27th EVGA Working Meeting, 6th-10th April 2025, Matera, Italy

The VLBI Scale Drift: Current Status and Remaining Challenges

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TU Wien, Austria

Background and Motivation

- with the realization of ITRF2020 (Altamimi et al, 2023)
  - unexpected positive linear trend in VLBI scale between 2013.75 and 2021.0
  - to ensure good scale agreement with no drift at the level of 1mm at the equator
    → data excluded from ITRF2020 scale definition!
- DTRF2020 (Seitz et al, 2023): no VLBI scale drift after 2013.75

Background and Motivation

Kern, L., Krásná, H., Nothnagel, A., Böhm, J. (2025) Terrestrial reference frame scale drift anomalies in VLBI and the contribution of Ny-Ålesund radio telescopes. Earth, Planets and Space, 77(40). https://doi.org/10.1186/s40623-025-02159-z

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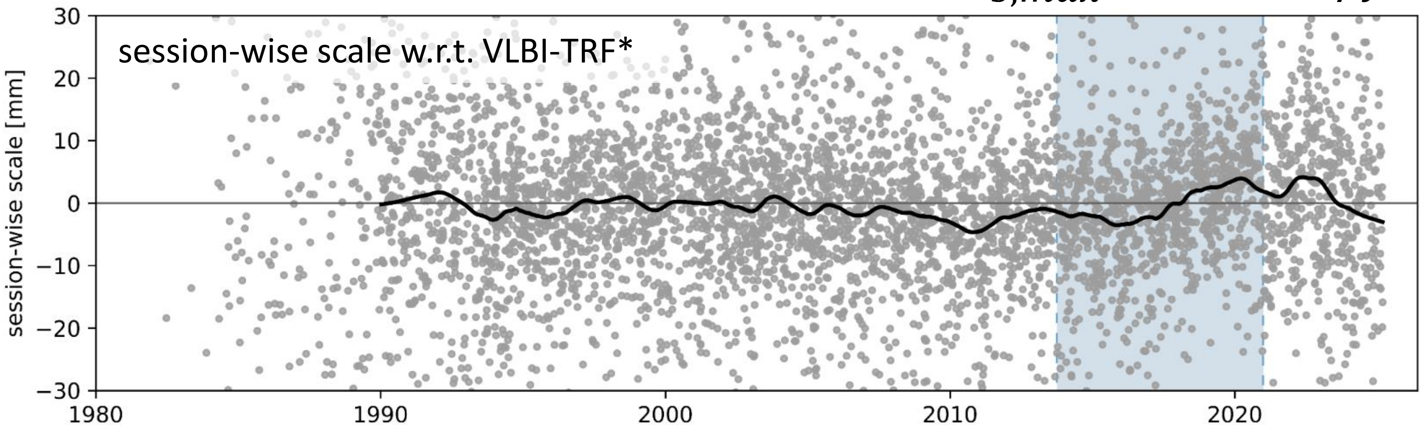
$$t_s = 1.1mm/yr$$
$$t_{s,max} = 1.9mm/yr$$

- Investigating scale w.r.t. VLBI-TRF*

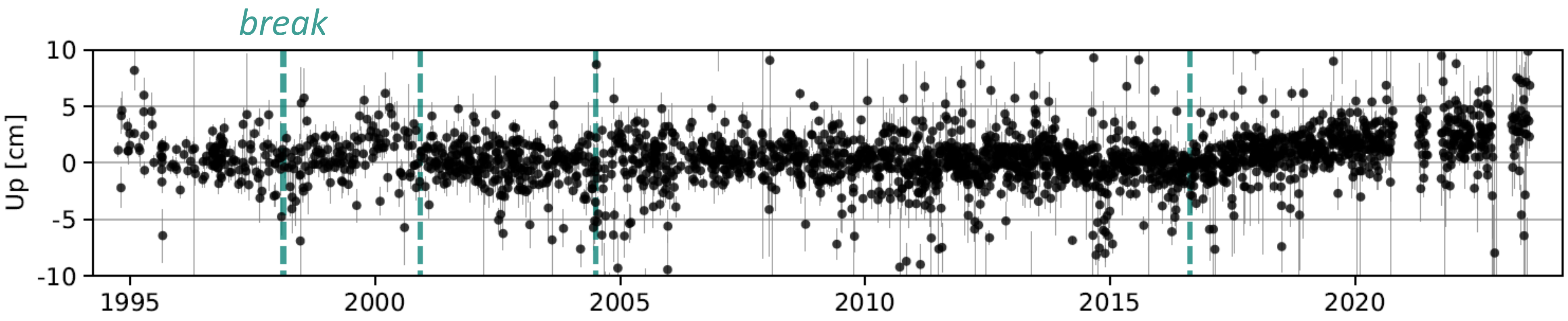
*contribution of ITRF2020:
a priori coordinates and **discontinuity models**



Station discontinuity models

= describe movement of station over time by introducing discontinuities/breaks in position/velocity

→ due to natural (e.g., Earthquakes, climate-related processes) or „man-made“ causes



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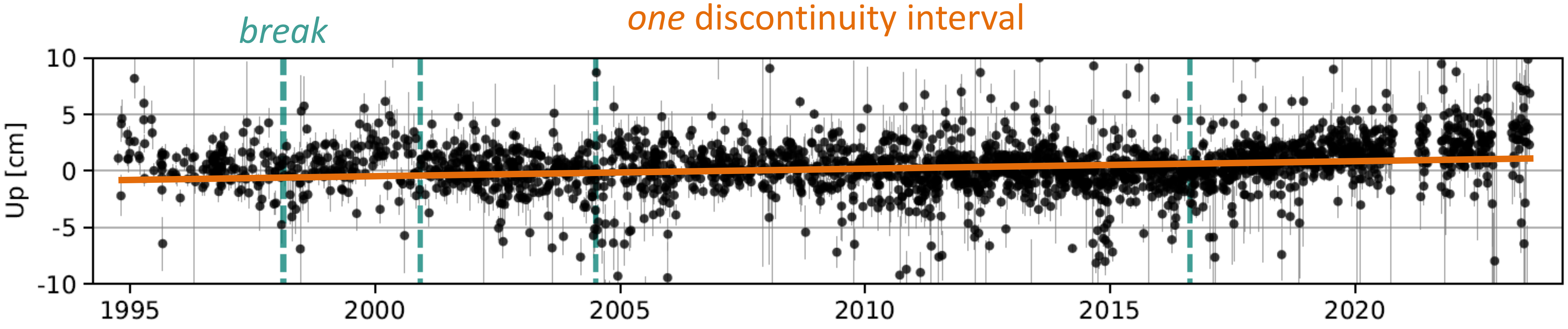

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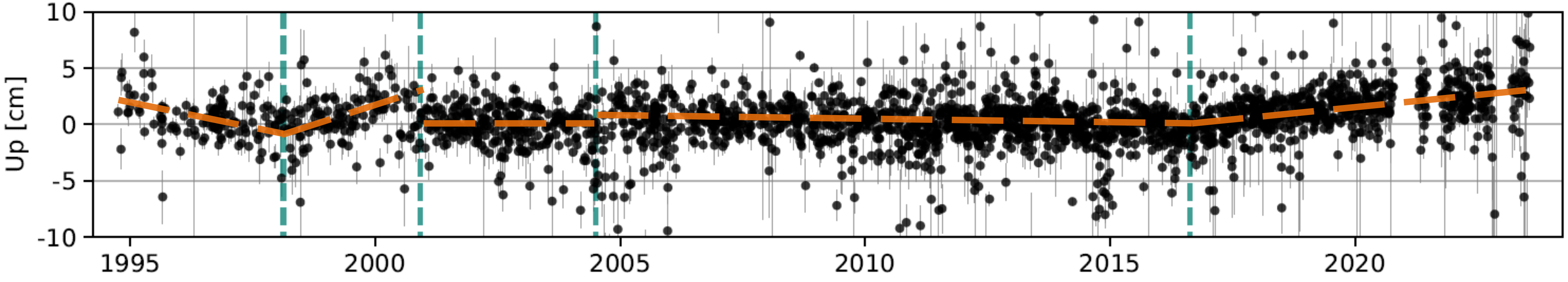
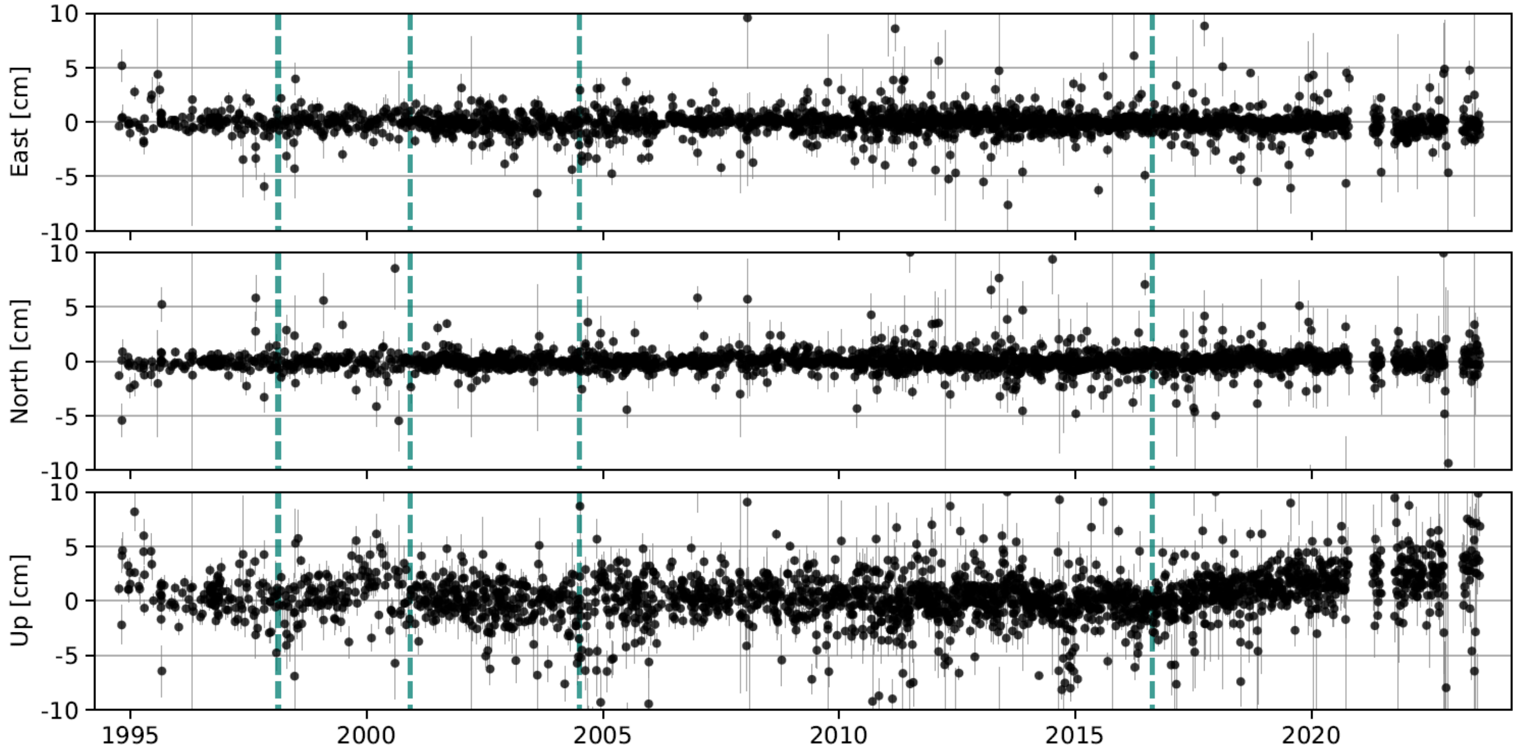
break   *one* discontinuity interval



multiple discontinuity intervals

- accurate station discontinuity models allow better description of station motion!

Ny-Ålesund Geodetic Observatory (Svalbard, Norway)



- S/X VLBI antenna NYALES20
- co-located GNSS receivers (NYAL, NYA1)

→ deviating station discontinuity models due to close proximity! (Le Bail et al, 2023; IVS WG 9)

station	starting epoch of discontinuity interval [yy:doy]				
NYALES20	94:277				
NYAL	94:002	98:047	00:340	04:186	16:233
NYA1		98:071		04:186	16:233

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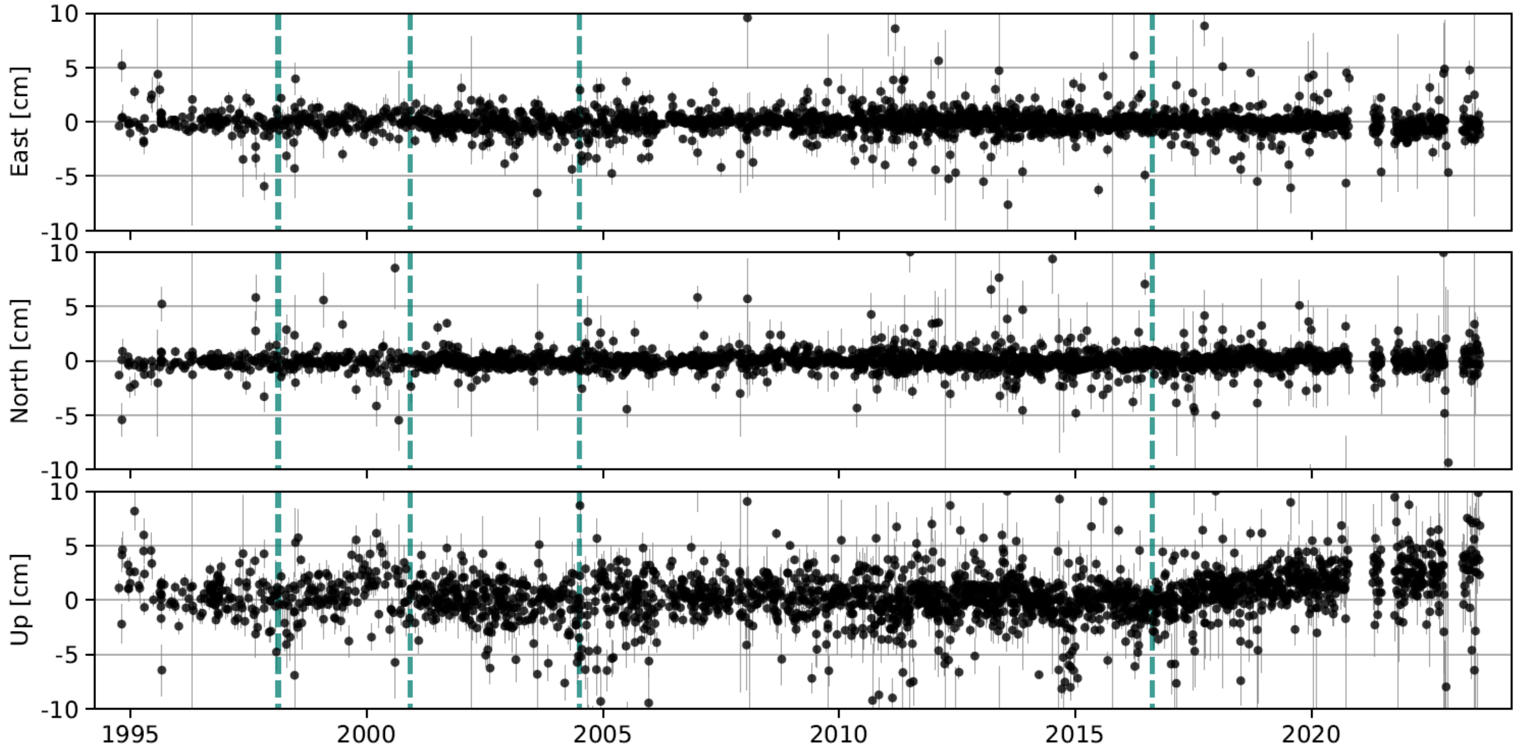

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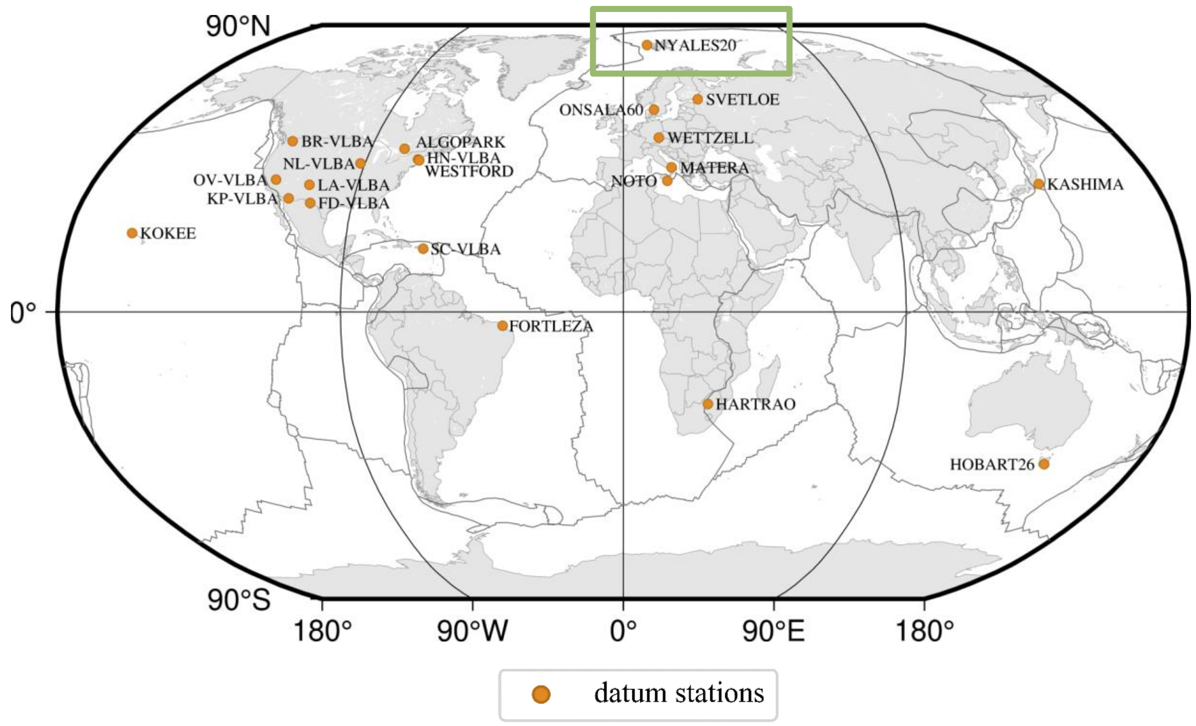
station	starting epoch of discontinuity interval [yy:doy]					
NYALES20	94:277					
NYAL	94:002	98:047	00:340	04:186	16:233	+4
NYA1		98:071		04:186	16:233	+2

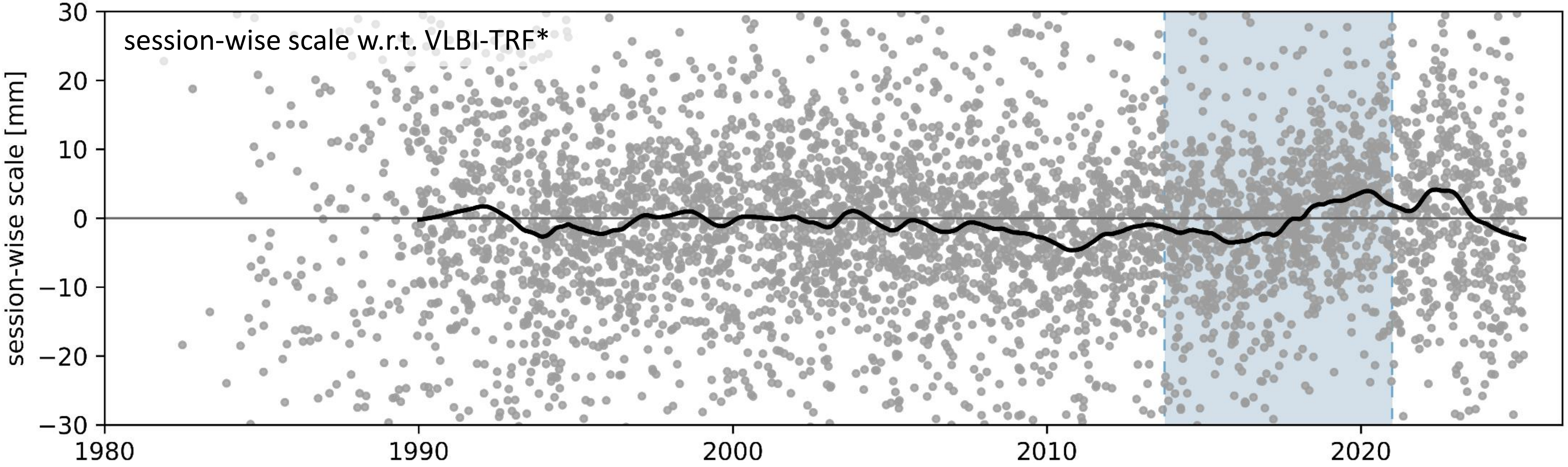
Method

- determination of TRFs with deviating station discontinuity models for NYALES20 in *VieCompy*
  (24-hour S/X VLBI session between 1980.0 and 2025.0)

- estimation of session-wise scale factors (w.r.t. TRFs) within single-session solution in *VieVS-VLBI*
  (up to 2025.2)



Initial situation



$t_s = 1.1 mm/yr$

$t_{s,max} = 1.9 mm/yr$

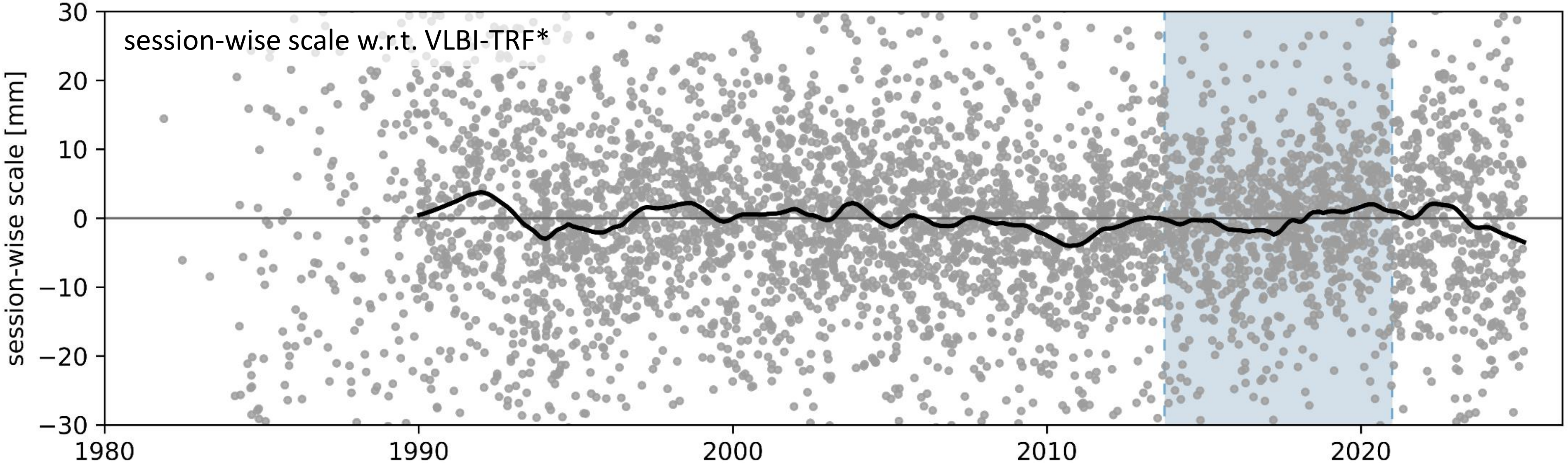
*contribution of ITRF2020:
a priori coordinates and discontinuity models

→ remark: no continuation of drift after 2021.0!

Additional breaks for NYALES20 (based on NYAL)

98:047
00:340
04:186
16:233

NYALES20 +4



$$t_s = 0.5mm/yr$$

$$t_{s,max} = 1.0mm/yr$$

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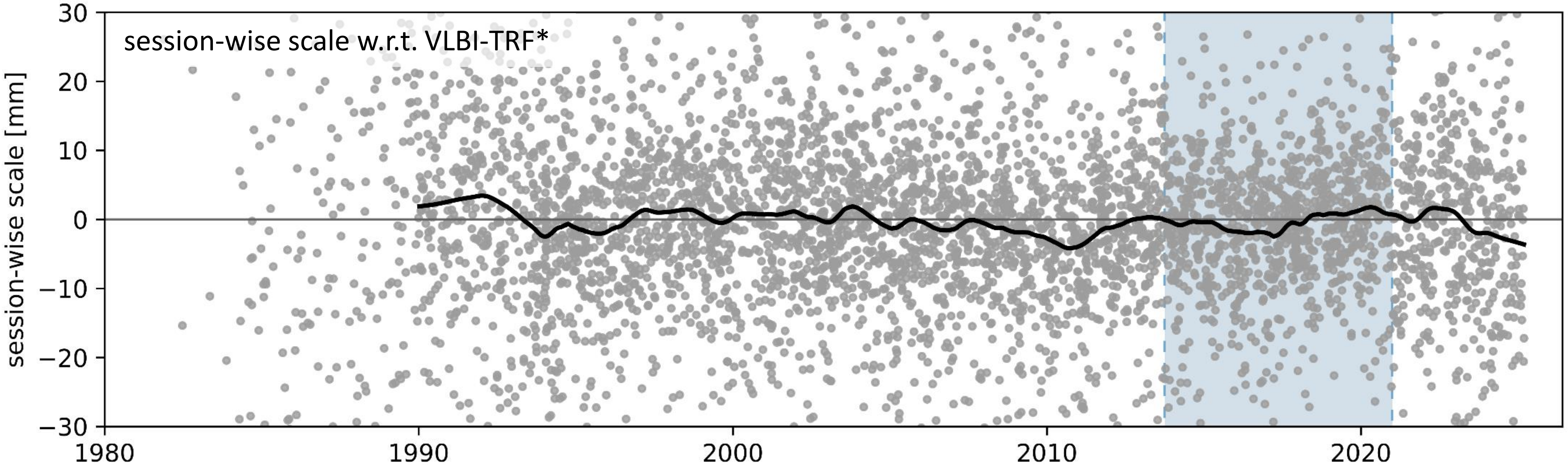
a priori coordinates and discontinuity models

Additional breaks for NYALES20 (based on NYA1)

98:047
00:340
04:186
16:233

NYALES20
+2



$$t_s = 0.5mm/yr$$

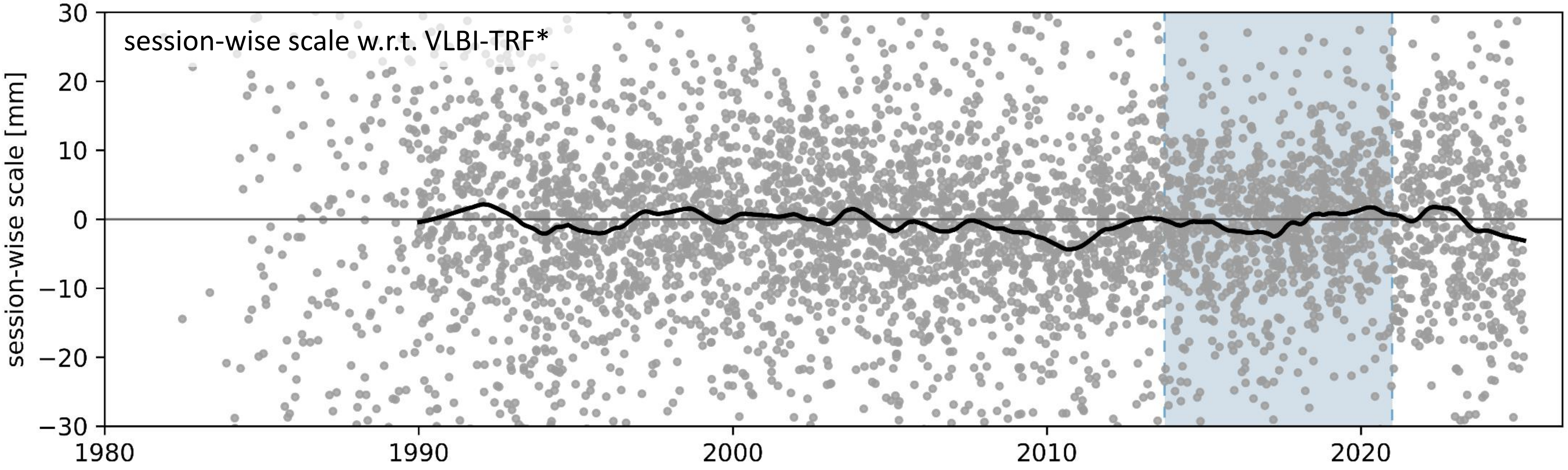
$$t_{s,max} = 0.9mm/yr$$

*contribution of ITRF2020:
a priori coordinates and discontinuity models

→ no remaining significant drift in scale!

Updated ITRF2020 – ITRF2020-u2023

FD-VLBA	HART15M	KP-VLBA	OV-VLBA	ZELENCHK	NYALES20
+1	+2	+1	+1	+1	+2



$t_s = 0.5 mm/yr$

$t_{s,max} = 1.1 mm/yr$

*contribution of **ITRF2020-u2023**:
a priori coordinates and discontinuity models

Summary

Station discontinuity model

- no continuation of scale drift after 2021.0!
- rework of discontinuity intervals in ITRF2020-u2023 = important update
- inaccurate discontinuity models can have a significant impact on global parameters (especially in the case of datum stations!)

Non-tidal loading models

- ITRF2020 (Altamimi et al, 2023): no NTL corrections applied in ITRF realization process

- DTRF2020 (Seitz et al, 2023):
  - considers all three NTL components (atmosphere, oceanic and hydrological) provided by the Global Geophysical Fluid Center
  - NYALES20 discontinuity break at 17:293

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- DTRF2020 (Seitz et al, 2023):
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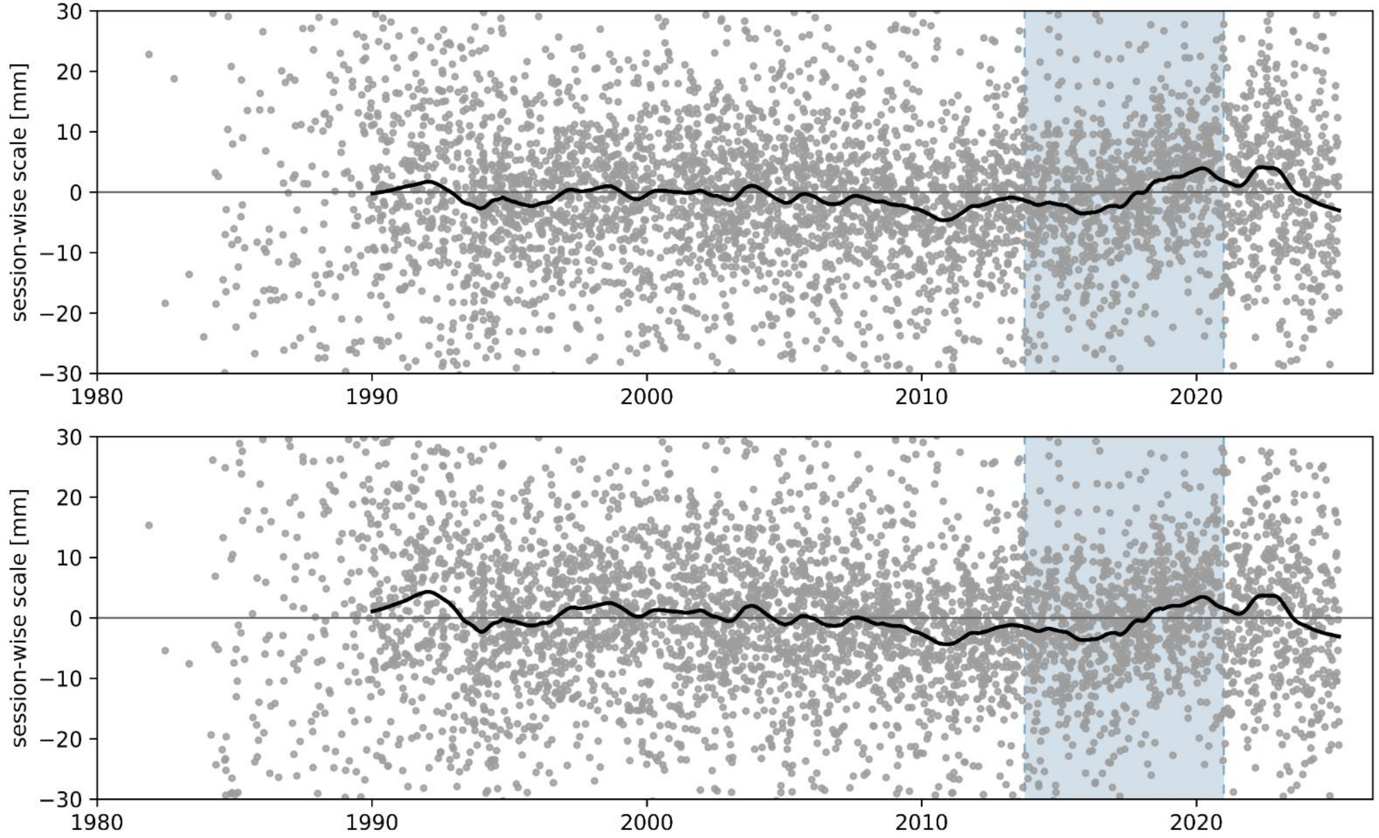
  – **NYALES20 discontinuity break at 17:293**

Non-tidal loading models

- considering only NTAL corrections (standard IVS procedure) ↔ all NTL corrections*



$t_s = 1.1 mm/yr$

$t_s = 1.0 mm/yr$

*provided by ESMGFZ (Dill and Dobslaw, 2013)

Summary

Station discontinuity model

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- rework of discontinuity intervals in ITRF2020-u2023 = important update
- inaccurate discontinuity models can have a significant impact on global parameters (especially in the case of datum stations!)

Non-tidal loading model

- minor impact of consideration of (additional) NTL corrections on VLBI scale drift anomaly (Glomsda et al, 2020)

References

Altamimi, Z., Rebischung, P., Collilieux, X., Métivier, L., Chanard, K. (2023) ITRF2020: an augmented reference frame refining the modeling of nonlinear station motions. Journal of Geodesy, 97(47).

Dill, R., & Dobslaw, H. (2013) Numerical simulations of global-scale high-resolution hydro-logical crustal deformations. Journal of Geophysical Research: Solid Earth, 118(9).

Glomsda, M., Bloßfeld, M., Seitz, M., & Seitz, F. (2020). Benefits of non-tidal loading applied at distinct levels in VLBI analysis. Journal of Geodesy, 94(90).

Kern, L., Krásná, H., Nothnagel, A., Böhm, J. (2025) Terrestrial reference frame scale drift anomalies in VLBI and the contribution of Ny-Ålesund radio telescopes. Earth, Planets and Space, 77(40). https://doi.org/10.1186/s40623-025-02159-z

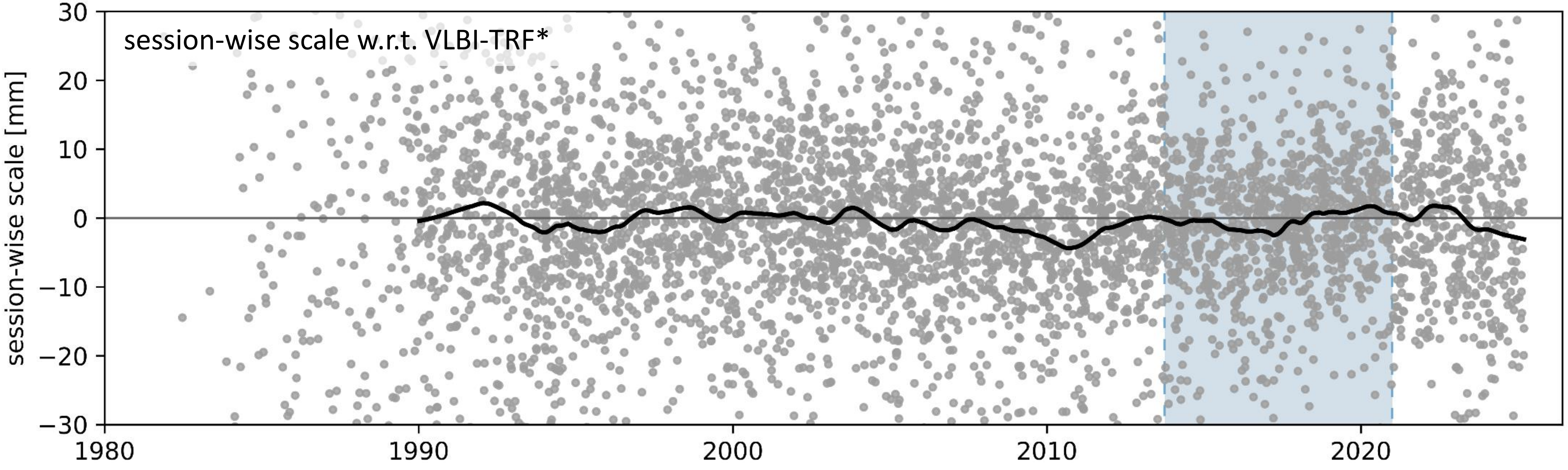
Seitz, M., Angermann, D., Bloßfeld, M., Glomsda, M., Rudenko, S., & Zeitlhöfler, J. (2022) DTRF2020: the ITRS 2020 realization of DGFI-TUM [Presented at the IAG Interna-tional Symposium on Reference Frames for Applications in Geoscience (REFAG),Thessaloniki, Greece, 17-20 October 2022]

Seitz, M., Bloßfeld, M., Angermann, D., Glomsda, M., Rudenko, S., Zeitlhöfler, J., & Seitz, F. (2023) DTRF2020 (Version v2) [Data set].

Appendix I –
Updated ITRF2020 – ITRF2020-u2023

FD-VLBA	HART15M	KP-VLBA	OV-VLBA	ZELENCHK	NYALES20
+1	+2	+1	+1	+1	+2

one break after 2021.0



$$t_s = 0.5mm/yr$$

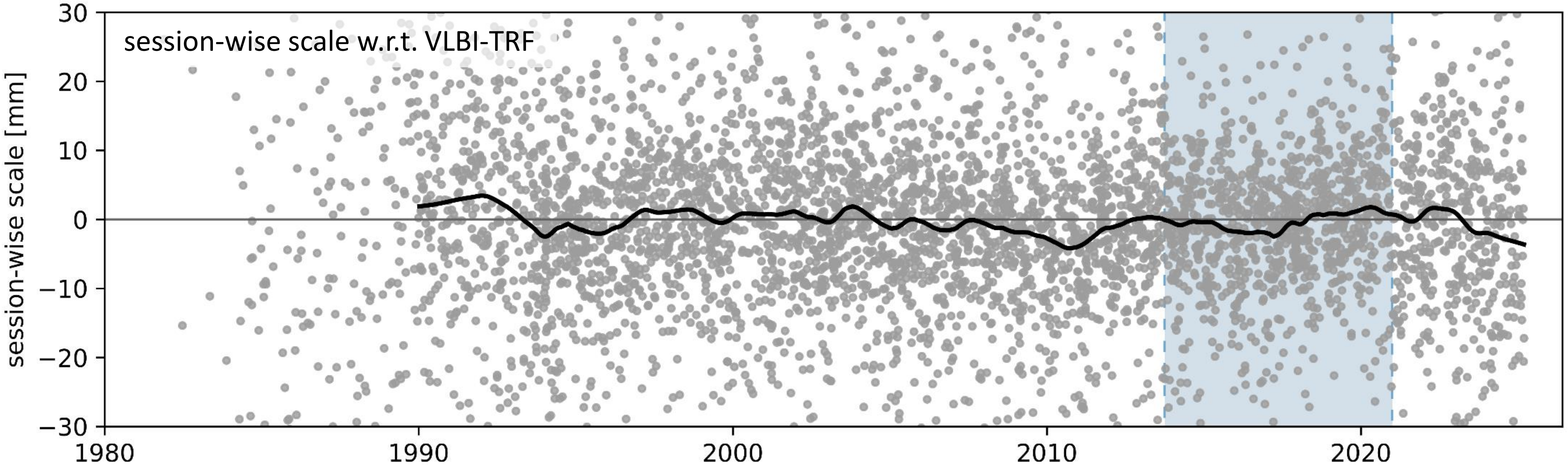
$$t_{s,max} = 1.1mm/yr$$

*contribution of **ITRF2020-u2023**:
a priori coordinates and discontinuity models

Appendix II – Additional breaks for NYALES20 (based on DTRF2020)

NYALES20
+1

17:293



$t_s = 0.6mm/yr$

$t_{s,max} = 0.8mm/yr$

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a priori coordinates and discontinuity models