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A database of synthetic observations for geomagnetic data assimilation practice

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Data assimilation aims at producing an optimal estimate of the state of the dynamical system one is interested in by combining two sources of information : physical laws (in the form of a numerical model) and observations. A mandatory step during the development of a data assimilation framework involves a validation phase using synthetic data. In this well-controlled environment, the true dynamical trajectory of the system is known (it results from the integration of the numerical model), and it is used to generate synthetic observations. Those are subsequently used to assess the efficacy, and to highlight possible shortcomings, of the chosen methodology.

Data assimilation has recently come to the fore in geomagnetism (e.g. Fournier et al., 2010), a surge motivated by our increased ability to observe the geomagnetic field (thanks to dedicated satellite missions), and by the concurrent progress in the numerical description of core dynamics. Open questions are related to the type of physical models one should resort to, and to the choice of a suitable algorithm, able to integrate the highly heterogeneous geomagnetic record at our disposal, and to deal with the non-linearities of the problem at hand (e.g. Aubert & Fournier, 2011; Fournier et al., 2011).

Here we report on the construction of a database of synthetic observations meant at reproducing the heterogeneity of the geomagnetic record (in terms of temporal and spatial coverage). This database relies on two dynamical trajectories:

1. a long-term dynamical trajectory (spanning the equivalent of the past few millenia) computed from a three-dimensional, convection-driven, dynamo model, able to represent accurately the long-term variability of the geomagnetic field
2. a short-term dynamical trajectory (spanning the equivalent of a few decades), computed from a high-resolution three-dimensional model, able to represent interannual to decadal core processes (e.g. Gillet et al., 2011), and whose basic state is determined from the long-term trajectory.

These two trajectories are used to generate synthetic observations representative of the current archeomagnetic, historical, observatory and satellite catalogs. For each catalog, we add realistic contributions from other sources (crust, external fields) and noise to the observations, with levels and properties expected for each. We also complement the archeomagnetic, historical and observatory catalog with a corresponding perfect catalog (in terms of the uniformity of the coverage), and with a catalog containing the Gauss coefficients describing the magnetic field at the surface of the Earth (with an arbitrary level of truncation).

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