ON THE RANGE OF GEOMAGNETIC PREDICTABILITY

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By analogy with the pioneering works in the field of dynamic meteorology, which made it possible to determine the range of predictability for weather forecasts, we would like to know how much time in advance a given event in the evolution of a numerical dynamo (such as a polarity reversal) might be predicted. We take for granted the fundamentally non-linear dynamics of the geodynamo, and consider the insufficient knowledge of the initial state as the main limitation to predictions at infinite range.

To address this issue, we scrutinise the sensitivity of numerical dynamos by submitting them to small random perturbations, alternately applied to the flow, the magnetic field and the distribution of thermal anomalies. We show that before reaching a macroscopic level and irreparably perturb the system, these small errors exponentially grow with a rate of amplification independent of the kind, time and amplitude of perturbation. A systematic study indicates that the ratio between the characteristic time of the exponential growth and the characteristic time of the secular variation of the magnetic field tends to be constant. These two quantities indeed display the same dependence on the magnetic Reynolds number (which quantify the turbulence degree in the induction equation).

Applying this result to the geodynamo, we find that a 10% uncertainty on the measure of the geomagnetic field can be seen as a random perturbation that reaches a macroscopic level after a time period on the order of a century. We interpret this time as an upper bound of predictability for geomagnetic forecasts, meaning that no reliable prediction can be hoped beyond this date. Considering the present-day decrease in the dipole strength, this result in particular endorses the idea that it is premature to predict the next polarity reversal of the Earth's magnetic field, since it will obviously not occur within the next few centuries.

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