DATA USE OF GNSS AND REFINED GGM FOR DETERMINING NORMAL HEIGHTS REFERRED TO THE IBVD AND IHRS

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1. Introduction

To obtain the normal height value referenced to any of the Brazilian Vertical Datum (BVD), at a given point in the Brazilian territory, it is possible to carry out levelling heights from a Level Reference (RN) station, and to interpolate of the real gravity value using Brazilian gravimetric network data. However, with the expressive technological development experienced in recent decades, new methods for obtaining altimetric data have gained projection. In this context researches have proposed the use of GNSS ellipsoidal heights in conjunction with data provided by Global Geopotential Model (GGM), which can be refined by Residual Terrain Modelling (RTM) technique using Digital Terrain Models (DTM) data, to obtain physical heights. For example, Forsberg and Tscherning (2008) and Hirt et al. (2010), Gerlach and Rummel (2012) and Montecino et al. (2013).

2. Objective

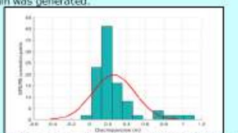
The research aimed to evaluate the use of GNSS ellipsoidal height in conjunction with height anomalies provided by a GGM, refined by RTM technique, for the determination of normal heights in Brazil, referred to the Imbituba Brazilian Vertical Datum (IBVD) and to the future IHRS. For the linkage, an adaptation of the method based on geopotential space indicated in Ihde et al. (2017) has been used. In the case of linkage at the IBVD, local estimated parameters and the one obtained by Sánchez and Sideris (2017) at national level have been analyzed. In the second case, the IHRS W_0 value has been used for the linkage.

3. Local modelling approach

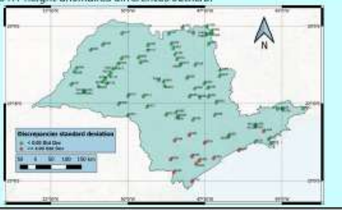
A local modelling approach has been analyzed in contrast to the national modeling approach based on the reference geopotential value obtained by Sánchez and Sideris (2017). This methodology is based on obtaining zero-level geopotential value of a Local Vertical Datum (DVL), and its difference in relation to the zero-level geopotential value of a global HRS. The proposed adaptation in this research is to use the value of directly to obtain the normal height already transformed. The linkage has been performed by adapting the methodology indicated in Ihde et al. (2017).

4. Spatial Clustering analysis

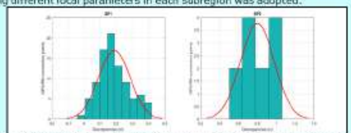
For the case of local modeling, after obtaining the discrepancies between the height anomalies BGS and GGM, calculated for the 102 GPS/RN connection stations in the study region limited by the state of São Paulo-Brazil, a histogram was generated.



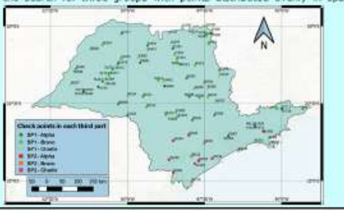
In the local modeling, two study subregions were defined using the spatial clustering analysis based on standard deviations of IBVD and GGM/DTM height anomalies differences outliers.



After ranking the points in each subregion, the normality of the associated datasets was verified. In both cases the datasets was normally distributed. The histograms of discrepancies between the height anomalies and in each subregion of study are presented. Through these results, the idea of estimating different local parameters in each subregion was adopted.



Regarding the question of evaluating the estimated parameters, a procedure of third parts was applied with the stations available in each subregion, alternately Alpha, Bravo and Charlie. The criterion used was the search for three groups with points distributed evenly in space and in discrepancies.



5. Analysis of the linkage results

In the case of local modeling, using the reference points defined for each third in each subregion, it was possible to determine the $\overline{W_0^{IBVD}}$ local transformation parameters. The calculated values are shown, as well as their respective standard deviations. For comparison purposes, the value of $\overline{W_0^{IBVD\_SS}}$ obtained by Sánchez and Sideris (2017) is also presented.

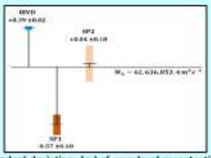
Parameter	Study subregion		Third part
	SP1	SP2	
$\overline{W_0^{IBVD}}$ m^2/s^2	62,636,858.992±0.972	62,636,852.970±1.702	Alpha
	62,636,859.024±0.955	62,636,852.981±1.737	Bravo
	62,636,859.041±0.958	62,636,853.109±1.929	Charlie
$\overline{W_0^{IBVD\_SS}}$	62,636,849.610±0,18		----

$\overline{W_0^{IBVD\_SS}}$ and $\overline{W_0^{IBVD}}$ local transformation parameters and standard deviations.

In their study, Sánchez and Sideris (2017) present offsets between the surface defined by the IHRS and by the South American reference data, including the IBVD. For comparison purposes, show adaptations of the Figure published by authors, with the inclusion of the subregions mean zero-level geopotential value of the thirds.

Vertical Datum	Offsets (m)	ΔW_0^i (m^2/s^2)	Potentials (m^2/s^2)
IBVD	0.387 ± 0.018	3.79 ± 0.18	62,636,849.61 ± 0.18
SP1	-0.574 ± 0.098	-5.62 ± 0.96	62,636,859.02 ± 0.96
SP2	0.039 ± 0.179	0.38 ± 1.75	62,636,853.02 ± 1.75

Offsets and difference of zero-level geopotentials.



Offsets and standard deviations (m) of zero-level geopotentials values from SP1 and SP2 to IHRS level.

In the parameters validation step, Root Mean Square Errors (RMSE) of the discrepancies $RMSE_{\Delta H^N}$ between transformed normal heights and Brazilian official normal heights have been calculated. In both subregions more accurate results have been obtained with the local modeling $\overline{RMSE_{\Delta H^N_{IBVD}}}$. In one of the subregions, the accuracy has increased tenfold.

Study subregion	Third part	$RMSE_{\Delta H^N_{IBVD}}$	$RMSE_{\Delta H^N_{IBVD}}$	$RMSE_{\Delta H^N_{SS}}$	$RMSE_{\Delta H^N_{SS}}$
SP1	Alpha	0.096	0.098	0.972	0.966
	Bravo	0.099		0.965	
	Charlie	0.098		0.962	
SP2	Alpha	0.188	0.172	0.405	0.388
	Bravo	0.182		0.400	
	Charlie	0.143		0.359	

$RMSE_{\Delta H^N}$ of discrepancies

6. Conclusion

With this research, the perspective is broadened of determining normal heights of points of interest in a study region in Brazil, with a fieldwork of only a GNSS survey of the point. This survey integrated with a post-processing, using the transformation parameter, allows obtaining the normal height of the point referred to IBVD and the future IHRS/SHRS.

7. References

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