USING POSITIONAL OBSERVATIONS OF NUMBERED MINOR PLANETS FOR DETERMINATION OF STAR CATALOG ERRORS

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ABSTRACT. The systematic errors of star catalogs have been defined by the O-C of the asteroid positional observations. 102 760 633 positional observations for 404 941 numbered asteroids were used. The considerable systematic errors for the USNO A2.0 catalog are founded. For this catalogue we can estimated also the value of variation of systematic errors for some areas on the celestial sphere.

1. INTRODUCTION

The Ephemerides of minor planet are calculated by Institute of Applied Astronomy of Russian Academy of Science. For this Ephemerides the elements of minor planet are improved by the differential method using all available observations.The O-C of asteroid positional observations ("observed-calculated" residuals) are calculated.These values of O-C are used for estimation of the systematic errors of star catalogs. Improvement of asteroid orbits was conducted in two steps. At the first step the orbital elements of Ceres, Pallas and Vesta were improved, taking into account the perturbations from the major planets, the Moon, Pluto using DE405 and their mutual perturbations. Then we calculated ephemerides of these three planets. To calculate the orbital elements of other numbered asteroids we used obtained ephemerides and all available positional observations. 102 760 633 values of O-C for 404 941 numbered asteroids were chosen. We chosen observations made after 2001. The greatest number of observations after 2001 refers to the following catalogs: USNO A2.0 (37 732 050 observations), UCAC-2 and 3 (27 529 078 observations), USNO B1.0 (11 778 775 observations) and UCAC-4 (4 501 387 observations).

2. PROCEDURE OF CALCULATION OF CATALOGUE BIASES

The celestial sphere is split into 10212 about equal areas. Then each O-C value was associated with the corresponding area. The mean value of O-C of the basic star catalog was calculated for each areas and interpreted as a star catalog systematic bias of the area. Then larger number of O-C for different planets we used to calculate the mean value for each area then smaller its error is obtained. Our results shows that a few thousand observations for hundred different planets are needed for reliable determination of catalogue bias in the area.

We calculated the star systematic biases for 4 catalogs. The greatest errors have been obtained for the USNO A2.0. We can calculated also the variation of the systematic errors for this catalog for some areas on the celestial sphere. The the variation of the systematic errors is calculated by the following way.The mean values of individual areas were calculated using O-C referred to six different time intervals:$(2001-2002), (2003-2004), (2005-2006), (2007-2008), (2009-2010), (2011-2014)$. The obtained values were approximated by the linear equations:

$$\begin{cases} \Delta\dot{\alpha}(t_i - 2011.5) + \Delta\alpha_0 = \Delta\alpha_i \\ \Delta\dot{\delta}(t_i - 2011.5) + \Delta\delta_0 = \Delta\delta_i \end{cases} \tag{1}$$

where $t_i = 2001.5, 2003.5, \ldots, 2011.5$ – the middle of the intervals. Then the overdetermined (1) system was solved by MLS. Using the obtained values the error of USNO A2.0 catalog for some areas at various epochs are calculated.

3. CALCULATION AND COMPARISON

We calculated the errors of right ascensions and declinations at 2011 and 2014 $\Delta\alpha_{2011}$, $\Delta\delta_{2011}$, $\Delta\alpha_{2014}$ and $\Delta\delta_{2014}$ and compared them with the results in (Chesley, et al., 2010). The results of comparison for some areas are given in the Table 1, where: α, δ (in terms of hours and degrees) are the coordinates of an area center ; $\Delta\alpha, \Delta\delta$ (in terms of arcseconds) are the systematic errors of right ascensions and declinations of the USNO A2.0 catalog (in terms of arcseconds) given in (Chesley, et al., 2010). The next columns contain $\Delta\alpha_{2011}$, $\Delta\delta_{2011}$, $\Delta\alpha_{2014}$ and $\Delta\delta_{2014}$ – right ascensions and declinations at 2011 and 2014. The values $\Delta\alpha_{2014}$ and $\Delta\delta_{2014}$ are shown with its errors. The data of Table 1 are shown that the variations of the systematic errors for the USNO A2.0 catalog are not large. It should be noted that jumps of systematic errors of the USNO A2.0 catalog for certain areas in (Chesley, et al., 2010) are revealed. In particular for the area with coordinates $(0^h.753, 3^\circ.21)$ the bias of declination obtained in (Chesley, et al., 2010) differs from the other in neighboring areas. Systematic errors that are defined by us vary more smoothly from area to area, but we calculated star errors for areas contained sufficient number of observations of different planets. Therefore the catalog biases of USNO A2 are not estimated by us for all areas on the celestial sphere as it were done in (Chesley, et al., 2010).

α	δ	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha_{2011}$	$\Delta\delta_{2011}$	$\Delta\alpha_{2014}$	$\Delta\delta_{2014}$
$23^h.914$	$4^\circ.82$	-0.08	0.33	-0.01	0.34	0.02±0.02	0.39±0.03
0.082	4.82	-0.02	0.27	-0.01	0.44	0.02±0.01	0.49±0.05
0.250	3.21	-0.05	0.35	-0.21	0.48	-0.21±0.01	0.53±0.05
0.418	3.21	-0.03	0.46	0.17	0.54	0.21±0.01	0.60±0.03
0.586	3.21	-0.01	0.47	-0.03	0.49	-0.01±0.01	0.56±0.03
0.753	3.21	-0.09	0.01	-0.02	0.41	0.02±0.00	0.47±0.03
0.921	3.21	-0.12	0.24	-0.07	0.31	-0.05±0.02	0.36±0.02
1.089	3.21	-0.04	0.44	-0.06	0.41	-0.03±0.02	0.45±0.03
1.257	3.21	-0.14	0.32	0.14	0.59	0.18±0.04	0.67±0.04
1.425	3.21	-0.11	0.33	-0.18	0.49	-0.16±0.03	0.55±0.04

Table 1: Catalog biases of USNO A2 at Epoch 2011 and 2014.

4. CONCLUSION

The accuracy and number of new positional observations of asteroids allow to estimate the accuracy of reference star catalogs.

The variation of the systematic errors for the USNO A2.0 catalog are shown.

The values of the systematic errors for USNO A2.0 catalog vary from area to area as well as with time.

Using our calculation the observations based on this catalog can be corrected not only depending on the different areas, but the different epochs as well.

5. REFERENCES

Chesley, S.R., Baer, J., Monet, D.G., 2010, "Treatment of star catalog biases in asteroid astrometric observations", Icarus, 210, pp. 158–181.