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Height system unification based on the Fixed Geodetic Boundary Value Problem with limited availability of gravity data

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Regional height reference systems are generally related to individual vertical datums defined by specific tide gauges. The discrepancies of these vertical datums with respect to a unified global datum cause height system biases that range in an order of 1-2 m at a global scale.

One approach for unification of height systems relates to the solution of a Geodetic Boundary Value Problem (GBVP). In particular, the fixed GBVP, using gravity disturbances as boundary values, is solved at GNSS/leveling benchmarks, whereupon height datum offsets can be estimated by least squares adjustment. In spherical approximation, the solution of the fixed GBVP is obtained by Hotine's spherical integral formula. However, this method relies on the global availability of gravity data. In practice, gravity data of the necessary resolution and accuracy is not accessible globally. Thus, the integration is restricted to an area within the vicinity of the computation points. The resulting truncation error can reach several meters in height, making height system unification without further consideration of this effect unfeasible.

This study analyzes methods for reducing the truncation error by combining terrestrial gravity data with satellite-based global geopotential models and by modifying the integral kernel in order to accelerate the convergence of the resulting potential. For this purpose, EGM2008-derived gravity functionals are used as pseudo-observations to be integrated numerically. Geopotential models of different spectral degrees are implemented using a remove-restore-scheme. Three types of modification are applied to the Hotine-kernel and the convergence of the resulting potential is analyzed. In a further step, the impact of these operations on the estimation of height datum offsets is investigated within a closed loop simulation. A minimum integration radius in combination with a specific modification of the Hotine-kernel is suggested in order to achieve sub-cm accuracy for the estimation of height datum offsets.