Earth orientation parameters determined from Very Long Baseline Array experiments conducted at K-band (24 GHz)

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Abstract
The terrestrial and celestial reference frames are connected through rotational transformations including the Earth orientation parameters (EOP). The EOP are estimated from space geodetic observations. Very Long Baseline Interferometry (VLBI) is the only space geodetic technique which allows one to directly estimate all five EOP and the only technique providing the access to the celestial pole position. The officially published VLBI estimates of the EOP are based solely on observations from the S/X-band (2.3/8.4 GHz).
We present EOP determined from the Very Long Baseline Array experiments at K-band (24 GHz) which are independent from the traditional S/X frequency band. Our dataset starts in May 2002 and consists of more than 120 24h observing sessions. We calculate comparisons before and after each major change in data rate in order to quantify any change in EOP quality due to changes in the observing system.

VLBI data (24 GHz)

Sessions
124 24h observing sessions: 05/2002 – 06/2022
87 VLBA sessions
37 single baseline sessions Ho-Hh (+ Ti, T6)

Data rates
2002-2010: 128-256 Mbps
2015-10/2019: 2048 Mbps (VLBA)
11/2019 – present: 4096 Mbps (VLBA)

Setup of the solutions

USNO-k-220705
- CALC/SOLVE

- group delay + delay rates
- ionosphere from 2 hour average JPL GPS ionosphere maps
- baseline dependent weighting
- trop. mapping functions: VMF1 (h+w)
- DAO trop. gradients with constraints of 0.5 mm (offset) and 2.0 mm/day (rate)

VIE-k-220919
- VieVS 3.2
- NGS cards until 2019, Version 4 vgosDB since 2019
- group delays
- ionosphere until 2019: JPL GPS maps
- ionosphere since 2019: CODE ionex map with 1 hour spacing www.aiub.unibe.ch/download/CODE/
- elevation dependent weighting (Gipson et al., 2008)
- trop. mapping functions: VMF3 (h+w)
- zero trop. gradients a priori with absolute constraints of 1 mm and 0.5 mm after 6 hours

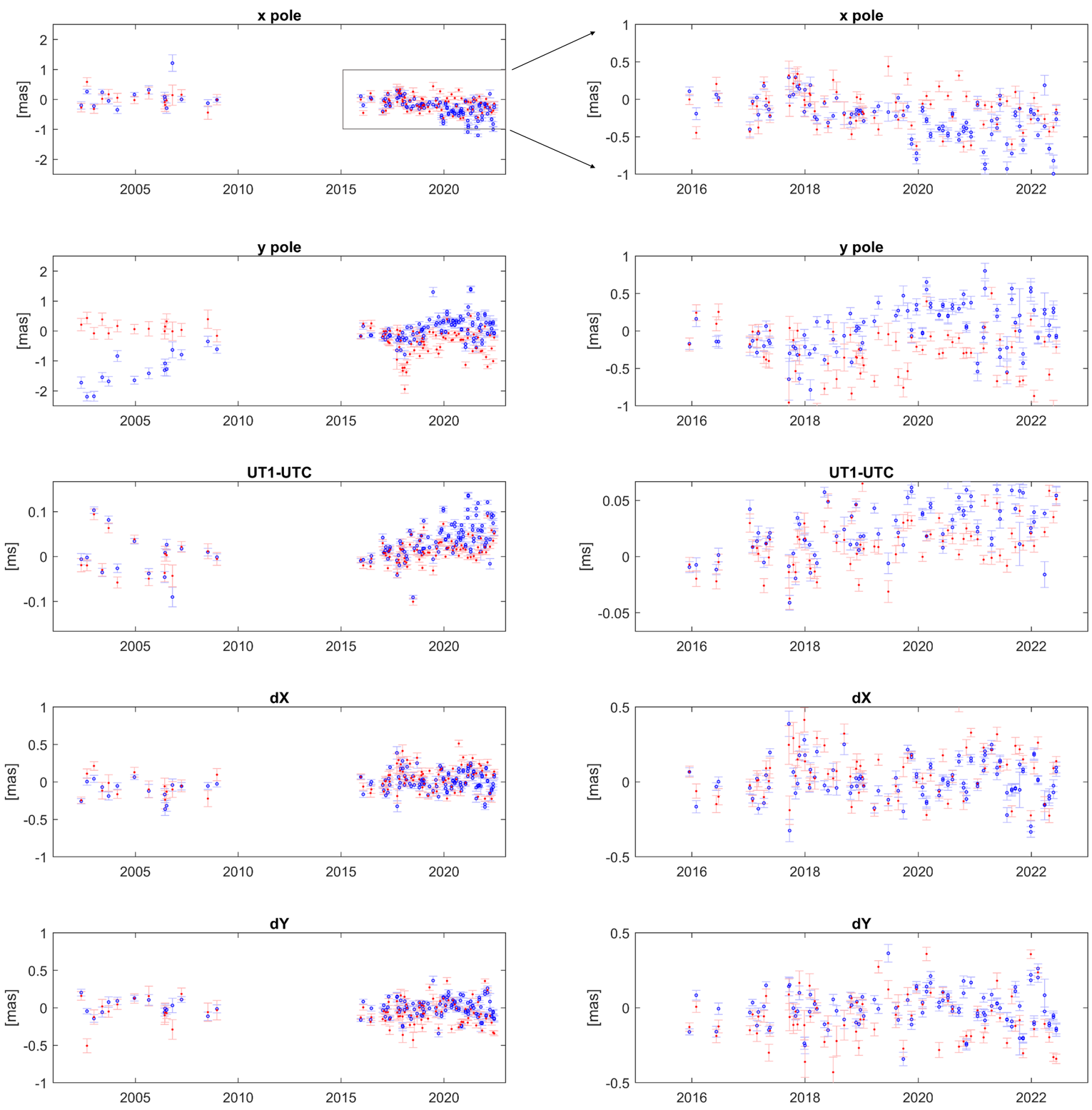
Parametrisation of the solutions
Global solution – datum definition (USNO-k-220705)
- NNT/NNR w.r.t. recent USNO S/X solution on VLBA antennas
- uniform weighted NNR w.r.t. ICRF3sx (Charlot et al., 2020) on 272 defining sources

Global solution – datum definition (VIE-k-220919)
- NNT/NNR w.r.t. ITRF2020 (Altamimi et al., 2022) VLBA antennas except MK-VLBA
- unweighted NNR w.r.t. ICRF3k (Charlot et al., 2020) on 193 defining sources

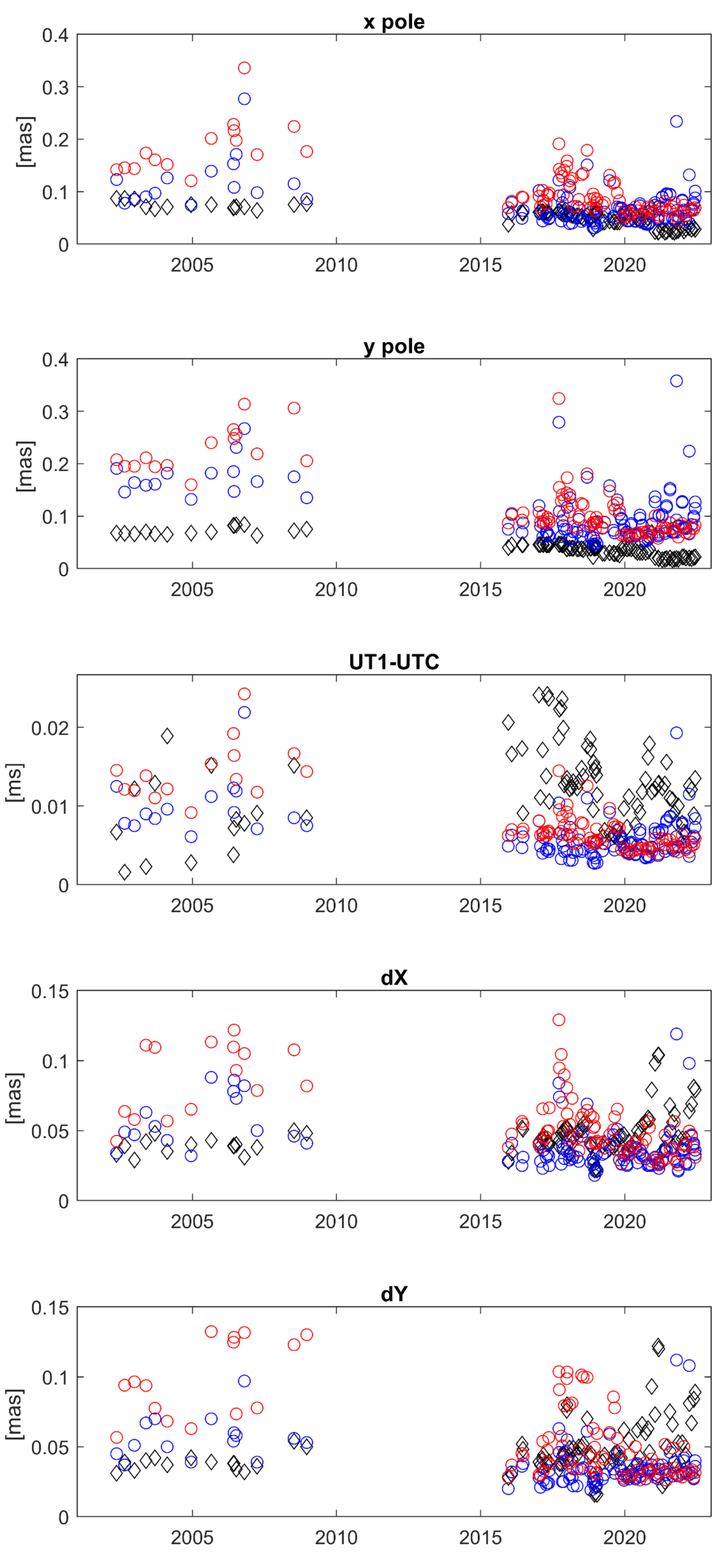
EOP in single baseline Ho-Hh (+ Ti, T6) sessions fixed to a priori values
EOP from VLBA sessions – offset and rate (usno) or pwlo (vie) at midnights for pole coordinates and UT1-UTC, one offset for nutation

In VIE-k-220919 the EOP are kept in the global NEQ, i.e. data from separate polarizations files (L + R, since 11/2019) are stacked together

EOP estimates from USNO-k-220705 and VIE-k-220919 w.r.t. IERS 14 C04



EOP formal errors of USNO-k-220705, VIE-k-220919 and IERS 14 C04



Earth Orientation Parameter Statistics: K-band vs. IERS 14 C04 combined series

	x pole (μ-arcsec)		y pole (μ-arcsec)		dUT1 (μ-sec)		Nutation dX (μ-arcsec)		Nutation dY (μ-arcsec)	
	VIE-k-220919	USNO-k-220705	VIE-k-220919	USNO-k-220705	VIE-k-220919	USNO-k-220705	VIE-k-220919	USNO-k-220705	VIE-k-220919	USNO-k-220705
weighted mean	8 / -100 / -208	35 / -109 / -439	118 / -401 / -289	-1322 / -90 / 227	8 / 5 / 24	16 / 14 / 58	-53 / 33 / 89	-77 / 11 / 37	5 / -64 / -57	29 / -23 / 12
wRMS (detrended)	250 / 228 / 242	229 / 130 /250	172 / 405 / 356	391 / 218 / 321	44 / 25 / 22	45 / 25 / 29	162 / 128 / 168	118 / 107 / 119	170 / 117 / 181	100 / 94 / 118
formal errors	186 / 103 / 62	121 / 63 / 65	228 / 113 / 73	175 / 86 / 92	14 / 7 / 5	10 / 5 / 5	88 / 57 / 37	58 / 36 / 35	98 / 56 / 34	56 / 33 / 35

The statistics is computed for three groups of data according to their data rates: pre-2015 / from 2015 until Nov 2019 / since Nov 2019

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Summary

- Earth Orientation Parameters from K band VLBA sessions are presented
- EOP estimation was done with two independent software packages (VieVS 3.2 and Calc/Solve)
- The presented EOP time series are comparable with the official IERS 14 C04 time series, despite the obvious disadvantages such as single band observations or dimension of U.S. network
- Post-2015 formal errors are noticeably improved for all five EOP
- In VIE solution the EOP are estimated as global parameters, i.e. the EOP from LCP and RCP data since November 2019 are stacked together. This causes a decrease in EOP formal errors by a factor of $\sqrt{2}$
- IERS 14 C04 polar motion formal errors are dominated by GNSS technique
- By UT1-UTC and nutation the K band formal errors lie below the IERS 14 C04 values in the recent years