IAA VLBI Analysis Center 2017–2018 Biennial Report

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Abstract This report presents an overview of the IAA VLBI Analysis Center activities during 2017 and 2018, its current status, and its future plans.

1 General Information

The IAA IVS Analysis Center (IAA AC) operates at the Institute of Applied Astronomy of the Russian Academy of Sciences in St. Petersburg, Russia. The IAA AC contributes to IVS products, such as daily SINEX files, TRF- and CRF-solutions, rapid and long-term series of EOP and tropospheric parameters, which are obtained from the IVS observational sessions. The IAA AC also converts NGS files from Mark III DBH (beginning from version 3). We stopped submitting NGS files to IVS because IVS started using the VGOS format since the middle of 2018. The IAA AC has started to convert NGS files from the VGOS format since the end of year 2018 for QUASAR and OCCAM/GROSS software usage. Besides IVS VLBI data, IAA AC processes domestic observations produced by both the RT-32 radio telescopes (SVETLOE, ZELENCHK, and BADARY) and the RT-13 VGOS radio telescopes (ZELRT13V, BADRT13V, and SVERT13V).

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2 Activities during the Past Years

During 2017 and 2018, the IAA AC analyzed the data of IVS and domestic observations and made some investigations.

2.1 Rapid Analysis

In 2017 and 2018, the IAA AC continued to generate daily SINEX (DSNX) files from the analysis of IVS-R1 and IVS-R4 sessions using QUASAR software. Some delay in operational data analysis was due to the IVS transition to the new VGOS data format. DSNX files were submitted to the IVS for combination with the results of other Analysis Centers. The IAA AC processed the 24-hour and Intensive VLBI sessions using OCCAM/GROSS software and submitted the results to IERS and IVS on a regular basis.

2.2 Global Solution

Several celestial reference frame (CRF) solutions have been calculated with the QUASAR software. The latest CRF catalog, submitted for the ICRF3 prototype research, contains 4,466 radio sources with three or more observations. It was calculated from analysis of 6,202 daily VLBI sessions (13,093,744 observational delays) observed from 1980 through March 2018.

A new global solution was calculated using 5,713 sessions from April 1979 through December 2018. A total of 11,107,906 delays were processed. The stochastic parts of the signals (for WZD and clock offsets) were estimated using the least-squares collocation technique (LSC). The radio source coordinates, station coordinates, and velocities were estimated as global parameters. EOP, troposphere gradients, and polynomial coefficients for WZD and station clocks were considered as arc parameters for each session. We prepared a new source position catalog iaa2019a.crf for 4,214 sources and a station position and velocity catalog iaa2019a.trf for 214 stations.

2.3 Data Analysis from Domestic VLBI Observations

The IAA Analysis Center processes all the observational data of domestic VLBI programs RuE, RI, R, and test sessions. Table 1 presents the main types of Russian domestic sessions at X/S range. The standard IVS designation of the stations is used in the table: Sv – Svetloe, Zc – Zelenchukskaya, and Bd – Badary for RT-32 and Bv – Badary, Zv – Zelenchukskaya, and Sw – Svetloe for RT-13. Test 0.5-hour sessions named RX over the S/X/Ka range were performed once a day as a rule, on the baseline BvZv.

Observational data from all these sessions are transmitted to the correlators using e-VLBI data transfer. The processing of RI sessions is fully automated. The calculated UT1-UTC time series is available at [1]. The EOP time series calculated from RuE data is available at [2].

In 2017 and 2018, 78 RuE and 735 RI sessions were observed. During 2017–2018 the new Badary-Zelenchukskaya VGOS radio interferometer observed 2,687 R domestic program one-hour sessions. For the R sessions, the dUT1 RMS with respect to IERS series finals.dat is about 35 μs.

Coordinates for the new radio telescopes (ZELRT13V and BADRT13V) were improved from the set of 22 series of 24-hour sessions on the five station network SVETLOE, ZELENCHK, BADARY, ZELRT13V, and BADRT13V. The SVERT13V positions were improved from one six-station session on November 22, 2018. The results are given in Table 2. RT-13 station velocities were fixed for the solution by the values from ITRF2014 for corresponding RT-32 antennas.

Table 2 RT-13 station positions at 2010.0 epoch.

Station	ZELRT13V	BADRT13V	SVERT13V
X, m	3451257.389	-838326.608	2730074.965
	± 0.001	± 0.002	± 0.001
Y, m	3060268.147	3865797.208	1562230.721
	± 0.003	± 0.003	± 0.010
Z, m	4391933.204	4987598.308	5530072.747
	± 0.004	± 0.004	± 0.010

2.4 UT1 Series Combination from Set of IVS Intensive Sessions

Our first attempt to combine IVS Intensive SINEX files using SINCOM software [3] has been made. A series of UT1 was built for 385 IVS Intensive 2017–2018 sessions. BKG, GSF, IAA, and USNO SINEX files were used. The RMS, after removal of the bias of the difference between the computed UT1 series and IERS C04, is 32 μs, with finals.dat - 20 μs. The difference between the combined UT1 series with C04 and finals is shown in Figure 1.

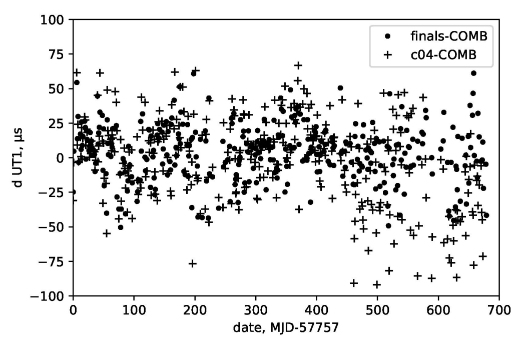

Fig. 1 The difference between the combined UT1 and IERS series (C04 and finals).

2.5 Covariance Functions for Stochastic Signals for LSC on Hourly Intervals

Covariance functions are used in the processing of VLBI measurements to determine the stochastic sig-

Table 1 Domestic X/S range session description.

Program	RI	RuE	R	RI(RT13)
Network	BdZc(Sv)	SvZcBd	ZvBv(Sw)	ZvBv
Duration, hours	1	24	1	1
Aim	dUT1	EOP	dUT1	dUT1
Turn-around time, hours	2	120	2–6	2–6
Schedule	daily	weekly	3–7 times a day	daily
Start time, UT	20:00	Fri, 20:00		20:00
Scan duration, s	22-127	60	10	22-127
Sources set	150 (>0.25 Jy)	60 (>0.5 Jy)	156	150 (>0.25 Jy)
Sour.number per session	20	50	60	20
Sampling, bit	1	1	2	1
Bandwidth, MHz	8	8	512	512
Data rate, Mbit/s	256	256	2048	2048
Scan number	25	350	120	25
Number of observations	25	1000	45–120	25
Correlator	IAA ARC	IAA ARC	RASFX, DiFX	RASFX, DiFX

nals of clock offset and troposphere delay (WZD) with the QUASAR software. Average covariance functions for WZD were constructed from the data of the Badary station Water Vapor Radiometer. The clock covariance function was constructed from the data analysis of the clock offsets. The parameters of the function used by the QUASAR software were refined according to the results of VLBI session processing from 1980–2018. In the left part of Figure 2, the covariance functions of the troposphere are presented over the daily and hourly intervals (the bottom and the upper part of the figure, respectively). The covariance functions of the clock (the right-hand picture) at the daily and hourly intervals (the bottom and the upper part of the figure, respectively) are shown below.

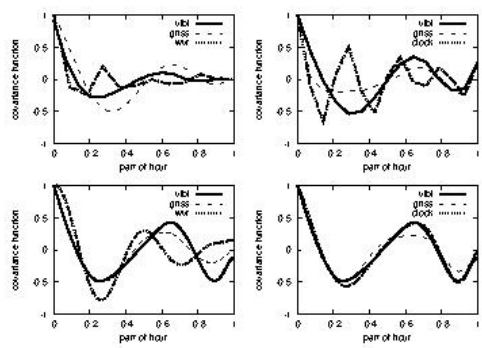

Fig. 2 Covariance functions for WZD (left column plots) and clocks (right column) over hourly (upper row) and daily (bottom row) intervals.

2.6 Intensive Session Scheduling Study

Studies aimed at improving the scheduling for the Intensive sessions were made. A new improved algorithm for the covariance matrix optimization strategy was proposed. The numerical simulations were performed in order to compare the algorithm proposed with the algorithms implemented in the Sked software [5] and VieVS (The Vienna VLBI and Satellite) software [6]. It was shown that, using the improved algorithm, one can obtain better variance of the ΔUT1 parameter.

3 Current Status

The IAA AC processes the data of all kinds of VLBI geodetic observation sessions. We use the QUASAR and the OCCAM/GROSS types of software for VLBI data analysis. All the observation models in these packages conform to the IERS Conventions (2010). Both packages use NGS files as input data. The QUASAR and the OCCAM/GROSS software packages are supported and are being developed. Some modifications were made to QUASAR and OCCAM/GROSS.

The IAA AC staff are:

- Sergey Kurdubov: the development of the QUASAR and the analysis software.
- Prof. Vadim Gubanov: the development of the QUASAR software and the methods of stochastic parameter estimation.
- Elena Skurikhina: the team coordination; VLBI data processing, and OCCAM/GROSS software development.
- Svetlana Mironova, PhD Student: the development of the QUASAR software, VLBI data processing, global solution and DSNX file calculation, data combination with SINCOM software.
- Alexey Kudelkin, PhD Student: the development of the new technique of scheduling VLBI observations.

4 Future Plans

- To continue submitting all types of IVS product contributions.
- To continue investigations of EOP, station coordinates, and tropospheric parameter time series.
- To improve algorithms and software for processing VLBI observations.
- To continue studying in the field of improving the scheduling technique.

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