IAU2000: COMPARISON WITH THE VLBI OBSERVATIONS AND OTHER NUTATION THEORIES

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ABSTRACT. The modern nutation theories of the nonrigid Earth predict the nutation amplitudes with very high precision and the differences between main amplitudes sets of these theories are small. Therefore complete comparison of the theories impossible without estimation of the differences between theoretical nutation angles and VLBI observations. This comparison for modern nutation series (IAU2000 (Mathews et.al.(2002)), GF99(Getino and Ferrandiz (2000)), HJL2001 (Huang et.al. (2001)) and ZP2003 series (Zharov and Pasynok (2003))) were made.

The IVS *.ngs files for VLBI observations from 1980 to 2002 and package OCCAM5.0 (Titov and Zarraoa (2001)) were used for calculation of corrections for theories. As results the corrections to the nutation angles $\Delta\varepsilon$ and $\sin\varepsilon_0\Delta\psi$ for each theory were obtained. The IAU2000 theory (without FCN) achieves the best accuracy.

The main term of the differences between theory and observations is the free core nutation (FCN). This term is different for each theory.

1. INTRODUCTION

The 4 modern nonrigid nutation theories were selected for analysis: IAU2000a, GF99, ZP2003, HJL2001. The theories IAU2000a and GF99 are now well known. The ZP2003 has specific atmospheric account and more detailed analysis of the conservation low. This theory differs from ZP2002 (Zharov and Pasynok (2002)) by the elastic nonlinear term in tidal potential. The HJL2001 theory uses the numerical integration method.

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The IVS *.ngs files for VLBI observations from 1980 to 2002 and package OCCAM5.0 (Titov and Zarraoa(2001)) were used for calculation of corrections for theories. Original package was modified but the processing core of the OCCAM5.0 was not changed: only new nutation theory were included and new interface was created.

The processing VLBI observation for every theory was uniform: every *.ngs file was processed with the every theory as the start approximation. The observable additions to the theoretical

Table 1: The nutation amplitudes for the main nutation term (18.6 years) in *mas*.

Theory	S0psi	C0eps
IAU2000	-17206.416	9205.233
GF99	-17206.393	9205.018
ZP2003	-17206.366	9205.162
HJL2001	-17206.271	9205.147

Table 2: The correlation between FCN for nutation theories for $\delta\psi$ nutation angle.

	IAU2000	**GF99**	**ZP2003**	**HJL2001**
IAU2000	1	0.40	0.61	0.22
GF99	0.40	1	0.28	0.03
ZP2003	0.61	0.28	1	0.37
HJL2001	0.22	0.03	0.37	1

nutation angles were determined. The results were clipped at the 1 mas wrms error level.

2. NUMERICAL RESULTS

The differences between theoretical and observational nutation angles are plotted on the Fig. 1 and Fig. 2 (gray line). The solid black lines are running average of these differences. These lines are determined mainly by the free core nutation(FCN). As we see this term is different for each theory, especially for $\delta\psi$ angle (see Table 2).

The wrms of differences between theories and observations are shown in the Table 3. But for more clear comparison it is convenient to introduce the approximation quality coefficient according to:

$$K \equiv \frac{\sqrt{\frac{1}{2}\left((\delta\varepsilon_{IAU2000})^2 + (\sin\varepsilon_0\delta\psi_{IAU2000})^2\right)}}{\sqrt{\frac{1}{2}\left((\delta\varepsilon)^2 + (\sin\varepsilon_0\delta\psi)^2\right)}}$$

The approximation quality coefficients for theories are shown in the Table 4.

Table 3: The wrms of the nutation theories(μas).

Theory abbreviation	$\Delta\varepsilon$	$\sin\varepsilon_0\Delta\psi$
IAU2000	218	171
GF99	232	173
ZP2003	230	204
HJL2001	288	223

Table 4: The approximation quality coefficient.

Theory abbreviation	K
IAU2000	1
GF99	0.96
ZP2003	0.90
HJL2001	0.76

Table 5: The wrms of the differences between nutation theories for $\delta\varepsilon(\mu as)$.

	IAU2000	**GF99**	**ZP2003**	**HJL2001**
IAU2000	0	128	143	186
GF99	128	0	183	175
ZP2003	143	183	0	160
HJL2001	186	175	160	0

It is interesting to compare the wrms of the differences between theories and observations and wrms of the differences between different theories (rms of the differences between theories which were weighted using observations weights). The comparison of the Table 3 with Table 5 and Table 6 shows that differences between any theory and observations and differences between this theory and other theory are similar.

The every theory achieves the best accuracy only with the it's own precession rate and pole biases (Table 7). It is interesting that differences between these parameters for different theories are much more then internal accuracy of any theory (Table 8).

3. CONCLUSIONS

The brief conclusions from numerical results are following.

1. The best approximation is provided by IAU2000 theory($K = 1$). But GF99, ZP2003, HJL2001 are very close to it ($0.76 < K < 0.96$). Thus, all theories provide good approximation of the VLBI observations.

2. From the statistical point of view the differences between theories are negligible small. (Because of time of the VLBI observations is short (approximately 1 main nutation period) and the wrms of the differences between theories are approximately the same as the differences between any theory and VLBI observations).

3. The theories predict the different precession rate corrections and pole biases. Therefore

Table 6: The wrms of the differences between nutation theories for $\delta\psi(\mu as)$.

	IAU2000	**GF99**	**ZP2003**	**HJL2001**
IAU2000	0	115	282	271
GF99	115	0	317	305
ZP2003	282	317	0	331
HJL2001	271	305	331	0

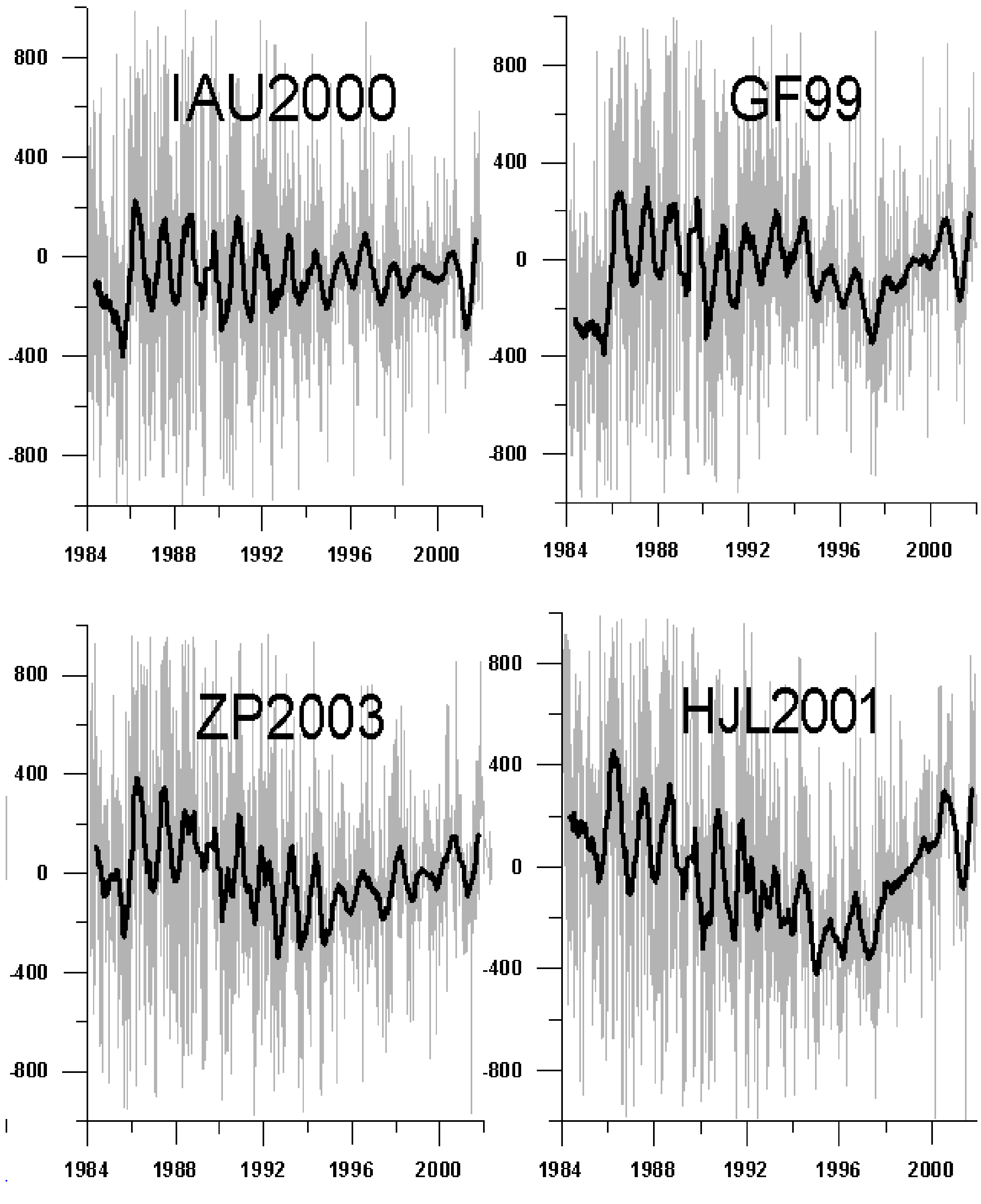

Figure 1: Differences between theories and observations for $\delta\varepsilon$ nutation angle in μas(gray line). The black line is the running average of this differences which mainly determined by FCN.

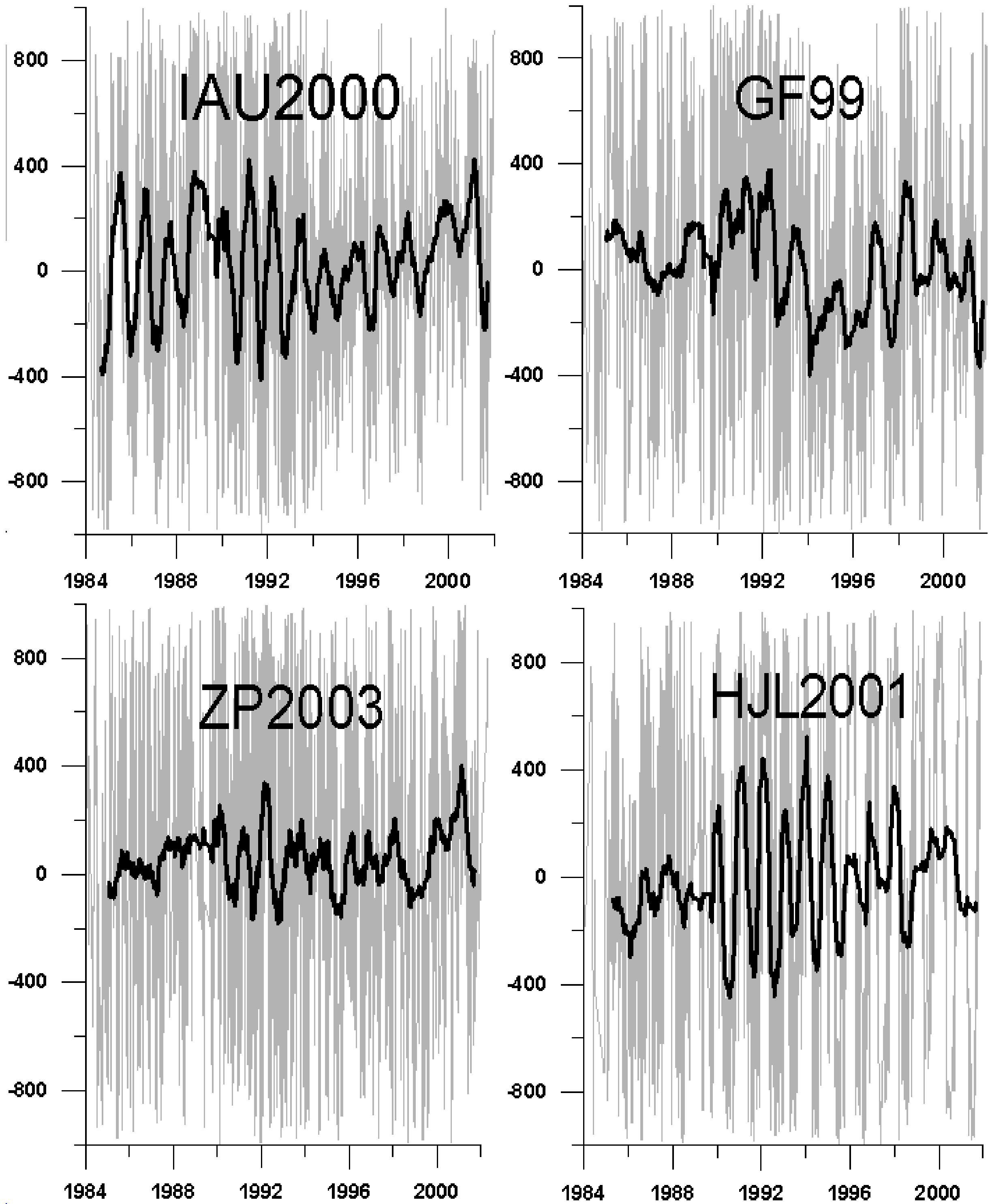

Figure 2: Differences between theories and observations for $\delta\psi$ nutation angle in μas(gray line). The black line is the running average of this differences which mainly determined by FCN.

Table 7: The precession rate corrections and pole biases.

	IAU2000	**GF99**	**ZP2003**	**HJL2001**
$\delta\psi_A$("/c)	-0.2996	-0.3001	-0.3115	-0.3050
$\delta\varepsilon_A$("/c)	-0.0252	-0.0282	-0.0226	-0.0249
ξ_0(")	-0.016617	-0.017129	-0.015873	-0.017196
η_0(")	-0.006819	-0.005390	-0.006838	-0.005192

Table 8: The accuracy of the precession rate corrections and pole biases.

	External (between different theories)	**Internal (IAU2000)**
$\delta\psi_A$("/c)	0.010	0.00040
$\delta\varepsilon_A$("/c)	0.003	0.00010
ξ_0(")	0.001	0.00001
η_0(")	0.001	0.00001

the more correct theory can be determined with time. The monitoring of the differences between the best nutation theories and VLBI observations is needed for determination of the most correct theory.

4. The FCN term is different for each theory. Therefore it can be describe correctly until the most correct theory will be determined. From the statistical point of view the time of the VLBI observation have to be equal to at least 3 main nutation periods for this purpose.

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