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Understanding core dynamics through combined geomagnetic and space geodetic studies

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The Earth's fluid outer core is in convection through its history. The core flow varies on time scales ranging from several years to perhaps geological time scales. Manifestation of the dynamical processes includes observed surface geomagnetic and paleomagnetic properties. However it also includes gravity anomalies on various time scales that may be also observable at the Earth's surface. We study the latter phenomena, aiming at obtaining insights on core dynamics through surface gravity observations.

Associated with the convective core flow are density anomalies in the bulk of the fluid core, and the non-hydrostatic pressure. Both contribute to gravity variation in the following forms: mass-redistribution in the core due to advection of density anomalies, and the internal loading due to the pressure on the core-mantle boundary (CMB). In the past, two effects on time-variable gravity have only been partially and separately examined. In our study here, we investigate both effects through the MoSST core dynamics model and the PREM model for the mantle, to understand the correlation between the two processes, and estimate the net effect of the core dynamical processes in the outer core on time-variable gravity. Our numerical model results show that both effects are approximately "in-phase" in temporal variation. However, the contribution from the pressure loading on the CMB is in general smaller than that from the mass-redistribution in the bulk of the fluid core. The net contribution is larger than the estimations of the individual effects and, in particular, its spatial-temporal variation is similar to that of the core flow. Our results suggest that long-term, global gravity measurements could provide a non-magnetic probe to dynamical processes in the Earth's fluid core.