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Spherical and ellipsoidal arrangement of the topography and its impact on gravity gradients in the GOCE mission

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The basic observables of the recently launched satellite gravity gradiometry mission GOCE are the second derivatives of the earth gravitational potential (components of the full Marussi tensor). These gravity gradients are highly sensitive to mass anomalies and mass transports in the earth system. The high- and mid-frequency components of the gradients are mainly affected by the topographic and isostatic masses whereby the downward continuation of the gradients is a rather difficult task. In order to stabilize this process the gradients have to be smoothed by applying topographic and isostatic reductions.

In the space domain the modelling of topographic effects is based on the evaluation of functionals of the Newton integral. In the case of GOCE the second-order derivatives are required. Practical numerical computations rely on a discretisation of the earth's topography and a subdivision into different mass elements. Considering geographical gridlines tesseroids (spherical prisms) are well suited for the modelling of the topographic masses. Since the respective volume integrals cannot be solved in an elementary way in the case of tesseroids numerical approaches such as Taylor series expansion, Gauss-Legendre cubature or a point-mass approximation have to be applied.

In this paper the topography is represented by the global Digital Terrain Model DTM2006.0 which was also used for the compilation of the Earth Gravitation Model EGM2008. In addition, each grid element of the DTM is classified as land, see or ice providing further information on the density within the evaluation of topographic effects. The computation points are located on a GOCE-like circular orbit. The mass elements are arranged on a spherical earth of constant radius and, in a more realistic composition, on the surface of an ellipsoid of revolution. The results of the modelling of each version are presented and compared to each other with regard to computation time and accuracy.

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