24th EVGA Working Meeting

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CONT17 from a VieVS Perspective

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Vienna VLBI and Satellite Software (VieVS)

- VLBI analysis module
- Ray-tracer
- Scheduling tool VieSched++
- …

https://github.com/TUW-VieVS

Outline

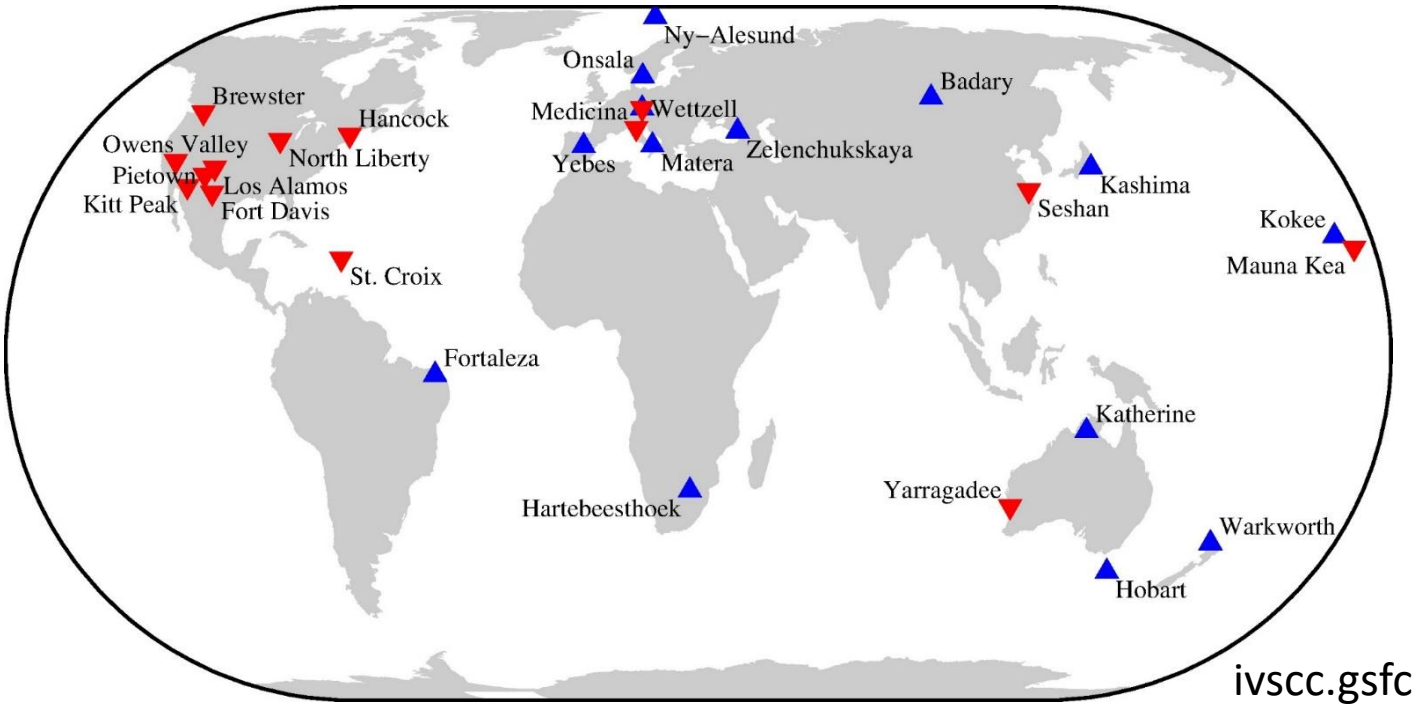
- VLBI analysis of CONT17 networks
- Ray-traced delays for Intensives during CONT17
- Tropospheric delays from VLBI and ray-tracing
  - comparison against other techniques at Wettzell
- CONT17 schedules with VieSched++

CONT17 networks

- Three independent networks
  - two legacy networks A and B in X/S band
    - 28 Nov. 2017 0:00 to 12 Dec. 2017 24:00
  - one network broadband
    - 4 Dec. 2017 0:00 to 8 Dec. 2017 24:00

Network	#stations	data rate	correlator	comment
Legacy A	14	256 Mbps	Socorro	VLBA
Legacy B	14	512 Mbps	Bonn	
VGOS-Demo	6(7)	8 Gbps	Haystack	

CONT17 A and B networks



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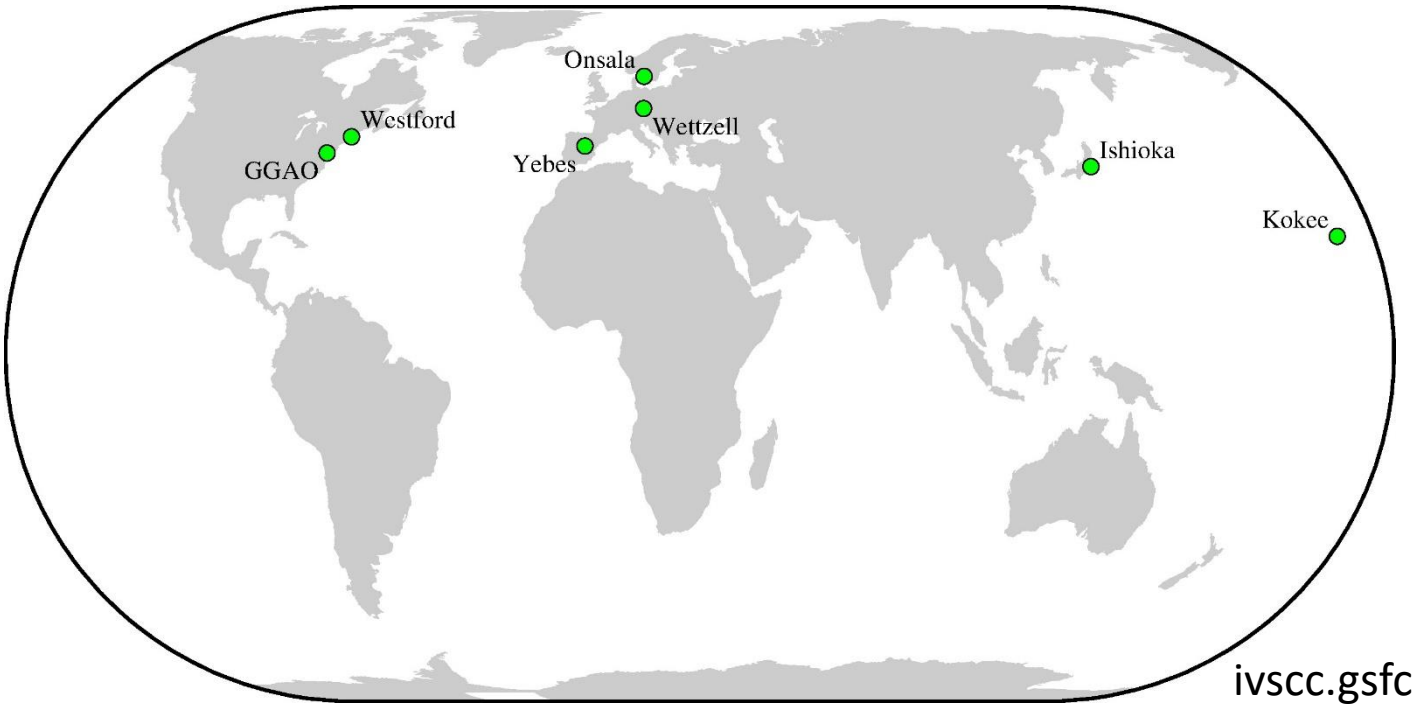
CONT17 A

CONT17 B

CONT17 VGOS network



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VGOS Demo

VLBI Analysis 1/3

- Starting with vgosDB files "level4"
- ICRF3 source positions fixed
- IERS14 C04 as a priori EOP
- VMF3 with surface pressure for zenith hydrostatic delays
- Atmosphere loading corrections (Vienna APL)
- Formal errors of observation increased by 1 cm^2
- Outlier elimination based on 5-sigma test

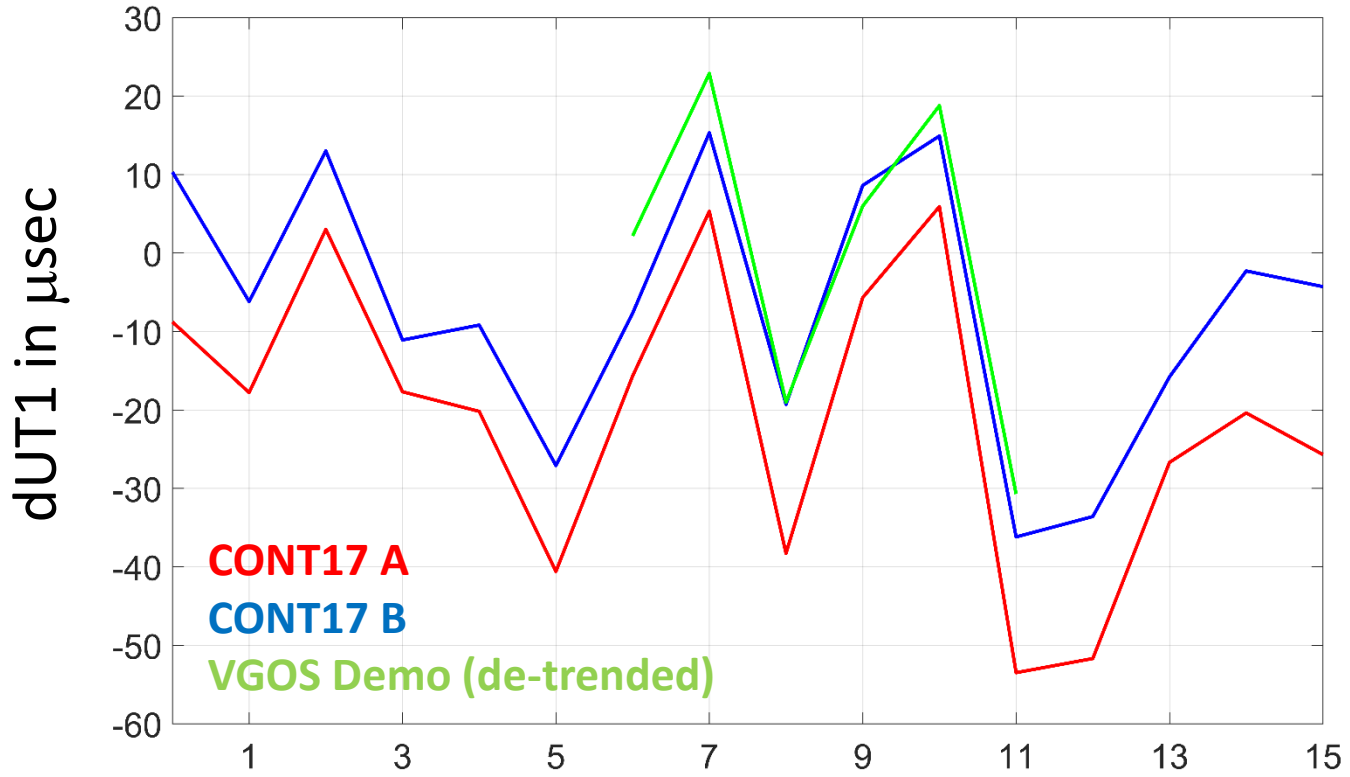
VLBI Analysis 2/3

- Auxiliary parameters estimated as piecewise linear offsets
- Additional quadratic functions estimated for clocks

	PWLO interval	relative constr.	absolute constr.
Zenith wet delay	30 min	1.5 cm	-
Gradients	180 min	0.5 mm	1 mm to 0
Clocks	60 min	1.3 cm	-

VLBI Analysis 3/3

- Global solution
  - Station coordinates w. NNR/NNT on subset of ITRF2014
  - EOP as 24 h PWLO (x-pol, y-pol, dUT1, X, Y)



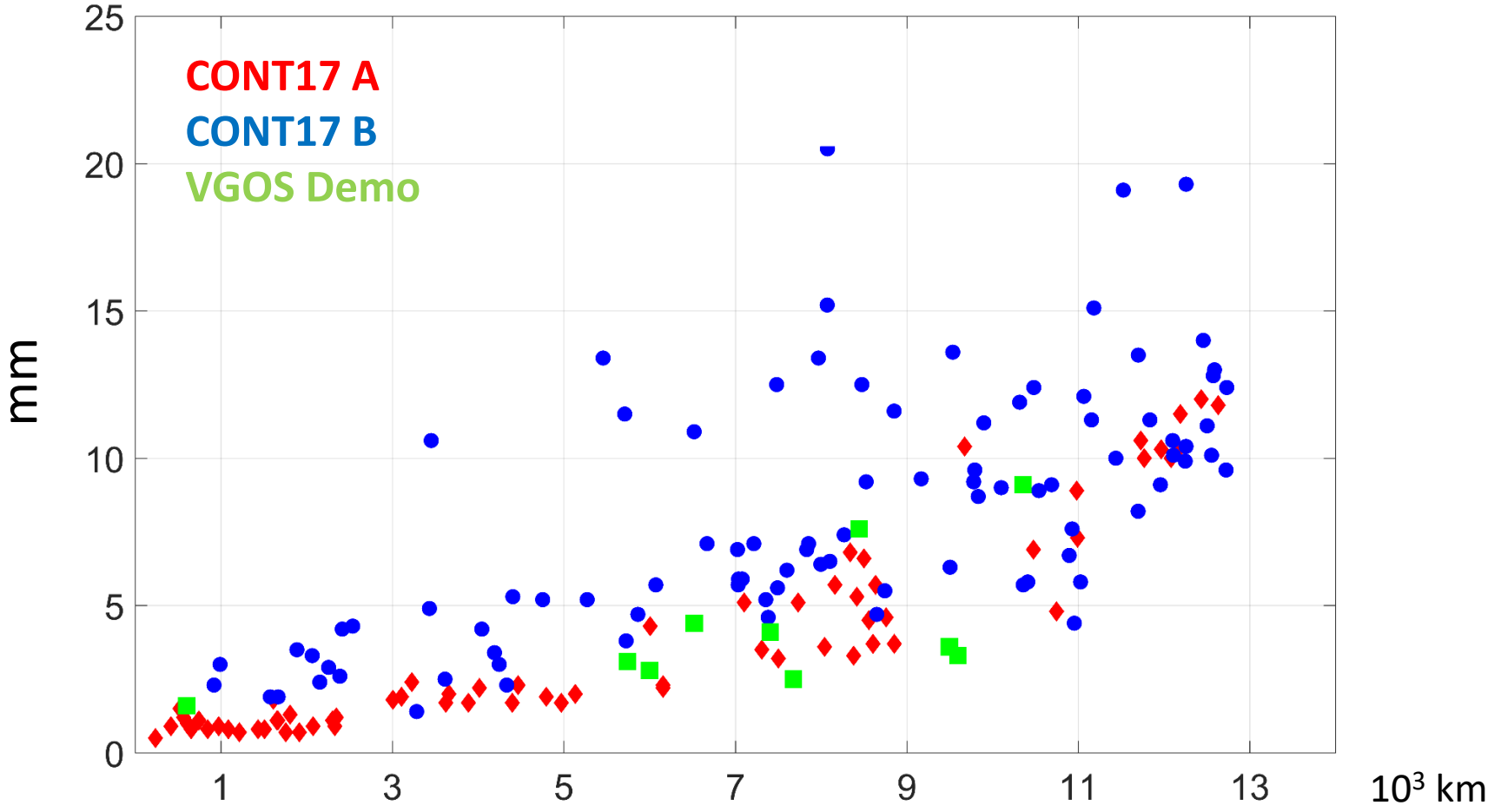
Earth orientation parameters

CONT17	x-pol µas	x-pol µas	dUT1 µs	X µas	Y µas
Formal error A	25.4	28.4	1.0	23.6	23.8
Formal error B	27.7	26.6	1.7	24.4	24.9
Std. Dev. A/B	82.7	99.3	4.6	65.8	92.2

- More in-depth analysis is required

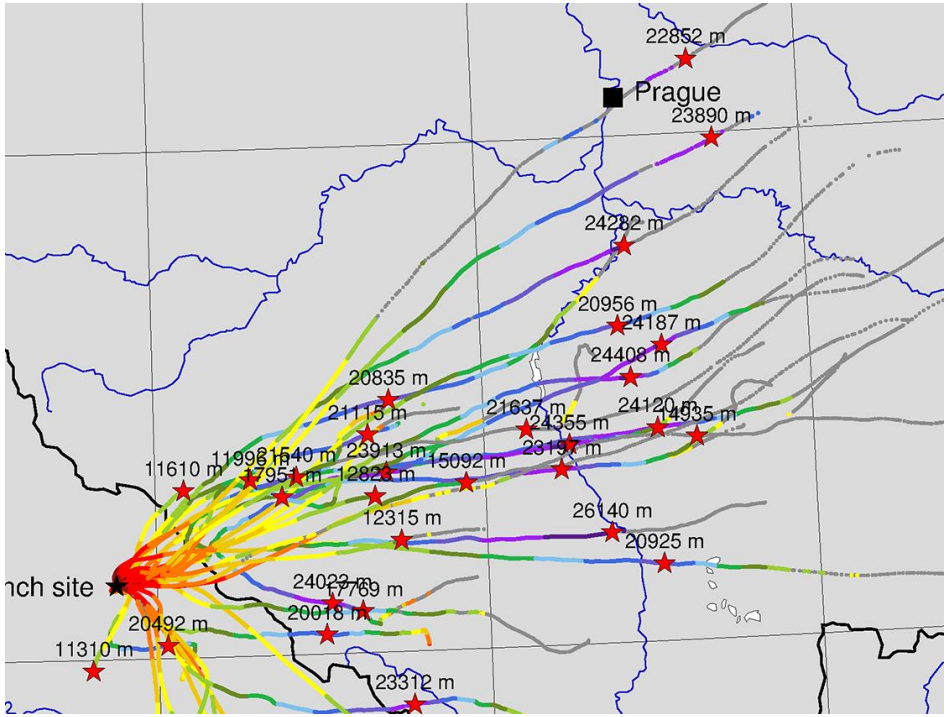
Baseline length repeatabilities

- Weighted BLR from CONT17 A and B and VGOS Demo



Tropospheric parameters

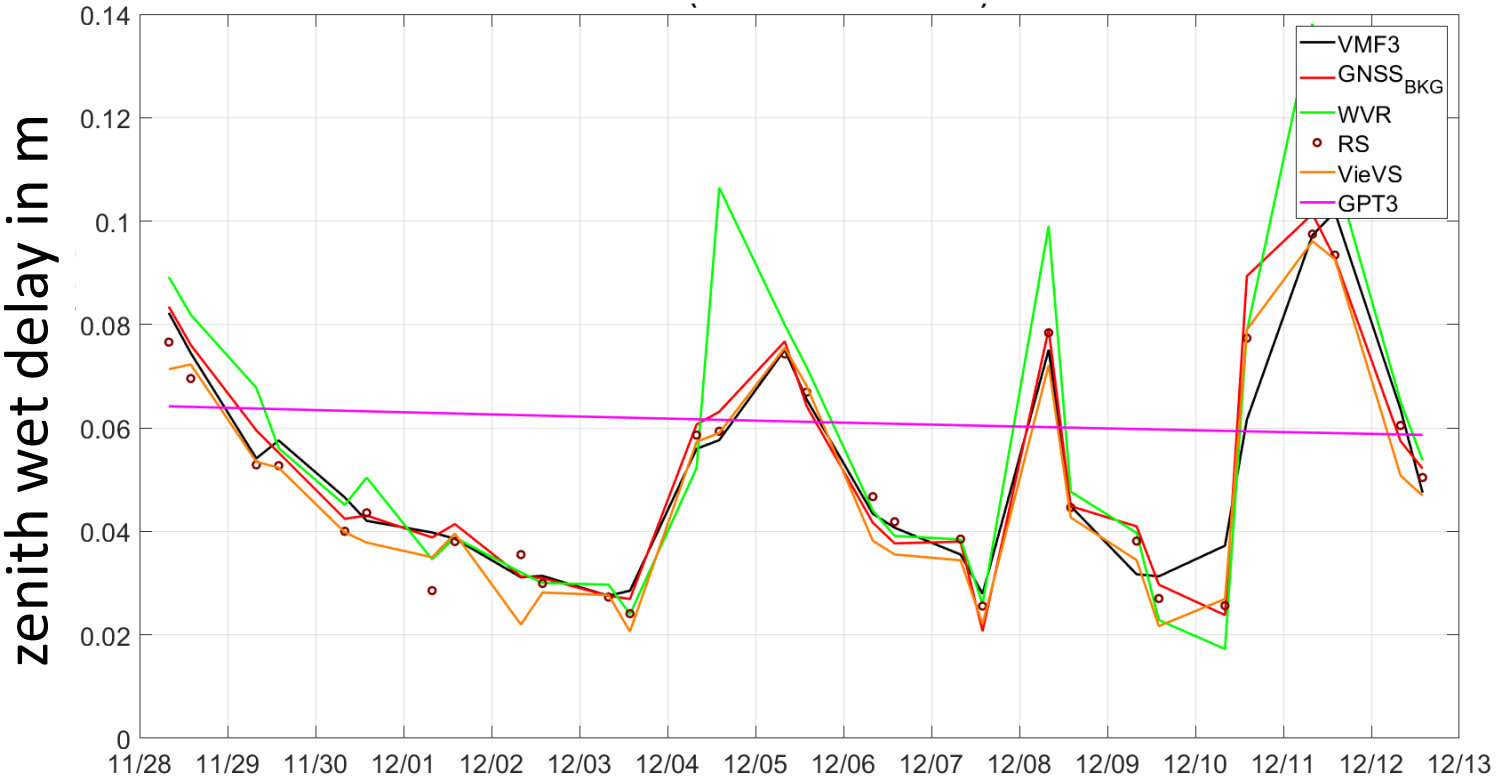
- Atmospheric data set from the Geodetic Observatory Wettzell during the CONT-17 VLBI campaign (Klügel et al., 2019)
- https://doi.pangaea.de/10.1594/PANGAEA.895518
- For example, radiosonde launches twice a day



Klügel et al., 2019

Tropospheric parameters

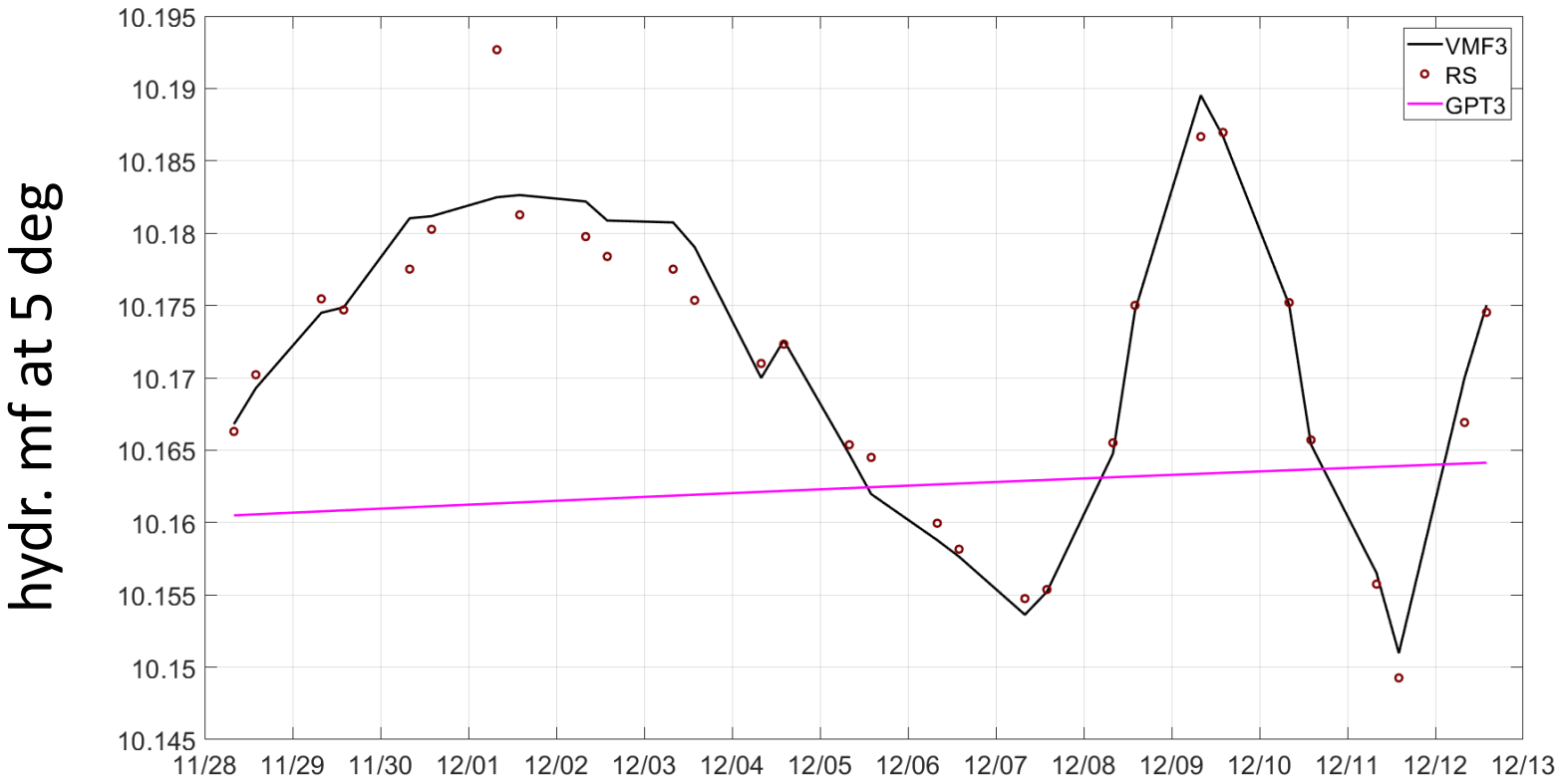
- Comparison against zenith wet delays from radiosondes (RS)



	VMF3	GNSS	VLBI	WVR	GPT3
Std. dev.:	5 mm	4 mm	4 mm	12 mm	21 mm

Tropospheric parameters

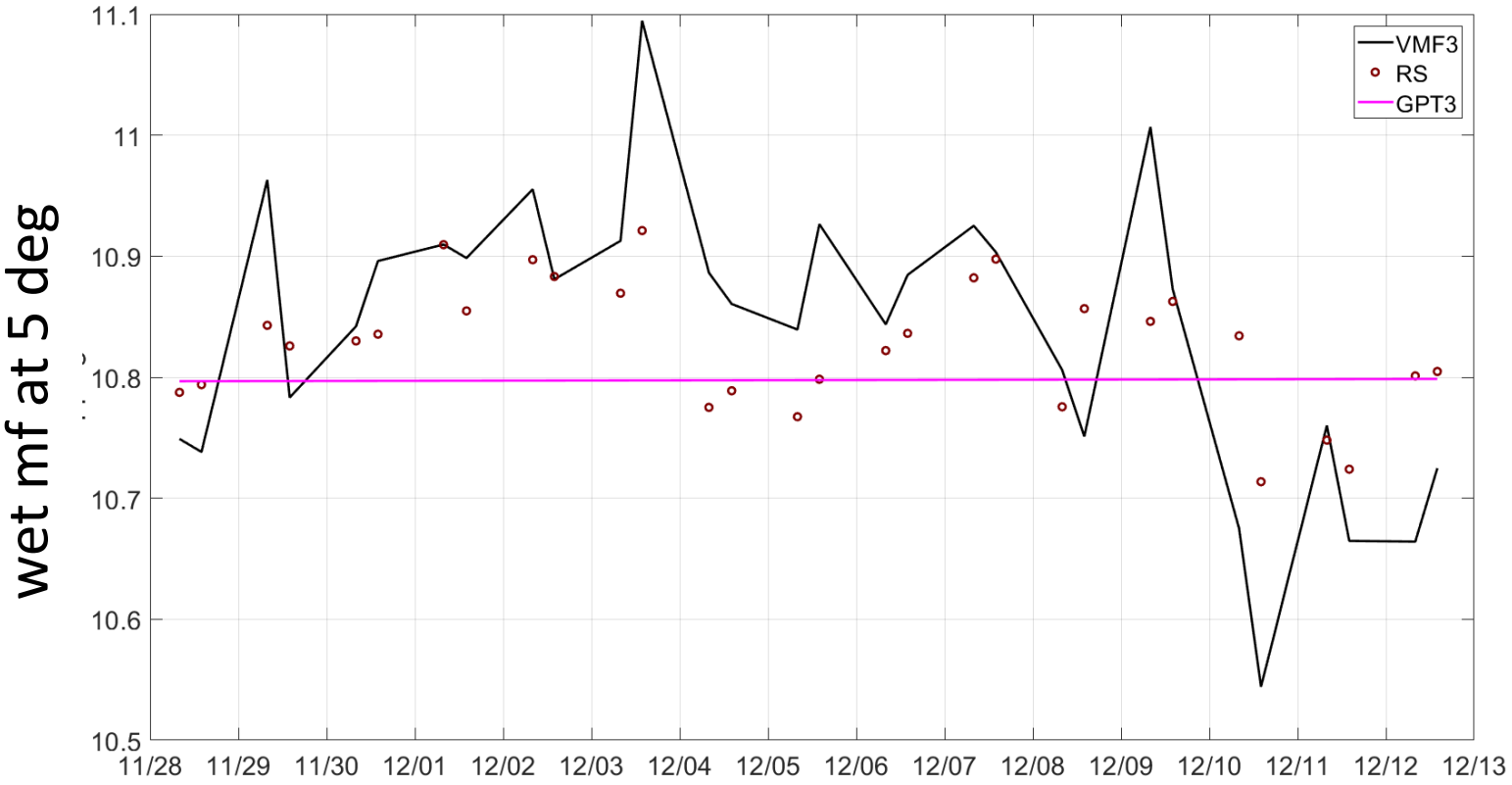
- Hydrostatic mapping functions from radiosonde data



	VMF3	GPT3
Std. dev. at 5 deg:	5 mm	23 mm

Tropospheric parameters

- Wet mapping functions from radiosonde data



	VMF3	GPT3
Std. dev. at 5 deg:	5 mm	3 mm

Schedules with VieSched++ for CONT17 B

- Multi-scheduling mode
  - more than 1000 schedules generated with various weight factors (sky-coverage, #obs, duration, ...)
  - more than 150 tested with Monte Carlo simulations (500 runs)
    - Tropospheric Turbulence
      - Scale height 2 km, Cn = $1.8 \cdot 10^{-7}$ $m^{-1/3}$
    - Clocks: random/integrated random walk 10^{-14}@50min
    - 30 ps white noise per observation

Schedules with VieSched++ for CONT17 B

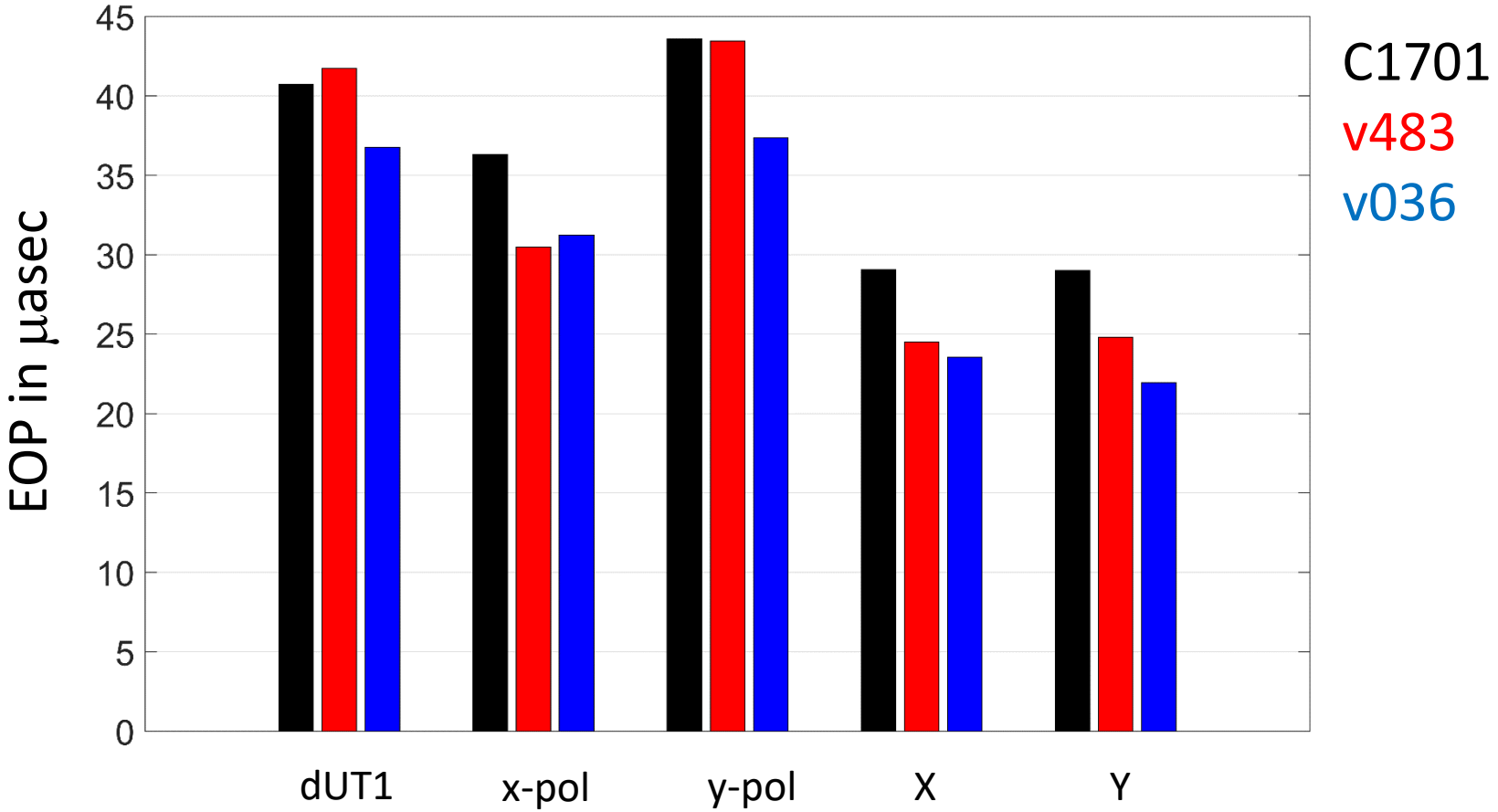
- Finally two schedules selected out of the 150 schedules
  - same source list and fluxes as sked: v483
  - extended list with good sources: v036

	# obs	# scans
C1701	13499	1499
v483*	14921	1278
v036	15094	1478

  - *1000 schedules range from 11000 to 17500 observations

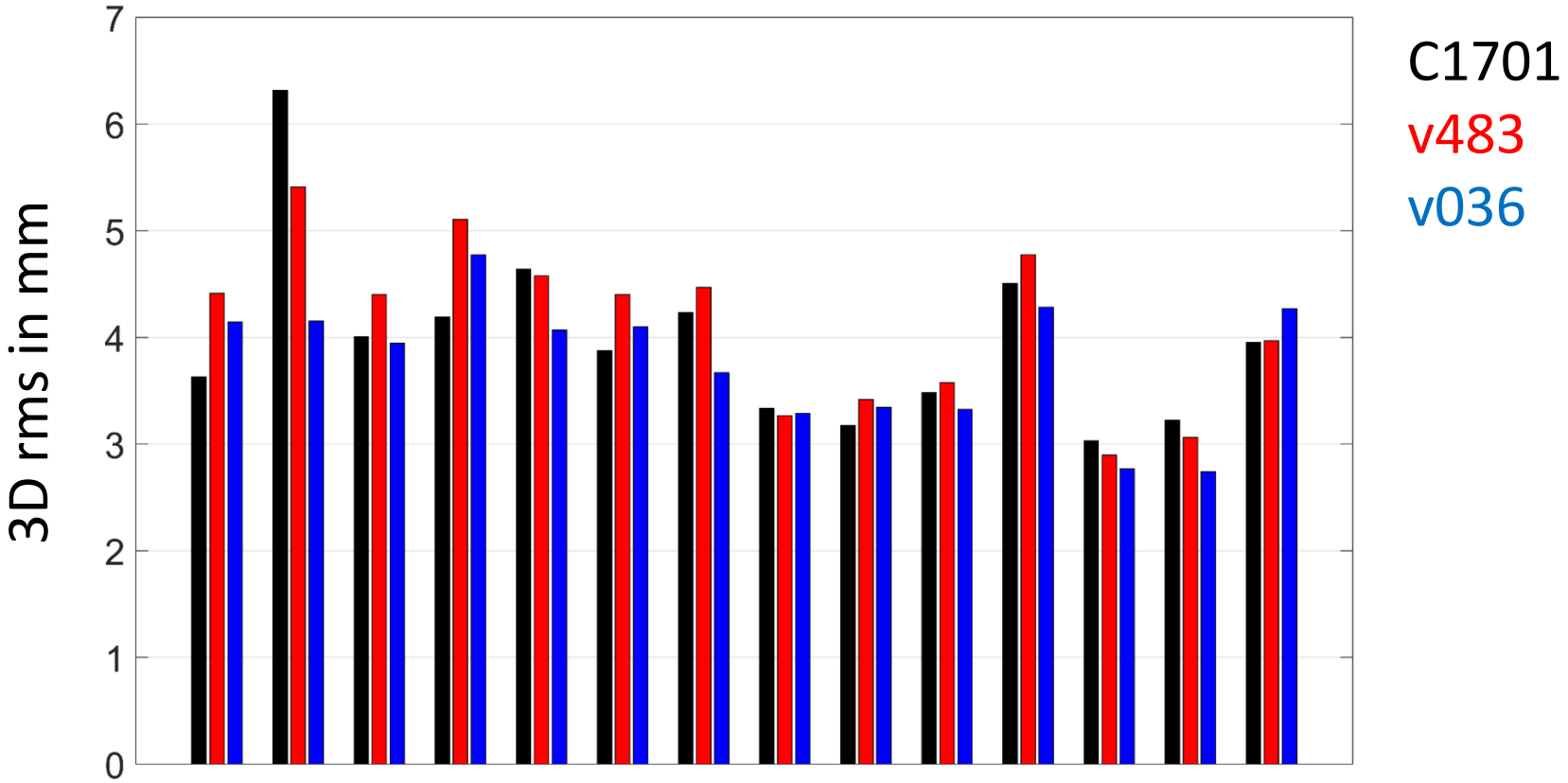
CONT17 simulations: Earth orientation parameters

- Repeatability from Monte Carlo simulation



CONT17 simulations: Earth orientation parameters

- Repeatability from Monte Carlo simulation



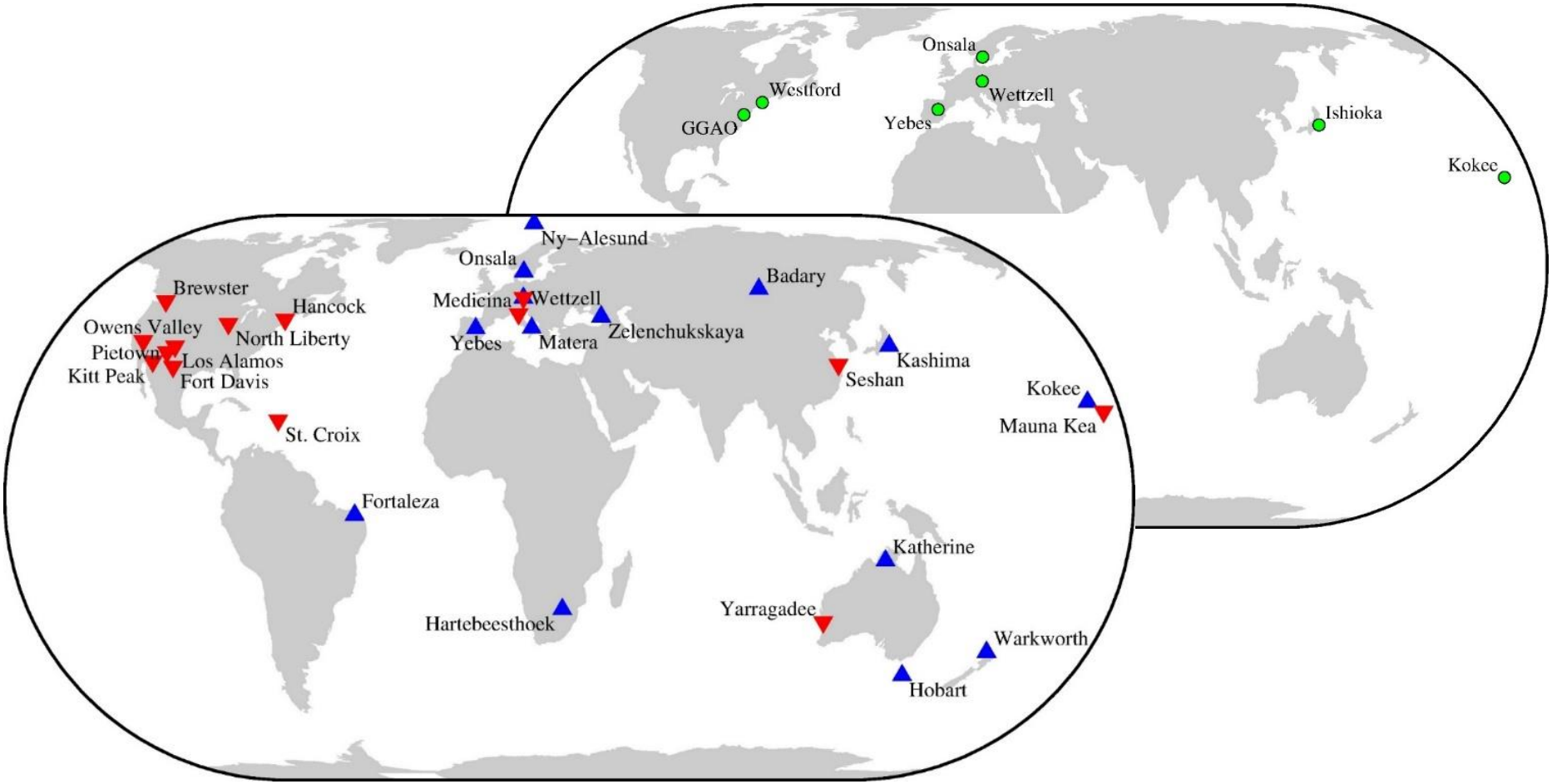
Schedules with VieSched++ for CONT17 VGOS Demo

- Core network: GGAO12M, WESTFORD, KOKEE12M, RAEGYEB
- Tagalong: ISHIOKA, ONSA13NE, ONSA13SW, WETTZ13S
- 30 seconds scans, same down-times
- Finally two schedules used
  - same source list and fluxes as sked: v066
  - extended list with good sources (> 250 mJy): v058

	# obs	# scans
17DEC03VS	12985	1180
v066	21041	1948
v058	21061	1985

Schedules with VieSched++ for CONT17 Mixed Mode

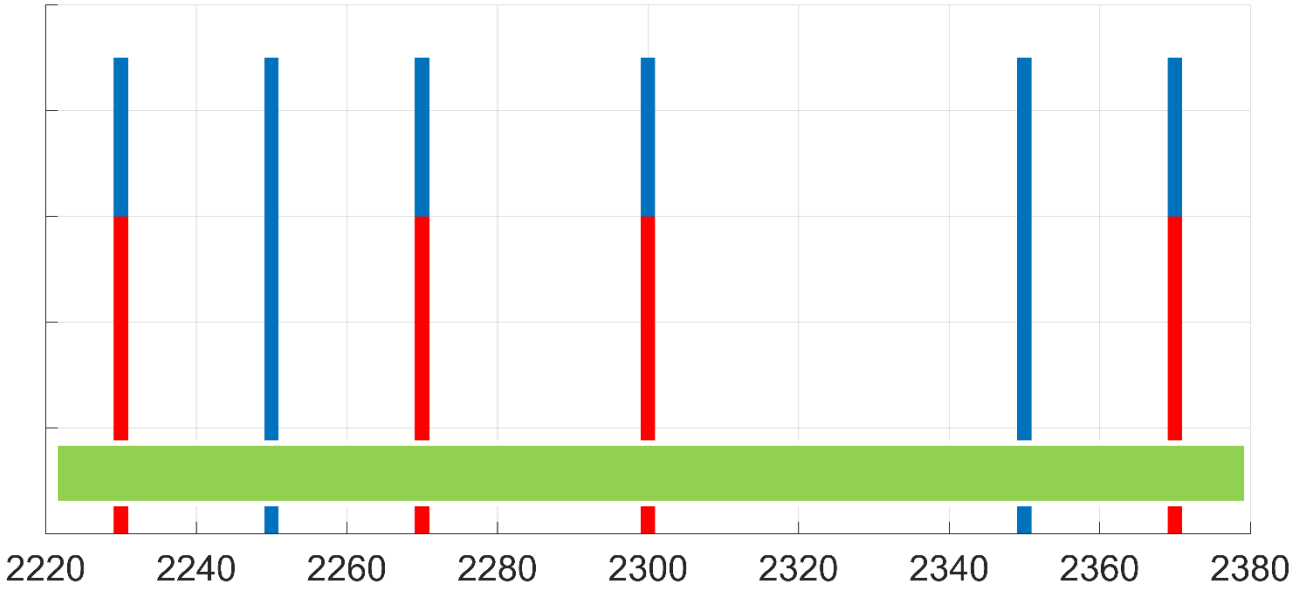
- All CONT17 stations (36 stations) for 24 hours



Schedules with VieSched++ for CONT17 Mixed Mode

- Baselines

data rate	# basel.	combination
S: 128 Mbit/s	399	XA-XA, XA-XB,XA-BR
S: 192 Mbit/s	203	XB-XB, XB-BR
S: 2048 Mbit/s	28	BR-BR

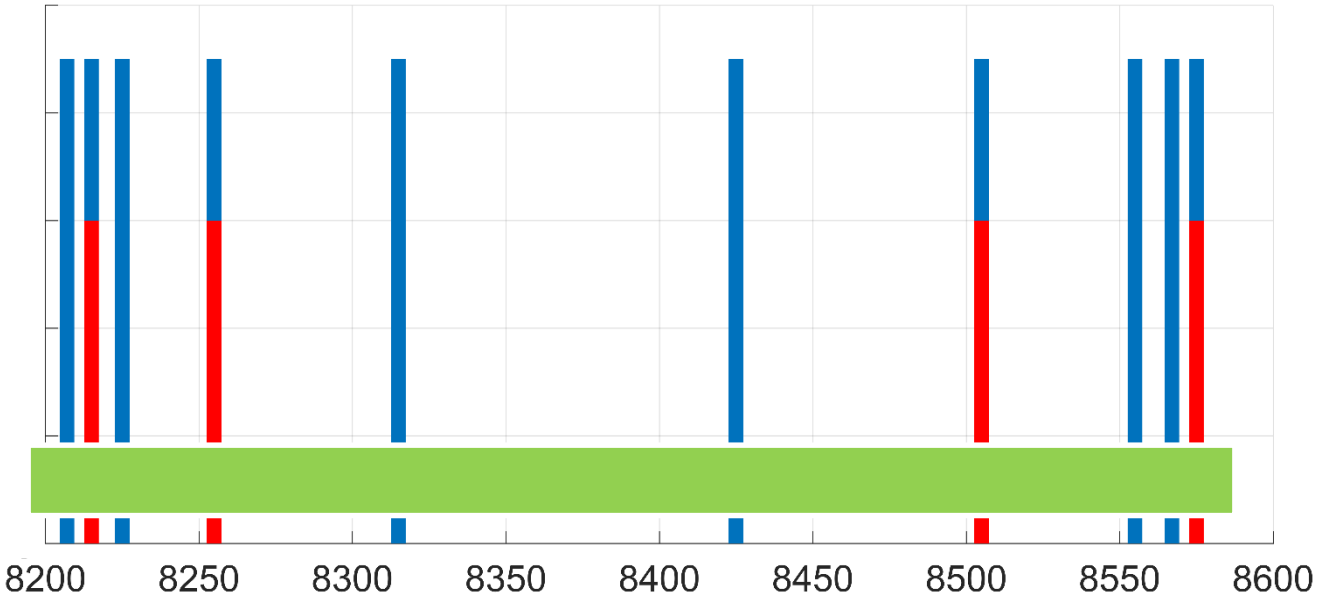


Schedules with VieSched++ for CONT17 Mixed Mode

- Baselines

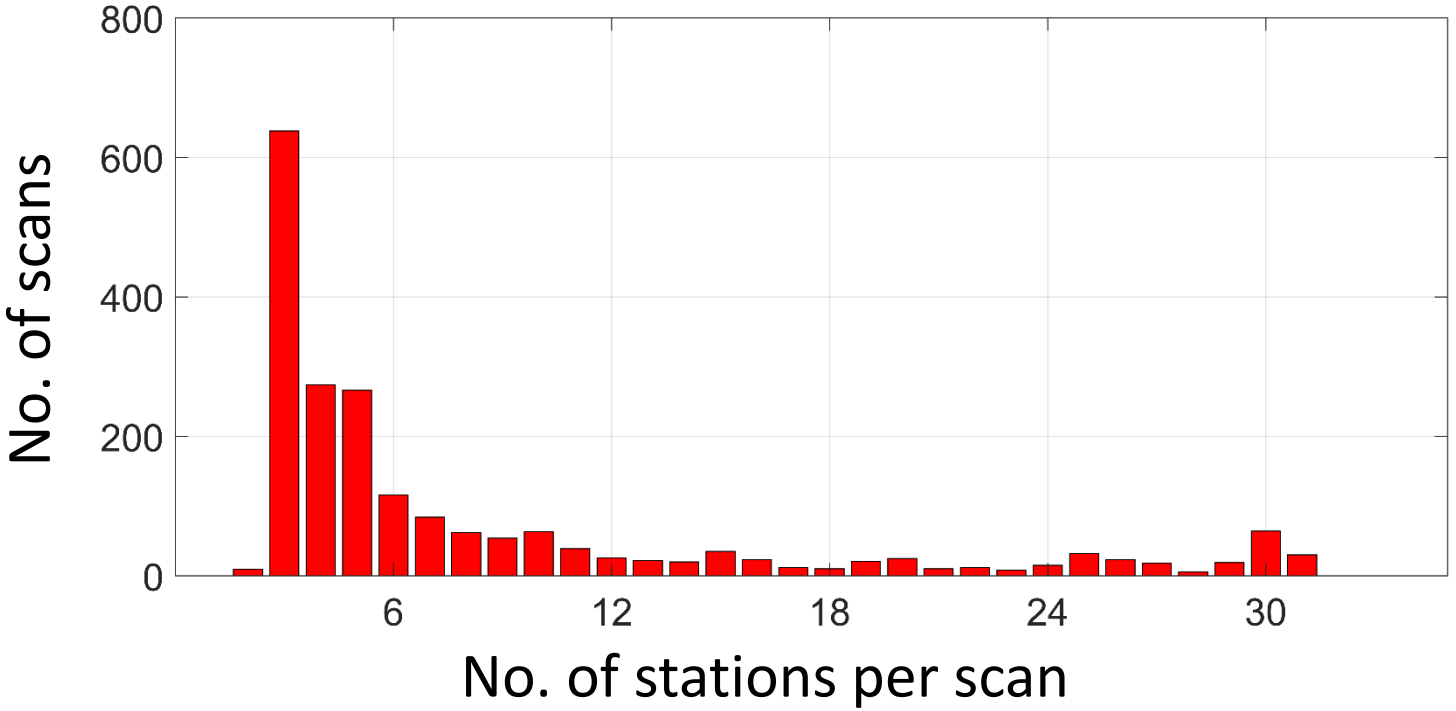
data rate	# basel.	combination
X: 128 Mbit/s	399	XA-XA, XA-XB,XA-BR
X: 320 Mbit/s	203	XB-XB, XB-BR
X: 2048 Mbit/s	28	BR-BR

We did not consider different polarizations in calculation of integration time



Schedules with VieSched++ for CONT17 Mixed Mode

- Results
  - Number of scans: 2016
  - Number of observations: 126592
  - Average idle time: 2.4 %



Schedules with VieSched++ for CONT17 Mixed Mode

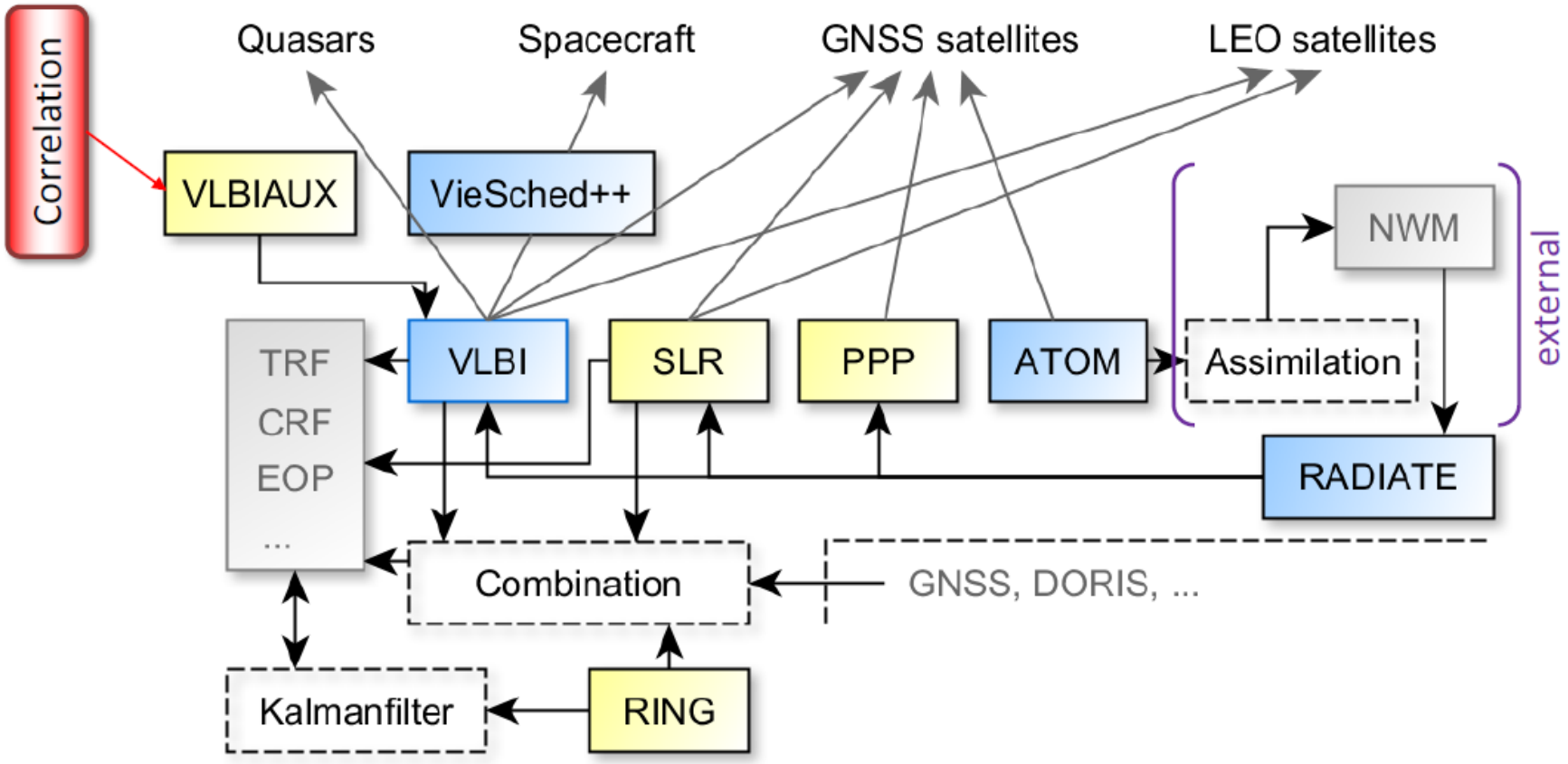
- Next steps
  - run Monte-Carlo simulations
  - adapt simulated noise per observations (now 30 ps)
- Questions
  - How to treat polarization in the calculation of the integration time?

Summary

- The Vienna VLBI and Satellite Software (VieVS) is umbrella for
  - VLBI analysis software
  - Scheduling tool VieSched++
  - Raytracing tool
  - …
- CONT17 is very good testbed to test and combine these efforts
- Could CONT2020 be observed in mixed mode?

Thanks for your attention!

Vienna VLBI and Satellite Software (VieVS)



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VieVS
Vienna VLBI and Satellite Software

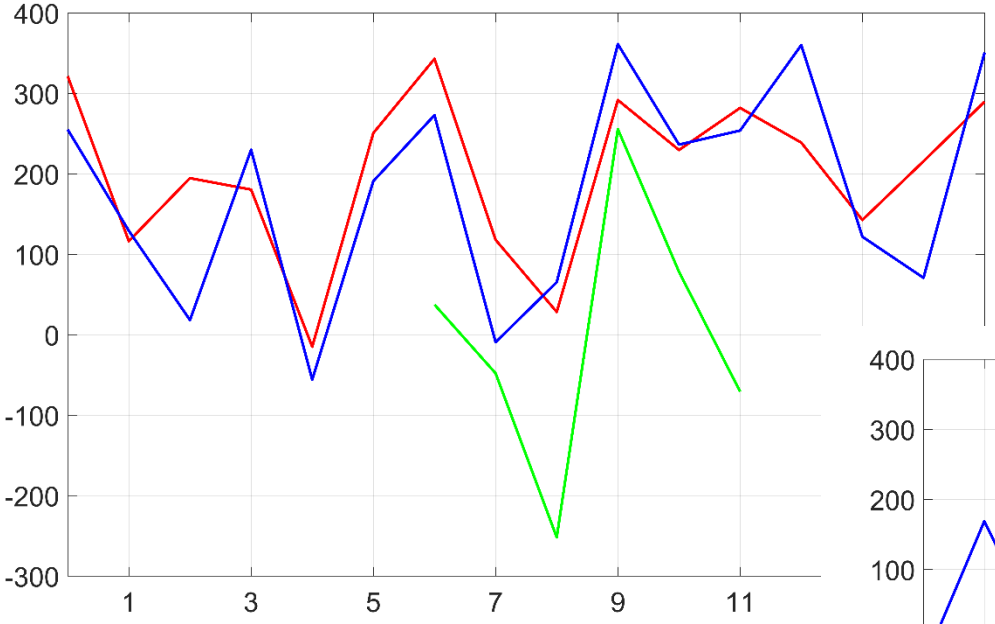
Earth orientation parameters

CONT17	x-pol µas	x-pol µas	dUT1 µs	X µas	Y µas
Formal error A	25.4	28.4	1.0	23.6	23.8
Formal error B	27.7	26.6	1.7	24.4	24.9
Bias A/B	23.5	-224.4	-13.6	-27.0	-45.5
Std. Dev. A/B	82.7	99.3	4.6	65.8	92.2

- Large residuals in some CONT17 B datum stations
- For same reason, EOP from VGOS had to be de-trended
  - we need more VGOS data to derive station coordinates

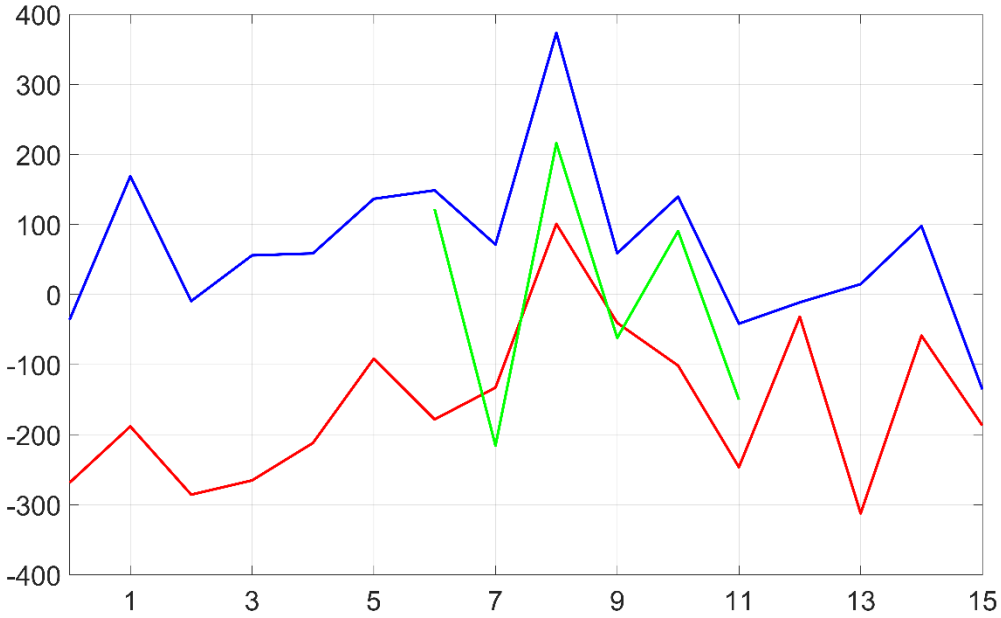
Earth Orientation Parameters

- Polar motion w.r.t. IERS14 C04 in µas



x-pol

CONT17 A
CONT17 B
VGOS Demo (de-trended)



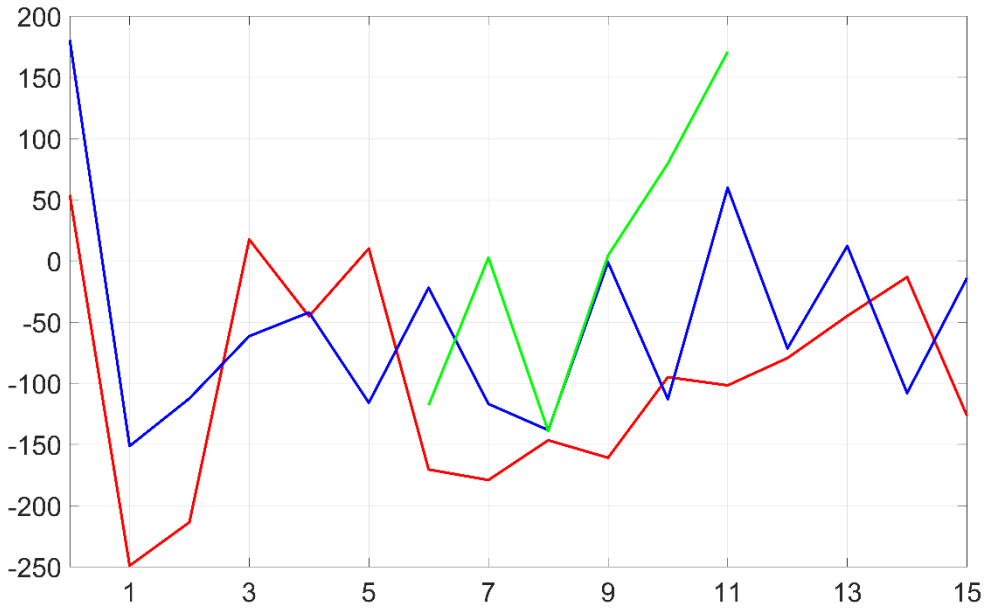
y-pol

Earth Orientation Parameters

- Celestial pole offsets w.r.t. IERS14 C04 in µas

CONT17 A
CONT17 B
VGOS Demo (de-trended)

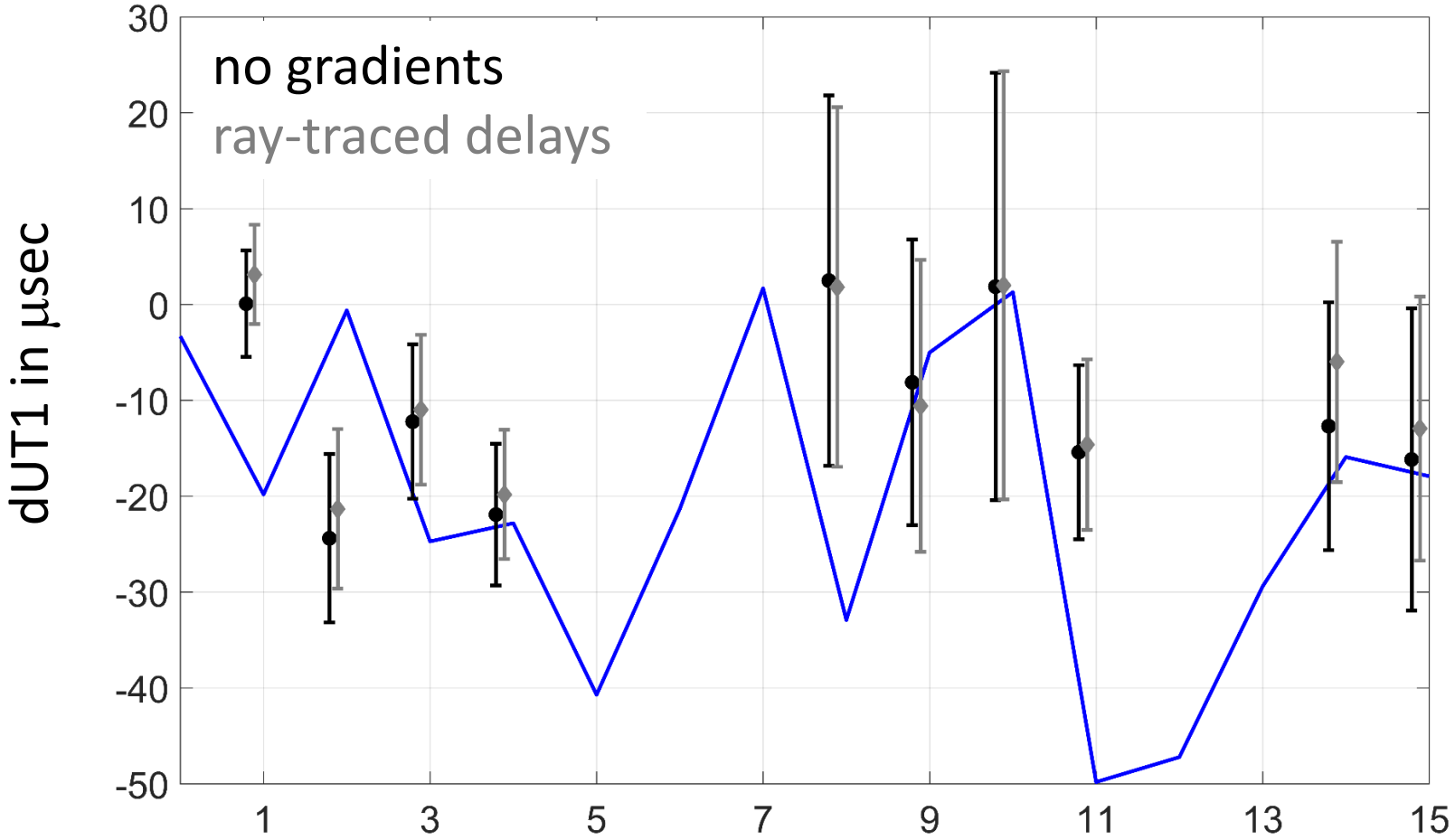
Y



X

Intensives INT1 with ray-traced delays

- Standard deviation w.r.t. CONT17 B: 11 μs (CONT17 A: 13 μs)



Tropospheric parameters

- Zenith wet delays at Wn, Wz, and Ws
- Standard deviations between series at 5 to 6 mm level