EGU GA 2024, Vienna, Austria, 14–19 April 2024

Verifying the impact of additional breaks in station coordinates on VLBI scale drift

Sharing is encouraged

This presentation participates in OSPP — Outstanding Student & PhD candidate Presentation contest

[1]TU Wien, Vienna, AUSTRIA
✉ lisa.kern@tuwien.ac.at

Lisa Kern[1], Hana Krásná[1], Johannes Böhm[1] and Axel Nothnagel[1]

1 In a Nutshell

We compute global terrestrial reference frames (TRF) from Very Long Baseline Interferometry (VLBI) normal equations using our newest state-of-the-art combination software, **VieCompy**, and independently investigate the potential VLBI scale drift and access the impact of additional discontinuities in station positions (Le Bail et al. 2023) on the session-wise estimated scale drift after 2013.75.

2 Background & Motivation

With the realization of the International Terrestrial Reference Frame 2020 (ITRF2020; Altamimi et al. 2022), an unexpected positive VLBI scale drift after 2013.75 was observed. This phenomenon was confirmed by the Onsala Space Observatory (OSO; Le Bail et al. 2023), starting an investigation on the impact of additional discontinuities in the position of the following VLBI stations on the scale. The VLBI scale drift w.r.t. ITRF2020 after 2013.75 could be flattened from approximately $\mathbf{0.599\ mm/yr \rightarrow 0.097\ mm/yr}$ (**case 1+2**):

CASE 1
NYALES20+4

In **case 1**, the in sum *4* additional breaks at NYALES20 due to GIA + PDIM* are obtained from the solutions of a co-located GNSS antenna, NYAL.

CASE 2
MATERA+3
WETTZELL+1
ONSALA60+1

In **case 2**, discontinuities were introduced according to the history of station events** at the stations (Matera+Wettzell+Onsala60), resulting in *3+1+1* additional breaks.

We at the **Vienna Center for VLBI** now want to independently investigate the VLBI scale drift and assess the impact of these additional breaks on the session-wise estimated scale on the basis of a VLBI TRF determined through a combination of VLBI sessions from 1979 to 2020 at normal equation level with **VieCompy** (Kern et al. 2023).

For the VLBI TRF determination using VieCompy the following a priori models and parameterizations are used:

- Legacy 24h VLBI networks with >3 stations (almost 5600 sessions processed)
- EOP + clocks + troposphere are reduced session-wise
- Source coordinates are fixed to ICRF3sx (Charlot et al. 2020)
- Station coordinates + velocities are estimated w.r.t. ITRF2020 (NNT+NNR for 21 datum stations; minimum criteria 15 sessions over 5 years; Krásná et al. 2023)
- Velocity constraints on co-located stations (Krásná et al. 2023)

* Glacial Isostatic Adjustment + Present-Day Ice Melt
** repairs, replacements or readjustments

VieCompy — Vienna VLBI and Satellite Software

3 Results

Case 0 – ITRF2020 breaks

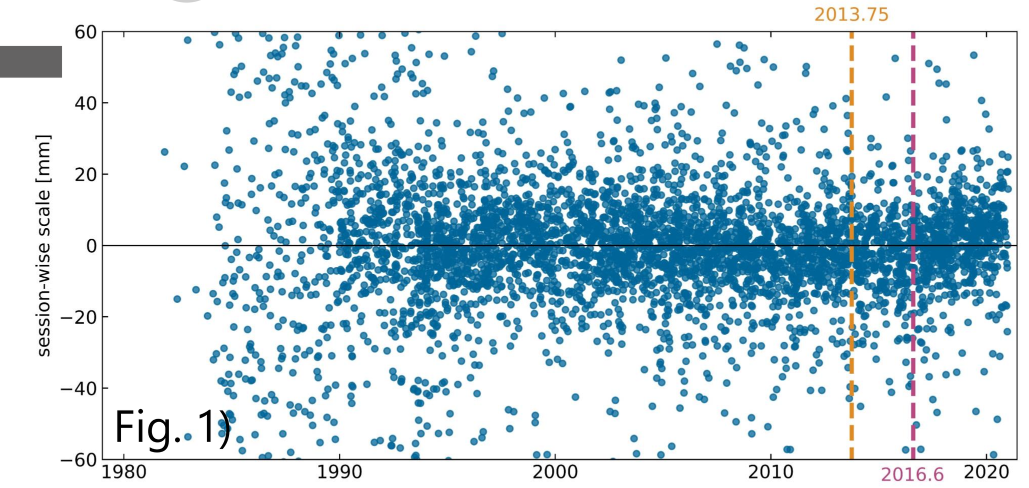

Fig. 1)

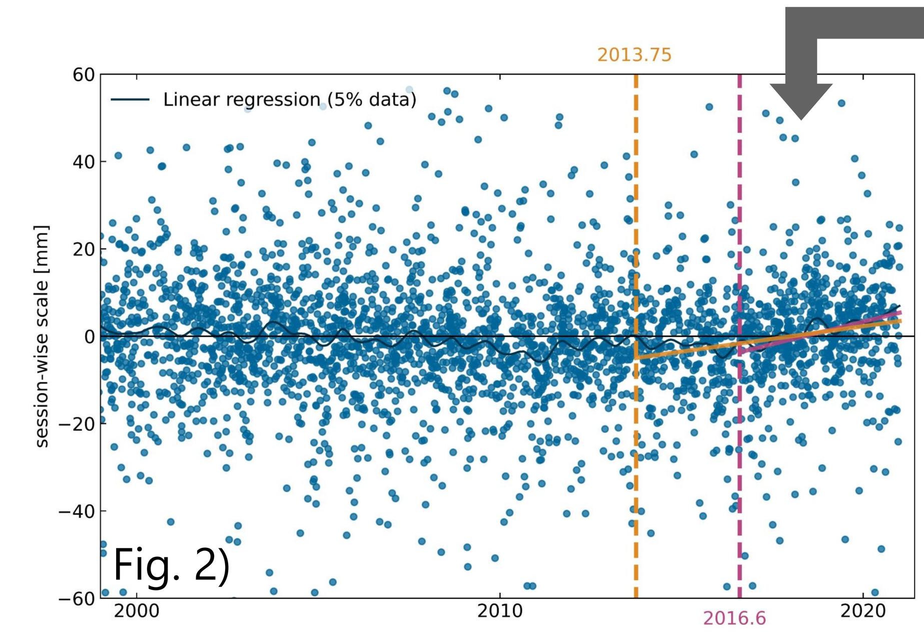

Fig. 2)

case	$VIE_{2013.75}$	$VIE_{2016.6}$
Case 0	1.163 mm/yr	2.050 mm/yr

Case 1 – NYALES20

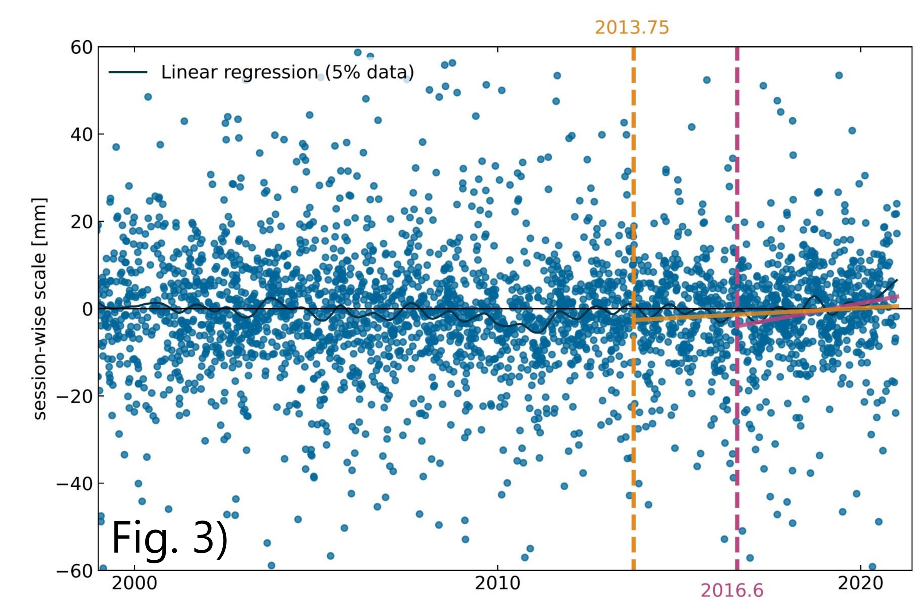

Fig. 3)

Additional breaks*:

98:047	NYALES20
00:340	
04:186	
16:233	

case	$VIE_{2013.75}$	$VIE_{2016.6}$
Case 1	0.435 mm/yr	1.535 mm/yr

Case 2 – MATERA+WETTZELL+ONSALA60

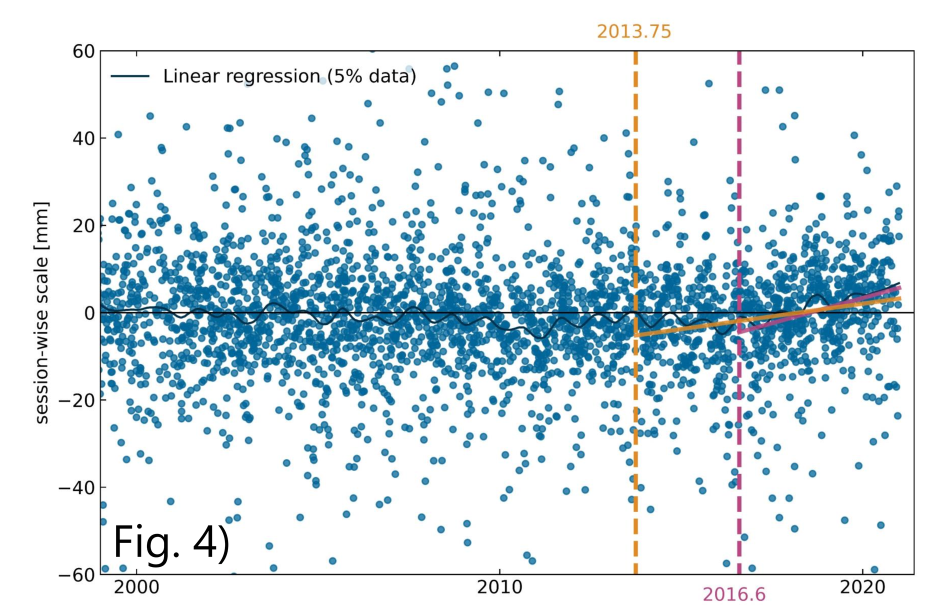

Fig. 4)

Additional breaks*:

05:182	MATERA
08:144	
09:120	
10:333	WETTZELL
18:031	ONSALA60

case	$VIE_{2013.75}$	$VIE_{2016.6}$
Case 2	1.164 mm/yr	2.306 mm/yr

Case 1+2

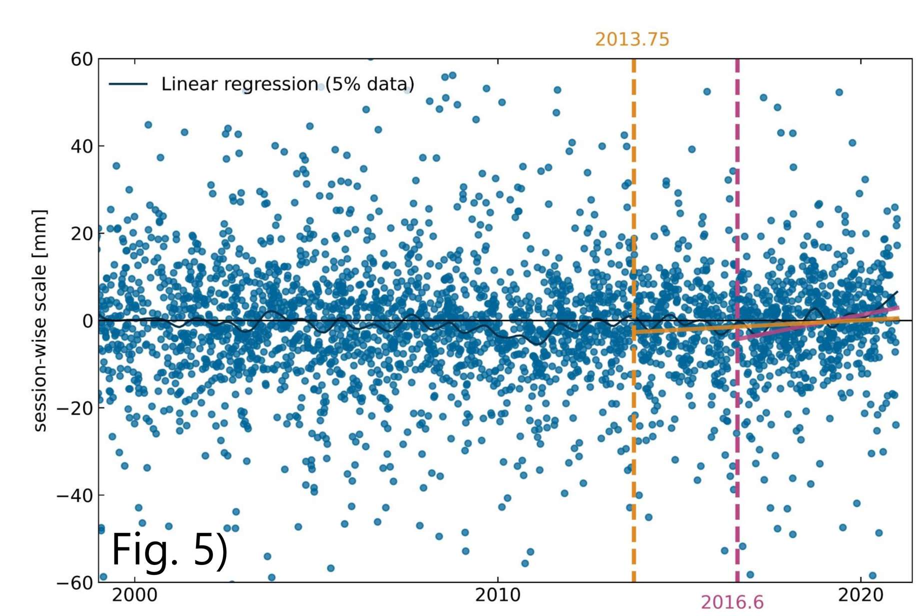

Fig. 5)

case	$VIE_{2013.75}$	$VIE_{2016.6}$
Case 1+2	0.434 mm/yr	1.629 mm/yr

* Le Bail et al. (2023)

4 Summary

The study reveals a visible drift of the VLBI scale over the past decade. In contrast to the results from OSO, which declare 2013.75 as the initial epoch, this study shows an even more dominant scale drift towards epoch 2016.6 with a positive drift of up to $2.050\ mm/yr$ (**case 0**, Fig. 1+2). Introducing additional breaks to selected station coordinates, as recommended by Le Bail et al. (2023), leads to alternations in the behavior of the VLBI scale drift, as follows:

Introducing *4* additional breaks in the station coordinates of NYALES20 (**case 1**, Fig. 3), derived from the solutions of a co-located GNSS station NYAL, flattens the drift to $0.435\ mm/yr$ (2013.75) and $1.535\ mm/yr$ (2016.6).

Due to the history of repairs, replacements and/or adjustments at the stations MATERA, WETTZELL and ONSALA60, a total of *5* additional breaks are introduced (**case 2**, Fig. 4), resulting in no flattening of the drift in this study.

In **case 1+2** (Fig. 5), all the above-mentioned additional breaks in the station coordinates are considered in the VLBI TRF determination. At the OSO, this case provided by far the best results in terms of reducing the VLBI scale drift. In this study, the introduction of in sum 9 additional breaks lead to a positive drift of $0.434\ mm/yr$ (2013.75) and respectively $1.629\ mm/yr$ (2016.6).

In this study, **case 1** resulted in the most substantial reduction of the VLBI scale drift from:

$\mathbf{1.163\ mm/yr \rightarrow 0.435\ mm/yr}$ (2013.75) and
$\mathbf{2.050\ mm/yr \rightarrow 1.535\ mm/yr}$ (2016.6).

5 Outlook

Since the DGFI-TUM (Seitz et al. 2022) does not identify any drift in the VLBI scale w.r.t. DTRF2020 over the past decades, a subsequent investigation will aim to understand the underlying causes contributing to this observed drift.

Additionally, besides the positive drift in the last decade, a long-term signal is visible (see Fig. 1), which is also not visible for the DTRF2020. Further investigations are necessary to understand these phenomena.

References

Altamimi Z, Rebischung P, Collilieux X, et al (2022) ITRF2020: main results and key performance indicators. EGU General Assembly 2022 3958.
Charlot P, Jacobs CS, Gordon D, et al (2020) The third realization of the International Celestial Reference Frame by very long baseline interferometry. Astronomy & Astrophysics 644:A159.
Kern L, Krásná H, Böhm J, et al (2023) Vienna Combination Software – VieCompy. In R. Haas, Schroth Eva, & A. Neidhardt (Eds.), Proceedings of the 26th European VLBI Group for Geodesy and Astrometry Working Meeting.
Krásná H, Baldreich L, Böhm J, et al (2023) VLBI Celestial and Terrestrial Reference Frames VIE2022b. Astronomy & Astrophysics 679:A53.
Le Bail K, Ishigaki M, Mouyen M et al (2023) The impact of station position modelling on terrestrial reference frames. 28th IUGG General Assembly, Berlin, Germany.
Seitz M, Angermann D, Bloßfeld M et al (2022) DTRF2020: the ITRS 2020 realization of DGFI-TUM. REFAG 2022.