RECENT COMPILED CATALOGUE OF RADIO SOURCE POSITIONS RSC (GAOUA) 01 C 01

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ABSTRACT. The GAOUA series of compiled catalogue of radio source positions is briefly described. New catalogue RSC(GAOUA) 01 C 01 is compiled and compared with ICRF.

1. INTRODUCTION

The preparation of the GAOUA series of compiled catalogues of radio source positions has been started in 1989. The Kyiv arc length method proposed by Ya. Yatskiv and A. Kur'yanova, 1990, has been used for this purpose. It consists of several steps:

* selection of "basic"catalogues of radio source (RS) positions as subset of the collected individual catalogues;

* search for defining RSs common to each selected "basic" catalogues;

* calculation of arc lengths (in the following simply "arcs") between common defining RSs in each "basic" catalogue:

* intercomparison of calculated arcs for all "basic" catalogues, which resulted in evaluation of catalogue weights; determination of mean values of the arcs and "arc minus mean arc" residuals;

* construction of the so-called individual "rigid"frames which are based on the arcs and system of which are defined by positions of two selected RSs (in the following "basic" RS) ;

* construction of combined "rigid" frame using the data of previous steps;

* alignment of this combined "rigid" frame to a standard celestial reference frame in particular to the ICRF, and construction of a compiled reference frame under the following conditions: absence of a net rotation ; minimum displacements among common defining RSs of the standard and compiled frames;

* extension of the combined reference frame realized by common defining RSs to additional RSs, involved in process of constructing the frame.

2. THE GAOUA SERIES OF COMPILED CATALOGUE OF RADIO SOURCE POSITIONS OVER 1991 - 2000

By using the approach described above the seven combined solutions based on individual catalogues of RS positions provided by IERS CB and/or IERS AC were obtained (O.Molotaj et al, 2000; A.Kur'yanova and O.Molotaj, 2001). Table 1 gives overview of individual VLBI frames used to construct corresponding compiled catalogues of the GAOUA type.

Table 1. Statistics of individual celestial reference frames and the GAOUA series of compiled catalogues. N is the number of RSs in a frame; N_d is the number of the defining RSs, which are common for "basic" frames; σ_α and σ_δ are the averaged formal uncertainties (in $0.001''$) for right ascension and declination, respectively; W is the weight of "basic" frame used for constructing the combined "rigid" frame; $\overline{\Delta\alpha}^*$ and $\overline{\Delta\delta}$ are the mean differences in terms of "Frame - ICRF" calculated for defining RSs; $<\Delta\alpha^*>$ and $<\Delta\delta>$ are the m.r.s. of those differences

Frame	N	N_d	σ_α	σ_δ	W	$\overline{\Delta\alpha}^*$	$\overline{\Delta\delta}$	$<\Delta\alpha^*>$	$<\Delta\delta>$
				1991					
RSC(GSFC)90 R 01	72	6	0.11	0.20	0.60				
RSC(JPL)90 R 02	197	6	0.39	0.55	0.17				
RSC(NGS)90 R 01	70	6	0.16	0.30	0.23				
RSC(USNO)90 R 02	77	4	0.18	0.25	–				
RSC(GAOUA)91 C 02	228	59	0.75	1.15	–	-.05	.17	1.82	1.36
RSC(GAOUA)91 C 02	228	6	0.15	0.17	–	-.02	.15	.24	.25
				1993					
RSC(GSFC)92 R 01	357	10	0.10	0.15	0.35				
RSC(NOAA)92 R 01	84	10	0.18	0.29	0.29				
RSC(JPL)92 R 01	282	10	0.19	0.27	0.36				
RSC(NAOMZ)92 R 01	125	9	0.22	0.23	–				
RSC(USNO)92 R 02	113	6	0.07	0.10	–				
RSC(GAOUA)93 C 02	426	158	0.48	0.52	–	-.01	.24	.88	1.04
RSC(GAOUA)93 C 02	426	15	0.08	0.10	–	.02	.12	.16	.14
				1994					
RSC(GSFC)93 R 05	449	25	0.14	0.21	0.55				
RSC(JPL)92 R 02	333	25	0.13	0.16	0.17				
RSC(NOAA)93 R 02	107	25	0.36	0.69	0.28				
RSC(USNO)93 R 09	125	5	0.12	0.15	–				
RSC(GIUB)93 R 01	44	11	0.26	0.31	–				
RSC(GAOUA)94 C 02	505	195	0.52	0.55	–	.03	.27	.92	1.54
RSC(GAOUA)94 C 02	505	58	0.21	0.19	–	.02	.33	.25	.32

Frame	N	N_d	σ_α	σ_δ	W	$\overline{\Delta\alpha^*}$	$\overline{\Delta\delta}$	$<\Delta\alpha^*>$	$<\Delta\delta>$
				1997					
RSC(USNO)95 R 04	556	27	0.07	0.08	0.57				
RSC(GSFC)95 R 01	550	27	0.12	0.09	0.33				
RSC(JPL)95 R 01	287	27	0.14	0.21	0.03				
RSC(NOAA)95 R 01	249	27	0.18	0.25	0.07				
RSC(GIUB)95 R 01	89	5	0.17	0.24	–				
RSC(SHA)95 R 01	45	3	0.06	0.08	–				
RSC(GAOUA)97 C 01	598	212	0.15	0.18	–	.00	.20	.27	.31
				1998					
RSC(USNO)97 R 08	615	82	0.15	0.18	0.36				
RSC(GSFC)97 R 01	600	82	0.14	0.18	0.49				
RSC(JPL)97 R 01	287	82	0.20	0.28	0.15				
RSC(GIUB)97 R 01	266	26	0.78	0.59	–				
RSC(GAOUA)97 R 01	129	17	0.21	0.38	–				
RSC(GAOUA)98 C 01	631	212	0.11	0.13	–	.00	.00	.24	.26
				1999					
RSC(SHA)99 R 01	720	205	0.15	0.18	0.09				
RSC(USNO)99 R 01	652	205	0.12	0.14	0.46				
RSC(GSFC)99 R^{**}	644	205	0.11	0.14	0.25				
RSC(GIUB)99 R 01	602	205	0.15	0.17	0.20				
RSC(IAA)99 R 01	506	82	0.46	0.56	–				
RSC(FFI)99 R 01	431	58	0.16	0.12	–				
RSC(GAOUA)99 C 03	726	212	0.06	0.07	–	.00	.00	.23	.27
				2000					
RSC(SHA)00 R 01	636	204	0.15	0.18	0.30				
RSC(GSFC)00 R 01	624	204	0.11	0.13	0.42				
RSC(BKGI)00 R 01	621	204	0.15	0.17	0.28				
RSC(IAA)00 R 03	312	81	0.13	0.20	–				
RSC(GAOUA)00 R 01	191	47	0.22	0.39	–				
RSC(FFI)00 R 01	104	41	0.13	0.11	–				
RSC(GAOUA)00 C 01	669	212	0.07	0.08	–	.00	.01	.24	.26

3. NEW REALISATION OF CELESTIAL REFERENCE FRAME RSC(GAOUA)01 C 01

Table 2 gives some characteristics of the four individual reference frames which have been used for construction of RSC(GAOUA)01 C 01 by the Kyiv arc method. Three frames, namely RSC(BKGI)01 R 01, RSC(GSFC)01 R 01 and RSC(SHA)01 R 01 had sufficient number of defining sources to be used as individual "basic" frames in process of constructing the compiled catalogue of the GAOUA type. RS 1606+106 and RS 2145+067 were selected as "basic" sources in our approach.

Compiled and individual frames have been compared to the ICRF-Ext.1 and RSC(GAOUA)01 C 01 respectively by using the IERS model represented in equations (1):

$$\begin{aligned} A_1 \tan\delta\cos\alpha + A_2 \tan\delta\sin\alpha - A_3 + D_\alpha(\delta-\delta_\circ) &= \alpha_1 - \alpha_2 \\ -A_1\sin\alpha + A_2\cos\alpha + D_\delta(\delta-\delta_\circ) + B_\delta &= \delta_1 - \delta_2 \end{aligned} \qquad (1)$$

where A_1, A_2, A_3 are rotation angles between two frames under consideration; D_α, D_δ, B_δ represent the systematic effects by three deformation parameters, namely D_α – drift in right ascension as a function of the declination; D_δ – drift in declination as a function of the declination; B_δ – bias in declination.

Table 2. List of VLBI frames under consideration. N is the number of radio sources in the frame; N_b is the number of defining RSs common for the first three catalogues: σ is internal r.m.s. uncertainty ($0.001''$); W is frame weight used for constructing the combined "rigid" frame

Frame	N	N_b	σ_α	σ_δ	W
RSC(BKGI)01 R 01	578	202	0.13	0.16	0.30
RSC(GSFC)01 R 01	552	202	0.08	0.11	0.31
RSC(SHA)01 R 01	660	202	0.14	0.17	0.39
RSC(IAA)01 R 02	331	86	0.25	0.27	–
RSC(GAOUA)01 C 01	670	202	0.08	0.09	–

Only defining sources common to each frame and RSC(GAOUA)01 C 01 were used in the comparisons. The transformation parameters were evaluated by a least squares fit without weights. The relative global orientation and the deformation parameters are given in Tables 3 and 4 respectively.

Table 3. Relative orientation between individual frames and RSC(GAOUA) 01 C 01 (below GAOUAc). A_1, A_2, A_3 are the rotation angles which transform coordinates from the individual VLBI frames to GAOUAc. N_d is the number of common defining sources. Unit: $0.001''$

Frames	N_d	A_1	A_2	A_3
BKGI–GAOUAc	209	$+0.040 \pm 0.011$	$+0.033 \pm 0.011$	-0.031 ± 0.012
GSFC–GAOUAc	202	$+0.007 \pm 0.009$	$+0.000 \pm 0.009$	$+0.012 \pm 0.011$
SHA–GAOUAc	209	$+0.045 \pm 0.015$	$+0.019 \pm 0.015$	-0.021 ± 0.017
IAA–GAOUAc	86	$+0.050 \pm 0.048$	$+0.072 \pm 0.050$	-0.140 ± 0.060
GAOUAc–ICRF	211	-0.011 ± 0.025	-0.023 ± 0.025	-0.004 ± 0.029

Table 4. Drift and biases evaluated in the comparison between individual frames and RSC(GAOUA)01 C 01. D_α, D_δ are the drifts in right ascension and declination respectively, B_δ is the bias in declination. They are evaluated in a global solution together with the rotation angles. Units: $0.001''/deg$ for the drifts, $0.001''$ for the biases

Frames	D_α	D_δ	B_δ
BKGI–GAOUAc	$+0.000 \pm 0.000$	$+0.000 \pm 0.000$	-0.014 ± 0.009
GSFC–GAOUAc	$+0.000 \pm 0.000$	$+0.000 \pm 0.000$	$+0.018 \pm 0.008$
SHA–GAOUAc	$+0.000 \pm 0.001$	$+0.000 \pm 0.000$	-0.027 ± 0.013
IAA–GAOUAc	-0.003 ± 0.002	$+0.001 \pm 0.001$	-0.048 ± 0.051
GAOUAc–ICRF	-0.001 ± 0.001	$+0.000 \pm 0.000$	$+0.010 \pm 0.022$

The four individual celestial frames used for construction of RSC(GAOUA) 01 C 01 have been compared to ICRF-Ext.1 at Celestial System Section (CSS) of the IERS Central Bureau (IERS Annual Report, 2000). No significant slopes in RA and Dec were detected in any individual frames. Moreover constrains applied to align the respective frames as well as GAOUAc to ICRF have resulted in agreements of frames at a few tens of microarcsecond (see values in Table 3).

Figures 1 and 2 show, for the defining sources common to GAOUAc and ICRF, the postfit residuals in RA and in Dec as a function of the declination, and the normalized residuals in Dec as a function of RA respectively.

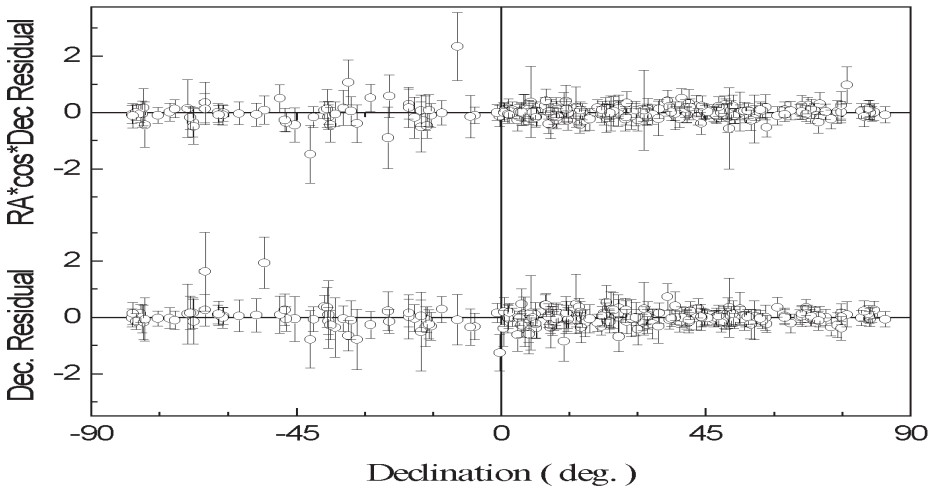

Figure 1: Postfit residuals "GAOUAc–ICRF" against declination for common defining RSs

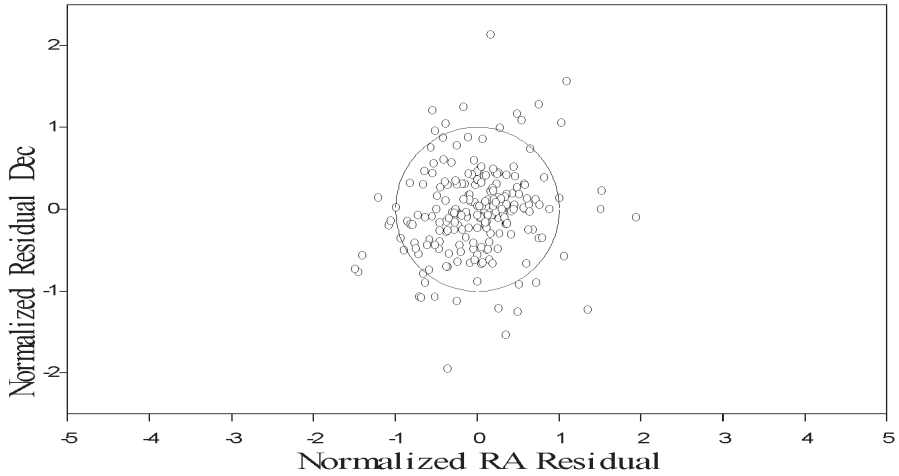

Figure 2: Distribution of normalized residuals "GAOUAc–ICRF" for common defining RRs

4. ON THE INCONSISTENCY OF INDIVIDUAL AND COMPILED CATALOGUES OF RADIO SOURCES WITH THE ICRF

It is pointed out in the report of CSS(see, IERS Annual Report 2000, p.46) that the four individual catalogues under consideration were not inconsistent with the ICRF, at its expected level of accuracy ($\sim 0.25mas$). We try to verify this statment based on the following calculations:

a) formal average values of positions of radio sources were derived for different set of individual and combined/compiled catalogues (SO - system);

b) differences d_{io} between positions of i-th frame and SO-system were calculated and used for determination of the coefficient of correlation r_{ij} between i-th frame and j-th frame.

Table 5. Statistics of individual and compiled catalogues derived from their mutual comparison ($\bar{a}$ is mean differences in RA and in Dec for catalogues under consideration, σ is root squares differences in RA and Dec respectively, and r is the correlation coefficient between the frames under consideration)

Frames		ICRF-Ext.1			RSC(GAOUA)01C 01		
		$\bar{a}$	σ	r	$\bar{a}$	σ	r
RSC(GAOUA)01 C 01	RA	0.011	0.162	-0.01			
	Dec	-0.005	0.194	0.06			
RSC(BKGI)01 R 01	RA	0.008	0.157	0.19	-0.003	0.096	0.35
	Dec	0.005	0.253	-0.51	0.010	0.135	0.05
RSC(GSFC)01 R 01	RA	0.012	0.181	0.00	0.002	0.056	0.88
	Dec	-0.042	0.206	0.17	-0.036	0.077	0.86
RSC(SHA)01 R 01	RA	0.010	0.159	0.10	0.000	0.069	0.58
	Dec	0.002	0.247	-0.31	0.007	0.141	0.12
RSC(IAA)00 R 02	RA	0.014	0.408	-0.56	0.003	0.366	-0.78
	Dec	0.021	0.409	-0.38	0.026	0.375	-0.76

Table 5 gives overview of statistics of the catalogues derived for the common defining radio sources . All catalogues exept RSC(IAA)00 R 02 are consistent with the ICRF at the level of accuracy ~ 0.25 mas.

5. REFERENCES

IERS Annual Report. 2000, Central Bureau of IERS – Bundesamt fur Kartographie und Geodesie, Frankfurt am Main.

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