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The Contribution of Data from Recent Satellite Missions to Local Geoid Modelling in Turkey

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Precise determination of the local geoid has a particular importance for height determination in applications using the Global Positioning System. In relatively small areas, a geometrical method of deriving geoid heights from GPS-derived ellipsoidal heights and levelling heights is often used. On the other hand, the geopotential model, gravity data and terrain corrections used in the gravimetric method of geoid determination make significant contributions to the accuracy of even local geoid models and should be seriously considered.

With the recent advances in space based data acquisition techniques, such as from the GRACE, CHAMP, ERS1&2, SRTM, and other missions, improved global geopotential models, gravity data over oceans and digital elevation models have been produced, from which significant accuracy improvements in local geoid models are expected. In this study, the local geoid models are computed in two different test areas in the west part of Turkey using the classical remove-restore approach, and the results are compared with both the Turkish regional geoid model TG99A and GPS/leveling-derived undulations. The first test area is between 40° and 42° North latitudes and 27° and 31° West longitudes, while the second test area is between 38° and 39° North latitudes and 26° and 29° West longitudes. In the computation of geoid models, gravity anomalies with 5'x5' spatial resolution on land and altimetry-derived gravity anomalies with 2'x2' resolution at sea were used. For the topographical effects, a digital terrain model from the Shuttle Radar Topography Mission (SRTM) with 3"x3" resolution was used. Several geopotential models were compared, and the combined gravity field model EIGEN-CG03C, which is based on CHAMP and GRACE missions data and also terrestrial surface data, was chosen for use in the geoid computations.

For the transformation of GPS heights to orthometric heights, a corrector surface was determined for the gravimetric geoid by an appropriate regression equation (second and third order polynomials). For this purpose, 561 GPS/levelling points in the first test area and 301 GPS/levelling points in the second area (including both modeling points and independent control points) were used, trying to maintain an as homogeneous as possible distribution of these points. In the data sets used, the accuracy of GPS-heights is 3.5 cm and of leveling heights is approximately 2 cm. The computed geoid model with corrector surface fitting provided approximately 7 cm improvement in absolute accuracy in comparison to TG99A in the first test area. Compared to the control GPS/leveling undulations, the absolute accuracies of the new geoid model in the first test area were 34 cm and 16 cm before and after fitting a third-order polynomial corrector surface, respectively; in the second area, they were 18 cm before and 11 cm after fitting a second order polynomial corrector surface. The relative accuracy of the model in the first area was 4.7 ppm for baselines of 37 km and 3.7 ppm for baselines of 102 km in length. In the second area, it was 2.0 ppm for baselines of 31 km and 1.4 ppm for baselines of 100 km in length.