Paris Observatory Analysis Center OPAR: Report on Activities, March 1999 - December 2000

A.-M. Gontier, M. Feissel, N. Essaïfi, D. Jean-Alexis, K. Le Bail

Abstract

The OPAR Analysis Center activities over March 1999 - December 2000 focused on analyses of the time stability of the celestial reference frame. The routine analysis of the intensive and 24-hour sessions was continued. The team was not changed, except for the help of one student (six months in 2000).

1. Activities

1.1. Stability of ICRF

The capability of the VLBI geodetic and astrometric programs to maintain stable directions in space was evaluated [1] on the basis of time series of session-per-session source coordinates computed at USNO using the CALC-SOLVE software [2].

The systematic and random characteristics of several hundreds of source apparent motions were investigated in order to derive a set of qualifiers that would be helpful in selecting sources to maintain a precise and stable celestial reference frame. We developed a selection process based on the density of observations over 1987-1999 and on the time stability of averaged yearly coordinates. The stability considered is that along the maximum variability direction in a source-fixed frame. 242 sources were thus selected. The rotation angles of the corresponding differential celestial reference frames are shown on Figure 1.

The results of this selection process are compared to the current ICRF qualifiers [3], i.e. "defining", "candidate" and "other" sources, and structure index, is shown in Table 1. The following comments can be made.

1. ICRF categories. The stability test keeps practically all "defining" and "candidate" sources that were preselected on the basis of their observational history, and most of the "others". When considering the complete ICRF-Ext.1, one can note first that only 1/3 of the "candidate" sources were selected on the basis of long and dense observational history. In fact we know that a number of "candidate" sources are considered so because their time span of observation is still too short. We also know that a number of sources were qualified as "other" although they had a dense observational history, explaining the selection of 3/4 of them. The selection rate of the "defining" sources is between the other two (1/2). Already at this first level, the first part of our selection scheme (based on the observational history of the source) provides a pre-qualification of sources which is quite different from the current ICRF one. Once this first selection is performed, the second one, based on the internal consistency of the time series of coordinates in the direction of the maximum variability, keeps nearly all "defining" and "candidate" sources, thus confirming their current ICRF status. Meanwhile, 7/10 of the "other" sources are still kept. This seems to indicate that using time series information might bring in more sources that would contribute to stabilize the celestial reference frame.

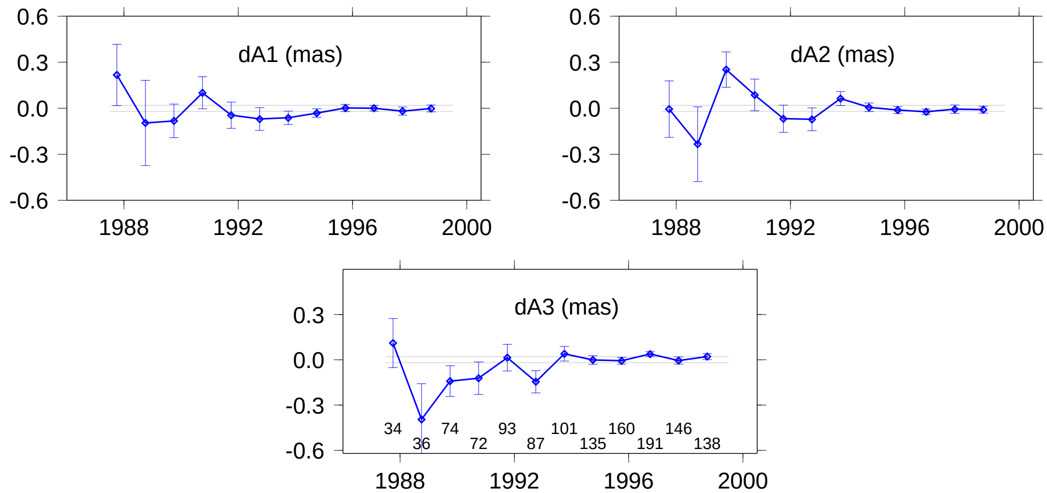

Figure 1. Rotation angles of 12 yearly differential CRFs relative to a mean one, using 242 sources selected on the basis of dense observational history and time stability over 1987-1999. The numbers of sources whose coordinates were available in a given year are listed (dA3 graph). The double horizontal line corresponds to the stated uncertainty of the ICRF axes directions (± 20 μas).

Table 1. Match of the source selection with the ICRF source qualifiers. The sources are first selected on the basis of a dense observation history, then a percentage of them is recognized as stable.

	Number presel.	% stable	All sources	% stable		Number presel.	% stable
1. ICRF categories					2. Structure index		
Defining	108	95%	212	49%	1	49	86%
Candidates	98	88%	294	29%	2	87	80%
Other	73	67%	102	48%	3	63	87%
					4	26	85%

2. The structure index for each source [4] qualifies the level of position disturbance expected from the irregularity of the source emission structure (1 for the less disturbed, 4 for the most disturbed). The lack of correlation between this index and our stability criterion suggests that, for the data set used in this study, the observational and analysis errors due to other factors tend to dominate the source structure effect.

This study also highlights the usefulness of considering the time evolution of radiosource directions, not only for internal purposes such as the ICRF quality control or applications like differential VLBI, but also to enhance the support of VLBI to scientific research, as in the understanding of the physical properties of the non-rigid Earth through analysis of precession and nutation observations, or for realistic studies of source structure or microlensing effects.

In another study [5], using a set of 16 well observed radio sources (north of +20 degrees), it was shown that reliable information can be obtained on the local motions in the sources since the end of the 1980's, with a 0.5-year time resolution. The analysis showed that the variability of these objects have varied spectral characteristics, that could possibly be related to diverse physical processes taking place in the sources.

1.2. OPAR time series of source coordinates

Computation of time series of source coordinates referred to the ICRF was initiated. Preliminary results were obtained for 52 sources over 1999. Figure 2 shows the average coordinates of 37 of them, for which the 1998 coordinates could also be derived from the USNO [2] series. The weighted standard deviations of the yearly position differences between the USNO and OPAR analyses are 0.13 mas in R.A.cos(Dec) and 0.18 mas in Declination.

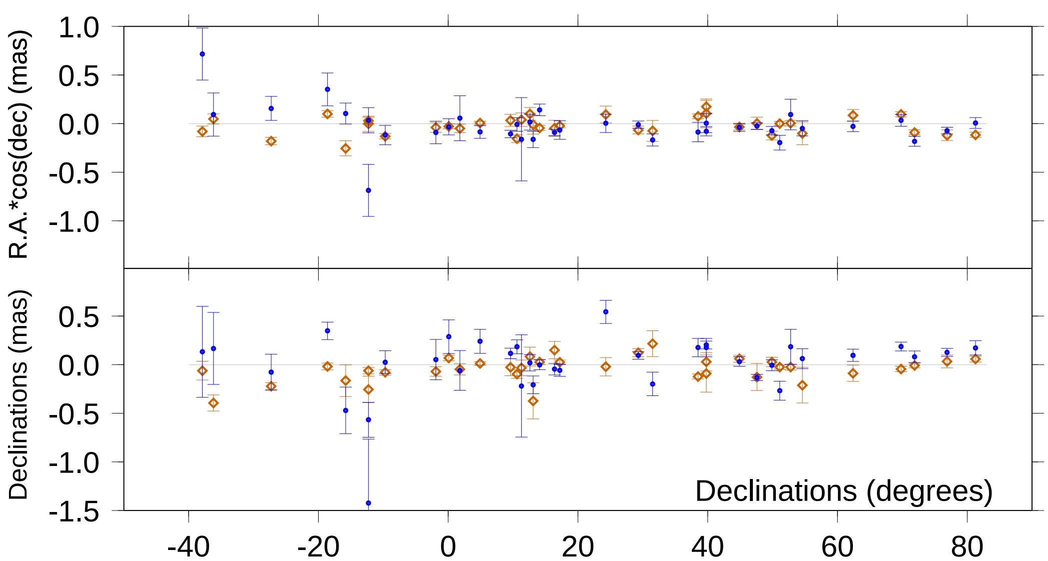

Figure 2. Average coordinates for 37 common sources: USNO 1998 (brown/light) and OPAR 1999 (blue/heavy)

1.3. Operational analyses

The analysis of the intensive one-baseline sessions was continued and that of the 24-hour sessions was initiated. Results were provided to IERS and IVS. The results obtained are illustrated in Figure 3. The standard deviation of the differences of the OPAR solutions with the IERS series C04 over 1999 is ± 20 μs on UT1-UTC for the intensive sessions; for the 24-hour sessions: ± 0.28 mas on polar motion, ± 12 μs on UT1-UTC and ± 0.22 mas on celestial pole offsets.

2. Prospects

Our plan is to continue developing reference frame studies and applications. Most of these studies will contribute to the work of the IERS ICRS Product Center, with which the OPAR IVS

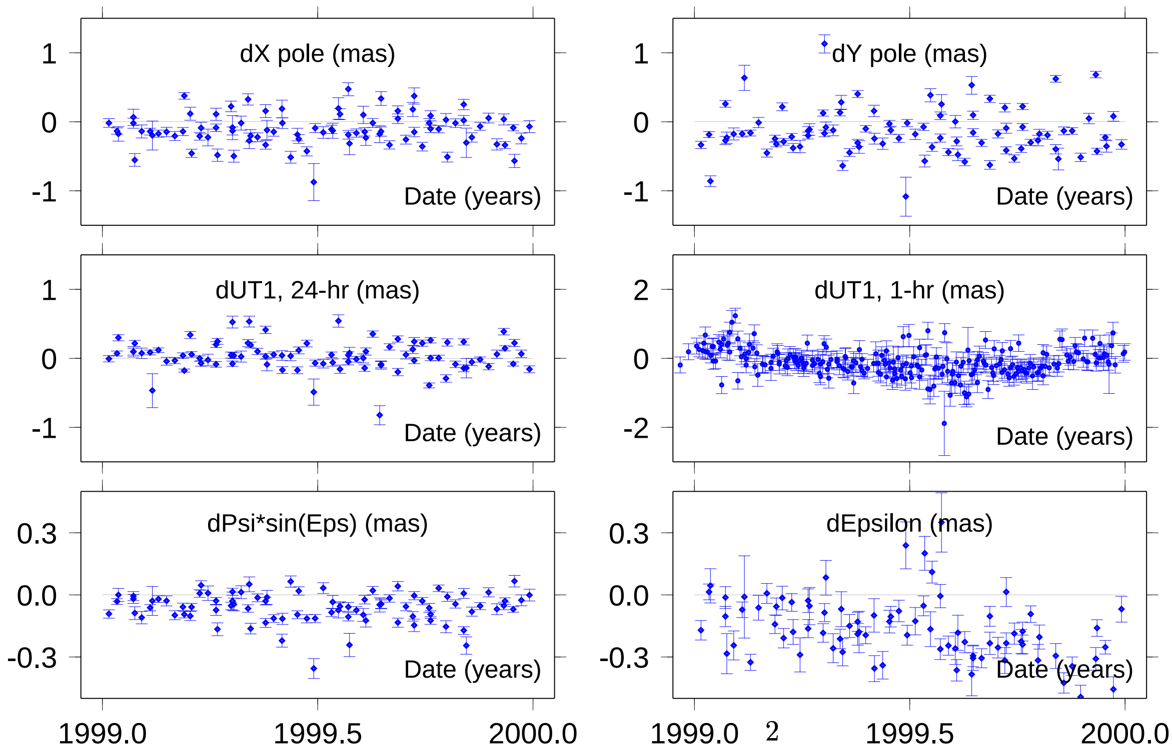

Figure 3. OPAR EOP results in 1999. Difference with EOP(IERS) C04.

Analysis center is closely associated.

1. Time series of source coordinates referred to the ICRF. These time series can be used in several research and operational applications, e.g. the astrophysical interpretation of observed apparent motions, the accurate use of the sources in differential VLBI, the scheduling of IVS observing sessions, the optimization of future revisions of ICRF. The time series will be available on the ICRS-PC website (http://hpiers.obspm.fr/icrs-pc).
2. Global celestial reference frame analyses.
3. Time series of terrestrial reference frames.

References

[1] A.-M. Gontier, K. Le Bail, M. Feissel, T. M. Eubanks, 2001. Stability of the extragalactic VLBI reference frame. AA (in press)

[2] T.M. Eubanks. Private communication

[3] International Earth Rotation Service (IERS), 1999, 1998 Annual Report, 83. Observatoire de Paris.

[4] A.L. Fey, P. Charlot, 2000, ApJS, 128, 17

[5] M. Feissel, A.-M. Gontier, T.M. Eubanks, 2000, AA, 359, RN1201