

DORIS

DAYS
2021

November 16, 17 and 18

Introduction to DORIS for POD & Geodesy

Laurent Soudarin (CLS)



November 16

Session 1 – Presentation 1

What is DORIS?



In Greek mythology, Doris is a famous Oceanid, mother of the Nereids, the sea nymphs who form the procession of Poseidon, the god of the sea and oceans.



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 in a few words



DORIS is:

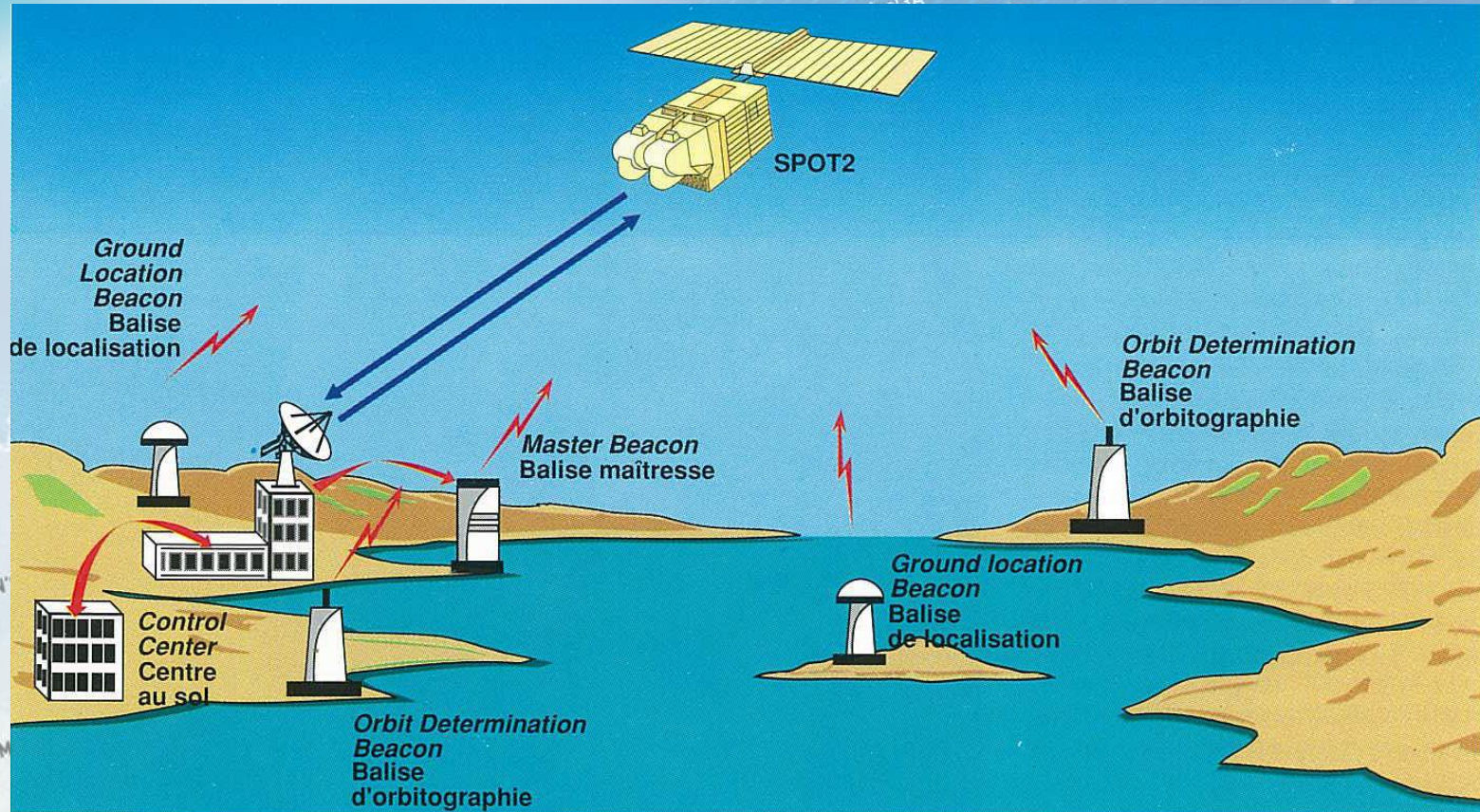
- A French civil satellite tracking system designed for **Precise Orbit Determination (POD)** and high accuracy **ground positioning**
- Developed by **CNES**, the French space agency, in partnership with France's mapping and survey agency **IGN** and the space geodesy research institute **GRGS**
- Optimized 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

The DORIS system



The main components of the system are:

- a **network of emitting stations** covering the globe
- the **equipment onboard the satellites** (receivers and antenna)
- a **Control Center** receiving the DORIS measurements at each satellite pass



DORIS newsletter Nov. 1990

The DORIS constellation



past mission

current mission

- Spot-2
- Topex
- Spot-3
- Spot-4
- Jason-1
- Envisat
- Spot-5
- Jason-2
- HY-2A
- Cryosat-2
- Saral
- Jason-3
- Sentinel-3A
- Sentinel-3B
- HY-2C
- Sentinel-6A
- HY-2D

3 generations of DORIS instruments

4 altitudes

3 orbit planes

1G 2G 2GM DGXX DGXX-S

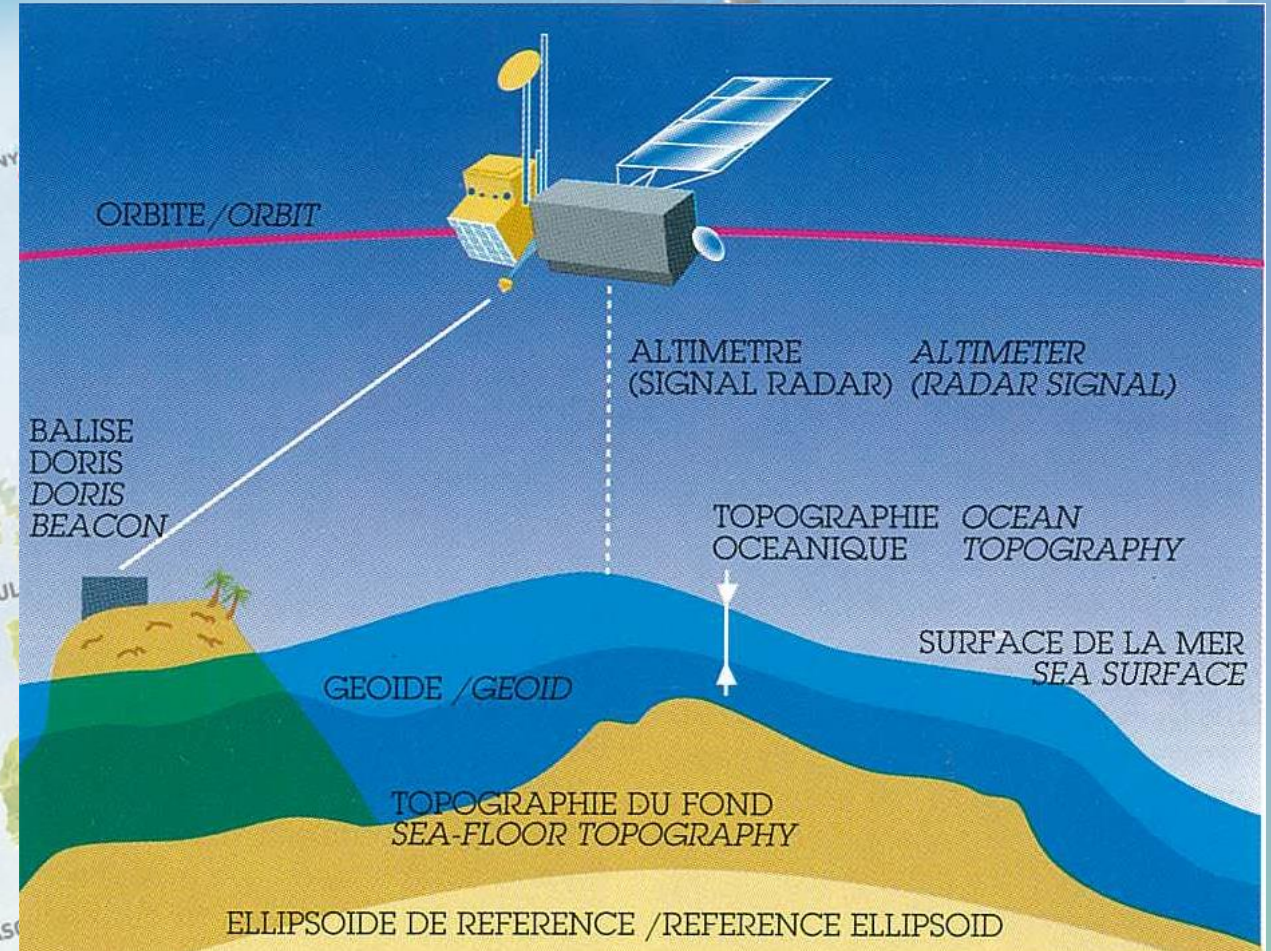
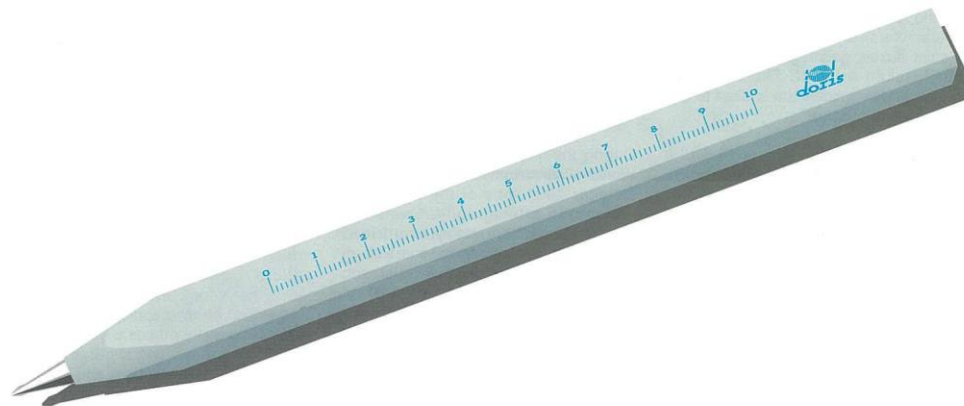
1336 kms 971 kms ~800 kms ~700 kms

98° 92° 66°

DORIS for POD



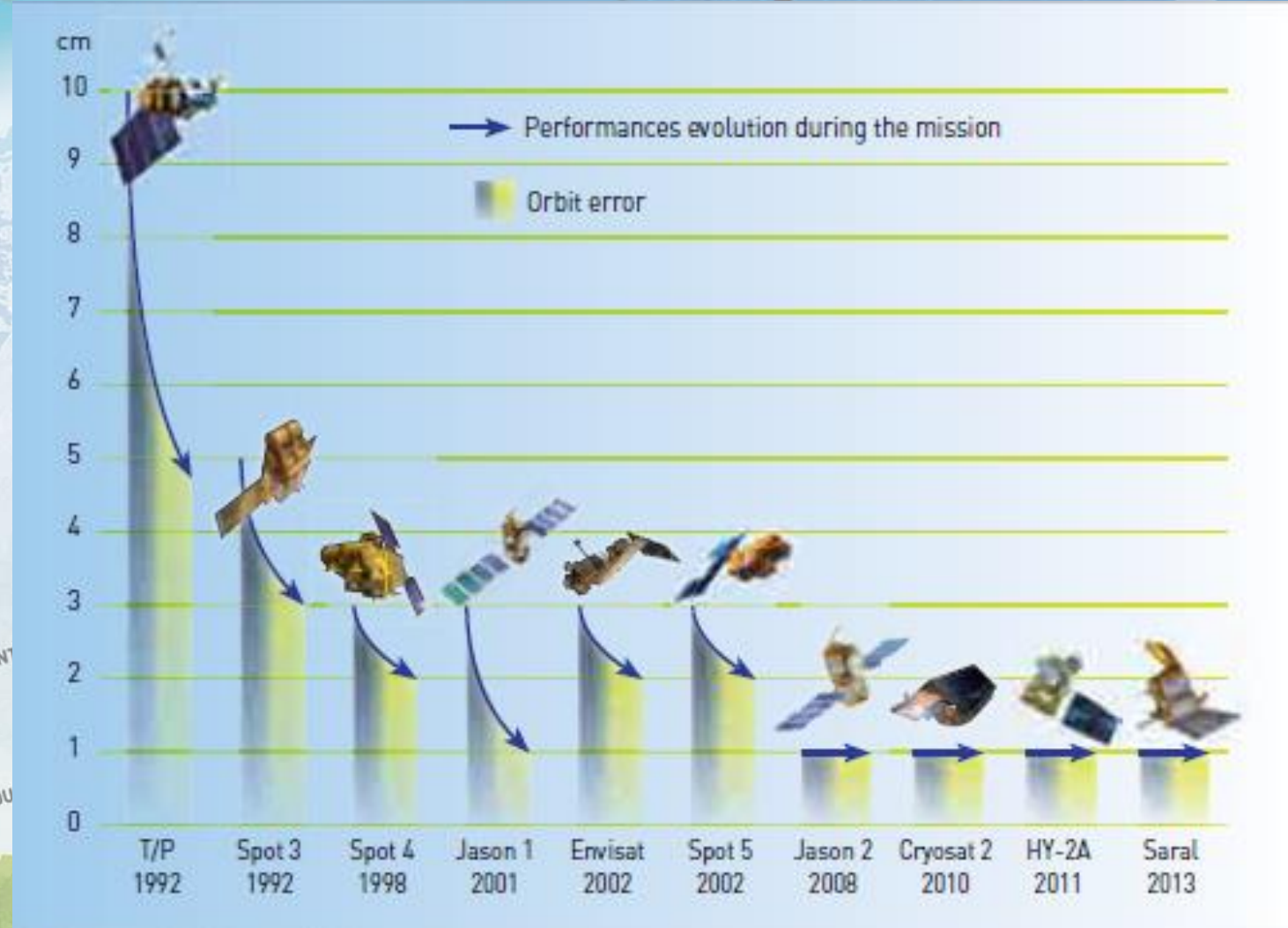
- Initially designed to meet the need for very-high precision orbit determination of TOPEX/Poseidon (1992-2005)
- Objectif: orbit restitution within 10 cm.



DORIS newsletter Nov. 1990

POD performances

- Objective 10-cm precision quickly met and exceeded
- From 10 cm to 2.5 cm for the satellites carrying the first two generations of instruments
- Since Jason-2, 1 cm or even better thanks to the improvements made to the whole system (on-board and ground instruments, monumentation, processing, ...)



DORIS for Geodesy

From its conception, DORIS has been designated for the precise location of the network stations.

- **1990**: the first DORIS instrument is on board **SPOT-2**
- **1992-1993**: first publications on **DORIS positioning** with SPOT-2 data: positioning accuracy of 10-20 cm, then 5-7 cm after improvement of the processing strategy
- **1994**: first contribution to **ITRF** (2 groups: IGN and LEGOS/CLS)
- **1995**: measurements of **tectonic plate motion** with 3 years of data; first geodetic determination for the African plate
- **1999**: first comparison between altimetry and tide gauge and **DORIS vertical motions**

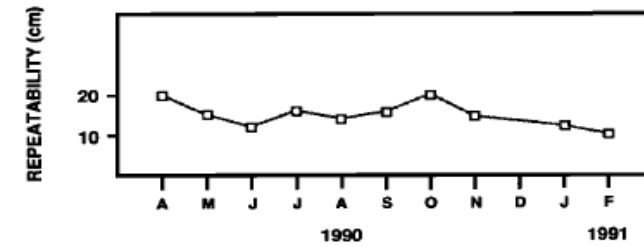
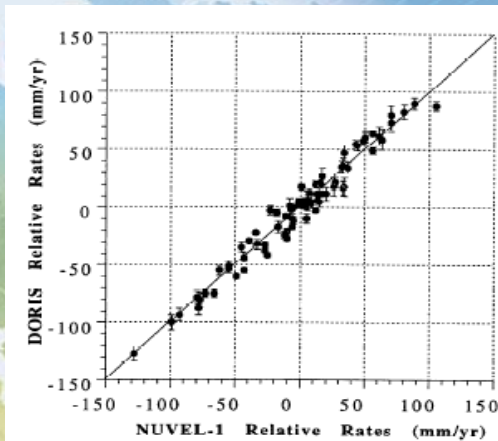


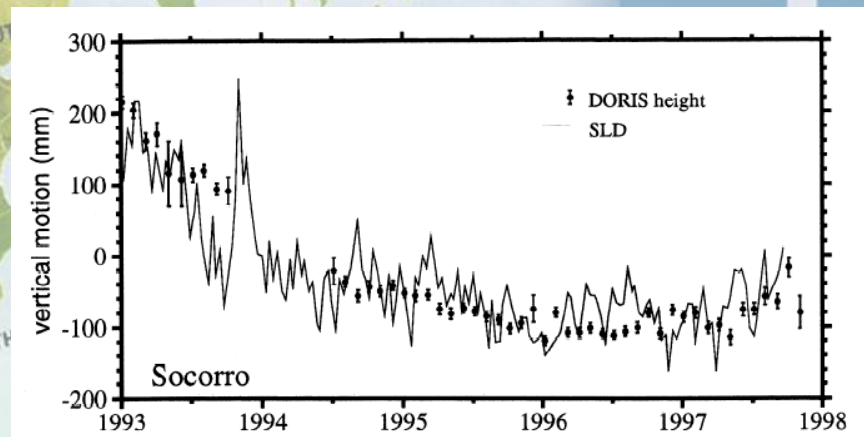
Fig. 6. Monthly repeatability in absolute positioning (whole DORIS network considered)



Cazenave, Valette,
Boucher (1992)



Soudarin and Cazenave (1995)



What DORIS can observe to characterize the geodetic properties of Earth



- ❖ Tectonic plate parameters [*Kraszewska et al., 2018*]
- ❖ Horizontal and vertical velocities of the stations [*Moreaux et al., 2016*]
- ❖ Glacial Isostatic Adjustment [*King et al., 2010*]
- ❖ Long-time series of station positions, records of events affecting the DORIS stations such as:
 - Earthquakes (eg Gorkha Earthquake recorded at Everest's station [*Moreaux et al., 2019*]),
 - present day ice melt of nearby glaciers (eg uplift acceleration in Thule, Greenland [*Moreaux et al., 2019*]),
 - volcanic activity (eg deflation of the Mt. Evermannn volcano observed at Socorro [*Briole et al., 2009*])
 - subsidences (eg slow subsidence of the Tahiti island [*Fadil et al. 2011*]), ...
- ❖ Contribution to the realization of the ITRF [*Moreaux et al., 2016*]
- ❖ Geocenter motion [*Couhert et al., 2018*] and Scale of the TRF [*Štěpánek and Filler, 2018*]
- ❖ Earth Pole coordinates and estimation of LOD [*Štěpánek et al., 2018*]
- ❖ Precise orbits for altimeter missions contributing to determination of the Mean Sea Level [*Rudenko et al., 2019*]
- ❑ Contour of the SAA at the altitude of Spot and Jason [*Capdeville et al., 2016*]
- ❑ Vertical Total Electron Content of the Earth's ionosphere [*Dettmering et al., 2014*]
- ❑ Detection of scintillations (eg CITRIS project (2007-2009) [*Siefring et al., 2011*])
- ❑ Thermosphere perturbations during severe geomagnetic conditions [*Willis et al., 2005*]
- ❑ Long time-series of tropospheric delays and precipitable water [*Bock et al., 2014*]

What is the IDS?



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

- To provide a support, through DORIS data and products, to geodetic, geophysical, and other research and operational activities
- To give access to data, derived products and informations related to the DORIS system

IDS submits DORIS solutions to **IERS** for ITRF realizations.

IDS is a component of **GGOS**

IDS is a member of the **ICSU WDS** network

IAG = International Association of Geodesy

IERS = International Earth Rotation and Reference Systems Service

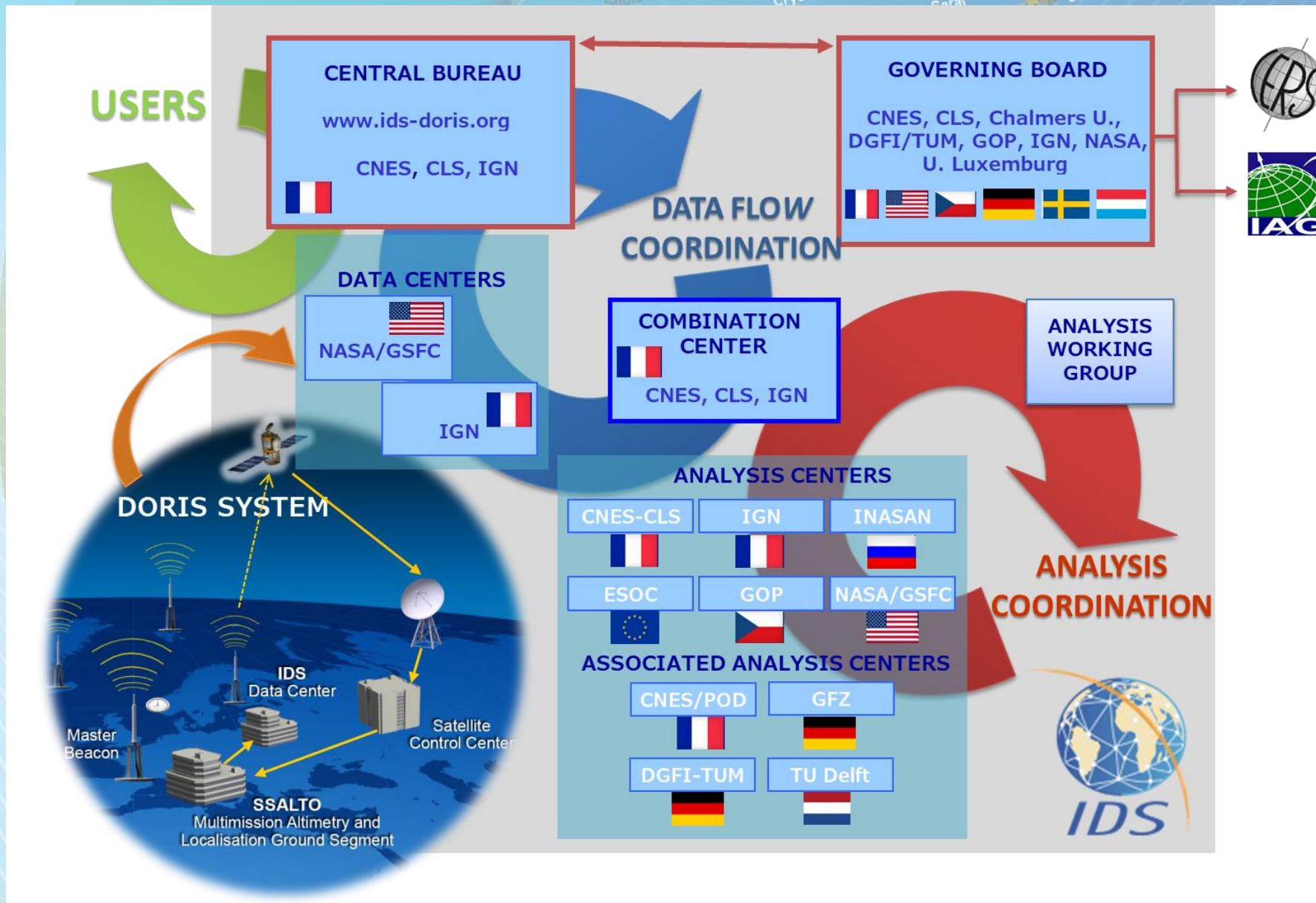
GGOS = Global Geodetic Observing System

WDS = World Data System

ICSU = International Council for Science



IDS organization



IDS life



• Meetings

IDS Workshop:

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

→ next: IDS workshop, Venice, Italy, 21-23 March 2022

Analysis Working Group (AWG) meeting:

1 or 2 every year

Currently: virtual meetings

• Publications

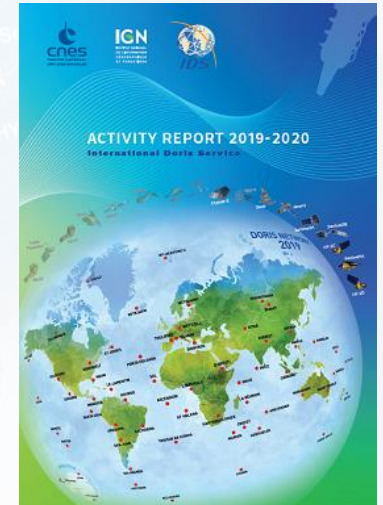
Annual activity reports

- Content:

About IDS / DORIS system /

User service / Analysis Activities

- Available on IDS web site



Newsletters

- Articles about:

project news / the network /

Analysis results / IDS life

- Distributed by email

and available on IDS web site



A new method for monitoring the geocenter motion using DORIS observations

Major water and atmosphere mass transport occurring over large regions gives rise to a motion of the deformable terrestrial crust, that is the geometrical center-of-mass (CM), with respect to the center-of-mass (CM) of the Earth. This motion is strongest at the annual frequency where it mostly reflects non-tidal fluid mass redistribution on the Earth's surface. This heartbeat of the Earth is called the "geocenter motion".

Even though the expected amplitude is smaller than the size of a hair and up to 5 mm in the direction of the polar axis, it is now necessary to account for its perturbing effect on the modeling of ground station coordinates due to the crust, used to observe the natural motion of the satellite, resulting through application of the laws of motion, naturally arise about the Earth's CM, not assuming properly for the geocenter motion effects both satellite altimetry precision and observation and satellite-derived estimates of the change in regional mean sea level of climate change, and the need to both measure the change in sea level and understand their impact on sea level and global fluid mass redistribution, we must develop strategies to better observe and model these subtle variations in the Earth's geocenter motion.

The precise geocenter coordinates of the geocenter motion is still in its infancy compared to satellite altimetry using different techniques that require differences as large as the signal level. The geocenter motion is one of the most demanding requirements of high precision geodesy techniques due to the current precision of the geocenter motion.

The authors of the article presented in Coultas et al. (2020)* provide a new method for monitoring the geocenter motion using DORIS observations which must be rigorously handled to the geocenter motion.

If you want to subscribe to the newsletter, please send an email to: idsnewsletter@ids.fr with "Newsletter" in the subject.

Contributions and feedback are welcome at any time. Please send them to: idsnewsletter@ids.fr with "Feedback" in the subject.

Key points



The DORIS system has been working since 1990

- A performing system for POD and observation of geodetic variables of the Earth
- Current constellation: 8 satellites



International DORIS Service since 2003

- Mission: provide a support, through DORIS data and products, to geodetic, geophysical, and other research and operational activities
- Perspectives: grow the community, lower barriers to entry, technology evolutions ...