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Effects of heterogeneous boundary from mantle convection modeling in dynamo simulations in a rotating spherical shell

Effects of heterogeneous boundary from mantle convection modeling in dynamo simulations in a rotating spherical shell

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Numerical dynamo simulations in a rotating spherical shell with boundary heterogeneity at the top are used to investigate the possibility of dynamo solutions with the heat flux heterogeneity inferred from numerical thermo-chemical mantle convection simulations. Here we focus on the possibility to find the dynamo solutions with huge value of amplitude of heat flux heterogeneity and correlation between CMB and ICB heat flux. In order to evaluate boundary heterogeneity from mantle convection models, five scenarios are prepared: 1. Thermally uniform CMB, 2. CMB heat flux converted from seismic tomography based on Amit and Choblet [2009] ($q_* = 0.5$), 3. CMB heat flux calculated from numerical mantle convection with recycled basalt, 4. CMB heat flux including the effect of continental lithosphere and 5. CMB heat flux including both effects of continental lithosphere and compositionally-distinct material in the CMB region. With thermally uniform and heat flux heterogeneity inferred from seismic tomography cases, the dipolar magnetic field is found at the top boundary and correlation between CMB and ICB heat flux seems to be good, which has been inferred from other study [Gubbins et al., 2011], because, for the tomographic case, the amplitude of heterogeneity is small so that the dipolar solution can be found. For cases of CMB heat flux calculated from numerical mantle convection simulations, the dynamo action is found with large amplitude of heat flux heterogeneity but not dipolar solution. Strong patches of magnetic field corresponding to large amplitude of CMB heat flux are found. The correlation between CMB and ICB heat fluxes is lower than for uniform and tomographic models. This means that the ICB heat flux does not tend to be the transparency of CMB heat flux. Since the heat flux heterogeneity inferred from numerical mantle convection is likely to be larger than the expected value from numerical dynamo simulations [Nakagawa and Tackley, 2008], the possible magnetic field features at the CMB seem to be more complicated than the expected.

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