Conducting an absolute gravity base tie in other to measure the reference gravity value at the Marine Gravity System-6 installed on the Hydro-Oceanographic Research Ship Vital de Oliveira (H39).

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Abstract

This paper presents a methodology that was used to do an absolute gravity base tie. For the purpose of measure the reference gravity value at the Microg Lacoste Marine Gravity Sistem-6 (MGS-6) installed in the Hydro-Oceanographic Research Ship Vital de Olivera (H39) dry laboratory. The main goal of the work is get reference gravity value to enter into the settings of Piperpro software. In other to calculate the gravity reference value, an absolute gravity station IGSN71 nº 40123 "A" was transferred from Museu de Astronomia e Ciências Afins (MAST) to the Diretoria de Hidrografia e Navegação (DHN) at Ponta da Armação lighthouse base station, so the absolute gravity value of lighthouse base station is 978789.689 milliGal. Then, it was realized another gravity transfer from the lighthouse base station to a dock station (P103), which it is the closest place at the pier to MGS6 gravimeter. The absolute gravity at the P103 station is 978789.032 milliGal. This absolute gravity base tie was made by CG5 Scintrex equipment borrowed from the Pool de Equipamentos Geofísicos do Brasil. Finally, the absolute gravity at the MGS6 location was calculated using the average raw gravity value from MGS6 data during the tie and the difference in height from the P103 dock station to MGS6 location on the ship. In a result, the gravity reference value is 977925.8171 milliGal.

Introduction

The Observatório Nacional (ON) is the oldest Brazilian Research Institute and it was founded in Rio de Janeiro, 1827. Furthermore, it has several research areas in Geophysics and one of these areas is Gravimetry. Also, it has been working and processing gravimetric data all over Brazil and it has been operating and maintaining the Brazilian Fundamental Gravimetric Network (RGFB) since 1978. The Brazilian Diretoria de Hidrografia e Navegação requested for ON to calculate the gravity reference value of the Marine Gravity Sistem-6 installed in the dry laboratory of the Hydro-Oceanographic Research Ship Vital de Oliveira in November 2016 due to gravimetric knowledge ON developed thought years. The MGS6 is made by Micro-g LaCoste and it is the last generation of relative Marine Gravity System, further it is used to geoid mapping, petroleum exploration, regional geophysics and mineral exploration. Before start collect gravity data, we need to set the reference gravity value from the place at ship is docked because this value is important to calculate the drift correction. In order to calculate this value a gravity transfer was done from IGSN71 station to the closest place at the dock station of the MSG6 gravimeter location and it was used CG5 relative gravimeter to do this work. Moreover, we have to calculate the difference in height from the dock point to MGS6 location on the ship and the average raw gravity value from MGS-6 data during the tie. Finally, the reference gravity of MGS6 relative gravimeter can be calculated.

Method

The methodology was used to calculate the reference gravity value to MGS6 gravimeter is divided in a few steps. In addition, it was sent by Microg Lacoste experts. The workflow is describe below:

- Find a suitable location at the ship's dock, as close as possible to the MGS6 location on the ship;
- Start recording data on the MGS6;
- Read the CG5 at the absolute base station, then travel to the dock station and read the CG5;
- Reaped the previous step five times;
- Finish with a final CG5 reading at the absolute base station;
- Stop recording data on the MGS6. Measure the difference in height (Δh) from the dock station to the MGS6 location on the ship. The difference in height should be measure during the slack water time;
- Calculate the average raw gravity value from MGS6 data during the tie;
- Calculate the average of the differences of the base station and dock station CG5 reading. So, calculate the absolute gravity value at the dock station as base station gravity value minus the average value of the difference;
- Calculate the absolute gravity at the MGS6 location as (absolute gravity at the dock station) – (Δh * Free Air constant)
- Finally, find the average value of the raw gravity logged on the MGS6 during the tie, and subtract from the absolute gravity at the MGS6 value to get the Gravity Reference to enter into the setting of PiperPor software.

Results

Transferring Gravity station

First, it was realized a gravity transfer from IGSN71 nº 40123 "A" absolute gravity station at Museu de Astronomia e Ciências Afins - São Critovão, RJ (22 53' 43.9" S/ 43 13' 23.6" W) to Diretoria de Hidrografia e Navegação lighthouse base station – Niteroi, RJ (22º 53' 04,39" S/ 43º 08' 01.91" W) – Figure 1 , it was used CG5 Scintrex Nº 343. So, we started measure the IGSN71 station then we measure the lighthouse base station (P100), after we remeasure the IGSN71 station. We did that routine measures once.

IGSN71 nº40123 "A"←1X→lighthouse base station (P100)

Figure 1 – DHN lighthouse base station (P100) – Niteroi, RJ.

The difference average values between base station IGSN71 nº 40123 and DHN lighthouse base station (P100) is **0.168 milliGal**.

CG5	Station	Date	Time	Reading	Interval
343	40123 "A"	08/07/2016	11:45	9156.050	0.173
343	P100	08/07/2016	12:47	9156.886	0.164
343	40123 "A"	08/07/2016	15:02	9157.053	0.167

Table1 – CG5 differential gravimeter read of IGSN71 nº 40123 "A" station and DHN lighthouse Station (P100) station.

Transferring Gravity Station to dock station

Then, it was realized a gravity transfer from DHN lighthouse base station (P100) to dock station (P103) – Figure 2, it was used the CG5 Scintrex Nº 343. The dock station station (22º 53' 4" S/ 43º 8' 8" W) is the closest point on the pier Almirante Paulo Irineu Roxo Freitas to the MGS6 gravimeter - Figure 3. So, we started measure the P100 then we measure the P103 station, after we remeasure the P100. We did that routine measures five times.

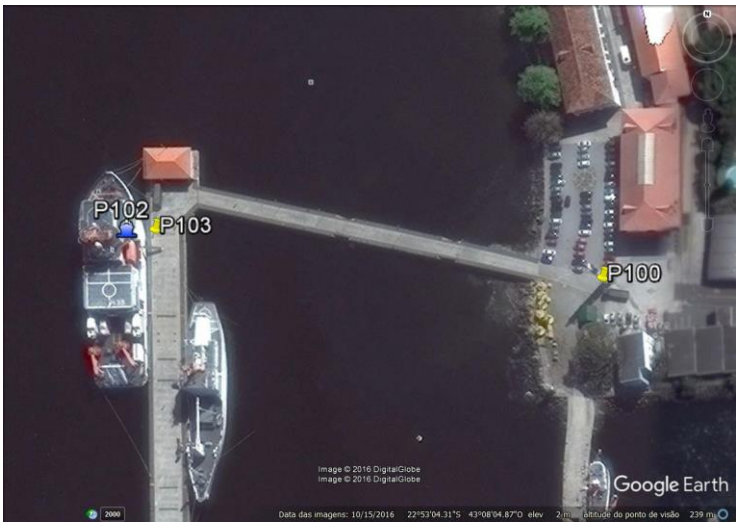

Figure 2 – P100 DHN lighthouse base station, P102 Vital the Oliveira ship and P103 dock station at Pier Almirante Paulo Irineu Roxo Freitas (Google Earth, 2017).

Figure 3 – P103 Dock station. Red square represents the MGS6 place inside the ship.

CG5	Station	Date	Time	Reading	Interval	Residual
344	P100	24/12/16	13:19	4910.390		
344	P103	24/12/16	13:27	4909.805	0.602	-0.044
344	P100	24/12/16	13:38	4910.403	0.672	-0.026
344	P103	24/12/16	13:47	4909.725	0.688	0.042
344	P100	24/12/16	13:54	4910.417	0.692	-0.045
344	P103	24/12/16	14:02	4909.792	0.638	-0.009
344	P100	24/12/16	14:10	4910.425	0.606	0.041
344	P103	24/12/16	14:20	4909.816	0.630	-0.016
344	P100	24/12/16	14:29	4910.455	0.660	-0.013
344	P103	24/12/16	14:39	4909.748	0.706	0.060
344	P100	24/12/16	14:47	4910.445	0.635	0.012

Table 2 – CG5 differential gravimeter read of DHN lighthouse Station (P100) station and dock station (P103).

The difference average between DHN lighthouse station (P100) and dock station (P103) is **0.653 milliGal**

Calculating the absolute gravity of dock station (P103)

G_{ABS} P100 = $G_{absoluto}$ IGSN71 40123 "A" – 0.168

G_{ABS} P100 = 978789,684 milliGal

G_{ABS} P103 = G_{ABS} P103 – 0.653

$G_{ABSOLUTE}$ P103 = 978789.032 milliGal

Station	Absolute Gravity	Difference Average
40123 "A"	978789.852	0.168
P100	978789.684	
P103	978789.032	0.653

Table 3 – The absolute gravity of the stations.

Calculating difference in height from the dock station to the MGS6 location on the ship

So, to calculate the difference in height from the dock station to the MGS6 location on the ship (Δh). We measured the height of the gravimeter up to the waterline (h) and the height difference between the tide level and dock station P103 (m). The constant 2,996 m is the draft height of the ship.

Δh = 2.996 – h – m

Δh = 2.996-2 - (-0.131)

Δh = 1.127m

Calculating the absolute gravity on MGS6 Location

Before we got the absolute gravity on MGS6 location, we have calculated the absolute gravity value of dock station (P103) and the difference in height of MGS6 gravimeter and the dock station.

G_{ABS} MGS-6= (G_{ABS} P103) – (Δh * Fator de Free Air)

G_{ABS} MGS-6= (G_{ABS} P103) – (Δh * 0.3086)

G_{ABS} MGS-6= (978789.032) - (1.127m * 0.3086)

$G_{ABSOLUTE}$ MGS-6 = 978788.9972 milliGal

Calculating the average raw gravity value from MGS6 during the tie

So, we calculated the average raw gravity value by dividing the sum of the MGS6 measures during the tie by their number and we got **-880,2208759 milliGal.**

Calculating the Reference Gravity value

Finally, the reference gravity value is absolute gravity of MGS-6 location minus the average raw gravity value.

G_{REF}MGS-6= ($G_{ABSOLUTE}$ MGS-6) – ($\bar{X}$ Raw Gravity)

G_{REF}MGS-6 = (978788.9972) – (-880.2208759)

$G_{REFERENCE}$ Gravity MGS-6 = 979669.2181 mGal

Conclusions

In a conclusion, the main goal of this paper was reached. It is possible to calculate the reference gravity of Marine Gravity System 6 with this methodology. So, the gravity value of MGS-6 at the Diretoria de Hidrografia e Navegação pier is 979669.2181 milliGal. The values of the transfer gravity value from DHN lighthouse station to dock station are accurate because the residual values are ± 0.05. In addition, we create an absolute base station at the east side of the DHN lighthouse, 978789.684 milliGal.

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