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Unified height systems after GOCE

Reiner Rummel (1), Thomas Gruber (1), Michael Sideris (2), Elena Rangelova (2), Phil Woodworth (3), Chris Hughes (3), Johannes Ihde (4), Gunter Liebsch (4), Axel Rülke (4), Christian Gerlach (5), and Roger Haagmans (6)

(1) Astronomical & Physical Geodesy, Technische Universität München, Germany (rummel@bv.tum.de), (2) Dept Geomatics Engineering, Univ of Calgary, Canada, (3) National Oceanography Centre, Liverpool, United Kingdom, (4) Bundesamt Kartographie Geodäsie, Frankfurt/M, Germany, (5) Kommission Erdmessung Glaziologie, BAdW, München, Germany, (6) ESA/ESTEC, Noordwijk, Netherlands

The objectives of global height unification are twofold, (1) the realization of accurate geopotential numbers C together with their standard deviation σ(C) at a selected set of stations (datum points of national height systems, geodetic fundamental stations (IERS), primary tide gauges (PSMSL) and primary reference clocks (IERS)) and (2) the determination of height off-sets between all existing regional/national height systems and one global height reference. In the future the primary method of height determination will be GPS-levelling with very stringent requirements concerning the consistency of the positioning and the gravity potential difference part. Consistency is required in terms of the applied standards (ITRF, zero tide system, geodetic reference system). Geopotential differences will be based on a next generation geopotential model combining GOCE and GRACE and a best possible collection of global terrestrial and altimetric gravity and topographic data. Ultimately, the envisaged accuracy of height unification is about 10 cm2/s2 (or 1cm). At the moment, in well surveyed regions, an accuracy of about 40 to 60 cm2/s2 (or 4 to 6cm) is attainable. Objective One can be realized by straight forward computation of geopotential numbers C, i.e. geopotential differences relative to an adopted height reference. No adjustment is required for this. Objective Two, the unification of existing height systems is achieved by employing a least-squares adjustment based on the GBVP-approach. In order to attain a non-singular solution, this requires for each included datum zone at least one geo-referenced station per zone, i.e. its ellipsoidal height h and, in addition, the corresponding physical height H (geopotential number, normal height, orthometric height, etc.). Changes in geopotential numbers of consecutive realizations reflect (1) temporal changes of station heights, (2) improvements or changes of the applied geopotential (or geoid) model and (3) improvements of the adopted standards and methodology.
This procedure will allow bringing all included stations into one and the same height datum. In sparsely surveyed regions of our planet the uncertainty of height off-sets may be at the level of 20 to 40cm (with extreme values up to 1m). In coastal regions, applying ocean levelling, these numbers may be improved. Ocean levelling is the combination of a “best” ocean topography model with either an altimetric mean sea surface or, at tide gauges, mean sea level as derived from a combination of tide gauge recording and GNSS positioning. The classical geoid definition and realization is operational at the level of a decimeter but poses significant theoretical and operational challenges at the sub-decimetre level.