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Seasonal and solar-cycle variations of DP-type polar magnetic fields resolved via EOF analysis

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We describe our application of the Empirical Orthogonal Function (EOF) method to characterise and separate contributions to the variability of the Earth's external magnetic field (EMF) in the northern polar region, using ground magnetometer measurements. The EOF method analyses the spatio-temporal co-variance of the data to decompose it into dynamically distinct modes (each mode is a pair of spatial and temporal basis vectors). Briefly, the benefits of this analysis method are firstly that a small number of the modes can cumulatively represent most of the variance of the original data, and secondly that the basis vectors are defined by the data. Hence, the structure of the EMF is resolved compactly without a priori assumptions, in contrast to other decomposition methods such as Fourier and spherical harmonic expansions.

We present the modes from 11 years (1997—2008) of magnetic vector data at 5 minutes resolution, recently collated by the SuperMAG archive of observatory and variometer data. Despite the sparse and irregular station distribution, a complete spatial morphology of the EMF is achieved using a self-consistent iterative infill method. Using a comparison of the temporal behaviour of the modes alongside independent measures of solar-terrestrial coupling, we demonstrate that the leading three modes describe the well-known Disturbance-Polar currents types 2 and 1 (DP2, DP1) and the system of cusp currents (DPY). These three modes account for the majority of the variance of the data – other modes describe the spatial motions of these current systems.

The variation in the DP2, DP1 and DPY currents throughout the last solar cycle is presented, and the utility of this database of magnetic perturbations (to which further analysis methods can be applied) is highlighted.