Geophysical Research Abstracts
Vol. 13, EGU2011-9787, 2011
EGU General Assembly 2011

An investigation of the common adjustment between GPS, geoid and orthometric heights in a network of BMs in northern Greece with the recent GOCE-based GGMs and local geoid models

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With the successful launch of GOCE in March 17, 2009 and the release of its first couple of months of data, the first earth geopotential models based on ESA's mission have become available through IAG's ICGEM service. This, combined with the continuous release of new CHAMP- and GRACE-based satellite-only and combined GGMs allows their use, among other purposes, for the common adjustment of the so-called GPS/Leveling and GGM-derived geoid heights. The combined adjustment of GPS/Levelling observations on trigonometric and levelling benchmarks with gravimetric geoid heights has been the focus of extensive research both from the theoretical and practical point of view. Until recently, with few exceptions, the main blame for the inconsistencies/disagreement between these three types of heights has been put to the geoid heights due mainly to their lower accuracy and the large long-wavelength errors of the available at that time GGMs. With the advent of the new CHAMP-, GRACE- and GOCE-based global geopotential models and the realization of EGM2008 the achievable cumulative geoid accuracy has improved significantly, while shorter-wavelengths features of the Earth's gravity field are represented as well. As a result, modern day GGMs provide geoid heights whose differences to GPS/Levelling heights reaches the few cm level for baselines as short as 20-30 km. In Greece, GPS observations on BMs are very scarce and cover only small parts, in terms of spatial scale, of the country. A database was compiled recently and was based on GPS measurements performed during a four-year period on levelling BMs, so that reliable GPS/Levelling and gravimetric geoid height adjustment studies can be carried out. This resulted in most part of northern Greece to be covered with reliable observations within an area extending 6 degrees in longitude and 3 degrees in latitude, where common adjustments of the available geometric, orthometric and geoid heights are carried out using various parametric surfaces to model and interpret the detected differences. The parametric surfaces used are based on the well-know four- and five-parameter similarity transformation models as well as polynomial ones of various orders. The adjusted differences between the three types of heights are used to come to some conclusions on the accuracy of the various geoid models employed (both global geopotential and local gravimetric models), while an extensive outlook is paid to the varying behaviour of the orthometric heights. Moreover, the performance of the various parametric models is evaluated along with the stability of the solutions they provide. Absolute as well as relative differences are determined in order to investigate the accuracy offered by the GGMs, the improvement brought by GOCE data in modelling the long- and medium-wavelengths of the gravity-field spectrum and, finally, the accuracy that can be achieved when GPS/Levelling is utilized for the determination of orthometric heights. The latter is especially important for the Greek territory since the available benchmarks are delaminated in so-called "map-leaflets" and a common adjustment of the entire vertical network has not been carried out so far. It is concluded that even between neighbouring "map-leaflets" large biases in the adjusted GPS/Levelling and gravimetric geoid heights exist, which indicates distortions in the Greek vertical datum as this is realized by the levelling benchmarks.