High resolution simulations of Earth-like dynamos

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The geomagnetic field reflects the dynamics in the Earth's deep interior and its long time variations such as polarity reversals may influence the surface environment. Therefore it is of particular importance for us to correctly understand the dynamo process in the Earth's core. Our knowledge of the geodynamo is obtained from numerical simulations but with parameters which are far from the real values of the Earth. For example, viscosities in the previous numerical models are 4 orders larger than that of the Earth. We have made an attempt to lower the Ekman number down to 10 to the -6 which corresponds to decreasing viscosity by one order. To accomplish that, we optimized a numerical code for Earth Simulator and found that we can extract 45% of peak performance of 64 nodes in calculating the model with spherical harmonics of degrees up to 256. This calculation size is enough to carry out a geodynamo simulation with the Ekman number of the order of 10 to the -6. We found from preliminary results that a solution at such a small Ekman number has very large magnetic energy density so that the time stepping is not restricted by fluid velocity but by Alfven velocity. If we need one million time steps, it requires two days to accomplish the simulation by using 64 nodes of Earth Simulator. Though it is not easy to explore the parameter space, it is now possible to analyze a more Earth-like dynamo model. We expect that the geodynamo processes in extremely low Ekman numbers become unraveled in near future.