Assessment of ITRF2014 for precise orbit determination of altimetry satellites

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Introduction

A terrestrial reference frame (TRF) is a basis for precise orbit determination of Earth orbiting satellites. Three new TRF realisations became recently available. These are ITRF2014 (Altamimi et al., 2016), DTRF2014 (Seitz et al., 2016) and JTRF2014 (Abbondanza et al., 2016). In this paper, we assess one of them, namely, ITRF2014 for precise orbit determination of altimetry satellites ERS-1 (1991-1996), ERS-2 (1995-2003), TOPEX/Poseidon (1992-2005), Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2015) at the time intervals given, as compared to the previous (ITRF2008) realization. For this purpose, we have computed GFZ VER13 orbits of these satellites using the ITRF2014 reference frame and analyse them, as compared to the GFZ VER11 orbits (Rudenko et al., 2016) of the same satellites derived using the ITRF2008 reference frame (Altamimi et al., 2011). We compare residuals of observations used for orbit determination, two-day arc overlaps, investigate the impact of the ITRF realizations on the geographically correlated and radial errors and on the global and regional mean sea level trends.

Impact of the TRF realizations on the orbit quality

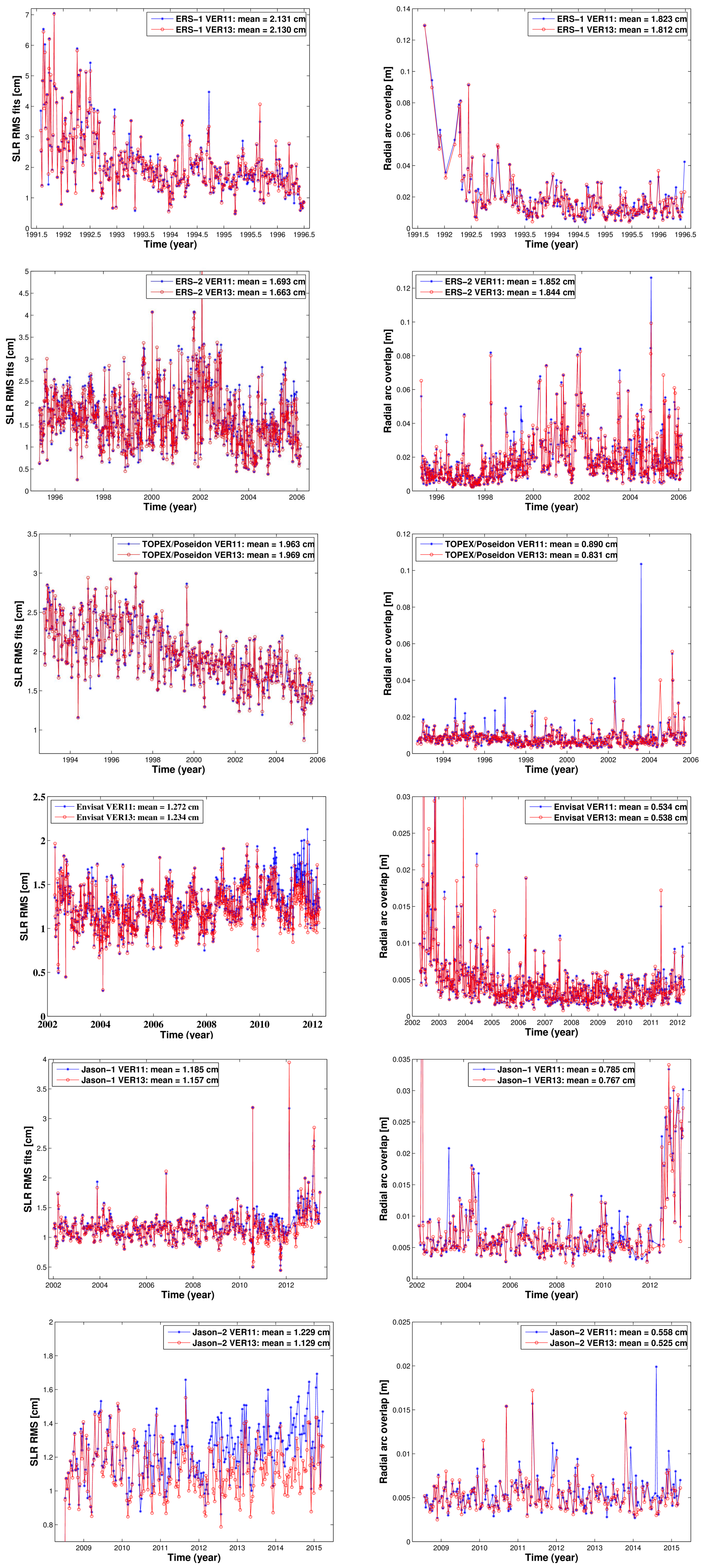

Fig. 1-12: SLR RMS fits (left) and 2-day radial arc overlaps (right) of GFZ VER11 and VER13 orbits derived using ITRF2008 (blue) and ITRF2014 (red) reference frame realizations, respectively

Impact of the TRF realizations on the radial sea surface height errors

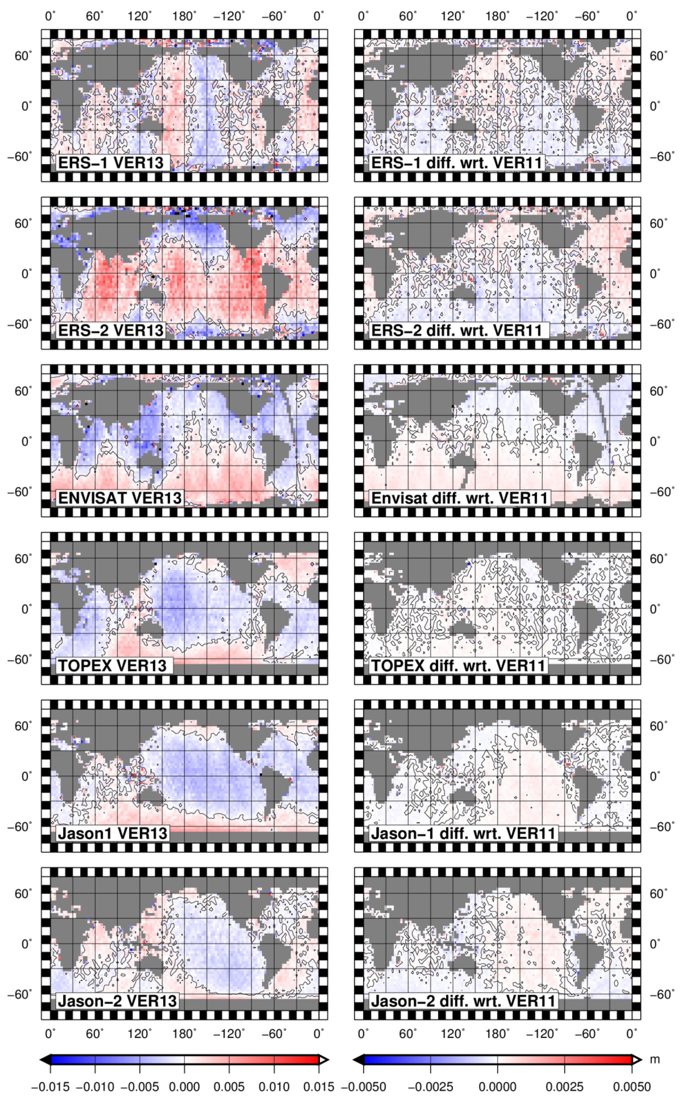

Fig. 13: Geographically correlated errors (GCE) of the VER13 orbits (left) and the differences of GCE computed using VER13 and VER11 orbits

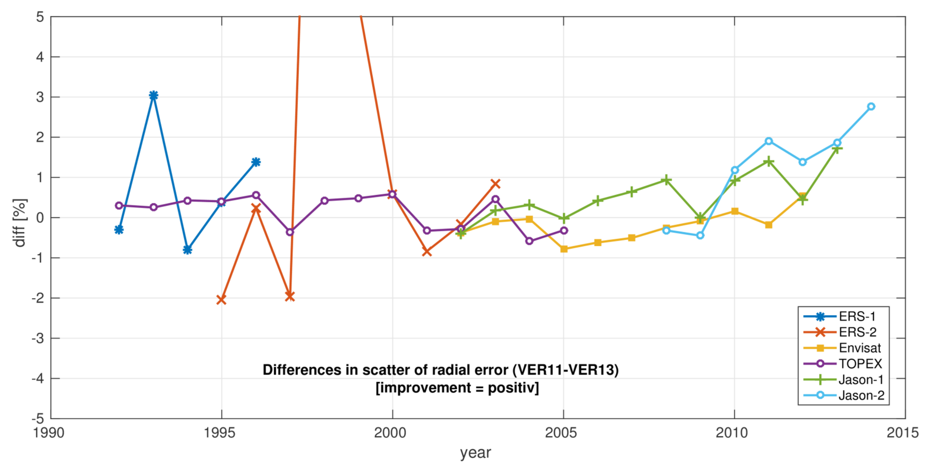

Fig. 14: Differences in scatter of radial error (VER11 minus VER13)

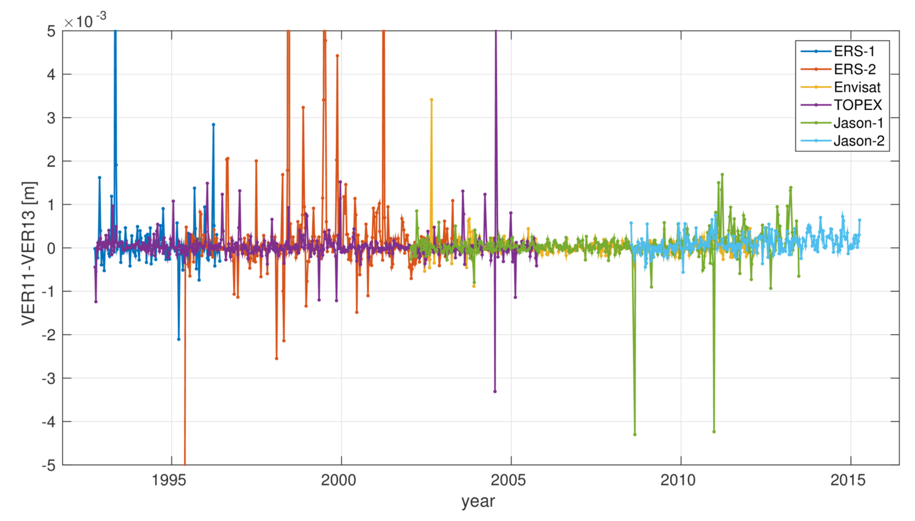

Fig. 15: Differences in the standard deviation of single-satellite crossover differences (VER11 minus VER13)

Satellite	VER11	VER13	Diff. (cm)	Diff. (%)
ERS-1	1.893	1.870	0.023	1.2
ERS-2	2.615	2.567	0.048	1.8
Envisat	1.648	1.651	-0.003	-0.2
TOPEX	1.486	1.485	0.001	0.1
Jason-1	1.567	1.564	0.003	0.2
Jason-2	1.103	1.086	0.017	1.6

Tab. 1: Scatter of the radial errors (cm) obtained using VER11 and VER13 orbits of six satellites and their difference (a positive value means an improvement, when using ITRF2014)

Satellite	VER11 crossover RMS (cm)	VER13 crossover RMS (cm)	Difference (%)	VER11 crossover mean (mm)	VER13 crossover mean (mm)	Difference (%)
ERS-1	5.832	5.820	0.22	1.832	1.672	8.7
ERS-2	6.060	6.036	0.41	-1.679	-1.755	-4.5
Envisat	4.547	4.545	0.04	4.064	4.459	-9.7
TOPEX	4.893	4.889	0.08	-3.504	-3.315	5.5
Jason-1	4.503	4.497	0.12	3.854	3.421	11.2
Jason-2	4.261	4.250	0.26	2.523	1.958	22.4

Tab. 2: Standard deviation (RMS) and mean of single-satellite crossover differences computed using VER11 and VER13 orbits of six satellites and their differences (rot marked values indicate degradation, when using ITRF2014)

Impact of the TRF on the global and regional mean sea level trends

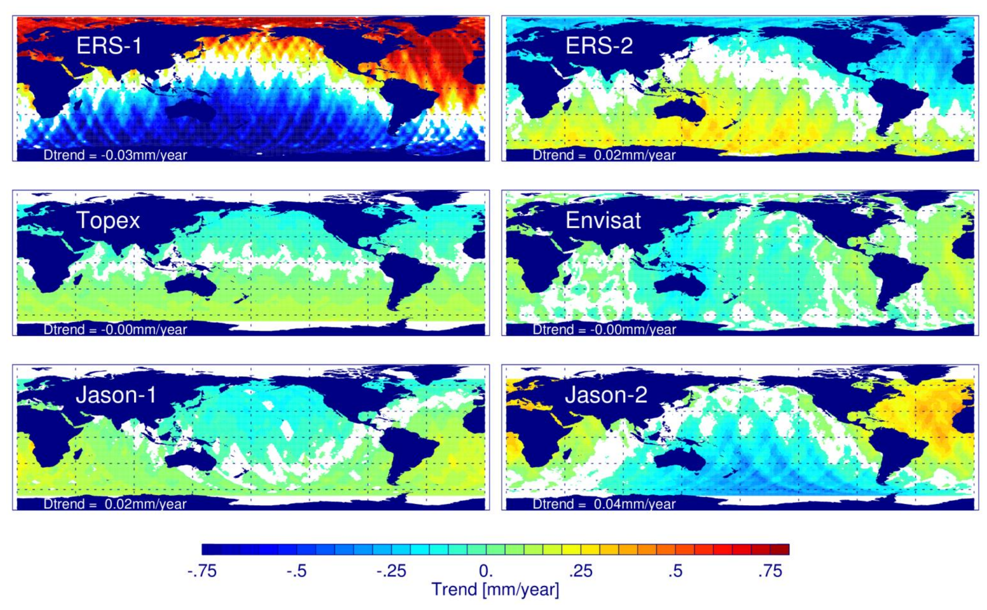

Fig. 16: Radial trend differences (VER11 minus VER13) for all six missions

Satellite	Impact on the global trend (mm/y)	Regional min and max trend differences (mm/y)
ERS-1	-0.03	-1.2 to 1.4
ERS-2	0.02	-0.4 to 0.4
Envisat	-0.00	-0.2 to 0.2
TOPEX	-0.00	-0.2 to 0.2
Jason-1	0.02	-0.2 to 0.3
Jason-2	0.04	-0.5 to 0.4

Tab. 3: Global and regional trend differences obtained using orbits derived in the ITRF2014 and ITRF2008 reference frames

Conclusions: impact when using ITRF2014 instead of ITRF2008

1. The major improvement of the orbit quality is obtained for years 2010-2015.
2. The mean values of the RMS fits of SLR observations improved by 1.8, 3.1, 2.4 and 8.8% for ERS-2, Envisat, Jason-1 and Jason-2, respectively, and are almost not impacted for ERS-1 and TOPEX/Poseidon.
3. Two-day arc overlaps in the radial direction improved by 0.4, 0.6, 2.4, 5.1 and 7.1% for ERS-2, ERS-1, Jason-1, Jason-2 and TOPEX/Poseidon, but slightly (by 0.7%) degraded for Envisat.
4. The scatter of the radial errors improved by 0.1-1.8% for all satellites, but degraded by 0.2% for Envisat.
5. The standard deviation of crossover differences improved by 0.04-0.41% for all satellites.
6. The mean of crossover differences improved by 5.5-22.4% for TOPEX, ERS-1. Jason-1 and Jason-2, but degraded by 4.5% for ERS-2 and 9.7% for Envisat.
7. The impact on the global mean sea level trend is less than 0.01 mm/y for Envisat and TOPEX, equals to 0.02 mm/y for ERS-2 and Jason-1, -0.03 mm/y for ERS-1 and 0.04 mm/y for Jason-2.
8. The impact on the regional mean sea level trend is -0.2 to 0.3 mm/y for Envisat, TOPEX and Jason-1, -0.5 to 0.4 mm/y for ERS-2 and Jason-2 and -1.2 to 1.4 mm/y for ERS-1.

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