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Evaluation of the ITRS 2020 realizations for POD of altimetry satellites




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Outline

- Tests of ITRF2020 (SLRF2020), DTRF2020 and JTRF2020 on precise orbit determination (POD).

Comparisons with respect to ITRF2014 (SLRF2014), DTRF2014 and JTRF2014.

- Satellites and time spans used: Jason-1 (13.01.2002 – 30.06.2013), Jason-2 (20.07.2008 – 08.09.2019),

and Jason-3 (17.02.2016 – 28.06.2023).

- Type of observations used: SLR.

- The same background models and parametrizations were used for all satellites (Rudenko et al., 2023)

- The impact of the following three xTRF2020 realizations on the POD has been investigated:

  ITRF2020 (SLRF2020) with post-seismic deformations (PSD) and periodical variations of station coordinates,
  DTRF2020 with discrete post-seismic deformations (dPSD), non-tidal loading (NTL), and SLR translations,
  JTRF2020 – daily files.

- For all three ITRS 2020 realitations, the following files were used:

ILRS Data Handling File (DHF) of 20230621, ILRS occupation file of 20230314.

- No time biases were used in these tests. Range biases were estimated only for stations as recommended in the ILRS DHF.

ITRS 2020 realizations

- With each publication of a new ITRS realization, institutes which are in charge with the analysis and the application of space geodetic observations have to implement the most recent version of the ITRF
- Besides the official IAG IERS product computed and published by IGN, DGFI-TUM and JPL also compute ITRS realizations
- The ITRS realizations are based on identical input data but on different combination strategies. This results in a different array of products

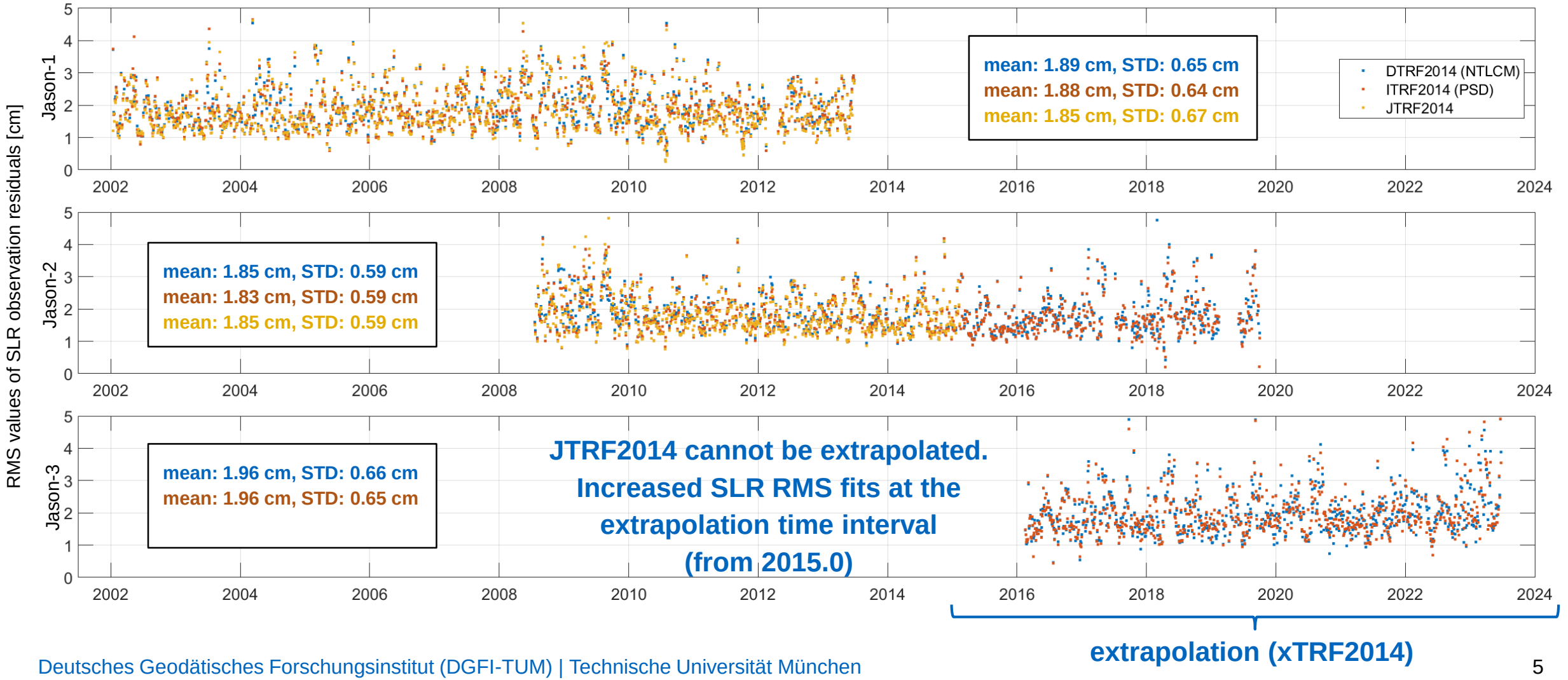
	ITRF2020 (Altamimi et al., 2023)	DTRF2020 (Seitz et al., 2023)	JTRF2020 (Gross et al. 2023)
combination level	solution	normal equation	solution
station coordinates	positions and velocities at reference epoch 2015.0	positions and velocities at reference epoch 2010.0	daily positions
post-seismic deformation (PSD)	coefficients of PSD function	discrete PSD correction time series	-
periodic corrections	(semi-)annual + GNSS draconitic periods (and harmonics)	-	-
non-tidal loading (NTL) corrections	-	correction time series for atmospheric, oceanic and hydrological NTL corrections	-
SLR network translations	1)	translation time series between 1983.0 and 2020.0	-
Helmert transformation residuals	1)	residual time series between 1979.0 and 2020.0	-
history	ITRF1994, ITRF1996, ITRF1997, ITRF2000, ITRF2005, ITRF2008, ITRF2014	DTRF2008, DTRF2014	JTRF2014

1) available at https://itrf.ign.fr/en/solutions/ITRF2020#itrf2020-based-time-series-of-origins-and-scales

Impact of the TRF realizations on the RMS values of SLR observation residuals and estimated parameters

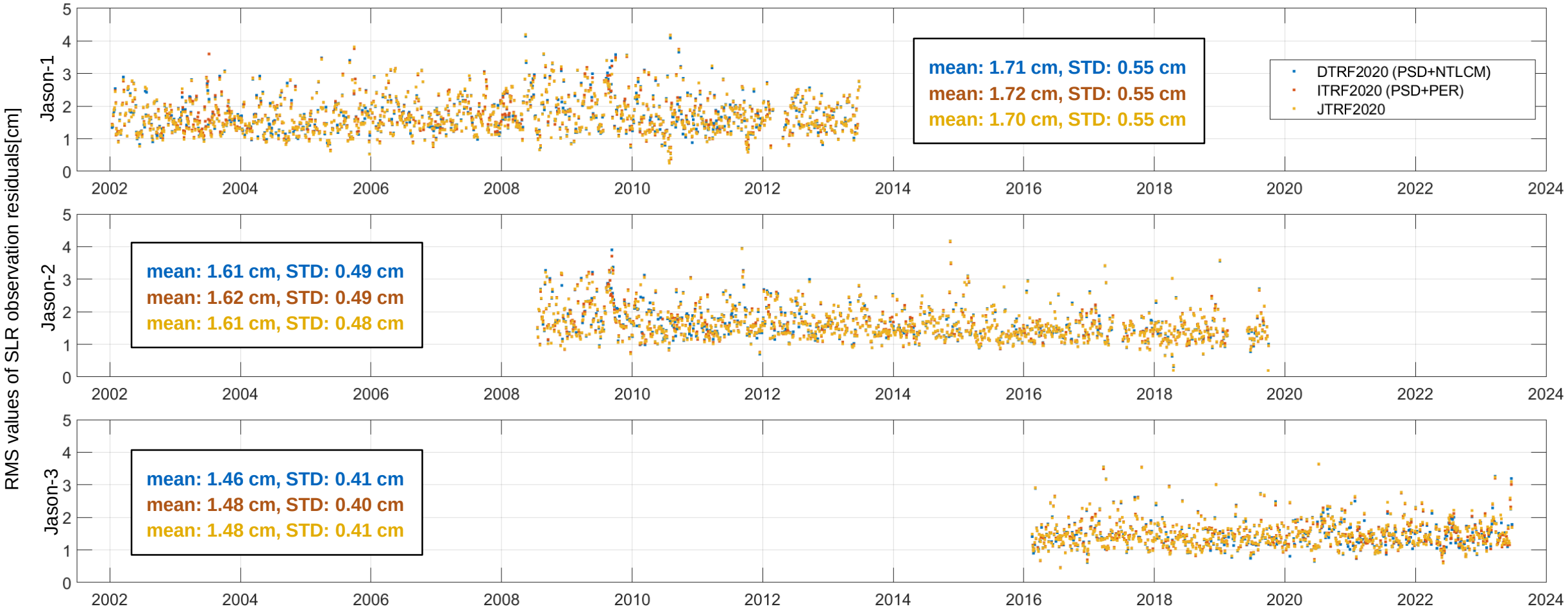
RMS values of SLR observation fits for Jason-1/2/3 using xTRF2014

- **No obvious differences** between the RMS values of the SLR observation residuals found for all xTRF2014 solutions (important note: **no ILRS DHF was used for the POD!**)



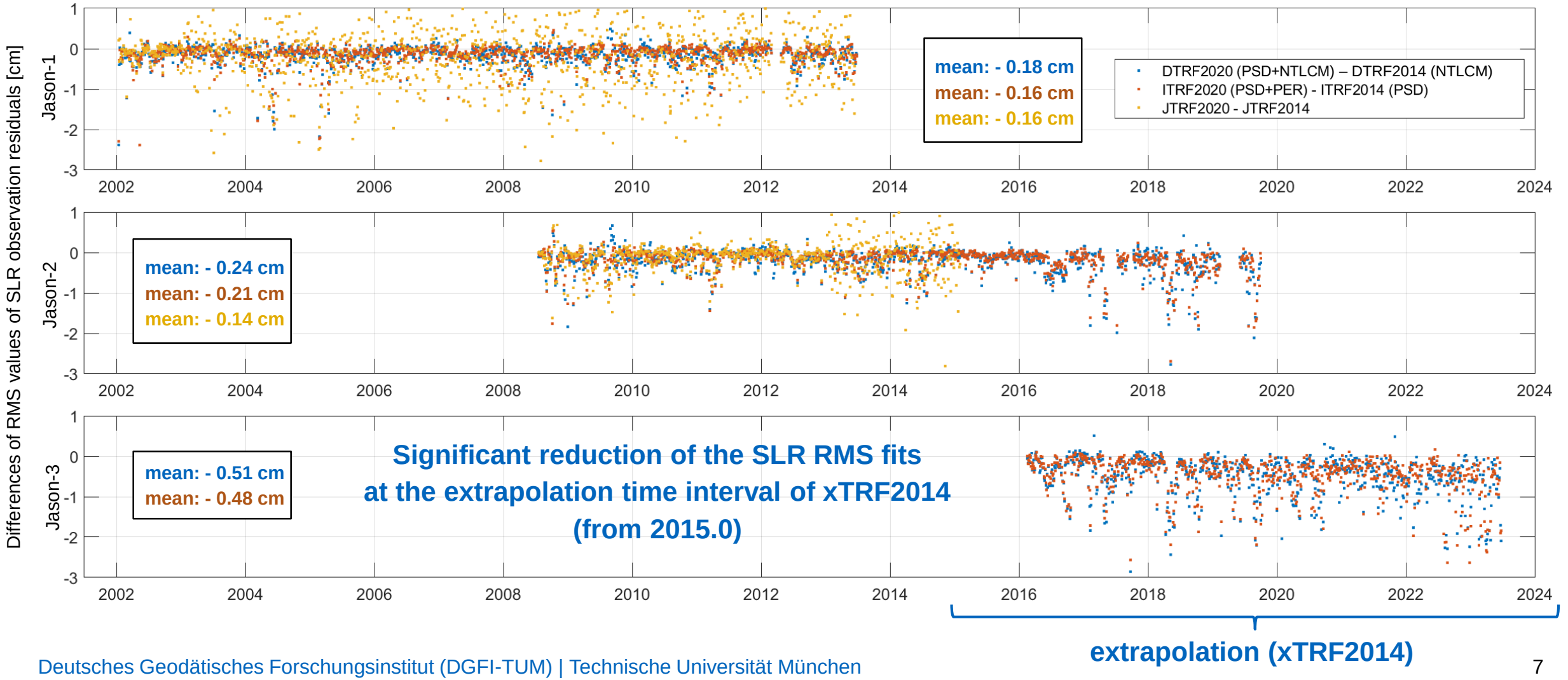
RMS values of SLR observation fits for Jason-1/2/3 using xTRF2020

- **No obvious differences** between the RMS values of the SLR observation residuals found for all xTRF2020 solutions (**most recent ILRS DHF used; cf. LAGEOS-1 RBs for Jason-1/2/3**)



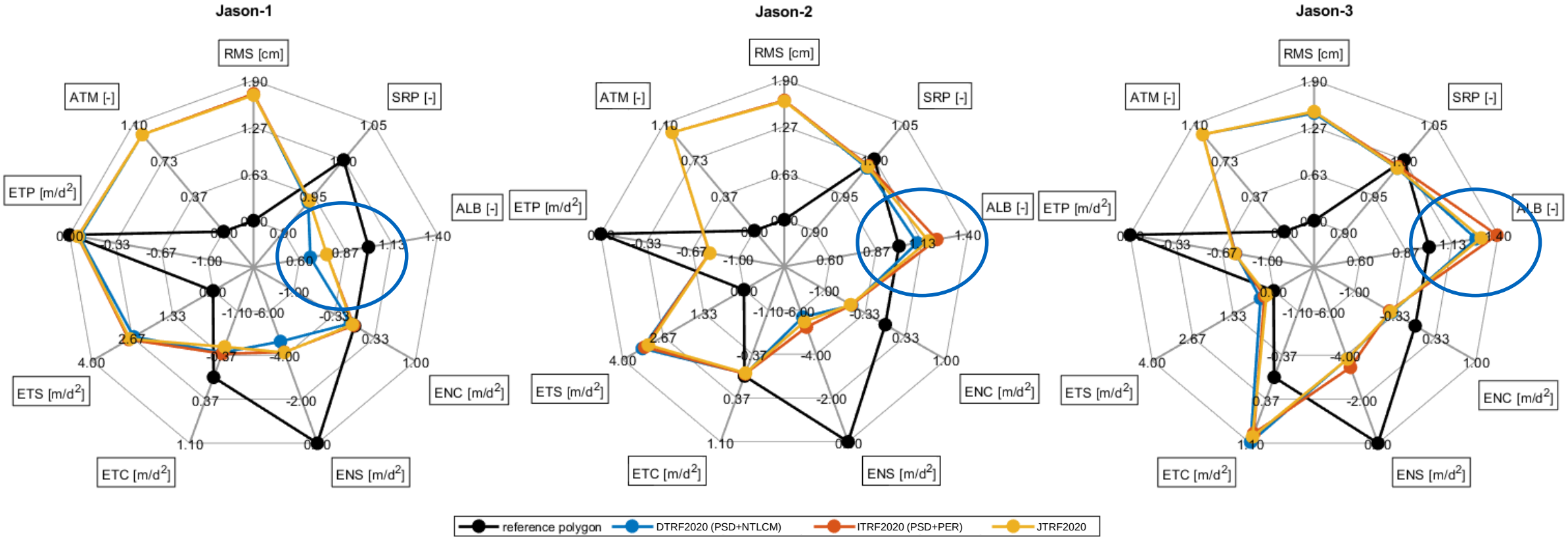
Differences of RMS SLR data fits for Jason-1/2/3: xTRF2020 - xTRF2014

- **RMS values of the SLR observation residuals are smaller for D/ITRF2020 solutions than for D/ITRF2014 solutions**; JTRF2020 solution does not systematically improve the POD results: large scatter of differences



Impact of xTRF2020 on the estimated parameters of the Jason-1/2/3 POD

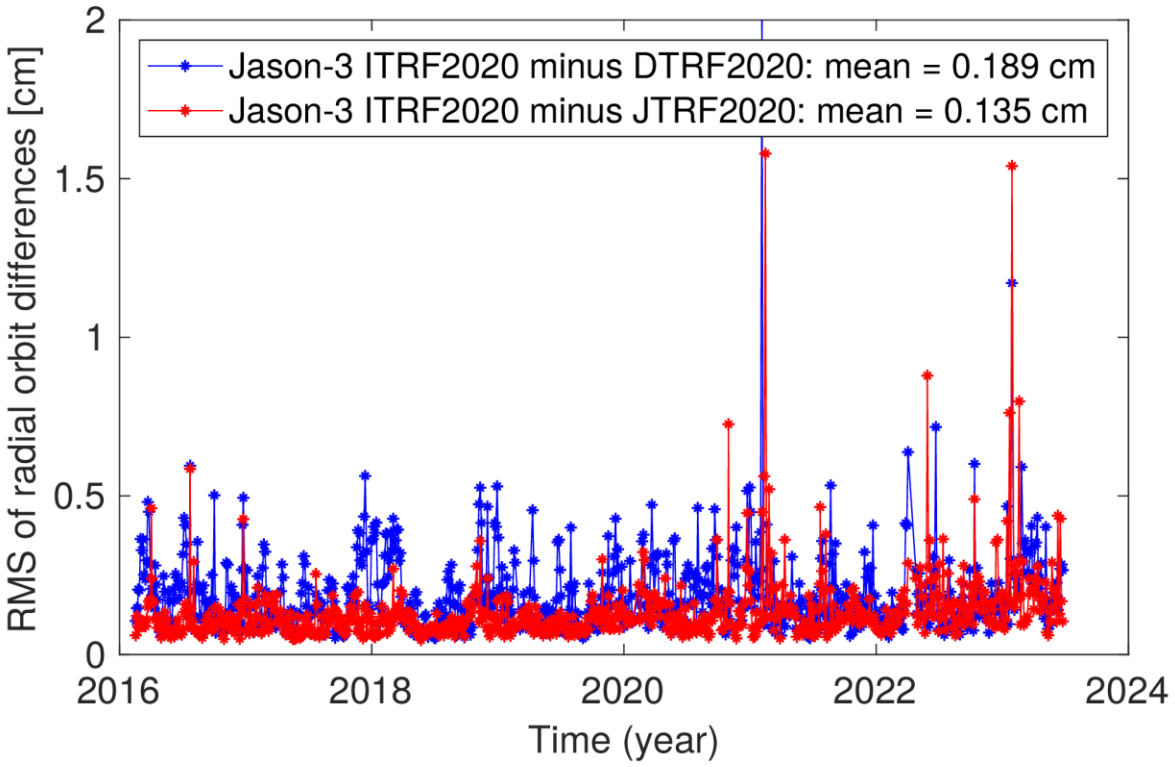
- Nearly all orbit parameters are very similar using different TRF solutions
- Estimated **Earth albedo scaling factor differs** due to different realization of xTRF2020 scales?

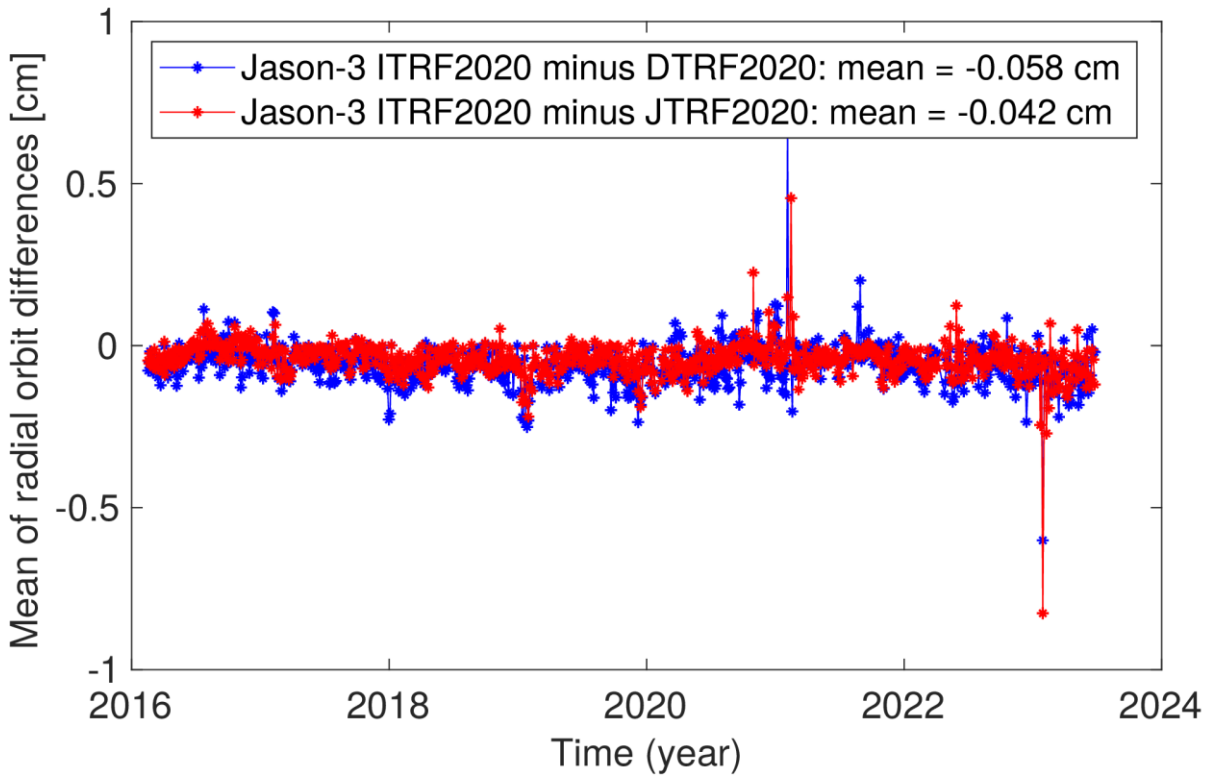


RMS – root mean square	ENC/S – empirical cosine/sine coefficient (normal to orbit)
SRP – solar radiation pressure scaling factor	ETC/S – empirical cosine/sine coefficient (tangential to orbit)
ALB – Earth Albedo scaling factor	ETP – empirical piece-wise linear polygon (tangential to orbit, 12h resolution)
ATM – Atmospheric scaling factor polygon (12h resolution)	

Impact of the TRF realizations
on the satellite orbit differences in the radial direction

RMS and mean of radial orbit differences for Jason-3 using xTRF2020

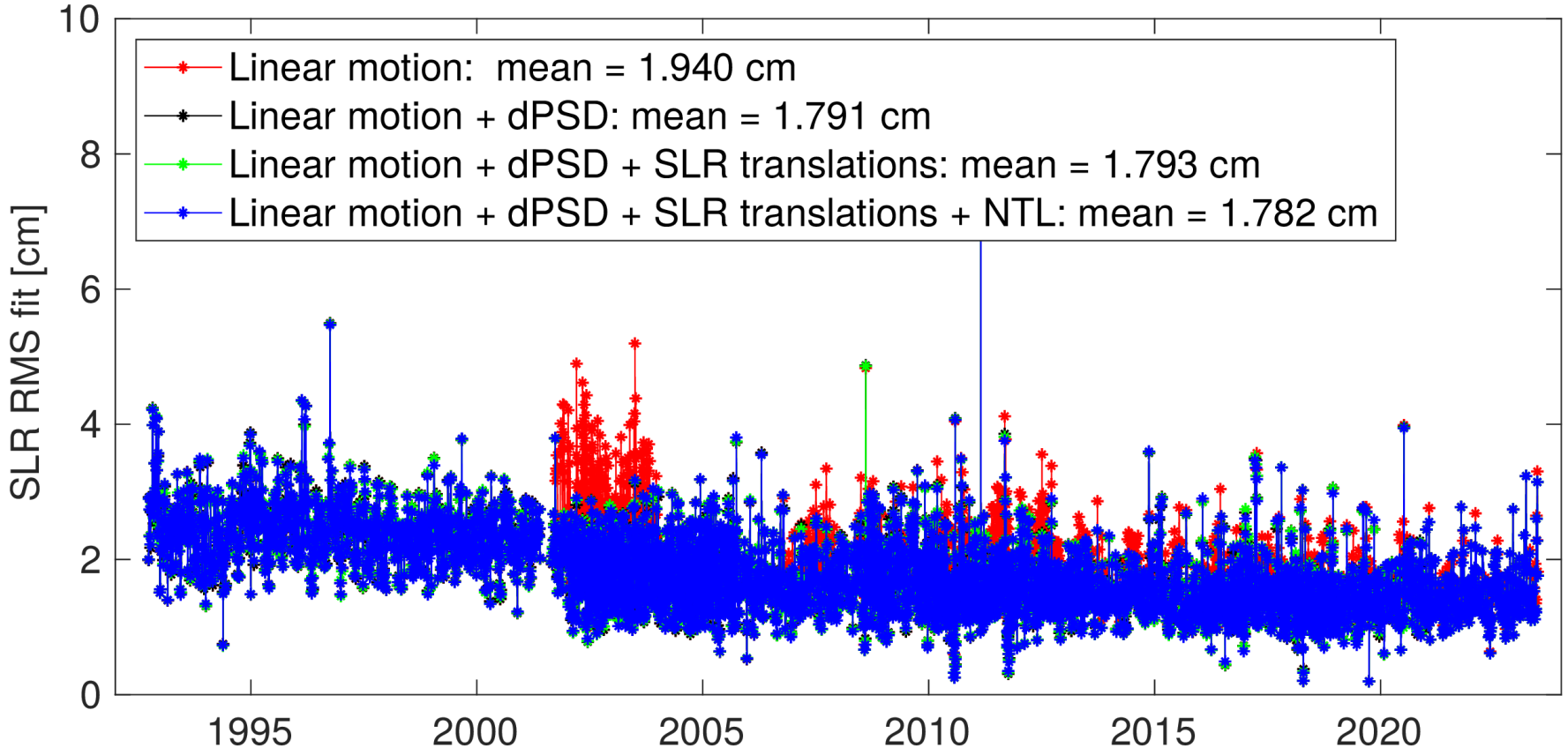




- ITRF2020 and JTRF2020 based orbits fit together better than ITRF2020 and DTRF2020 based orbits
- The RMS and mean values of the orbit differences in the radial direction for xTRF2020-based orbits of Jason-3 are 1.4-1.9 mm and –(0.4-0.6) mm, respectively.

Impact of various corrections for DTRF2020 on RMS values of SLR observation residuals

RMS fits of SLR observations

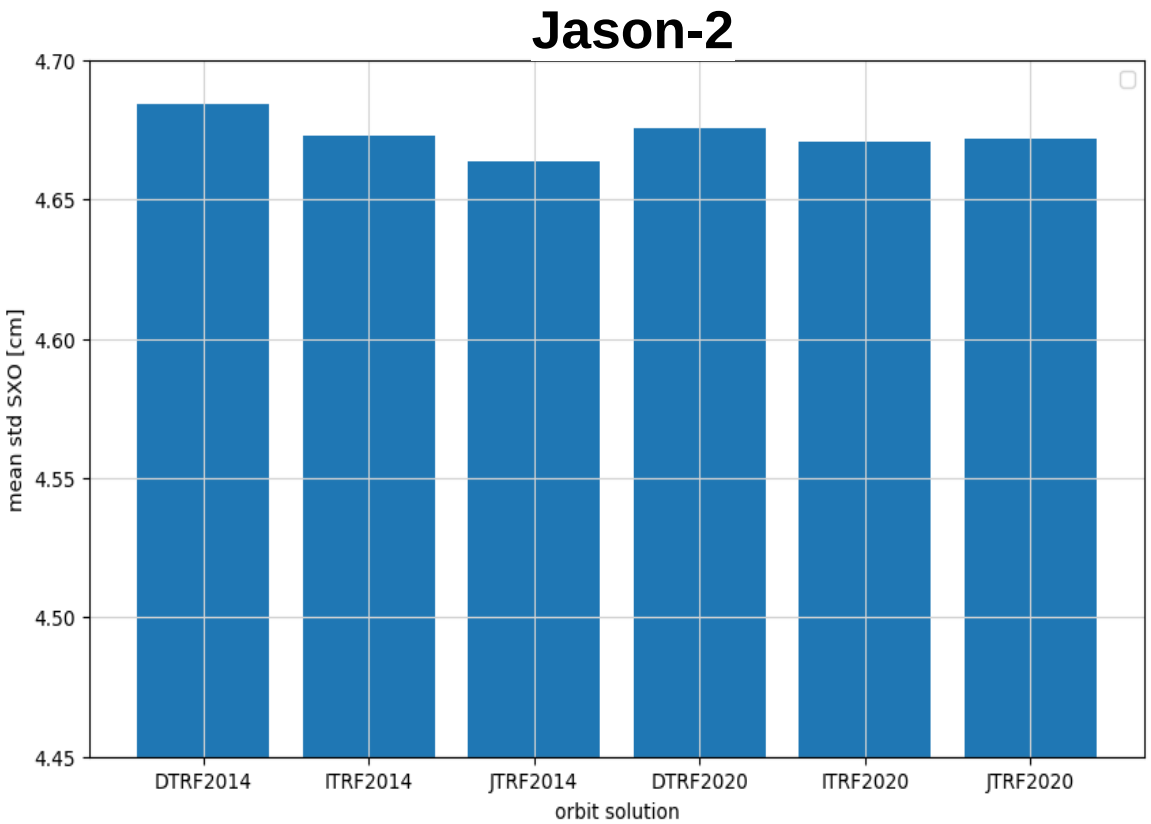


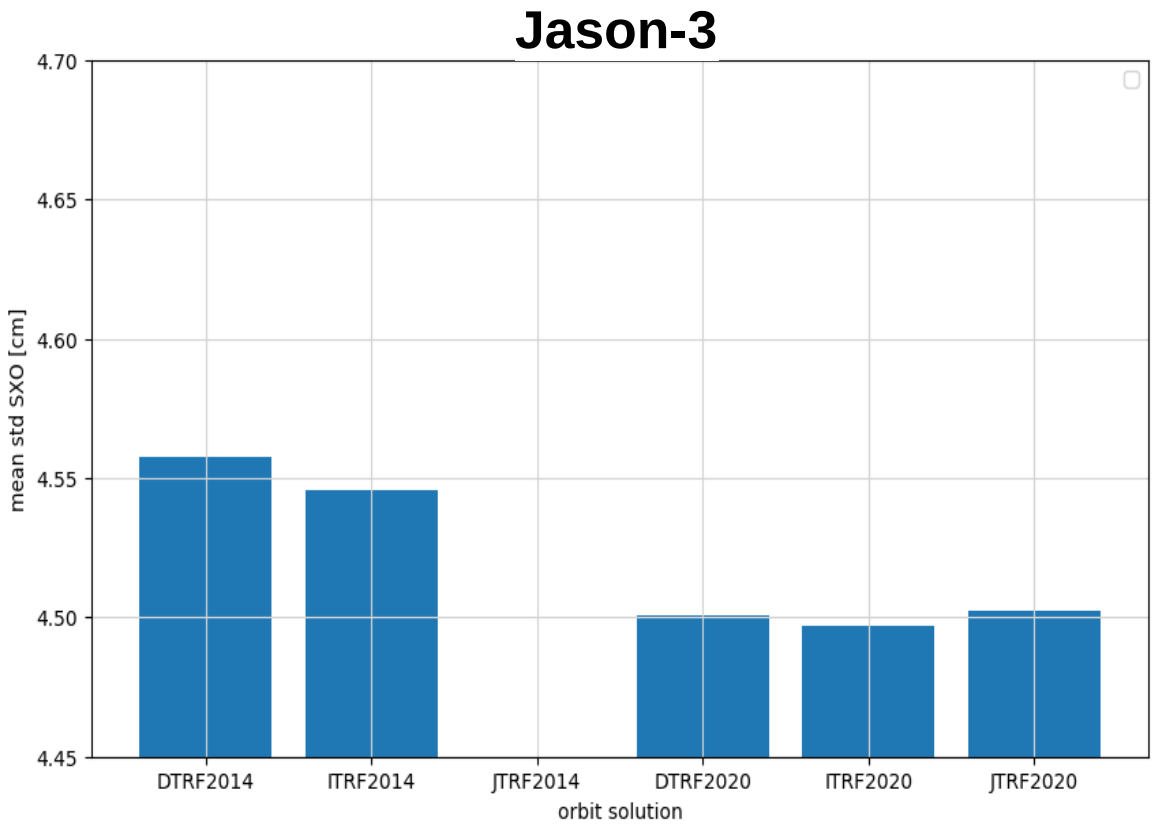
- Modeling of discrete post-seismic deformations (dPSD) due to the Arequipa and other major earthquakes is absolutely necessary. The best results are obtained, when the dPSD, non-tidal loading (NTL) and SLR translations are taken into consideration.

Impact of the TRF realizations
on single-satellite sea surface height crossover differences,
radial altimeter corrections,
and geographically correlated mean errors

[more info about methodology: Bosch et al. (2014)]

Standard deviation of single-satellite crossover differences (SXO)



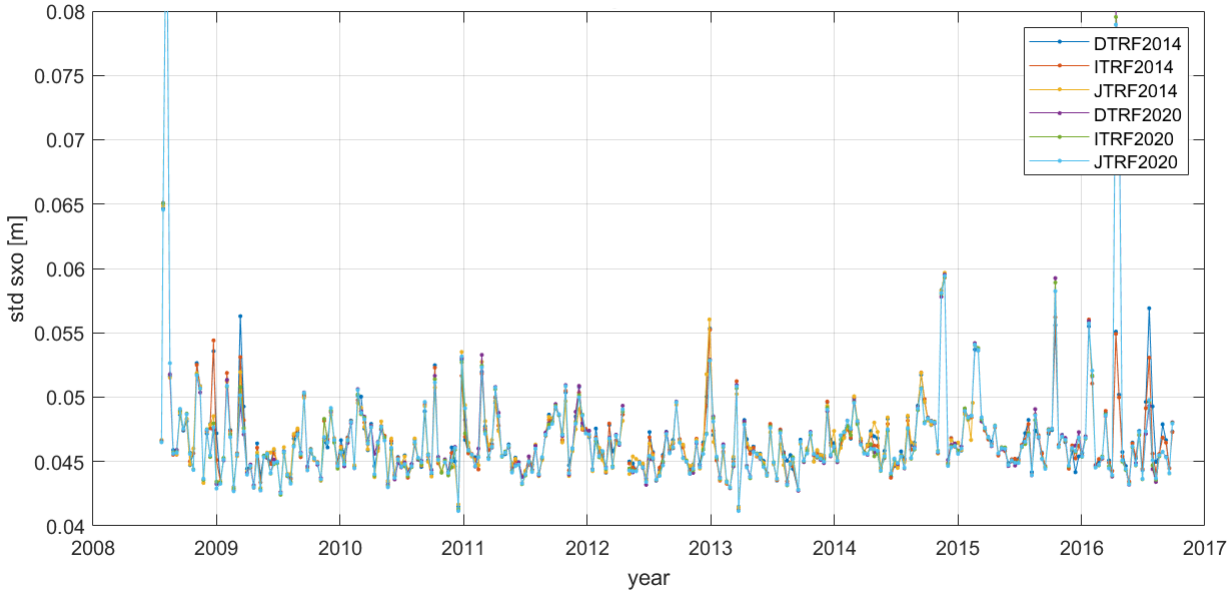


- Jason-2: mean differences between versions negligible (smaller than 0.5 mm)
- Jason-3: smaller values for xTRF2020 solutions than for xTRF2014 (but only sub-millimeter differences)
- Jason-3 shows better performance than Jason-2

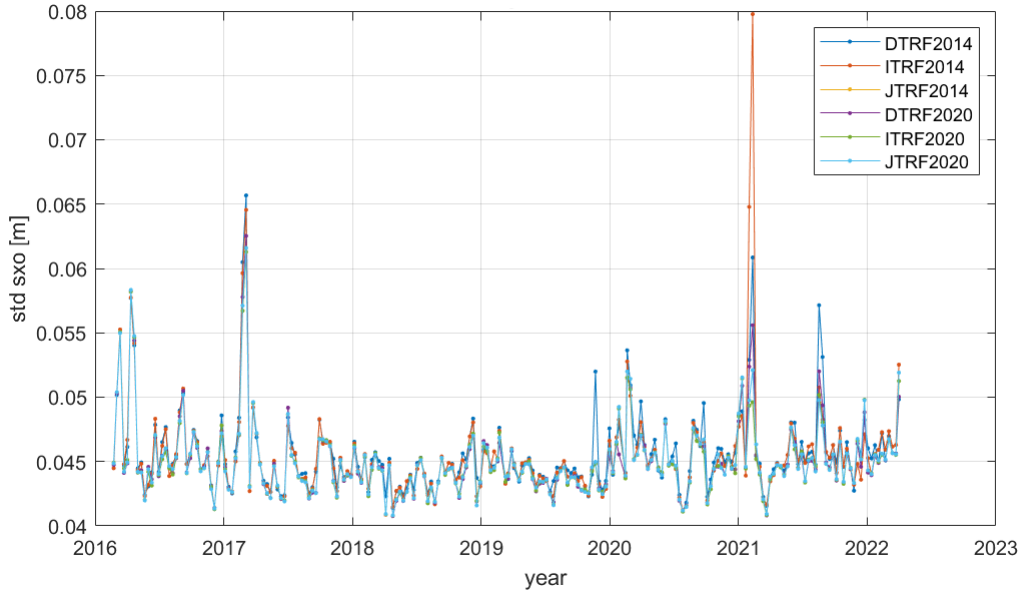
Standard deviation of single-satellite crossover differences (SXO)

temporal evolution (10-day standard deviations; full repeat cycle)

Jason-2



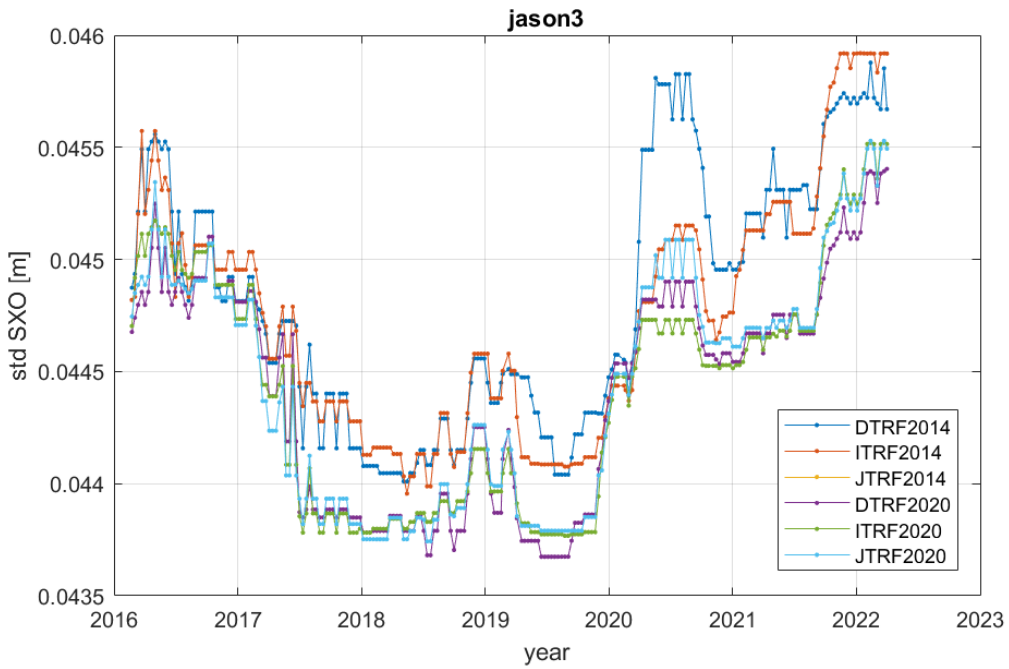
Jason-3



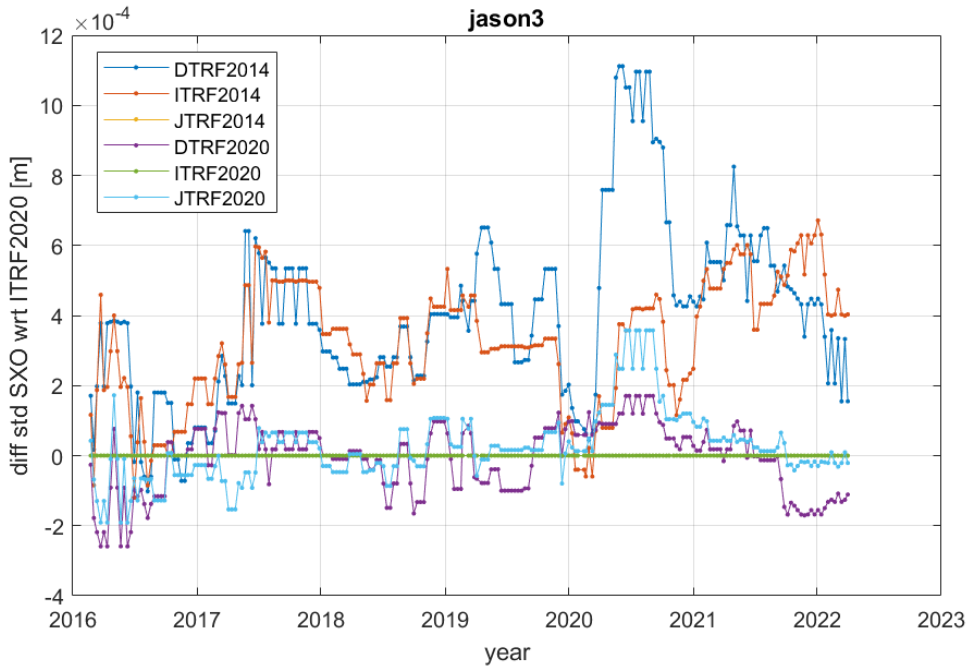
- temporal variability higher than mean differences

Standard deviation of single-satellite crossover differences (SXO)

Jason-3: temporal evolution – smoothed (1-year moving median)

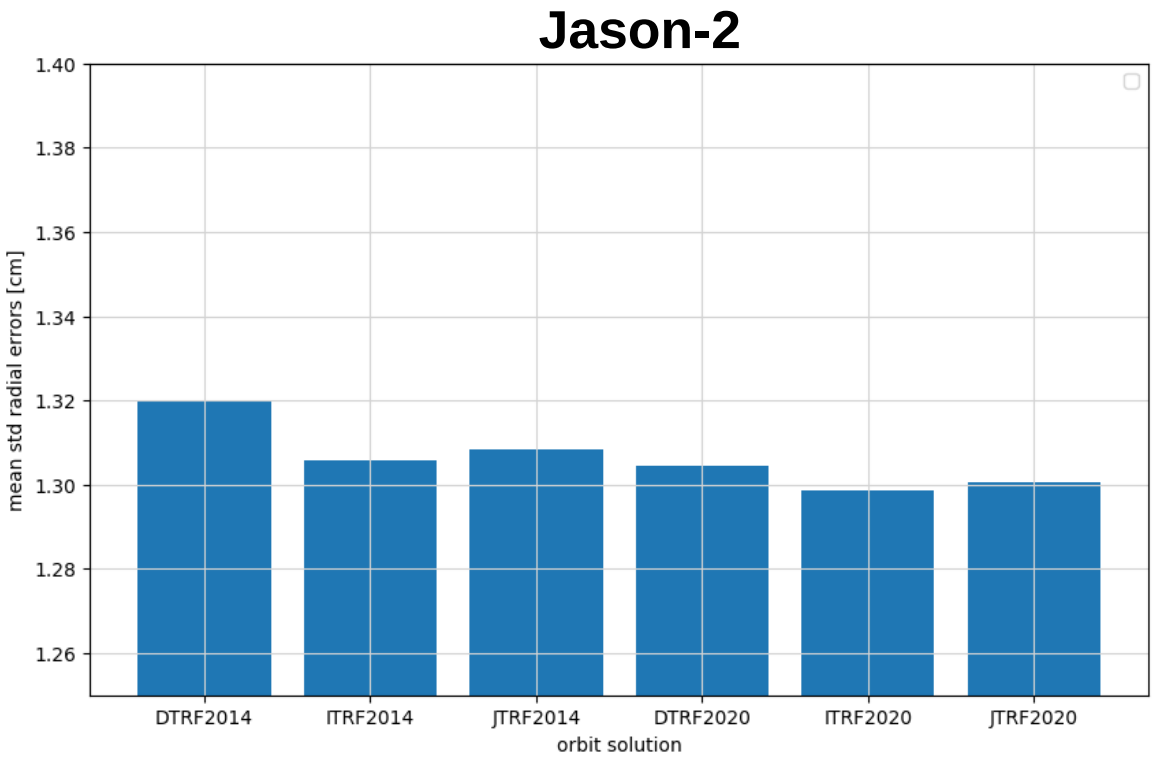


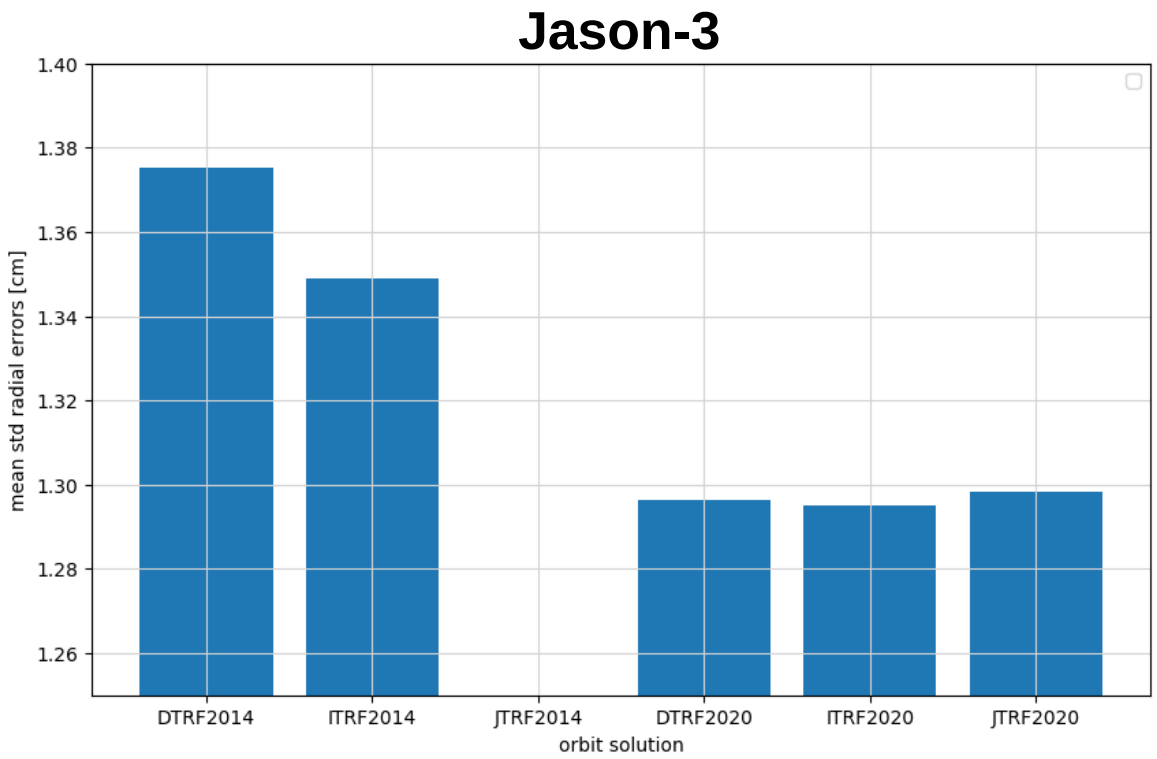
relative to ITRF2020



- Smoothing shows long-term changes (not necessarily due to orbit, since visible in all solutions)
- Clear improvement in xTRF2020 solutions with respect to xTRF2014 solutions

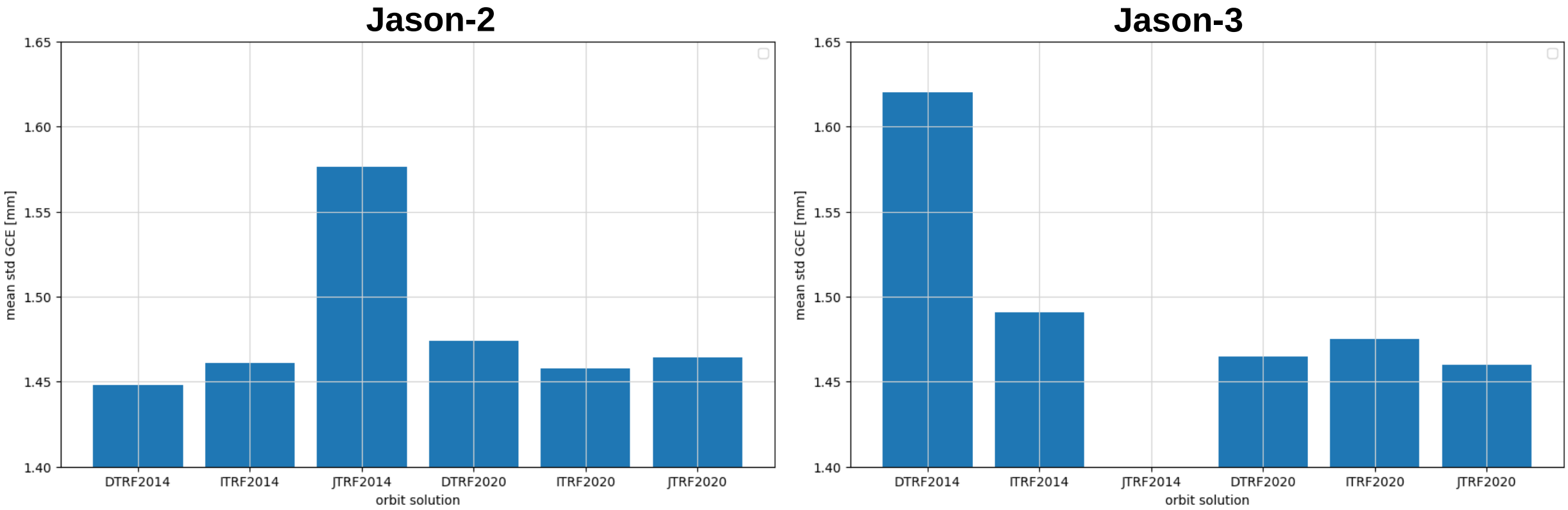
Standard deviation of estimated radial errors (RE)





- similar behavior to SXO
- but: Jason-3 xTRF2020 no longer superior to Jason-2 (probably due to the fact that other missions in MMXO are still based on ITRF2014)

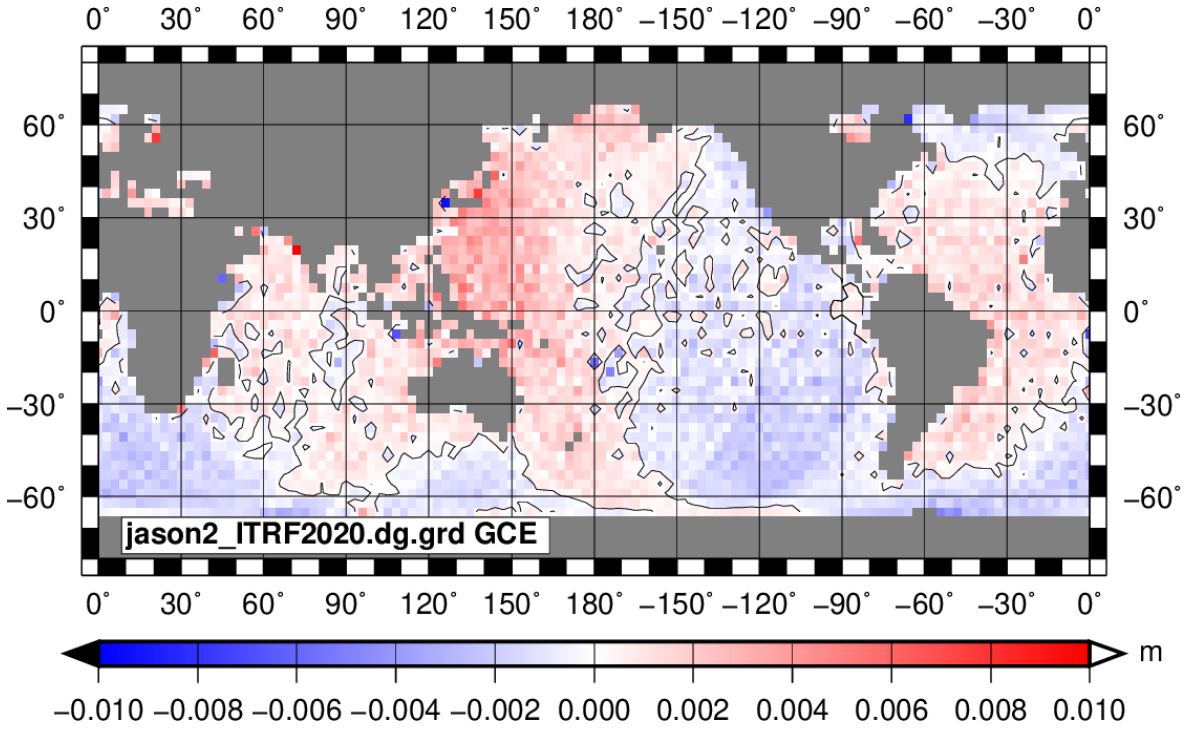
Standard deviation of geographically correlated errors (GCE)



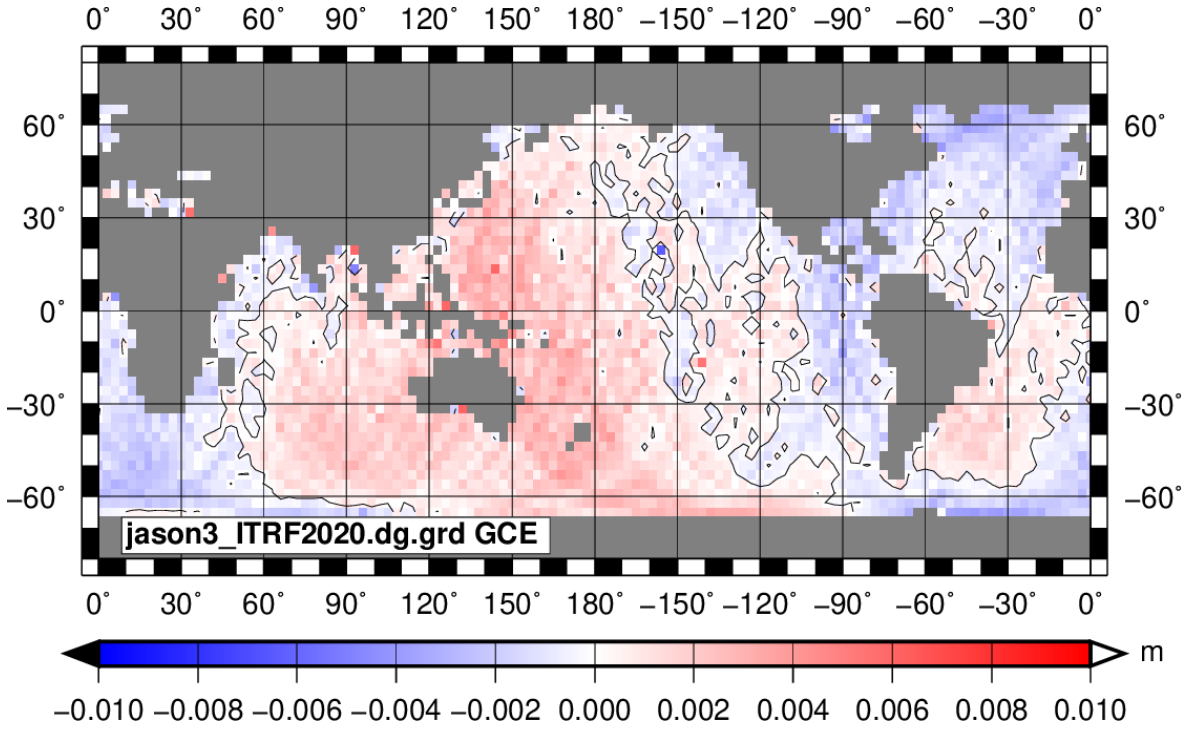
- JTRF2014 shows largest GCE for Jason-2
- DTRF2014 shows largest GCE for Jason-3, i.e. at the interpolation time interval
- The xTRF2020 realizations provide smaller GCE for Jason-3 than the xTRF2014 ones

Geographically correlated errors (GCE)

Jason-2 ITRF2020



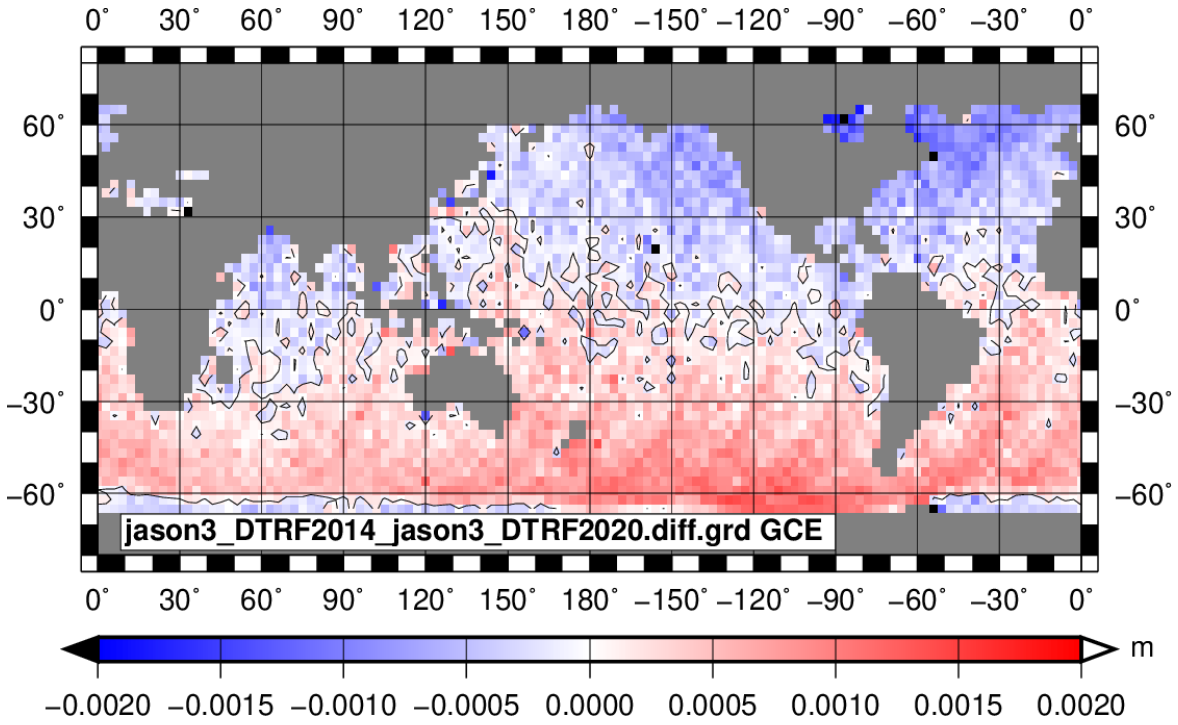
Jason-3 ITRF2020



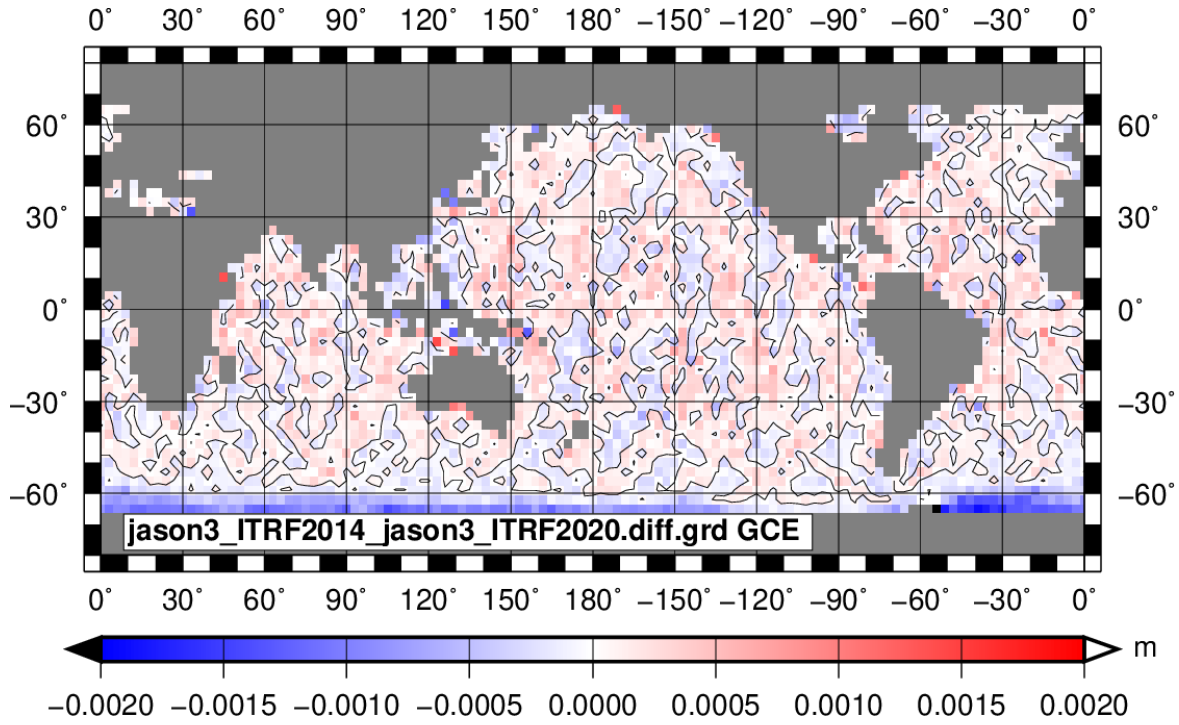
- Large-scale pattern for both satellites
- Differences between the xTRF solutions are better visible from the difference plots (next slides)

Geographically correlated errors (GCE) – Differences in Jason-3

DTRF2014 – DTRF2020



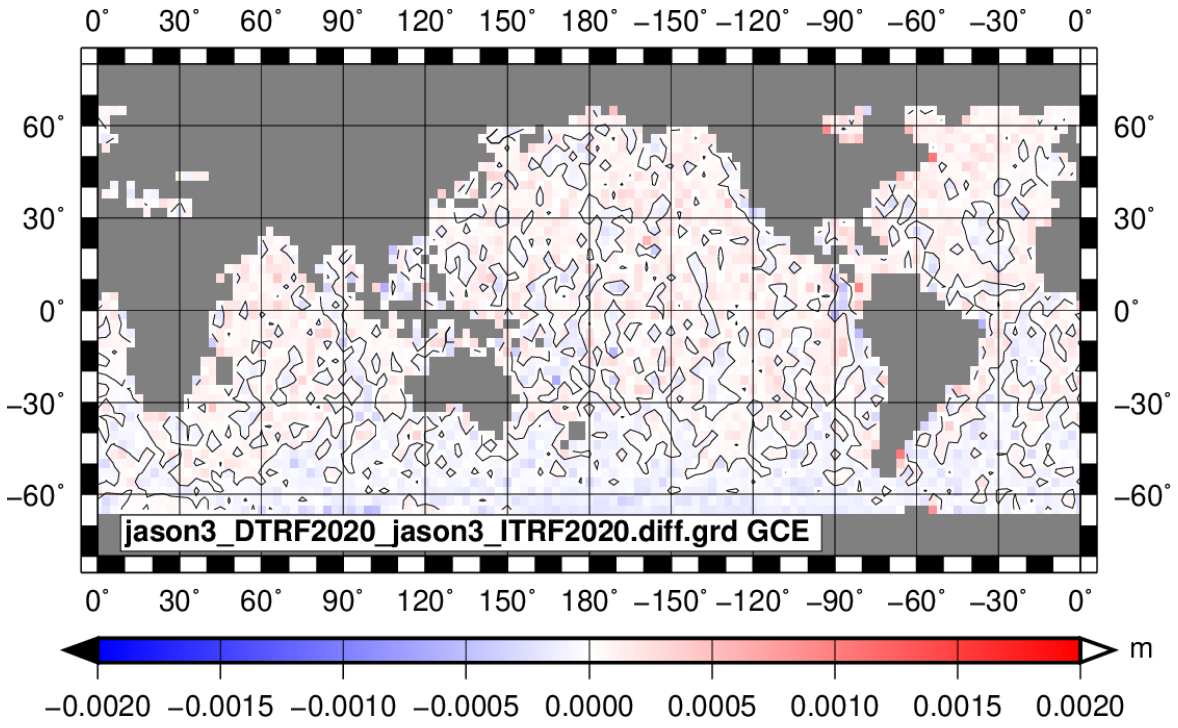
ITRF2014 – ITRF2020



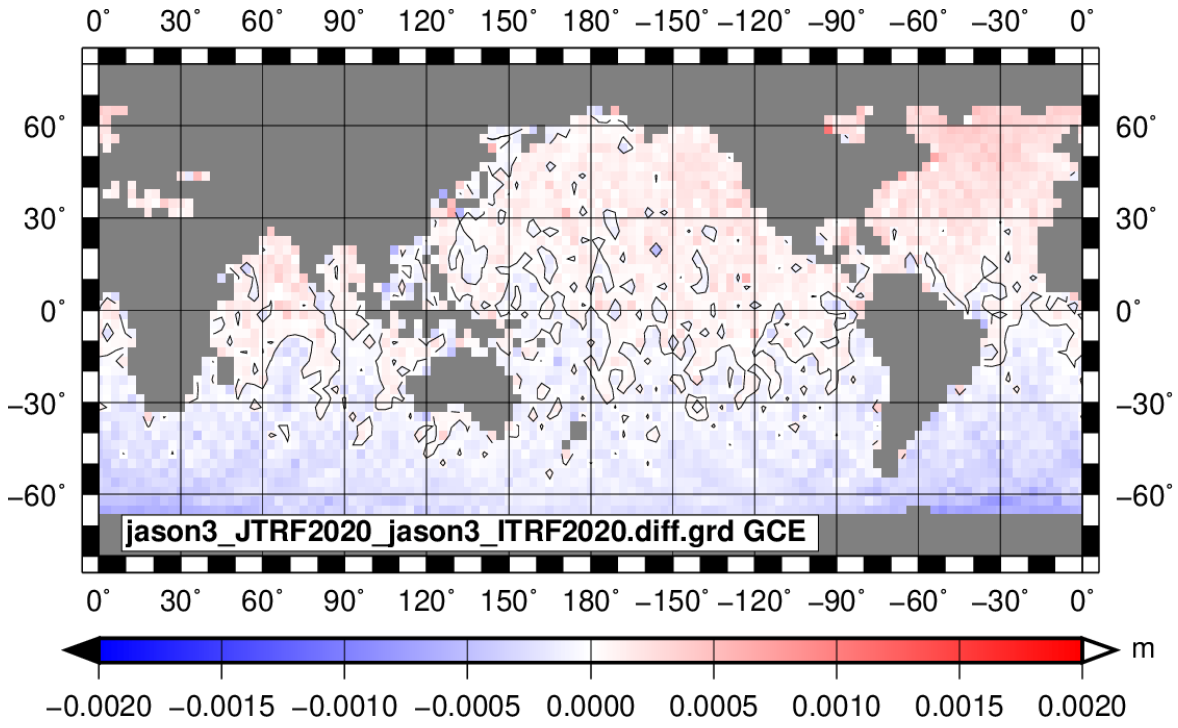
- Z-shift visible in differences between DTRF2014 and DTRF2020
- no geographical systematics from ITRF2014 to ITRF2020

Geographically correlated errors (GCE) – Differences for Jason-3 orbits

DTRF2020 – ITRF2020



JTRF2020 – ITRF2020

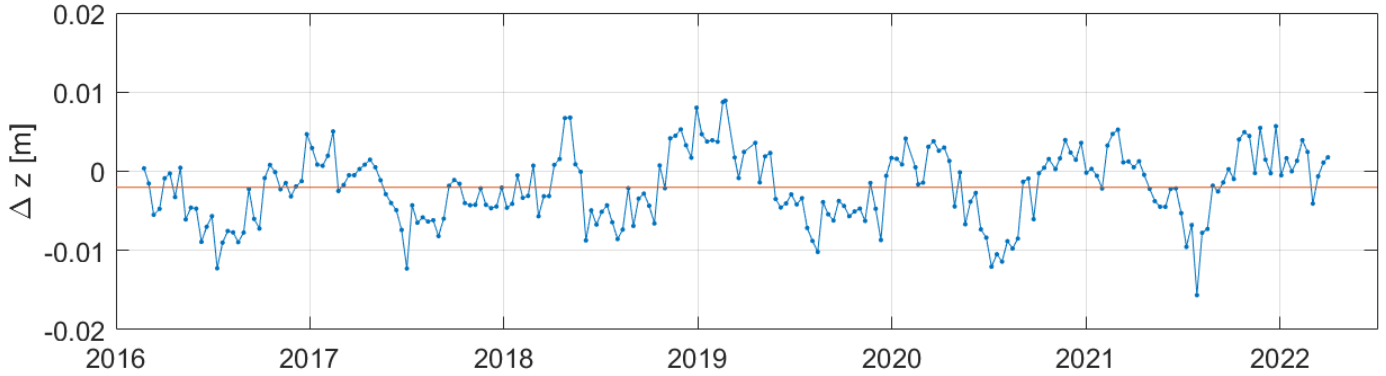


- no geographical systematics from DTRF2020 to ITRF2020
- Moderate z-shift between JTRF2020 and ITRF2020

Center-of-Origin z-shifts, Jason-3

DTRF2014 – DTRF2020

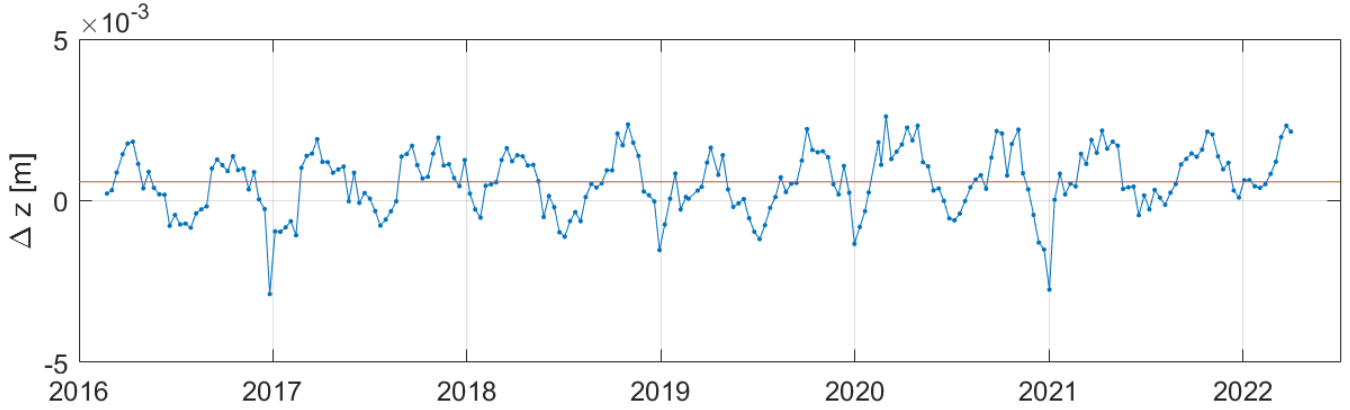
4 cm



dz = -2.0 mm

JTRF2020 – ITRF2020

1 cm



dz = +0.6 mm

Conclusions

- All three 2020 realizations of the ITRS (ITRF2020, DTRF2020 and JTRF2020) provide rather comparable values of the RMS and mean fits of SLR observations and estimated parameters. Only estimated albedo scale factor indicates notable differences, when using these realizations, most probably, due to different realizations of scale.

- The xTRF2020 realizations notably (by about 25%) reduce RMS fits of observations for Jason-3, as compared to the xTRF2014 realizations.

- For the DTRF2020, the smallest RMS and absolute mean fits of observations are obtained, when using the dPSD, non-tidal loading and SLR translations. Ignoring the dPSD corrections causes a degradation of the orbit quality, since the coordinates of earthquake affected stations (e.g., Arequipa) are imprecise.

- The RMS value of the radial orbit differences of Jason-3 is 1.4 mm (ITRF2020 vs. JTRF2020) and 1.9 mm (ITRF2020 vs. DTRF2020).

Conclusions (continue)

Altimetry crossover analysis shows

- Differences due to different orbit solutions are small for both satellites and for all analyzed parameters.

- For Jason-2, the differences in mean standard deviations of single-satellite crossover differences are smaller than 0.5 mm (1%)

- For Jason-3, xTRF2020-based orbits outperform xTRF2014-based orbits (smaller crossover differences and smaller standard deviations of radial errors).

- Geographically correlated errors are similar for all ITRF2020 and DTRF solutions; JTRF2020 shows a small z-shift compared with ITRF2020; DTRF shows a clear z-shift when comparing the 2014 and 2020 solutions

References

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Acknowledgements

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