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Stochastic modeling of the archeomagnetic field

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Modeling of the archeomagnetic field relies on indirect estimations of the ancient field recorded both in archeological artifacts and lake sediments. The sparse repartition of archeomagnetic data in space and time and their associated large measurement and dating uncertainties limit our ability to recover the spatio-temporal variations of the geomagnetic field over the past few millennia. The time regularization generally used to overcome the problem of non-uniqueness leads to models that are generally too smooth compared to geomagnetic time-series.

The aim of this study is to perform a stochastic inversion of archeomagnetic data in order to build an ensemble of regional models covering the past few millennia. The inverse problem is solved using a priori information on the Gauss coefficients. We rely on a time correlation function, which is compatible with present knowledge of the geomagnetic spectra and also with the rapid fluctuations observed in the geomagnetic time series. The method we developed allows us to account for dating errors in a probabilistic framework, at the expense of an inflated dataspace. We argue also the importance of covariance existing between inclination and intensity which provides additional information when few data are available. The resulting ensemble of models not only provides reliable information for processes occurring in the core but is also useful in a purpose of archeomagnetic dating.

We present synthetic results to test the validity of our method and to illustrate the effect of dating errors. Furthermore, we take advantage of the large amount of data and the relatively dense temporal coverage in Western Europe to construct intensity master curves for Syria and directional and intensity curves for France. The last curves allow us to discuss the importance of covariance between inclination and intensity.