IAA VLBI Analysis Center 2015–2016 Biennial Report

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Abstract This report presents an overview of the IAA VLBI Analysis Center activities in 2015 and 2016 and our future plans.

1 General Information

The IAA IVS Analysis Center (IAA AC) operates in the Institute of Applied Astronomy of the Russian Academy of Sciences, 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 generates and submits to IVS NGS files transformed from Mark III DBH files.

Besides IVS VLBI data, IAA AC processes domestic observations produced by both the RT32 radio telescopes (Svetloe, Zelenchukskaya, and Badary) and the new RT13 new generation radio telescopes located at the Zelenchukskaya and Badary observatories.

2 Staff

- Sergey Kurdubov: development of the QUASAR software, global solutions, and DSNX file calculation.
- Prof. Vadim Gubanov: development of the QUASAR software and development of the methods of stochastic parameter estimation.
- Elena Skurikhina: team coordination; VLBI data processing, and OCCAM/GROSS software development.
- Svetlana Mironova, PhD Student: development of the QUASAR software, global solutions, and DSNX file calculation.

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3 Activities during the Past Two Years

3.1 Routine Analysis

In 2015 and 2016, the IAA AC continued to generate daily SINEX (DSNX) files from analysis of IVS-R1 and IVS-R4 sessions using the QUASAR software. DSNX files are submitted to the IVS for combination with results from other Analysis Centers.

The IAA AC operationally processed the 24-hour and Intensive VLBI sessions using OCCAM/GROSS software and submitted the results to the IERS and the IVS on a regular basis. Processing of the Intensive sessions is fully automated.

Calculation of new EOP time series with ITRF2014 is performed.

3.2 Global Solution

A new global solution was calculated using all available IVS VLBI data from November 1979 to May 2016. A total of 7,877,714 delays were processed.

The CRF was fixed by NNR constraints to 212 radio sources. The TRF was fixed by NNR and NNT constraints to the station positions and velocities of 15 stations: BR-VLBA, FD-VLBA, FORTLEZA, HN-VLBA, KP-VLBA, LA-VLBA, MATERA, NL-VLBA, ALGOPARK, WESTFORD, WETTZELL, HARTRAO, KOKEE, NYALES20, and ONSALA60. Stochastic signals were estimated by means of the least-squares collocation technique. The radio source coordinates, station coordinates, and corresponding velocities were estimated as global parameters. EOP, WZD, troposphere gradients, and station clocks were considered as arc parameters for each session. The following 6,732 global parameters were determined: 3,258 source positions, the positions and the velocities of 117 VLBI stations, and 23 position and velocity discontinuities. A station position catalog containing 132 stations was calculated as well.

We prepared a new source position catalog, iaa-sx-161013-b.cat, as one of the catalogs that were created for the IERS/IVS ICRF3 Working Group. Differences between the coordinates of iaa-sx-161013-b.cat and ICRF2 are approximately at the same level as differences between other catalogs and ICRF2. Formal uncertainties in declination and right ascension of sources observed at least 100 times do not exceed 1 mas.

3.3 EOP Parameter Calculation from Domestic Observations

The IAA Analysis Center processes all observational data of domestic VLBI programs Ru-E, Ru-I, R, and test sessions. Table 1 presents the main types of Russian domestic sessions. 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 and Zv – Zelenchukskaya for RT-13.

Observational data from all of these sessions are transmitted to the correlators using e-VLBI data transfer. The data of 24-hour sessions are shipped to the IAA correlator on disk modules only from the "Svetloe" observatory. The processing of Ru-I sessions is fully automated. A calculated UT1-UTC time series is available at ftp://quasar.ipa.nw.ru/pub/EOS/IAA/eopi-ru.dat. The EOP time series calculated from Ru-E data is available at ftp://quasar.ipa.nw.ru/pub/EOS/IAA/eops-ru.dat.

Table 1 Specifications of the Russian domestic sessions.

Program	Ru-I	Ru-E	R
Stations	BdZc(Sv)	SvZcBd	ZvBv
Duration, hours	1	24	0.5–1
Aim	dUT1	EOP	dUT1
Turn-around time	2 hours	3–5 days	2–6 hours
Schedule	daily 20:00 UT	weekly Fri 22:00 UT	3–7 times per day
Range	X/S	X/S	X/S
Scan duration, s	22–127	60	10
Sources set	150(>0.25 Jy)	60 (>0.5 Jy)	156
Num sources/sess	20	50	60
Sampling	1-bit	1-bit	2-bit
Bandwidth, MHz	8	8	512
Data rate, Mbit/s	256	256	2048
Number scans	25	300–350	120
Number obs.	25	1000	120
Correlator	IAA ARC	IAA ARC	RASFX, DiFX

In 2015 and 2016, 72 Ru-E and 735 Ru-U sessions were observed. The accuracy of EOPs estimated by the IAA AC from the analysis of these observations in comparison to the IERS EOP 14 C04 series for two years is presented in Table 2.

Table 2 RMS differences with respect to EOP IERS 14 C04.

EOP	N_{sess}	Bias	RMS
X_p, mas	72	−0.23	0.84
Y_p, mas	72	0.12	1.25
UT1-UTC, μs	72	15	44
X_c, mas	72	0.31	0.43
Y_c, mas	72	−0.09	0.45
UT1-UTC Int., μs	735	−0.07	43

In 2015–2016, the new Badary–Zelenchukskaya VGOS radio interferometer observed 1,515 one-hour sessions in the scope of the R domestic program. The UT1-UTC accuracy obtained from these observations is about 30 μs. Preliminary coordinates of the new RT-13 radio telescopes (ZELRT13V and BADRT13V) were estimated from test sessions with one baseline, and then the coordinates were improved using the series of 24-hour sessions that observed the five station network of SVETLOE, ZELENCHK, BADARY, ZELRT13V, and BADRT13V. The results are presented in Table 3. The following fixed velocity values have been used for the solution: $v_x = -0.0222$ m/year, $v_y = 0.0144$ m/year, and $v_z = 0.0092$ m/year for Zelenchukskaya and $v_x = -0.0281$ m/year, $v_y = 0.0009$ m/year, and $v_z = -0.0020$ m/year for Badary.

Table 3 RT-13 station positions at 2005.0 epoch.

Coordinate	Zelenchukskaya	Badary
X, m	3451257.503 ± 0.002	−838326.468 ± 0.002
Y, m	3060268.061 ± 0.002	3865797.199 ± 0.004
Z, m	4391933.124 ± 0.003	4987598.314 ± 0.007

3.4 Earth Tidal Deformation Study

Some investigations were made in the field of solid Earth tidal deformation at the limit of the capabilities of modern astronomical and geodetic observations. We obtained corrections to the theoretical values of frequency-dependent tidal parameters (Love/Shida numbers) from the analysis of all available IVS VLBI observations for the period 1980–2014. The frequency dependence of these parameters is caused by resonance effects due to Retrograde Free Core Nutation (RFCN). On the whole, our results confirm the high precision model of the Earth tides as it is represented in the modern international astronomical and geodetic standards IERS Conventions (2010). However, some harmonics of lunisolar tide generating potential are in significant disagreement. Thus, the estimate of the real part of Love number h for the K_1 harmonic with a frequency of 1 cycle per sidereal day (cpsd) equals $\Delta h^R = -0.0142 \pm 0.0006$. This may indicate the existence of a deeper resonance in the diurnal tides than it is predicted by the theory.

4 Current Status

The IAA AC processes the data of all kinds of VLBI geodetic observation sessions. We use the QUASAR and the OCCAM/GROSS softwares for VLBI data analysis. All observation models in these packages are compliant with 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 have been made to QUASAR. Memory allocation was changed from static to dynamic due to the number of delays having grown in single sessions. This makes it possible to use almost all of the memory system of a computer.

5 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 contribute to the ICRF3 Working Group studies.