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EXPOSURE-DEPENDENT VARIATIONS IN AIR TEMPERATURE AND HUMIDITY ON THE MORAINE OF THE AAVATSMARK GLACIER (NW SPITSBERGEN) IN THE SUMMER SEASON OF 2010

Abstract: The article presents results of research on the development of air temperature and relative humidity at a height of 5 cm above the active surface of the terminal lateral moraine of the Aavatsmark Glacier, relative to its exposure in the summer season of 2010. Variations in the two conditions were analysed for five measurement sites situated on northerly (S_N), easterly (S_E), southerly (S_S) and westerly (S_W) slopes, as well as on the flat top surface of the moraine (S_{Top}), in different weather conditions. The article also includes a temperature and humidity stratification in the near surface air layer (5–200 cm) above the moraine. The issues were investigated for mean values from the whole period of research, as well as for individual days demonstrating distinct degrees of cloudiness and wind speed.

Key words: air temperature and humidity, microclimate, synoptic situations, Kaffiøyra, Spitsbergen

Introduction

One of the basic objectives of any micro- and topoclimatic studies is to determine the spatial diversity of various climatic elements on a local level. In the polar regions, at high latitudes, the factors that affect microclimatic variations of minor terrain features, such as the Aavatsmark Glacier moraine analysed in this article, are the amount of incoming solar radiation, the slope of land, type of ground surface and cover, etc. The heat balance leads to a specific thermal regime of the ground surface and the near surface air layer. The type of active surface and the nature of its cover (including vegetation) are the most influential factors on the air humidity conditions in the near surface layer, and less so in higher air layers. The near surface layer of the atmosphere warms up or cools down at the air-ground interface due to molecular conductance and a turbulent heat exchange. Changes in temperature, connected with advection of warmer or cooler air masses, can also influence to some extent the energetic processes on a local level.

As regards the area of Kaffiøyra, there has been only one study on the exposure-dependent changes in air temperature patterns on the active surface of the Aavatsmark Glacier moraine (Araźny and Grześ 2000). In that article, the authors presented, for example, the values of air temperature at a height of 1 cm above the surface of the moraine in question. Although in the area of Kaffiøyra research into temperature and humidity stratification of the near surface air layer has been carried out since the summer of 1980 (Wójcik et al. 1989; Przybylak et al. 1993), this kind of research for the rest of Spitsbergen is scarce (cf. Baranowski 1968; Markin 1975).

In this article, main factors driving variations of air temperature and humidity in near surface layer (5–200 cm) above the moraine in the summer season of 2010 are presented.

Materials and methods

Field research was performed in the summer season (from 8 July until 31 August 2010) on five measurement sites on the slopes facing north (S_N), east (S_E), south (S_S) and west (S_W), and on the flat top surface of the moraine (S_{Top}) of the Aavatsmark Glacier (Fig. 1). The moraine is situated in the north of the Kaffiøyra Plain (φ = 78°41’34” N; λ = 11°51’39” E). S_{Top} is situated at 11 m a.s.l., while the other sites are 2 m lower (Fig. 2). The moraine is located on the terminal-lateral moraine of the Aavatsmark Glacier, which consists of sandy clay, gravelly clay and loamy clay. The surface of the moraine is dark and thus has a low albedo. It is covered with vegetation to approximately 20% (Araźny 2012a).

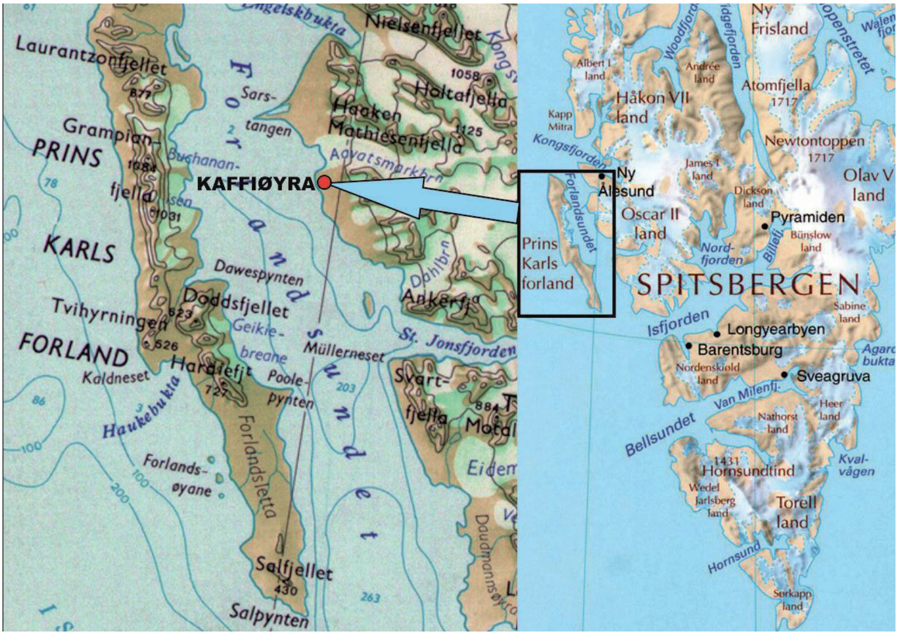

Fig. 1. Location of the research area on Spitsbergen

Fig. 2. Moraine of the Aavatsmark Glacier with the weather station (as seen from NW) and three visible sites of microclimatic measurements (S_{Top}, S_N and S_W) (photo by A. Araźny)

Measurements of temperature and humidity were carried out using MadgeTech automatic loggers, installed in radiation-proof enclosures at a height of 5 cm a.g.l. Before measurements were started, readings of the equipment were verified against calibrated mercury-in-glass thermometers. In this paper, meteorological data obtained from a Davis Vantage Pro 2 automatic weather station were also used. The device had sensors placed at a height of 200 cm a.g.l. (Fig. 2). Measurements of the elements were recorded at 10-minute intervals, which enabled not only a description of micro- and topoclimatic characteristics, but also of the dynamic of short-term changes. Maximum and minimum diurnal values of air temperature (Tmax and Tmin, respectively) and of relative humidity (f max and f min) were selected from 144 10-minute values recorded during a day.

In order to present the characteristics of atmospheric circulation in the examined area for individual days, the calendar of circulation types for Spitsbergen was used (Niedźwiedź 2011). The author identified 21 circulation types for Spitsbergen, denominated in the catalogue as follows: Na, Nc – situations with northerly advection of the air, NEa, NEc – north-easterly advection, Ea, Ec – easterly advection, SEa, SEc – south-easterly advection, Sa, Sc – southerly advection, SWa, SWc – south-westerly advection, Wa, Wc – westerly advection, NWa, NWc – north-westerly advection, Ca – central anticyclonic situations, no advection, anticyclonic centre, Ka – anticyclonic wedge, Cc – central cyclonic situations, Bc – cyclonic trough, X – other situations, non-classifiable, including barometric cols. The letter 'a' is added to identify anticyclonic (high-pressure) systems, and 'c' is used to denominate cyclonic (low-pressure) systems. More details about atmospheric circulation types that occur on Spitsbergen can be found in the work of Niedźwiedź (1993).

RESULTS

General weather conditions in the summer of 2010

In the summer season of 2010, northern sector types were evidently much more frequent as compared with the multiannual period of 1975–2005. Their anomalies amounted to approx. 20% and 10% for the anticyclonic and cyclonic type, respectively. Particularly high negative anomalies (approx. 13%) were found in easterly types, which did not occur at all. Such specific atmospheric circulation resulted in a cool summer (Przybylak and Maszewski 2012).

The mean air temperature (Ti) (calculated from 10-minute values) at a height of 200 cm over the moraine was 4.6°C for the whole studied period of 2010. The values of air temperature revealed a high day-to-day variability over the whole period (Fig. 3). From the beginning of measurement until the middle of August the air temperature was gradually decreasing. On 16 August the absolute minimum temperature was recorded (–0.4°C). Towards the end of week 3 of August the temperatures rose with the absolute maximum temperature recorded on 20 August (11.3°C). After that, the air temperature was systematically decreasing to the end of the measurements. The absolute amplitude of air temperature amounted to 11.7°C for the whole period.

The mean degree of cloudiness (C) in the summer of 2010 was 8.6 (Kejna 2012), the highest amount of clouds was observed between 11 and 20 July (9.6), whereas the smallest cloud cover occurred between 11 and 20 August (7.8) (Fig. 3). In the summer season of 2010, the sunshine duration (SS) amounted to 259.8 hours. The sunniest ten-day period occurred at the end of August (76.8 h), whereas the least amount of sunshine was recorded in the ten-day period of 11–20 July (24.5 h) – Figure 3. The relative sunshine duration was as low as 19.6% (Kejna 2012).

Mean diurnal values of relative humidity (fi) at 200 cm a.g.l. were high (Fig. 3) and ranged from 72% (20 August) to 99% (17 July), with the mean reaching 89% (Araźny et al. 2011). This somewhat uniform course of day-to-day relative humidity and its high values were caused by low temperatures, the proximity of the Arctic ocean and an intense cyclonic activity, which carries humid air from over the North Atlantic.

In the whole period of observations, the average speed of wind (v) at 200 cm over the examined moraine amounted to 5.2 ms^{-1} according to measurements recorded automatically every 10 minutes. The wind on the S_{Top} site, just like in the whole area of Kaffiøyra, is stronger due to a tunnel effect observed along the Forlandsundet (NNW-SSE) (Przybylak and Araźny 2006).

What follows from an analysis of the weather conditions on the Kaffiøyra Plain in the summer season of 2010 (i.e. from 21 July until 31 August) is that the period in question revealed the highest wind speed and the lowest precipitation (only 8.5 mm) of all 19 seasons ever analysed, when compared with mean values calculated for the years of 1975–2011. It was also the second coldest summer season of the time (together with the summer of 1980) (Przybylak and Araźny 2012).

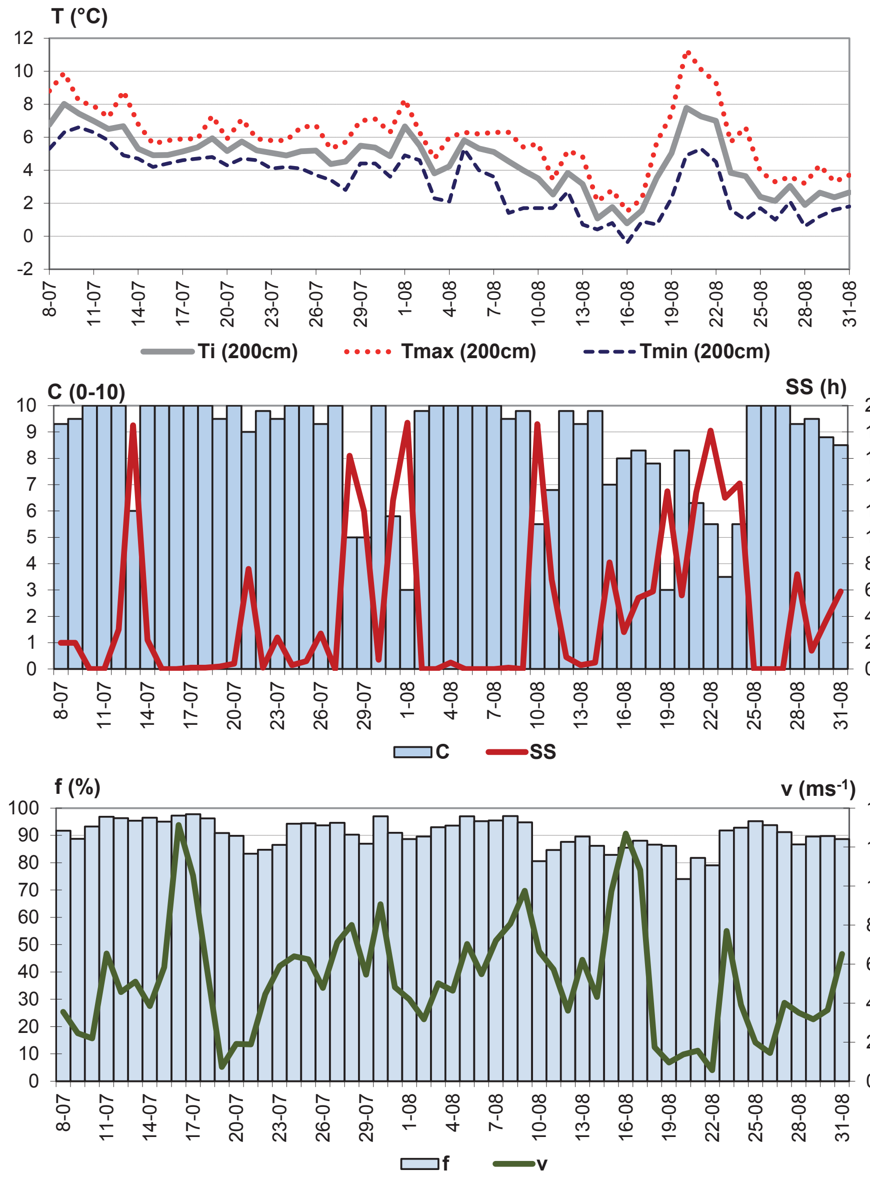

Fig. 3. Courses of selected meteorolgical elements at the Base Station on the Kaffiøyra Plain in summer 2010: air temperature (Ti, Tmax and Tmin), cloudiness (C), actual sunshine duration (SS), relative humidity (f) and wind speed (v)

Temperature of the air

The course of mean daily air temperature at a height of 5 cm over the active surface of the terminal lateral moraine of the Aavatsmark Glacier is very similar to the one observed at 200 cm a.g.l. (Figs 3 and 4). The differences between mean values on all four slopes are negligent, reaching only 0.2°C (Table 1). In the summer season of 2010, the lowest mean air temperatures were recorded at the top of the moraine (5.5°C). The highest values were expected to be found on S_S and S_W slopes, which are the most exposed to the sun. Nevertheless, in the whole summer season the warmest slopes (5.8°C) were S_N and S_E. On individual occasions, predominantly on days with a high sunshine duration (e.g. 13 July; 10, 21 and 29–31 August), the S_S slope was indeed the warmest (Fig. 4); however it must be noted that on those days the wind blew exclusively from NW-NNW. In those circumstances the air was fairly strongly warmed, for Arctic conditions, on the opposite sides of the S_S and S_W slopes.

Table 1. Air temperature values (°C) at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S, S_{Top}), in the period of 8 July–31 August 2010

Site/Variable	Ti	Tmax	Tmin	DTR	Tmax abs	Tmin abs
S_N	5.8	8.1	3.9	4.2	15.0	−0.7
S_E	5.8	8.2	3.8	4.5	15.7	0.1
S_W	5.7	8.4	3.7	4.6	15.7	−0.4
S_S	5.6	8.4	3.6	4.8	15.6	−0.1
S_{Top}	5.5	7.5	3.8	3.7	12.8	−0.3

Explanations: Ti, Tmax, Tmin, Tmax abs, Tmain abs – parameters of air temperature; DTR- diurnal temperature range

The ranges of mean maximum and minimum values of air temperature on the four slopes demonstrated a similar trend. The difference between the highest mean maximum temperature on the S_S and S_W slopes (both 8.4°C) and the lowest mean maximum temperature on S_N (8.1°C) was just 0.3°C. Similarly, the difference between the highest mean minimum temperature on the S_N slope (3.9°C) and the lowest one on the S_S slope (3.6°C) was also 0.3°C (Table 1).

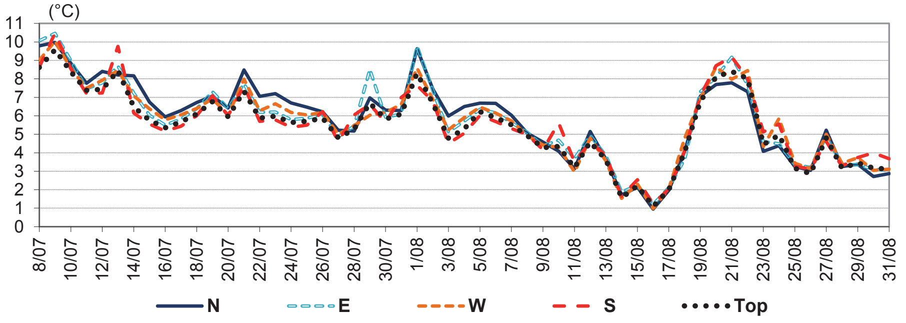

Fig. 4. Courses of mean daily air temperature at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), in the summer of 2010

In the summer of 2010, the lowest mean amplitude of air temperature (3.7°C) occurred on S_{Top}, whereas the highest mean was observed on the S_S slope (4.8°C). The absolute amplitude for the whole period of measurements was 16.4°C. The highest maximum temperature (15.7°C) was recorded twice: first, at 11.30 on 8 July on S_E (circulation type Sc) and then at 17.20 on 20 August on S_W (circulation type NEa). On the other hand, the lowest temperature (–0.7°C) was recorded at 06.50 on 16 August on the S_N slope (circulation type Nc). These results corroborated multi-annual correlations, according to which – in the summer – the coldest air masses flow to the area of Kaffiøyra from the N–NW sector (2.4–3.4°C), whereas the warmest air is brought from the S–NE sector (>6°C). Generally, the type of pressure system is not very important (Przybylak et al. 2012).

Figure 5A presents the mean diurnal course plotted on the basis of data logged from 144 measurement times on 5 sites (S_N, S_E, S_W, S_S and S_{Top}). The dates on which minimum and maximum temperatures occurred depend on the path of the sun and weather conditions. The highest mean amplitude of temperature (3.0°C) was observed on the S_S slope, whereas the lowest values (2.1°C) were characteristic of S_{Top} and S_N (2.3°C) (Fig. 5A).

On individual days, the diurnal courses of air temperature in the near surface layer of the air are often considerably different from the mean course, which was mainly caused by the occurrence of various synoptic situations. Two days were selected for a detailed analysis of the measurements: 1 August and 5 August 2010. The first day was very sunny with 18.7 h of actual sunshine duration (77.9% relative sunshine duration) and the

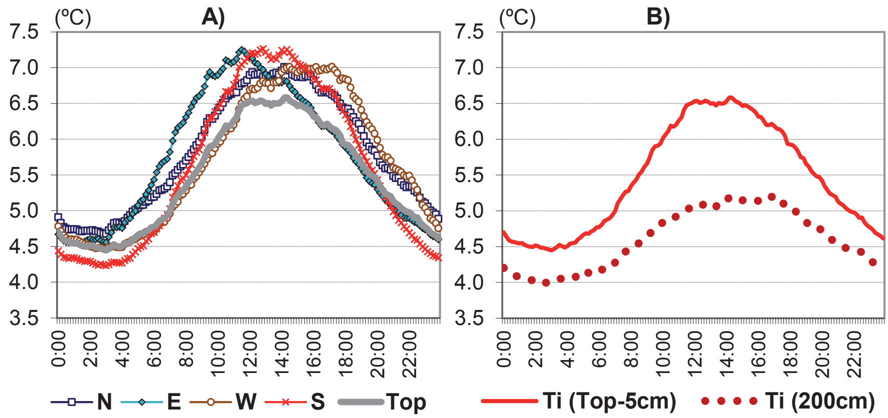

Fig. 5. A) Mean diurnal courses of air temperature at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), and B) at 5 and 200 cm over the top of the moraine in the period of 8 July – 31 August 2010

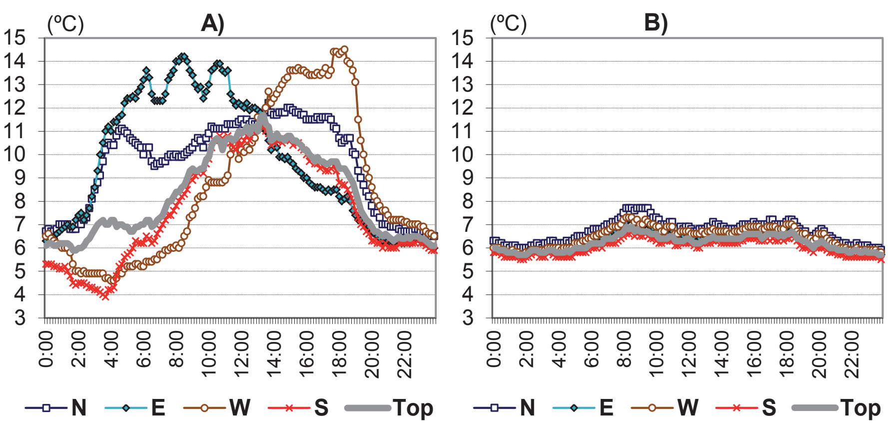

Fig. 6. Mean diurnal courses of air temperature at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}) on selected days: A) 1 August 2010 – with a low degree of cloudiness, and B) 5 August 2010 – with completely overcast sky, in the area of Forlandsundet

synoptic pattern of the NEc type, while the other day was overcast with a Ka synoptic pattern (Figs 6A and 6B). On the sunny day, the air temperature was quickly rising from morning hours on the S_N and S_E slopes. At about 13.00, the temperatures became even (settling at approx. 11.5°C) on all the sites. In the afternoon, on the S_W slope the air temperature reached its maximum value (14.5°C) of all the sites on the moraine on that day. On the other day, i.e. 5 August, the diurnal amplitudes of air temperature on all the sites were recorded to approx. 2°C. It must be noted that on 5 August even the S_N slope was slightly warmer than S_S. A similar situation occurred on the first of the analysed days, 1 August, in the afternoon. That was a result of high wind speeds from the prevalent SSE direction, along the Forlandsundet.

As mentioned earlier, a number of factors contribute to the spatial diversity of air temperature in the near surface layer. In order to come back to the influence of wind speed and direction on the exposure-dependent temperature values we shall now refer to Figures 7A and 7B, showing courses of mean diurnal temperatures during 8 windy days ($v > 8$ ms^{-1}) and 9 days with very light wind ($v < 2$ ms^{-1}). On four of the days with high winds the prevailing direction was NNW, whereas on the other four days the winds blew from SSE. On those days the amplitudes of air temperature were low (2–2.5°C) on all sites. On the windy days both mean maximum and mean minimum temperatures occurred at each site at the same time (Fig. 7A). On the eight examined days with high winds the mean air temperature on all 4 slopes (S_N, S_E, S_W and S_S) was identical (4.0°C). This was due to intense and turbulent mixing of the air. The temperature on the S_{Top} site was slightly lower on those days (3.9°C). These findings were supported by observations from individual days, e.g. from 16 July (Fig. 8A). However, on the days with very light wind, both the courses of mean temperatures (for 9 days – Fig. 7B) and for individual days (Fig. 8B) show a relationship between the temperature (and its maximum values in particular) and the position of the Sun, as well as the prevalent weather. The south and west slopes (S_S and S_W) are evidently thermally privileged as compared to the thermally impaired north and east slopes (S_N and S_E). For example, on the nine days with $v < 2$ ms^{-1}, the mean temperature was the highest on the S_S and S_W slopes (6.8°C), but the lowest on S_N and S_{Top} (6.5°C).

Correlations between series of mean daily values of air temperature at a height of 5 cm over the moraine (S_N, S_E, S_W, S_S and S_{Top}) and the values registered in a standard instrument shelter (Ti, Tmax and Tmin) at 200 cm are very strong (Table 2). All the correlations are statistically significant on the level of $p < 0.05$. The relationship between air temperature on the slopes and the wind speed is also strong and statistically significant (except for Tmin). In all other combinations of data series covering other weather elements the correlations are very weak. As expected, strong and statistically

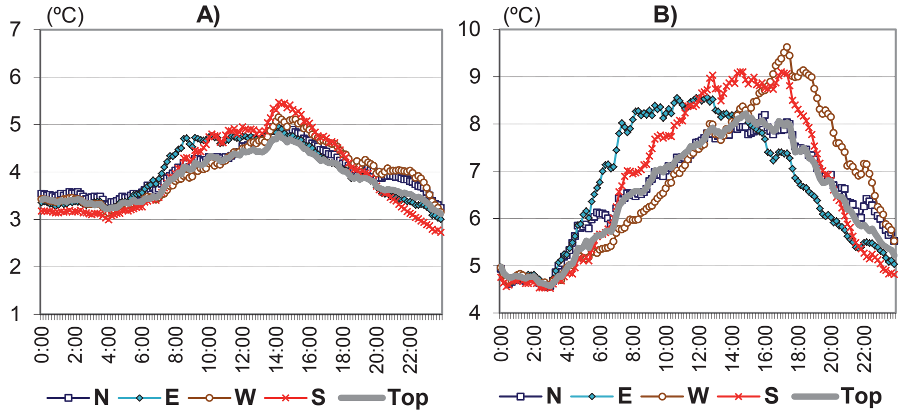

Fig. 7. A) Mean diurnal courses of air temperature at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}) A) on days (n=8) with high wind (v > 8 ms^{-1}) and B) on days (n=9) with very light wind (v < 2 ms^{-1})

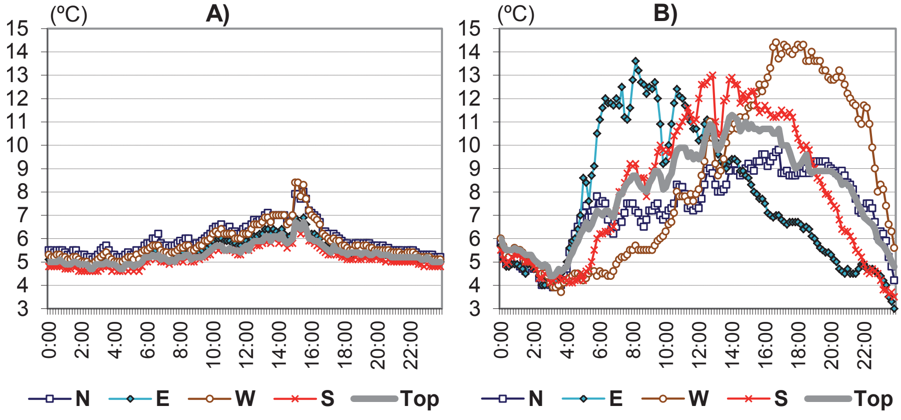

Fig. 8. Mean diurnal courses of air temperature at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}) on selected days: A) 16 July 2010 – with high wind, and B) 22 August 2010 – with light wind, in the area of Forlandsundet

significant correlations were found between series of air temperature on the S_S slope and sunshine duration.

The thermal conditions at the standard height of 200 cm over the top of the Aavatsmark Glacier moraine deviate from the characteristics of the near surface air layer. Figure 5B presents courses of mean diurnal air temperature at 5 and 200 cm above the level of the moraine in the period of 8 July – 31 August 2010. In the whole period of observations the mean temperature at 5 cm was 0.9°C higher than the temperature at 200 cm. The recorded diurnal amplitude of temperature was higher at 5 cm (2.1°C) than at 200 cm (1.2°C). Over the surface of the glacier moraine (up to 2 m) the mean vertical gradient was 0.44°C/1 m. On individual days, the thermal stratification in the near surface air layer is more diversified than the mean values for the whole period. On the 8 days with high wind the mean gradient was smaller than average and was equal to 0.26°C/1m, whereas on the 9 days with light wind it was larger (0.51°C/1 m).

Table 2. Matrix of coefficient correlations of mean daily values of selected meteorological elements over the Aavatsmark Glacier moraine (NW Spitsbergen) in the period of 8 July–31 August 2010

Variable	Ti S_E	Ti S_W	Ti S_S	Ti S_{Top}	Ti	Tmax	Tmin	f	v	C	SS
Ti S_N	**0.97**	**0.97**	**0.91**	**0.97**	**0.94**	**0.87**	**0.91**	0.14	**−0.36**	0.01	0.06
Ti S_E		**0.96**	**0.96**	**0.99**	**0.95**	**0.91**	**0.88**	0.03	**−0.40**	−0.13	0.19
Ti S_W			**0.96**	**0.99**	**0.97**	**0.93**	**0.88**	0.07	**−0.41**	−0.07	0.16
Ti S_S				0.98	0.95	0.94	0.84	−0.04	**−0.43**	−0.20	**0.30**
Ti S_{Top}					**0.98**	**0.94**	**0.89**	0.04	**−0.40**	−0.11	0.19
Ti						0.95	0.92	0.07	**−0.32**	−0.04	0.11
Tmax							**0.78**	−0.06	**−0.40**	−0.19	0.27
Tmin								0.20	−0.21	0.16	−0.07
f									**0.33**	**0.44**	**−0.48**
v										0.07	−0.14
C											**−0.92**
SS											

Explanations: values of correlation coefficients statistically significant at the level of 0.05 are shown in bold; Ti S_N, Ti S_E, Ti S_W, Ti S_S and Ti S_{Top} – 5 cm; Ti, Tmax, Tmin, f, v – 200 cm

In the summer season of 1998 (10 August – 2 September) similar observations were carried out on the moraine. The air temperature was measured four times a day at a height of 1 cm over the active surface of the Aavatsmark Glacier moraine, depending on the exposure (Araźny and Grześ 2000). At that time, the authors found the situation to be 'normal', i.e. the warmest slopes were S_S and S_W, due to the general weather conditions during that summer, which had the highest mean temperature values of all 19 seasons examined in the years 1975 – 2011, whereas its mean speed of wind was 1.8 ms^{-1} lower than in 2010 (Przybylak and Araźny 2012).

Relative humidity of the air

The water vapour content in the air on Spitsbergen is not very high in the summer, because of the low temperatures. They would be even lower if Spitsbergen were not an island and, as such, were not subject to intense cyclonic activity. The air humidity over the surface of the Aavatsmark Glacier moraine undergoes significant changes depending on the direction of advection. There is less water vapour in the air masses coming from the northern than from the southern sector (Araźny et al. 2011; Araźny 2012b).

The course of mean daily values of relative humidity at a height of 5 cm over the active surface of the glacial moraine is close to the corresponding course of relative humidity of the air at 200 cm (Figs 3 and 9). The mean values of humidity for the whole period of observations on the four slopes: S_N, S_E, S_W and S_S oscillated from 92% to 93% (Table 3). Differences between the mean values were so small (1%) that they actually fall within the measurement error. The highest mean relative humidity of the air occurred on the top of the moraine (95%). The mean minimum relative humidity at the five points of exposure is more varied than its mean maximum values. The difference between the highest mean minimum relative humidity (86%) on S_{Top}, and the lowest mean value from the S_W slope (80%) was 6%. On the other hand, the difference between the highest mean maximum relative humidity on S_{Top} and S_S (100%) and the lowest mean value from the other sites, i.e. the S_N, S_E and S_W slopes (99%) was only 1% (Table 3).

The lowest mean amplitude of relative humidity (13%) was observed on the S_{Top} site, and the highest one on the S_W slope (19%). The absolute amplitude for the whole period of observations was 49%. Saturated air was frequently observed on all sites, while the lowest humidity (51%) was recorded on the S_W slope at 17.20 on 20 August (with NEa circulation type).

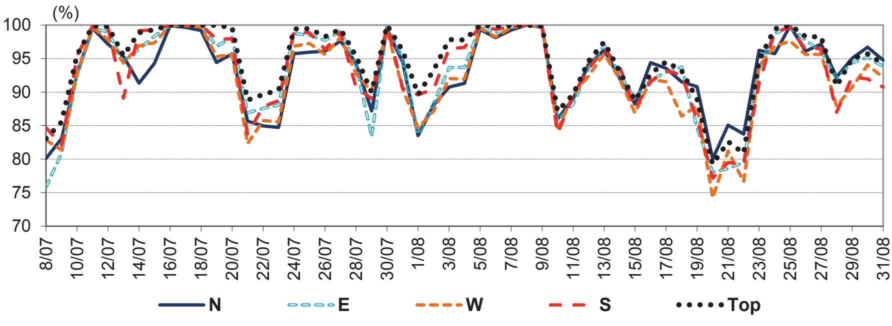

Fig. 9. Courses of mean daily relative humidity of the air at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), in the summer season of 2010

Table 3. Values of relative humidity of the air (%) at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), in the period of 8 July–31 August 2010

Site/Variable	Fi	f max	f min	DHR	f max abs	f min abs
S_N	93	99	84	15	100	63
S_E	93	99	84	15	100	57
S_W	92	99	80	19	100	51
S_S	93	100	81	18	100	57
S_{Top}	95	100	86	13	100	63

Explanations: fi, f max, f min, f max abs, f main abs – parameters of humidity; DHR- diurnal humidity range

The mean diurnal course of relative humidity is the opposite of the mean diurnal course of air temperature. Averaged diurnal courses of relative humidity on individual sites demonstrate one diurnal minimum and one maximum (Fig. 10A). The lowest mean value of humidity occurred most often at 12.00–17.00 CET, the time when the highest temperature of air was also observed.

The maximum values of relative humidity in the 'night time' and in the morning were connected with the minimum values of air temperature (Araźny 2012). Mean diurnal amplitudes are the lowest on the S_{Top} and S_N sites (7%), and the highest on the S_S slope (11%). On all five sites, the relative humidity is higher in the first half of the day, which is connected with lower air temperatures in that part of the day.

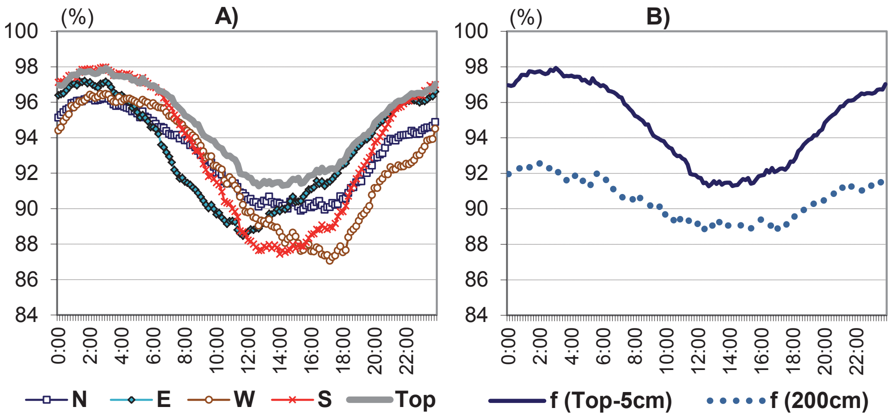

Fig.10. A) Mean diurnal courses of relative humidity of the air at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), at 5 and 200 cm over the top of the moraine, in the period of 8 July – 31 August 2010

As mentioned earlier, the diurnal courses, e.g. of relative humidity of the air, on individual days follow a different pattern from the mean courses. For example, on the sunny 1 August relative humidity substantially varied on individual slopes and on the top of the moraine (Fig. 11A). On 1 August, the highest amplitude of relative humidity (37%) was observed on the west slope (S_W). On the day when the sky was totally overcast (5 August), the values of relative humidity hardly changed throughout the day. On that day, deprived of the influx of direct solar radiation, the instantaneous values of relative humidity recorded on the sites were similar. Also, their amplitude was small (within the range of a few per cent) and was observed at the beginning of the day only (Fig. 11B).

In the period of observations, the mean relative humidity at 5 cm a.g.l. was 4% higher than the same value at 200 cm a.g.l. (95 and 91%, respectively). Over the surface of the moraine (up to 2 m), the mean vertical gradient calculated for the summer of 2010 was 2.1%/1m. On the selected 8 days with high wind only, the gradient was identical (2.1%/1m); however on the 9 days with light wind the value increased to 2.6%/1m.

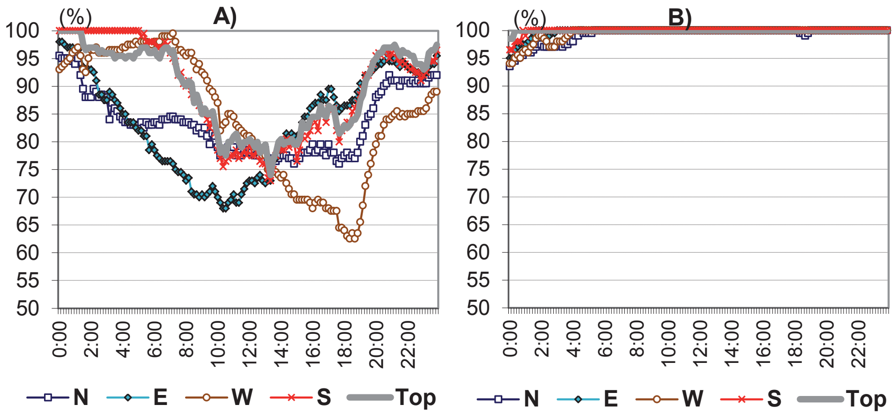

Fig. 11. Mean diurnal courses of relative humidity of the air at 5 cm over the Aavatsmark Glacier moraine (NW Spitsbergen), depending on the exposure (S_N, S_E, S_W, S_S and S_{Top}), on selected days: A) 1 August 2010 – with a low degree of cloudiness, and B) 5 August 2010 – with completely overcast sky, in the area of Forlandsundet

CONCLUSIONS

In the examined summer season of 2010, the general thermal and humidity conditions in the near surface layer of the air (5 cm) on the slopes of the Aavatsmark Glacier moraine were very similar, even characterised by different exposure to the Sun (S_N, S_E, S_W and S_S). The measurement site situated on the top of the moraine (S_{Top}) was the coldest (5.5°C) and the wettest (95%).

The times of occurrence of maximum and minimum values of air temperature are strongly related to the position of the Sun and the prevailing weather conditions. In a mean diurnal course, minimum values occurred on all sites at about 03.00 CET, whereas the maximum values were found to vary with the angle of solar radiation (from about 11.00 CET on the S_E slope, to about 17.00 CET on S_W).

Diurnal amplitudes of air temperature and humidity on cloudy days were low and uniform on all examined sites. They did not usually exceed 1–2°C (temperature) and approx. 5% (RH) on all the sites.

In sunny weather, the variability of temperature and humidity was very strong. On sunny days, the slopes inclined to the west or south were substantially more thermally privileged (at a few degrees Celsius) than the others. On days with radiation weather, in afternoon hours the differences in relative humidity of the air between individual sites exceeded 20%.

Except for the solar factor, the speed and direction of wind was found to be very influential on the temperature of the air over the Aavatsmark Glacier moraine (exposing to or sheltering from high winds). This was corroborated in strong and statistically significant correlations between the temperature of the air on the slopes and the speed of wind (the highest correlations were found for the S_W and S_S slopes).

In the near surface layer of the air, up to 2 m, the air temperature gradient on days with strong wind was only half of that on days with light wind (0.26 and 0.51°C/1 m, respectively). The wind speed was found to have little effect on the gradients of near surface humidity of the air.

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