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Comparative Study of the EOP Series Derived for the Second IVS Pilot Project

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Abstract

Biases and rms of IVS 2001 Pilot series with respect to the IERS reference series C04 are presented and compared to those derived by the GPS operational series. Significant inconsistencies appear and are discussed.

1. Consistency of EOP Series

An important task of the IERS is to maintain reference series for Earth Orientation Parameters (EOP), providing users the rotation matrix between the International Celestial Reference Frame (ICRF) and the International Terrestrial Reference Frame (ITRF). The reference series, labelled as C04, is achieved from the combination of individual EOP series for a given space geodetic technique and are collected at the EOP Product Center at the Paris Observatory.

The Earth Orientation Parameters of the reference series C04 present significant biases and trend with respect to those of the individual series. The most common explanation is that they arise from the small rotation matrix between the ITRF, respectively the ICRF - to which is theoretically referred the C04 series, and the terrestrial, respectively the celestial, reference frame associated with the individual series.

Let Δx, Δy be the observed biases for x and y pole coordinates, $\Delta UT1$ the observed bias for $UT1 - UTC$, $\Delta\psi$, $\Delta\varepsilon$ the observed biases for nutation offsets. The theoretical biases can be induced from infinitesimal rotation angles $R_{i(i=1,2,3)}$ (respectively $A_{i(i=1,2,3)}$) from the ITRF (respectively ICRF) to the terrestrial (respectively celestial) frame associated with the individual series. The closure relation between observed biases and theoretical ones are called consistencies, and have the following expressions :

$$\begin{aligned} C(x) &= \Delta x - R_2 \\ C(y) &= \Delta y - R_1 \\ C(kUT1) &= k\Delta UT1 - (-R_3 + A_3) \\ C(\delta\psi \sin\varepsilon_0) &= \Delta\psi - A_2 \\ C(\delta\varepsilon) &= \Delta\varepsilon + A_1 \end{aligned}$$

where $k = 1.00273$ is the conversion factor from the mean solar day to the sidereal day and ε_0 the obliquity of the ecliptic at the epoch J2000.0.

When considering all the available series, we can distinguish two cases :

- Consistencies of a given EOP parameter present small dispersion with respect to a significant average. In this case the C04 series present a shift with respect to international reference frames, and have to be corrected by adding offsets.
- Consistencies present large dispersion: we can conclude there are inconsistencies in the individual series.

For a better understanding of the origin of inconsistencies, IVS organized a campaign analysis in which EOP parameters are determined by constraining the radio source coordinates to those of the ICRF-Ext1 and the station source coordinates to those of the ITRF 2000. In this case angles $R_{i(i=1,2,3)}$ and $A_{i(i=1,2,3)}$ are equal to zero, and consistencies are directly equal to observed bias. In turn if C04 series be ideal, biases should be equal to zero.

In the following section, we present the bias of IVS Pilot series with respect to C04. Then we shall present similar analysis for GPS and SLR operational series collected at the EOP Product Center. Finally we discuss the "mean consistency" of all these series.

2. Bias of IVS Pilot Series

IVS Pilot series were derived from all available NEOS-A 24hr VLBI session. They range from 1999.0 to 2001.0. Estimated parameters include the pole components x-pole, y-pole, UT1-UTC and the nutation offsets $d\psi$, $d\varepsilon$ with respect to IAU 1980 model. Eleven centers participated in this campaign. Actually some of the series considered here are operational ones, updated twice a week (IAA, BKG, AUS, SPBU, GSF).

We have computed the biases and rms of these series with respect to C04 series, and for each EOP parameter. They are displayed on Figures 1 for x-pole and y-pole.

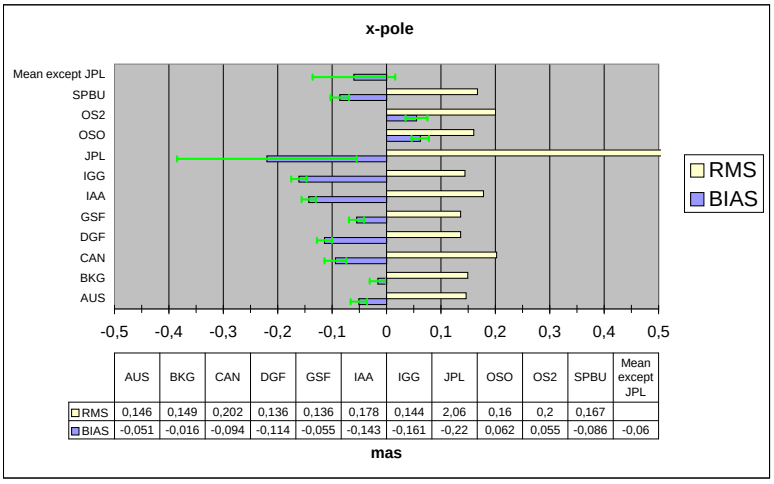
For x-pole coordinate, the bias are not so homogeneous ranging from -0.016 mas (BKG) to -0.22 mas (JPL). The standard deviations are between 0.1 and 0.2, except for the JPL series which presents a suspect rms. The averaged bias, without considering JPL series, is about -0.060 ± 0.076 mas. For y-pole coordinate biases are much more homogeneous than for x-pole, and are centered around the mean value 0.326 ± 0.024 mas. The JPL series and CAN series have anomalous bias and too large rms.

For UT1-UTC the biases range between 5 and 25 microseconds. Again the JPL series present anomalous rms.

For nutational offsets, the bias and rms are much less homogeneous than for the other parameters. For IGF and DGF series the observed large bias and rms, according to the authors of these series, do not reflect reality but some analysis problem linked to bad choice of unit. The mean value of the bias, except for anomalous values, is -0.012 ± 0.058 mas for $d\psi \sin \varepsilon_0$ and 0.048 ± 0.034 mas for $d\varepsilon$.

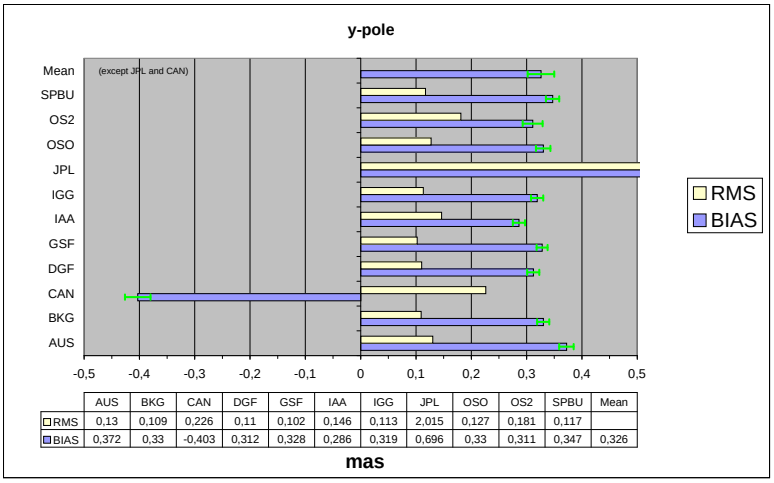
3. Biases of GPS Operational Series

The same kind of approach was done for the nine GPS operational series, covering the period 1999-2001, which we collect at Paris Observatory in the framework of the EOP Product Center of the IERS. We report bias and rms for x-pole and y-pole on Fig. 2. The biases are much more hetereogeneous than in the case of VLBI pilot series. This could be expected from the fact that GPS series are referred to ITRF 2000 sub-network, which present significant small rotations with



	AUS	BKG	CAN	DGF	GSF	IAA	IGG	JPL	OSO	OS2	SPBU	Mean except JPL
RMS	0,146	0,149	0,202	0,136	0,136	0,178	0,144	2,06	0,16	0,2	0,167	
BIAS	-0,051	-0,016	-0,094	-0,114	-0,055	-0,143	-0,161	-0,22	0,062	0,055	-0,086	-0,06

mas



	AUS	BKG	CAN	DGF	GSF	IAA	IGG	JPL	OSO	OS2	SPBU	Mean
RMS	0,13	0,109	0,226	0,11	0,102	0,146	0,113	2,015	0,127	0,181	0,117	
BIAS	0,372	0,33	-0,403	0,312	0,328	0,286	0,319	0,696	0,33	0,311	0,347	0,326

mas

Figure 1. Biases and rms of VLBI Pilot series with respect to C04 : x-pole, y-pole.

respect to ITRF 2000.

The mean bias for x-pole is -0.024 ± 0.024 mas and for y-pole 0.170 ± 0.058 mas.

The rms are about two times smaller than in the case of VLBI series. Actually this does not prove that GPS series are better, but this reflects the greater weighting of GPS operational series in the combined solutions C04.

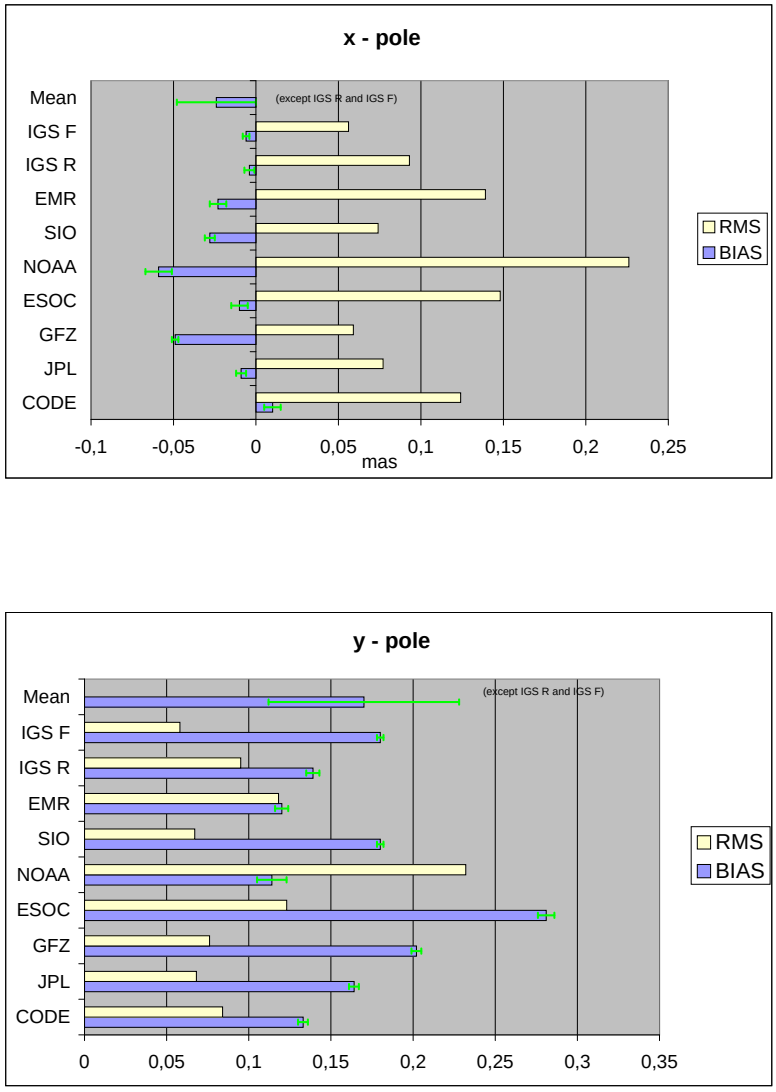


Figure 2. Biases and rms of GPS operational series with respect to C04 : x-pole, y-pole.

4. Mean Consistencies

Considering that the series are in principle referred to ITRF and ICRF, their corresponding consistencies are directly given by their bias with respect to C04. We present here a comparison between the mean consistency for IVS Pilot series, GPS operational series, SLR operational series, and VLBI series analysed in the framework of the IERS 2000 annual report.

Fig. 3 shows that all consistency values have the same sign, except for SLR series. Notice that consistencies of polar motion derived from SLR is almost perfect.

For nutational pole offsets inconsistencies are at the level of 0.04 mas, but are smaller than the rms of the individual series (more than 0.1 mas).

A larger confidence can be attributed to the mean consistencies for polar motion. In the case of VLBI Pilot series they are about two times larger than in the case of GPS series. Comparison with the mean consistencies of VLBI series for IERS annual report 2000 cannot be done strictly, in the sense the consistency analysis has been for a much larger interval of data, in most of the cases 1988-2000.

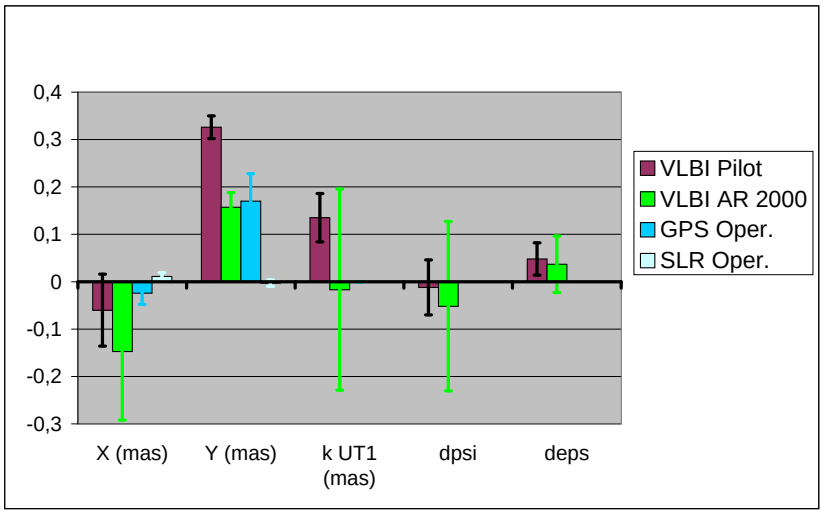


Figure 3. Mean consistencies of VLBI Pilot, GPS operational, VLBI Annual Report 2000, SLR operational series.

5. Conclusion

Systematic differences appear between the IVS Pilot series and C04 for the time span 1999-2001. The most significant ones concern polar motion, up to 0.3 mas for y-pole coordinate. GPS operational solutions for polar motion present also significant offset with respect to C04, on average two times smaller than the IVS Pilot series. Mean differences between VLBI and GPS Pilot solutions are -0.036 mas for x-pole and 0.156 mas for y-pole.

Such discrepancies could be due to sub-network effects, insufficient modelling of the tropospheric correction. More investigations are needed at the level of the analysis centers, for instance the test of the influence of the network for GPS solutions.

These results show slight inconsistency of the C04 polar motion. It seems that C04 is a little bit shifted with respect to ITRF 2000, by -0.30 mas in y-component according to Pilot series, -0.15 mas according to GPS operational series, and that a jump of the opposite quantities (but which ones?) should be applied for setting it in agreement with ITRF 2000.