AN ANALYSIS OF SOURCE MOTIONS DERIVED FROM POSITION TIME SERIES

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ABSTRACT. In this paper, an attempt is made to extract a systematic part from the source apparent motions obtained from the position time series provided by nine IVS Analysis Centers in the framework of the ICRF-2 project. Our preliminary results show that the radio source velocities and the parameters of the systematic part of the velocity field differ substantially between the source position time series.

1. INTRODUCTION

Many radio sources observed during astrometric/geodetic VLBI sessions show progressive variations in its position derived from single session solutions. Several physical effects can cause systematic apparent movement of celestial objects. Hence investigation of the radio source apparent velocity field can help in investigations in various fields, such as fundamental physics, cosmology, etc. Several analysis strategies for computation of systematic part in the radio source velocities can be used:

a) estimate source position and velocities from global solution, then fit spherical harmonics to the velocities (Gwinn et al. 1997);

b) compute the coefficients of spherical harmonics as global parameters (MacMillan 2005; Titov 2008);

c) compute velocities from position time series, then fit spherical harmonics to the velocities.

In this paper, we will test the latter approach which, hopefully, can provide a possibility for supplement comparisons and accuracy assessment. For this work, we have used 26 source position time series computed at nine VLBI analysis centers in the framework of the ICRF-2 project[1] making use of six different software, which provides a good opportunity for comparisons. For more rigorous comparison we also selected the data at common epochs for 17 series. Only the time series having at least 5 sessions and 3-year time span were used. Time series statistics is shown in Table 1.

2. COMPARISON OF VELOCITIES AND SPHERICAL HARMONICS

The source velocities were computed as weighted linear drift of the submitted source positions with weights inversely proportional to the reported variances of source positions. Since some time series contain positions with unlikely small errors (down to 1 μas in the iaa series), which leads to problems with computing the velocity as the weighted trend, it was decided to use a minimal error value of 20 μas, i.e. all errors less then this value were replaced by 20 μas. No series except iaa were substantially affected by this procedure.

At this stage we could compare both values of the source velocities and their errors obtained from different time series. Comparison of velocities showed that they can differ by several times. Median errors in velocities are shown in Table 1; they can serve as an index of the scatter of position time series. One can see that some time series are much more noisy than others.

Then we compute the coefficients of two spherical harmonics ΔH_{12} and ΔH_3 using the following formulas (Titov 2008):

$$\mu_\alpha = -\Delta H_{12} \sin 2\alpha \,, \quad \mu_\delta = -\frac{\Delta H_{12}}{4} \cos 2\alpha \sin 2\delta + \frac{\Delta H_3}{2} \sin 2\delta.$$

The results of computation are presented in Table 1. It can be noted that using more strict criteria, such as minimum 10 sessions and 10 years of observations gives statistically similar result, with smaller value of the formal error in the harmonics coefficients when more observations are used. In the last row

[1] http://ivscc.gsfc.nasa.gov/ivsmisc/ICRF2/timeseries

of the table the results are presented corresponding to the cumulative solution including all the velocity estimates in the input time series.

Table 1: Median errors in velocities $V_\alpha \cos\delta$, V_δ, and spherical harmonics ΔH_{12}, ΔH_3. Unit: μas

Series	All sessions					Common sessions				
	Nsou	$V_\alpha \cos\delta$	V_δ	ΔH_{12}	ΔH_3	Nsou	$V_\alpha \cos\delta$	V_δ	ΔH_{12}	ΔH_3
aus000a	71	7	11	-8.76±3.15	1.02±2.33	—	–	–	—	—
aus001a	343	19	28	-4.53±1.08	-2.13±0.87	—	–	–	—	—
aus002a	308	18	26	-0.34±1.22	-0.47±0.99	—	–	–	—	—
aus003a	322	18	29	-3.80±1.12	-2.47±0.90	—	–	–	—	—
bkg000c	537	14	18	-1.01±0.83	0.85±0.74	350	17	21	-0.27±0.91	-1.27±0.83
dgf000a	277	19	25	-3.84±1.44	4.88±1.49	—	–	–	—	—
dgf000b	476	15	18	-1.66±0.73	1.12±0.70	350	18	21	-1.06±0.74	-0.73±0.71
dgf000c	476	15	21	-0.27±0.90	1.23±0.76	350	19	26	0.88±0.93	-1.08±0.80
dgf000d	476	15	19	-1.94±0.75	1.14±0.72	350	19	23	-1.47±0.77	-0.71±0.73
dgf000e	476	15	19	-2.08±0.73	1.08±0.71	350	19	22	-1.71±0.77	-0.57±0.73
dgf000f	531	16	23	-0.29±0.86	1.27±0.71	350	19	26	0.85±0.97	-0.88±0.81
dgf000g	531	16	19	-2.09±0.71	1.18±0.67	350	19	23	-1.83±0.80	-0.43±0.75
gsf001a	582	13	17	-0.62±0.70	-0.09±0.64	350	15	19	-0.77±0.86	-0.76±0.78
gsf002a	592	13	17	-0.39±0.65	0.64±0.59	350	17	20	0.50±0.83	-1.46±0.76
iaa000b	458	15	22	1.23±1.37	0.80±1.16	350	18	22	3.49±1.21	1.70±1.08
iaa000c	481	16	22	1.15±1.34	2.16±1.15	350	20	23	2.75±1.24	3.44±1.17
mao000b	555	23	31	0.05±1.05	1.01±0.86	350	25	34	0.14±1.26	-0.35±1.07
opa000a	384	15	19	0.11±1.10	-0.46±0.95	—	–	–	—	—
opa000b	510	16	23	-6.14±1.09	0.46±0.88	350	19	28	-10.55±1.52	-1.01±1.21
opa001a	392	15	18	0.20±0.99	-0.37±0.87	—	–	–	—	—
opa002a	511	17	19	0.66±0.87	-0.53±0.77	350	16	20	-0.21±0.94	0.15±0.85
sai000b	501	25	37	-1.96±1.18	1.79±0.95	350	30	45	0.27±1.37	-1.39±1.14
usn000d	572	13	18	-0.70±0.78	0.18±0.70	350	17	20	-0.25±0.90	-1.44±0.81
usn001a	572	21	29	-5.94±1.22	1.53±1.02	350	25	34	-6.57±1.67	-0.28±1.38
All data				-1.24±0.19	0.62±0.17				-0.54±0.23	-0.51±0.21

3. CONCLUDING REMARKS

Although most results obtained in this paper are formally statistically reliable, they differ substantially between input time series, and also between various sets of data selected. This fact, along with results of velocity comparison, may indicate that source position time series should be used with care for analysis of the fine effects in the source motions.

Further study is needed to investigate a possibility to use combined or cumulative solution as the most reliable estimate of spherical harmonics. In particular, careful selection of input series should be performed. For instance, in our cumulative solution dgf data are clearly overweighted due to 6 series used, often with very similar position estimates. On the other hand, it seems to be inappropriate to use only one series from one analysis center because some centers compute two and more series using quite different approaches, and this would be important to compare all of them, because there is no indisputable proof in favor of only one approach.

4. REFERENCES

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