The International DORIS Service

July 2003 – December 2005 report

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This volume of reports is the first International DORIS Service Report documenting the work of the IDS components between the official IDS acceptance in August 2003 and the end of 2005. The individual reports were contributed by IDS groups in the international geodetic community who constitute the permanent components of IDS.

The IDS 2003-2005 Report describes history, changes, activities and progress of the IDS. The Governing board and Central Bureau kindly thank all IDS components who contributed to this Report.

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

http://ids.cls.fr/html/report/governing_board.html

1 INTRODUCTION

In 2003, the IERS changed its name to the International Earth rotation and Reference system Service and reorganized its structure. The IERS now assumes that all space geodetic techniques manage the data collection and intra-technique combinations within their respective services and that the IERS will only perform the inter-technique combinations of their specific products (Rothacher et al. 2004): Earth Orientation Parameters (EOP), and Terrestrial Reference Frame (TRF). Most space-techniques were already organized into services in the 2003 timeframe: 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). This organization by technique is fundamental to meet the scientific goals of the newly created project of the International Association of Geodesy (IAG), now called Global Geodetic Observing System (GGOS) (Rummel et al. 2005; Willis et al. 2005).

However, there was no IAG service to federate the research and developments related to the DORIS technique. An International DORIS Service was thus created in 2003 to organize the expected DORIS contribution to IERS and GGOS 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. Four analysis groups provide results, such as weekly or monthly station coordinates, geocentre variations or Earth polar motion that will be used soon to generate IDS combined products for geodesy or geodynamics.

2 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, laser and VLBI techniques as a contributor to the IERS in the framework of ITRF-94. 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 Centre, 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 (see chapter 8 about Pilot and early IDS campaigns).

Several meetings were organized in the framework of the DORIS Pilot Experiment:

- DORIS Days were held in Toulouse in May 2000 (see programme and contributions in http://ids.cls.fr/html/report/doris_days_2000/programme.html),
- an IDS Workshop was held in Biarritz in June 2002 (see programme and contributions in http://lareg.ensg.ign.fr/IDS/events/biarritz.html),
- an IDS Analysis Workshop was held in Marne La Vallée in February 2003 (see programme and contributions in http://lareg.ensg.ign.fr/IDS/events/prog_2003.html).

The IDS was officially started on July 1, 2003 as an IAG Service after the decision 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://lareg.ensg.ign.fr/IDS/events/prog_2004.html).

3 ORGANIZATION

The IDS organization is similar to the organization of other IAG and IERS Services.

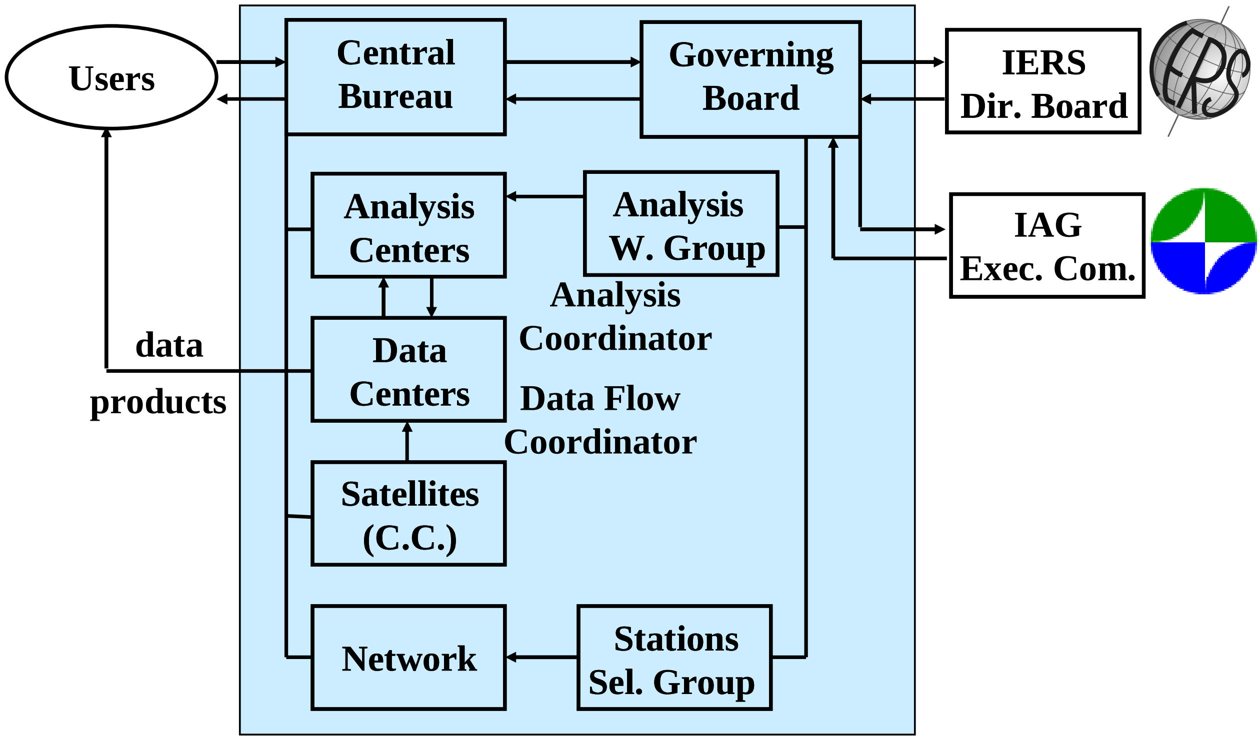


Figure 1. IDS organization

3.1 GOVERNING BOARD

Martine Feissel-Vernier retired at the end of October 2005 and left the function of IDS Analysis Coordinator that she initiated in February 2002. The IDS governing board and Central Bureau would like to friendly and warmly thank Martine Feissel-Vernier for her most valuable contribution as the first IDS Analysis Coordinator.

Frank Lemoine was elected as Analysis Coordinator in February 2006. He will carry on this major contribution with the support of the Central Bureau.

Gilles Tavernier	CNES	Chairperson
Hervé Fagard	IGN	Network representative
Frank Lemoine	NASA GSFC	Analysis coordinator
Carey Noll	NASA GSFC	Data Flow coordinator
Ron Noomen	Delft UT	Representative of the IERS
John Ries	UTEX CSR	Member at large

Laurent Soudarin	CLS	Director of the Central Bureau
Pascal Willis	IGN / JPL	
TBD	Stations Selection Group Chairperson & representative of the IAG	

3.2 CENTRAL BUREAU

Laurent Soudarin	CLS	Director
Hervé Fagard	IGN	
Jean-Pierre Granier	CNES	
Gilles Tavernier	CNES	
Jean-Jacques Valette	CLS	
Pascal Willis	IGN / JPL	

4 THE CENTRAL BUREAU: IDS INFORMATION SYSTEM

Laurent Soudarin (1)

(1) CLS, 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.

4.1 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 webpage at IGN/LAREG

The baseline storage rules are as follows:

DC store observational data and products + formats and analysis descriptions. The DCs will issue monthly bulletins (with respective dates shifted by 1/2 month) giving the current status of the data and product storage. .

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 site.

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

4.2 WEB AND FTP SITES

4.2.1 IDS WEB SITE

address : http://ids.cls.fr

The IDS web site gives general information on the Service, and on the DORIS system (link : all about DORIS). It is composed of the following headings:

- About IDS: general information about the service
- Organization: structure of the service, terms of reference, components
- Events: links to meeting, workshop, assembly announcement
- Data centers: access information to the IDS Data Centers
- Reports: IDS documents, DORIS bibliography, meeting presentations, DORIS-related peer-reviewed publications, mail system messages, citation rules, etc.
- Contacts and links: information about related activities

It is also supplemented by a site index, FAQs, news on the IDS and news on DORIS.

The heading « All about DORIS » gives access to important information useful for the users:

- the Site logs of the network stations
- the System Events file
- time series of station coordinates
- satellite and station daily performance plots

This site is maintained by the Central Bureau.

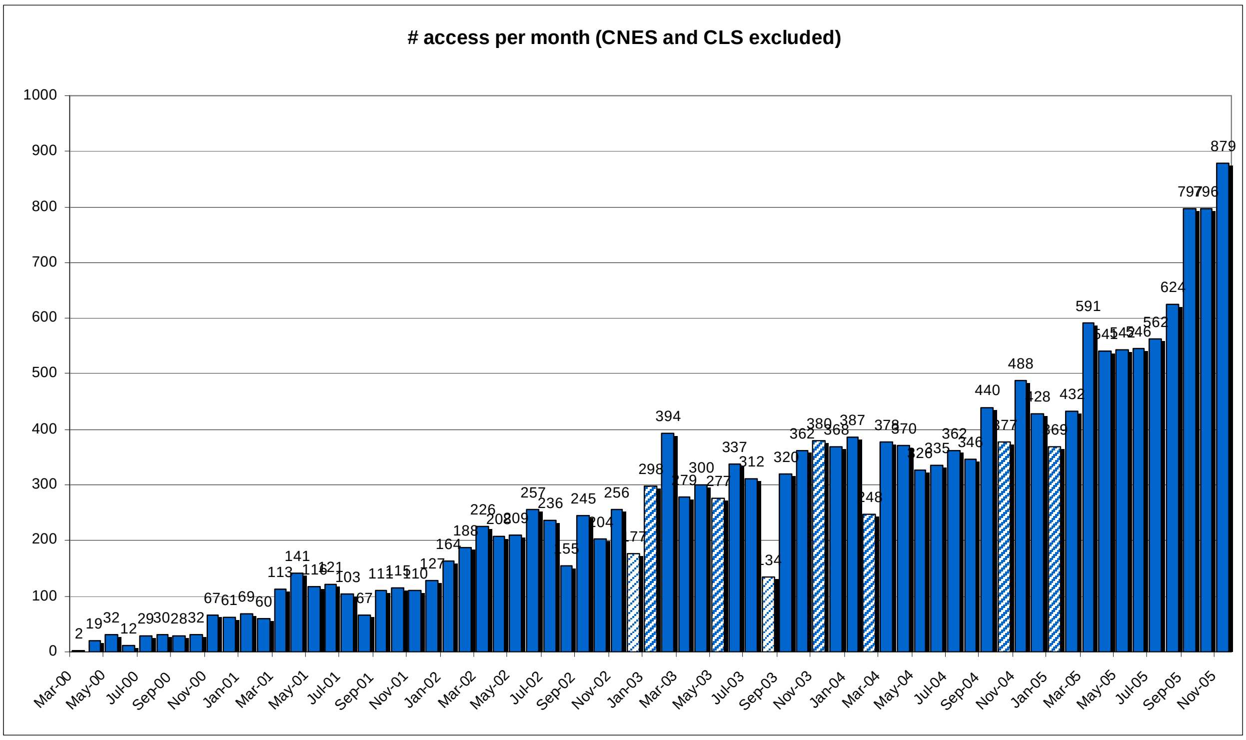


Figure 2. IDS web site number of access per month (CNES and CLS excluded)

4.2.2 IDS FTP SERVER "BASIC INFO"

address: ftp://ftp.cls.fr/pub/ids

The IDS ftp server gives basic information on the DORIS system. It concerns:

- the centers: presentation and analysis strategy of the ACs
- the data: format description 1.0 and 2.1
- the dorimails and dorisreports: archive of the messages and indexes
- the products: format of eop, geoc, snx, sp1,stcd
- the satellites: macromodels, nominal attitude model, maneuver histories, arcs/cycles calendar with maneuver types
- the stations: ties, colocations, host agencies, ITRF2000, antennas description, Jason visibility

This site is maintained by the Central Bureau.

There's a mirror site at CDDIS: ftp://cddisa.gsfc.nasa.gov/pub/doris/cb_mirror/

4.2.3 DORIS WEB SITE

Address: http://www.jason.oceanobs.com/html/doris/

The official DORIS web site is hosted by the Aviso website which is dedicated to altimetry, orbitography and precise location missions. The DORIS pages present the principle and the applications of the system. Technical information will be added.

This site is maintained by the Aviso webmaster with the support of the IDS Central Bureau.

4.2.4 ANALYSIS COORDINATION WEB SITE

Address: http://lareg.ensg.ign.fr/IDS

The Analysis coordinator maintains a website which provides information and discussion areas about the analysis strategies and models, and analyses of the products of the Analysis Centers. See the report of the Analysis Coordinator.

4.2.5 DATA CENTERS' WEB SITES

Data and products, formats and analysis descriptions are stored at the CDDIS and IGN Data Centers. A detailed description is given in the report of the Data flow Coordinator.

Address of the CDDIS web site: http://cddis.gsfc.nasa.gov/doris_datasum.html

Address of the CDDIS ftp site: ftp://cddis.gsfc.nasa.gov/doris/

Address of the IGN ftp site: ftp://lareg.ensg.ign.fr/pub/doris/

4.3 THE MAIL SYSTEM

In May 1996, in the frame of the IERS DORIS Coordination activities, IGN has set up the DORISmail service to send general information for a large DORIS audience. This mailing list became then one of the communication tool of the IDS. In October 2004, two new lists were created, dedicated to information and discussion specific to the analysis: the DORISreport and the IDS Analysis Forum.

A description of the mailing lists can be found on the IDS web site on the page:
http://ids.cls.fr/html/report/doris_mails.html

4.3.1 DORISMAIL

e-mail: dorismail@cls.fr (replacing the original dorismail@ensg.ign.fr)

The DORISmails are used to distribute messages of general interest to the users' community (175 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 IGN/ENSG at the following address:

http://list.ensg.ign.fr/wws/arc/dorismail

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

ftp://ftp.cls.fr/pub/ids/dorismail/

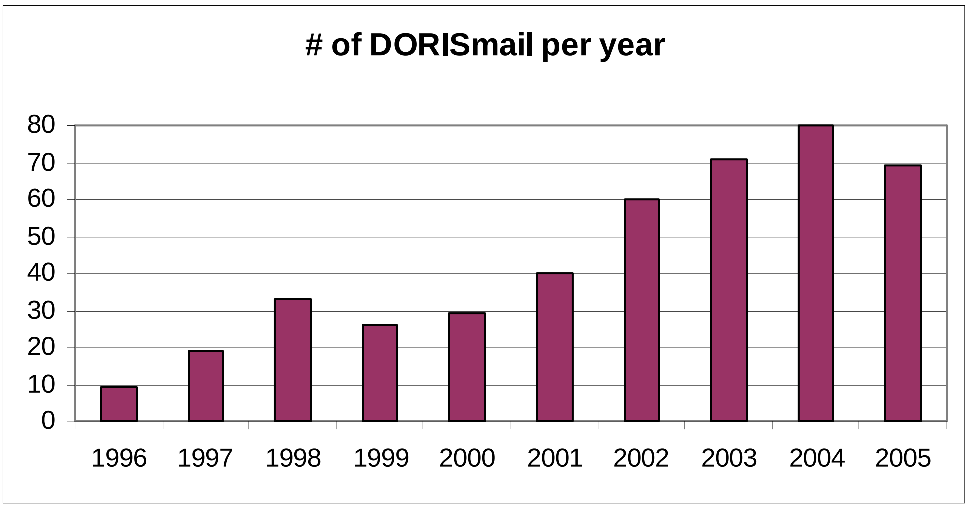


Figure 3. 436 DORISmails were distributed between May 1996 and December 2005

4.3.2 DORISREPORT

e-mail : dorisreport@cls.fr

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 (30 subscribers).

95 messages were distributed in 2004, 360 in 2005. They are all archived on the mailing list server of CLS at the following address:

http://listes.cls.fr/wws/arc/dorisreport

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

ftp://ftp.cls.fr/pub/ids/dorisreport/

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

4.3.3 IDS ANALYSIS FORUM

e-mail : ids.analysis.forum@cls.fr

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 (Martine Feissel-Vernier, Jean-Jacques Valette and Laurent Soudarin, in France) and John Ries (in the USA).

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

http://listes.cls.fr/wws/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://lareg.ensg.ign.fr/IDS/disc.html

4.4 HELP TO THE USERS

e-mail : IDS.central.bureau@cls.fr

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.

Since 2003, many exchanges took place with the Analysis Centers and groups which are expected to contribute soon to the IDS (AIUB, Observatory of Pecny, IAA, GSFC, Geoscience Australia).

4.5 FUTURE PLAN

Sections of the IDS Websites will be revised in the near future. The homepage will be improved to give a better access to the information. Information from the Analysis Coordination Web pages will be included in the IDS Website. The station site-log pages will be supplemented by other information relative to the IDS tracking network, such as coordinate time-series and local events related to seismic or volcanic activity. In the area of data analysis, new products, such as satellite orbits, as well as additional contribution for existing products, such as time-series of the geocenter and of EOPs, will be provided to the IDS by the Analysis Centers. The Central Bureau will continue to support any new ACs as they join the service.

5 THE NETWORK

Hervé Fagard (1)

(1) IGN, France

5.1 GENERAL STATUS OF THE NETWORK

The stations that are currently part of the ground segment of the DORIS system can be divided in two groups:

- The "permanent stations", whose primary purpose is to take part in the orbit determination for the satellites carrying DORIS instruments. Such stations were installed for an a priori unlimited time period, following an initial CNES and IGN proposal. Nevertheless some circumstances may require that we have to remove a station and look for another host agency.
- The "IDS stations", which have been installed following proposals submitted by other organizations with varied scientific motivations, for a limited or undefined time period.

Figure 4 shows the status of the permanent network at the end of 2005, and the IDS experiments that have been operating sometime in 2004 and/or 2005.

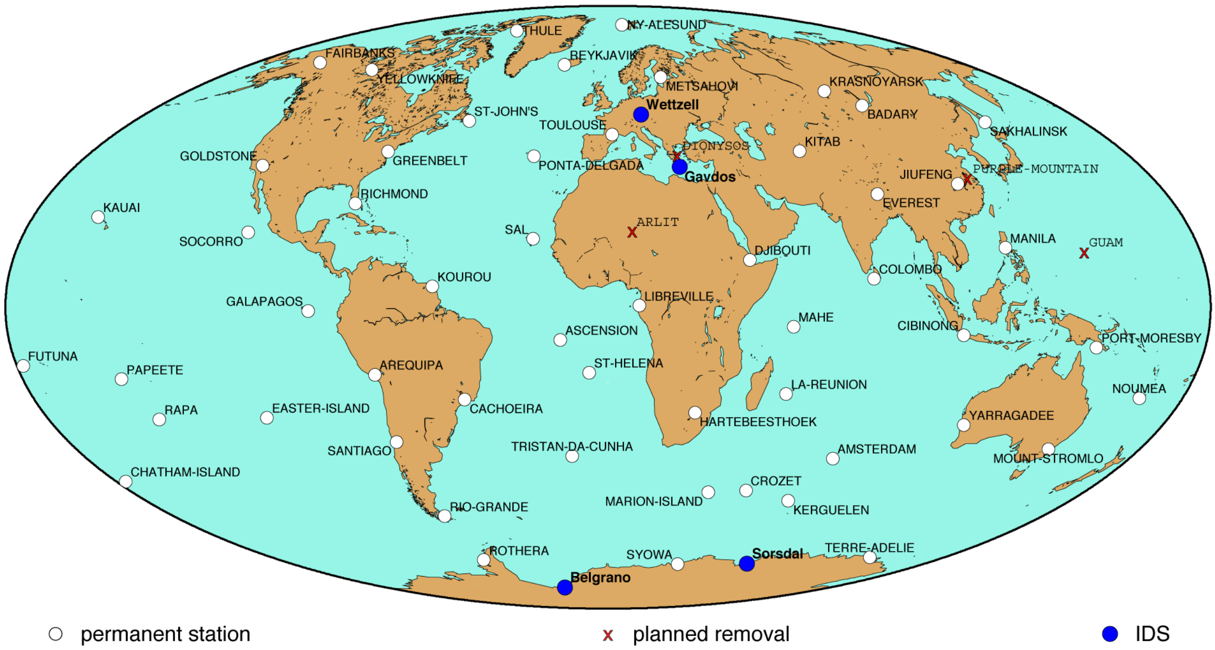


Figure 4. IDS experiments in 2004 and 2005

5.2 RENOVATION PROGRAM OF THE PERMANENT NETWORK

The current status of the DORIS permanent network, as regards the antenna stability, is shown on figure 5. The stations renovation program, initiated in 2000 in order to improve the long term stability of the antenna support, was continued, as illustrated in figure 6.

In 2004 the following stations were renovated:

- Mount Stromlo (Australia)
- Cachoeira Paulista (Brazil)
- Marion Island (South Africa)
- Badary (Russia)
- Yuzhno-Sakhalinsk (Russia)
- Reykjavik (Iceland)
- Kourou (French Guyana): new master beacon.

In 2005 the following stations were renovated:

- Rothera (British base in Antarctica)
- Belgrano (Argentine base in Antarctica). This station, initially installed in 2004 following a joint AWI-IAA proposal to the IDS, is now included in the DORIS permanent network thanks to its excellent results.
- Nouméa (New-Caledonia)
- Libreville (Gabon)
- Hartebeesthoek (RSA): third master beacon

and the following new stations were installed:

- Male (Maldives), replacing Colombo
- Miami (California, USA), replacing Richmond
- Santa Cruz (Galapagos, Ecuador), replacing Galapagos
- Monument Peak (California, USA), replacing Goldstone

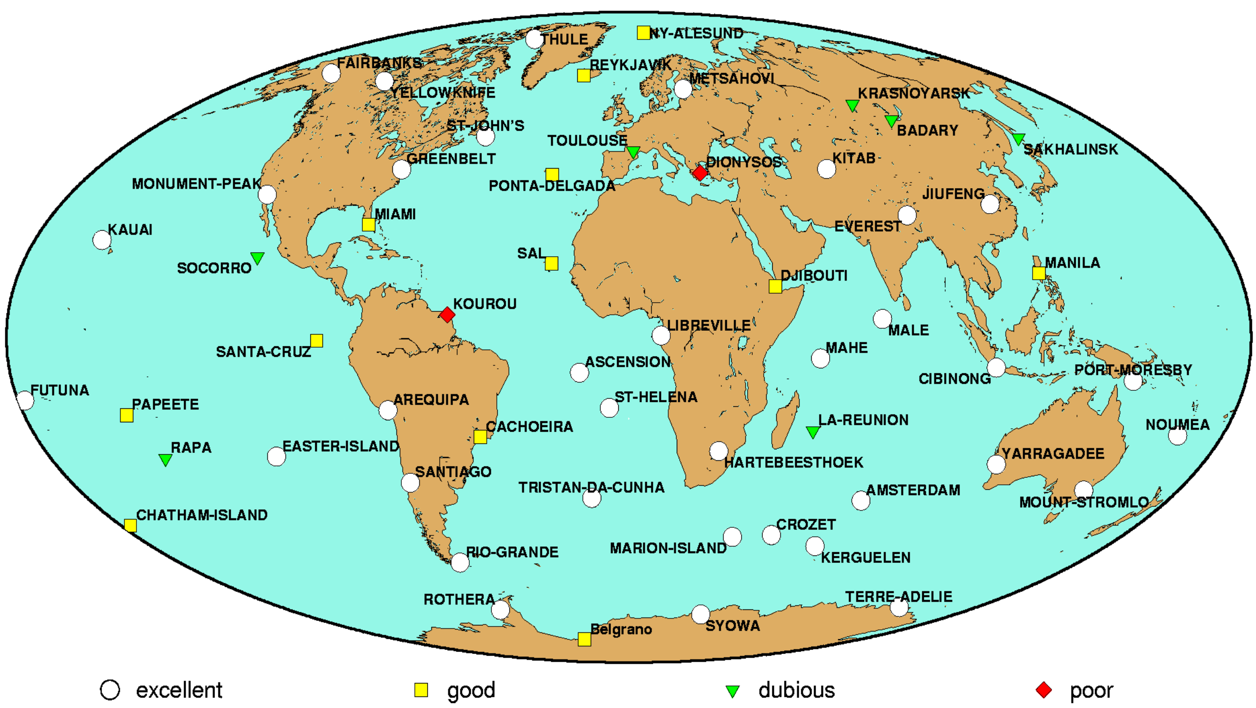


Figure 5. Estimated stability of the DORIS permanent stations (end of 2005)

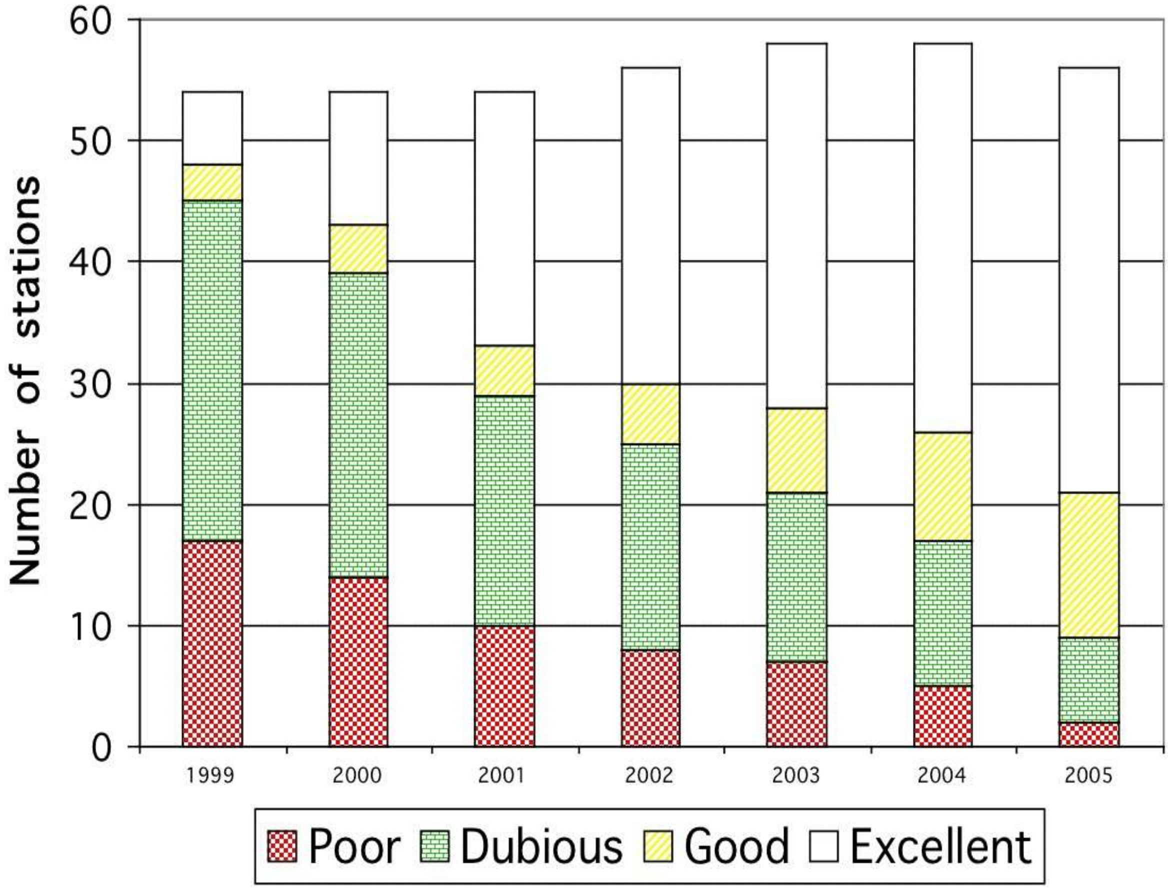


Figure 6. DORIS permanent network renovation

At the end of 2005, 47 out of 56 stations (in the permanent orbitography network) are considered to have good or excellent stability.

5.3 THIRD GENERATION BEACONS DEPLOYMENT STATUS

The deployment of the third generation beacons, which are intended to replace the first and second generation beacons still operating at many DORIS sites, has been interrupted for several months, after a serial failure on the 2 GHz channel was identified. Half of the beacons have been affected by this failure, and all units had to be sent back to the manufacturer in order to be retrofitted. The on-site replacement of defective units could only start in October, as retrofitted beacons became available.

The evolution of the proportion of the three beacon types in the permanent network are shown on figure 7. The total number of beacons is lower than 58 because some of the stations whose closure is planned are not taken into account.

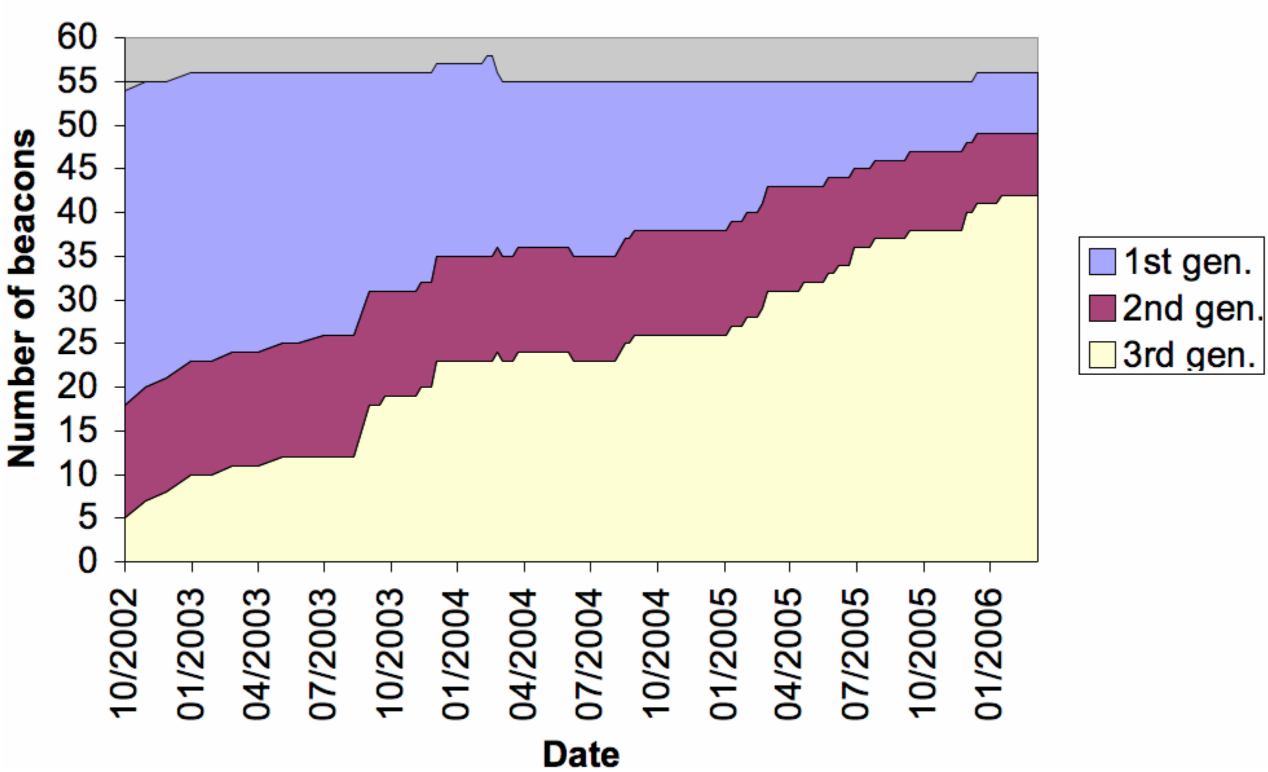


Figure 7. beacons models in the permanent network

5.4 IDS EXPERIMENTS

The following experiments have been continued or initiated in 2004 (see figure 4):

- The second Sorsdal experiment (Glacier movement monitoring in Antarctica) was carried out by Auslig, from November 2003 to January 2004.
- A new station was installed at Belgrano II, an Argentine base in Antarctica, following a joint proposal to the IDS by the Alfred Wegener Institute and the Insituto Antárctico Argentino.
- The stations at Wettzell (Germany) and Gavdos (Greece) have been down most of the time due to a beacon failure.

5.5 CO-LOCATIONS WITH OTHER IERS TECHNIQUES

The number of co-locations with currently operating stations of the other techniques contributing to IERS is as follows.

- GPS: 37 sites
- SLR: 9 sites
- VLBI: 7 sites

The following new co-locations were made available in 2004 and 2005:

- DORIS-SLR tie at Jiufeng measured in December 2003
- DORIS-GPS tie at Yuzhno-Sakhalinsk measured in August 2004
- DORIS-VLBI tie at St-John's measured in 2003

- DORIS-GPS tie at Male measured in January 2005
- DORIS-GPS tie at Santa Cruz measured in April 2005
- DORIS-GPS tie at Monument Peak measured in December 2005, and DORIS-SLR tie derived from the known GPS-SLR tie

Figure 8 shows the distribution of DORIS co-locations (<10 km) with currently operating GPS (IGS), SLR and VLBI.

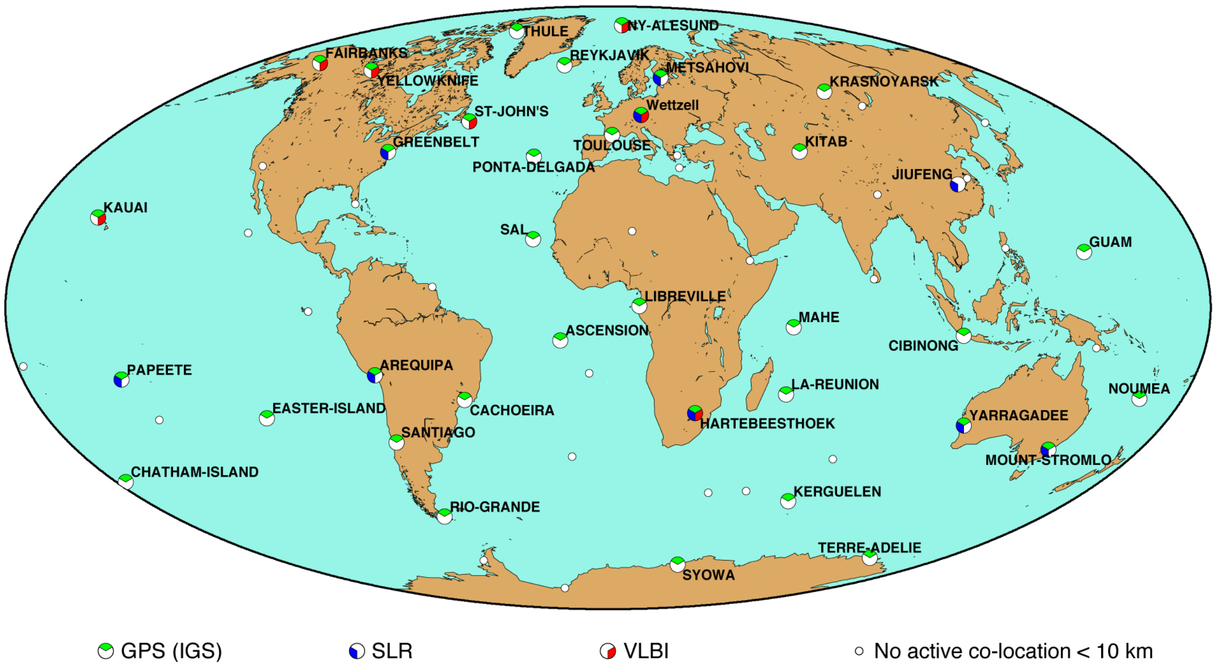


Figure 8. co-locations with other active IERS techniques

6 THE SATELLITES FITTED OUT WITH DORIS RECEIVERS

Gilles Tavernier (1)

(1) CNES, France

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

- SPOT-2, a CNES remote sensing satellite was launched in 1990, with the first DORIS receiver for a 6-month probationary experiment. More than 16 years after the launch, this receiver is still fully operational,
- 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 has delivered an astonishing 13+ years of data from orbit: the DORIS mission ended with the second receiver failure in November 2004 whereas the ocean surface topography mapping ended in October 2005,
- SPOT-3 (CNES) was launched in 1993; the spacecraft was lost in November 1996,
- SPOT-4 (CNES) was launched in 1998, featuring the first DORIS real time on-board orbit determination (DIODE).

In the mid-nineties, CNES developed a second generation dual channel DORIS receiver which was miniaturized in the late nineties:

- 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 and automatically started. The orbit accuracy is getting close to one centimeter on 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 Oscillators (USO) (Willis et al. 2004), however a correction model has recently been developed (Lemoine and Capdeville submitted),
- 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.

Figure 9 gives a summary of the satellites providing 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.

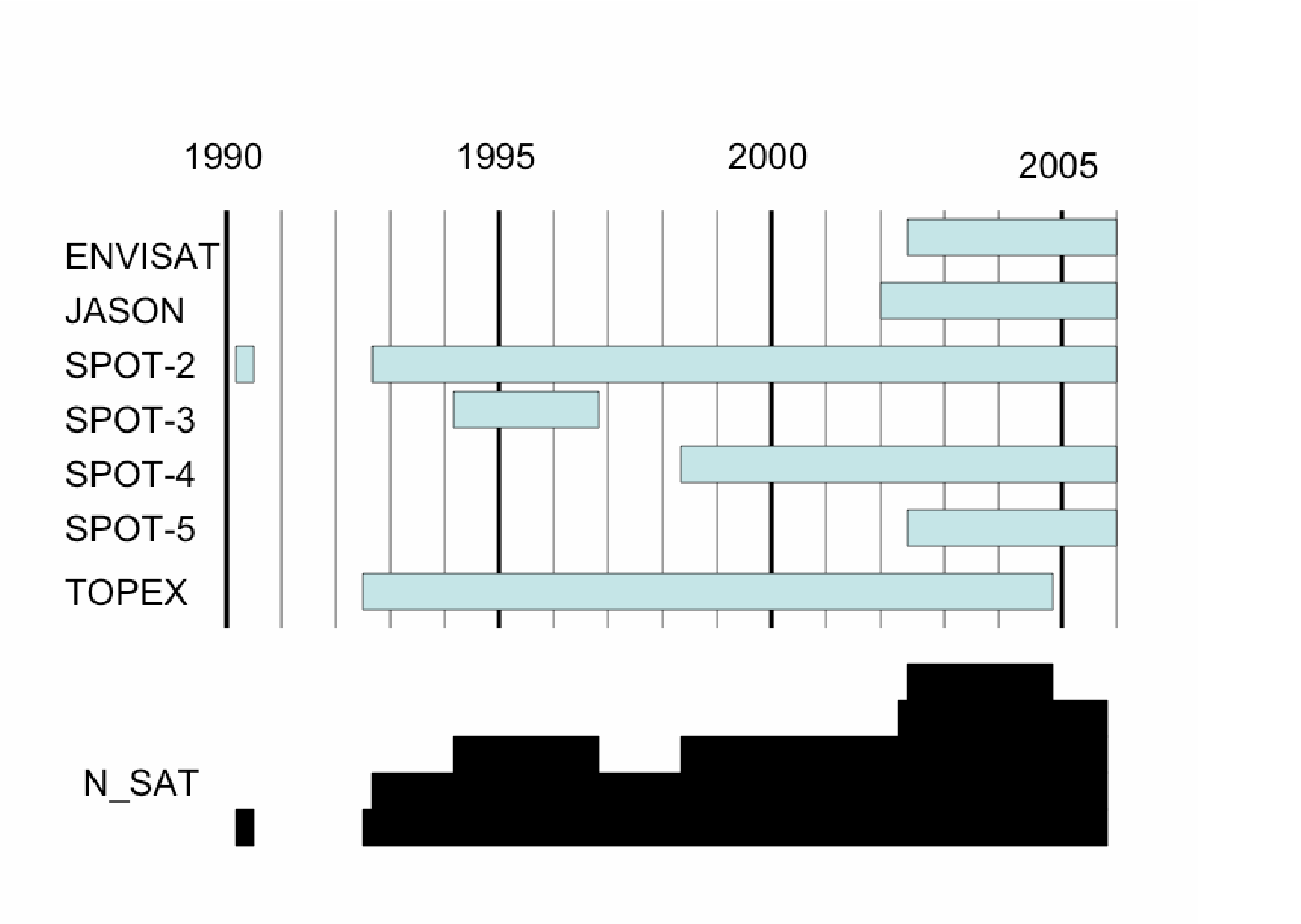


Figure 9. DORIS observations available at the IDS Data Centers (April 2006).

A DORIS (and CERTO) receiver dedicated to global ionospheric measurements should fly on-board STPSAT1 (Plasma Physics and Space Systems Development Divisions, Naval Research Laboratory) by the end of 2006 (launch scheduled November 2006).

There won't be any new launch before 2008:

- Jason-2/OSTM: June 2008
- CryoSat-2: March 2009
- Alti-KA: June 2009

7 IDS DATA FLOW COORDINATION

Carey Noll (1)

(1) NASA/GSFC

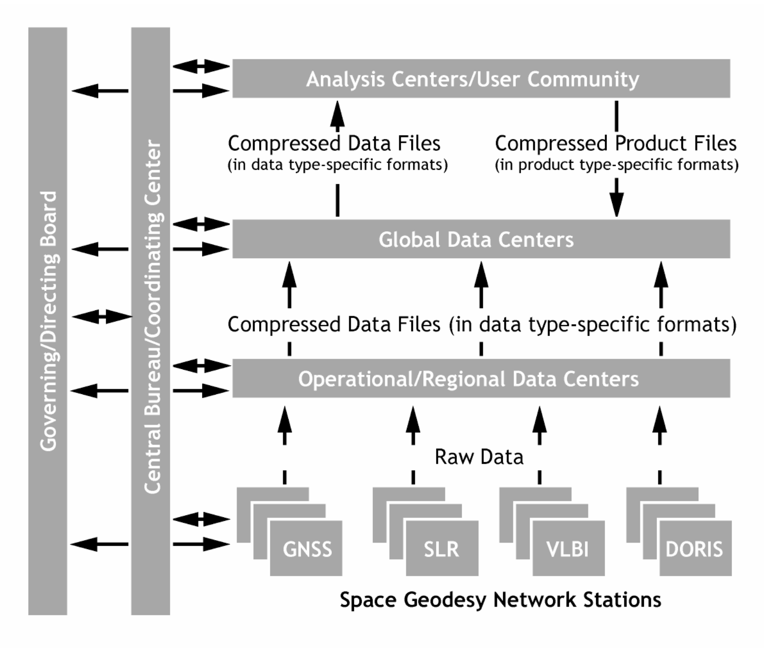
Two data centers currently support the archiving and access activities for the IDS:

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

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

7.1 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 geodetic services (IGS, ILRS, and IVS) and is shown in Figure 10. IDS data and products are transmitted from their source 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 (at this time, CDDIS only). 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 10. 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 Analysis Coordinator's website at *http://large.ensg.ign.fr/IDS/doc/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/cb_mirror* with general information and data and product documentation (maintained by the IDS Central Bureau)

IGN currently mirrors the contents of the CDDIS data and product archives. Future plans call for SSALTO to possibly deliver data 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.

Table 1. Main Directories for IDS Data and Products

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*
Product Directories		
/doris/*prodtype*/*ccc*/	orbits/*ccc*/*cccsssVV*.*bXXDDD*.*eYYEEE*.sp1.*LLL*.Z	Satellite orbits in SP1 format from analysis center *ccc*, satellite *sss*, solution version *VV*, start date year *XX* and day *DDD*, end date year *YY* and day *EEE*, and file version number *LLL*
	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*
	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*
	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*
	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*
	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*
	iono/*ccc*/*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*.
Information Directories		
/doris/cb_mirror		Mirror of IDS central bureau files

7.2 DORIS DATA

SSALTO deposits DORIS data to the CDDIS server *cddis.gsfc.nasa.gov*. Software at CDDIS peruses this incoming data area for new files and automatically archives the files to public disk areas using the directory structure and filenames specified by the IDS. IGN mirrors the CDDIS DORIS data archive thus providing a second identical access point to the IDS community. The IDS data centers archive DORIS data from five operational satellites (SPOT-2, -4, -5, Jason-1, and Envisat); data from future missions (e.g., Jason-2, CryoSat-2, Alti-KA…) will be archived within the IDS. Historic data from 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 are archived in multi-day (typically 10-day) "cycle" files using the DORIS data format 2.1 (since January 15, 2002). 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 average latency of data availability after the last observation day satellite specific:

- SPOT: ~27 days
- Jason-1: ~22 days
- Envisat: ~35 days

The delay by file and satellite is shown in Figure 11.

Table 2. DORIS Data Holdings

Satellite	Time Span
Envisat	13-Jun-2002 through present
Jason-1	15-Jan-2002 through present
SPOT-2	31-Mar through 04-Jul-1990.
	02-Jan through 22-Mar-1992
	16-Oct-1992 through present
SPOT-3	01-Feb-1994 through 09-Nov-1996
SPOT-4	01-May-1998 through present
SPOT-5	11-Jun-2002 through present
TOPEX/Poseidon	25-Sep-1992 through 01-Nov-2004

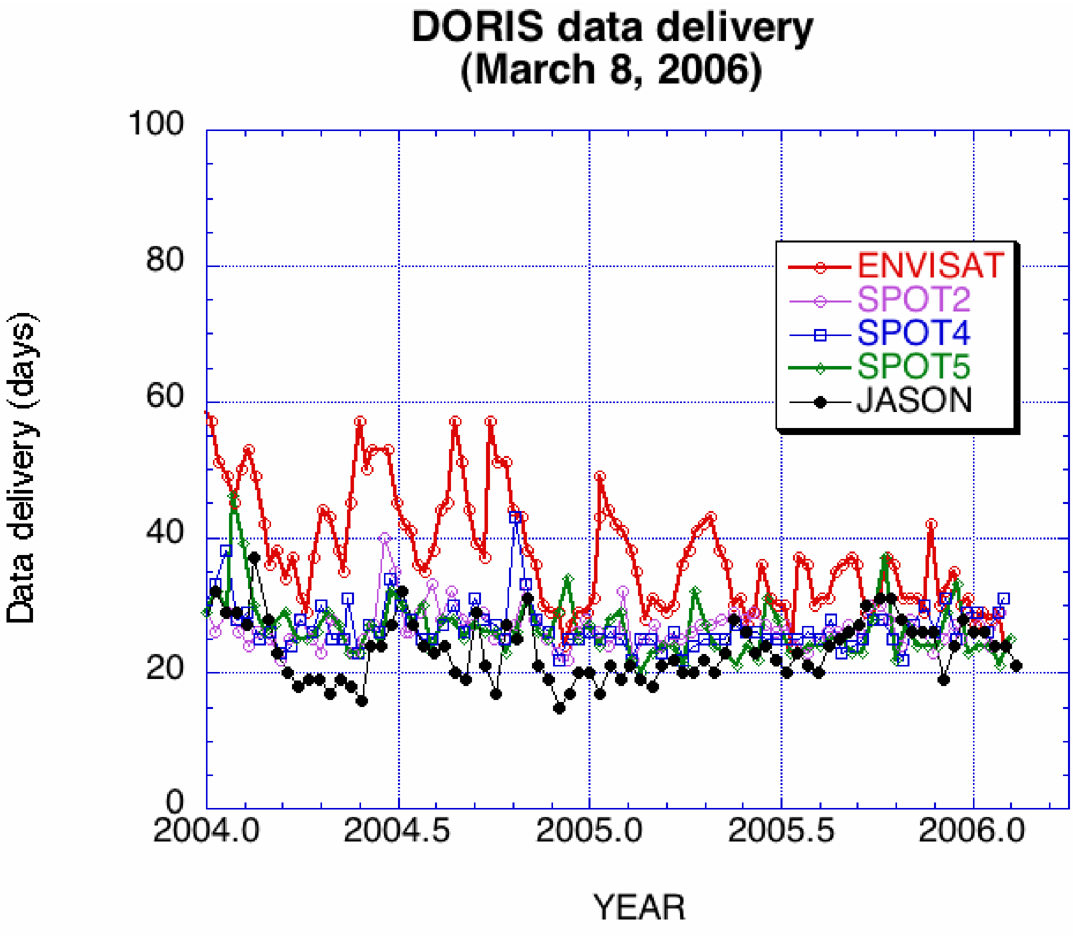


Figure 11. Delay in delivery of DORIS data to the CDDIS (all satellites, 01/2004-04/2006)

7.3 DORIS PRODUCTS

IDS analysis centers utilize similar procedures by putting products to the CDDIS server. Automated software detects any incoming product files and archives them to the appropriate product-specific directory. The following analysis centers (ACs) have submitted products to the IDS; their AC code is listed in ():

- NASA GSFC (gsc) USA, F. Lemoine
- Institut Géographique National/JPL (ign) France, P. Willis
- INASAN (ina) Russia, S. Tatevian
- LEGOS/GRGS-CLS (lca) France, J.-F. Crétaux
- CNES/SOD (sod) France, J.P. Berthias
- SSALTO (ssa) France, G. Tavernier

IDS products are archived by type of solution and analysis center. The types and sources of products available through the IDS data centers in 2003-2004 are shown in Table 3.

Table 3. IDS Product Types and Contributing Analysis Centers

Type of Product	GSC	IGN	INA	LCA	SOD	SSA
Time series of SINEX solutions	X (W)	X (W, M)	X (W, M)	X (W, M)	X (W)	X (W,M)
Global SINEX solutions		X				
Time series of coordinates of the TRF origin		X (W)				
Orbits/satellite				X (Jason)		
Ionosphere products/satellite						X (All)
Time series of EOP		X (W)				
Time series of station coordinate		X (W)		X (M)		X (W)

Notes: W=weekly solution
M=monthly solution

7.4 FUTURE PLANS

The IDS will investigate the redundant transmission of data and products to both IDS data centers. This capability would ensure the availability of data and products should either data center be unavailable. The IDS data centers will also investigate procedures to regularly compare holdings of data and products to ensure that the archives are truly identical. Lastly, the data centers will investigate the utility of issuing regular reports of data holdings through the DORISReport email system.

7.5 IDS DATA CENTERS

7.5.1 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 GPS Service (IGS)
- International Laser Ranging Service (ILRS)
- International VLBI Service for Geodesy and Astrometry (IVS)
- International DORIS Service (IDS)
- International Earth Rotation 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 an Oracle data base and utilized to generate data holding reports on a daily basis.

During 2005, over 180 groups in 48 countries accessed DORIS data and information from the CDDIS.

7.5.1.1 CONTACT

Carey Noll, CDDIS Manager	Email:	Carey.Noll@nasa.gov
NASA GSFC	Voice:	301-614-6542
Code 690.1	Fax:	301-614-6099
Greenbelt, MD 20771	ftp:	*ftp://cddis.gsfc.nasa.gov/pub/doris*
USA	WWW:	*http://cddis.gsfc.nasa.gov*

7.5.2 INSTITUT GEOGRAPHIQUE NATIONAL (IGN), PARIS FRANCE

Procedures have been established at IGN to routinely mirror the contents of the data and product archives at the CDDIS.

7.5.2.1 CONTACT

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6-8 avenue Blaise Pascal	Fax:	+33 (0) 1
77455 Marne-la-Vallée CEDEX 2	ftp:	*ftp://lareg.ensg.ign.fr/pub/doris*
FRANCE	WWW:	*http://lareg.ensg.ign.fr/DORIS/index.html*

8 ANALYSIS COORDINATION

Martine Feissel-Vernier (1,2),

K. Le Bail (2,3), L. Soudarin (4), J.-J. Valette (4)

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(4) Collecte Localisation Satellites (CLS), France

(5) NASA Goddard Space Flight Center, USA

The main products available at IDS after 18 months of existence are time series of Terrestrial Reference Frames (TRF) and derived parameters at monthly and weekly intervals since 1993. The sets of parameters that are used to qualify the geodetic performance of the DORIS system are series of station coordinates, and series of coordinates of the TRF origin and scale. The quality of geodetic results is improving with time, as new DORIS-equipped satellites launched in 1994, 1998 and 2002, and network stations rejuvenated starting in 2000. The stability of time series of TRF origin and scale are shown to be sensitive to software and analysis strategies at the level of a few millimeters. Spurious annual signatures are present up to 1-2 cm in the TRF origin and 5 mm in the scale. We show that the measurement of station motions has a white noise error spectrum in the time domain. Over the 1993-2004 time frame, the median stability of station coordinates for a one year sampling time reaches 5 mm in the horizontal plane as well as in the vertical direction.

8.1 INTRODUCTION

The role of the Analysis Coordinator is defined as follows in the IDS terms of Reference.

"The Analysis Coordinator assists the Analysis Centers. The Analysis Coordinator monitors the Analysis Centers activities to ensure that the IDS objectives are carried out. Specific expectations include quality control, performance evaluation, and continued development of appropriate analysis standards. The Analysis Coordinator, with the assistance of the Central Bureau, is also responsible for the appropriate combination of the Analysis Centers products into a single set of products."

In addition to contributing to the improvement in accuracy and consistency of the IDS products, the Analysis Coordinator is responsible for providing the IDS evaluation of the DORIS terrestrial reference frame (TRF) and Earth Orientation Parameters (EOP) to the IERS.

The reference frame topics are discussed with the other providers (GPS, SLR, and VLBI) within the IERS. The international discussion of Doris satellite orbits takes place within the space oceanography users' community, in particular through the yearly NASA/CNES Ocean Surface Topography Science Team Meetings.

The IDS data and products are described in section 8.2 and some specific analysis tools are described in section 8.3. Sections 8.4 and 8.5 summarize the main results obtained in two analysis campaigns that were initiated in 2002 and in 2003, concerning the station coordinates repeatability and the sensitivity of the Terrestrial Reference Frames (TRF) origin and scale to the gravity field and the analysis strategy and software.

Section 8.6 shows a comparison of the DORIS-observed seasonal motion of the TRF origin with SLR results, and with geophysical prediction of the geocenter motion. Section 8.7 gives an estimation of the medium term stability of DORIS-derived TRFs. The results presented in sections 8.5 and 8.6 are further developed in several presentations at meetings (see section 8.8.2), and in journal articles in preparation.

Sections 8.8 and 8.9 give references to the IDS information Centers and to publications and communications connected to the IDS Analysis Coordination.

The reader may also refer to the position paper “DORIS data analysis strategies” by P. Willis and J.-F. Crétaux (http://lareg.ensg.ign.fr/IDS/events/2004_files/pw-jfc-pp.pdf).

8.2 IDS DATA AND PRODUCTS

8.2.1 DATA

The beacon tracking data collected since 1993 by six DORIS-equipped satellites, with altitudes ranging from 800 to 1300 km, are used by IDS for geodetic purposes: Spot 2, 3, 4 & 5 (sp2, sp3, sp4, sp5), Topex/Poseidon (top), and Envisat (env). Spot 3 was active only until November 1996. The DORIS receiver on board Topex/Poseidon ceased operation at the end of October 2004. The perturbation of the Jason (jas) receiver frequency at each transit of the satellite over the Southern Atlantic Anomaly region creates a large perturbation of the estimated station coordinates. Therefore these data are currently not used to derive IDS products.

Figure 12 summarizes the evolution of the performance of the Doris system in terms of the average scatter over the available network of weekly station coordinates. The plotted parameters are the yearly median standard deviation of series of station coordinates determinations with respect to the linear trend estimated for the same year. The start and end dates of operation of the satellites are shown. The yearly numbers of stations with series of coordinates are shown at the bottom of the figure. The successive improvements associated with the increase in the number of satellites and with the rejuvenation of the stations (see section "Network stations") are visible. The effect of the station rejuvenation that was started in mid-2000 appears before the addition of new satellites and continues afterwards.

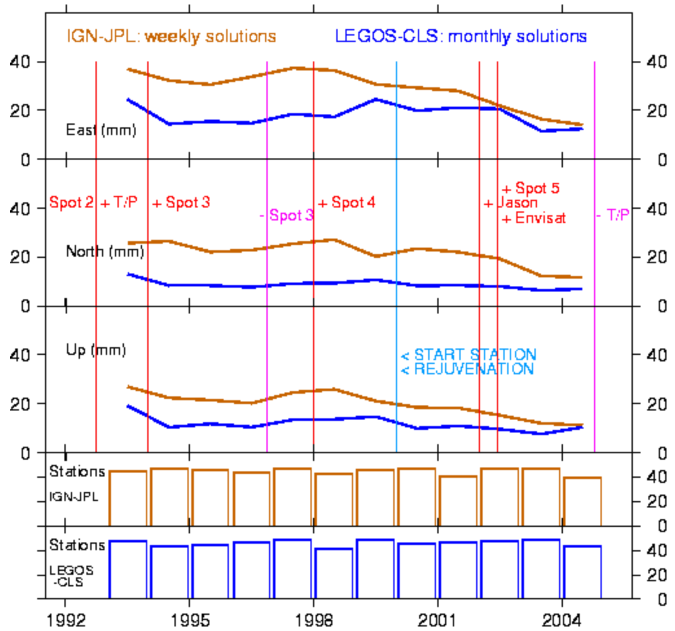

Figure 12. Evolution of the quality of DORIS positioning: median standard deviation of detrended series of station coordinates, computed year by year. Solutions: ign03wd01 (weekly, brown) and lcamd02 (monthly, blue)

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8.2.2 PRODUCTS

The standard IDS products are listed in table 4, together with the status of their availability and valorization as of January 2005. The valorization takes place not only within IDS, but also at the IERS Product Centers and in the framework of Ocean Surface Topography Science Team. The products analyzed in this report are listed in table 5.

Table 4. products availability and valorization, as of February 2005

Product	Availability	Comparison	Combination
Orbits	X	X	
Global TRF SINEX	X	X	X
TRF-EOP SINEX time series	X	X	X
Times series of:			
Station coordinates	X	X	
TRF origin (“geocenter”) and scale	X	X	
EOP	X	X	X
Ionosphere	X		

As of February 2005, the main available IDS products are the following.

- weekly IGN-JPL times series of terrestrial reference frames (TRF), together with daily polar motion, contributed to the Combination Pilot Project
- weekly IGN-JPL time series of TRF translation (‘geocenter’ coordinates) and scale
- weekly IGN-JPL time series of station coordinates
- long term IGN-JPL cumulative TRF solutions
- monthly LEGOS-CLS time series of TRFs
- monthly LEGOS-CLS time series of TRF translation (‘geocenter’ coordinates) and scale parameters
- monthly LEGOS-CLS time series of station coordinates

LEGOS-CLS is preparing for the routine submission of weekly times series of terrestrial reference frames (TRF) including daily polar motion to contribute to the IERS Combination Pilot Project.

- INASAN time series of TRF translation and scale parameters
- weekly INASAN time series of station coordinates

The IGN-JPL(ign) and INASAN (ina) centers make use of the GIPSY-OASIS software (JPL). LEGOS-CLS (lca) makes use of the GINS-DYNAMO software (GRGS).

The products analyzed in the remaining of this report are briefly described in table 5. All products are under the form of time series, at weekly or monthly intervals.

Table 5. Time series of IDS and other products analyzed in this report

Analysis Center (AC)	Product Name (1).	Data	Data span	Gravity field	Product analyzed	Sections
DORIS IGN-JPL (France-USA) P. Willis Y. Bar-Sever	ign**m**d03	Sp2/3/4, top	1993-2002	EGM96	TRF Or. & scale	4
	ign**w**d02	Sp2/3/4, top	1993-2003	EGM96	TRF Or. & scale (2)	5
	ign**w**d03	Sp2/3/4, top	1993-2004	EGM96	TRF Or. & scale	5
	ign**w**d04	Sp2/3/4/5, top, env	1993-2004	GGM01C	TRF.Or. & scale	5
	ign**w**d05	Sp2/3/4/5, top, env	1993-2002	GGM01C	TRF Or. & scale (3)	5, 6
	ign03**w**d01	Sp2/3/4/5, top, env	1993-2004	GGM01C	Station coordinates	7
DORIS LEGOS/CLS (France) J.F. Crétaux L. Soudarin	lca**m**d02	Sp2/3/4, top	1993-2002	GRIM5-C1	TRF Or. & scale	4, 5, 6
	lca**m**d02	Sp2/3/4, top, env	1993-2004		Station coordinates	7
	lca**w**d01		10-12 2002	EGM96	TRF Or. & scale	5
	lca**w**d02	Sp2/3/4, top,env	-id-	GRIM5-C1	TRF Or. & scale	5
	lca**w**d03		-id-	GGM01C	TRF Or. & scale	5
	lca**w**d04		-id-	GGM01S	TRF Or. & scale	5
	lca**w**d05		-id-	EIGEN-01S	TRF Or. & scale	5
	lca**d**d01		10-12 2002	EGM96	Orb. diff. (4)	5
	lca**d**d02		-id-	GRIM5-C1	Orb. diff. (4)	5
	lca**d**d03	Sp2/4/5,top,	-id-	GGM01S	Orb. diff. (4)	5
	lca**d**d04	env, jas	-id-	EIGEN-01S	Orb. diff. (4)	5
DORIS INASAN (Russia) S. Tatevian S. Kuzin	ina**m**d01	Sp2/3/4, top	1999-2002	JGM-3	TRF Or. & scale	4
	ina04**w**d01	Sp2/3/4, top	1999	JGM-3	TRF Or. & scale	5
Comparison: SLR ASI (Italy) C. Luceri	SLR(ASI)	Lageos 1 & 2	1993-2003 (weekly)		TRF Or. & scale (5)	6

Notes:

1. “d”, “w” or “m” in the solution name indicate time intervals of one day, one week or one month.
2. Unconstrained time series ignwd03 referred to ITRF2000 with the CATREF software.
3. Unconstrained time series ignwd04 referred to ITRF2000 with the CATREF software.
4. Helmert transformation parameters of orbital planes wrt to those referred to GGM01C.
5. Unconstrained time series referred to ITRF2000 with the CATREF software.

8.3 ANALYSIS TOOLS

8.3.1 CATREF DATA MODELLING AND ANALYSIS

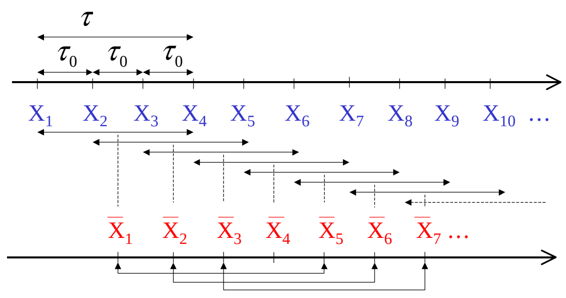
CATREF is a TRF combination software developed at the ITRS Product Center of IERS (Altamimi et al., 2002). It is used here for referring a time series of sets of station coordinates derived from space-geodetic techniques in a free network approach. The datum of the time series of coordinates is set to ITRF2000 (Altamimi, Z., Sillard, P., Boucher, C., Feissel-Vernier, M., 2004. IERS Technical Note 31) by aligning the Helmert transformation parameters and their time derivatives for a subset of well observed reliable stations. The combination makes use of the variance-covariance matrices of the individual sets of stations coordinates. This process provides a unified series of TRFs, where the individual station velocities are not directly constrained by the ITRF2000 one, and a series of translation, scale and rotation parameters that can be used to study the global behavior of the DORIS terrestrial reference frame. The series obtained in this way are marked in table 2. The other series were aligned by the IDS Analysis Centers themselves, using a similar technique.

8.3.2 EXTRACTING SEASONAL AND LOW FREQUENCY COMPONENTS: THE CRONO_VUE ALGORITHM

Crono_Vue is a time series visualizing tool. It extracts from the time series various components, such as trend, cyclic and irregular components. It also analyses the spectral content and performs Allan variance stability analyses. The cyclic components are extracted by numerical filtering. The main output is graphical. Crono_Vue makes use of classical statistical concepts that the reader will find in the papers listed in the references. The software source and documentation, as well as examples of applications, are available through URL http://lareg.ensg.ign.fr/IDS/software.html.

8.3.3 ALLAN VARIANCE

The Allan variance (Allan, D.W., 1966. Proc.IEEE 54, 221) may be defined as follows. Let us consider a stochastic process whose realizations are available at a constant time interval time. For a sampling time (being a multiple of:), we split the measurement time span into sub-samples with length and we write the measurement as $(X_k)_{k=i,i+M-1}, i \in \{1, N-M+1\}$



The average value over these sub-samples is:

$$\overline{X}_{l,M} = \frac{1}{M}\sum_{i=l}^{l+M-1} X_i \ , \ l \in \{1, N-M+1\}, \text{ with } M = \frac{\tau}{\tau_0}.$$

The Allan variance for the sampling time τ is then defined by:

$$\sigma_X^2(\tau) = \frac{1}{2}E[(\overline{X}_{k+M,M} - \overline{X}_{k,M})^2], \text{ with } M = \frac{\tau}{\tau_0}.$$

The Allan variance analysis (see Rutman, J., 1978. Proc. IEEE 66, 1048) allows one to characterize the power spectrum of the variability in time series, for sampling times ranging from the initial interval of the series to about 1/3 of the data span, in particular white noise (spectral density S independent of frequency f), flicker noise (S ~ f -1), and random walk (S ~ f -2). Note that one can simulate flicker noise in a time series by introducing steps with random amplitudes at random dates. In the case of a white noise spectrum, accumulating observations with time eventually leads to the stabilization of the estimated parameter. In the case of flicker noise, extending the time span of observation does not improve the quality of the estimated parameters. A convenient and rigorous way to relate the Allan variance of a signal to its error spectrum is the interpretation of the Allan graph, which gives the changes of the Allan variance for increasing values of the sampling time τ. In logarithmic scales, slopes -1, 0 and +1 correspond respectively to white noise, flicker noise and random walk. The signature of a periodic term is the superimposition of a high for a sampling time around 1/2 of the period, and a low at exactly the period. The size of this added feature is dependent of the relative amplitudes of the periodic component and of the underlying noise.

8.4 THE 2002 ANALYSIS CAMPAIGN

In the context of the DORIS Pilot Experiment, the Central Bureau initiated in 2002 an Analysis Campaign that focused on time series of station coordinates derived from observations of the Spot 2, Spot 4 and Topex/Poseidon satellites. Five Analysis Centers participated: IGN-JPL, LEGOS-CLS, INASAN, CNES/SOD, and CNES-CLS/SSALTO. The data were collected under the form of time series of Sinex files with station coordinates. The analysis made use of the

CATREF software. The data were analyzed in terms of series of coordinates of the origin and scale of the terrestrial reference frame, and the series of station residuals (available at ftp://ftp.cls.fr/pub/ids-cls/camp02). The analysis included also the detection of outliers and the investigation of breaks in the station histories. Table 6 gives an example of global statistics for these time series. The report of the 2002 Analysis Campaign is available at http://lareg.ensg.ign.fr/IDS/events/2002_camp_report.pdf.

Table 6. Station monthly position residuals after taking out stations linear velocities.

	ignmd03 **1993-2002**	**lcamd02** **1993-2002**	**inamd01** **1999-2002**
North (mm)	19	17	20
East (mm)	25	25	29
Up (mm)	19	20	21
3D (mm)	22	22	24

8.5 THE 2003 ANALYSIS CAMPAIGN

Following the release of the first gravity field models derived from the Grace mission in 2003, an analysis campaign was launched to study the impact of the gravity field model on the derived terrestrial and orbital reference frames, and to develop tools for the comparison, validation and combination of terrestrial reference frames. The final report of the campaign is planned to be available at http://lareg.ensg.ign.fr/IDS/events/2003_camp_report.pdf. Partial analyses are also available at http://lareg.ensg.ign.fr/IDS/events/prog_2004.html.

While the time series collected for the previous analysis campaign were produced by the Analysis Centers at monthly intervals, the data available for this one are at weekly intervals. This shorter interval was chosen to meet the requirements of IERS combinations processes. A three-month period (Oct-Dec 2002) was proposed for comparing geodetic results based on five gravity fields. The LEGOS-CLS Analysis Center provided the requested five three-month solutions, and in addition it provided orbital plane comparisons. IGN-JPL provided solutions for only two gravity fields, covering a longer time interval (1993-2002). INASAN provided a three-year time series of TRF origin and scale parameters. Therefore the analyses were extended to all collected solutions.

8.5.1 SENSITIVITY OF ORBITAL REFERENCE PLANE TO GRAVITY FIELD

The impact of the gravity field on the definition of the orbital plane of the satellites was studied. 90 daily orbits were computed over the October-December 2002 time span for Spot 2, 4 and 5, TOPEX/Poseidon, Jason and Envisat, using five different gravity field models: EGM96, GRIM5, EIGEN-GRACE01S (GFZ01S), GGM01S and GGM01C. The differences of orbital reference frames referred to the first four models with those referred to GGM01C were described by time series of their origin coordinates and scale. Differential biases, slopes and periodic components were evaluated. The stability of the origin and scale up to one month was derived for the four gravity fields. As an example, the differences between Jason and Topex/Poseidon orbital origins are found to stay under 1.5 mm and 5mm/90d in rate. The scale differences stay under 0.03 ppb and 0.15 ppb/90d in rate. The scale differences between gravity fields show a 60-day periodic component with amplitude between 0.02 and 0.25 ppb. Table 7 gives the average over the six satellites of the relative biases found for the four gravity field models considered.

Table 7. Average orbital planes differences over the six DORIS satellites for various gravity field models. Observing period: Oct-Dec 2002. Reference gravity field model: GGM01C

	Origin (mm)						Scale (ppb)	
	Standard Deviation			Bias (2002.9)			Std Dev	Bias
	Tx	Ty	Tz	Tx	Ty	Tz		(2002.9)
EGM96	3.6	2.9	3.6	1.2 +- .4	0.2 +- .3	0.6 +- .4	0.20	0.05 +- .02
GRIM5	2.7	2.7	3.5	1.5 +- .2	-2.3 +- .2	-3.2 +- .2	0.18	-0.17 +- .01
GFZ01S	1.5	1.2	1.6	-0.5 +- .2	-0.4 +- .1	0.9 +- .2	0.06	0.00 +- .01
GGM01S	1.8	1.5	1.6	-0.9 +- .1	-0.9 +- .1	0.1 +- .2	0.21	-0.10 +- .01

8.5.2 SCALE OF THE DORIS TERRESTRIAL REFERENCE FRAMES

The scale of the DORIS TRFs are compared with the ITRF2000 scale, which is based on the most reliable SLR and VLBI solutions. The differences are listed in table 8. The differences amount to a few ppb, with a remarkable difference of sign depending on the analysis package used. The reason for this difference is under investigation. The discrepancies between linear trends may be associated with different performances of the techniques used to refer the time series of unconstrained TRFs to ITRF2000.

Table 8. Biases at 1997.0 and trends in time series of TRF scale. Weighted residuals (WRMS) are computed after taking out the seasonal component, except for the ina04wd01 time series. The reference is not ITRF2000 but just a mean between LCA and IGN solutions.

Time series	Time span	Analysis software	Gravity Field	Bias (ppb)	Linear trend (ppb/yr)	WRMS (ppb)
lcamd02	1993-2002	GINS-DYNAMO	GRIM5-C1	+3.1	-0.37	0.7
ignwd02	1993-2003	GIPSY-OASIS	EGM96	-3.3	-0.09	0.6
ignwd05	1993-2004	GIPSY-OASIS	GGM01C	-3.3	-0.10	0.6
ignwd04	1993-2004	GIPSY-OASIS	GGM01C	-2.7	-0.05	0.7
inawd01	1999-2002	GIPSY-OASIS	JGM-3	-3.9	+0.17	+1.7

In addition, as shown on figure 13, the IGN solutions have a distinct annual signature, at the level of 0.8 ppb peak to peak with a slow time variation. The two IGN solutions shown were referred to ITRF2000 using the CATREF method, and are based on two different gravity fields, EGM96 and GGM01C. The change of gravity field model affects only weakly the amplitude. The corresponding series ignwd03 and ignwd04 (not shown), that were attached to ITRF2000 by the Analysis Center, show the same signature. The LCA series, based on the GRIM5-C1 gravity field model, has a weak annual signature, with some interannual variations which are less present in the IGN solutions. We may again make the hypothesis that these systematic differences are associated with the software package.

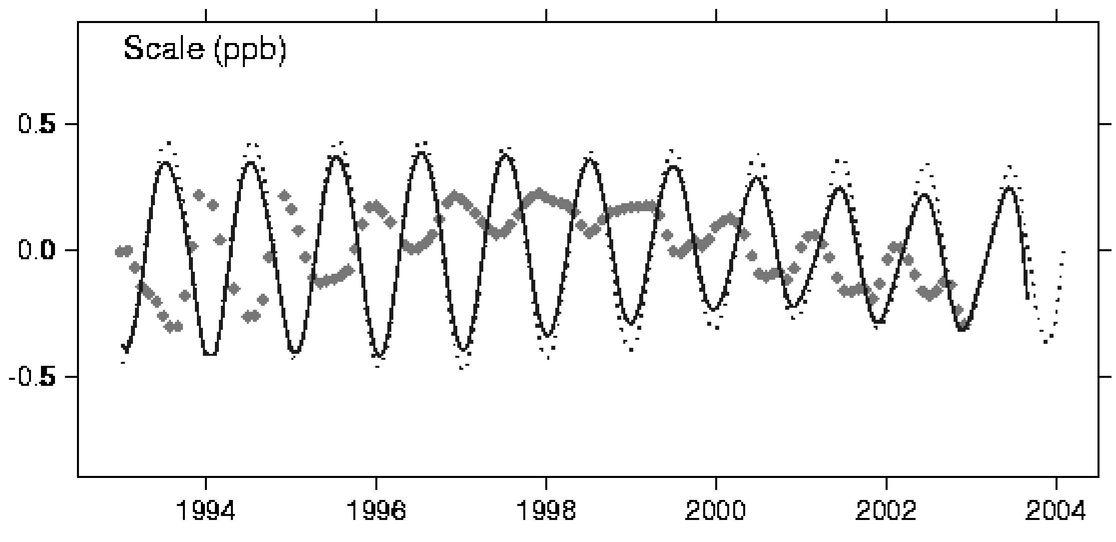


Figure 13. Annual component of TRF scale measured with DORIS. Source: report on the 2003 Analysis Campaign, Feb. 2005. Diamonds: lcamd02; dotted line: ina04wd01; solid line: ignwd05.

Figure 14 shows the behavior of the TRF scale time series under a spectral viewpoint, using the Allan graph description. The INA series has a higher level of noise, in agreement with the statistics of table 6. An annual component signature is slightly visible, in a white noise context. The IGN spectrum is similar, with better visibility of an annual term, which is consistent with the data in table 9 and figure 13. Its scale stability reaches 0.2 ppb for a one year sampling time. The LCA spectrum is a characteristic flicker noise one, reflecting long term drift that may be associated with the method used to refer the series to ITRF2000.

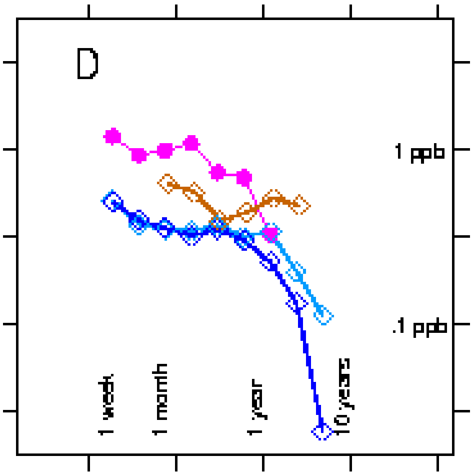


Figure 14. Spectral content of DORIS time series of TRF scale. Color code: pink: ina04wd01, brown: lcamd02, light blue: ignwd03, blue: ignwd05. A slope equal to -1 is the signature of white noise.

8.5.3 SENSITIVITY OF TERRESTRIAL REFERENCE FRAMES TO GRAVITY FIELD AND TO ANALYSIS CENTER

From the 13 weeks over October-December 2002, IGN-JPL provided two free-network solutions and LEGOS-CLS provided five loose constraint solutions (see table 5). Table 9 shows the quality of the TRF parameters adjustment in the CATREF combination per solution. Each series is expressed in ITRF2000 by application of the minimal constraint equation. One can see that GGM01C provides much smaller residuals in the IGN solutions compared to EGM96. The difference is not so important in the LEGOS -CLS solutions. A possible explanation is that EGM96 model is truncated in IGN solutions. The comparisons of the TRF parameters also show significant differences on the Z-translation and the scale factor between IGN EGMG6 and GGM01C solutions. GGM01C always gives the best adjustments, slightly better than GRIM5. Note that some weeks presents rms residuals around 5 mm, which was not yet achieved.

Table 9. Post fit weighted rms residual on station coordinates (mm) from TRF time series combinations.

Gravity field	LCA	IGN
EGM96	**15.5**	**21.2**
GGM01C	**na**	**15.6**
GGM01S	**13.3**	**-**
GRIM5	**14.9**	**-**
EIGEN-GRACE01S	**na**	**-**

Extensive comparisons of series of TRFs obtained by the above mentioned Analysis Centers were performed, considering linear trends, annual and interannual signals. Table 7 summarizes the order of magnitudes of the differences that could be attributed to gravity field model, datum definition technique and general analysis strategy, connected either to the software or to its use.

Table 10. Variability of times series of DORIS TRFs

Parameter	***Gravity field***	***Datum definition***	***Software & Analyst***
Origin (Equatorial)			
Annual amplitude	**1** mm	**1** mm	**5** mm
Interannual	**1** mm	**1** mm	**3** mm
Trend	**0.4** mm/yr	**1** mm/yr	**1.5** mm/yr
Origin (Axial)			
Annual amplitude	**1** mm	**10** mm, **variable**	**15** mm
Interannual	**4** mm	**4** mm	**4** mm
Trend	**0.1** mm/yr	**0.2** mm/yr	**6** mm/yr
Scale			
Annual amplitude	**0.1** ppb	**0.3** ppb, **variable**	**0.5** ppb, **var.**
Interannual	**0.05** ppb	**0.05** ppb	**0.25** ppb
Trend	**0.01** ppb/yr	**0.05** ppb /yr	**0.6** ppb /yr

8.6 DORIS OBSERVED GEOCENTER MOTIONS

The motion of the Earth's centre of mass (geocenter) with respect to a conventional terrestrial reference frame attached to the crust is usually described by time series of the coordinates of the origin of the individual data sets derived from SLR, DORIS or GPS. This approach uses the geocentric character of the dynamical modeling of satellite observations. The SLR observations of the geocenter motion are considered to be the most accurate in the field. They are used here for comparison purposes.

On the other hand, the available data and models of mass motions in the atmosphere, ocean and ground waters can be used to derive the expected motion of the total Earth centre of mass. We compare here the observed time-series of Doris and SLR geocenter components with the ones computed from such model outputs.

We summarize hereafter results of comparison of DORIS measurements with SLR and with geophysical expectations from the surface fluid reservoir contributions, in terms of seasonal components and spectral behavior.

8.6.1 SEASONAL SIGNAL

All components of the geophysically predicted geocenter signal are dominated by a seasonal signature. These components are not all in phase, resulting in a total seasonal motion of similar amplitudes, 1 cm peak to peak, when projected on the usual Cartesian geocentric reference axes. Figure 5 show the annual component of DORIS, SLR, and geophysical time series extracted by the Crono_Vue technique, for the time interval where all series were available.

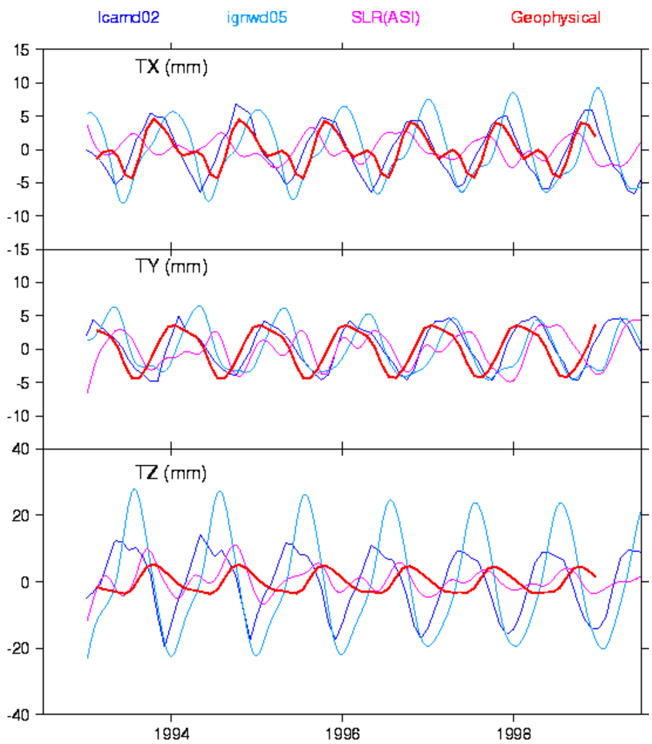


Figure 15. Annual component of series of the TRF translation parameters. Color code: blue: LCA (Doris), light blue: IGN (Doris), pink: ASI (SLR), red: geophysical.

The observed geodetic seasonal signals show some large differences between DORIS solutions and between DORIS and SLR or the geophysical signal. The phase differences are probably a mechanical effect of the superimposition of an annual systematic error to the geophysical signal. The following general features are seen.

- In Tx, the SLR signal includes a semi-annual component comparable to that present in the geophysical signal. The latter originates from the atmosphere and ocean contributions, combined with a slight phase shift of the ground waters one.

- The amplitudes of all signals in Ty are of similar amplitudes. Note a slow amplitude increase in Tx and a slow decrease in Ty in the case of the IGN solution.
- In the Tz direction, the amplitudes of both DORIS signals are much larger than expected from geophysical data, and the amplitudes of the IGN and LCA series differ by nearly a factor of two. The SLR signal has an amplitude compatible with the geophysical expectation.

8.6.2 SPECTRUM

Figure 16 shows the behavior of the TRF origin time series under a spectral viewpoint, using the Allan graph description. The four DORIS solutions have similar signatures in the equatorial plane components: the seasonal signature is imbedded in a noise with a spectrum close to white noise, with the exception of the IGN solutions, which show a long term drift signature for sampling times longer than two years. The DORIS Tx and Ty components reach a stability of ~2 mm for a one-year sampling time. The spectrum of the Tz variations is quite noisier than those in the equatorial plane, with poor long term stability, except for INA. In all three components the spectral power of the DORIS signal remains higher than that of the geophysical signal.

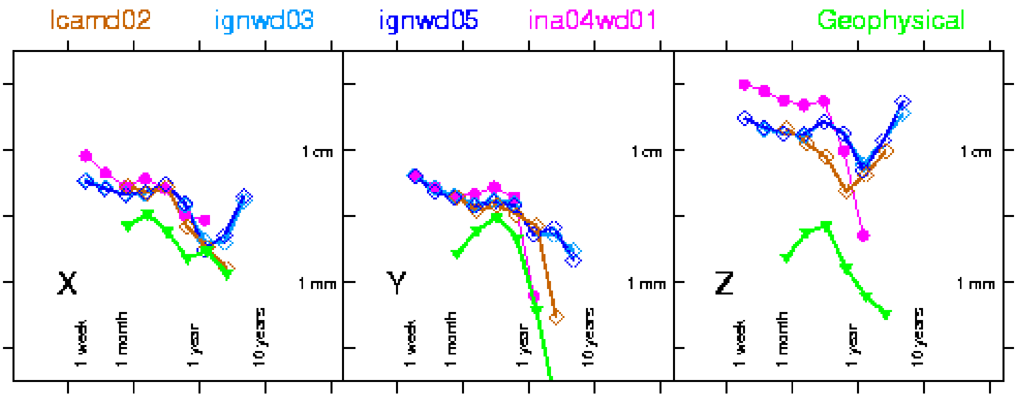


Figure 16. Spectral signature of geocenter motion observed with DORIS, SLR and expected from geophysical data. Color code: pink: ina04wd01, brown: lcamd02, light blue: ignwd03, blue: ignwd05, red: geophysical. A slope equal to -1 is the signature of white noise.

8.7 ANALYSES OF STATION STABILITY

Time series of DORIS station coordinates go back to 1993. They are provided at weekly or monthly intervals as series of Cartesian coordinates in some defined geocentric terrestrial reference frame. The major signature in time series of station coordinates is usually modeled as a tri-dimensional linear drift in the local directions to the East, North and Up. The horizontal component is mostly related with the tectonic plate motion, while the Up component is assumed to reflect uplift or subsidence. Seasonal signatures are often present. The non linear signal may be analyzed as noise related to local geophysical phenomena, instrumentation, or to the analysis strategies and modeling. Various quality criteria may be considered to identify and characterize these effects. We show here examples based on the Allan variance. More detailed stability studies, using in particular Principal Component Analysis in the time domain, are being prepared for publication in refereed journals.

We consider here two sets of DORIS station coordinates, described in table 2: ign03wd01 at weekly intervals over 1993-2004 and lcamd02 at monthly intervals over 1993-2004. Their stability is characterized by two parameters, as follows.

- The Allan standard deviation for a one-year sampling time. The latter is chosen as a compromise between long term qualification and robustness of the estimate, which requires time series that are long enough with respect to the investigated sampling time. As the theory says that the Allan variance is insensitive to cyclic components for sampling times that are multiples of the cycle length, the choice of a one-year sampling time frees the stability estimation from residual seasonal errors.
- The slope of the Allan graph, giving the linear dependence of the Allan variance on the sampling time in logarithmic scales. A slope equal to –1 is the signature of white noise. A slope equal to 0 is the signature of flicker noise.

Figure 17 shows a comparison of the stability performances of the IGN and LCA solutions, considering 30 common stations with an observing time span longer than 6 years between 1993.0 and 2005.0. The Fairbanks and Arequipa series are not considered. The noise spectrum is consistently qualified as white noise in both solutions, an indication of long term stability of DORIS measurements. The level of noise for a one-year sampling time is loosely correlated between the two solutions, LCA being more stable in the East direction, and IGN being more stable in the North and Up directions. This suggests that there is still room for improvement in both analyses.

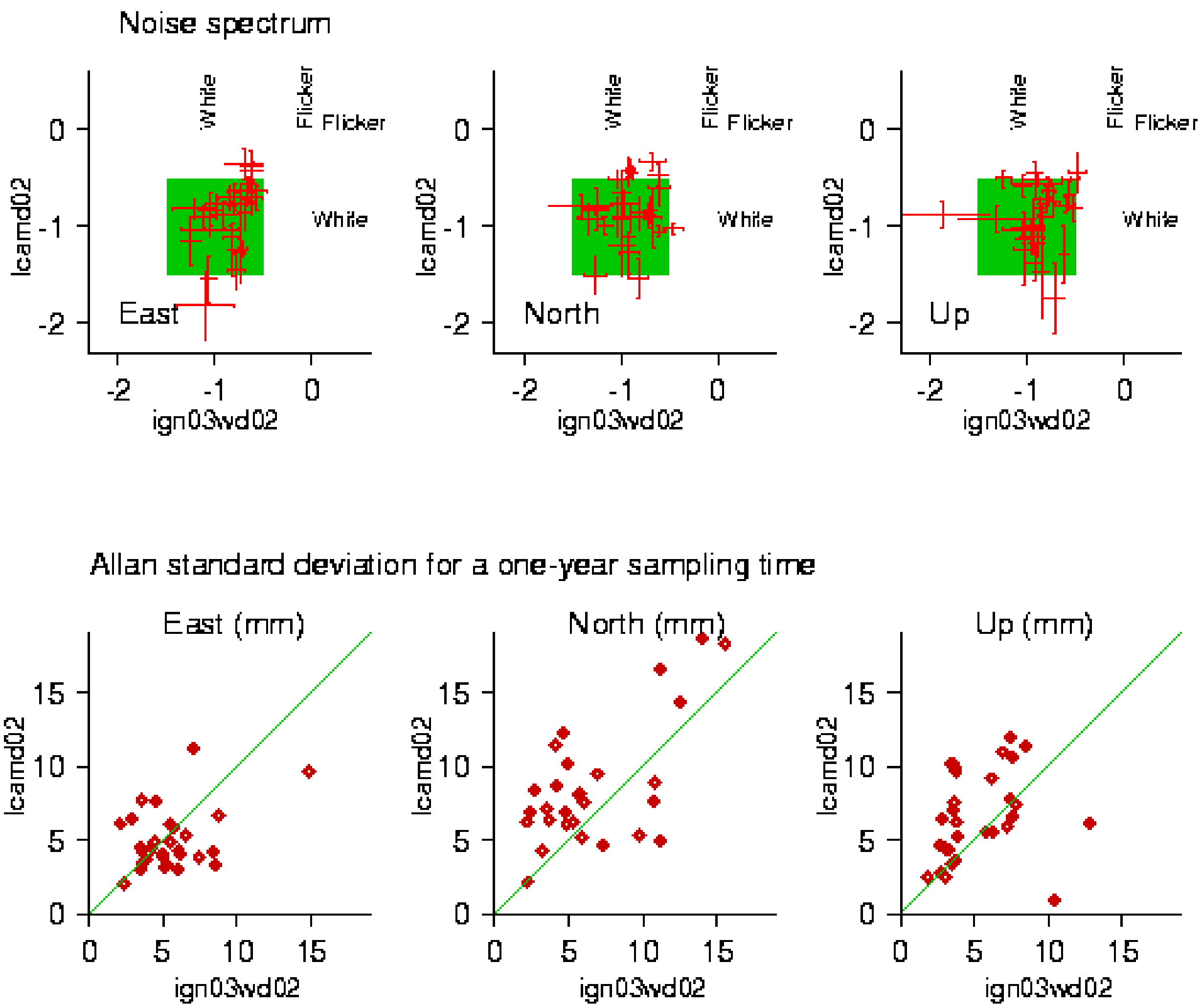


Figure 17. Spectral signature and stability of the non linear, non seasonal, motion in the local frame derived from Doris station coordinates time series over 1993-2004. Upper part: noise spectrum as determined by the Allan variance graph slope. Values in the central square may be considered as white noise. Lower part: Allan standard deviation for a one year sampling time. IGN-JPL values are in abscissa, LEGOS-CLS values are in ordinates.

8.8 IDS CONTRIBUTIONS TO ITRF 2005

Table 11. Modelling Summary for IDS Contributions to ITRF2005

	IGN/JPL	CLS/LEGOS	INASAN
Static Gravity	GGM01C (120x120)	GRIM5C1 (95x95 for ENV./SPOT's; 70x70 for TOPEX).	GGM01C (120x120)
Atmospheric Gravity	Not applied	Applied from ECMWF atmospheric pressure (6h 3D grids) over land, inverted barometer model over oceans	Not applied

Earth GM Value	GGM01C	GRIM5C1	GGM01C
Time-Variable Gravity	GGM01C	GRIM5C1	GGM01C
Ocean Tides		FES2002	FES2002
Ocean Loading	FES2002	FES2002	FES2002
Earth Tides	IERS2003	IERS2000	IERS2003
Precession/Nutation	Precession: IAU 1976 Nutation: IAU 1980	Precession: IAU 1976 Nutation: IAU 1980	Precession: IAU 1976 Nutation: IAU 1980
Atmospheric Drag	DTM94	DTM94	DTM94
Albedo/IR	Not applied	Applied using 4.5° radiance grids from ECMWF	Not applied
A priori station coordinates	IGN04D02, Updated continuously.	ITRF2000 Updated continuously with IGN DORISmails.	IGN04D02, Updated continuously.
Elevation cutoff	Before 18-9-2005: None After 18-09-2005: 15°	12°	None
Pole Tide	applied	applied	applied
Nonconservative Forces-macromodel.	CNES	CNES	CNES
Satellite & Ground Antenna Offset Corrections	Applied from DORIS data.	Applied from DORIS data for data after Dec 28 2003 (computed before this date) except ENVISAT (applied from DORIS data since mission start)	Applied from DORIS data.
EOP (*a priori*)	Bulletin B	Bulletin B	Bulletin B
Arclengths	Data: 24 hr; Arclength: 30hrs	3.5 days	Data: 24 hr; Arclength: 30hrs
Drag Parameters adjusted per arc	Cd/6-hrs (SPOTs and ENVISAT). None for TOPEX. Adjust 1 constant accels. along-track per arc (30hr) for TOPEX	Cd/4-hrs (ENV. Spots); Cd/12-hrs (TOPEX).	Cd/6-hrs (SPOTs and ENVISAT). None for TOPEX. Adjust 1 constant accels. along-track per arc (30hr) for TOPEX
Opr Parameters adjusted per arc	Along & cross-track per 30-hr arc.	Along & cross-track /arc (SPOTs, Topex) /day (ENVISAT)	Along & cross-track per 30-hr arc.
Troposphere Scale Adjustment	Per satellite-station pass, with time constraints (Willis et al. 2005)	Per satellite-station pass.	Per satellite-station pass, with time constraints (Willis et al. 2005)
Constraints for Coordinate and EOP Solutions	10 m X,Y,Z 5 m polar motion 5 mas/d pole rate	10 m X,Y,Z 500 mas polar motion	10 m X,Y,Z 5 m polar motion 5 mas/d pole rate
Software Used	Update to GIPSY/OASIS 4.0.3	GINS 4.1 (GINS 6.1 for data from 2006.01)	GIPSY/OASIS 4.0.3 (Linux version)

For LCA: Atmospheric loading applied from 6 hours ECMWF 3D pressure grids

9 REPORT OF THE IGN/JPL ANALYSIS CENTER

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9.1 CONTEXT

The Institut Géographique National and the Jet Propulsion Laboratory, California Institute of Technology have joined their efforts to develop an International DORIS Service (IDS) Analysis Center (AC) based on the use of the GIPSY/OASIS II software. DORIS data from all available satellites are regularly processed and DORIS products are sent to the IDS Data Center at NASA/CDDIS.

This report summarizes the different products generated by the IGN/JPL AC since the official beginning of the IDS in July 2003 and summarized in Table 11.

Table 12. List of IGN/JPL products delivered at the International DORIS Service (March 22, 2006).

Product	Latest version	Frequency	Delay	Number of files
Weekly sinex - free-network - ITRF2000	 ignwd04 ignwd05	 weekly weekly	 4-8 weeks 4-8 weeks	 683 683
Geocenter	ign03wd01	1 (updated weekly)	4-8 weeks	1
EOP series	ign03wd01	1 (updated weekly)	4-8 weeks	1
Cumulative solution	ign04wd01 ign04wd02	1 per year 1 per year	Up to 1 year Up to 1 year	1 1

Detailed description of present and previous IGN/JPL IDS products can also be found at:

ftp://cddisa.gsfc.nasa.gov/pub/doris/products/sinex_global/ign.snx.readme

9.2 WEEKLY DORIS SOLUTIONS

All products are based on the weekly free-network solutions (obtained themselves by combination of daily results from all DORIS satellites except Jason because of the SAA effect).

Since late 2003, the GIPSY/OASIS software has been fully automated to process all new DORIS data at CDDIS, to generate all the products and to deliver them to CDDIS in a timely manner (within 1 day and without any human supervision). Figure 18 shows that the product delivery now follows closely the availability of ENVISAT data (latest DORIS data delivered at CDDIS).

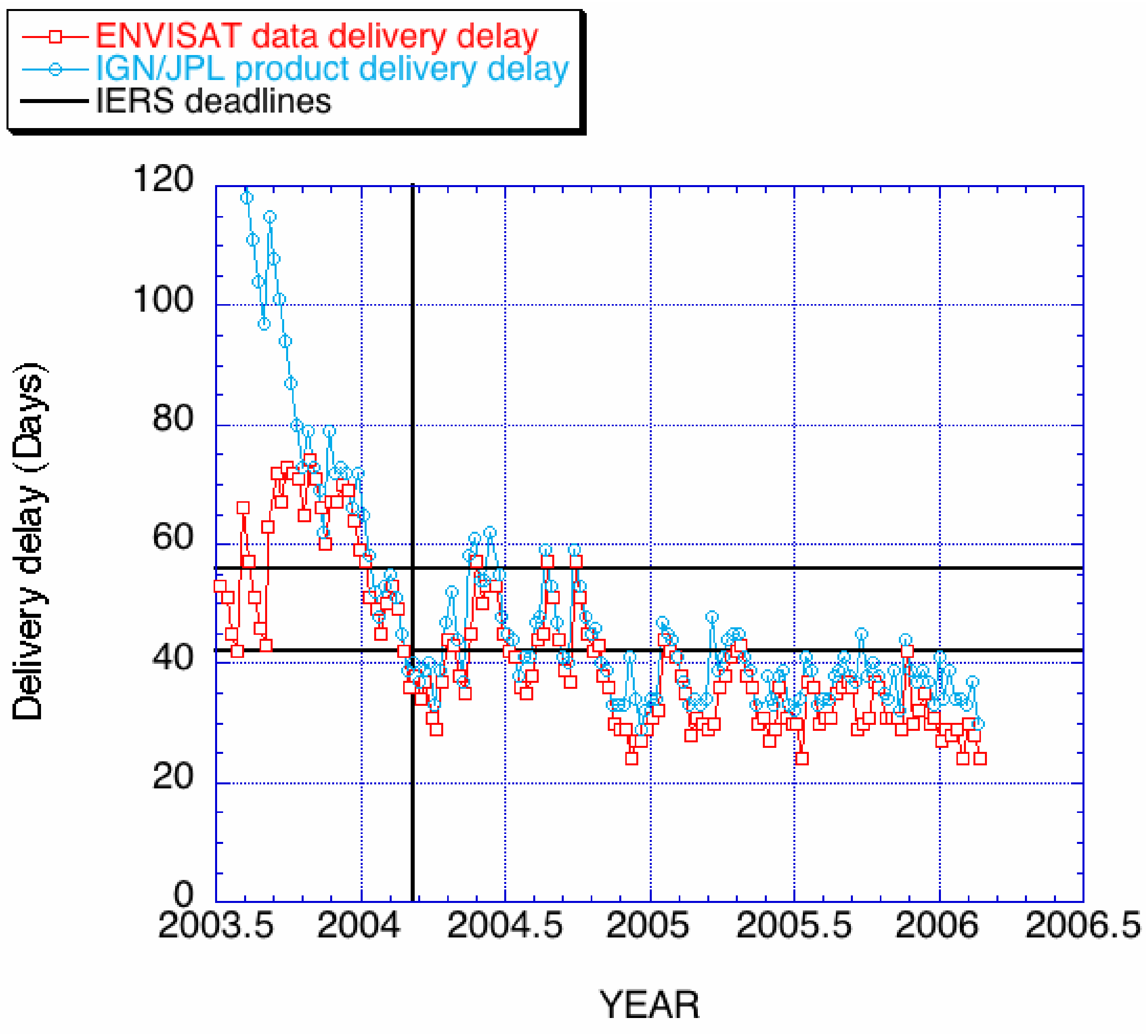

Figure 18. Delivery delay of DORIS/ENVISAT data at CDDIS and delivery delay of IGN/JPL IDS products (First submission, as March 22, 2006).

The free-network SINEX solutions are also delivered to the IERS (Combination Pilot Project), respecting the 6 to 8 weeks deadline since very beginning in March 2004. For each week, a summary file provides information on the actual data processed. The summary files are also delivered as DORISReports.

Best results with 5 satellites show now a 10 to 15 mm agreement with long-term solutions (DORIS internal cumulative solution).

For other users, we also provide sinex solutions directly expressed in ITRF2000 as well as very recently stcd files (differences of coordinates in ITRF2000 toward a specific reference) (see DORISMail #357).

All these weekly products are delivered usually the day of availability of the DORIS data (on average once a week), with the proper documentation.

9.3 DERIVED PRODUCTS. GEOCENTER, EOPS AND CUMULATIVE SOLUTIONS

Geocenter series is derived directly from the weekly solutions and the file (ign03wd01) is updated with every weekly submission. Annual signals are highly visible and artifact effects at 120-day frequency were removed from previous submissions due to improved data processing (solar pressure on TOPEX).

Earth Orientation Parameters time series is also updated weekly. Latest results with five satellites now show agreement with GPS at 1.6 mas in X and 1.0 mas in Y or better.

In 2004, we have derived two DORIS cumulative solutions: ign04wd01 that is a direct combination of all free-network solutions from 1993.0 to 2004.8 and ign04wd02 which is the same combination but including DORIS-DORIS local ties provided by IGN/SIMB (using proper weighting), projected and transformed in ITRF2000. ign04wd02 can be seen as the latest realization of the ITRF2000 for the DORIS network. To improve accuracy, several improvements were made in this submission such as better handling of station discontinuities or data screening. The estimated accuracy is around 10 mm or less for station positions and 2 mm/yr for the best stations compared to external results (GPS).

9.4 CONCLUSIONS

Since the start of the International DORIS Service, the IGN/JPL is the only Analysis Center to deliver a wide range of DORIS products in a timely and efficient manner.

Acknowledgement

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

10 REPORT OF THE LEGOS/CLS ANALYSIS CENTER

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Anny Cazenave (2), Jean-Jacques Valette (1)

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10.1 SUMMARY

The LEGOS 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 developed by the GRGS (Groupe de Recherche en Géodésie Spatiale).

The 2003-2004 activities of the LEGOS/CLS Analysis Center (LCA) were devoted to the definition of a new analysis strategy and the complete processing of the DORIS data available since 1993. In 2005, all the data available until Oct. 2005 were processed.

Series of weekly free-network solutions for station coordinates and pole parameters are delivered to the IDS, as well as stcd files of coordinate differences.

10.2 DATA PROCESSING

In 2003, a computation strategy was defined to meet the IDS requirements, and to take into account the improvements brought to the GINS/DYNAMO software during the two previous years. Data are now processed on 3.5-day arcs and weekly solutions are obtained from the combination of two arcs.

The version of GINS used for the new processing includes corrections of the model of DORIS measurement function. Medium and long terms of the onboard frequency were implemented, and the troposheric correction reviewed. Models for the new satellites Jason, Spot-5 and Envisat launched late 2001 and mid 2002 were added.

New models were evaluated. In particular, the first versions of the GRACE gravity models from GFZ and CSR were compared to GRIM5-C1 and EGM96. Finally, we chose to keep GRIM5-C1, as in the previous configuration. We found indeed that GRIM5-C1 is at the same level of performance as the GRACE models, the contribution of the GRACE measurements being slight at the altitude of the DORIS satellites (830 and 1300 kms). Compared to EGM96, an important gain is obtained (up to 4% on the Doppler residuals, 2 to 4 mm on the laser residuals, up to 1 mm in weekly positioning repeatability).

Historically, our group used to process data using a CNES internal format. The processing of the public format 2.1 is now possible from the version 4.1 of GINS. We chose to use the data available in this format at the CDDIS for the whole Envisat mission. For the other missions, we used the internal CNES format for the period 1993-2003, and we started to use the 2.1 format for the data acquired after Dec. 28, 2003.

In 2004 and 2005, we processed with this strategy all the data (1993-2005) of all the DORIS satellites (except Jason because of the SAA effect).

10.3 PRODUCTS DELIVERED TO IDS

Weekly free-network solutions of station and pole coordinates are generated in the SINEX format. Several series were provided to the IDS. Each submission is an improved version of the previous one (see ftp://cddis.gsfc.nasa.go/pub/doris/products/sinex_series/lcawd.snx.readme.txt)

The series lcawd12 covers the whole period 1993.0-2006.0. Its main characteristics are:

- station coordinates solution with loose constraints (10 meters)
- daily pole coordinate with loose constraints (10 mas)
- Spot2, Spot4, Spot5, Envisat and Topex data (1993-2005)

Detail description can be found at:

ftp://cddis.gsfc.nasa.go/pub/doris/products/sinex_series/lcawd/lcawd12_snx_dsc.txt

The series lcawd12 replaces the series lcawd11 that was delivered to the CDDIS in Oct. 2004 but was removed after that a large scale factor anomaly was discovered.

Monthly stcd files are also delivered. They give differences of coordinates at the observation epoch. Monthly solutions are performed using minimal constraints and expressed in ITRF2000. The reference positions are from a cumulative solution over 1993/01/01-2004/12/31 also performed using minimal constraints and expressed in ITRF2000.
See description in ftp://cddis.gsfc.nasa.gov/pub/doris/products/stcd/lca.stcd.readme.

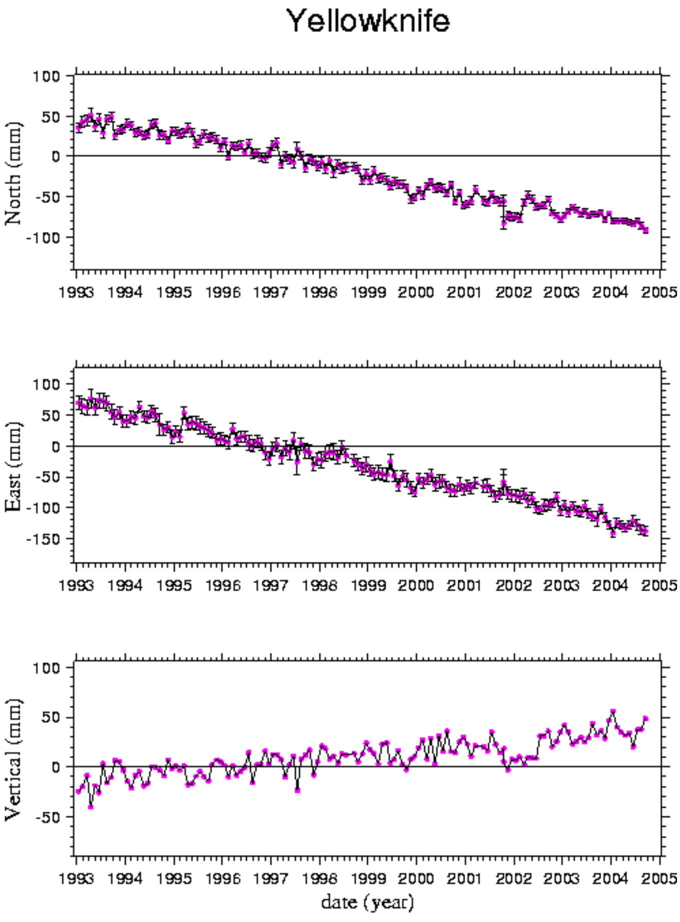

Figure 19. Coordinate time series of Yellowknife (Canada)

10.4 CAMPAIGN « GRAVITY FIELD COMPARISON »

In 2003, the Analysis Center participated to the IDS analysis campaign “Gravity field”. We provided two series (with and w/o Jason) of weekly position solutions over three months for each of the following gravity fields: GRIM5-C1, EGM96, the GFZ GRACE model EIGEN-GRACE01S (GFZ01S), and the two CSR GRACE models GGM01S and GGM01C.

In addition, we provided orbital plane comparisons that were analyzed by the Analysis Coordinator (see Analysis Coordinator’s report).

Table 13. List of the LCA sinex series provided for 2003 analysis campaign.

Satellites used	EGM96	GRIM5-C1	GGM01C	GGM01S	GFZ01S
Sp2/4/5,Top,Env, Jas	lca02wd01	lca02wd02	lcawd03	lcawd04	lcawd05
Idem w/o Jason	lca02wd06	lca02wd07	lcawd08	lcawd09	lcawd10

10.5 PARTICIPATION TO THE GRGS CRC FOR THE IERS

The Analysis Center, as DORIS data processing center with GINS, participates to the Combination Research Center (CRC) set up by the GRGS in the frame of the IERS combination campaign. The objective of the CRC is the processing of the geodetic techniques DORIS, GPS, VLBI and SLR as well as LLR with the GINS software using the same computation configuration, and the combination by the DYNAMO tool in order to realize the terrestrial and celestial reference systems. After a preparation phase in 2004, the GRGS/CRC started in 2005 its participation to the IERS Combination Pilot Project. LCA provided DORIS weekly matrices over 2005 to the CRC for combination and analysis. They include stations coordinates and velocities, EOP, precession and nutation.

11 REPORT OF THE INASAN ANALYSIS CENTER

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11.1 INTRODUCTION

After establishment an International DORIS Service (IDS) in 2003 the Institute of Astronomy Russian Academy of Sciences is operating as one of the DORIS Analysis Center (AC). The processing of the DORIS data is performed with the use of the GIPSY/OASIS II software developed by JPL. All satellites data (except Jason because of the SAA effect)available at the moment of measurements are included in the computation.

Table 13 summarizes current products delivered by INASAN to the IDS.

Table 14. List of INASAN products provided for IDS (May 2006)

Product	Latest version	Span
Sinex weekly	inawd03	1992.8 - 2005.0
Geocenter	ina05wd02	1992.8 - 2004.4

The files of the products description can be found at:

1) sinex series

ftp://cddis.gsfc.nasa.gov/doris/products/sinex_series/inawd/inawd03.snx.dsc

2) geocenter

ftp://cddis.gsfc.nasa.gov/doris/products/geoc/ina05wd02.geoc.dsc.

11.2 PRODUCT AND ANALYSIS RESULTS DESCRIPTIONS

The basis for all products is weekly free-network solutions, which obtained after merging daily free-network solutions. Each sinex weekly file contains stations coordinates and EOP. After transformation of the free-network solutions into a well defined reference frame (ITRF2000) standard deviations of station coordinates are estimated at the level of 0.5-5.0 cm depending on the number of satellites in the solution. RMS of the X-pole and Y-pole are estimated as 2.83 (mas) and 1.70 (mas), respectively, over 2000-2004 regarding to C04 solution (D.Gambis,M.Sail, T.Carlucci "Combination of Polar motion parameters series obtained from DORIS",IDS workshop, Venice, 13-15 March 2006).

Annual geocenter variations were derived by least squares method and were estimated as 5.5+-0.3 mm, 4.3+-0.3 mm, 23.7+-1.2 mm, for X, Y and Z components, correspondingly (relatively to ITRF2000).

X and Y components of the geocenter variations, derived from DORIS data, have slightly higher amplitudes (compare to SLR solution) and considerably higher for Z component.

12 REPORT OF THE GEOSCIENCE AUSTRALIA/NASA GSFC ANALYSIS CENTER

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(2) Geoscience Australia, Australia

12.1 INTRODUCTION

During 2004 and 2005 the analysis center conducted orbit tests using SLR/DORIS data on satellites carrying DORIS receivers. The tests compared the orbit performance using different gravity models, and assessed the SLR fits of DORIS-only orbits for TOPEX/Poseidon (TP), ENVISAT, and JASON-1. In addition SINEX files were developed after analyzing the DORIS data for 2004, and these test files were submitted to the CDDIS. The analyses were based on the 0401 and 0407 versions of GEODYN for the orbit tests and data reductions and the 2002 versions of SOLVE for the reduction of the normal equations. Other utilities were created to transform the SOLVE output to the SINEX format. The orbit and gravity model tests were done while FGL was a visiting scientist at Geoscience Australia.

12.2 GRAVITY MODEL TESTS (DESCRIPTIONS)

The purpose of these tests was to assess the new generation of gravity models, and determine which might be the best for use in the analysis of DORIS and SLR data. The gravity models tested included those developed from the CHAMP and GRACE missions, as well as historical models that have been in use in the community since the mid 1990's. These include JGM-3[Tapley et al., 1996] which has been used to compute the precise orbits for TOPEX/Poseidon, EGM96 [Lemoine et al., 1998], DGM-E04 [Scharroo et al., 1998] a tuned model derived from EGM96. The full list of tested models is provided in Table 1, together with the maximum degree and order of the model.

The modelling for the orbit tests included all the gravity models to 90x90, with the exception of JGM-3, DGME04, and EGM96 which were included only through 70x70. Each model applied the appropriate reference radii, and Earth gravitational constant (GM), as well as the time-varying coefficients intrinsic to the each field (C20-dot, C21-dot, S21-dot, C30-dot, etc.). The earth and ocean tide modelling were held fixed to a derivative solution from EGM96, and included k2=0.29, k3=0.09 and special modelling for the free core nutation (see Lemoine et al., 1998 for a detailed description). We note these orbit tests were carried out before the IERS2003 standards were fully implemented in GEODYN. The station coordinates applied were derived from ITRF2000, with corrections to some of the SLR and DORIS stations as applied by the Topex precise orbit team at NASA GSFC (Zelensky, 2004, personal communications). The atmospheric drag applied was from MSIS86 [Reference et al.]. Ocean loading was derived from the ocean tide model GOT00.3.

The tests with Jason-1 specifically excluded stations heavily affected by the South Atlantic Anomaly (SAA) effects on the Jason-1 oscillator. The DORIS-only orbits used the SLR data only as an independent assessment of the orbit quality. For JASON-1, only the altimeter crossovers were independent. Arclengths were 7 days for TP, 10 days for Jason-1, and 2-7 days for ENVISAT . All arcs adjusted along-track and cross-track empirical accelerations per day. A drag coeffcient (cd) was adjusted per 8 hrs for Jason-1 and TP, and per 6 hrs for ENVISAT.

Table 15. Satellite Test Arc Data Spans

ENVISAT Data Span	(SLR+DORIS): 20 arcs, April 04, 2003 – July 11, 2003; (DORIS-only): July 9, 2002 to July 11, 2003 (51 arcs).
JASON-1 Data Span	(SLR+DORIS+CROSSOVERS) 42 arcs, March 25, 2002 to June 24, 2003.
TP Data Span	(DORIS-only): 18 arcs, Jan 1-June 15, 1997.

12.3 GRAVITY MODEL TESTS (RESULTS)

The results of the orbit tests are summarized in Tables 3-4 for ENVISAT, Jason-1. ENVISAT, being at a lower altitude than TP is a better discriminator of gravity models. Of the pre-CHAMP and GRACE models, GRIM5C1 performs extremely well on the ENVISAT orbit. Of the new generation models, the GRACE models have the best orbit fits. The GFZ and JPL GRACE models perform better than GGM01C and GGM01S for the SLR+DORIS orbit tests. For the DORIS-only orbits, the best orbit fits are with the GGM01C gravity model. For Jason-1, GGM01S yields the best SLR fit in the orbit tests, while GGM01C yields the best (independent) altimeter crossover fits, Since TP is in the same orbit as Jason-1, we analyze only the DORIS-only orbits. The DORIS-only orbits for TP all produce average RMS of fit of about 4 cm. For ENVISAT, the floor on the DORIS-only orbits appears to be about 5.5 cm. The larger fit for the SLR data for the ENVISAT and TP DORIS-only orbits reflects in part the timing bias on the DORIS which is not applied. These tests would suggest that for geodetic analyses, different GRACE models would be optimum for different DORIS satellites. For example the JPL and GFZ models are preferred for ENVISAT, whereas GGM01S is preferred for Topex and Jason-1.

Table 16. ENVISAT Average RMS of fit for test arcs.

Gravity Model	SLR+DORIS orbits		DORIS-only orbits (SLR independent)	
Data	SLR (cm)	DORIS (mm/s)	SLR (cm)	DORIS (mm/s)
JGM3	-----	-----	9.86	0.600
EGM96	4.75	0.587	8.67	0.581
GRIM5C1	2.05	0.561	5.84	0.562
DGME04	3.64	0.574	7.51	0.572
EIGEN3p	5.90	0.584	6.84	0.572
PGS7777B (GSFC)	2.02	0.561	5.71	0.562
GGM01S	2.04	0.561	5.98	0.562
GGM01C	2.05	0.562	5.51	0.562
Grace-Eigen02	1.92	0.560	5.91	0.563
Grace-JPLmean_aprnov2003	1.90	0.560	5.76	0.562

Table 17. Jason-1 Orbit Test Summary

Gravity Model	SLR (cm)	DORIS (mm/s)	Altimeter Crossovers (cm)
EGM96	1.96	0.412	5.822
EIGEN3p	1.73	0.411	5.765
PGS7777B (GSFC)	1.71	0.411	5.801
GGM01S	1.65	0.411	5.749
GGM01C	1.75	0.411	5.745
Grace-Eigen02	1.96	0.411	5.730
Grace-JPLmean_aprnov2003	1.67	0.411	5.737

12.4 SINEX SERIES SUBMITTED TO THE CDDIS

Two solutions, gsc04wd01.snx, and gsc04wd02.snx, were generated as part of a test using data in 2004 to compare solutions between different DORIS analysis centers/data users. This analysis was part of a paper presented at the Vienna EGU 2005 by authors P. Willis, L. Soudarin, F.Lemoine. These solutions are available from the CDDIS.

13 REPORT OF THE OBSERVATORY PECNY ANALYSIS CENTER

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In a cooperation among the AIUB (Astronomical Institute, University of Bern), the GOPE (Geodetic Observatory Pecný) and the IGN (Institut Géographique National), DORIS data analysis capabilities were implemented into a development version of the Bernese GPS Software. The DORIS Doppler observables are reformulated such that they are similar to Global Navigation Satellite System (GNSS) carrier phase observations allowing the use of the same observation models and algorithms as for GNSS carrier phase data analysis with only minor modifications.

Sophisticated dynamical models for non-conservative forces on DORIS carrying satellites are not yet fully available in the current development version. For the experiments, daily orbit arcs were modeled with six Keplerian elements as well as with nine empirical parameters (3 constant and 6 once-per-revolution accelerations) with loose constrains ($1x10^{-6}$ ms-2). Remaining model deficiencies were mitigated by estimating stochastic parameters (equivalent to velocity changes) in radial, along track and cross track directions (only in radial direction for TOPEX). The constrains on the stochastic parameters and the intervals were adapted such that the RMS of the estimated orbits with respect to POE precise orbits was minimized. With stochastic parameters at intervals of 15 minutes, optimum constrains were $6x10^{-5}$ ms-1 for the radial and cross track directions, and $3x10^{-5}$ ms-1 for the along track direction. For TOPEX, no improvement of the orbit was achieved using the stochastic parameters in along track and cross track direction, therefore stochastic parameters were used only in the radial direction. No air drag parameters were estimated.

The results of network and pole estimation of three weeks of DORIS data (September 2004, five satellites) at GOPE are promising and of a slightly lower quality than corresponding solutions routinely computed within the IDS (LCA, IGN). The weekly coordinate repeatability RMS is of the order of 2-3 cm for each station coordinate. Comparison with corresponding estimates of stations coordinates from current IDS Analysis Centers demonstrates closed precision (figure 20). Daily pole components estimates show a mean difference from IERS C04 of 0.6 mas in Xp and -0.5 mas in Yp and standard deviation of 0.8 mas in Xp and 0.9 mas in Yp (mean removed). An automatic analysis procedure is under development at GOPE and routine DORIS data processing is planed to start before the end of the year 2006.

14 CONCLUSION

IDS is a young service (initiated in 2003), involving a small but active international scientific community. During its infancy, the IDS benefited greatly from the experiences learned from the other existing IAG services, the IGS, ILRS, and IVS. The current accuracy of the products is 10 mm with white noise spectrum for weekly station coordinates time series, 5 to 8 mm for monthly station coordinates time series, 5 mm in the equatorial plane and 30 mm in the axial direction for geocenter weekly time series and significantly better than 1 mas for polar motion. Starting in 1993, DORIS offers long stable times series as expected for Terrestrial Reference Frame maintenance and geodynamic studies. Until now, only a few ACs have contributed to IDS. IGN/JPL and LEGOS/CLS have delivered station coordinates for many years, joined more recently by INASAN and Geoscience Australia/NASA/GSFC. At the same time, different other groups are working on DORIS data processing, regularly attend IDS meetings and actively take part in technical discussions. Some of them should be able to contribute soon such as Geodetic Observatory Pecny (Stepanek et al. submitted).

The combination of DORIS results started recently to derive a real IDS-product (multi-solution, accuracy, integrity) as a new contribution to ITRF and GGOS in the same way as other services.

15 PUBLICATIONS (2003-2005)

15.1 PEER-REVIEWED PUBLICATIONS

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