Pulses and decay of the dipolar field during the Holocene

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Temporal changes in the main geomagnetic field, the so-called secular variation, can range from decades to millennia without showing any clear periodicity. A better knowledge of the secular variation behaviour is important to determine the mechanisms that maintain the magnetic field and can help to establish constraints in dynamo theories. Considering that the magnetic dipole contributes to around 90 % of the total main field, we have searched for periodicities in this component over the last 10,000 years using four global paleomagnetic field reconstructions (SHA.DIF.14k, CALS10k2, BIGMUDI4 and SHAWQ2k). We have applied three techniques commonly used in signal analysis: a) the Fourier transform to identify the characteristic frequencies of the dipole field; b) the Empirical Mode Decomposition to separate the secular variation of the dipole into short and long wavelength signals; and c) the wavelet analysis to know how the characteristic periods are distributed over the time studied. Results show that for short-wavelength terms we find a recurrent periodicity of 700 – 800 years, present throughout most of the last 10,000 years with small variations. Focusing on long-wavelength terms for SHA.DIF.14k and CALS10k2, we observed a drop in the dipole field, controlled by the axial dipole, starting around 7000 BC. We have fitted it as an exponential decay obtaining a relaxation time of 8,000 – 10,000 years, which well agrees with the theoretical diffusion time of the geomagnetic field. The dipole field starts to increase around 4,500 BC for nearly 4,000 years. If we consider that this increase is comparable to the charge of a capacitor, it would give a characteristic time of 15,000 years. However, the theoretical maximum value obtained for the axial dipole field is never reached and the charge stops at 40 % around the year 100 AD. At that time, the dipole impulse ended and the present large trend dipole decrease seems to start, with a relaxation time of 13,000 years.