MODEL OF THE FREE CORE NUTATION FOR IMPROVEMENT OF THE EARTH NUTATION SERIES

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ABSTRACT. The Free Core Nutation (FCN) is one of a normal mode of the Earth. It is observed as retrograde oscillation with period of 430 days and variable amplitude. The FCN contribution in difference between the model and observed nutation is significant and has to be explaned for further improvement of the nutation theory. In order to model and predict the FCN signal the theory of the atmospheric tides is suggested to use.

1. INTRODUCTION

New model MHB2000 (Mathews et al., 2002) of nutation and precession was adopted as official IAU model. It does not include the FCN because its contribution can not be predicted rigorously. The FCN signal is observed as an oscillation with retrograde period of 430 days and amplitude between 0.1 and 0.3 milliarcseconds.

Several models are proposed for the FCN signal. Herring et al. (2002), assumed the constant frequency of the FCN, determined empirical sine and cosine amplitudes for two-year intervals. Mathematical model for the FCN with variable period and amplitude was developed by Malkin (2003). Other model was proposed by Shirai and Fukushima (2001), in which the FCN is considered as damped sinusoidal oscillation. This physical model is based on the hypothesis of excitation of the FCN by strong earthquakes.

In all models the parameters of the FCN signal are estimated from differences between theoretical and observed nutation. Strictly speaking, this models represent the estimation of the FCN signal from the VLBI data. In this paper, I will try to use the theory of the atmospheric tides to predict the FCN. It was shown (Gegout et al., 1998) that the atmosphere excitation sources are powerful enough to excite the FCN to its mean 0.2 mas observed level in VLBI series. The theory of the atmospheric tides allows to predict the amplitude of the ψ_1 tide, corresponding the retrograde annual oscillation. So frequency of the ψ_1 tide is close to the frequency of the FCN, and this tide can be one of the sources of excitation the FCN.

2. METHOD

In our approach the ψ_1 atmospheric tide is result of semi-annual modulation of the thermal tide S_1. This conclusion is confirmed by Fig.1 on which amplitudes of the tides ψ_1 and π_1 depending on time are shown (uncertainties of each point are of order of 0.07 mas). If these tides are result of semi-annual modulation of the tide S_1 then their amplitudes have to be equal. Amplitudes were estimated be least square method on three-year intervals using the pressure term of the atmosphere angular momentum series (Kalnay et al., 1996).

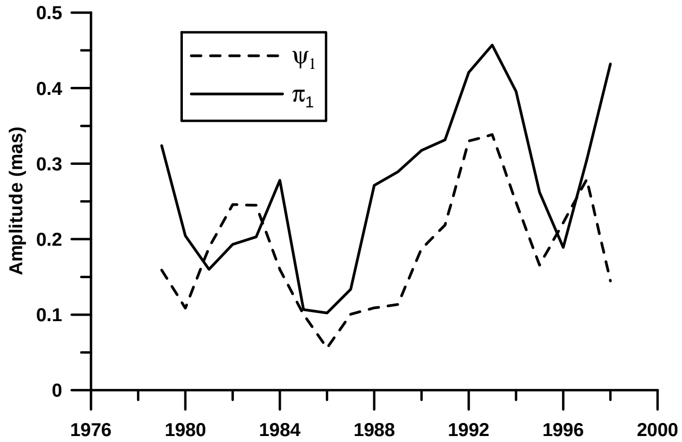

Figure 1: Amplitudes of the atmospheric tides ψ_1 and π_1

Figure 2 shows the spectrum of the pressure term in retrograde diurnal frequency band.

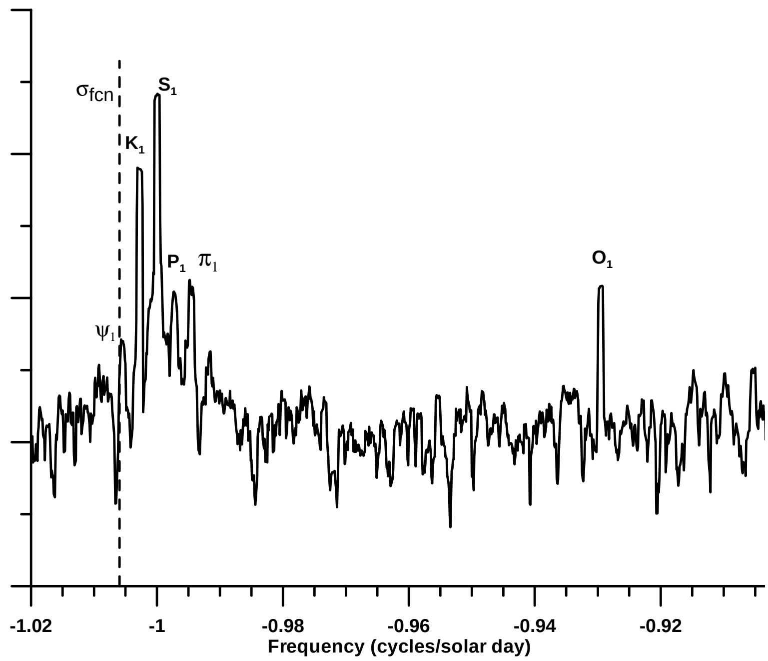

Figure 2: Spectrum of the pressure term

As shown in Zharov (1997) annual modulation of S_1 and appearance of the K_1 and P_1 tides can be explained by the annual variation of water vapour distribution in the atmosphere. Semi-annual modulation can be obtained by application of more complicated model of seasonal variations of water vapour.

The different nutation series MHB2000, GF99 (Getino, Ferrandiz, 2000), ZP2003 (Zharov, Pasynok, 2002) were used to estimate the parameters of the FCN. As was shown by Pasynok (2003) the FCN terms are different for these theories. The OCCAM software (Titov and Zarraoa,

2001) was used for calculation of corrections for $\Delta\psi \sin\varepsilon_0$ and $\Delta\varepsilon$ for each nutation series. In spectra of residuals between the theoretical and observed nutation the strong peak around -430 days is clearly determined but amplitudes of the FCN are different (Fig.3).

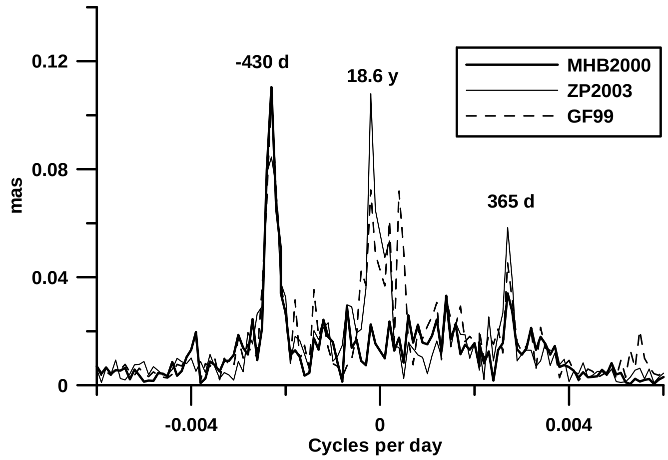

Figure 3: Spectra of complex residuals for different nutation series

Variations of the FCN amplitudes are shown in Fig.4. They were calculated together with the period and quality factor by weighted non-linear least square fitting on two-year intervals. One can see that theories MHB2000 and ZP2003 show similar behavior of the FCN amplitude but theory GF99 differs significantly. The time variations of the FCN period are small ($\sim$ 3 days) and less then formal errors from least square solution, but the quality factor vary significantly.

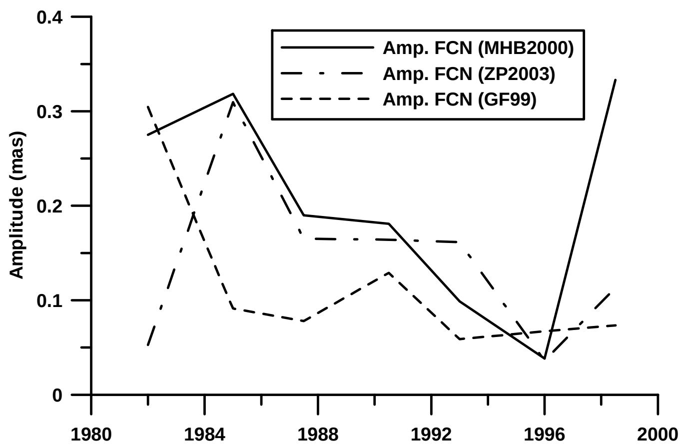

Figure 4: The FCN amplitude

3. CONCLUSIONS

The general conclusion from analysis is that the time variation of the FCN amplitude most probably excited by the atmospheric tides. The time variation of the ψ_1 tide can be connected with the seasonal distribution of water vapour that can be modeled. This approach may be useful for prediction of the FCN amplitude but we suffer failure in explanation of variabilities of the FCN period and quality factor.

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