COMPARISON OF THE TIME SERIES OF COORDINATES OF THE ICRF SOURCES

V.E. ZHAROV, E.A. RASTORGUEVA
Sternberg State Astronomical Institute
Universitetsky pr. 13, Moscow 119992
zharov@sai.msu.ru

ABSTRACT. The time series of $\Delta\alpha\cos\delta$ and $\Delta\delta$ obtained by various IVS centers were analyzed. These series for each source were fitted by the best polynomial regression model to estimate the motions of the sources. It was shown that variations of coordinates of the sources can be both linear and curvilinear, and motions have to be taken into account during generation of new ICRF catalog.

1. MODEL OF MOTION

Model of motion was represented as polynomial with respect to time.

It is necessary to find the best multiple linear regression model:

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 x_i^3 + \varepsilon_i,$$

where x_i is the time of i's observation, y_i is the correction $\Delta\alpha\cos\delta$ or $\Delta\delta$ to the adopted coordinates, β_j are the regression coefficients, and the ε_i's are independently distributed normal errors, each with mean zero and variance σ^2.

The "best" model (or degree of polynomial) is defined by the criteria:

$$R^2 = 1 - \frac{\sum w_i(y_i - \widetilde{y})^2}{\sum w_i(y_i - \overline{y})^2},$$

where w_i is the weight of y_i and $\overline{y}$ is the weighted mean. The best fitting function $\widetilde{y}$ has to maximize the value of the multiple-correlation coefficient R^2.

The highest degree of polynomial was chosen as "three" to guarantee predictability of motion: we can expect that extragalactic radio sources have small motions.

2. ANALYSIS OF MOTION

Nine time series obtained by the IVS centers: AUS, BKG, DGF, GSFC, IAA, MAO, OPA, SAI, USNO were used to analyze the sources' motions.

On Fig. 1 histograms $\beta_i/\sigma(\beta_i)$ for i=1,2,3 are shown ($\sigma(\beta_i)$ are uncertainties of the regression coefficients). If use criteria $\beta_i/\sigma(\beta_i) > 2$, then approximately 40% of observed sources show significant motion.

New classification of sources can be proposed based on this conclusion: the best fitting function $\widetilde{y}$ is used to predict position of source, for example, at 2025. Prediction intervals D_α for α and D_δ for δ depend on trend and noise of corresponding time series. The criteria $D = \sqrt{D_\alpha^2 + D_\delta^2} < n$ can be used for selection of "stable" sources. In our analysis we used $n = 2.5$ mas.

According this criteria only 32 sources: 0014+813, 0059+581, 0133+476, 0202+149, 0212+735, 0234+285, 0528+134, 0552+398, 0556+238, 0602+673, 0727-115, 0749+540, 0804+499, 0851+202, 0923+392, 0955+476, 1044+719, 1101+384, 1300+580, 1308+326, 1357+769, 1418+546, 1611+343, 1638+398, 1726+455, 1739+522, 1741-038, 1803+784, 2037+511, 2145+067, 2200+420, 2356+385 show predictable motion with small noise. One can note that these sources are observed very frequently: from 350 (0602+673) to 3500 times (0552+398).

According the polynomial models one can divide apparent motions in several types: linear, uniform motion; linear, non-uniform motion; motion on conic section with constant velocity module; curvilinear motion with variable velocity. Motion of part of sources ($\sim 70\%$) can be explained by simple physical

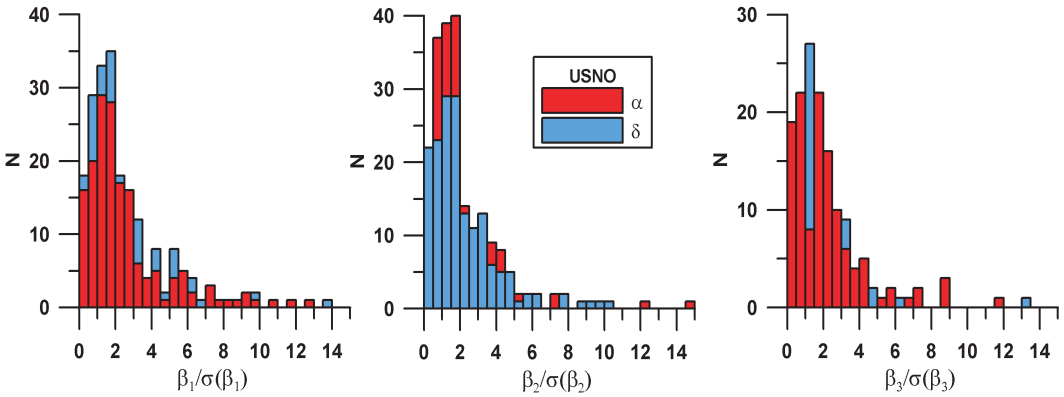

Figure 1: Statistics of motion (USNO)

models of motion and evolution of quasar (Zharov et al., this issue). Polynomial models of motion of rest sources are too complicated to be explained now. Their non-predictable motions lead to noise in orientation of ICRF.

In our model corrections $\Delta\alpha$ or $\Delta\delta$ to adopted coordinates depend on time. So, catalog of sources must contain both their coordinates and motions, sometimes including quadratic term. Because coordinates depend on time orientation of new catalog relative the ICRF depends on time too. Three rotation angles $\theta_1, \theta_2, \theta_3$ around the axes of the equatorial coordinate system are shown on Fig. 2. Sources observed more than 100 times were selected at first (black line). Then the defining sources were used for estimation of $\theta_1, \theta_2, \theta_3$ (red line). As seen from Fig. 2 in order to improve stability of the ICRF, the no-net-rotation condition has to be applied to well observed sources without dividing them in different categories. Among defining sources there are many sources observed only 15-50 times; it is not enough to determine reliable parameters of motion.

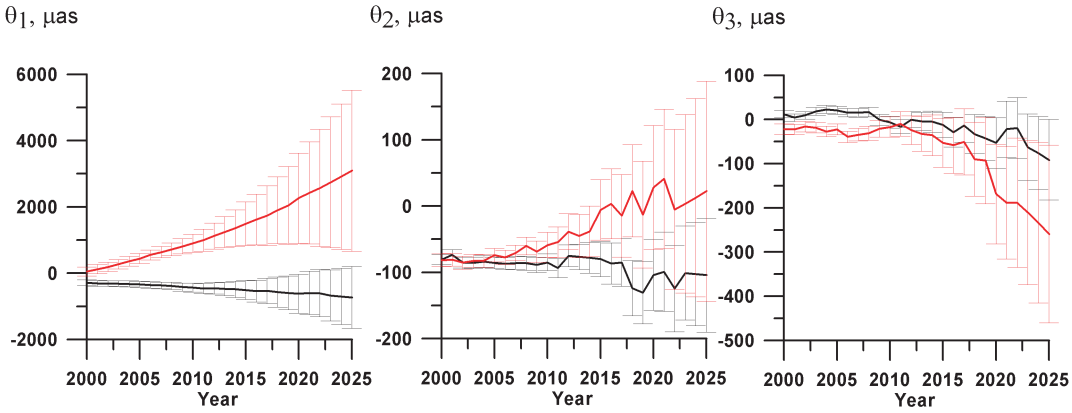

Figure 2: The rotation angles based on the USNO time series

Acknowledgements. Research supported in part under RFBR grants 08-02-00971 and 07-01-00126.

3. REFERENCES

Zharov, V.E., Sazhin, M.V., Sementsov, V.N., Kuimov, K.V., Sazhina, O.S., Rastorgueva, E.A., this issue.