A geomagnetic field model covering the past 4000 years

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The systematic monitoring of the geomagnetic field reveals a strong decrease of its global dipole strength along with the expansion of a large-scale low intensity anomaly in the South Atlantic within the last century. In order to thoroughly scrutinize this evolution, the observation period is extended further back into the past by consideration of historical, archeo- and paleomagnetic field records. The resulting models provides field predictions for the last 4000 years and can be used for archeomagnetic dating purposes.

Different record types allow for the reconstruction of the geomagnetic past. Historical man-made measurements date back to 15th century and have mainly been performed using compasses due to orientation and navigation purposes. A further extension into the past is provided by the investigation of the remanent magnetization acquired by rocks and archeological artifacts (archeomagnetic and paleomagnetic data). These different record types have been compiled within the HISTMAG database (https://cobs.zamg.ac.at), which forms the basis of the geomagnetic modelling approach.

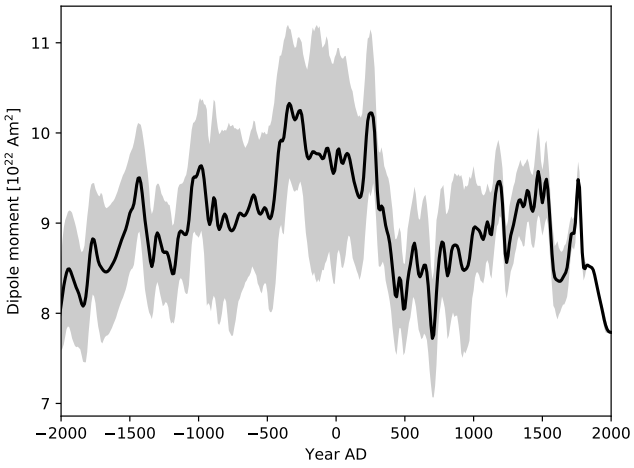

Figure 1: Temporal evolution of the dipole moment over the last 4000 years.

The high variabilty of spatio-temporal data coverage, types and uncertainties represents the major obstacle for geomagnetic field reconstructions. In order to overcome these challenges, a Bayesian modelling approach was developed resulting in the first self-consistent field model based on the combination of historical and archeo- and paleomagnetic records. Resulting model BIGMUDI4k.1 (Arneitz et al., 2019, https://doi.org/10.1016/j.pepi.2019.03.008) provides geomagnetic field predictions everywhere on Earth over the last 4000 years, which can be retrieved online (https://cobs.zamg.ac.at). These predictions can be used as reference curves for archeomagnetic dating approaches.

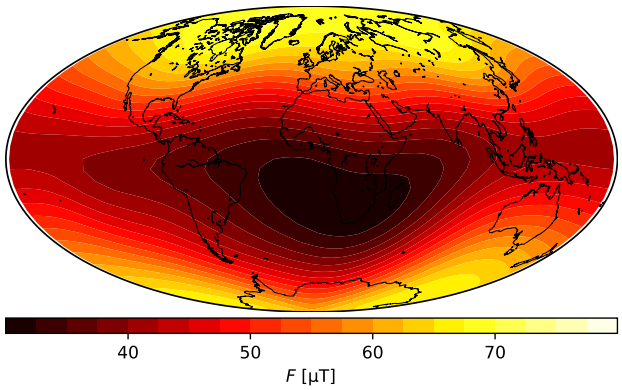

Figure 2: Temporal average of field intensity F over the last 2000 years.

Furthermore, BIGMUDI4k.1 enables a detailed analysis of striking geomagnetic field features. For instance, the currently observed decrease of the dipole moment can be compared to its evolution in the past (Fig. 1). This comparison reveals periods with similar variations for previous millenia. Moreover, the evolution of the South Atlantic Anomaly (SAA) can be outlined (Fig. 2). This study indicates persistent anomalous field behavior around this region over the last 2000 years. An evaluation of SAA in the years BC is limited by the lack of data in the Southern hemisphere.

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