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Ellipsoidal Effects in the Fixed Geodetic Boundary Value Problem

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After applying topographic reductions and downward continuation on the observed boundary data the linearized Geodetic Boundary Value Problem (GBVP) degenerates into an ellipsoidal problem. Although the ellipsoidal boundary surface possesses a much simpler topology than the original topographical surface of the Earth, this simplified problem still cannot be solved in an elementary analytical way; in contrast, the "simple" GBVP related to a spherical boundary surface and the normal (radial) derivative is rigorously solvable by spherical integral formulae.
In the past, various approaches have been developed for approximate solutions of the ellipsoidal GBVP, starting from the classical work by Sagrebin (1956). These approaches, mainly applied to the free GBVP, rely on first order approximations with respect to the flattening of the ellipsoid of revolution and can be subdivided in three groups. The first group is based on modifications of the spherical integral kernel, resulting in anisotropic kernel functions depending on the azimuth between the computation point and the moving integration point. In the second group the boundary data are reduced for "ellipsoidal effects" and inserted into spherical integral formulae. Finally, in the third group the ellipsoidal boundary data is formally inserted into the spherical solution formula, and a correction term is added for consideration of the ellipsoidal effect. An advantage of the third approach, propagated by Heck and Seitz (2003) for the linearized scalar-free GBVP, consists in the fact that the correction term can easily be evaluated from some global geopotential model in the form of a spherical harmonic series.
In the paper the three groups of approaches are discussed for the case of the fixed GBVP. A first-order solution of the fixed GBVP related to an ellipsoidal boundary is derived in detail according to the procedure presented in Heck and Seitz (2003). Finally, the resulting ellipsoidal correction term is investigated numerically in the space as well as in the frequency domain.