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A Comparison of the VLBI Nutation Series with IAU2000 Model

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Abstract

This paper presents preliminary results of investigation of VLBI nutation series available in the IVS data base. It is shown that rather large systematic differences exist between these series, especially in 1984–1986. However, all series reveal common details in comparison with IAU2000A and MHB2000 nutation models. From analysis of the differences between VLBI and model nutation series preliminary values of corrections to precession parameters are estimated.

1. Introduction

This paper continues an analysis of investigation of the VLBI results of determination of nutation of the Earth's rotation axis in comparison with the latest nutation models ([4]). At the first step of this study we performed mutual comparison of the VLBI nutation series. Then they are compared with the MHB2000 model ([3]) and IAU2000 model available in the draft IERS Conventions (2000) distribution available at `ftp://maia.usno.navy.mil/conventions/`. The only difference between these models is that the latter does not include unpredictable, time-varying Free Core Nutation (FCN) contribution.

We used for comparison four long-time VLBI series available in the IVS data base and MHB2000 series available at `http://www-gpsg.mit.edu/~tah/`. The latest MHB2000 version used here is of the end of 2001 and provides FCN amplitudes determined from observations for period ended at epoch June 1, 2001. After this date FCN value is available only as prediction and one should keep this in mind during comparisons of the model with observations after this date.

2. Preliminary Investigation of the VLBI Series

We have used for our analysis four series: BKG00001, GSF2001C, USN2001D computed with CALC/SOLVE, and IAAO0106 computed with OCCAM. Only one of three BKG series available in the IVS was used after preliminary analysis which showed that systematic differences in nutation series between them is negligible for this study. No one reported data were excluded except several GN88 experiments present in the BKG solution.

Figure 1 shows formal errors reported in the compared series. Since formal errors and overall rms differences with MHB2000 differ for compared series at the level about 10% no weighting of input series was applied.

It was found [4] that differences between nutation series obtained with CALC/SOLVE and OCCAM packages contain an annual term with amplitude about 0.16-0.17 mas, whereas the differences between series obtained with the same software are very small (usually less than corresponding rms). Detailed investigation of this problem led us to the conclusion that the most probable reason for that systematic difference is the double account of the effect of geodesic precession in OCCAM.

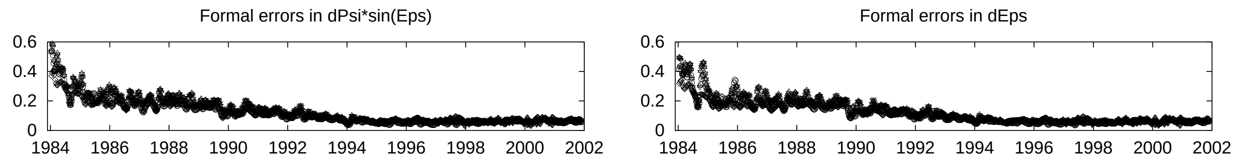

Figure 1. Formal errors in nutation series: BKG (circles), GSF (triangles), IAA (diamonds), USN (inverted triangles).

Table 1 shows comparison of nutation series before and after correction of OCCAM (IAA) data. One can see that after correction systematic differences between IAA and CALC/SOLVE-based series practically disappeared. Fortunately, this error can be easily corrected in submitted OCCAM series without re-processing.

Table 1. Annual term in differences between IAA and others $\Delta\psi$ series before (on the left) and after (on the right) correction of the IAA series, μas.

	AUS	BKG	GSF	SPU	USN
IAA	25	176	189	72	184
	±30	±28	±26	±30	±26

	AUS	BKG	GSF	SPU	USN
IAA	147	38	33	100	32
	±30	±29	±26	±30	±26

Another possible reason of systematic differences between nutation series computed in various Analysis Centers is using different models of daily and subdaily EOP variations models. Judging by descriptions of VLBI EOP solutions present in the IVS data base four or five models of short-period tidal variations are used in various AC which lead to inconsistency of nutation series. For preliminary estimation of a possible effect we compared two series computed at the IAA with two models of daily and subdaily EOP variations. The result presented in Table 2 show small but visible influence of choice of model on estimates of nutation. Obviously, this problem should be investigated in more detail.

Table 2. Differences between series computed with two models of daily and subdaily EOP variations (Eanes's model – Ray's model): bias, rate/year, amplitude of annual term, amplitude of semiannual term, μas.

EOP	bias	rms	rate	rms	amp(a)	rms	amp(sa)	rms
$\Delta\psi$	−27	18	16.3	7.3	20	26	27	26
$\Delta\epsilon$	22	9	2.2	3.4	7	12	5	12

3. Comparison with the MHB2000 Model

The result of comparison of the VLBI series with the MHB2000 model is shown in Figure 2. One can see that differences are rather large for the period before about 1990.0, especially for 1984–1985 where, in addition, systematic difference between IAA and CALC/SOLVE-based series is clearly detected. Also, all series show the same discrepancy with the MHB2000 model during last several months which evidently can be explained by errors in FCN extrapolation after 2001.4.

Some analysts suppose that a reason for peculiarities in the EOP series in the 1980s is non-linear motion of HRAS station. However, in all the compared series its position is modelled with linear velocity, and a possible effect of irregular HRAS motion must be the same for all

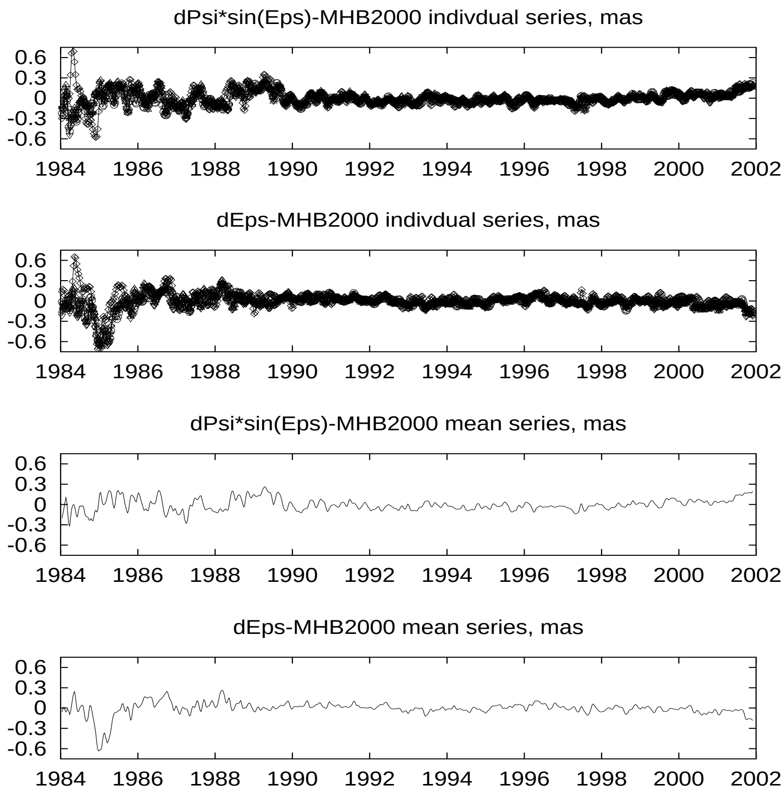

Figure 2. Comparison of the VLBI series with the MHB2000 model (smoothed). Two top plots show individual nutation series: BKG (circles), GSF (triangles), IAA (diamonds), USN (inverted triangles). Two bottom plots show unweighted average values.

compared series. Besides, analysis made by L. Petrov (GSFC) showed that differences between nutation series obtained with linear and more sophisticated model of HRAS motion are much lesser than found here (`http://gemini.gsfc.nasa.gov/pet/discussion/hras_eop/hras_eop.html`). Evidently more detailed analysis is needed to explain these differences.

In any case, FCN model evidently requires substantial correction for the period 1984–1985. On the other hand, these differences can be a result of some common error in the VLBI results, indeed.

4. Comparison with the IAU2000 Model

Figure 3 shows the results of comparison of the VLBI nutation series with the IAU2000 model which can be interpreted as FCN contribution. Again, all series show a good agreement except for the period 1984–1985.

It is of common interest to investigate how accurate the FCN contribution can be predicted. The first experiments with auto-regression algorithm show that it can be predicted with accuracy at least 50 μas for a period of several months.

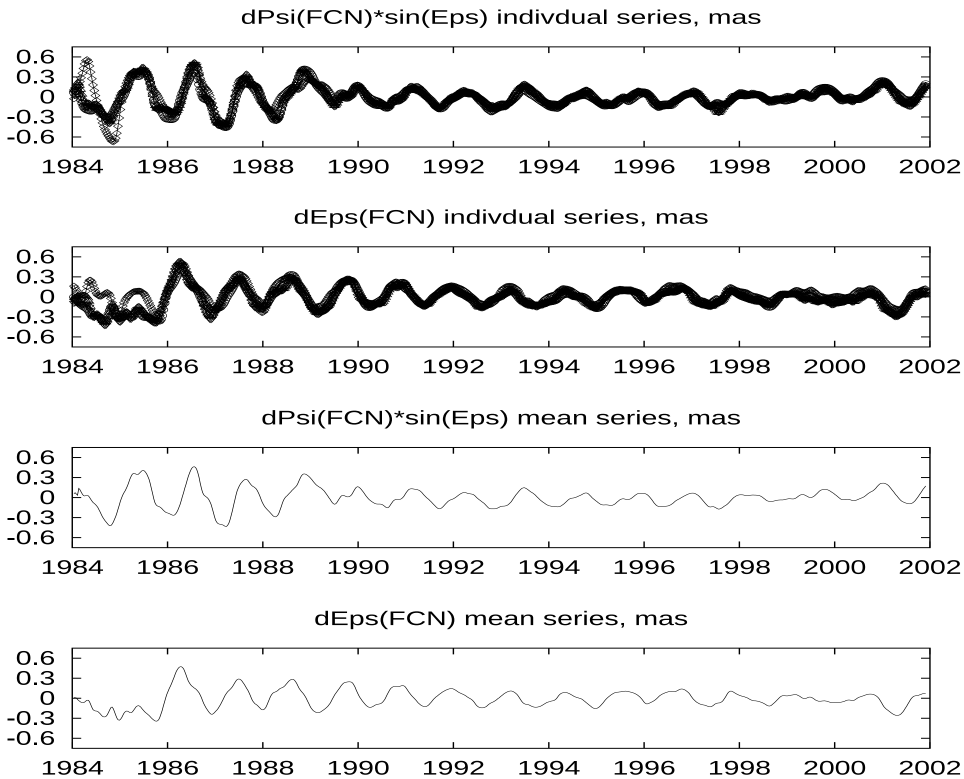

Figure 3. Comparison of the VLBI series with the IAU2000A model (FCN contribution, smoothed). Two top plots show individual nutation series: BKG (circles), GSF (triangles), IAA (diamonds), USN (inverted triangles). Two bottom plots show unweighted average values.

5. Corrections to Precession Parameters

Precession parameters were estimated as linear trend along with largest long-period terms 6798.38^d, 3399.19^d, 365.26^d, 182.62^d, 121.75^d. One can see from Figures 1 and 2 that VLBI results show significant improvement beginning from epoch ~1990.0. So, we have computed the precession parameters both for the whole interval 1984.0–2001.9 and for 1990.0–2001.4. (In the latter case the term with period 6798.38^d was not included in the adjustment procedure.)

The results of computation are presented in Table 3. For more detailed comparison we computed results both for individual series and for all their combinations. Table 3 contains results for individual series, averaged CALC/SOLVE series and averaged over all four compared series. One can see that there is no evident systematic differences between OCCAM and CALC/SOLVE results for $\Delta\psi$, however such a difference obviously exists for $\Delta\epsilon$.

Obtained corrections to precession parameters $\Delta\psi$ and $\Delta\epsilon$ rates averaged over all the series are in reasonable good agreement with those found in [1, 2].

6. Conclusions

The results of this study allow us to make some conclusions.

Table 3. Corrections to precession parameters.

Series	1984.0–2001.9				1990.0–2001.4			
	$\Delta\psi$		$\Delta\epsilon$		$\Delta\psi$		$\Delta\epsilon$	
	bias	rate	bias	rate	bias	rate	bias	rate
BKG	−14±9	+42±4	−25±4	+11±2	−42±5	+24±2	−10±2	−6±1
GSF	+18±9	+20±4	−27±3	+6±2	−36±5	+13±2	−20±2	−9±1
IAA	+12±9	+34±4	+37±3	−5±2	−72±5	+25±2	+29±2	−2±1
USN	−23±9	+27±4	−34±4	+8±2	−71±6	+14±2	−14±2	−8±1
BKG GSF USN	−7±8	+31±4	−28±3	+8±2	−50±5	+17±2	−14±2	−8±1
BKG GSF IAA USN	−2±8	+32±4	−11±3	+4±1	−57±5	+19±2	−5±2	−6±1

1. Results of determination of nutation angles with OCCAM and CALC/SOLVE differ substantially in the period 1984–1986 which must be investigated in more detail. All VLBI series indicate that MHB model (most probably FCN component) requires substantial correction for this period.
2. The analysis of differences between observed and theoretical nutation values along with comparison of formal errors of the VLBI nutation series give a hint that maybe only VLBI results obtained for observations made after 1989 are accurate enough for meaningful comparison with the modern models of Earth's rotation.
3. The influence of adopted model of short-period EOP variations should be investigated in more detail. It seems reasonable to use a unified model in all Analysis Centers for better consistency between EOP series.

7. Acknowledgement

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