EFFECTS OF THE DATUM CONFIGURATION OF RADIO SOURCES ON EOP DETERMINED BY VLBI

V. RAPOSO-PULIDO[1,2], R. HEINKELMANN[1], T. NILSSON[1], M. KARBON[1], B. SOJA[1], E. TANIR KAYIKCI[3], C. LU[1], J. MORA-DIAZ[1], H. SCHUH[1], J. GOMEZ-GONZALEZ[2]
[1] Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences
Department 1: Geodesy and Remote Sensing, 14473 Potsdam, Germany
raposo@gfz-potsdam.de
[2] IGN, National Geographic Institute Madrid, Spain
[3] Karadeniz Technical University, Department of Geomatics Engineering, Trabzon, Turkey

ABSTRACT. The Earth Orientation Parameters (EOP) provide the orientation of the International Terrestrial Reference System (ITRS) relative to the Geocentric Celestial Reference System (GCRS) as a function of time. How many and which radio sources are taken into account for the datum definition has a significant effect on the EOP determined by Very Long Baseline Interferometry (VLBI). In this work, using different options for the Celestial Reference Frame (CRF) datum definition, we show how the accuracy of the EOP and the radio source positions can be improved increasing the number of radio sources in the southern hemisphere.

1. INTRODUCTION

The special 24-hour session IYA09 (09NOV18XA) was conducted in the International Year of Astronomy (IYA) in order to observe as many of the 295 ICRF2 (Fey et al. 2009) defining sources as possible in a single session. A typical modern session contains 50-70 sources with a terrestrial network of seven to eleven stations, while the IYA09 includes 237 radio sources and 32 stations. This provides a much stronger geometry to study the impact of the datum definition on the EOP.

2. DATA ANALYSIS: RADIO SOURCE AND EOP ADJUSTMENTS

The data were analyzed with the Vienna VLBI Software (VieVS, Böhm et al. 2012) under consideration of the IERS Conventions (Petit and Luzum, 2010). The celestial datum was realized by applying NNR+dz conditions including different subsets of radio sources, where dz means that the sum of corrections in declination is constrained to zero. Radio sources with less than three observations were excluded from the analysis to avoid singularity problems. Datum A is the reference approach (ICRF2 defining sources, 229 sources), and B ($\delta \geq 0°$, 161), D ($-30° \leq \delta \leq 30°$, 135), E ($0h \leq \alpha \leq 12h$, 127), G ($12h \leq \alpha \leq 24h$, 102) and H ($\delta \leq 0°$, 68) are geometrical subsets. Subset C ($SI \leq 3$, 157) takes into account the structure index (SI), that describes the expected magnitude of the effects of intrinsic radio source structure on VLBI delay observations (Fey & Charlot, 1999). For subset F (F-V sources, 103) the radio sources were selected by statistical tests on the time-varying behavior of radio source coordinates (M. Feissel-Vernier, 2003). The overall formal error (d) was compared with the reference datum A (see Fig. 1). To estimate d we used the equation: d=$\sqrt{\sigma^2_{\alpha cos\delta} + \sigma^2_\delta + \sigma_{\alpha cos\delta}\sigma_\delta C(\alpha,\delta)}$ with C(α,δ)=$\frac{Cov(\alpha,\delta)}{\sigma_\alpha \sigma_\delta}$. Larger variations were found for radio sources of the southern hemisphere. C and F cover almost the same declination and right ascension ranges compared to A and thus showed the smallest differences. Comparing datum configurations B and H with E and G, the impact of the geometrical restriction in declination direction was much larger than in right ascension. For $dUT1$ the formal errors increased when the right ascension range was limited. A good right ascension range is necessary to accurately determine the origin given by the x-axis. Concerning the celestial pole offsets dX and dY, the maximal formal errors appeared for approach H, where the low number of radio sources and the restriction of the datum to the southern hemisphere introduced a defect. For the pole coordinates x_p and y_p the values were stable on the level of a few μas (see Table 1).

3. DATA ANALYSIS: CELESTIAL REFERENCE FRAME

The relative orientations of two 3D frames (e.g. CRF) can be modeled by three rotation angles ($A1$, A_2, A_3) around the x, y, z axes. In addition, systematic frame deformations, such as shearing (D_α, D_δ) and the bias in declination (dz) can be modeled at the same time: $\{d\alpha = A_1 tan\delta_1 cos\alpha_1 + A_2 tan\delta_1 sin\alpha_1 - A_3 + D_\alpha \delta_1$; $d\delta = -A_1 sin\alpha_1 + A_2 cos\alpha_1 + D_\delta \delta_1 + dz\}$ These equations were weighted by using the inverse of the variance of the offsets $(\sigma^2_{d\alpha}, \sigma^2_{d\delta})$ and then inverted. We compared the individual VLBI frames (A to H) with ICRF2 based on the corresponding radio sources. When all the defining sources were included (A), the formal uncertainties of the six parameters were smallest. Approach H showed the largest rotations and deformations with an absolute value of about 120 μas for A_3. Approach C with good geometry but only 157 radio sources showed results comparable to A, but with slightly higher uncertainties. Although the distribution of the radio sources of approach F is comparable to A and C, this approach contains only 103 radio sources and the shearing parameter D_α increased to about -1.5 μas/deg. When the geometry is restricted, i.e., the right ascension or declination range are not covered, the number of radio sources did not seem to play a significant role.

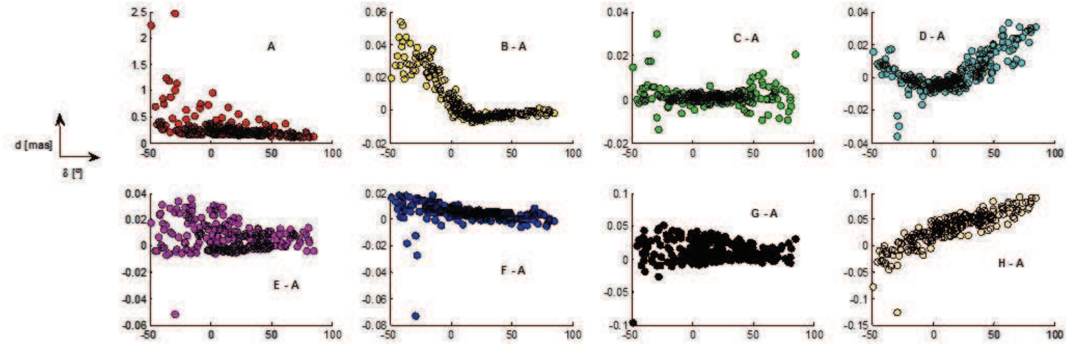

Figure 1: Formal errors of the radio source positions with datum A (upper left plot) and differences of formal errors w.r.t. those of the other subsets

	B-A	C-A	D-A	E-A	F-A	G-A	H-A
$\Delta\,\sigma_{dUT1}[\mu s]$	-0.14	-0.7	-0.9	0.88	0.28	1.74	2.08
$\Delta\,\sigma_{x_p}[\mu as]$	0.79	0.02	0.08	0.29	0.14	0.48	-0.38
$\Delta\,\sigma_{y_p}[\mu as]$	-0.006	-0.003	-0.04	-0.03	0.001	-0.11	-0.005
$\Delta\,\sigma_{dX}[\mu as]$	8.68	5.07	5.42	4.30	9.99	7.44	46.33
$\Delta\,\sigma_{dY}\ [\mu as]$	5.92	1.50	3.33	11.01	6.71	18.62	58.18

Table 1: Differences of the formal errors relative to the reference solution (see text)

Acknowledgements. We acknowledge IGN for its support and IVS for providing the data analyzed in this study, in particular all stations which took part at the IYA09 session.

4. REFERENCES

Böhm, J., Böhm, S., Nilsson, T., Pany, A., Plank, L., Spicakova, H., Teke, K., and Schuh, H., 2012, The New Vienna VLBI Software VieVS, doi: 10.1007/978-3-642-20338-1_126.

Feissel-Vernier, M., 2003, Selecting stable extragalactic compact radio sources from the permanent astrogeodetic VLBI program, doi: 10.1051/0004-6361:20030348.

Fey, A.L., Gordon, D., Jacobs, C.S., 2009, The Second Realization of the International Celestial Reference Frame by Very Long Baseline Interferometry, IERS Technical Note No. 35, ISBN: 3-89888-918-6.

Fey, A.L. and Charlot, P., 1999, VLBA Observations of radio reference frame sources. III. Astrometric suitability of an additional 225 sources, doi: 10.1086/313382.

Petit, G. and Luzum, B., 2010, IERS Conventions (2010), IERS Technical Note No. 36, ISBN: 3-89888-989-6.