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DIFFERENTIATION OF THERMAL CONDITIONS IN THE FORLANDSUNDET REGION (NW SPITSBERGEN) IN SUMMER 2010

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INTRODUCTION

The aim of this poster is to demonstrate spatial differentiation of the most important meteorological element determining a topoclimate, i.e. the temperature of air, in the area of Forlandsundet (NW Spitsbergen).

The Department of Climatology of the Nicolaus Copernicus University (NCU) has been studying thermal conditions on Spitsbergen since 1975. Initially, the area of research was limited to the Base Station (KH) in Kaffiøyra, however later (in 1978) it extended onto the Waldemar Glacier. In some summer seasons measurements of the temperature of air were taken on the Elisa and Aavatsmark glaciers, Sarsøyra and in St. Jonsfjorden (Wójcik et al. 1997).

The results of measurements and meteorological observations carried out in the years of 1975-2009 can be found, for example, in the papers of Wójcik et al. (1993), Przybylak and Araźny (2006); Przybylak et al. (2008); Kejna et al. (2010). The geographical scope of research was further significantly extended in the summer of 2010, when measurements of the key weather elements started on Prins Karls Forland and in the area of St. Jonsfjorden (Fig. 1).

In the first half of July, 2010, eighteen air temperature measurement sites were established, equipped with automatic weather stations Davis Vantage PRO2 and MadgeTech data loggers (Tab. 1, Fig. 1). All sensors used to record the temperature were fitted with radiation-proof shields and installed at the height of 2 m above ground level. The measurements of the temperature of air were recorded every 10 minutes, however for the purpose of this investigation only the hourly data was used, as these have been proven to suffice when calculating mean daily values (Przybylak and Vizi 2005).

Table 1. Meteorological sites working during summer 2010 in Forlandsundet region (Spitsbergen)

No.	Sites		φ	λ	h (m a.s.l.)
1	KH	Kaffiøyra-Heggodden	78°41'34" N	11°51'39" E	11.5
2	SAT	Sarstangen	78°43'38" N	11°28'50" E	2.0
3	SAO	Sarsøyra	78°42'55" N	11°43'26" E	9.0
4	KT	Terasa	78°40'39" N	11°58'03" E	90.0
5	ATA	ATA	78°40'31" N	11°59'30" E	137.0
6	KU	Kuven	78°40'53" N	12°00'53" E	193.0
7	GF	Gråfjellet	78°39'59" N	12°00'33" E	345.0
8	LW1	Lodowiec Waldemara-tongue	78°40'31" N	12°00'01" E	130.0
9	LW2	Lodowiec Waldemara-cirque	78°40'59" N	12°05'15" E	375.0
10	PH1	Prins Heinrichfjella-1	78°40'51" N	11°59'28" E	500.0
11	PH2	Prins Heinrichfjella-2	78°41'01" N	12°06'25" E	590.0
12	PK1	Prins Karls Forland-west	78°28'10" N	11°11'56" E	9.0
13	PK2	Prins Karls Forland-middle	78°30'18" N	11°12'47" E	68.0
14	PK3	Prins Karls Forland-Klubben	78°32'46" N	11°14'42" E	8.0
15	PK4	Prins Karls Forland-east	78°40'52" N	11°59'28" E	6.0
16	SJ1	St. Jonsfjord Cooper	78°30'10" N	12°43'03" E	2.0
17	SJ2	St. Jonsfjord Hus	78°31'36" N	12°51'53" E	4.0
18	SJ3	St. Jonsfjord mutton	78°34'10" N	13°09'22" E	14.0

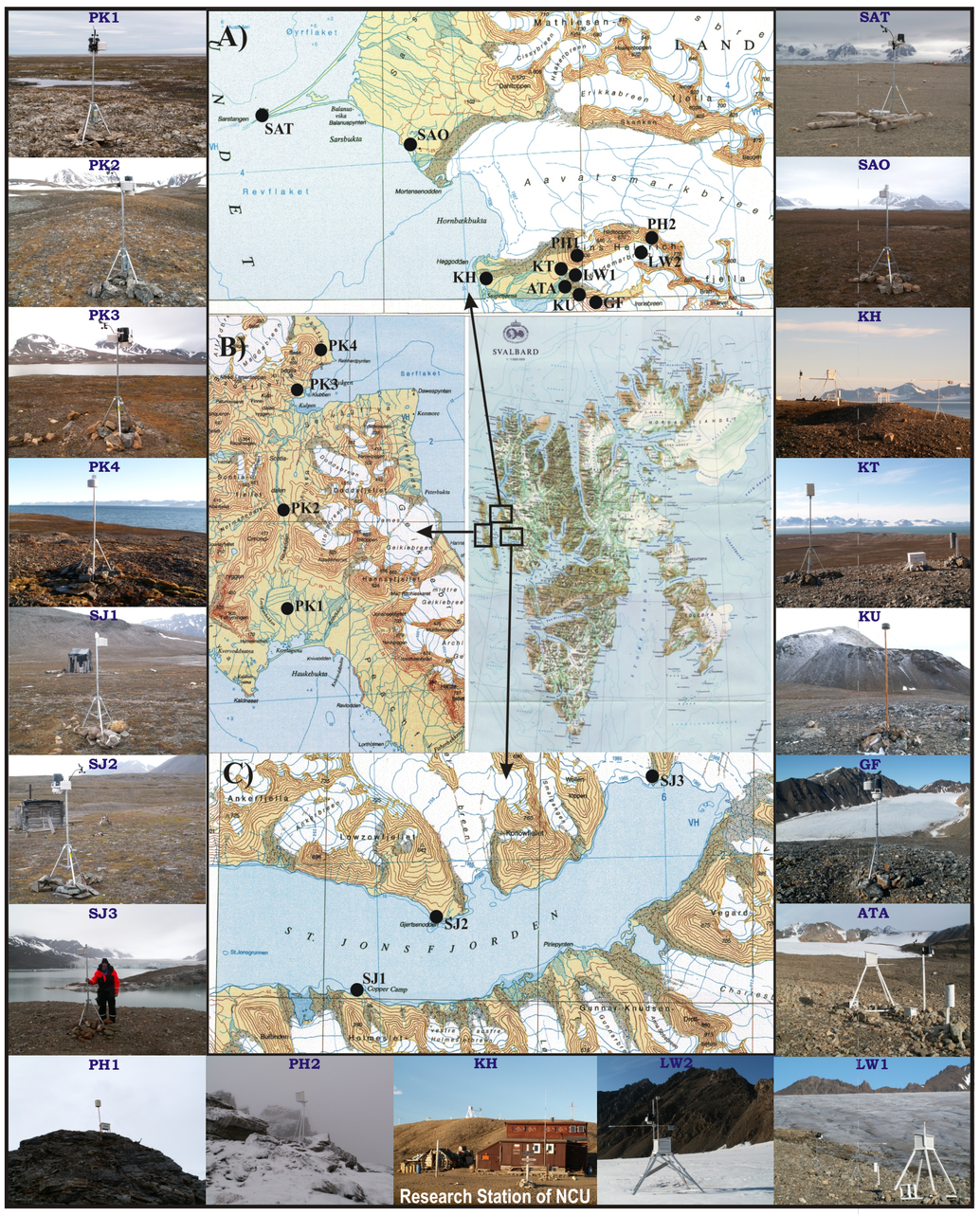

Fig. 1. Location of meteorological sites used in this study shown on a topographic map produced by the Norwegian Polar Institute (A- Kaffiøyra region; B- Prins Karls Forland; C-St. Jonsfjorden; KH, LW1, etc. - meteorological sites, see Table 1)

RESULTS

Most of the sites situated below 100 m a.s.l. were warmer than the Base Station, with the exception of PK2 (in the middle of Prins Karls Forland island) and SJ3 (clearly chilled by the neighbouring glaciers) (Tab. 2). The highest mean temperature (4.6°C) was observed in the west of Prins Karls Forland (PK1), and a slightly lower temperature (4.5°C) was recorded in the east part of the island (PK3) and at the exit from St. Jonsfjorden (SJ1). On all the sites situated above 100 m a.s.l. the mean temperature is lower than 4.0°C. The coldest place appears to be not the highest elevated mountain range (PH1 and PH2 sites), but the firn field of the Waldemar Glacier (LW2, 1.6°C). It means that the cooling power of the Spitsbergen snow and ice cover in summer is greater than the usual influence of height above the sea level.

Figure 2 shows the highest and the lowest values of air temperature as well as their mean diurnal ranges (DTR) in the reference period. The absolute maximum values of the temperature were evidently higher on the sites located in the mountains and far from the sea, whereas the lowest temperatures were observed on the glaciated areas and on the sites situated close to glaciers and the open sea. The highest maximum temperature of 13.9°C was recorded on PH1 on 20 August, and the lowest (9.6°C) on SJ3 on the same day. The lowest minimum temperature in the analysed period (-4.3°C) was recorded on the lowest situated site, PH2 (on 16 August), and the highest (0.3°C) on PK4 (on 15 August) (Fig. 2). The diversity of the absolute temperature values for the sites exceeded 4°C, being bigger than in the case of mean values.

It is interesting to look at the mean DTRs. The greatest values clearly occurred on the highest elevated sites (PH1 and PH2), where they reached 4.5 and 4.8°C, respectively (Fig. 2). The cause must have been the intensive warming up of the mountain ranges often situated beyond the reach of low-level clouds, which in turn prevent such warming of the lower situated areas. The lowest DTRs were observed on the sites where the influence of the sea is the strongest, namely SAT (2.4°C), SJ3 (2.8°C) and SJ1 (2.9°C). The SAT station is at the end of a narrow peninsula, jutting into the Forland Sound (Fig. 1) and, as shown, its DTR is absolutely the lowest (on average, approx. 0.5°C lower than on other seaside sites).

Generally, the pattern of spatial diversity over individual days may show considerable differences, such as towards the end of August 2010, when significant warming occurred (except for the area of St. Jonsfjorden), whose increased intensity was observed mainly in the mountains, leading to events of strong air temperature inversion (Tab. 1 and Fig. 3). The increase of the mean temperature of air between the second and the third week of August ranged from 0.2-0.4°C on lower situated sites to 0.7°C (GF and LW2) and even 1.4°C and 1.8°C in higher areas (PH1 and PH2, respectively). For the latter, the mean daily temperature of air increased by as much as 6°C at that time. On the first few days towards the last week of August the temperature values were about 2°C higher there than on KH (Fig. 3).

The analysis of mean daily courses of air temperature also provides some interesting results, clearly demonstrating that the vicinity of glacial areas contributes to chilling the air more in the daytime than "at night" (Fig. 4). The temperature differentiation between individual sites is predominantly higher during the day than in the "night" hours. The differentiation is also much bigger and more complex (due to a stronger influence of local conditions) on sunny days than in cloudy weather.

In order to eliminate the effects of elevation on the spatial differentiation of air temperature within the studied area its values were reduced for all the sites to the sea level, using the lapse rate of 0.6°C/100 m. Only two sites are colder than the KH, namely SJ3 (by 0.5°C) and LW2 (by 0.4°C). The cause of the lower values of air temperature recorded there is the chilling power of the glaciated surfaces. The sites situated the highest are definitely the warmest (PH1 and PH2). In comparison to Kaffiøyra the areas are warmer by 1.0°C and 1.3°C, respectively.

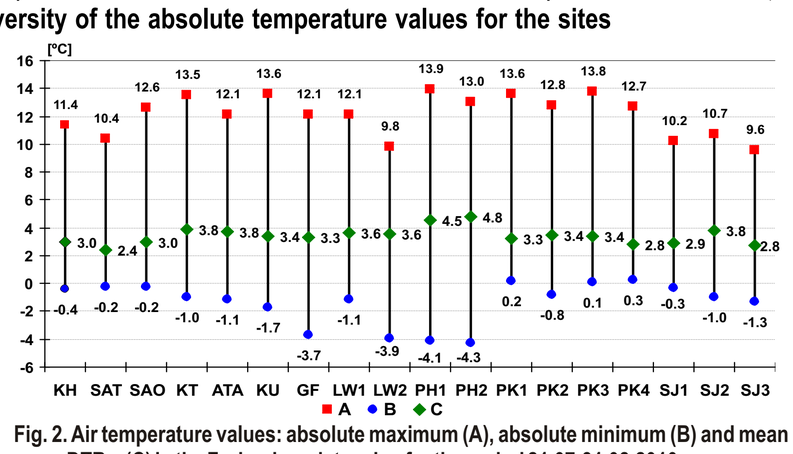

Fig. 2. Air temperature values: absolute maximum (A), absolute minimum (B) and mean DTRs (C) in the Forlandsundet region for the period 21.07-31.08.2010

Table 2. Mean values of air temperature (°C) in Forlandsundet region, summer season 2010

No.	Site	11.07-20.07	21.07-31.07	01.08-10.08	11.08-20.08	21.08-31.08	21.07-31.08
1	KH	5.7	5.1	4.9	3.1	3.5	4.1
2	SAT	5.8	5.3	5.0	3.4	3.6	4.3
3	SAO	5.9	5.2	4.9	3.3	3.6	4.3
4	KT#	5.1	4.9	4.7	3.4	3.8	4.2
5	ATA*	5.4	4.6	4.5	3.1	3.5	3.9
6	KU&	4.5	4.0	3.9	2.8	3.2	3.5
7	GF&	3.2	2.6	2.5	1.5	2.2	2.2
8	LW1*	4.9	4.4	4.2	3.0	3.3	3.7
9	LW2*	3.0	1.9	1.8	0.9	1.6	1.6
10	PH1	.	2.2	2.3	1.4	2.8	2.2
11	PH2	.	1.8	2.4	1.0	2.8	2.0
12	PK1	6.3	5.3	4.8	3.9	4.2	4.6
13	PK2	5.5	4.6	4.3	3.3	3.6	4.0
14	PK3	6.1	5.3	5.1	3.8	4.0	4.5
15	PK4	5.8	5.3	4.7	4.1	3.4	4.4
16	SJ1	.	5.4	5.4	3.6	3.6	4.5
17	SJ2	.	5.1	5.1	3.4	3.3	4.3
18	SJ3	.	4.5	4.2	3.0	2.8	3.6

Explanations: # -15.07-31,08; *- 13.07-31.08; &- 14.07-31.08

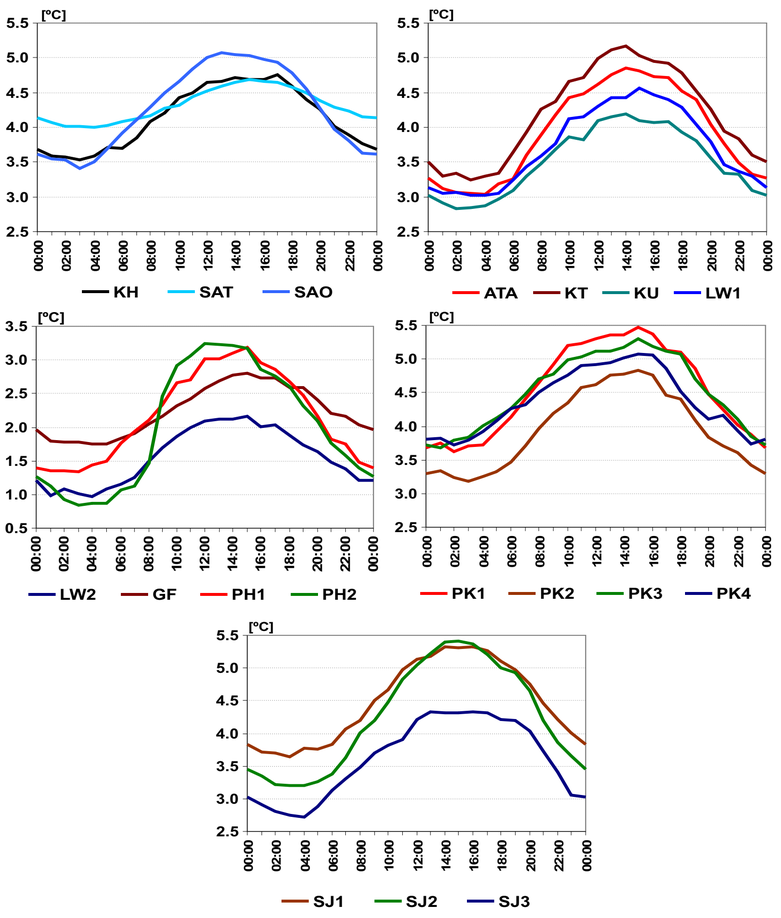

Fig. 4. Mean daily courses of air temperature in the Forlandsundet region (21.07-31.08.2010)

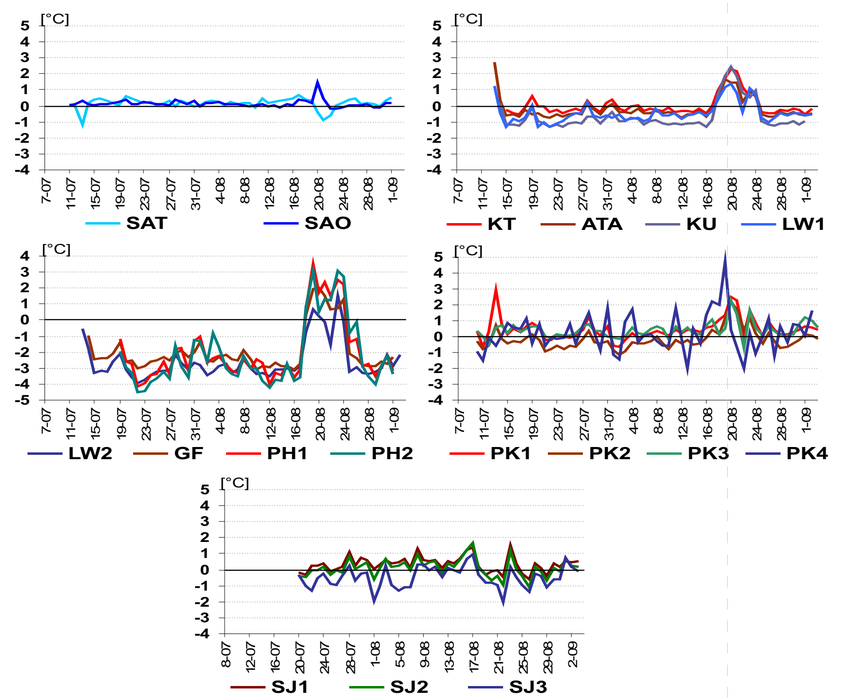

Fig. 3. Differences of mean values of air temperature (°C) between the KH and other measurement sites in Forlandsundet region, summer season 2010

CONCLUSIONS

i) Spatial temperature differentiation in the study area in the summer season is significant and reaches values of 3 and 4°C for mean seasonal and extreme characteristics, respectively,

ii) The highest temperature occurred on the Prins Karls Forland island, while the coldest one was in the firn field of the Waldemar Glacier. On the other hand, the highest values of temperature reduced to sea level were noted on the summit of Prins Heinrichfjella. No change was noted in the case of the spatial occurrence of the coldest temperatures,

iii) Markedly the highest values of the diurnal temperature range were noted in the summit area of Prins Heinrichfjella, while the lowest ones were in the sites with the greatest maritime influences,

iv) Larger spatial differentiation of temperature was noted in diurnal hours than in "night" hours, as well as in days with less cloudiness and with the occurrence of local winds, e.g. foehns.

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