Geophysical Research Abstracts
Vol. 20, EGU2018-2164, 2018
EGU General Assembly 2018

Denoised high-resolution observatory data and new geomagnetic field models using the MagPySV Python package

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Measurements obtained at ground-based geomagnetic observatories are crucial to our understanding of secular variation (SV) of the geomagnetic field and permit investigations of Earth's deep interior. Observatory monthly means are widely used for this purpose, but are highly sensitive to measurement errors due to their high temporal resolution and also suffer from significant external magnetic field contamination. These noise sources often obscure fine-scale details required for studying rapid observed features, such as geomagnetic jerks.

We present results obtained using MagPySV, a python package designed to process and denoise observatory hourly means distributed by the World Data Centre for Geomagnetism at the British Geological Survey, Edinburgh. This package allows the user to obtain the dataset in WDC format from BGS servers and produces time series of the X, Y and Z components of the field and SV at the desired frequency (typically monthly means), having applied corrections for all documented baseline jumps. Optionally, the user may exclude data using the Ap index, which removes effects from documented geomagnetic storms. Robust statistics are used to identify and remove outliers. The software extends the denoising methods of Wardinski & Holme (2011, GJI) and Brown et al (2013, PEPI), which use the covariance matrix of the residual between the observed SV and that predicted by a global field model to create and remove a proxy for external field signal from the data. This extension creates a single covariance matrix for all observatories of interest combined and applies the external field correction to all locations simultaneously.

We consider two case studies of cleaned data in different geographic regions and discuss their application to geomagnetic jerks: monthly first differences for Europe, previously well-studied using annual differences, and annual differences for northern high latitude regions, which are often neglected from studies due to their high noise content. Using our cleaned high-resolution data, we construct new geomagnetic field models that permit sharper temporal changes than current field models, in order to better fit jerk-like features in the data. We model the data by minimising the squared model difference from an existing a priori field model (we use the COV-OBS model of Gillet et al. 2015, EPS), and simultaneously minimising the misfit to the SV data, and a norm of the time variation of the field calculated at the core-mantle boundary to avoid unphysically sharp time variations. We seek to allow sharper changes in the field evolution consistent with observed geomagnetic jerks; the model then allows consideration of the implications of these jerks for the time evolution of the field at the core-mantle boundary.