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A Catalogue of Radio Source Coordinates Obtained from NEOS and CORE VLBI Programs

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Abstract

A new catalogue of radio source coordinates is constructed as a combination of catalogues derived from NEOS and CORE VLBI programs for the period 1997–1999 using ERA package. One of the main goals of this study was an attempt to investigate systematic differences between source coordinates derived from geodetic VLBI observations made by various sets of stations and estimate a possible proper or apparent motion of radio sources. At the first stage nine catalogues were obtained from observations of NEOS-A, CORE-A and CORE-B programs for 1997, 1998 and 1999. At the next stage six catalogues were derived: three catalogues for years 1997, 1998, 1999 using all observations for these years and three catalogues for each program NEOS-A, CORE-A, and CORE-B for the whole period 1997–1999. Finally, after analysis of differences between catalogues and time variations of source coordinates a combined catalogue was made.

1. Introduction

The improvement of the ICRF is one of the most urgent tasks of modern astrometry and this problem can be solved only by the VLBI method. Modern VLBI observations can provide accuracy of CRF determination at the level 0.1–0.3 mas [1]. To achieve such accuracy one should account for many factors contributing to the CRS error budget.

This paper presents preliminary results of investigation of the influence of radio source structure on CRF. There are at least two possible errors caused by complicated structure.

The first one is the dependence of radio source coordinates of VLBI network configuration. To investigate this effect we compare catalogues of source coordinates derived from observations collected in various VLBI programs NEOS-A, CORE-A, and CORE-B.

The second factor is the apparent (or proper) motion of radio sources. It is evident that for extragalactic radio sources only apparent motion caused by displacement of source emission barycenter can be detected with modern technology. This effect can amount to a few tenths of a mas/y [2]. It can be investigated from coordinate time series, e.g. from a series of catalogues derived from a relatively short period of observations. We used a series of catalogues obtained for one year observation period.

The strategy of this study was the following. At the first stage nine catalogues were obtained from observations of NEOS-A, CORE-A and CORE-B observations for 1997, 1998 and 1999. These catalogues were computed using ERA v. 7 program package from global solutions for observations collected from each program during every year. Hereafter they will be referred as "primary" catalogues.

At the second stage six catalogues were derived from the "primary" ones: three catalogues for years 1997, 1998, 1999 averaged over observational programs and three catalogues for each

Table 1. Statistics of observations.

Year	Network	Period	Number of sessions	Number of observations	Number of stations	Number of radio sources
1997	NEOS-A	weekly	52	53698	7	227
1998	NEOS-A	weekly	52	58191	11	234
1999	NEOS-A	weekly	51	61217	11	252
1997	CORE-A	biweekly	23	22590	5	46
1998	CORE-A	biweekly	25	35377	6	67
1999	CORE-A	biweekly	14	18807	8	63
1997	CORE-B1	bimonthly	5		8	
	CORE-B2	bimonthly	5	21503	9	45
	CORE-B3	bimonthly	5		10	
1998	CORE-B1	bimonthly	6		11	
	CORE-B2	bimonthly	6	39225	9	56
	CORE-B3	bimonthly	6		9	
1999	CORE-B4	bimonthly	5		6	
	CORE-B5	bimonthly	4	21853	7	59
	CORE-B6	bimonthly	5		10	

program NEOS-A, CORE-A, and CORE-B averaged over the period 1997–1999. Finally, after analysis of differences between catalogues and time variations of source coordinates a combined catalogue was made. The paper with the combined catalogue is presented on the web page http://www.ipa.nw.ru/PAGE/DEPFUND/GEO/ENG/lab_e.htm.

2. Observations and Primary Processing

The are 155 NEOS-A, 62 CORE-A, and 47 CORE-B sessions for the period 1997–1999 that were processed. The information on observations is given in Table 1.

At this step equations of conditions accumulated for every year/program were processed in global adjustment to derive corrections to a priori values of radio source coordinates which were taken from RSC(IAA)99R02.

After solving corresponding normal systems nine catalogues have been derived for NEOS-A, CORE-A, and CORE-B for 1997, 1998, and 1999. These "primary" catalogues were used for further study.

The station positions and subdiurnal tidal terms in UT1 were also estimated at this stage, but have not been analyzed in this paper.

3. Comparison of Catalogues Obtained from Different Observational Programs

The differences in right ascension and declination were studied for NEOS-A and CORE-A, NEOS-A and CORE-B, CORE-A and CORE-B observational programs. To calculate these differences three catalogues for NEOS-A, CORE-A, and CORE-B averaged over 1997–1999 were used. The differences of angular positions obtained from different observational programs are shown in

Table 2. Differences between catalogues obtained from different observational programs.

Differences	NEOS-A – CORE-A	NEOS-A – CORE-B	CORE-A – CORE-B
All	51	50	58
> 1.5 mas	2	2	6
< 0.5 mas	43	39	40
< 0.25 mas	33	27	29
< 0.10 mas	11	5	9
$\Delta\alpha, \mu$as	–39±19	–71±17	–30±30
$\Delta\delta, \mu$as	–10±19	–20±19	–23±31
$\Delta\alpha_\alpha, \mu$as	64±30	65±24	75±36
$\Delta\delta_\alpha, \mu$as	23±27	52±27	45±45

Fig. 1. The sources with differences in right ascension or declination greater than 1.5 mas are not presented. For NEOS-A–CORE-A differences such sources are 0106+013, and 1451-375; for NEOS-A–CORE-B, 0106+013, 1313-333; for CORE-A–CORE-B, 0106+013, 0919-260, 0920-397, 1313-333, 2134-00 and 2255-282. 1255-316 has a few observations and a large error and also is not presented. The differences of right ascension and declination are mostly within 0.25 mas. The statistics of these differences are given in Table 2.

We tried also to estimate bias ($\Delta\alpha$ and $\Delta\delta$) and periodic term in differences between catalogues ($\Delta\alpha_\alpha$ and $\Delta\delta_\alpha$).

4. Analysis of Apparent Motion of the Radio Sources

A simple way to analyze the time variability of radio sources is to estimate rates of change of their coordinates with time. For this purpose the differences between catalogues derived from annual series of observations were analyzed. We used both "primary" catalogues based on observations collected with each observational program NEOS-A, CORE-A, and CORE-B, and three catalogues for years 1997, 1998, and 1999 averaged over observational programs.

Two approaches were tried. The first one is based on the analysis of differences 1997–1998, 1998–1999, and 1997–1999 between "primary" catalogues. The second method is least squares estimation of linear trend in coordinates from averaged catalogues.

Formally, one may consider as meaningful a value of computed apparent motion that is greater than say two or three standard deviations. But it is well known that formal estimates of standard deviation do not reflect actual error of observations. So, we plan to use supplemental criteria and longer series of observations to find radio sources having detectable proper or apparent motion.

At this stage we found only several candidates that might have detectable apparent motion. As can be expected they mostly belong to "candidates" or "others" sources according to ICRF classification.

5. Combined Catalogue

A combined catalogue was constructed as a weighted average from nine "primary" catalogues. It is presented on the web page http://www.ipa.nw.ru/PAGE/DEPFUND/GEO/ENG/lab_e.htm.

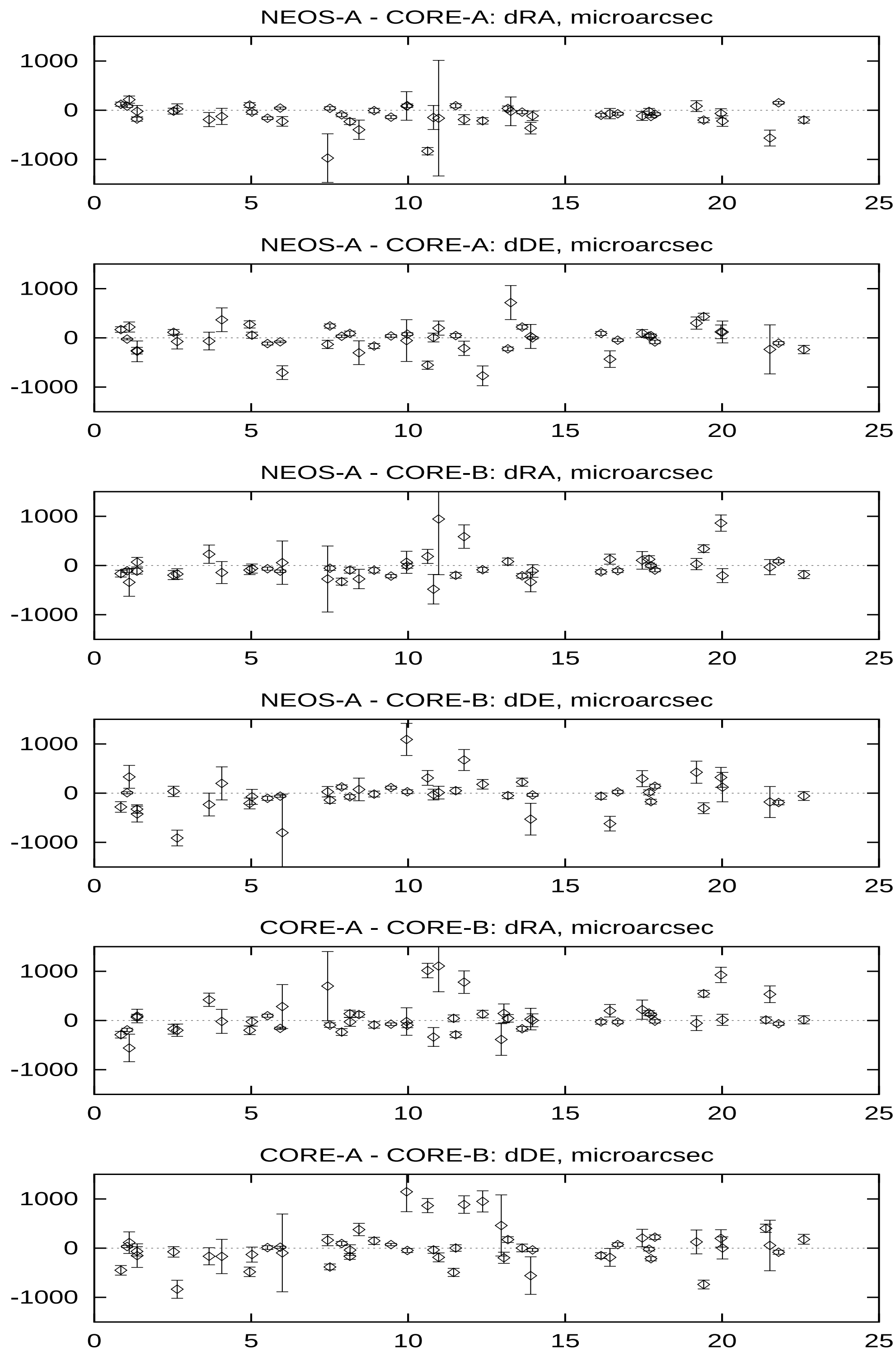

Figure 1. Differences in radio source coordinates obtained from different observational programs as function of RA.

As usual, we can suspect that formal errors in coordinates are underestimated. So, we consider a new procedure for estimation of standard deviation of coordinates which could reflect actual accuracy of observations.

6. Conclusions

This study is based on analysis of "primary" year/program catalogues. It is found that this is an appropriate way to investigate both systematic differences between source directions derived from different observational programs (i.e. on different configuration of network) and detect time variations of coordinates of radio sources. Besides, comparison of annual catalogues allows us to obtain more realistic estimates of errors in source coordinates in the combined catalogue.

Of course, the amount and especially the period of observations are not sufficient to get a definite solution of the problem under investigation. So, we plan to extend this study for all available VLBI observations.

It is clear also that splitting observational data in VLBI programs is only a first approach in studying the dependence of source coordinates on network configuration. Evidently, the next step should be to derive separate catalogues using observations collected from definite network configurations stable during long periods.

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