Bulletin of Geography – physical geography series
No 3/2010: 47–64

https://www.doi.org/10.2478/bgeo-2010-0003

Andrzej Araźny

Department of Climatology, Institute of Geography,
Nicolaus Copernicus University, Gagarina 9, 87–100 Toruń, Poland
andy@umk.pl

BIOMETEOROLOGICAL CONDITIONS IN THE ARCTIC DURING THE FIRST INTERNATIONAL POLAR YEAR, 1882–1883

Abstract: The article provides an initial description of the biometeorological conditions in the Arctic during the first International Polar Year (IPY 1) of 1882–1883. The study is based on hourly measurements taken from nine stations which represent most of the climatic regions in the Arctic. The diversity of biometeorological conditions was analysed in relation to the height above sea level, the distance from the sea and the character of the ground. The analysis made use of such biometeorological indices as wind chill index (WCI), predicted insulation of clothing (Iclp) and the cooling power of the air (H). A considerable spatial diversity of the biometeorological conditions was found during the period investigated. The least favourable thermal sensations occurred at the Sagastyr station, and the most favourable conditions were observed at Kapp Thordsen.

Key words: Arctic, First International Polar Year, biometeorological conditions

Introduction

The polar areas are an active constituent of our planet. They can provide us with extensive information on important current and historical changes concerning the behaviour of the whole global system. More than 125 years ago an international project was established to conduct scientific investigations in the Earth's polar regions. On the initiative of the International Meteorological Organisation the period 1882–1883 was designated the First

International Polar Year. The main scientific objective of IPY 1 was to carry out meteorological, geophysical and oceanographic research.

Surveys performed during IPY 1 have been published in scientific and statistical studies of various problems concerning weather conditions (Przybylak 2004; Przybylak and Panfil 2005; Wood and Overland 2006; Lüdecke 2007; Przybylak and Jankowska 2009; Przybylak and Wyszyński 2009; Przybylak et al. 2010), the permafrost and thermal conditions of the soil (Wood and Streletskiy 2008), geomagnetism (Newitt and Dawson 1984) and the content of carbon dioxide in the atmosphere (Baker 2009). However, there have so far been no studies on biometeorology or bioclimatology for the period concerned. The present article attempts to redress this research gap.

This article presents the results of hourly measurements of selected biometeorological indices – WCI, Iclp and H – for 9 arctic stations (Fig. 1): Lady Franklin Bay, Kingua Fjord, Godthåb, Jan Mayen, Kapp Thordsen, the Kara Sea, Malye Karmakuly, Sagastyr and Point Barrow. The borders of the Arctic and the climate division were taken after the *Atlas Arktiki* (Treshnikov 1985). The principal sources of meteorological data used in this article (air temperature and wind speed) were the reports from the polar expeditions during IPY 1, issued between 1886 and 1910 (Ray 1885; Greely 1886; Lenz 1886a and b; Neumayer and Börgen 1886; Paulsen 1886; Wohlgemuth 1886; Ekholm 1890; Snellen and Ekama 1910).

Data and methodology

In order to evaluate meteorological and biometeorological conditions, actual hourly values of meteorological data from the period August 1882 – August 1883 were used. The biometeorological conditions (WCI, Iclp and H) were calculated using an empirical formula and a computer software package – BioKlima 2.6 (Błażejczyk and Błażejczyk 2009).

In order to evaluate the wind conditions and to calculate the biometeorological indices, the values of the wind speed, measured at a variety of heights at which the anemometers were situated in the stations, were reduced to 2 m above ground level (AGL), using Milewski's formula (as quoted by Kozłowska-Szczęsna et al. 1997):

$$V_z = V_w (h_z/h_w)^{0.2}$$

where: V_z – wind speed at h_z = 2 m,

V_w – wind speed at the point of measurement (anemometer) h_w.

Fig. 1. Location of the Arctic stations during the First International Polar Year of 1882–1883 *(www.arctic.noaa.gov/aro/ipy-1)*

The biothermal conditions in the Arctic region during IPY 1 were determined on the basis of such factors as the wind chill index, assuming that the human body was protected by means of heavy winter arctic clothing with a thermal insulation value of 4.0 clo. WCI a means of quantifying the threat of rapid cooling during breezy or windy conditions that may result in hypothermia in cold conditions. Siple and Passel (1945) developed empirical formulas relating air temperature and wind speed to the rate of heat loss from exposed human skin (Glickman 2000).

$$WCI = (10 \cdot v^{0,5} + 10.45 - v)(33.0 - T) \cdot 1.163$$

where T – air temperature (°C), v – wind speed ($m \cdot s^{-1}$).

The individual values of WCI correspond to specific thermal sensations experienced by humans in a given atmospheric environment (Kozłowska-Szczęsna et al. 1997). The thermal sensation range for the WCI was as follows: extremely hot (≤ 58.2 $W \cdot m^{-2}$), hot (58.3–116.3 $W \cdot m^{-2}$), warm (116.4–232.6 $W \cdot m^{-2}$), comfortable (232.7–581.5 $W \cdot m^{-2}$), cool (581.6–930.4 $W \cdot m^{-2}$), cold (930.5–1628.2 W·m^{-2}), frosty (1628.3–2326.0 W·m^{-2}), extremely frosty (>2326.0 W·m^{-2}).

Another quantity used in the analysis is the predicted clothing insulation index (Iclp) as proposed by Burton and Edholm (1955) for the purposes of studies on thermal and physiological conditions of work in the open. The value is determined using the following formula:

$$Iclp = 0.082\cdot[91.4-(1.8\cdot T+32)]/(0.01724\cdot M)-1/(0.61+1.9\cdot v^{0.5})$$

where: T- air temperature (°C), v – wind speed (m·s^{-1}), M – metabolism (W·m^{-2}).

For the purposes of calculating the *Iclp* a metabolism of 135 W·m^{-2} was adopted, typical of a person walking at 4 km·hour^{-1}. Finally, *Iclp* values were derived for specific weather conditions (in clo). The clo unit was introduced by Gagge et al. (1941) to express the relative resistance to heat transfer by clothing. A clo is a unit of thermal insulation that will maintain comfort in a resting/sitting person, whose metabolic rates is 58 W·m^{-2}, at an environmental temperature of 21°C, air movement of 10 cm·s^{-1} and relative humidity less than 50 per cent.

The following assessment of thermal conditions may be attributed to the Iclp values: very warm (< 0.30 clo), warm (0.31–0.80 clo), neutral (0.81–1.20 clo), cool (1.21–2.00 clo), cold (2.01–3.00 clo), very cold (3.01–4.00 clo) and arctic cold (> 4.00 clo).

The cooling power of the air (H) means the amount of heat loss from the body surface in a unit of time. The H index is useful for determining the thermal comfort of a walking person, properly dressed according to the season. The index was derived using Hill's empirical formulas (Kozłowska-Szczęsna et al. 1997):

$$H = (36.5 - T)\cdot(0.20 + 0.4\cdot v^{0.5})\cdot 41.868, \text{ if } v \leq 1 \text{ m}\cdot\text{s}^{-1}$$
$$H = (36.5 - T)\cdot(0.13 + 0.47\cdot v^{0.5})\cdot 41.868, \text{ if } v > 1 \text{ m}\cdot\text{s}^{-1}$$

where: T- air temperature (°C), v – wind speed (m·s^{-1}).

The values of H which were calculated were presented as a frequency distribution on the thermal sensation scale of Petrovič and Kacvinsky (after Kozłowska-Szczęsna et al. 1997). The scale comprises the following stages: extremely cold and windy (>2100.1 W·m^{-2}); very cold (1680.1–2100.0 W·m^{-2}); cold (1260.1–1680.0 W·m^{-2}); cool (840.1–1260.0 W·m^{-2}); slightly cool (630.1–840.0 W·m^{-2}); neutral (420.1–630.0 W·m^{-2}); hot (210.1–420.0 W·m^{-2}) and very hot (< 210.0 W·m^{-2}).

Results

Air temperature and wind speed

Thermal stimuli are among the most perceptible of all climatic influences, and therefore they are the principal and universal criterion when the state of the weather is evaluated. The results of the air temperature measurements based on the hourly measurements taken in the Arctic during IPY 1 were analysed by Przybylak (2004) and Przybylak and Panfil (2005). The lowest mean temperatures were observed in the NE part of the Canadian Arctic (Lady Franklin Bay), while the warmest area was the western part of the Norwegian Arctic (Jan Mayen) – Table 1 and Figure 2. In the annual course of the air temperature in the Western Arctic (without Alaska), the coolest month was February (Table 1). In the Eastern Arctic and Alaska February was the warmest (of the period from December to March). In that part of the Arctic the coolest months were December or January, with the exception of Jan Mayen station with its prevailing maritime climate, where the coolest month was March. The warmest month of IPY 1 was July or August. The lowest mean air temperature (-42.0ºC) was recorded at Sagastyr in February 1883, whereas the highest monthly mean value (7.4ºC) was measured at Kingua Fjord in August 1883. Individually, the lowest air temperature (-53.2ºC) was recorded at Sagastyr on 9 February 1883, and the highest (19.7ºC) at Kingua Fjord on 3 August 1883. The highest absolute air temperature amplitude (67.8ºC as recorded during routine measurements) occurred at Kingua Fjord, while the lowest was at Jan Mayen, where a maritime climate prevails (39.6ºC).

In the Arctic, the high wind and low air temperature may cause substantial disturbances in the human heat balance. The mean wind speed, reduced to the common height of 2 m AGL at all stations, was notably lower at Lady Franklin Bay and Kingua Fjord, whereas the windiest sites proved to be Jan Mayen, Godthåb and Malye Karmakuly (Table 1). In the annual course the maximum wind speed at most of the sites occurs in the winter months, which is connected with significant cyclonic activity. Only at Lady

Table 1. Mean and extreme values of the thermal and wind conditions (at 2 m AGL) in the Arctic during the First International Polar Year of 1882–1883

Station	Parameter	1882					1883							
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Godthab	T max abs	11.2	9.0	6.8	1.8	6.1	7.4	2.0	11.2	5.3	7.1	14.1	14.9	14.7
	Ti	4.6	2.8	-3.0	-5.5	-7.5	-9.7	-14.6	-6.0	-5.6	0.1	2.7	6.3	5.1
	T min abs	2.6	1.4	-4.3	-7.2	-9.3	-11.9	-17.6	-9.0	-7.5	-1.6	0.6	4.1	2.7
	v	4.2	6.1	5.6	5.9	5.4	6.4	7.8	7.5	5.7	5.1	5.8	5.1	4.2
	v max	18.1	18.1	15.6	14.0	13.2	13.2	22.2	24.7	21.4	18.1	17.3	17.3	11.5
Jan Mayen	T max abs	9.0	7.9	8.6	5.0	3.2	2.8	2.7	2.1	4.3	3.2	7.1	8.4	
	Ti	3.1	1.9	2.1	-1.9	-9.6	-7.3	-4.4	-10.3	-2.7	-4.0	1.8	3.5	
	T min abs	-1.3	-4.8	-5.5	-15.6	-30.6	-28.6	-19.1	-22.4	-12.8	-14.0	-2.3	-1.0	
	v	5.2	7.0	7.6	6.6	6.4	6.3	10.1	6.5	7.6	6.5	5.1	5.8	
	v max	15.4	20.5	25.6	19.6	20.5	16.2	29.0	24.7	18.8	17.9	13.7	17.9	
Kapp Thordsen	T max abs		4.7	6.4	1.0	-2.9	-4.4	2.1	-2.7	2.7	5.7	7.2	11.6	13.6
	Ti		-1.4	-3.5	-8.6	-18.5	-16.0	-8.5	-16.7	-7.0	-5.0	1.8	4.4	5.7
	T min abs		-9.4	-16.1	-25.4	-30.7	-35.5	-25.5	-26.6	-22.8	-15.9	-4.2	0.8	1.3
	v			4.1	4.5	1.3	3.9	4.1	2.5	3.6	3.0	3.1	3.0	3.0
	v max			15.5	13.6	10.0	15.5	15.9	15.2	13.9	16.8	15.7	14.9	11.5
Kara Sea	T max abs		5.6	0.4	-0.9	-1.8	-6.0	-1.0	-4.5	1.7	3.0	3.2	4.9	3.6
	Ti	3.1	1.8	-11.2	-18.7	-18.5	-28.4	-18.7	-19.3	-12.4	-9.5	-0.5	1.7	0.2
	T min abs		-10.1	-31.3	-39.6	-37.4	-47.9	-37.5	-38.5	-32.1	-28.4	-6.4	-2.4	-7.6
	v	4.9	4.6	5.0	3.8	4.3	3.8	4.2	3.8	4.4	3.8	3.9	3.7	4.0
	v max	7.7	7.7	9.3	7.7	8.5	7.0	9.3	8.5	8.5	7.7	7.0	7.0	8.5
Kingua Fjord	T max abs			0.0	-2.5	-1.3	-9.5	-24.2	3.7	2.1	7.9	10.7	15.8	19.7
	Ti		0.3	-10.9	-18.1	-21.7	-30.5	-35.8	-21.2	-15.2	-0.9	2.4	5.9	7.4
	T min abs			-24.5	-33.4	-34.9	-40.9	-45.2	-48.1	-30.6	-11.6	-5.2	0.4	0.0
	v		1.8	1.8	1.4	0.6	0.3	0.3	1.8	0.9	1.6	2.2	2.1	2.2
	v max		5.8	7.5	7.7	16.7	4.3	4.8	9.9	5.0	9.9	8.4	6.9	6.1
Lady Franklin Bay	T max abs	8.8	-2.6	-10.0	-18.4	-14.7	-27.8	-20.6	-6.7	-14.1	0.2	4.2	11.3	
	Ti	1.8	-7.7	-22.1	-33.3	-33.2	-37.7	-39.4	-27.7	-26.0	-9.6	0.3	2.9	
	T min abs	-5.1	-17.4	-30.8	-43.3	-42.2	-45.9	-49.2	-45.1	-38.5	-25.0	-5.2	-1.8	
	v	1.7	1.5	1.0	0.3	0.3	0.1	0.1	0.8	0.5	1.3	1.9	1.3	
	v max	9.2	10.2	10.8	7.2	6.6	2.6	2.3	17.1	4.9	13.1	12.1	11.2	
Malye Karma-kuly	T max abs		7.9	3.1	-0.9	-1.8	-1.6	0.2	-2.5	3.7	9.8	8.8	15.7	14.9
	Ti		-0.3	-6.5	-12.0	-15.1	-21.2	-9.7	-14.9	-6.4	-5.1	1.3	5.7	5.5
	T min abs		-11.0	-23.4	-29.6	-29.7	-39.4	-28.2	-28.9	-20.1	-17.3	-2.2	-0.5	-0.4
	v		4.4	5.8	5.5	5.5	6.8	6.3	6.5	6.3	6.0	5.2	5.2	4.9
	v max		18.2	27.0	21.1	26.3	28.4	21.1	29.2	29.2	29.2	24.8	23.3	19.7

Station	Parameter	1882					1883							
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Point Barrow	T max abs	14.9	10.7	4.8	-1.8	-13.3	-10.9	-4.2	-3.2	-8.9	3.2	10.5	11.8	15.8
	Ti	3.3	-0.3	-12.9	-21.7	-27.3	-27.2	-21.3	-25.2	-19.3	-4.9	0.2	2.3	2.8
	T min abs	-3.0	-6.9	-29.9	-37.5	-41.1	-41.0	-36.8	-46.3	-37.2	-25.6	-7.7	-2.6	-5.3
	v	5.1	4.7	4.7	6.4	2.8	4.6	4.8	3.9	2.8	4.1	4.0	4.0	5.0
	v max	15.4	19.4	13.0	14.7	14.0	20.1	25.1	11.4	11.0	10.0	12.0	9.4	11.4
Sagastyr	T max abs		11.0	-2.5	-18.3	-19.4	-25.9	-27.0	-18.1	-10.2	3.3	12.5	12.1	12.8
	Ti		0.1	-15.2	-27.9	-33.6	-36.9	-42.0	-33.3	-21.0	-8.8	0.7	4.9	3.5
	T min abs		-12.3	-29.6	-36.3	-49.2	-47.8	-53.2	-41.6	-32.8	-24.2	-12.6	-0.2	-1.2
	v		5.3	5.1	4.5	4.2	3.4	4.0	3.7	4.4	5.5	5.4	7.1	5.6
	v max		13.5	17.5	13.5	14.3	15.1	15.1	10.3	11.9	15.1	14.3	13.5	12.7

Note: thermal characteristics as presented by Przybylak (2004) and Przybylak, Panfil (2005)

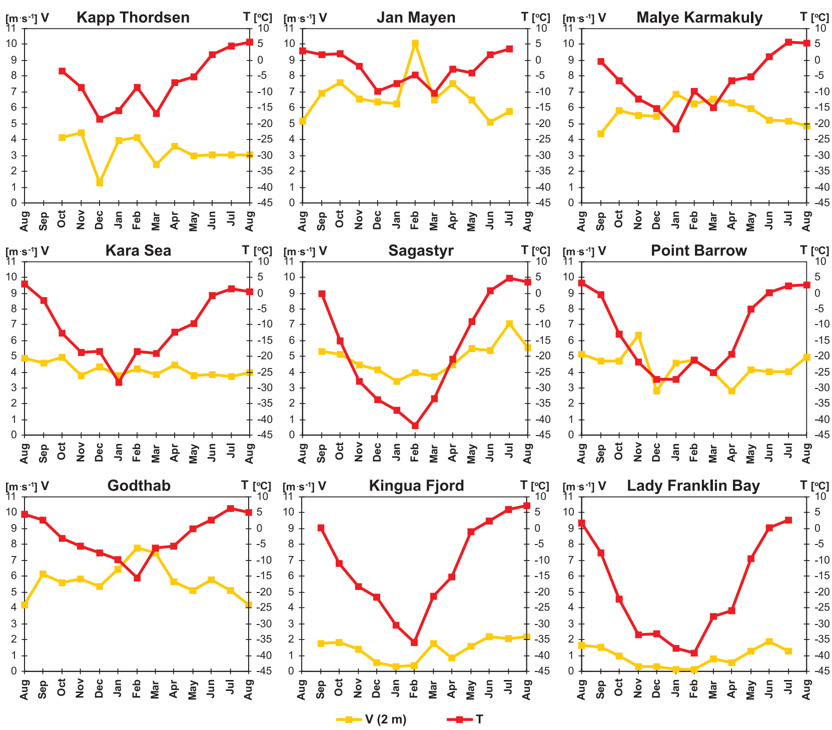

Fig. 2. Annual course of the air temperature (T) and the wind speed (V) at 2 m AGL in the Arctic during the First International Polar Year, from August 1882 until August 1883

Franklin Bay and Kingua Fjord was an annual maximum wind speed value recorded in summer. In the study period the lowest mean monthly wind speed (0.1 $m \cdot s^{-1}$) occurred at Lady Franklin Bay in January and February 1883, while the highest speeds (10.1 $m \cdot s^{-1}$) were recorded at Jan Mayen in February the same year. The highest maximum instantaneous wind speed in the whole area analysed (29.2 $m \cdot s^{-1}$) was observed at Malye Karmakuly in the spring of 1883 (4 May).

Wind Chill Index

The wind chill index is a valuable biometeorological tool allowing us to determine the thermal conditions of the environment at low temperatures (Siple and Passel 1945). The occurrence of the most favourable conditions on individual days at the stations analysed is connected with the higher air temperatures and lower wind speeds (Table 1, Fig. 2).

During IPY 1 in the Arctic the actual values (measured every hour) at all stations range from "comfortable" to "extremely frosty". In the analysed period "cold" sensations definitely prevailed, usually accounting for over 50% of all observations made at individual stations (Figs. 3–4).

The highest absolute amplitude of the WCI ranged from 334.1 $W \cdot m^{-2}$ (Godthåb, 22 June 1883, 7.00 pm) to 2784.7 $W \cdot m^{-2}$ (Malye Karmakuly, 24 January 1883, 10.00 pm) (Table 2).

On the days when wind chill index exceeded 1628.3 $W \cdot m^{-2}$ there was a risk of frostbite in parts of the body exposed to the cold wind. The polar explorers at the Sagastyr station, situated at the mouth of the River Lena, were the group that was exposed to that risk the most often (44% of the duration of their expedition) (Fig. 4). The best conditions in terms of the threat of frostbite were at Kingua Fjord and Lady Franklin Bay (for only 2% of the year).

Predicted insulation of clothing

Clothing is the simplest protection against the unfavourable influence of the weather, particularly in the polar regions. The thermal insulation properties of clothing depends mainly on its thickness, number of layers, kind of fabric, texture, fashion of clothing, colour and the way it is worn. In order to assess the biometeorological conditions in the analysed area from the point of view of clothing requirements that would ensure proper thermal comfort,

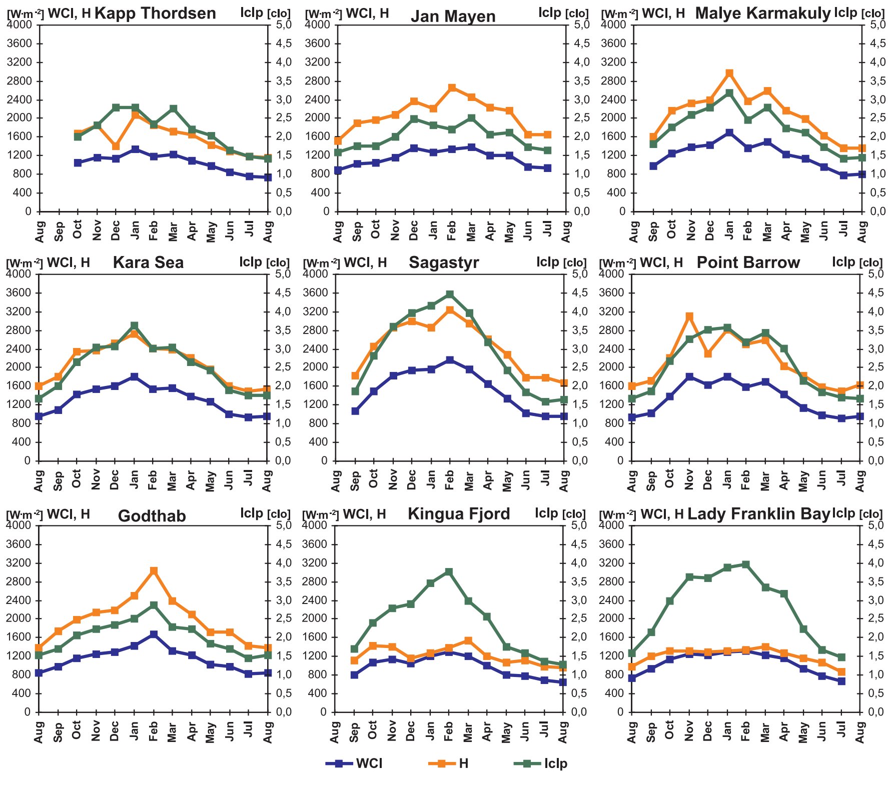

Fig. 3. Annual courses of the biometeorological indices (WCI, Iclp and H) in the Arctic during the First International Polar Year, from August 1882 until August 1883

the predicted insulation index of clothing was used for a person walking outdoors at 4 km·h^{-1}. Considering the demand for clothing with optimum insulation properties for a walking person, during the winter months of IPY 1 heavy arctic clothing was a necessity (especially at Sagastyr and Lady Franklin Bay – Figs. 3 and 5). In the summertime, the ideal clothing at all analysed arctic stations had to have a thermal protective performance of at least 1.5–2.0 clo (Table 2, Fig. 3). In addition, a human body needs twice as much clothing insulation for thermal comfort when standing upright as does a body in motion (Araźny 2006, 2008). A standing body produces only 70 W·m^{-2} of heat, which is roughly 50% of what is produced by the metabolism of a walking person. In the study period, considering the values for a moderate human effort, the predominant thermal conditions were “cool”

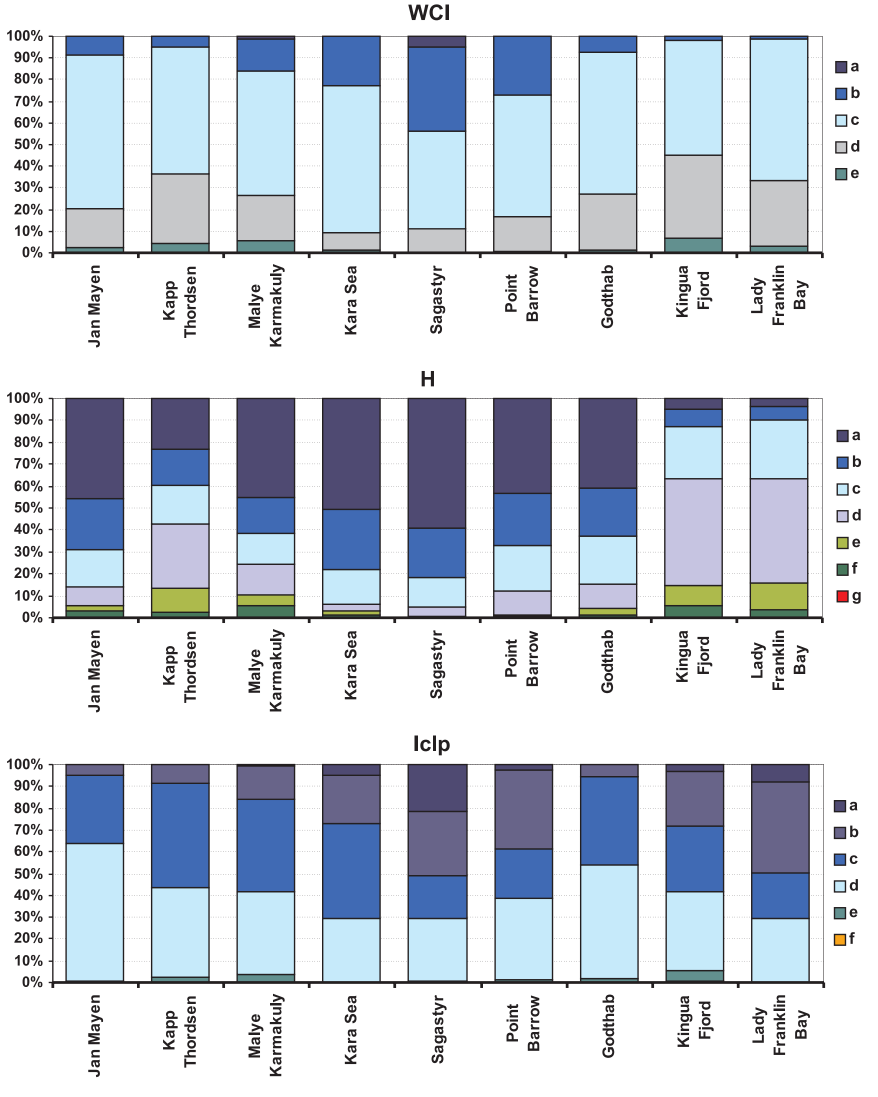

Fig. 4. Annual course of the frequency of occurrence (%) of various human thermal sensations (%), defined by WCI, H and Iclp in the Arctic during the First International Polar Year, from August 1882 until August 1883

Explanation:

WCI: a – extremely frost, b – frosty, c – cold, d – cool, e – comfortable;

H: a – extremely cold and windy; b – very cold; c – cold; d – cool; e – slightly cool; f – neutral; g – hot;

Iclp: a – arctic cold, b – very cold, c – cold, d – cool, e – neutral, f – warm

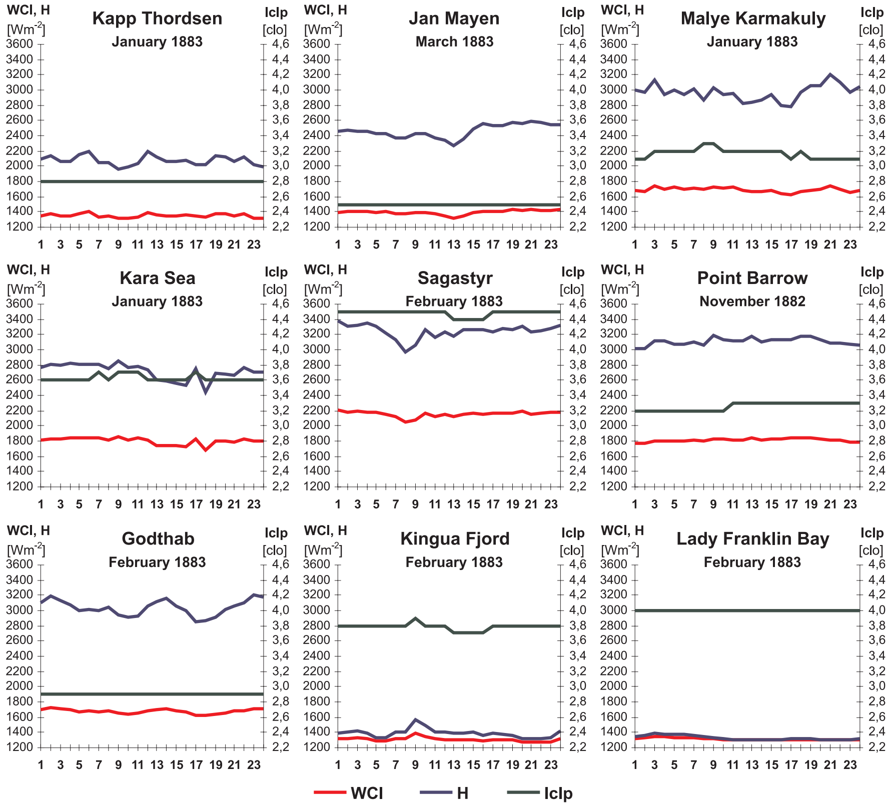

Fig. 5. Diurnal courses of the biometeorological indices (WCI, Iclp and H) at individual stations in the months with the worst conditions and thermal sensations during the First International Polar Year of 1882–1883

and “cold” (from approx. 50% at Sagastyr and Lady Franklin Bay to 95% at Jan Mayen). It should be noted that the least favourable thermal environment was found at Sagastyr and Lady Franklin Bay, where “very cold” and “arctic cold” thermal conditions occurred in 50% of all cases (Fig. 4).

Cooling power of the air

During IPY 1 in the Arctic region substantial differences were found in the values of H for the polar stations analysed. In the human thermal sensation scale of Petrovič and Kacvinsky, the optimum conditions for a moving person range from 420.1 to 840.0 W·m^{-2} and include the sensations of “neutral” and “slightly cool”. At lower values, the organism becomes overheated and

Table 2. Absolute values of the biometeorological indices (WCI, Iclp and H) in the Arctic during the First International Polar Year, from August 1882 until August 1883

Station	Index	1882					1883							
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Jan Mayen	WCI (max abs)	1318.2	1378.4	1347.9	1892.7	2336.5	2089.2	2073.6	2151.8	1714.5	1751.9	1325.9	1209.1	
	WCI (min abs)	457.8	528.6	540.9	574.5	611.6	581.6	701.8	578.1	551.5	567.5	473.8	491.4	
	H (max abs)	2869.4	3488.5	3391.7	4083.0	5063.1	4410.0	5949.4	4934.9	3915.4	4097.8	2865.0	2811.7	
	H (min abs)	492.4	559.4	571.1	602.9	638.1	609.6	723.5	606.2	581.1	596.2	507.4	524.2	
	Iclp (max abs)	2.0	2.1	2.2	2.9	3.8	3.6	3.2	3.3	2.8	2.8	2.1	2.0	
	Iclp (min abs)	1.0	1.3	1.3	1.4	1.6	1.4	1.8	1.4	1.3	1.4	1.1	1.1	
Kapp Thordsen	WCI (max abs)			1830.2	2078.6	1981.0	2436.4	1965.2	2006.7	1698.9	1498.2	1283.2	1215.3	1096.9
	WCI (min abs)			560.4	606.3	662.9	684.1	595.7	689.4	579.8	565.7	479.1	440.2	413.4
	H (max abs)			3760.7	4079.4	3629.0	4670.3	4058.2	3849.7	3616.0	3329.3	2969.5	2775.8	2324.0
	H (min abs)			589.5	633.0	686.6	706.7	623.0	711.8	607.9	594.5	512.5	475.6	468.9
	Iclp (max abs)			2.9	3.5	3.7	4.0	3.3	3.5	3.1	2.8	2.1	1.8	1.8
	Iclp (min abs)			1.3	1.5	1.7	1.8	1.5	1.8	1.4	1.4	1.1	0.9	0.8
Malye Karmakuly	WCI (max abs)		1742.9	2088.8	2387.9	2034.3	2784.7	2103.5	2268.8	2076.2	1836.8	1323.0	1220.0	1216.1
	WCI (min abs)		480.8	544.5	618.7	772.5	618.7	602.8	682.4	608.1	463.2	427.8	335.9	403.0
	H (max abs)		3830.0	4800.3	5467.6	4977.6	7140.5	4916.2	5935.3	5935.3	5365.3	3485.9	2942.6	2969.1
	H (min abs)		514.1	574.4	644.8	790.5	644.8	629.7	705.1	634.7	497.4	463.9	376.8	440.5
	Iclp (max abs)		2.7	3.4	3.7	3.7	4.3	3.6	3.8	3.1	2.9	2.0	2.0	1.9
	Iclp (min abs)		1.1	1.3	1.6	2.0	1.6	1.5	1.8	1.5	1.0	0.9	0.6	0.8
Kara Sea	WCI (max abs)	1186.1	1394.9	2039.7	2204.2	2114.8	2449.9	2105.3	2197.6	1908.5	1841.2	1200.8	1161.7	1193.0
	WCI (min abs)	397.7	537.4	613.4	696.5	799.0	1203.8	885.6	710.6	625.8	608.1	532.1	521.5	551.5
	H (max abs)	2162.2	2534.0	3440.6	3702.0	3697.6	3766.6	3571.3	3609.4	3147.0	2824.6	2185.2	2122.0	2173.7
	H (min abs)	435.4	567.7	639.7	718.5	815.6	1199.1	897.6	731.9	651.5	634.7	562.7	552.7	581.1
	Iclp (max abs)	2.1	2.5	3.9	4.3	4.2	4.9	4.1	4.3	3.8	3.6	2.2	2.0	2.1
	Iclp (min abs)	0.8	1.3	1.5	1.9	2.0	2.4	2.0	1.9	1.6	1.5	1.3	1.2	1.3

Sagastyr	WCI (max abs)		1636.9	2386.7	2535.5	2621.4	2591.3	2767.2	2384.6	2105.8	1882.5	1483.3	1185.3	1234.2
	WCI (min abs)		495.0	744.2	1016.5	1163.2	1170.3	1062.4	1085.4	1097.7	648.8	516.2	613.3	445.5
	H (max abs)		3467.4	4810.1	5199.2	5542.0	5578.0	5733.6	4468.0	3869.7	3956.2	3210.2	2581.1	2471.0
	H (min abs)		527.5	763.7	1021.6	1160.6	1167.3	1065.1	1086.9	1110.3	773.7	547.6	913.0	524.2
	Iclp (max abs)		2.7	3.8	4.2	4.7	4.7	5.2	4.5	4.0	3.4	2.6	1.9	2.0
	Iclp (min abs)		1.1	2.0	3.0	3.0	3.6	3.2	3.0	2.5	1.5	1.1	1.1	0.9
Point Barrow	WCI (max abs)	1201.4	1412.2	1911.4	2327.6	2227.2	2283.9	2414.6	2420.0	2016.8	1812.7	1267.0	1210.3	1346.6
	WCI (min abs)	488.9	590.4	701.2	897.8	991.7	896.0	888.7	948.1	765.1	528.6	438.0	514.3	429.6
	H (max abs)	2512.7	3509.6	3561.5	4934.0	4601.9	5310.8	5514.1	4150.4	3874.8	3222.9	2609.1	2310.8	2679.7
	H (min abs)	533.4	618.0	866.7	928.2	998.1	926.5	919.4	1085.7	800.1	559.4	484.3	558.0	465.6
	Iclp (max abs)	2.0	2.2	3.6	4.0	4.2	4.3	4.0	4.6	3.9	3.4	2.2	2.0	2.1
	Iclp (min abs)	0.9	1.2	1.6	2.0	2.9	2.5	2.2	2.1	2.1	1.3	0.9	1.1	0.9
Godthab	WCI (max abs)	1182.4	1257.2	1511.5	1671.6	1733.7	1958.9	2186.1	2038.6	1790.0	1387.1	1272.8	1154.4	1157.9
	WCI (min abs)	431.3	480.8	581.6	613.4	625.0	725.1	793.7	615.2	605.5	484.4	334.1	426.0	482.2
	H (max abs)	2845.7	2746.2	3246.7	3562.2	3514.9	4035.5	4434.3	4014.1	4172.5	3299.6	3055.1	2740.9	2330.6
	H (min abs)	467.2	514.1	609.6	639.7	671.6	899.1	810.6	641.4	733.5	517.5	375.1	480.6	535.9
	Iclp (max abs)	1.9	2.0	2.4	2.6	2.8	3.2	3.5	3.4	2.7	2.1	2.0	1.8	1.8
	Iclp (min abs)	0.9	1.1	1.4	1.6	1.4	1.4	1.8	1.2	1.3	1.1	0.6	0.8	1.0
Kingua Fjord	WCI (max abs)		1168.8	1647.0	2041.4	1701.5	2038.7	2128.2	1951.1	1709.7	1362.7	1161.7	1002.2	1006.2
	WCI (min abs)		523.3	599.3	694.7	659.4	786.7	1043.0	631.1	565.7	516.2	426.0	381.8	339.4
	H (max abs)		1958.8	2830.9	3368.9	3571.7	3177.2	3394.0	3732.4	2684.8	2701.1	2187.4	1851.1	1614.8
	H (min abs)		554.3	626.3	716.8	683.3	803.9	1046.7	656.5	594.5	547.6	462.2	420.4	380.2
	Iclp (max abs)		2.2	3.3	3.7	3.8	4.2	4.4	4.6	3.4	2.5	2.0	1.8	1.9
	Iclp (min abs)		1.2	1.5	1.9	1.7	2.2	3.1	1.6	1.4	1.2	0.9	0.7	0.5
Lady Franklin Bay	WCI (max abs)	1083.4	1494.3	1857.1	1934.7	2059.4	1865.3	1949.7	1962.3	1726.2	1660.8	1253.6	1044.2	
	WCI (min abs)	519.8	638.2	864.4	967.0	922.8	1110.2	1005.9	915.7	832.6	621.6	530.7	505.3	
	H (max abs)	1906.0	2813.5	3410.9	3159.8	3455.3	2617.0	2660.6	4124.6	2496.1	3120.3	2372.8	1953.6	
	H (min abs)	563.2	663.2	877.6	974.7	932.8	1110.3	1011.5	926.1	847.4	661.5	573.8	549.2	
	Iclp (max abs)	2.1	2.8	3.6	4.2	4.2	4.3	4.6	4.3	4.0	3.3	2.1	1.9	
	Iclp (min abs)	1.2	1.6	2.5	2.8	2.6	3.3	3.0	2.6	2.3	1.6	1.2	1.2	

when exposed to prolonged or extensive cooling it first becomes stimulated and then overcooled. The optimum conditions in the summer of IPY 1 occurred only between 1% of the time at Sagastyr and Point Barrow and 16% at Lady Franklin Bay. The feeling of cold discomfort (H > 1260.1 $W \cdot m^{-2}$) comprises such sensations as "cold", "very cold" and "extremely cold and windy". The cold discomfort days were most frequent at Sagastyr (95%) and Kara Sea (94%), and occurred least often at Kingua Fjord (36%) and Lady Franklin Bay (37%) (Fig. 4). The highest absolute amplitude of the cooling power of the wind, as recorded at routine measurements, ranged from 375.1 $W \cdot m^{-2}$ (Godthåb, 22 June 1883, 7.00 pm) to 7140.5 $W \cdot m^{-2}$ (Malye Karmakuly, 24 January 1883, 10.00 pm) (Table 2).

Summary and conclusions

The aim of this paper was to investigate the biometeorological conditions in the Arctic during the First International Polar Year of 1882–1883. The spatial distribution of the values of the meteorological and biometeorological conditions analysed was sizeable. Unfavourable thermal conditions in the Arctic during IPY 1 were caused by low air temperatures and their considerable changeability, particularly in the winter months. The actual temperature range is determined by location, season, current weather conditions, and wind chill factor; however, the basics of dressing for cold weather are the same regardless of temperature. The occurrence of high winds added to the unfavourable thermal sensations. In the study period, the feeling of "cold" (WCI) was predominant, constituting typically more than 50% of all observations made at individual stations. During First International Polar Year the clothing used by people in the Arctic, even if they were active, had to have excellent thermal protective parameters. The predicted insulation of clothing for an person must be characterised by high heat retention properties in the Arctic. An analysis of the cooling power of the air proved that, in most of the Arctic area, cold discomfort prevailed at the majority of stations. The IPY 1 polar explorers working at Sagastyr were exposed to the most unfavourable thermal sensations. On the other hand, the most 'thermally privileged' of all the nine stations was the Spitsbergen site, Kapp Thordsen.

A comparison of bioclimatic conditions at the time of First International Polar Year with contemporary data was only possible for one station – Jan Mayen (Table 3). There are no publications on the topic of bioclimatic conditions for other areas of the Arctic, therefore no other comparisons could be

Table 3. Average differences between monthly and annual values of the biometeorological indices at Jan Mayen, calculated for the historical and contemporary data (1971–2000, Araźny 2008)

Index	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
WCI	-19.8	-108.2	-168.1	-71.6	-234.0	-74.2	-138.6	-93.4	-127.6	-29.4	-14.7	-131.7	-100.9
H	-25.4	-541.9	-344.2	-335.0	-609.2	-240.5	-406.4	-272.3	-408.0	-251.9	-117.1	-241.9	-316.2
Iclp	-0.1	0.0	-0.3	0.0	-0.3	0.0	-0.1	-0.1	-0.1	0.1	0.0	-0.3	-0.1

made. However, the analysis carried out for the area of Jan Mayen indicates that human thermal sensations in the historical study period were worse than today. The most unfavourable differences between the past and the present bioclimatic conditions occurred in May and March.

Acknowledgements

This article was prepared as part of the special research project of the Ministry of Science and Higher Education No. 1195/IPY/2007/0131/IPY/2007, *The 19th- and Early 20th-century History of the Arctic Climate in the Early Instrumental Period (ACEIP)* and *Arctic Climate and Environment of the Nordic Seas and the Svalbard – Greenland Area (AWAKE)* funded within the framework of the Polish-Norwegian Research Fund (PNRF– 22– AI–1/07). The author would like to thank all the people who participated in the digitisation of the hourly data of the air temperature and wind speed from IPY 1 resources. I also want to thank my two anonymous reviewers for valuable comments and suggestions.

References

Araźny A., 2006, Variability of the predicted insulation index of clothing in the Norwegian Arctic for the period 1971–2000, Polish Polar Res., 27(4), 341–357.

Araźny A., 2008, Bioklimat Arktyki Norweskiej i jego zmienność w okresie 1971–2000, Wyd. UMK, Toruń, 215 pp.

Baker F.W.G., 2009, The first International Polar Year (1882–1883): French measurements of carbon dioxide concentrations in the atmosphere at Bahia Orange, Hoste Island, Tierra del Fuego, Polar Record, 45: 265–268, DOI:10.1017/S0032247408008176.

Błażejczyk K., Błażejczyk M., 2009, BioKlima©2.6, software package, www.igipz.pan.pl/ geoekoklimat/blaz/bioklima.htm.

Burton A. C., Edholm O. G., 1955, Man in a cold environment, E. Arnold Publ., London, 333 pp.

Ekholm N.G., 1890, Observations faites au Cap Thorsden, Spitzberg, par l'expédition suédoise, Stockholm: Kongl. Boktryckeriet. P.A. Norstedt & Söner, Tome I: 3, Observations Météorogiques.

Gagge A. P., Burton A. C., Bazett H. C., 1941, A practical system of units for the description of heat exchange of man with his environment, Science, 94, 428–430.

Glickman T.S. (ed.), 2000, Glossary of meteorology, American Meteorological Society, Boston, 855 pp.

Greely A.W., 1886, Report on the Proceedings of the United States expedition to Lady Franklin Bay, Grinnell Land. Washington. D.C., Government Printing Office, 2 vols.

Kozłowska-Szczęsna T., Błażejczyk K., Krawczyk B., 1997, Human bioclimatology, Methods and applications, Wyd. IGiPZ PAN, Monografie 1, Warszawa, 200 pp.

Lenz R. (ed.), 1886a, Beobachtungen der Russischen Polarstation an der Lenamündung, Expedition der Kaiserl, Russischen Geographischen Gesellschaft, II. Theil, Meteorologische Beobachtungen bearbeitet von A. Eigner.

Lenz R. (ed.), 1886b, Beobachtungen der Russischen Polarstation auf Nowaya Semlja, Expedition der Kaiserl, Russischen Geographischen Gesellschaft, II. Theil, Meteorologische Beobachtungen bearbeitet von K. Andrejeff.

Lüdecke C., 2007, Über die Globale Vereilung von Luftdruck und Temperatur am Beispiel des 1, Internationalen Polarjahres 1882/1883, Hamburg: http://meetings.copernicus.org/ dach2007/download/ DACH2007_A_00400.pdf.

Newitt L.R., Dawson E., 1984, Magnetic Observations at International Polar Stations in Canada, Arctic, 37 (3), 255–262.

Neumayer G.B., Börgen C.N.J., 1886, Die Beobachtungs-Ergebnisse der Deutschen Stationen, Berlin, Verlag von A. Asher & Co., Band I. Kingua-Fjord und die meteorologischen Stationen II, Ordnung in Labrador: Hebron, Okak, Nain, Zoar, Hoffenthal, Rama, sowie die magnetischen Observationen in Breslau und Göttingen.

Paulsen A.F.W., 1886, Observations Internationales Polaires 1882–1883, Expédition danoise, Observations faits à Godthaab, L'Institut Météorologique de Danemark, København: Chez G.E.C. Gad, Librarie de L'Université, Tome II, I Météorologie.

Ray P.H., 1885, Report of the International Polar Expedition to Point Barrow, Alaska, Washington, D.C., Government Printing Office.

Przybylak R., 2004, Temperatura powietrza w Arktyce w okresie Pierwszego Międzynarodowego Roku Polarnego 1882/83, Polish Polar Stud., XXX Międzynarodowe Sympozjum Polarne, Gdynia, 307–320.

Przybylak R., Panfil M., 2005, Warunki klimatyczne w stacji Sagastyr (ujście Leny) w okresie 1.09.1882–30.06.1884, Polish Polar Stud., XXXI Sympozjum Polarne, Kielce, 143–152.

Przybylak R., Jankowska J., 2009, Ciśnienie atmosferyczne w Euroazjatyckim sektorze Arktyki w okresie 1841–1920, Probl. Klimatol. Pol., 19, 81–98.

Przybylak R., Wyszyński P., 2009, Ciśnienie atmosferyczne w Arktyce w okresie Pierwszego Międzynarodowego Roku Polarnego 1882/83, Probl. Klimatol. Pol.,19, 99–114.

Przybylak R., Vizi Z., Wyszyński P., 2010, Air temperature changes in the Arctic from 1801 to 1920, Int. J. Climatol., 30, 791–812.

Siple P. A., Passel C. F., 1945, Measurements of dry atmospheric cooling in subfreezing temperatures, Proc. Amer. Philosoph. Soc., 89(1), 177–199.

Snellen M., Ekama H., 1910, Rapport sur l'Expédition Néerlandaise qui a hiverné dans la Mer de Kara en 1882/83, Utrecht, J. Van Boekhoven.

Treshnikov A. F. (ed.), 1985, Atlas Arktiki, Glavnoye Upravlenye Geodeziy i Kartografiy, Moscow.

Wohlgemuth E.E. Von, 1886, Die österreichische Polarstation Jan Mayen: ausgerüstet durch Seine Escellenz Graf Hanns Wilczek, Beobachtungs-Ergebnisse, Herausgegeben von der Kaiserlichen Akademie der Wissenschaften, Wien, Aus der Kaiserlich-königlichen Hof- und Staatsdruckerei, in Commission bei Karl Gerold's Sohn, 1 III.Theil, 1 Abtheilung Meteorolgie bearbeitet von Adolf Sobieczky.

Wood K., Overland J.E., 2006, Climate lessons from the first International Polar Year, Bull. Amer. Met. Soc., 1685–1697, DOI:10.1175/BAMS-87–12–1685.

Wood K., Streletskiy D.A., 2008, Soil and Permafrost Temperature Data Obtained during the First International Polar Year, 1882–1883, Proceed-

ings of the Ninth International Conference on Permafrost (NICOP), University of Alaska, Fairbanks, June 29-July 3, 2008.
WEB PAGE: www.arctic.noaa.gov/aro/ipy-1.