Geophysical Research Abstracts
Vol. 20, EGU2018-5180, 2018
EGU General Assembly 2018

Application of spherical Slepian functions to decomposing core surface flows

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Spherical Slepian functions (or ‘Slepian functions’) are mathematical functions which can be used to decompose potential fields, as represented by spherical harmonics, into smaller regions covering part of a spherical surface. This allows a spatio-spectral trade-off between aliasing of the signal at the boundary edges while constraining it within a region of interest. While Slepian functions have previously been applied to crustal magnetic data, this work further applies Slepian functions to decomposition of flow on the core-mantle boundary. There are two main reasons for restricting flow models to certain parts of the core surface as, firstly, we have reason to believe that different dynamics operate in different parts of the core and, secondly, the modelled flow is ambiguous over certain parts of the surface. Spherical Slepian functions retain many of the advantages of our usual flow description, concerning for example the boundary conditions it must satisfy, and allowing easy calculation of the power spectrum, although greater computational effort is required.

We examine the applicability of Slepian functions to core flow models by first demonstrating the effectiveness of the technique on a range of energy spectra from randomly generated noise profiles. Once the method has proven to be robust, we apply Slepian functions to decompose (i) numerical geodynamo flow models and (ii) models from inverted satellite magnetic data, with a more restricted spherical harmonic degree range, into a chosen region and its corresponding complement. We examine two regional decompositions: (i) the ambiguous patch from the geostrophic flow assumption and (ii) the cylinder tangent to the inner core. As well as investigating the flow maps and kinetic energy profiles, the output flows are entered into secular variation forecasts to investigate how change within these regions contributes to the change in magnetic field.