Pulkovo Observatory IVS Analysis Center (PUL) Report 2017–2018

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Abstract This report briefly presents the PUL IVS Analysis Center activities during 2017–2018 and plans for the coming year. The main topics of the scientific investigations of the PUL staff in that period were ICRF related studies, EOP series analysis, celestial pole offset (CPO), and free core nutation (FCN) modeling. Regular activities include UT1 Intensive data processing, OCARS catalog support, and support of the PUL archives of data and products.

1 General Information

The PUL IVS Analysis Center was organized in September 2006. It is located at and sponsored by the Pulkovo Observatory of the Russian Academy of Sciences. It is a part of the Pulkovo EOP and Reference Systems Analysis Center (PERSAC) [1]. The main topics of our IVS related activity are:

- Regular computation of UT1 from Intensive IVS sessions.
- Improvement of the International Celestial Reference Frame (ICRF).
- Modeling of the celestial pole offset (CPO) and free core nutation (FCN).
- Analysis of Earth rotation parameters (EOP) and source position time series.
- Computation and analysis of observation statistics.

The PUL Analysis Center Web page [2] is supported. Its contents were described in previous reports.

Pulkovo Observatory

Pulkovo Analysis Center (PUL)

IVS 2017+2018 Biennial Report

PUL staff members participated in activities of several IAU, IAG, IERS, and IVS committees, commissions, and Working Groups.

2 Staff

The following persons contributed to the PUL activity in 2017–2018:

1. Zinovy Malkin (70%) — team coordinator, EOP and CRF analyst;
2. Yulia Lopez (née Sokolova) (50%) — CRF analyst.

3 Activities and Results

The main activities and results of the PUL IVS Analysis Center during 2017–2018 included the following topics.

3.1 ICRF related research.

- Team members participated in the preparation of the third ICRF release, ICRF3, which was finalized and approved by the IAU General Assembly in 2018 (Charlot et al., in preparation).
- The link problem between radio (ICRF) and optical (*Gaia*-CRF) celestial reference frames was analyzed [7]. Both systems should be a realization of the ICRS (International Celestial Reference System) at the microarcsecond level of accuracy. Therefore, the link between the ICRF and *Gaia*-

CRF should be obtained with similar accuracy, which is not a trivial task due to relatively large systematic and random errors in source positions at different frequency bands. In this work, additional possibilities of improving the *Gaia*-CRF–ICRF link's accuracy are discussed. In particular, a possibility of increasing the number of ICRF and *Gaia*-CRF common objects is considered using advanced scheduling of the regular IVS sessions such as R1 and R4. It is shown that inclusion of supplemental prospective southern sources in these sessions allows enrichment of the southern ICRF zone without noticeable loss of accuracy of geodetic results. Another topic discussed in this presentation is using the correlations between radio source coordinates, which can impact the orientation angles between two frames at a level of a few tens of μas.
- A new combined catalog of the radio source positions was constructed and compared with ICRF2. An overview of the works of the Pulkovo Observatory in the field of comparison and combination of radio source position catalogs in 2006–2017 was published [4]. The adopted procedure of the construction of the combined catalog consists of two stages. First, the difference between input catalogs and the celestial reference system ICRF (ICRF2) is presented in a series of spherical functions using the Brosche method. Each catalog is then corrected for the found differences (catalog system), and the corrected catalogs are averaged. Then the input catalog systems obtained at the first stage are averaged, and the resulting average system is considered to be a systematic correction to the ICRF catalog. The addition of the average system to the catalog that was obtained at the first stage results in a final combined catalog. The first Pulkovo combined catalog was computed in 2006, and it allowed us to substantially improve the accuracy of the computation of Universal Time and celestial pole coordinates. The second catalog was computed in 2013, and it allowed us to get preliminary estimates of the systematic errors of the ICRF2 catalog. The third catalog of 2016 described in this paper made it possible to get more reliable estimates of these errors.
- A method was developed to compute the structure delay of extended radio sources without constructing their radio images [9]. The residuals derived after the adjustment of geodetic VLBI observations are used for this purpose. We show that the simplest model of a radio source consisting of two point components can be represented by four parameters (the angular separation of the components, the mutual orientation relative to the poleward direction, the flux-density ratio, and the spectral index difference) that are determined for each baseline of a multi-baseline VLBI network. The efficiency of this approach is demonstrated by estimating the coordinates of the radio source 0014+813 observed during the two-week CONT14 program organized by the International VLBI Service (IVS) in May 2014. Large systematic deviations were detected in the residuals of the observations for the radio source 0014+813. The averaged characteristics of the radio structure of 0014+813 at a frequency of 8.4 GHz can be calculated from these deviations. Our modeling using four parameters has confirmed that the source consists of two components at an angular separation of 0.5 mas in the north-south direction. Using the structure delay when adjusting the CONT14 observations leads to a correction of the average declination estimate for the radio source 0014+813 by 0.070 mas.
- The OCARS catalog (Optical Characteristics of Astrometric Radio Sources) is being supported [3]. The catalog provides source type, redshift information, photometric data in 11 visual and three NIR bands, and cross-identification with several catalogs at different bands [8].

3.2 CPO and FCN related research

- Two CPO and two FCN series are being updated daily and are available at the PERSAC Web page [1].
- Three combined celestial pole offset (CPO) series computed at the Paris Observatory (C04), the United States Naval Observatory (USNO), and the International VLBI Service for Geodesy and Astrometry (IVS), as well as six free core nutation (FCN) models, were compared from different perspectives, such as stochastic and systematic differences and FCN amplitude and phase variations [5]. The differences between the C04 and IVS CPO series were mostly stochastic, whereas a low-frequency bias at the level of several tens of

μas was found between the C04 and USNO CPO series. The stochastic differences between the C04 and USNO series became considerably smaller when computed at the IVS epochs, which can indicae possible problems with the interpolation of the IVS data at the midnight epochs during the computation of the C04 and USNO series. The comparison of the FCN series showed that the series computed with similar window widths of 1.1 years to 1.2 years were close to one another at a level of 10 μas to 20 μas, whereas the differences between these series and the series computed with a larger window width of four years, and seven years reached 100 μas. The dependence of the FCN model on the underlying CPO series was investigated. The RMS differences between the FCN models derived from the C04, USNO, and IVS CPO series were at a level of approximately 15 μas, which was considerably smaller than the differences among the CPO series. The analysis of the differences between the IVS, C04, and USNO CPO series suggested that the IVS series would be preferable for both precession-nutation and FCN-related studies.

- The accuracy of prediction of the celestial pole coordinates (precession-nutation angles) was investigated using the actual predictions obtained in 2007–2017 at the Pulkovo Observatory and at the United States Naval Observatory (USNO) [6]. To get a reliable and comprehensive comparison, three estimators of the prediction errors were computed: root-mean-square error, mean absolute error, and maximum error. It was found that the accuracy of the predictions computed at the Pulkovo Observatory is substantially better than that for the predictions provided by the USNO.

3.3 Regular Activities

- Operational data processing of IVS Intensive sessions in operational automated mode and submission of results to IVS was continued. The latest UT1 time series includes ~5,700 UT1 estimates for 1999–2018 and is available at the IVS Data Centers and at the PERSAC Web page [1].
- The PUL archive of VLBI data and products obtained in the framework of IVS activity is supported. At present, all available X-band NGS cards for ~16.5 thousand sessions observed in 1979–2018 are stored. The PUL NGS archive contains ~17 million (~14 million good) observations and looks to be the most complete among other IVS NGS card archives.
- Development of algorithms and software for data processing and analysis continued.

4 Future Plans

Plans for the coming years include:

- Continuing ICRF related studies.
- Continuing CPO/FCN related studies.
- Continuing OCARS catalog support.
- Continuing development of algorithms and software for data processing.
- Continuing support of the PUL archives of data and products.

References

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