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Spectrally complete residual terrain modelling (RTM) – On solving an often neglected filter problem

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The residual terrain modelling (RTM) technique is a well-established method for modelling short-scale gravity effects implied by the topographic masses, e.g. as given by digital elevation models. In physical geodesy the RTM technique is used in applications such as high-resolution combined gravity field modelling, smoothing/reduction of gravity observations (remove compute restore approaches), the computation of Bouguer anomalies, global height system unification and many more.

A crucial step in the technique is the creation of high-pass filtered topographic source masses: the residual terrain model. The high-pass filtering is achieved by the subtraction of some (long-wavelength) reference topography from the digital elevation model. The subsequent conversion to gravity does not account for the fact that filtering in the topography domain is not equivalent to filtering in the gravity domain. Therefore unwanted low-frequency gravity signals enter the RTM-gravity, and parts of the wanted high-frequency signals are missing in the RTM-gravity. We present approaches to mitigate this imperfection by means of corrections that are designed to be applied to already computed RTM-gravity signal. Our approaches are based on recent efforts in spectral domain forward modelling of the topographic potential and ultra-high degree spherical harmonic transforms (SHA/SHS) at the Technical University Munich and the Slovak University of Technology. Performed case studies involve a degree-2160 reference topography and gravity effects modelled up to degree 21,600. Our validation over Switzerland shows that the residuals between a combined gravity field model based on RTM-gravity and ground-truth gravity observations, can be reduced by about 17 % due to the low-frequency correction and by another 8 % when also accounting for the high-frequency inconsistency. The low-frequency correction is most efficient when modelled from degree 360 to 2160 instead of in the bandwidth 0 to 2160 as one could expect (in case of our degree-2160 reference topography).

Concluding, we expect the corrections to be of great value for geophysical interpretations of RTM-reduced/Bouguer gravity at short-scales and for combined high-resolution gravity field modelling, however, the characteristics of the low-frequency correction deserve further investigations.