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Investigations of the extreme temperatures of the ground surface in the Gåshamnöyra region (Spitsbergen)

ABSTRACT: In the summer of 1979, in South Spitsbergen investigations of the extreme temperatures of the ground surface were carried out. The investigations permitted the determination of the magnitude of the extreme temperatures of the ground surface and their relation to the air temperature. The spatial variability of the extreme temperatures of the ground surface was observed.

Key words: Arctic, Spitsbergen, ground surface temperature

1. Introduction

In the summer of 1979, the scientific expedition of the Silesian University worked in South Spitsbergen, in the area adjacent to Gås Bay (Kamiński 1980a). It carried out a wide programme of geographic research, whose preliminary results were given by: Kamiński (1980b, 1982), Wach (1980), Jania et al. (1981), Szczypek (1980, 1981, 1982). The elements of the research included measurements of the maximum and minimum temperatures of the ground surface.

Temperature is commonly recognized as a major element of climate. It determines, among other things, the course of physical erosion, and particularly those processes which occur either as a result of variable heating of rocks or as a result of their variable cooling. In both cases the causes are temperature variations related to the difference between the solar radiation reaching the ground and the energy radiation by the latter, but in the former case the main role is played by 24-hour temperature amplitudes, in the latter — temperature variations about 0°C. Because of this, it seems essential to know the 24-hour behaviour of the extreme temperatures of the ground surface in the Arctic region, where 24-hour amplitudes, although smaller compared to other climate zones, can affect significantly the erosion process.

Polish scientific publications include a few papers on the thermics of ground in the Arctic region (Jahn 1948, Baranowski 1960, 1963, 1968, Czeppe 1960). However, there is no elaboration devoted to the thermal conditions of the ground surface. This problem was partly discussed by Baranowski (1960), and some information about the phenomenon was given by Schöne and Wiedrich (1966). Investigations in this field were also carried out by Leszkiewicz (1977), who studied the extreme temperatures of the ground surface in the Kaffiöyra region. General remarks about the extreme temperatures of the ground surface in the region of interest were given by Kamiński (1984). This problem was also considered by Ptaszny (unpublished paper).

The purpose of the paper is to establish the magnitude of the amplitude of the extreme temperatures of the ground surface in the area under study and to find the relation between the extreme temperatures of the ground surface and the corresponding air temperatures.

2. Area, material, methods

The area investigated was the region of the forefield of Gås Glacier (Gåshamnöyra), South Spitsbergen. The localisation of the meteorological station, measurement points and the geophysical conditions of the study points were described by Kamiński (1979, 1980b). The basic features of the climate of the area investigated were given by Troitskij at al. (1975).

The investigations were carried out from July 15 to September 5, 1979. The measurement points were localised close to the meteorological station of the expedition in various parts of the tundra. Fig. 1 shows the positions of the points. The measurement point no. 1 was situated in the outwash, close to a storm bank, at a distance of about 90 m from the sea shore, at a height of 2.7 above the sea level, in a nearly flat terrain, slightly inclined to the west and bereft of vegetation. The point no. 2 was localised on an old sea terrace, remodelled by soliflux processes, a terrain inclined to the southwest at an angle of 20°, at an altitude of 13.5 m above the sea level, in a waterlogged area of dark colour, overgrown by mosses and saxifrages. The ground surface was formed from detritus mixed with clay. The point no. 5 was inside a stone ring with 5 m external diameter and 2.8 external one, situated on a sea terrace modelled by frost processes. The interior of the ring was filled by fine-grain material mixed with clay, of a yellow colour. The terrain was inclined to the west, with an altitude of 20 m above the sea level.

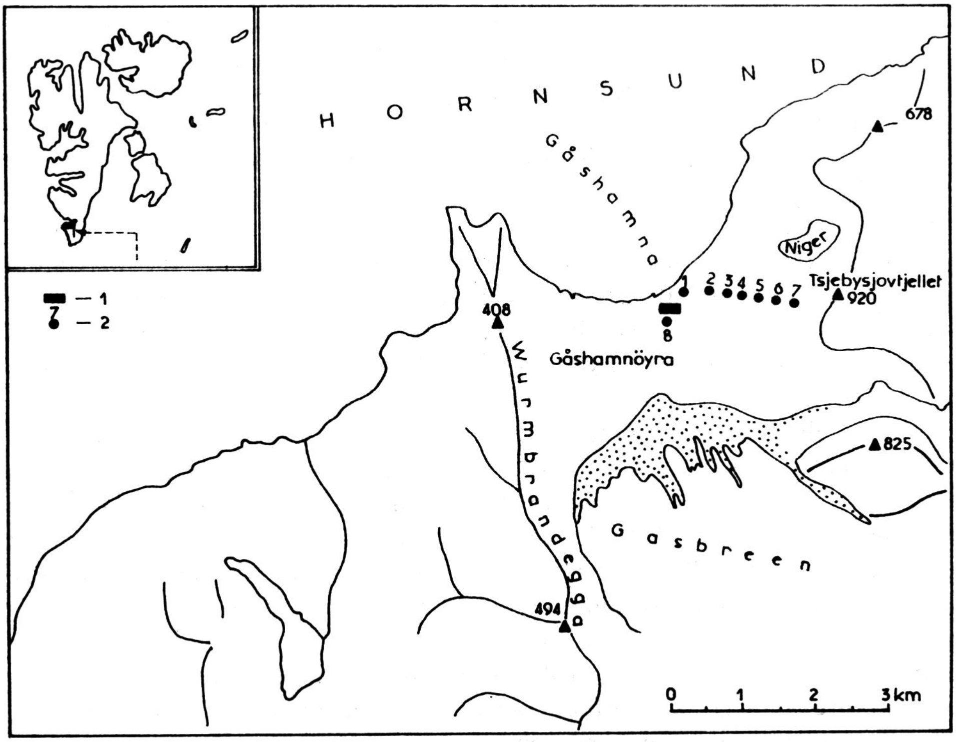

Fig. 1. Schematic diagram of the arrangement of the measurement points in the area studied 1 — meteorological station, 2 — points of measurements of the extreme temperature of the ground surface

The point no. 4 was also situated inside a stone ring of size similar to the point no. 3. The interior of the ring was filled by fine-grain material with a considerable addition of coarse material, with the colour of the material being light and at an altitude of 31 m above the sea level. The point no. 5 was localised on a scree cone built of rock detritus with pieces up to 10 cm in diameter. The deteritus contained dolomites and limestones from the slopes of Tsjebysjovfiellet. The terrain was dry, bereft of vegetation, inclined to the west at an angle of 10° and at an altitude of 47 m over the sea level. The point no. 6 was situated on the slope of Tsjebysjovfiellet, at an altitude of 73 m above the sea level. The ground surface was formed of eroded dark slates. It was dry and without vegetation. The point no. 7 was situated at an altitude of 101 m above the sea level up the slope of Tsjebysjovfiellet. The ground surface was formed from phyllites of dark green colour. The permafrost occurred at low depth, of 70 cm, in the base. In the other points, permafrost occurred at depths below 1 m. The point no. 8 was in the meteorological garden ($\lambda = 15°54'08''$, $\varphi = 76°56'06''$), (H = 4 m over the sea level) on a flat sea terrace sparsely overgrown with mosses and saxifrages. The ground surface was formed from gravels of grey colour. At a distance of 10 m from the measurement point there is a river. Permafrost lay in the period of the investigations at depths between 220 and 160 cm. A detailed description of the measurement posts was given by Ptaszny (unpublished).

At all the points mentioned, everyday measurements of the maximum and minimum temperatures of the ground surface were carried out. The temperature was measured by maximum and minimum meteorological thermometers placed on the ground surface. The containers of the thermometers were covered by a 0.5 cm ground layer. After the readout and cancellation of the results, the thermometers were laid again at the same place. The temperature was read out once every 24 hours, between 13 and 14 hours GMT, always in the same succession beginning from point 8 and then in order from points 1 to 7. The readout time was so selected that it occurred after the 24-hour minimum and maximum temperatures. The investigations showed (Kamiński, 1984) that the 24-hour air temperature minimum occurred in the area under study at 2 — 3 GMT, whereas the maximum came at 12 hours GMT. It is known in turn that the minimum temperature of the ground surface coincides with the minimum air temperature, whereas the maximum ground temperature precedes by 1 — 2 hours the maximum air temperature.

The maximum and minimum 24-hour results obtained served in calculating the 24-hour amplitude of the temperature of the ground surface. The maximum and minimum temperatures and the amplitude of the extreme temperatures measured at particular points served to obtain a thermal characteristic of the ground surface. In order to grasp some regularities, simple characteristics were calculated in the form of the pentad means of particular elements. Comparisons were also made between the extreme air temperatures and the corresponding temperatures of the ground surface, for the post no. 8 (the meteorological station) correlation coefficients and regressions equations were calculated, illustrating the relationship between the extreme air temperature and the mean 24-hour air temperature and the maximum and minimum temperatures of the ground surface. Comparisons were made with the ground temperature at a depth of 5 cm.

3. Results of investigations

The temperature characteristic of the investigation period. It was found that in the investigation period the mean 24-hour air temperature varied between 0.0°C on 3.09 to 9.1°C on 15.08, the highest air temperature was 17.0°C, whereas the minimum one was −4.5°C. In the investigation period, the amplitude of the extreme air temperatures was 21.5°C (Table I). A detailed meteorological characteristic of the investigation period was given by Kamiński (1982, 1984).

The time distribution of the temperature of the ground surface. It was found that in the investigation period the highest values of the maximum temperature of the ground surface occurred between 16 and 20 July, i.e. in the beginning of the investigation period, when the greatest solar energy radiation reaches the ground surface. From the fifth pentad on, the maximum temperature of the ground surface decreases; however, considerable temperature variations occur (Table II). The mean pentad

Table I

24-hour values of the maximum temperature (Max) and the minimum one (Min), amplitude of the extreme air temperatures (A), mean 24-hour air temperature (t) and mean 24-hour ground temperature at a depth of 5 cm (t_5).
Spitsbergen — Gåshamnöyra 1979

Date	Air temperature				t_5°C
	Max.	Min.	A.	$\bar{t}$	
15 VII	9.0	3.7	5.3	6.2	12.3
16	11.2	5.2	6.0	6.5	13.6
17	9.9	5.2	4.7	7.1	14.1
18	9.1	5.2	3.9	7.4	11.9
19	12.4	5.4	7.0	8.4	14.1
20	10.9	4.5	6.4	8.8	12.3
21	9.0	3.1	5.9	6.3	11.0
22	6.6	1.9	4.7	4.3	9.8
23	6.1	1.0	5.1	2.9	9.9
24	9.5	3.0	6.5	5.3	9.4
25	10.2	1.7	8.5	6.3	10.2
26	8.3	4.9	3.4	6.2	9.6
27	7.8	3.1	4.7	4.5	8.4
28	5.6	2.5	3.1	4.2	7.6
29	4.5	2.0	2.5	3.0	7.0
30	5.8	1.5	4.3	3.5	7.0
31	4.4	0.5	3.9	2.0	5.1
1 VIII	3.8	0.5	3.3	1.6	4.8
2	8.1	0.6	7.5	2.0	5.1
3	3.2	0.9	2.3	2.2	5.5
4	4.6	2.4	2.2	3.1	5.4
5	6.5	4.0	2.5	5.2	6.0
6	6.5	3.5	3.0	4.7	6.5
7	6.3	3.2	3.1	5.1	6.5
8	3.5	0.5	3.0	2.8	6.4
9	4.6	2.4	2.2	3.4	5.1

10	6.4	2.0	4.4	4.0	6.0
11	6.5	1.6	4.9	3.7	5.4
12	5.9	2.0	3.9	3.8	6.1
13	7.0	−0.4	7.4	2.0	6.7
14	6.1	2.9	3.2	5.1	5.8
15	17.0	2.7	14.3	9.1	7.8
16	9.5	3.5	6.0	6.7	7.2
17	7.9	2.2	5.7	5.5	6.4
18	6.6	2.1	4.5	4.3	5.7
19	7.3	2.9	4.4	5.1	5.5
20	5.6	1.1	4.5	3.4	5.8
21	4.4	0.9	3.5	2.7	4.4
22	7.6	−4.5	12.1	3.0	3.8
23	6.8	1.1	5.7	4.4	4.5
24	4.9	1.4	3.5	3.8	3.1
25	5.6	0.0	5.6	3.2	4.6
26	2.1	−0.8	2.9	0.7	3.4
27	2.6	1.0	1.6	0.8	4.1
28	5.8	0.5	5.3	1.4	4.1
29	4.9	0.0	4.9	0.6	2.2
30	4.2	−0.1	4.3	0.4	0.8
31	1.5	0.0	1.5	0.6	0.4
1 IX	2.8	−0.1	2.9	0.7	0.6
2	2.4	−0.6	3.0	1.0	1.6
3	1.5	−0.6	2.1	0.0	1.3
4	1.2	−1.5	2.7	0.4	1.4
5	2.8	0.2	2.6	1.2	1.6

values of the maximum temperature are shown in Table III. The time distribution of the minimum temperature of the ground surface looks similar, its highest values were found in the fourth pentad of July, the lowest in the first pentad of September (Table III). The highest amplitude of the extreme temperatures of the ground surface was found at all the measurement posts in the same pentad and as a rule on the same day when there occurred the highest maximum temperature of the ground surface. The magnitude of the amplitude of the extreme temperatures of the ground surface was considerable, at the post no. 8 it varied between 1.5 — 19.4°C (Table II).

The spatial variability of the extreme temperature of the ground surface. Comparison of the extreme temperature of the ground surface, measured at the particular measurement points, shown some differentiation among them within the area under study. The highest mean maximum temperature was in the period of the investigations found for the ground surface at post 1, the lowest mean minimum one occurred at the ground surface at post 5, where also the highest mean amplitude of the extreme tem-

Table II

Maximum (Max.) and minimum (Min.) temperatures of the ground surface and amplitude (A) of the extreme temperatures °C. Spitsbergen — Gåshamnöyra 1979

Post no.	1			2			3			4			5			6			7			8		
Date	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.	Max.	Min.	A.
15 VII	24.2	6.2	18.0	17.6	6.0	11.6	17.9	5.0	12.9	20.0	4.0	16.0	19.5	5.0	14.5	17.0	4.5	12.5	23.7	5.0	18.7	23.4	6.4	17.0
16	27.4	8.3	19.1	18.5	8.0	10.5	19.4	6.7	12.7	22.2	6.4	15.8	17.2	6.3	10.9	23.4	6.6	16.8	25.7	7.0	18.7	25.9	8.3	17.6
17	25.0	8.0	17.0	18.4	6.2	12.2	19.1	5.2	13.9	23.6	4.1	19.5	21.9	4.0	17.9	26.9	4.9	22.0	25.1	5.4	19.7	26.0	7.8	18.2
18	26.5	8.3	18.2	17.8	6.5	11.3	19.5	5.2	14.3	24.6	5.6	19.0	19.9	4.9	15.0	25.9	5.6	20.3	29.6	6.4	23.2	21.0	7.6	13.4
19	29.2	8.0	21.2	18.8	7.4	11.4	19.0	6.1	12.9	25.6	6.0	19.6	20.0	5.0	15.0	24.6	5.8	18.8	24.0	6.3	17.7	26.8	7.4	19.4
20	24.4	10.5	13.9	17.6	8.9	8.7	18.4	7.5	10.9	22.4	8.6	13.8	22.0	8.0	14.0	23.1	8.6	14.5	25.7	8.9	16.8	15.3	10.1	5.2
21	21.1	6.9	14.2	14.8	5.3	9.5	13.9	3.5	10.4	17.5	5.7	11.8	23.5	4.5	19.0	22.2	4.2	18.0	16.8	5.2	11.6	19.2	7.0	12.2
22	22.4	3.1	19.3	14.8	2.6	12.2	14.9	1.3	13.6	16.6	0.8	15.8	21.1	0.3	20.8	20.3	1.2	19.1	19.8	1.1	18.7	21.5	3.8	17.7
23	22.3	3.9	18.4	15.2	3.4	11.8	15.6	2.0	13.6	13.7	0.9	12.8	20.6	0.7	19.9	20.4	1.1	19.3	25.4	2.4	23.0	20.6	3.9	16.7
24	20.6	4.4	16.2	14.2	4.5	9.7	13.6	3.4	10.2	16.4	3.1	13.3	18.0	2.5	15.5	19.8	4.1	15.7	22.0	4.8	17.2	18.0	5.1	12.9
25	21.5	6.4	15.1	15.2	5.2	10.0	14.9	3.9	11.0	15.1	4.7	10.4	21.4	3.0	18.4	22.7	3.8	18.9	23.2	4.5	18.7	22.6	6.8	15.8
26	21.6	5.6	16.0	15.1	5.1	10.0	14.9	3.8	11.1	13.1	4.9	8.2	19.4	3.1	16.3	22.7	3.9	18.8	22.9	4.6	18.3	17.4	6.4	11.0
27	11.9	5.3	6.6	11.6	4.8	6.8	11.5	3.7	7.8	13.6	4.8	8.8	11.5	4.8	6.7	11.7	3.5	8.2	11.7	4.0	7.7	13.2	5.4	7.8
28	14.0	5.1	8.9	13.4	4.6	8.8	13.0	3.2	9.8	16.5	4.4	12.1	13.5	2.7	10.8	17.1	3.4	13.7	9.5	3.8	5.7	13.2	5.6	7.6
29	10.4	4.4	6.0	8.6	3.5	5.1	8.5	2.3	6.2	9.9	3.4	6.5	9.2	2.0	7.2	10.0	2.4	7.6	8.4	2.7	5.7	10.5	5.0	5.5
30	18.9	3.2	15.7	14.5	3.5	11.0	14.5	2.4	12.1	18.0	3.0	15.0	15.0	0.9	14.1	15.9	2.0	13.9	14.4	2.5	11.9	21.0	3.9	17.1
31	13.0	3.1	9.9	10.8	3.1	7.7	11.4	2.0	9.4	12.0	2.0	10.0	15.8	0.9	14.9	16.6	1.2	15.4	14.5	2.0	12.5	14.2	3.4	10.8
1 VIII	12.8	0.1	12.7	11.4	0.4	11.0	12.0	−1.0	13.0	14.8	0.2	14.6	13.8	−1.8	15.6	14.0	−1.4	15.4	14.2	−0.9	15.1	12.2	0.1	12.1
2	12.6	1.6	11.0	10.4	2.0	8.4	10.5	0.1	10.4	13.6	1.4	12.2	12.0	−0.1	12.1	11.9	0.0	11.9	11.7	0.9	10.8	10.5	2.5	8.0
3	13.1	1.4	11.7	10.3	0.1	10.2	10.7	−0.5	11.2	10.1	1.0	9.1	10.6	−0.2	10.8	9.2	0.0	9.2	7.5	0.6	6.9	13.3	2.2	11.1
4	14.0	3.5	10.5	11.0	3.0	8.0	11.7	1.5	10.2	17.1	2.6	14.5	15.9	1.3	14.6	19.2	1.6	17.6	15.7	2.9	12.8	8.3	3.4	4.9
5	13.4	4.5	8.9	10.1	4.2	5.9	11.0	2.9	8.1	14.5	4.2	10.3	12.7	2.4	10.3	11.5	2.9	8.6	8.0	3.6	4.4	9.0	3.9	5.1
6	15.5	4.1	11.4	11.5	4.0	7.5	12.6	2.5	10.1	14.6	3.5	11.1	13.2	1.7	11.5	14.4	2.1	12.3	12.9	2.8	10.1	14.7	3.8	10.9
7	13.4	3.2	10.2	11.3	3.1	8.2	11.1	1.6	9.5	13.6	3.6	10.0	12.0	1.0	11.0	11.6	1.3	10.3	11.0	2.8	8.2	12.6	3.0	9.6
8	14.1	3.8	10.3	11.6	3.7	7.9	12.5	2.2	10.3	17.1	3.0	14.0	18.9	1.5	17.4	21.1	2.1	19.0	17.6	2.9	14.7	14.0	2.1	11.9
9	12.1	4.3	7.8	10.5	3.7	6.8	11.2	2.1	9.1	12.2	3.4	8.8	12.5	1.6	10.9	12.0	2.3	9.7	11.4	3.0	8.4	6.2	3.7	2.5
10	14.0	2.2	11.8	12.4	2.5	9.9	12.5	0.9	11.6	12.1	1.6	10.5	17.4	0.0	17.4	19.5	0.9	18.6	18.5	1.9	16.6	14.5	2.0	12.5
11	14.7	1.5	13.2	12.0	1.6	10.4	12.6	0.0	12.6	18.0	0.2	17.8	17.0	−0.8	17.8	16.8	0.5	16.3	16.4	1.7	14.7	14.5	1.7	12.8
12	14.5	4.2	10.3	11.6	4.2	7.4	12.0	2.6	9.4	9.9	4.0	5.9	16.0	2.4	13.6	17.0	3.4	13.6	15.1	4.4	10.7	9.5	4.0	5.5
13	13.2	3.0	10.2	11.9	3.5	8.4	12.2	1.9	10.3	15.2	2.2	13.0	19.2	0.6	18.6	16.4	1.6	14.8	16.2	2.2	14.0	17.6	3.9	13.7
14	12.8	3.6	9.2	11.4	4.1	7.3	12.0	2.2	9.8	13.1	3.0	10.1	17.0	1.9	15.1	16.6	4.4	12.2	16.2	5.5	10.7	9.8	4.4	5.4
15	17.7	2.4	15.3	15.0	2.5	12.5	14.9	2.1	12.8	18.9	2.1	16.8	16.4	0.6	15.8	16.8	1.4	15.4	13.5	2.5	11.0	20.5	2.3	18.2
16	16.6	2.0	14.6	14.0	6.6	7.4	14.3	5.2	9.1	19.7	6.6	13.1	18.3	4.8	13.5	18.6	6.0	12.6	17.0	7.4	9.6	11.0	6.5	4.5
17	9.1	4.6	4.5	9.0	4.9	4.1	8.7	3.4	5.3	9.2	4.7	4.5	8.9	3.0	5.9	9.5	3.7	5.8	8.3	5.3	3.0	12.3	4.7	7.6
18	9.3	4.5	4.8	9.2	4.9	4.3	9.0	3.4	5.6	10.7	4.5	6.2	9.4	3.5	5.9	10.0	4.2	5.8	9.2	5.4	3.8	10.6	4.5	6.1
19	10.5	4.0	6.5	10.1	4.2	5.9	9.2	2.9	6.3	8.8	4.0	4.8	9.2	2.5	6.7	9.5	3.0	6.5	10.0	4.4	5.6	14.4	4.2	10.2
20	13.5	3.2	10.3	10.8	3.8	7.0	10.8	1.9	8.9	13.2	3.1	10.1	14.2	1.1	13.1	14.4	1.9	12.5	15.6	2.8	12.8	15.6	3.9	11.7
21	12.0	0.4	11.6	10.0	0.6	9.4	9.9	−1.1	11.0	13.0	−0.6	13.6	11.9	−2.2	14.1	12.6	−1.5	14.1	10.9	−0.4	11.3	10.6	0.9	9.7
22	11.0	−1.0	12.0	8.9	−0.9	9.8	8.6	−2.1	10.7	12.5	−2.6	15.1	11.9	−3.8	15.7	13.1	−2.4	15.5	10.2	−1.0	11.2	12.0	−0.9	12.9
23	13.9	1.0	12.9	10.3	0.2	10.1	9.5	−1.0	10.5	13.2	−0.1	13.3	14.9	−2.0	16.9	13.7	−1.7	15.4	12.8	0.0	12.8	14.1	1.1	13.0
24	11.4	2.6	8.8	6.9	1.5	5.4	6.8	0.0	6.8	9.8	2.4	7.4	9.8	−0.1	9.9	10.6	−0.5	11.1	10.1	1.0	9.1	8.5	2.5	6.0
25	11.0	1.2	9.8	8.8	1.0	7.8	8.0	−0.6	8.6	10.3	1.0	9.3	10.0	−0.8	10.8	10.6	−0.6	11.2	10.1	0.6	9.5	11.6	1.5	10.1
26	13.0	−1.7	14.7	10.5	−1.2	11.7	8.5	−2.5	11.0	15.8	−2.6	18.4	11.6	−3.6	15.2	8.8	−3.0	11.8	11.2	−1.2	12.4	14.0	−1.0	15.0
27	9.4	2.4	7.0	8.1	2.0	6.1	7.0	0.4	6.6	9.5	1.8	7.7	8.0	0.0	8.0	9.0	−0.2	9.2	8.6	1.5	7.1	9.2	2.4	6.8
28	10.2	1.5	8.7	9.8	1.6	8.2	8.0	0.0	8.0	12.0	1.0	11.0	11.0	−0.9	11.9	12.6	−0.6	13.2	10.8	0.9	9.9	10.6	2.1	8.5
29	10.0	0.6	9.4	7.0	0.6	6.4	7.0	0.6	6.4	12.8	0.8	12.0	10.0	−0.9	10.9	13.2	−0.6	13.8	12.0	0.9	11.1	4.0	1.5	2.5
30	3.0	0.0	3.0	2.5	0.0	2.5	2.5	−1.9	4.4	2.4	−0.1	2.5	2.4	−2.2	4.6	2.5	−2.0	4.5	2.4	−0.8	3.2	3.5	0.0	3.5
31	1.5	−0.5	2.0	1.8	0.0	1.8	1.5	−1.5	3.0	1.2	0.1	1.3	1.2	−2.1	3.3	1.0	−2.0	3.0	0.8	0.0	0.8	1.5	0.0	1.5
1 IX	5.0	−1.0	6.0	1.7	−0.6	2.3	1.6	−2.4	4.0	3.1	−0.9	4.0	1.2	−3.0	4.2	0.2	−2.6	2.8	0.3	−1.4	1.7	4.6	−1.1	5.7
2	8.0	−2.4	10.4	5.2	−1.0	6.2	5.5	−2.5	8.0	10.0	−2.6	12.6	6.6	−4.5	11.1	3.6	−3.9	7.5	3.0	−2.6	5.6	8.1	−1.2	9.3
3	9.0	−0.1	9.1	6.8	0.0	6.8	5.8	−1.5	7.3	10.0	−1.6	11.6	6.8	−2.6	9.4	3.8	−2.4	6.2	2.6	−0.5	3.1	4.0	−0.5	4.5
4	5.4	−0.9	6.3	4.5	−0.5	5.0	4.5	−2.0	6.5	5.0	−1.6	6.6	4.0	−3.2	7.2	4.5	−3.2	7.7	2.0	−1.1	3.1	6.0	−1.0	7.0
5	6.0	−0.1	6.1	4.4	−0.1	4.5	4.6	−1.5	6.1	6.5	−0.5	7.0	3.7	−2.5	6.2	3.7	−3.0	6.7	2.4	−1.7	4.1	6.5	0.2	6.5

Table III

Mean pentad, maximum (Max) and minimum (Min) temperatures of the ground surface and amplitude (A) of the extreme temperatures (°C). Spitsbergen — Gåshamnöyra 1979

Post no.	1			2			3			4			5			6			7			8		
Pentada Month	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A	Max.	Min.	A
4/VII	26.5	8.6	17.9	18.2	7.4	10.8	19.1	6.1	13.0	23.7	6.1	17.6	20.2	5.6	14.6	24.8	6.3	18.5	26.0	6.8	19.2	23.0	8.2	14.8
5/VII	21.6	4.9	16.7	14.8	4.2	10.6	14.6	2.8	11.8	15.9	3.0	12.9	20.9	2.2	18.7	21.1	2.9	18.2	21.4	3.6	17.8	20.4	5.3	15.1
6/VII	15.0	4.4	10.6	12.3	4.1	8.2	12.3	2.9	9.4	13.8	3.8	10.0	14.1	2.4	11.7	15.7	2.7	13.0	13.6	3.3	10.3	14.9	5.0	9.9
1/VIII	13.2	2.2	11.0	10.6	1.9	8.7	11.2	0.6	10.6	14.0	1.9	12.1	13.0	0.3	12.7	13.2	0.6	12.6	11.4	1.4	10.0	10.7	2.4	8.3
2/VIII	13.8	3.5	10.3	11.5	3.4	8.1	12.0	1.9	10.1	13.9	3.0	10.9	14.8	1.2	13.6	15.7	1.7	14.0	14.3	2.7	11.6	12.4	2.9	9.5
3/VIII	14.6	2.9	11.7	12.4	3.2	9.2	12.7	1.8	10.9	15.0	2.3	12.7	17.1	0.9	16.2	16.7	2.3	14.4	15.5	3.3	12.2	14.4	3.3	11.1
4/VIII	11.8	3.7	8.1	10.6	4.9	5.7	10.4	3.4	7.0	12.3	4.6	7.7	12.0	3.0	9.0	12.4	3.8	8.6	12.0	5.1	6.9	12.8	4.8	8.0
5/VIII	11.9	0.8	11.1	9.0	0.4	8.6	8.6	−0.8	9.4	11.8	0.0	11.8	11.7	−1.8	13.5	12.1	−1.3	13.4	10.8	0.0	10.8	11.4	1.0	10.4
6/VIII	7.8	0.5	7.3	6.6	0.5	6.1	5.8	−1.0	6.8	9.0	0.2	8.8	7.4	−1.6	9.0	7.8	−1.4	9.2	7.6	−0.2	7.8	7.1	0.8	6.3
1/IX	6.7	−0.9	7.6	4.5	−0.4	4.9	4.4	−2.0	6.4	6.9	−1.4	8.3	4.5	−3.2	7.7	3.2	−3.0	6.2	2.1	−1.5	3.6	5.8	−0.7	6.5
Mean 4/VII—1/IX	14.3	3.1	11.2	11.0	3.0	8.0	11.1	1.6	9.5	13.6	2.4	11.2	13.6	0.9	12.7	10.2	1.5	8.7	13.5	2.4	11.1	13.3	3.3	10.0

peratures of the ground sufrace showed (Table III). Table IV ahows the frequency of the occurrence of the highest and lowest extreme temperatures of the ground surface. It follows from Table IV that most frequently the highest maximum temperatures of the ground surface occurred at posts 4 and 8, with the lowest being most distinct at post 5. The explanation of the different occurrence frequency of the extreme temperatures of the ground surface should be sought in the physical properties of the soils at the particular measurement posts and their position, particularly the inclination of the slope.

Table IV

Occurrence frequency of the highest (Max) and the lowest (Min) temperatures of the ground surface at the particular posts in the area investigated and the highest amplitude of the extreme temperature (A) — in percentage of the total number of observations. Spitsbergen — Gåshamnöyra 1979

Measurement post no. Element	1	2	3	4	5	6	7	8
Max.	12	2	0	24	9	18	13	22
Min.	2	0	8	2	83	5	0	0
A	9	0	0	16	28	31	9	7

The relationship with the air temperature. A high positive correlation, $r = 0.78$, was found to exist between the maximum temperature of the ground surface and the mean 24-hour air temperature. The relationship between the maximum temperature of the ground surface and the corresponding maximum air temperature is expressed by the equation $y = 1.64x + 2.76$, with a high positive correlation, $r = 0.80$. Similar relationships exist between the minimum temperature of the ground surface and the mean 24-hour air temperature, where a high positive correlation, $r = 0.80$, was found, while the relationship between them is expressed by the equation $y = 0.95x - 0.31$. Between the minimum temperature of the ground surface and the corresponding minimum air temperature, there is a high positive correlation, $r = 0.84$, and the relationship between relationship between them is expressed by the equation $y = 1.8x + 1.29$.

Correlations also exist among the extreme temperatures of the ground surface and the mean 24-hour ground surface at a depth of 5 cm, and between the amplitude of the extreme temperatures of the ground surface and the amplitude of the extreme air temperatures. Namely, it was found that between the maximum temperature of the ground surface and the mean 24-hour ground temperature at a depth of 5 cm, there is a high positive correlation, $r = 0.99$, while the relationship between them is expressed by the equation $y = 150x + 3.95$. The correlation between the minimum temperature of the ground surface and the mean 24-hour ground temperature at a depth of 5 cm is $r = 0.88$, while the relationship between them is expressed by the equation $y = 1.33x - 3.82$. There are weaker correlations between the amplitude of the extreme temperatures of the ground surface and the amplitude of the extreme air temperatures. The correlation found, $r = 0.48$, is only considerable. The relationship between them is expressed by the equation $y = 0.49x + 7.75$.

4. Discussion of the results

The investigations permitted the characteristic of the behaviour of the extreme temperatures of the ground surface during part of the Arctic summer to be obtained. They failed, however, to ensure a full characteristic of the thermal relationships of the ground surface, because of the short observation period and limited range of measurements.

In view of the small number of papers devoted to the extreme temperatures of the ground surface in the Arctic, it is very difficult to evaluate the results obtained and compare them with the literature data. For the southern region of Spitsbergen, there is a total lack of such information. It can, however, be recognized that confirmation has been found for Baranowski's observation (1968) that in the period without snow cover the temperature of the ground surface is higher than that of the air. Analysis of the behaviour of the extreme temperatures of the ground surface indicates that in the area investigated there occurs the phenomenon of a drop of the minimum temperature below zero, which is unknown from the literature (Hess, 1967) as typical for the forefield of mountain glaciers. During the Arctic day this is prevented by constant supply of the solar radiation energy to the ground surface. However, large amplitudes of the extreme temperatures of the ground surface can indicate the cooling effect of the glaciers nearby, above all Gås Glacier.

Comparison of the measured values of the maximum and minimum temperatures of the ground surface with the data given by Leszkiewicz (1977) leads to the statement that these quantities are comparable, which would suggest low temporary variability, from year to year, of the element studied. These values are also close to the minimum temperatures of the ground surface measured at Kigsbay by the German expedition (Schöne and Wiedrich 1965). At the same time, it should be stated that the observed amplitudes of the temperature of the ground surface, although much lower than those in medium and low latitudes, reach periodically high values up to 20°C (23,2°C).

5. Conclusions

1. The extreme temperatures of the ground surface are much higher than the corresponding air temperatures, and their amplitude reaches 23°C.
2. Considerable spatial variability of the maximum and minimum temperatures of the ground surface was found in the area under study.
3. There is a close relationship between the extreme temperatures of the ground surface and the air temperature and the mean 24-hour temperature of the ground at a depth of 5 cm.

6. Резюме

Летом 1979 года в южном Шпицбергене на территории, прилегающей к заливу Гас, работала научная экспедиция Слёнзкого университета реализируя широкую программу географических исследований. В ее состав входило проведение измерения экстремальных температур поверхности грунта. Исходя из положения, что температура является элементом климата важным для многих физических процессов, происходящих на поверхности грунта, автор старался изучить ход экстремальных температур этой поверхности. Наблюдения проводились в части арктического лета (табл. II). Одновременно были прослежены во времени и пространстве изменения максимальной и минимальной температуры поверхности грунта (табл. II и III). Была высчитана частота проявления максимальной и минимальной температур поверхности грунта в отдельных наблюдательных пунктах изученной территории (табл. IV). Проблема рассматривалась на фоне суточного хода температуры поверхности слоев грунта (табл. I). Установлена связь между максимальной и минимальной температурой поверхности грунта и ее амплитудой и соответствующими им элементами температуры воздуха.

Исследования позволили установить, что экстремальные температуры поверхности грунта значительно выше температуры воздуха, а их амплитуда может в условиях Шпицбергена достигать 30°C (29,6°C). Температуры поверхности грунта на изучаемой территории сильно меняются в зависимости от рода грунта и условий притока солнечной радиации на поверхность грунта.

7. Streszczenie

Latem w roku 1979 pracowała na południowym Spitsbergenie w obszarze przyległym do Zatoki Gas, wyprawa naukowa Uniwersytetu Śląskiego. Realizowała ona szeroki program badań geograficznych. Jednym z elementów badań były pomiary temperatur skrajnych powierzchni gruntu. Wychodząc z założenia, że temperatura to ważny element klimatu, istotny dla wielu procesów fizycznych odbywających się na powierzchni gruntu czynnik, starano się poznać przebieg temperatur skrajnych powierzchni gruntu w części okresu arktycznego lata (Tab. II). Jednocześnie prześledzono czasową i przestrzenną zmienność temperatury maksymalnej i minimalnej powierzchni gruntu (Tab. II i III), wyliczając też częstość występowania najwyższej i najniższej temperatury powierzchni gruntu na poszczególnych stanowiskach badawczych obszaru (Tab. IV). Całość zagadnienia rozpatrywano na tle przebiegu dobowego temperatury powietrza i średniej dobowej temperatury powierzchniowych warstw gruntu (Tab. I). Stwierdzono związki korelacyjne pomiędzy temperaturą maksymalną

i minimalną powierzchni gruntu oraz ich amplitudą a odpowiadającymi im elementami temperatury powietrza.

Badania pozwoliły na stwierdzenie, że temperatury skrajne powierzchni gruntu znacznie przewyższają temperatury powietrza a ich amplituda może dochodzić w warunkach Spitsbergenu do ponad 20 C (23.2 C). Istnieje duża przestrzenna zmienność temperatury powierzchni gruntu w badanym obszarze, wynikająca głównie z właściwości gruntu i warunków dopływu energii promieniowania słonecznego do powierzchni gruntu.

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