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The prediction of lithospheric magnetic anomalies using the inversion of magnetisation data for vector spherical harmonics

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High resolution lithospheric magnetic field anomaly maps derived from satellite data now offer immense opportunities to interpret anomalies in terms of crustal magnetic properties such as susceptibility, magnetic crustal thickness, magnetisation type and intensity.

We present a new method in which the magnetic field at satellite altitude is found by solving an inverse problem using our magnetisation estimates as data. This avoids the need for magnetisation estimates on a uniform grid and allows proper estimation of error propagation. A vector spherical harmonic formulation allows proper estimation of the annihilators, those parts of the magnetisation that produce internal and non-potential fields. These yield zero potential field at satellite altitude for perfect data (i.e. perfect and complete magnetisation estimates) but will contaminate the satellite field when the magnetisation estimates are inaccurate and incomplete.

A major limitation in the interpretation of such anomalies is the inherent difficulty in separating and evaluating the relative contributions of induced and remanent magnetisation using standard inversion techniques. This is particularly relevant over oceanic regions, where lithospheric anomalies contain a significant remanence signature. Furthermore, it is difficult to separate the core field from the crustal contribution, particularly over continents, where magnetisation estimates are poorly constrained. We approach the scale-separation problem by forward modelling the satellite field using separate estimates of lithospheric magnetisation that do not depend on satellite data, with particular emphasis on the oceans. Induced and remanent contributions are determined separately. Remanent magnetisation is derived from a combination of magnetic crustal thickness, a remanence-age profile superimposed onto a geomagnetic polarity timescale, and magnetisation directions derived from the implementation of updated plate reconstruction models. Induced magnetisation is derived from a combination of magnetic crustal thickness and standard magnetic susceptibilities associated with major geological units. In both induced and remanent cases, magnetisation data points are restricted to locations where we have confidence in our estimates; although good geographical coverage is desirable, equally-spaced data are not necessary. We present comparisons between an initial magnetic anomaly map predicted by the present work, and a lithospheric magnetic field model.