Rapid fluctuations of Earth's outer core - Towards a better detection with ground-based magnetic observations

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We investigate detectability of the interannual fluctuations of Earth's fluid core motion without using recent satellite magnetic observations. From ground-based monthly mean data for 1957.0-2015.4 we develop a new magnetic model, C^{3}FM2.x, to be inverted for a core flow model. Fluctuations of the core angular momentum (CAM) associated with this "ground-based" flow model are then evaluated by comparing them to those based on "satellite" flow model derived from CHAOS-6.x2. Fluctuations of the length-of-day (LOD) predicted from the both models show comparable coherencies with the 6-year oscillation of the observed LOD. This implies that the phase of the rapid CAM fluctuations can be as well detectable even in the earlier times of C^{3}FM2.x as in the recent satellite era. We also discuss a need to optimise the magnetic model by improving the monthly dataset that significantly contain interannual signals from the magnetospheric sources.

Magnetic measurements by recent satellite missions have made it possible to reliably extract interannual fluctuations of the core magnetic field (~2 nT/yr at Earth surface). As a hypothesis to explain them, a presence of the 6-year torsional Alfvén waves has been suggested, which is supported as well by the corresponding oscillation in the LOD observation [1]. However, inferred waves depend crucially on models of the magnetic field variation employed [2].

We assess the use of ground-based magnetic models for detecting the tiny interannual core signals. A temporally continuous magnetic field model C^{3}FM2.x is developed that encompasses both the satellite era (1999-) and pre-satellite era. It is estimated with the same modelling method as for C^{3}FM2 [3] from an updated monthly dataset created by avaraging all hourly mean data from magnetic stations available for 1957.0-2015.4. The model is characterised by its temporal parametrisation with order 6 B-splines at 1.4-year interval, allowing a higher time variability than other pre-satellite magnetic models.

A core flow model is built from C^{3}FM2.x by imposing a weak quasi-geostrophy assumption [2]. Following [1,2,4], the CAM variation is then calculated and translated into a prediction of the LOD variation. Fig. 1 shows its time derivative in comparison with those predicted from recent satellite magnetic model CHAOS-6.x2 and calculated from the observation. The predictions are roughly in phase with the observed 6-year oscillation, and interestingly enough, seem correlated even after 2010, where the oscillation is irregular. The C^{3}FM2.x prediction also shows significant coherency with the interannual LOD observation in the pre-satellite era, as may be expected from its dataset distributed roughly evenly in time.

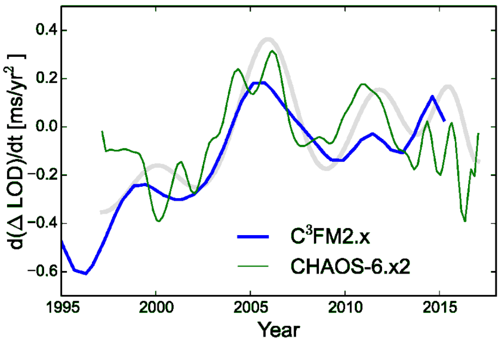

Figure 1: Time derivatives of the observed (gray) and predicted LOD fluctuations.

We note that ground-based magnetic models can still result in rapid CAM fluctuations agreeing relatively poorly with the observed LOD phase [4]. For a more precise detection, it would be necessarily to maximally eliminate interannual contributions of the magnetospheric currents, which we think still contaminate C^{3}FM2.x. A careful strategy for dataset cleaning should be implemented, for instance, by referring to the Dst index or its alternative indices [5].

References:

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