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Combining geomagnetic data with physical models of Earth's core dynamics: an introduction to data assimilation in geomagnetism

Alexandre Fournier[1]

[1] *Institut de Physique du Globe de Paris, Paris, France*

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Data assimilation in geomagnetism designates the set of inverse methods for geomagnetic data analysis which rely on an underlying prognostic numerical model of core dynamics. Within that framework, the time-dependency of the magnetohydrodynamic state of the core needs no longer be parameterized. The model trajectory (and the secular variation it generates at the surface of the Earth) is controlled by the initial condition, and possibly some other static control parameters. The primary goal of geomagnetic data assimilation is then to combine in an optimal fashion the information contained in the database of geomagnetic observations and in the dynamical model, by adjusting the model trajectory in order to provide an adequate fit to the data.

The recent developments in that emerging field of research are motivated mostly by the increase in data quality and quantity during the last decade, owing to the ongoing era of magnetic observation of the Earth from space, and by the concurrent progress in the numerical description of core dynamics.

In this talk I will review briefly the current status of our knowledge of core dynamics, and elaborate on the reasons which motivate geomagnetic data assimilation studies, most notably a) the prospect to propagate the current quality of data backward in time to construct dynamically consistent historical core field and flow models, b) the possibility to improve the forecast of the secular variation, and c) on a more fundamental level, the will to identify unambiguously the physical mechanisms governing the secular variation and to make inferences on the interior of Earth's core, which is not directly sampled by geomagnetic observations. I will next present the different approaches to geomagnetic data assimilation which have been followed so far, and discuss in particular what those have already taught us regarding the state of the interior of Earth's core.