On topographic mass integration for local geoid modeling

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Topographic reduction is one of the most imperative steps in geoid modeling, where the gravity field inside the masses needs to be modeled. This is quite challenging because no one can measure gravity inside the topography at a desired resolution (only a very limited number of borehole gravity measurements are available in the whole world). Therefore, topographic mass modeling is usually treated either by the residual terrain modeling (RTM) or by the Helmert's 2nd condensation among other alternative reduction schemes. All of these topographic reductions need intense computation efforts for the integration of topographic mass induced gravity effects. Currently, the most popular tool for topographic mass modeling is the 'tc' program available in the GRAVSOFT package. In this program, the mass elements provided by a digital terrain model (DTM) are treated as rectangular prisms which cannot directly take the Earth curvature into account and suffer from geometrical shape change due to meridian convergence. In this study, the tesseroids which are naturally obtained from a DTM are employed and their gravity effects are precisely evaluated by numerical integrations. Four topographic mass integration schemes are proposed and programmed in FORTRAN. Their computational performances in computing the RTM effect, terrain correction, and total topographic effect with and without using parallelizing technique are tested in the Colorado area. Then they are applied to local geoid modeling to see the geoid model differences among these various integration schemes in the RTM case. The numerical findings reveal that: (1) The application of parallelization techniques can greatly reduce the computation time without the loss of any computation accuracy; (2) Among the four integration schemes, the maximum absolute difference of RTM effect, terrain correction, and total topographic effect is about 3 mm, 6 cm, and 7.5 cm for the height anomaly, and 4 mGal, 3 mGal, and 40 mGal for the gravity anomaly; (3) In the RTM case, the geoid model difference can reach a maximum of 1 cm in the target area, and a larger difference should be expected in areas with rougher terrain; (4) The effects on geoid models from mass density anomalies is bigger than from the counterparts from DTM errors.