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Green's function, reproducing kernel and Galerkin's matrix for the exterior of an ellipsoid: Application in gravity field studies

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In gravity field studies the complex structure of the Earth's surface makes the solution of potential problems (typically for the exterior of the Earth) rather demanding. This equally concerns classical methods of potential theory as well as modern methods often based on a weak solution concept. Green's functions, integral kernels, reproducing kernels of the respective Hilbert spaces, kernels associated with the integral equation method, but also linear (e.g. Galerkin's) systems resulting from the use of direct methods are usually constructed for a solution domain of boundary that is slightly simplified in comparison with reality. The measure of this simplification has an essential impact on the convergence of iteration procedures applied in this connection. Very often a sphere is used, but it seems this is not an adequate choice for a global approach to the solution. In this paper an attempt is made to discuss an apparatus suitable for the determination of a harmonic function that meets a prescribed boundary condition on an ellipsoid of revolution. Ellipsoidal harmonics come into play. The structure of the kernels mentioned above similarly as of the entries of Galerkin's matrix becomes rather complex. Therefore, an approximation of ellipsoidal harmonics based on an approximation version of Legendre's ordinary differential equation, resulting from the method of separation of variables in solving Laplace's equation, is used. The idea is applied to the construction of Green's function, reproducing kernel and Galarkin's matrix with a particular view to potential problems in gravity field modeling.