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Accuracy requirements of the gravity measurements for sub-centimetre geoid

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In this contribution, we estimate the uncertainty (error) of the input gravity measurements needed for the determination of the geoid with an internal sub-centimetre accuracy. The accuracy of the geoid height is a function of the resolution/accuracy of the input gravity and topographical data, and the methodology used to solve a geodetic boundary value problem. The purpose of this study is to estimate the maximum allowable error in the terrestrial gravity measurements based on a required standard deviation of the error in the geoid heights (e.g., ≤1cm). This is done with an assumption of a known Digital Elevation Model (DEM), and an Earth Gravitational Model (EGM) along with their error estimates.

We use the one-step integration method (one-step kernel) for the determination of the geoid. In this method, the anomalous gravity at any surface above the geoid is estimated by integrating over the geoid-level disturbing potentials in harmonic space. By applying the covariance law to the one-step integration method, the error of the gravity measurements at the Earth's surface can be estimated using the expected error of the geoid heights. Taking advantage of the remove-compute-restore technique, we estimate the error of the residual surface gravity measurements using the (known) error estimates of the topographical and EGM corrections.

We select the Colorado test area (35°N - 40°N, 250°E - 258°E) to generate a $1^{c} \times 1^{c}$ grid of geoid random errors with a standard deviation of 1cm. We use the topographical data from the Shuttle Radar Topography Mission (SRTM) Ver. 3.0. and the global model of DIR_R5 up to degree/order 140 to apply the remove-compute-restore technique. The uncertainty estimate of the SRTM heights and the covariance matrix of the spherical harmonic coefficients of the DIR_R5 are used to calculate the errors of the topographical gravitational attraction and low-degree EGM signals on the geoid heights and surface anomalous gravity data.

Our preliminary results show that to achieve a sub-centimetre accuracy in the Colorado area, we

require grid surface gravity measurements with a standard deviation of less than 2.5mGal. This result is optimistic as in the geoid determination process, the anomalous gravity data are downward continued from the Earth's surface to the geoid, whereas this step is not required in our experience. Besides, we assume a constant standard deviation of 1cm for all the errors of the geoid heights, whereas such high accuracy may not be needed in high mountains. We will provide further results for the elevation-dependent geoid error and also investigate the effect of downward continuation on our results.