Pulkovo Observatory (PUL) Analysis Center Report 2019–2020

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Abstract This report briefly presents activities of the IVS Analysis Center at the Pulkovo Observatory (PUL) during 2019–2020 and plans for the coming years. The main topics of the scientific investigations at the PUL AC in that period were ICRF-related studies and research in the field of Earth rotation and geodynamics. Regular activities include 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:

- Improvement of the International Celestial Reference Frame (ICRF).
- Analysis of Earth rotation parameters (EOP).
- Modeling of the celestial pole offset (CPO) and free core nutation (FCN).
- Computation and analysis of IVS observation statistics.

The PUL AC supports a website at [2]. Its contents was described in previous reports.

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

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2 Staff

The following persons contributed to the PUL activity in 2019–2020:

1. Zinovy Malkin (70%).

3 Activities and Results

3.1 ICRF-related Research

The Analysis Center was involved in a number of ICRF-related activities:

- Team members participated in the activity of the IAU Division A WG "Third Realization of International Celestial Reference Frame" in preparation of the third release of the ICRF (ICRF3) [5].
- Team members contributed to the activity of the IVS Working Group 8 (WG8) on Galactic Aberration [6].
- Support of the OCARS catalog (Optical Characteristics of Astrometric Radio Sources) continued [7]. This compiled catalog provides source position, source type, redshift info, and photometric data in eleven visual and three NIR bands, as well as cross-identification with general radio, optical, NIR, Gamma-ray, X-ray, and UV catalogs for more than 13,000 radio sources (as of December 2020) with published VLBI-based positions. About 40 radio source position catalogs and separate radio source position determinations are used in OCARS. OCARS magnitudes and redshifts are taken from several data sources, such as Sloan

Digital Sky Survey[1] (SDSS), NASA/IPAC Extragalactic Database[2] (NED), SIMBAD[3] database managed by the Centre de Donnees astronomiques de Strasbourg (CDS), the Million Quasars (Milliquas) catalog[4], and Large Quasar Astrometric Catalogue[5] (LQAC), in the order of preference. The OCARS catalog is updated every several weeks and the latest version is available on the PUL website [3]. It consists of five files:

`ocars.txt`	main catalog file
`ocars_p.txt`	position data
`ocars_m.txt`	photometry data
`ocars_n.txt`	cross-identification table
`ocars.csv`	OCARS in CSV format

- A new method is proposed to divide the spherical surface into equal-area cells [8, 9]. The method is based on dividing a sphere into latitudinal rings of near-constant width with further splitting each ring into equal-area cells. It is simple in construction and use, and provides more uniform width of the latitudinal rings than other methods of equal-area pixelization of a spherical surface. The new method provides rectangular grid cells with latitude- and longitude-oriented boundaries, near-square cells in the equatorial rings, and the closest to uniform width of the latitudinal rings as compared with other equal-area isolatitudinal grids. The binned data is easy to visualize and interpret in terms of the longitude-latitude rectangular coordinate system, natural for astronomy and geodesy. Grids with arbitrary number of rings and, consequently, a wide and theoretically unlimited range of cell size can be built by the proposed method. The maximum number of rings that can be achieved with SREAG for coding with 32-bit integer is 41,068, which corresponds to the finest resolution of $\sim16''$. Comparison with other methods used in astronomical research showed the advantages of the new approach in the sense of uniformity of the ring width, a wider range of grid resolution, and simplicity of use. Supporting routines for using SREAG are available on the PUL website [4].

[1] http://www.sdss.org
[2] http://ned.ipac.caltech.edu
[3] http://simbad.u-strasbg.fr/simbad/
[4] https://heasarc.gsfc.nasa.gov/W3Browse/all/milliquas.html
[5] https://cdsarc.unistra.fr/viz-bin/cat/J/A%2bA/624/A145

3.2 Earth Rotation Research

Two CPO and two FCN series were computed and analyzed. All the series use the IVS combined EOP solution as the primary data source for investigation of the celestial pole motion. These series are updated daily and are available on the PERSAC webpage [1]. Some series also include CPO/FCN prediction.

3.3 Other IVS-related Research

A statistical analysis of the results of 20 years of IVS activities was performed [10]. During the period of 1979–2018, the IVS Data Center has accumulated more than 18 million observations obtained in more than 17,000 observation sessions, including more than 10,000 short sessions for rapid determination of UT1. The dynamics of IVS development based on the statistical processing of the IVS observational data was followed. Statistics for observation years, stations, baselines, and radio sources are given. The evolution of observation statistics and the accuracy of the results obtained from the processing of VLBI observations is studied.

3.4 Regular Activities

Regular activities of the Analysis Center include:

- Archiving IVS data in NGS card format.
- Archiving IVS and IERS products.
- 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 research on Earth rotation and geodynamics based on the IVS data and products.
- Continuing OCARS catalog support.
- Continuing support of PUL archives of data and products.

References

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