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

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Vertical datum parameters

The International Association of Geodesy (IAG) 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 level surface of the Earth’s gravity field realised by the conventional value $W = 62,636,524.24$ m and a main component of the IHRS is the integration of the existing height systems into the global one; i.e., existing vertical coordinates should be referred to one and the same reference level realised by the conventional value $W$. 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 (Eq. 1):

$$ \Delta W_i = W_i - W_0 $$

Eq. [1]

Observation equations for the vertical datum unification

The estimation of the vertical datum parameters is based on the comparison of the height anomaly $\zeta$ (or geoid undulation $\delta$) obtained from the solution of the geodetic boundary value problem (GBVP) with the height anomaly $\zeta$ or geoid undulation $\delta$ derived from combining satellite-based ellipsoidal heights (a) with levelling based geopotential numbers (c) or physical heights (h) or t. For a general formulation, independent of normal or orthometric heights, the observation equations are given here in terms of potential quantities:

$$ L_i = -\delta W_i \zeta_i - C_i \zeta_i - \nabla W_i \cdot \nabla \delta_i + \Delta \delta_i = \delta_i - \zeta_i $$

Eq. [2]

To answer Q1, Table 1 summarises the omission error of the DIR5 model computed at tide gauges in North America. Although this error decreases when averaged over many points, it is significant for some central regions. In other words, the classical disturbing potential $\Delta T_i$ at individual datum regions should always be computed by combining a GGM with the available local gravity data and topography data.

Vertical datum unification in North America

The formulation of the observation equations [2] and [4] implies the availability of terrestrial geodetic anomalies, levelling-based geopotential numbers, ellipsoidal heights from GNSS on land and from satellite altimetric in oceans, and border levelling points with geodetic data referring to neighbouring vertical datums. According to the geodetic data available in South America, this study is based on:

- 14 observation equations of the type Eq. [2] in the marine areas nearby the reference tide gauges (Fig. 4a);
- 663 observation equations of the type Eq. [2] at the reference stations of the continental reference frame SIRGAS (Fig. 4b);
- 7 observation equations of the type Eq. [4];

connections between Ecuador and Colombia, Colombia and Venezuela, Venezuela and Brazil, and Brazil and Argentina (Fig. 4c).

Vertical datum unification in South America

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