A NUTATION MODEL WITH EARTH INTERIOR PARAMETERS ESTIMATED ON THE TIME DOMAIN DATA.

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1. INTRODUCTION

The nutation response of the non-rigid Earth to the gravitational forcing by the Moon, the Sun, and the planets has been modeled by Mathews et al. (2002). This semi-analytic model depends on unknown Earth interior parameters (such as the dynamical ellipticities of the Earth and fluid core, e and e^f, the compliances representing elasticity effects of the whole Earth and fluid core, κ and γ, and the coupling constants at the core-mantle and inner-core boundaries, K^{CMB} and K^{ICB}) which are estimated by fitting the model to the nutation data.

The classical method used to model the nutations is to compute the nutation of a hypothetic rigid Earth with the same dynamical ellipticity as the real Earth and to convolve it with a transfer function accounting for the effects of non-rigidity. As the gravitational forcing is mainly periodic, nutation is modeled in Mathews et al. (2002) as a function of frequency:

$$\eta(\mathbf{p}, \sigma) = TF(\mathbf{p}, \sigma)\ .\ \eta_R(\sigma), \tag{1}$$

where $\eta = \Delta\psi \sin\epsilon_0 + i\Delta\epsilon$ is the complex amplitude of nutation, $\mathbf{p}$ is the vector of the geophysical parameters to be estimated, σ is the frequency of the nutation term, TF is the transfer function for the non-rigid Earth and η_R is the complex amplitude of the rigid Earth nutation. To adjust this model to the observations, nutation data must be transformed into a series of complex amplitudes for fixed frequencies, to which the geophysical parameters are fitted with a linearized least-squares method.

In this paper, we propose a new fitting procedure of the nutation model to the observations. We add a time dependence to the nutation model by multiplying each nutation term by the argument $\arg(\sigma, t)$ given in the rigid Earth series. We include the precession rate $P(e)$ and an empirical parameter $\frac{d\Delta\epsilon}{dt}$, accounting for the secular variation in obliquity, in the nutation model:

$$\eta(\mathbf{p}, t) = \sum_{\sigma} [TF(\mathbf{p}, \sigma)\ .\ \eta_R(\sigma)] \exp(i\ \ \arg(\sigma, t)) + \left(P(e)\sin(\epsilon_0) + i\frac{d\Delta\epsilon}{dt}\right) t. \tag{2}$$

We adjust this model to the nutation observations in time series and estimate the geophysical parameters with a Bayesian inversion method.

This method offers the advantages to take the time variable quality of the data into account, to allow for the estimation of non-periodic terms and, in particular, the precession and obliquity rates, simultaneously with the geophysical parameters and to use an inversion method which does not assume a linear dependence of the model in the parameters.

2. NUMERICAL RESULTS

The geophysical parameters are estimated with the Bayesian inversion method and sampled with the Metropolis algorithm. The numerical values obtained as well as the adjustement from the values of PREM model (Dziewonski and Anderson 1981) are shown in Table 1 and compared to the results of Mathews et al. (2002).

Parameter	This Paper		Mathews et al. (2002)	
	Estimate	Adjustment	Estimate	Adjustment
e	**0.0032845456** ± 6 10^{-10}	0.000037	**0.00328454**79 ± 1 10^{-9}	0.000037
e^f	**0.0026**527 ± 6 10^{-7}	0.0001048	**0.0026**456 ± 10^{-6}	0.0000973
κ	**0.0010**168 ± 7 10^{-6}	-0.0000222	**0.0010**340 ± 9 10^{-6}	-0.0000043
γ	**0.0019**643 ± 1 10^{-6}	-0.0000007	**0.0019**662 ± 1 10^{-6}	0.0000007
Im(K^{CMB})	**-0.0000**136 ± 7 10^{-7}	...	**-0.0000**185 ± 1 10^{-6}	...
Re(K^{ICB})	**0.000**935 ± 1 10^{-4}	...	**0.00**111 ± 1 10^{-4}	...
Im(K^{ICB})	**-0.00**183 ± 2 10^{-4}	...	**-0.00**078 ± 1 10^{-4}	...

Table 1: Numerical values of the geophysical parameters.

In addition to the geophysical parameters, the secular variation of the obliquity was estimated as an empirical parameter. The correction to the IAU precession rate can be directly obtained from the estimated geophysical parameter e. Numerical results are shown in Table 2.

Parameter	This Paper (mas/y)	Herring et al. 2002 (mas/y)
$P(e)$	-3.031 ± 0.009	-2.997 ± 0.007
$\frac{d\Delta\epsilon}{dt}$	-0.254 ± 0.003	-0.252 ± 0.003

Table 2: Correction to the IAU precession rate and empirical obliquity rate.

3. CONCLUSIONS

We estimate the Earth interior parameters using all the available nutation data in time series. By using the data in the time domain, we estimate simultaneously the precession and obliquity rates and the geophysical parameters. We use a fit procedure which does not make linearizations in the parameters. The values obtained for the parameters are close to the values of Mathews et al. (2002) but are not always within their error bars.

REFERENCES

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