITRF2008 appears to be a consistent improvement over LPOD2005. The RMS difference in altimeter crossover variances seems to suggest that for TOPEX in 2002, the ITRF2008-derived SLR orbits provide 2 mm reduction in radial orbit error.

test DORIS-only	number stations	average points / cycle	average residuals per cycle		
			DORIS (mm/s)	SLR (cm)	Xover (cm)
TOPEX/Poseidon (Apr 19, 1993 – July 17, 1993)					
dpod2005	45	57135	0.5386	4.81	5.936
dpod2005*	42	54342	0.5393	4.94	5.939
itrf2008	42	54342	0.5391	4.90	5.942
itrf2008d	42	54342	0.5391	4.90	5.939
TOPEX/Poseidon (Jan. 15, 2002 – Aug. 11, 2002)					
dpod2005	53	57365	0.4733	4.16	5.622
itrf2008	51	56015	0.4736	4.20	5.621
itrf2008d	52	57251	0.4731	4.16	5.616
Jason-2 (Jan. 26, 2009 – Jan. 28, 2010)					
dpod2005 *	51	151295	0.3774	2.38	5.577
itrf2008	51	151307	0.3761	2.39	5.556
itrf2008d	51	151305	0.3766	2.39	5.559

Table 5 POD tests for TOPEX and Jason-2 using DORIS-only orbits using ITRF2005 (DPOD2005), ITRF2008, and ITRF2008d(DGFI), computed by N. Zelensky (GSC Analysis Center). SLR and Altimeter crossover fits are independent. DPOD2005* indicates the DPOD2005 complement was edited to have the same stations as appeared in ITRF2008

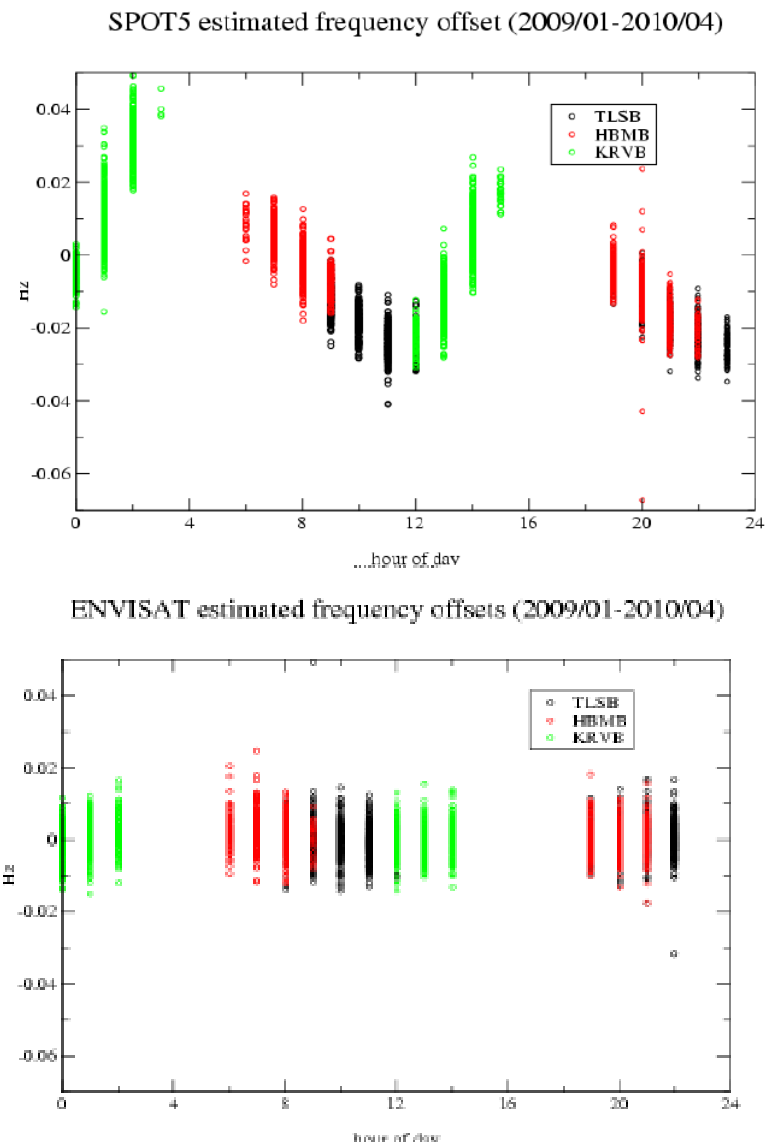

Figure 10. Hourly offset satellite DORIS USO wrt to the master beacons vs time for 2009/01 to 2010/04 for SPOT5 (left) and Envisat (right) from computations by LCA. The diurnal signature is consistent with an SAA effect on the SPOT-5 DORIS USO**.**

The IDS thus faces a decision as to how to handle this issue. The station coordinate (particularly height) and velocity determinations for at least stations near the SAA (Cachoeira, Arequipa, Santiago, Kourou, St Helena) are apparently deleteriously affected by this phenomenon. Outright deletion of all SPOT5 from the weekly DORIS solutions does not seem warranted as it seems that SPOT5 data are not seriously affected further away from the SAA. The potential mitigation strategies are (1) deletion of the data for the SAA stations; (2) Estimation of a frequency correction term (df/dt) either per pass or per day for the affected stations; (3) Development of an SAA model for SPOT5 as was accomplished for Jason1. This issue must be addressed prior to the development of the next ITRF and it will be important to test and validate suitable mitigation strategies in time before the systematic reprocessing of the DORIS data is initiated.

The outstanding modeling issues for the IDS include:

(1) radiation pressure modeling for the DORIS satellites: Continued efforts to develop improved models as with ANGARA (Doornbos, 2001) or UCL, (Ziebart et al., 2005) or to tune the macromodel parameters (e.g. Le Bail et al. 2010, Gobinddass et al., 2009) are needed. Most ACs use the Knocke et al. (1998) simplified planetary radiation pressure model, and with the current levels of accuracy in orbit modeling, upgrade to a more detailed and updated model would be desirable.

We note that L. Cerri has developed a reference document for macromodels of the DORIS satellites: " DORIS satellites models implemented in POE processing, (ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf)", which is available at the IDS website (http://ids-doris.org). This model was developed and released in response to an action item from the IDS AWG. The document provides a detailed description of the macromodels, coordinate systems, DORIS phase center locations, and general description of attitude laws for all the DORIS spacecraft, as well as an estimate of the amplitude of the daily empirical along-track accelerations from these models' implementation in the CNES software. The document corrects several errors in the previous versions of the online documentation for the DORIS satellites, and it will be important for the ACs to verify the implementation of the attitude laws and macromodels against what is described in this document.

(2) troposphere modeling: In ITRF2008 not all AC's used the IERS-recommended troposphere mapping functions GMF (Boehm et al., 2006) or VMF, so at a minimum all AC's are encouraged to update their software as soon as possible;

(3) ocean tide modeling: Ocean tide modeling concerns both the dynamic effects in the tidal geopotential and the station-based corrections due to ocean loading. Two of the seven ITRF2008 ACs used an older tide model (CSR3). It would be preferable if all the ACs used more modern vintage tide models, e.g., FES2004 (Lyard et al., 2006), GOT4.7p (Ray et al., 1999) EOT08a. Some attention may need to be paid to the ocean loading corrections for some stations near Greenland or Antarctica where tests with GRACE data have shown that the tide models continue to have some deficiencies (Ray et al., 2009);

(4) DORIS USO satellite time biases: Zelensky et al. (2006) and Le Bail et al. (2010) calculated the DORIS system time biases for TOPEX using SLR-DORIS orbits. These timing offsets can be significant (up to 10-15 µsecs) would at some level impact the DORIS station position.

In terms of other outstanding analysis issues, despite the availability of RINEX data for Jason2 and Cryosat2, none of the analysis centers have embarked in earnest on use of this data in lieu of the standard

2.2 format data. Since the old format will be retired for the newer satellites, it will be important for the ACs to test the processing with DORIS RINEX data as expeditiously as possible.

As a result of the IDS AWG meetings in Darmstadt and in Lisbon, the IDS ACs agreed to submit SINEX files on a routine basis at three month intervals. The combination center in Toulouse would then use whatever the ACs had supplied to construct an operational combination. Feedback on the 2010 submissions would be provided at the 2011 IDS AWG meeting scheduled for Paris in May 2011.

11 IDS ANALYSIS COORDINATION

Guilhem Moreaux (1)

(1) CLS, France

11.1 ACTIVITY SUMMARY

IDS combination activities in 2010 were mainly devoted to the analysis of the IDS 2010 single satellite campaign and to the initialization of the routine combination.

11.2 IDS 2010 CAMPAIGN

For the AWG meeting held in Darmstadt (May 2010), the IDS Combination Center evaluated weekly SINEX series from ACs with and without Jason-2 DORIS data. This evaluation showed that adding Jason-2 in the multi-satellite combination centers the Tz parameter (see **Figure 11**). Since such a pattern was not observed with Topex mission which had the same orbit as Jason-2, the AWG decided to ask ACs to provide weekly SINEX single satellite solutions over 2009.

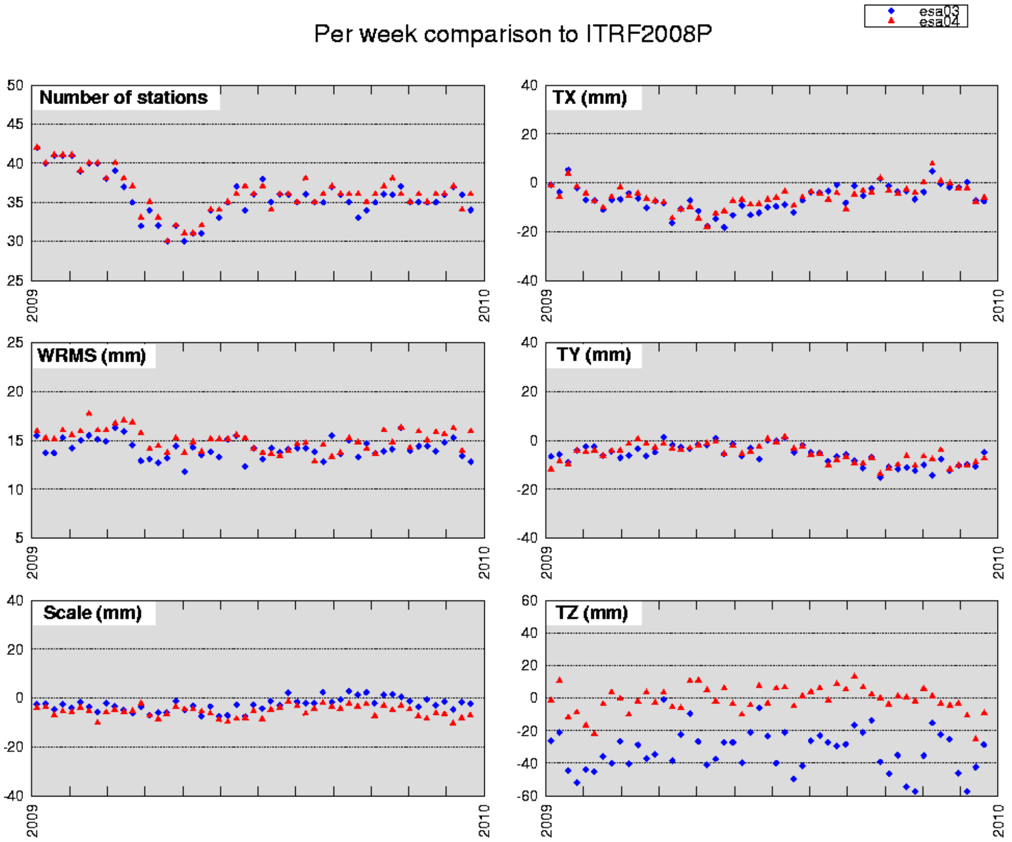

Figure 11. Example of 7 transformation parameters evaluation for combined solutions without (blue dots) and with (red dots) Jason-2

Then, 6 ACs (ESA, GAU, GOP, GSC, IGN and LCA) sent Spot4, Spot5, Envisat and Jason-2 only solutions, and Spot2 for some of them (ESA, GAU, GOP, GSC and LCA). In line with the evaluation process used for the DORIS contribution to ITRF2008, the IDS Combination Center computed the seven transformations parameters of the single satellite SINEX series. As presented during the last IDS Workshop which took place in Lisbon, the Jason-2 Tz series of all the ACs are centered (see Figure 12 as example) and since the number of observations for Jason-2 is equal to the sum of the observations of all the over DORIS missions (due to the 7 dual frequency measurement channels of Jason-2), we could think that these two effects explain why the combined solutions including Jason-2 have also a Tz centered.

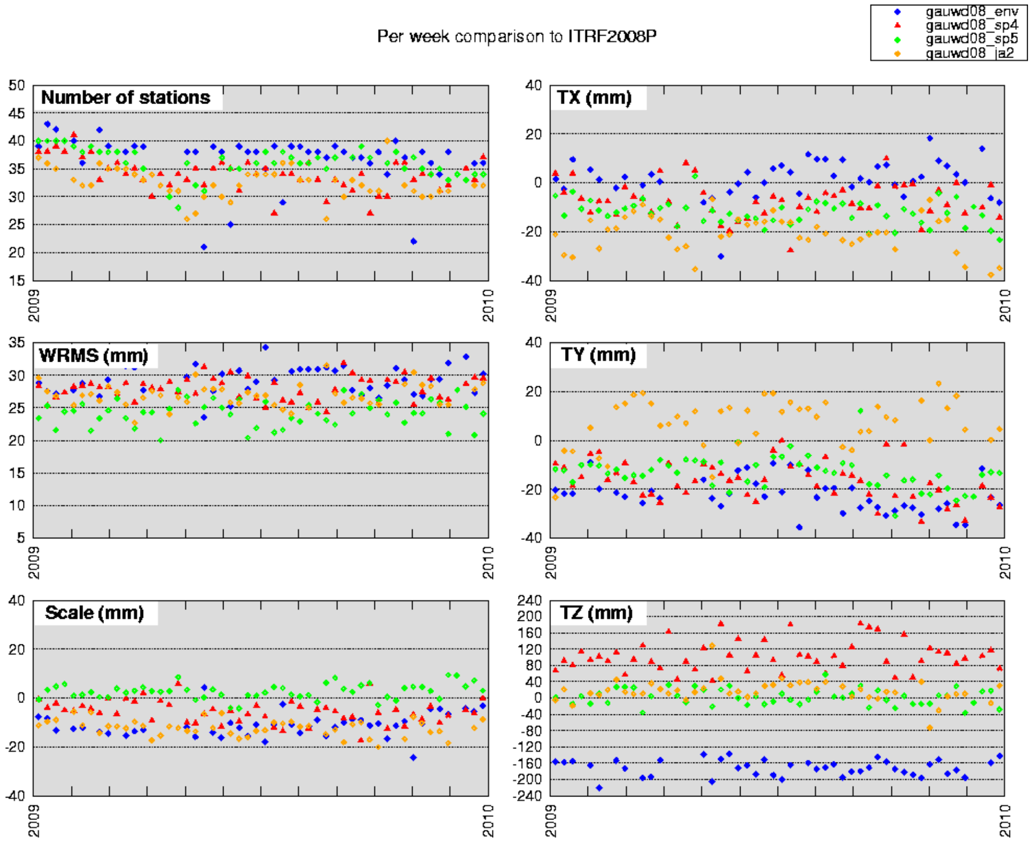

Figure 12. Example of single satellite 7 transformation parameters evaluation.

This IDS 2010 campaign also pointed out that Tz series from Spot4 and Envisat are far apart from Spot5 and Jason-2 ones, so additional investigations will be done on Spot4 and Envisat treatments to identify the origin of this phenomenon.

11.3 IDS ROUTINE COMBINATION

In line with the successful DORIS contribution to ITRF2008, IDS decided to extend the combination process to an operational service.

At this stage of the service development, the ACs agreed to deliver every three months, with three months of delay, three months of their latest combined SINEX series. Then, a few days after the submission deadline, the Combination Center will download the ACs solutions and will start to evaluate each SINEX series. This evaluation step has been designed to check the internal continuity of the individual solutions and will be used to create weekly lists of ACs contribution to the combined solution. After delivery of an evaluation report to the ACs, combination of weekly SINEX series will be performed.

At the end of 2010, the routine combination is still in development. Meanwhile, evaluation of the first two deliveries (first six months of 2010) has been done and associated evaluation report is available for all the contributing ACs (ESA, GAU, GOP, GSC, INA, IGN and LCA).

11.4 REORGANIZATION

Jean-Jacques Valette, CLS, responsible for the IDS Combination Center, has changed positions in the middle of 2010. Therefore, the activities of the Combination Center had to be reorganized. The new persons responsible of the Combination Center are:

- Guilhem MOREAUX, CLS, Guilhem.Moreaux@cls.fr
- Laurent SOUDARIN, CLS, Laurent.Soudarin@cls.fr

11.5 FUTURE PLANS

The activity of the IDS Combination Center in 2011 will concern the pursuit of the development of the operational combination service, the realization of routine combinations and the analyze of forthcoming results of the IDS 2010 campaign.

12 REPORT OF THE ESA/ESOC ANALYSIS CENTER (ESA)

Michiel Otten (1), John Dow (1)

(1) European Space Operation Centre, Darmstadt, Germany.

12.1 INTRODUCTION

Whereas in 2009 the focus of the European Space Operation Centre activities have been on improving and harmonizing our orbit processing strategy, 2010 has been about automation and routine delivery of the ESA IDS solutions to CDDIS.

Further we have incorporated both Jason-2 and Cryosat-2 in our routine processing and currently the latest ESA IDS solution (esawd05) includes both satellites beside Envisat, Spot-4 and Spot-5.

12.2 ROUTINE PROCESSING AND THE NEW ESAWD05 SOLUTION

Since August 2010 the ESA IDS weekly solutions has been routinely generated as soon as all the DORIS data became available. This processing has been fully automated meaning a considerable reduction in manual work needed at ESOC for the IDS processing.

ESOC has continued to harmonize our orbit processing strategy for all the different altimeter missions: ERS-1/2, Envisat, Jason-1/2 and Cryosat-2. This means that all the missions are processed with the same software package (NAPEOS) but also the standards and models that are used for these missions are as identical as possible. The main improvement here for 2010 has been that all missions now can use the same box-wing modeling for all surfaces forces, i.e., drag, solar radiation and albedo and infrared Earth radiation. Further we no longer exclude a satellite on a day that is has a maneuver. Instead we estimate the manoeuvre thanks to the new maneuver files that have been made available at the IDS ftp server.

Further ESOC has generated a new IDS solution called esawd05. The difference between esawd05 and esawd04 is that Cryosat-2 is incorporated into our IDS solutions. The figure below shows the improvement that has been obtained with each new solution. The figure shows the weekly repeatability for the various ESA solutions. The weighted RMS is obtained from inverting our normal equation network free solution using loose constrains. Clearly visible is the big improvement that is obtained by including the new generation of DORIS DGXX receivers as flown on Jason-2 and Cryosat-2 which allow the simultaneous tracking of up to 7 beacons.

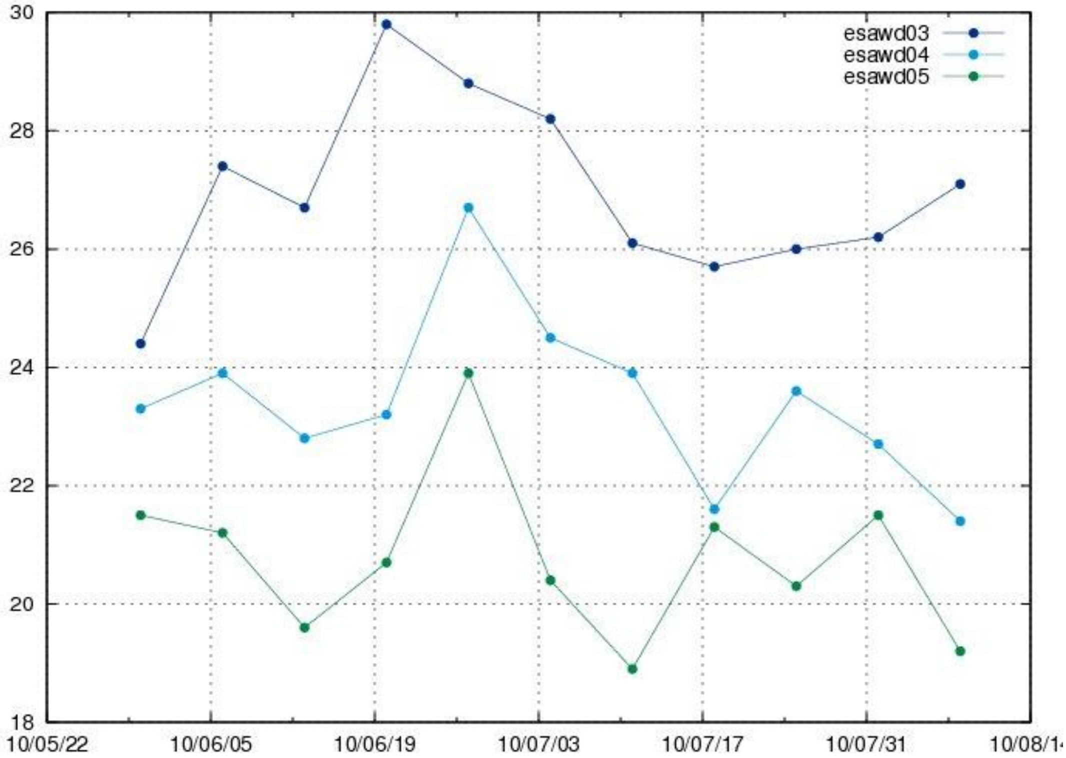

Figure 13 Weekly repeatability of the various ESOC IDS solutions (network free).

The esawd05 solution is the new routine solution of ESA and the older esawd04 and esawd03 solution will be discontinued.

12.3 FUTURE ACTIVITIES

The Navigation Support Office plans for 2011 to switch to processing the DORIS RINEX data for Jason-2 and Cryosat-2 instead of the older DORIS Data Exchange Format. Further we are currently investigating the best way to handle the large number of low elevation data that has become available with the new DORIS DGXX receivers. We are participating in the combination on the observation level campaign (COL) and as part of these activities will generate a new ESA IDS test solution which will use not only the DORIS data but also will make use of all available SLR data for the missions that are equipped with SLR reflector.

13 REPORT OF THE GEOSCIENCE AUSTRALIA ANALYSIS CENTER (GAU)

Ramesh GOVIND (1)

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The main DORIS analysis activity during 2010 was to contribute weekly multi-satellite SINEX solution to the IDS Combination Centre, finalise two publications for the Advances in Space Research DORIS Special Issue, undertake study of DORIS system time bias (with respect to SLR) for the Envisat and Jason-2 satellites, implement ITRF2008 as the reference frame for the DORIS data processing and prepare for the inclusion of Cryosat-2 in future DORIS submissions. The IDS analysis activity at Geoscience Australia is undertaken in collaboration with the GSFC Analysis centre.

DORIS data up to the end of October 2010 from four satellites (SPOT-4, SPOT-5, Envisat and Jason-2) were processed, and combined SINEX solutions were submitted to the IDS combination centre. In addition, one-year's (2009) single satellite weekly SINEX solutions, for these satellites, were also submitted as a contribution to the IDS study into systematic differences that may influence the quality of the IDS combined product. DORIS data processing for Cryosat-2 has also begun with the intention of including it in the weekly combined submission.

Two papers Govind at al. (2010a) and Govind et al. (2010b) were finalised and published in Advances in Space Research, DORIS Special Issue. The initial results from a continuing study of DORIS system time bias for Envisat and Jason-2, which are also tracked by SLR, was presented at the IDS Workshop, Lisbon (Govind et al. 2010c).

The ITRF2008 was also implemented in the Geoscience Australia data processing system.

The computation standards, using the NASA/GSFC Geodyn0812/Solve software suite are described in ftp://ftp.cls.fr/pub/ids/combinations/ITRF2008-IDS/gauwd06.snx.dsc, ftp://ftp.cls.fr/pub/ids/centers/Template_analysis_summary.xls and Govind et al., 2010a and 2010b.

The weekly SINEX submissions to the IDS combination centre continue as a routine analysis activity.

14 REPORT OF THE GEODETICAL OBSERVATORY PECNY ANALYSIS CENTER (GOP)

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14.1 INTRODUCTION

This section summarizes the activities of the Geodetic Observatory Pecný analysis center (GOP). There are three major subjects of interest. The free-network solutions on weekly basis and their analysis are the important part of the GOP activities. Both, multi- and single-satellite solutions were analyzed. The studies of the relations with the South Atlantic Anomaly (SAA) are bringing the proofs of the significant SAA effect. The last part of the text briefly describes an early stage of the new orbit modeling development.

14.2 WEEKLY FREE NETWORK SOLUTION

All the DORIS data observed from January to September 2010 were processed and analyzed. The corresponding weekly multi-satellite solutions were created and delivered to the data center(s). For the first half of the year 2010, two different kinds of the solutions were developed: solution called ”31” including all the available satellites except Jason-1 and Jason-2; and solution called “32”, including Jason-2 in addition. The major impact of the Jason-2 observations was the higher stability of the estimated Z-Geocenter component.

The GOP analysis center participated also on the single-satellite campaign. The single satellite solutions were created on weekly basis for the complete year 2009. The major differences between individual solutions were found in Z-Geocenter component. While its absolute average value derived from Jason-2 and SPOT-5 solutions was under 1 cm, Envisat solution average was -10.3 cm and SPOT-4 solution average was 13.3 cm. These high differences were confirmed by the other IDS ACs.

14.3 SENSITIVITY OF THE SPOT-5 DORIS OSCILLATOR TO THE SOUTH ATLANTIC ANOMALY

The major current scientific activity of GOP AC is the study of the relation between the SPOT-5 DORIS measurement and the SAA. The strong effect of the SAA on the Jason-1 DORIS oscillator is very well known and documented. However, significant SAA effect on the other DORIS satellites has not been known until 2009. In 2009, the GOP analysis uncovered the significant bias of the SPOT-5 solution derived parameters, mainly estimated station height and the zenithal total delay (ZTD). The geographical location of the biased stations was corresponding to the area where the satellite flies through the SAA.

The goal of the analyses done during the year 2010 was to bring the conclusive proof of the relation between SPOT-5 bias and the SAA and to estimate the size of the effect more precisely. Considering the fact that the SAA directly influences the frequency of the onboard satellite oscillator, the oscillator frequency was the most important quantity to be tested. **Figure 14** shows an estimated frequency offset for each SPOT-5 pass (from 2010.0 to 2010.5) over the master beacons. The values are figured with respect to the hour of the day (SPOT-5 is a sun-synchronous satellite). Since the master beacons are equipped with atomic clocks, the estimated beacon offset is related to the onboard oscillator, with respect to the a priori applied polynomial model. The satellite revolutions passing during the SAA are almost corresponding to the revolutions with observation of Kourou master beacon. The strong positive drift of frequency offset for Kourou and a bit less expressive negative offset for other master beacons corresponds to the SAA. However, such a drift was not observed for SPOT-2, SPOT-4 and Envisat.

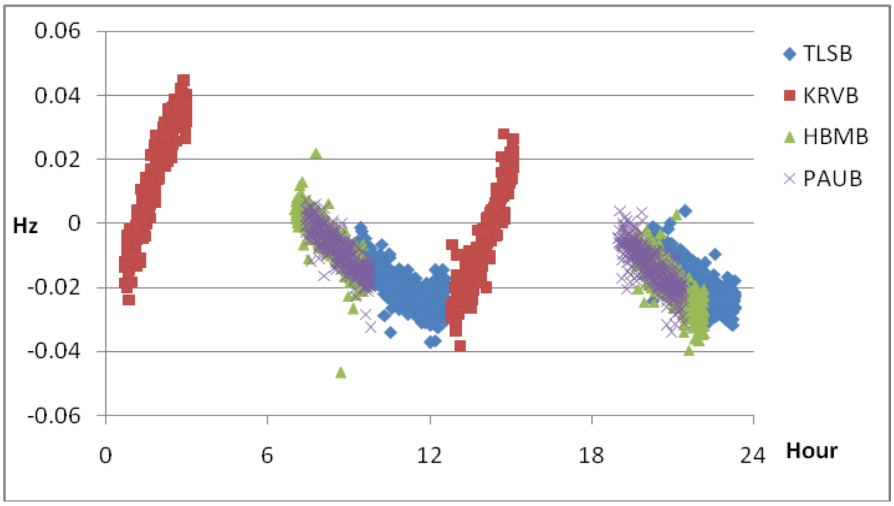

Figure 14 Master beacon frequency offset with respect to the hour of the day. Data from 2010.0 – 2010.5

Another test was based on the estimation of frequency time derivative. Frequency time derivative values were derived from the post-fit residuals. The beacon frequency offset as well as the troposphere parameters were not estimated, but interpolated from SPOT-5, SPOT-4, Envisat and Jason-2 solutions. **Figure 14** represents the frequency offset time-derivative for each DORIS station. Maximal values correspond to the stations from the SAA region (Cachoeira Paulista, Santiago, Arequipa).

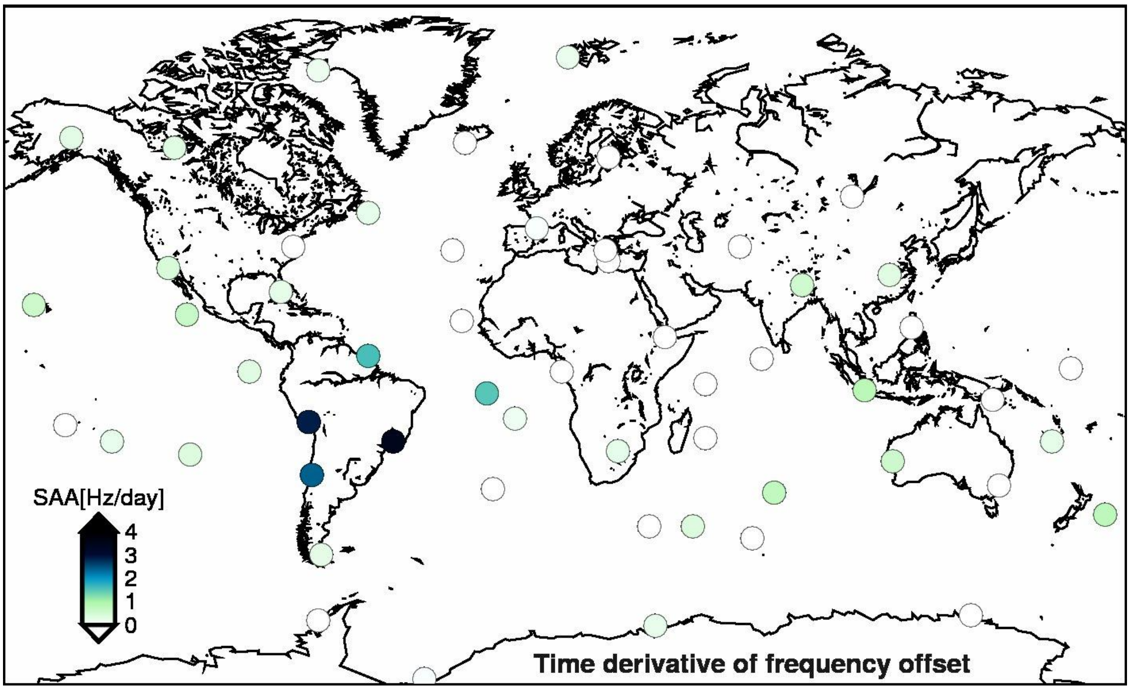

Figure 15 Time derivative of the frequency offset for the DORIS stations. Data from 2009.0-2010.5

Important results were obtained from the estimated network comparisons. Table 5 summarizes a station height offset of the most effected stations Cachoeira Paulista, Santiago and Arequipa, derived from mutual comparison of SPOT-5 single-satellite solution and multi-satellite solutions (both including and excluding SPOT-5). The height offset of the most corrupted station Cachoeira Paulista is around 27 cm for the SPOT-5 single satellite solution and nearly 7 cm for the multi-satellite solution. These values are definitely far from being negligible.

station/sat.	All-S5 All	All S5 only	All-S5 S5 only
C. PAULISTA	**-6.6 ± 1.2 cm**	-20.6 ± 3.4 cm	**-27.1 ± 3.9 cm**
AREQUIPA	**-3.4 ± 1.3 cm**	-7.4 ± 2.4 cm	**-10.8 ± 3.4cm**
SANTIAGO	**-2.9 ± 0.7cm**	-6.8 ± 1.9 cm	**- 9.7 ± 2.4cm**

Table 6 Height offset for the stations Cachoeira Paulista, Santiago and Arequipa. Comparison of the SPOT-5 single satellite solution (S5 only), the multi-satellite solution including SPOT-5 (All) and the multi-satellite solution excluding SPOT-5 (All-S5). Data from 2009.0-2010.5

14.4 ORBIT MODEL DEVELOPMENT

Current GOP DORIS solutions are based on the empirical and pseudo-stochastic modeling. This approach is supplying exact non-conservative force models, missing in the Bernese GPS Software. The important goal to improve the orbit modeling is the implementation of the satellite attitude, macro-models and non-conservative perturbation force models. The development started in 2010, as the joint project of GOP and the Institute for Astronomical and Physical Geodesy at the Technische Universität München. The early testing experiments used SPOT-5 data.

15 REPORT OF THE NASA/GSFC ANALYSIS CENTER (GSC)

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The GSC analysis center participated in the following IDS-related activities in 2010: (1) An analysis campaign focused on 2009 dedicated to the single-satellite analysis of weekly SINEX solutions; (2) Submission of SINEX solutions with and without Jason-2 to IDS data centers through September 2010; (3) The testing of ITRF2008; (4) Analysis of Cryosat-2 data following the launch of the satellite in April 2010.

15.1 2009 ANALYSIS CAMPAIGN AND SINGLE SATELLITE SOLUTIONS

The objective of the 2009 analysis campaign was to create single satellite solutions and submit these to the IDS combination center. The data from SPOT4, SPOT5, Envisat, and Jason-2 were processed weekly and submitted as individual SINEX files. The 2009 data had not previously been analyzed and was not included in the GSC submission for ITRF2008. SPOT2 was not included in the single satellite campaign due to the relative sparsity of the tracking, and the fact that the mission terminated in July 2009. A summary of the mean RMS of fit for the 2009 data for these different satellites is given in **Table 6**. The modeling for SPOT4 and Envisat was identical to that described in Le Bail et al. (2010). For SPOT5, we apply the modified macromodel of Le Bail et al. (2010) with the scaling factor for solar radiation pressure of 0.8208 after January 2008. However, we have tested directly modeling change in pitch of the solar array of 40 degrees, which was implemented after January 2008. This more properly models the nonconservative (radiation pressure and drag) forces that act on the spacecraft and results in lower residual daily empirical along-track acceleration amplitudes.

However recently Luca Cerri (CNES) identified that the X and Z faces are reversed in the online macromodel documentation for the SPOT4 (email dated October 14, 2010 to IDS AWG), so the modeling for this satellite will eventually need to be updated in a new generation of processing.

In **Figure 17** we show the TZ and scale offsets for weekly single-satellite solutions for Envisat, SPOT4, and SPOT5, with respect to DPOD2005 from 2003 to 2010. These SINEX solutions correspond to the normal equations that were included in the gscwd10 weekly SINEX series which has been updated through 2010. Guilhem Moreaux (CLS) at the IDS workshop in Nice (October 2010) performed a similar analysis with the 2009 GSC SINEX normal equations but with respect to ITRF2008 and found a mean in TZ of -5 mm for SPOT5, 52.8 mm for SPOT4, and -101.3 mm for Envisat. The relative centering of SPOT5 and the dispersion of SPOT4 and Envisat was common to all the analysis center results which implies a common mode analysis or data issue.

Satellite	No. Arcs (2009)	Avg. Obs per arc	Avg Arc RMS of fit (mm/s)
SPOT2	*32*	*10785*	*0.4015*
SPOT4	58	30141	0.4254
SPOT5	55	66997	0.4108
Envisat	60	48073	0.4719
Jason2	54	109990	0.3650
SPOT2 was not included in the 2009 single-satellite analysis campaign, however the data were included in the gscwd10 and gscwd11 SINEX solutions through July 2009.			

Table 7: GSC RMS of fit for 2009 DORIS data

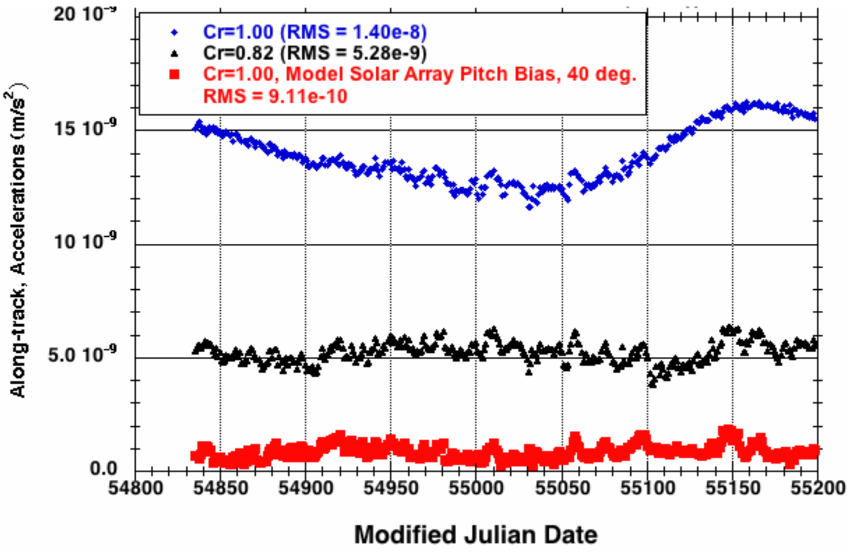

Figure 16 SPOT5 Daily along-track acceleration amplitude in 2009 with different implementations of the SPOT5 macromodel of Le Bail et al. (2010)

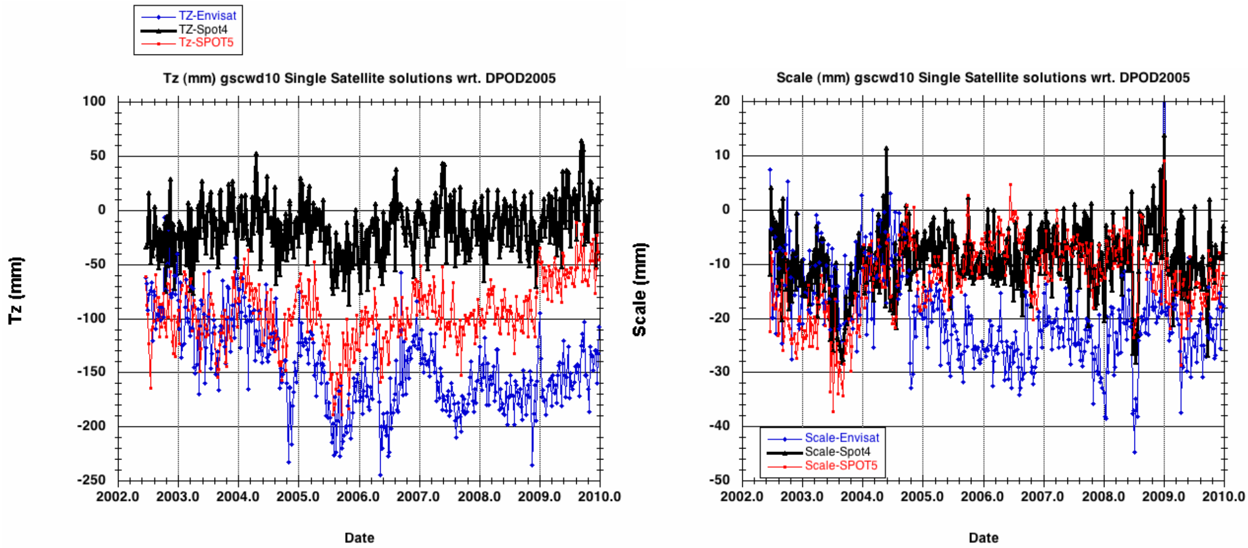

Figure 17 (Left) TZ wrt. DPOD2005 for individual satellite solutions (SPOT4, SPOT5, Envisat) for the gscwd10 SINEX series, 2002-2010;

(Right): Scale wrt. DPOD2005 for individual satellite solutions (SPOT4, SPOT5, Envisat), 2002-2010.

From the results in **Figure 17**, we see that this SPOT4 dispersion is common throughout the period from 2003 to 2010, however SPOT5 seems to separate from Envisat in consistency after approximately 2004.75. In terms of scale (see **Figure 17** right), we find that SPOT4, SPOT5, Envisat are relatively consistent through about 2004.75, but afterwards the Envisat scale maintains a clear offset with respect to SPOT4 and SPOT5. The cause of this behavior is not understood at this time and requires further investigation.

15.2 ITRF2008

The GSC analysis center participated in the evaluation of ITRF2008 by analyzing the DORIS complements for DPOD2005 (the *a priori* extension of ITRF2005), ITRF2008 (the official solution from the IGN), and ITRF2008d (the test solution created by the DGFI) with respect to their performance on TOPEX/Poseidon, and Jason-2. Three distinct periods were analyzed: (1) April 19, 1993 – July 17, 1993; (2) Jan. 15, 2002 – Aug. 11, 2002; (3) January 26, 2009 – January 28, 2010. The arcs were generally ten days long, spanning one ground-track repeat cycle. The independent SLR and altimeter crossover fits were also computed. The results are summarized in **Table 8**. The analysis shows that ITRF2008 is slightly better than DPOD2005 over the solution time span (up until 2008), but performs progressively better than DPOD2005 after that date. On a station-by-station basis, as measured by the RMS of fit, ITRF2008 outperforms ITRF2008d for nearly all stations.

DORIS-test	No. of stations	Avg. No. of Obs. /cycle	DORIS (mm/s)	SLR (cm)	Xover (cm)
TOPEX/Poseidon (Apr. 19, 1993 – July 17, 1993)					
DPOD2005	45	57135	0.5386	4.81	5.936
DPOD2005*	42	54342	0.5393	4.94	5.939
ITRF2008	42	54342	0.5393	4.94	5.942
ITRF2008d	42	54342	0.5391	4.90	5.939
TOPEX/Poseidon (Jan. 15, 2002 — Aug. 11, 2002)					
DPOD2005	53	57635	0.4733	4.16	5.622
ITRF2008	51	56015	0.4736	4.20	5.621
ITRF2008d	52	57251	0.4731	4.16	5.616
Jason-2 (Jan. 26, 2009 — Jan. 28, 2010)					
DPOD2005*	51	151295	0.3774	2.38	5.577
ITRF2008	51	151307	0.3761	2.39	5.556
ITRF2008d	51	151305	0.3766	2.39	5.559
NB: DPOD2005* = DPOD2005 with the same stations as in ITRF2008.					

Table 8: DORIS RMS of fit for TOPEX/Poseidon and Jason2 with ITRF2005 (DPOD2005), ITRF2008 and ITRF2008d (SLR and Altimeter crossover fits are independent).

15.3 TOPEX/POSEIDON, JASON-1, AND JASON-2:

The precise orbits for these altimeter satellites have been recomputed with updated models using SLR and DORIS data and made available to the science community. The orbits were computed in the ITRF2005 reference frame (using DPOD2005 and LPOD2005; Willis et al., 2009; Ries, 2008) and were made available to the scientific community. The new processing are documented in the papers by Lemoine et al. (2010) and Zelensky et al. (2010).

The TOPEX, Jason-1, and Jason-2 std0905 orbits are available via anonymous ftp from the following locations: NASA Center for the Computational Sciences (NCCS), NASA GSFC.

Host: dirac.gsfc.nasa.gov. login: anonymous

TOPEX: cd pub/earth/repro_topex/swt09

Jason-1: cd pub/earth/repro_jason/swt09

Jason-2: cd pub/earth/repro_jason/ostm/swt09

NASA Crustal Dynamics Data Information System (CDDIS).

Host: cddis.gsfc.nasa.gov. login: anonymous

TOPEX: cd /pub/doris/products/orbits/gsfc/topex

Jason-1: cd / pub/doris/products/orbits/gsfc/jason1

Jason-2: cd / pub/doris/products/orbits/gsfc/jason2

The std0905 orbits (POE, or Precision Orbit Ephemeris files) are available in Unix compressed ASCII format at the above locations. The files provide an ASCII listing of the satellite trajectory. The interchange format was designed early in the TOPEX mission, and all NASA GSFC TOPEX and Jason-1 and Jason-2 orbits have been exported in this format since 1992. The POE orbit files consist of sequential (ascii) records with the Date (Time Tag), Greenwich Hour Angle, Polar Motion Values (X and Y in radians), DOY (Day of Year), the XYZ true of data inertial and the XYZ pseudo-body fixed coordinates of the spacecraft. Note that Pseudo body-fixed is not the same as body-fixed, because polar motion has not been applied. The reason these files have included the polar motion, was to allow intercomparisons to be made between analysis centers, if the same earth orientation solutions were not used in the data reduction. The files are available by repeat cycle (9.91 days), except where cycles are broken by maneuvers or spacecraft anomalies. Ancillary files consisting of a header record, and an UT1-UTC file are also available. A example FORTRAN program using a Hermite interpolator is provided that can read the files, apply the earth orientation, and compute the spacecraft body-fixed coordinates and satellite height above the reference ellipsoid at the time point of interest.

JASON2:

Jason-2 (J2) Precise Orbit Determination (POD) processing at GSFC over 2010 consisted of both testing new models and of extending the most accurate time series of SLR/DORIS J2 orbits using the latest POD standards consistent with reprocessing of the TOPEX/Poseidon and Jason-1 orbits. A new time series of orbits was computed for Jason-2 using ITRF2008. The DORIS/SLR ITRF2008 complements were extended using 14-parameter transformation of several DPOD2005/LPOD2005 stations important to POD, but not included in ITRF2008, and a new set of POD orbits, std1007, based on the previous std0905 (ITRF2005-based, Lemoine et al., 2010) standards and ITRF2008, were established. The results were presented at the Lisbon SWT meeting in October 2010, and at other IDS and ILRS meetings. The latest std1007 dynamic and reduced-dynamic orbits were compared to available state-of-the-art orbits from CNES and JPL by using GEODYN to compute DORIS, SLR, and altimeter crossover residuals for evaluation, and by analysis of the orbit differences. The orbits compared radially to within 1 cm.

The following Jason-2 orbits were delivered in 2010:

cycles 1-75 dynamic and reduced-dynamic std0905 and std1007 to CDDIS for inter comparison with orbits produced at JPL, CNES, and ESOC in support of the October Lisbon SWT meeting. The DORIS, SLR, and independent altimeter crossover RMS of fit are summarized in **Table 9**.

J2 solution summary cycles 1-75	DORIS		SLR			Xover (cm) cycles 1-48
	points	RMS (mm/s)	points	mean (cm)	RMS (cm)	
std0905 dynamic	156974	0.3618	4108	-0.055	1.095	5.577
std1007 dynamic	156895	0.3609	4123	0.022	1.032	5.564
std0905 red-dyn	154727	0.3610	4206	-0.089	1.092	5.522
std1007 red-dyn	156678	0.3606	4123	0.013	0.984	5.507

Table 9: Jason-2 SLR/DORIS POD solution summary (Cycles 1-75)

In addition, the GMF model (Boehm et al., 2006) was implemented in GEODYN and tested on Jason-2. The previous processing with GEODYN (cf., Le Bail et al., 2010; Lemoine et al., 2010; Zelensky et al., 2010) had used the Niell (1996) mapping function. Thus, in the future when there is a full delivery of a new DORIS SINEX weekly time series, GSC will incorporate this model upgrade to more full comply with the IERS2003 standards.

15.4 CRYOSAT2:

The Cryosat2 satellite was launched in April 2010. In order to analyze these data, a new analytical attitude module was developed and implemented in GEODYN. The analytical attitude module was validated with Cryosat2 quaternion data provided by the CNES (Luca Cerri, personal communications, 2010). SLR and DORIS data from June through September 2010 were processed. The modeling included the CNES-supplied macromodel with a solar radiation reflectance coefficient of unity, the EIGEN-GL04S1 gravity model (Förste et al., 2008), the ITRF2008 solution for DORIS and SLR coordinates, and an elevation cutoff of 10 degrees. The drag coefficients (cd’s) were adjusted per six hrs, and along-track and cross-track once-per-rev empirical accelerations were adjusted daily. We also have adjusted 4-hr cd’s (with an exponential decaying time-correlation of 4 hrs), and find slight improvements to the RMS of fit. **Table 10** presents the summary of the Cryosat-2 data arcs from May 30, 2010 to September 26, 2010. One characteristic of the Cryosat2 data is the large number of observations available below 10 degrees. A typical seven-day arc has on the order of 65,000 usable observations above 10 degrees, and a further 21,000 to 23,000 observations between 5 and 10 degrees elevation. It might be desirable to slightly lower the elevation cutoff for Cryosat2 to allow more data to contribute to the POD solutions. The DORIS2.2 format contains data to as low as 3 degrees. When we adjust a Cr parameter for arcs that do not estimate empirical accelerations, we find that the average value is 1.020 ± 0.013 (for these twenty arcs) when the CNES macromodel is used.

Cryosat2 (May 30, 2010 – Sept. 26, 2010)	No. Arcs
Narcs	20
Avg. No. of SLR obs.	979
Avg. SLR fit (cm)	2.17
Avg. No. of DORIS obs.	54469
Avg. DORIS RMS of fit (mm/s)	0.4176
Avg. Adjusted Cr (when OPR empirical accelerations not adjusted; CNES macromodel)	1.020 ± 0.013
Avg. Daily Along-track OPR amplitude (m/s^2)	3.63×10^{-9}
Avg. Daily Cross-track OPR amplitude (m/s^2)	2.44×10^{-9}

Table 10: GSC Analysis Center Cryosat2 Preliminary POD Results

15.5 2010 SINEX SERIES SUBMISSIONS TO THE NASA CDDIS:

The gscwd10 series (created for inclusion in the IDS/ITRF2008 combination) was extended to 2010/ DOY 283 (October 10, 2010). In 2009 and 2010, this series consists of weekly solutions from SPOT2 (through July 2009), SPOT4, SPOT5, and Envisat. The processing is described by Le Bail et al. (2010).

The gscwd11 series was also created. The processing is identical to the gscwd10 series, however Jason2 is also added into the weekly solutions. As of the end of 2010, the gscwd11 series is available from 2009/DOY004 (January 4, 2009) to 2010/DOY 269 (September 26, 2010).

In addition single satellite SINEX series were delivered for 2009 for all satellites (SPOT4, SPOT5, Envisat, and Jason2).

All GSC submissions are in SINEX/Normal equation format and starting in December 2010, a DORISReport is prepared to document the submission.

16 REPORT OF THE IGN/JPL ANALYSIS CENTER (IGN)

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16.1 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 2010, IGN used several successive versions of GOA 5.0 while the most recent version (GOA 6.0) was only delivered and installed in November 2010. This software package is installed on both sites at IGN in Saint-Mandé and at IPGP in Tolbiac. In 2010, all results were generated to IDS by the IPGP site. Computation is done routinely on a daily basis using a crontab command launching several scripts successively, depending on DORIS data availability. New solutions are then submitted simultaneously to both IGN and NASA/CDDIS data centers. Internal validation is done after the facts using an internal Website available at IPGP, eventually leading to a few resubmissions of weekly SINEX solutions.

16.2 PRODUCTS DELIVERED IN 2010

The latest delivered IGN weekly time series is still ignwd08 (in free-network), and called ignwd09 (when transformed into ITRF2005). This is the solution that was used in preparation of ITRF2008 and available for combined solutions IDS-1, IDS-2 and IDS-3. Models and strategy estimation remain unchanged but new SINEX solutions are generated every week (on average).A new ignwd10 solution is in preparation at the end of 2010 (the same as ignwd08 but transformed into ITRF2008). Derived products are also updated every week (see **Table** 11).

Besides these IDS products, several IGN results were also provided to the Analysis Coordinator for test purposes: satellite orbits in sp3 format, weekly SINEX solution by satellites, multi-satellites weekly SINEX solutions with or without Jason-2 data.

In 2010, as no cumulative solution (position and velocity of all DORIS stations derived using the full DORIS data set available since 1993) was generated, ign09d02 still remains the latest available solution provided by the IGN group and available at the IDS data centers. However, tests of the recently available ITRF2008P, ITRF2008D and ITRF2008 solutions were conducted. Preliminary studies toward the realization of a new cumulative solution were performed : identification of station discontinuities in time series of station positions for coordinates and/or for velocities, detection of outliers, external comparisons with GPS,… Furthermore, new work was conducted toward the realization of a new DPOD2008 solution (terrestrial reference frame for precise orbit determination derived from ITRF2008).

Product	Latest version	Update	Data span	Number of files
Weekly SINEX				
-free-network	ignwd08	Weekly	1993.0-2009.9	924
- inITRF2005	ignwd09	Weekly	1993.0-2009.9	924
- summary files	ignwd08	Weekly	1993.0-2009.9	924
STCD	ign09d01	Weekly	1993.0-2009.9	152
Geocenter	ign09d01	Weekly	1993.0-2009.9	1
EOPs	ign09d01	Weekly	1993.0-2009.9	1

Table 11: IGN products delivered at IDS data centers in 2010. As of November 5, 2010.

Finally comparisons of DORIS-derived tropospheric zenith delays were also performed toward GPS PPP solutions (Bock et al., 2010). For test purposes, VMF-1 mapping function was also used during CONT08 campaign leading to tropospheric comparisons toward VLBI and GPS estimates (Teke et al., in press). Systematic comparisons of horizontal tropospheric gradients were also generated with regards to GPS PP solutions provided by Jet Propulsion Laboratory for the International GNSS Service (Willis et al., in press).

16.3 MAJOR IMPROVEMENTS IN 2010

Major improvements of the ignwd08 solution include (Willis et al., 2010):

- use of the more recent GGM03S gravity field (still without taking into account seasonal variations)

- rescaling of the solar radiation pressure models using an empirical coefficient determined using a large DORIS data set for each satellite (Gobinddass et al., 2009). This mitigates errors in the Z-geocenter at periods of 118 days and 1 year and also improve vertical component of high latitude stations.

- hourly estimation of drag coefficient for lower DORIS satellites at 800 km (Gobinddass et al., 2010). This avoids problem related to high geomagnetic activity (geomagnetic storm and maximum of 11-year solar cycle around 2001).

- use of GMF mapping function for tropospheric correction

16.4 NEW DEVELOPMENTS

In 2010, new data from Jason-2 were processed for test purposes but are not yet delivered. New models were also developed for Cryosat-2 (attitude model, satellite physical parameters) and preliminary orbit tests were successfully conducted.

17 REPORT OF THE INASAN ANALYSIS CENTER (INA)

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17.1 INTRODUCTION

In 2010, INASAN (ina) DORIS Analysis Center continued processing DORIS data using GIPSY-OASIS II software developed by JPL with updated DORIS part of GIPSY developed by IGN/JPL (Linux version). During the year all DORIS data for 1993.0 – 2010.8 were fully reprocessed with the improved models. Table 12 summarizes current products delivered by INASAN to the IDS.

Product	Latest version	Span
Sinex weekly free-network	inawd07	1993.0 - 2010.8
Geocenter	ina10wd01	1993.0 - 2010.8
EOP-series	ina10wd01	1993.0 - 2010.8
STCD-series	ina10wd01	1993.0 - 2010.8

Table 12: List of INASAN products provided to the IDS (November 2010).

The files with the product description can be found at:

1) sinex series

ftp://cddis.gsfc.nasa.gov/pub/doris/products/sinex_series/inawd/inawd07.snx.dsc

2) geocenter

ftp://cddis.gsfc.nasa.gov/pub/doris/products/geoc/ina10wd01.geoc.dsc

3) EOP-series

ftp://cddis.gsfc.nasa.gov/pub/doris/products/eop/ina10wd01.eop.dsc

4) STCD-series

ftp://cddis.gsfc.nasa.gov/pub/doris/products/stcd/ina.stcd.readme

17.2 PRODUCT AND ANALYSIS RESULTS DESCRIPTIONS.

Weekly free-network solutions, obtained after merging daily free-network solutions, have been used for the calculations of all products. Each weekly SINEX file contains stations coordinates and EOP. After the transformation of free-network solutions into a well-defined reference frame ITRF2005 (more exactly into the long-term cumulative ign09d02 solution), the standard deviations of station coordinates were estimated at the level 0.5-4.0 cm, depending on the number of satellites used in the solution.

Significant improvements were made in computation process connecting with using new models. Below you can see the main improvements in the computation models compare with the old ones.

Old models:

1) an elevation cutoff angle = 15 degrees
2) the gravity field is GGM01C (120x120)
3) solar radiation pressure coefficients were estimated
4) Lanyi tropospheric mapping function was used
5) atmospheric density model DTM94 as a priori
6) estimating atmospheric drag every 6 hrs for SPOT's and every 24 hrs for TOPEX
7) polar motion rates were estimated

New models:

1) an elevation cutoff angle = 15 degrees and data down weighting at low elevations were applied
2) the gravity field is GGM02C (120x120)
3) fixed daily coefficients for solar radiation pressure models
4) Niell tropospheric mapping function was used
5) atmospheric density model DTM2000 as a priori
6) estimating atmospheric drag every 1 hr
7) polar motion rates were not estimated

One of the results, obtained after applying the new models, can be seen in the significant dropping amplitude of the annual signal of Z-component geocenter time series (from 27 mm for the old ina05wd01geoc time series to 6 mm for the new ina10wd01geoc time series). In addition to the usual linear regression analysis (LRA) for geocenter movements studies, the so-called dynamic regression modelling method (DRM method) has been applied for the same set of DORIS data (ina05wd01 series 1993.0-2009.0). This is a rather complicated approach, which includes the next main steps:

- Trend-stability estimation
- Estimation and removal of trend component
- Estimation of harmonic components (spectral and wavelet analysis)
- Development of CARCH model for the residuals obtained from the previous step
- Application of Kalman's filter.

The comparison of the results of geocenter motion variations by LRA and DRM methods for ina05wd01 time series (1993.0-2009.0) shows a rather good agreement for the amplitudes of annual and semiannual signals of X,Y and Z components. Spectral analysis of the above mentioned geocenter time series with the method of dynamic regression modeling allowed to find out several other harmonics with periods of 2,3,5 years and valuable amplitudes (1-3 mm for X,Y components and about 10 mm for Z component) and to develop a model of the geocenter dynamics. The simulated values of geocenter coordinates, estimated for the 2008 year with the use of shortcut model, limited by 1993-2007 data, coincide with "observable" (calculated with use of DORIS measurements) data with the correlation coefficient 0.7-0.8 during the next 10 weeks.

18 REPORT OF THE CNES/CLS ANALYSIS CENTER (LCA)

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18.1 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 2010 was to restart the routine processing and product delivery to IDS, contribute to IDS campaign of single-satellite solutions, and include Jason-2 and Cryosat-2 in the data analysis.

18.2 DATA PROCESSING AND PRODUCTS DELIVERED TO IDS

The routine processing, suspended in 2008 to focus on the contribution for ITRF2008, has been started again in late 2009, including Jason-2 data. Deliveries to IDS were resumed early 2010. They concerns weekly free-network solutions for station coordinates and pole parameters as well as orbit files per satellite and per arc (typically 3.5 days). According to the recommendations of the AWG met in Darmstadt in May 2010, the strategy applied for the post-ITRF2008 routine processing stays the same as the one used for ITRF2008. Hence, the LCA products based on the data collected from 2008/12/28 may be considered as homogeneous with the LCA products (lcawd24) derived for the IDS-3 final solution included in ITRF2008.

18.2.1 WEEKLY SINEX

Two series of weekly sinex are provided:

-the series lcawd24, in continuation of the series included in the IDS-3 solution;

-the series lcawd26, based on the same strategy, but with the only difference that it includes Jason-2. This series is available from 2008/12/28 (lca08363wd26.snx)

The following description files can also be seen at the IDS Data Centers: lcawd24.snx.dsc, lcawd26.snx.dsc, lca.snx_series.readme.

18.2.2 ORBITS

Orbits are regularly delivered to the IDS Data Centers. These are DORIS+SLR mixed orbits for ENVISAT, Topex/Poseidon, and Jason-2, and DORIS-only orbits for the SPOT satellites.

In June, the format of the orbit files was switched from sp1 to sp3c. The sp1 series version 03 (from 1993/01/01 up to 2008/12/27) and the sp3 series version 01 (starting on 2008/12/28) may be considered as homogeneous, as they are derived from the same data analysis performed for or in the continuation of our contribution to the IDS-3 solution included in ITRF2008. Both series are freely available at the IDS Data Centers in pub/doris/products/orbits/lca. Descriptions are given in pub/doris/products/orbits/lca/lca.sp3.readme and lca.sp1.readme.

We plan to start delivering Cryosat-2 DORIS+SLR orbits in 2011.

Product	Produced for IDS-3 (1993/01-2008/12)	Post-ITRF2008 processing
SINEX weekly free-network	lcawd24	lcawd24 lcawd26 (with Jason2)
Orbit files	lca03.sp1	lca01.sp3

Table 13: List of the latest CNES/CLS recommended products

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18.3 CONTRIBUTION TO THE IDS 2010 CAMPAIGN OF SINGLE-SATELLITE SOLUTIONS

The CNES/CLS Analysis Centre participated also in the single-satellite campaign initiated by the IDS Analysis Coordination. Weekly single-satellite SINEX of station coordinates and EOP were created for the year 2009 for SPOT-2, -4, -5, Envisat and Jason-2. They have been named lcawd26 and are available at IDS Data Centers in pub/doris/products/2010campaign/lcawd/

Our solutions have been compared by the IDS Combination Center to the solutions of the other Analysis Centers. Those comparisons have shown our time series of scale and geocenter are similar to the other AC's. However, we can note that for Envisat, we obtain the best residual RMS (15-20 mm), while our scale bias is the only one to be positive (9.76 mm) and our Tz series is the less biased but still with a large average value (-50.07 mm).

18.4 ANALYSIS OF THE DORIS CRYOSAT-2 DATA AND CONTRIBUTION TO THE MULTI-SATELLITE COMBINATION

In 2010, GINS was upgraded to take into account Cryosat-2. The 14 first weeks of the mission have been processed. **Figure 18** shows the WRMS orbit residuals obtained for each mission. For Cryosat-2 Doppler and Laser measurements, they are at the level of 0.36 mm/s and 1.5 cm.

We performed some tests to evaluate the contribution of Cryosat-2 to the multi-satellite combination. The comparison of the combinations SPOT4+SPOT5+Envisat+Jason2 and SPOT4+SPOT5+Envisat+Jason2+Cryosat2 showed that, over the 14 weeks, including Cryosat-2 gives an improvement of 3 to 5 mm in latitude, larger than 5mm in longitude and about 5 mm in height. In addition, the combination Jason2+Cryosat2 (DGXX instruments, inclinations 66° and 92°, altitudes 710 and 1330 km) gives better results than SPOT4+SPOT5+Envisat (1G, 2G and 2GM instruments but same inclination at 98° and about same altitude around 800km), and even a better precision on the East component than SPOT4+SPOT5+Envisat+Jason2.

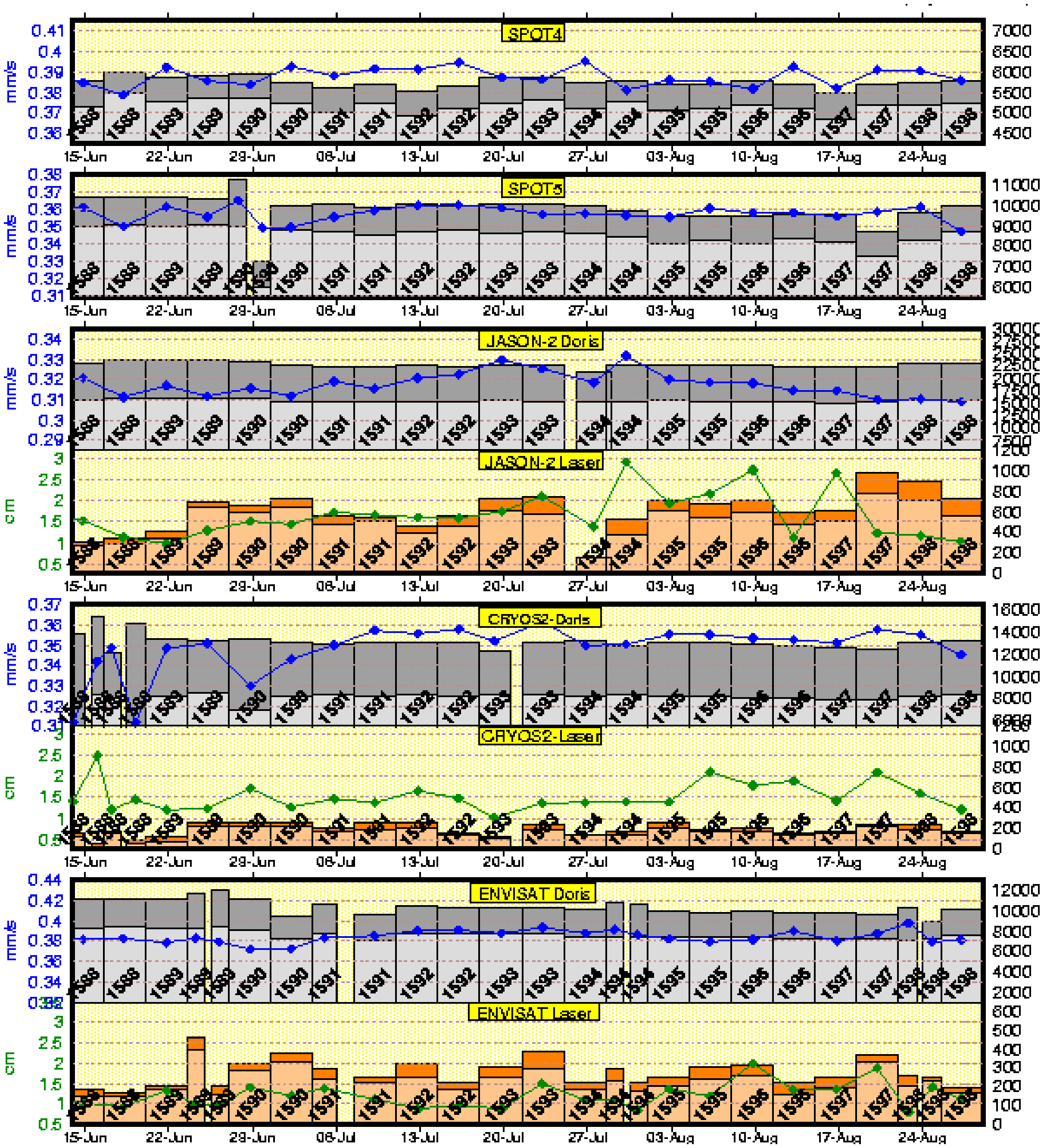

Figure 18 Doppler residual WRMS from the orbit determination processing over 11 weeks (#1588 to #1598, June-Aug. 2010), as well as the Laser residual WRMS for Jason-2, Cryosat-2 and Envisat. Mean daily value of data: edited (dark grey), validated (light grey). The cut-off angle is 12 deg. for every mission. The mean values of the orbit residuals are:

[Doppler] Spot4 0.39 mm/s; Spot5 0.36; Jason2 0.32; Cryosat-2 0.36; Envisat 0.38

[Laser] Cryosat-2 1.5 cm Envisat 1 cm Jason2 1.5 cm

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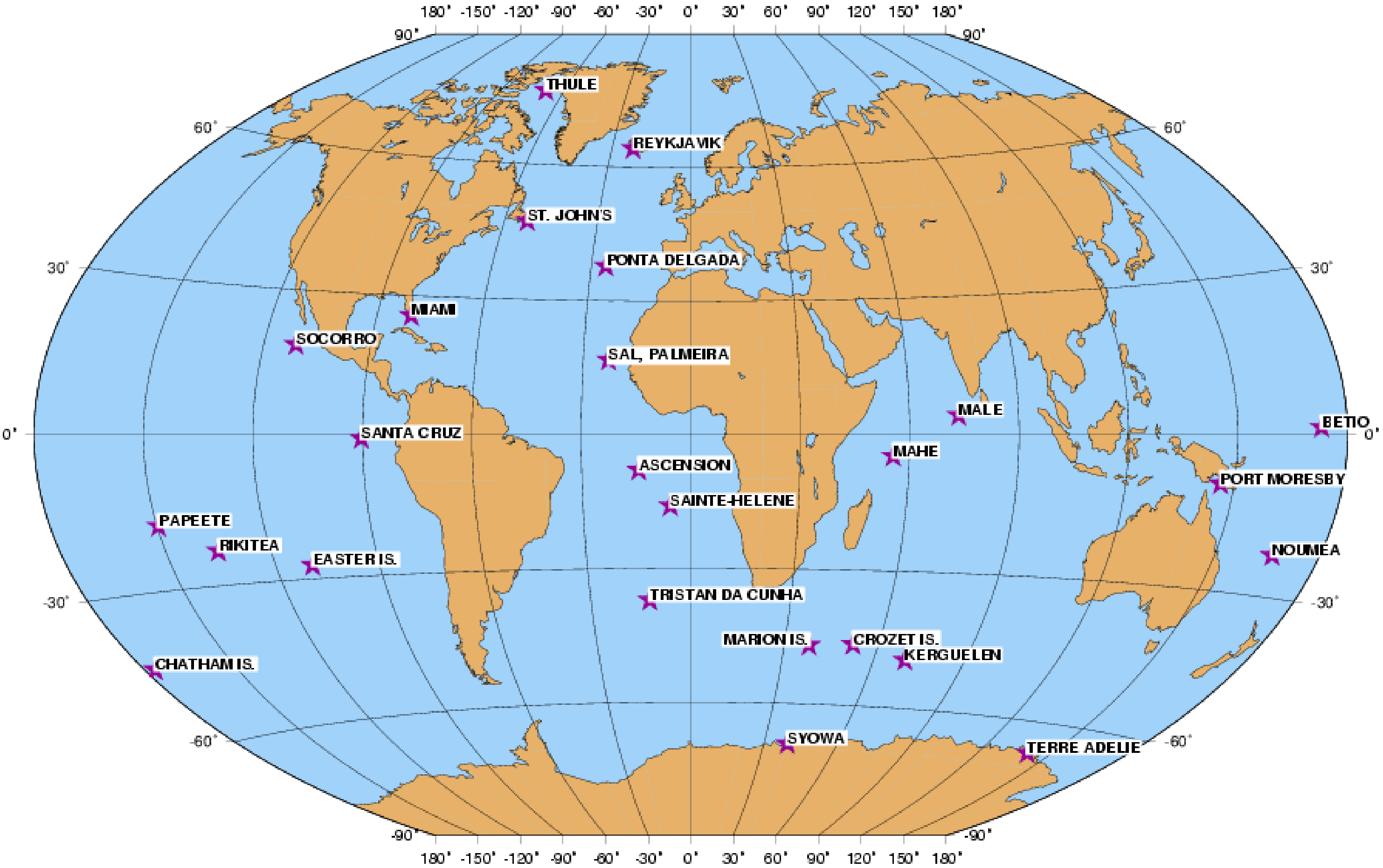
APPENDIX 1: DORIS STATIONS COLOCATION WITH TIDE GAUGES

The table and the figure below are courtesy provided by the « Système d'Observation du Niveau des Eaux Littorales » (SONEL, Université de La Rochelle, France). They are regularly updated at the following address : http://www.sonel.org/stations/cgps/survey/survey.doris.html



DORIS Name	Longitude	Latitude	Country	Start date	Distance	GLOSS id	PSMSL id
ASCENSION	-14.33	-7.92	UK	1997-02-28	6500	263	402001
BETIO	172.92	1.35	KIRIBATI	2006-10-22	1600	113	730009
CHATHAM ISLAND	-176.57	-43.96	NEW ZEALAND	1999-02-28	1200	128	------
COLOMBO	79.87	6.89	SRI LANKA	1991-06-06	5000	033	520001
CROZET ISLAND	51.85	-46.43	FRANCE	2003-12-21	850	21	433001
EASTER ISLAND	-109.38	-27.15	CHILI	1988-11-17	7000	137	810003
KERGUELEN	70.26	-49.35	FRANCE	1987-01-28	3300	023	434001
MAHE	55.53	-4.68	SEYCHELLES	2001-06-20	300	273	442007
MALE	73.53	4.20	MALDIVES	2005-01-15	500	28	454011
MARION ISLAND	37.86	-46.88	SOUTH AFRICA	1987-05-15	1000	020	------
MIAMI	-80.17	25.73	USA	2005-02-10	180	---	960001
NOUMEA	166.41	-22.27	FRANCE (CALEDONIA)	1987-10-20	3600	123	740001
PAPEETE	-149.61	-17.58	FRANCE (POLYNESIA)	1995-07-27	7000	140	780011
PONTA DELGADA	-25.66	37.75	PORTUGAL (AZORES)	1998-11-02	1500	245	36002
PORT MORESBY	146.18	-9.43	PAPUA NEW GUINEA	1988-03-29	6000	---	670012
REYKJAVIK	-21.99	64.15	ICELAND	1990-07-04	2500	229	010001
RIKITEA	-134.97	-23.13	FRANCE (POLYNESIA)	2006-09-23	800	138	808001
SAINTE-HELENE	-5.72	-15.92	UK	2011-01-25	-	264	425001
SAL	-22.98	16.78	CAPE VERDE	2002-12-15	7000	329	380021
SANTA CRUZ	-90.30	-0.75	ECUADOR	2005-04-01	1600	---	845031
SOCORRO	-110.95	18.73	MEXICO	1989-06-09	400	162	830062
ST. JOHN'S	-52.68	47.40	CANADA	1999-09-27	4000	223	970121
SYOWA	39.58	-69.01	JAPAN (ANTARCTICA)	1993-02-10	1000	095	A--041
TERRE ADELIE	140.00	-66.67	FRANCE (ANTARCTICA)	1987-02-05	500	131	------
THULE	-68.83	76.54	DENMARK (GREENLAND)	2002-09-28	300	---	------
TRISTAN DA CUNHA	-12.30	-37.05	UK	2011-02-01	2000	266	------

APPENDIX 2 : DORIS STATIONS / HOST AGENCIES

The DORIS system is 20 years old in 2010. It is a technical, operational and scientific success.

DORIS has put its unique network of stations and its precise positioning capability at the service of geodesy and geophysics.

As early as 1986, the CNES and the IGN installed autonomous stations worldwide which are used as reference points on the ground, to continuously cover the trajectory of the satellites. Thanks to an exemplary joint project, the DORIS system represents a network of some 60 stations uniformly spread across the globe.

The DORIS network of beacons has been maintained and improved with renovated stations. Its homogeneity, maintenance and ongoing monitoring make the network of DORIS stations a major asset of the system and a guarantee of a stable performance.

The high quality of this network and its continuously improved robustness and reliability, is due, for a big part to the skill and to the efficiency of the local teams which take care of these DORIS stations.

The following table gives the list of the DORIS stations, and the institutes involved as DORIS host agencies.

Station name	Institute	City, Country
Amsterdam	Laboratoire de Géophysique	FRANCE
Arequipa		Arequipa, PERU
Ascension	ESA Telemetry & Tracking Station Cable & Wireless SA	Ascension island, SOUTH ATLANTIC OCEAN
Badary	Badary observatory of the Institute of Applied Astronomy Russian Academy of Sciences	village Badary, RUSSIA
Belgrano	Instituto Antártico Argentino	Buenos aires ARGENTINA
Betio	Kiribati Meteorological Service	KIRIBATI, Australia
Cachoeira Paulista	Instituto Nacional de Pesquisas Espaciais (INPE)	Cachoeira Paulista, BRESIL
Chatham Island	MetService	NEW ZEALAND
Cibinong	Bakosurtanal	Cibinong , INDONESIA

Station name	Institute	City, Country
Cold Bay	National Geodetic Survey NOAA	Silver Spring USA
Cold Bay	USCG Navigation Center	alexandria, USA
Crozet	Laboratoire de Géophysique	FRANCE
Dionysos	National Technical University Of Athens	Zografou GREECE
Djibouti	Observatoire d'Arta	Arta, REPUBLIQUE DE DJIBOUTI
Easter Island Santiago	Centro De Estudios Espaciales Universidad de Chile	Santiago, CHILI
Everest	Comitato Ev-K²-CNR	Bergamo, ITALY
Fairbanks	Command and Data Acquisition Station	Fairbanks, USA
Futuna	IRD	Nouméa NOUVELLE CALEDONIE
GRASSE	Observatoire de la Côte d'Azur Grasse	Grasse, FRANCE
Gavdos	Laboratory of Geodesy & Geomatics Engineering	Chania Crete, GREECE
Greenbelt	NASA / GSFC	USA
Hartebeesthoek	CSIR	Pretoria South AFRICA
Jiufeng	Institute of Geodesy and Geophysics	Wuhan, CHINA
Kauai	Kokee Park Geophysical Observatory	Kauai, USA
Kerguelen	Laboratoire de Géophysique	FRANCE
Kitab	Ulugh Beg Astronomical Institute	Tashkent, UZBEKISTAN
	Kitab Latitude Station, Astronomical Observatory	Kitab, UZBEKISTAN
Kourou	Centre Spatial Guyanais	Kourou, FRENCH GUYANA
Krasnoyarsk	Siberian Federal University	Krasnoyarsk, RUSSIA
La Réunion	Observatoire Volcanologique du Piton de La Fournaise	LA REUNION
Libreville	Station Ariane	Libreville, GABON
Mahe	Ministry of environment and transportDivision of policy, planning & services	Mahe, SEYCHELLES

Station name	Institute	City, Country
Male	Department of Meteorology	Male, REPUBLIQUE DES MALDIVES
Manille	National Mapping and Ressources Information Authority (Namria)	PHILIPPINES
Marion Island	HartRAO Space Geodesy Programme	Krugersdorp, SOUTH AFRICA
	Antartica & Island Dept of Environmental Affair & tourism	Cape town, SOUTH AFRICA
Metsahovi	Finnish Geodetic Institute	Masala, FINLAND
Miami	RSMAS	Rickenbacker Causeway, USA
Monument Peak	NASA SLR Tracking Station	Mt. Laguna, USA
Mount Stromlo	Earth Monitoring Group	Canberra AUSTRALIA
Nouméa	DITTT/ST/BGN	Nouméa, NOUVELLE CALEDONIE
	CENTRE IRD	Nouméa NOUVELLE CALEDONIE
Ny-Alesund	Statens Kartverk	Alesund, NORWAY
Papeete	Université de la Polynésie Française (UPF) Observatoire Géodésique de Tahiti (OGT)	Tahiti , FRENCH POLYNESIA
Ponta Delgada	Direcçao de Serviços de Cartografia e Informaçao Geografica	Azores, PORTUGAL
	Universidade dos Açores	Azores, PORTUGAL
Port Moresby	Surveyor General	PAPOUASIE NOUVELLE GUINEE
Reykjavik	Landmælingar Islands	ICELAND
Rikitea	Meteo-France	France, Polynésie Française
Rio Grande	Estacion Astronomica Rio Grande	ARGENTINA
Riyadh	KACST	Riyadh, SAOUDI ARABIA
Rothera	British Antarctic Survey	Cambridge, UK
Sal	Instituto Nacional de Meteorologia e Geofisica	Sal, CAP VERT

Station name	Institute	City, Country
Sakhalinsk	Institute of Marine Geology and Geophysics Russian Academy of Sciences	Yuzhno-Sakhalinsk, RUSSIA
Santa Cruz	Charles Darwin Foundation (AISBL)	Galapagos, ECUADOR
Socorro	INEGI	MEXICO
St John's	Natural Resources Canada Geodetic Survey Division	Ontario, CANADA
St John's	Neary's Consulting	New-Foundland , CANADA
St-Helena	Meteorological Station	St Helena, SOUTH ATLANTIC OCEAN
Syowa	National Institute of Polar Research,	Tokio JAPAN
Terre Adélie	INSU-Laboratoire de Geophysique	FRANCE
Thule	DNSC	Cppenhaguen DANEMARK
	NS Comm Greenland Contractors	Pituffik DENMARK
Tristan	Telecommunications Department	Tristan da Cunha, SOUTH ATLANTIC OCEAN
	“Technologie” Development Proudman Oceanographic Laboratory	Liverpool, UK
Yaragadee	Australian Space Office	AUSTRALIA
	Geoscience Australia (GA)	AUSTRALIA
Yellowknife	NR Can	Yellowknife CANADA
Yuzhno-Sakhalinsk	Institute of Marine Geology & Geophysics	Yuzhno-Sakhalinsk, RUSSIA

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IDS

www.ids-doris.org

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CLS

IGN Institut Géographique National

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esa

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