

Propagation of terrain and density effects in gravimetric geoid modeling

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In areas with complex topography, the accuracy of gravimetric geoid modeling depends on the representation of the topographic geometry, density and the geoid-quasigeoid separation (GQS). This study analyzes the effects on Taiwan by computing detailed terrain corrections (TCs), refined GQS estimations with density variations and different digital elevation model resolutions.

A set of experiments was carried out using island-wide SRTM1, 20 m LiDAR and a locally 1 m LiDAR data in selected mountainous area. A constant topographic density of 2.67 g/cm^3 results on TCs, GQS and geoid was compared with a laterally varying density model in the analysis. A three-term GQS formulation was evaluated against traditional simplified approaches. The resulting geoid models have been validated with two independent GNSS/leveling datasets.

The results suggest that terrain resolution is important in mountainous areas. Replacing the 20 m LiDAR DEM by SRTM1 causes terrain-correction differences of some tens of milligals and local modifications of GQS and geoid heights up to the decimeter level. The full three-term GQS formulation leads to substantial local differences in comparison to the classical approach. In the denser 1,994-station validation dataset the residual standard deviation drops from 6.4 cm for the traditional solution to 5.8 cm for the three-term solution. Lateral density variations produce spatially coherent changes related to geological structures but do not always reduce the GNSS/leveling residual scatter compared to the constant density solution. A local experiment with 1 m LiDAR data further demonstrates that detailed terrain can change GQS and geoid heights by centimeters to decimeters in extreme relief areas. The results contribute to the prioritization of topographic data and methodological improvements in high-accuracy geoid modeling.