Possible interaction between the core and mantle inferred from a core surface flow model

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Fluid flow in the Earth's liquid outer core is responsible for the dynamo action by which the geomagnetic field is generated and maintained. The fluid flow can be estimated from geomagnetic field data, such as spatial distribution of geomagnetic field and its temporal change referred to as secular variations. This implies that spatial and temporal variations of fluid flow in the core provide information on any interaction between the core and mantle. To investigate possible core-mantle interaction, a core surface flow model is obtained from a geomagnetic field model, COV-OBS.x1 (Gillet et al., 2015) using the method of Matsushima (2015). That is, inside a viscous boundary layer at the core-mantle boundary (CMB), magnetic diffusion is assumed to significantly contribute to temporal change of geomagnetic field, and the radial dependence of core flow is expressed in terms of a spiral similar to the Ekman spiral. Below the boundary layer, magnetic diffusion is neglected as in the frozen-flux approximation, and the tangentially magnetostrophic constraint is imposed on the flow.

Any inhomogeneous structure, such as temperature or heat flux, at the CMB is likely to have a strong effect on the core flow. The inhomogeneity successively influences the flow pattern. Therefore, average of fluid flow is expected to show possible core-mantle interaction. Hence, fluid flows inside and below the boundary layer are averaged over the time from 1840 to 2015 covered by the COV-OBS.x1 model. However, mean amplitudes of upwelling and downwelling flows as well as mean horizontal flows are found to be smaller than those at respective times. This result suggests that possible thermal heterogeneity due to the lowermost mantle structure has little effect on the core surface flow; that is, compositional convection is dominant in the Earth's outer core. It should be noted, however, that there is a noticeable upwelling flow corresponding to a counterclockwise vortex beneath the south of Africa, and that the location is just outside the tangent cylinder, an imaginary cylinder parallel to the rotational axis and attached to the equator of the inner core. This may indicate that the vortex corresponds to an edge of columnar convective motion, although the other edge in the northern hemisphere is unclear.

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