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Improvement of Coastal Satellite Altimetry Data for Evaluating the Brazilian Geodetic Height System

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Abstract. Satellite altimetry is an important tool for the connection of geodetic vertical datums and their link to the future global height systems. It gives valuable information for a reliable realization of the concept of a global Geoid, but its results in coastal areas are still to be improved. First attempts to such kind of improvement at the Brazilian coast were performed at the Brazilian Vertical Datum at Imbituba, allowing the comparison of data coming from satellite altimetry and tide gauge observations. Now investigations continue on the connection of the reference levels from tide gauge and satellite altimetry data. This will help to evaluate the Brazilian Fundamental Vertical Network and its improvement by gravity and GPS integration.

Palavras-chave: Levelling, Gravity, Geopotential Number, Vertical Reference Frame, SIRGAS, Nivelamento, Gravidade, Números Geopotenciais, Estruturas Geodésicas de Referência Vertical.

1. Extended Abstract

Mean sea level (MSL) as a materialization of the Geoid was the traditional way for the definition of almost all the vertical datums of national geodetic networks around the world (Torge, 2001, p. 3). This procedure was also applied in the Brazilian Geodetic System (BGS), whose heights are referred to the Brazilian Vertical Datum at Imbituba (BVD-I), defined by the mean value of the annual MSL from 1949 to 1957 established with tide gauge observations at Imbituba Harbour, Santa Catarina State (Alencar, 1990).

Many problems arise from the implicit negligence of the so-called sea surface topography (SST), i.e., the deviation of the MSL from the Geoid. Even considering long periods of sea level observation, there are semi-permanent effects – depending on tide gauge location, prevailing winds, and even the type of equipment (Luz, 1996) – that still contaminate the resulting MSL. In some regions the vertical crust movements known as post glacial rebound (PGR), are responsible for strong apparent sea level rises. Finally, local disturbances of the

Earth's gravity field can also introduce bias in the vertical datum definition with sea level observations (Freitas et al., 2002b).

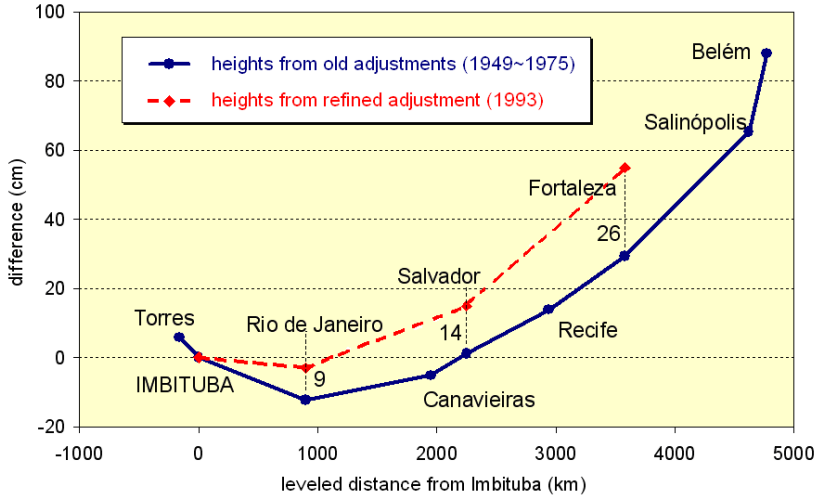
Considering all of these aspects, it is extremely difficult to compare heights from different national systems, whose implicit SST values can be very different. An impressive example is South America, where the national vertical datums were defined with sea level observations carried out on its Pacific, Atlantic and Caribean coasts and consequently show great divergences (Hernández et al., 2002; Sánchez, 2002; Freitas et al., 2002a). Presently the SIRGAS Project are undergoing efforts to unify the vertical systems of the continent (Drewes et al., 2002; Luz et al., 2002).

Satellite altimetry is one of the most important tools in this unification process, as it gives valuable information for a reliable realization of the concept of "Global Geoid" (Heck and Rummel, 1990; Heck, 2004). It revolutionized Physical Oceanography in the last few years, but its results in coastal areas are still to be improved (Bosch, 2002; Bosch et al., 2006). First attempts to such kind of improvement at the Brazilian coast were performed at the own BVD-I (Dalazoana, 2006), allowing the comparison of spectral characteristics of altimetric and tide gauge observations. These studies also included SST modeling Brazilian south coast allowing an ensemble of reliable information about its time evolution.

Now we are investigating the connection of the reference levels from tide gauge and satellite altimetry data, which will allow applying corrections for SST at some selected tide gauges along Brazilian coast. This will help to validate the studies on the "land part" of that unification process.

The first activities regarding the integration of BGS conventional data (levelling and gravity surveys, i.e., the "land part") toward its link to a future world height system must be the computation of high precision physical heights in more than 65000 benchmarks (Luz et al., 2006). In the past, the evaluation of internal errors of the Brazilian Fundamental Vertical Network (BFVN) was very difficult due to the absence of an independent, suitable tool for this purpose (Luz and Guimaräes, 2001; Luz and Guimaräes, 2003). The use of satellite altimetry for the homogenization of the tide gauge reference levels are going to be such a tool in a new promising context. **Figure 1** shows the differences between heights referred to BVD-I and local MSL along Brazilian coast – presently there are no reliable information on the contributions from BFVN's internal errors and from local SST at each tide gauge to these differences.

Figure 1 – Discrepancies between BVD-I and several local MSL along Brazilian coast



Source: Luz and Guimarães (2003), after Alencar (1990)

References

Alencar, J. C. M. Datum Altimétrico Brasileiro. **Cadernos de Geociências**, v. 5, p. 69-73, Rio de Janeiro: IBGE, 1990. Available in Portuguese at: <http://www.ibge.gov.br /home/geociencias/geodesia/default_artigos.shtm>. Accessed on: 14 nov. 2006.

Bosch, W. The Sea Surface Topography and its Impact to Global Height System Definition. **International Association of Geodesy Series**, v. 124 (Vertical Reference Systems), p. 225-230, Berlin: Springer, 2002.

Bosch, W.; Fenoglio-Marc, L.; Wöppelmann, G.; Marcos, M.; Novotny, K.; Savcenko, R.; Karpytchev, M.; Nicolle, A.; Becker, M; Liebsch, G. Coastal Sea Surface Topography – a Synthesis of Altimetry, Gravity, and Tide Gauges. **Aviso Newsletter**, n. 11, Toulouse: CNES, 2006, in press.

Dalazoana, R. **Estudos Dirigidos à Análise Temporal do Datum Vertical Brasileiro**. xiv+188 p. Tese (Doutorado em Ciências Geodésicas) – Curso de Pós-Graduação em Ciências Geodésicas, UFPR, Curitiba. 2006. Available in Portuguese at: <http://hdl.handle.net/1884/3922>. Accessed on: 14 nov. 2006.

Drewes, H.; Sánchez, L.; Blitzkow, D.; Freitas, S. Scientific Foundations of the SIRGAS Vertical Reference System. **International Association of Geodesy Series**, v. 124 (Vertical Reference Systems), p. 297-301, Berlin: Springer, 2002.

Freitas, S. R. C.; Medina, A. S.; Lima, S. R. S. Associated Problems to Link South American Vertical Networks and Possible Approaches to Face Them. **International Association of Geodesy Series**, v. 124 (Vertical Reference Systems), p. 318-323, Berlin: Springer, 2002a.

Freitas, S. R. C.; Schwab, S. H. S.; Marone, E.; Pires, A. O.; Dalazoana, R. Local Effects in the Brazilian Vertical Datum. **International Association of Geodesy Series**, v. 125 (Vistas for Geodesy in the New Millennium), p. 102-107, Berlin: Springer, 2002b.

Heck, B. Problems in the Definition of Vertical Reference Frames. **International Association of Geodesy Series**, v. 127 (Hotine-Marussi Mathematical Geodesy), p. 164-173, Berlin: Springer, 2004.

Heck, B.; Rummel, R. Strategies for solving the vertical datum problem using terrestrial and satellite geodetic data. **International Association of Geodesy Series**, v. 104 (Sea Surface Topography and the Geoid), p. 116-128, Berlin: Springer, 1990.

Hernández, J. N.; Blitzkow, D.; Luz, R.; Sánchez, L.; Sandoval, P.; Drewes, H. Connection of the Vertical Control Networks of Venezuela, Brazil and Colombia. **International Association of Geodesy Series**, v. 124 (Vertical Reference Systems), p. 324-327, Berlin: Springer, 2002.

Luz, R. T. **A Influência das Ondas de Alta e Média Freqüência na Observação do Nível do Mar para Aplicações Geodésicas**. xvii+168 p. Dissertação (Mestrado em Engenharia Oceânica) – Coordenação dos Programas de Pós-Graduação em Engenharia, UFRJ, Rio de Janeiro. 1996.

Luz, R. T.; Guimarães, V. M. Realidade e Perspectivas da Rede Altimétrica de Alta Precisão do Sistema Geodésico Brasileiro. In: Colóquio Brasileiro de Ciências Geodésicas (CBCG), 2., 2001, Curitiba. **Anais**... Curitiba: UFPR, 2001. CD-ROM. Available in Portuguese at: <http://www.ibge.gov.br /home/geociencias/geodesia/default_artigos.shtm>. Accessed on: 14 nov. 2006.

Luz, R. T.; Fortes, L. P. S.; Hoyer, M.; Drewes, H. The Vertical Reference Frame for the Americas – the SIRGAS 2000 GPS Campaign. **International Association of Geodesy Series**, v. 124 (Vertical Reference Systems), p. 302-305, Berlin: Springer, 2002.

Luz, R. T.; Guimarães, V. M. Dez Anos de Monitoramento do Nível do Mar no IBGE. In: Colóquio Brasileiro de Ciências Geodésicas (CBCG), 3., 2003, Curitiba. **Anais**... Curitiba: UFPR, 2003. CD-ROM. Available in Portuguese at: <http://www.ibge.gov.br /home/geociencias/geodesia/default_artigos.shtm>. Accessed on: 14 nov. 2006.

Luz, R. T.; Freitas, S. R. C.; Dalazoana, R.; Baez, J. C.; Palmeiro, A. S. Tests on Integrating Gravity and Leveling to Realize SIRGAS Vertical Reference System in Brazil. **International Association of Geodesy Series**, v. 130 (Dynamic Planet), Berlin: Springer, 2006, in press.

Sánchez, L. A Reference Surface for the Unified Height System in the Northern Part of South America. **International Association of Geodesy Series**, v. 125 (Vistas for Geodesy in the New Millennium), p. 84-89, Berlin: Springer, 2002.

Torge, W. **Geodesy**. 3rd edn. Berlin: Walter de Gruyter, 2001. 416 p.