DPOD2014: a new DORIS extension of ITRF2014 for Precise Orbit Determination

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Abstract

As one of the tracking systems used to determine orbits of the altimeter mission satellites (such as TOPEX/Poseidon, Envisat, Jason-1/2/3 & Cryosat-2), the position of the DORIS tracking stations provides a fundamental reference for the estimation of the precise orbits and so, by extension is fundamental for the quality of the altimeter data and derived products. Therefore, the time evolution of the position of both the existing and the newest DORIS stations must be precisely modeled and regularly updated. To satisfy operational requirements for precise orbit determination and routine delivery of geodetic products, the International DORIS Service maintains the so-called DPOD solutions, which can be seen as extensions of the latest available ITRF solution from the International Earth Rotation and Reference Systems Service (IERS).
In mid-2016, the IDS agreed to change the processing strategy of the DPOD solution. The new solution from the IDS Combination Center consists of a DORIS cumulative position and velocity solution using the latest IDS combined weekly solutions. The first objective of this study is to describe the new DPOD development scheme and to show the IDS Combination Center internal validation steps. The second purpose is to present the external validation process made by an external team before the new DPOD is made available to all the users. The development and the validation procedures will be illustrated by preliminary tests done with the ITRF2008 solution and by the presentation first version of the DPOD2014 (ITRF2014 DORIS extension) and validation.

DPOD2014 Construction Scheme

The new DPOD2014 will be based on a DORIS cumulative position and velocity solution from the latest IDS combined series. The cumulative solution will be augmented to include any new stations specified in recent DORISmails. Then, the construction of the DPOD2014 can be divided in three main steps:

1. **Construction of the IDS combined series from the six IDS Analysis Center multi-satellite weekly solutions starting in 1993.0.** To include almost all the DORIS stations, since the IDS contribution to the ITRF2014 (see Moreaux et al., 2016), the combination process:
   i. Does not anymore reject stations with regards to the length of the observation period (2.5 years at least for ITRF2014).
   ii. Includes stations as soon as they are observed by at least 2 ACs (3 for ITRF2014).
2. **Construction of the DORIS position and velocity cumulative solution.**
   a) Update of the position discontinuity and velocity constraint files. These two files are updated after analysis of the station coordinate time series from the IDS web service (http://ids-doris.org/webservice/). Velocity constraints are used to constrain velocities to the same value over multiple segments unless a velocity discontinuity was observed.
   b) Update of the DORIS-to-DORIS tie vector file from IGN.
   c) Update of the DORIS core network. The core network is the subset of the DORIS sites used to align the cumulative solution on the ITRF2014. The core network is composed of sites with more than 500 weeks of observations and localized neither in seismic active zones nor SAA region. Currently, the core network includes 36 sites with 17 sites in the northern hemisphere (see Figure 1).
   d) Computation of the cumulative solution. The cumulative position and velocity solution is obtained from the stacking of the weekly solution files and then aligned to the ITRF2014 with No-Net-Rotation (NNR) condition by the IGN CATREF software.
3. **Including of the most recent DORIS stations** which are not already part of the cumulative solution. Positions and velocities will be either extracted from the DORISmails or deduced from the DORIS-to-DORIS tie vectors.
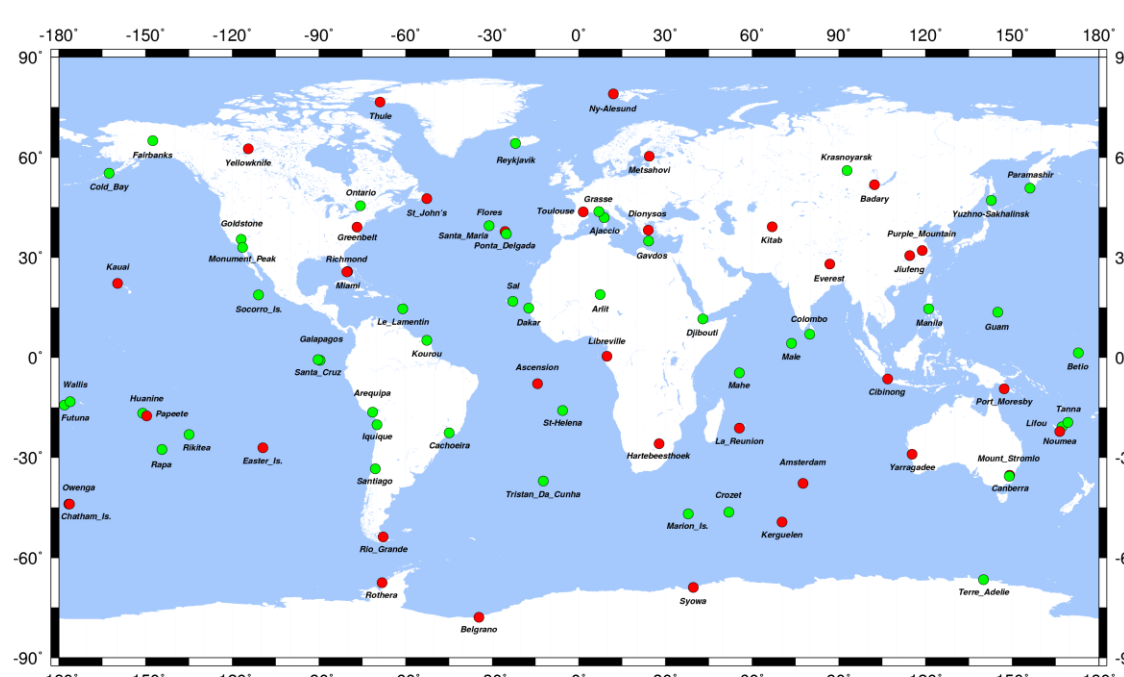
Figure 1 – Network of the 82 DORIS sites included in the first release of the DPOD2014 solution (red dots indicate sites included in the core network).

Internal Validation

Before sending the DPOD solution to the validation group (see external validation), the IDS Combination Center do several tests. These tests include:

- Analysis of the station position residuals.
- Analysis of the DORIS-to-DORIS tie vector residuals.
- Comparison of positions and velocities with the ITRF2014 solution.
- Estimation of the DORIS-to-GNSS tie vectors at co-located sites and comparison with the tie vectors from IGN.
- Prediction and analysis of the position formal errors at T+3 years.
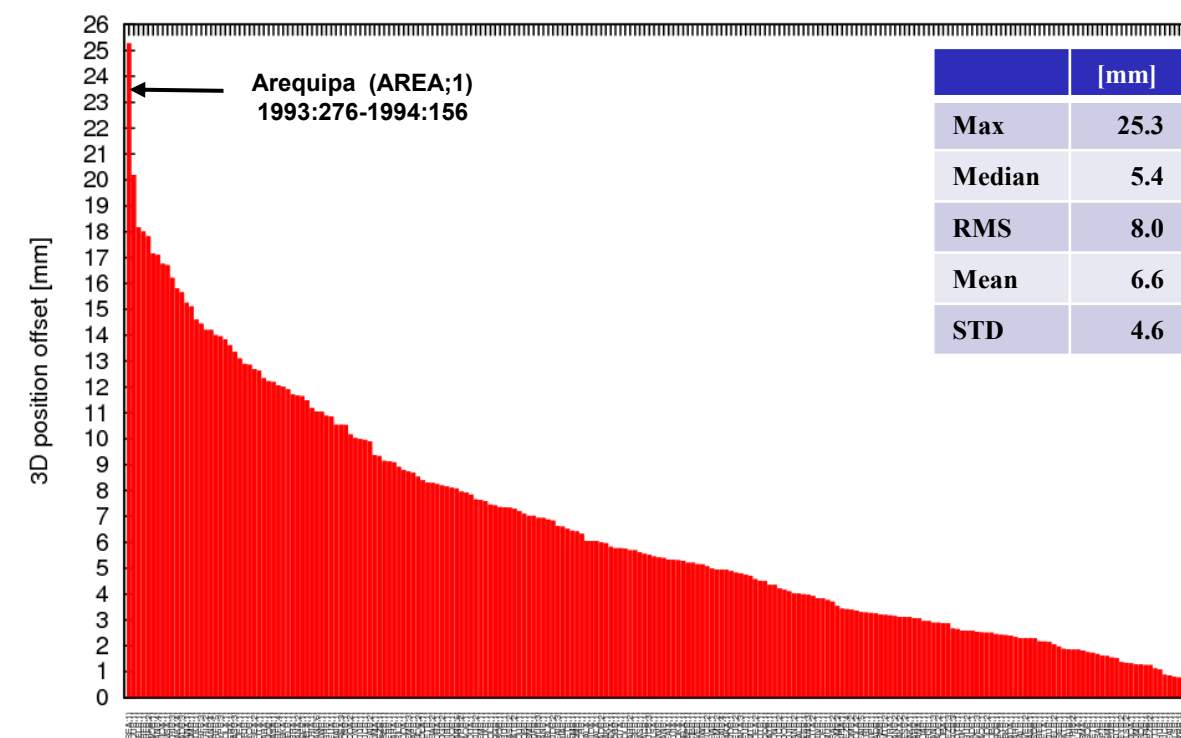
Figure 2 – 3D position differences with ITRF2014 (Post-Seismic Deformation included).
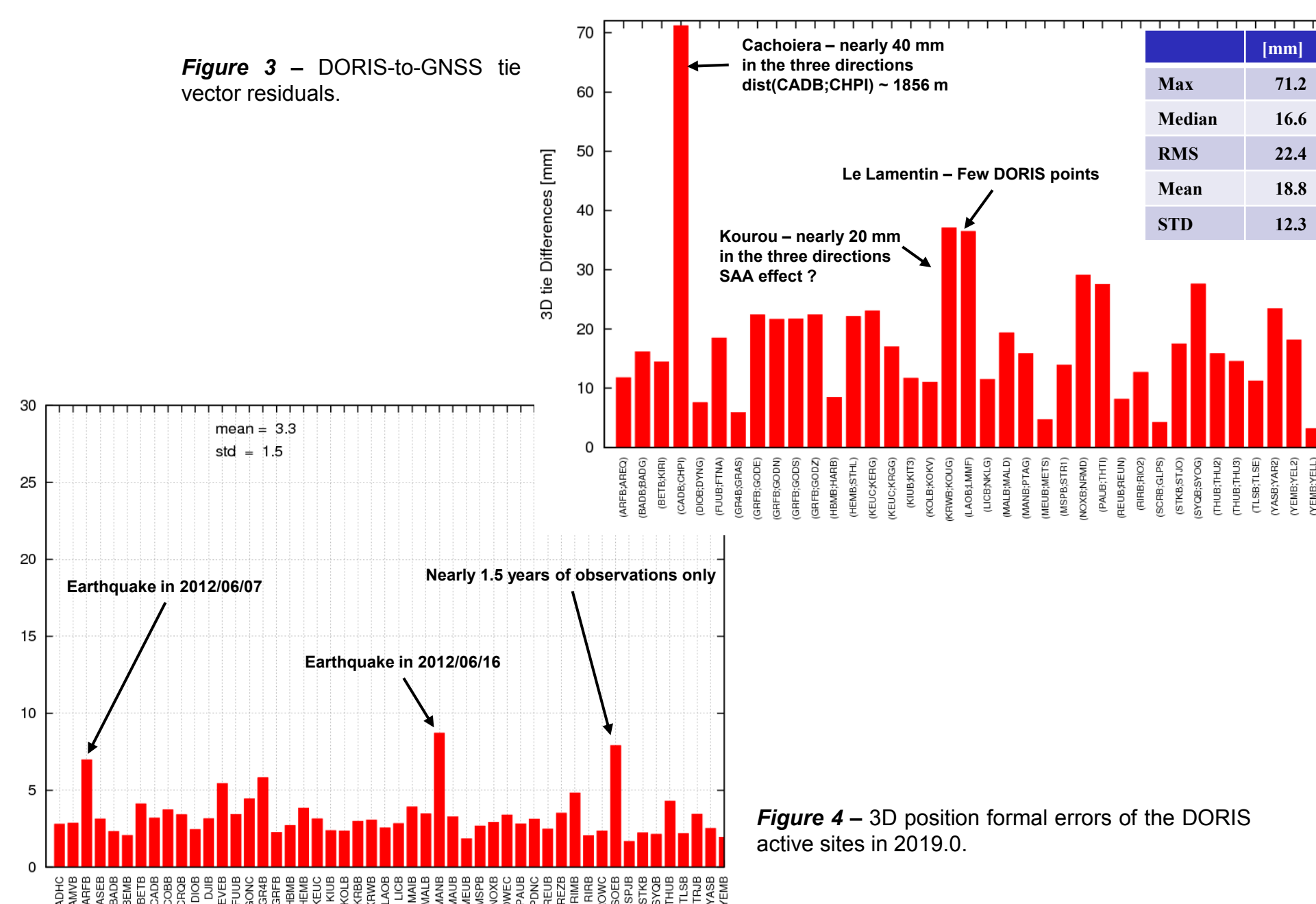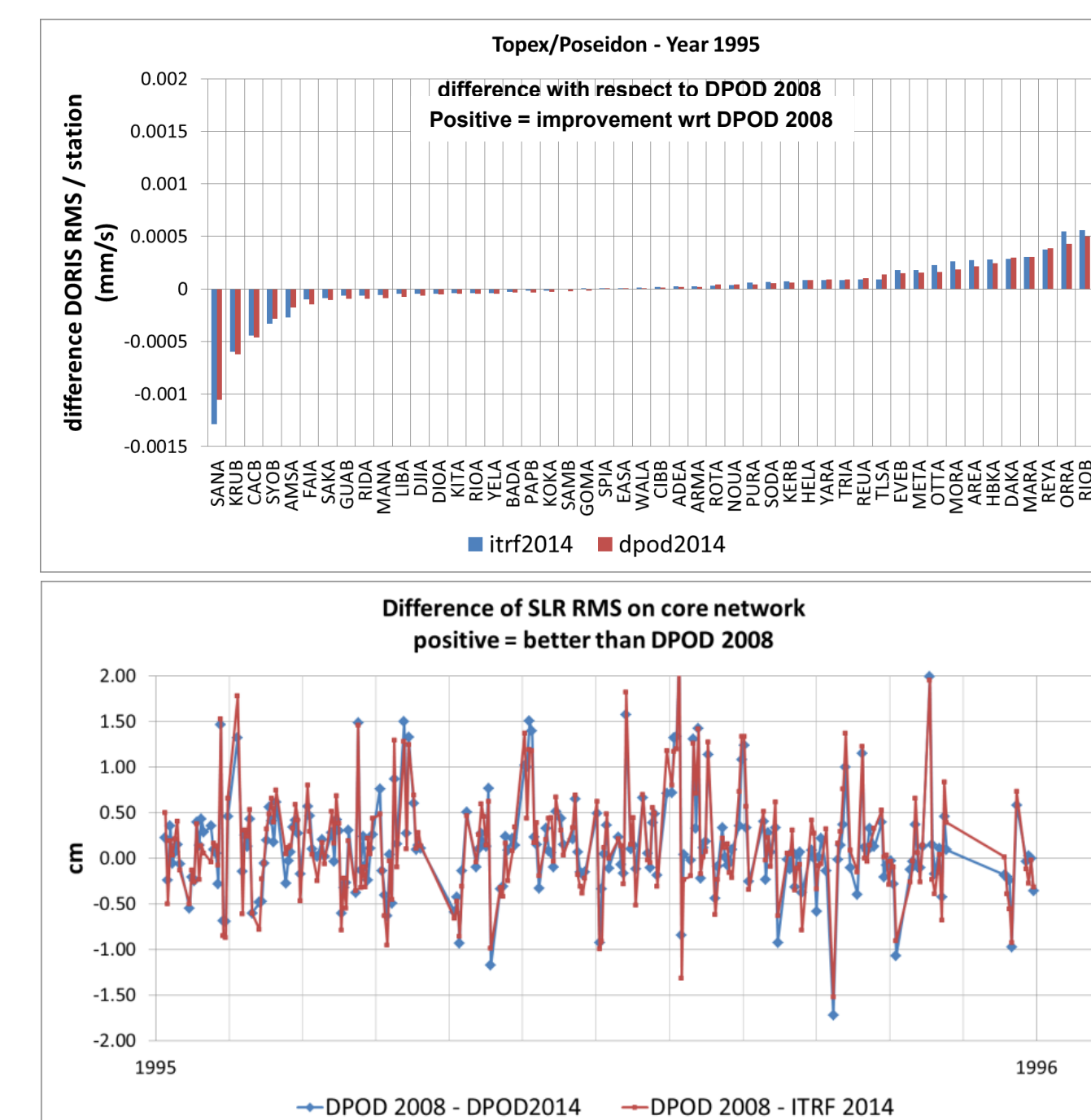
	[mm]
Max	25.3
Median	5.4
RMS	8.0
Mean	6.6
STD	4.6

Arequipa (AREA;1) 1993:276-1994:156

Figure 3 – DORIS-to-GNSS tie vector residuals.

	[mm]
Max	71.2
Median	16.6
RMS	22.4
Mean	18.8
STD	12.3

Cachoiera – nearly 40 mm in the three directions dist(CADB;CHPI) – 1856 m

Le Lamentin – Few DORIS points

Kourou – nearly 20 mm in the three directions SAA effect ?

mean – 3.3   std – 1.5

Earthquake in 2012/06/07

Earthquake in 2012/06/16

Nearly 1.5 years of observations only

Figure 4 – 3D position formal errors of the DORIS active sites in 2019.0.
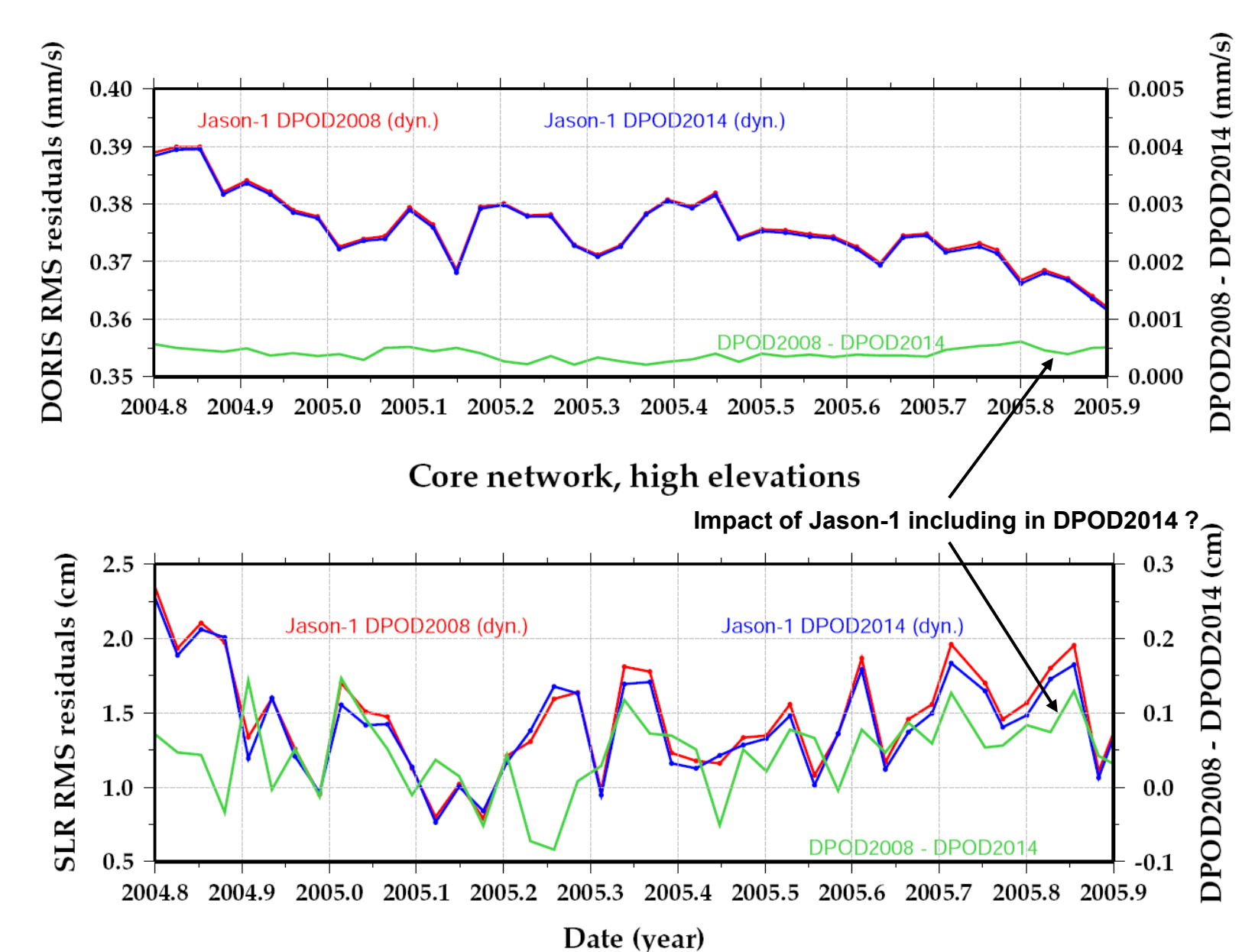
External Validation

Several tests related to POD will be done by the validation group. These tests include:

- Verifying that all DORIS stations are provided in the DPOD solution.
- Verifying that the coordinates of the new stations are consistent with the latest available DORIS data.
- Verifying that POD solutions are not degraded by looking at:
  ✓ DORIS residuals and comparisons with ITRF2014 and DPOD2008 performances.
  ✓ SLR residuals and comparisons with ITRF2014 and DPOD2008 performances.
  ✓ Long term orbit drift as shown with the Mean Z ITRF2008 orbit differences.
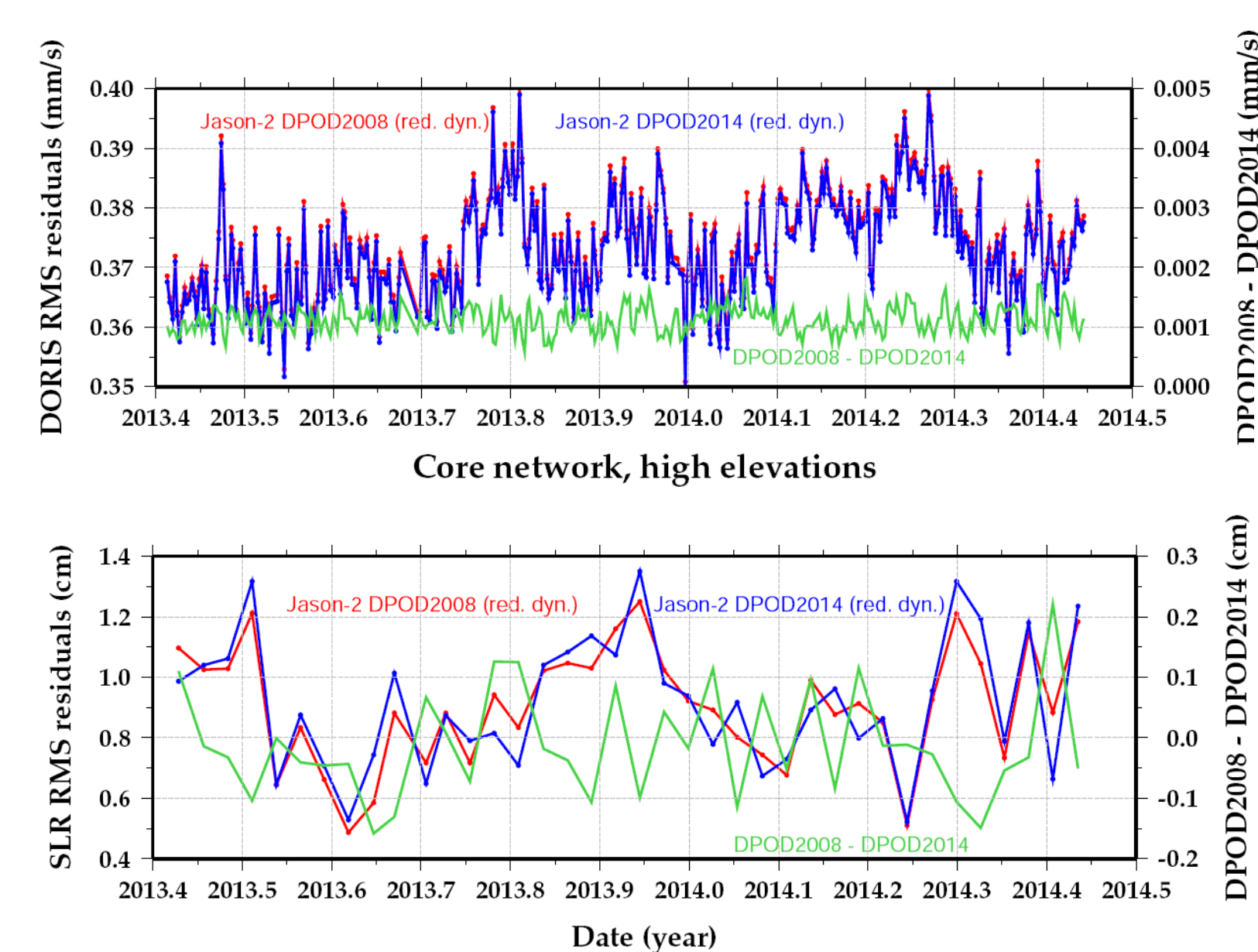 ✓ JPL16a radial orbit differences.
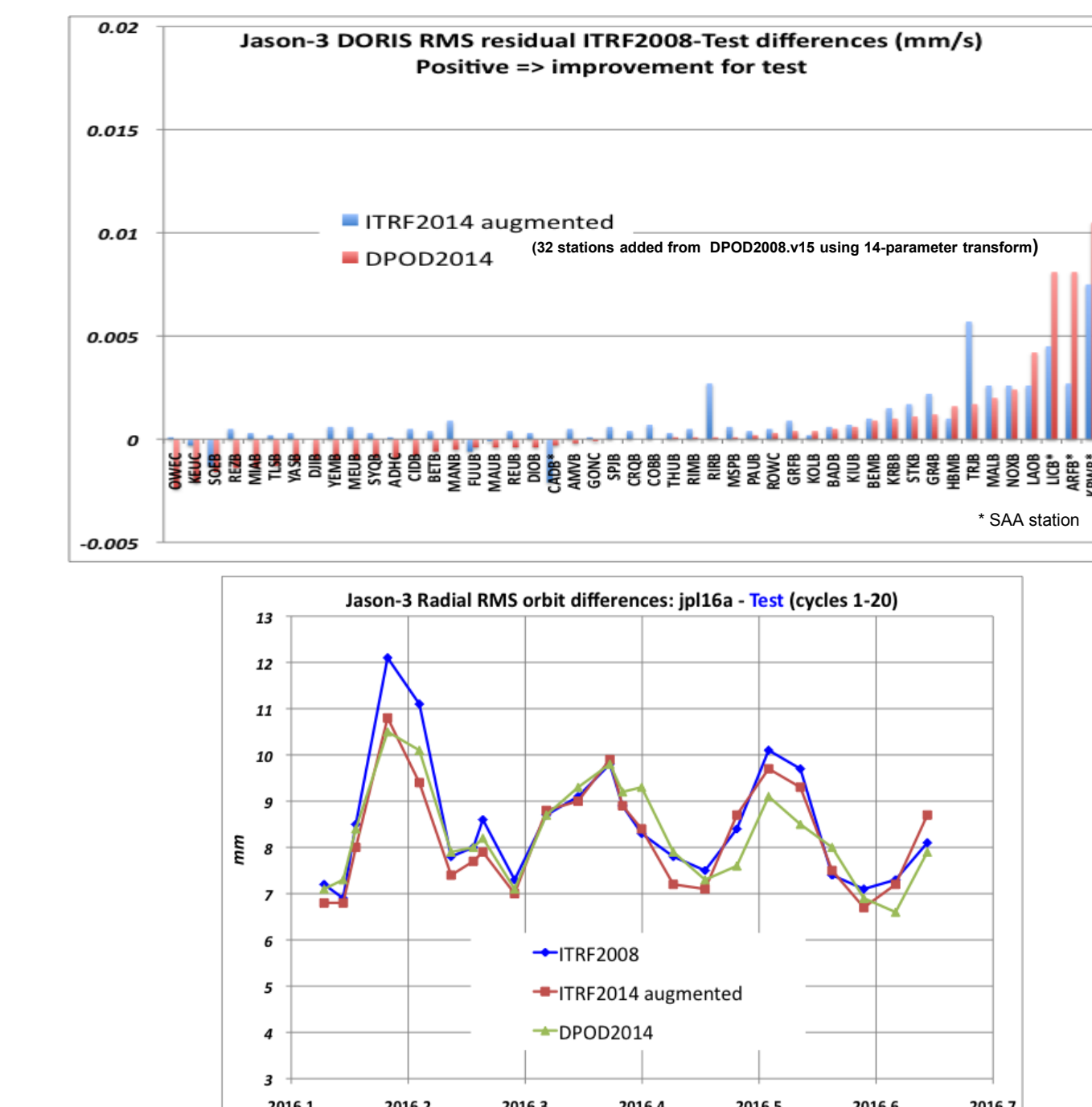 ✓ …

❏ TOPEX/Poseidon

Topex/Poseidon - Year 1995

Difference of SLR RMS on core network positive = better than DPOD 2008

❏ Jason-1

Core network, high elevations

Impact of Jason-1 including in DPOD2014 ?

❏ Jason-2

Core network, high elevations

❏ Jason-3

Jason-3 DORIS RMS residual ITRF200B-Test differences (mm/s) Positive => improvement for test

Jason-3 Radial RMS orbit differences: jpl16a - Test (cycles 1-20)

Conclusions

- The IDS Combination Center developed a new method to estimate a DORIS extension of ITRF2014 for POD.
- The new DPOD2014 is based on a DORIS cumulative position and velocity solution from the latest IDS combined series. That cumulative solution is augmented to include any new stations specified in recent DORISmails.
- Therefore, by construction, the new DPOD differs from DPOD2005, DPOD2008 (see Willis et al., 2016) and is similar to IGb08 and to a less extent (as DPOD2014 does not include PSD corrections) to IGS14.
- So far, the validation tests showed slightly better performances of DPOD2014 compared to ITRF2008, ITRF2014 and DPOD2008.

What's next ?

- Including of observations in 1992 in the cumulative solution.
- For the Jason-2 and Jason-3, some of whose data are affected by the South Atlantic Anomaly; Deweight the SAA-affected stations at the Analysis Center level in the multi-satellite combination.
- Update every 6 months.

How to get DPOD2014 ?

- The DPOD2014 solution will be available in 3 formats: SINEX, SSC and Text.
- The DPOD2014 and DORIS cumulative solution files will be downloadable from the 2 IDS Data Centers (CDDIS and IGN) as well as from the IDS ftp server.

References

• Moreaux, G., Lemoine, F.G., Capdeville, H., et al., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame. *Adv. Space Res.*, in press, doi: 10.1016/j.asr.2015.12.021.
• Willis, P., Zelensky, N.P., Ries, J., et al., 2016. DPOD2008, a DORIS-oriented Terrestrial Reference Frame for Precise Orbit Determination, *IAG Symposia Series*, 143, 175-181, doi: 10.1002/2014JB011176.

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