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Vertical datum unification for the International Height Reference System (IHRS)

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The International Association of Geodesy released in July 2015 a resolution for the definition and realisation of an International Height Reference System (IHRS). According to this resolution, the IHRS coordinates are potential differences referring to the equipotential surface of the Earth's gravity field realised by the conventional value W0= 62 636 854.3 m2s-2. A main component of the IHRS realisation is the integration of the existing height systems into the global one; i.e. existing vertical coordinates should be refer to one and the same reference level realised by the conventional W0. This procedure is known as vertical datum unification and its main result are the vertical datum parameters, i.e. the potential differences between the local and the global reference levels. This contribution presents the observation equations for the vertical datum unification in terms of potential quantities based on the geodetic boundary value problem (GBVP) approach. Those observation equations are empirically evaluated for the vertical datum unification of the North American and South American height systems. In the first case, simulations performed in North America provide numerical estimates about the impact of omission errors and direct and indirect effects on the vertical datum parameters. In the second case, a combination of local geopotential numbers, ITRF coordinates, satellite altimetry observations, tide gauge registrations and high-resolution gravity field models is performed to estimate the level differences between the South American height systems and the global level W0. Results show that indirect effects vanish when a satellite-only gravity field model with a degree higher than n = 180 is used for the solution of the GBVP. However, the component derived from satellite-only global gravity models has to be refined with terrestrial gravity data to minimise the omission error and its effect on the vertical datum parameter estimation. The empirical evaluations demonstrate that the vertical datum unification should be based on geodetic stations of highest quality and standardised geodetic data; for example, geometric coordinates should refer to the same ITRF and be given in the same tide system and reference epoch like the geopotential numbers and gravity field model. After a standardisation of the input data used in the unification of the South American height systems and a rigorous error propagation analysis, we demonstrate that the vertical datum parameters can be estimated with accuracy better than $\pm$5 cm in well-surveyed regions and some decimetres ($\pm$ 40 cm) in sparsely surveyed regions. This contribution concludes with detailed guidelines for the appropriate data treatment when the integration of a local vertical datum into the IHRS is desired. These guidelines may be applicable in any region of the world.