Determination of Mean Gravity Anomalies in the Taiwan Island

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ABSTRACT

In the present paper the fitting and proper regression coefficients have been made of 117 10'x10' blocks with observed gravity data and corresponding elevation in the Taiwan Island. To compare five different predicted models, and the proper one for the mean gravity anomalies were determined. The predicted gravity anomalies of the non-observed gravity blocks were decided when the coefficients obtained through the model with the weighted mean method. It was suggested that the mean gravity anomalies of 10'x10' blocks should be made when comprehensive the observed and predicted data.

1. INTRODUCTION

The purposes of the paper is to understand the relationship of gravity anomaliy with the topography and the area, doing further research, comparing the good and bad points from the most common used mean computing models. Analysising which model is more suitable for Taiwan Island and meatime computing the accuracy of mean gravity anomaly. This paper is mainly stressed on Taiwan area, surrounded by the longitude from 120° E to 122° E, the latitude from 21.5° N to 25.5° N.

2. COMPUTATION MODELS

There are five formulas of the mean gravity anomaly will be discussed [Uotila, 1967a&b ; Kassim, 1980; Sünkel, 1983]:

(1) $\overline{\Delta g} = a + b\bar{h}$, (1)

(2) $\overline{\Delta g} = 1/n\ \Sigma \Delta g_i$, (2)

(3) $\overline{\Delta g} = 1/n\ \Sigma\ [\Delta g_i - b\ (h_i - \bar{h})]$, (3)

(4) $\overline{\Delta g} = \Sigma\ (\Delta g_i / s_i^{3.5}) / \Sigma (1/s_i^{3.5})$, (4)

(5) $\overline{\Delta g} = \{\Sigma\ [(\Delta g_i - b h_i)/s_i^{3.5}] / \Sigma (1/s_i^{3.5})\} + b\bar{h}$, (5)

which $\overline{\Delta g}$ is the mean gravity anomaly of square block; Δg_i is the ith gravity anomaly in square block; $\bar{h}$ is the mean height of square block; h_i is the ith height in square block; a, b are the regression coefficients; s_i is the distance between number the ith point and the centre of the square block; 3.5 is the weighted exponent.

In these five computing models, the needed parameters as Δg_i, h_i, $\bar{h}$, s_i, a, b. And Δg_i, h_i are obtained from the observation values, s_i is the distance betwen the observation point and the centre point in block, $\bar{h}$ is obtained from digital terrain model. Therefore, the regression coefficients a, b are obtained from the first order of the stochastic functions of the gravity anomaly and height. In this paper, they come from two main resources: (1) using more than two points data in every individual block to calculate its a, b value in block, (2) using all observed gravity materials, setting different groups according to the height of topography then calculate the a, b value in three different topography in Taiwan area (Table 1).

Table 1. The three groups of regression coefficient value of heights

HEIGHT(m)	a (mGal)	b(mGal/m)
$h \leq 100$	- 1.8585	0.1091
$100 < h \leq 1000$	13.7330	0.0281
$h > 1000$	-63.8362	0.1195

Therefore, as long as using mean height in each block, the selected a, b coefficient can be determined. a, b are calculated with data from all over Taiwan, so the stability is very strong. When the height is between 100 metre and 1,000 metre, the value of b is regarding 0.0281 to 0.119, somewhate different in theory but it is due to the effect of topography and area.

3. THE RESULT AND ANALYSIS

Having 117 blocks in observed gravity data, it makes difficult to show them all. We picked 12 block results at random to discuss as a base line. We select different topography - plain, hill, mountain besides chosing each block in different location from the east to west and the south to the north. In keeping with comparing and analysing the effect from five different computing models, the results of above selected 12 blocks is showed in Table 2, and among the five numbered gravity are corresponding with the sequence of computing data.

As following, we point out and explain some results, we compared and analysed: (1) Clearly, the computed result from five models may be devided into three categories: $\overline{\Delta g}_1$ as a independent, $\overline{\Delta g}_2$, $\overline{\Delta g}_4$ as category, $\overline{\Delta g}_3$, $\overline{\Delta g}_5$ is another one. $\overline{\Delta g}_2$, $\overline{\Delta g}_4$ as deficit result of height and gravity anomaly which the relationship between them has not been considered. And $\overline{\Delta g}_3$, $\overline{\Delta g}_5$ as a group result from the effect of height was considered. Then why the result is differentin $\overline{\Delta g}_1$ with the effect of height? The reason in $\overline{\Delta g}_1 = a+b\bar{h}$ within, we set a as fixed value. In the contrary, by using a value for section area to compute $\overline{\Delta g}_1$, the result is unified in mathematical meaning and $\overline{\Delta g}_3$. (2) The different between the group ($\overline{\Delta g}_2$, $\overline{\Delta g}_4$) and $\overline{\Delta g}_3$ $\overline{\Delta g}_5$) is explained by location of height. The difference in these two depend on if there is affecting existance from height to gravity anomaly. Thus inter-relation may very well became greater by increasing the height. In the contrast, the deficit is greater comparing mountain with hill, the hill somewhate larger than the plain. Therefore the relationship between height and gravity anomaly have to be stressed on particularty the mountains areas. Providing standardizesd data in mean gravity anomaly in any topography, we must disregard height in predicted model. Then the group of $\overline{\Delta g}_3$ and $\overline{\Delta g}_4$ is abandoned. (3) Finally, in group $\overline{\Delta g}_3$ and $\overline{\Delta g}_5$, the reason, the deficit existed is if the locations of points can represent the mean position as a whole in any blocks. $\overline{\Delta g}_3$ is computed from any point position, $\overline{\Delta g}_5$ is using the position of the centre point in the block to compute mean value. The closer the points to the centre are, the closer result of $\overline{\Delta g}_3$ and $\overline{\Delta g}_5$ are. Again if the points in block are situated uniformly, the $\overline{\Delta g}_3$ value will be the most accurate. In $\overline{\Delta g}_5$, it is no way to prove if the mean gravity in centre position can represent mean value according to the result obtained from Table 2, there are a small discrepancy and $\overline{\Delta g}_3$ computing model is simpler and the more idealistic positions are, the more reasonable result are. Therefore, the present paper decided to use $\overline{\Delta g}_3$ as computing method for mean gravity anomaly model.

Table 2. The results of five computation models

NOS. OF BLOCK \ MEAN GRAVITY ANOMALY	$\overline{\Delta g}1$	$\overline{\Delta g}2$	$\overline{\Delta g}3$	$\overline{\Delta g}4$	$\overline{\Delta g}5$
179	-1.86	-31.30	-58.66	-31.3	-58.66
183	6.87	-25.36	-17.81	-24.67	-16.76
63	3.60	-14.39	- 9.79	-14.03	-9.43
260	3.60	2.69	- 4.55	13.04	4.77
165	36.78	50.64	69.65	38.83	58.17
185	24.97	-37.84	-29.51	-41.60	-34.08
53	29.19	65.98	77.14	66.6	77.23
250	28.49	9.76	20.25	17.89	25.56
177	95.10	39.10	166.73	34.68	159.05
162	121.39	-17.88	122.08	-17.88	122.08
113	68.81	19.47	96.11	18.12	95.41
237	82.55	38.59	122.84	36.02	117.97

4. THE ACCURACY OF THE MEAN GRAVITY ANOMALY

Because of being unable to observe the exact mean gravity anomaly in each block, we have no way to discuss the experimental accuracy of the block, we can use the law of propagation of errors to estimate the accuracy of the block. The present paper decided to use the mean gravity anomaly computing model, that

$$\overline{\Delta g} = 1/n \, \Sigma \, [\Delta g_i - b \, (h_i - \bar{h})] \, ,$$

we can predict mean gravity anomaly in block in Taiwan Island with observed data (Table 3).

Table 3 Categorlized by topography to determine the accuracy of the mean anomaly in the block

ACCURACY \ TOPOGRAPHY	PLAIN	HILL	MOUNTAIN
$\sigma \, \overline{\Delta g}$ (mGal)	4.8	3.5	16.1

5. CONCLUSION

Being the 2/3 of Taiwan Island is mountain, situated on earthquake zone, the gravity anomaly is greatly different by year. At present, Taiwan Island we have just completed the levelling stations to promote gravity observations. Along with doing dense in mountain area, we strongly believer we can obtain more accurate mean gravity anomaly in this area.

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