Joint time-domain modelling magnetic field signals of ionospheric and magnetospheric origin. An approach and its implementation to observatory data

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Summary

Accurate global models of the spatial-temporal structure of external current systems are critical for imaging Earth's electrical conductivity at mid and lower mantle depths. Such models can also be helpful for better isolating core and crustal fields. Three ionospheric current systems – equatorial electrojet (EEJ), polar electrojet (PEJ), and mid-latitude current system (MLCS; in quiet time called Sq) – produce quasi-periodic diurnal variations (DV). The signals at longer periods (LP) are due to irregular fluctuations of magnetospheric ring current (RC). Conventionally, DV and LP signals are treated separately. For example, the analysis of RC signals is often based on night-time data to diminish the effects from ionospheric sources. However, due to EM induction in the Earth, the signals of ionospheric origin also persist during the night. As for DV, their analysis is usually performed in the frequency domain. However, the morphology of all ionospheric sources varies from day to day, depending on the solar activity and the Earth's orbital position, advocating analysis of DV in the time domain. Besides, the analysis of EEJ and MLCS signals is usually based on non-polar data to diminish the effects from PEJ. In this study, we present a methodology to simultaneously model magnetic fields from all the sources directly in the time domain using non-polar and polar data. An approach exploits two types of source parameterisation (data-based and physics-based) and accounts for 3-D electromagnetic (EM) induction effects. Using observatory data, we obtain continuous spatio-temporal models of multi-source external and induced magnetic fields for 1998-2021. We also discuss an adaptation of the approach to analyse satellite data.

Keywords: mantle conductivity; geomagnetic depth sounding; observatory and satellite data