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A smoothing effect of the topographical correction on gravity disturbances in rugged mountains and flat regions – Case study for the Canadian Rocky Mountains

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We compare the roughness of and the correlation with topography of the observed gravity disturbances and the topographically corrected gravity disturbances. The numerical investigation is done for the gravity disturbances at the earth's surface and for the upward continued gravity disturbances at different altitudes. The area of study comprises a rough part of the Canadian Rocky Mountains, surrounded by flat regions and a small part of the Pacific Ocean. The results reveal a positive correlation of 0.59 between the topography and the observed gravity disturbances at the earth's surface. Over the mountainous sub-region, this correlation increases up to 0.76, while over the selected flat sub-region decreases to 0.14. When the topographical correction to gravity disturbances is applied, the correlation changes significantly and becomes strongly negative. This indicates that a substantial part of the anomalous gravity signal is due to isostatic compensation. The correlation between the topography and the topographically corrected gravity disturbances at the earth's surface is in this case -0.76. This correlation decreases (in absolute sense) to -0.60 over the mountainous sub-region, and to -0.29 over the flat sub-region. The results of the upward continuation at the altitudes from 10 to 50 km reveal that over the mountainous sub-region the correlation of all the two types of gravity disturbances with the topography decreases in absolute sense with altitude, while surprisingly increases over the flat sub-region. The changes of the correlation with the elevation are approximately within $\pm 4\times$10E-3 and $\pm 5\times$10E-3 per km, except for a much smaller change of the correlation of the upward continued gravity disturbances over the flat sub-region where this change is only $1.5\times$10E-3 per km. Since not only the relief of topography significantly contributes to the roughness but also the subsurface density heterogeneities, the correlation of gravity data with topography might not be the best measure of the smoothness/roughness of gravity data. For this reason, we measure the roughness of gravity data also by statistical analysis of the slopes of gravity data on a grid with a 1 km step. This analysis objectively shows that at the earth's surface the topographically corrected gravity disturbances are smoother than the observed gravity disturbances. The topographically corrected gravity disturbances are thus better suited for the harmonic upward continuation. This has a practical consequence for the application of the topographic correction before the ground gravity data are upward continued for instance to validate the airborne gravity data. The smoothing effect with growing altitude, when upward continuing the two types of gravity disturbances, works differently for each of the two types. For the whole study area the topographically corrected gravity disturbances contain at higher altitudes (from about 20 km) more signal, in terms of our roughness measure, than the observed gravity disturbances: The topographically corrected gravity disturbances are dominated by a signature of the isostatic compensation of the Rockies.