



DORIS

DAYS
2021

November 16,17 and 18



How to become involved in the DORIS community?

November 17

Session 2 – Presentation 6

Karine Le Bail (Chalmers University of Technology /
Onsala Space Observatory)

Frank Lemoine (NASA/GSFC)

How to become involved in the DORIS community?

- Processing DORIS data / Analysis of DORIS data
- Improving modeling of DORIS / technique development
- Using DORIS products for (geo)science applications
- Hosting a DORIS beacon

Different levels of involvement:

- ☐ IDS Analysis Centers / IDS Associate Analysis Centers
- ☐ IDS Working Groups
- ☐ Research projects (MASTER, PhD, research work...)

Become an IDS Analysis Center or an IDS Associate Analysis Center



- Role of an:
 - **IDS Analysis Center** (AC): it provides at least one of the IDS products on a regular basis.
 - **IDS Associate Analysis Center** (AAC): it provides specialized or derived products, not necessarily at regular intervals (precise orbits, station positions, Earth orientation parameters, ionospheric products, tropospheric delays,...).
- How? By mutual agreement
- Who to contact?
 - IDS Analysis Coordinators
 - Petr Stepanek (Pecny Observatory, Czech Republic)
 - Hugues Capdeville (CLS, France)
 - IDS Central Bureau
 - Guilhem Moreaux (CLS, France)

Join an IDS Working Group

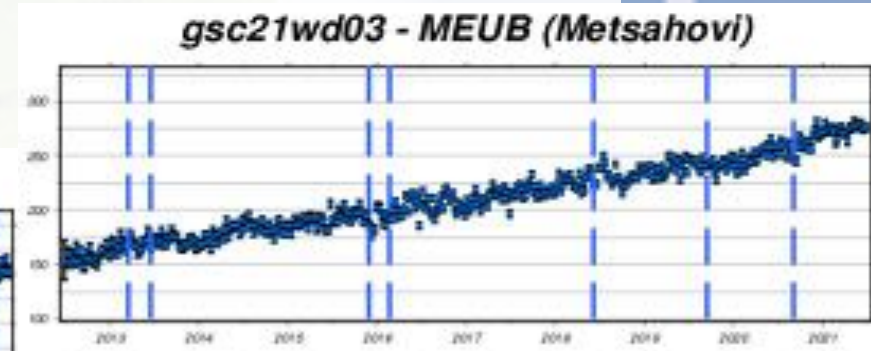
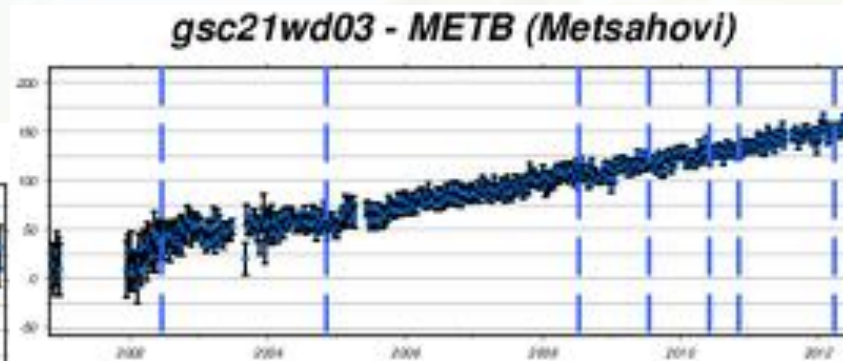
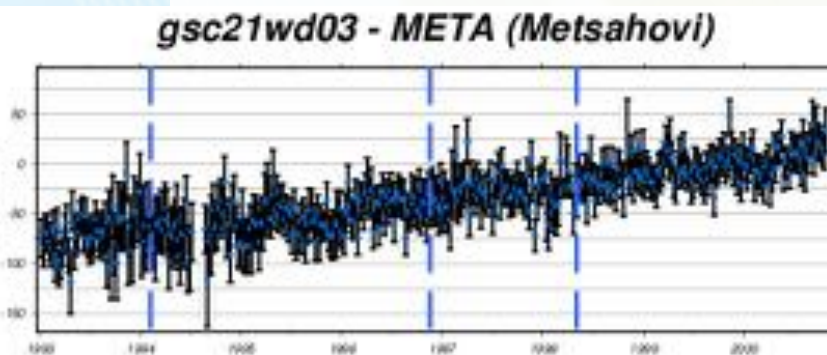


- What?
 - **IDS Working Groups** provide expertise on particular topics related to the IDS components and on development of particular IDS product(s) or service(s) relying on the IDS infrastructure.
- Currently active IDS Working Group:
 - *Near Real Time (NRT) DORIS data*
 - Chair: Denise Dettmering (DGFI/TUM, Germany)
- Proposed IDS Working Group:
 - *Geocenter*
 - Proposed Chair: Alexandre Couhert (CNES, France)

Few ideas of research topics

- a) How to better *model radiation impact on USOs*. Previously suggested by Jean-Michel Lemoine (CLS, France)
- b) How to leverage the long time series of data at DORIS sites for long-term *monitoring of climate* through development of a troposphere product

North (mm) – Metsahovi DORIS site
1993 to 2021



Few ideas of research topics

- a) How to better *model radiation impact on USOs*. Previously suggested by Jean-Michel Lemoine (CLS, France)
- b) How to leverage the long time series of data at DORIS sites for long-term *monitoring of climate* through development of a troposphere product
- c) How to infuse *new technology* into DORIS system
- d) *Non-conservative modeling* (Solar Radiation Pressure) for DORIS satellites
- e) Systematic test of improved modeling for ground oscillators using *connected GNSS receivers*
- f) Processing *phase data* in DORIS RINEX files
- g) How to *use the NRT products* of DORIS in an innovative manner



Possible topics for IDS Working Groups or research projects

Study Particular Topics with IDS collaborators



Improve non-conservative force modelling for DORIS satellites:

- Satellites orbit at low altitude where drag is more important; They have shapes that complicate radiation-pressure or atmospheric drag modelling.
- Motivation is better force modelling, but to prevent aliasing into geodetic products, but also better POD.

Using GPS Clocks to better model local oscillators (USOs).

- USO behavior on-orbit and perhaps on ground is limiting error source.
- *Stepanek et al. (2020, J. Geodesy)* showed how using the GPS clock solutions can improve the modelling of the DORIS-on-orbit USO for the Sentinel satellites.
- Recently some ground stations have been connected in the same fashion.

Phase processing of DORIS data, as opposed to processing data as Doppler data. Closer to raw observable, but is more complex (as a start see *Mercier et al., 2010, Adv. Space Res.*).

Use DORIS products



DORIS products:

- Coordinates and velocities of IDS tracking stations
- Geocenter and scale of the TRF
- High accuracy ephemerides of DORIS satellites
- Earth Orientation Parameters
- Ionosphere corrections

Applications:

- Realization of global accessibility to and improvement of the ITRF
- Monitoring deformations of the solid Earth
- Monitoring crustal deformation at tide gauges
- Monitoring variations in the hydrosphere (sea-level, ice-sheets,...)
- Orbit determination for scientific satellites

What DORIS can observe

L. Soudarin presentation 1 in session 1

- 1) Tectonic plate parameters
- 2) Horizontal and vertical velocities of DORIS stations
- 3) Glacial Isostatic Adjustment
- 4) Earthquakes, present day ice melt of nearby glaciers, volcanic activity, subsidence
- 5) Contribution to the realization of the ITRF
- 6) Geocenter motion and scale of the TRF
- 7) Earth Pole coordinates and estimation of LOD
- 8) Precise orbits for altimeter missions contributing to determination of the Mean Sea Level
- 9) Contour of the SAA at the altitude of Spot and Jason
- 10) Vertical Total Electron Content of the Earth's ionosphere
- 11) Detection of scintillations
- 12) Thermosphere perturbations during severe geomagnetic conditions
- 13) Long time series of tropospheric delays and precipitable water

What DORIS can observe

L. Soudarin presentation 1 in session 1

1) Tectonic plate parameters

2) Horizontal and vertical velocities of DORIS stations

3) Glacial Isostatic

4) Earthquakes, post-glacial
subsidence

5) Contribution to

6) Geocenter motion

7) Earth Pole coordinates

8) Precise orbits for satellites

Mean Sea Level

9) Contour of the

10) Vertical Total Earth

11) Detection of sea level

12) From Moreaux

13) et al., 2016

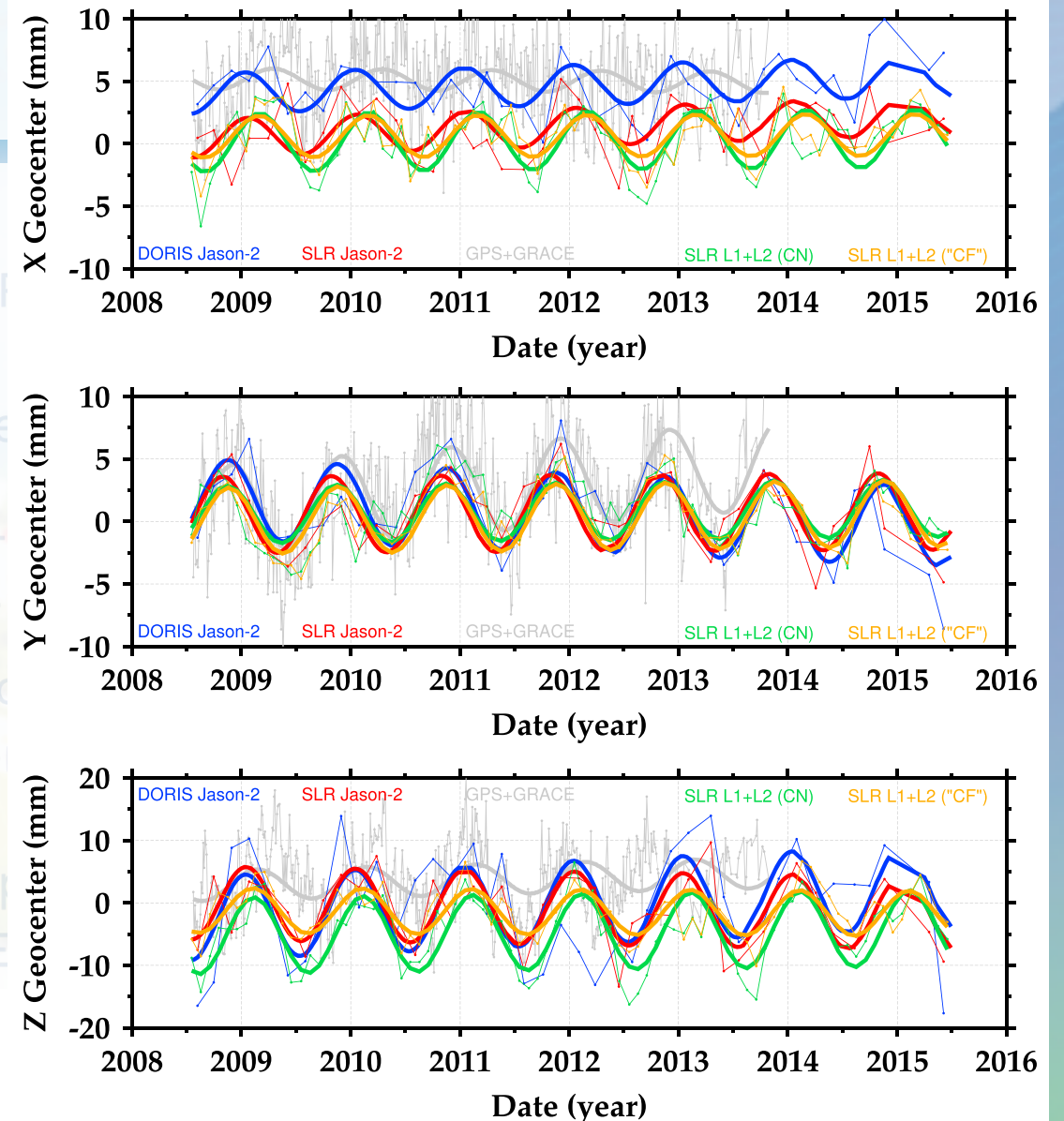


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- 5) Contribution to the realization of the ITRF
- 6) **Geocenter motion** and scale of the TRF
- 7) Earth Pole coordinates and estimation of Earth rotation
- 8) Precise orbits for altimeter missions compared to GPS
- 9) Contour of the SAA at the altitude of SAA
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- 13) Long time series of tropospheric delays and precipitable water

From Couhert
et al., 2018



What DORIS can observe

L. Soudarin presentation 1 in session 1

- 1)
- 2)
- 3)
- 4)
- 5)
- 6)
- 7)
- 8)

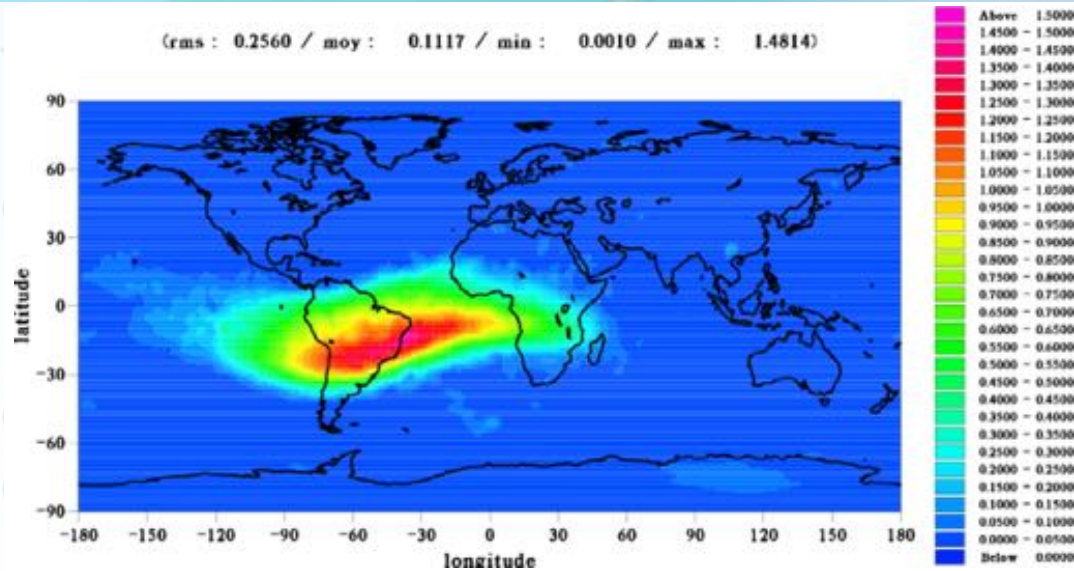


Fig. 1. Plot of the DORIS derived relative dose exposure in 2002-2005 at 1300 km altitude

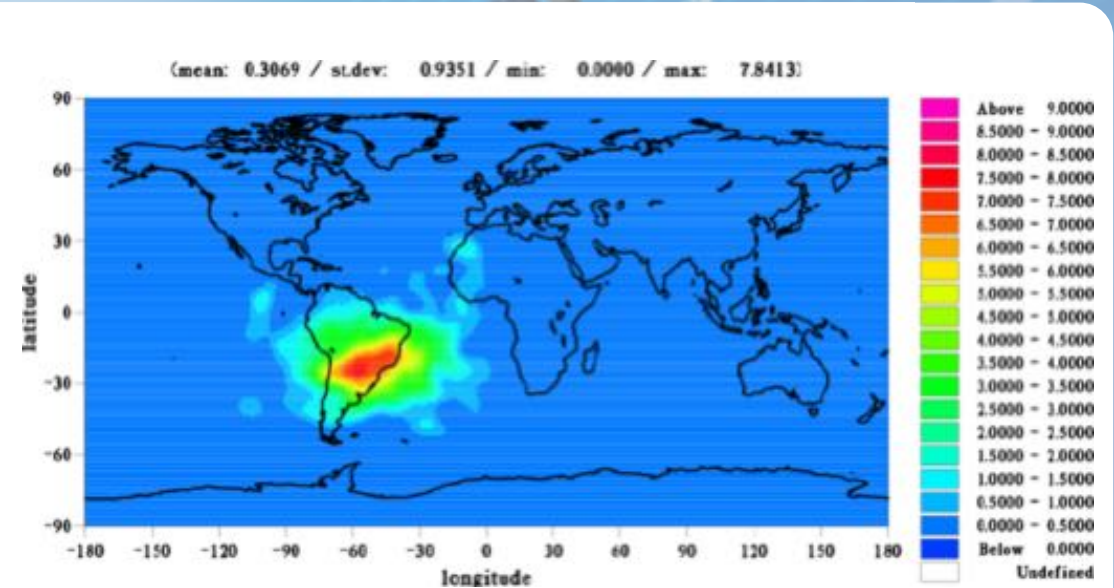


Fig. 18. Plot of the DORIS derived relative dose exposure in 2009-2011 at the altitude of SPOT-5

9) Contour of the SAA at the altitude of Spot and Jason

10) Vertical Total Electron Content of the Earth's ionosphere

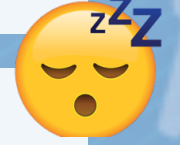
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12) Thermosphere perturbations during severe geomagnetic conditions

13) Long time series of tropospheric delays and precipitable water

From Capdeville et al., 2016

Attend an IDS meeting



IDS Analysis Working Group meetings:

- On the order of twice per year;
- Focused on analysis issues with data or products;
- Attendees: mostly from ACs, AACs, but all are welcome.

IDS Workshop:

- Bi-annual meeting associated with Ocean Surface Topography Science Team Meeting (OSTST);
- Next meeting: March 21-23, 2022, Venice, Italy;
- Most probably hybrid meeting (in-situ + virtual presence).
- See: <https://ostst-altimetry-2022.com/>

Participate in the DORIS Special Issue



Previous DORIS Special Issues

- Journal of Geodesy (2006);
- Adv. Space Research (2010, 2016): Associated with ITRF2008, ITRF2014.

“New Results from DORIS for Science and Society”

Special Issue Adv. Space Research.

Nominal Submission deadline January 31, 2022.

Co-editors:

Denise Dettmering (DGFI/TUM, Germany)

Ernst J.O. Schrama (TU Delft, Netherlands)

<https://cosparhq.cnes.fr/assets/uploads/2021/05/DORIS-announcement.pdf>

Create your own DORIS mission



- Mid-2000's: development of the CITRIS receiver by the US Navy Research Lab to use the DORIS beacons to monitor ionosphere scintillations.

Bernhardt et al. "Ionospheric applications of the scintillation and tomography receiver in space (CITRIS) mission when used with the DORIS radio beacon network". J Geodesy 80, 473–485 (2006). See Fig. 1

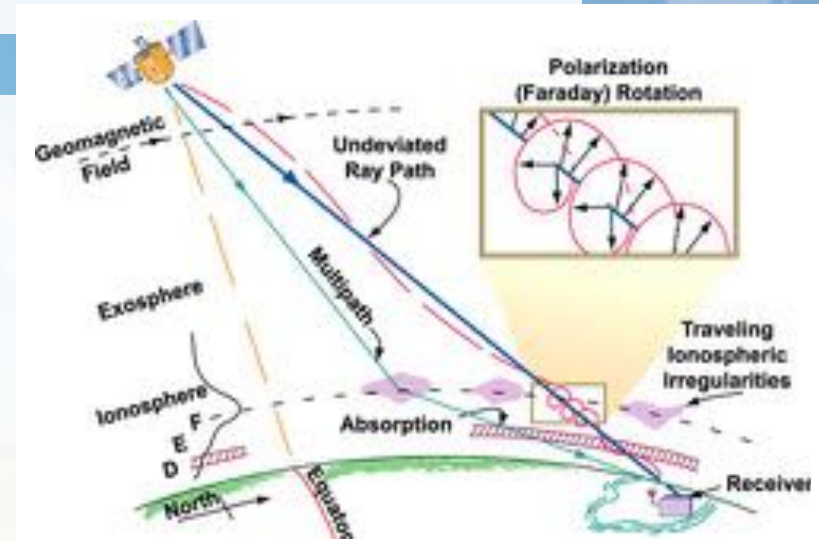


Fig. 1 Major ionospheric propagation effects on space-to-ground links (Adapted from Davies 1990)

- Advent of Cubesat technology → easier to develop own mission. Open possibilities to exploit the DORIS network for:
 - Various studies, e.g. time transfer (as in T2L2);
 - Ionosphere (as in Bernhardt et al., 2006);
 - Test-bed for new technology (new types of frequency oscillators).



Key points

Ways to get involved in the DORIS community

- Join an existing or a proposed working group.
- Explore DORIS products.
- Look at station coordinate time series viewer.
- Partner with an existing Associate Analysis Center or Analysis Center in analysis of DORIS data.
- Help elucidate key modelling problems.
- Propose a new DORIS site that would support the network and satisfy clear scientific objectives.



Show your interest!

Go to www.menti.com

Use the code: 9250 5668

<https://www.menti.com/rin8am6pwq>



- Level of interest. Participation in the DORIS community as...
 - IDS AC
 - IDS AAC
 - IDS working group (e.g. geocenter, SAA, technology)
 - Research project
 - Science application
 - Master or PhD study
 - Teaching of geodesy
 - DORIS Special Issue
 - IDS Workshop (March 2022)
- Which topics are you interested in?
Examples: ITRF, colocation of space geodesy techniques, NRT products