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Abstract

The OPAR Analysis Center operational activities in 2001 focused on the implementation of a new version of the Gloria software and improved analyst support by the development of hypertext-based screening of analysis parameters and results. The impact of the celestial reference frame stability on the monitoring of precession and nutation was investigated.

1. Software Development

- A new version of the Gloria software was developed. It includes a series of improvements concerning the data base handling, the consideration of diurnal terms in polar motion and universal time, and the data editing and weighting. When applied to the intensive sessions, this new analysis scheme results in the decrease of the scattering of the UT1 results. The rms residual with respect to the IERS values in 1999 is $\pm 18\mu$s, to be compared to the previous value of ± 20 μs.
- The production of loosely constrained terrestrial reference frames per session (SINEX format) was initiated.
- Quick post-analysis screening is now possible through hypertext-based file cataloguing.

2. Impact of Source Stability on Precession-Nutation Studies

In a collaboration with the Royal Observatory of Belgium and the GSFC, studies [1] of the impact of celestial frame stability were performed, to check to which extent source instability may propagate into the VLBI estimation of precession or some nutation components. The reference nutation model is the one adopted by the IAU in 2000, MHB2000 [2]. The VLBI data used are of three types, as follows.

- Five series of $d\psi$, $d\epsilon$ submitted to the IERS in 2001: BKG 01R01, GSFC 01R01, IAA 01R01, SHA 01R01 and USNO 99R03 over the 1980-2000 time span, that are used to compute the residual departure of VLBI results from the reference precession-nutation model.
- Two series of $d\psi$, $d\epsilon$ especially computed by C. Ma (GSFC) over the 1980-2001 time span, with and without considering the sources known to have instable positions (the "arc sources" in ICRF-Ext.1 [3]). These results are used to estimate spurious precession-nutation effects, labelled "Arcs" hereafter.
- Time series of source coordinates already analysed in [4]. These results are used to estimate spurious precession-nutation effects, labelled "CRF" hereafter. The "Arcs" and the "CRF" corrections are obtained by looking for source coordinate signatures that would mimic precession or nutation signals. They differ both in the approach and in the list of sources considered. They represent two approximations of the real effect.

Table 1. Modeled and estimated values of trends in the celestial pole motion

Data	Precession corr. 0.001”/year		Obliquity rate 0.001”/year	
MHB2000	-2.997			
MHB residual	.036	± .018		
VLBI-MHB	.018	± .005		
Estimated perturbation due to source selection				
Arcs	-.001	± .008	-.031	± .003
CRF	.009	± .002	-.008	± .001

2.1. Precession and Obliquity Rate

Table 1 gives the values of the precession correction that is associated with the MHB2000 nutation model, the difference of the VLBI results with this reference value, and the two estimates of the effect of source instability on the precession and obliquity rates. The VLBI discrepancy with the MHB2000 precession correction is in statistical agreement with the MHB2000 residual. The two estimates of the source instability effect are in weak agreement, but their similar order of magnitude, as well as their amplitudes relative to the MHB2000 residuals, are an indication of the relevance of considering this aspect.

2.2. The 18.6-year Nutation Term

Figure 1 shows the two estimates of the impact of source instability on the determination of the 18.6-year nutation term. The point labelled “VLBI” is the average of the estimates derived from the five mentioned $d\psi$, $d\epsilon$ series. The estimate of the atmospheric effect is taken from [1]. The “CRF” correction estimate is smaller than the “Arcs” one. The correction obtained by the two methods are somewhat in disagreement: “CRF” would better reconcile the observations with the model in the case of the prograde component, while “Arcs” works better in the retrograde component. Again, the similar order of magnitude, both between the two estimates and with the discrepancy with the MHB2000 model, gives arguments for the relevance of the question asked.

2.3. The Annual Nutation

Figure 2 illustrates the influence of source coordinate treatment in the determination of the time-varying forced annual nutation. The atmospheric excitation in the seasonal frequency band is active mainly in the retrograde component and it varies with time [1]. One indeed hopes to observe these variations in the VLBI results. The observed prograde component shows negligible variations after about 1986, especially when only the stable sources are used. The retrograde component results show significant time variations, as expected. Note that the solution based on the more stable sources is shifted toward positive in-phase values.

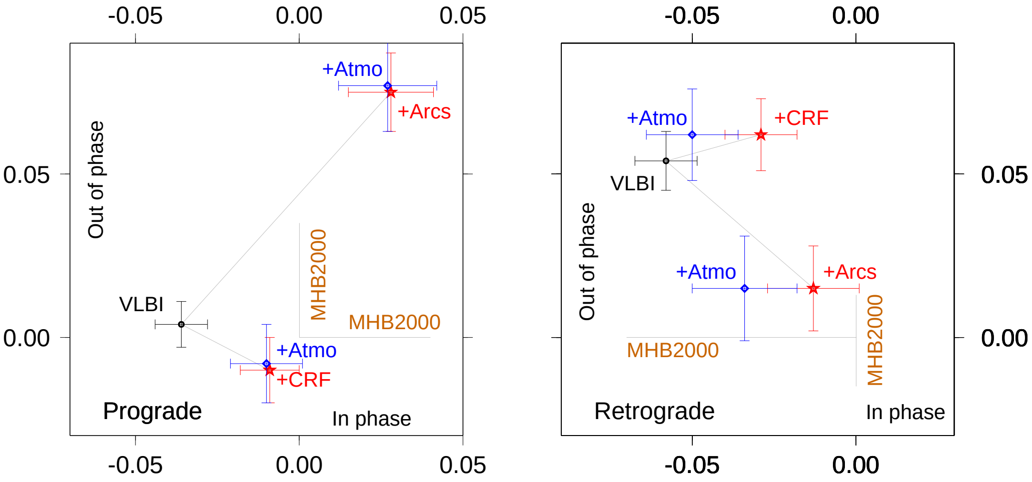

Figure 1. Corrections to the MHB2000 18.6-year nutation term, obtained from the analysis of the five VLBI series (VLBI), corrected for the effect of instable sources (+Arcs) or of celestial pole motion effect (+CRF), and then for the atmospheric excitation (+Atmo). Unit: 0.001".

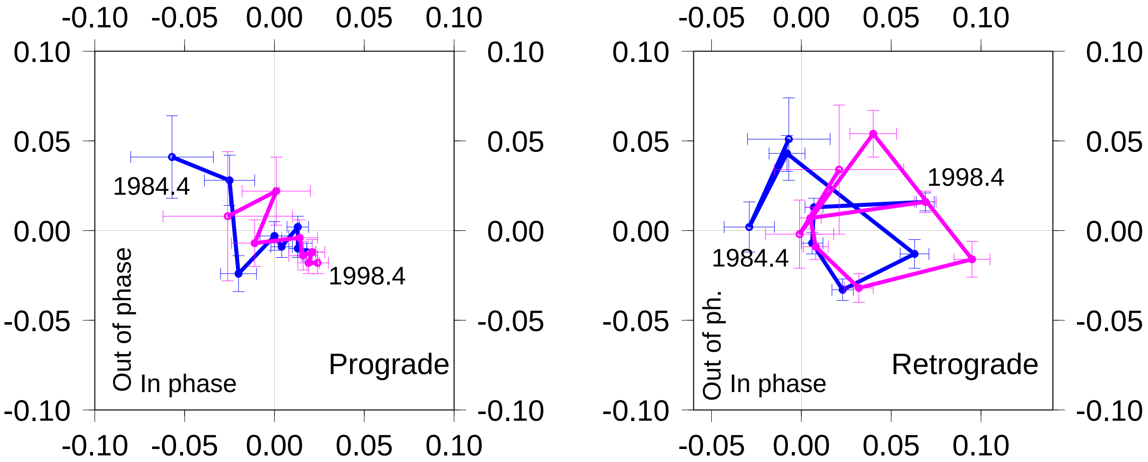

Figure 2. Corrections to the MHB2000 annual nutation. Prograde and retrograde components of the annual nutation derived from VLBI observations. In blue (dark), based on all sources; in pink (light), based on the stable sources only. Unit: 0.001"

2.4. The Free Core Nutation

In figure 3, the influence of source coordinate treatment in the determination of the time-varying Free Core Nutation (retrograde 430-day) is shown to be non-negligible in the 1980s. However, it cannot be invoked as a cause for the change in phase and amplitude around 1990. Dehant et al. [1] give arguments in favor of an atmospheric origin for this change.

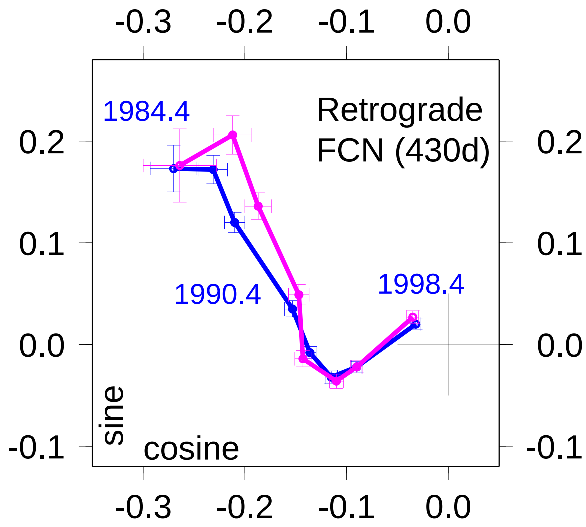

Figure 3. VLBI-derived retrograde component at the FCN frequency (430 days). In blue (dark), based on all sources; in pink (light), based on the stable sources only. The origin of phases is J2000.0. Unit: 0.001”

2.5. Conclusion

While the precision of VLBI-derived precession and nutation results is at the level of ±10 μs, these results show clearly that the role of the celestial frame stability is worth analyzing in a rigorous way if further progress is sought in the understanding of the Earth’s precession and nutations.

References

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[2] Mathews, P.M., Herring, T.A., and Buffett, B.A., 2001, Modeling of nutation-precession: new nutation series for nonrigid Earth, and insights into the Earth’s interior., J. Geophys. Res., in press.

[3] International Earth Rotation Service (IERS), 1999, 1998 Annual Report, 83. Observatoire de Paris.

[4] A.-M. Gontier, K. Le Bail, M. Feissel, T. M. Eubanks, 2001. Stability of the extragalactic VLBI reference frame. AA 376, 661