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Rigorous Orthometric Heights: theoretical overview and advantages of use

Ismael Foroughi (1), Marcelo C. Santos (1), Yosra Afrasteh (2), Robert Kingdon (1), and Petr Vaníček (1)
(1) University of New Brunswick, Fredericton, Canada (msantos@unb.ca), (2) University of Tehran

The congruency of a height system can be assessed by measuring the norm of differences between geoid/quasigeoid heights, computed by gravimetric and topographic information, versus the differences between geodetic and orthometric/normal heights, derived from spirit levelling at GMSS control points. Usually L2 norm (STD) of the differences is considered to assess the congruency in which smaller the value of the L2, the better the congruency of a height system is. To assess a normal height system in this way, normal heights are provided at control points, where in assessing a classical height system, orthometric heights should be computed. Helmert approximation of the orthometric heights are the most commonly used heights in classical heights system as it simplifies the topographical mass density variation between the geoid and the Earth's surface. To best assess the congruency of a classical height system, rigorous orthometric heights must be computed at GNSS/levelling points. Despite time consuming process, this is nowadays a possible task by availability of the accurate topographical information through satellite missions and topographical lateral density variations from globally available lithospheric maps.
We use abovementioned freely available data to compute rigorous orthometric heights on the GNSS/levelling points of the Auvergne area and the country of Iran. The correction to Helmert orthometric heights in Auvergne area varies between -3.6 and 1.1 cm and in Iran between -28.1 and 0 cm. In both cases using rigorous orthometric heights show better congruency of the height system (smaller value of STD of differences between geoid heights and geodetic minus orthometric heights). Besides smaller STD, the rigorous orthometric heights provide the closest physical heights to reality. The effect of sea surface topography on the heights also can be computed more accurately when rigorous orthometric heights are available.