Geophysical Research Abstracts
Vol. 20, EGU2018-7107, 2018
EGU General Assembly 2018
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COV-ARCH/COV-LAKE, new ensembles of archeomagnetic field models for the past three millennia

Gabrielle Hellio (1) and Nicolas Gillet (2)

(1) Laboratoire de Planétologie et Géodynamique, Université de Nantes, France (gabrielle.hellio@univ-nantes.fr), (2) ISTerre, Université Grenoble-Alpes, France, (nicolas.gillet@univ-grenoble-alpes.fr)

We present two ensembles of geomagnetic field models spanning the last three millennia: COV-ARCH is calculated using all available archeological artifacts and volcanic lava flows; lake sediment records are added to this dataset to build COV-LAKE.
Given the sparse distribution of archeomagnetic observations and their associated large uncertainties, the recovery of magnetic field changes from such data is an ill-posed inverse problem that requires assuming some prior information. This is usually performed by imposing arbitrary regularizations in space and time. Instead, we construct the prior knowledge entering the objective function to be minimized from spatial and temporal statistics of the geomagnetic field, as available from satellites, ground-based observatories and paleomagnetic measurements, and validated by numerical dynamo simulations. Our approach relies on the projection of model coefficients onto temporal cross-covariance functions, avoiding the arbitrary filtering that results from the widely used interpolation with ad hoc support functions (such as cubic B-splines).
Our results advocate for an almost constant dipole decay from 1400 onward, and a dipole growth over 900-1400 AD. We observe in both hemispheres persistent low to high latitude patches over the past 3000 yrs. We also confirm a westward drift of flux patches at the core mantle boundary at a speed of 0.14°/yr. Despite the sparse data distribution in the Southern hemisphere, the South Atlantic Anomaly appears in both ensembles of models around 1800 AD. A similar low intensity event seems to have appeared below the Indian Ocean over 400 - 1100 AD. Both global models are in general good agreement with regional master curves, though filtering out some of the centennial oscillations. Such models and their associated uncertainties are suited to be used as observations in geomagnetic data assimilation studies.