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Seasonal and solar-cycle variations of polar magnetic fields resolved via eigenanalysis and graph theory

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We apply the meteorological analysis method of Empirical Orthogonal Functions (EOF) to ground magnetometer measurements, and subsequently use graph theory to classify the results. The EOF method is used to characterise and separate contributions to the variability of the Earth's external magnetic field (EMF) in the northern polar region. EOFs decompose the noisy EMF data into a small number of independent spatio-temporal basis functions, which collectively describe the majority of the magnetic field variance. We use these basis functions (computed monthly) to infill where data are missing, providing a self-consistent description of the EMF at 5-minute resolution spanning 1997—2009 (solar cycle 23).

Each of the EOF basis functions can typically be associated with one of the Disturbance Polar (DP)-type current systems (e.g. DP2, DP1, DPY, NBZ), or with the motion of these systems. This association allows us to describe the varying behaviour of the current systems over the 144 months (i.e. 1997—2009) of our reanalysis. However, the EOF basis functions are (by definition) ranked by their contribution to the total variance, and thus a given current system may be described by a different rank of basis vector from month to month. We use graph theory to find clusters of quantifiably-similar spatial basis functions, and thereby track a given pattern throughout the span of 144 months. Via this method, we present the seasonal and solar cycle variations in the polar current systems.