A Dynamo Cascade Interpretation of the Geomagnetic Dipole Decrease

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Abstract

We propose a spectral transfer model for the secular variation of the geomagnetic core field to explain the simultaneous decrease in dipole field intensity and the increase in non-dipole field intensity from 1840 to the present in terms of a dynamo cascade process. The main assumption of this model is that magnetic energy is transferred between adjacent spherical harmonic degrees in the Mauersberger-Lowes spectrum of the geomagnetic field. The key parameters are a set of coefficients $\gamma_n$ that indicate the rate and direction of magnetic energy transfer through the spectrum. Applying the spectral transfer model to the historical period, we find that the quadrupole family of the core field can be characterized by a persistent inverse magnetic energy cascade from higher toward lower spherical harmonics. In the dipole family of the core field, we find cascade behavior generally from lower to higher spherical harmonics, consistent with axial dipole decrease, but with a high level of time variability that correlates with variations in the dipole family intensity. During time intervals when the dipole family intensity rapidly decreases, energy appears to cascade toward higher spherical harmonics, beyond the limit of the observable part of the core field spectrum. During time intervals when the dipole family intensity is nearly constant, a more limited forward cascade appears to trap energy at intermediate spherical harmonics. Similar fluctuations in the rate and direction of spectral transfer are also seen...
in the Mauersberger-Lowes spectrum of a numerical dynamo model during a dipole decrease event that led to a polarity excursion. We discuss the possibility of this scenario for the current geomagnetic dipole decrease.