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

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Time evolution of Earth’ s fluid outer core may be viewed as a superposition of (1) rapid perturbations on (2) a slowly growing basic state. Among (1) are various modes of the hydromagnetic wave. Their characteristic morphologies and frequencies have been theoretically and numerically predicted for simple models of the quasi-steady state (2). Detecting tiny signals due to (1) is important for not just investigating the rapid core dynamics itself but also constraining (2) from observations. Precise magnetic measurements by recent satellite missions after 1999 have made it possible to reliably extract interannual fluctuations of the core magnetic field (~2 nT/yr at Earth surface). These imply a presence of the 6-year torsional Alfven waves, which is supported as well by the corresponding oscillation in the length-of-day (LOD) observation extending back to the early 1960s.
Here we investigate detectability of the interannual core fluctuations without using satellite magnetic observations. A temporally continuous magnetic model C3FM2.x is developed alone from ground-based monthly mean data available for 1957.0-2015.4. C3FM2.x is then inverted for a core flow model, in order to evaluate its rapid fluctuations after 1999 by comparing them with those of a flow model based on CHAOS-6.x2, the latest satellite magnetic model. According to temporal behaviors of the core angular momentum (CAM), C3FM2.x is of as much use as the satellite model for inferring at least the phase of the 6-year variation. The 6-year CAM variations calculated from the two flow models are both coherent with the observed LOD oscillation. They are even consistent with an anomalous LOD periodicity after 2010. It is expected that C3FM2.x provides comparable performance prior to the recent satellite-era, in view of its dataset distributed roughly evenly in time. For a further optimization of the ground-based model, nevertheless, it is absolutely necessary to maximally eliminate interannual signals from the magnetospheric currents, which we think still contaminate C3FM2.x. A careful strategy for dataset cleaning needs to be applied, for instance, by using the Dst index or its alternative indices recently proposed.

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