IAA VLBI Analysis Center Report for 1998-1999

Zinovy Malkin, Elena Skurikhina, George Krasinsky, Vadim Gubanov, Igor Surkis, Alexander Stotskii

Abstract

The report contains a brief overview of IAA activity as IVS Analysis Center in 1998-1999 and our plans for near future in the following fields: EOP service, investigation of short-time irregularities in Earth rotation, atmosphere investigations, combination of VLBI data with ones obtained with other space geodesy techniques, comparison of EOP series and software. Results of investigations obtained during period March 1998 – March 1999 are presented.

1. Introduction

Four groups of four labs of the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA) have been involved in processing of the VLBI observations:

1. Lab of Space Geodesy and Earth Rotation: Dr. Zinovy Malkin (head), Elena Skurikhina, Dr. Alexander Voinov, Dr. Mariya Sokolskaya. The main tasks of this group related to IVS activity are: management of the IAA EOP Service, determination of EOP and station coordinates using OCCAM package, combination of VLBI data with other ones, comparison of EOP series and software. Recently ERA package is under installation in the lab, too. See section 2 for more details.

2. Lab of Ephemeris Astronomy: Dr. George Krasinsky (head). The main tasks of this group related to IVS activity are: determination of EOP, station and source coordinates using ERA package [1], combination of VLBI data with SLR and LLR. See sections 2 and 3 for more details.

3. Lab of New Methods in Astrometry and Geodynamics: Prof. Vadim Gubanov (head), Igor Surkis, Sergei Petrov. The main tasks of this group related to IVS activity are: determination of EOP, station and source coordinates using new package QUASAR with emphasis on investigation of stochastic parameters (EOP, troposphere). See section 4 for more details.

4. Laboratory of Radio Physics: Prof. Alexander Stotskii. The main task of this group related to IVS activity is investigation of the Earth atmosphere path delay fluctuations. See section 5 for more details.

2. EOP Service

EOP Service of the IAA based on regular processing of VLBI observations collected from NEOS-A program is being worked beginning from 1997. Package OCCAM is used for routine processing. Both operative and yearly final EOP series have been regularly contributed to IERS.

Last final solution EOP(IAA)99R01 is based on NEOS-A VLBI observations from 05-May-1993 till 16-Mar-1999 (306 sessions with 7 days interval). The solution was obtained using OCCAM package v. 3.5 developed during last year. Model of reduction follows IERS Conventions (1996) except relativistic correction which was computed according to IERS Standards (1992). Celestial reference frame was fixed to RSC(IAA)99R02 (see section 3). Wet tropospheric delays and clock offsets were modeled as random walk stochastic process and estimated using Kalman filter technique. Wettzell was used as reference station for most sessions. Pole coordinates, UT1–UTC and nutation angles have been estimated. Terrestrial reference frame ITRF97 with the associated velocity field was used for station coordinates.

Random and especially systematic accuracy of this series have been significantly improved as compared with previous solution obtained with OCCAM v. 3.4.

In 1999 the first global solution with package ERA was obtained. Solution includes two series EOP(IAA)99R02 and RSC(IAA)99R02 and based on processing VLBI observations, made in the frame of NEOS-A program (251 sessions observed in 1994–1998). The following data are presented: EOP (X, Y, UT1, dPsi, dEps), a catalog of 301 sources, and estimated corrections to the sine and cosine coefficients of eight short-periodic terms in UT1 as given by Ray theory (see section 3). After determining the EOP, time scale and atmospheric extra-path delay parameters from diurnal sessions, the observations for each of the five years were processed simultaneously and as a result the improved coordinates of the sources and participated stations were obtained. Coordinates of the station NRAO20 as well as the longitude and latitude of the station Wettzell were fixed. The process was iterated until convergence was reached. Then the resulting catalog of 301 quasars was obtained by averaging the coordinates from the five annual catalogs.

Estimations of accuracy of both EOP series are given in Table 1.

Table 1. Estimated accuracy of the IAA EOP series

Series	X_p, mas	Y_p	$UT1$, 0.1 ms	$\Delta\psi$, mas	$\Delta\varepsilon$, mas
EOP(IAA)99R01	0.22	0.19	0.11	0.35	0.16
EOP(IAA)99R02	0.30	0.29	0.11	0.57	0.22

In the near future we are going to focus our researches on development software, improvement of our analysis products, combination of VLBI EOP (and later SSC) series with ones obtained with satellite techniques, comparison of OCCAM, ERA (and later QUASAR) packages. It is planned also to provide daily coordinate solutions in parallel to operative EOP series. In addition to NEOS-A, observations of other programs will be included in processing, too.

3. Ocean Tidal Effects in Universal Time

Geodetic VLBI observations of 1984-1998 have been processed to estimate eight diurnal and semi-diurnal terms in UT induced by oceanic tides. The estimates were obtained independently for each of the 13 annual time intervals and then their time behavior was studied. We have used VLBI observations of 1984-1998 carried out in the frame of IRIS, CDP and NEOS-A programs (about 530,000 observations excluding for some technical reasons the years 1987 and 1992).

All stages of processing were carried out with the help of the universal program package ERA designed for solving ephemeris and dynamic problem of various types (see [1]). First the observations of each diurnal session were processed separately considering coordinates of stations and quasars as known parameters. In this step we estimated coefficients of a polynomial approximation of the atmospheric delays and the clock behavior, as well as five EOP parameters with their diurnal trends. In the second step the observations of every year were treated simultaneously to estimate corrections to the coordinates of stars and quasars, and corrections to eight ocean tidal terms in UT (sine and cosine components). The theory of the ocean tides, recommended by IERS standards, was used as a nominal model.

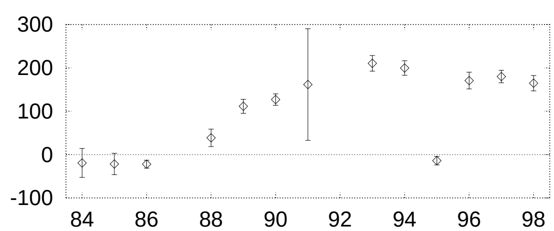
The station NRAO20 was chosen as a reference after the year 1994; for the earlier dates Westford was used as reference station. As constraints we fixed the longitude and latitude of the station Wettzell. The two steps were repeated until convergence was reached. RMS of residuals of the annual series change from 35 ps to 50 ps (for the old observations).

The corrections obtained after averaging the annual estimates of the tidal terms are given in Table 2.

Table 2. Corrections to diurnal and semi-diurnal terms in UT (in μs).

Tide	l	l'	F	D	Ω	θ	sin	σ	cos	σ
Q_1	-1	0	-2	0	-2	1	-0.2	0.2	0.3	0.1
O_1	0	0	-2	0	-2	1	-0.4	0.1	0.0	0.2
P_1	0	0	-2	2	-2	1	0.3	0.3	0.1	0.3
K_1	0	0	0	0	0	1	0.1	0.4	-0.9	0.7
N_2	-1	0	-2	0	-2	2	-0.4	0.2	0.0	0.2
M_2	0	0	-2	0	-2	2	0.2	0.2	0.6	0.3
S_2	0	0	-2	2	-2	2	0.1	0.3	0.3	0.1
K_2	0	0	0	0	0	2	0.9	0.3	-0.1	0.3

The corrections are small affirming the high accuracy of the nominal model. However, some of them are statistically significant. It is interesting to study repeatability of the corrections for every year. For that the phases of the largest corrections ($K_1 and K_2$ tides) are presented in Fig. 1.



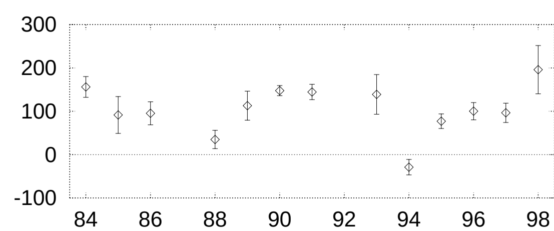


Figure 1. Tides K_1 (left) and K_2 (right): time dependence of phases of corrections.

One can see that the corrections are strongly correlated. Moreover, for K_1 the phase slowly changes with time.

4. Package QUASAR for Processing VLBI Observations

New program package QUASAR designed for scientific studies based upon VLBI observations on global networks is being developed during last year. Calculation of (O-C) values are made in line with the IERS Conventions (1996), they are referred to the ICRF celestial reference frame and the ITRF96 terrestrial reference frame. Parameters are evaluated by means of the least squares colocation technique. Stochastic parameters are as follows:

a) sub-diurnal fluctuations of the wet tropospheric delay in zenith for all the stations;

b) sub-diurnal variations of hydrogen masers phase for all the stations with respect to a reference station;

c) nearly-diurnal variation of polar motion and Universal time due to geophysical effects.

Main part of the package is already completed and applied for analysis of the CONT'94 campaign. Among the achieved results, the most interesting are the estimates of regular and stochastic components of the wet tropospheric delay for station ONSALA in good agreement with independent WVR-measurements. Important is the fact that taking into account the stochastic parameters decreases by several times the RMS of the residual deviations of the data model and makes them closer to the formal errors given in the Mark III files.

5. Modeling of the Earth Atmosphere Path Delay Fluctuations

In the previous years the model of spatial/temporal structure function of the electrical thickness of the Earth neutral atmosphere was developed [2]. Last solution is presented in Fig. 2.

The model consists of three domains:
(I) – power-law of 5/3 described three-dimensional small scale turbulence;
(II) – power-low of 2/3 for two-dimensional large scale turbulence;
(III) – saturation of random fluctuations and regular variations.
The model parameters - structure coefficients, domain boundaries, and the relationship between spatial and temporal structure functions was defined from radioastronomical and radiosonde measurements. Next year plan is to use the results of VLBI experiments for refine the model parameters and for further improvement of the model especially in the large scale region of the spatial structure function.

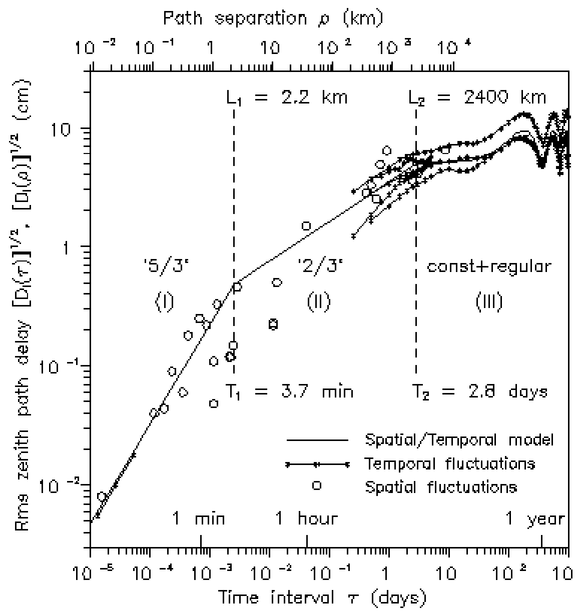


Figure 2. The model of the Earth atmosphere electrical thickness fluctuations.

References

[1] Krasinsky G. A., Vasilyev M. V.: ERA: Knowledge base for ephemeris and dynamical astronomy. In: Proc. IAA Coll. 165, Poznan, Poland, Kluwer Acad. Publ., 239–244, 1997.

[2] Stotskii A. A.: Propagation delay fluctuations in the Earth troposphere: random and regular components. In: Proc. 11th Working Meeting on European VLBI for Geodesy and Astrometry, Onsala, 1996, 83–88, 1996