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Distribution of temperature perturbation in the Earth's outer core

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If the Earth's core convection is simply regarded as thermal convection, it is important to know how the temperature perturbation is distributed inside as a driving source of convection. Recent numerical simulations of low-viscosity Earth-type dynamos show that a westward zonal flow concentrated near the equatorial part of the core surface, associated with a meridional circulation, upwelling along the equatorial plane and downwelling in the high latitudes, plays an important role to sustain a large-scale toroidal magnetic field and a strong axial dipole. The westward flow is driven by a thermal-wind mechanism in which a buoyancy torque due to a strong positive temperature anomaly near the equator is compensated by a Coriolis torque. The geomagnetic westward drift that is most evident in the equatorial part beneath Africa and the Indian Ocean may represent the zonal flow structure at the core surface, raising a possibility to know the thermal structure at the base of the mantle.

In previous numerical geodynamo models, it was common to use the Boussinesq approximation. These models assume that (1) the fluid is incompressible, (2) the density gradient is neglected in the pressure term in the momentum equation, and (3) the temperature equation is not consistent in the sense of energetics. The former two approximations could be verified because the adiabatic density gradient is not so great in the Earth's core. However, the last one may have a critical effect on temperature distribution in the core and a resulting zonal flow strength. Anufriev and Hejda (2010, submitted) present a modification to the Boussinesq approximation by introducing the Archimedean cooling (heating) in the temperature equation, which represents adiabatic cooling (heating) effects and guarantees energy conservation. This modification is easy in computational implementation and could be a practically better approximation. I present some results of currently ongoing attempts to evaluate changes of temperature perturbations due to the modified Boussinesq approximation.

Keywords: geodynamo, Boussinesq approximation, geomagnetic westward drift