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Generalization techniques to reduce the number of volume elements for terrain effect calculations in fully analytical gravitational modeling

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The available volumetric models of the crust of the Alps - Pannonian basin - Carpathians region and the 30 m x 30 m resolution DTM of Hungary contain several million and hundred million volume elements, respectively. Either rectangular prisms or polyhedrons can be used to discretize the density distribution inside these 3D structures. The calculation of the closed formulae given for the gravitational potential and its higher order derivatives, however, needs twice more runtime than that of the rectangular prism computations. Although the more detailed the better principle is generally accepted (or assumed) it is basically true only for errorless data. As soon as errors are present any calculation from the model is only a possible realization of the true gravitational field at the significance level determined by the errors. So if one really considers the reliability of input data (e.g. Moho depths, topographic heights) used in the calculations then sometimes the “less” can be equivalent to the “more” in statistical sense. As a consequence, the computational time can be significantly reduced by the optimization of the number of volume elements based on the accuracy estimates of the input data.

New algorithms are proposed to minimize the number of model elements defined both in local and global coordinate systems. Common gravity field modeling programs generate optimized models for every computation points (dynamic approach), whereas the static approach provides only one optimized model for all computational points. The number of volume elements depends on a threshold value pre-defined by the error statistics of the input data. It represents the maximum difference allowed along the vertical direction Z between the initial and optimized model.

Based on the static approach two different algorithms were developed. The grid-based algorithm starts with the maximum resolution polyhedral model defined on a uniform grid and generates a new polyhedral surface. The other algorithm is more general, it works for irregularly distributed data (points) connected by triangulation. Beyond the description of the optimization schemes some applications of these algorithms in regional and local gravity field modeling are presented too.

Keywords: polyhedron, rectangular prism, forward gravitational modeling, DTM error, error of gravity potential, model generalization