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Torques on the inner core and polar motion at decade timescales

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Exchanges of angular momentum between the mantle, the fluid core and the solid inner core results in changes in the Earth's rotation. Torques in the axial direction produce changes in amplitude, or changes in length of day, while torques in the equatorial direction lead to changes in orientation of the rotation vector with respect to the mantle, or polar motion. In this work, we explore the possibility that a combination of electromagnetic and gravitational torques on the inner core can reproduce the observed decadal variations in polar motion known as the Markowitz wobble. Torsional oscillations, which are a type of wave in the fluid core with typical periods of decades, exert strong axial electromagnetic torques on the inner core, creating axial angular displacements of the latter with respect to a fixed mantle. When the inner core is axially rotated, its surfaces of constant density are no longer in alignment with the gravitational potential imposed by density heterogeneities in the mantle. This results in a gravitational torque between the two. This torque has an axial component, which is believed to be partly responsible for decadal changes in length of day, and an equatorial component, which results in polar motion. The amplitude of the polar motion produced by this mechanism is a function of the density structure in the mantle, the elastic properties of the inner core, and the angle of axial misalignment between the inner core and the mantle. The latter is reconstructed using models of torsional oscillations that are recovered from the geomagnetic secular variation, and also depends on the strength of the magnetic field near the inner core boundary. Hence, a match in both amplitude and phase between the observed and predicted Markowitz wobble through the above mechanism places useful constraints for flow models in the core, mantle tomography models, magnetic field strengths deep inside the core, and rheology of the Earth at decade timescales.