Geophysical Research Abstracts
Vol. 15, EGU2013-5901, 2013
EGU General Assembly 2013

Vectorial Slepian functions and the estimation of the crustal magnetic field

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Within the past two decades increasingly sophisticated magnetometry satellite missions have brought us data of ever improving quality and will reach a new pinnacle with the Swarm satellite mission to be launched in 2013. In order to make optimal use of this rich source of information for the lithospheric structure of Earth, and other planets, the computational algorithms used to obtain the crustal magnetic field from satellite data should be designed to take the specific properties of the data into account (e.g. their bandlimitation, their noise properties, the satellite altitude, their vectorial character). Ideally, the method should also be able to focus on chosen regions, be it as a means of regularization in a specifically targeted investigation or in order to discern between areas of intrinsically different properties of the field, such as for example crustal versus oceanic field. Such a merging of properties can be achieved using Slepian functions, a basis of bandlimited and spatially concentrated functions. The scalar version of Slepian functions has proven to be useful in a wide range of fields including geodesy, gravimetry, geomagnetism, and geodynamics. In order to make use of all three components of the vectorial data set we recently developed vectorial Slepian functions. In this presentation we combine the vectorial Slepian functions with the up- and downward continuation of vector fields to construct a fully vectorial estimation scheme for the regional crustal magnetic field from data at satellite altitude. We test our method with artificial data for different regions and bandlimits and compare different implementations of the method including regional concentration at satellite altitude, regional concentration on Earth's surface, and an estimation scheme employing vectorial Slepian functions that are constructed to ideally incorporate the defocusing effect due to altitude continuation.