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On different physical Contents of Models of the internal magnetic Field for the Earth's Surface and for Satellite Altitudes

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The SHA field models for the internal magnetic field of the Earth are determined as a set of Gauss coefficients according to a functional system being referred to a reference surface. As reference surfaces concentric spheres, ellipsoids etc. represent the Earth's surface and the satellite altitudes, respectively. SHA field models referred to different concentric reference surfaces use different functional systems with its relevant Gauss coefficients. Because of practical reasons for the numerical calculations finite partial sums have to be used as approximations instead of the infinite SHA expansions. Consequently, magnetic field models referred to the Earth's surface in comparison to the satellite altitudes have different physical contents. This is in agreement with the fundamental theorem for potential fields that there is only a unique relation between the field and its sources if the field is available and known in all points of the three-dimensinal space including all points of the source region. This is the necessary prerequisite that the potential function of the field can be completely determined. This means also that e.g. field data from different concentric reference surfaces make additional physical contents available which cannot be calculated by any geometrical relation between the concentric reference surfaces.

Contrastingly, it appears useful to record the field separately at different reference surfaces and at the same epoch, to calculate separate field models and to determine their different physical contents. The comparison of the independent field models requires upward and downward field continuations. Practically, for the downward field continuation the author has derived a mathematical procedure by comparing the related contributions of the spherical harmonic terms in the mathematical space.

Differences between independently and simultaneously determined field models re-

ferred to concentric reference surfaces can be evaluated approximately by mathematical upward and downward field continuations of high quality. These comparisons enable to separate internal and external magnetic field contributions being differently contained in the different data sets.

The simple upward and downward field continuations by the ratio of radii of the concentric reference surfaces do not distinguish for the different physical contents of the field models and therefore means a first rough approximation in comparison to the more detailed investigations given here.

To derive field models and interpretations of high quality (e.g. for the relatively small contributions of the crust to the field data) being most adequate to the high accuracy of the field data used requires to take into account in detail the differences of the data from different reference surfaces.

Analytical formulae and figures for CHAMP and Oersted demonstrate the procedures.

Reference:

Webers, W. A., 2002: Downward field continuation in combining satellite and ground-based internal magnetic field data, J. of Geodynamics, Vol. 33/1-2, pp. 101-116