Temporal average of core surface flow obtained from a geomagnetic field model gufm1

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Fluid motion near the Earth's core surface can be estimated from the spatial distribution and temporal variation of the geomagnetic field. Such core surface flow models provide useful information about a realistic geodynamo mechanism, a thermal structure at the core surface, and the effect of core-mantle boundary (CMB) on the flow, and so on.

The frozen-flux hypothesis, which has been assumed to estimate most of core flow models, would be valid for a time scale much shorter than the magnetic diffusion time scale. Inside the boundary layer at the CMB, which is assumed to be infinitely thin in the frozen-flux approximation, the effect of magnetic diffusion can be more significant than that of magnetic induction (Takahashi et al., 2001).

Therefore, to model the core surface flow, we have developed a new method; existence of a boundary layer with finite thickness at the CMB is presumed; the magnetic diffusion is assumed to be effective inside the boundary layer, but it is neglected below the boundary layer as in the frozen-flux approximation. The radial dependence of horizontal components of core surface flow is represented in terms of the boundary layer compatibility condition; that is, inside the boundary layer, presumed is balance among the pressure gradient, the Coriolis force, and the viscous force which should play an important role there, whereas the flow below the boundary layer is presumed to be in a geostrophic state. Thus we derive core surface flows inside and below the boundary layer at the CMB.

A geomagnetic field model, gufm1 (Jackson et al., 2000) provides us with the evolution of the geomagnetic field at the core surface as well as at the Earth's surface from 1590 to 1990. However, the axial dipole component before 1840 is linearly extrapolated, since geomagnetic intensity data are unavailable. Therefore core surface flows are computed every year from 1840 to 1990, and their average with respect to the time is calculated.

In general, the flow pattern below the boundary layer shows upwellings and downwellings located near the equator. Between these upwelllings and downwellings, pairs of upwellings and downwelligs are situated, suggesting that there exist some columnar convection cells near the core surface around the equator. On the other hand, these features are not obvious in the temporary averaged flow.