Viscous core-mantle coupling and core surface flow in a viscous boundary layer

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Secular variations of the Earth's magnetic field are caused by fluid motions in the electrically conducting core. Such core flows can be derived from the spatial distribution of the geomagnetic field and its temporal variation. Core flow models thus derived contain useful information on a realistic geodynamo mechanism, a physical state at the core surface, coupling of the core with the mantle which may have relation to the LOD (length of day), or the Earth's rotation rate, and so forth.

Most of core surface flow models have been obtained on the basis of the frozen-flux hypothesis, which is likely to be valid for a time scale much shorter than the geomagnetic diffusion time scale. The magnetic diffusion term is then neglected in the induction equation. It should be noted that a boundary layer at the core-mantle boundary (CMB) is presumed to be infinitely thin. In reality, however, its thickness would be finite, and the effect should be taken into account to estimate core flows near the CMB.

A new method to derive the core surface flow has been developed by Matsushima (2015); that is, the magnetic diffusion is incorporated inside a viscous boundary layer at the CMB, while it is neglected below the boundary layer as in the frozen-flux approximation. Temporal variations of core surface flows thus estimated have information on phenomena related with possible core-mantle coupling such as a geomagnetic jerk, the LOD, spin-up/spin-down of core flows, and so on. In particular, core surface flows inside the boundary layer show an interesting feature in relation with Earth's rotation.