PRACE GEOGRAFICZNE, zeszyt 107

Instytut Geografii UJ
Kraków 2000

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AIR TEMPERATURE IN THE CANADIAN ARCTIC IN THE MID-NINETEENTH CENTURY BASED ON DATA FROM EXPEDITIONS

Abstract: The paper presents the first results of the project aimed at collecting and analysing early instrumental records from the Arctic, from the period 1846-1854. Air temperature is characterized for the Canadian Arctic using data from various expeditions and a comparison with the present-day climate is also made.

Key words: climate change, Arctic, air temperature.

1. Introduction

The Arctic is a region particularly sensitive to variation in climate. Climatic models for a scenario of twice the modern atmospheric concentration of greenhouse gases have consistently identified the Arctic as the region of the greatest winter and annual warming (Houghton et al.1990, 1992, 1996). Any climatic change in the Arctic due to anthropogenic influences will be superimposed on natural variability. To detect and separate the anthropogenic signal from the natural background, long time climatic series are needed.

The instrumental record of the Arctic climate is brief and geographically sparse. Only five records (all from Greenland) extend back to the second half of the nineteenth century. Outside Greenland the first station was established in Spitsbergen in 1911 (Green Harbour). In the 1920s the next 7 stations started operations, mainly in the Atlantic region of the Arctic. Most Russian stations were established after the Second Polar Year (1932/1933) and most Canadian stations after the Second World War. For this reason both the spatial distribution and reliable estimates of air temperature characteristics in the Arctic are possible only for the last forty to fifty years.

In this context, any climatic data from before the 1950s, and especially from before the 1920s, are very important for an evaluation of the variation and change of climate in the Arctic. The main aim of this paper is to present the characteristics of

air temperature in the Canadian Arctic in the mid-nineteenth century using data from various expeditions. A comparison with the present-day climate is also made.

2. Area, Data and Methods

The analysed data were gathered during the wintering of vessels which were sent to the Canadian Arctic by the Royal Navy after 1845 in order to find a lost expedition under the command of Sir John Franklin. More than twenty such expeditions were sent to this region in the fifteen years after this tragedy. Useful meteorological observations may be noted from the period when vessels, due to severe winter conditions, were frozen up. Usually, wintering lasts from September to July and meteorological measurements, according to high Royal Navy standards, were mostly carried out hourly, two-hourly, four-hourly or six-hourly a day.

In the present paper only data from expeditions wintering near the location of present-day meteorological stations (Resolute, Cambridge Bay and Coral Harbour) have been chosen for analysis. The list of these expeditions with some additional information is given in Table 1. The correctness and quality of the temperature measurements was checked by Dr John Rae. However, the temperatures are still not

Tab. 1. A list of expeditions to the Canadian Arctic, records from which have been employed in the present paper.

Locality	φ	λ	Ships/Station	Captain or Observer	Years	No. of months	Observations
Repulse Bay	66°32'N	86°56'W	Station	John Rae	1846-47	11	3 daily
Repulse Bay	66°32'N	86°56'W	Station	John Rae	1853-54	11	3 daily
Cambridge Bay	69°03'N	105°12'W	H.M.S. "Enterprise"	Sir R. Collinson	1852-53	12	Four-hourly
Port Leopold	73°50'N	92°12'W	H.M.S. "Enterprise" and "Investigator"	Sir James C. Ross	1848-49	12	Two-hourly
Griffith Island	74°34'N	95°20'W	H.M.S. "Resolute"	Sir H. Austin	1850-51	12	Two-hourly
Assistance Bay	74°40'N	94°16'W	"Lady Franklin"	W. Penny	1850-51	12	Four-hourly
Beechey Island	74°43'N	91°54'W	H.M.S. "North Star"	W.J.S. Pullen	1852-54	25	Four-hourly
Wellington Channel	75°31'N	92°10'W	H.M.S. "Assistance"	Sir E. Belcher	1852-53	12	Two-hourly

exactly comparable with those of the modern period because of differences in instrumentation, exposure, and frequency of readings. For details please see the publication entitled *Contribution to our knowledge of the meteorology of the Arctic Regions, Part I (1879), II (1880), III (1882), IV (1885) and V (1888).* This publication includes the average monthly and annual temperatures for fixed hours. On the other hand, some raw data are also available in ships' log books, held in the archives of the Scott Polar Research Institute in Cambridge and in the Meteorological Office in Bracknell (Great Britain). For details see Headland (1995).

3. Results

3.1. Air temperature in the Repulse Bay region

Meteorological observations from Fort Hope, located on the north shore of Repulse Bay (Tab. 1), were carried out during two winterings in 1846-47 and 1853-54 by John Rae. The meteorological stations were established near the coast and only a few metres above sea level. The annual course of air temperature in these years in comparison with the average (1951-1990) annual course for Coral Harbour is presented in Fig. 1a. It appears from the results that the coldest period is January (in 1846-47) or February (in 1853-54) and the warmest is July. The lowest mean monthly temperatures oscillated between –33.1°C (Jan. 1846) and –36.8°C (Feb. 1854) and the highest between 4.8°C and 6.3°C. In comparison with present-day temperature for Coral Harbour station, the analysed periods were significantly colder (about 3°C in annual values) (Table 2). In both years, though particularly in 1853-54, the winter months

Tab. 2. Differences (in °C) between mean monthly and annual temperatures observed during mid-nineteenth century Arctic expeditions and modern data from meteorological stations.

Month	1 1846-47	2 1853-54	3 1852-53	4 1849-50	5 1850-51	6 1850-51	7 1852-53	8 1853-54	9 1853-54	10 1849-54
September	-2,9			0,5	-4.2*	-1,0	-0,5	-2,6		-1,3
October	-2,9		-3,7	4,1	-2,9	-1,7	0,3	1,5		0,9
November	0,8	-10,4	2,1	0,7	2,7	3,0	5,2	-1,8	-3,6	0,7
December	-1,8	-6,0	-4,7	-6,6	-1,4	-0,5	-2,0	-1,9	-3,9	-3,1
January	-3,5	-5,3	-4,5	-3,3	-2,9	-1,8	-5,3	-3,2	-6,9	-4,2
February	-2,2	-7,3	-0,2	-1,7	-2,5	-1,3	5,4	-2,9	-6,6	-1,6
March	-4,1	-1,5	3,8	2,6	-0,6	1,3	6,3	0,8	-3,4	1,3
April	-2,8	0,9	2,5	2,5	1,5	3,6	6,6	5,7	2,8	4,0
May	-0,7	2,1	1,2	3,2	-1,7	0,0	4,0	2,5	-1,4	1,5
June	-2,8	0,9	-1,4	0,5	0,4	1,7	2,7	0,9	-1,9	0,7
July	-4,0	-2,5	-3,6	-1,9	-1,7	-0,9	-0,1	-0,5		-1,0
August				-1,4			-0,9	1,1		-0,4
Mean	**-2,4**	**-3,2**	**-0,9**	**-0,1**	**-1,2**	**0,2**	**1,8**	**0,0**	**-3,1**	**-0,2**

Key: 1 i 2 - Repulse Bay - Coral Harbour; 3 - Cambridge Bay (19th century) - Cambridge Bay (present); 4 - Port Leopold - Resolute; 5 - Griffith Island - Resolute; 6 - Assistance Bay - Resolute; 7 i 8 - Beechey Island - Resolute; 9 - Wellington Channel - Resolute; 10 - regional mean (4 - 9) – Resolute; * - calculated over a period of 18 days (13-30)

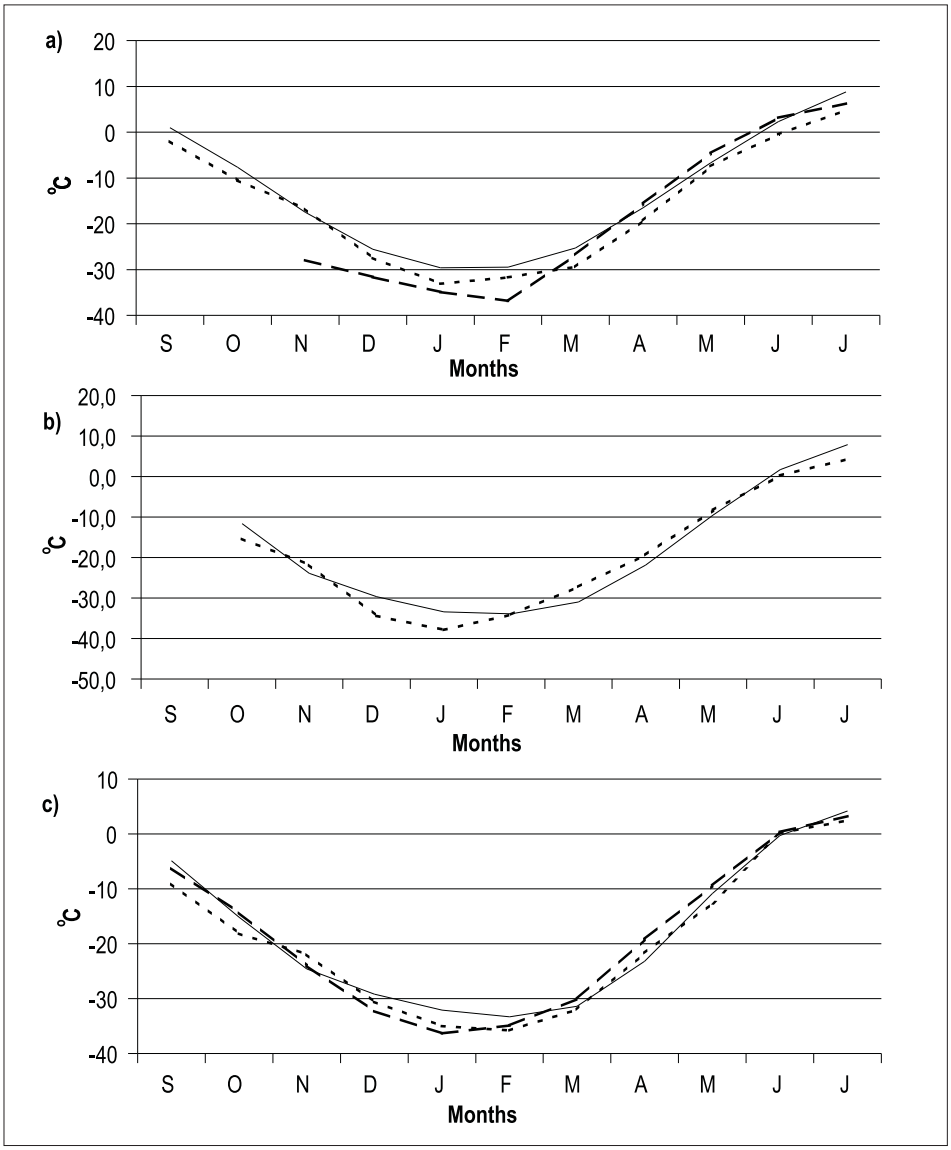

Fig. 1. Annual courses of air temperature in the Canadian Arctic:
a) short dashed line – Repulse Bay (1846-47), long dashed line – Repulse Bay (1853-54), solid line – Coral Harbour (1951-1990),
b) dashed line – Cambridge Bay (1852-53), solid line – Cambridge Bay (1951-1989),
c) short dashed line – average temperature from Griffith Island and Assistance Bay, long dashed line – average temperature from five expeditions listed in Table 2 as Nos. 4-9, solid line – Resolute (1951-1990).

were exceptionally cold with differences oscillating between –5°C and -10°C. On the other hand, summer was colder in 1847 than in 1854 by about 1.5°C in July and 3.7°C in June (see Fig. 1a). However, temperatures observed in the mid-nineteenth century mostly remained within the distance of two standard deviations from the modern mean. Comparison of the early instrumental records presented here with modern data reveals, as mentioned earlier, varied sources of errors and biases (different locations, instrumentation, calibration, exposure, and recording schedule). Thus, real differences can differ from those presented here, but the general tendency of temperature changes (colder, warmer) should be fairly accurate. I must add that differences presented in Table 2 should be reduced for winter months and enlarged for summer months by about 1.0-1.5°C. This correction results from the fact that Coral Harbour station is situated about 300 km to the SE of Repulse Bay. In January Repulse Bay is colder than Coral Harbour by the values mentioned, while in July it is warmer (see Atlas Arktiki 1985).

The highest temperature recorded in Repulse Bay was 14.7°C on 16th July 1854 and was a result of air advection from SW. This temperature was simultaneously the lowest temperature noted during all the expeditions analysed. The lowest temperature, -45.6°C, occurred in 1854 on 7th February. Here, as well as in other places analysed, the lowest temperature was observed during calm or weak winds from the northern sector. The analogous temperature extremes in Coral Harbour in the period 1951-1990 were 25.0°C (4th August 1954) and –52.8°C (17th January 1975).

3.2. Air temperature in the Cambridge Bay region

Meteorological measurements in Cambridge Bay, on the north side of Dease Strait, were carried out during wintering in 1852-53 by Captain Sir R. Collinson. Information surrounding the taking of the measurements is sparse, but the meteorological observations were probably conducted on board the ship "Enterprise", as on other expeditions. This means that the temperature, especially in the cool half-year is warmer than temperature measured on an ice floe or on land. Such results were obtained during wintering in Wellington Channel in 1853-54. Comparison with present-day data is helped by the fact that the meteorological station is located on the shore of Cambridge Bay. Thus, the spatial distance between the historical and present measurement points is very close.

Mean monthly air temperatures and their differences in Cambridge Bay in both periods are presented in Fig. 1b and Table 2. In 1852-53 the lowest mean monthly temperature occurred in January (-37.9°C), while at present the coldest, on average, occurs in February (-33.9°C), though January has only a slightly higher temperature (-33.4°C). In both periods the maximum temperature was noted in July. As can be seen in Fig. 1b and Table 2, the mean annual temperature in 1853-54 was, on average, colder by about 0.9°C. As in the previous region, the winter months in particular were colder than at present, with temperature differences in December and January exceeding 4°C. Summer months were also significantly colder (from 1.5°C to 4°C).

Similar to Repulse Bay in 1854, spring in 1853 was warmer in Cambridge Bay (from about 1 to 4°C). Aside from the July temperature, all temperatures lie within the two standard deviation distances from the present mean.

The highest recorded temperature (12.8°C) in Cambridge Bay occurred on 24th July 1853 during weak air advection from the west. The lowest temperature (-46.9°C) was observed on 6th January 1853 during a period of calm.

3.3. Air temperature in the region of the Resolute Station

A large concentration of wintering ships in the mid-nineteenth century was noted near (up to 150 km) the present location of the Resolute Meteorological Station (Cornwallis Island). Four temperature records exist for a period of 12 months and one for a period of 25 months (Table 1). Two of them (from Griffith Island and Assistance Bay) are, in particular, of great importance for purposes of comparison because they come from areas close to the present-day location of the Resolute Meteorological Station. However, another three records can also be successfully compared with modern data due to significant spatial temperature uniformity in the analysed region (see Atlas Arktiki 1985).

Fig. 1c presents the mean annual course of air temperature averaged for the two mentioned localities (1850-51) and for all records analysed for this region (for different years). On the other hand, Table 2 presents non-averaged temperature differences between the historical and modern periods. The average temperature from Griffith Island and Assistance Bay in 1850-51 was coldest in February (-35.2°C) and warmest in July (2.9°C). Similar times of extreme occurrences in the annual course may be observed today. The year analysed was, on average, colder by 0.5°C. Similar to the previous regions, the cool half-year period (except November and March) and high summer months were colder than today. The spring months, except for May, were warmer, with maximum temperatures in April. Averages from all expeditions (Fig. 1c) show slightly lower temperatures in January (-36.3°C) than in February (-34.9°C), but the highest temperature is still observed in July (3.3°C). The winter temperature in comparison with the year 1850-51 (Fig. 1c), was similar, and significantly cooler (from 2°C to 4°C) than today. In the rest of the year, temperatures were higher than in 1850-51. Spring was particularly warm, with mean monthly temperature differences, in comparison with modern data, reaching 4°C in April. In summer, the temperature was slightly lower than today. It seems that the regional mean temperatures calculated from all the records analysed here are the most reliable for comparison purposes with modern data.

The highest recorded temperature (13.9°C) in this region was observed on Griffith Island on 5th July 1851 during weak air advection from SW. The lowest temperature observed during all expeditions (-47.2°C) occurred on Beechey Island on 10th January 1853. In Resolute, during the period 1951-1980, both higher absolute maximum (18.3°C) and lower absolute minimum (-52.2°C) temperatures occurred.

4. Summary and Concluding Remarks

The paper presents the first results of the project aimed at collecting and analysing early instrumental records from the Arctic. This author has concentrated on a period of about 8 years (1846-1854) when a great number of search expeditions were sent to the Canadian Arctic by the Royal Navy in order to find the lost members of Sir J. Franklin's expedition. Most of these expeditions wintered in different places in the Canadian Arctic (Table 1). During this time meteorological measurements according to high Royal Navy standards were carried out.

Analysis of these data allows the following conclusions to be drawn:

i) Annually the average air temperature in the mid-nineteenth century in the Canadian Arctic was colder than today by about 0-1°C or more, if correction due to the ship's influence on measurements is introduced. Not all regions show negative differences, though the majority do (see Table 2),

ii) In all analysed regions (Fig. 1a-c) there is a good correspondence in temperature relation with modern records. Everywhere air temperature in the cool half-year (but, in particular, in winter months) was significantly colder than today (by 1 to 4°C). Also summer was colder than today. On the other hand, the spring months, and April in particular, were characterised by mostly large positive temperature differences (from 1°C to 4°C),

iii) Almost all monthly mean temperatures (except mainly those for July) lie within the distance of two standard deviations from the present mean. This means that dispersion of air temperature in the mid-nineteenth century does not exceed the present range of natural air temperature fluctuations in the Canadian Arctic.

References

Atlas Arktiki, 1985, Glavnoye Upravlenye Geodeziy i Kartografiy, Moskva, p. 204.

Contributions to our Knowledge of the Meteorology of the Arctic Regions, Published by the Authority of the Meteorology, London, Part I (1879), Part II (1880), Part III (1882), Part IV (1885), Part V (1888).

Headland R. K., 1995, *Archival Data and the Assessment of Polar Climate Change*, [in:] *Bipolar Information Initiatives: The Needs of Polar Research*, Walton D.W.H., Mills W. J., Phillips C. M. (eds.), Proceedings of the 15th Polar Libraries Colloquy, Bluntisham, England, Bluntisham Books, 87-92.

Houghton J. T., Jenkins G. J., Ephraums J. J. (eds.), 1990, *Climate Change: The IPCC Scientific Assessment*, Cambridge University Press, Cambridge, p. 365.

Houghton J. T., Callander B. A., Varney S. K. (eds.), 1992, *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*, Cambridge University Press, p. 200.

Houghton J. T., Meila Filho L.G., Callander B. A., Harris N., Kattenberg A., Maskell K. (eds.),1996, *Climate Change 1995: The Science of Climate Change*, Cambridge University Press, p. 572.

Kay P. A., 1995, *An Early Nineteenth Century Meteorological Register from the Eastern Canadian Arctic*, Polar Record, 31, 335-342.

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