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Spatial differentiation of air temperature and humidity on western coast of Spitsbergen in 1979–1983

ABSTRACT: Spatial differentiation of temperature and relative humidity of air on western coast of Spitsbergen in 1979–1983 is presented. Applying the author's classification of types of atmospheric circulation in the studied area, its influence on distribution of these elements is shown. Air temperature in the area is related more to the degree of climate continentality than to its latitude. The lowest mean 5-year temperatures were calculated for stations with highest degrees of thermic continentality (Svea Gruber and Svalbard Lufthavn). The highest thermic differentiation occurs from November to March (1–4°C) and the lowest in May–June and August–October (0.0–1.5°C). It is opposite if relative humidity is concerned: the highest differences occur in summer (10–15%) and the lowest in winter (0–9%). Influence of atmospheric circulation on air temperature is larger during a polar night than a polar day. Again, it is opposite in the case of relative humidity. In both analyzed seasons the highest thermic differentiation occurred at the circulation type C_a. However, it was the lowest during a polar night at advection of air from northern and southern sectors, and during a polar day at advection from a northern sector and at the type C_c.

Key words: Arctic, Spitsbergen, climate, air temperature and humidity

Introduction

The study is based on measurements of temperature (T) and relative humidity (U) of air in 1979–1983 at 4 meteorological stations on western coast of Spitsbergen (Fig. 1): Ny Ålesund (φ=78°55'N, λ=11°56'E), Svalbard Lufthavn (φ=78°15'N, λ=15°28'E), Svea Gruber (φ=77°54'N, λ=16°43'E) and Hornsund (φ=77°00'N, λ=15°33'E). For a comparison, the data of a typical maritime climate from the Björnöya meteorological station

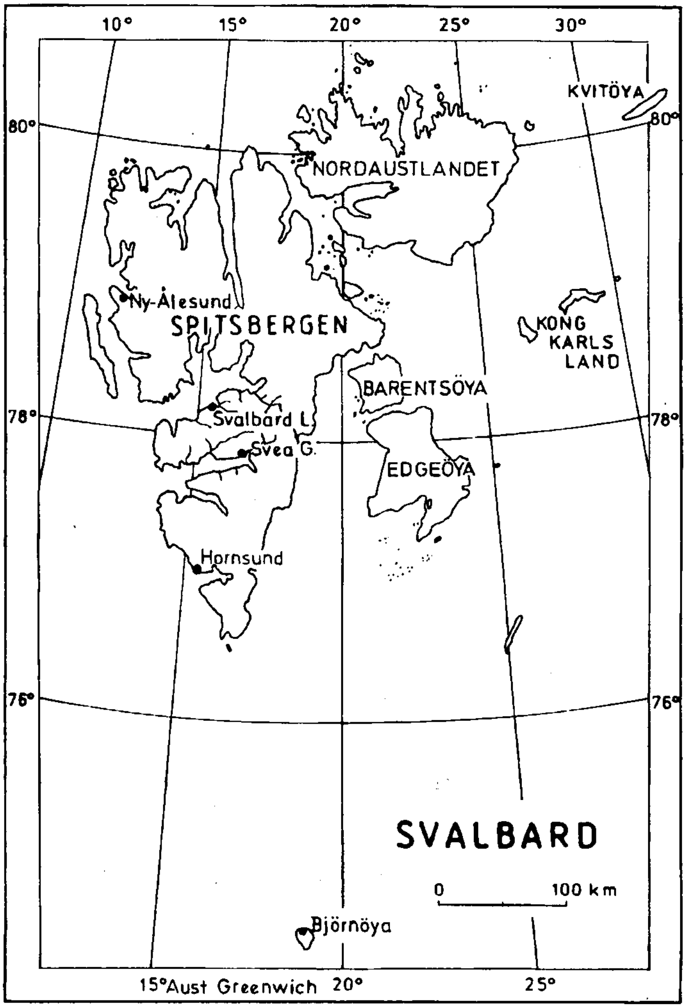

Fig. 1. Location of meteorological stations in the Svalbard archipelago, from which data were analyzed

($\varphi = 74°31'N$, $\lambda = 19°01'E$), in the northern Bear Island are also given. All the stations are located in non-glacial area and at approximately the same longitude, altitude and distance from a sea. The recorded spatial differentiation of thermic and humidity conditions results therefore from influence of solar and circulatory factors, distribution of sea currents, extent of sea ice around the island and from local conditions. Influence of atmospheric circulation on spatial distribution of T and U on western coast of Spitsbergen is shown with use of 10 isolated circulation types (Przybylak 1992). Capital letters relate to direction of air advection whereas the indices *a* and *c* – respectively to cyclonal and anticyclonal situations, *e.g.*: $NW+N+NE_a$ and $NW+N+NE_c$ define subsequently anticyclonal and cyclonal situations with air advection from a northern sector, *i.e.* from the northwest, north and northeast. In this way 6 types are characterized by evident air inflow (besides the above ones they are: $E+SE_a$, $E+SE_c$, $S+SW+W_a$ and $S+SW+W_c$). Remaining four situations are characterized by no advection or changeable directions of air inflow into the territory of Spitsbergen:

C_a – central anticyclonal situation, no advection, high-pressure center over Spitsbergen,
C_c – central anticyclonal situation, low-pressure center over Spitsbergen,
K_a – anticyclonic ridge, few unclear centers, spread area of high pressure or axis of high pressure ridge,
B_c – cyclonal trough, spread area of low pressure or axis of cyclonal trough.

The calendar of circulation types for Spitsbergen in 1979–1983 made it possible to show influence of atmospheric circulation on thermic and humidity relations in Hornsund (Przybylak 1992). A similar survey was presented by Niedźwiedź (1987), based on his own classification of circulation types, yet limited to air temperature in Hornsund.

So far there are only few papers dealing with spatial differentiation of air temperature and humidity in the studied area, *e.g.* by Knothe (1931), Baranowski (1975), Markin (1975), Marciniak and Przybylak (1987) and Przybylak 1992. Most of them, however, deals with such differentiation in summer only.

This study presents general differentiation of spatial distribution of T and U on western coast of Spitsbergen and examines influence of atmospheric circulation on distribution of these elements in the studied area. It should be underlined that the last problem has not been studied so far in this area on a macroclimatic scale.

Average spatial differentiation of air temperature and humidity

Normally, due to the angle of solar radiation, a decline of T should be followed when approaching to the north. Such a rule however does not seem to be always true if particular parameters, both monthly and yearly average ones are concerned (cf. Figs. 2–3, Tables 1–3). T in western coast of Spitsbergen indicates a more significant relation to degree of climate continentality of the station. The lowest mean yearly T values occur in places with the highest degree of continentality (Table 1). The lowest mean of the five-year T occurred in Svea Gruber (-7.4°C), then in Svalbard Lufthavn (-6.8°C), Ny Ålesund (-6.4°C) and Hornsund (-5.7°C). Calculated coefficients of continen-

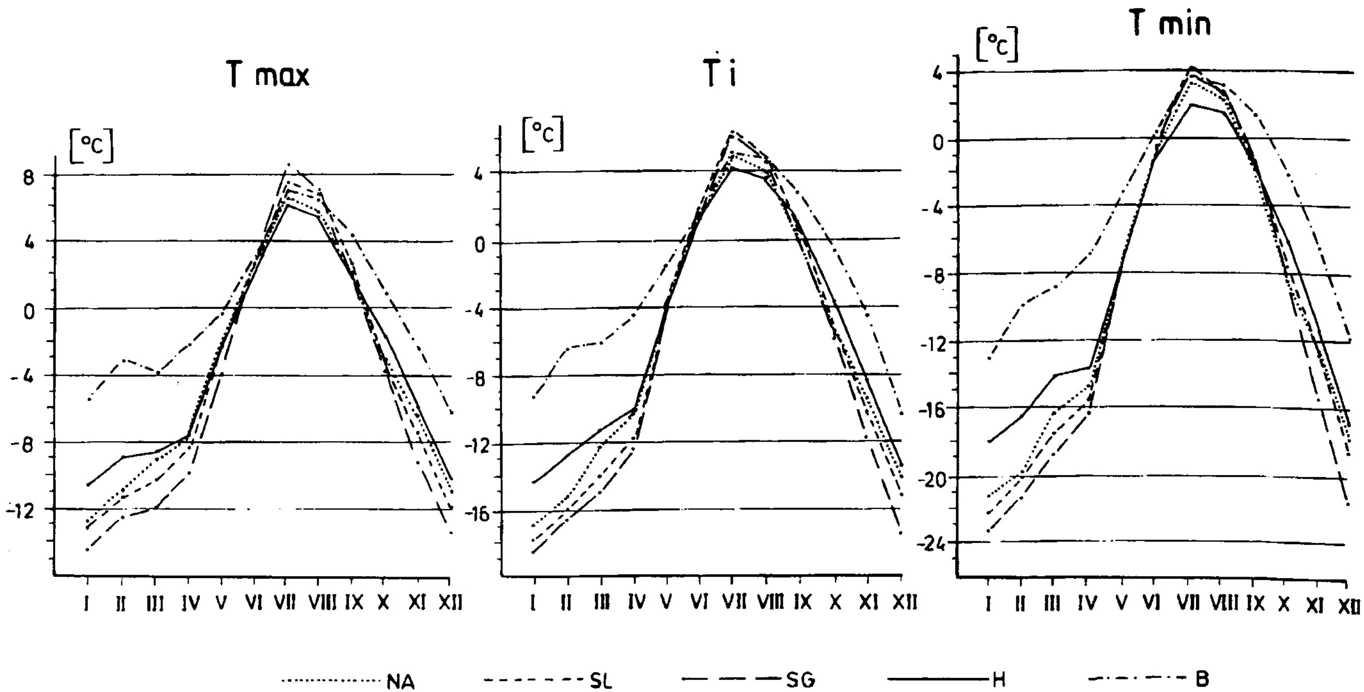

Fig. 2. Annual course of T_{max}, T_i and T_{min} according to monthly mean at selected stations of Svalbard in 1979–1983
NA – Ny Ålesund, SL – Svalbard Lufthavn, SG – Svea Gruber, H – Hornsund, B – Björnöya

Table 1

Mean monthly and annual values of T (in °C) in selected stations of Svalbard (NA – Ny Ålesund, SL – Svalbard Lufthavn, SG – Svea Gruber, H – Hornsund, B – Björnöya) in 1979–1983*

Years	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII
	NA	-18.9	-19.2	-12.2	-15.1	-6.2	0.0	6.2	4.8	1.3	-4.2	-6.5	-11.7	-6.8
	SL	-20.5	-20.5	-15.8	-16.8	-7.5	-0.2	8.1	5.2	1.2	-4.3	-6.8	-12.7	-7.6
1979	SG	-19.5	-20.7	-18.1	-15.3	-7.5	0.2	7.8	4.8	1.1	-4.6	-7.5	-13.5	-7.7
	H	-15.4	-16.6	-13.7	-13.6	-7.0	0.1	5.1	3.8	1.2	-2.8	-4.9	-9.6	-6.1
	B	-10.6	-7.4	-5.1	-6.6	-3.2	1.8	6.7	5.6	3.2	0.0	-2.2	-5.0	-1.9
	NA	-14.8	-13.8	-12.0	-7.9	-2.7	3.0	4.7	4.2	0.8	-7.1	-13.6	-16.6	-6.3
	SL	-16.7	-14.8	-15.1	-8.9	-3.0	3.8	6.3	4.5	1.2	-7.5	-15.1	-18.9	-7.0
1980	SG	-16.6	-15.2	-14.8	-9.2	-2.9	4.2	6.7	4.8	1.4	-7.6	-17.0	-19.5	-7.1
	H	-11.8	-11.7	-11.4	-7.8	-2.4	2.6	4.7	4.0	1.9	-5.5	-13.5	-16.3	-5.6
	B	-7.5	-7.3	-6.6	-2.7	-1.3	2.9	4.3	6.1	3.2	-1.5	-6.9	-12.8	-2.5
	NA	-22.4	-12.1	-18.1	-9.9	-3.7	0.5	5.1	4.9	1.2	-3.7	-6.8	-13.5	-6.5
	SL	-22.0	-12.5	-19.2	-11.8	-4.8	0.3	5.6	5.7	1.4	-3.6	-7.4	-14.3	-6.9
1981	SG	-22.7	-13.6	-20.2	-13.3	-3.8	1.2	5.3	6.0	1.5	-3.3	-8.6	-18.0	-7.5
	H	-17.8	-9.0	-16.7	-11.0	-3.9	0.8	4.0	4.8	2.0	-2.2	-5.0	-14.6	-5.7
	B	-12.0	-3.2	-12.1	-6.3	-1.0	1.3	4.4	4.6	3.2	0.0	-1.4	-10.0	-2.7
	NA	-17.3	-14.4	-8.7	-8.5	-4.0	1.3	4.1	3.3	-3.6	-4.4	-7.2	-12.7	-6.0
	SL	-19.7	-15.5	-8.5	-9.5	-3.7	1.3	5.4	4.1	-2.4	-5.3	-8.6	-13.2	-6.3
1982	SG	-21.1	-15.7	-9.6	-11.1	-4.9	1.2	5.0	3.8	-2.6	-5.9	-10.3	-15.1	-7.2
	H	-17.1	-12.4	-6.3	-9.0	-4.2	0.5	2.9	2.7	-1.5	-4.1	-6.5	-11.4	-5.5
	B	-12.0	-7.0	-3.5	-3.3	-1.8	0.3	4.4	3.0	0.9	-0.5	-2.5	-5.9	-2.3
	NA	-11.0	-17.2	-9.8	-10.5	-2.5	0.8	5.3	3.4	0.6	-7.2	-13.2	-15.7	-6.4
	SL	-10.8	-15.8	-10.0	-11.3	-2.9	1.6	6.3	4.8	1.2	-6.4	-14.3	-17.1	-6.2
1983	SG	-12.2	-17.1	-11.7	-12.4	-3.7	1.7	6.2	4.4	0.9	-6.3	-16.8	-20.2	-7.3
	H	-9.0	-13.3	-7.8	-9.7	-3.2	1.2	4.4	3.4	1.6	-4.3	-12.8	-15.2	-5.4
	B	-4.1	-6.4	-2.9	-2.6	-0.4	3.6	6.2	4.7	3.5	-0.7	-8.8	-11.6	-1.6
	NA	-16.9	-15.3	-12.2	-10.4	-3.8	1.1	5.1	4.1	0.1	-5.3	-9.5	-14.0	-6.4
1979–	SL	-17.9	-15.8	-13.7	-11.7	-4.4	1.4	6.3	4.9	0.5	-5.4	-10.4	-15.2	-6.8
1983	SG	-18.4	-16.5	-14.9	-12.3	-4.6	1.7	6.2	4.8	0.5	-5.5	-12.0	-17.3	-7.4
	H	-14.2	-12.6	-11.2	-10.2	-4.1	1.0	4.2	3.7	1.0	-3.8	-8.5	-13.4	-5.7
	B	-9.2	-6.3	-6.0	-4.3	-1.5	2.0	5.2	4.8	2.8	-0.5	-4.4	-9.1	-2.2

* – mean values of T were computed from 3 climatological observation terms, i.e. 07, 13 and 19 LMT

Table 2

Mean monthly and annual values of Tmax (in °C) in selected stations of Svalbard (NA – Ny Ålesund, SL – Svalbard Lufthavn, SG – Svea Gruber, H – Hornsund, B – Björnöya) in 1979–1983

Years	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII
1979	NA	-14.8	-14.8	-9.2	-11.4	-3.6	1.9	8.2	6.6	3.4	-1.4	-4.2	-8.2	-4.0
	SL	-15.0	-16.4	-12.1	-12.8	-4.8	2.0	11.7	7.6	3.2	-1.3	-4.0	-8.6	-4.2
	SG	-15.7	-16.9	-15.8	-12.9	-5.4	1.3	11.2*	6.4	2.7	-2.0	-5.4	-8.9	-5.1
	H	-11.7	-12.6	-11.0	-11.0	-4.8	1.5	7.9	5.8	2.6	-0.2	-2.8	-6.3	-3.6
	B	-6.6	-4.7	-3.4	-4.0	-1.7	3.2	9.0	7.1	4.4	1.5	-0.7	-2.6	0.1
1980	NA	-10.5	-9.1	-9.4	-4.9	-0.6	4.6	6.0	5.9	2.3	-5.1	-10.7	-13.6	-3.8
	SL	-11.5	-9.5	-11.2	-5.6	-0.9	5.8	8.4	6.6	3.1	-4.6	-12.6	-14.7	-3.9
	SG	-11.9	-10.5	-11.5	-7.1	-6.7	5.7	8.8	6.5	2.7	-5.2	-14.3	-16.3	-5.0
	H	-7.6	-7.6	-8.8	-5.3	-0.1	4.1	5.9	5.4	3.2	-3.2	-10.5	-13.0	-3.1
	B	-3.8	-3.9	-4.6	-0.7	-0.2	4.4	5.8	8.1	4.4	0.4	-5.0	-9.7	-0.4
1981	NA	-17.6	-7.0	-14.8	-7.1	-1.2	2.1	6.6	6.5	3.2	-1.8	-3.5	-10.7	-3.8
	SL	-15.8	-8.4	-15.5	-8.6	-2.3	2.1	7.8	7.9	3.4	-1.6	-4.4	-11.8	-3.9
	SG	-17.6	-9.8	-16.4	-10.6	-2.1	2.4	7.1	7.5	2.9	-2.0	-5.4	-14.6	-4.9
	H	-13.6	-5.5	-13.4	-8.0	-1.8	2.4	5.5	6.5	3.4	-0.7	-2.3	-11.4	-3.2
	B	-7.4	-0.5	-8.7	-3.6	0.4	2.5	6.3	6.2	4.8	1.1	0.6	-7.2	-0.5
1982	NA	-14.1	-10.8	-5.3	-5.6	-1.7	3.1	5.6	4.5	-1.4	-2.3	-4.5	-9.2	-3.5
	SL	-15.8	-11.3	-5.5	-6.7	-1.8	3.0	7.7	5.8	-0.7	-2.7	-5.3	-10.1	-3.6
	SG	-17.6	-11.6	-7.2	-8.6	-3.2	2.9	7.3	5.5	-1.0	-4.1	-7.0	-11.7	-4.7
	H	-13.6	-9.4	-4.1	-6.3	-1.8	2.3	4.8	4.5	-0.1	-2.3	-3.9	-8.1	-3.2
	B	-7.6	-3.3	-1.4	-1.4	-0.4	1.4	6.3	4.7	2.4	1.0	-0.2	-3.5	-0.2
1983	NA	-7.2	-12.0	-6.3	-7.7	-0.3	2.9	7.2	5.1	2.8	-4.5	-9.5	-12.1	-3.5
	SL	-7.1	-10.9	-6.8	-8.0	-1.1	3.6	8.5	6.3	3.6	-4.3	-11.6	-13.2	-3.4
	SG	-8.8	-13.3	-8.5	-9.7	-1.6	3.4	8.0	6.1	2.5	-4.2	-13.7	-15.4	-4.6
	H	-6.1	-9.1	-5.4	-7.3	-1.4	2.9	6.8	5.3	-0.2	-2.3	-10.3	-11.6	-3.2
	B	-1.8	-3.0	-1.1	-0.7	0.8	5.5	8.1	5.9	5.0	0.5	-6.7	-7.6	0.4
1979–1983	NA	-12.8	-10.7	-9.0	-7.3	-1.5	2.9	6.7	5.7	2.1	-3.0	-6.5	-10.8	-3.7
	SL	-13.0	-11.3	-10.2	-8.3	-2.2	3.3	7.5	6.8	2.5	-2.9	-7.6	-11.7	-3.9
	SG	-14.3	-12.4	-11.9	-9.8	-3.8	3.1	8.5	6.4	2.0	-3.5	-9.2	-13.4	-4.9
	H	-10.5	-8.8	-8.5	-7.6	-2.0	2.6	6.2	5.5	1.8	-1.7	-6.0	-10.1	-3.3
	B	-5.4	-3.1	-3.8	-2.1	-0.2	3.4	7.1	6.4	4.2	0.9	-2.4	6.1	-0.1

* – data were interpolated

T a b l e 3

Mean monthly and annual values of Tmin (in °C) in selected stations of Svalbard (NA – Ny Ålesund, SL – Svalbard Lufthavn, SG – Svea Gruber, H – Hornsund, B – Björnöya) in 1979–1983

Years	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII
	NA	-24.0	-23.8	-16.4	-20.6	-10.1	-2.5	4.1	2.6	-0.8	-7.5	-8.9	-15.7	-10.3
	SL	-24.8	-24.1	-20.8	-21.7	-10.2	-2.1	5.1	3.1	-0.7	-6.8	-8.8	-15.8	-10.6
1979	SG	-24.2	-24.9	-21.7	-19.3	-10.8	-1.5	4.7*	2.9	-0.4	-7.3	-10.2	-18.2	-10.9
	H	-19.5	-20.7	-17.1	-17.2	-9.8	-1.5	2.4	1.6	-0.5	-5.4	-7.0	-13.1	-9.0
	B	-14.8	-10.0	-7.8	-9.3	-5.3	0.3	4.5	4.0	2.1	-1.4	-3.9	-7.5	-4.1
	NA	-20.1	-18.2	-15.9	-11.9	-5.8	1.0	3.2	2.4	-1.5	-9.4	-16.6	-20.3	-9.4
	SL	-21.4	-19.4	-18.6	-13.3	-4.9	1.8	4.5	2.6	-0.6	-9.6	-17.3	-22.1	-9.9
1980	SG	-22.3	-20.6	-18.9	-13.3	-2.9	1.5	4.4	2.9	-0.3	-9.8	-19.8	-23.3	-10.2
	H	-16.3	-15.3	-13.8	-11.2	-5.5	0.6	2.8	2.2	0.1	-8.1	-16.9	-20.1	-8.5
	B	-11.4	-11.0	-9.6	-5.1	-2.5	1.5	2.8	4.1	1.8	-3.5	-8.7	-16.0	-4.8
	NA	-26.8	-17.0	-22.5	-13.9	-7.7	-1.5	3.3	3.4	-0.6	-6.3	-10.3	-17.2	-9.8
	SL	-27.3	-16.4	-23.1	-15.5	-7.3	-1.4	3.8	3.9	-0.4	-5.6	-10.5	-17.8	-9.8
1981	SG	-28.1	-18.4	-25.4	-18.0	-7.5	-0.9	3.0	3.9	-0.1	-5.0	-11.9	-21.8	-10.8
	H	-22.7	-13.0	-20.2	-15.0	-6.9	-1.6	2.0	2.4	0.1	-4.1	-8.1	-17.6	-8.7
	B	-16.3	-6.5	-15.6	-9.3	-2.8	-0.1	2.4	2.9	1.9	-1.5	-3.7	-12.3	-5.1
	NA	-20.9	-18.6	-12.9	-12.6	-7.1	-0.6	2.5	1.8	-7.1	-7.3	-11.3	-16.1	-9.2
	SL	-23.2	-19.7	-12.0	-13.1	-5.8	-0.4	3.5	2.7	-4.5	-7.8	-11.6	-16.5	-9.0
1982	SG	-25.2	-20.1	-13.0	-14.6	-7.9	0.9	2.4	2.1	-4.6	-8.4	-15.0	-19.4	-10.2
	H	-20.7	-15.7	-8.8	-12.0	-7.1	-1.4	1.0	0.9	-3.7	-6.1	-10.1	-14.0	-8.1
	B	-16.5	-11.3	-6.3	-5.9	-3.3	-1.3	2.5	1.4	-0.4	-1.9	-5.1	-8.3	-4.7
	NA	-14.6	-22.1	-13.8	-14.9	-5.2	-0.9	3.8	2.0	-1.3	-9.8	-16.6	-19.7	-9.4
	SL	-14.5	-21.3	-12.9	-14.9	-5.3	-0.6	4.4	2.8	-0.6	-8.2	-16.9	-20.8	-9.0
1983	SG	-16.6	-23.1	-15.4	-16.3	-6.9	-1.0	3.9	2.7	-0.8	-10.8	-20.3	-24.7	-10.8
	H	-11.9	-17.8	-10.7	-12.7	-5.7	-1.1	2.4	1.6	-5.7	-6.3	-15.5	-19.3	-8.6
	B	-6.3	-10.7	-4.8	-4.8	-1.9	1.9	4.8	3.4	2.0	-2.3	-11.2	-16.1	-3.8
	NA	-21.3	-19.9	-16.3	-14.8	-7.2	-0.9	3.4	2.4	-2.3	-8.1	-12.7	-17.8	-9.6
1979–	SL	-22.2	-20.2	-17.5	-15.7	-6.7	-0.5	4.3	3.0	-1.4	-7.6	-13.0	-18.6	-9.7
1983	SG	-23.3	-21.4	-18.9	-16.3	-7.2	-0.2	3.7	2.9	-1.2	-8.3	-15.4	-21.5	-10.6
	H	-18.0	-16.5	-14.1	-13.6	-7.0	-1.0	2.1	1.7	-1.9	-6.0	-11.5	-16.8	-8.6
	B	-13.1	-9.9	-8.8	-6.9	-3.2	0.5	3.4	3.2	1.5	-2.1	-6.5	-12.0	-4.5

* – data were interpolated

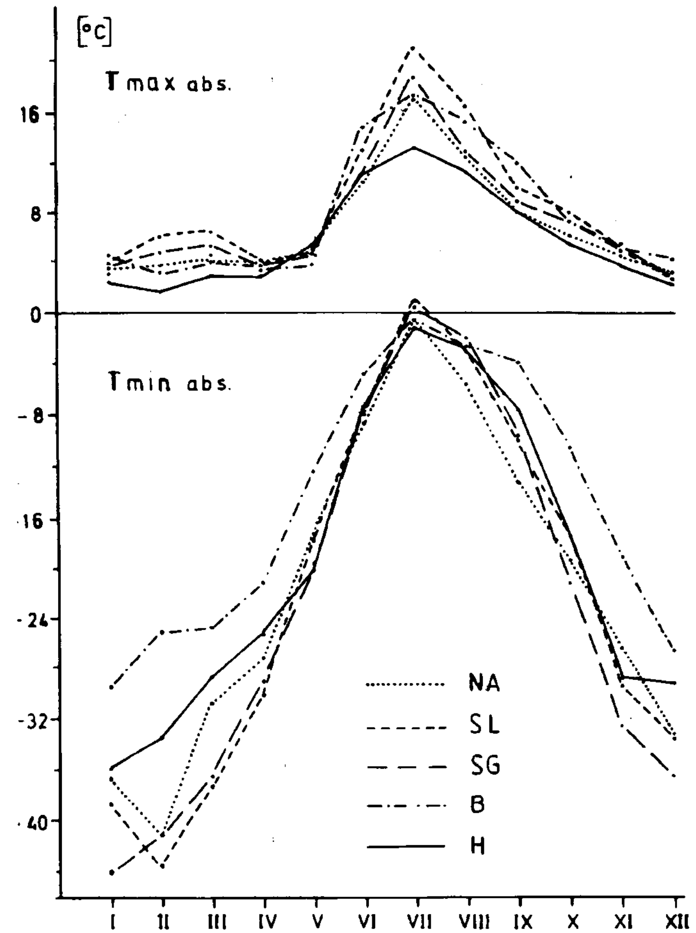

Fig. 3. Annual course of $T_{max\ abs}$ and $T_{min\ abs}$ at selected stations of Svalbard in 1979—1983
Explanations as in Fig. 2

tality according to Gorczyński (Okołowicz 1969) for this period were 22.4, 21.6, 17.7 and 11.7% respectively. In the annual course of mean monthly T the greatest thermic differences between these stations occur in a cool season, particularly in November—March (*ca.* 1—4°C). The smallest differentiation takes place in turn in May and June and from August to October (0° — 1.5°C). In high summer (mainly in July and at the beginning of August) the secondary maximum of differences between the analyzed stations can be noted, reaching 1—2°C (Fig. 2). The highest mean monthly T values for a five-year period exceed 4°C in July and August. In winter they drop to values from -12°C to -17°C. On the average, July was the warmest month at all the examined stations and January was the coolest one. As results from surveys of Steffensen (1969, 1982) for the period 1946—1965, March was generally the coolest month in

Longyearbyen and Isfjord Radio. Results obtained for the period 1979–1983 prove a significant structural change. Even in particular years the March has not been the coolest month at any analyzed station. The coldest winters occur in central part of western coast of Spitsbergen (Svea Gruber, Svalbard Lufthavn); they are much milder in the north (Ny Ålesund) and especially in the south (Hornsund). In summer, the central part of the island is the warmest due to the highest degree of climate continentality. Northwestern Spitsbergen is a little cooler and its southwestern part is the coolest (Table 1, Fig. 2). The lowest T in this area is due to cooling caused by the cold South Cape Current and intense cyclonal activity that caused very large cloudiness, limiting considerably a solar radiation (Marciniak and Przybylak 1987).

Annual variations of mean monthly extreme temperatures (minimum T_{min} and maximum T_{max}) in 1979–1983 at analyzed stations are very similar to the ones of a mean daily temperature (T_i) and differ in absolute values only (Tables 1–3, Fig. 2). The highest mean T_{max} occurs in July and the lowest in January. In stations with more continental climate (Svalbard Lufthavn and Svea Gruber) T_{max} is higher in July and lower in January (Fig. 2). In other stations *e.g.* at Hornsund, it is 0.5–2.0°C lower in summer and 2–4°C higher in winter. In particular years there are wider differences (Table 2). The mean five-year T_{min} on western coast of Spitsbergen is the highest in July (2–4°C) and the lowest in January (from -18°C to -24°C) (Table 3, Fig. 2). The highest mean T_{min} in summer and the lowest in winter are recorded at stations in central Spitsbergen. At Hornsund they are markedly lower in summer (by *ca.* 1–2°C) and higher in winter (by *ca.* 3–5°C). The lowest differentiation of T_{min} in Spitsbergen occurs in May and September. Significant differences between Hornsund and other stations in Spitsbergen (*cf.* Fig. 2, Tables 2 and 3) are noted for T_{min} (1–2°C for five-year mean annual values) rather than for T_{max} (0.4–1.6°C). If Hornsund is excluded, T_{max} are mostly differentiated on western coast of Spitsbergen, both in summer and winter. Similar results for summer were obtained by Marciniak and Przybylak (1987).

$T_{max\ abs}$ in 1979–1983 were above 0°C in all the months (Fig. 3). In particular years, however T can be equally often above and below 0°C. The highest $T_{max\ abs}$ occurs most often in July and the lowest $T_{max\ abs}$ in December or January. An exceptionally high T_{max} was recorded on 16th July 1979 at Svalbard Lufthavn (21.3°C), whereas at Hornsund, the same year, it was only 13.4°C (11th July). Hornsund has the lowest $T_{max\ abs}$ throughout the year except in May (Fig. 3).

$T_{min\ abs}$ on western coast of Spitsbergen can be below 0°C in all the months (Fig. 3). The values above 0°C occur however most often in July and much less frequently in August. The lowest T_{min} is recorded in winter, especially in January and February. The lowest T_{min} in 1979–1983 occurred at Svea Gruber on 16th January 1981 (-44.1°C). It was slightly higher at Svalbard Lufthavn on 25th February 1979 (-43.7°C). At Hornsund the lowest value was measured

Table 4

Mean monthly and annual values of U (in %) in selected stations of Svalbard (NA – Ny Ålesund, SL – Svalbard Lufthavn, H – Hornsund, B – Björnöya) in 1979–1983*

Years	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I–XII
1979	NA	80	77	78	82	79	90	88	85	88	83	76	80	82
	SL	70	70	69	74	69	80	67	71	76	74	68	73	72
	H	69	75	73	74	76	83	81	83	85	77	75	73	77
	B	80	83	85	82	78	84	83	85	86	80	79	78	82
1980	NA	76	82	76	78	80	86	83	88	89	69	71	72	79
	SL	69	74	71	69	68	67	74	75	79	81	72	71	72
	H	72	79	75	76	75	77	85	86	85	71	68	66	76
	B	80	81	83	84	79	86	93	89	91	83	85	92	86
1981	NA	77	86	81	86	87	89	91	93	91	84	84	75	85
	SL	71	80*	67	68	71	72	72	75	78	67	71	70	72
	H	66	80	67	72	75	81	90	87	86	74	77	69	77
	B	87	93	91	89	89	89	93	92	91	87	87	85	89
1982	NA	83	92	86	70	63	70	82	79	73	73	70	67	76
	SL	74	75	70	69	61	65	70	71	66	70	70	68	69
	H	70	78	82	81	78	84	90	86	74	79	75	80	80
	B	88	91	90	90	87	89	96	91	91	88	92	92	90
1983	NA	71	77	67	66	73	75	81	81	77	71	61	64	72
	SL	68	72	71	70*	79	73	76	74	76	75	74	72	73
	H	76	72	76	73	81	79	86	86	82	75	75	68	77
	B	95	94	92	93	93	88	93	86	89	84	79	86	89
1979–1983	NA	77	83	78	76	76	82	85	85	84	76	72	72	79
	SL	70	74	70	70	70	71	72	73	75	73	71	71	72
	H	71	77	75	75	77	81	86	86	82	75	72	71	77
	B	86	88	88	88	85	87	92	89	90	84	84	87	87

* – mean values of U were computed from 3 climatological observation terms, i.e. 07, 13 and 19 LMT, * – data were interpolated

the same day, but it was considerably higher (-35.9°C). It should be noted that in summer at stations with the lowest degree of thermic continentality (Hornsund, Björnöya) T_{min} is lower than at other stations what is difficult to explain. One of the reasons may result from warm air coming from the east and northeast. The air arrives to the region of Bear Island and south Spitsbergen without any difficulty and does not change its physical features. Further to the north, however, it meets mountain barriers and a vast land area which, on one hand, impede the air flow to the western coast and, on the other, results in its transformation.

Amount of water vapour in the air over Svalbard is low due to the low T. Mean annual vapour pressure at Hornsund oscillates between 4 and 5 hPa (Przybylak 1992). The highest values are recorded in summer and the lowest in winter.

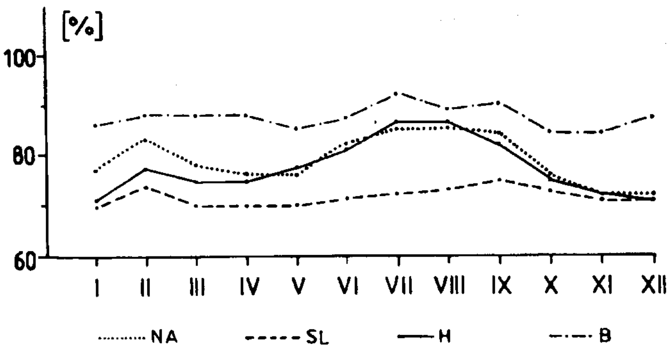

Fig. 4. Annual course of U according to monthly mean at selected stations of Svalbard in 1979–1983 Explanations as in Fig. 2.

Air relative humidity (U) at Hornsund is high due to occurrence of low T and its oceanic location (Table 4, Fig. 4). The highest mean five-year values occurred in the northwest (Ny Ålesund – 79%) and southwest coasts of the island (Hornsund – 77%). The higher U at Ny Ålesund is caused by lower T dominating there, especially in winter (Fig. 2). Subsequently, its lower values on the central coast, despite the lowest T, should be connected with a higher degree of climate continentality of the area and atmospheric circulation causing inflow of drier air from the island interior. The highest U values occur in summer and the lowest in various periods of a cool season. The annual course is most clear at Hornsund and Ny Ålesund, whereas it is most smoothed at other stations. The largest mean five-year differences of U between central and its southwestern and northwestern coasts of Spitsbergen occur in summer and they diminish significantly in winter (Fig. 4).

Influence of atmospheric circulation on spatial distribution of air temperature and relative humidity

The atmospheric circulation, as one of three main climatic factors, plays an important role in the Arctic due to specific light and radiation conditions. Its influence is most significant in a cool season when there is almost no solar energy yield, but its intense loss due to radiation from a ground occurs. The energy lost in this way is mainly compensated by heat advection from lower latitudes.

Air circulation over Spitsbergen changes seasonally. It is connected with thermic gradients that varies in its annual course between high and moderate latitudes. Radiation relations and a specific bed of the atmosphere in the Arctic cause the gradient to be the highest in winter and lowest in summer. In result intensive atmospheric processes occur, manifested in frequent low pressure, strong winds and storms in winter. In summer, due to a decreased T contrast between the Arctic and moderate latitude masses, a cyclonal activity becomes weaker. Depth of cyclones diminishes and so does heat transport. However, their frequency in this period is not much lower than in winter due to drop of atmospheric pressure in the central Arctic, opposing a tendency to weaken a cyclonal activity which results from lower thermic differences.

The above statements agree with the obtained frequency of circulation types over Spitsbergen in 1979–1983 (Przybylak 1992). Mean five-year frequencies of cyclonal situations were highest in winter (*ca.* 73%) and autumn (*ca.* 71%), lower in summer (*ca.* 57%) and the lowest in spring (*ca.* 48%) compared to the mean annual (63.2%). The following types of circulation occurred with the highest mean frequency: $E+SE_c$ (17.3%), $NW+N+NE_c$ (16.6%) and $S+SW+W_c$ (14.1%). Types C_a (2.5%) and $S+SW+W_a$ (3.6%) were the most rare.

Due to significant influence of atmospheric circulation on climate of Spitsbergen, its influence on spatial differentiation of T and U was analyzed for a polar night (PN) and a polar day (PD). For this purpose, for majority of circulation types (6), the days when they are best expressed were selected from both periods in such a way to fall in the middle of a period (Table 5), for which examined circulations were stable. A mean time of duration of types for which the days were selected, was equal to 5.0 days in PN and 4.7 days in PD (Table 5). A limited number of circulation types, for which their influence on T and U on western coast of Spitsbergen was examined, results from the fact that thermic and humidity features of air masses coming from northern and southern sectors in summer and winter do not differ significantly if referred to a type of isobaric system (Przybylak 1992). Moreover, it results from quoted sources that similar types C_a and K_a as well as C_c and B_c influence similarly T and U in Hornsund during the analyzed seasons.

Table 5

Daily values of some meteorological elements on western coast of Spitsbergen for different types of circulation during polar night (top of table) and polar day (bottom of table)

Type of circulation	Duration in days	Chosen day	Ny Ålesund Tmin	Ny Ålesund Ti	Ny Ålesund Tmax	Ny Ålesund U	Ny Ålesund C	Svalbard Lufthavn Tmin	Svalbard Lufthavn Ti	Svalbard Lufthavn Tmax	Svalbard Lufthavn U	Svalbard Lufthavn C
NW+N+NEc	3	12.11.1981	-14.9	-13.4	-11.2	88	5.7	-16.0	-13.4	-10.3	58	4.0
E+SEc	12	28.01.1983	-16.2	-14.9	-10.8	57	1.7	-19.2	-18.0	-13.4	55	1.0
E+SEa	7	2.02.1979	-22.5	-18.5	-14.0	64	0.7	-23.2	-21.7	-18.1	57	1.0
S+SW+Wc	4	31.12.1982	-5.0	-3.7	0.2	81	7.0	-4.2	-2.9	1.2	75	6.7
Ca	2	5.02.1982	-27.0	-17.5	-12.3	73	6.7	-30.3	-25.6	-23.3	71	3.7
Cc	2	23.12.1982	-15.3	-13.6	-7.5	72	2.7	-16.0	-11.5	-9.2	67	5.0
NW+N+NEa	5	8.07.1980	2.7	4.1	6.2	93	6.9	4.5	4.8	9.2	78	6.0
E+SEc	3	3.07.1981	1.8	8.1	9.4	74	6.0	5.6	7.8	9.8	39	6.3
E+SEa	4	21.08.1979	0.8	3.6	7.5	94	1.3	2.7	6.3	8.5	68	2.0
S+SW+Wc	5	27.07.1982	4.2	5.9	7.8	69	5.7	2.2	7.4	10.0	56	5.0
Ca	3	22.08.1981	-0.6	1.2	5.0	98	8.0	2.0	5.1	7.2	69	2.7
Cc	8	13.06.1981	-1.6	1.7	4.1	86	4.3	-0.1	0.8	2.0	69	6.7

cont.

Svea Gruber Tmin	Svea Gruber Ti	Svea Gruber Tmax	Svea Gruber U	Svea Gruber C	Hornsund Tmin	Hornsund Ti	Hornsund Tmax	Hornsund U	Hornsund C	Björnöya Tmin	Björnöya Ti	Björnöya Tmax	Björnöya U	Björnöya C
-15.5	-12.9	-10.2	–	5.7	-13.6	-10.4	-7.6	69	–	-6.6	-5.9	-2.5	60	7.7
-22.0	-20.9	-14.9	70	1.7	-18.8	-16.6	-9.7	71	2.1	-6.5	-5.7	-1.9	89	6.0
-26.8	-26.5	-22.4	–	2.0	-23.0	-21.6	-17.0	74	8.0	-17.8	-7.4	-4.0	89	8.0
-5.0	-2.6	1.5	62	6.0	-3.7	-1.7	2.2	77	7.6	-3.0	-0.8	4.5	92	4.7
-33.0	-27.4	-23.3	–	1.7	-21.8	-19.3	-18.0	74	5.0	-22.5	-16.4	-14.0	83	3.0
-20.3	-16.0	-11.4	82	4.3	-13.8	-9.4	-4.6	85	5.9	-6.4	-4.5	-2.4	91	6.0
2.8	5.0	9.0	–	8.0	3.2	4.8	5.7	88	7.9	1.3	1.9	3.0	93	8.0
3.5	5.4	6.7	–	8.0	2.4	5.8	6.5	70	7.7	1.6	1.9	3.9	98	8.0
2.3	3.1	7.3	69	0.6	1.8	3.0	6.0	78	4.0	3.8	3.9	5.6	92	8.0
1.6	4.1	6.2	–	4.7	0.7	3.1	4.7	88	3.5	2.0	6.6	8.1	96	8.0
1.5	6.6	8.4	–	2.7	1.2	4.3	6.2	83	–	1.0	2.1	3.3	88	6.3
-0.4	1.3	2.4	–	7.0	-1.1	1.3	2.5	79	7.0	0.1	1.2	2.3	82	7.0

Tmin – daily minimum air temperature (in °C), Ti – mean daily air temperature (in °C) computed from 3 climatological observation times, i.e. 07, 13 and 19 LMT, Tmax – daily maximum air temperature (in °C), U – relative air humidity (in %), C – degree of cloudiness (in scale 0–8).

Air temperature

When air masses from northern and southern sectors inflow during PN, the air temperature on western coast of Spitsbergen falls accordingly with latitude. Between the warmest (Hornsund) and coldest (Ny Ålesund) areas the smallest differences are for T_{min} (1.3°C at both stations) and much greater (*ca.* twice for situation $S+SW+W_c$ and *ca.* three times for situation $NW+N+NE_c$) for T_i and T_{max} (Table 5). During circulation types $E+SE_a$ and $E+SE_c$ the central area (Svea Gruber and Svalbard Lufthavn) is definitely the coldest and the northern one (Ny Ålesund) is the warmest. The differences in T between these areas reach 6–8°C for all the thermic parameters.

During the synoptic situation C_a spatial distribution of T in PN is similar to circulation types $E+SE_a$ and $E+SE_c$. The differences are even greater, especially as regards T_i and T_{max}. They reach *ca.* 10°C between the coolest (Svea Gruber) and the warmest area, whereas the difference of T_{min} reaches only 6°C. The lowest cloudiness resulting in intensive heat escape from ground and atmosphere to the space was conducive to occurrence of the lowest T values at Svea Gruber. During the circulation type C_c it was the coldest at Svea Gruber and the warmest at Hornsund. The mean daily T were -16.0°C and -9.4°C respectively. Similar differences between the mentioned areas were also reported for T_{min} and T_{max}. During PD, especially in summer, the influence of atmospheric circulation on spatial distribution of T is different from the one during PN. Not only the values of thermic differences between particular areas of western coast of Spitsbergen change, but also sometimes their sign (Table 5).

During inflow of air masses from northern sector (8th July 1980) it was the warmest at Svea Gruber and the coolest at Ny Ålesund (mean daily values were 5.0°C and 4.1°C respectively). A much bigger difference was recorded in T_{max} (2.8°C). In turn, T_{min} was very similar at all the stations, except Svalbard Lufthavn.

At the circulation type $E+SE_c$ the northern part of western coast was the warmest (from Ny Ålesund to Svalbard Lufthavn). Mean daily T was close to 8.0°C and T_{max} exceeded 9.0°C. The high values of T were caused probably by frequent processes of foehnization occurring at inflow of air masses from the eastern sector, as proved by low values of U, particularly at Svalbard Lufthavn (39%). Further to the south the mean daily T oscillated between 5° and 6°C. As regards their values, T_{max} were mostly differentiated.

At synoptic situation $E+SE_a$ it was the warmest at Svalbard Lufthavn where air foehnization probably took place (all the three thermic parameters were the highest there). In the remaining area T_i were as much as twice lower, oscillating between 3.0 and 3.6°C. It was the coolest at Hornsund on that day, mainly due to the highest cloudiness (4.0).

When air masses flew from a southern sector (27th July 1982) it was the coolest in the southern part of western coast of Spitsbergen, *i.e.* at Hornsund and at Svea Gruber, and the warmest at Svalbard Lufthavn. The difference of T_i between stations Hornsund and Svalbard Lufthavn was as much as 4.3°C. Probably, also at this type of circulation (like the two previous ones), the air underwent the foehnization process, but only in the area between Svalbard Lufthavn and Ny Ålesund. What is to be explained by occurrence of much lower values of U (*ca.* 20–30%) and greater cloudiness.

Circulation type C_a at PD (like at PN) is inducive to occurrence of greater thermic differences on western coast of Spitsbergen. In that time difference T_i reached as much as 5.4°C between the warmest (Svea Gruber) and the coolest (Ny Ålesund) areas. It should be noted that the situation was reverse when compared to the PN period, while analyzing the spatial distribution of T.

The smallest differences of T on western coast of Spitsbergen occurred at the circulation type C_c. They were less than 1.0°C for T_i, $\leqslant$1.5°C for T_{min} and $\leqslant$2.1°C for T_{max}.

The analysis indicates that both at PD and PN the greatest thermic differentiation on western coast of Spitsbergen occurs at the circulation type C_a. However, it is the lowest during PN when there is advection of air masses from northern and southern sectors and during PD at advection from the northern sector and for the type C_c.

Relative air humidity

During PN at the inflow of air masses from a northern sector, the clearly highest U occurs in northern part of western coast (Ny Ålesund – 88%) and the lowest in its central part (Svalbard Lufthavn – 58%). It rises further to the south to reach 69% at Hornsund (Table 5).

Advection of air masses from an eastern sector (circulation types $E+SE_a$ and $E+SE_c$) causes occurrence of the lowest U (55–65%) between Ny Ålesund and Svalbard Lufthavn, and the highest between Svea Gruber and Hornsund (*ca.* 70–75%).

At inflow of air masses from a southern sector a relative humidity reaches the highest values in northern (Ny Ålesund) and southern (Hornsund) parts of western coast of Spitsbergen, where mean daily values reached 81 and 77% respectively. They were the lowest in the center and reached 65–70%.

The lowest spatial differentiation of U (to *ca.* 10%) in the investigated area occurred at circulation types C_a and C_c. In the area between Hornsund and Svea Gruber a mean daily value of U was equal 80% and *ca.* 70% further to the north.

During PD at all circulation types the highest mean daily values of U occurred in northern (Ny Ålesund) and southern (Hornsund) part of western coast of Spitsbergen, what agrees with mean annual distribution of this element in the area (*cf.* Tables 4 and 5). It should be added that higher values of

U occurred more often in the north. They were different only at the circulation type $S+SW+W_c$.

Conclusion and final remarks

1. Air temperature on western coast of Spitsbergen is more connected with the degree of climate continentality than with the latitude. The lowest mean annual five-year T values occur in the central part (Svea Gruber /-7.4°C/ and Svalbard Lufthavn /-6.8°C/), where this degree is the highest.

2. In annual course of T based on the monthly five-year temperatures the greatest thermic differences occur from November to February (*ca.* 1–4°C) and the lowest in May–June and August–October (from 0.0 to 1.5°C).

3. The highest mean annual five-year values of U occurred in the northwest (Ny Ålesund – 79%) and in southwest (Hornsund – 77%) coasts of the island. The greatest mean monthly differences of U between the central coast and southwestern and northwestern coasts are in summer (*ca.* 10–15%) with tendency to decrease in winter (0–9%).

4. Atmospheric circulation acts as a very important factor in distribution of T nad U on western coast of Spitsbergen. Its influence on T is greater during PN than PD. The situation is reverse in the case of U.

5. Although the most suitable examples were analyzed, the analysis of spatial differentiation of T and U on western coast of Spitsbergen on the basis of selected synoptic situations does not allow to generalizations. Climatological formulation requires spatial differentiation of these elements to be defined with the largest possible number of occurrences of particular circulation types *e.g.* in a given month or season. Such analysis, in spite of being time-consuming, is supposed to be made later. So far, there have been surveys dealing with influence of atmospheric circulation (using numerous occurrences of particular circulation types in a given month or season of a year) on air temperature and humidity (Niedźwiedź 1987, Przybylak 1992) at Hornsund.

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Streszczenie

W artykule przedstawiono zróżnicowanie przestrzenne temperatury (T) i wilgotności względnej (U) powietrza na zachodnim wybrzeżu Spitsbergenu w okresie 1979—1983. Do analizy wykorzystano dane meteorologiczne ze stacji: Ny Ålesund, Svalbard Lufthavn, Svea Gruber, Hornsund i Björnöya, leżących na obszarze niezlodowaconym w przybliżeniu na tej samej długości geograficznej, wysokości n.p.m. i odległości od morza (fig. 1). Stąd też stwierdzone tu zróżnicowanie przestrzenne warunków termicznych i wilgotnościowych jest efektem wpływu czynników solarnych, cyrkulacyjnych (atmosfery i oceanu), zasięgu lodów morskich wokół wyspy oraz warunków lokalnych. Wpływ cyrkulacji atmosferycznej na rozkład przestrzenny T i U na zachodnim wybrzeżu Spitsbergenu został ukazany przy wykorzystaniu wydzielonych 10 typów cyrkulacji.

W badanym obszarze T wykazuje większy związek ze stopniem kontynentalizmu klimatu niż z szerokością geograficzną (por. tab. 1—3, figs. 2 i 3). Najniższe średnie roczne 5—letnie T występują w środkowej części zachodniego wybrzeża Spitsbergenu (Svea Gruber -7,4°C i Svalbard Lufthavn -6,8°C), gdzie stopień ten jest najwyższy. W zimie jest tutaj najchłodniej a latem najcieplej. Odwrotna sytuacja pod tym względem, występuje w Hornsundzie. W przebiegu rocznym T według średnich miesięcznych 5—letnich (fig. 2) największe różnice termiczne między tymi stacjami występują w okresie listopad—marzec (ok. 1—4°C), a najmniejsze w okresach maj—czerwiec i sierpień—październik (0,0—1,5°C).

Najwyższe średnie roczne 5—letnie wartości U wystąpiły na NW (Ny Ålesund — 79%) i na SW wybrzeżach wyspy (Hornsund — 77%) (tab. 4 i fig. 4). Największe średnie miesięczne różnice U między środkowym wybrzeżem i jego SW i NW wybrzeżami są latem (ok. 10—15%), ulegając znacznemu zmniejszeniu w zimie (0—9%).

Cyrkulacja atmosferyczna nad obszarem Spitsbergenu odznacza się wyraźną sezonowością, która związana jest ze zmieniającym się w przebiegu rocznym gradientem termicznym między wysokimi i umiarkowanymi szerokościami geograficznymi. Powoduje ona większe zróżnicowanie T na zachodnim wybrzeżu Spitsbergenu w okresie PN niż w PD (tab. 5). W przypadku U sytuacja jest odwrotna.

Dla obydwu analizowanych sezonów roku największe zróżnicowanie termiczne na badanym obszarze występowało przy typie cyrkulacji C_a. Najmniejsze było ono natomiast w okresie PN przy adwekcji mas powietrza z sektorów N i S, a w PD przy adwekcji z sektora N oraz przy typie C_c (tab. 5).

W okresie PD przy wszystkich typach cyrkulacji najwyższe średnie dobowe wartości U występowały na północnym (Ny Ålesund) i południowym (Hornsund) fragmencie zachodniego wybrzeża Spitsbergenu, co jest zgodne ze średnim rocznym rozkładem tego elementu na tym obszarze. W okresie PN sytuacja jest bardziej skomplikowana. Najmniejsze zróżnicowanie przestrzenne U (do ok. 10%) na badanym obszarze wystąpiło przy typach cyrkulacji C_a i C_c (tab. 5).