The benefits of the Australian mixed-mode program (2018 - 2023) for the celestial reference frame at S/X-band

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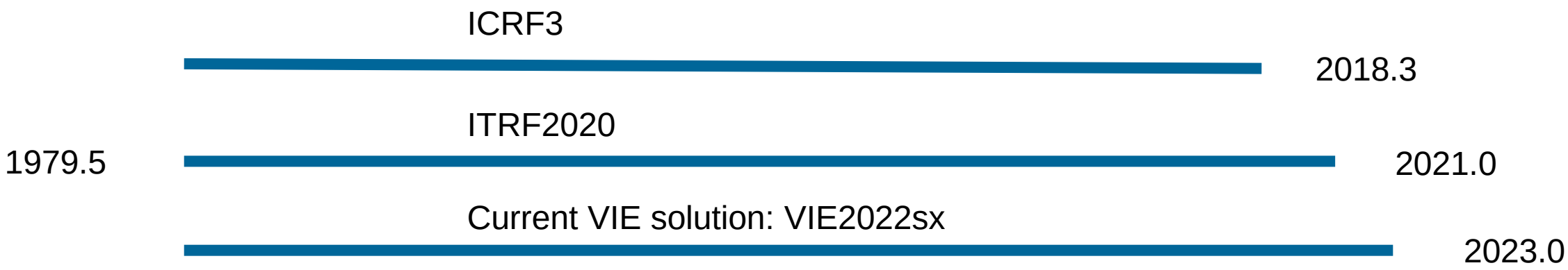
Outline

- Introduction of global solution VIE2022sx (TRF + CRF + EOP)
- Benefits of the Australian mixed-mode program (AUM) for the CRF

VIE2022sx solution (TRF + EOP + CRF)



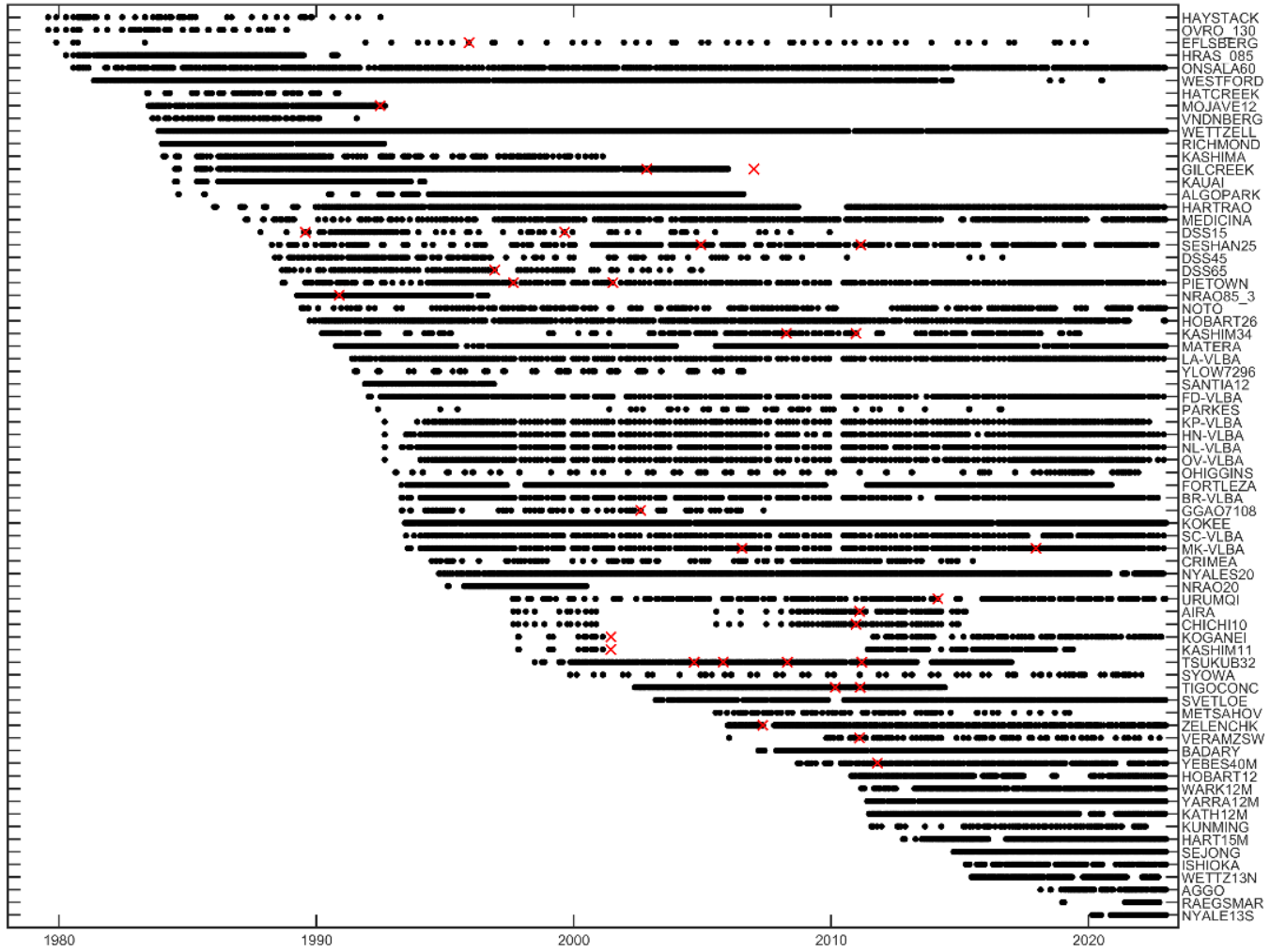
VieVS – Vienna VLBI and Satellite Software

- VieVS-VLBI modul: geodetic VLBI analysis software package, open-source, available on GitHub https://github.com/TUW-VieVS
- Input: group delays provided in the IVS vgosDB format via IVS Data Centers

- Theoretical delay is modelled following the latest IERS Conventions 2010 (+ updates)
- Adjustment of data is done with the Least Squares Method

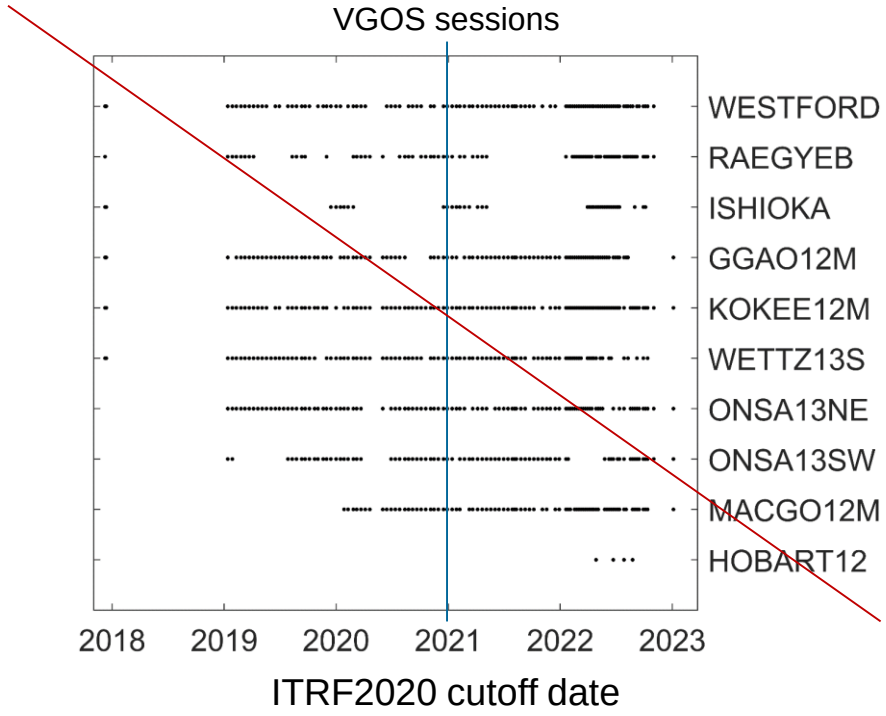
TRF-VIE2022sx

Antennas participating in > 50 sessions in VIE2022sx



- 7300 24-h IVS S/X sessions

VGOS sessions are not included in VIE2022sx

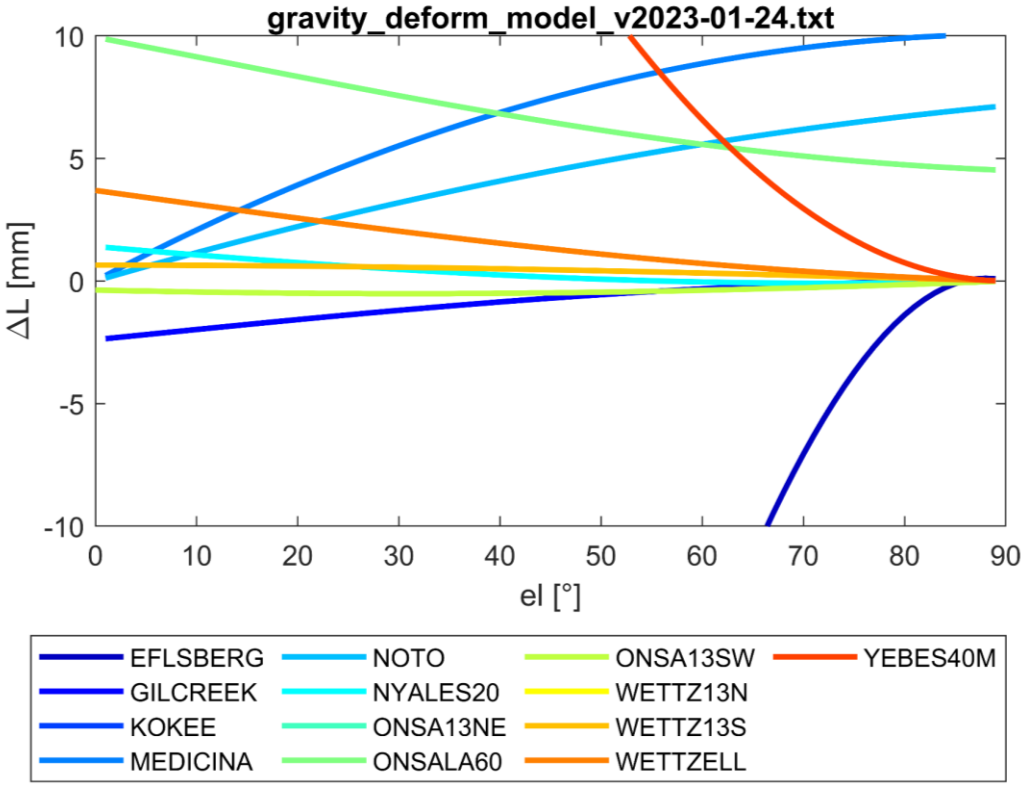


Updated Gravitational Deformation models

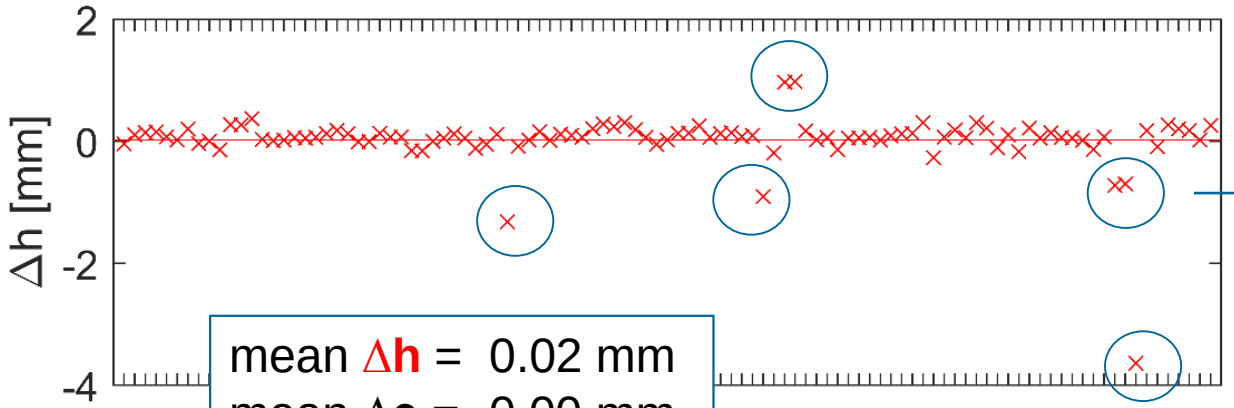
- IVS (VIE) submission to ITRF2020
  - Effelsberg, Gilcreek, Medicina, Noto, Onsala60, Yebes40m

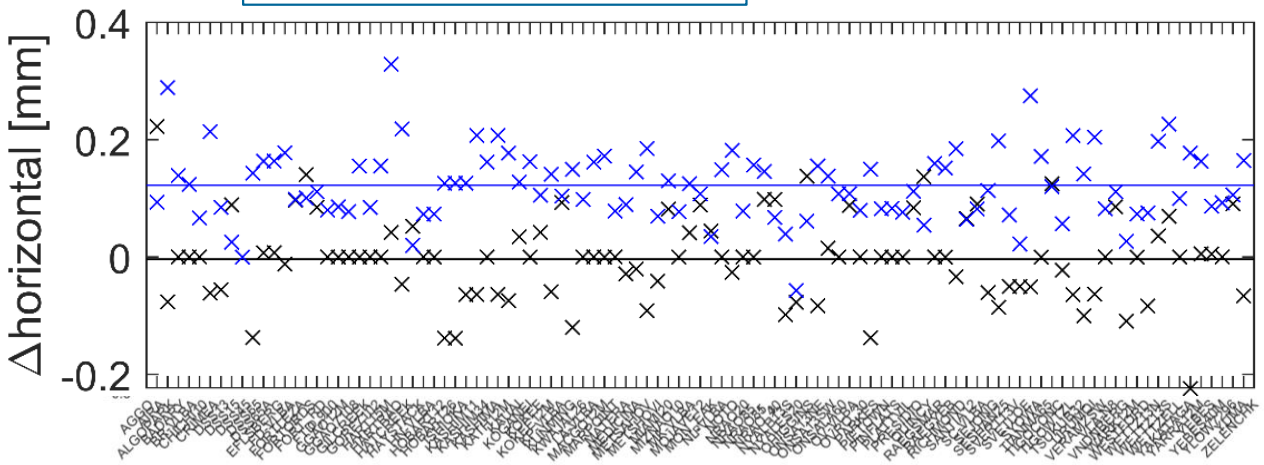
- 02/2023 reprocessed data submitted to the Combination Center with gravitational deformation models for the additional antennas:
  - Wettzell, Wettzell13 twins, Onsala twins, Nyales20, Kokee

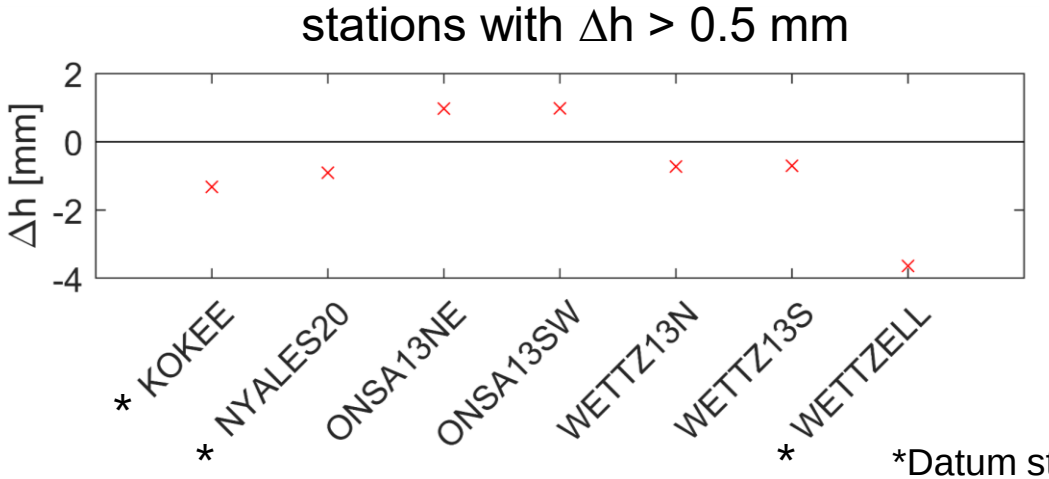
→ VIE2022sx



VIE2022sx new – old gravitational def model







*Datum stations

Δh	John Gipson IVS analysis email 2022/12/16	VIE2022sx [mm]
KOKEE		-1.3
NYALES20	few mm expected	-0.9
ONSA13NE; SW	0.6 mm expected	1.0; 1.0
WETTZ13N; S	0.6 mm	-0.7; -0.7
WETTZELL	4 mm	-3.6

Transformation parameters

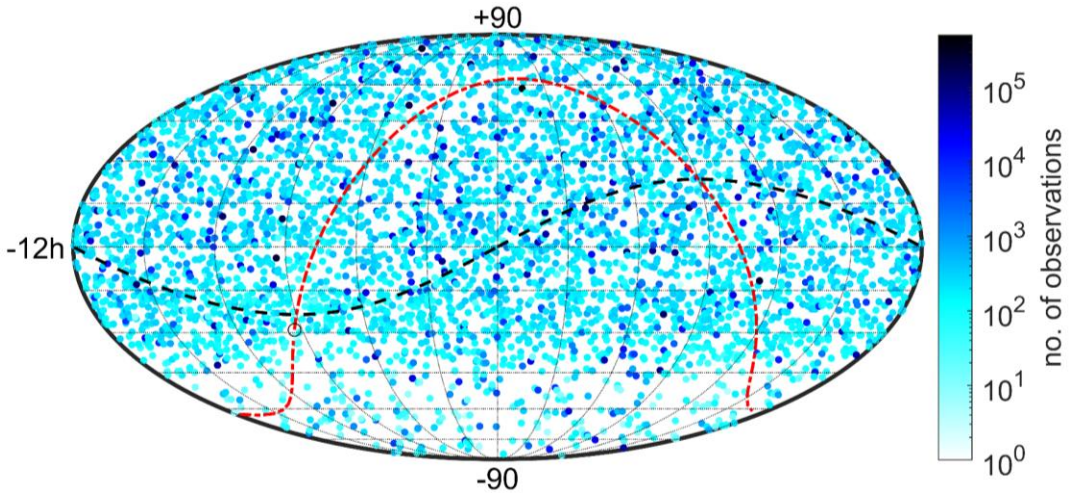
at epoch 2015 from ITRF2020 to VIE2022sx

HP w.r.t. ITRF2020	Tx [mm]	Ty [mm]	Tz [mm]	Rx [µas]	Ry [µas]	Rz [µas]	Scale [mm]
Grav. def. file 2023-01-24	2.1 ± 0.8	-1.3 ± 0.8	-2.1 ± 0.8	38 ± 30	46 ± 30	17 ± 24	2.9 ± 0.7
Grav. def. file 2019-11-21	2.2 ± 0.8	-1.3 ± 0.8	-2.2 ± 0.7	38 ± 30	47 ± 30	18 ± 24	3.1 ± 0.7

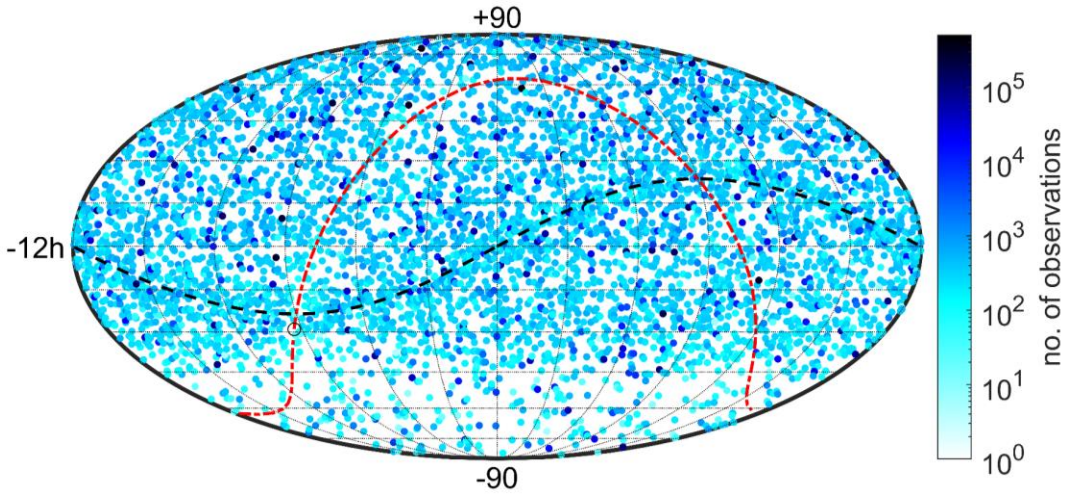
HP rates w.r.t. ITRF2020	Tx‘ [mm/y]	Ty‘ [mm/y]	Tz‘ [mm/y]	Rx‘ [µas/y]	Ry‘ [µas/y]	Rz‘ [µas/y]	Scale‘ [mm/y]
Grav. def. file 2023-01-24	0.15 ± 0.02	-0.14 ± 0.02	-0.17 ± 0.02	4.3 ± 0.7	2.7 ± 0.7	1.6 ± 0.6	0.17 ± 0.02
Grav. def. file 2019-11-21	0.15 ± 0.02	-0.14 ± 0.02	-0.17 ± 0.02	4.3 ± 0.7	2.7 ± 0.7	1.6 ± 0.6	0.17 ± 0.02

Celestial Reference Frame VIE2022sx

VIE2022sx versus ICRF3sx

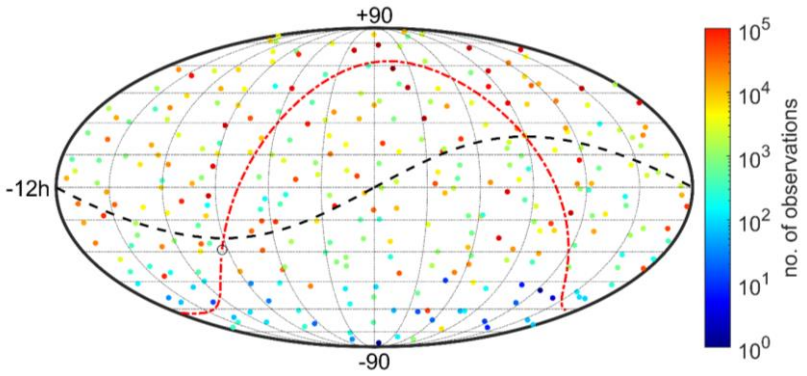


ICRF3sx		# sources	# obs.	median obs. per sou.
all sources	<0°, 90°>	2615	9.8e+06	254
	<-45°, 0°>	1665	3.1e+06	186
	<-90°, -45°>	256	2.7e+05	58



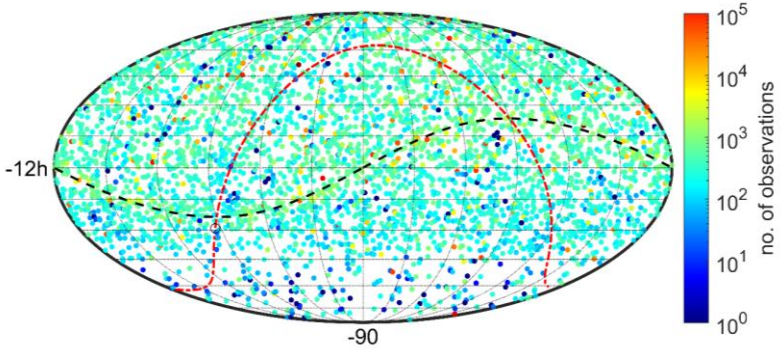
VIE2022sx		# sources	# obs.	median obs. per sou.
all sources	<0°, 90°>	3125	1.3e+07	426
	<-45°, 0°>	2038	4.5e+06	303
	<-90°, -45°>	268	4.0e+05	148

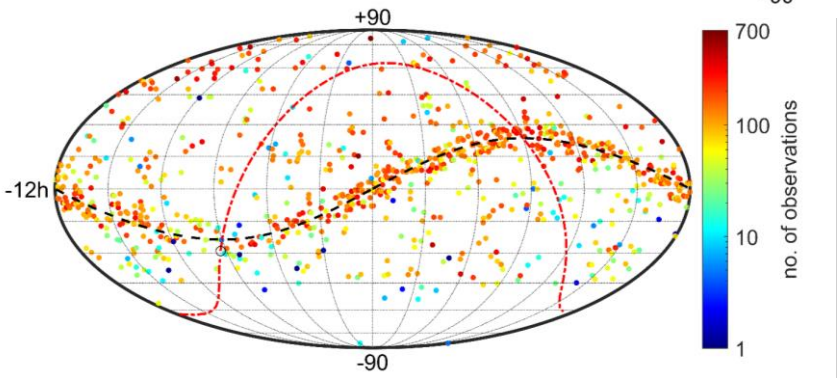
Observations in VIE2022sx after ICRF3sx cutoff date



303 defining ICRF3sx

4234 non-defining ICRF3sx





894 non ICRF3sx

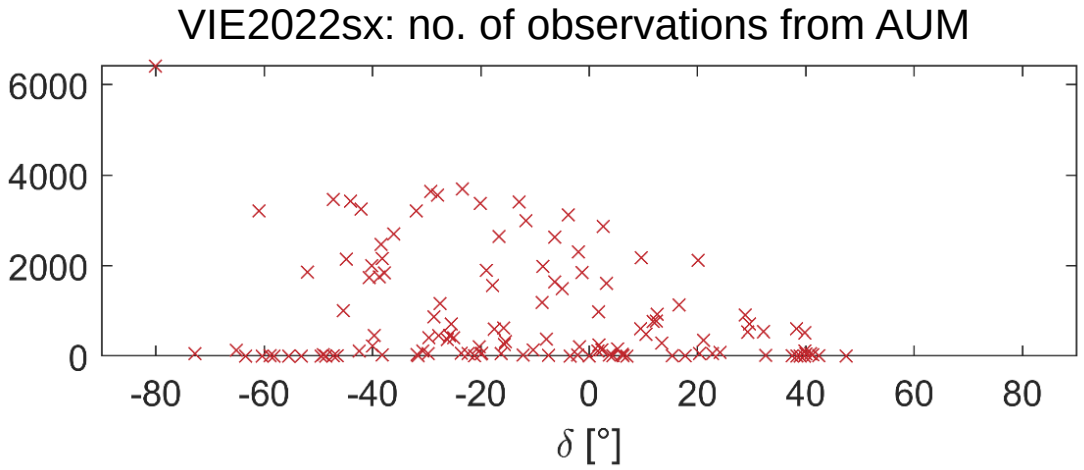
		# sources	# obs.	median obs. per sou.
def	<0°, 90°>	149	1.7e+06	3548
	<-45°, 0°>	105	8.4e+05	2140
	<-90°, -45°>	49	5.7e+04	277
non-def	<0°, 90°>	2467	1.6e+06	199
	<-45°, 0°>	1561	5.0e+05	126
	<-90°, -45°>	206	7.1e+04	63
new	<0°, 90°>	510	1.0e+05	197
	<-45°, 0°>	373	5.8e+04	141
	<-90°, -45°>	12	5.6e+02	29

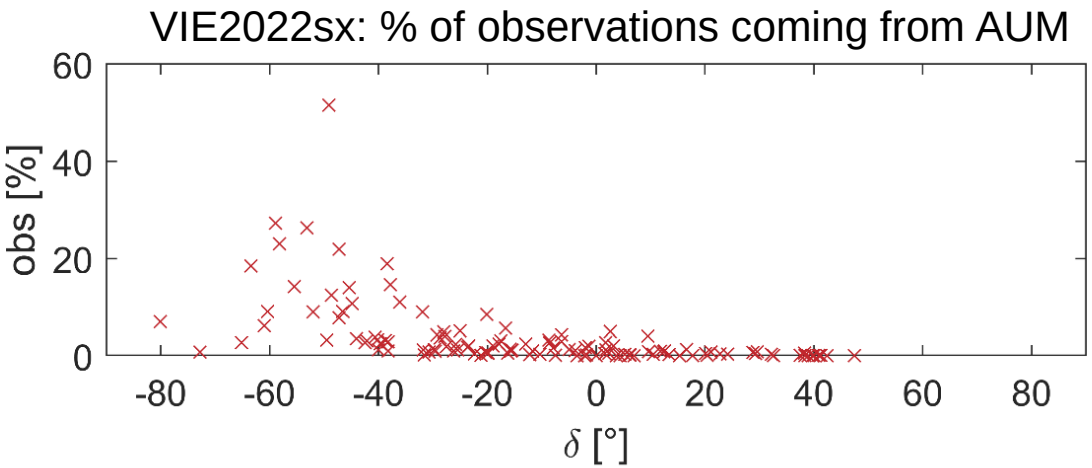
IVS-CRDS program: Weston et al. (2023)

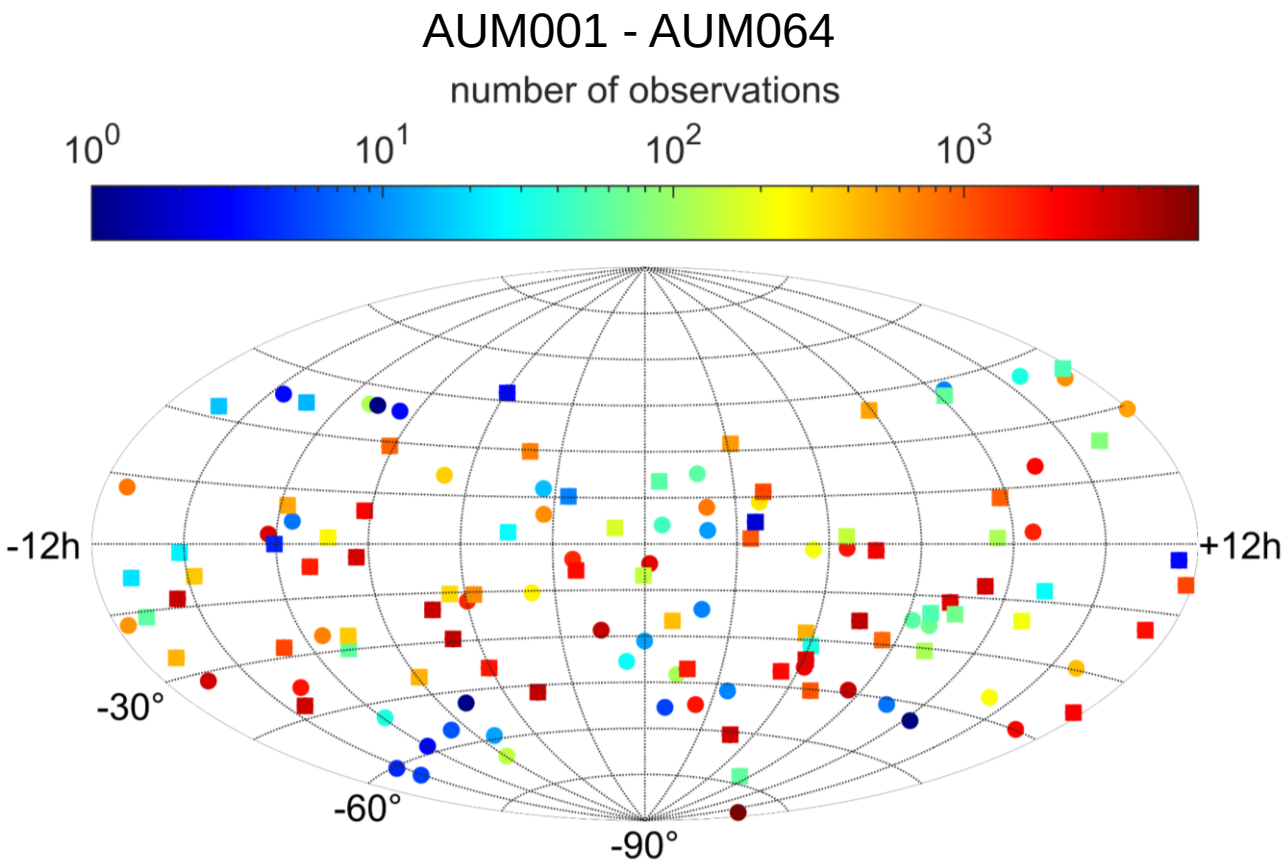
AUM sessions

- Australian mixed-mode program started in July 2018
  - L. McCallum et al. The Australian mixed-mode stations in a nutshell --> POSTER
- Dedicated 24-hour sessions with a focus on weakly observed ICRF3sx sources in the south since AUM049
- First block: AUM049 – AUM058
  - run at weekends 08/2022 – 10/2022
  - Hb-Ke-Yg network
- New observing block in 2023
  - includes also Ho and Ww
- Sessions are scheduled geodetically, i.e. aiming for a high number of scans.
- In each session, 5 target sources are observed in 4-5 scans of 10 minutes duration. This setup still ensures about 25 scans/hr/station, which is seen as a foundation even for good geodetic results.

No. of observations in AUM001 - AUM064





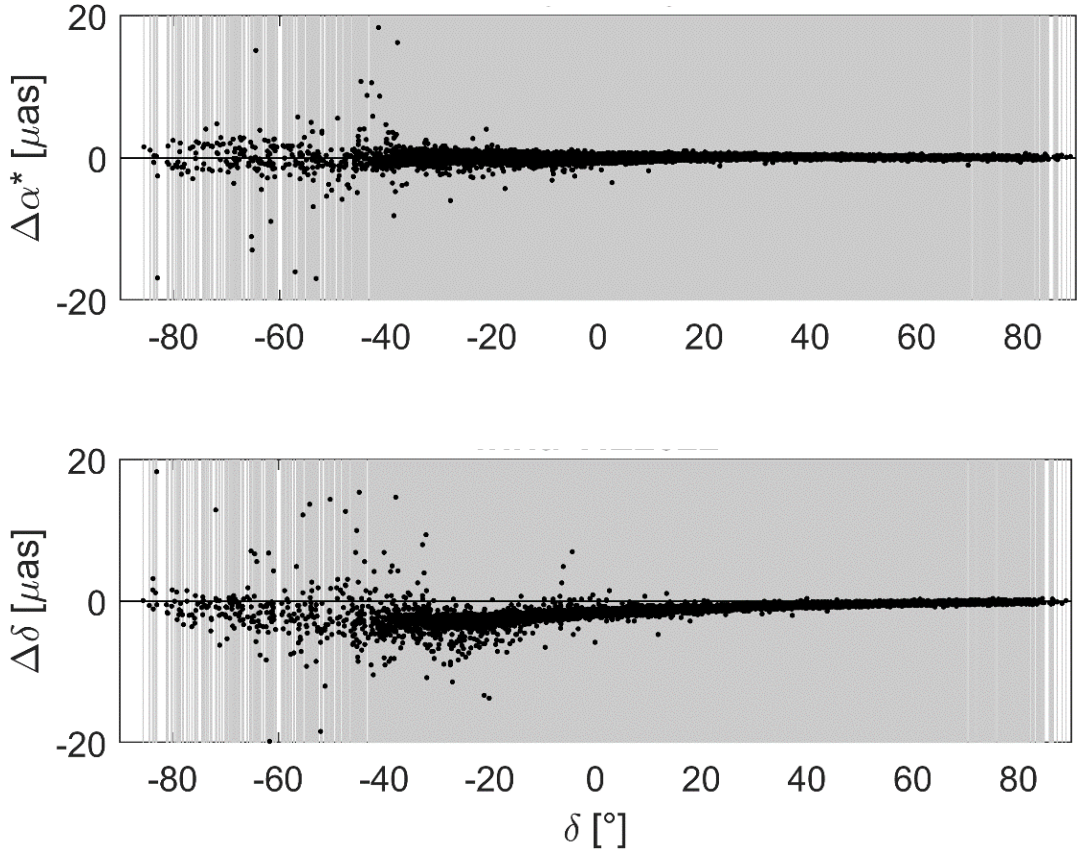


□ defining ICRF3sx sources
○ non-defining ICRF3sx sources

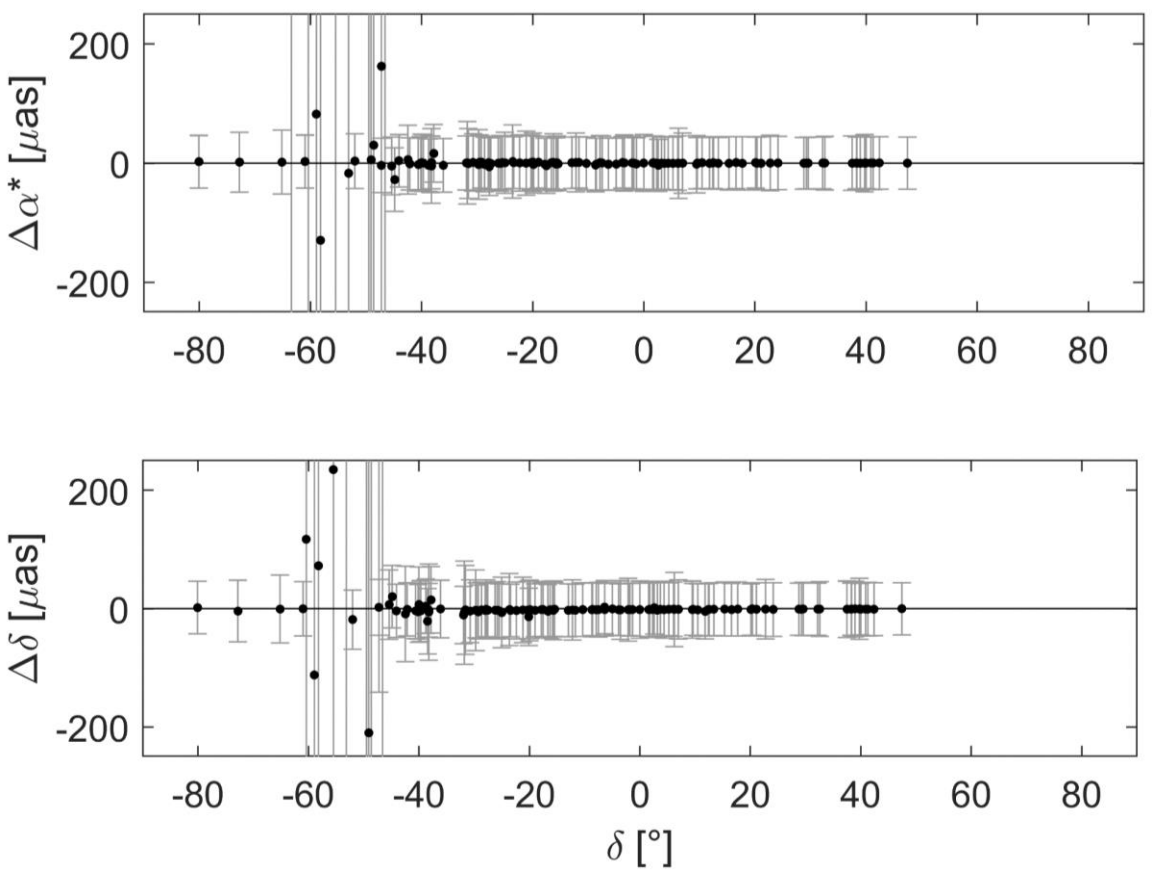
Differences in source position

- VIE2022sx without AUM – VIE2022sx

all sources



sources observed in AUM



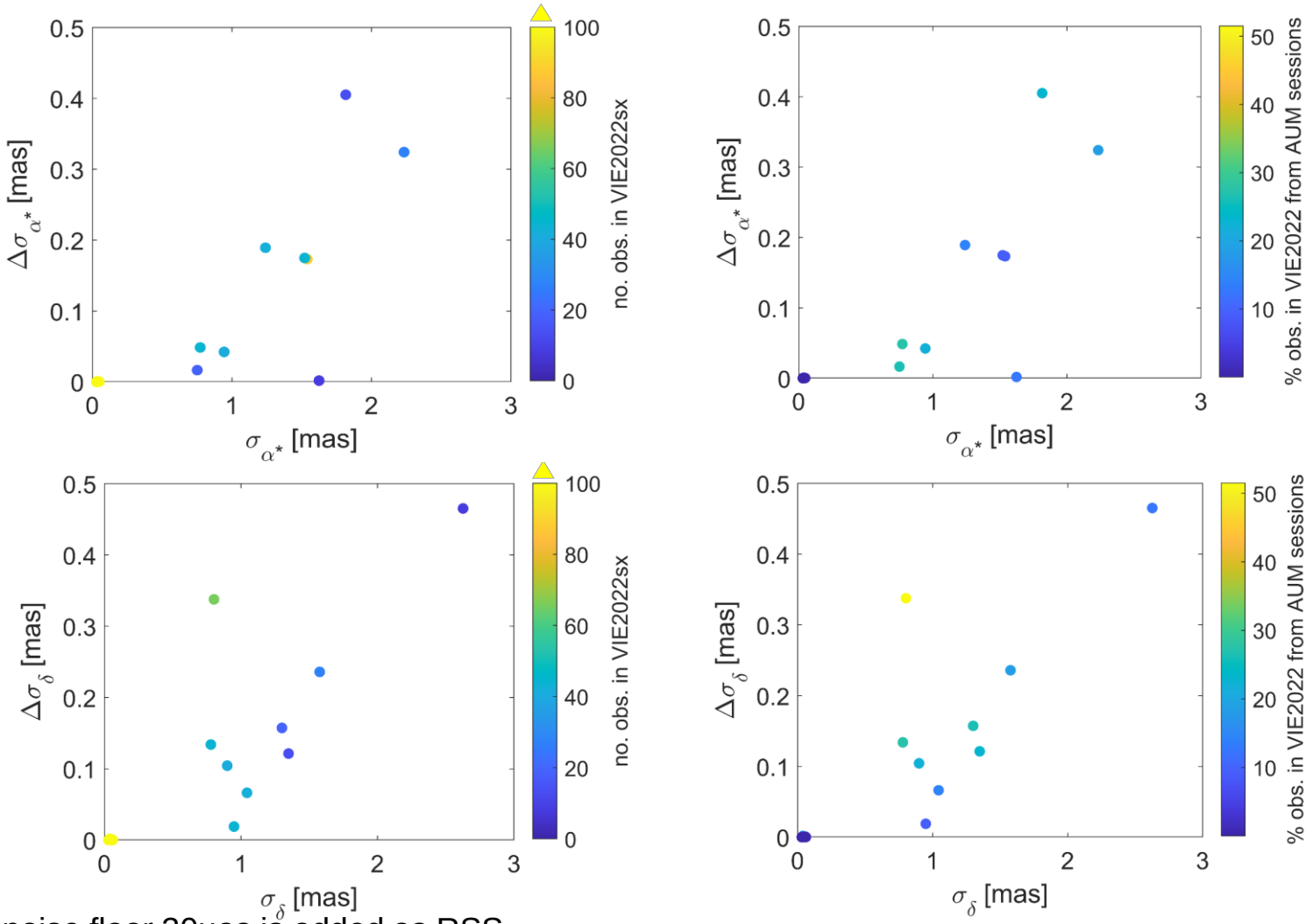
Formal errors are inflated by scaling factor 1.5 and noise floor 30µas is added as RSS.

Differences in formal errors

11 sources show a reduction of formal error larger than 100 µas in one or both coordinates

0035-534, 0219-474, 0700-465
0809-493, 1343-601, 1352-632
1556-580, 1600-489, 1722-554
1830-589, 1839-486

These sources have large formal error in “VIE2022sx without AUM” (1-3 mas) mainly due to low number of observations (< 100).



Formal errors are inflated by scaling factor 1.5 and noise floor 30µas is added as RSS.

Conclusions

- Vienna VLBI Center provides consistent TRF + CRF + EOP global solutions

- The latest solution VIE2022sx includes 24-h IVS S/X sessions until 2023.0
  - available at https://www.vlbi.at
  - solution S/X + VGOS sessions is available as well

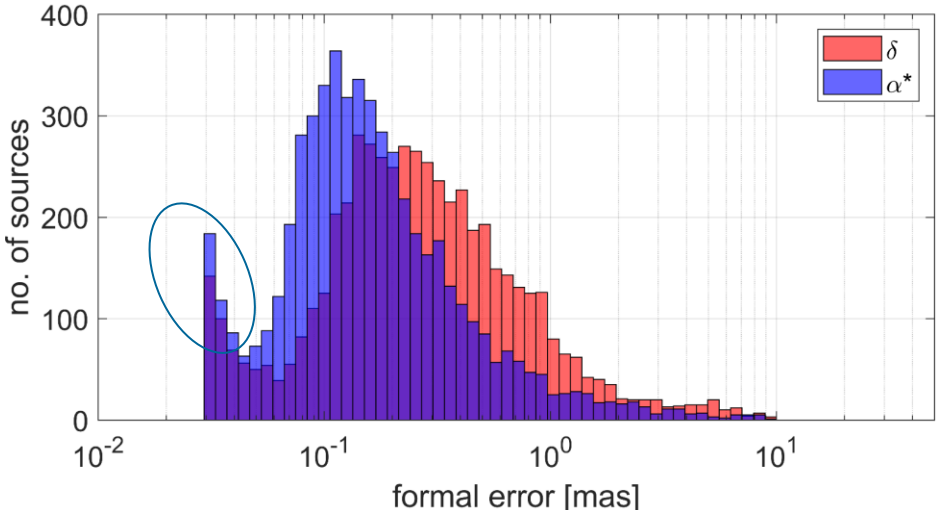
- AUM sessions (since AUM001 in 07/2018) contribute to strengthen the CRF in the south
  - since AUM049 (08/2022) with a special focus on weakly observed ICRF3sx sources in the south
  - in 2022 only small dishes available (Hb-Ke-Yg network)
  - large reduction of formal errors of the source position (100-500 µas) for 11 weakly observed sources (< 100 observations) in VIE2022sx

- The AUM program in ongoing with a double session (one weekend) per month.
- We are open to suggestions about which sources shall be observed and also welcome other telescopes to join in.

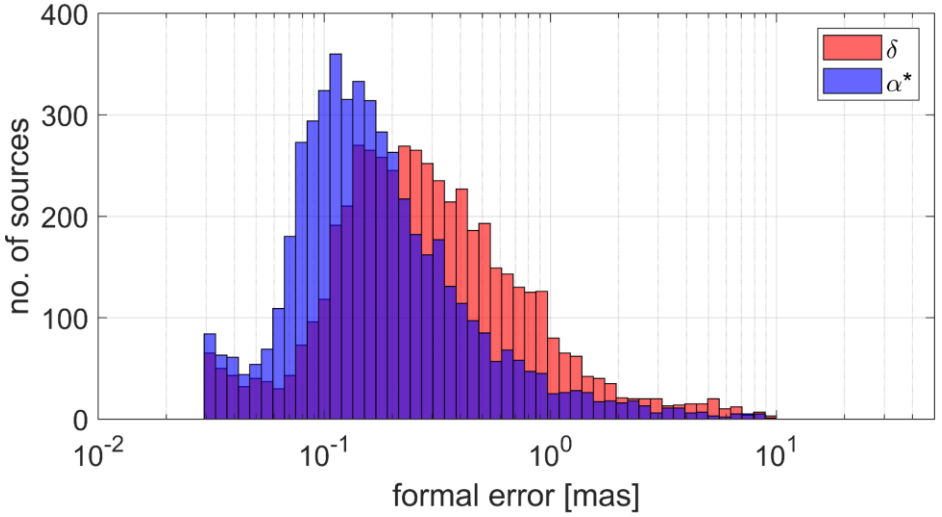
Thank you for your attention!

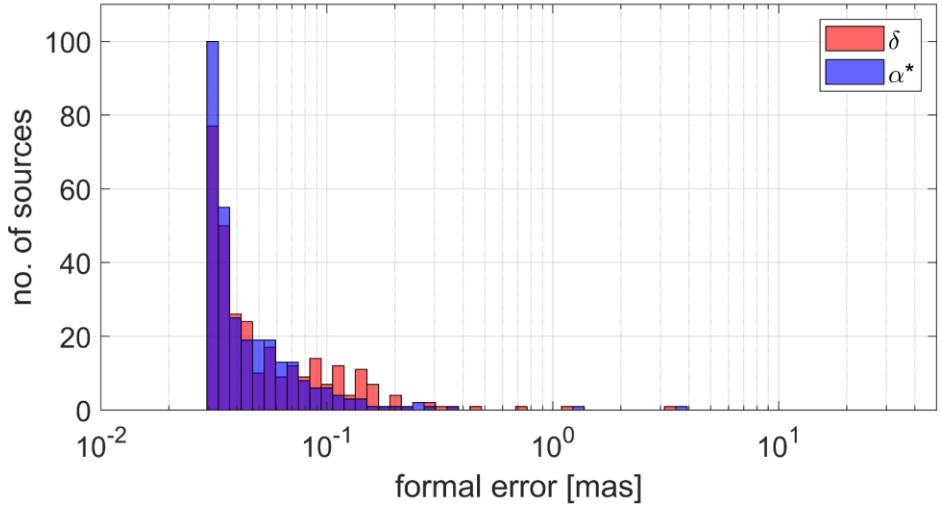
Backup

Distribution of formal errors in VIE2022sx

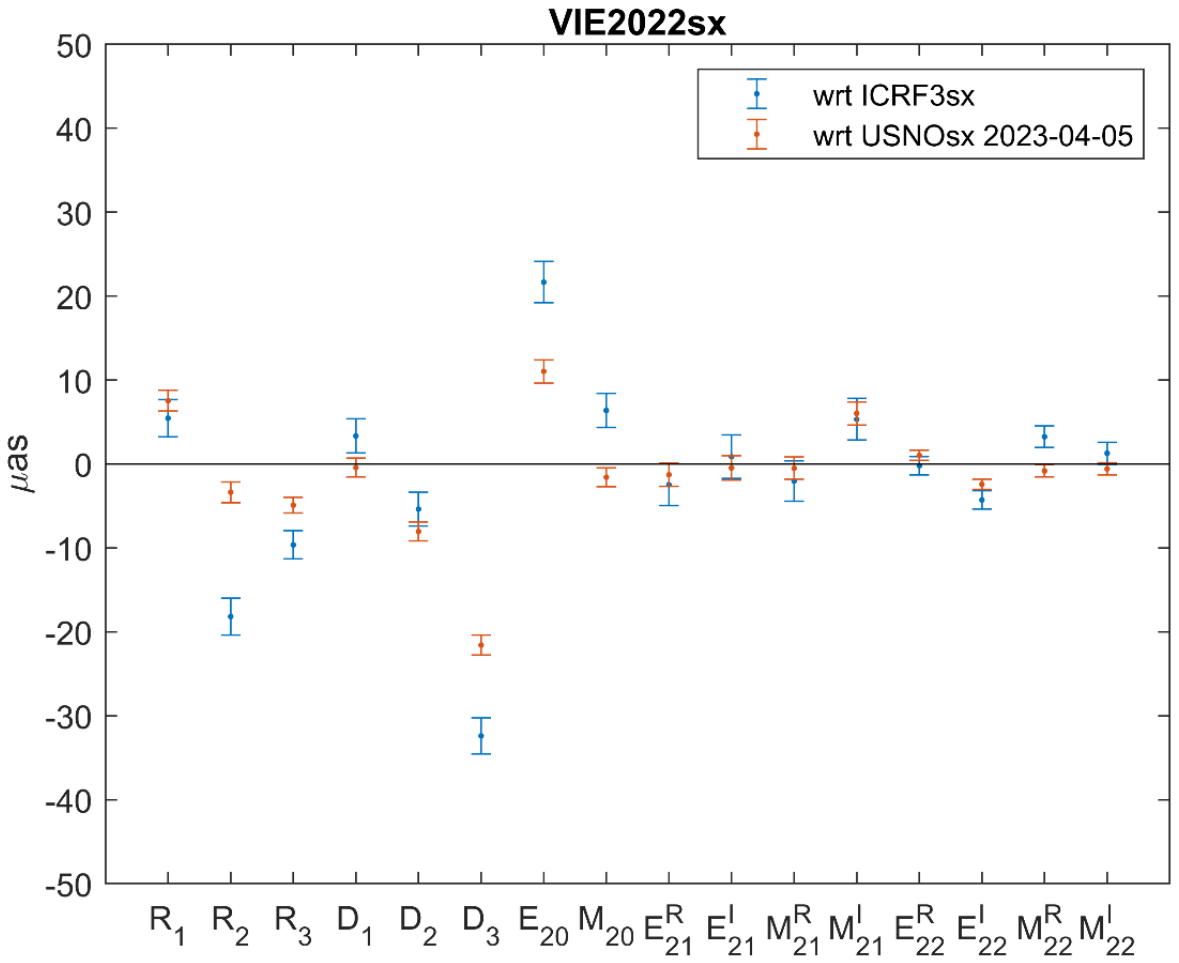


median formal error	α* [μas]	δ [μas]
all sources in VIE2022sx	143	249
non-defining	151	265
defining	37	41





VSH parameters up to degree 2



Vector spherical harmonics decomposition (VSH, Mignard & Klioner, 2012; Titov & Lambert, 2013)

- Rotation (R_1, R_2, R_3)
- Dipole (D_1, D_2, D_3)
- Coefficients for quadrupole harmonics

- 35 AGN removed as outliers
  angular separation to ICRF3 > 10 mas