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Radial vorticity constraint in the core flow modeling

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We study the compatibility of core flow models with the radial vorticity constraint (RVC) arising from the assumption of electrically insulating mantle. A necessary condition of the RVC has been derived from the radial component of the quasi-steady, and diffusionless, vorticity equation just below the core-mantle boundary (CMB). This condition is a set of integral constraints defined for a given Br model at the CMB, and requires the conservation of radial planetary vorticity within every closed contour of Br = 0. In this work, instead of investigating the integral constraints in the spatial domain, we directly deal with the vorticity equation in the spectral domain. The core flow inversion process is regularized such that the flow components incompatible with that equation are minimized. We here report the effect of this new constraint, in particular when modeling purely toroidal (PT) flow. Outside the new constraint, the method and the input magnetic model (t-CHAOS for 1999.1-2006.0) for the PT flow inversion are fundamentally the same as in Wardinski et al. (2008). It is found that, as the weight for the RVC regularization is increased, the PT flow solution becomes dominated by zonal components. In the limit toward the RVC strictly met, the solution converges to a purely zonal flow which fails to explain the magnetic model. Nonetheless, within reasonable ranges of the misfit to the magnetic model and the flow velocity, there can be a PT flow model with a significant improvement in fitting to the RVC.