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Characteristics of meteorological conditions at the Arctowski Station during the summer season of 1979—1980*)

ABSTRACT: This study gives an analysis of the variation of main meteorological parameters on the Station Arctowski in the time from December 1979 through March 1980 — the summer season of the IV Antarctic Expedition of the Polish Academy of Sciences.

Characteristics of wind speed and direction, of air temperature, atmospheric pressure, precipitation, cloudiness, soil temperature at the station and surface water temperatures of the Admiralty Bay are based on the standard synoptic observations.

Key words: Antarctic, meteorological conditions at Admiralty Bay

1. Introduction

The study contains characteristics of the most significant meteorological elements observed during the austral summer season, from December 1979 till the end of March 1980. The basic material used were the standard meteorological observations made regularly eight times a day at the Arctowski Antarctic Station of the Polish Academy of Sciences, the additional measurements of soil temperatures at the station site and surface water temperatures of Admiralty Bay. All the data were preliminarily checked and verified. Only the results of the measurements made later than March 17, 1980, were not controlled, as they were obtained by teleprinter after the termination of the summer expedition and may contain, therefore, eventual innaccuracies due to difficulties in teletransmission of data. Parts of Fig. 3 and Fig. 4, illustrating those data, are drawn with dashed lines.

Data contained in the Meteorological Yearbook Arctowski 1978—1979 (Skrzypczak 1980) were also used for comparison.

*) The work was done during the Fourth Polish Antarctic Expedition at the Arctowski Station as part of Project MR-II-16 granted by the Polish Academy of Sciences.

2. Wind

Wind is a meteorological element, which, owing to the location of the Arctowski Station — the orography of King George Island and sharply indented coast line of Admiralty Bay — may be strongly deflected in relation to the air flow resulting from synoptic conditions. Nonetheless, the synoptic situation has a marked influence upon speed and direction and even upon the character of the air flow in the Admiralty Bay. Thus, knowing the main features of wind speed and direction — the mean and extreme values and frequency distribution — character of prevailing synoptic conditions, which caused them, may be inferred.

During the whole period from December 1979 till the end of February 1980 southeasterly winds prevailed at the station with frequencies of 16.7%; the easterly ones were as frequent as 13.2%; of similar frequencies were also the northerly and northwesterly winds — 13.6 and 12.9% respectively. Least frequent during that time were the southerly and westerly winds — 5.5 and 6.0% respectively. A high frequency of calms and light variable winds was noted during that period, amounting jointly to 15.2%. The mean wind speed in the time from December to the end of February was 5.7 $m \cdot s^{-1}$. The highest gusts reached 28 $m \cdot s^{-1}$. A fairly differentiated distribution of wind speeds and directions in subsequent months is considered to be noteworthy (Fig. 1).

In December the predominant winds were south-easterly, northerly and northwesterly, whereas the westerly and southerly ones occurred very rarely. The frequency of calms and light winds was jointly 9.6%. In that month no storms of speed exceeding 17 $m \cdot s^{-1}$ were observed and the frequency of gales between 13 and 16 $m \cdot s^{-1}$ was 5.6%. The frequencies of the prevailing light and moderate winds of speed up to 8 $m \cdot s^{-1}$ were 67.1%.

In January, northwesterly and southeasterly winds were still predominant, the northerly and northeasterly ones being less frequent than in December, whereas the frequency of westerly and easterly winds was nearly twice as high as in that month. Stroms and gales were from due northwest. Calms and light variable winds occurred with nearly twice greater frequency than in December. The mean wind speed in January was 5.6 $m \cdot s^{-1}$.

In February, the last of the months under analysis, easterly and southeasterly winds were decidedly predominant, followed closely, in order of frequency, by northerly and northeasterly winds. Jointly the frequency of these directions was 57.3% of all the winds recorded. The percentage of winds occurring from all other points: south, southwest, west and northwest was by about a half less (23.7%). The frequency of calms and light variable winds was 19.0%. The mean monthly wind speed was in February slightly higher than in December and January, reaching 6.0 $m \cdot s^{-1}$.

The above analysis reveals a slightly different distribution of wind directions and speeds of the summer season 1979/1980 as compared with analogous periods of the two precedent years. Westerly and southwesterly wind derections, prevailing in the two precedent summer seasons, were of a very low frequency in the period under discussion (westerly only 6%, southwesterly — 9.5%). The mean monthly wind speeds were also lower

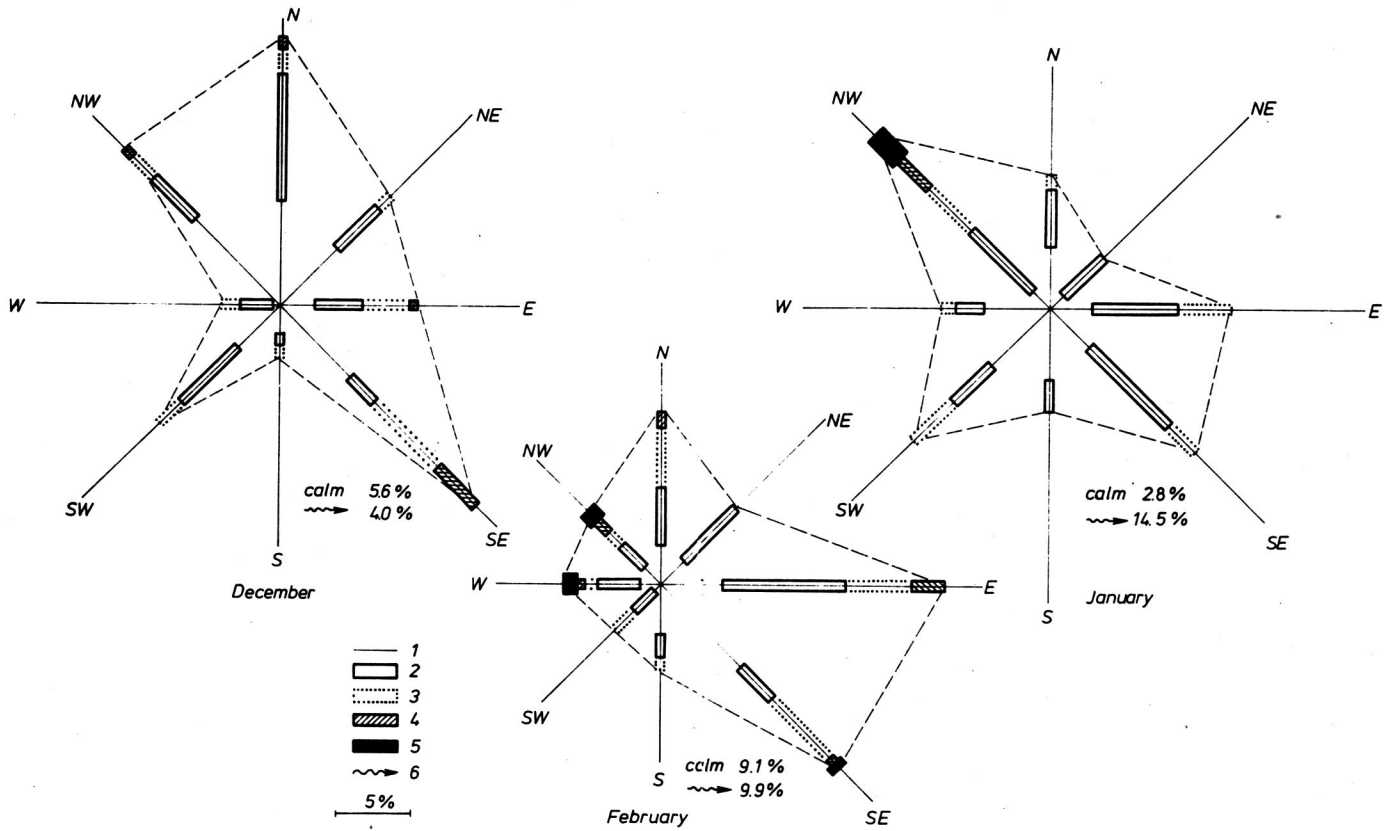

Fig. 1 Distribution of wind speed in relation to wind direction at the Arctowski Station during the summer season 1979/1980

Wind speed ranges: *1* — 0—4 $m \cdot s^{-1}$, *2* — 5—8 $m \cdot s^{-1}$, *3* — 9—12 $m \cdot s^{-1}$, *4* — 13—16 $m \cdot s^{-1}$, *5* — 17 $m \cdot s^{-1}$, *6* — variable wind

than in analogous periods in precedent years, moreover, calms and light variable winds occurred more often (Kowalewski and Wielbińska 1979; Nowosielski[1]); Kratke and Wielbińska 1981).

3. Air temperature

In the warmest season of the year mean monthly air temperatures at the Arctowski Station were: 1.7°C in December 1979, 2.3°C in January, 1.9°C in February and 0.2°C in March, 1980. They were higher than the means during many years for analogous months over the whole period of thirteen years of observations (1948—1960) at the British Station Admiralty Bay, situated on the northern coast of the Bay (World Weather Records 1951—1960, 1968; Dolgin and Petrov, 1977). The monthly mean temperature at Arctowski in summer 1979/80 excedeed the means of thirteen years observation at the station Admiralty Bay by 1.1°C in December and January, by 0.8°C in February and 0.1°C in March.

In the course of decade temperature values (means, means of maximum and of minimum temperatures), illustrated in Fig. 2, two considerably warm periods may be singled out. The first one, with the mean temperature as high as 3.7°C, coincided with the last decade of December and was preceded by a fairly long time of gradual rise of temperature. The second

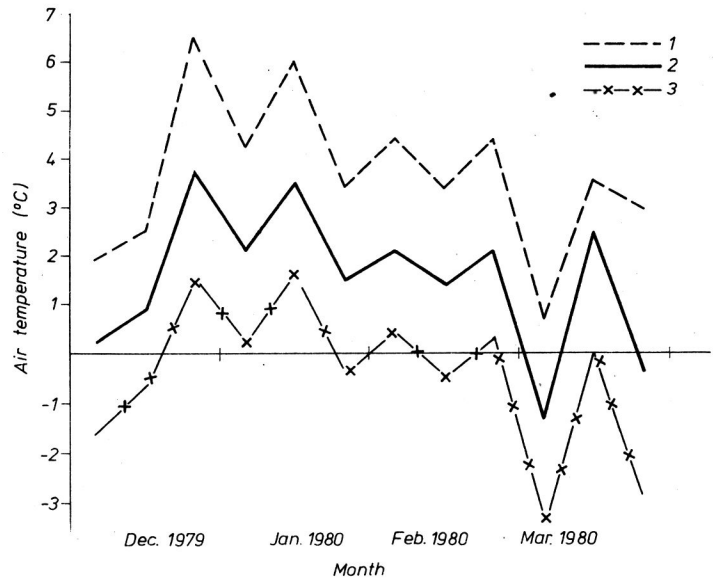

Fig. 2. Decades means of air temperature at the Arctowski Station during the summer 1979/1980
1 — daily temperatures 2 — maximum temperatures 3 — minimum temperatures

[1]) Sprawozdanie z realizacji zadań z meteorologii, podczas II wyprawy Antarktycznej PAN.

one, with the mean temperature reaching 3.5°C occurred between the 11th and 20th January. These two warmest periods of the summer were separated by a cooler one, of only 2.1°C mean.

In February the decade means were markedly lower and in each of the two warmer periods they were 2.1°C. The last, rather sudden rise of temperature was observed between the 10th and 20th March, where the decade mean reached 2.5°C. This warm spell occurred between the two coldest decades of the summer 1979/80: the first ten days of March had the mean temperature as low as — 1.4°C, whereas the mean of the last ten days of that month was −0.5°C. The decadal averaging did not deform the character of the temperature curve: the variation of the decade means and the mean decade maximum and minimum temperatures remained similar to the daily means curve.

The highest maximum temperatures occurred on 23rd December (9.7°C), 14th January (9.2°C), 24th February (9.1°C) and 15th March (up to 6.3°C); whereas the minimum temperatures were noted on 3rd December (−3.2°C), 23rd January (−4.9°C), 27th February (−3.4°C) and 4th March (−7.8°C).

A thorough consideration of the decade means alone suffices to prove that there must have existed a quasi-twenty-day period of temperature fluctuations in the summer under discussion. This is confirmed by an analysis of eleven days overlapping means. The variation curve of those means shows great regularity reaching its maxima between 21—31 December, 10—20 January, 25 January to 5 February, 18—28 February and 10—20 March. The amplitudes of particular oscillations at the beginning and at the end of the season, i.e. in December and in March, amounted

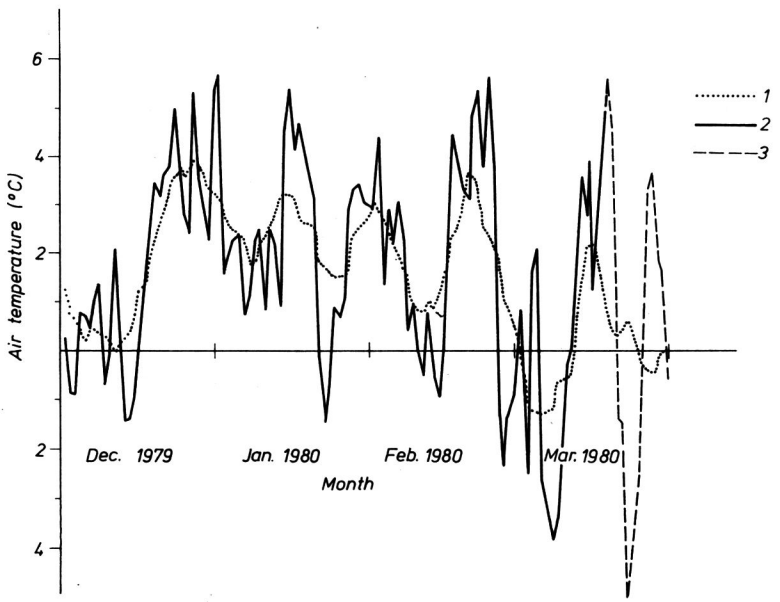

Fig. 3 Variation of air temperature at the Arctowski Station during the summer 1979/1980
1 — eleven-day overlapping means 2 — daily means 3 — data unchecked

to 4—5°C, whereas in the midsummer they were about 2°C. The curve illustrating overlapping eleven-day means, drawn against daily means, is shown in Fig. 3. In the same Fig. 3 the span of the daily means can be examined. Their values amount to 5.7°C (three times throughout the season) to about −5°C in March, thus their amplitude exceeds 4°C. The interdiurnal changes of mean daily temperatures (interdiurnal amplitutes) vary from 1.3 to above 8°C.

4. Atmospheric pressure

The region between latitudes 60°S and 65°S is subject to the sub-Antarctic low pressure systems. The mean monthly pressures for the British Station Admiralty Bay in the summer seasons of the decade 1951—1960 were as follows: 992.4 hPa in December, 989.2 hPa in January, 988.7 hPa in February and 989.4 hPa in March (World Weather Records 1951—1960, 1968). In analogous months, in the summer season 1979/1980 at the Arctowski Station, these values were higher — 996.7 hPa, 990.8 hPa, 993.5 hPa and about 992 hPa respectively. The last value is an unchecked one due to the mentioned lack of possibility of checking the data from March. During the period from lst December, 1979, to 29th February, 1980, the highest pressure (1008.7 hPa) was recorded on 17th December 1979, at 00 GTM, the lowest (974.7 hPa) on 19th January 1980, at 12 GMT. The most abrupt fall of pressure, 6.3 hPa within three hours, occurred on 17th February 1980, between observation times at 12 and 15 GMT, the most sudden rise of pressure occurred on the following day, between 06 and 09 GMT and amounted to 5.5 hPa.

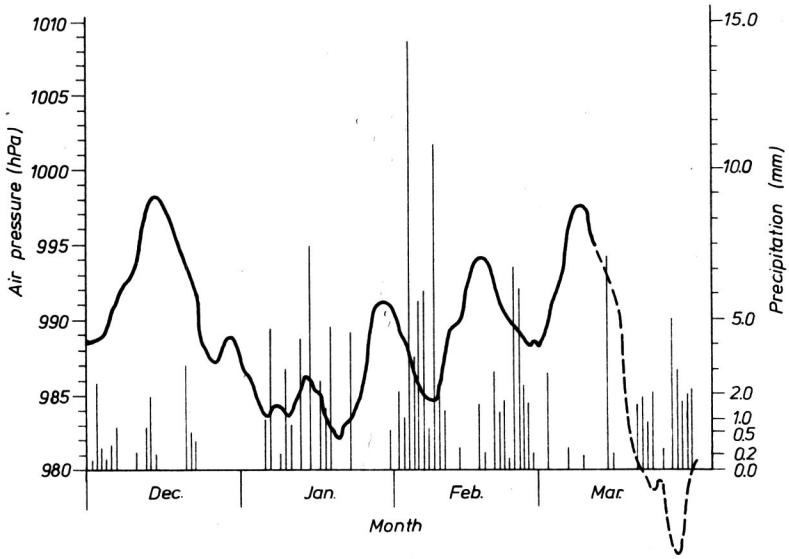

Fig. 4 Eleven-day overlapping means of atmospheric pressure and daily amounts of precipitation at the Arctowski Station during the summer season of 1979/1980
4 — data unchecked

Variation of atmospheric pressures during the summer season 1979/1980 was subject to more or less regular fluctuations. In order to obtain an estimate of the variability of pressure, eleven-day overlapping means were calculated smoothing smaller deviations (Fig. 4). This has brought to light a series of cycles which, just as in the case of the earlier discussed variations in temperature, covered on the average a period of about 20 days, provided the variation of pressure between 28th December and 19th January can be taken as a deformed cycle, in which the maximum that should occur between 1—10th January, was replaced by two shorter cycles with very small amplitude of fluctuations.

There was a great similarity in the periodicity of the temperature and atmospheric pressure throughout the four months of observations. There is a phase lag ranging from about a quarter to a half of the period in the temperature fluctuations in relation to the atmospheric pressure fluctuations. The maximum of pressure preceded the maximum of temperature. The period of lowest temperatures occurred at the time of developing of high pressure systems.

5. Precipitation

Precipitation is an element strongly differentiated, as well with respect to the distribution in time as to the region over which rain-bringing air masses move. Orography of the sub-Antarctic archipelagoes in connection with frequent changes in the direction of air flow in the regions of high cyclonal activity adds to the irregularity in falling out the moisture contained in clouds. This is also apparent in the monthly amounts of precipitation in various years of observation.

In the summer season of 1979/1980 at the Arctowski Station the monthly sum of precipitation was lowest in December, reaching hardly 10.7 mm; in January it was 35.7 mm, whereas in February it was comparatively very high amounting to as much as 75.5 mm. In March, according to the still unchecked data, it was 31.6 mm. The respective values for the summer 1978/1979 were as follows: 54.4 mm in December, 27.2 mm in January, 57.5 mm in February and as much as 123.9 mm in March. (Skrzypczak 1980, Nowosielski[1]). In the summer season of 1977/1978 the recorded values were: 37.7 mm in January, 79.2 mm in February and 93.5 mm in March, (Kratke and Wielbińska 1981). Thus, the summer season 1979/1980 was considerably drier than the analogous periods in two preceding years of observation.

Precipitation, though not abundant, occurred frequently in diverse forms and intensity. In December, out of the total number of 26 days with precipitation, 15 days showed values $\leqslant 0.1$ mm. The highest diurnal amount of precipitation was 3.1 mm. In January, likewise, 26 days with precipitation were recorded including 13 days with diurnal amount not exceeding 0.1 mm and a few days with values over 4 mm.

[1]) See page 4.

As already mentioned, February was most abundant in precipitation, as compared with other summer months. There were only 3 days without precipitation and out of the remaining 26 days as many as 22 had precipitation sums $\leqslant 0.1$ mm, 6 days — more than $\geqslant 5.0$ mm and 2 days — more than $\geqslant 10.0$ mm.

In March, 9 days without precipitation and 7 days with scanty precipitation $\leqslant 0.1$ mm were noted. Among the remaining 15 days only 2 days showed diurnal amount of precipitation exceeding 5.0 mm.

The association between the occurrence of more abundant precipitation and cyclonal activity is not so distinct marked in summer. This is shown in Fig. 4, illustrating variation of the diurnal amount of precipitation in relation to consecutive mean pressure values. From this figure it is apparent that periods of higher pressure are associated with small amount or lack of precipitation, whereas lower pressure is associated with an increase in amount and frequency of precipitation. Only the end of December and the beginning of January are an exception — there was no precipitation accompanying relatively low pressure but this was probably due to the fact, that it should have been the beginning of the new cycle of rising pressure, which should have started in the last days of December. It is even well marked by a small rise of the pressure curve (Fig.4). Then a disturbance of the periodicity interfered and two shorter, irregular cycles appeared instead, as was already mentioned in the section on atmospheric pressure. But the tendency of maintaining a precipitation-poor spell remained and one could even speal of periodicity in the precipitation during that summer.

6. Humidity

Relative humidity is subject to great variability during the day. Under the summer season conditions at the Arctowski Station, diurnal variations of relative humidity are on the average in the range of several percent, though they may occasionally exceed 40%. Mean monthly values were: 83% in December, 82% in January, 85% in February and 79% in March (until March 17). The lowest daily mean relative humidities ranged from 69% to 75%. The lowest relative humidity observed — 41% — was recorded on 11 January 1980, at 21 GMT. It occurred under the conditions of westerly air flow.

Saturation vapour pressure ranged from 3.3 to 7.7 hPa, reaching the mean monthly values: 5.7 hPa in December, 6.0 hPa in January and February and 4.9 hPa in March (until 17 March 1980).

7. Cloudiness

During the observation period from December to March 17 cloudy days and overcast skies prevailed (Table I). In the summer months clear days are very infrequent at the Arctowski Station. Cloudless skies

Table I.

Frequency (days) of cloud amount at the Arctowski Station during the summer season of 1979—1980

	Dec.	Jan.	Feb.	Mar. (until 17th)
Clear (< 1/8)	—	—	—	—
Fairly clear (1/8-2/8)	—	1	—	—
Partly cloudy (3/8-5/8)	5	2	2	4
Cloudy (6/8-7/8)	18	19	13	10
Overcast (8/8)	8	9	14	2

were observed only once on 11 January 1980, barely for a few hours, throughout the period of observation. The most frequently occurring were low clouds with a relatively low base, mainly about 300 m. Clouds were diversified with respect to types and forms, species and varieties. Clouds formed under orographic effects were often observed: wave clouds (lenticularis) and on the lee side of glaciers domes föhn-wall sloping down in intense, descending motion. The cumuliform clouds did not develop vertically.

8. Soil temperature

Mean monthly soil temperatures at the depth of 5, 10, 20, 50 and 100 cm, and the air temperature at 5 cm above the surface of the ground are shown in Fig. 5. As results from the analysis, the ground warmed up gradually during December and January, a complete defreezing at the depth of 1 m was observed at the end of that time. The warming of the soil downwards to the depth of 50 cm was quite intensive during the first two summer months. The differences in mean temperatures of December and January increased at particular levels with the increase in depth, ranging from 0.5°C at the depth of 5 cm to over 2°C at the depth of 50 cm.

In February the soil was observed to cool again; the cooling was more intense at small depths, less intense deeper downwards, decaying at the depth below 50 cm, whereas the temperature at the level of 1 m was still rising at that time. The temperature of air above the surface of the ground was cooler than that of the soil, already. In the contact layer between the atmosphere and the subsoil (5 cm over the ground and 5 cm in the soil) great values of temperature gradient were observed.

9. Surface water temperature

The temperature of the water surface at Admiralty Bay was measured once a day at noon in a permanent place near the cliffs with beacon light. Mean monthly temperatures of the water surface layer were: 1°C in December,

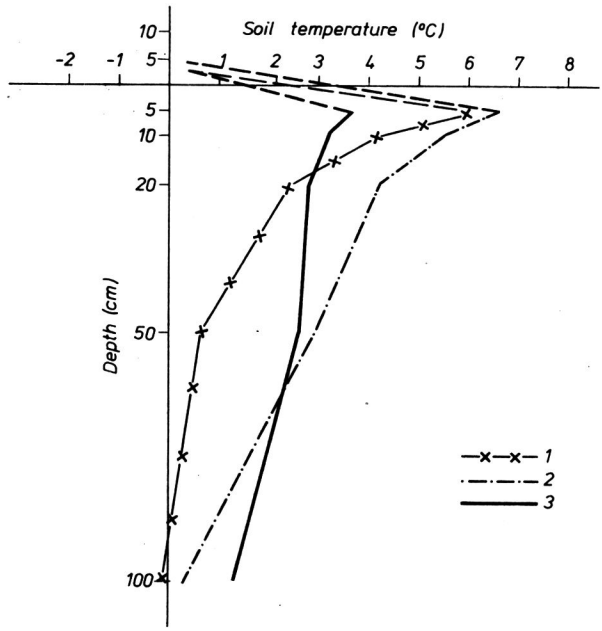

Fig. 5 Mean monthly soil temperatures at the Arctowski Station during the summer of 1979/1980
1 — December, 2 — January, 3 — February

1.6°C in January, 1.4°C in February and 1.2°C in March (until 17th). The highest temperature, 3.6°C, was recorded on 31 January 1980, the lowest temperatures, some tenths below freezing point, were observed in cases when large quantities of ice drifted into the Bay.

10. Summary

Selected meteorological elements: wind derection and speed, air temperature, atmospheric pressure, precipitation, air humidity, soil temperature and temperature of the water surface of Admiralty Bay, observed on the Arctowski Station during the summer season of 1979/1980 are discussed.

Some of the meteorological parametres recorded in this period during many years differ slightly from the quasi-normal means for this region and also from the data of two precedent summer seasons of the activity of the Polar Station.

During the summer of 1979/1980 southeasterly and easterly winds prevailed followed closely by northerly and northwesterly; westerly and southerly winds were observed less frequently (Fig. 1). Calms and light variable winds occurred frequently. Pressure and temperature values did not deviate from the average values. A more detailed analysis (Fig. 2, 3 and 4) of the variation of these elements revealed fairly regular fluctuations of a period lasting about twenty days, with a phase lag between the pressure and temperature waves ranging from a quarter to about a half of the period.

Precipitation (Fig. 4) in various forms and of varying intensity was observed very frequently, yet, due to relatively small monthly amounts the summer of 1979/1980 was on the whole drier as compared with analog periods in the two preceding years.

Very cloudy days or completely overcast skies prevailed; clear days were very infrequent. Mean monthly relative humidity values ranged from 79% to 85%. Great variability of relative humidity was observed during the day.

A rapid warming of the soil was observed at the beginning of the summer until a complete defreezing of the ground to the depth of 1 m in January and then, anew, a gradual cooling of the soil during February, progressing from the surface downwards (Fig. 5).

The surface temperature of Admiralty Bay rose from about 1°C at the beginning of the summer reaching the highest values in January and decreasing gradually later on.

11. Резюме

Представлено характеристику избранных метереологических элементов: скорость и направление ветра, температуру воздуха, давления, осадков, пасмурности, влажности воздуха, температуры почвы а также температуры поверхностной воды залива Адмиралты летом 1979/1980.

С проведенного анализа вытекает, что ход некоторых метереологических параметров в в.у. периоде откланяется от средних многолетних из этого района, а также отличается от двух предшествующих летних сезонов деятельности польской полярной станции.

Летом 1979/1980 преобладали юго-восточные ветры а также северные и северо-восточные, реже наблюдались западние и южные (рис. 1). Частым явлением были тишина и слабые неустойчивые ветры.

Давление и температуры не откланялись от средних. Их анализ (рис. 2, 3 и 4) обнаружил довольно регулярные колебания с периодом достигающим до 20-ти дней передвинуты в фазисе от $\frac{1}{4}$ до около пововины периода.

Часто выступали атмосферные осадки (рис. 4) в разных формах интенсивности но из-за относительно небольших месячных сумм, лето 1979/1980 надо зачислить к более сухим в сравнении с аналогическими периодами двух предшествующих лет. Преобладали дни с небольшой пасмурностью, ясные дни выступали очень редко. Средняя месячная относительная влажность воздуха колебалась в пределах 79—85%. Суточная переменчивость относительной влажности воздуха довольно интенсивна.

Замечено быстрое нагревание почвы в начале лета до полного оттаивания на глубине 1 м в январе, с февраля выступало постепенное охлаждение поступающее с поверхности почвы вглубь (рис. 5).

Поверхностная температура вод Залива Адмиралты возрастала от 1°C в начальном периоде достигая максимум в январе а позже понижалась.

12. Streszczenie

Scharakteryzowano wybrane elementy meteorologiczne: kierunek i prędkość wiatru, temperaturę powietrza, ciśnienie, opad, zachmurzenie, wilgotność powietrza, temperaturę gruntu oraz temperaturę wody powierzchniowej Zatoki Admiralicji z okresu lata 1979/1980.

Z przeprowadzonej analizy wynika, że przebieg niektórych parametrów meteorologicznych w omawianym okresie odbiega nieco od wartości średnich wieloletnich z tego rejonu a także różni się od dwóch wcześniejszych sezonów letnich działalności polskiej stacji polarnej.

Latem 1979/1980 przeważały wiatry południowo-wschodnie i wschodnie oraz północne i północno-zachodnie, mniej natomiast obserwowano zachodnich i południowych (rys. 1). Cisze i słabe wiatry zmienne były zjawiskiem częstym. Wartości ciśnienia i temperatur nie odbiegały od przeciętnych. Ich bliższa analiza (rys. 2, 3 i 4) ujawniła dosyć regularne wahania o okresie wynoszącym około dwadzieścia dni, przesunięte w fazie od 1/4 do około połowy okresu.

Notowano dosyć często, opady atmosferyczne (Fig. 4) różnej postaci i intensywności aczkolwiek ze względu na ich stasunkowo niewielkie sumy miesięczne, lato 1979/1980 zaliczyć należy do bardziej suchych w porównaniu z analogicznymi okresami dwu lat wcześniejszych.

Przeważały dni z zachmurzeniem dużym i całkowitym; dni pogodne występowały bardzo rzadko. Średnia miesięczna wilgotność względna powietrza wahała się w granicach od 79% do 85%. Zmienność dobowa wilgotności względnej powietrza była dość intensywna.

Obserwowano szybkie nagrzewanie się gruntu na początku lata, aż do jego całkowitego rozmarznięcia na głębokości 1 m w styczniu, a następnie od lutego następowało wychładzanie, postępujące od powierzchni gruntu w głąb (Fig. 5).

Temperatura powierzchniowa wody Zatoki Admiralicji wzrastała od 1°C w początkowym okresie osiągając najwyższą wartość w styczniu, później stopniowo obniżała się.

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