SAI VLBI Analysis Center Report 2009

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Abstract

This report presents an overview of the SAI VLBI Analysis Center activities during 2009 and the plans for 2010. The SAI AC analyzes all IVS sessions for computation of the Earth orientation parameters (EOP), time series of source positions at the scope of future realizations of the ICRF, makes submissions of data and analysis products, and performs research and software development aimed at improving the VLBI technique.

1. General Information

The SAI VLBI Analysis Center is located at Sternberg State Astronomical Institute of Lomonosov Moscow State University in Moscow, Russia. The Analysis Center participates in geodetic and astrometric VLBI analysis, software development, and research aimed at improving the VLBI technique.

2. Component Description

The SAI AC performs data processing of all kinds of VLBI observation sessions. For VLBI data analysis we use the ARIADNA software package developed at SAI. All reductions are performed in agreement with the IERS Conventions (2003).

Our package uses files in the NGS format as input data.

3. Staff

- Vladimir Zharov, Prof.: development of the ARIADNA software, development of the methods of parameter estimation.
- Mark Kaufman, scientific researcher: development of the ARIADNA software, solutions, and analysis
- Dmitry Duev, post-graduate student: VLBI data processing, troposphere modeling
- Nikolay Voronkov, scientific researcher: global solutions

4. Current Status and Activities

- **Software development for VLBI processing**

  The ARIADNA software is being developed to provide contributions to IVS products. The software is used for calculating all types of IVS products.

- **Routine analysis**

  During 2009 the routine data processing was performed with the ARIADNA software using the least-squares method with constraints. The SAI AC operationally processed the 24-hour and Intensive VLBI sessions. The formation of data bases for the VLBI sessions and the processing of all sessions is fully automated. The EOP series sai2008a.eops and sai2008a.eopi were continued. These series were computed with the catalog ITRF2005 of station positions and velocities.

Differences Δ between the EOP from solutions sai2008a.eops and EOP05C04 and the variance σ of each difference are shown in Table 1. The values of Δ are WRMS estimates for the period 1984—2008.

Table 1. Difference between EOP from solutions sai2008a.eops and EOP05C04 and variance.

EOP	Δ	σ
$x, \mu as$	-66	272
$y, \mu as$	-54	281
$UT1 - UTC, \mu s$	-2	13
$\Delta\psi \sin\varepsilon, \mu as$	-49	437
$\Delta\varepsilon, \mu as$	7	206

- **Global solution**

  During 2009 software to obtain a global solution was developed and tested by N. Voronkov. Data for 2008 were processed. The radio source coordinates and velocities and the station coordinates and velocities were estimated as global parameters. EOP, troposphere wet zenith delay (approximated as a polynomial function), troposphere gradients, and station clocks (approximated as a polynomial function) were estimated as arc parameters for each session.

  The variance σ_1 of differences between the EOP from solution sai2008a.eops and gsf2008a.eops and σ_2 between global solution and gsf2008a.eops are shown in Table 2.

Table 2. Comparison of EOP (solution sai2008a.eops and global solution for 2008) to solution gsf2008a.eops.

EOP	σ_1	σ_2
$x, \mu as$	260	30
$y, \mu as$	390	30
$UT1 - UTC, \mu s$	7	0.8
$\Delta\psi \sin\varepsilon, \mu as$	600	30
$\Delta\varepsilon, \mu as$	250	10

- **Participation in the IERS/IVS Working Group on the Second Realization of the ICRF**

  Time series of frequently observed sources were calculated using the ARIADNA software. Source positions for every source were obtained from a solution for each VLBI 24-hour session. A priori source positions were taken from the ICRF-Ext.2 catalog. Corrections of the coordinates of defining sources were calculated with the NNR constraint, and coordinate corrections for other sources were calculated without this constraint.

It was shown that some of the radio sources, including the defining sources, show significant apparent motion [1]. The method of approximation of time series of coordinates by polynomial models was used, and a few methods to select stable radio sources were suggested [2]. The linear and uniform motion of sources has been explained by the precession of jet. Some of the sources demonstrate non-uniform motion related to the acceleration processes of the matter in jets.

The motion of the defining sources leads to a rotation of the celestial reference frame axes. To improve the stability of the ICRF, we suggested additional principles for the generation of the new ICRF catalog [3]. The new selection criteria are based on not only statistical properties of the position time series but also on physical properties of the quasars. It was shown that inclusion of a subset of sources formed on the basis of cosmological criteria makes stability of the ICRF better. The main conclusion of our work is that any new catalog of reference radio sources has to contain both coordinates and apparent motions.

- **Troposphere modeling**

  At the stations with missing meteorological data, we used surface data files (temporal coverage: four times daily; spatial coverage: a 2.5 degree latitude x 2.5 degree longitude global grid) from NCEP/NCAR Reanalysis (http://www.cdc.noaa.gov/data/gridded/data.ncep.reanalysis.surface.html) for calculating air temperature, pressure and relative humidity. For that purpose a program was written to interpolate these data to the given coordinates of the station at the time of the observations.

  For calculating the atmospheric path delay, a sophisticated tool was developed (D. Duev). It uses the ray-tracing technique through the NOAA NCEP/NCAR Reanalysis I numerical weather model (3-D pressure level data). Transformation of meteorological parameters (temperature, pressure, and relative humidity) into refractive index was made with the help of the MPM93 model. The tool developed performs slightly better (or at least not worse) than results based on Vienna Mapping Functions I (VMF1) and Niell Mapping Functions (NMF) which are widely used in VLBI and GPS analysis. The increase of spatial and temporal resolution of the NMW will immediately improve the quality of results obtained with our tool.

5. Future Plans

We plan to:

- Continue to submit all types of IVS product contributions and to start to submit SINEX files both for IVS 24-hour and Intensive sessions.
- Continue investigations of VLBI estimation of EOP, station coordinates, and troposphere parameters, and comparison with satellite techniques.
- Continue studies in the framework of the Third Realization of the ICRF.
- Further improve algorithms and software for processing VLBI observations.

References

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[2] V. E. Zharov, M. V. Sazhin, V. N. Sementsov, K. V. Kuimov, O. S. Sazhina, N. T. Ashimbaeva. The celestial reference frame stability and apparent motions of the radio sources. In "Relativity in Fundamental astronomy: dinamics, reference frames and data analysis". Proc. of the IAU Symp. 261. Ed. by S. A. Klioner, P. K. Seidelmann and M. H. Soffel 2010, Cambridge Univ. Press, p. 50-55.

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