Representation of the time variable gravity field due to hydrological mass variations by surface layer potentials

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In the evaluation of GRACE observations the hydrological mass variations at the Earth's surface are often represented by a single layer mass distribution spread over a sphere; in general, a transformation from the space domain to the frequency domain is performed using a spherical harmonic representation of the single layer potential in combination with a spatial windowing or smoothing.

In the present paper a space domain representation of the water mass fluctuations is proposed, based on a discretisation of the spherical surface by a geographical grid, postulating that the surface density is constant over any spherical rectangular grid element. However, the resulting surface integrals for the gravity potential and its derivatives cannot be solved by elementary analytical integration. For this reason, an approximate solution of these integrals is suggested based on Taylor series expansions including third-order terms. The resulting formulae are derived for the gravitational potential and its first and second order spatial derivatives at the satellite position. Further refinements of this approach, such as considering geographical grid elements on an ellipsoid of revolution, are indicated.