Deep geomagnetic sounding by Sq variations in Europe: A 3-D inversion based on the regional-to-local transfer functions

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SUMMARY

The spatial configuration of the ionospheric currents precludes the use of simple local transfer functions in geomagnetic deep sounding by the solar quiet (Sq) variations. The global-to-local transfer functions relate the local vertical magnetic field at a particular observatory to the spherical harmonic coefficients describing the ionospheric source. The latter must be obtained by initial processing of the horizontal magnetic field measurements, and using an a-priori conductivity model.

The approach presented here introduces two novel points in this concept. First, the global spherical harmonic base is replaced on the regional scale with vector Slepian functions, concentrating the EM fields in the area of interest while still allowing to use the well developed spherical-harmonic formalism. Second, the Dirichlet boundary condition is applied in the forward problem, prescribing the total horizontal magnetic field in the Slepian base, and thus avoiding the use of an a-priori conductivity model. Such formulation allows a straightforward prediction of the regional-to-local transfer functions, which relate the vertical magnetic field at a particular point with the coefficients of the Slepian expansion of the horizontal component.

The methodology is tested on a synthetic quasi-realistic scenario for European observatories. A 3-D conductivity model WINTERC-e Wd-emax, based on a thermochemical state of the mantle and laboratory conductivity measurements, is used to generate the responses, and subsequently is successfully recovered from them by 3-D inversion.

In the next step, we obtain robust estimates of the regional-to-local transfer functions for the daily time harmonics from geomagnetic field measurements at European observatories, and invert them in terms of 3-D electrical conductivity distribution in the upper mantle below Europe. Finally, we look at the interpretation of the conductivity model in terms of the mantle thermochemical structure.

Keywords: Sq variations, geomagnetic deep sounding, transfer functions, upper mantle conductivity below Europe