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On magnetic estimation of the Earth's core angular momentum variation

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Inversely modelling the core surface flow from a geomagnetic field model C^3FM2 for 1957.0 to 2008.0, we systematically investigate temporal evolution of the Earth's core angular momentum (CAM). Various models are built by varying two parameters involved in the inversion. The first parameter, $p(= -1, 0, 1$ and $3)$, controls the regularization implemented in the inversion, where weights for each spherical harmonic degree l are such that a power-law $\propto l^{-p}$ is imposed on resulting flow power spectrum. The second parameter concerns tangential geostrophy (TG) constraint that is imposed in a weak form, and regulates the fraction of ageostrophic flow content admitted. All the models meet tangential magnetostrophy constraint tightly, and their misfits to the C^3FM2 secular variation are fixed at a constant level.

CAM variations derived from these flow models are then examined in the time domain, with particular reference to the two notable features of the observed length-of-day (LOD) variation: the secular trend and 6-year variation. The moderately negative trend of the observed LOD is consistent only with the CAM variations for flow models of two contrasting types, each obtained with either $p = -1$ under a strong TG constraint, and $p \geq 0$ under a weak TG constraint. For the strong TG case the power spectrum peaks at spherical harmonic degrees at 10 to 15, while the spectra are dominated by powers at the lowest degrees for the weak TG cases. These models may be interpreted as corresponding to the two distinct dynamo regimes identified in previous numerical simulations, i.e. the strong/weak TG case corresponding to geostrophic/magnetostrophic state associated predominantly with weak/strong magnetic field and intermediate/large scale flows. Temporal derivatives of the CAM variations reveal rapid behaviours, with their extrema well synchronized for any models estimated with the wide range of parameters. The rapid CAM phase thus seems robustly determined for a given magnetic model and inversion scheme. The extrema sometimes match those of the observed 6-year LOD variation. However, a more detailed analysis is needed to quantify the CAM variability and its relation to the rapid LOD variations.