Contribution of the DORIS system to the observation and determination of essential variables for geodesy

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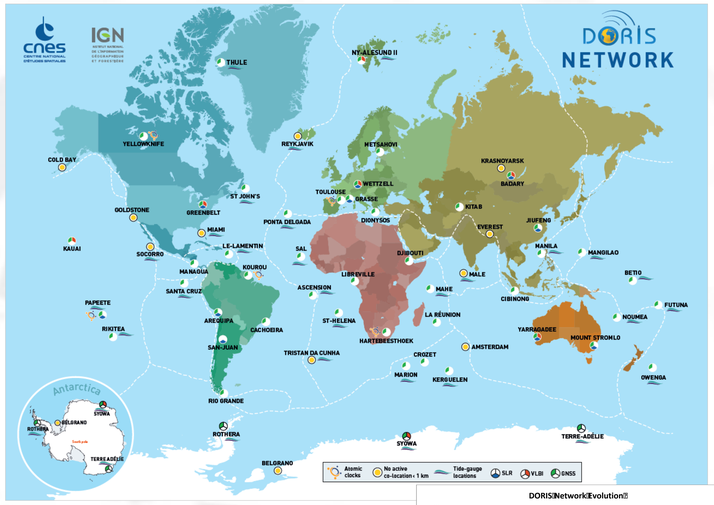
Summary

The **DORIS** system was designed to meet needs in precise orbit determination for satellite-based ocean radar altimetry. Since the launch of TOPEX/Poseidon in 1992, DORIS has played a **key role in the altimetric missions** which contribute to the continuous monitoring of essential variables for Ocean and Climate (e.g. the 25-year series of the Global Mean Sea Level).

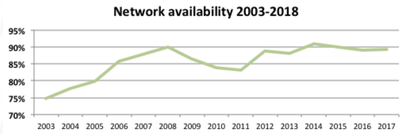
DORIS has also proven greatly valuable for **geodesy and geophysics applications.** Technological and methodological improvements have allowed the improvement in the estimates of the positions of the DORIS tracking ground stations, the Earth rotation parameters and other geodetic variables such as the geocenter and the scale of the ITRF.

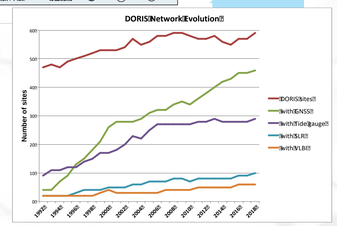
The **IDS** was implemented in 2003 and since then it has guaranteed access to DORIS data and derived products for the user community.

A high performing network (almost 30 years of service)



Network availability 2003-2018





A network build to meet the orbit determination requirements for satellite altimetry

Very homogeneous geographical distribution with ~60 stations

Continuing effort to co-locate DORIS with others techniques

48 co-locations with GNSS and/or SLR and/or VLBI out of 59 DORIS sites

- all tie vectors at co-located sites are available in a maintained file on IDS web

Half of the network co-located with tide gauges (13 within a 1 km radius)

New equipment to make the network more robust

Development of 4th Generation Beacon

- up-to-date electronics allowing reliable operation through 2033.
- beacon-antenna distance up to 50 m providing better options for antenna placement.

New generation of ground antennae: 2GHz phase center stably defined to +/- 1 mm

- Starec C type from Sept. 2014. Today, about 25% of the network has Starec "C".
- Starec D type with new RF characteristics will be deployed from 2019.

Reliability and availability as permanent objectives

Long-term life and stability
Standardizing installations (since 2007)
Integrity monitoring system (since 2010)
12 maintenance operations (equipment replacement) in 2017-2018
Network availability maintained over 85% of operating stations from 2012

Main challenges

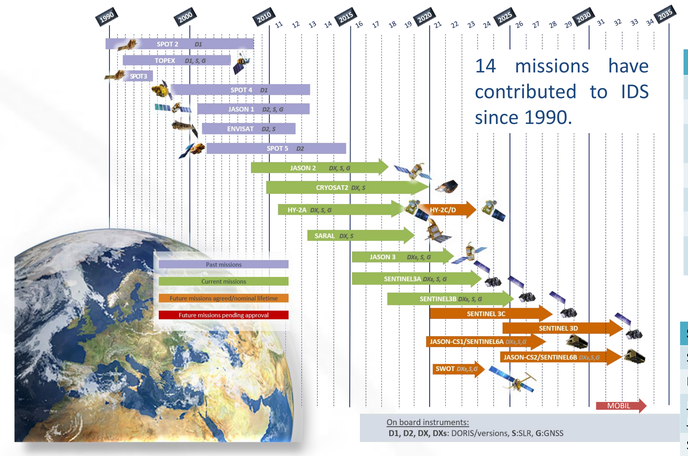
DORIS / VLBI RF compatibility (at GGOS core sites)

- tests performed at Greenbelt (2014); Wettzell (2015-16); Papenoo (2017)

Monument stability monitoring → GGOS goal: 0.1mm/year

- Equipping sites with control points and targets to carry out stability monitoring surveys

A constellation of DORIS contributor satellites guaranted up to 2030+



All current and future DORIS satellites carry a DGXX-class receiver, which can track up-to seven DORIS stations at one time, greatly increasing the available data.

Current Missions: 7

Satellite	Sponsors	Alt. (km)	Inc. (º)	Dates	SLR, GNSS
Sentinel-3B	ESA/Copernicus	814	98.65	4/25/18 – 2025+	S, G
Sentinel-3A	ESA/Copernicus	814	98.65	02/2016 – 2023+	S, G
Jason-3	NASA/CNES/NOAA/ EUMETSAT	1336	66.0	1/17/16–2021+	S, G
SARAL	CNES/ISRO	800	98.5	03/2013 – 2018+	S
HY-2A	CNSA/NSOAS	960	99.0	11/2011 – 2018+	S, (G)
Cryosat2	ESA	717	92.0	06/2010 – 2019	S
Jason-2	NASA/CNES/NOAA/ EUMETSAT	1336	66.0	07/2008 – 2019 +	S, G

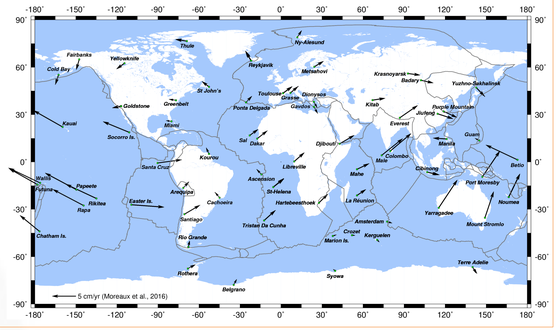
Future Missions: 7 confirmed

Satellite	Sponsors	Alt. (km)	Inc. (º)	Dates	SLR, GNSS
Sentinel-3C, 3D	ESA/Copernicus	814	98.65	2023, 2025 + 5 yrs	S, G
HY-2C, 2D	CNSA/NSOAS	960	66	2019, 2020 + 3 yrs	S, (G)
Jason-CSA/Sentinel-6A Jason-CSB/Sentinel-6B	ESA/Copernicus/NOAA/ NASA/CNES/EUMETSAT	1336	66.0	2020, 2025 + 7 yrs	S, G
SWOT	NASA/CNES	970	78	After 2021 + 3 yrs	S, G
MOBIL	Proposal to ESA, gravimetry, geodesy	LEO-HEO	TBD	After 2028	S,G, + VLBI

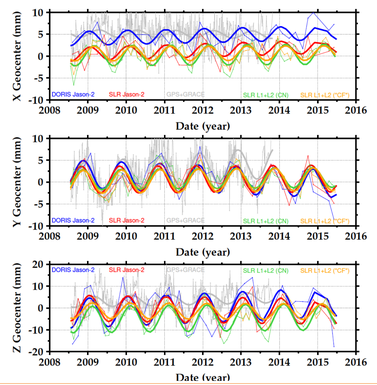
What DORIS can observe to characterize the geodetic properties of Earth

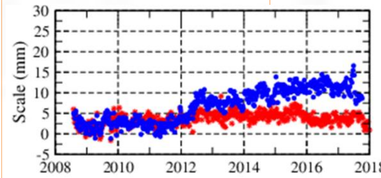
❖Tectonic plate parameters **[a]**
❖Horizontal and vertical velocities of the stations **[b]**
❖Glacial Isostatic Adjustment **[c]**
❖Long-time series of station positions, records of events affecting the DORIS stations such as:
-Earthquakes (eg Gorkha Earthquake recorded at Everest's station **[d]**),
-present day ice melt of nearby glaciers (eg uplift acceleration in Thule, Greenland **[d]**),
-volcanic activity (eg deflation of the Mt. Evermannn volcano observed at Socorro **[e]**)
-subsidences (eg slow subsidence of the Tahiti island **[f]**), …
❖Contribution to the realization of the ITRF **[g]**
❖Geocenter motion **[h]** and Scale of the TRF **[i]**
❖Earth Pole coordinates and estimation of LOD **[j]**
❖Precise orbits for altimeter missions contributing to determination of the Mean Sea Level **[k]**
❖Contour of the SAA at the altitude of Spot and Jason [l]
❖Vertical Total Electron Content of the Earth's ionosphere **[m]**
❖Detection of scintillations (eg CITRIS project (2007-2009) **[n]**
❖Thermosphere perturbations during severe geomagnetic conditions **[o]**
❖Long time-series of tropospheric delays and precipitable water **[p]**

Horizontal displacement of the DORIS stations, reflecting the plate tectonique motion (**[b]** *Moreaux et al., 2016)*



Geocenter time series (**[h]** *Couhert et al., 2018)*
DORIS data can be processed to produce a geocenter time series comparable to that derived from LAGEOS1+2. This points to the possibility to derive a new IDS product for users using the non-polar orbiting satellites (e.g. Jason-2, Jason-3, HY-2C, SWOT). The IDS GB is considering to establish a Pilot Project and Working Group to further explore the development of this potential new product.





Scale of the TRF (CNES/CLS Analysis Center)
The DORIS scale w.r.t ITRF2014 was characterized by an anomalous increase after 2012 ((blue curve). After identifying the causes and applying corrections, the DORIS scale is now more homogeneous for the entire period from 2008 to 2018 (red curve).

[a] *Kraszewska et al., 2018. DOI: 10.1007/s11600-018-0169-3*
[b] *Moreaux et al., 2016. DOI: 10.1093/gji/ggw265/j.crte.2011.02.002*
[c] *King et al., 2010. DOI: 10.1007/s10712-010-9100-4*
[d] *Moreaux et al., 2019. DOI: 10.1016/j.asr.2018.08.043*
[e] *Briole et al., 2009. DOI: 10.1111/j.1365-246X.2009.04087.x*
[f] *Fadil et al. 2011. DOI: 10.1016*
[g] *Moreaux et al., 2016. DOI: 10.1016/j.asr.2015.12.021*
[h] *Couhert et al., 2018. DOI: 10.1029/2018JB015453*
[i] *Štěpánek and Filler, 2018. DOI: 10.1007/s11200-018-0406-x*
[j] *Štěpánek et al., 2018. DOI: 10.1016/j.asr.2018.04.038*
[k] *Rudenko et al., 2019. DOI: 10.5194/se-10-293-2019*
[l] *Capdeville et al., 2016. DOI: 10.1016/j.asr.2016.02.009*
[m] *Dettmering et al., 2014. DOI: 10.1007/s00190-014-0748-2*
[n] *Siefring et al., 2011. DOI: 10.1029/2010RS004585*
[o] *Willis et al., 2005. DOI: 10.1016/j.asr.2005.03.029*
[p] *Bock et al., 2014. DOI: 10.1002/2013JD021124*

IDS prepares the future

IDS retreat in June 2018 in the Southwest of France.
20 participants from and outside IDS
Five subjects of special interest addressed:
✓possible evolution of the DORIS technology
✓Precise Orbit Determination
✓DORIS geocenter and pole estimations
✓IDS scientific goals and organization
✓interest in ionospheric-tropospheric derived products
Next steps:

- preliminary version of the IDS strategic plan
- consultation with the DORIS system stakeholders
- strategic plan with medium and long term actions

Towards NRT applications

Actions are underway to reduce data latency to meet the needs of new applications such as the ionosphere modelling. *(NRT WG Chair: Denise.Dettmering @ tum.de)*

Join IDS community

- DORIS products and IDS data are free, and no subscription is needed to get them
- People interesting in DORIS data processing can contact the CNES/CLS Analysis Center which can help using the GINS software.
  (contact: Jean-Michel.Lemoine @ cnes.fr)
- To share your results with IDS Analysts, just contact us.

Contact: ***ids.central.bureau@ids-doris.org***
IDS website: ***https://ids-doris/org***
DOR-O-T webservice: ***https://ids-doris.org/webservice***