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Climate of Bunger Oasis, (region of A. B. Dobrowolski Station, Antarctic)

The so-called Antarctic oases are the few fragments of this continent free of permanent ice cover. Their formation is due to Holocene warming of climate and reduction of the thickness of ice cover on the Antarctic shore. As a result of isostatic movements the shore has risen, in some places the ice cover melted and the continental glacier flowing to the ocean has omitted these areas (Simonov 1971). The biggest Antarctic oasis is the one discovered in 1947 by flightlieutenant A. Bunger (member of Byrd's expedition) and therefore give his name. According to Korotkevič (1968) total surface are of this oasis is 952 km^2 and almost half of this area (470 km^2) is covered by saline lakes of lagoon origin which are the remnants of sea water cut from the ocean as a result of isostatic movements. Because of evaporation (500—600 $nm \cdot year^{-1}$) they become drier and more saline. Rocks and stony areas cover 395 km^2, permanent snow and ice fields — 51 km^2, freshwater lakes of lagoon origin — 36 km^2.

Bungers Oasis is 50 km long and 20 km broad. It lies in the eastern part of the Land of Queen Mary and is divided from the ocean by Shackleton's Glacier. Between October 1956 and November 1958 on the Figure Lake Russian scientific station Oasis carried out research (latitude $\varphi = 66^\circ 16'S$, longitude $\lambda = 100^\circ 45'E$). In January 1955 this station was given to the Polish Academy of Sciences and obtained the name of A. B. Dobrowolski. Since then no constant observations were carried out, amongst other things because of very expansive transport, as the Bungers Oasis can be reached only by means of air conveyance. The Polish programme of polar investigations plans to use this station for investigations and thus it seems worthwhile to sum up and analyse the meteorological data obtained by Russian scientists (Atlas Antarktyki I, 1966; II, 1969, Dolgin, Maršunova and Petrov 1976, Dolgin and Maršunova 1977, Rusin 1961). Although two years of activity of the Oasis station is a period too short to characterise the climate fully (a 3-years period is at least required), nevertheless it illustrates the basic character of local climate.

1. Solar conditions and energy balance

The Dobrowolski station is some 31.5 km from the polar circle and therefore the polar night practically does not occur there and during all days of the year the sun's disk or its part is above the horizon and the shortest day lasts 2.5 hours (Table I).

Table I

Monthly and annual values of chosen elements of solar climate in Bunger Oasis
(acc. to data from Station Oasis, 1956—1958, Dolgin, Maršunova and Petrova (1976) and Rusin (1961)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Day length (hour, min.)	20.56	16.28	12.56	9.16	5.40	2.32	4.02	7.38	11.20	14.56	19.02	24.00	—
Sun's altitude at noon on the 15th of a given month — in degrees	44.9	36.5	25.9	14.0	4.9	0.4	2.1	9.5	20.6	32.1	42.1	47.0	
Sun's max altitude	46.7	41.1	31.4	19.3	8.7	1.7	5.3	14.9	26.4	37.7	45.3	47.1	
Direct radiation ($W \cdot m^{-1}$)	1082	1068	1040	949	537	0	572	886	1019	1068	1103	1117	1117
Maxima-normal surface and horizontal surface	768	670	516	314	42	0	49	167	440	628	768	796	796
Diffused radiation													
Mean totals ($MJ \cdot m^{-2} \cdot month^{-1}$)	352	243	151	63	8	0	29	0	117	197	335	398	1892
Contribution to the total radiation — cloudfree conditions (%)	15	18	21	22	.	.	.	.	26	20	15	14	18
Mean contribution to the total radiation (%)	45	48	55	58	.	.	.	.	51	49	52	51	51
Total radiation													
Mean totals ($MJ \cdot m^{-2} \cdot month^{-1}$)	17.1	12.0	6.6	2.6	0.6	0	0.1	1.3	5.5	9.5	15.3	18.6	89.2
Transmission coeffic. k	0.67	0.71	0.83	0.84	.	.	.	.	0.92	0.73	0.69	0.65	0.73
Net radiation (totals — $MJ \cdot m^{-2} \cdot month^{-1}$)													
Total range	440	285	113	−59	−75	−84	−75	−46	54	201	326	494	1574
Short-wave range	603	393	188	71	13	0	0	33	134	293	511	632	2872
Long-wave range	−163	−109	−75	−130	−88	−84	−75	−80	−80	−92	−184	−180	−1298
Other elements of solar climate													
Reflected radiation ($MJ \cdot m^{-2} \cdot month^{-1}$)	113	109	88	38	13	0	0	21	96	105	130	146	858
Albedo (%)	16	22	32	35	50	.	.	38	42	27	20	19	30

1.1. Direct radiation

Thanks to exceptionally high transparency of atmosphere over the Antarctic the intensity of direct solar radiation on its shore attains values recorded in other parts of the world, even at higher altitudes of sun but only in the mountains. Although the altitude of sun in Bungers Oasis does not exceed 47° the highest intensity of direct radiation on the normal surface S was here 1117 $W \cdot m^{-2}$ (1.60 $ly \cdot min^{-1}$)[1], under good weather conditions the average was 921 $W \cdot m^{-2}$ (1.32 ly·min), and on horizontal surface S′ — 796 $W \cdot m^{-2}$ (1.14 $ly \cdot min^{-1}$), (Table I). Assuming constant cloudfree conditions (sun disk not covered by clouds) the annual direct radiation S′ would be 4354 $MJ \cdot m^{-2}$ (104 kly), thus exceeding by 628 $MJ \cdot m^{-2}$ (15 kly) the annual total radiation under real conditions. However, in reality the total of direct radiation is much smaller and its annual otal is 2512 $MJ \cdot m^{-2}$ (60 kly) lower as compared with calculations for good weather conditions.

The relation between intensity of direct radiation and the sun's altitude is illustrated in Figures 1 and 2. Although for cloudfree conditions (Fig. 1) this relation can be presented by means of simple functions: hyperbole for S and a straight line for S′, these relations are less regular with regard to the cloud factor (Fig. 2). Then the curves S and S′, with the exception of winter months approximate and the differences between them (S – S′) at $h_0 \geqslant 5°$ are 140—280 $W \cdot m^{-2}$ (0.2—0.4 $ly \cdot min^{-1}$).

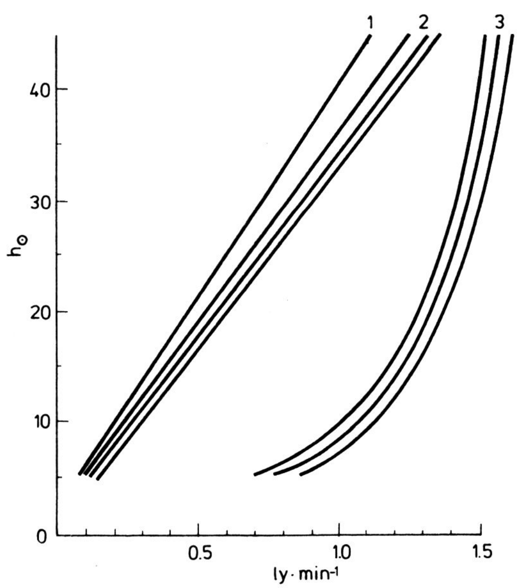

Fig. 1. Dependence of the mean direct solar radiation on the horizontal surface (1), and of extremal and mean intensity of total (2) and direct (3) radiation on the normal surface at the altitude of sun (h_0) at full sunshine at Bungers Oasis Acc. to data of Rusin (1961).

[1]) 1 ly (langley) = 4 $J \cdot cm^{-2}$, 1 kly = 1000 ly. These units are given in Figures.

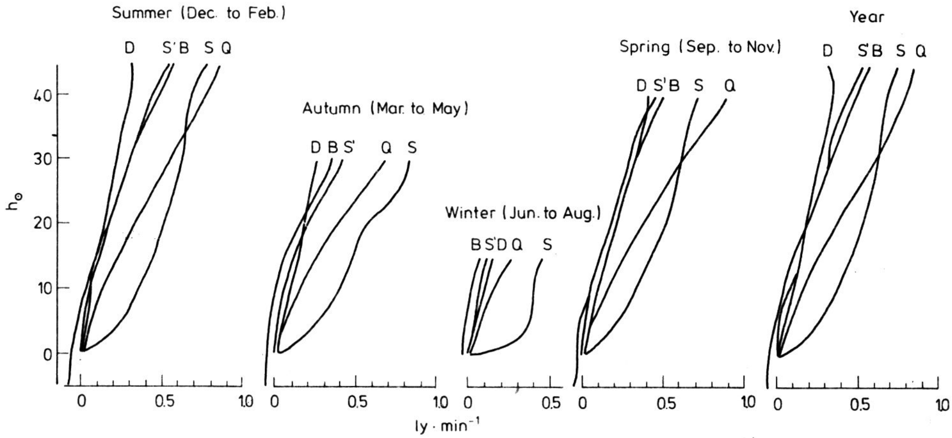

Fig. 2. Seasonal and annual dependence of net radiation (B), direct radiation on normal surface (S), direct radiation on horizontal surface (S′), diffused radiation (D) and total radiation (Q) on the altitude of sun (h_0) at Bungers Oasis
Acc. to data of Dolgin, Maršunova and Petrov (1976).

1.2. Diffused radiation

All the year round sums of diffused radiation approximate generally those of direct radiation on normal surface, whereas in the total radiation the contribution of diffused radiation is slightly higher than of the direct one (Table I). This contribution decreases considerably under cloudfree conditions, because it is some 30% at overcast sky and depends also directly on the h_0 (Fig. 3). Although at $h_0 = 5$ the contribution of diffused radiation to the total one is 100% under average conditions, and under cloudfree conditions it is only 48%, still at $h_0 > 20°$ these differences decrease from 52° to 30°. Under cloudfree conditions diffused radiation is almost twice lower than under average conditions and depends slightly on the sun's altitude (Fig. 4), whereas at an increase of h_0 from 5 to 45° it increases only by 63 $W \cdot m^{-2}$ (0.09 $ly \cdot min^{-1}$). This relation occurs most distinctly at sky overcast by high and middle clouds; intensity of diffused radiation increases within $h_0 = 5°$ and $h_0 = 45°$ and is then 586 $W \cdot m^{-2}$ (0.84 $ly \cdot min^{-1}$), i.e., is almost 9.5 times higher than under cloudfree conditions. With regard to other radiations the diffused one shows the relatively lowest increments as the h_0 rises.

1.3. Total radiation

Total annual radiation in Bungers Oasis (3735 $MJ \cdot m^{-2}$ almost 90 kly — Table I) approximates radiation recorded in northen Poland (Kołobrzeg 3756 $MJ \cdot m^{-2}$ $year^{-1}$). But the December totals exceed by 126 $MJ \cdot m^{-2}$ (3 kly) the June totals at the Polish coast (Podogrocki 1970). They are also higher than values recorded for most of the Arctic (Fowinkel, Orving 1973,

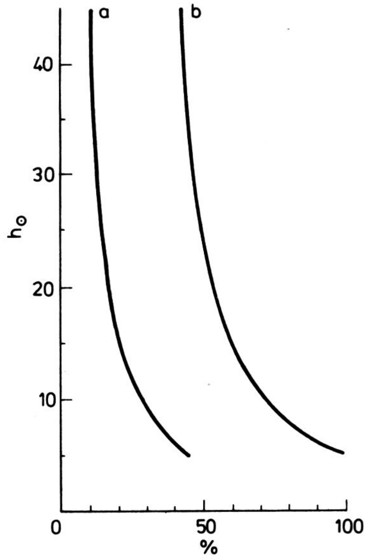

Fig. 3. Dependence of the percentage of diffused radiation in total radiation on the altitude of sun (h_0)
a — cloudless sky, b — average cloudiness at Boungers Oasis
Acc. to data of Rusin (1961).

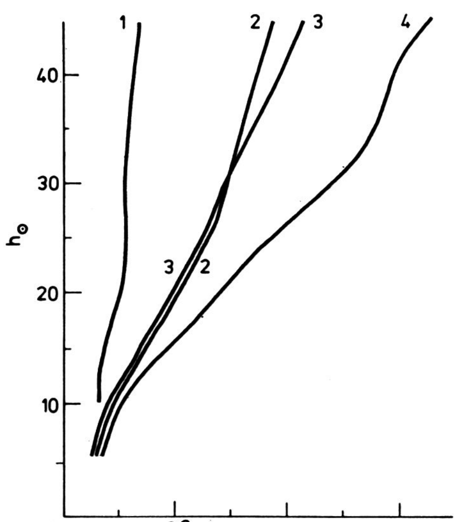

Fig. 4. Dependence of the diffused solar radiation on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0, 2 — 10/10 overcast sky, 3 — mean cloudiness, 4 — sky overcast by high and middle clouds at Bungers Oasis
Acc. to data of Rusin (1961).

Baranowski 1977). Under cloudfree conditions there is a rectilinear dependence of total radiation on h_0, which increases annually on average by 126 W·m^{-2} (0.18 ly·min^{-1}) at a rise of h_0 by 5°. The highest intensity of total radiation at the highest altitude of sun equal 45° is then on the average 907 W·m^{-2} (1.3 ly·min^{-1}), (Fig. 1). These values decrease with increasing cloudiness; at full high overcast (Ci, Cs, Cc) they are already 796 W·m^{-2} (1.14 ly·min^{-1}) and at full sky overcast by high and middle clouds 558 W× ×m^{-2} (1.3 ly·min^{-1}) (Fig. 1), and at heavy overcast (10/10) only 279 W·m^{-2} (0.4 ly·min^{-1}). At h_0 about 5° and an increase of cloudiness from 0 to 10 the intensity of total radiation increases only from 28 to 56 W·m^{-2} (0.04 to 0.08 ly·min^{-1}), whereas at $h_0 = 45°$ this increase is 516 W·m^{-2} (0.74 ly× ×min^{-1}), i.e., is 18.5 times higher.

Bunger Oasis has a considerable dispersion of momentum values of total radiation as regards mean values (Rusin 1961). Although at the highest altitudes of sun the recorded total radiation stayed within the range 140—977 W·m^{-2} (0.2—1.4 ly·min^{-1}) in Mirnyj it was 419—838 W·m^{-2} (0.6—1.2 ly·min^{-1}), Pionierskaya — 638—768 W·m^{-2} (0.9—1.1 ly·min^{-1}), and on Vostok station hardy 698—768 W·m^{-2} (1.0—1.1 ly·min^{-1}). This can be explained by higher frequency of heavy overcast on the Antarctic shore, especially in oases, of very heavy overcast of convective origin, which do not occur inland.

The annual mean, and also in spring and summer at $h_0 = 30$—35° the total radiation exceeds direct radiation on normal surface on the average by 70 W·m^{-2} (0.1 ly·min^{-1}), whereas below 30—35° it is lower by some 140—210 W·m^{-2} (0.2—0.3 ly·min^{-1}), (Fig. 2). In autumn and winter when the sun is not high total radiation at each h_0 is lower on normal surface than direct radiation.

On particular stations of the Antarctic coast especially on glaciers and in oases, total radiation may differ considerably. For example, if under cloudfree conditions the intensity of total radiation in Bungers Oasis is slightly higher than in Mirnyj then at the appearance of high clouds total radiation on Mirnyj at $h_0 > 20°$ increases by 2—6% as compared with station Oasis (Fig. 5 and 6). At sky overcast by middle clouds total radiation on Mirnyj increases from 10% at $h_0 = 5°$ to 42% at $h_0 = 45°$. Privileged solar areas of the continental glacier as compared to the oasis are best observed at heavy overcast, when at $h_0 = 35$—45° total radiation on Mirnyj is almost twice higher than in Bungers oasis. These differences can be explained by the significance of secondary reflection between the base of clouds and the surface of continental glacier. There also of some significance is another kind of cloudiness in the oasis as compared to the continental glacier, and especially the small albedo of aquatic and rock surfaces of oasis as compared with the continental glacier.

An additional characteristic of radiation conditions is the transmission coefficient of total radiation k through clouds calculated as a ratio of totals of real radiation to potential (not covered sun's disk). At heavy overcast, three-fold decreasing the intensity of total radiation, this coefficient does not change much and even decreases slightly with the altitude. At sky overcast by middle and high clouds and at mean cloudiness there is usually

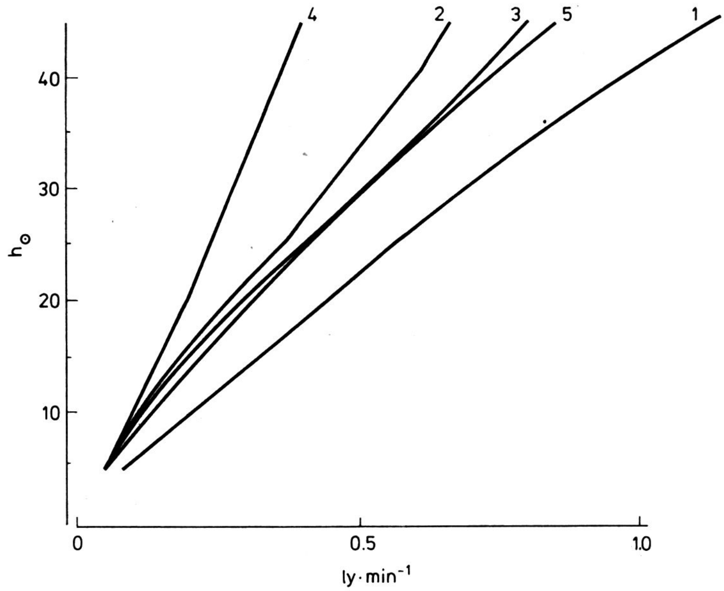

Fig. 5. Dependence of the intensity of total solar radiation on the altitude of sun (h_0) at the given cloudiness: 1 — 10/0, Ci, Cs, Cc; 2 — 10/0, As, Ac; 3 — 10/0 sky overcast by high and middle clouds; 4 — 10/10, 5 — mean cloudiness at Bungers Oasis Acc. to data of Rusin (1961).

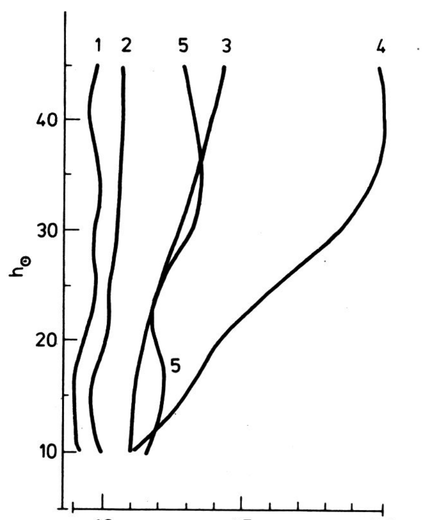

Fig. 6. Dependence of the ratio of total radiation on Stations Mirnyj and Oasis (Q_M/Q_O) on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0, 2 — 10/0, Ci, Cs, Cc; 3 — 10/0, As, Ac; 4 — 10/10; 5 — mean cloudiness Acc. to data of Rusin (1961).

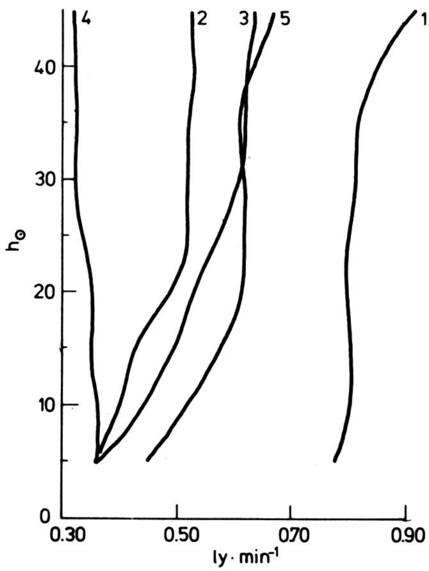

Fig. 7. Dependence of the transmission of solar radiation through the clouds on the altitude of sun (h_0) at the given cloudiness: 1 — 10/0, Ci, Cc, Cc; 2 — 10/0, As, Ac; 3 — 10/0, Ci, Cs, Cc+ As, Ac; 4 — 10/10; 5 — mean cloudiness at Bungers Oasis .
Acc. to data of Rusin (1961).

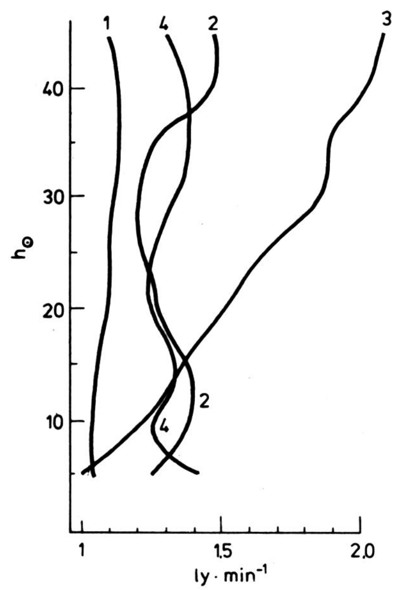

Fig. 8. Dependence of the transmission coefficient of total radiation on Stations Mirnyj and Oasis (k_M/k_O) on the altitude of sun (h_0) at the given cloudiness: 1 — 10/0, Ci, Cs, Çc; 2 — 10/0, As, Ac; 3 — 10/10; 4 — mean cloudiness
Acc. to data of Rusin (1961).

a distinct increase of coefficient k with the sun's altitude. Under average conditions at h_0 increasing from 5 to 45° this coefficient increases on the average by 0.23 (Fig. 7).

The transmission coefficient k depends also on the albedo of active surface. In Bungers Oasis the values of k at the same cloudiness are usually much lower than on Mirnyj (Fig. 8). Although, at high overcast, coefficient k on Mirnyj is higher than in Bungers Oasis by 3—13%, at heavy overcast it exceeds it twice or even more (at h_0 40—45°), distinctly increasing with the sun's altitude.

1.4. Reflected solar radiation and albedo

One of the more important characters of solar and Antarctic conditions are small sums of reflected radiation which on Oasis did not exceed 245 MW·m^{-2} month^{-1} (3.5 kly·month^{-1}) and 1435 MW·m^{-2} year^{-1} (20.5 kly × × year^{-1}). As shown in (Fig. 9) this radiation depends on the sun's altitude

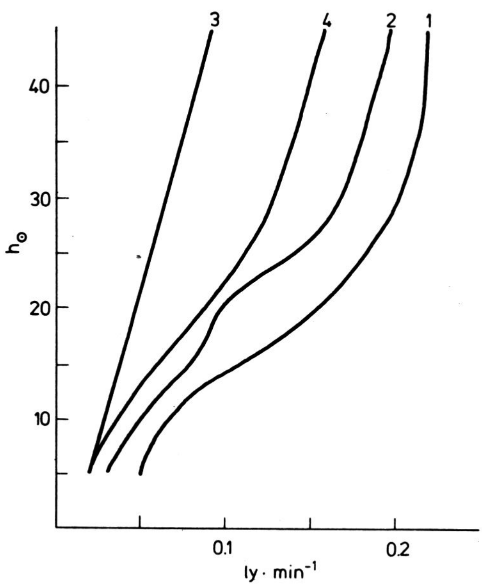

Fig. 9. Dependence of the intensity of reflected solar radiation on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0, 2 — 10/0; 3 — 10/10; 4 — mean cloudiness at Bungers Oasis Acc. to data of Rusin (1961).

and type of cloudiness. The highest values 35—154 W·m^{-2}, on the average 112 W·m^{-2} (0.05—0.22, on average 0.16 ly·min^{-1}), are obtained under cloud-free conditions, and the lowest 14—63 W·m^{-2} on the average 42 W·m^{-2} (0.02—0.09, on the average 0.06 ly·min^{-1}) at heavy overcast. At sky overcast by middle and high clouds intensity of reflected radiation has intermediate values 21—140 W·m^{-2}, on the average 91 W·m^{-2} (0.03—0.20, 0.13 ly·min^{-1} on the average). Cloudiness decreases the intensity of reflected radiation depending on the thickness of clouds and the sun's altitude (Fig. 10). At

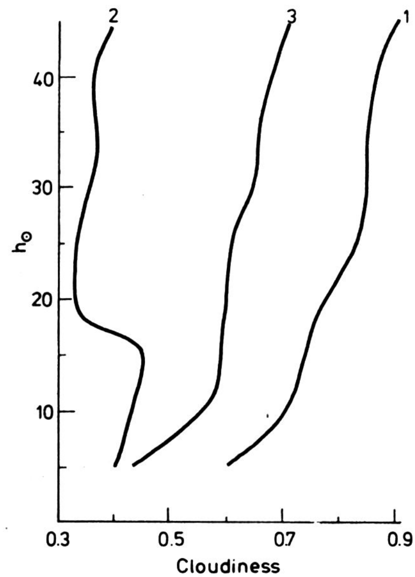

Fig. 10. Dependence of the ratio of intensity of reflected solar radiation at the given cloudiness: 1 — 10/0; 2 — 10/10; 3 — mean cloudiness and at clear sky on the altitude of sun (h_0) at Bungers Oasis
Acc. to data of Rusin (1961).

sky overcast by middle and high clouds the intensity of reflected radiation decreases from 10 (at $h_0 = 45°$) to 40% ($h_0 = 5°$), and under mean conditions from 28% ($h_0 = 45°$) to 57% ($h_0 = 5°$) as compared with cloudfree conditions. The relation between weaker radiation reflected through heavy overcast, 62% on average, and h_0 is smaller. It is also weaker at $h_0 = 5°$ and 45°.

The low total of reflected radiation at thigh total radiation is why the albedo of active surface in Bungers Oasis is much smaller than the surface of the continental glacier. According to the data presented by Rusin (1961) the albedo of oasis surface is at the end of winter 2.5 times smaller than that of surrounding glaciers; in spring and summer even 4.5 times smaller. Also, contrary to the continental glacier, the surface area of oases, including Bungers Oasis, have a distinct annual course of albedo. In summer (Dec. — Feb.) when it ranges between 16 and 22% it is almost identical with the mean value recorded by Kozłowska-Szczęsna for Poland (Apr. — Nov.). In winter, due to greater durability of ice cover, it exceeds 50%, whereas in Poland it is of an order 40—45%.

Albedo also depends distinctly on the sun's altitude and type of coloudiness (Fig. 11). Up to h_0 of the order 10° the albedo increases 20—30%, but in the interval 10—45° — only 10—12%, i.e., about 0.3° per 1° of sun's altitude. The smallest albedo (16—45%, on the average 24%) occurs under cloudfree conditions, and the highest one (25—75%, on the average 38%) at sky overcast by high and middle clouds. At heavy overcast the albedo is 22—50%, on the average 30%.

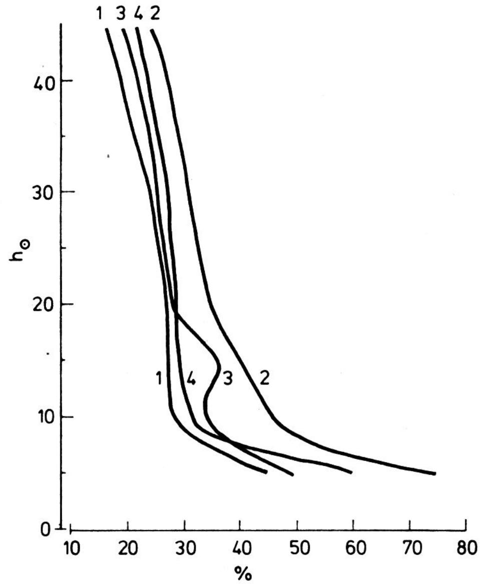

Fig. 11. Dependence of the albedo of the surface on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0; 2 — 10/0; 3 — 10/10; 4 — mean cloudiness at Bungers Oasis Acc. to data of Rusin (1961).

1.5. Net radiation

The result of low albedo of Antarctic oases, including the region of Dobrowolski station, are also high values of net radiation (so-called radiation balance) which during the warmer part of the year (Oct. — Mar.), usually void of ice cover, are even several times higher than on the continental glacier. Thus Antarctic oases and nunataks are the only areas of this continent, where additional annual totals of net radiation occur. Their annual average is 2177 $MJ \cdot m^{-2}$ (52 kly) (on the continental glacier over 4400 $MJ \cdot m^{-2}$ (105 kly)) lower than total radiation. The highest total daily net radiation in Bungers Oasis is 13 $MJ \cdot m^{-2}$ (0.3 kly) and approximates those recorded on deserts of southern USSR.

Otherwise than on snowy area, where net radiation passes through 0 at h_0 = ca 17—19°, in the oasis this occurs on average at $h_0 = 6°$ (in autumn and winter at 7°, in summer at 5° and in spring at 6°). In summer (Dec. — Jan.) additional net radiation occurs between 3—4 a.m. and 8—9 p.m., i.e., 18—19 hours per day. In February and November this passage through zero is recorded at 4—5 a.m. and 7—8 p.m., in October and March — at 7—8 a.m. and 5—6 p.m., respectively, in September at 8 a.m. and 4 p.m., in April at 9 a.m. and 3 p.m. and in August at 10.30 a.m. and 1.30 p.m. Between May and July there is constant negative net radiation with values approximating those recorded beyond the oasis. The duration of a period with additional mean daily net radiation is 7 months, 3 months longer than on Mirnyj (Rusin 1961).

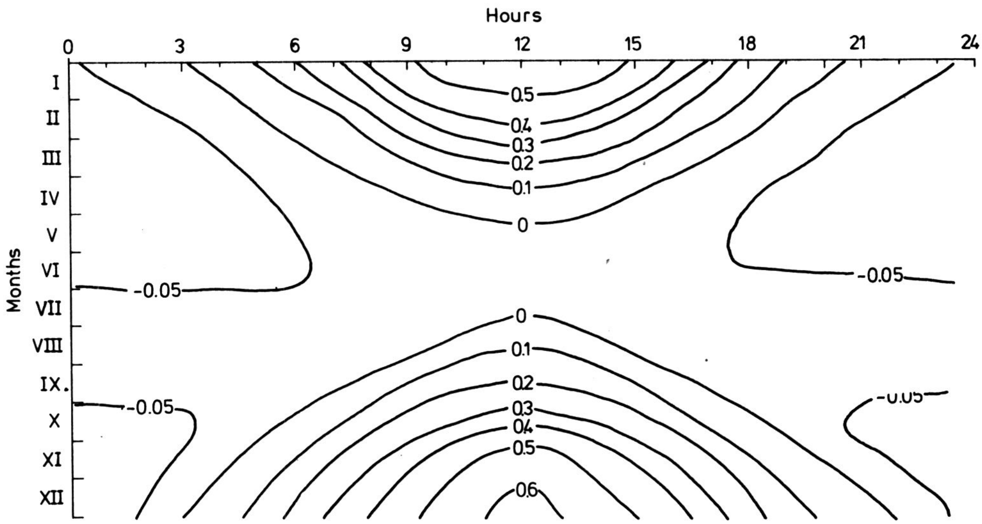

Fig. 12. Isopleths of net radiation at Bungers Oasis
Acc. to data of Rusin (1961).

The daily and annual net radiation are illustrated by isopleths in Figure 12. Among other things, they show that all the year round between 9 p.m. and 3 a.m. negative net radiation takes place. At noon, with the exception of the May — July period, positive values of this radiation are recorded which attain the maximum in December — 419 $W \cdot m^{-2}$ (0.6 $ly \cdot min^{-1}$). The highest daily amplitude of net radiation are between November and January: 412—461 $W \cdot m^{-2}$ (0.59—0.66 $ly \cdot min^{-1}$), whereas in June they do not exceed 70 $W \cdot m^{-2}$ (0.1 $ly \cdot min^{-1}$).

Similarly as other radiation fluxes the net radiation is closely related to the sun's altitude and cloudiness (Figs. 2 and 13). The highest positive

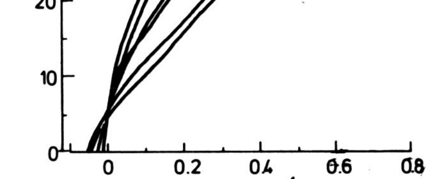

Fig. 13. Dependence of the intensity of net radiation on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0; 2 — 10/0, Ci, Cs, Cc; 3 — 10/0, As, Ac; 4 — 10/0 Ci, Cs, Cc + As, Ac; 5 — 10/10; 6 — mean cloudiness at Bungers Oasis
Acc. to data of Rusin (1961).

and the lowest negative values of this radiation occur under cloudfree conditions ranging from -42 W·m^{-2} (-0.06 ly·min^{-1}) at $h_0 < 0°$ to 551 W × × m^{-2} (0.79 ly·min^{-1}) at $h_0 = 45°$ (on the average 279 W·m^{-2}, 0.40 ly·min^{-1}), and the lowest at heavy overcast (10/10), where -14 W·m^{-2} (-0.02 ly·min^{-1}) and 153 W·m^{-2} (0.22 ly·min^{-1}), (on the average 77 W·m^{-2}, 0.11 ly·min^{-1}), respectively.

The range of short-wave net radiation is absorbed radiation having an annual total 1298 MJ·m^{-2} (31 kly) higher than in the total range and is 77% of total radiation (Table I). In particular months this per cent ranges from less than 65% in the colder part of year (Apr. — Sept.) to 68—84% in the warmer part (Oct. — March.). Within the continental glacier these values are much smaller and do not exceed 20%, being on the average 12—16%. The highest mean monthly of absorbed radiation reaching 632 MJ × × m^{-2} (15.1 kly) exceeds by 147 MJ·m^{-2} (3.5 kly) the June totals calculated by Kozłowska-Szczęsna (1973) for Poland. On the whole during the year the Bungers Oasis obtains almost 43 kly of solar radiation more than the surrounding glaciers. This is a basic factor deciding about the climatic distinctness of Antarctic oases.

The dependence of absorbed radiation on the sun's altitude approximates the rectilinear (Fig. 14). Under cloudfree conditions and at the highest altitudes of sun it exceeds slightly 698 W·m^{-2} (1 ly·min^{-1}), being on the average 377 W·m^{-2} (0.54 ly·min^{-1}). At sky overcast by middle and high clouds (10/0) it is 419 W·m^{-2} (0.6 ly·min^{-1}) (on the average 195 W·m^{-2} (0.28 ly·min^{-1})) and at heavy overcast only 216 W·m^{-2} (0.31 ly·min^{-1}), on the average 126 W·m^{-2} (0.18 ly·min^{-1}).

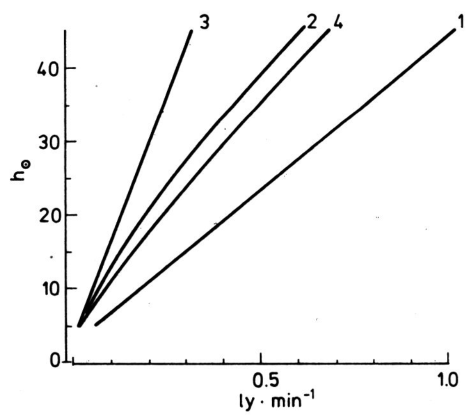

Fig. 14. Dependence of the intensity of short-wave net radiation (absorbed radiation) on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0, 2 — 10/0, 3 — 10/10, 4 — mean cloudiness at Bungers Oasis
Acc. to data of Rusin (1961).

A part of long-wave net radiation is called an effective radiation. As a result of higher temperature of active surface the effective radiation is here higher than on the surrounding continental glacier. Its annual total is 1298 MJ·m^{-2} (31 kly) thus exceeding by 377 MJ·m^{-2} (9 kly) the total for

Mirnyj and by 209—251 $MJ \cdot m^{-2}$ (5—6 kly) the total on the continent, where the radiation is higher due to minimal water vapour content. The effective radiation as a function of temperature of active surface and water vapour content in the atmosphere has a less regular course of isopleths (Fig. 15) as compared to net radiation as regards the total range. The highest daily amplitude of effective radiation — 119 $W \cdot m^{-2}$ (0.17 $ly \cdot min^{-1}$) is in December, when its values range between 42 $W \cdot m^{-2}$ (0.06 $ly \cdot min^{-1}$) and 160 $W \cdot m^{-2}$ (−0.23 $ly \cdot min^{-1}$), whereas the lowest one occurs in the 3 winter months (June. — Aug.) and does not exceed 7 $W \cdot m^{-2}$ (0.01 $ly \cdot min^{-1}$). The highest annual amplitude of this radiation 133 $W \cdot m^{-2}$ (0.19 $ly \cdot min^{-1}$) occurs around noon whereas the lowest amplitude not exceeding 35 $W \cdot m^{-2}$ (0.05 $ly \cdot min^{-1}$) is observed at night.

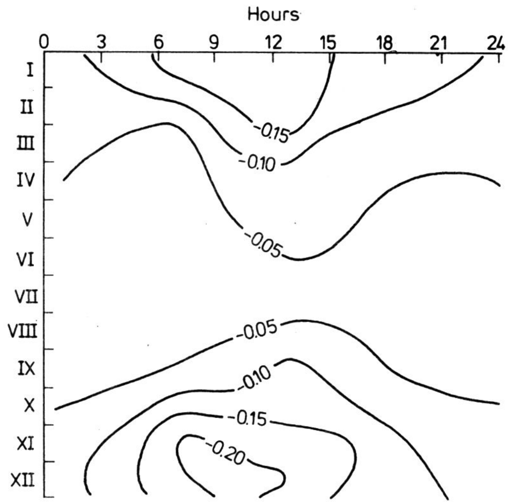

Fig. 15. Isopleths of long-wave net radiation (effective radiation) at Bungers Oasis Acc. to data of Rusin (1961).

For the different of cloudiness (0/0, 10/0 and 10/10) the effective radiation increases distinctly with the sun's altitude, which is the highest under cloudfree conditions when it increases from −42 $W \cdot m^{-2}$ (−0.06 $ly \cdot min^{-1}$) at $h_0 = 5°$ to −160 $W \cdot m^{-2}$ (−0.23 $ly \cdot min^{-1}$) at $h_0 = 45°$, thus obtaining the average −98 $W \cdot m^{-2}$ (0.14 $ly \cdot min^{-1}$). At overcastsky effective radiation is on the average almost 2.5 times smaller than under cloudfree conditions, at an increase of h_0 from 5 to 45° increasing from −7 $W \cdot m^{-2}$ (−0.01 $ly \cdot min^{-1}$) to −63 $W \cdot m^{-2}$ (−0.09 $ly \cdot min^{-1}$). But on the average at h_0 increase from 15 to 35° a decrease of effective radiation is observed (Fig. 16). This phenomenon can be explained by higher cloudiness in this interval.

1.6. Energy balance

According to assumptions of Rusin (1961) there is no or only slight evaporation on the stony surface of oasis and the majority of heat obtained by means of radiation is used for air heating thus being the sensible healt

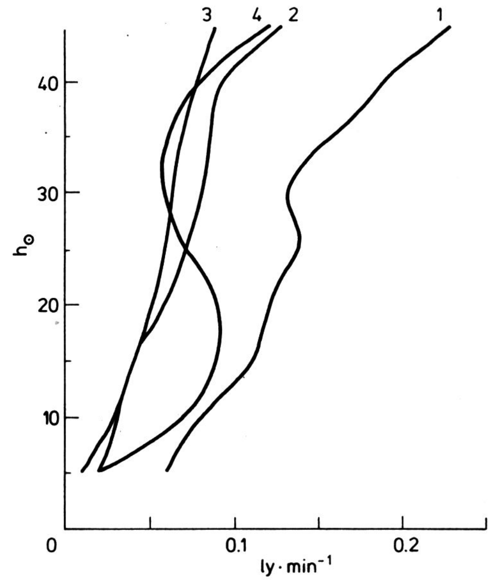

Fig. 16. Dependence of the long-wave net radiation (effective radiation) on the altitude of sun (h_0) at the given cloudiness: 1 — 0/0, 2 — 10/0, 3 — 10/10, 4 — mean cloudiness at Bungers Oasis
Acc. to data of Rusin (1961).

flux. Measurements of Rusin show that the daily course of energy balance components is typical for desert and semi-desert zones (Budyko 1976). Maximal of net radiation 454 $W \cdot m^{-2}$ (0.65 $ly \cdot min^{-1}$) and of sensible heat flux 384 $W \cdot m^{-2}$ (-0.55 $ly \cdot min^{-1}$) is at noon. The highest intensity of ground heat flux -68 — $+68$ $W \cdot m^{-2}$ (-0.10 — $+0.10$ $ly \cdot min^{-1}$) is at 10 a.m. and 8—10 p.m. Between 4 a.m. and 4 p.m. this flux becomes "$-$", whereas at other hours "$+$"[2]).

The distribution of components of energy balance is different above the snow surface area surrounding the oasis. The sensible heat flux is directed towards the active surface and attains the maximal value 174 $W \cdot m^{-2}$ (0.25 $ly \cdot min^{-1}$) at about 6 o'clock in the morning. At the same time there is the greatest loss of heat for evaporation from the snow surface (latent heat flux) which in the morning exceeds -279 $W \cdot m^{-2}$ (-0.40 $ly \cdot min^{-1}$). Minimum of latent heat flux is attaining values close to 0 in the evening hours. Daily maximal net radiation on the continental glacier is twice lower than in the oasis and does not exceed 223 $W \cdot m^{-2}$ (0.32 $ly \cdot min^{-1}$).

Table II shows that although in the oasis all heat obtained by means of radiation is used for heating the air layer near the surface of continental glacier not only does not receive energy but loses it almost constantly and the turbulent sensible heat flux, similarly as solar radiation flux, is directed to the snow surface.

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[2]) Positive component of energy balance equation means that the flux is directed towards the active surface, whereas the negative one — towards the atmosphere or deep into the ground.

Table II

Daily totals of energy balance components on Station Oasis and the surrounding continental glacier on a fine day (acc. to data of Rusin (1961))

Energy balance component ($MJ \cdot m^{-2}$)	Surface of oasis	Surface of glacier
Net radiation	13	4
Exchange of heat with air (sensible heat flux)	−12	6
Loss of heat by evaporation (latent heat flux)	0	−9
Heat flux in ground	−0.4	0
Loss of heat by thawing of snow	0	−2

The prevalent, i.e., 80% of heat obtained by active surface of the glacier, is used for evaporation, the water equivalent of which reaches 2—3 mm per day. The remaining 20% is used for heating and thawing. In the morning almost all heat obtained by the surface of continental glacier is used for evaporation (sublimation) and heating the snow surface, during the day for its thawing and in the evening and at night for heating the snow surface losing heat intensely by means of effective radiation.

In summer, at noon, the evaporation from snow fields in the oasis is 0.5 $mm \cdot hour^{-1}$, which requires 1.0—1.2 kJ (250—300 cal). Net radiation provides about 1/3 of that heat and the rest comes from the air as the sensible heat flux. According to measurements of Rusin (1961) this flux at noon is 209—279 $W \cdot m^{-2}$ (0.3—0.4 $ly \cdot min^{-1}$) and within 24 hours 2.4 $MJ \cdot m^{-2}$ (200 ly) together which is usually a full compensation for the heat losses in evaporation.

2. Temperature of air and ground

A considerable amount of absorbed solar radiation results in strong heating of the active surface in oasis. Temperature of ground surface may reach 41°C and of water surface — 17°C. Thus in the warmer half of the year, and especially in summer, air temperatures in Antarctic oases are higher than on the surrounding continental glacier. Mean air temperature of two warmest months (Dec. — Jan.) on station Oasis exceeds by 4° that on Mirnyj and even by 0.5°C that in the region of second Polish Antarctic station, 4.3° lower as regards the latitude. In all months Bungers Oasis is thermally privileged and the difference between the annual means for Oasis and Mirnyj is 2°C.

Figure 17 shows the course of mean temperature for every ten days and of mean and absolut extremes. Temperatures in Bungers Oasis vary greatly up to 15°C in late autumn and winter (May. — Aug.). In summer this variability decreases and does not exceed in general 5°C. Amplitudes of mean and absolute maxima and minima are higher than in the sub-Antarctic

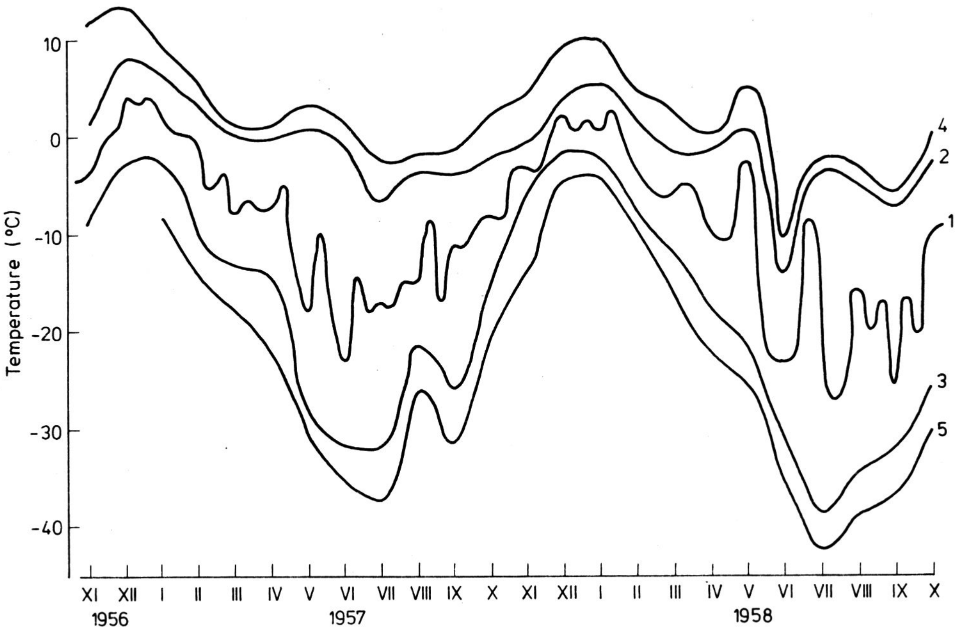

Fig. 17. Annual course of air temperature: 1 — ten-days mean, 2 — mean maxima, 3 — mean minima, 4 — highest maxima, 5 — lowest minima at Bungers Oasis
Acc. to data of Dolgin and Maršunova (1977).

region of the Arctowski station. Mean and absolute annual minima are below 0°C. Mean maxima > 0°C are characteristic for the summer, late and early autumn, whereas the absolute maxima decrease below 0°C only in winter. The highest temperatures one should expect in Bungers Oasis are 10—15°C in summer and −40, −45°C in winter.

The highest summer temperatures in this region, as in other Antarctic oases, are connected with radiation type of weather with not many clouds and with low wind velocities. In winter, when the radiation factor is of lesser importance, the highest temperatures are caused by advection of Antarctic-oceanic air masses coming from the free of ice areas of southern Pacific, whereas the lowest temperatures are caused by catabatic winds of bora type bringing much cooled air from the central part of the continental glacier.

During the summer (Dec. — Feb.) ground temperature in Bungers Oasis is on the average higher by 5.2°C from the temperature of air and in the winter lower by 3.3°C (Table III). Beyond the oasis the temperature of substrate in winter is some 1—2°C lower than that of the air, in-between seasons and in summer these differences are close to 0. Calculations of Rusin (1961) also indicate that with the exception of 2 winter months (Jun. — Jul.) the temperature of active surface in the oasis is higher than of the surrounding continental glacier. In summer this difference is 9—10°C, whereas in winter (Jun. — Jul.) the ground temperature is lower by 4—5°C.

The highest negative differences between the temperature of ground and air up to 4.5°C are recorded in the oasis between May and August, i.e., during the occurrence of negative net radiation. In that period there are

Table III

Monthly and annual values of some climate components in Bungers Oasis
(acc. to data from station Oasis, 1956—1958, Dolgin and Maršunova, 1977 and Rusin, 1961)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Mean temperature of active surface (°C)		7.6	1.9	−4.8	−8.8	−13.8	−25.2	−19.9	−18.8	−17.0	−9.7	1.2	7.4	−8.3
Mean air temperature (°C)		1.8	−2.2	−6.0	−7.6	−11.3	−20.6	−16.8	−16.5	−16.0	−11.2	−3.5	1.7	−9.0
Mean air pressure (900+...) (hPa)		89.9	88.4	85.4	84.0	92.0	97.4	89.2	83.6	80.8	82.6	86.0	93.6	87.8
Highest pressure November: 900+..., other: 1000+... (hPa)		2.8	2.8	4.1	3.8	21.1	27.6	14.2	6.7	1.7	2.6	97.3	8.7	27.6
Lowest pressure (900+...) (hPa)		75.1	77.2	62.4	37.5	57.4	74.8	52.6	53.7	56.9	68.0	72.2	78.2	37.5
Mean wind velocity ($m \cdot sec^{-1}$)		6.4	5.2	5.1	10.0	7.6	4.5	7.4	8.6	7.7	5.1	7.7	5.8	6.8
Highest wind velocity ($m \cdot sec^{-1}$)		34	34	40	56	40	50	48	49	40	40	45	34	56
Number of days with wind $\geq 15\ m \cdot sec^{-1}$		9	6	9	17	13	7	12	15	13	7	8	6	122
Relative humidity (%)		45	48	54	52	60	62	70	65	63	56	46	48	56
Water vapour pressure (hPa)		3.1	2.5	2.1	2.0	1.8	0.9	1.4	1.3	1.2	1.5	2.2	3.3	1.9
Total cloudines (o)		7.0	7.1	6.9	8.2	7.8	6.0	7.2	7.2	7.1	7.3	6.1	6.2	7.0
Heavy overcast (n)		3.5	5.4	4.2	5.2	4.5	2.2	3.4	3.2	4.4	3.4	3.2	3.9	3.9
Frequency of cludiness 0—2 (%)	o	22	23	26	16	16	34	22	24	24	23	28	30	24
	n	60	40	52	40	45	76	61	64	43	60	62	56	55
Frequency of cludiness 3—7 (%)	o	14	10	9	7	11	14	9	8	8	8	15	15	11
	n	9	15	9	12	16	6	8	6	17	8	9	8	10
Frequency of cloudiness 8—10 (%)	o	64	67	65	77	73	52	69	68	68	69	57	55	65
	n	31	46	39	48	40	18	30	30	40	32	28	35	35
Number of fine days (0—2)	o	4	2	4	2	2	3	2	4	2	4	5	5	39
	n	13	5	12	6	8	22	14	14	10	12	11	12	139
Number of cloudy days (8—10)	o	17	14	14	20	18	9	18	17	16	16	12	11	182
	n	4	6	4	6	5	4	4	5	7	4	4	4	57
Total precipitation (mm)		2.5	3.0	13.8	4.7	31.3	10.2	17.2	28.8	68.8	13.4	0.5	9.9	204.1
Number of days with precipitation 0.1 mm		6	2	8	6	12	6	10	8	12	9	13	11	93
Number of days with hard fall		10	14	18	12	18	8	14	12	18	14	8	10	156
Number of days with blizzard		0	2	2	4	6	4	10	8	10	4	2	1	53

ground inversion temperatures and at moderate wind velocities the ground surface is supplied with warmer air from higher atmospherical layers thus preventing the excessive cooling of the ground. Therefore, the temperature in winter in top layers of bare ground does not differ much from the temperature in the ice cover. In summer these differences are greater and positive temperatures penetrate the ground of oasis down to the depth of 2 m (Rusin 1961).

The daily course of differences between temperature in the snow cover and on the stony ground without snow at depths: 0.8, 1.6 and 2.4 m on Mirnyj Station shows that with the exception of January the temperature is higher in the snow cover and the differences increase with the depth of the bare ground. If the mean annual value at the level 0.8 m is 0°C, then at 1.6 m — 1.5°C, and at 2.4 m — 3.2°C. Daily amplitudes of temperatures of ground surface in the oasis are 25—30°C in summer and do not exceed 3°C at the depth of 20 cm. At this depth the phase shift of daily extreme temperatures in 6—8 hours as compared to its surface.

3. Atmospheric pressure, wind direction and velocity

Bungers Oasis is on the southern margin of Antarctic low pressure belt, and similarly as the King George Island shows high variability of this element. Over the year the main pressure maximum is in winter (Jun.) and the secondary one — in summer (Dec.). But the main pressure minimum is in spring (Sep. — Oct.) and the secondary one — in autumn (Mar. — Apr.). Absolute pressure maxima are in late autumn and winter (May — Jun.) and the minima are in autumn (Apr.).

Frequent and strong pressure drops are due to frequent and unexpected hurricane winds, lasting sometimes several days and being the main obstacle for living there and for carrying the research. Although most frequent (2/3 of all cases) are scant and moderate winds up to 5 $m \cdot sec^{-1}$ the number of windy days > 15 $m \cdot sec^{-1}$ is 1/3 of all days in the year (Tables IV and V). The most windy periods are in the middle of autumn (Apr.) and in the winter/spring season (Aug. — Sep.), when the mean monthly wind velocity is of the order of 8—10 $m \cdot sec^{-1}$; the frequency of days with high wind (> 15 $m \cdot sec^{-1}$) is about 50% and the maximum wind velocity may exceed 50 $m \cdot sec^{-1}$.

The majority of winds having maximum velocity have been recorded from the east direction, all cases from the ENE—ESE octant. These are the most frequent directions. N direction prevailed only in December 1956 and 1957, and W direction — in June 1958 (after Dolgin and Maršunova 1977). This is of great practical significance as regards the locality and safety of station buildings and instruments. The rarest directions are from the western half of horizon, 1/4 of all recordings. The mean velocity is hardly 2—3 $m \cdot sec^{-1}$ and is lower by 6 $m \cdot sec^{-1}$ as compared with the velocity from the eastern half of horizon.

Table IV

Mean wind velocity (m·sec^{-1}) at particular directions and frequency of directions and lulls (%) in Bungers Oasis (acc. to data from station Oasis, 1956—1958; Dolgin and Maršunova 1977)

		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW	C
Jan.	v	3.2	4.0	4.8	8.5	10.4	12.3	5.5	7.0	3.2	2.8	2.4	1.8	2.2	3.0	2.2	0.0	—
	α	6.4	4.8	6.9	6.0	16.4	11.7	8.0	1.2	5.3	5.2	3.6	1.7	5.6	2.0	4.4	0.4	10.5
Feb.	v	2.7	5.2	3.8	6.6	12.1	10.7	3.7	2.7	1.2	2.7	2.9	0.5	4.0	2.2	1.6	1.5	—
	α	9.8	4.4	10.4	5.0	23.4	3.6	3.2	1.4	3.6	2.7	5.8	0.4	6.7	1.8	3.2	0.9	13.8
Mar.	v	2.5	3.1	4.1	5.9	15.0	10.2	9.2	2.5	2.3	1.1	2.5	4.8	2.2	1.9	2.5	1.3	—
	α	6.0	4.4	5.6	2.8	15.8	9.2	3.6	0.8	4.8	2.0	7.3	2.8	11.8	1.2	2.4	1.2	18.2
Apr.	v	0.7	5.4	6.5	10.2	21.6	23.3	7.9	19.0	1.7	2.0	2.2	0.8	2.3	1.8	2.7	1.5	—
	α	2.9	3.4	4.2	2.9	29.6	9.5	3.3	0.8	5.0	1.3	3.3	2.5	8.3	2.9	3.0	1.3	15.8
May	v	2.5	6.0	6.7	13.4	16.0	19.4	9.0	2.0	2.0	1.2	1.9	2.0	3.0	3.4	3.2	3.5	—
	α	0.8	1.6	2.4	4.5	13.7	16.7	6.0	2.4	3.1	1.2	3.2	3.6	5.2	2.0	6.0	1.6	25.9
Jun.	v	1.0	0.0	2.2	1.2	21.4	14.6	8.0	11.0	1.1	2.0	1.4	1.5	2.6	1.2	1.7	0.5	—
	α	3.7	0.0	3.7	1.3	8.6	5.8	8.8	0.8	3.3	2.5	4.6	0.8	6.3	1.6	3.0	0.4	45.2
Jul.	v	2.4	4.2	5.1	10.0	22.3	8.7	5.4	0.5	0.7	3.3	1.1	0.4	2.8	2.5	4.4	3.0	—
	α	3.6	4.4	4.3	3.6	23.1	3.2	4.8	0.8	1.6	1.6	2.0	0.8	4.8	1.6	4.8	0.8	34.0
Aug.	v	3.1	2.5	3.6	18.2	18.9	25.6	6.7	7.0	0.7	4.5	3.0	1.0	1.0	1.7	2.7	1.4	—
	α	2.4	0.8	2.8	7.7	26.3	2.8	7.2	0.8	0.8	2.0	2.4	0.8	2.8	2.0	2.8	1.2	34.4
Sep.	v	2.5	3.5	6.0	15.8	22.9	20.2	4.5	5.5	3.2	3.0	2.0	2.0	3.1	3.4	2.5	1.6	—
	α	4.2	1.2	7.1	4.2	20.5	5.8	3.3	0.8	1.6	1.2	5.4	1.2	6.2	2.1	2.5	1.2	31.2
Oct.	v	2.6	5.5	4.9	20.5	17.6	20.1	3.6	1.0	2.2	1.8	2.8	3.6	3.1	2.5	2.6	1.5	—
	α	4.4	2.8	5.6	3.6	17.4	4.0	2.8	0.4	4.8	1.6	6.4	2.8	10.2	2.0	4.0	0.8	26.9
Nov.	v	3.4	4.8	2.2	7.3	15.2	13.1	4.7	4.2	4.9	3.5	3.4	2.4	2.4	3.2	2.8	2.2	—
	α	6.7	5.4	4.2	5.9	15.4	12.9	4.6	1.2	2,1	8.0	3.4	3.3	5.4	9.2	4.6	3.0	5.0
Dec.	v	4.4	4.4	4.5	10.4	12.4	7.7	6.3	1.0	1.3	3.4	1.8	2.0	2.4	4.4	2.2	2.5	—
	α	13.4	13.4	10.9	10.9	13.7	6.0	2.8	0.8	1.2	8.0	1.2	1.2	2.8	2.7	2.0	2.4	6.0
Year	v	4.1	4.0	4.5	10.7	17.2	15.5	6.2	5.3	2.0	2.6	2.3	1.9	2.6	2.6	2.6	1.7	—
	α	5.4	3.9	5.7	4.9	16.7	6.8	4.9	1.0	3.1	3.1	4.0	1.8	6.3	2.6	3.6	1.3	22.2

Table V

Frequency (%) of particular wind velocity intervals ($m \cdot sec^{-1}$) in Bungers Oasis (acc. to data from station Oasis, 1956—1958; Dolgin and Maršunova 1977)

Monts	Velocity intervals									
	0—1	2—5	6—10	11—15	16—20	21—24	25—28	29—34	35—40	> 40
Jan.	14.8	43.9	21.5	7.6	8.6	1.0	0.9	1.7	0.0	0.0
Feb.	29.6	43.2	11.6	6.7	5.0	1.3	1.3	1.3	0.0	0.0
Mar.	40.5	32.4	11.4	4.9	5.0	0.5	3.7	1.2	0.4	0.0
Apr.	31.5	23.5	10.9	5.5	11.2	5.0	4.6	2.1	4.3	1.4
May	38.5	23.4	13.7	4.0	8.4	2.4	3.6	4.4	1.4	0.0
Jun.	65.4	15.0	5.8	4.2	2.5	1.2	1.7	0.4	1.3	2.5
Jul.	51.0	15.7	10.9	2.4	6.4	4.0	2.0	3.6	2.8	1.2
Aug.	38.3	19.7	11.2	6.4	9.2	4.0	3.6	2.0	4.4	1.2
Sep.	41.9	20.1	11.7	3.8	8.7	4.2	3.4	3.0	3.4	0.0
Oct.	40.6	32.8	14.1	1.5	4.0	3.1	0.8	2.8	0.3	0.0
Nov.	15.8	48.0	15.0	6.2	7.1	5.4	1.7	0.8	0.0	0.0
Dec.	10.5	54.5	22.2	6.4	4.0	0.4	0.4	1.6	0.0	0.0
Year	34.9	31.0	13.3	5.0	6.7	2.7	2.3	2.1	1.5	0.5

The frequency of very low wind speed and lulls (0—1 $m \cdot sec^{-1}$) is characterized by distinct annual course with a maximum in winter (Jun., Jul.) and a minimum late is spring and summer (Nov. — Feb.). This is connected with higher frequency of anticyclonic states in winter and the shifting in that time of the low pressure belt more towards the north as compared with the summer. Simultaneously in the winter the frequency of highest wind velocities (> 35—40 $m \cdot sec^{-1}$) is recorded (but not in summer). The highest frequency of velocity 15—30 $m \cdot sec^{-1}$ is in April, i.e., in the middle of Antarctic autumn. Snow storms and blizzards are connected with high wind speed. In the colder part of the year (Apr. — Sep.) the frequency of days with blizzards is 23% and Jul. — Sep. — 30%.

Bungers Oasis situated at the bottom of a plateau is in the zone of slope winds. But the main line of descending air masses, similarly as the descending to the shore continental glacier, miss the elevated oasis or pass above this area. Thus the mean wind velocity in oases, including the Bungers Oasis, twice and even 2.5—3 times lower in winter than on neighbouring stations on the continental glacier. In Bungers Oasis winds of cyclonic origin prevail and are more frequent by 20—30% than on Mirnyj.

Although the frequency of particular intervals of wind velocity in the oasis and on the continental glacier is similar (e.g. frequency of interval 2—10 $m \cdot sec^{-1}$ in Bungers Oasis was 69% and on Mirnyj 68%) still differs in winter. This is especially so as regards the frequency of lulls: 1% on Mirnyj station and 39% in Bungers Oasis, on the average, 45% in June and over 50% in some years. In summer the frequency of lulls due to intense local circulation decreases 2.5 times in the oasis. At the beginning of the spring and when permanent snow cover disappears in the oasis the circulation is especially noticeable under cloudfree conditions. During this circulation the wind blows counter clock'wise following the apparent movement of sun and turning 360° in 24 hours. Then the wind velocity attains the maximum (ca 7 m·sec^{-1}) at noon hours and the minimum (ca 5 m·sec^{-1}) in the evening and at night. But in Mirnyj Station, on the margin of continental glacier, the daily maximum (9—11 m·sec^{-1}) is recorded at night and the minimum (6—8 m·sec^{-1}) at noon and evening hours.

Characteristic anemological phenomena are local foehns caused by passage of air through a hill range surrounding Bungers Oasis and frequently being the cause of temperature rise and greater wind velocity. Their durability varies. In case of foehns occurring before the depression their durability is 1—10 hours. Then relative humidity decreases by 20—30% and air temperature increases by 4—6°C. After the depression the foehn lasts on the average 3—4 hours causing a temperature rise by 2—3°C and decrease of relative air humidity by 10—20%.

Thermal wind rose, made for Oasis by Rusin (1961), shows that similarly as on Mirnyj, the lowest air temperatures in winter are connected with southern winds or lulls when the air temperature drops to −32°C and below. Still, as opposed to Mirnyj, N and NW winds in Bungers Oasis are also accompanied by low air temperatures. With these directions there are low wind velocities, some clouds or none at all which favours higher heat loss due to radiation and greater temperature drops. The warmest in winter are NE, ENE and E directions with mean temperatures −3.0, −6.4 and −7.3°C, respectively.

The situation is different in summer when N—NE winds of mean temperatures 0.5—0.6°C are the coldest in the Oasis because they are accompanied by advection of air masses from the cold sea. It is characteristic that the coldest in summer are SE, SSE and S winds of mean temperatures 3.3, 2.2 and 2.1°C, respectively, and WNW wind of a temperature 2.8°C, connected with local circulation.

4. Relative humidity and water vapour pressure

Another climatic element different in Bungers Oasis as compared to areas close to the continental glacier is the relative air humidity. Tables III and VI show that the air in Bungers Oasis and especially in summer is rather

Table VI

More important characteristics of relative humidity and water vapour pressure in Bunger Oasis (acc. to data from the Station Oasis (Rusin 1961) in particular season of the year)

Season	Relative humidity (%)		Frequency (%) of days with relative humidity in the one of observ. times			Water vapour pressure		
	Mean	Minimum	> 30%	> 50%	> 80%	Mean	Maximum	Minimum
Winter	62	15	3.3	16.3	6.5	1.4	5.6	0.1
Spring	52	13	6.6	24.2	1.1	1.8	4.2	0.3
Summer	47	12	10.0	30.0	1.1	3.2	6.3	0.9
Autumn	51	16	8.7	27.2	2.2	2.3	5.4	0.6

dry — a typical character for all Antarctic oases as the advection of relatively dry and cold air onto the warmer area of the oasis results in heating the air and lesser saturation. During some summer days relative humidity approximates that recorded on waterless deserts. For example, in January 29, 1956 at 4 a.m. — 14%, at 7 a.m. — 19%, at 10 a.m. and 1 p.m. — 22% and at 4 p.m. — 33%. Mean annual relative humidity (56%) is 30% lower than in the region of the Arctowski Station and 15—20% lower than on neighbouring stations on the continental glacier. In late spring and summer (Nov. — Feb.) the mean monthly relative humidity is below 50% in Bungers Oasis and > 60—70% in winter.

Water vapour pressure — function of air temperature and relative humidity — is also low and had a winter minimum and summer maximum (Table III). Studies on the course of daily water vapour pressure and relative homidity in Bungers Oasis and beyond, conducted in January 1956 at good weather conditions for 11 days, showed (Rusin 1961) that although water vapour pressure during the day in the oasis was 1.4—2.0, on the average 1.7 hPa (lower than beyond the oasis), then the difference in relative humidity was 22—40% (on the average 26%).

In winter the lowest relative humidity is when the wind blows from ESE—SE and in winter — from ENE—SE, when air masses change into foehn clouds when passing the range of hills surrounding the oasis.

As the evaporation on the stony surface of oasis is very small thus the evaporation from surrounding glaciers is the main source of water vapour in oases. Contrary to snow and ice fields, where the water vapour content decreases together with he height, its vertical increase is observed frequently on the surface of oasis.

5. Cloudiness and fogs

Mean annual cloudiness (7 in the scale 1—10) is similar here as on other stations of the Eastern Antarctic coast and attains higher values than inland nevertheless lower as compared to Antarctic Peninsula, where it is 8—9. Annual cloudiness has the minimum (6.0) at the beginning of winter (Jun.) and the maximum (8.2) in the middle of autumn (Apr.).

Similarly as on other Russian Antarctic stations the cloudiness for Oasis was estimated for all kinds of cloudiness together and separately for heavy overcast. Thus the heavy overcast (base ⩽ 2 km) is 56% of total overcast.

The frequency of cloud-free conditions and of cloudiness ⩽ 2 is quite high — 25% of all recordings, i.e., much more than on Southern Shetlands, where on station Bellinghausen 0—2 cloudiness is recorded in 5% of clases. The highest frequency (about 30% of cases) of 0—2 cloudiness is in June and December, and the lowest (16%) in April and May. The frequency of 0—2 cloudiness only by low clouds is much higher: 55% on the average, winter maximum, main minimum in autumn and secondary one in spring. Characteristic is the low frequency of mean cloudiness with the broadest interval (3—7). Both as regards total cloudiness and heavy overcast this interval is recorded only in 10% of cases and its frequency in particular months ranges between 6 and 17%, similarly as on Bellinghausen station.

As regards total cloudiness the highest frequency is for the interval 8—10, i.e., cloudy conditions; the maximum of this interval (77%) is recorded in the middle of autumn (Apr.) and the minimum (52—55%) in June and December, i.e., at the beginning of winter and summer. Heavy overcast is almost twice lower in this interval with winter minimum (18%) and autumn maximum (48%).

The number of fine days[3]) is not more than 5 on the average during the most sunny months (Nov. — Dec.) and during the year is 5 times (in autumn even 9—10 times) lower than the number of cloudy days. However, when examining only the heavy overcast this ratio changes and the number of fine days (cloudiness 0—2) is almost 2.5 times higher than the number of cloudy days (cloudiness 8—10). This points to distinct contribution of middle and high clouds.

In the warmer part of the year a strong thermal convection over the oasis causes the formation of well developed cumuli gradually disappearing when moving towards the continental glacier. They form about 7—8 a.m., attain maximum development between noon and 2 p.m. and 4—5 p.m. and disappear at 8 p.m. (Rusin 1961). The frequency of Cu type of cloudiness in Bungers Oasis in spring and autumn is 4—6% and in summer 8—10%. Frequency of particular degrees and kinds of cloudiness and the number of fine and cloudy days are similar on station Oasis and Mirnyj.

Considerable air dryness and high frequency of foehn phenomena explain the rare occurrence of for in Bungers Oasis. Over 2 years of the functioning of station Oasis there were only 4 foggy days (in July 1958), whereas on King George Island (the Bellingshausen Station) this phenomenon occurs each month, exceeding sometimes the frequency 50%.

6. Precipitation and evaporation, snow-storms and blizzards

Detailed estimation of total precipitation under Antarctic conditions is a difficult problem. Precipitation evaporates from the rain-gauge, it remains on walls of the apparatus or the snow is blown out or blown into the measuring device during storms and blizzards. Tretiakow's rain gauge was used on station Oasis and no corrections as regards what has been said above were made. Thus total precipitation values in Table III are overestimated.

Annual precipitation of 204 mm in Bungers Oasis is lower than on other stations of the Antarctic coast (Mirnyj — 624 mm, Bellingshausen 729 mm) but several times higher than inland. The highest precipitation has been recorded in 2 months time (May and Sep.), almost 50% of the annual total for Oasis, and only 13% of the annuals total-during the 4 warmest

[3]) Mean daily cloudiness 0—2.

months (Nov. — Feb.). On the average there is a rainfall or snowfall every 4 days ⩾ 0.1 mm, but in the colder half of the year (Apr. — Sep.) 58% of days are with precipitation. This is mainly snow, wet snow, granular snow or hail — treated jointly as hard fall. The number of days with hard fall is 1.7 times higher than the number of days with ⩾ 0.1 mm fall. The highest number of all days with precipitation is for the transitional seasons of the year: autumn and spring.

According to Smirnov (Rusin 1961) the permanent snow cover does not form even in winter. The snow fall quickly evaporates and first of all is blown off open areas and cumulates in suitable landscape forms thus forming numerous snow fields tens of metres thick and with a surface area from several tens of metres to 200—300 m^2. The evaporation from water, ice and snow surface is 450—600 mm$\cdot$year^{-1} and thus exceeds 2—3 times the annual precipitation.

Total permanence of snow storms and blizzards in Bungers Oasis is 7—8 times smaller than beyond the oasis: 500—600 hours, whereas on Mirnyj — 4430 hours. The frequency of this phenomenon on both stations is 5.7—6.8% and 50.6%, respectively. The total mass of snow transferred at the ground surface is then 0.1—0.8 g$\cdot$cm$^{-2}\cdot$min^{-1}, and at simultaneous snowfall — 1.2—3.2 g$\cdot$cm$^{-2}\cdot$min^{-1}.

7. Bioclimatic conditions

Data on bioclimatic conditions of Bungers Oasis can be found in papers by Gregorczuk (1978a, 1978b, 1979). The course of wind chill shows that between June and September at monthly means 5600 kJ$\cdot$m^{-2} hour^{-1} there is a great probability for freezing unprotected parts of body. Even under summer conditions (Dec. — Feb.), when mean monthly wind chill stays within the range 3600—4000 kJ$\cdot$m$^{-2}\cdot$hour^{-1}, the sensitivity scale describes it as "very cold". The thermal radiation effect not taken into consideration by wind chill factor, increases the sensible temperature on the average by 4—5°C in summer and late in spring and by 1—4°C in autumn and early spring. But the wind effect decreases the temperature by some 2°C summer, 4—4.5°C in winter and 2.5—4°C in the transitional seasons.

In winter the temperature of not covered face may attain negative values resulting in 2nd degree frost bite, and in the transitional seasons (tempera-ure > 0—6°C) the frost is being felt unpleasantly. The heat-preserving clothes required in winter: 6—7 Clo units at rest, 4—4.5 Clo when working at a moderate intensity and about 3 Clo at hard work. In summer these values are respectively: 3.5—4, 2—2.5 and 1.6 Clo, in transitional seasons the values are between the winter and summer ones. The data presented here show that the least favourable bioclimatic conditions are in April. Although mean air temperatures are then higher by 13°C than in the coldest month, the frequency of high and very high winds is the highest as well as of the cloudy conditions, the frequency of fine days is the lowest and there is a great variability of atmospheric pressure — exceptionally difficult conditions for carrying research.

Nevertheless, Antarctic oases, including the biggest one — Bungers Oasis, are relatively the best parts of Antarctic for man because of their mild climate compared even with other coastal stations of the continental glacier. At present in all bigger oases there are research stations.

As assumed by Rusin (1961) the climatic effect of Bungers Oasis goes as far as 3—5 km into the glaciers. As a source of heat, especially in the warmer half of the year, oases accelerate the thawing of surrounding glaciers and systematically increase their surface area, and the considerable prevalence of evaporation over precipitation is very important. As a result of distinct prevalence of ENE and E winds the warmer air from above the oasis and mineral particles blown from that area move towards WNW and W direction, where further rock surface are released from the ice cover. Thus Bungers Oasis stretches in the ENE—WSW direction.

Complex studies on a group of factors responsible for the formation and evolution of surface areas of Antarctic oases seem to be one of the more significant scientific problems of the Antarctic.

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