



Presentation of the DORIS system and the International DORIS Service

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International Workshop for the
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The DORIS system



What is DORIS?

DORIS stands for

- 🇬🇧 Doppler Orbitography and Radiopositioning Integrated by Satellite
- 🇫🇷 Détermination d'Orbite et Radiopositionnement Intégrés par Satellite
- 🇪🇸 Determinación de Órbita y Radioposicionamiento Integrados por Satélite
- 🇵🇹 Determinação de Órbita e Radioposição Integrado por Satélite

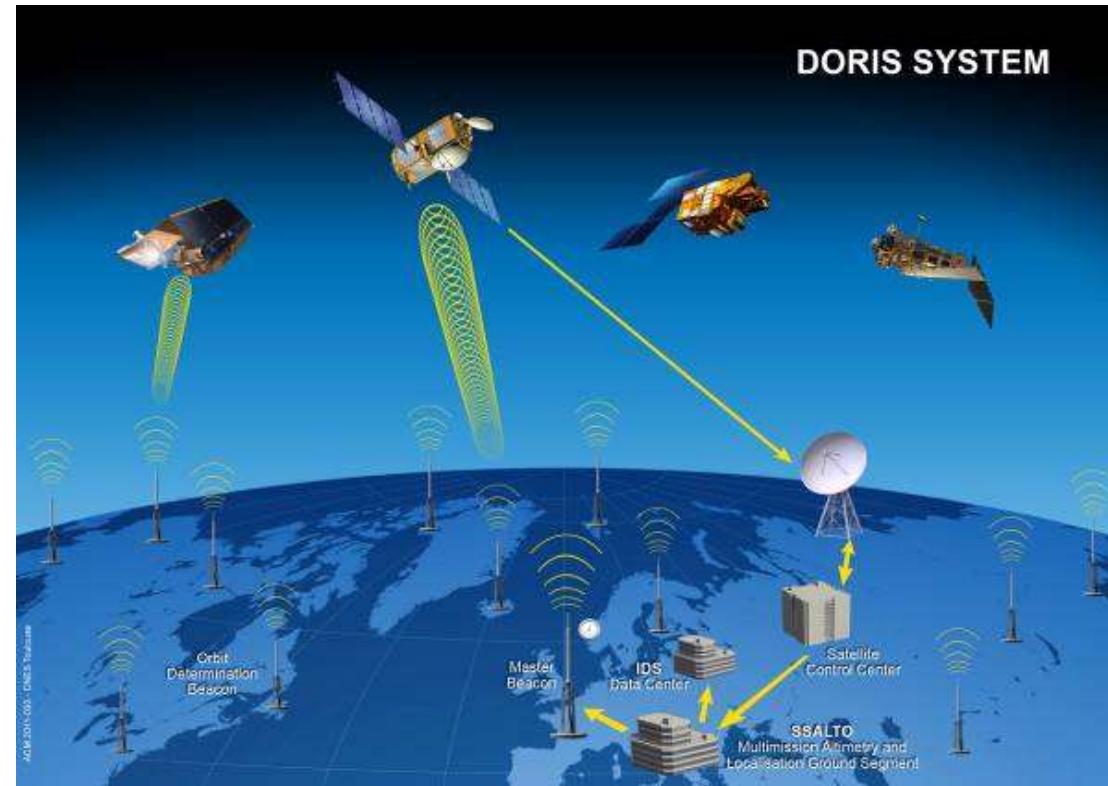
DORIS is:

- A French civil satellite tracking system designed for precise **orbit determination** and high accuracy **ground positioning**
- Optimized for the **ocean's topography observation missions** with extreme precision, global coverage and all-weather measurements.
- An **uplift** and **centralized** system based on **Doppler** shifts measurements of RF signals transmitted by a worldwide beacons network
- Developed by **CNES**, the French space agency, in partnership with France's mapping and survey agency **IGN** and the space geodesy research institute **GRGS**

An uplift and centralized system

System composed of :

- a network of emitting stations covering the globe
- onboard receivers able to track up to 7 stations simultaneously (DGXX receiver)
- a Control Center receiving the DORIS measurements at each satellite pass



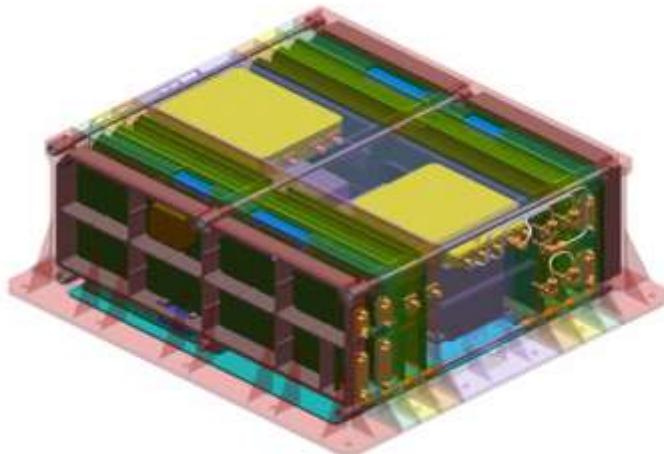
Two frequencies:

- 2.03625 GHz for precise measurement of the Doppler effect
- 401.25 MHz for ionospheric effect compensation

Accuracy: 0.3 mm/s (radial velocity)

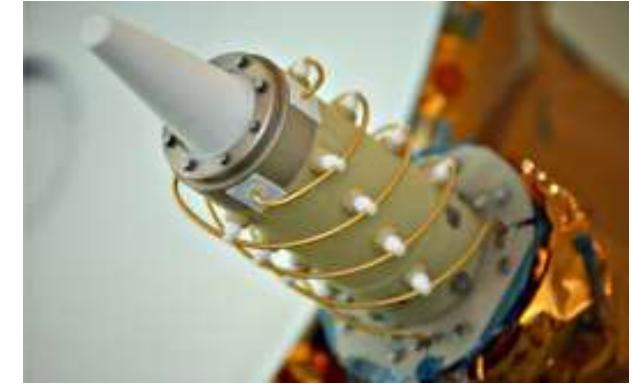
The signal is free. No limitation for the number of satellites carrying DORIS receivers

On board payload



Current DORIS dual frequency instrument (DGXX)

- cold redundancy of receivers and Ultra Stable Oscillators (USOs)
- weight = 18 kg
- 390 x 370 x 165 (mm)
- 23 W typical
- DIODE software included for on-board real-time orbit determination (sub metric) for payload driving and products location, platform navigation or ground operations
- Provider = Thalès Systèmes Aéroportés



Automatic RF antenna switching
on active receiver

Operations reduced to almost nothing:
just switch on and let it work

Excellent availability
(e.g. Jason-2 no failure since launch
in June 2008)

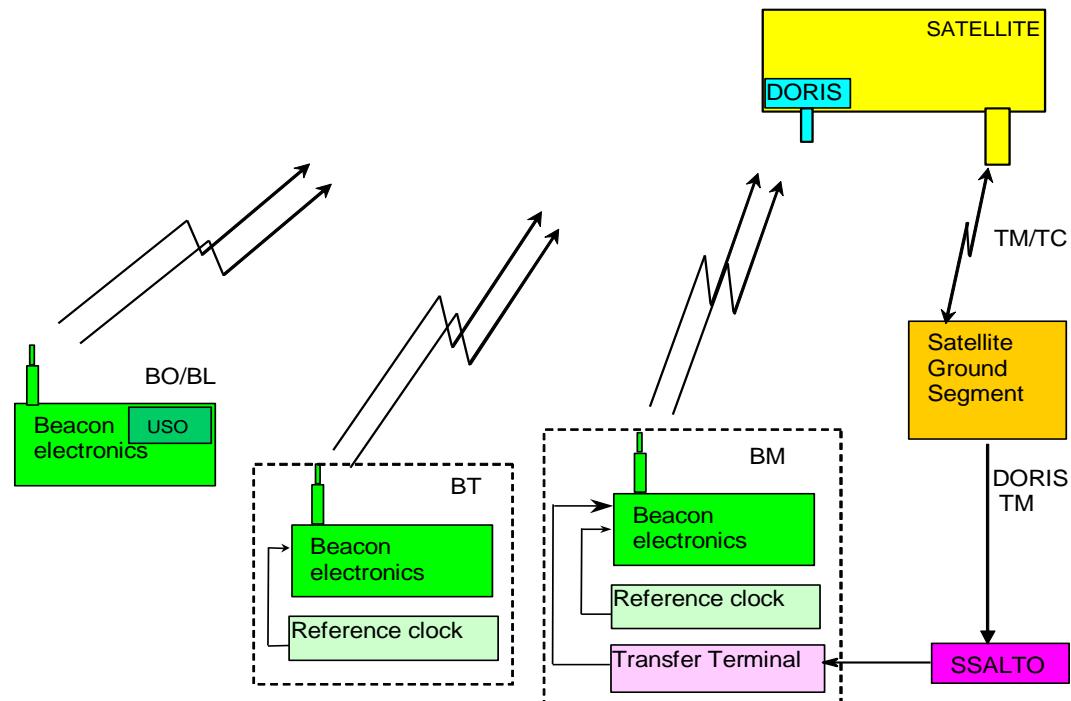
Ground equipment

DORIS station = antenna + beacon



3 types of beacons:

- Standard beacon (BO)
- Time beacon (BT)
- Master beacon (BM)





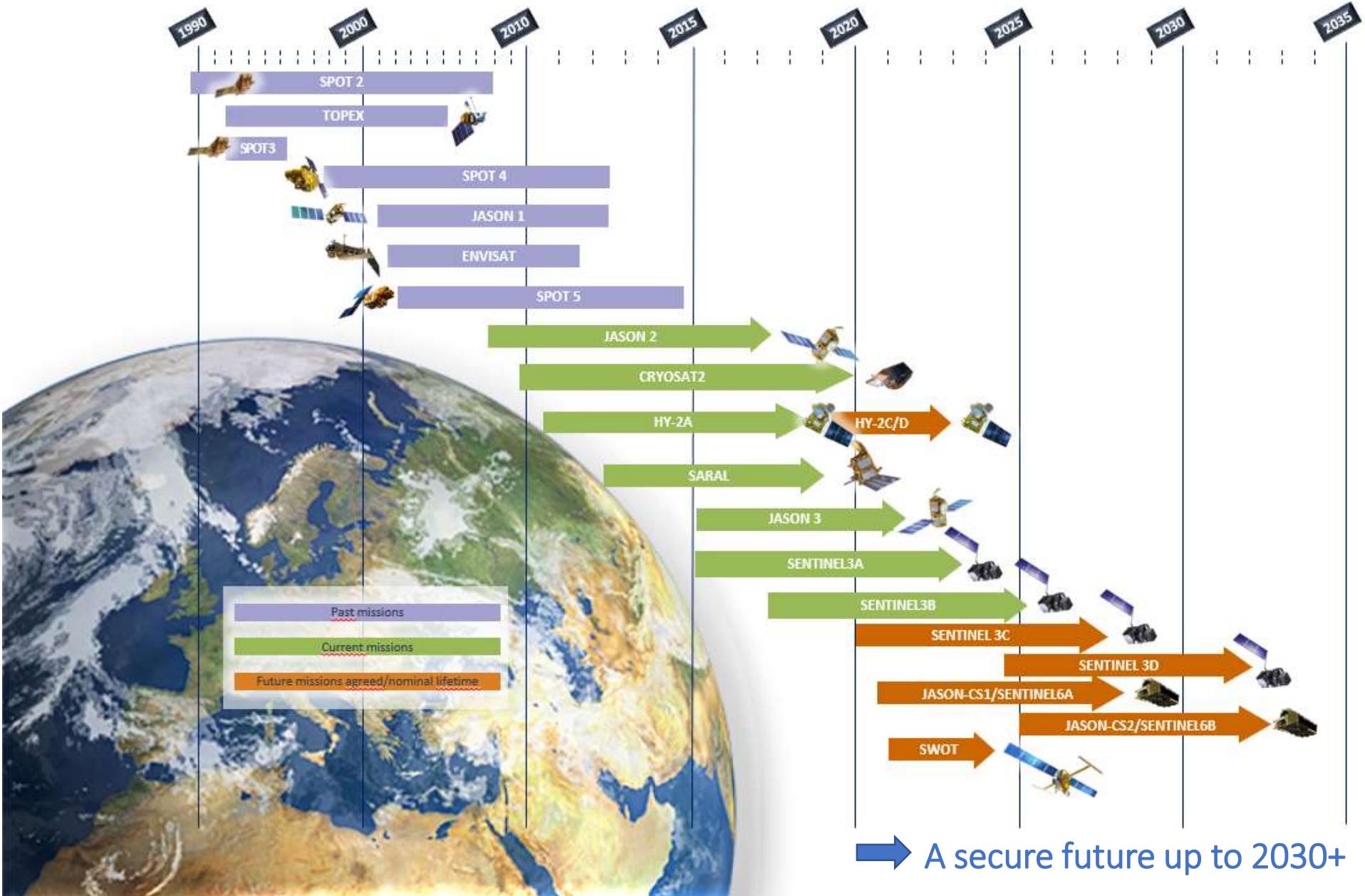
DORIS-equiped satellites

Satellites	Agency	Launch date	Altitude (km)	Inclination (deg.)	Repetitivty (days)	DORIS receiver generation	Other tracking system	Mission End	DORIS mission length (year)
SPOT-2	Cnes	22-Jan-1990	830	98	25	1G	-	29-Jul-2009	19,5
TOPEX/POSEIDON	Nasa/Cnes	10-Oct-1992	1336	66	10	1G	SLR+GPS	9-Oct-2005	12,1
SPOT-3	Cnes	26-Sep-1993	830	98	25	1G	-	14-Nov-1996	3,1
SPOT-4	Cnes	24-Mar-1998	830	98	25	1G	-	24-Jun-2013	15,3
JASON-1	Cnes/Nasa	7-Dec-2001	1336	66	10	2GM	SLR+GPS	21-Jun-2013	11,5
ENVISAT	Esa	1-Apr-2002	790	98	35 then 30	2G	SLR	9-May-2012	9,0
SPOT-5	Cnes	4-May-2002	830	98	25	2GM	-	11-Dec-2015	13,6
JASON-2	Cnes/Nasa/ Eumetsat/Noaa	20-Jun-2008	1336	66	10	DGX	SLR+GPS	-	(>11)
CRYOSAT-2	Esa	8-Apr-2010	707	92	369 (sub-cycle 30)	DGX	SLR	-	(>9)
HY-2A	China Academy of Space Technology	15-Aug-2011	971	99	14 then 168	DGX	SLR+GPS	-	(>8)
SARAL	Isro/Cnes	25-Feb-2013	706	98	35	DGX	SLR	-	(>6)
JASON-3	Cnes/Nasa/ Eumetsat/Noaa	17-Jan-2016	1336	66	10	DGX-S	SLR+GPS	-	(>3)
SENTINEL-3A	Esa	16-Feb-2016	814	98	27	DGX-S	SLR+GPS	-	(>3)
SENTINEL-3B	Esa	25-Apr-2018	814	98	27	DGX-S	SLR+GPS	-	(>1)

- 14 DORIS missions contributing to IDS since 1990
- 7 DORIS instrument operating in orbit, all with a DGXX receiver
- Polar orbits, Topex/Jason orbits (66°)
- altitude range: 700-1300 kms



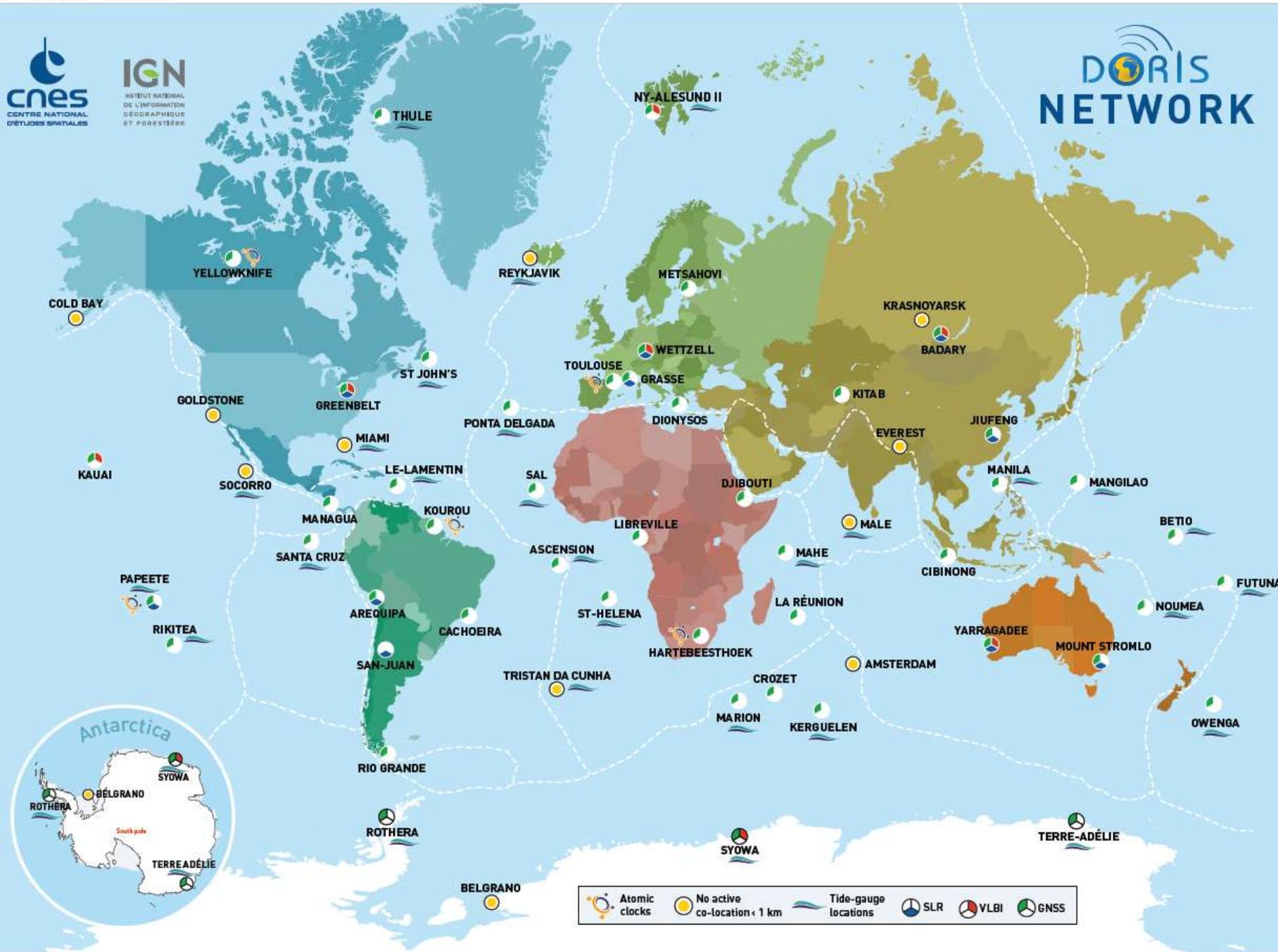
Past, current and future missions





IGN
INSTITUT NATIONAL
DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE

 DORIS
NETWORK



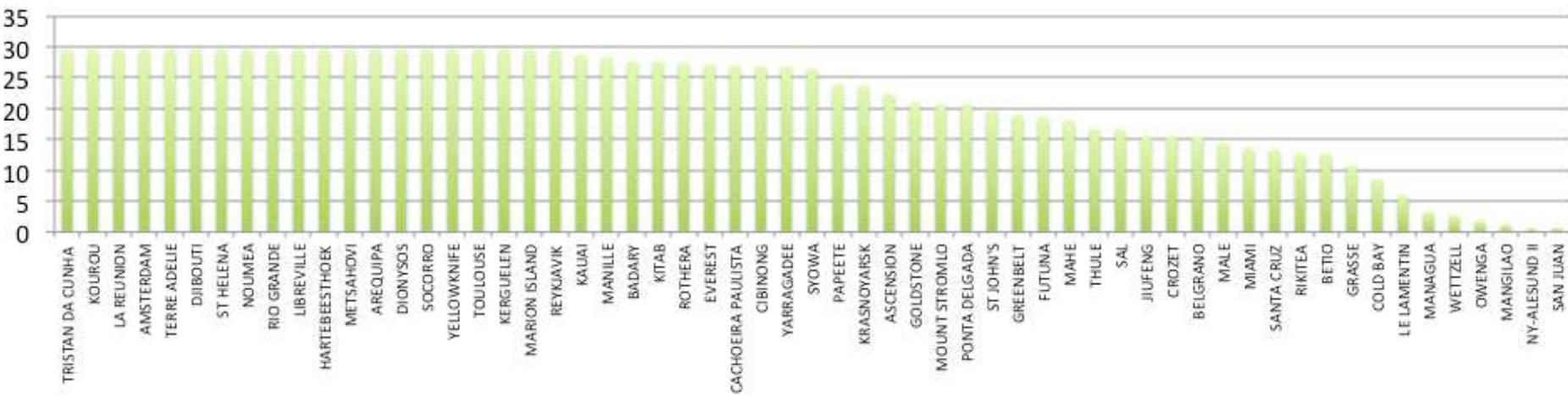
Strengths of the DORIS network

Managed by a single entity (CNES/IGN)

- Centralized control of the network deployment and evolution

Long time series

- Operating time of the current stations: 21 yr (average) / 26.4 yr (median)
- Network availability rate around 90%



The much more homogeneous station distribution

- Half of stations located on islands or coastal areas
- Good North-South distribution

Co-location with other space geodetic techniques and tide-gauges

- 48 stations out of 59 co-located with other techniques (GNSS: 47; SLR: 10; VLBI: 7)
- 28 stations out of 59 co-located with tide gauges

Equipment improvement

Ground antenna C type

- Improvement in manufacturing processes of the ground antenna to improve the repeatability
- Consolidated specifications: standard uncertainty of the 2GHz phase center position in the vertical direction was reduced to 1 mm from 5 mm
- Deployment started from Sept. 2014: today 18 stations equipped



Foot of the antenna

4th generation beacon

- Up-to-date electronic components: to be operational up to 2033
- Signal amplifier at the foot of the antenna: longer distance between beacon and antenna (up to 50 m vs. 15 m before)
- Deployment started from June 2019



4th generation beacon

Antenna cables: 50 m long
 → Finding better environment
 for the signal transmission



The positive impact of the GGOS project

Opportunities to move to new geodetic observatories

- Many countries followed the GGOS call to build the core network infrastructure
- DORIS moved to Wettzell (2016), San-Juan (2018), Ny-Alesund II (2018), Papenoo (2022?)

Synergy between the different techniques

- DORIS-VLBI RF compatibility studies
- Increase in surveying co-located sites and improving the accuracy of the site surveys
- Fruitful discussions and cooperative investigations

Instrument and infrastructure performance improvement

- New goals according to the GGOS objectives: 1 mm position and 0.1 mm/yr velocity accuracy
- DORIS ground antenna characterization to draw up an error budget (2014)
- Assessment of the DORIS network monumentation (2016)
- Deployment of the 4th generation beacon (as of mid-2019): with the aim of securing the future of DORIS and improving the stations performance





DORIS site	Host agency
Arequipa PERU <i>since Dec 1988</i>	Instituto Astronómico y Aeroespacial P. Paulet
Cachoeira Paulista BRAZIL <i>since Aug 1992</i>	Universidad Nacional de San Agustin (UNSA)
Kourou French Guyana, FRANCE <i>since Dec 1986</i>	Instituto Nacional de Pesquisas Espaciais (INPE)
Le Lamentin Martinique, FRANCE <i>since June 2013</i>	Centre Spatial Guyanais (CSG)
Managua NICARAGUA <i>since April 2016</i>	Météo-France
Rio Grande ARGENTINA <i>since Dec 1987</i>	Estación Astronómica de Rio Grande (EARG), Universidad Nacional de la Plata (UNLP)
San Juan ARGENTINA <i>since Oct 2018</i>	Observatorio Astronómico Félix Aguilar Universidad Nacional de San Juan (UNSJ)
Santa Cruz Galápagos, ECUADOR <i>since April 2005</i>	Fundación Charles Darwin (FCD)
Socorro MEXICO <i>since Feb 1991</i>	Instituto Nacional de Estadística y Geografía (INEGI) Secretaría de Marina (SEMAR)
Belgrano ARGENTINA base <i>since Feb 2004</i>	Instituto Antártico Argentino (IAA)

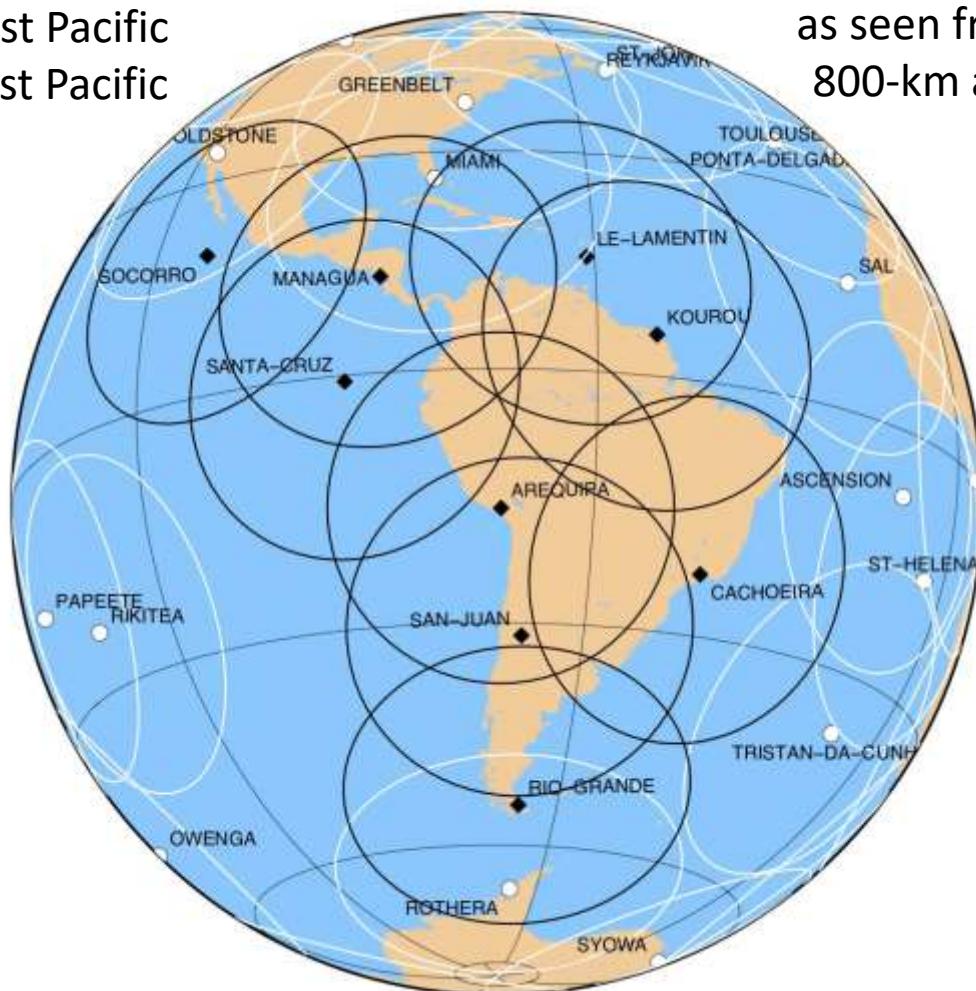
DORIS visibility circles

Good cover of the continent with parts of Southwest Atlantic and Southeast Pacific but a gap to be filled in Southeast Pacific

→ contact with Chile University for a station at Easter Island;
2nd DORIS station on Nazca plate



The DORIS stations as seen from the 800-km altitude





Summary

The DORIS system has been working since 1990

In February 2020, we celebrate the 30th anniversary of the first DORIS measurement on SPOT-2.

- Now:
7 satellites, 59 ground stations, 48 co-locations with other IERS techniques

- Future:
4G beacon being deployed
Several more satellites to come up to 2030+
 - HY-2C&D
 - Sentinel-3C & 3D
 - JASON-CS1/SENTINEL6A and JASON-CS2/SENTINEL6BA
 - SWOT



The International DORIS Service



What is the IDS?

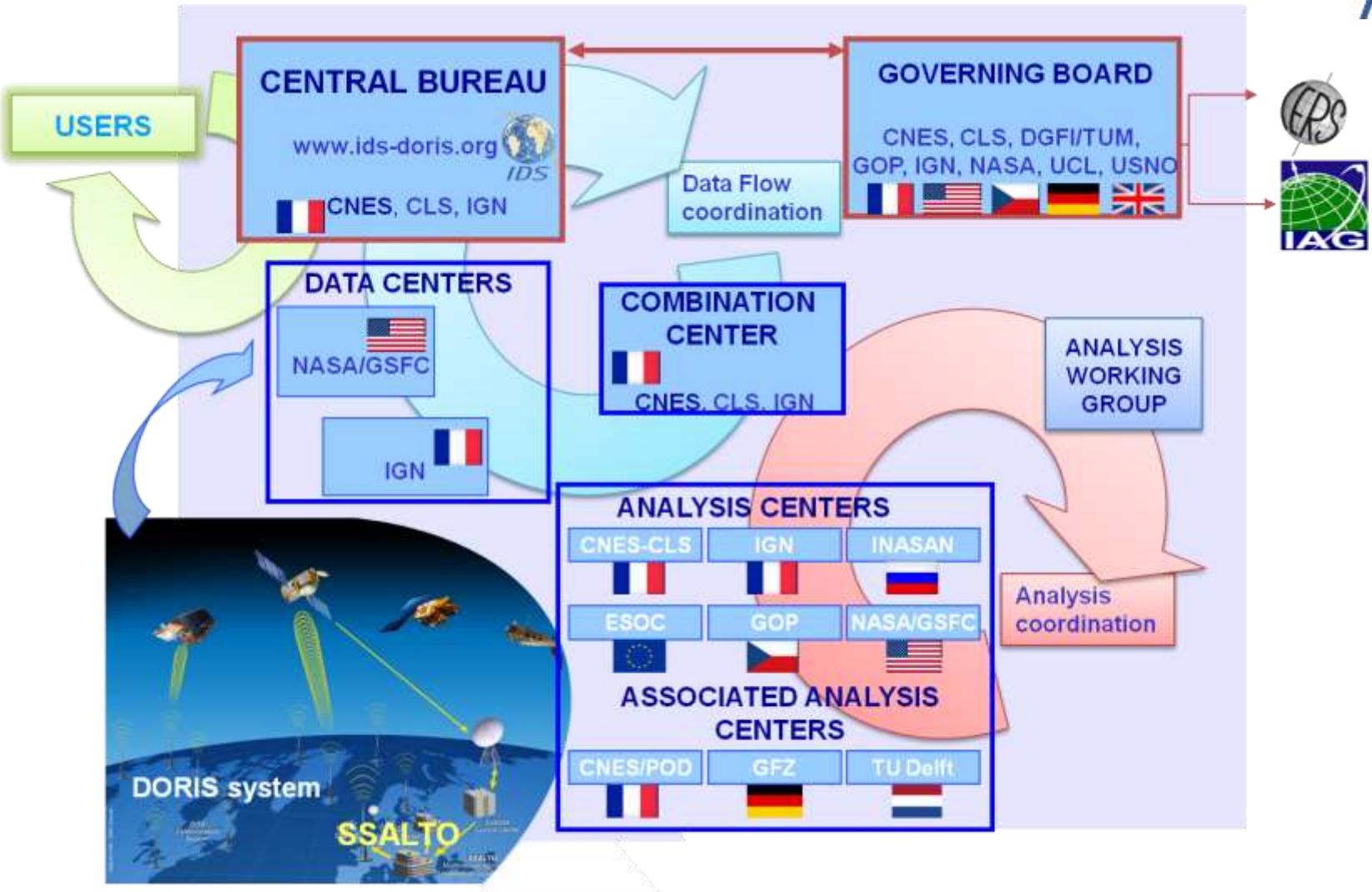
The International DORIS Service is an IAG service created in 2003.

Its mission is to:

- provide a support to research activities in geodesy and geophysics based on DORIS data and derived products.
- give access to data, products and documents related to the DORIS system

IDS submits DORIS solutions to IERS and participates in GGOS

IDS organization



+ WG « Near real time data » (chair: D. Dettmering, DGFI/TUM)

Objective: delivery of NRT DORIS data for assimilation in ionospheric models

Participants

- **Analysis Centers**

Analysis Center (<i>IDS code</i>)	Contact	Country	Software package
ESA/ESOC (ESA)	M. Otten	Germany	NAPEOS
NASA/GSFC (GSC)	F. Lemoine	USA	GEODYN
Geodetic Observatory of Pecny (GOP)	P. Stepanek	Czech Rep.	Bernese
IGN (IGN)	P. Willis	France	GIPSY-OASIS
INASAN (INA)	S. Kuzin	Russia	GIPSY-OASIS
CNES/CLS (GRG)	H. Capdeville	France	GINS/DYNAMO

- **Analysis Coordination**: Hugues Capdeville (CLS) and Petr Stepanek (GOP)
- **Combination Center**: Guilhem Moreaux (CLS) with the support of Zuheir Altamimi (IGN) (CATREF software and strategy)
- **Associate Analyse Centers**: CNES/POD (A. Couhert), GFZ (R. Koenig), TU Delft (E. Schrama)
- **Other associated groups**: UCL, DGFI/TUM, CSR, IAA, NCL

All work together within the **Analysis Working Group (AWG)** and meet 1-2 each year.

IDS meetings

- IDS Workshop: 1 every 2 year (with Ocean Surface Topography Science Team (OSTST) meeting in Europe)

2018 Ponta Delgada, São Miguel Island, Azores Archipelago (Portugal), 24-26 September

2016 La Rochelle, France, 31 October - 1 November

2014 Konstanz, Germany, 27-28 October

2012 Venice, Italy, 25-26 September

2010 Lisbon, Portugal, 21-22 October

....

- Analysis Working Group (AWG) meeting: 1 or 2 every year

2019 Munich, next in Paris (30 Sep. – 1 Oct.)

2018 Toulouse

2017 London

2016 Delft

...

*AWG meeting in Munich,
Germany, April 2019*

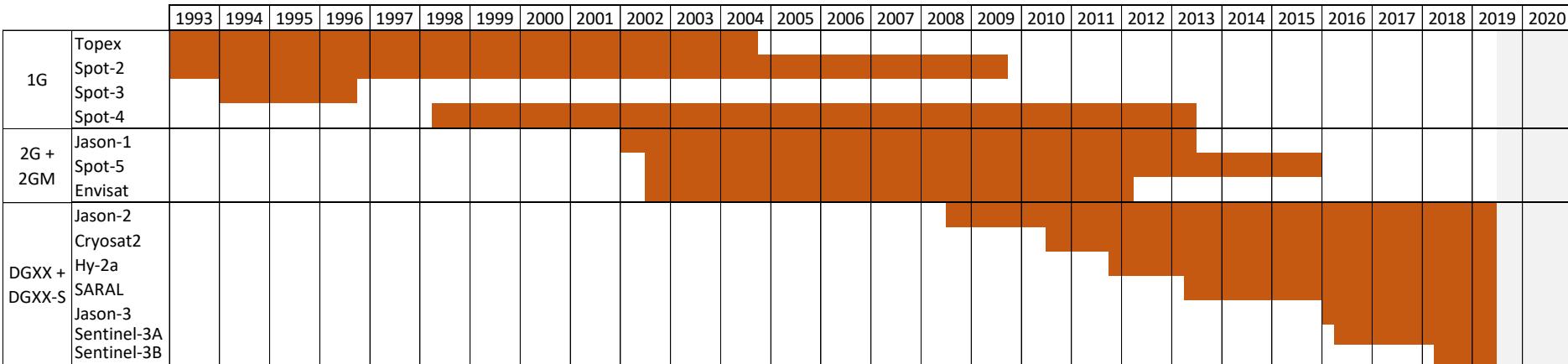




Information provided by IDS

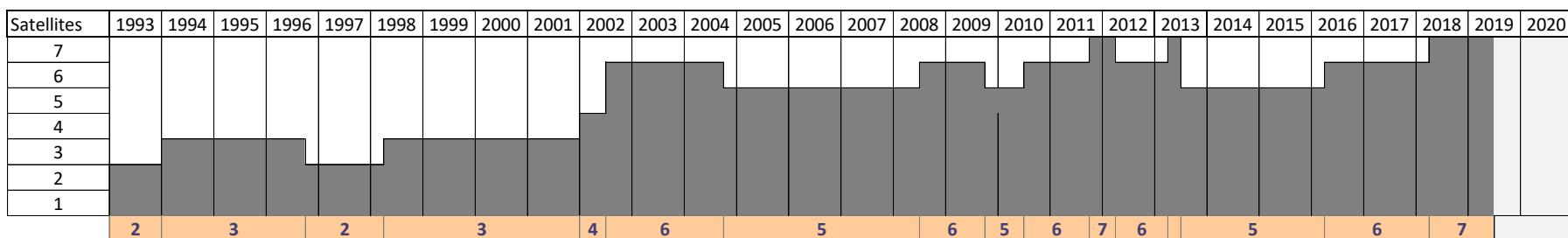
- DORIS data
 - DORIS measurements and ancillary data
 - ftp download from Data Centers and Central Bureau
- IDS products
 - Produced by Analysis Centers and Combination Center
 - ftp download from Data Centers
- Documents
 - Technical documents, presentations, reports, mails,...
 - download from IDS website
- Metadata for web applications
 - Numerical values, texts, links ...
 - Stored in a data base

Available data



Data available at IDS Data Centers (1993.01.01 - 2019.07.01)

→ More than 123 years of data



Number of satellites of the DORIS constellation (1993.01.01 - 2019.07.01)

NB: DORIS measurements in RINEX-like format since 2008 (Jason-2)



IDS products

products	content	latency	sample interval	archive locations	format	provider	missions
station coordinates	time series of station coordinates differences	quaterly	1 week	CDDIS ; IGN	stcd	IDS CC, ACs	combination
orbits	orbit ephemerides	3-4 weeks	1 min	CDDIS ; IGN	sp3c	ssa (official orbits), ACs	all satellites
geocenter motion	TRF origin solution	occasionally	1 week	CDDIS ; IGN	geoc	ACs	combination
Earth Orientation Parameters	polar motion	occasionally	1 day	CDDIS ; IGN	eop	ACs	combination
ionosphere	ionospheric corrections	week	10 s	CDDIS ; IGN	iono	ssa	en1, ja1, sp2, sp4, sp5, top
reference frame	station coordinate and velocity solution	yearly	global	CDDIS ; IGN	sinex	CC	combination
SINEX	series of station coordinate solutions	quaterly	1 week	CDDIS ; IGN	sinex	IDS CC, ACs	combination

DORIS data and IDS products are available free



The information system

- A web site: <https://ids-doris.org>
- A ftp site: <ftp://ids-doris.org>
- A webservice: ids-doris.org/webservice
- Mailing lists
(dorismail, dorisreport, dorisstations, ...)

IDS website



	IDS Organization of the service and documentation, access to the data and products, event announcements, contacts and links...
	DORIS System Allows to access general description of the system, and give information about the system events and the tracking network.
	Analysis Coordination Provides information and dissemination areas about the analysis strategies and models used in the IDS products. It includes also the information about the Coordination Center activities.
	Web service Gives access to DORIS O-T, the IDS Web service, that proposes a family of plot tools to visualize time series of DORIS-related products and a research center to select ideas.

Youtube channel



Table of events

Date	Type	Event	Description	Start	End
2011/09/19 00:00:00	satellite	MATOS 2 - launch	2011-09-19T00:00:00Z 14:50:05 UTC DORIS 2 satellite sent to the ground. MATOS has measured during that period 1500 sats.	2011-09-19T00:00:00Z	2011-09-19T14:50:05Z
2011/09/19 23:47:39	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-09-19T23:47:39Z 2011-09-20T00:00:00Z	2011-09-19T23:47:39Z	2011-09-20T00:00:00Z
2011/09/24 00:00:00	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-09-24T00:00:00Z 2011-09-25T00:00:00Z	2011-09-24T00:00:00Z	2011-09-25T00:00:00Z
2011/09/29 00:00:00	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-09-29T00:00:00Z 2011-10-01T00:00:00Z	2011-09-29T00:00:00Z	2011-10-01T00:00:00Z
2011/10/03 05:40:54	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-10-03T05:40:54Z 2011-10-04T00:00:00Z	2011-10-03T05:40:54Z	2011-10-04T00:00:00Z
2011/10/07 11:00:00	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-10-07T11:00:00Z 2011-10-08T00:00:00Z	2011-10-07T11:00:00Z	2011-10-08T00:00:00Z
2011/10/17 14:07:36	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-10-17T14:07:36Z 2011-10-18T00:00:00Z	2011-10-17T14:07:36Z	2011-10-18T00:00:00Z
2011/10/28 00:00:00	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-10-28T00:00:00Z 2011-10-29T00:00:00Z	2011-10-28T00:00:00Z	2011-10-29T00:00:00Z
2011/11/04 00:00:00	satellite	2011 DORIS 2011 DORIS 2011 DORIS	2011-11-04T00:00:00Z 2011-11-05T00:00:00Z	2011-11-04T00:00:00Z	2011-11-05T00:00:00Z

Information on satellite

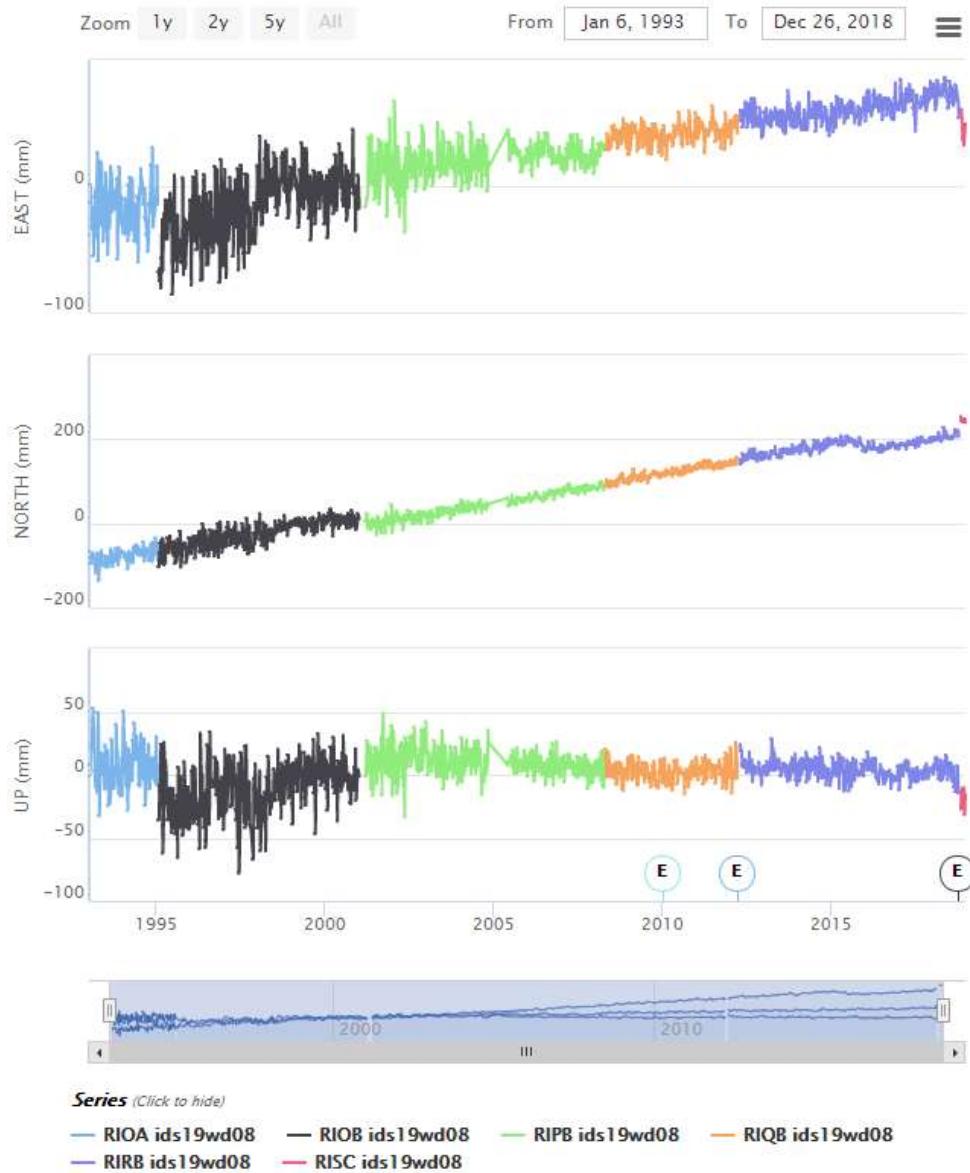
Attributes	
operator	1801161
launch_date	2010/02/18
launch_site	Plesetsk Cosmodrome, Russia
vehicle	RokuSat/BS-XX
doris_instrument_id	-
mission_end_date	-
perigee	800 km
apogee	800 km
period	100.99 minutes
inclination	98.82°
eccentricity	0.0003
doris_receiver_generation	OCX-E
doris_redundancy	Yes
other_tracking_systems	SGL+GPS
up3_code	L74

ETC ...

Time series of station positions



- Rio Grande, Argentina
- ❖ RIOA (1987-1995)
 - ❖ RIOB (1995-2001)
 - ❖ RIPB (2001-2008)
 - ❖ RIQB (2008-2012)
 - ❖ RIRB (2012-2018)
 - ❖ RISC (2018- ...)



Network viewer



DORIS: DORIS sites since network deployment start

GNSS: IGS sites colocated with DORIS

PLATES: Plate boundaries from Bird, 2003

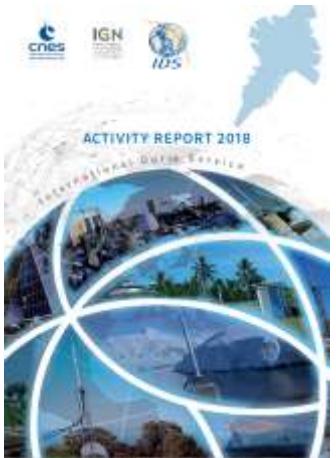
H. VELOCITIES: Horizontal velocity vectors from DPOD2014 solution

V. VELOCITIES: Vertical velocity vectors from DPOD2014 solution

EARTHQUAKES: USGS Earthquakes with mag. ≥ 6 around DORIS stations



IDS publications



IDS AR 2018

Soon available

Annual activity reports

- Content:
 - About IDS
 - DORIS system
 - User service
 - Analysis Activities
- Distribution by postal mail to Host Agencies and stakeholders
- Available on IDS web site <https://ids-doris.org/documents/report/>

Newsletters

- Articles about:
 - The missions: project news
 - The network: focus on a station with insert written by the host agency presenting its institution
 - Analysis results
 - IDS life
- Distributed by email and available on IDS web site <https://ids-doris.org/documents/newsletters/>



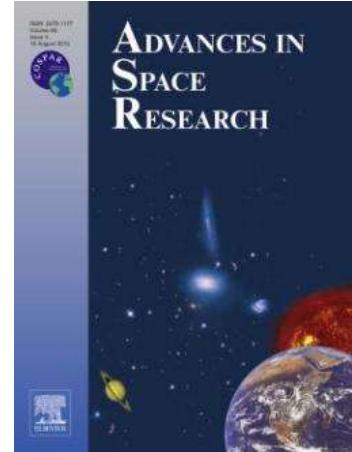
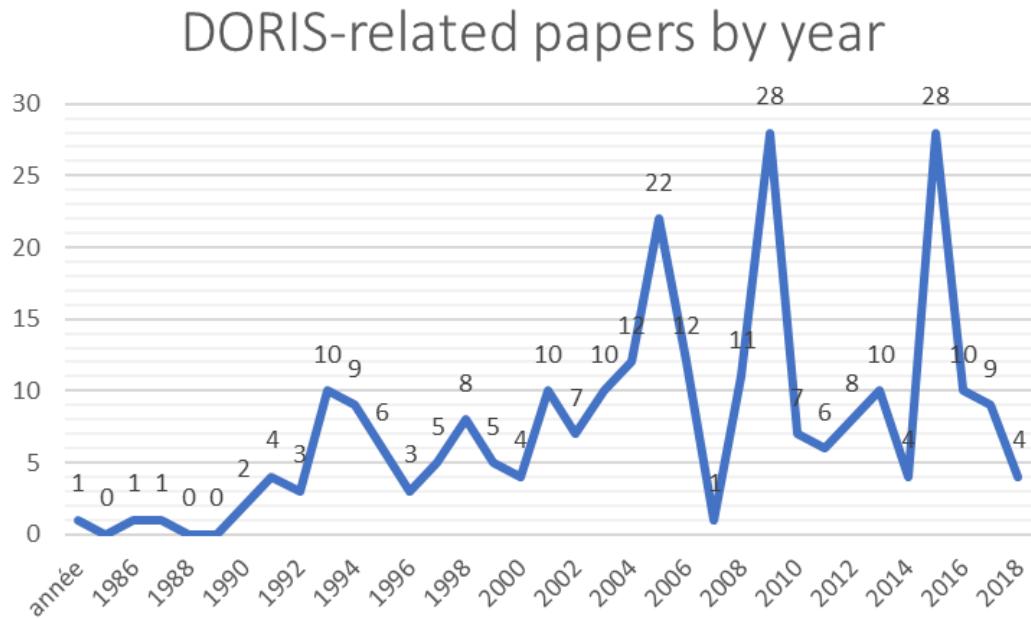
IDS Newsletter # 6

Feb. 2019

DORIS bibliography

The IDS maintains a list of DORIS publications in international peer-reviewed journals
<https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html>

261 articles in the list (1985-2019)



DORIS Special Issue 2016 in ASR

18 papers, 5 themes:

1. ITRF2014
2. DORIS Ultra Stable Oscillator
3. Precise Orbit Determination
4. DORIS System and Network
5. Intertechnique comparisons of DORIS Products

Summary

International DORIS Service since 2003

- Now:
 - 6 analysis centers, 3 associated analysis centers, 2 data centers,
1 combination center, Analysis Working Group, WG NRT data
- Future:
 - data reprocessing for contribution to ITRF2020
 - set up NRT delivery of the DORIS data
 - prepare the future (strategic plan in preparation)
 - grow the community
 - lower barriers to entry
 - technology evolutions ...



This presentation will be available on IDS web:

IDS > Documentation > Meeting presentations > IDS-related presentations

<https://ids-doris.org/ids/reports-mails/meeting-presentations/ids-related-presentations.html>

with some back-up slides:

- IDS and DORIS quick reference list
- more contacts

Web: ids-doris.org

Contact: ids.central.bureau@ids-doris.org





Back-up slides



IDS and DORIS quick reference list (1/4)

IDS website

<https://ids-doris.org/>

Contacts

Central Bureau ids.central.bureau@ids-doris.org

Governing Board ids.governing.board@ids-doris.org

Data Centers

CDDIS: <ftp://cddis.gsfc.nasa.gov/doris/>

IGN: <ftp://doris.ensg.eu> and <ftp://doris.ign.fr>

Tables of Data and Products

<https://ids-doris.org/ids/data-products/tables-of-data-products.html>

IDS web service

<https://ids-doris.org/webservice>

DOR-O-T for DORIS Online Tools (pronounced in French like the given name Dorothée) is the IDS web service developed to promote the use of the DORIS products. The current version of the service provides tools to browse time series in an interactive and intuitive way, and a network viewer.



IDS and DORIS quick reference list (2/4)

Citation

The following article is suggested for citation in papers and presentations that rely on DORIS data and results:

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

IDS Newsletters

Find all the issues published in color with live links on the IDS website

<https://ids-doris.org/ids/reports-mails/newsletter.html>

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



IDS and DORIS quick reference list (3/4)

List of the documentation

It gives a table compiling links to the various pages providing documents, grouped in four categories: DORIS system components; IDS information system; Publications, presentations; Documents

<https://ids-doris.org/ids/reports-mails/documentation.html>

List of presentations given at DORIS or IDS meetings

Full list of presentations given at DORIS or IDS meetings with the corresponding access links

<https://ids-doris.org/ids/reports-mails/meeting-presentations.html>

List of documents and links to discover the DORIS system

<https://ids-doris.org/analysis-coordination/documents-related-to-data-analysis.html>

List of DORIS publications in international peer-reviewed journals

<https://ids-doris.org/ids/reports-mails/doris-bibliography/peer-reviewed-journals.html>



IDS and DORIS quick reference list (4/4)

Overview of the DORIS system

<https://www.aviso.altimetry.fr/en/techniques/doris.html>

Overview of the DORIS satellite constellation

<https://ids-doris.org/doris-system/satellites.html>

Site logs

DORIS stations description forms and pictures from the DORIS installation and maintenance department: <https://ids-doris.org/doris-system/tracking-network/site-logs.html>

Virtual tour of the DORIS network with [Google Earth](#)

Download the file at <https://ids-doris.org/doris-system/tracking-network/network-on-google-earth.html> and visit the DORIS sites all around the world.

IDS video channel

Videos of the DORIS-equipped satellites in orbit

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

Photo Gallery

<https://ids-doris.org/ids/gallery.html>



More contacts (1/2)

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

Governing Board

Frank Lemoine (chairman)

NASA Goddard Space Flight Center

Code 61A, Geodesy and Geophysics Laboratory

Greenbelt, Maryland 20771 U.S.A.

Phone: +1 (301) 614-6109

E-mail: Frank.G.Lemoine@nasa.gov

Central Bureau

Laurent Soudarin (director)

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Parc Technologique du Canal

31520 Ramonville Saint-Agne

France

Phone: +33 (0)5 61 39 48 49 / 5 61 39 47 90

E-mail: laurent.soudarin@cls.fr

DORIS System

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31401 Toulouse Cedex 9

France

Phone: +33 (0)5 61 28 30 66

E-mail: pascale.ferrage@cnes.fr

Network

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