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Double diffusive convection in the Earth's core and the morphology of the geomagnetic field

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Convection in the Earth's outer core is driven by thermal and compositional buoyancy. Thermal convection is driven by superadiabatic part of temperature gradient within the core coming from secular cooling of the core, latent heat release upon solidification of iron at the inner core boundary, and possibly decay of radioactive elements such as potassium. Compositional convection occurs due to ejection of light elements into the outer core at the front of inner core solidification. Conventionally, temperature and composition are collapsed into one variable called codensity instead of treating them separately, assuming the eddy diffusivity due to turbulence. However, it is not evident to what extent the codensity approach is applicable to the Earth's core. Moreover, it is impossible to separate contributions from the two agents to the flow dynamics in the codensity approach. Here we examine effects of co-existence of the two buoyancy sources on core dynamics and morphology of the geomagnetic field using numerical dynamo models with double diffusive convection at thermal Prandtl number, PrT = 0.1 and compositional Prandtl number, PrC = 1. We find that the morphology of the magnetic field is determined by fraction of the two driving mechanisms. Dipolar magnetic field is maintained as long as power injected by compositional buoyancy explains at least 30-40% of the total. Otherwise, non-dipolar fields grow instead of the dipolar field because of increasing influence of inertia. The dominantly dipolar structure of the present geomagnetic field suggests that fraction of power injection by compositional convection in the present geodynamo exceeds the threshold.

Keywords: core, geomagnetic field, dynamo, double diffusive convection