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Core surface flow modeling with geomagnetic diffusion

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Estimation of fluid motion in the Earth's liquid outer core enables us to understand a realistic geodynamo mechanism, to examine the thermal structure at the core surface, and to constrain the effect of core-mantle boundary (CMB) on the flow. Most of core flow models have been derived from geomagnetic field models based on the frozen-flux approximation, where the magnetic diffusion term in the induction equation can be neglected for a time scale much shorter than the magnetic diffusion time scale. However, the effect of magnetic diffusion is found to be more significant than that of magnetic induction inside the boundary layer at the CMB. Hence, to model the core surface flow, we presume that the magnetic diffusion is effective inside the boundary layer. On the other hand, below the boundary layer, we neglect the magnetic diffusion in the induction equation as in the frozen-flux approximation. It is likely that the viscous force plays an important role in the boundary layer. We therefore presume balance among the pressure gradient, the Coriolis force, and the viscous force in the equation of motion inside the boundary layer. Below the boundary layer, we presume that the flow is in a geostrophic state. The radial dependence of horizontal components of core surface flow is represented in terms of the boundary layer compatibility condition. Thus the core surface flow is modeled with geomagnetic diffusion.

Keywords: core surface flow, magnetic diffusion, geomagnetic field