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CHARACTERISTICS OF VARIATION OF METEOROLOGICAL ELEMENTS IN EZCURRA INLET DURING THE POLISH ACADEMY OF SCIENCES' SECOND ANTARCTIC EXPEDITION FROM 20 DECEMBER 1977 TO 16 MARCH 1978 *

1. INTRODUCTION

During the Polish Academy of Sciences' II Antarctic Expedition, meteorological and hydrological observations were carried out on King George Island, South Shetland Islands, throughout the Antarctic summer 1977/1978, both on a coastal station and on board ship. The Arctowski Station was established on a small promontory at the entrance from Admiralty Bay to the inner fiords of the island. The ship was anchored 2 miles WSW off the coastal station, in Ezcurra Inlet (Fig. 1). The fiord, Ezcurra Inlet, only 1.3 miles wide, stretches approximately from SW to NE, its length being 4.3 miles. It extends beyond Admiralty Bay NE, into Martel Inlet. There is an elongated rocky island, Dufayel, protruding perpendicularly from the middle of the fiord, making a natural prolongation of a small, but very steep peninsula, dividing the west coast of the fiord into two coves. Both Dufayel and the peninsula have an approximate height of 200 m. All the slopes of the Ezcurra Inlet are steep, the tops of the surrounding hills being covered with snow and glaciers.

2. SHORT SYNOPTIC INFERENCE

The pressure pattern occurring during the time in question in the region of the south-western part of the South Atlantic and the adjacent part of the Southern Ocean resembled more the winter type pressure systems:

Over the Weddell Sea a deep depression remained stationary throughout the whole period, with the pressure values in the centre

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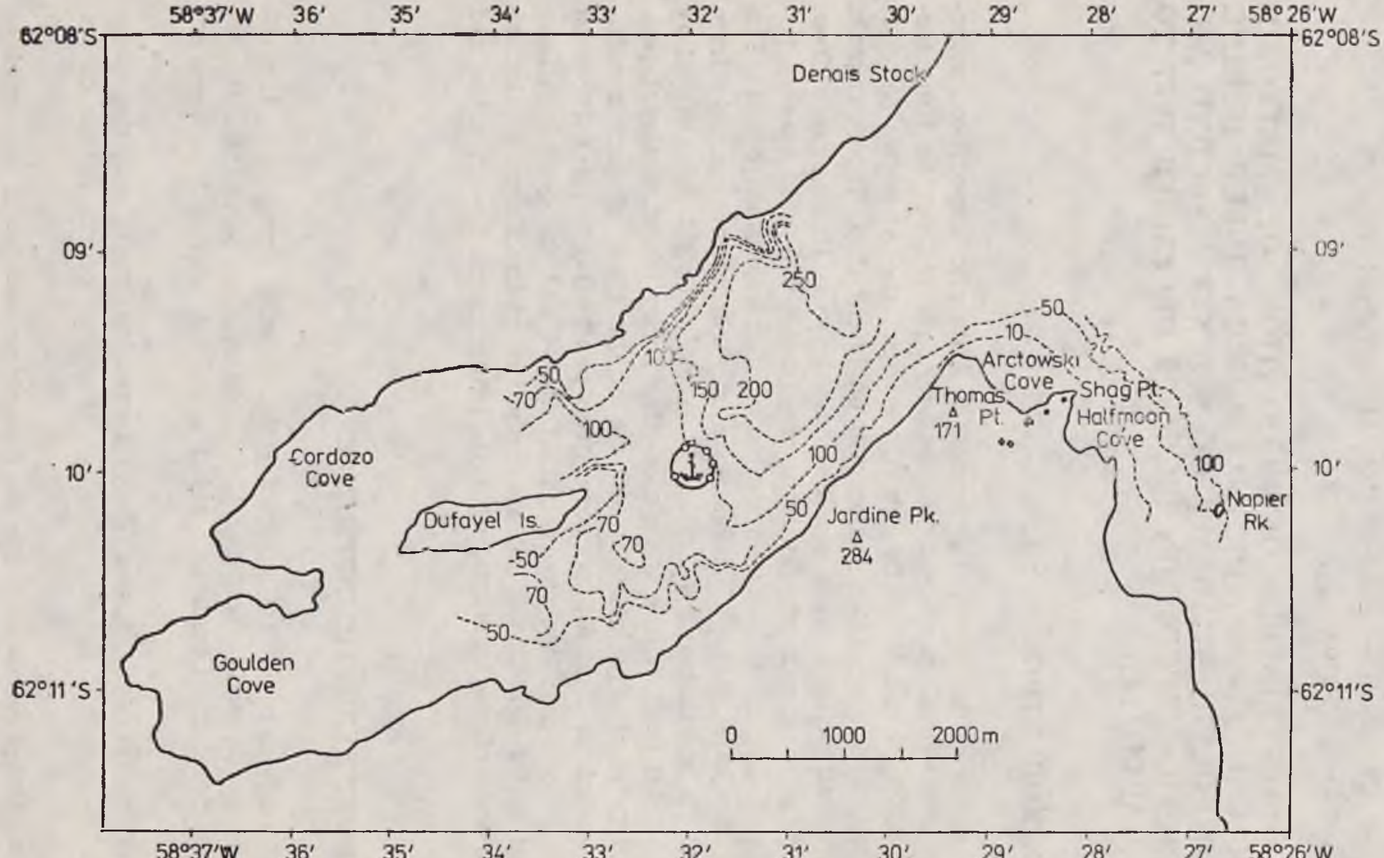

Fig. 1. Ezcurra Inlet on the King George Island, South Shetland Islands
The point at which the ship on which observations were performed was anchored, is marked by an anchor sign

Rys. 1. Fiord Ezcurra na Wyspie Króla Jerzego (Szetlandy Południowe)
Miejsce kotwiczenia statku, na którym były wykonywane obserwacje, oznaczone jest kotwicą

oscillating between 960 to 985 mb (Fig. 2). Highs were usually spread over the south-eastern Pacific and south Atlantic. Active depressions separated by only weak ridges of higher pressure, moved east or east

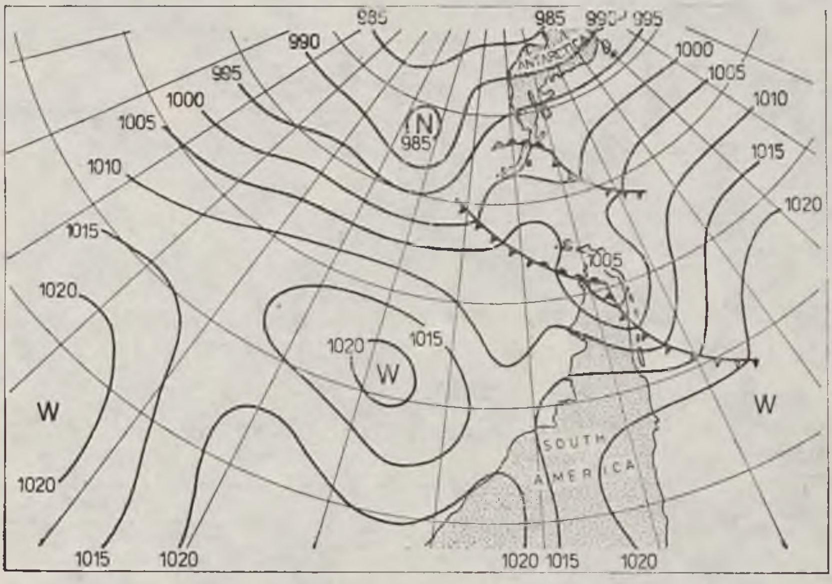

Fig. 2. Illustration of pressure pattern typical for summer 1978: synoptic weather map of February 6th

Rys. 2. Układ ciśnienia typowy dla lata 1978: mapa synoptyczna z dnia 6 lutego

south east over the Bellingshausen Sea and Drake Passage, passing the Antarctic Peninsula and South Shetland Islands. Anticyclons occasionally developed over the Antarctic Peninsula.

A very well known feature of the antarctic and subantarctic summer is the significant cyclonic activity, resulting in stormy weather. Similarly, in the summer of 1977/1978, some of the lows striking the South Shetland Islands were accompanied by very strong gales which hindered both the unloading of the ship and constructional and research work on the island. Mention should be made of the stormy days at the end of December and the beginning of January, the first two decades of February and 5-7th March. The pressure pattern which caused this stormy weather resulted from the deepening depression over the Weddell Sea and a simultaneously increasing high spreading from the south east Pacific towards Patagonia and Falkland Islands.

Fine spells were observed, when centres of the depressions moved further north across Drake Passage, or when an anticyclon persisted over the Antarctic Peninsula, as, for instance, in the first days of March.

3.1. ATMOSPHERIC PRESSURE

Due to the strong cyclonic activity mentioned, oscillations of substantial amplitude were observed in the pressure variation. With mean values of 988.6 and 990.5 mb in January and February respectively, the extreme values observed were 1018 mb on March 3rd and 969.6 on February 2nd, 1978. All these values fit well in the multi-annual characteristic of pressure. Table 1 contains pressure characteristics for the decade 1951—1960 at the English station Admiralty Bay, as compared with pressure data of 1978 at the Arctowski Station, the two stations being only 4.5 miles apart.

Table 1. Values of atmospheric pressure, mb, South Shetland Islands: at the Admiralty Bay Station, 1951—1960 and on the Arctowski Station, January — March, 1978

Tab. 1. Wartości ciśnienia atmosferycznego w mb na Szetlandach Południowych: na stacji meteorologicznej Admiralty Bay, 1951—1960 oraz na Stacji Arctowskiego, styczeń — marzec 1978

	1951—1960			1978		
	monthly mean	maximum monthly value	minimum monthly value	monthly mean	maximum value	minimum value
January	989.2	998	994	998.6	1004.2	972.2
February	988.7	998	982	998.5	1013.4	971.2
March	989.5	997	982	993.4	1017.8	966.7

It is not only the value of atmospheric pressure that is significant for the prevailing type of weather. An important parameter indicating strong variability of pressure systems are the pressure tendencies, i.e. the changes of pressure in three hour intervals. During persisting anticyclonic spells the changes of pressure are usually small and the tendencies do not exceed some tenths of mb oscillating around zero, but in a period of strong cyclonic activity they may reach as much as 10 mb per 3 hrs when the pressure rises and not much less, when it falls.

In the antarctic summer of 1978 pressure tendencies reached considerable values, both positive (rise of pressure) and negative (fall of pressure). Several times the rise of pressure exceeded 6 mb per 3 hrs, whereas the negative tendencies in some cases exceeded 4 mb per 3 hrs interval. The longest period of uninterruptedly and gradually rising pressure lasted from 06.00 hours GMT on January 17th to 21.00 hours GMT on January 20th. The total rise amounted to 34.3 mb, from 970.3 to 1004.6 mb. The longest period of gradually and smoothly falling pressure was observed between 21.00 hours GMT on February 2nd and 09.00 hours GMT on February 5th. The total decrease from 1007.5 to 969.9 mb reached 37.9 mb.

It is worth noticing that due to the strong dynamic effects exerted by the wind system of King George Island, differences in atmospheric pressure may persist for several hours or days, even between two places lying not very far apart, as in the case between the Arctowski Station and Ezcurra Inlet, where the pressure was measured on board ship.

3.2. WIND DIRECTION AND SPEED

The shape and morphometry of the Ezcurra Inlet influenced considerably the wind direction and speed over the fiord. The fiord, cut deep into the steep, glacier-covered rocks, separated additionally into two narrow canyons near Dufayel Island (Fig. 1), produces an extremely strong funnel effect whenever the wind blows in any direction approximately parallel to it. As in the zonal flow, dominating in the area of the South Shetland Islands in summer, the westerly component of the wind prevails, winds blowing along the Ezcurra Inlet are common. In such cases, the air stream coming from above the ocean, after having passed over the ice-covered, smooth massif of the island, is jammed into the narrow passages of the Ezcurra Inlet, where it speeds up considerably, inclining to the direction forced by the morphometry of the fiord.

An example of the forcing abilities of the local conditions were the frequently observed cases, when in Ezcurra, at the ship's anchorage, steady westerly winds with velocities between 15 and 18 m/s were blowing, while at the Arctowski Station much lighter winds were measured, with velocities between 6 and 10 m/s, reaching 12—14 m/s only in gusts, and directions varying between S, SW, W and NW. In an intensive northerly air flow over the island — which could be stated either by means of cloud movement observations or by comparing the wind data from the Arctowski Station — in the Ezcurra Inlet variable directions of wind prevailed, the velocities being extremely unstable and gusty. They were observed to change from 3 m/s to 25 m/s or even more. This was again caused by the specific conditions of the morphometry of the island, as the air was moving athwart the walls of the fiord. The sharp variability of the wind direction and the wind speed intensity in such cases could be easily noticed while observing the state of sea: the rough and disturbed surface of the Ezcurra Inlet, and the much more calmer north-eastern fiords. The same could be stated, while observing the behaviour of the ships at anchor. There were, of course, cases observed when, with reverse wind directions, the north-eastern fiords were more disturbed, while over Ezcurra only light winds or calms persisted. Comparatively great frequency of calms or light variable winds is another feature of the wind regime in the Ezcurra Inlet. This is easy understandable: the steep walls of the fiord form a very good shelter against the horizontal flow of air.

The greatest wind velocity in Ezcurra that could be measured on board ship by means of a hand anemometer, was 34.4 m.p.s. (averaged over a period of 100 sec.). This speed was recorded at 00.15 hours GMT on March 6th, while at the observation time, 00.00 hours GMT, the measured velocity was 28.7 m.p.s. The winds were accompanied by strong gusts, estimated as being from 40 to 50 m.p.s.

Mean wind velocities computed using 8 observations daily, amounted to 8 m.p.s during the whole period considered; in February the winds were stronger and the mean velocity for this month exceeded 9 m.p.s.

The features described are illustrated by means of a wind rose (Fig 3). Westerly (40 per cent of cases) and south westerly (18 per cent) winds were most frequent. The winds from the opposite direction, the north easterly ones, accounted for 10 per cent of the cases. Least frequent were the easterly winds (1.5 per cent). In the same Fig. 3, frequency distribution of wind directions at the Arctowski Station is shown, for comparison.

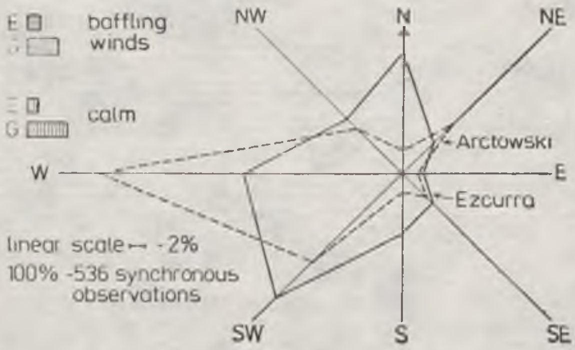

Fig. 3. Frequency distribution of wind directions at the Ezcurra and Arctowski stations during the period January 1st — March 16th, 1978

Rys. 3. Rozkład częstości kierunków wiatru we fiordzie Ezcurra i na Stacji Arctowskiego od 1 I do 16 III 1978

If only strong winds were compared, the differences in frequency of occurrence of particular wind directions were much more striking.

Fig. 4 shows the frequency of wind directions, when the velocities exceeded 10 m.p.s, for both the stations considered. The predominance of westerly winds in the Ezcurra Inlet was overwhelming. With the increasing velocities, however, the predominance of westerly winds be-

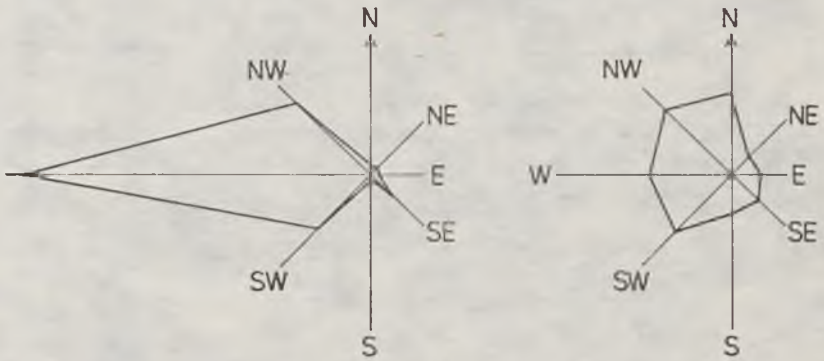

Fig. 4. Frequency distribution of wind directions at the Ezcurra and Arctowski stations for cases, when the wind velocities exceeded 10 mps, January 1st — March 16th, 1978

Rys. 4. Rozkład częstości kierunków wiatru na stacjach Ezcurra i Arctowskiego przy prędkościach przekraczających 10 m/s w okresie od 1 I do 16 III 1978

came less pronounced, and the strongest winds, with velocities above 25 and 30 m.p.s came from north westerly directions in Ezcurra and from both northerly and north westerly — at the Arctowski Station. In Table 2 the number of observations is summarized, illustrating in detail the relations described.

Table 2. Frequency of wind directions at the Ezcurra and Arctowski stations when the wind velocities exceeded 10 m/s, January 1st — March 16th, 1978

Tab. 2. Częstość kierunków wiatru na stacjach Ezcurra i Arctowskiego przy prędkościach wiatru przekraczających 10 m/s, od 1 stycznia do 16 marca 1978

Station	Wind velocity	Wind direction									Sum
		N	NE	E	SE	S	SW	W	NW	variable	
E	10 m/s	3	3	2	11	1	32	136	39	6	233
A		33	8	11	14	14	33	36	35	—	184
E	15 m/s	2	2	—	4	1	13	82	33	3	162
A		27	2	7	7	5	17	15	31	—	111
E	20 m/s	2	1	—	—	—	1	31	22	3	60
A		17	1	1	3	1	4	2	17	—	46
E	25 m/s	1	—	—	—	—	—	6	9	1	17
A		11	1	—	1	—	1	—	10	—	24
E	30 m/s	—	—	—	—	—	—	—	5	—	5
A		7	—	—	—	—	—	—	2	—	9

E — Ezcurra
A — Arctowski

Common phenomena observed were the fallwinds — katabatic movement of the air, cooled diabatically when in contact with the ice--covered island and then gliding rapidly downward, striking strongly upon the water surface, generating waves and spray.

3.3. AIR TEMPERATURES

Air temperature oscillations are not very great in the antarctic summer. In an inner fiord of a subantarctic island they may be greater, as the air temperatures are deformed compared to those from above the surrounding oceans due to many factors: the height of the mountains which forces the air up when flowing over an island, contact with the surface — either bare rocks or snow cover, further, the morphometry of the inner fiord itself. The main phenomena resulting in temperature changes of the flowing air are the cool fall winds, already described in the paragraph on winds, and the föhn processes, causing rise of temperature. On King George Island föhn winds are especially common in Ezcurra Inlet: when rising up the north-western slopes of the island, the wet oceanic air cools adiabatically and part of the moisture it contains condenses, the condensation heat causing the temperature of the air stream to rise. When after having passed the ridges of the hills, the now dry and warmer air settles down into Ezcurra, it warms adiabatically, at a higher rate than it cooled when rising as wet air. The sensible heat of the air is now greater and may be recorded as a rise of temperature of even several degrees. Such a rise of air temperature of föhn origin, from 5.2°C to 9.6°C was recorded at 15.00 hrs GMT (approximately noon local time) on January 2nd 1978. It was accompanied by gusts from WNW reaching 18 m.p.s. The effect was entirely local, as only 4.9°C and a wind speed of not more than 11 m.p.s. were recorded at the Arctowski Station.

Temperatures of more than 7°C were observed several times. The minimum temperature recorded was as low as —3.2°C and occurred in clear, calm weather, at 03.00 hrs GMT (approximately midnight local time) on March 3rd. At that time, the temperature was one degree higher at the Arctowski Station. It must be stated that changes of temperature at both stations were not simultaneous: the momentary differences amounted to 3° and were often changing sign. The mean values at both observation points were very similar.

Only one monthly mean could be calculated for the air temperatures in Ezcurra Inlet, that for February, which was +2.4°C. In January there was an interval when no observations were carried out and on March 16th the ship left for Gdynia.

3.4. RELATIVE HUMIDITY

Mean relative humidity of the air was not very high during January —March 1978 and amounted to about 80 per cent. There were cases — evidently connected with the local föhn effects — when the relative humidity did not exceed 60 per cent. The lowest value observed was 55 per cent at 21.00 hrs GMT on January 24th.

3.5. VISIBILITY

Visibility is another meteorological parameter that is strongly affected by the local influences of the fiord and may remain diametrally different in different directions. Poor visibilities were very often encountered in the inner part of the fiord. They were reduced either by low ceiling or by orographic clouds gliding down the glaciers, to the water surface. The lee sides of the fiord walls were very often curtained by precipitation. In stormy weather, when the rain mixed with spray blown by gusts, visibility very often decreased to a few hundred metres. The best visibility was usually observed in the north-eastern direction, towards Martel Inlet. Very good visibility could not be estimated other than by comparing the contrast of contours of the distant nunataks and details of the distant glaciers, beyond the bay and inlets.

Fog did not occur often due to the good ventilation of the fiord. Fogs, which reduced visibility to less than 200 m, were observed only three times.

3.6. CLOUDINESS

Predominantly cloudy or overcast skies prevailed, only three days, i.e. about 4 per cent of all cases observed, were clear. The mean cloud cover was 6.5 octas.

Characteristic features of the cloudiness were:

— very low ceiling, usually not exceeding 200—300 m in height, with clouds covering the higher parts of slopes and glacier domes; a ceiling of Stratus, between 50 and 100 m was common;

— great variety of cloud genera, species and varieties, many of them fed by the stationary orographic wave;

— rotor clouds.

The movement of clouds, at both low and higher levels, was very vivid, the direction of movement followed the coastline and the configuration of the fiord's indentations. On the lee side of the glaciers a föhn bank with easily recognizable downward motion was frequently observed.

3.7. PRECIPITATION

Precipitation was observed in all varieties of forms. Most frequent was intermittent rain, followed by drizzle. Precipitation of this form preceded approaching warm fronts or continued, when a stationary depression was filling in the vicinity of South Shetland Islands. After the passage of a cold front, rain was usually replaced by snow pellets and grains. Precipitation in steady form was encountered during the whole summer 1977/1978. Showers were observed quite often, without the vertical development of clouds. Several times precipitation was carried by the wind from as far as the föhn bank to the ship, with no clouds in the zenith.

Observations of precipitation form and density were sometimes difficult due to spray, raised from the water surface by the wind and blown up to a score and more metres.

Snow cover formed by freshly fallen snow did not persist long on the soil, but on board ship it presented a severe danger to the people, moving about on deck.

3.8. SURFACE WATER TEMPERATURE

Measurements of the surface water temperature began when the last parts of the fast ice in the fiord desintegrated and left Ezcurra, driven by a strong WSW wind. After that, in the last decade of December 1977, the temperature of the surface water rose gradually from —0.2° to 0.6°C. During January and February it oscillated around +1°C and only when a longer period of calm and clear (sunny) weather persisted, did the surface water warm considerably for a short time. The highest surface temperature in Ezcurra was +3.4°C at 21.00 hrs GMT on January 17th. The lowest was —0.2°C at 18.00 hrs GMT on December 22nd.

3.9. WAVES

There was no undisturbed wave motion in Ezcurra Inlet. The wave parameters were strongly dependent on the wind direction due to very short distance of the observation point from the coast and due to the additional shelter provided by Dufayel Island. The best developed waves were generated by stormy winds from the SW to NW sector, blowing along the fiord. The maximum wave height measured was 2.5 m, this having a period of 4 s. The most frequent state of the sea was 2—3, but, as the waves were steep, even at this state, i.e. with wave height of about 0.5 m, work on the water was very difficult. Very often disturbed waves, coming from several directions simultaneously, were observed, generated due to the effect of the vehement strokes of the fall winds gliding down the glaciers. No swell from Bransfield Strait was observed in the fiord.

3.10. SEA ICE

The rest of fast ice covering the fiord desintegrated and was removed from the inner waters by a strong gale in the afternoon on December 22nd. As the glaciers were calving systematically, however, the growlers and brash ice were flowing out of the fiord and Admiralty Bay into the Bransfield Strait throughout the whole summer. Occasionally sea ice came in from Admiralty Bay, when there were easterly winds or calms. Only twice troughout the whole period larger ice bergs were brought as far as Ezcurra Inlet. One of them grounded near Dufayel, where it remained for two days and afterwards, during a storm, desintegrated, its fragments being carried out of the fiord by the waves.

When the wind directions oscillated between SW and NW, and there were calms for longer periods, a lot of brash ice collected near the edges of the glaciers. The ice then flowed out, sometimes covering 20 per cent of the surface of the fiord. Such an accumulation of ice was very dangerous for the ship, work on the water and the oceanographic instruments, especially the current meters.

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CHARAKTERYSTYKA PRZEBIEGU ELEMENTÓW METEOROLOGICZNYCH WE FIORDZIE EZCURRA W CZASIE II EKSPEDYCJI ANTARKTYCZNEJ POLSKIEJ AKADEMII NAUK, 20.XII.1977—16.III.1978

Streszczenie

W czasie antarktycznego lata 1977/78 r. wykonywano równolegle pomiary meteorologiczne i hydrologiczne na brzegowej stacji Henryka Arctowskiego i na stacji we fiordzie Ezcurra na statku „Antoni Garnuszewski" (rys. 1).

Aktywność cyklonalna w tym okresie była bardzo duża. Ciśnienie średnie za okres letni wynosiło ok. 990 mb, lecz charakteryzowało się znacznymi wahaniami: najwyższą wartość, 1018 mb, zanotowano 3 marca, najniższą zaś, 969,6 mb, 5 lutego. Zmiany ciśnienia nie zawsze były wykładnikiem zmian pogody, zwłaszcza wiatru: obserwowano wypadki znacznych zmian ciśnienia nie przynoszące silnych wiatrów i przeciwnie, spotykano sytuacje, gdy silne i sztormowe wiatry nie były poprzedzone większymi zmianami ciśnienia.

Kierunek fiordu Ezcurra i znaczne wysokości zboczy miały decydujący wpływ na rozkład kierunku i prędkości wiatru. Przeważające wiatry zachodnie, po przejściu przez grzbiety górskie wyspy, wpadały ze zwiększoną prędkością do fiordu, przyjmując jego kierunek. Największą przewagę miały wiatry zachodnie: 40% i południowo-zachodnie: 18%. Najrzadziej natomiast występowały wiatry wschodnie: 1,5% i południowe: 3%. Największą prędkość wiatru: 34,4 m/sek zmierzono anemometrem 100-sekundowym 6 marca. Występujące wtedy jednocześnie porywy wiatru oszacowano na 50 m/sek. Najdłuższy okres nieprzerwanego sztormu wystąpił między 7 a 21 lutego.

Temperatura powietrza nie ulegała dużym wahaniom i oscylowała przeważnie między 4 i 0°C. Najwyższą temperaturę, 9,6°C, zanotowano 2 stycznia, najniższą, —5,8°, 16 marca, już w czasie opuszczania fiordu. Wahania temperatury powietrza we fiordzie i na stacji brzegowej nie przebiegały równolegle, jednak wartości średnie, obliczone dla wspólnego okresu obserwacji, różniły się bardzo nieznacznie.

Wilgotność względna powietrza ulegała dość znacznym wahaniom, co było często wynikiem lokalnych zjawisk fenowych. Przeciętna wilgotność względna we fiordzie wynosiła 80%, obniżając się sporadycznie do 60, a nawet 55%. Mgły występowały rzadko.

Przeważało zachmurzenie duże lub umiarkowane, wynosząc średnio 6,5 oktantów. Podstawa chmur była bardzo niska, przeważnie 200 do 300 m, a w wypadkach Stratusa tylko od 50 do 100 m. Chmury pokrywały wyższe partie zboczy i kopuły lodowców. Występowała duża różnorodność rodzajów, gatunków i odmian chmur, przy czym częste były chmury rotorowe. Bardzo często po zawietrznej stronie lodowców obserwowano wał fenowy. W bardzo szybkim ruchu chmur wszystkich pięter przejawiała się duża dynamika atmosfery.

Fiord Ezcurra charakteryzuje się bardzo zróżnicowaną widzialnością, zależnie od kierunku obserwacji. W niektórych sytuacjach anemometrycznych stoki nawietrzne były przesłonięte opadem. Lepszą widzialność obserwowano na ogół w kierunku zatoki Martel.

Opady występowały w różnych postaciach: najczęstszy był ciągły deszcz, okresami przechodzący w mżawkę. Opady przelotne występowały często bez wyraźnego pionowego rozwoju chmur.

Temperatura powierzchni wody oscylowała wokół 1°, osiągając maksimum, 3,4°, w połowie stycznia, przy bezwietrznej, słonecznej pogodzie. Resztki stałej pokrywy lodowej zostały w końcu grudnia rozkruszone przez sztorm i wypłynęły w morze. Przez całe lato lód obrywający się z lodowców gromadził się u ich podnóża, a następnie był wynoszony w morze.

Ze względu na morfometrię zbiornika falowanie regularne wewnątrz fiordu nie mogło się rozwinąć. Często obserwowano falę skłóconą, powstającą na skutek oddziaływania silnych wiatrów spadowych w różnych punktach fiordu.

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