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Relation between geoidal undulation, deflection of the vertical and vertical gravity gradient revisited

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The vertical gradient of the gravity anomaly can be related to the geoidal undulation and its first and second derivatives. In addition, it can be related to the horizontal derivatives of the deflection of the vertical. The latter relation is not exact as two terms are neglected, one of which depends on the tangent of the latitude. It is therefore not directly obvious that the negligence is allowed as the tan-term tends to infinity when approaching the poles. In this presentation a derivation is given that provides additional insight in the individual terms. The size of the neglected terms is assessed using EGM2008. With respect to the relation between the vertical gravity gradient and geoidal undulation, we learn from the standard physical geodesy textbooks that this relation is less suited for numerical evaluation because the double differentiation of the undulations leads to severe noise amplification. It seems nevertheless worthwhile to revisit this relation as today high resolution and highly accurate geoidal information is available. The error in the vertical gravity gradients is assessed using realistic geoidal error estimates.