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A new formulation of Stokes approach in determining the geoid

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To determine the geoid as well as the external gravity field, generally, a disturbing potential function, which is the difference between the geopotential and normal gravity potential, is introduced. For instance, by Stokes approach, given the gravity anomaly on the geoid (as the boundary), a disturbing potential function satisfying some kind of boundary conditions should be solved. The basic requirement is that the disturbing potential function should be harmonic in the region outside the geoid (after the masses outside the geoid are removed into the interior of the geoid). However, since the normal gravity potential is not defined inside the reference ellipsoid (taking the WGS84 ellipsoid as an example), in the case that the geoid lies inside the ellipsoid, the disturbing potential function is not harmonic in the whole region outside the geoid, and neither defined on the geoid. These are theoretical difficulties existed in Stokes approach. The aim of this paper is to provide a new formulation of Stokes approach, so that the difficulties existed in Stokes approach vanish. Besides the conventional WGS84 ellipsoid, we choose an inner ellipsoid with four fundamental parameters, of which, two parameters, the geocentric constant and rotation rate, coincide with the corresponding parameters of the WGS84 ellipsoid, and other two parameters are different from the corresponding ones of the WGS84 ellipsoid. The inner ellipsoid, with its center coinciding with that of the WGS84 ellipsoid, is completely enclosed by the geoid. Then, the normal gravity potential generated by the inner ellipsoid is determined by requiring that it holds a constant on the surface of the inner ellipsoid or on the surface of the WGS84 ellipsoid. By this new formulation, the disturbing potential function is harmonic in the whole region outside the geoid, and the difficulties existed in the conventional Stokes approach can be conquered. The new formulation proposed in this paper is also adequate for analogous geodetic boundary value problems, such as Molodensky problem. Numerical tests show that this new formulation is reliable. This study is supported by National Natural Science Foundation of China (grant No. 40974015).