Global induction response to 11 year period and the conductivity of the lower mantle

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SUMMARY

To date the electromagnetic response of Earth has been restricted to periods shorter than one year (with the exception of an estimate for the 11-year sunspot cycle by Harwood and Malin (1977)) because at longer periods the separation of the internal and external fields remains challenging. We adopt a simple approach to extracting the external P_1^0 variations and their inductive response from 117 years of hourly geomagnetic data from 192 observatories drawn from a recent compilation distributed by the British Geological Survey. Observatories were selected to be within 65° of the geomagnetic equator and data gaps of up to 48 hours were repaired using linear interpolation. Baseline corrections were made and the time varying International Geomagnetic Reference Field (IGRF) was removed from the data, which were rotated into geomagnetic coordinates year by year to allow for migration of the geomagnetic pole. Data were processed year by year by fitting hourly estimates of the internal and external coefficients of a P_1^0 field to the set of observatories that had no missing data for that year (a number that varies between 3 and 93), using one month overlaps between years to remove the small bias from year to year fits. Observatory years with excessive misfit were iteratively removed from the processing. Multi-taper spectral analysis and band averaging was used to estimate the power spectra and transfer functions between the two time series. A clear peak at the 11-year solar cycle appears in the external field spectrum, with a smaller but discernible peak at the first harmonic of 5.5 years, with associated peaks in the coherency spectrum. Error bars on complex admittance were estimated from the statistics of the cross-spectrum and a parametric bootstrap. The data can be fit to RMS 1.0 with a smooth Occam inversion model. A Bayesian inversion approach was also used, generating 10,000 models that fit acceptably well. A conductive core is seen in the models and is required by the data. The well-documented jump in conductivity between the upper and lower mantle is clearly seen, and a second jump in conductivity occurs at depth of 1,800 km.

Keywords: global induction, mantle conductivity, sunspot cycle

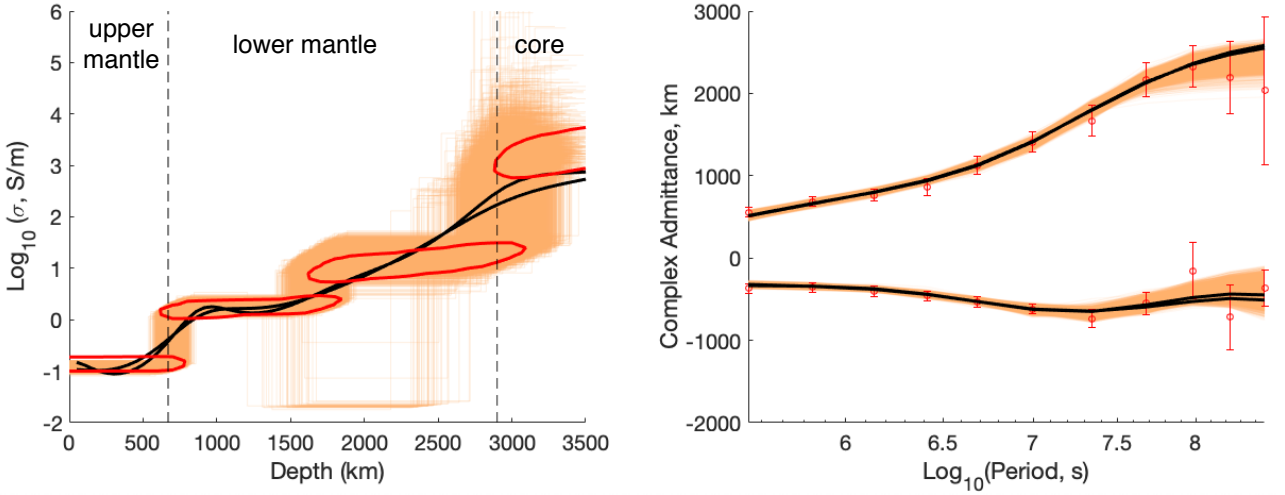

Figure 1: Inverted models, complex impedance data, and model responses. Orange lines are 10,000 4-layer models fitting between RMS 0.92 and 1.3. Black lines are Occam models and responses fitting to RMS 1.0 and 1.1. Red contours are the 95% bounds on acceptable model space.