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A new methodology for the computations of the mean gravity within the Earth's topography for precise orthometric height determination

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A new methodology for the computations of the mean gravity within the Earth's topography, needed for precise orthometric height determination has been developed and successfully tested. The method is realized according to the following steps:

1. Computation of gravity acceleration due to global and regional masses via ellipsoidal harmonic expansion to degree and order 360 plus the centrifugal acceleration.

2. Computation of gravity acceleration due to local masses via application of Newton integral in terms of the Cartesian coordinates of multi-cylindrical equal-area map projection of the reference ellipsoid.

3. Using the sum of the gravity accelerations derived at the steps 1 and 2 to compute the mean and standard deviation (STD) of gravity acceleration at the two points one at the surface of the Earth and the other one at the geoid, both along the plump line passing through the point of interest, where the orthometric height is to be computed.

4. Subdividing the distance along the plumb line between the two points of step 3 by adding a point in the middle of the plumb line and computing the mean and STD of gravity acceleration computed at these three points.

5. Continuing the subdivision of the distance along the plumb line by adding more points at the equality spaced distances until the standard deviation of the mean

value goes bellow the required limit. This limit is derived prior to the computations, by error propagation study with the goal of reaching to the required accuracy for the computed orthometric height.

6. The mean gravity value computed based on the steps 1-3 is the value that can be used for the calculation of an accurate orthometric height.

For the verification of the accuracy of the proposed method the gravity observation within the Earth at a borehole at the location $\lambda = 12.1194°$ and $\phi = 49.8164°$ is used. Based on the numerical computation at the selected borehole and comparisons with the observations following results has been obtained:

1. With proposed method the point gravity value within the Earth is computed with 10.768 mGal accuracy at the depth of 474.7 m, which was the deepest depth above the geoid at our test borehole.

2. The computed mean value of the gravity at he points where borehole gravity is measured differed from the mean of gravity observations with 5.56 mGal.

According to the error propagation analysis the accuracy of 5.56 mGal in the computations of mean gravity value can result in the accuracy of 2.78 mm in the computation of orthometric height, where in the same example the obtainable accuracy of the orthometric height computation based on the Helmert method is 5 times lower