Comparison of zenith troposphere delay from different techniques

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Each observatory of the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA RAS) in Svetloe, Badary and Zelenchuk is equipped by **VLBI** (very long baseline interferometry), **GNSS** and **WVR** (water vapor radiometer) instruments. The measurements of all of those techniques are routinely processed in IAA RAS using the software developed in the institute. In this poster some comparison of obtained ZPD from the data collected during **CONT2017** VLBI campaign is shown.

IAA RAS observatories: Svetloe, Zelenchuk, Badary

Each observatory is a space geodesy co-location station equipped with VLBI antennas (32m and 13 m) GNSS multi-system receivers, SLR-systems, weather station and water vapor radiometers. There is also the DORIS beacon at Badary. Each space geodetic instrument is connected to the H-maser standard.

CONT 2017 campaign

Campaign goal [1]:
"The plan for the CONT17 campaign is to acquire state-of-the-art VLBI data over a time period of about two weeks to demonstrate *the highest accuracy* of which the legacy S/X VLBI system is capable".
28 VLBI telescopes. Nov. 28, 2017 00:00:00 UT – Dec. 12, 2017 23:59:59 UT

VLBI-processing

- Program package **QUASAR** [4]. Developed in IAA RAS.
- Mainly all the physical and astronomical models correspond to IERS recommendations.
- Solution method is least-squares collocation [5].
- Troposphere modelling:
  - Dry: Zenith delay calculation Saastamoinen formula
  - Wet: Linear trend + stochastic signal.
  - Mapping function: Niell mapping function [6]

GNSS-processing

- Program package **GRAPE** [2]. Developed in IAA RAS
- Mainly all the physical and astronomical models correspond to IGS and IERS recommendations.
- Solution method is two-group least-squares.
- Operating regime: daily processing of 24-h observations of global network of about 140 GNSS stations with 30s step
- Troposphere parametrization: total zenith delay with GMF mapping function [3]

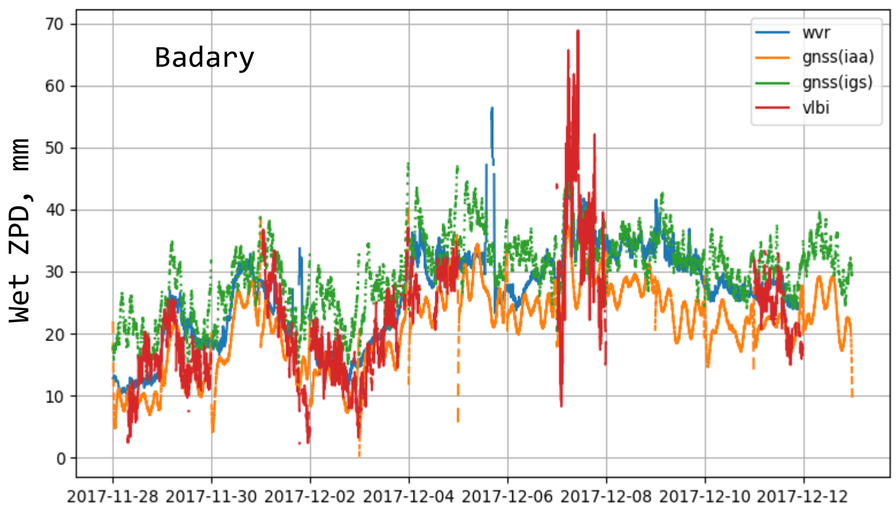
Water Vapor Radiometer

- Developed and built in IAA RAS.
- WVR measures atmospheric brightness temperature at K and Ka bands.
- WVR processing software: operation of the device, calibration, filtration of raw data, calculation of the total slant vapor and water content and wet troposphere delay. [7,8]

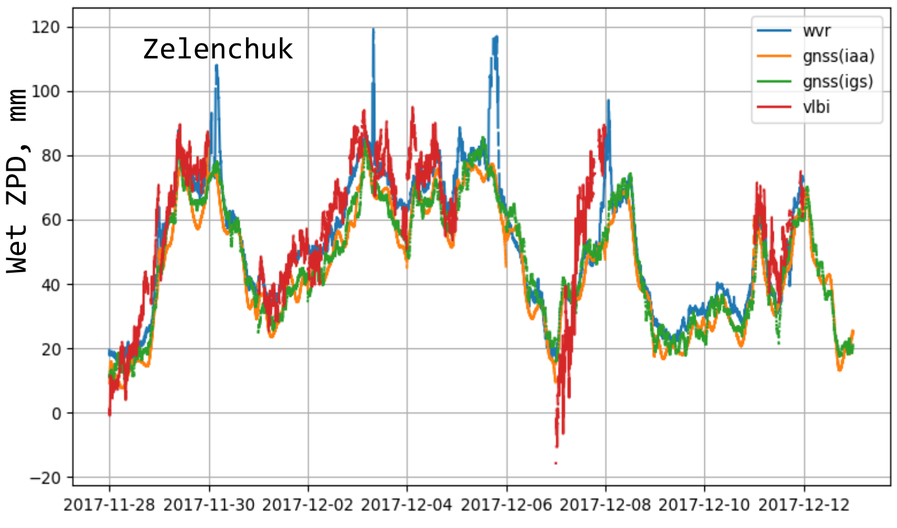
IGS Troposphere data

"The Final Troposphere products are produced using a PPP method and GMF mapping functions with the Bernese software. The expected latency is 3 weeks dependent on the availability of the IGS Final orbits, clock, etc." [9]

Results



Site	Diff	Bias, mm	StD, mm
Badary	GNSS IAA–IGS	-8.8	3.4
	GNSS–VLBI	-3.0	6.3
	GNSS–WVR	-5.1	3.4



Site	Diff	Bias, mm	StD, mm
Zelenchuk	GNSS IAA–IGS	1.7	4.2
	GNSS–VLBI	-9.2	9.9
	GNSS–WVR	-6.2	5.4

Summary

- **'Most accurate' VLBI results are less accurate than GNSS and WVR**
- **WVR is very sensitive to raw data processing parameters, additional study of processing algorithm is needed**
- **There are the biases between all the series different for each station**
- **Additional verification of GNSS processing models is needed**

References

1. https://ivscc.gsfc.nasa.gov/program/cont17/
2. Suvorkin V., Kurdubov S., Gayazov I. GNSS processing in Institute of Applied Astronomy RAS // Proceedings of the Journées 2014 "Systèmes de Référence Spatio-Temporels" Z. Malkin and N. Capitaine (eds), Pulkovo observatory, 252-253 (2015)
3. Boehm J.; Niell A.; Tregoning P., Schuh H. Global Mapping Function (GMF): A new empirical mapping function based on numerical weather model data // Geophysical Research Letters — Vol. 33. L01603 (2006)
4. Gubanov V, Kurdubov S. Tidal deformations of the Earth from VLBI observations. Astronomy Letters, 38 (2012) 10.1134/S1063773712050027.
5. Moritz H. Least-squares collocation, Rev. Geophys., 16(3), 421–430, (1978) doi: 10.1029/RG016i003p00421.
6. Niell A. Global mapping functions for the atmosphere delay at radio wavelengths // J. Geophys. Res. Vol. 101. — P. 3227. (1996)
7. Ilyin G., Troitsky A. Determining the Tropospheric Delay of a Radio Signal by the Radiometric Method. Radiophysics and Quantum Electronics. Vol. 60: Iss.4, p.291-299. (2017) https://doi.org/10.1007/s11141-017-9799-6
8. Rüeger J. Refractive Index Formulae for RadioWaves. JS28: Integration of Techniques and Corrections to Achieve Accurate Engineering, FIG XXII International Congress, Washington, DC, April 19-26 (2002)
9. Byram S. [IGSMAIL-6443] IGS Final Troposphere product transition to USNO