Observation of Tidal Variation of Gravity Made in Syowa Station, Antarctica†

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昭和基地における重力の潮汐変化の観測

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要　　旨

昭和基地における重力の潮汐変化の観測が，1968年6月18日07時から同年同月25日07時（UT）までの7日間にわたり，LaCoste 重力計 G-118を用いて，約1時間ごとの読みとりによって行なわれた．得られた資料は，最小自乗法によって解析せられ，1968年6月18日07時（UT）に対して，つぎのような結果が求められた．

	Gravimetric factor	phase lag
K_1分潮	1.376	−3°.73
O_1分潮	1.145	−3°.16

Abstract: Tidal variation of gravity was observed in Syowa Station, Antarctica, by means of LaCoste gravimeter G-118. It was carried out by visual reading at intervals of about one hour during a period of 7 days from June 18, 07h to June 25, 07h, 1968 (UT), the number of reading attaining to 169. The data obtained and the corresponding computed tides on a perfectly rigid earth were analyzed by the method of least squares and were compared with each other. It was then found that the tidal factor of gravity and phase lag are 1.376 and −3°.73 for K_1 constituent and 1. 145 and −3°.16 for O_1 constituent, respectively.

1. Introduction

A great many observations of earth tides are being made by means of various

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kinds of gravimeters, tiltmeters, extensometers and other instruments at many stations in the world especially since the International Geophysical Year 1957-1958. However, almost all of the observation stations in operation are situated in a zone bounded by latitudes of 10° to 60° in the northern hemisphere, and no report from the southern hemisphere has been known.

The present paper is a report of our attempts to determine the tidal factor of gravity and phase lag using the data obtained by means of a LaCoste gravimeter during a period of 7 days in Syowa Station, Antarctica.

2. Observation

A LaCoste and Romberg Model G Gravity Meter No. 118 was used in the present observation. The gravimeter was installed on a concrete block, its height above the bare rock being 60cm, in the corridor to a living room of Syowa Station. Location of the observation station is shown in Fig. 1. Latitude, longitude and height are 69°00'.3 S, 39°35'.4 E and 16.0 metres above mean sea level, respectively. The distance between the observation station and the nearest sea coast was about 165 metres.

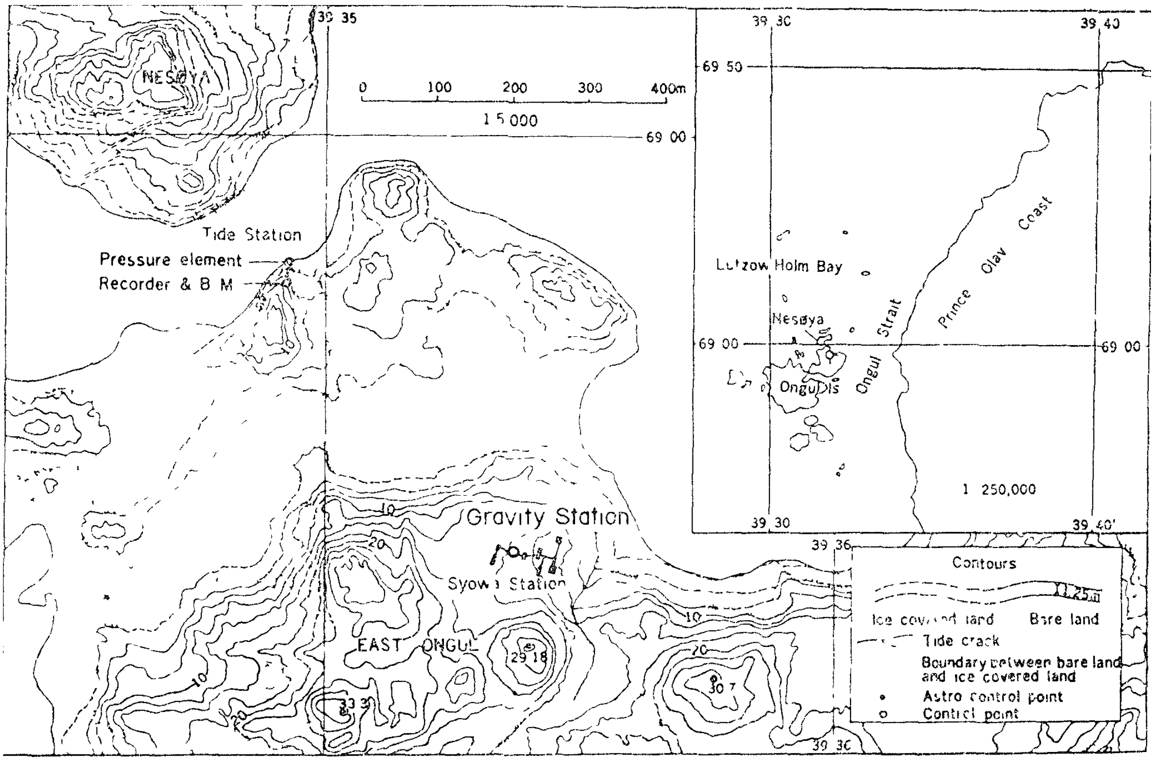

Fig. 1. Location of the observation station.

Visual reading of the gravimeter was carried out by three of the present authors (KAKINUMA, YANAI and ENDO) who stayed in Syowa Station for a year, at intervals of about one hour for a period of 7 days from June 18, 07ht o June 25, 07h, 1968 (UT) up to 0. 1 division of the gravimeter's dial scale, which corresponds to about 1 microgal in gravity change, and 169 reading value were obtained.

The observation was not carried out as an independent program but was made by the authors in their spare time while wintering in Syowa Station. This was the main reason why the observation period covered only 7 days.

3. Analysis and Its Results

A total of 169 reading values thus obtained were used in the succeeding analysis. As the drift is inevitably involved in the reading values, the drift of the gravimeter must be eliminated, first of all, from the reading values prior to harmonic analysis. In the present case, however, the drift of the gravimeter was almost linear for the whole period, so that only a linear ramp of the drift amounting to −9 microgals/day was eliminated from the reading values. The duration of the reading was too short for applying either the usual method of harmonic analysis or Fourier transform method. The least squares method was then employed in the present analysis.

Theoretically, amplitude of diurnal constituents is larger than that of semidiurnal ones in a region of high latitude. Therefore, the analysis was carried out for two cases. In the first analysis, four principal tidal constituents, M_2, S_2, K_1 and O_1, were assumed to be present to obtain tidal constants. In the second analysis, two principal diurnal constituents, K_1 and O_1, which have large amplitudes in a high latitude, were assumed to be present.

On the other hand, tidal variation of gravity based on a perfectly rigid earth has been theoretically computed with the same period and time interval as for the reading values, and the computed tides were then analyzed by the same method as for the reading values.

Tidal constants thus obtained are shown in Table 1 with mean square error. Tidal factor of gravity G and phase lag κ were calculated by comparing the tidal constants of the observed tides with those of the computed tides. The results are also shown in Table 1, where the positive sign of κ indicates that the observed tide lags behind the theoretically computed tide, while the negative sign shows that the former precedes the latter.

Table 1 Results of analysis on gravimetric tides.

Observation station : Syowa Station, Antarctica
Epoch of analysis : June 18, 07h, 1968 (UT)

Case 1 . Four tidal constituents, M_2, S_2, K_1 and O_1, were assumed to be present.

	Observed tides		Computd tides		G	κ (degree)
	Amplitude (μgal)	Phase (degree)	Amplitude (μgal)	Phase (degree)		
M_2	10.603	72 36	7.710	−103 38	1.375	175.74
S_2	1.566	− 33.59	2 853	51 60	0 549	−85 19
K_1	50.801	31.67	36 926	35.40	1.376	−3 73
O_1	21.497	−147.94	18 780	−144.78	1 145	−3 16
Er	0 915		0 122			

Case 2 Two tidal constituents, K_1 and O_1, were assumed to be present

	Observed tides		Computed tides		G	κ (degree)
	Amplitude (μgal)	Phase (degree)	Amplitude (μgal)	Phase (degree)		
K_1	51.486	30.95	36 345	36.04	1 417	−5 09
O_1	21.095	−148 86	18.991	−143.50	1 111	−5.36
Er	1.054		0.493			

4. Discussion and Conclusion

As described above, the analysis was made for two cases, assuming four tidal constituents, M_2, S_2, K_1 and O_1, in one case and two tidal constituents, K_1 and O_1, in the other case. Judging from Table 1, mean square error in the former is smaller than that in the latter. Consequently, values of tidal constants in the former are much reliable than those in the latter. It is noted that the results of the diurnal constituents are good but those of the semidiurnal ones are not good except the tidal factor of M_2 constituent.

Field temperature, atmospheric pressure and other meteorological elements were observed outside near the observation room. Tidal observation was also carried out by means of a tide gauge of pressure type on the coast about 500 metres northwest of the observation station. In the first graph of Fig. 2, the dots are the observed tides and the curve represents the predicted tides calculated using the tidal constants obtained by the least squares method. On the other hand, theoretically computed tides on a perfectly rigid earth are expressed by the second graph

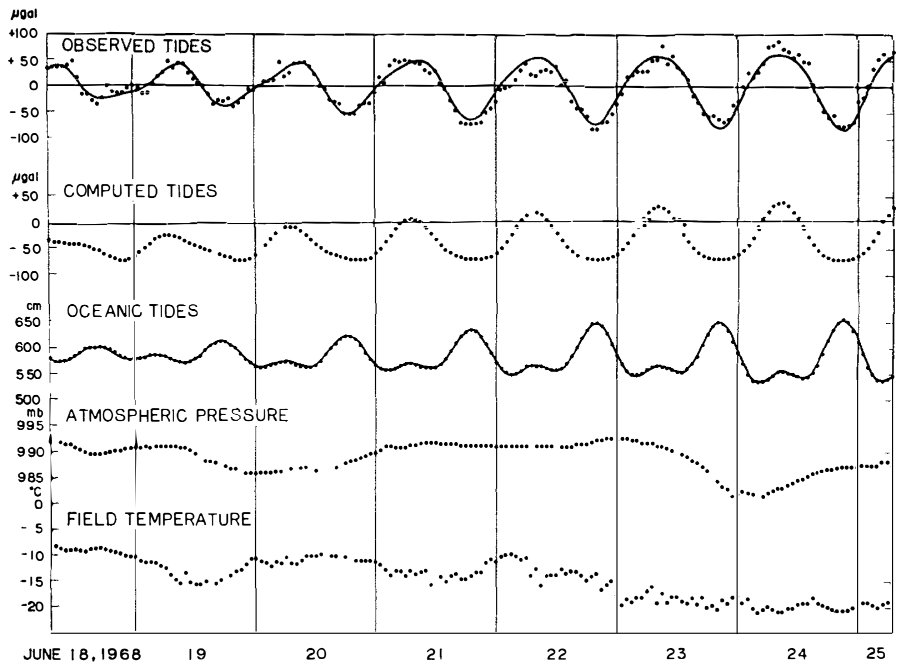

Fig 2. Observed tides : Values obtained by subtracting the linear term of drift from the reading values.
Computed tides : Theoretically computed tides based on a perfectly rigid earth.

of Fig. 2. In this figure, oceanic tides, atmospheric pressure and field temperature for the corresponding period are also shown as the third, fourth and fifth graphs, respectively.

As can be easily seen from Fig. 2, the observed tides are in good agreement with the computed tides, but the oceanic tides are certainly different. There exist clearly both diurnal and semidiurnal waves in the oceanic tides. High tide of the oceanic tides corresponds to gravity low. This indicates that the phase lag in both tidal variation of gravity and oceanic tides is very small, if present. Oceanic tides, field temperature and atmospheric pressure were then analyzed by the same method as for the observed tides, using the 169 hourly reading values. The results are shown in Table 2.

As mentioned before, either four or two principal tidal constituents were assumed to be present in determination of tidal constants. However, as the data used in the present analysis covered only 7 days, the number of data was too small to get reliable values of their amplitude and phase. Consequently, the values of tidal factor of gravity and phase lag obtained in the present analysis may not be reliable. In order to get more reliable values, it is requisite that continuous observations covering a longer period, at least one year, are made simultaneously at several

Table 2 Results of analysis on disturbing factors

Epoch of analysis June 18, 07h, 1968 (UT)

Oceanic tides

	Case 1		Case 2	
	Amplitude (cm)	Phase (degree)	Amplitude (cm)	Phase (degree)
M_2	19 716	−108 84		
S_2	9.462	78 86		
K_1	25.492	−144 77	26.978	−146 65
O_1	21.866	37.13	21.603	34 20

Atmospheric pressure

	Case 1		Case 2	
	Amplitude (mb)	Phase (degree)	Amplitude (mb)	Phase (degree)
M_2	0 249	91 09		
S_2	0 187	10 57		
K_1	0 292	−49 89	0 307	−47 10
O_1	0 564	−20.43	0 566	−19.57

Field temperature

	Case 1		Case 2	
	Amplitude (°C)	Phase (degree)	Amplitude (°C)	Phase (degree)
M_2	0 226	56 66		
S_2	0 149	− 94 86		
K_1	0 395	−142 95	0 382	−141 47
O_1	0.375	−133.17	0 372	−134.92

stations by means of different kinds of gravimeters with automatic recording apparatus.

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