Evaluation of ITRF2014/DTRF2014/JTRF2014 solutions in precise orbit determination by CNES/CLS IDS Analysis Center

Hugues Capdeville (1), Jean-Michel Lemoine (2), Adrien Mezerette (1).

(1) CLS, Collecte Localisation Satellites, 11 rue Hermès, 31520 Ramonville Saint Agne, France
(2) CNES Centre National d'Etudes Spatiales, 18 av Edouard Belin, 31400 Toulouse, France

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Introduction

Three IERS Production Centers (IGN, DGFI and JPL) delivered three independent solutions from the contributions of the four space geodetic techniques (DORIS, GNSS, SLR and VLBI). These three realizations (ITRF2014/IGN, DTRF2014/DGFI and JTRF2014/JPL) are evaluated by SLR and DORIS data processing for TOPEX, Jason-1, and Jason-2 satellites by comparison to the ITRF/DPOD2008. The DORIS post-fit residuals (global and per stations) and the SLR residuals on DORIS-only orbits are analyzed. We also show some orbits comparison in particular the RMS of radial differences and the mean of Z orbit differences.

POD modeling and processing context

Standards and models
We took the IERS conventions and the IDS recommendations
❏**Gravity field**:
EIGEN-GRGS.RL03-v2.MEAN-FIELD with mean slope extrapolation
❏**Surface forces and empiricals**
OPR empiricals: 2 coeff cos-sin /orbital period in normal direction and 2 coeff cos-sin /orbital period in tangential direction (per arc)
Drag coefficients adjusted: 1 coef/4 hours for Sentinel-3A and 1 coef/half day for Jason-3
Radiation pressure scale coefficient: 1 coef/day but strongly constrained to 0.99 for Jason-3 and 1.0 for Sentinel-3A
❏**Geometry:**
Troposphere: GPT/GMF + one gradient per station in North & East directions

❏**Satellite reference:**
Mass and Center of gravity. Post-launch values and variations.
Attitude model: nominal law likeTopex
Macromodel given by the CNES POD team available at:
ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf

Processing context:
We computed 3.5-day arcs with a cut-off angle of 12° with GINS/DYNAMO software

Time span processing:
TOPEX: January, 03 1993 to July, 17 2004
Jason-1: July, 18 2004 to July, 12 2008
Jason-2: July, 13 2008 to , December 27 2014
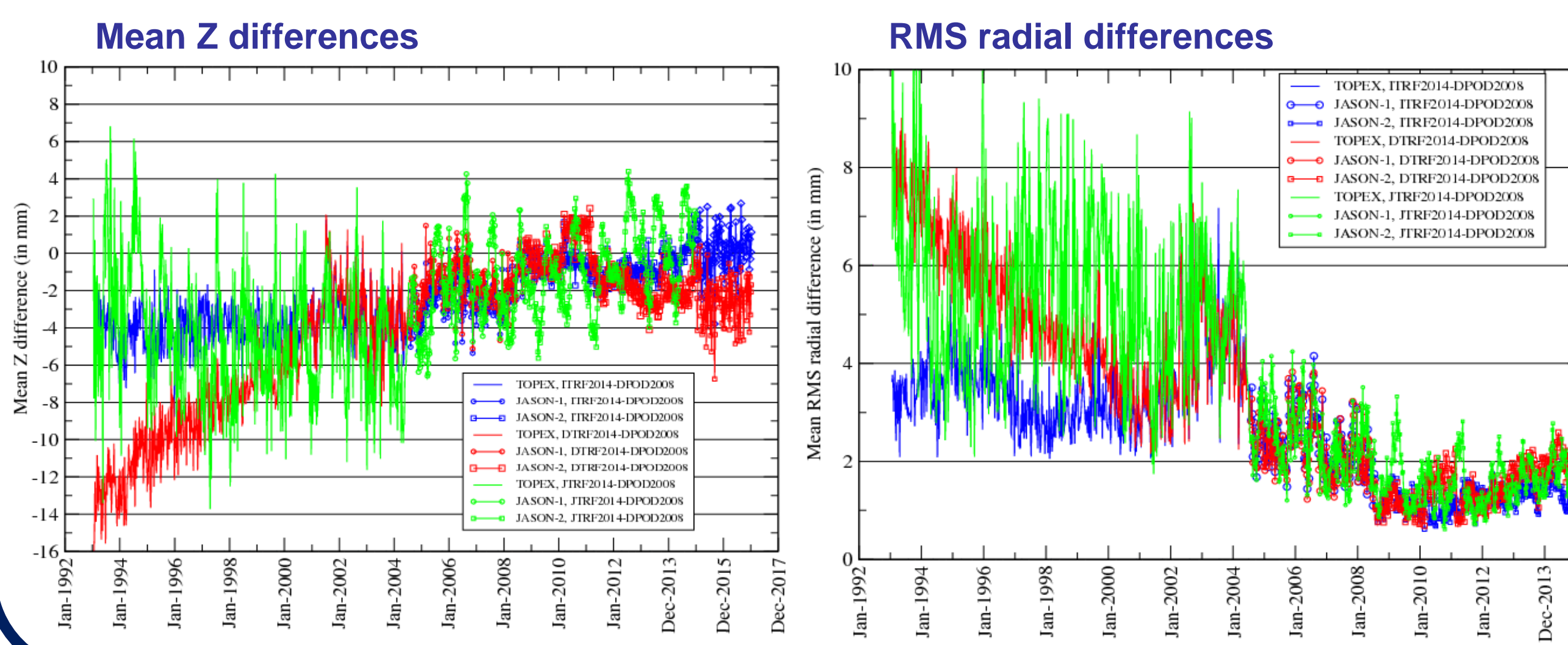
POD results and Orbits comparison

While ITRF2014 and DTRF2014 are formally similar, differing only by the Post Seismic Deformation model (PSD) which have been introduced in the IGN solution, the JPL solution is quite different, being a time series of weekly solutions obtained through a Kalman filter process.

Number of stations per arc processing
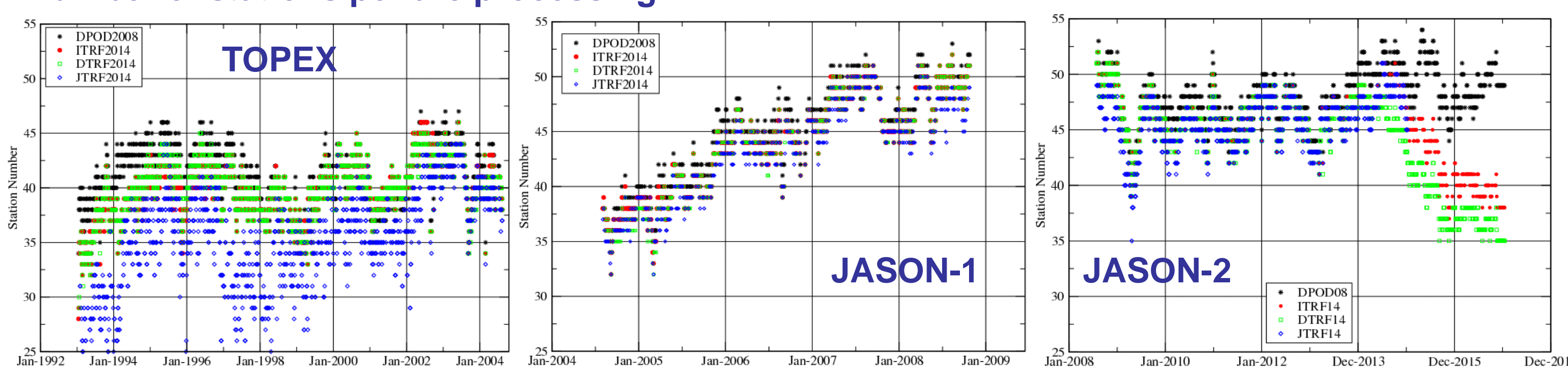
Due to editing criteria the JPL solutions contains less stations at a given time than the two others, particularly at the beginning of the processed period, in 1993. After the end of 2014 there are less stations for ITRF2014 and DTRF2014 compared to DPOD2008 because the new stations are not in the solutions. So, we make the comparison to DPOD2008 until the end of 2014. The Table on the right gives the summary of POD results.

Summary POD tests

SATELLITE	TRF Solutions	Average DORIS stations Number	Average RMS residuals	
			DORIS (mm/s)	SLR (cm)
TOPEX	**DPOD2008**	41.2	0.454	4.65
3 Jan. 1993	**ITRF2014**	39.8	0.455	4.58
To	**DTRF2014**	39.8	0.456	4.58
17 Jun. 2004	**JTRF2014**	35.3	0.452	4.69
JASON-1	**DPOD2008**	44.9	0.305	2.58
18 Jul. 2004	**ITRF2014**	43.9	0.307	2.52
To	**DTRF2014**	43.8	0.307	2.51
12 Jul. 2008	**JTRF2014**	43.2	0.307	2.53
JASON-2	**DPOD2008**	47.7	0.314	2.18
13 Jul. 2008	**ITRF2014**	46.3	0.313	2.15
To	**DTRF2014**	45.9	0.313	2.17
27 Dec. 2014	**JTRF2014**	45.7	0.312	2.15

Orbit difference w.r.t DPOD2008

Mean Z differences

RMS radial differences

Difference between DPOD2008 and the new TRFs
We give the mean Z differences and the mean RMS radial differences.
Orbit centering difference in the Z direction:
- important drift from 1993 to 2001 for DTRF2014
- drift consistent between the 3 TRFs after 2002
- annual signal for JTRF2014
(different geocenter than those of DPOD2008)
- correlated to the Tz parameter differences
Mean RMS radial differences:
- important drift from 1993 to 2001 for DTRF2014
- a few mm I-D-JTRF2014 after 2002
- annual signal in JTRF2014
- correlated to the scale differences

Conclusion and Perspective

Globally, all TRF realizations represent a low but significant improvement over the previous realization, ITRF/DPOD2008. The differences are at a very low level in particular for the Jason-1 and Jason-2 results. For ITRF2014 and DTRF2014, the most significant improvements are obtained for years 1992-1998 and 2010-2014, probably due to the improvement of the estimation of the station velocities compared to those estimated in the DPOD2008 realization. Based on the different criteria used for evaluation, it has been shown this is the ITRF2014 which presents the best overall performance. This realization will be used for the DPOD2014 which will be used for the operational processing of DORIS data.

POD results

We give here the orbit results obtained on the time span processing from January, 03 1993 to December 27, 2014 of TOPEX, Jason-1 and Jason-2 satellites for the three TRF2014 realizations compared to DPOD2008. The differences of the DORIS RMS of fit of the orbit determination between the 3 TRF2014 and DPOD2008 are given for each satellite. The DORIS-only orbits are evaluated by independent SLR data processing and the differences of SLR RMS with DPOD2008 case are also given. After, we focus on the differences of the DORIS RMS residuals per stations.
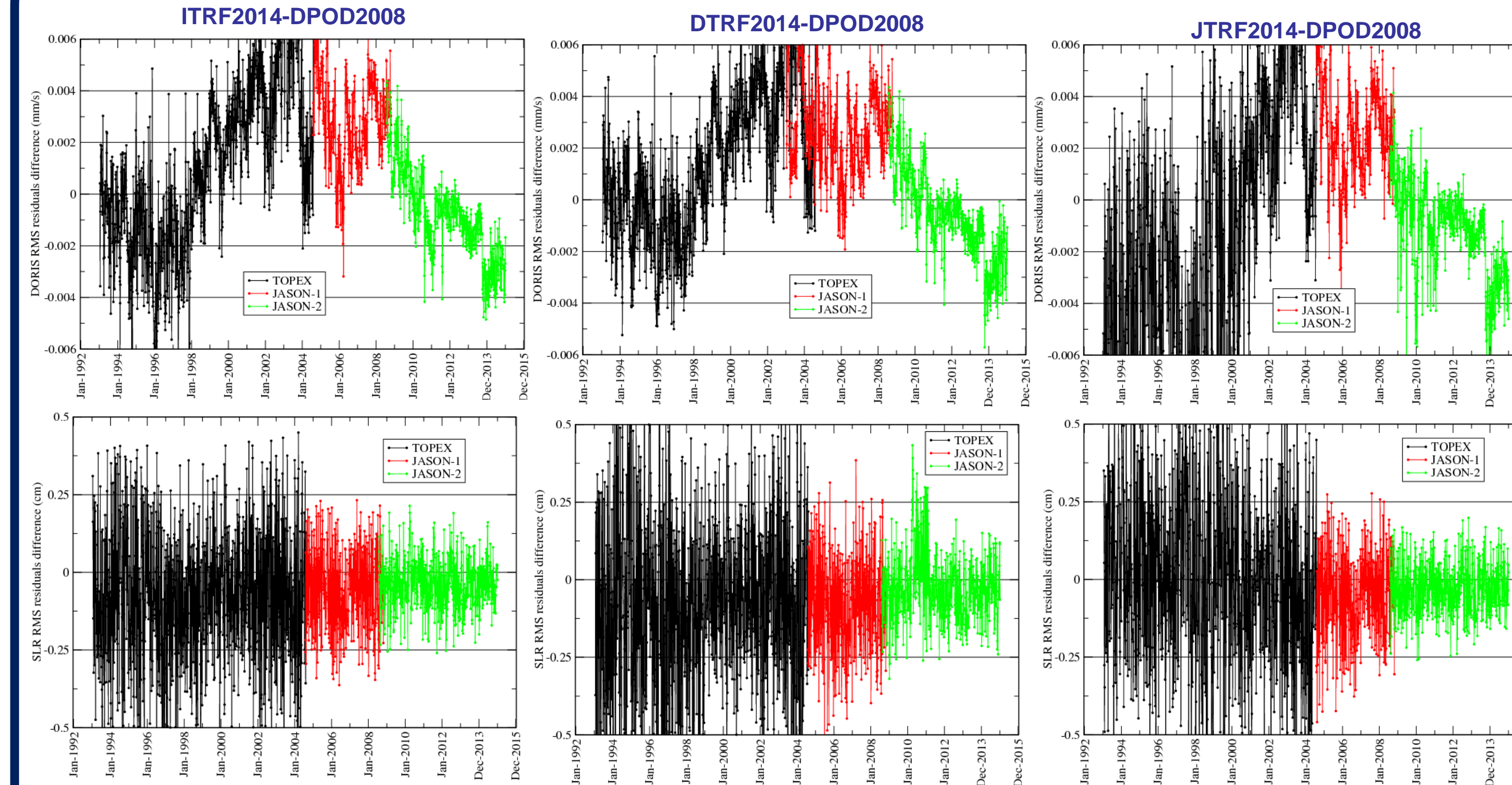
DORIS RMS residuals differences
When the differences are positives the DPOD2008 is better than all TRF2014
Two periods for TOPEX:
- from 1993 to 1998 improvement with the 3 TRF2014
- from 1999 to mid-2004 degradation with all new TRF
For Jason-1 degradation for all TRF2014 from mid-2004 to 2008
*For Jason-2, after 2010 improvement with all new TRFs*

DORIS-only orbit independent SLR RMS residuals differences
All new TRFs show an improvement except:
- JTRF2014 for TOPEX
- DTRF2014 for Jason-2 from 2010 to 2011
ITRF2014 shows the best improvement

DORIS RMS residual differences per station
For TOPEX, we note an improvement for JTRF2014 on the full processing period. For ITRF2014 and DTRF2014, as the improvement is only obtained from 1993 to 1998, these top figures show a degradation for the full TOPEX processing period. For Jason-1 (from 2004 to 2008), we have a slight degradation for all new TRFs except for some stations. For Jason-2 (2008-2014) an improvement is obtained for all TRFs except for about 10 stations. Note that the differences are at a very low level in particular for the Jason-1 and Jason-2 results.
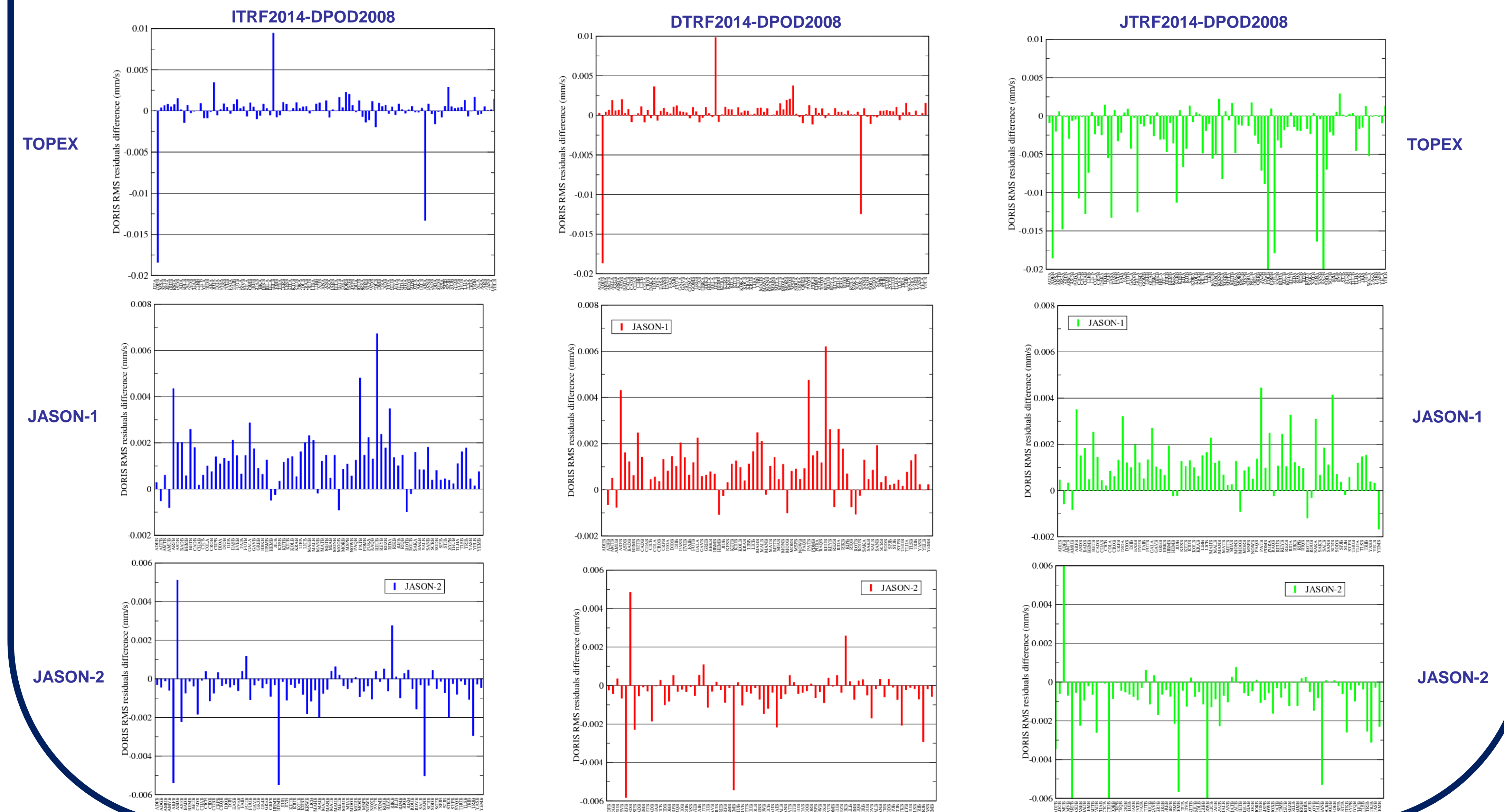
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