Earth Orientation Parameters estimated from K-band VLBA measurements

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Abstract

The Earth Orientation Parameters (EOP) which connect the Terrestrial and Celestial Reference Frame are regularly estimated by Very Long Baseline Interferometry (VLBI). The UT1-UTC and nutation components of EOP can only be measured using the VLBI technique. Until recently, published VLBI estimates of EOP were based solely on observations from the S/X frequency band.

We present VLBI estimates of EOP from an observing frequency independent of the traditional SX-band using Very Long Baseline Array (VLBA) measurements at K-band (24 GHz, 1.2 cm). We will have over two years of regular VLBA experiments conducted with telescopes located in U.S. territory. We investigate the potential of K-band VLBI to produce more accurate EOP because of its reduced source structure effects relative to SX-band. We compare our K-band EOP computed with two analyses software packages (Calc/Solve and VieVS) to the IERS C04 data.

VLBI Data and Parametrization

69 observing sessions
- 52 from VLBA on the U.S. territory (15 sessions before 2015)
- 17 HartRAO – Hobart single baseline sessions (it makes less than 1% of the total number of K-band observations)

Data rates increased significantly after 2014:
- 2002 - 2010: 128 to 256 Mbps
- 2014 - 2018: 2048 Mbps
- ~2019 - : 4096 Mbps (anticipated Mark6 recorder upgrade)

2 independent solutions
- Technical University of Vienna: TUW-k-190223 (VieVS, NGS cards as input)
- Goddard Space Flight Center: GSFC-k-190207 (CALC/Solve)

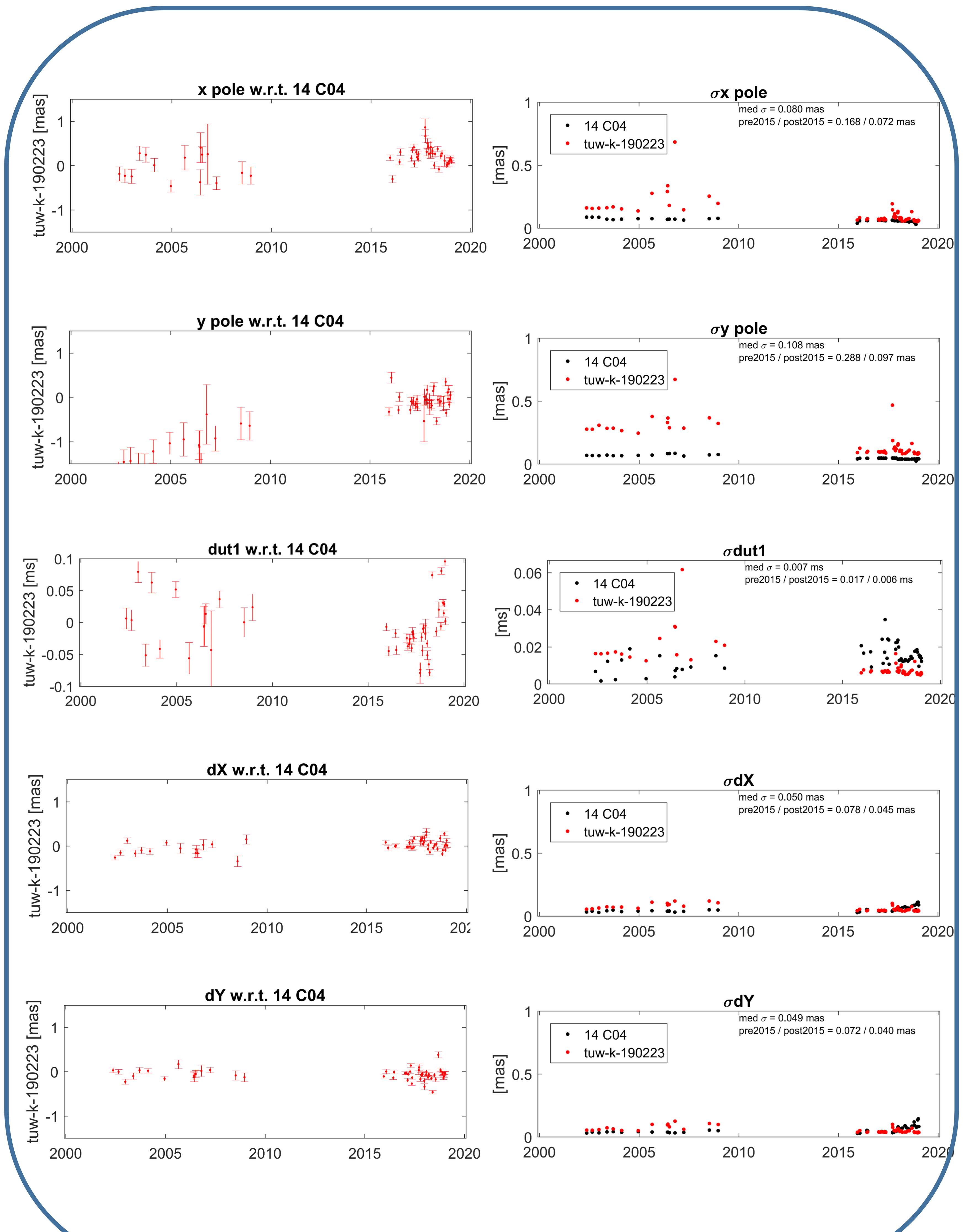
Some of the differences between the TUW and GSFC solution
- GSFC includes delay rates to the analysis
- Galactic aberration was modeled and applied in the GSFC solution to give source positions at the 2015.0 epoch (as in ICRF3)

Solution Global parameters
- Terrestrial Reference Frame (TRF) – VLBA station positions and linear velocities, epoch 2010, No Net Translation (NNT) + No Net Rotation (NNR) w.r.t. ITRF2014
- Celestial Reference Frame (CRF): source positions (TUW: unweighted NNR w.r.t. ICRF2 defining sources, GSFC: uniform weighted NNR constraint on 193 ICRF3 defining sources)

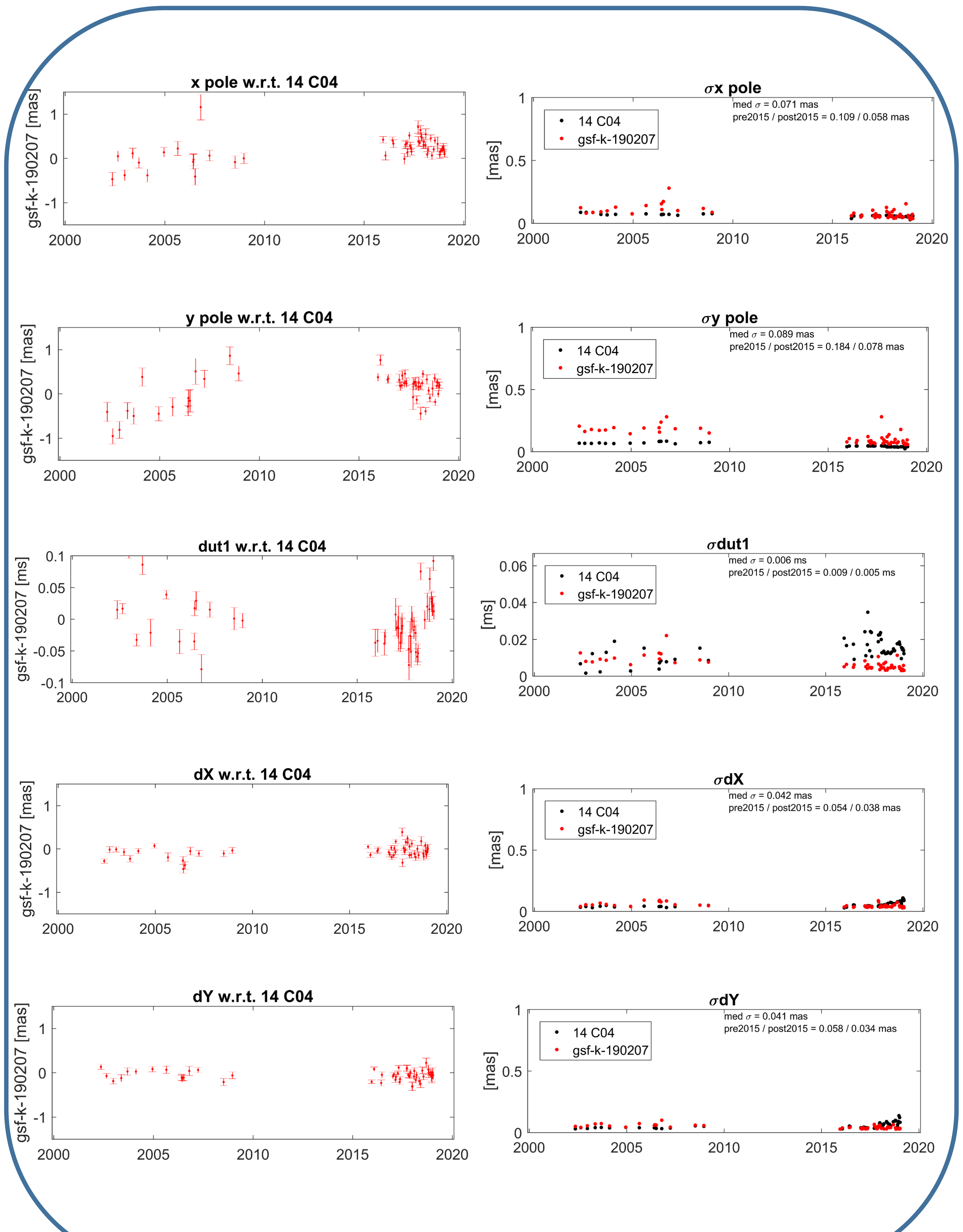
Session-wise parameters
- TRF – station position of HartRAO, Hobart26, Tianma65, Tidbinbilla70
- Clock parameters – 60 min. estimation intervals
- Zenith wet delay – 30 min. intervals with 1.5 cm relative constraints
- Troposphere gradients – 360 min. intervals with 0.05 cm relative constraints
- EOP – 1 offset per session from VLBA
- EOP from single baseline sessions fixed to IERS 14 C04 combined series (*Bizouard et al, 2017*), https://hpiers.obspm.fr/iers/eop/eopc04/C04.guide.pdf

Ionosphere corrections were estimated from GPS ionosphere maps and applied in the analysis.

Earth Orientation Parameters derived from Very Long Baseline Array data at K-band (24 GHz): Vienna and Goddard analyses vs. IERS 14-C04 combined series (*Bizouard et al, 2017*)



Vienna: TUW-k-190223



Goddard: GSFC-k-190207

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)	
	TUW-k-190223 pre-2015 / post-2015	GSFC-k-190207 pre-2015 / post-2015	TUW-k-190223 pre-2015 / post-2015	GSFC-k-190207 pre-2015 / post-2015	TUW-k-190223 pre-2015 / post-2015	GSFC-k-190207 pre-2015 / post-2015	TUW-k-190223 pre-2015 / post-2015	GSFC-k-190207 pre-2015 / post-2015	TUW-k-190223 pre-2015 / post-2015	GSFC-k-190207 pre-2015 / post-2015
weighted mean	-102 / 185	-49 / 272	-1228 / -72	-160 / 189	16 / -18	15 / -14	-66 / 58	-120 / -18	-39 / -62	-32 / -67
median	-164 / 218	-30 / 299	-1119 / -89	-287 / 232	4 / -18	15 / -14	-97 / 20	-106 / -45	-51 / -53	-62 / -58
wRMS	270 / 165	249 / 143	344 / 201	504 / 203	38 / 52	37 / 52	133 / 105	137 / 129	98 / 104	105 / 109
χ^2	1.92 ± 0.38 / 3.34 ± 0.24	3.69 ± 0.38 / 3.29 ± 0.24	1.28 ± 0.38 / 3.56 ± 0.24	7.20 ± 0.38 / 5.42 ± 0.24	3.88 ± 0.38 / 10.57 ± 0.24	10.48 ± 0.38 / 11.52 ± 0.24	12.98 ± 0.38 / 4.41 ± 0.24	4.10 ± 0.38 / 3.66 ± 0.24	7.25 ± 0.38 / 5.59 ± 0.24	2.44 ± 0.38 / 2.98 ± 0.24
$(\chi^2 - 1) / \sigma(\chi^2)$	2.42 / 9.94	7.11 / 9.71	0.74 / 10.85	16.41 / 18.76	7.61 / 40.62	25.08 / 44.63	31.69 / 14.48	8.21 / 11.29	16.53 / 19.46	3.80 / 8.42

Conclusions

- ✓ Reasonable EOP series can be produced from the K-band VLBA measurements.
- ✓ Comparison of two independent global adjustments computed with two software analysis packages (Vienna's VieVS and Goddard Calc/Solve) is shown.
- ✓ Post-2015 formal errors and wRMS scatter are noticeably improved for the polar motion. However, nutation do not improve much except for Vienna dX nutation.
- ✓ Nutation formal errors do improve post-2015.
- ✓ Offset in the Vienna y-pole is related to the VLBA telescope distribution.
- ✓ Future plans: We anticipate a factor of 1.4 increase in sensitivity from doubling the data rates to 4096 Mbps. Testing of the new rate will start this year. Operations may begin in 2019/20.
- ✓ Both the Celestial and Terrestrial Frames should improve with time thereby improving EOPs.

Acknowledgements

We acknowledge our respective sponsors: HK acknowledges the Austrian Science Fund (FWF, Project T697-N29). SARAO/HartRAO is a facility of the National Research Foundation (NRF) of South Africa. Portions of this work done at Jet Propulsion Laboratory, California Institute of Technology under contract with NASA. We gratefully acknowledge the grant of observing time on the VLBA under the USNO time allocation.

24th Meeting of the European VLBI Group for Geodesy and Astrometry (EVGA)
March 17-19 2019, Las Palmas (Gran Canaria, Spain)