Geophysical Research Abstracts
Vol. 16, EGU2014-8324, 2014
EGU General Assembly 2014

A fast iterative Bayesian inversion scheme for paleomagnetic, archeomagnetic and historical data

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A fundamental task of modern geomagnetic field reconstruction is to use the sparse and inaccurate data sources about the ancient geomagnetic surface field to infer the spatio-temporal variations of the Earth's geodynamo over an as large as possible time interval. To this end the surface field is conveniently described by a sufficiently smooth temporal evolution of its spherical harmonic coefficients. Historical data of the magnetic field before the time of Gauß and Humboldt are mainly declination measurements. Only few of these early data sets include also inclination. Indirect evidence of local field intensity or direction can be obtained from magnetic minerals within archeological artifacts or natural archives of known age and location, provided they have acquired a magnetization aligned with, and proportional to the geomagnetic field during production or use. Accordingly, the main problems for a reliable inversion of the available data into a global model of geomagnetic field variation are inhomogenous data distribution, and highly variable data quality. As a consequence, also the verification of a proposed model is a necessary request. A previous inverse field model for the Matuyama/Brunhes geomagnetic reversal approached these problems by 1) limiting the input data to few high-quality records, 2) testing the inversion scheme using artificial data sets from geodynamo models, and 3) verifying the resulting model against independent data sets, not used for the inversion, 4) calculating many different inversions, based on modified data sets, to obtain a bootstrap statistics. Here, we propose several new methods to adopt these strategies to other data sources. Main factors for progress are 1) the development of reliable error treatments, which allow to combine data from different sources without introducing modeling artifacts, 2) to accelerate the individual field inversion runs on large data sets, to enable multiple runs for a thorough statistical analysis, 3) to develop a verification method which adapts to the characteristics of the data set used for inversion.