Paris Observatory (OPAR) Analysis Center

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Abstract We report on operational and research activities directly related to VLBI at the Paris Observatory VLBI Analysis Center (OPAR) for calendar years 2017 and 2018. In addition to the operational activity, our main achievements are the contribution to the ICRF3 and to the validation process of the Gaia Data Release 2 catalog that took benefit from the skills of our personnel in terms of assessments of reference frames.

1 Analysis Service

Paris Observatory Analysis Center OPAR continued operational analyses of VLBI diurnal and Intensive sessions. All of the products, except SINEX files, were published on the OPAR Web site at

`http://ivsopar.obspm.fr`

together with exhaustive technical explanations and plots. SINEX files were only sent to the Data Centers. The Analysis Center is using the latest version of Calc/Solve and, since fall 2018, it has processed the databases in vgosDB format. The current global solution (opa2019a) is now using the ICRF3 as an a priori radio source catalog and includes a model for the Galactic aberration, i.e., a dipolar displacement field of the quasars toward the Galactic center of amplitude 5.8 μas per year, as recommended by the IVS Working Group 8 (MacMillan et al., 2019) and as used for the production of the ICRF3 catalog (Charlot et al., 2019). The reference epoch of the Galactic aberration modeling is 2015.0, consistent with the ICRF3. As a consequence, the opa2019a celestial reference frame (quasar coordinate catalog) should be read as follows: coordinates listed in the catalog correspond to the apparent position of the sources at 2015.0; at another epoch, the position of the sources should be corrected by the Galactic aberration effect using the above amplitude. As for the previous solutions, the free core nutation is constantly monitored at OPAR (Figure 1).

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A web page is dedicated to the radio source coordinate time series that allows one to follow the evolution of the radio center along time at

`http://ivsopar.obspm.fr/radiosources`

This page is especially useful for monitoring the defining sources and determining whether some of them should be excluded from the constraint because of unstable behavior (Figure 2).

2 Contribution to Celestial Reference Frames

Personnel of OPAR were involved in the generation of the ICRF3 (Charlot et al. 2019, in preparation) that was adopted as the fundamental reference frame by the International Astronomical Union (IAU) in August 2018. In more detail, people from OPAR, namely E. F. Arias, J. Souchay, and S. Lambert, were members of the dedicated IAU Working Group and contributed at two levels: (i) providing prototype solutions together with other Analysis Centers and, more importantly, (ii) setting up the validation chain that allowed the group to

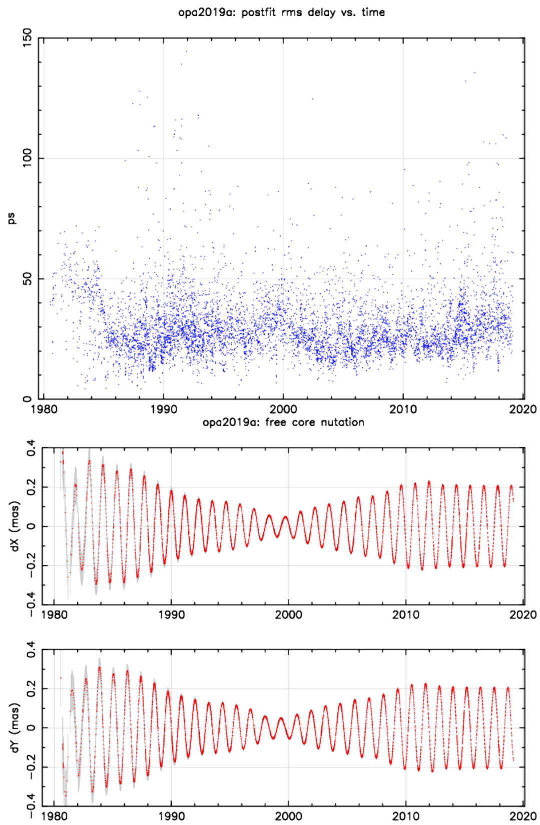

Fig. 1 Top panel: the postfit rms delays of the opa2019a global solution. Bottom panel: the free core nutation as adjusted to the nutation time series obtained in the opa2019a global solution. Plots are shown as they appear on the OPAR web site. These series are updated as new sessions are analyzed at OPAR.

make extensive comparisons between the prototype solutions and the existing reference frames (e.g., ICRF2 and Gaia). Comparisons were realized in terms of individual positions of the radio sources and in terms of large-scale systematics (rotations and higher-order deformations). The validation chain permitted clarification of the causes and the amplitude of the declination-dependent errors, especially thanks to the comparison with the Gaia DR2 counterpart.

Though the accuracy of the ICRF3 was determined internally to the Working Group by a method similar to Charlot et al. (2019), N. Liu and S. Lambert undertook similar investigations on independent solutions and with two complementary methods based on comparisons between standard errors, scatter, and differences between subset solutions. Our conclusion is that the current optimal accuracy of VLBI catalogs is close to 10 μas for sources having the longest observational history (Liu et al., 2018).

S. Lambert investigated the variability of the radio source coordinates using the Allan variance, which is a tool designed for separating the noise types at various time scales. The study revealed that one can grossly consider that none of the sources really behave as Gaussian noise. Rather, all sources are subject to either flicker noise or random walk episodes that constitute serious issues in terms of increasing their positional accuracy by adding new observations (Gattano et al., 2018).

Finally, S. Lambert, T. Carlucci, and C. Barache were involved in the validation phase of the first Gaia Data Release (Gaia DR2) in the framework of the Gaia Data Processing and Analysis Consortium (DPAC) coordination unit 9 (CU9) (Arenou et al., 2018). Our segment of the full validation process consisted essentially of characterizing the deformation between the Gaia DR2 catalog and the ICRF3 for which we provided and tested a six-parameter transformation consisting of three rotations and a glide. The same authors contributed also to the establishment of the first Gaia celestial reference frame aligned onto the ICRF3, so-called Gaia-CRF2 (Mignard et al., 2018).

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Radio source coordinate time series

The coordinate time series of radio sources are computed with a specific analysis configuration. The source name color indicates th
(darker means longer). The ICRF3 defining sources are highlighted in yellow. Plots are available for sources observed in more tha
series is available in a single file in SOLVE *lso* format. These data are constantly updated.

0001+478	0001-120	0002+051	0002+200	0002+541	0002-170	0002-350	0002-478
0003+123	0003+158	0003+340	0003+380	**0003-066**	0003-302	0004+240	0005+114
0005+568	0005+683	0005-239	0005-262	0006+061	0006+397	0006+771	0006-363
0007+016	0007+106	0007+171	0007+205	0007+439	0007+757	0007-048	0007-325
0008+006	0008+704	0008-222	**0008-264**	0008-300	0008-307	0008-311	0008-421
0009+081	0009+467	0009+655	0009-148	0010+336	0010+405	0010+463	0010-155
0010-401	0011+189	0011-046	0012+077	0012+319	0012+610	0012-184	0013-005
0013-184	0013-240	**0014+813**	0015+145	0015+529	0015-054	0015-280	**0016+731**
0017+200	0017+257	0017+296	0017-307	0018+715	0018+729	**0019+058**	0019+451
0019-000	0020+015	0020+446	0021+243	0021+464	0021-084	0022+390	0022-044
0022-227	0022-423	0023-263	0023-354	0024+092	0024+224	0024+348	0024+597
0024-114	0025+197	0025+449	0026+048	0026+346	0026-015	0027+056	0027+703
0027-024	0027-426	0028-396	0029-147	0030+196	0032+276	0032+612	0032-011
0033+142	0033+143	0033-088	0034+078	0034+108	0034+393	0034-220	0035+121
0035+238	0035+367	0035+413	0035+503	0035-024	0035-037	**0035-252**	0036-099

Fig. 2 Main page to access the radio source time series on the OPAR web site. Series are updated as new sessions are analyzed at OPAR. ICRF3 defining sources are displayed against a highlighted yellow background (e.g., 0007+106).