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High-resolution Models of the Earth's Main Magnetic Field

Veronika Soukhovitskaya and Jeremy Bloxham
Department of Earth and Planetary Sciences, Harvard University (vsoukhov@fas.harvard.edu)

We present two high-resolution spherical harmonic models of the Earth's main magnetic field: one based on vector data from recent satellite missions CHAMP and Oersted for the years 2001.0 - 2009.0 and a longer model covering the time period of 1957.0 - 2009.0 based on both observatory data and satellite data from CHAMP, Oersted, Magsat, DE-2 and POGO missions. We represent time-dependency using B-splines with knots spaced every year for the 1957-2009 model and every 0.1 years for the 2001-2009 model. We estimate the rate of change of the magnetic field from quiet observatory data with the use of penalized cubic splines and differentially filter satellite data depending on geomagnetic latitude. For model derivation, our approach is to produce spatially rough models (i.e. minimum spatial regularization applied) and instead truncate the final models at an appropriate spherical harmonic degree to avoid contributions from lithospheric fields and noise. Using geomagnetic spatial power spectrum and comparisons with the known features of the field at the core-mantle boundary, we show that we are able to resolve the core field to spherical harmonic degree 15 for the 2001-2009 model and to spherical harmonic degree 14 for the 1957-2009 model, allowing us to map in greater detail the spatial and temporal structure of the magnetic field at the core-mantle boundary. Next we use our 1957-2009 model to calculate core-surface flow velocity maps by first assuming a steady flow and then allowing it to vary slowly with time (on the order of 100s of years). We show that the slowly-varying background flow plus torsional oscillations can fully explain the observed secular variation. Such core flow models might prove useful in producing reliable forecasts of the Earth's main magnetic field.