Extraction of scaling laws from convective dynamo simulations

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Earth's magnetic field is generated by motions in the liquid-iron outer core. Numerical simulations of rotating convection in a spherical shell have been used to study core dynamics. However, the numerical simulations and Earth's core live in different regions of parameter space. In comparison with Earth's core, numerical dynamos have far too slow rotation (Ek too large), are less turbulent (Ra too small) and much too viscous relative to their electrical conductivity (Pm too large). In order to bridge this gap, scaling laws have been used to estimate relevant quantities in Earth's core, e.g. heat flux, flow velocity and magnetic field strength.

We are interested in the question of how many parameters should be included in a scaling law to account for the variability in the data. Our approach to this model selection problem is by leave-one-out cross-validation which rates models according to their predictive abilities.

We use an extensive data base of 116 numerical dynamos compiled by Christensen and co-workers. It turns out that in contrast to earlier results, the flow velocity and magnetic field strength in the numerical simulations are not independent of diffusivities. Under the assumption that the relevant processes are the same in numerical dynamos and in Earth's core, we find an Ohmic dissipation of 3-8 TW for the core which appears to be consistent with recent high core-mantle boundary heat flux scenarios.