Chapter 6

THE INFLUENCE OF ATMOSPHERIC CIRCULATION ON TEMPERATURE AND HUMIDITY CONDITIONS

Atmospheric circulation plays a crucial role in the shaping of the Spitsbergen climate. As regards the area of the Kaffiøyra, only four studies have been published so far, tackling the effects of atmospheric circulation on air temperature and precipitation (Wójcik et al. 1992; Araźny 1998; Przybylak and Araźny 2006 and Przybylak et al. 2012), nevertheless there is a deficiency of detailed studies on the influence of circulation on air humidity.

The data used in this Chapter comprises mean diurnal values of air temperature from the Base Station (KH) and mean values of relative humidity from the SAO site, as the sensor installed at KH failed. The SAO site was chosen because of its proximity to KH and the similar topoclimatic conditions at both places. Due to a lack of certain circulation types in the spring and autumn season, a decision was made to incorporate them as proposed by Przybylak (1992), and thus all identified circulation types have been included in the analysis of the influence of atmospheric circulation on temperature conditions.

6.1. The influence of atmospheric circulation on temperature conditions

Mean, maximum and minimum diurnal values of air temperature and absolute diurnal ranges for specific atmospheric circulation types on Spitsbergen are presented in Table 6.1 and Figure 6.1.

In the winter, the lowest values of mean diurnal air temperature were recorded during advection from the northern sector (NW+N+NE), both at anticyclonic circulation (-14.3°C), and - to a lesser extent - at the cyclonic type (-13.1°C) (Fig. 6.1). Inflowing air masses from the north contributed to prominent negative anomalies in air temperature (for NWa+Na+NEa, the anomaly reached -3.7°C, and for NWc+Nc+NEc, -2.5°C). The highest mean diurnal air temperatures were connected with an occurrence of the S+SW+W pattern, particularly with cyclonic circulation (-4.1°C) and, to a lesser extent, the anticyclonic type (-5.3°C). For the Sc+SWc+Wc pattern, the positive anomaly in air temperature reached 6.5°C, which was the highest of all the anomalies. The lowest mean temperatures were characteristic for the Ea+SEa pattern, occurring at anticyclonic and cyclonic circulation types (-29.1°C and -28.3°C, resp.). The highest recorded maximum temperature in the winter (3.6°C) was associated with the Sc+SWc+Wc pattern (Fig. 6.1).

Similarly to the mean diurnal values of air temperature, the lowest mean maximum temperatures (-11.7°C) and minimum temperatures (-16.8°C) occurred with the combined pattern of NWa+Na+NEa (Tab. 6.1).

Table 6.1. Mean diurnal maximum (*T*max) and minimum (*T*min) values and diurnal ranges (A) of air temperature (°C) observed during synoptic situation types identified at the KH site in the winter (November 2010 – March 2011), spring and autumn (April – May of 2011, September – October of 2010), and in the summer (June – August of 2011)

Types of circulation*	Winter				Spring and Autumn				Summer			
	Ti	T_{max}	T_{min}	A	Ti	T_{max}	T_{min}	A	Ti	T_{max}	T_{min}	A
NWa+Na+NEa	-14.3	-11.7	-16.8	5.0	-1.8	-0.7	-2.8	2.2	5.0	6.3	3.7	2.6
Ea+SEa	-12.7	-10.1	-15.4	5.3	0.7	1.7	-0.6	2.2	8.2	10.9	5.2	5.7
Sa+SWa+Wa	-5.3	-2.3	-8.9	6.5	0.1	1.6	-1.5	3.1	5.3	6.9	3.9	3.0
Ca+Ka	-10.1	-7.5	-12.6	5.0	-0.5	0.7	-2.2	3.0	4.7	5.9	3.4	2.5
NWc+Nc+NEc	-13.1	-11.0	-15.4	4.4	-3.5	-2.0	-4.9	2.9	5.3	7.7	3.8	3.9
Ec+SEc	-11.4	-8.6	-14.4	5.8	-2.1	-0.3	-4.0	3.8	6.0	7.4	4.6	2.8
Sc+SWc+Wc	-4.1	-1.1	-7.6	6.6	0.8	2.9	-1.0	3.9	2.2	2.9	1.4	1.5
Cc+Bc	-8.5	-5.0	-12.9	7.8	-1.4	0.4	-3.3	3.7	4.7	6.1	3.3	2.8
X	-11.8	-8.9	-14.3	5.3	-2.0	-0.1	-4.1	4.0	5.3	5.8	4.3	1.6
m	-10.6	-7.9	-13.6	5.7	-1.5	0.2	-3.1	3.3	5.1	6.7	3.7	2.9

Explanation: m – seasonal mean; * circulation type division acc. to Przybylak (1992)

In the transitional periods, unquestionably the lowest mean diurnal air temperatures (-3.5°C) occurred during advection from the northern sector (NW+N+NE), mostly in cyclonic circulation, but also the anticyclonic type (-1.8°C). The highest negative anomaly for the NWc+Nc+NEc pattern was -2.0°C. A characteristic feature of the above-mentioned combined patterns is the occurrence of relatively high values of absolute minimum temperature.

In the summer season, the diversity in maximum and minimum temperatures was much smaller. The highest mean diurnal air temperatures (8.2°C) and the highest measured maximum temperature (16.6°C) were associated with the Ea+SEa pattern (Tab. 6.1, Fig. 6.1). Such high values of air temperature are less characteristic of the Ec+SEc pattern. The occurrence of Ea+SEa was connected with a substantial positive anomaly in temperature (+3.1°C). One possible reason for this was the appearance of foehnic phenomena with that type of circulation. Also, in the case of mean maximum and minimum temperatures their highest values, 10.9°C and 5.2°C, respectively, coincided with the Ea+SEa pattern (Tab. 6.1). The Sc+SWc+Wc pattern exhibited low values of air temperature (with the lowest minimum air temperature recorded at KH, -0.2°C). In the winter, this pattern contributed to great positive anomalies in air temperature, however in the summer it caused a negative anomaly of -2.9°C.

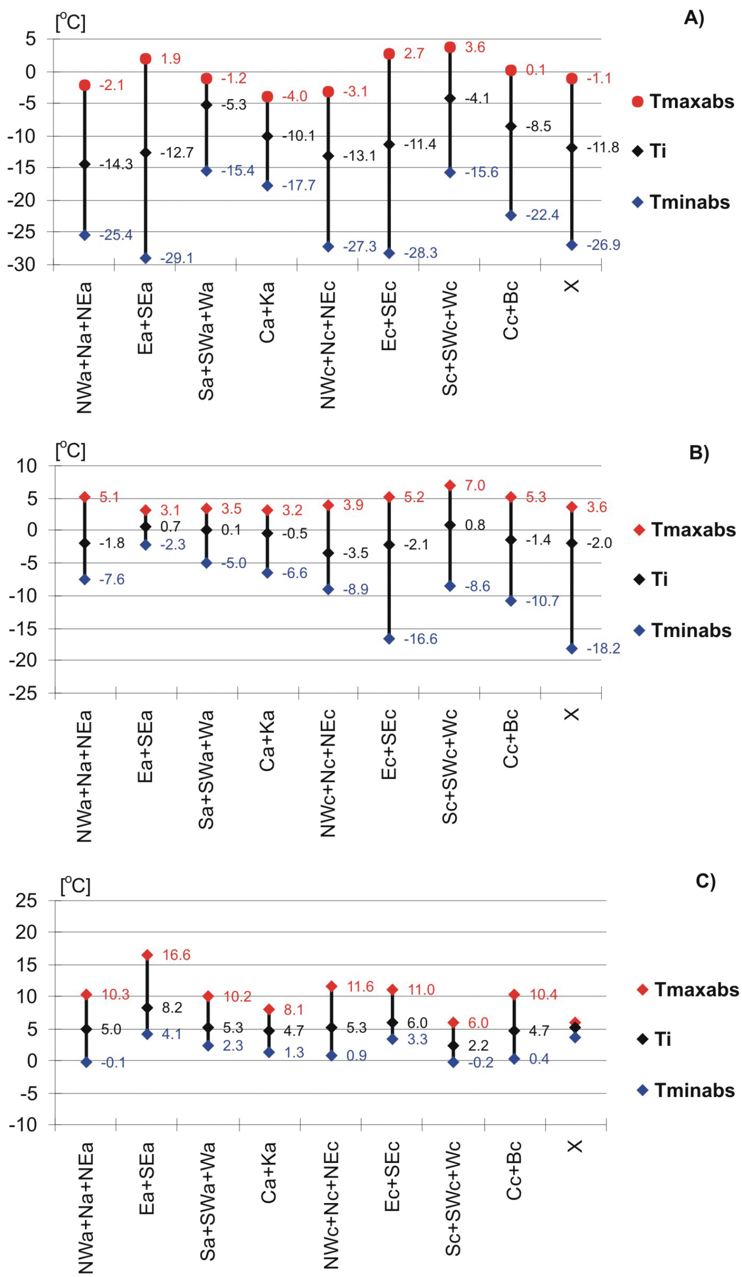

Figure 6.1. Values of diurnal mean (Ti), absolute maximum ($Tmax_{abs}$) and absolute minimum ($Tmin_{abs}$) air temperature at the Base Station (KH) during the winter (November 2010 – March 2011) (A), spring and autumn (April – May of 2011, September – October of 2010) (B), and summer (June – August of 2011) (C)

Atmospheric circulation also affects the diurnal ranges of air temperature (Tab. 6.1). In the winter, the highest diurnal ranges were typical for the Cc+Bc (7.8°C) and the S+SW+W patterns in anticyclonic and cyclonic circulation types (6.5°C and 6.6°C, respectively). This is probably due to the increased advection of usually warm and humid air, accompanying the above-mentioned patterns and, consequently, dramatic daily changes in air temperature. On the other hand, the lowest diurnal ranges of air temperature were observed during advection of cold and thermally stable arctic air masses, incoming from the northern sector, both in anticyclonic and cyclonic circulation types (5.0°C and 4.4°C, respectively) (Tab. 6.1).

In the spring, diurnal ranges of air temperature are slightly lower than in the winter, therefore the differences between the identified circulation types are smaller than in the winter. The highest ranges coincided with the X type (4.0°C) and with advection of air masses from the south and west in the cyclonic circulation pattern of Sc+SWc+Wc (3.9°C). The lowest spring and winter ranges occurred during advection of air masses from the northern sector in anticyclonic and cyclonic circulation (2.2°C and 2.9°C, respectively), and with the Ea+SEa pattern (2.2°C).

In the summer, the highest ranges were associated with the Ea+SEa pattern (5.7°C), which can be connected with a foehnic effect occurring with this circulation pattern, causing sudden fluctuations of air temperature.

6.2. The influence of atmospheric circulation on humidity conditions

Table 6.2 and Figure 6.2 show the diurnal mean, maximum and minimum values of relative humidity of air and its maximum and minimum absolute values at the SAO station, related to the type of atmospheric circulation on Spitsbergen.

In the winter, the lowest diurnal values of relative humidity occurred with the combined pattern of E+SE during anticyclonic (74%) and cyclonic circulation (79%) (Tab. 6.2). The negative anomaly of relative humidity at anticyclonic circulation connected with this pattern reached -10%. The E+SE pattern also exhibits the lowest values of mean minimum humidity (67% for anticyclonic circulation and 71% for the other). Moreover, the Ec+SEc and NWc+Nc+NEc patterns coincided with a low value of absolute minimum humidity (42%) – Figure 6.2. The low relative humidity during the occurrence of the E+SE pattern resulted from noticeable rises in air temperature and the drying of air under foehnic influence. The highest mean diurnal values of relative humidity were typical for the combined pattern of S+SW+W, both with cyclonic and anticyclonic circulation (94% and 90%, resp.), and contributed to positive anomalies in air humidity reaching +10% (cyclonic circulation). Additionally, the Sc+SWc+Wc pattern displayed the highest mean maximum humidity (100%). Except for Ea+SEa, other maximum absolute values of air humidity were 100% (Fig. 6.2).

Table 6.2. Values of diurnal mean (*f*i), maximum (*f*max) and minimum (*f*min) relative humidity (%) observed during synoptic situation types identified at the SAO site in the winter (November 2010 – March 2011), spring and autumn (April – May of 2011, September – October of 2010) and in the summer (June – August of 2011)

Types of circulation*	Winter			Spring and Autumn			Summer		
	fi	f_{max}	f_{min}	fi	f_{max}	f_{min}	fi	f_{max}	f_{min}
NWa+Na+NEa	80	89	72	86	93	78	91	97	83
Ea+SEa	74	81	67	91	97	84	80	91	70
Sa+SWa+Wa	90	97	82	94	99	88	97	100	92
Ca+Ka	85	93	76	91	97	83	96	100	92
NWc+Nc+NEc	80	89	71	83	91	77	90	97	78
Ec+SEc	79	86	71	84	91	75	94	99	87
Sc+SWc+Wc	94	100	82	95	99	89	98	100	91
Cc+Bc	90	97	79	95	99	88	94	98	88
X	88	95	80	94	99	86	96	99	93
m	84	91	75	89	95	82	92	98	85

Explanation: m – seasonal mean; * circulation type division acc. to Przybylak (1992)

In the transitional seasons, unlike in the winter and summer, the lowest values for the diurnal mean and minimum absolute humidity were recorded during advection from the northern sector (NW+N+NE) and cyclonic circulation (83% and 55% in 2010 and 2011, respectively) and anticyclonic circulation (86% and 58%) (Tab. 6.2). Negative anomalies caused by advection of arctic air masses from the northern sector did not exceed 6%. Similarly low values of relative humidity were observed in the Ec+SEc pattern, which was characterised by the lowest mean minimum value as well (75%). The highest relative air humidity (the diurnal mean and the mean maximum value) was typical for the combined S+SW+W pattern, with both types of circulation (cyclonic - 95% and 99%, anticyclonic – 94% and 99% in the both years). The two patterns contributed to positive anomalies in relative humidity of the air (6%), whereas the maximum absolute humidity at all circulation types reached 100% (Fig. 6.2).

In the summer, as it was in the winter, the lowest values of diurnal mean (80%) and minimum (70%) relative humidity of the air, and its minimum absolute value (41%) were connected with the Ea+SEa pattern (Tab. 6.2, Fig. 6.2). For this pattern, therefore, the highest negative anomaly in air humidity, -12%, was obtained (Tab. 6.2). The highest values of diurnal mean and maximum humidity, as in the winter, occurred in the analysed years with the combined type S+SW+W, during cyclonic (98% and 100%, respectively) and anticyclonic circulation (97% and 100%). The maximum absolute values of air humidity for all circulation types reached 100%.

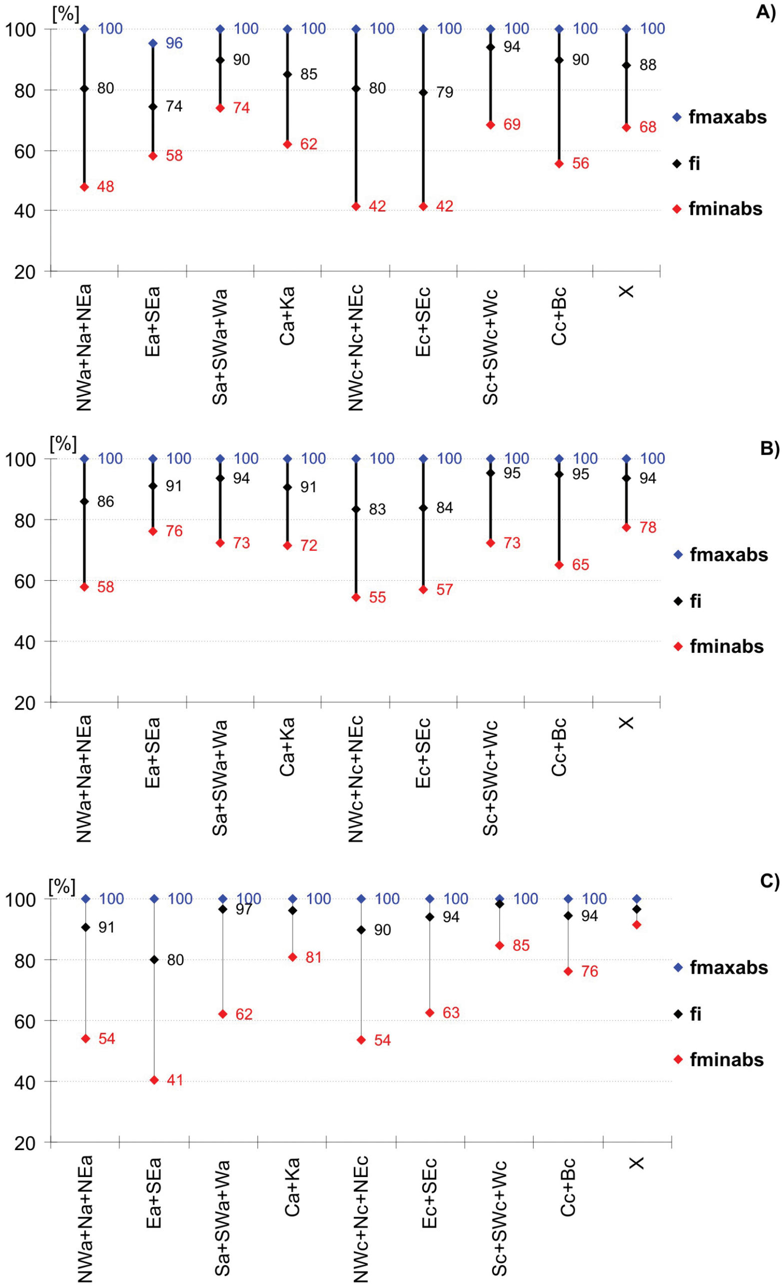

Figure 6.2. Relative air humidity: diurnal mean (fi), absolute maximum ($fmax_{abs}$) and absolute minimum ($fmin_{abs}$) values at the SAO site in the winter (November 2010 – March 2011) (A), in the transitional seasons (April–May of 2011, September–October of 2010) (B), and in the summer (June–August of 2011) (C)

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