OPERATIVE EOP ACTIVITIES IN VNIIFTRI

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ABSTRACT. VNIIFTRI as the Russian Main Metrological Center of Time, Frequencies and Earth Rotation Service carried out the EOP activities for many years. The brief information about these activities is presented.

1. INTRODUCTION

VNIIFTRI as the Russian Main Metrological Center of Time, Frequencies and Earth Rotation Service carried out the rapid EOP processing based on GNSS, VLBI and SLR observations for many years.

VNIIFTRI takes participation in GNSS and SLR observations of IGS and ILRS too.

The EOP activities at VNIIFTRI can be grouped in four basic topics:
1) Processing GNSS, SLR and VLBI observation data for EOP evaluation;
2) Combination of EOP series for evaluation of reference EOP values;
3) Combination of GLONASS satellites orbit/clock;
4) Providing GNSS and SLR observations at five metrological sites acting under the auspices of Federal Agency on Technical Regulating of Metrology(ROSSTANDART).

The processing of GNSS, SLR and VLBI observations is currently executed with the help of modern application program packages such as BERNESE GPS software (Dach et al., 2006; Dach & Walser, 2014), OCCAM software (Titov et al., 2006) and VieVS software (Boehm et al., 2009) that were properly adapted to the rapid service mode.

Combining daily EOP are calculated in Russian Main Metrological Center by means the combination of the eight independent individual EOP series provided by four Russian analysis centers.

The orbit/clock combination is carried out by means of the software which has been recently developed in VNIIFTRI.

GNSS observations on the five metrological sites are carried out permanently and hourly files are formed. The results of observations are collected in Russian Main Metrological Center in hourly mode. SLR observations are carried out at Mendeleevo and Irkutsk.

More detailed information one can find in the following sections.

2. GNSS, SLR AND VLBI DATA PROCESSING FOR EOP EVALUATION

Processing of measurements by phase GPS in VNIIFTRI has been started in 1999. Today EOP from GPS are obtained by processing of measurements on a Russian network, which includes approximately 35 GNSS receivers of the various organizations and departments(RSA , RAS, ROSSTANDART and others). Processing is carried out with the help of a program package BERNESE 5.0 (IAUB).

The actual algorithm was entered in 2006 (see Kaufman & Pasynok (2010)). It is based on the so-called method of Precise Point Positioning (PPP).

From 2004 EOP evaluations from VLBI technique are carried out with the help of software package OCCAM, specially adapted to the rapid service mode. In 2011 we began to process of new series of VLBI data using VieVS software developed at the Institute of Geodesy and Geophysics (IGG), Vienna University of Technology. According to requirements of rapid calculations (quick automatic processing without participation of operator), the special control program was written by Kaufman and Pasynok. No changes were made in VieVS blocks when developing the control program. Its task is receiving, processing and sending data without manual interaction. The details can be found in Kaufman & Pasynok (2012). Now VLBI observations are processed in VNIIFTRI with the help of OCCAM and VieVS packages.

Using of SLR observations of the Lageos-1 and Lageos-2 has been started in 1995. Processing was carried out with the help of a program package ITALAS (IAA). But the facilities and ideas which were realized in this program many years ago are not allowed to evaluate EOP with accuracy what is required now. So, using of this program for EOP evaluation in VNIIFTRI were stopped.

The preparation for renewal of regular operative calculations of EOP based on results of SLR measurements is conducted. As a base software product the BERNESE 5.2 is chosen. The additional blocks considering features of laser observations and program are developed by E. Tsyba and M. Kaufman and one can find the details in Tsyba & Kaufman (2015).

3. OPERATIVE AND RAPID COMBINATION OF EOP SERIES

Rapid combination of EOP for evaluation of reference EOP values has been started in VNIIFTRI at 1955. The form of bulletins and processing methods were changing in process of development of new methods of measurements and improvement of technics. D.Yu. Belocerkovskii and M.B. Kaufman were that scientists who were leading this work in VNIIFTRI.

Now the eight independent series are used for EOP combination (see Table 1). The method of combination which was developed and implemented by M. Kaufman in 2006 is used.

	Analysis centers of Russian EOPPC	Observation technics	Values
1	MMC NSTF (VNIIFTRI)	GPS	$X, Y, UT1$
2	MMC NSTF (VNIIFTRI)	VLBI	$X, Y, UT1, d\psi, d\varepsilon$
3	IAA RAS	SLR	$X, Y, UT1$
4	IAA RAS	GPS	$X, Y, UT1$
5	IAA RAS	VLBI	$X, Y, UT1, d\psi, d\varepsilon$
6	SVOEVP (from 1.07.13)	GPS/GLONASS	$X, Y, UT1$
7	MCC RSA	SLR	X, Y
8	IAC RSA	GPS	X, Y

Table 1: Separate series which are used for combination in 2013.

The $UT1 - UTC$ values of separate series which are used for combination are shown on Fig. 1.

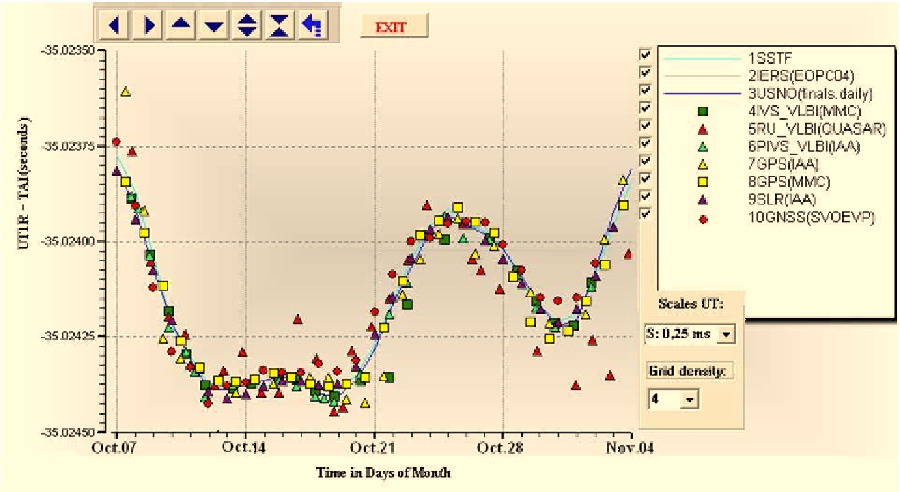

Figure 1: $UT1 - UTC$ values of separate series which are used for combination.

The basic stages of the method of combination processing according to Kaufman & Pasynok (2010) are:

— excluding of systematical errors;

— evaluation of average values EOP;

— prediction;
— estimation of accuracy;
— generation of bulletins with the target data.

The average of smoothed MMC series number 1 and 2 are used as a basis of Russian EOP system. For other series the regular amendments are estimated by exponential smoothing of EOP deviations of every series from basis values. After taking these amendments into account the averages of EOP values are formed using the weights which are calculated according to accuracy estimation for previous calendar year.

Calculations are conducted by three cycles:

— operative (ultra-rapid) values for the last day and predictions for the following of 30 days are evaluated every day;

— every Thursday saved measurements for the last calendar week are processed, the systematic errors of independent individual series are recalculated and the rapid values are evaluated;

— five weeks after end of the calendar month all saved measurements are processed and final values are evaluated.

Such mode of calculations allows quickly, though with limited accuracy to provide the current EOP values and prediction, and then to refine them as far as new observation data become avialable. So, during calculation of operative and rapid EOP values only the limited set of the observations is used. In particular, VLBI data are not used for calculation of operative EOP values, since results of their measurements are accessible with a delay of few days.

The RMS values for estimation based on internal convergence are counted up under the formula:

$$m_C = \left(\frac{\sum_j p_j \nu_j^2}{\sum p_j} \right)$$

where:

j is the numbers of individual EOP series listed in Table 1;

ν_j is deviations of individual daily EOP values from combined one;

p_j is the weights of individual EOP values.

Operative bulletin Q is issued daily at 6h UTC. It contains the values EOP for last day and the prediction data for next 30 days.

The bulletins are accessible only in electronic form ($ftp.vniiftri.ru/Out\_data/Bul\_rus\_Q/$).

Rapid Bulletin A is issued every Thursday. It contains daily values EOP(RU) for the last calendar week and the forecast for 7 next weeks. One release within each month contains finals values EOP(RU) in addition.

Bulletins A are accessible in electronic form ($ftp.vniiftri.ru/Out\_data/Bul\_rus\_A/$) and in printed one (disseminated on requests mark@imvp.ru).

4. COMBINATION OF GLONASS SATELLITES ORBIT/CLOCK

An algorithm and a program for GLONASS satellites orbits combination were developed. The calculations by this program as well as calculations of the coordinate differences for GNSS antennas in VNIIFTRI (Mendeleevo, Moscow reg.) and the North-Eastern branch of VNIIFTRI (Irkutsk) using different orbits and clock corrections are provided. Some theoretical estimates for RMS in satellites coordinate reference values determination were derived. It is shown that under condition when RMSs in satellite coordinates estimation provided by separate Analytic Centers during a long time interval are commensurable the RMS of reference values is no greater than RMS of satellite coordinates estimated by any of the Analytic Centers. The main program window is shown on Fig. 2.

The details one can be find in paper Bezmenov and Pasynok (2015).

5. PROVIDING OF THE GNSS AND SLR OBSERVATIONS AT THE ROSSTANDART SITES

The providing GNSS and SLR observations at five metrological sites acts under the auspices of Federal Agency on Technical Regulating of Metrology(ROSSTANDART). These sites are situated in VNIIFTRI (Mendeleevo, Moscow reg.) and its branches: North-Eastern (Irkutsk), Far Eastern (Khabarovsk) and

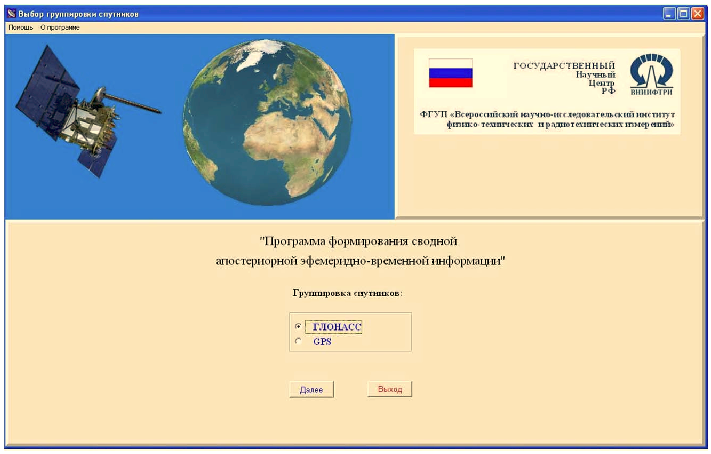

Figure 2: The main window of GLONASS satellites orbit\clock combination program.

Kamchatskii (Petropavlovsk-Kamchstskii). One site is situated in SNIIM (Novosibirsk). The SLR equipment had only 2 sites: Mendeleevo and Irkutsk.

The results of GNSS observations are accumulated in VNIIFTRI in hourly mode and are used for rapid EOP evaluation.

The direct results of SLR observations are transferred into IAC RSA and further in ILRS. Details can be found in Ignatenko et al.(2012) and Ignatenko & Zhestkov (2012).

6. CONCLUSIONS

The main directions of EOP activities in VNIIFTRI as the Russian Main Metrological Center of Time, Frequencies and Earth Rotation Service are presented. More information one can find by anonymous access on addresses ftp.vniiftri.ru and www.vniiftri.ru.

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