Geophysical Research Abstracts
Vol. 16, EGU2014-8869, 2014
EGU General Assembly 2014

Predicting geomagnetic reversals via data assimilation: a feasibility study

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The system of three ordinary differential equations (ODE) presented by Gissinger in [1] was shown to exhibit chaotic reversals whose statistics compared well with those from the paleomagnetic record. We explore the geophysical relevance of this low-dimensional model via data assimilation, i.e. we update the solution of the ODE with information from data of the dipole variable. The data set we use is "SINT" (Valet et al. [2]), and it provides the signed virtual axial dipole moment over the past 2 millions years. We can obtain an accurate reconstruction of these dipole data using implicit sampling (a fully nonlinear Monte Carlo sampling strategy) and assimilating 5 kyr of data per sweep. We confirm our calibration of the model using the PADM2M dipole data set of Ziegler et al. [3].

The Monte Carlo sampling strategy provides us with quantitative information about the uncertainty of our estimates, and –in principal– we can use this information for making (robust) predictions under uncertainty. We perform synthetic data experiments to explore the predictive capability of the ODE model updated by data assimilation. For each experiment, we produce 2 Myr of synthetic data (with error levels similar to the ones found in the SINT data), calibrate the model to this record, and then check if this calibrated model can reliably predict a reversal within the next 5 kyr. By performing a large number of such experiments, we can estimate the statistics that describe how reliably our calibrated model can predict a reversal of the geomagnetic field. It is found that the 1 kyr-ahead predictions of reversals produced by the model appear to be accurate and reliable. These encouraging results prompted us to also test predictions of the five reversals of the SINT (and PADM2M) data set, using a similarly calibrated model. Results will be presented and discussed.

References

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