NUTATION RESIDUALS AND PHYSICS OF THE EARTH INTERIOR

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ABSTRACT. Nutations are mainly determined from Very Long Baseline Interferometry (VLBI) data. The nutations allow us to infer properties of the Earth's interior, such as the flattening of the core-mantle boundary and, with some hypotheses, the electromagnetic fields at the inner core and outer core boundaries.

We examine how far we can go now in the understanding of the Earth's interior and how VLBI observations can be used to constrain Earth's interior models.

This allows us to get the confidence intervals on the Earth's interior parameters deduced from VLBI as done for the MHB2000 model.

1. OBSERVATION

Nutations are observed by Very Long Baseline Interferometry (VLBI). From arrival time delays of radio signals at two different stations, the orientation of the Earth in space and its time variations are deduced. Nutations coefficients are derived from this time series. The possible motions of the radio-sources limit the precision at a few tens of microarcseconds.

2. THEORY

The IAU adopted nutation model is the model MHB2000A by Mathews et al. (2002), based on geophysical considerations and geophysical parameters fitted on the observations. The nutations used for this fit are not corrected for the atmospheric effects except for a constant prograde annual contribution at the level of 0.1 milliarcsecond. Yseboodt et al. (2002) have demonstrated that the atmosphere also contributes to other nutation components at an observable level. These authors have also shown that, from one atmospheric model to the other, the atmospheric contributions to nutation varies strongly. The interpretation of the nutation data in terms of the physics of the Earth interior is therefore limited by the uncertainties on the atmospheric effects: in particular, MHB2000A erroneously interpret atmospheric effects as contribution of the Earth interior, and the inferred Earth interior parameters have an accuracy limited accordingly. Additionally, the MHB2000 nutation model is based on an Earth model, which is simplified (3 homogeneous layers, with ellipsoidal boundaries). Consequently, the Earth's interior parameters obtained from the nutation model are only valid in the limit of validity of this Earth model. In this study, we investigate how the uncertainties in the Earth interior contribution to the transfer function associated with the atmospheric contribution propagate into the Earth interior parameters.

3. STRATEGY

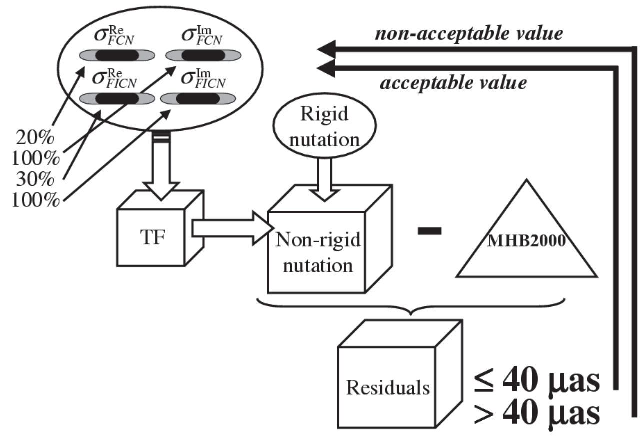

Figure 1: Strategy to test the Model of MHB2000.

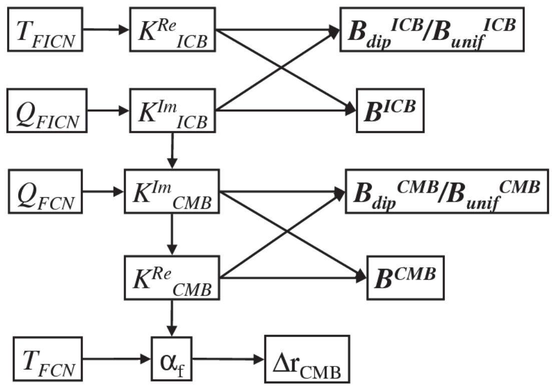

Figure 2: Parameter computational scheme

The strategy is explained by the sketch of Figure 1. It represents the different steps performed in the evaluations:

- to take values of the FCN and FICn complex freqeuncies within the interval given a priori,
- to compute the transfer function with these parameters,
- to convolve with the rigid Earth nutation in order to get the non-rigid Earth nutation,
- to compute the residuals with respect to MHB2000,
- if all residuals are smaller than 40 microarcseconds, to accept the starting value of the parameters, and
- if one of the residuals is larger than 40 microarcseconds, to reject the starting value of the parameters.

From that computation, we get acceptable ranges for the periods and damping of the Free Core Nutation (FCN) and Free Inner Core Nutation (FICN). From these values, it is possible to deduce the coupling constant involved at the Inner Core Boundary (ICB) and Core-Mantle Boundary (CMB). From the values of the coupling constants, the amplitude of the ICB magnetic field and the ratio between the dipole and uniform fields can be derived (supposed to be the only part of the field contributing to nutation in MHB2000 theory, see Buffett et al., 2002). From the value of the imaginary part of the FICN and from the damping of the FCN, one gets the real part of the coupling constant at the CMB. As shown in Figure 2, from the two coupling constant values at the CMB, one obtains the amplitude of the magnetic field and the ratio between the dipole part and the uniform part at the CMB. From the real part of the coupling constant and the real part of the FCN, the flattening of the core can be determined.

Error intervals on the damping factors and periods can so be converted into error intervals on Earth's interior parameters. The results are represented on Figure 3.

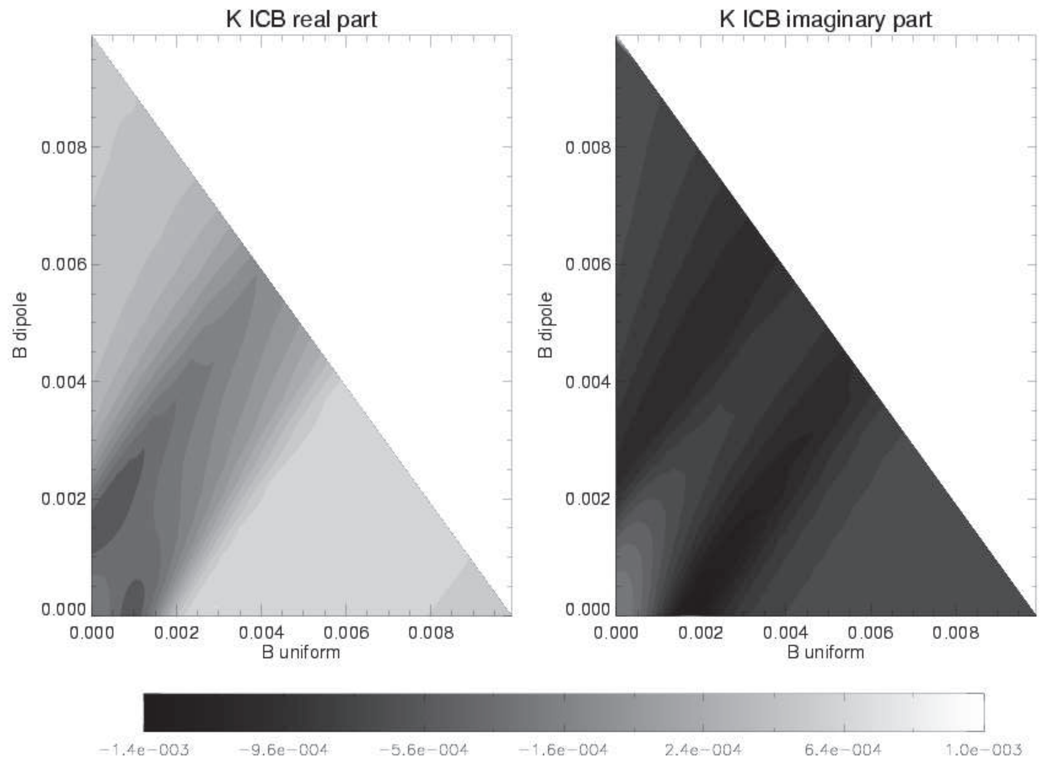

Figure 3: Interval on dipole and uniform magnetic field components

4. CONCLUSION

We have shown with this approach that the intervals given in MHB2000 on the parameters are reasonable if we take 40 microarcseconds uncertainty on the nutation amplitudes, and in the limit of validity of the model used.

5. REFERENCES

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