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Comparison of the Prediction Force of the Nutation Theories IAU 2000 and ERA-2005

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Abstract. A comparison of the nutation theories IAU 2000 and ERA-2005 has been carried out on the efficiency of their use in a nutation angles prediction program. As a result, the used prediction procedure yielded similar results for ERA-2005 and IAU 2000 to within the uncertainties of the measurements.

1. Introduction

According to the IAU Resolution B1.6 (2000), beginning on Jan. 1, 2003, the IAU 1976 Precession Model and IAU 1980 Theory of Nutation were replaced by the precession-nutation model IAU 2000 (MHB 2000, based on the transfer functions of Mathews, Herring and Buffett [1]). Besides this, the IAU recommends to continue the theoretical developments of non-rigid Earth nutation series for a more accurate account of some processes which are difficult to model.

Observations over the last five years have evidently shown that the best agreement of the theoretical and observable nutation angles is provided by the theory IAU 2000.

However, according to the carried out works [2, 3], higher accuracy is provided with the numerical theory ERA-2005 developed by George Krasinsky. Nevertheless, this direct comparison of the IAU 2000 and ERA-2005 nutation theories with VLBI observations does not allow to compare these theories properly for the following reasons:

– the rms of the discrepancies with VLBI observations for IAU 2000 theory is differs from the same value for ERA-2005 theory less than on about 10% rms of the discrepancies with VLBI measurements for IAU 2000 theory;

– the nutation theory ERA-2005 in particular describes retrograde nutation component which is treat as retrograde free core nutation (RFCN) in IAU 2000 theory. But according to IERS Technical Note No 29, the RFCN, being a free motion that cannot be predicted rigorously, is not a part of the IAU 2000 model.

Therefore the prediction power method is offered for the comparison of the nutation theories.

2. The Method

In this section the method of comparison is discussed and results of applying this method to some nutation theories are shown.

2.1. Explanation of the Method

The following idea underlies the offered comparison method. It is known that the disagreement of the predicted and the measured values grows with distance from the last point of the history (the observable data which were used for the construction of the prediction). Therefore, though disagreements of theories from the measured values are comparable, the disagreements of the prediction with use of these theories from the measured values grow with distance from last point of history. Therefore, there is such earliness of the prediction (in this paper the earliness of the prediction is understood as time distance of a prediction point up to the last history point) that disagreement of the prediction under one theory and the prediction under another theory will become large enough.

Fig. 1 explains the comparison method graphically.

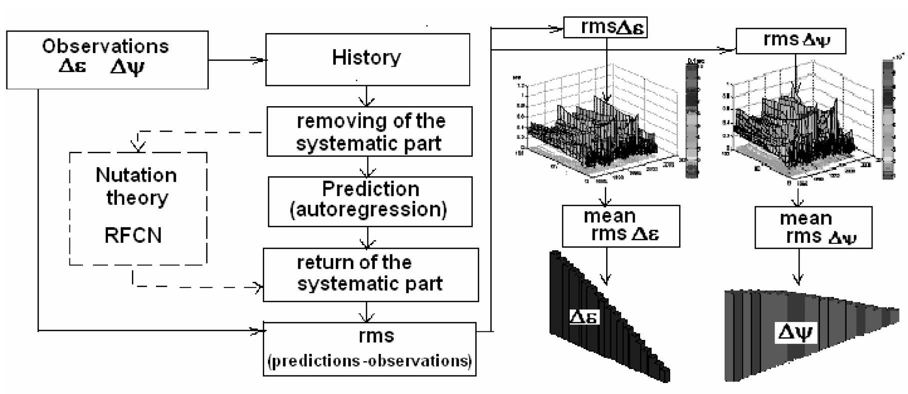

Figure 1. Explaining of the basis of the method

The prediction of each theory was calculated by the following algorithm:

1) The systematic part, which consisted of theoretical nutation angles, linear part, and RFCN mode, was subtracted from the history. Therefore RFCN was taken into account in a similar way for all compared theories.

2) The differences were predicted for 100 days forward with the help of autoregression.

3) After that the systematic part was added to the predicted values of the differences.

4) The measured values were subtracted from the obtained prediction for the same dates resulting in discrepancies between predicted values and observations.

5) The mean rms of the discrepancies between prediction and observation over the period from 1988 to 2008 were calculated for each value of earliness (from 10 to 100 days).

6) Further received mean rms for theories were compared among themselves. The limits of rms differences were estimated considering that 2σ for the observable nutation angle $d\varepsilon$ is 200 μs. Therefore, after dividing these values by the square root of the number of points one obtains that 2σ for mean rms values of $d\psi$ and $d\varepsilon$ nutation angles are 11 and 4 μs. These values were accepted as significant.

2.2. The Method Approbation

For approbation of the method two nutation theories were examined: IAU 2000 [1] and GF 1999 [4]. As a results the IAU 2000 nutation theory showed the best agreement between prediction and observations. The differences of rms were greater than 2σ.

3. Comparison of IAU 2000 and ERA-2005 Theories

After that the method described above was used to compare the theories IAU 2000 and ERA-2005. The mean rms values for the period from 1988 to 2008 are shown in Tabl. 1.

4. Conclusions

1. For the procedure of the prediction given, the results of the prediction for ERA-2005 and IAU 2000 yield similar results to within errors of measurements.

2. A smoothing average estimation was also provided in order to check the very exciting prediction of ERA-2005 of a super precession in the dpsi nutation angle. But super precession was not detected within the measurement errors.

Table 1. Comparison of IAU 2000 and ERA-2005 theories results: mean rms, differences mean rms and significant levels

Earliness days	$d\varepsilon$, μas				$d\psi$, μas			
	ERA-2005	IAU 2000	Δ	2σ	ERA-2005	IAU 2000	Δ	2σ
10	248.5	248.9	0.4	4	581.6	584.0	2.4	11
15	251.8	252.1	0.3		597.4	598.8	1.4	
20	252.9	253.1	0.2		608.2	608.6	0.4	
5	254.1	253.8	−0.3		606.3	605.9	−0.4	
30	254.0	253.6	−0.4		608.2	607.3	−0.9	
35	254.2	253.7	−0.5		612.9	611.2	−1.7	
40	255.5	254.6	−0.9		611.1	608.7	−2.4	
45	254.7	253.9	−0.8		611.7	608.5	−3.2	
50	255.0	253.9	−1.1		614.8	610.9	−3.9	
55	256.2	254.8	−1.4		613.2	608.5	−4.7	
60	255.9	254.5	−1.4		613.7	608.8	−4.9	
65	256.0	254.5	−1.5		616.1	610.5	−5.6	
70	257.1	255.3	−1.8		615.1	608.6	−6.5	
75	257.1	255.3	−1.8		616.0	609.1	−6.9	
80	257.4	255.4	−2		619.1	611.6	−7.5	
85	258.4	256.3	−2.1		618.9	610.8	−8.1	
90	258.8	256.6	−2.2		620.3	612.0	−8.3	
95	259.1	256.8	−2.3		622.7	613.5	−9.2	
100	259.7	257.4	−2.3		622.5	612.3	−10.2	

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