



# Presentation of the DORIS system and the International DORIS Service

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CENTRE NATIONAL D'ÉTUDES SPATIALES





International Workshop for the  
Implementation of the Global Geodetic Reference Frame (GGRF) in Latin America  
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# The DORIS system

# What is DORIS?

**DORIS** stands for

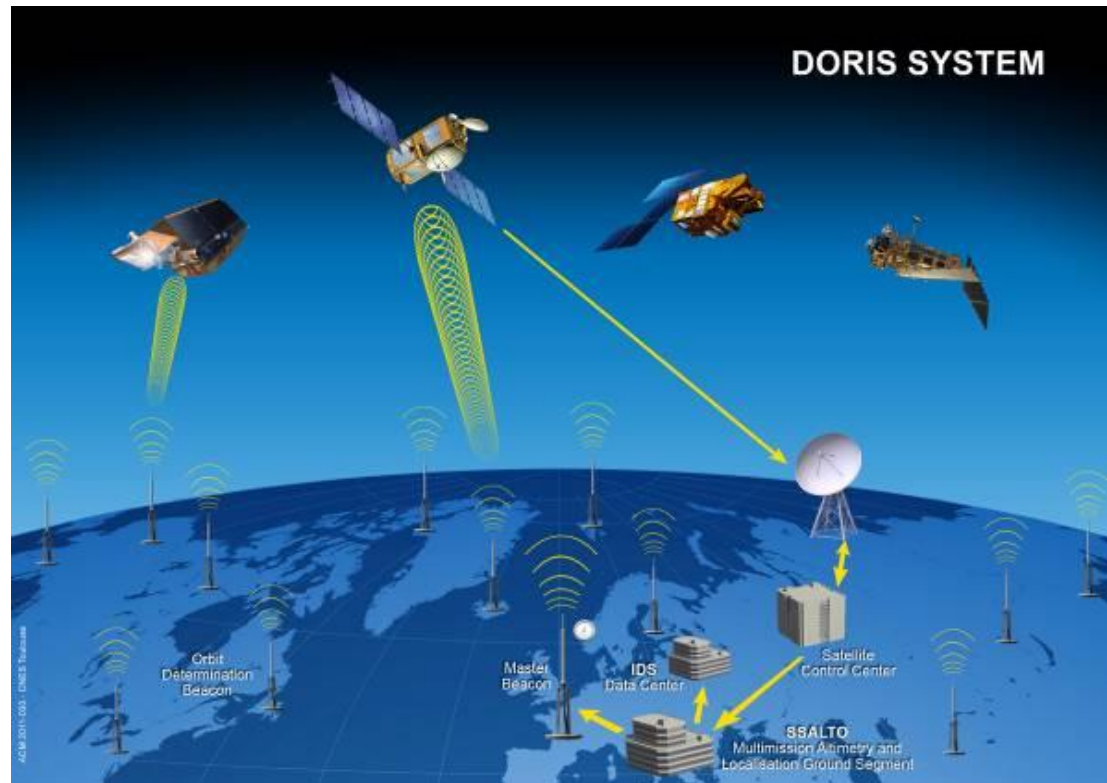
-  **D**oppler **O**rbitography and **R**adiopositioning **I**ntegrated by **S**atellite
-  **D**étermination d' **O**rbite et **R**adiopositionnement **I**ntégrés par **S**atellite
-  **D**eterminación de **Ó**rbita y **R**adioposicionamiento **I**ntegrados por **S**atélite
-  **D**eterminação de **Ó**rbita e **R**adioposição **I**ntegrado por **S**atélite

**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**

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

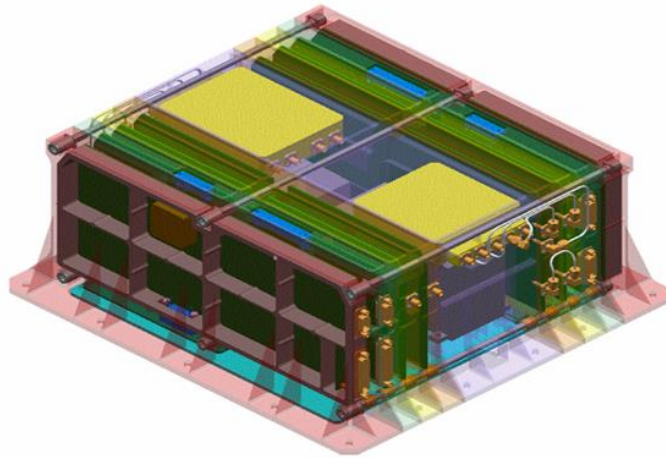


Two frequencies:

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

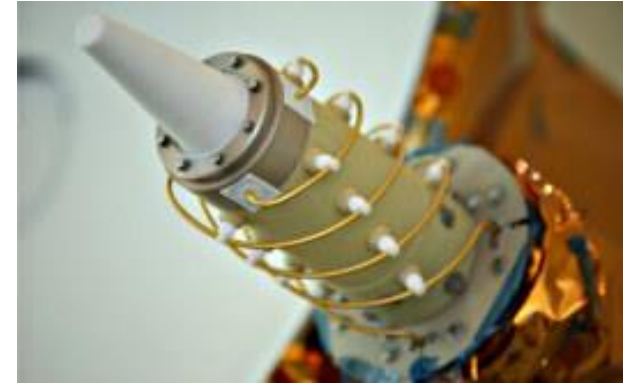
Accuracy: 0.3 mm/s (radial velocity)

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



## 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

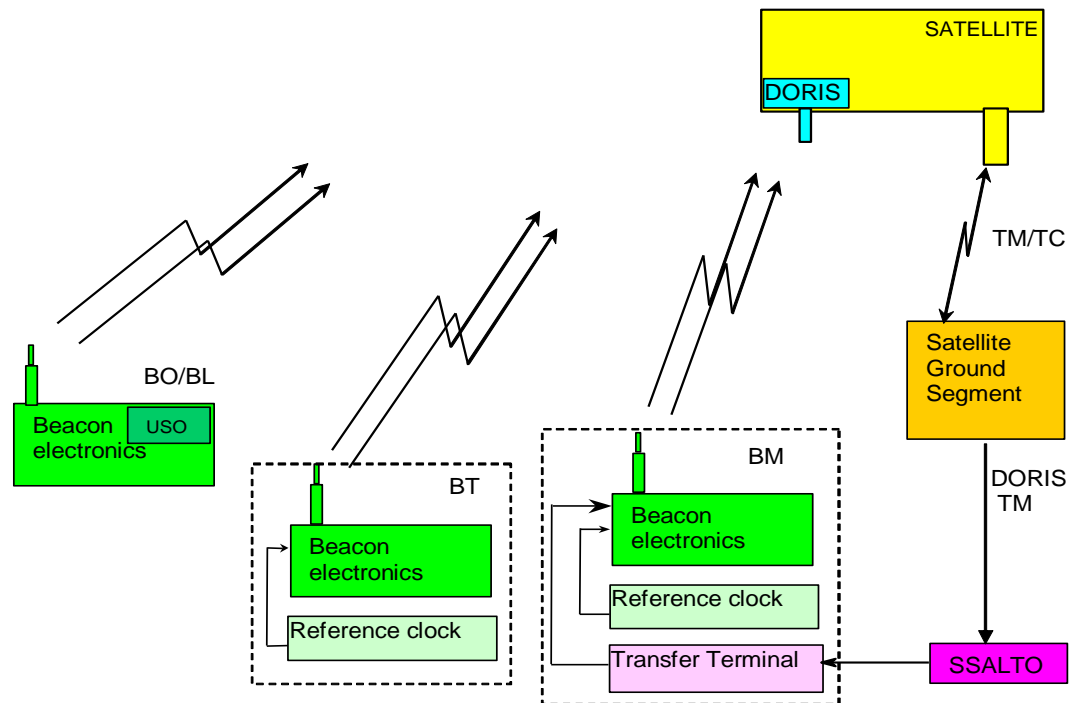
Excellent availability  
(e.g. Jason-2 no failure since launch  
in June 2008)

DORIS station = antenna + beacon



3 types of beacons:

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





# DORIS-equipped satellites

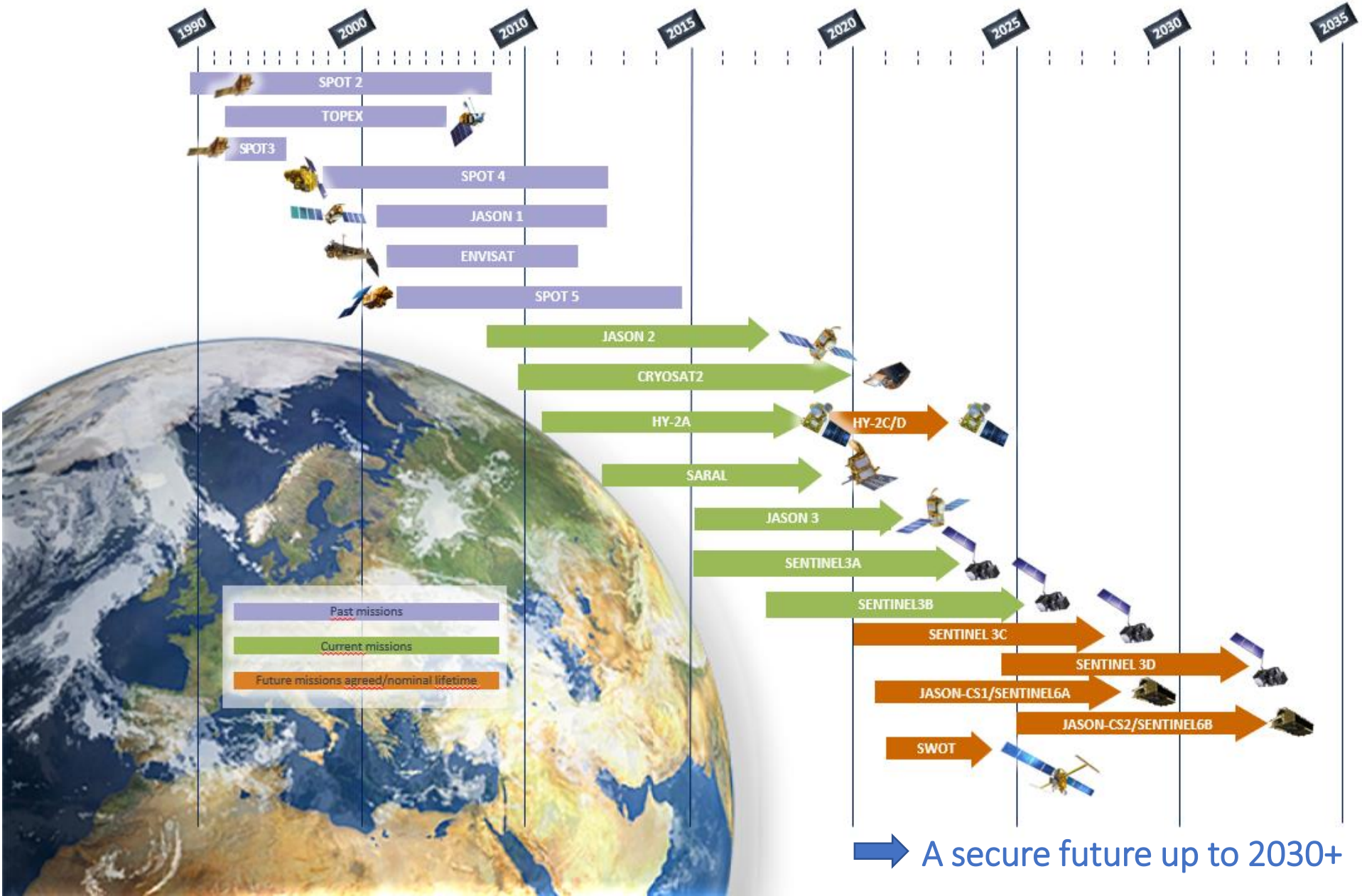
Satellites	Agency	Launch date	Altitude (km)	Inclination (deg.)	Repetitivity (days)	DORIS receiver generation	Other tracking system	Mission End	DORIS mission length (year)
SPOT-2	Cnes	22-Jan-1990	830	98	25	1G	-	29-Jul-2009	19,5
TOPEX/POSEIDON	Nasa/Cnes	10-Oct-1992	1336	66	10	1G	SLR+GPS	9-Oct-2005	12,1
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	DGXX	SLR+GPS	-	(>11)
CRYOSAT-2	Esa	8-Apr-2010	707	92	369 (sub-cycle 30)	DGXX	SLR	-	(>9)
HY-2A	China Academy of Space Technology	15-Aug-2011	971	99	14 then 168	DGXX	SLR+GPS	-	(>8)
SARAL	Isro/Cnes	25-Feb-2013	706	98	35	DGXX	SLR	-	(>6)
JASON-3	Cnes/Nasa/ Eumetsat/Noaa	17-Jan-2016	1336	66	10	DGXX-S	SLR+GPS	-	(>3)
SENTINEL-3A	Esa	16-Feb-2016	814	98	27	DGXX-S	SLR+GPS	-	(>3)
SENTINEL-3B	Esa	25-Apr-2018	814	98	27	DGXX-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

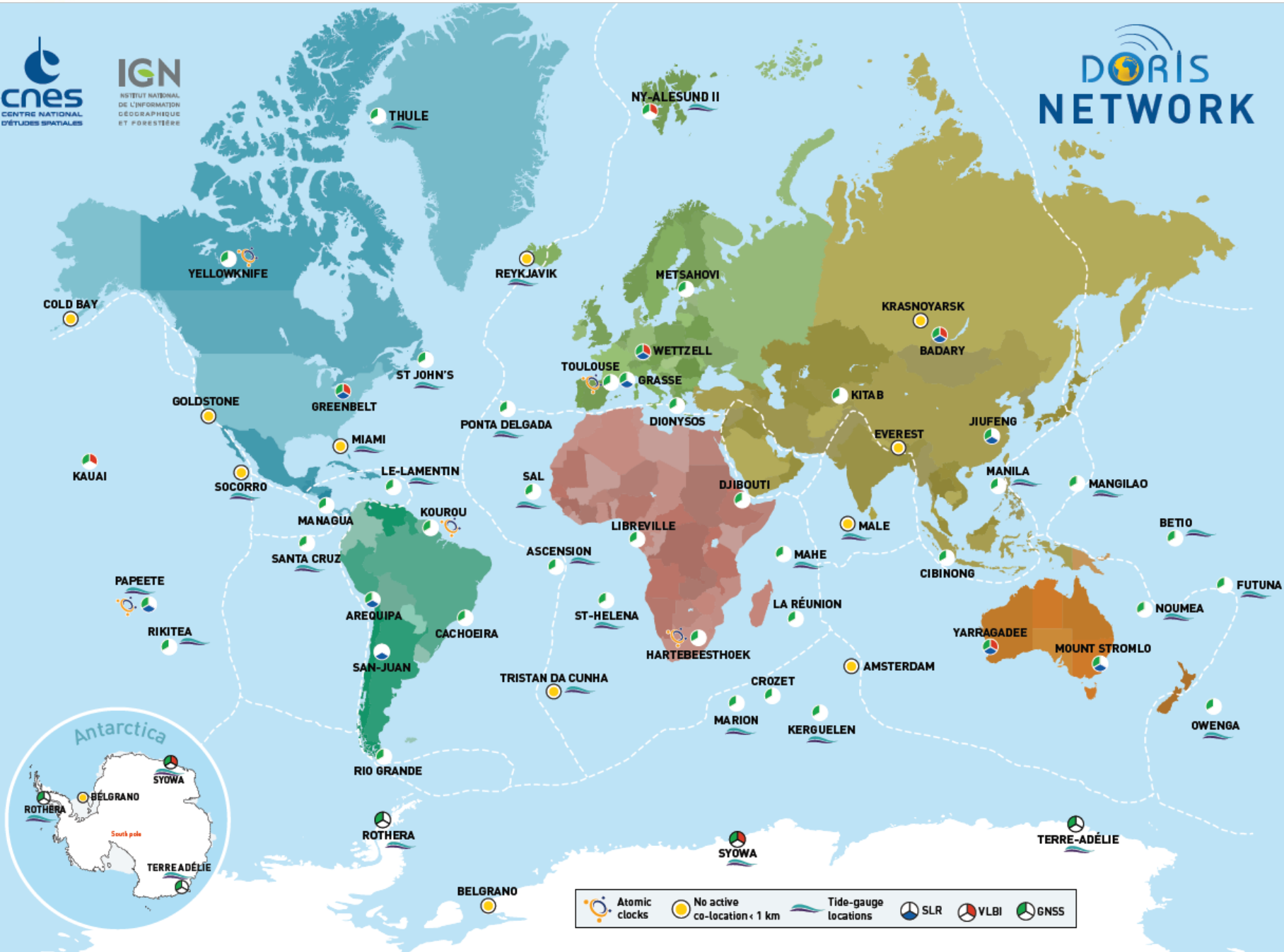


<https://ids-doris.org/doris-system/satellites.html>

# Past, current and future missions







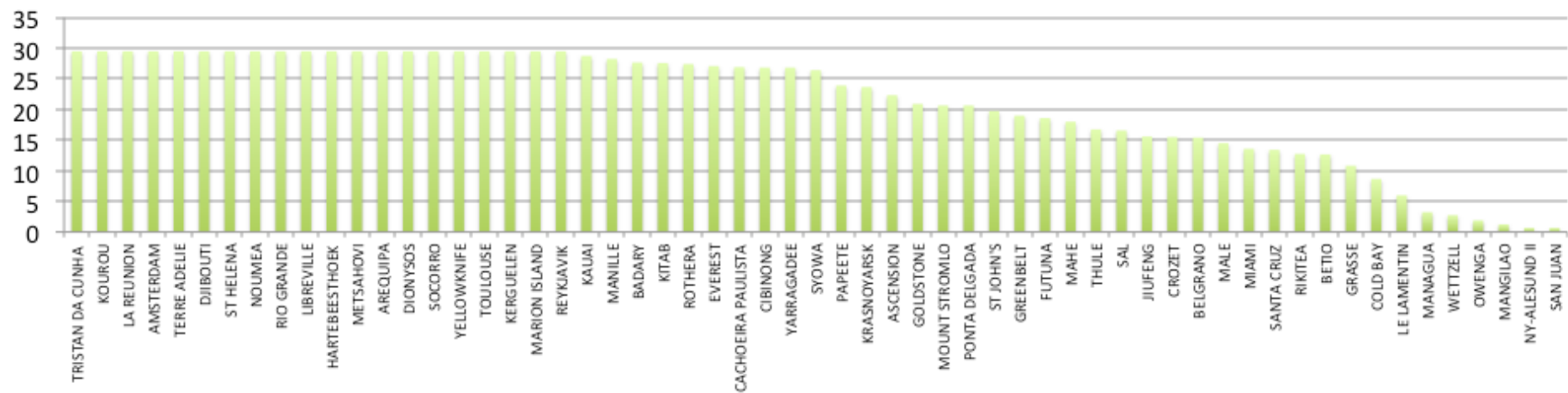
	Atomic clocks		No active co-location < 1 km		Tide-gauge locations		SLR		VLBI		GNSS
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## Managed by a single entity (CNES/IGN)

- ☐ 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

## 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

## 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



*Foot of the antenna*



*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  
stations  
in Latin  
America



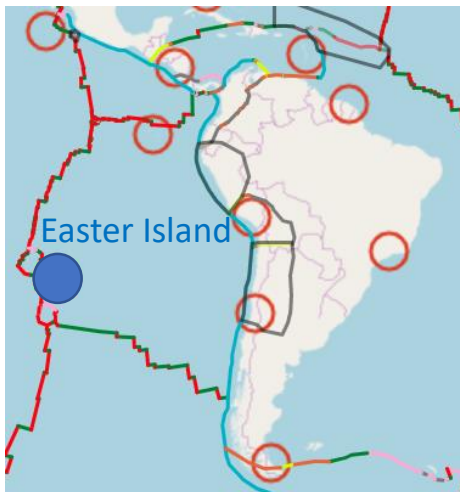
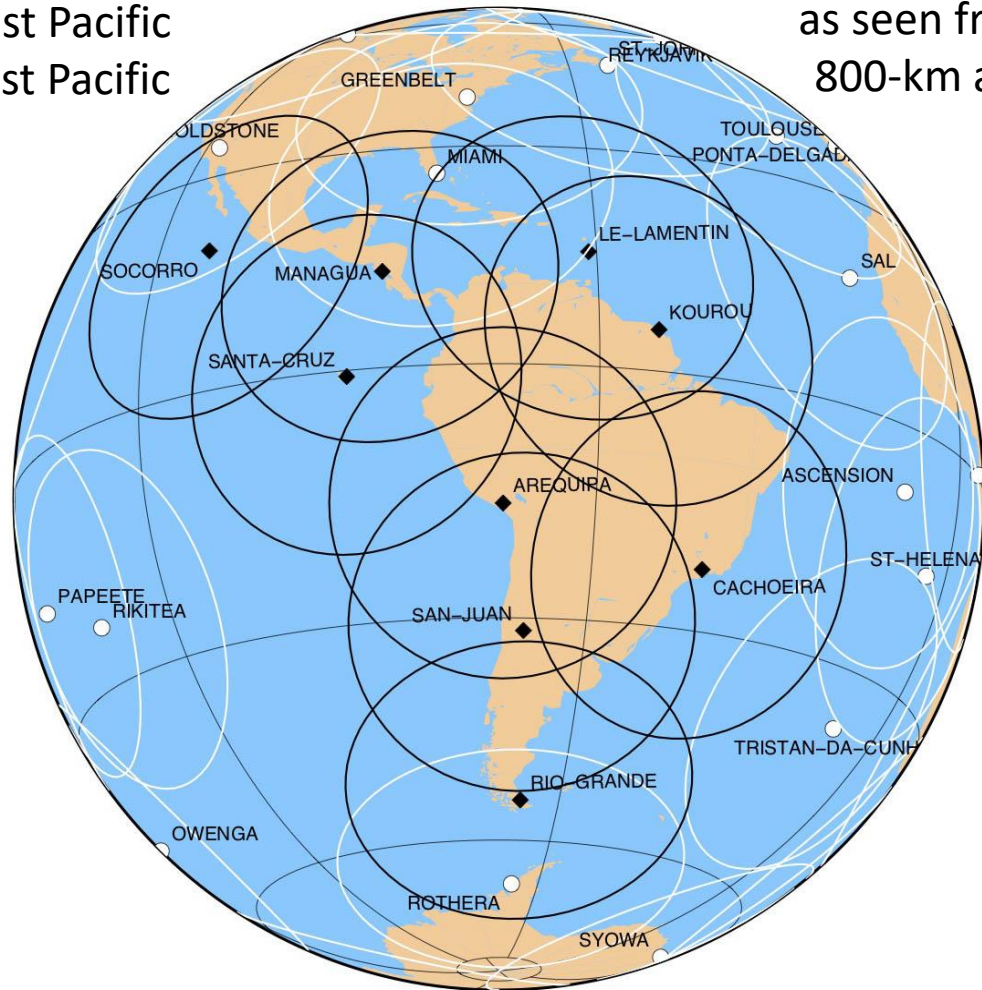
DORIS site	Host agency
<b>Arequipa</b> <b>PERU</b> <i>since Dec 1988</i>	Instituto Astronómico y Aeroespacial P. Paulet Universidad Nacional de San Agustín (UNSA)
<b>Cachoeira Paulista</b> <b>BRAZIL</b> <i>since Aug 1992</i>	Instituto Nacional de Pesquisas Espaciais (INPE)
<b>Kourou</b> <b>French Guyana,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

The DORIS stations as seen from the 800-km altitude

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





# 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?



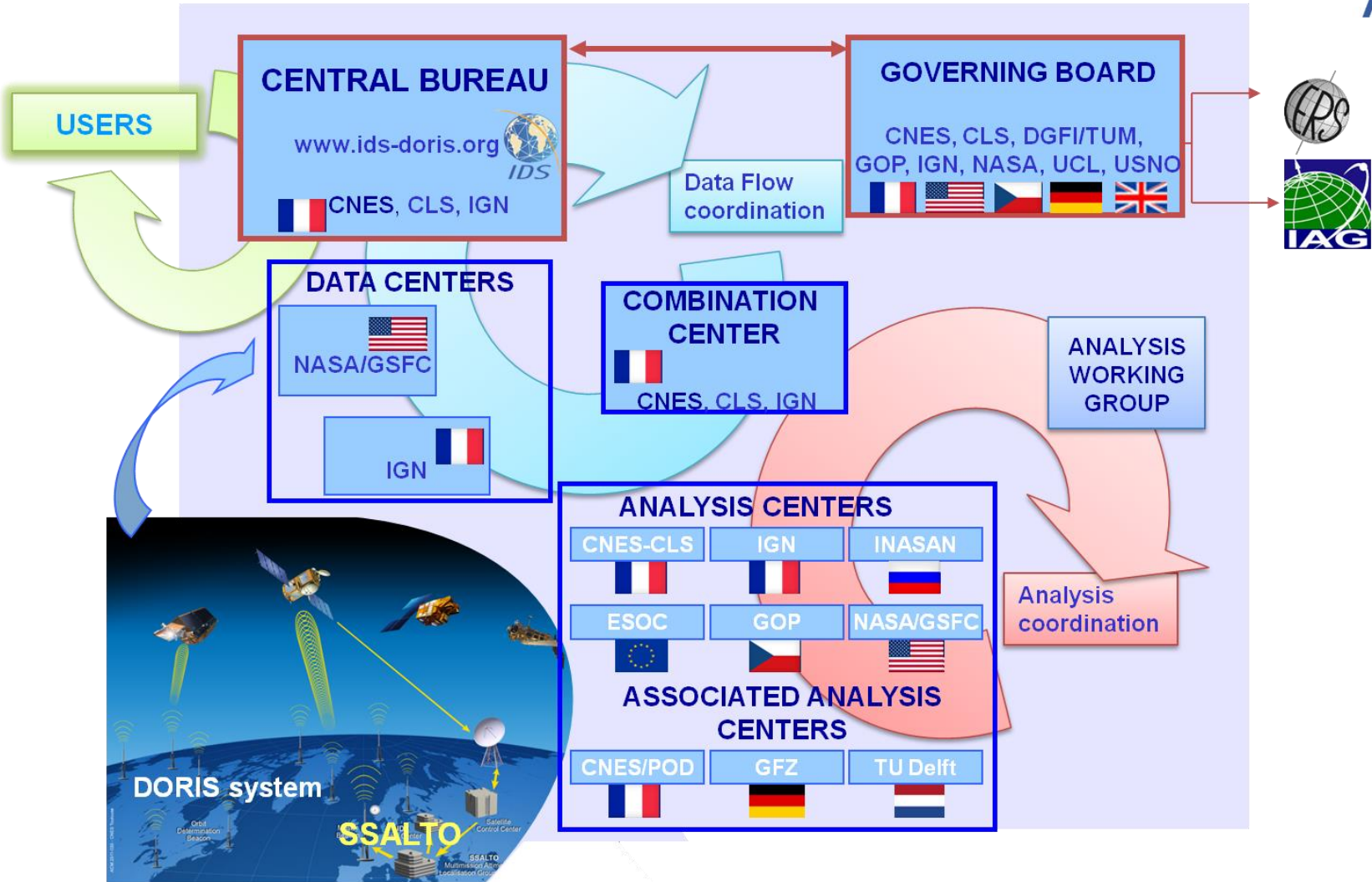
The International DORIS Service is an IAG service created in 2003.

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 ( <i>ESA</i> )	M. Otten	Germany	NAPEOS
NASA/GSFC ( <i>GSC</i> )	F. Lemoine	USA	GEODYN
Geodetic Observatory of Pecny ( <i>GOP</i> )	P. Stepanek	Czech Rep.	Bernese
IGN ( <i>IGN</i> )	P. Willis	France	GIPSY-OASIS
INASAN ( <i>INA</i> )	S. Kuzin	Russia	GIPSY-OASIS
CNES/CLS ( <i>GRG</i> )	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*

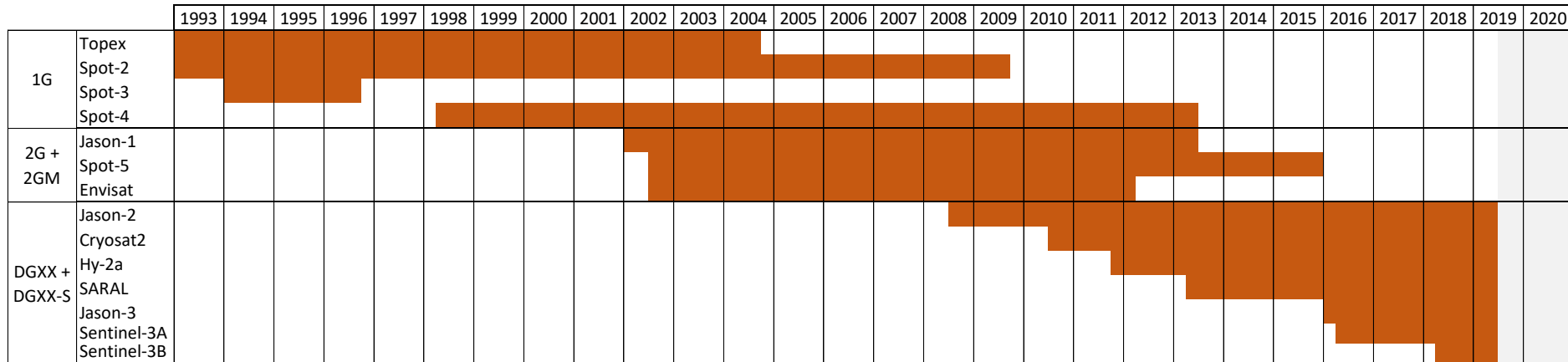


# Information provided by IDS



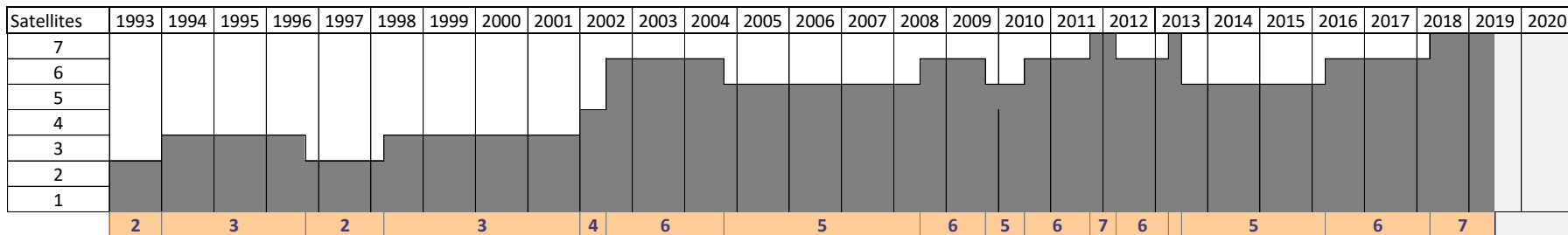
- DORIS data
  - DORIS measurements and ancillary data
  - ftp download from Data Centers and Central Bureau
- IDS products
  - Produced by Analysis Centers and Combination Center
  - ftp download from Data Centers
- Documents
  - Technical documents, presentations, reports, mails,...
  - download from 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
<b>station coordinates</b>	time series of station coordinates differences	quarterly	1 week	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">stcd</a>	IDS CC, ACs	combination
<b>orbits</b>	orbit ephemerides	3-4 weeks	1 min	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">sp3c</a>	ssa (official orbits), ACs	all satellites
<b>geocenter motion</b>	TRF origin solution	occasionally	1 week	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">geoc</a>	ACs	combination
<b>Earth Orientation Parameters</b>	polar motion	occasionally	1 day	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">eop</a>	ACs	combination
<b>ionosphere</b>	ionospheric corrections	week	10 s	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">iono</a>	ssa	en1, ja1, sp2, sp4, sp5, top
<b>reference frame</b>	station coordinate and velocity solution	yearly	global	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">sinex</a>	CC	combination
<b>SINEX</b>	series of station coordinate solutions	quarterly	1 week	<a href="#">CDDIS</a> ; <a href="#">IGN</a>	<a href="#">sinex</a>	IDS CC, ACs	combination

DORIS data and IDS products are available free



# The information system

IDS website

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

Youtube channel

Table of events

Date	Type	Element	Event	Source
2017/03/15 00:00:00	data	JASON-2	JASON-2 in safe hold mode from 2017/03/15 19:20:00 to 2017/03/29 14:30:00. No DORIS-2.2 data and no orbit for this period. RINEX files available during that period but with some gaps.	
2017/03/05 22:47:00	earthquake	[PORTADRESBY] MOSE 51001S003	Magnitude 6.5 Distance 446km	USGS (NEW)
2017/03/04 00:00:00	station	[SOCORRO] SOFC 40503S006	SOFC START	dorismail 1098
2017/03/04 00:00:00	station	[SOCORRO] SOEB 40503S005	SOEB END	dorismail 1098
2017/03/03 00:00:00	station	[RNOCTEA] RMB 62301S004	BEACON CHANGED	dorisstations 0128
2017/02/23 09:40:54	system	SENTINEL-3A	[on board] Orbit Maintenance Maneuver (end : 2017/02/23 09:40:51 [TA]), all data available	SSALTO
2017/02/15 13:30:00	system	JASON-3	[on board] Onboard GPS software reset. Less data from 2017/02/15 13:30:00 [TA] to 2017/02/15 20:51:00 [TA], less data available	SSALTO
2017/02/07 14:07:36	system	CRYOSAT-2	[on board] Orbit Maintenance Maneuver (end : 2017/02/07 14:09:51 [TA]), all data available	SSALTO
2017/01/29 23:14:13	system	JASON-2	[on board] Orbit Maintenance Maneuver (end : 2017/01/29 23:14:14 [TA]), all data available	SSALTO
2017/01/26 00:00:00	data	SENTINEL-3A	Start delivering RINEX with DIODE time tagging and completion of missing periods (version number of the files: 001)	

Information on satellite

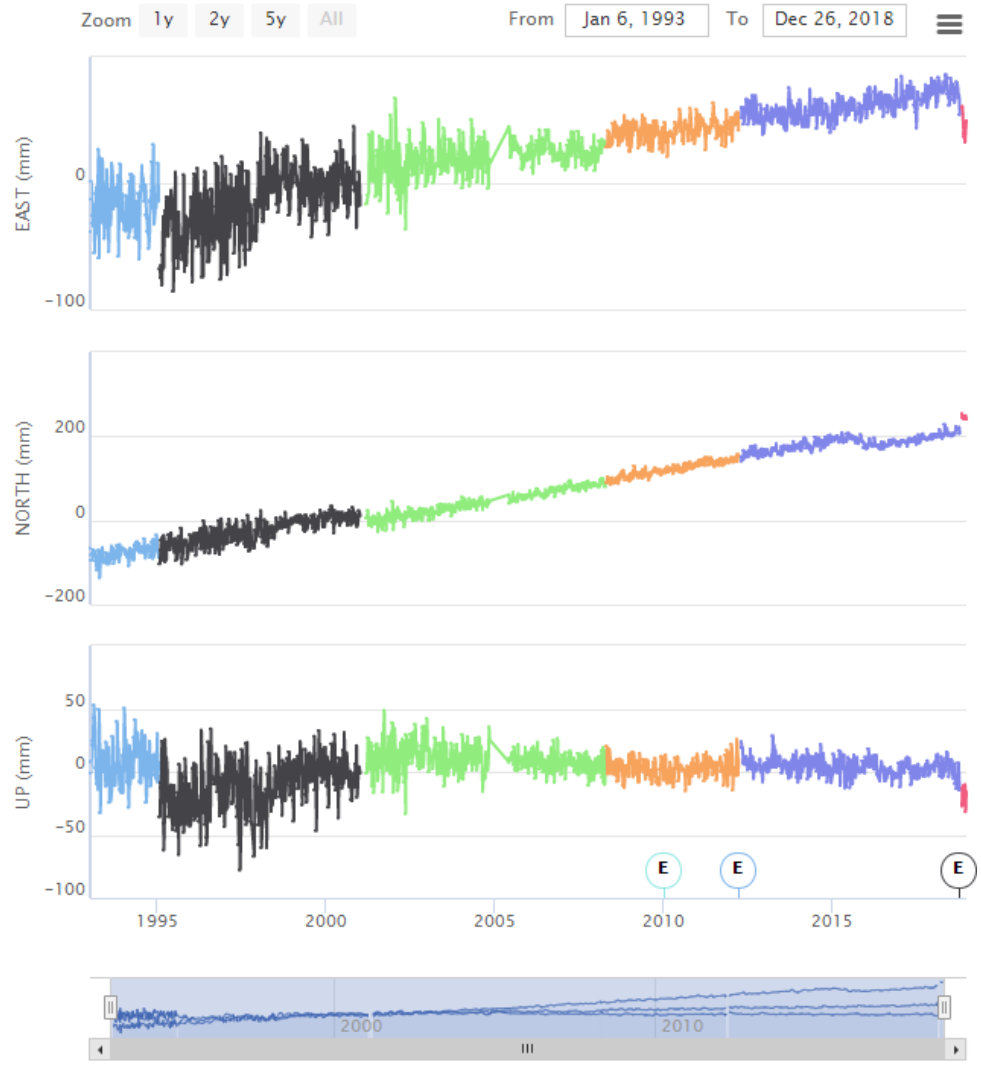
Attributes	
cospar :	1601101
launch_date :	2016/02/16
launch_site :	Plesetsk Cosmodrome, Russia
vehicle :	Rocket/Britz-KM
doris_instrument_end :	-
mission_end_date :	-
periaapsis :	802 km
apoaapsis :	807 km
period :	100.96 minutes
inclination :	98.62°
eccentricity :	0.0003
doris_receiver_generation :	DGXX-S
doris_redundancy :	Yes
other_tracking_system :	SLR+GPS
sp3_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.  $\geq 6$  around DORIS stations

# IDS publications

## 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/>



**IDS AR 2018**  
Soon available

## 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/>



### The synergy of SLR and DORIS as geodetic techniques

Frank Leinweber (NASA GSFC), Alexandre Bailly (NASA Postdoctoral Program, NASA GSFC), Corey Holt (NASA GSFC)



DORIS scientists, Frank Leinweber, Alexandre Bailly, and co-authors presented their paper at the 17<sup>th</sup> International Working Group on Laser Ranging, 5-9 November 2018 in Canberra, Australia. The "Synergy of Satellite Laser Ranging (SLR) and DORIS as Geodetic Techniques" and "Monitoring the True Bias in Laser Ranging Metrics Thanks to the DORIS Experiment". SLR data, in combination with the DORIS data, have been used to provide precise values to geodetic stations in Japan (S, C, and A, Spotsail SA, and 200 mly) and in Antarctica (Australia 1). DORIS data, in combination with the SLR data, have allowed us to measure the global rate of change and the contribution to global mean sea level over the past 20 years. The data from the new DORIS experiment, enabled by DORIS, have provided a new global geodetic view of the SLR stations.

During the workshop, F. Leinweber, A. Bailly, and co-authors presented their paper at the 17<sup>th</sup> International Working Group on Laser Ranging, 5-9 November 2018 in Canberra, Australia. The "Synergy of Satellite Laser Ranging (SLR) and DORIS as Geodetic Techniques" and "Monitoring the True Bias in Laser Ranging Metrics Thanks to the DORIS Experiment". SLR data, in combination with the DORIS data, have been used to provide precise values to geodetic stations in Japan (S, C, and A, Spotsail SA, and 200 mly) and in Antarctica (Australia 1). DORIS data, in combination with the SLR data, have allowed us to measure the global rate of change and the contribution to global mean sea level over the past 20 years. The data from the new DORIS experiment, enabled by DORIS, have provided a new global geodetic view of the SLR stations.



**IDS Newsletter # 6**  
Feb. 2019

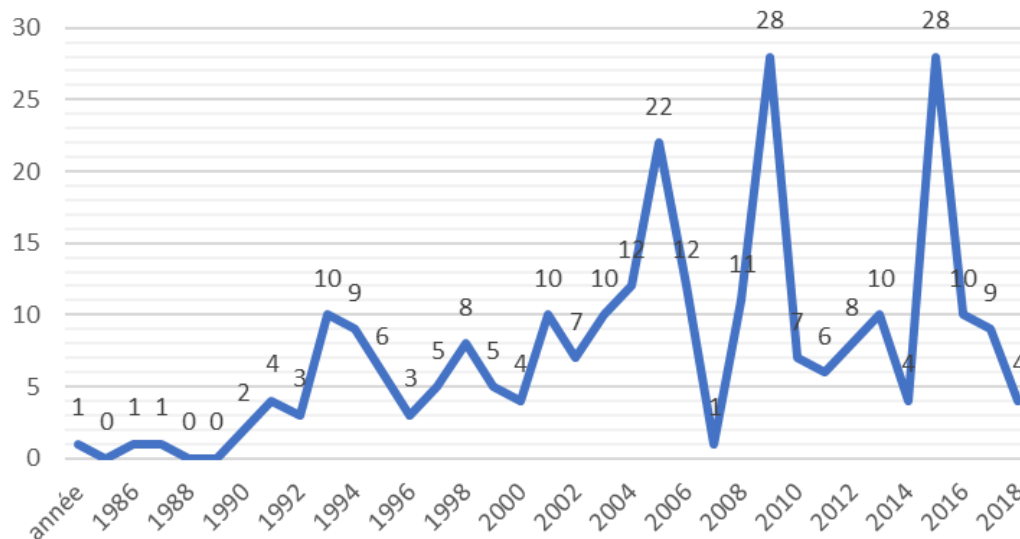
# DORIS bibliography



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-related papers by year



## 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](https://ids-doris.org)**

**Contact: [ids.central.bureau@ids-doris.org](mailto: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](mailto:ids.central.bureau@ids-doris.org)

Governing Board [ids.governing.board@ids-doris.org](mailto: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 Dorothee) 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](mailto: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:

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# More contacts (2/2)



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