System (POD, Positioning, & EOP) Performance

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November 17

Session 2 – Presentation 3

Evolution of the DORIS System

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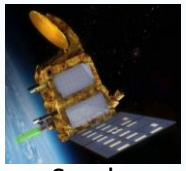
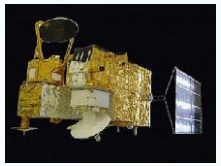
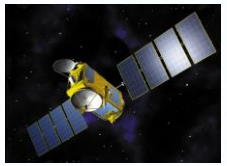
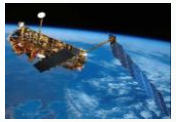

Saral


HY-2A

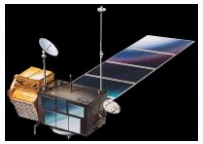

Jason-2


Cryosat-2

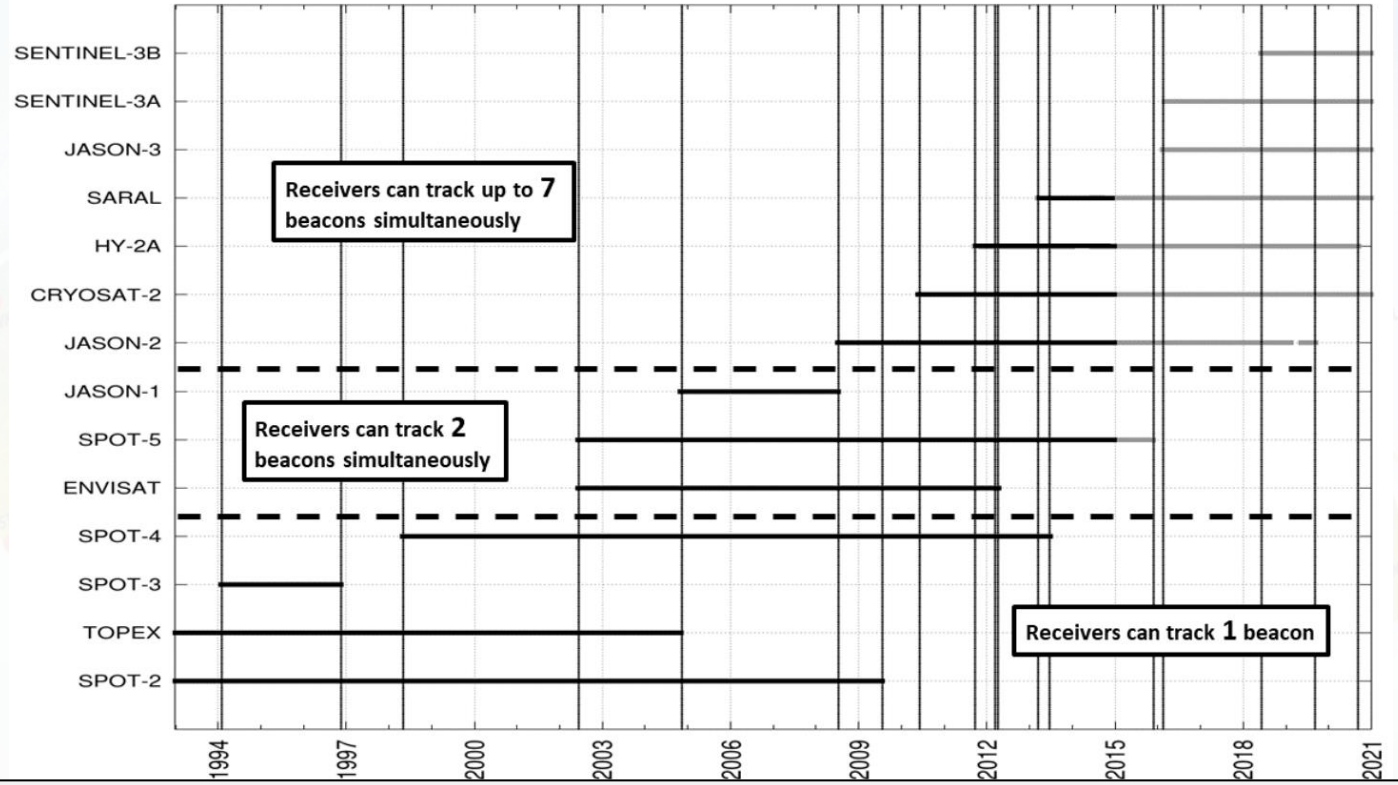

SPOT-5


ENVISAT


SPOT-2,3

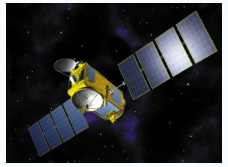

TOPEX/Poseidon

The increase in the number of satellites in the DORIS constellation, as well as the increase in number of beacons that can be tracked at one time both work to improve DORIS performance with time. The years 2002 & 2008 are inflection points in DORIS System performance.



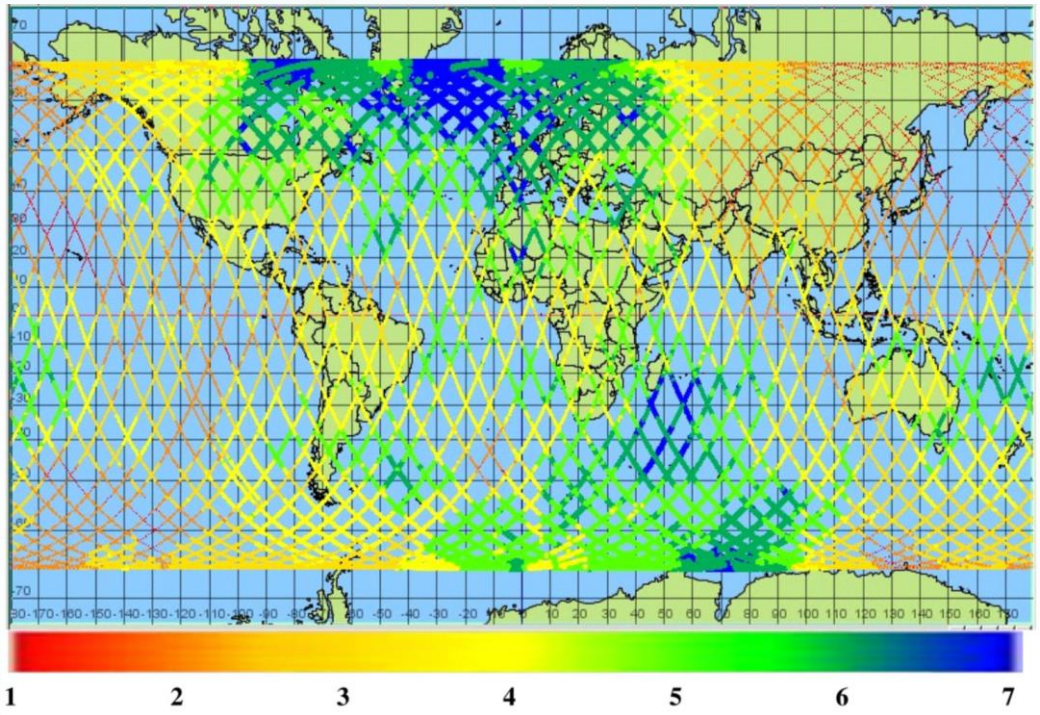
Satellite Data used in IDS ITRF2020 combination (*Moreaux et al., 2021, manuscript in preparation*)

Evolution of the DORIS System

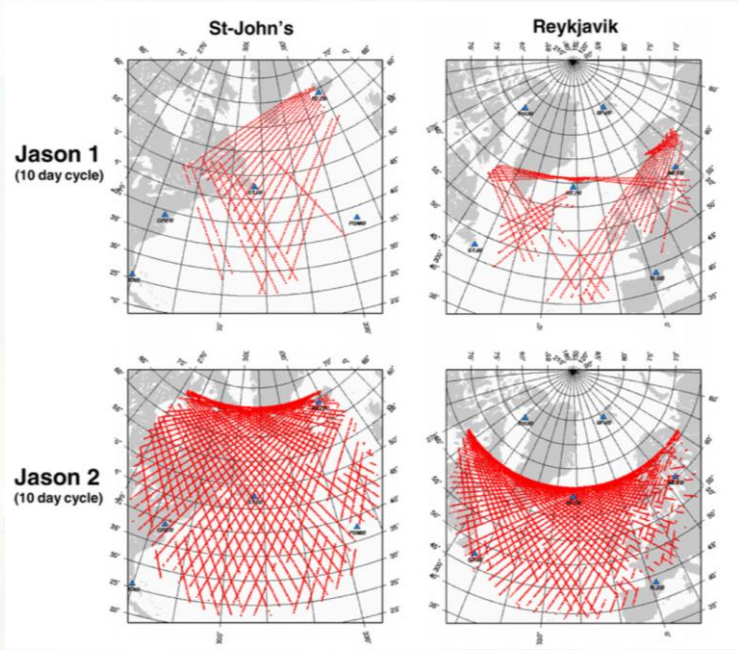


Jason-2

Geographic distribution vs. Number of beacons tracked for Jason-2 in 2008



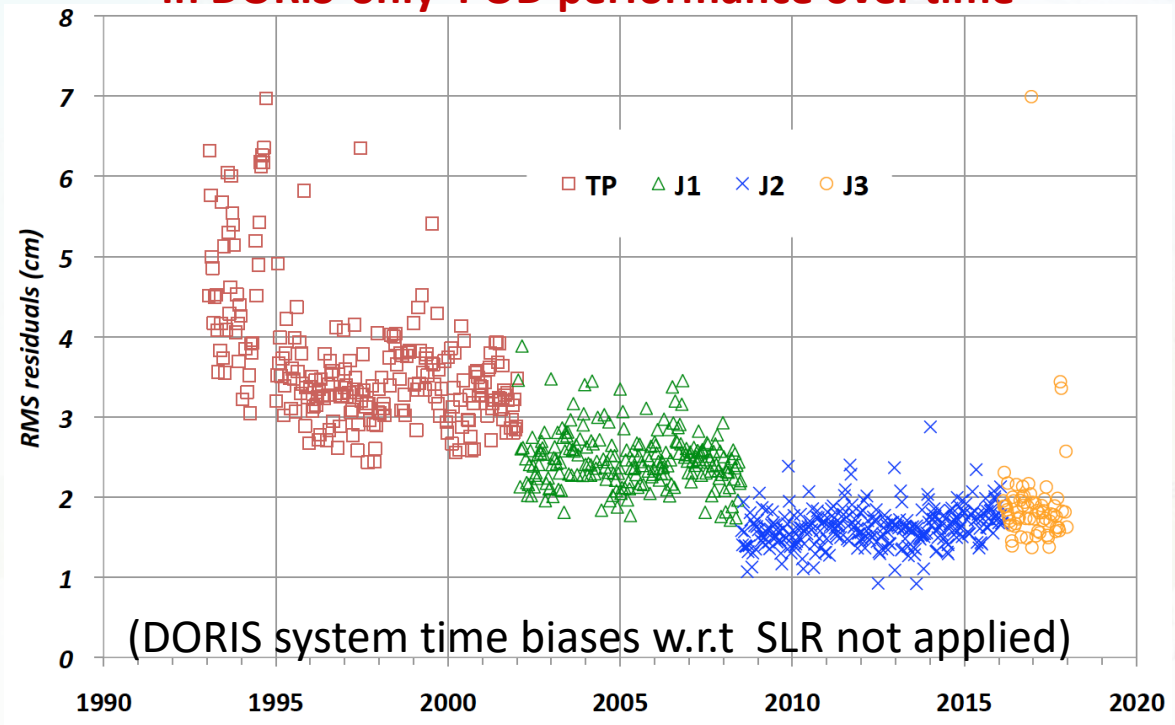
Tracking passes per 10-day period for Jason-1 & Jason-2



Auriol A. & C. Tourain (2010). Adv. Space Res.,46, 1484-1496 10.1016/j.asr.2010.05.015

Evaluation of DORIS-only orbits (1)

Independent Satellite Laser Ranging data Illuminates Improvement In DORIS-only POD performance over time

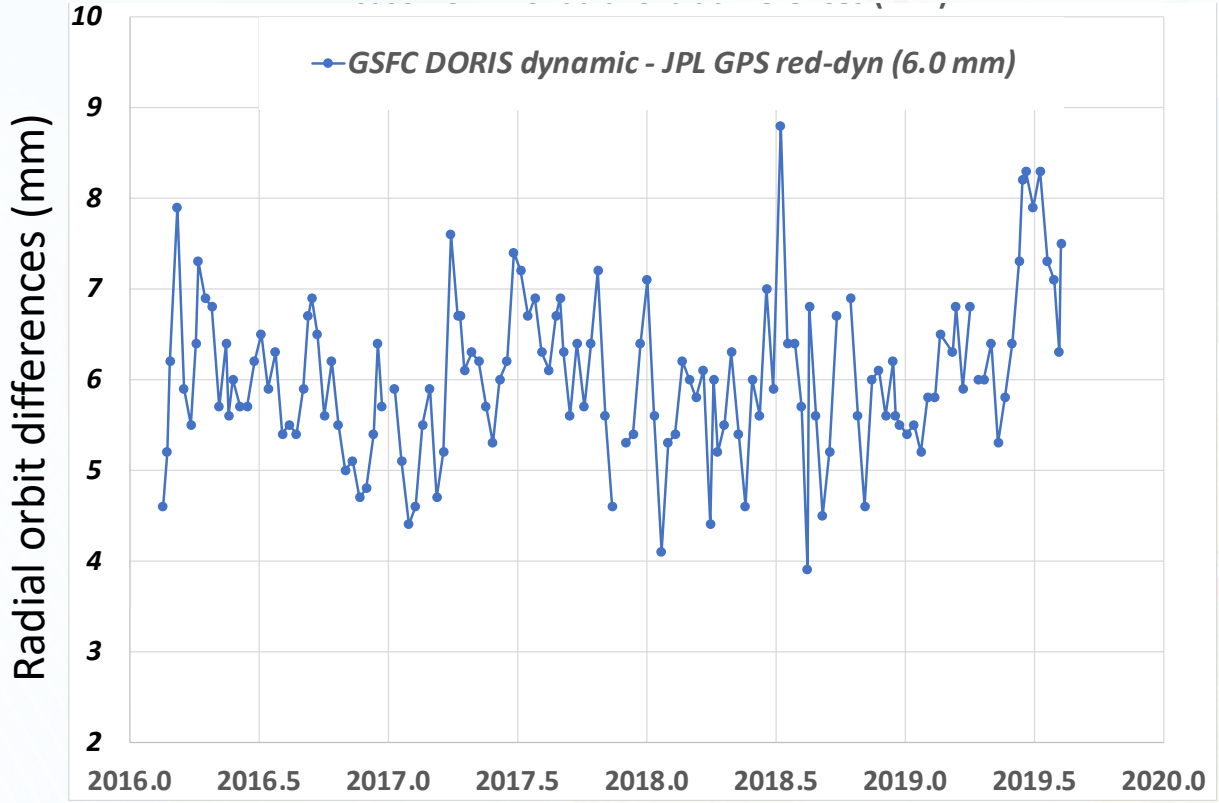


The SLR data illuminate improvements in the DORIS system:
~ June 2002: Expansion of DORIS satellite constellation, & Availability of two-channel DORIS receivers.
Summer 2008: Launch of first satellite with an seven-channel DORIS Receiver (Jason-2)
(Figure from Nikita Zelensky, Univ. Maryland/ESSIC)

Evaluation of DORIS-only orbits (2)

Jason-3 Orbit Differences: (DORIS-only vs. GPS reduced-dynamic)

(*RMS radial orbit differences per altimeter data cycle, per ~10 days*)



We routinely intercompare orbits produced by different data and from different centers to verify the quality of the orbits and to ensure the integrity of the orbits supplied for the altimeter products.

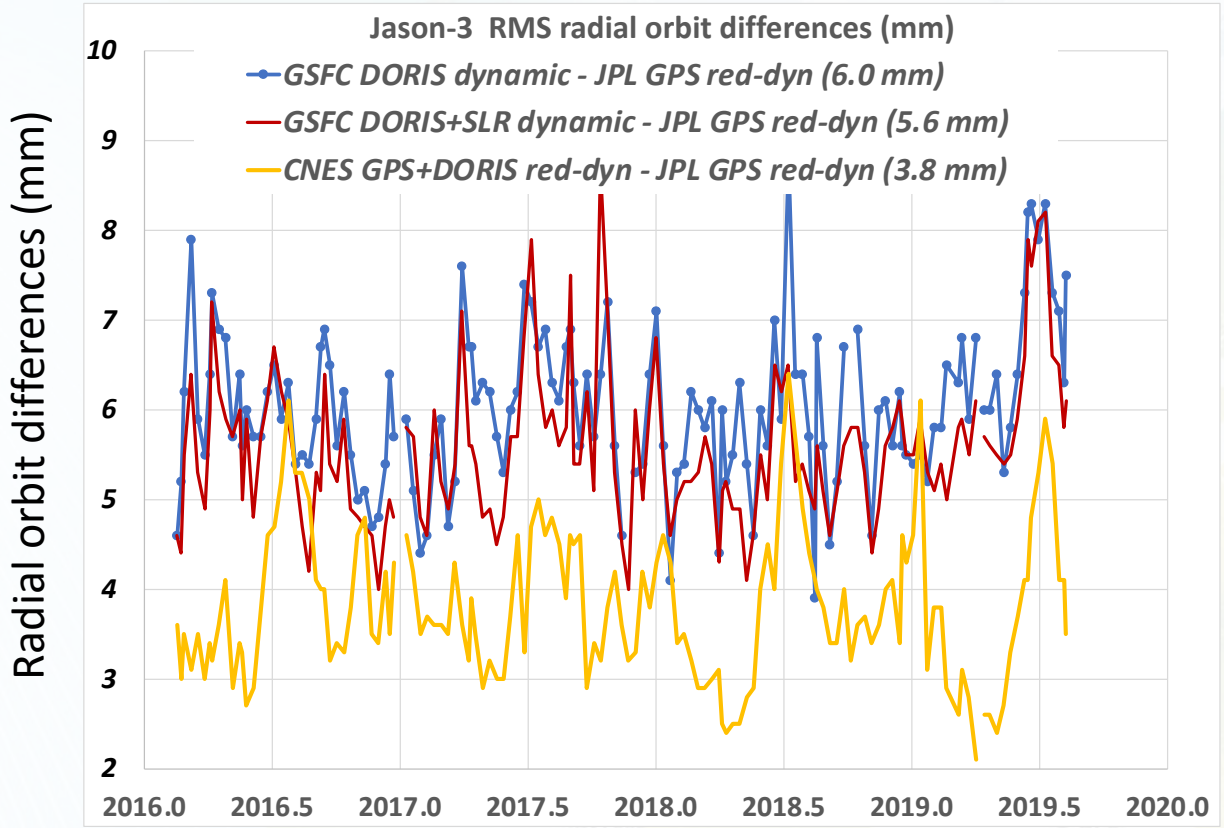
→ **Standard method of quality control for POD.**

Here we show a comparison of a GSFC **DORIS-only-orbit** for Jason3 vs. the independent JPL/**GPS red-dyn** orbits. The agreement has been between 6-8 mm for Jason-3.

Evaluation of Orbit Accuracy for Mean Sea Level

Jason-3 Orbit Differences: (Test orbit vs. JPL/GPS Red-dynamic)

(*RMS radial orbit differences per altimeter data cycle, per ~10 days*)



"Recognizing the 8–10 mm orbit accuracy on the Jason series and Sentinel-3 series of missions, the OSTST recommends that future oceanographic altimeter missions embark three independent precision orbit determination instruments: DORIS, GNSS, and SLR to achieve orbit accuracy sufficient to calculate key climate variables such as sea level change, and to allow for independent verification of that accuracy."

- **Resolution adopted by Ocean Surface Topography Science Team (OSTST), Ponta Delgada, Azores, (2018).**

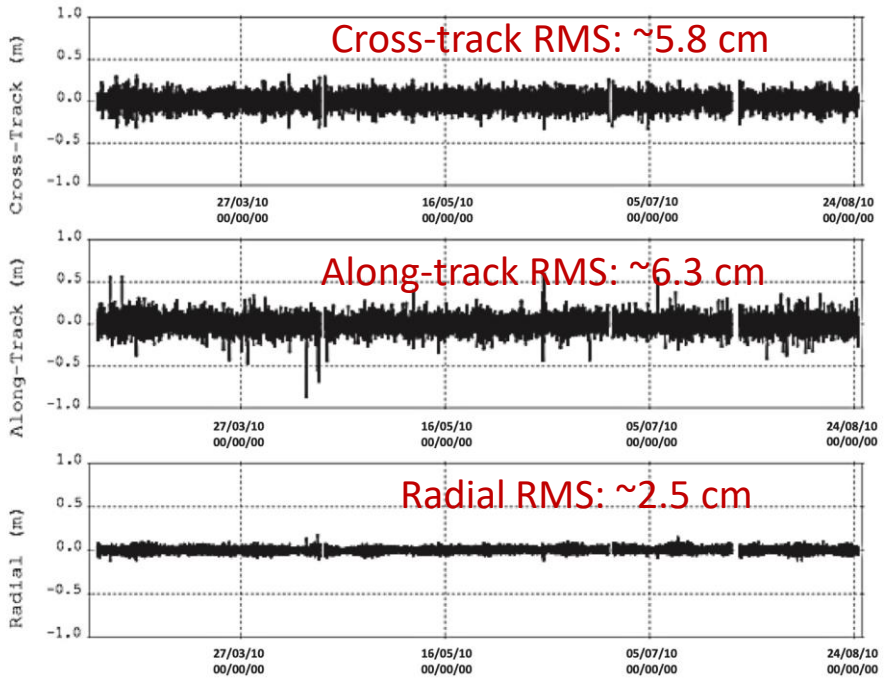
https://www.aviso.altimetry.fr/fileadmin/documents/OSTST/2018/OSTST_2018_Meeting_Report_Final.pdf pp 75-76.

Here we show a comparison of a different orbits of Jason3, computed by different centers (CNES, GSFC, JPL), and using different sets of data.

DIODE Performance

DIODE orbit performance on Jason-2

(comparison with an a posteriori precise ephemeris)



DIODE Orbit differences for 150 days in 2010

Jayles et al., (2016). *Adv. Space Res. 58,* 2691-2706, doi:10.1016/j.asr.2016.05.032

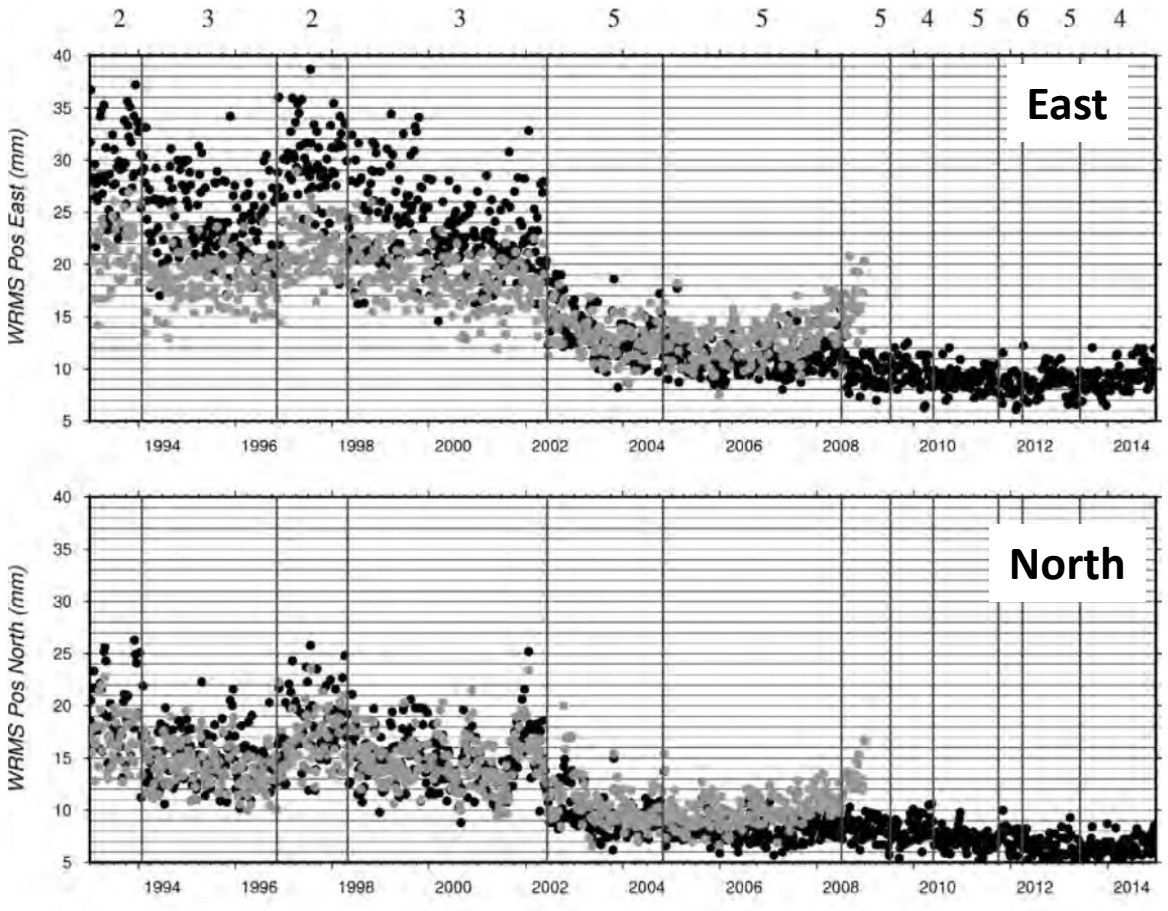
DIODE – On Board Kalman Filter

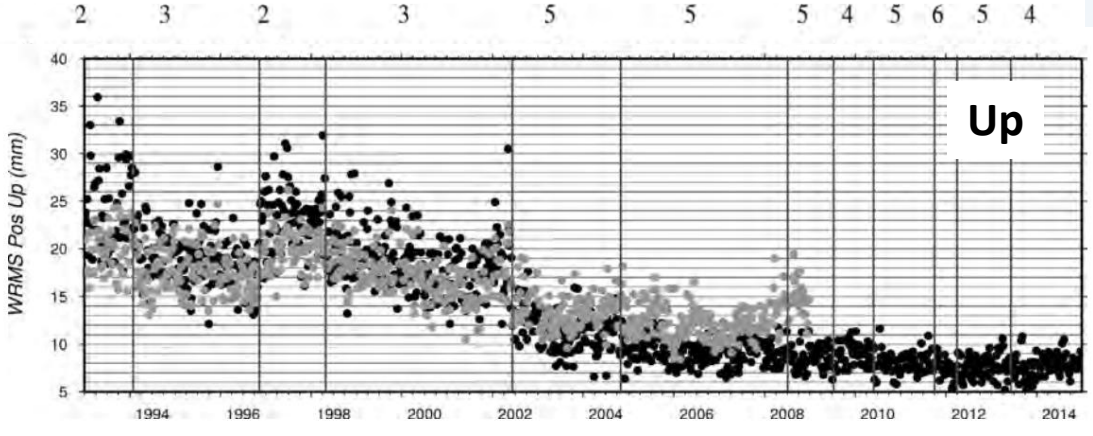
- Satellite state vector.
- Frequency of USO; Beacon parameters.

Satellite orbit in real-time

- **Steers satellite instruments (e.g. altimeter, or AOCS).**
- **Real-time orbit distributed with fast-delivery altimeter data (1-3 hrs latency).**
- **DIODE orbits (sp3 format) for Jason-3 at IGN data center (*along with DORIS/RINEX data*), 1-3 hr latency.**

DORIS Positioning through time from ITRF solutions (1)



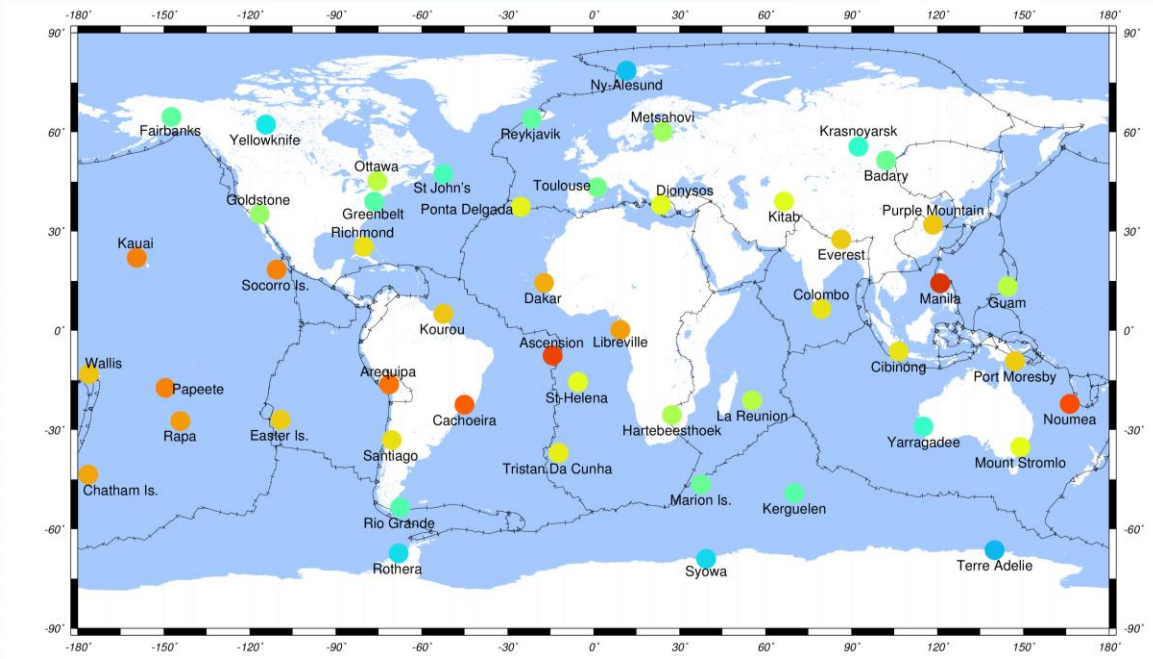


DORIS Position Residuals w.r.t ITRF2014 **for ITRF2008-like (grey)** and **ITRF2014 (black)** weekly solutions. The vertical lines correspond to changes in the number of satellites in the DORIS satellite constellation.

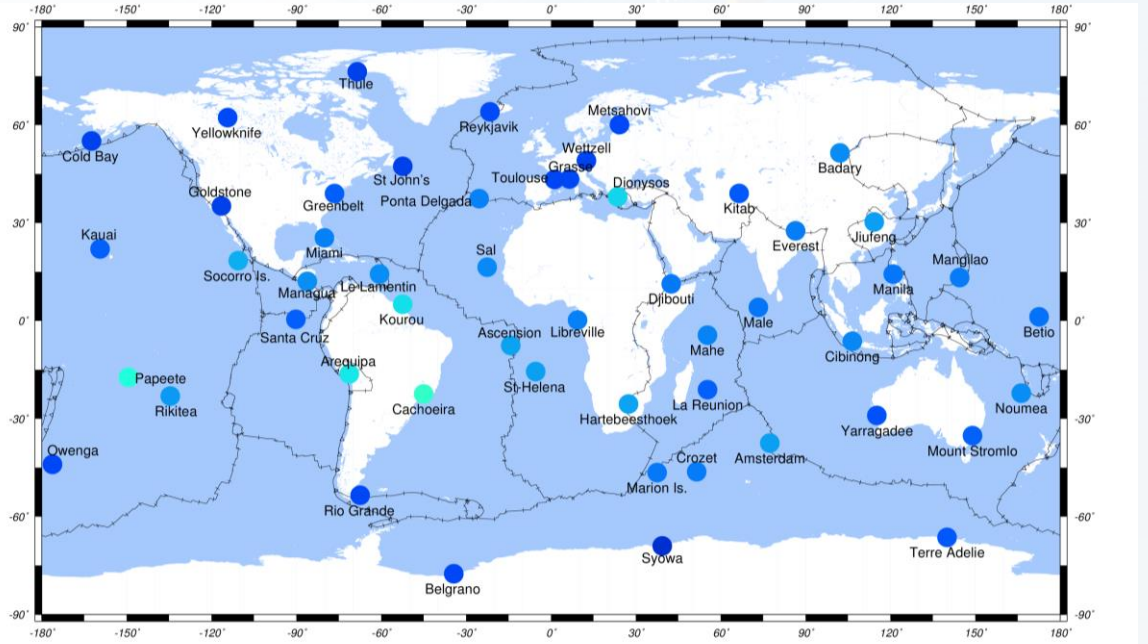
Moreaux et al. (2016). Adv. Space Res.,58, 2479-2504 doi:10.1016/j.asr.2015.12.021

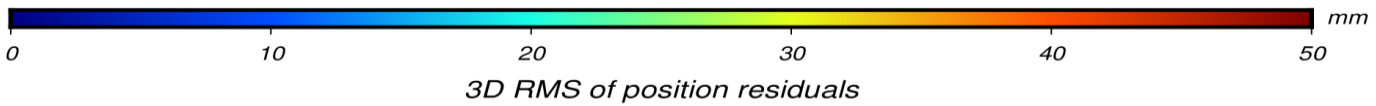
DORIS Positioning from the IDS Contribution to ITRF2020

Year 2000

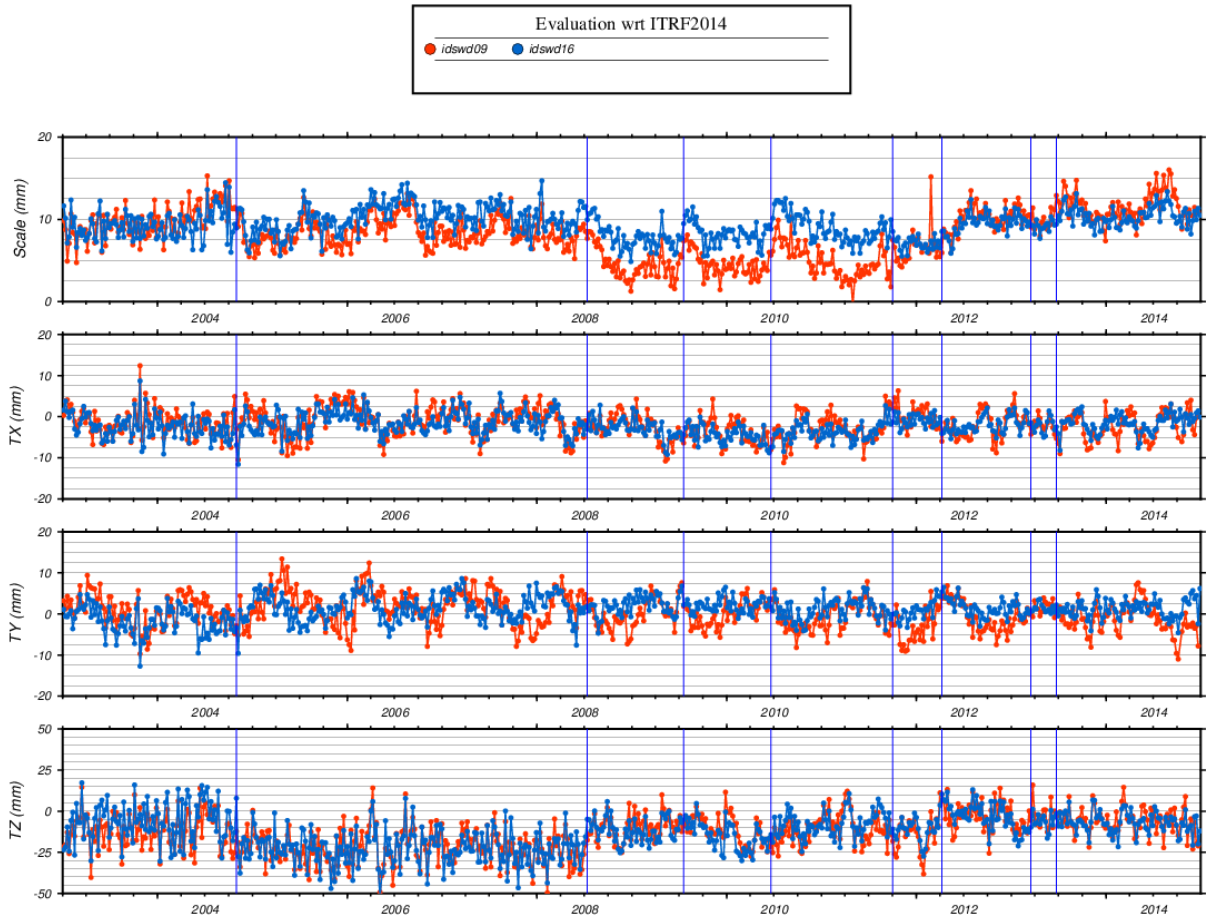


Year 2020





DORIS Geocenter & Scale from the IDS Contribution to ITRF2020

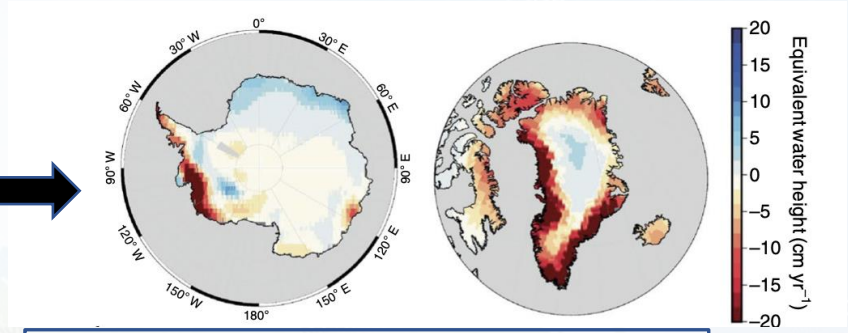


- Compared to ITRF2014, the ITRF2020 scale is more stable, especially from 2008-2012.
- Comparisons among ACs suggest that the weighting of the Jason-2 & Cryosat-2 matrices in the weekly solutions, relative to the other data, for 2008-2012.
- Annual variations in Ty scale are more reasonable with ITRF2020.

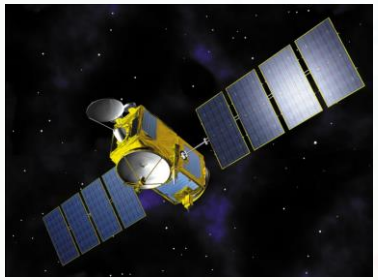
Modelling Improvements Implemented for ITRF2020

(Examples: not a complete list)

• Better modeling of the time-variable gravity field using more recent gravity solutions that include data from GRACE, GRACE FO, GOCE & other satellites.

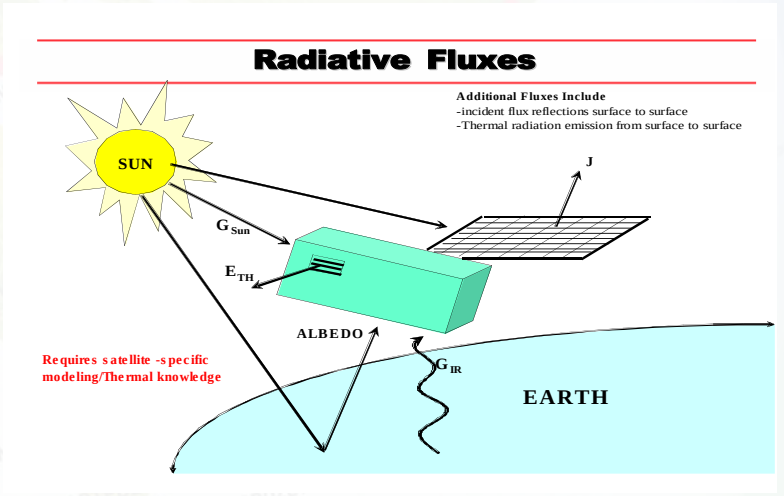


Tapley et al., Nature Climate Change, 2019
doi:10.1038/s41558-019-0456-2



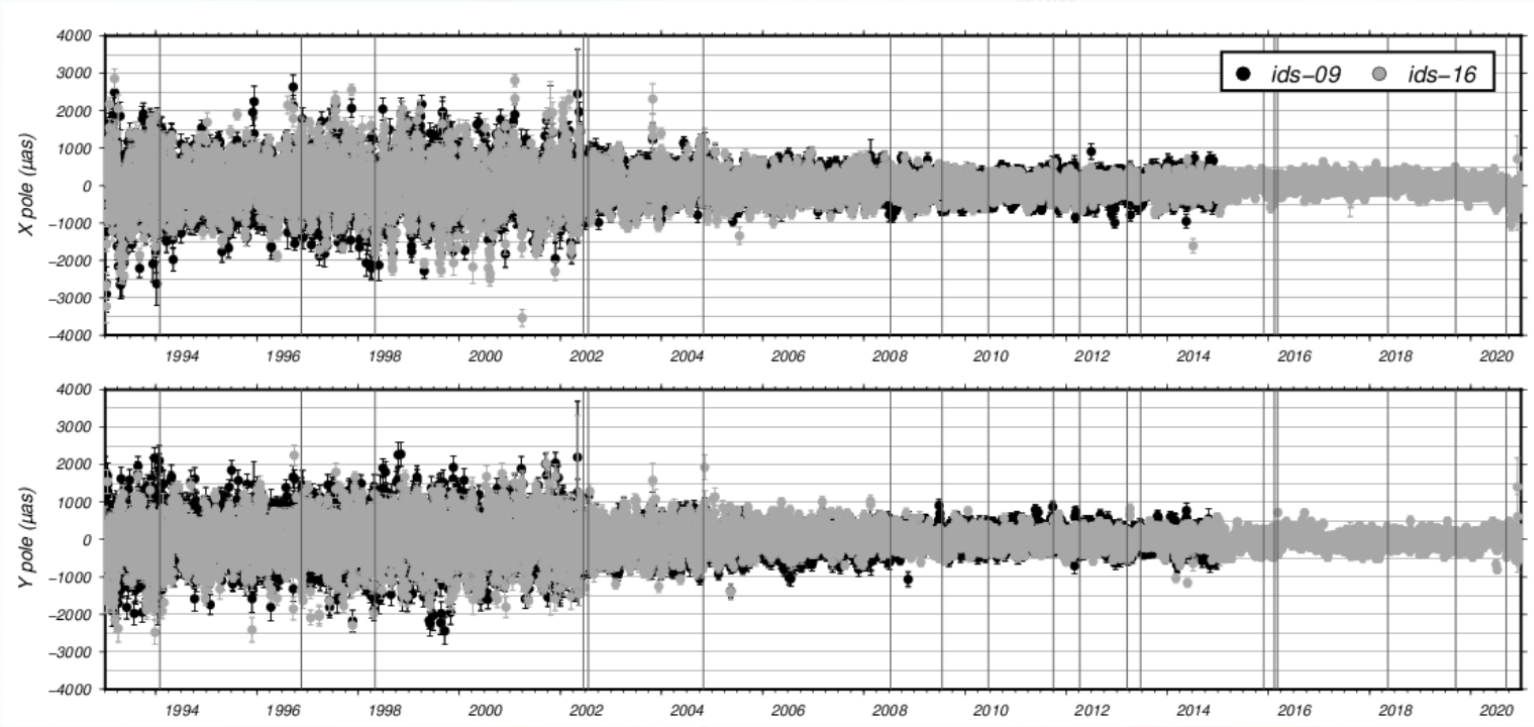
Jason-2

• Better modelling of non-conservative forces on Jason1,2,3 satellites (solar array quaternions, and adjust Cr/arc). → reduce 117-day signals in DORIS products.



Evolution of EOP Performance for DORIS

IDS EOP Differences with IERS C04 series for ITRF2014 (ids09) and ITRF2020 (ids16)



Std. Dev. Of Diffs. With IERS C04 (ids16)

1993-2002:
Xpole: 664 μas
Ypole: 587μas

2002-2008
Xpole: 331 μas
Ypole: 321 μas

2015-2021
Xpole: 192 μas
Ypole: 171 μas

Moreaux et al., 2021-2022, manuscript in preparation.

Key points: Overview of Products for DORIS

- Increases in the size of the satellite constellation and improvements in the number of beacons that DORIS receivers can track have driven improvements in DORIS POD, positioning and EOP quality from 1993 to 2020: 2002 & 2008 are important inflection points in DORIS system performance.
- These changes occurred in parallel to improvements in DORIS system monumentation as well as continuing efforts to improve all aspects of force & measurement modelling for precise orbit determination.
- DORIS-only orbits for altimeter satellites can produce radial RMS orbit accuracy of < 10 mm RMS, depending on the satellite.