Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

Application of ITRS 2020 realizations for SLR POD

Mathis Bloßfeld, Manuela Seitz, Julian Zeitlhöfler, Sergei Rudenko, Matthias Glomsda, Alexander Kehm

Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM)

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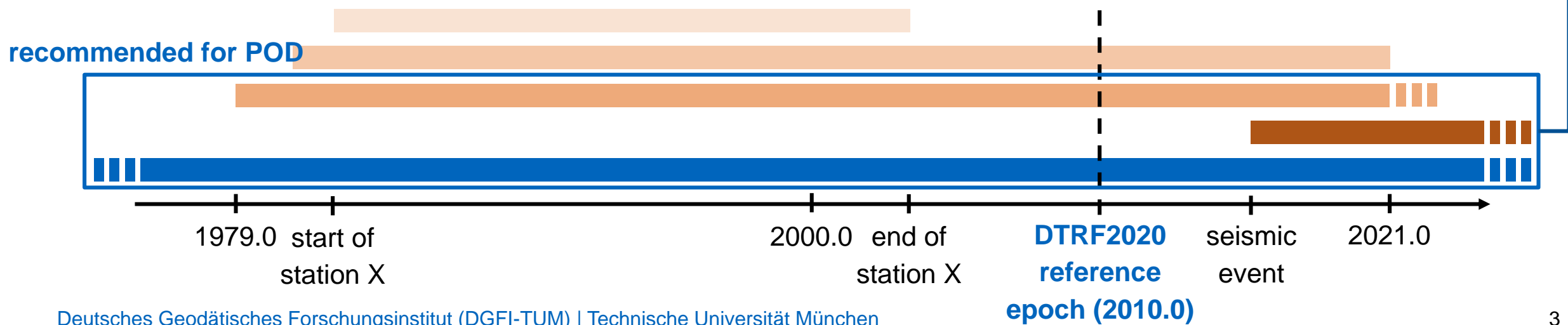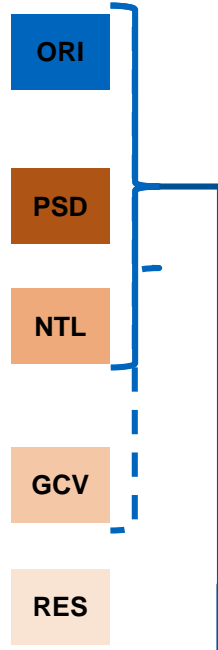Scientific analysis of SLR observations: past, current and future challenges and possibilities

2023 VIRTUAL INTERNATIONAL WORKSHOP ON LASER RANGING
OCTOBER 16-20, 2023
NEW DEVELOPMENTS IN SATELLITE LASER RANGING

ILRS

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., 2022)	DTRF2020 (Seitz et al., 2023)	JTRF2020
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

DTRF2020 data

- The DTRF2020 solution primarily comprises station positions and velocities (i.e. coordinates)

- The DTRF2020 publication also provides several non-linear corrections which a user might consider

  - discrete post-seismic deformation time series for selected stations (computed until 2030.0)

  - NTL correction time series for all stations (component-wise or sum, center-of-mass/figure (CM/CF) based; after 2021.0: time series from `http://loading.u-strasbg.fr/ITRF2020/displa/`; oceanic part only available for 2021)

  - translations derived from a Helmert transformation (7 parameters) of the not accumulated 15-/7-day SLR-only solutions on the combined DTRF2020 solution (SLR network; cf. next slide!)

  - residuals from a Helmert transformation (7 parameters) for all stations of the not accumulated technique-specific solutions on the combined DTRF2020 solution (network-specific)


ORI

PSD

NTL

GCV

RES

recommended for POD

1979.0 start of station X

2000.0 end of station X

DTRF2020 reference epoch (2010.0)

seismic event

2021.0

DTRF2020 - SLR 'geocenter variation'

➢ The DTRF2020 provides also the **ILRS network translations between 1983.0 and 2021.0**

- the translations (red) only contain the **'geocenter variation' which is not yet modelled by the NTL models** (i.e. only small seasonal variations but also SLR network effect)!

- for the **'full geocenter variation' one must add the NTL(CM)-NTL(CF) signal** to this time series (blue)

- due to the scatter and the end of the time series already in 2021.0, the translations **are not recommended for POD** (if considered, effect will be very small; cf. Rudenko et al., 2023)

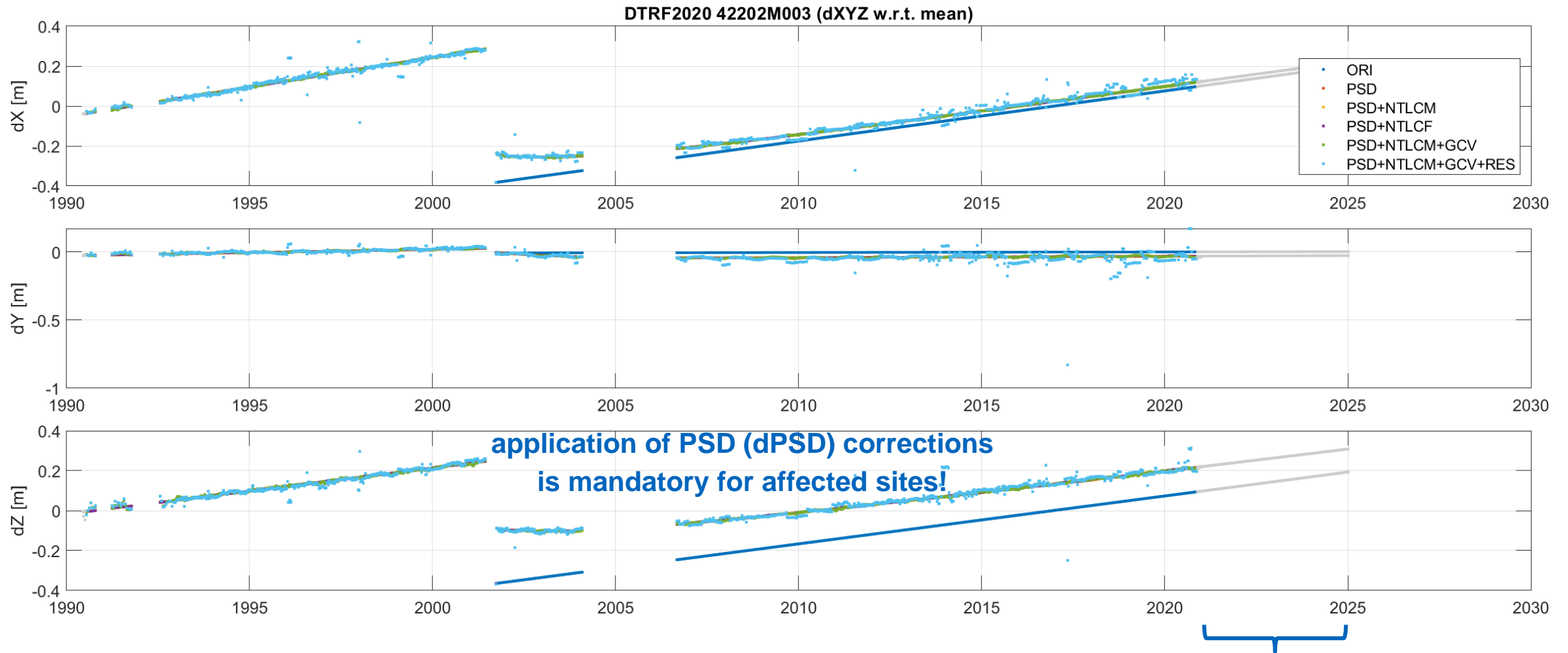# (I/D/J)TRF2020 → XTRF2020 vs. ILRSA contribution

- ➢ In XTRF2020 SINEX files, the SOLUTION/EPOCHS block provides validity intervals for each station

- ➢ "bold" lines in figure below **(A)**: stations are used **only according to SOLUTION/EPOCHS info**

- ➢ "thin" lines in figure below **(B)**: stations are still used **after interval of highest solution number ended (recommended for POD)**
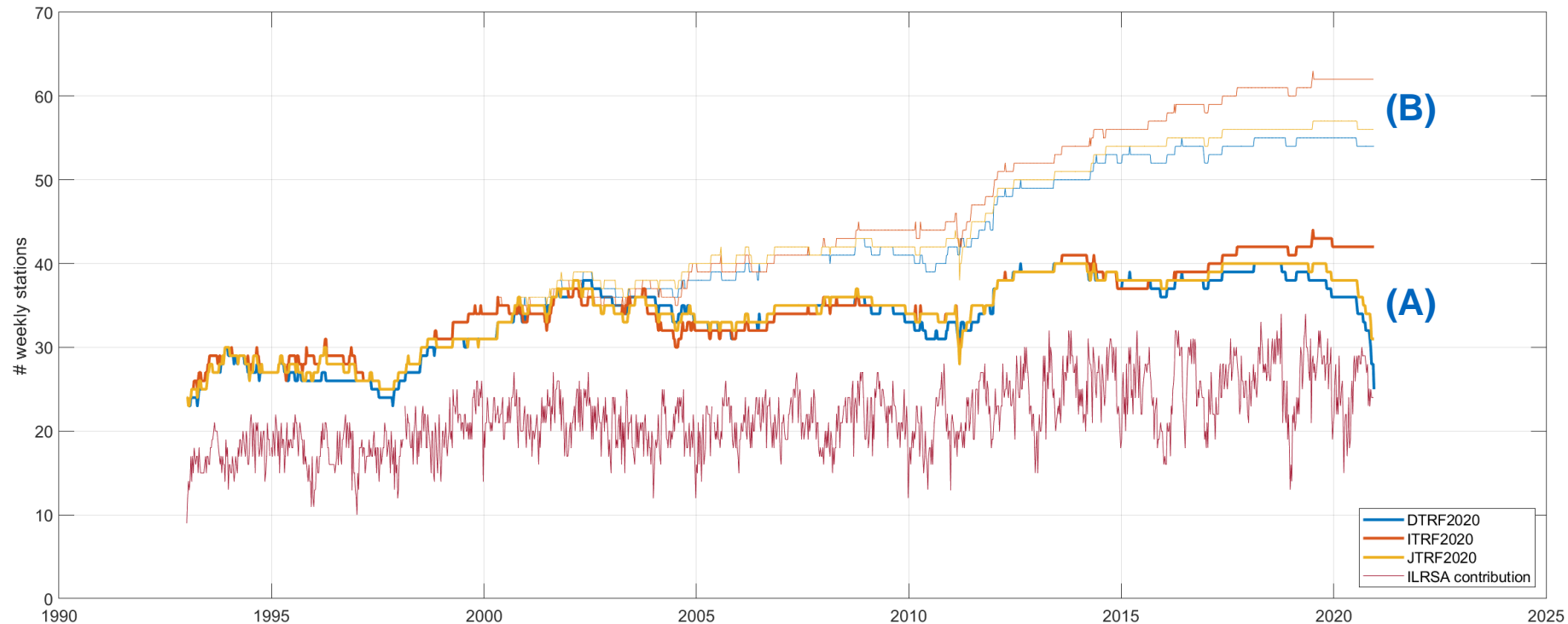
- ➢ About 30% of tracking network is defined in XTRF2020 but did not observe (SLR telescopes need "good" weather conditions)
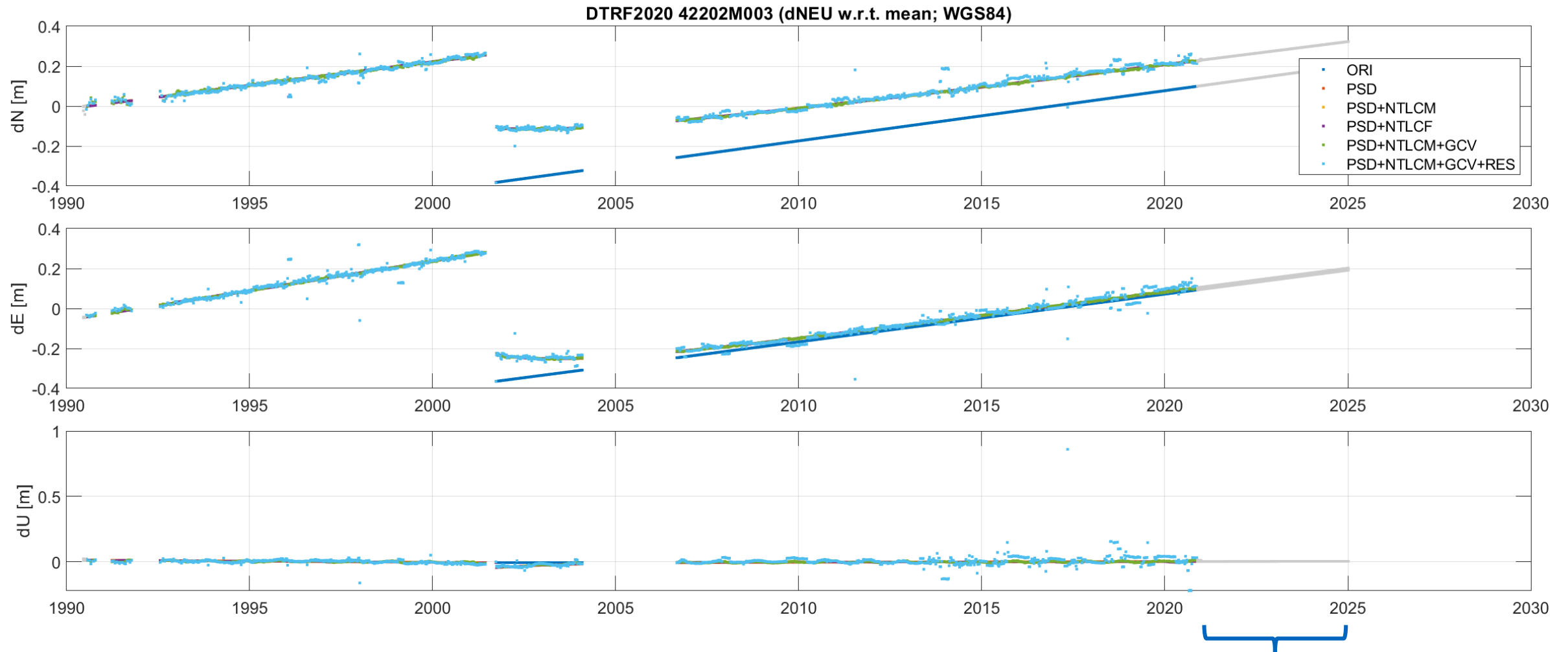
Example: Arequipa (Peru) – 42202M003 (7403, SLR) – DTRF2020

➢ Weekly DTRF2020 output based on different options: **ORI**, **ORI+PSD**, **ORI+PSD+…**

DTRF2020 42202M003 (dXYZ w.r.t. mean)

Legend:
- ORI
- PSD
- PSD+NTLCM
- PSD+NTLCF
- PSD+NTLCM+GCV
- PSD+NTLCM+GCV+RES

application of PSD (dPSD) corrections is mandatory for affected sites!
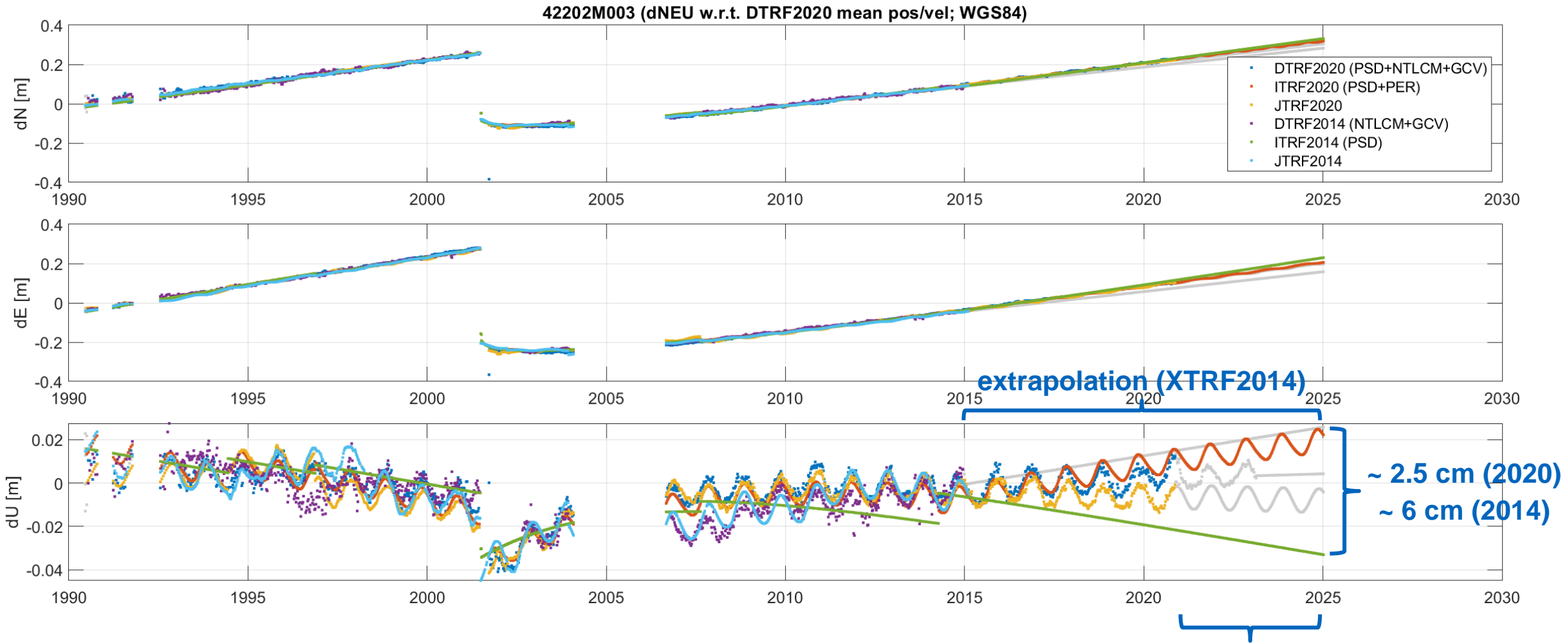
extrapolation of DTRF2020

Example: Arequipa (Peru) – 42202M003 (7403, SLR) – DTRF2020

➢ Weekly DTRF2020 output based on different options: **ORI**, **ORI+PSD**, **ORI+PSD+…**

DTRF2020 42202M003 (dNEU w.r.t. mean; WGS84)

Legend:
- ORI
- PSD
- PSD+NTLCM
- PSD+NTLCF
- PSD+NTLCM+GCV
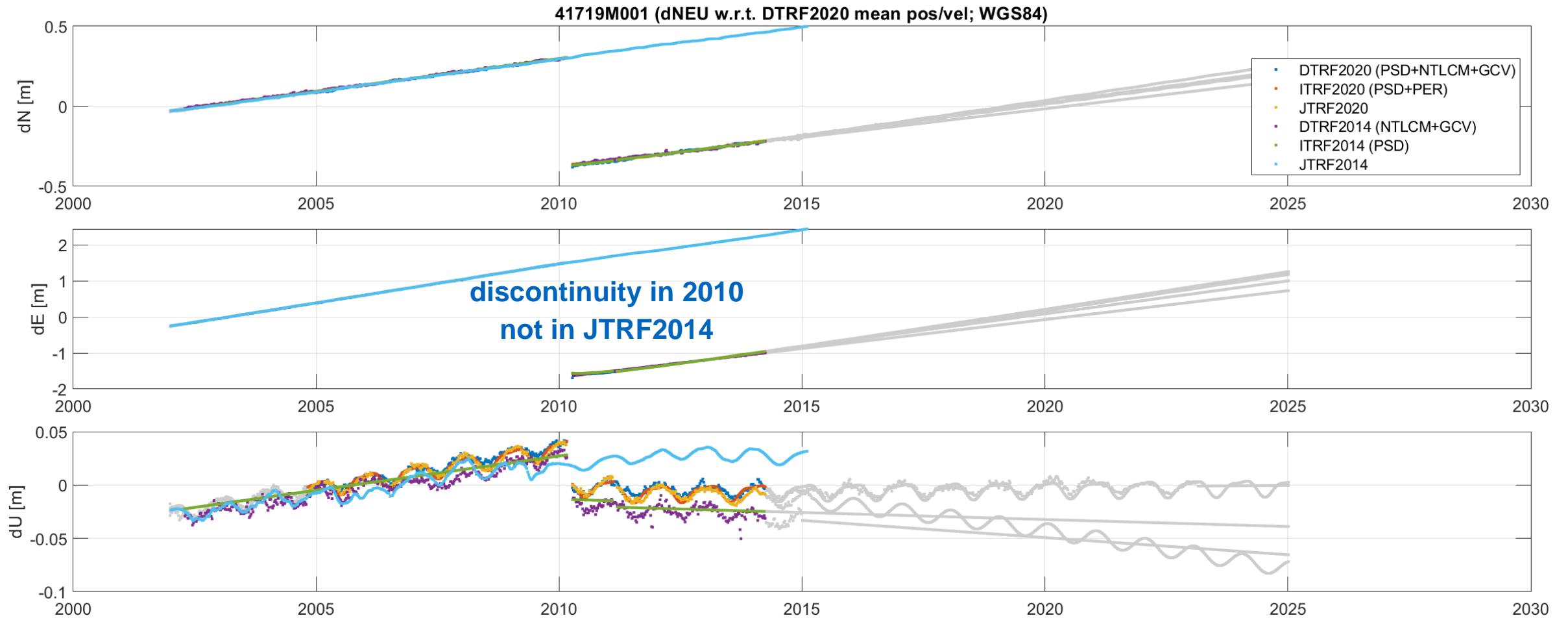- PSD+NTLCM+GCV+RES

extrapolation of DTRF2020

Example: Arequipa (Peru) – 42202M003 (7403, SLR) – XTRF2014/2020

➢ For the comparison of different weekly XTRF2020 outputs, a "most similar" list of settings is used (cf. legend)

42202M003 (dNEU w.r.t. DTRF2020 mean pos/vel; WGS84)

Legend:
- DTRF2020 (PSD+NTLCM+GCV)
- ITRF2020 (PSD+PER)
- JTRF2020
- DTRF2014 (NTLCM+GCV)
- ITRF2014 (PSD)
- JTRF2014

extrapolation (XTRF2014)

~ 2.5 cm (2020)
~ 6 cm (2014)
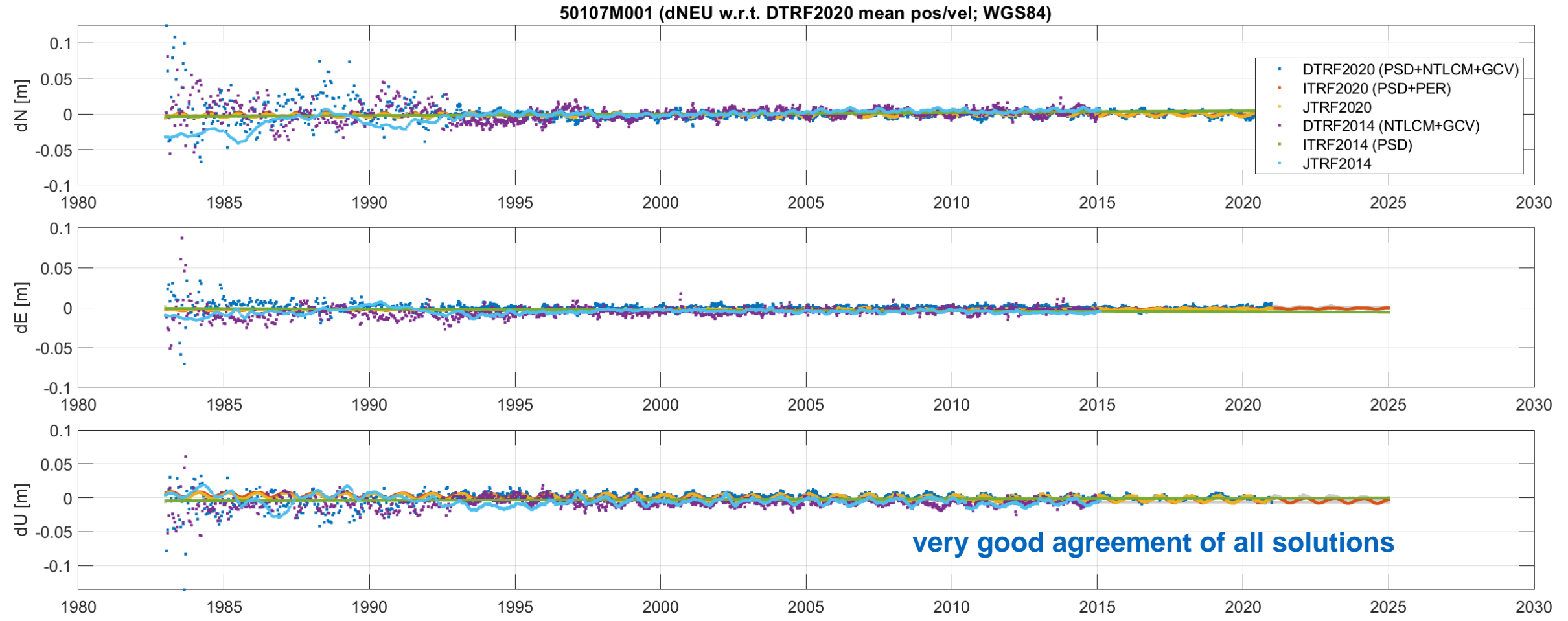
extrapolation of XTRF2020

Example: Concepcion (Chile) – 41719M001 (7405, SLR) – XTRF2014/2020

➢ For the comparison of different weekly XTRF2020 outputs, a "most similar" list of settings is used (cf. legend)

41719M001 (dNEU w.r.t. DTRF2020 mean pos/vel; WGS84)

Legend:
- DTRF2020 (PSD+NTLCM+GCV)
- ITRF2020 (PSD+PER)
- JTRF2020
- DTRF2014 (NTLCM+GCV)
- ITRF2014 (PSD)
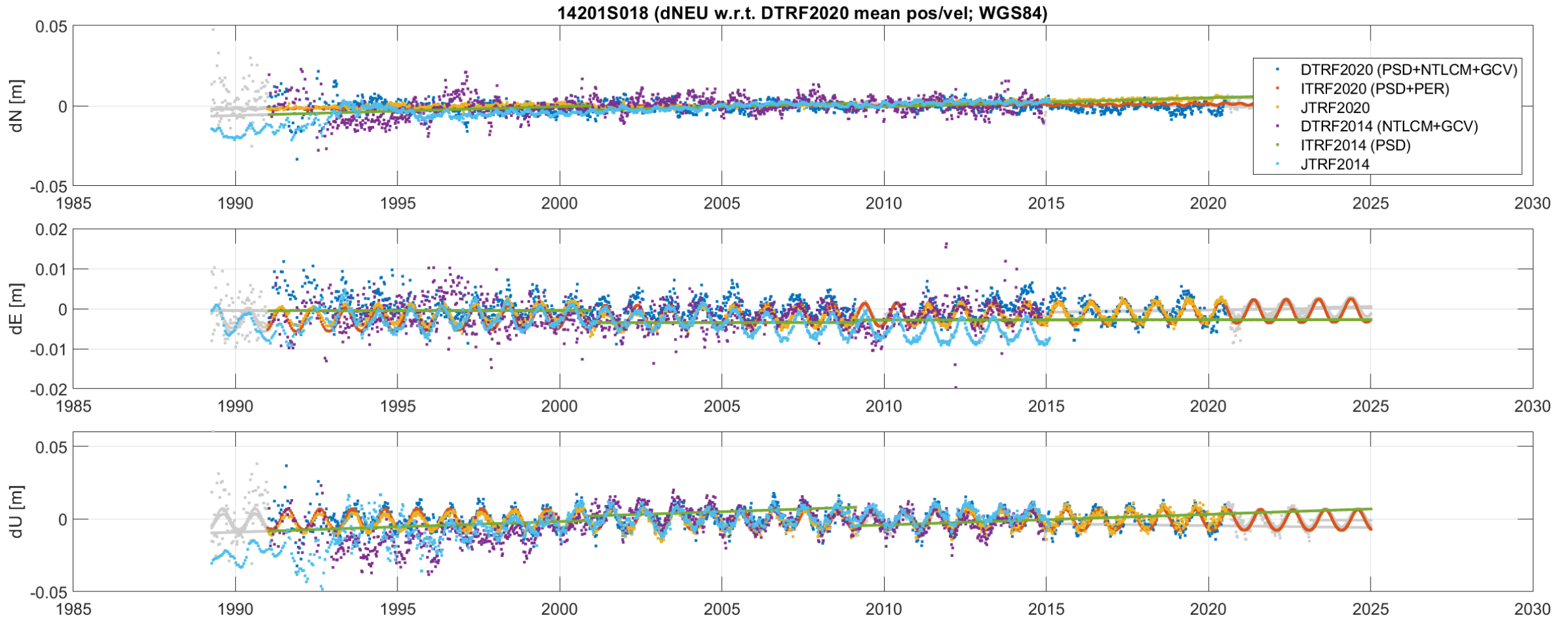- JTRF2014

discontinuity in 2010
not in JTRF2014

Example: Yarragadee (Australia) – 50107M001 (7090, SLR) – XTRF2014/2020

➢ For the comparison of different weekly XTRF2020 outputs, a "most similar" list of settings is used (cf. legend)

50107M001 (dNEU w.r.t. DTRF2020 mean pos/vel; WGS84)

Legend:
- DTRF2020 (PSD+NTLCM+GCV)
- ITRF2020 (PSD+PER)
- JTRF2020
- DTRF2014 (NTLCM+GCV)
- ITRF2014 (PSD)
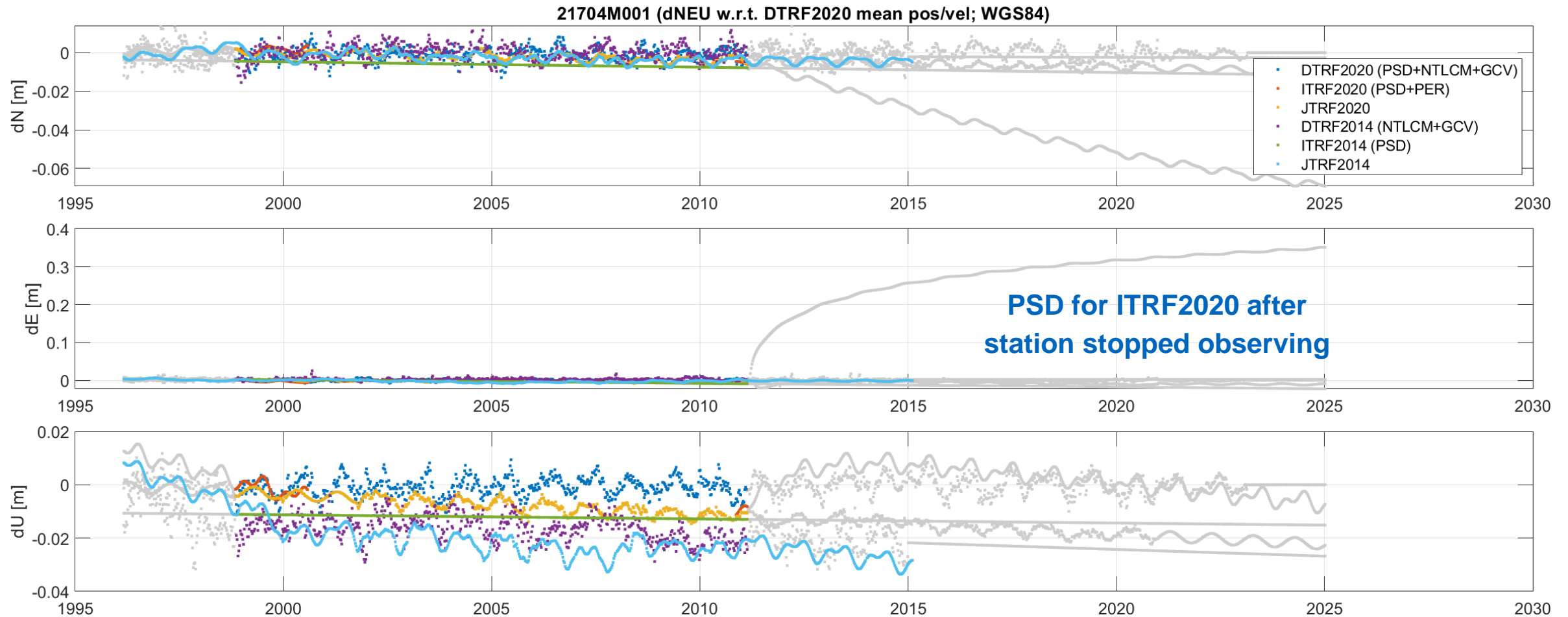- JTRF2014

very good agreement of all solutions

Example: Wettzell (Germany) – 14201S018 (8834, SLR) – XTRF2014/2020

➢ For the comparison of different weekly XTRF2020 outputs, a "most similar" list of settings is used (cf. legend)

14201S018 (dNEU w.r.t. DTRF2020 mean pos/vel; WGS84)

Legend:
- DTRF2020 (PSD+NTLCM+GCV)
- ITRF2020 (PSD+PER)
- JTRF2020
- DTRF2014 (NTLCM+GCV)
- ITRF2014 (PSD)
- JTRF2014

Example: Koganei (Japan) – 21704M001 (7328, SLR) – XTRF2014/2020

➤ For the comparison of different weekly XTRF2020 outputs, a "most similar" list of settings is used (cf. legend)

21704M001 (dNEU w.r.t. DTRF2020 mean pos/vel; WGS84)

Legend:
- DTRF2020 (PSD+NTLCM+GCV)
- ITRF2020 (PSD+PER)
- JTRF2020
- DTRF2014 (NTLCM+GCV)
- ITRF2014 (PSD)
- JTRF2014

PSD for ITRF2020 after station stopped observing

Jason-1/2/3 POD based on XTRF2014 solutions

➤ **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!**)
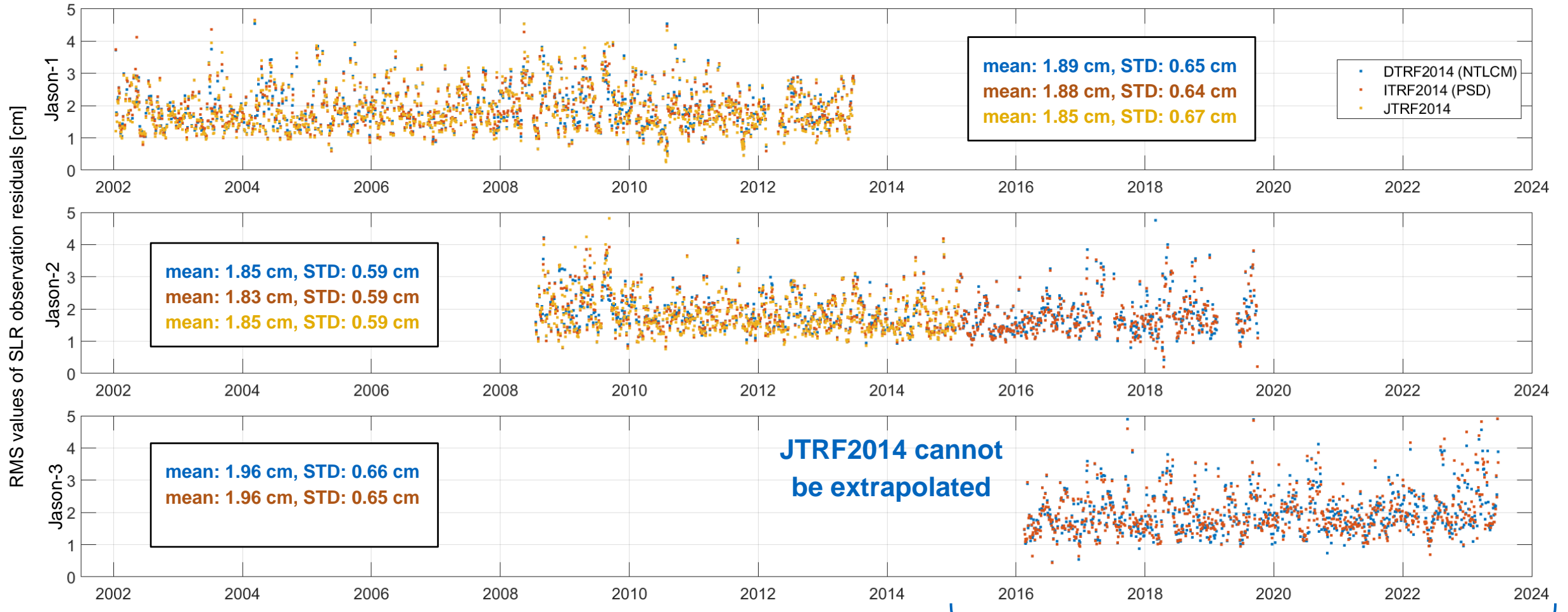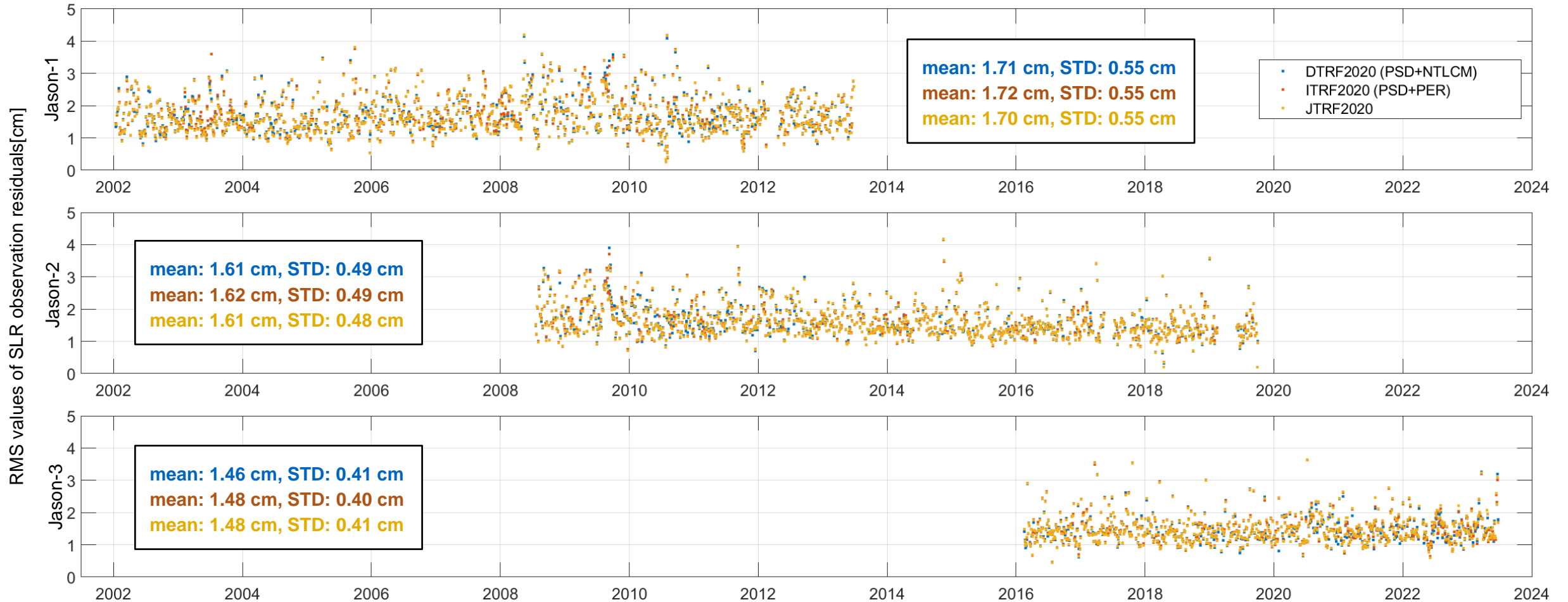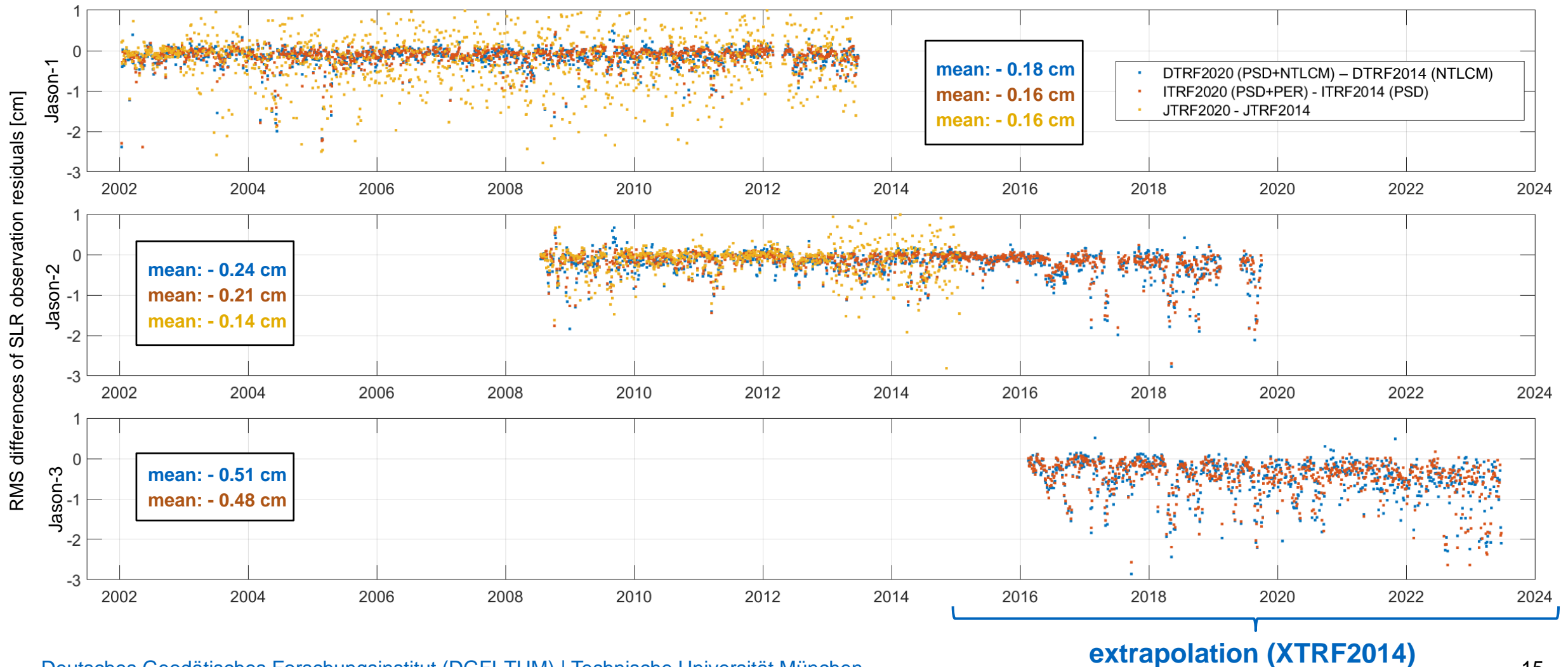
Jason-1/2/3 POD based on XTRF2020 solutions

➤ **No obvious differences** between the RMS values of the SLR observation residuals found for all XTRF2020 solutions (**most recent ILRS DHF used; cf. LA-1 RBs for Jason-1/2/3**)

mean: 1.71 cm, STD: 0.55 cm
mean: 1.72 cm, STD: 0.55 cm
mean: 1.70 cm, STD: 0.55 cm

DTRF2020 (PSD+NTLCM)
ITRF2020 (PSD+PER)
JTRF2020

mean: 1.61 cm, STD: 0.49 cm
mean: 1.62 cm, STD: 0.49 cm
mean: 1.61 cm, STD: 0.48 cm

mean: 1.46 cm, STD: 0.41 cm
mean: 1.48 cm, STD: 0.40 cm
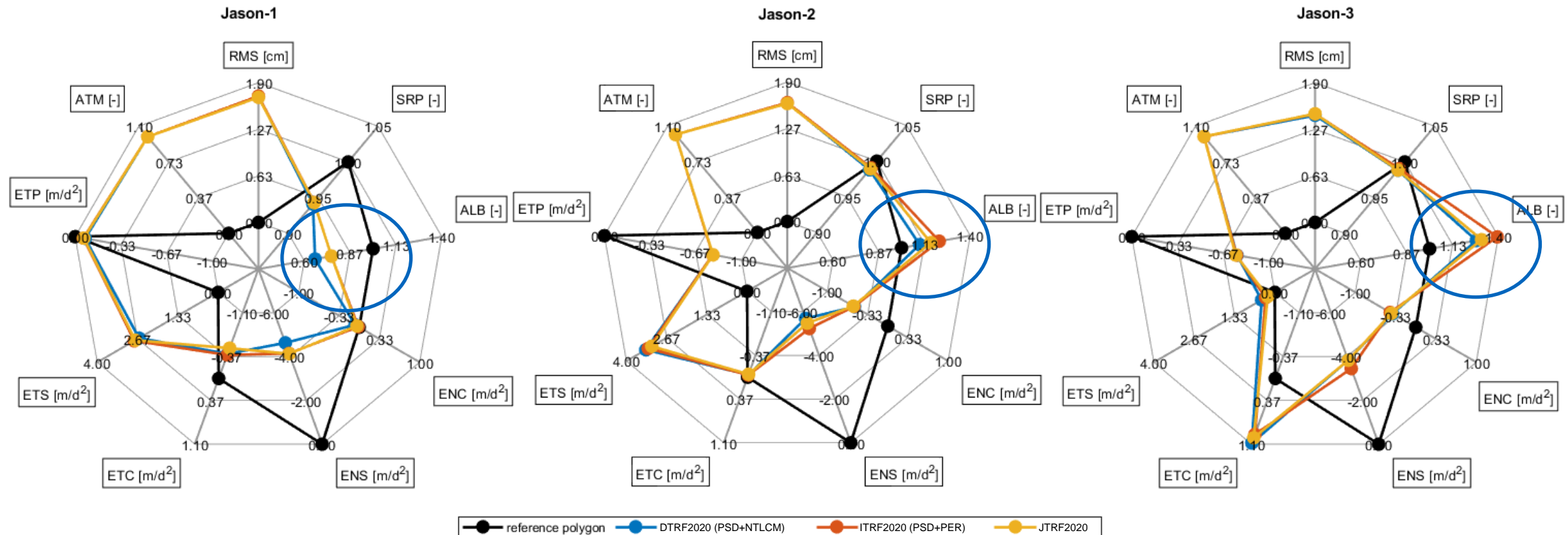mean: 1.48 cm, STD: 0.41 cm

Jason-1/2/3 POD based on XTRF2014/2020 solutions

➤ **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

Jason-1/2/3 POD based on XTRF2020 solutions

➢ 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
SRP – solar radiation pressure scaling factor
ALB – Earth Albedo scaling factor
ATM – Atmospheric scaling factor polygon (12h resolution)

ENC/S – empirical cosine/sine coefficient (normal to orbit)
ETC/S – empirical cosine/sine coefficient (tangential to orbit)
ETP – empirical piece-wise linear polygon (tangential to orbit, 12h resolution)

Conclusions – recommendations for satellite POD

- The different ITRS realizations easily cause station position differences of several centimeters

- If any XTRF2020 solution is used for a satellite POD, the following recommendations should be taken into account

  - **ITRF2020: use of PSD and periodic corrections**

  - **DTRF2020: use of PSD and NTL(CM)**

  - **JTRF2020: use as is**

  - use stations still after interval of highest solution number ended (i.e. SOLUTION/EPOCHS block)

  - ILRS Data Handling File (DHF)

    - **use most recent ILRS DHF (currently version 2023-06-21)**

    - apply LAGEOS-1 long-term mean range biases (RBs) for any satellite except LAGEOS-2 and Etalon-1/-2 or

    - use LAGEOS-1 long-term mean RBs as a priori values and estimate RBs

- XTRF2014-based POD results show larger RMS values of the SLR observation residuals compared to XTRF2020-based results (due to new RBs from ILRS DHF)

- Most Jason-1/2/3 orbit parameters are not changing significantly when different XTRF2020 solutions are used for POD (**except Earth albedo scaling factor**)