VLBI REALIZATIONS OF THE CELESTIAL REFERENCE FRAME

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ABSTRACT. We validate four recent VLBI astrometric catalogs submitted to the International VLBI Service for Geodesy and Astrometry (IVS) data center by various IVS analysis centers. We compare these catalogs to the most recent realization of the International Celestial Reference System (ICRF2). The catalogs are found consistent with the ICRF2 at less than 15 μas for two of them, and at the level of 20 to 30 μas for the other two.

1. DATA

We considered four recent catalogs submitted to the International VLBI Service for Geodesy and Astrometry (IVS; Schuh & Behrend 2010). They were established at Geoscience Australia, Canberra (aus2012b), the Federal Agency for Cartography and Geodesy, Leipzig, Germany, and Institute of Geodesy and Geoinformation of the University of Bonn, Germany (bkg2012a), the NASA Goddard Space Flight Center (GSFC), Greenbelt, Maryland, (gsf2012a), and the Paris Observatory, Paris, France (opa2012a).

All catalogs were obtained by a single inversion of ionosphere-free VLBI delays accumulated between 1979 and mid-2012. Extensive technical descriptions of the solutions are available at the IVS data center. These solutions used state-of-the-art analysis methods. In addition to source coordinates, all centers estimated session-wise Earth orientation parameters and rates, together with a global terrestrial reference frame (station coordinates and velocities), and a number of nuisance parameters relevant to clocks and troposphere. The Australian analysis center used the OCCAM 6.2 geodetic VLBI analysis software package. Other centers used the latest release of the SOLVE geodetic VLBI analysis software package, developed and maintained at NASA/GSFC. At the level of accuracy reached nowadays, the small variants in the analysis options from one analysis centers to another can have significant consequences on the final VLBI products.

2. ANALYSIS AND RESULTS

Table 1 summarizes the characteristics of each catalogs. It is worth noting that none of the catalogs estimated coordinates for all the 3414 ICRF2 sources. Same situation arises for the ICRF2 295 defining sources. Such a point should be fixed by analysis centers in the future by including in their session list all the sessions which were used for the generation of the ICRF2 catalog.

The source coordinate offsets to ICRF2 are displayed in Figure 2. The extension of the patterns reflect the WRMS of Table 1. Figure 1 was obtained by averaging errors within declination bands of 5°. The error worsens significantly between 20°S and 50°S. This effect likely results from a miscorrected troposphere delay for southern observations (see Fey et al. 2010 for more details). The inclusion of more southern sources in the IVS schedule and the enforcement of baselines covering the southern hemisphere will help in fixing this problem in the future.

The source coordinate difference between catalogs can be modeled by a coordinate transformation that expresses a global rotation between catalogs together with other types of deformations. The coordinate transformation recommended by the IERS reads (IERS 1996)

$$\begin{aligned}\Delta\alpha &= A_1\cos\alpha\sin\delta + A_2\sin\alpha\sin\delta - A_3 + D_\alpha(\delta-\delta_0),\\ \Delta\delta &= -A_1\sin\alpha + A_2\cos\alpha + D_\delta(\delta-\delta_0) + B_\delta,\end{aligned}$$

wherein A_1, A_2, and A_3 are rotation angles around the X, Y, and Z axes, respectively, D_α and D_δ drifts in right ascension and declination as a function of the declination, and B_δ a bias in declination.

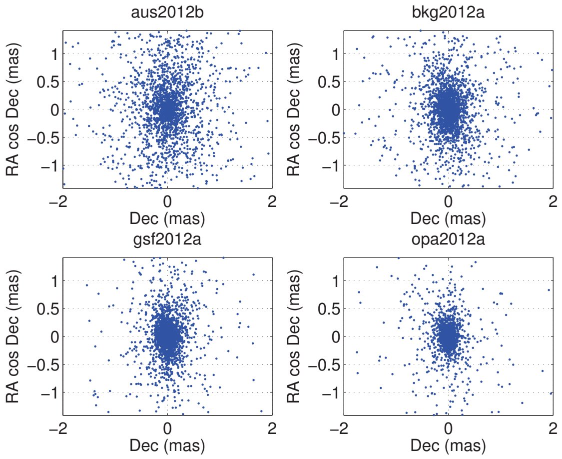

Figure 1: Offsets to ICRF2.

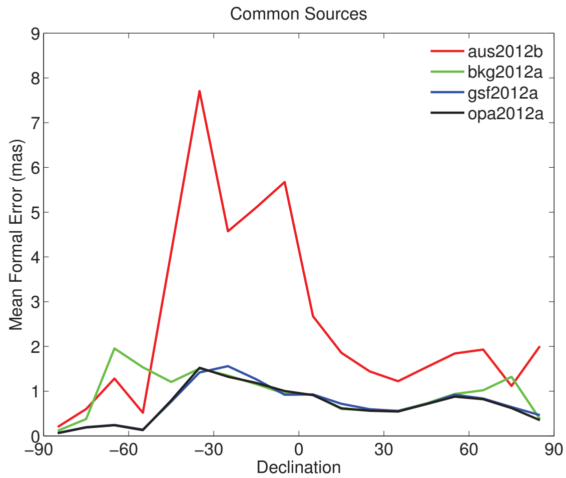

Figure 2: Mean formal error vs. declination for common sources.

Parameters were fitted to the coordinate differences of the defining sources by weighted least squares and reported in Table 2. Most of the catalogs are in agreement with the ICRF2 within 20 μas. The significant biases in declination observed in all catalogs reflect the dissymmetry between the two hemispheres. The small but significant departure in A_1 and A_2 should be further investigated by analysis centers.

	No. Sources			Right Ascension		Declination	
	Total	ICRF2	Defining	Mean	WRMS	Mean	WRMS
aus2012b	2895	2879	288	3.1	94.2	−7.2	83.6
bkg2012a	3253	3091	287	0.2	60.5	21.6	65.5
gsf2012a	3708	3407	294	3.5	55.6	−8.3	54.1
opa2012a	3526	3355	295	8.6	51.5	10.2	51.9

Table 1: Characteristics of the catalogs. Means and WRMS are expressed in μas.

	A_1	$\pm$	A_2	$\pm$	A_3	$\pm$	D_α	$\pm$	D_δ	$\pm$	B_δ	$\pm$
aus2012b	−23.4	*4.9*	3.6	*5.0*	2.8	*4.7*	0.6	*0.2*	0.4	*0.1*	−13.6	*4.7*
bkg2012a	6.7	*4.6*	15.2	*4.7*	0.6	*4.3*	0.1	*0.2*	0.3	*0.1*	17.6	*4.4*
gsf2012a	−2.6	*4.5*	6.8	*4.6*	−2.9	*4.2*	0.0	*0.2*	0.3	*0.1*	−13.7	*4.3*
opa2012a	−4.1	*4.6*	12.3	*4.7*	−6.7	*4.2*	0.2	*0.2*	0.1	*0.1*	9.7	*4.3*

Table 2: Transformation parameters to the ICRF2. Unit is μas.

3. REFERENCES

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