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Adam KRĘŻEL and Kazimierz PĘCHERZEWSKI
Institute of Oceanography, Gdańsk University, Gdynia

Preliminary data on total radiation in the region of Arctowski Station (King George Island, South Shetland Islands)*)

ABSTRACT: Studies conducted between December 20, 1978 and February 20, 1979 on Arctowski Station show that daily sums of total radiation ranged from 165.5 to 834.5 mWhr·cm $^{-2}$. Maximal mean hourly radiations were recorded from 12 to 14 hours (39.7—72.4 mWhr·cm $^{-2}$).

Key words: Antarctic, solar radiation

1. Introduction

Solar radiation is the basic source of energy for the majority of physical, biological and chemical processes occurring on Earth. Knowledge of the energy reaching Earth at a determined hour during the day may be a great significance for estimating conditions required for a number of biological processes and is an important element for estimating total primary production in the ecosystem (Budyko 1975).

General distribution of solar radiation on Earth shows high regularity depending on geographical lattitudes. However, there is a number of regional features connected mainly with the specific state of atmosphere and the ground which are responsible for deviations from this regularity. A detailed knowledge of the radiation regime in a given place on Earth usually requires additional actinometric studies. In the case of South Shetlands such investigations are especially justified because these areas have high cloudiness and its average values for summer months (December — February) exceed 0.85 (World Survey of Climatology 1970, Nowosielski 1980).

Total solar radiation was constantly recorded on Arctowski Station, other investigations being conducted, during the austral summer of 1978/1979.

*) The studies come under the Problem MR-II-16 and were conducted during the Third Expedition of Polish Academy of Sciences to Arctowski Station. The head of the expedition was Dr S. Rakusa-Suszczewski.

The aim of this study is a presentation and brief analysis of the obtained results on the basis of other accesible data conducted on the Soviet Station Bellingshausen (Spravočnik po klimatu Antarktidy 1976) and in the region adjacent to South Shetlands (Franceschini 1977).

2. Material and methods

Between December 20, 1978 and February 20, 1979 total radiation was measured by means of Yanishevsky Thermoelectric Pyranometer, type M80-M, connected with an integrating unit made in the Institute of Oceanography of Gdańsk University, which allowed for discrete recording of five-minute sums of solar radiation within the area of solar spectrum 0.3—3.5 μm (Fig. 1). During the recording, the pyranometer was placed on the flat roof of field laboratory in an open area on the shore of the Admiralty Bay (some 4 m a.s.l.).

In the given period about 15 000 five-minute sums of total solar radiation were recorded. These data were used as initial material for the present analysis.

Comparative material, as regards changes in temperature, pressure and water vapour pressure for the same period and for the region of Arctowski Station was made available by meteorologists of that expedition.

3. Results and discussion

Figure 2 shows the course of daily totals of solar radiation (Q) and mean daily atmospheric pressure (p), air temperature (T) and water vapour pressure (e) recorded during the austral-summer of 1978/1979 on Arctowski Station. These data show that the totals of solar radiation changed from 165.5 to 834.5 $mWhr \cdot cm^{-2} \cdot 24h^{-1}$ and were the effect of complex and varying synoptic and meteorological processes in that region.

Table I shows that the total radiation recorded in the summer of 1978/1979 on Arctowski Station is about 10% higher as compared to mean values for Bellingshausen Station in the years 1968—1973*) and the data obtained during the austral-summer 1974/1975 on a research vessel conducting investigations in the region of South Shetlands (Franceschini 1977).

Radiation in January (Fig. 3) was especially high, almost 15% more then mean radiation on Bellingshausen Station (Spravočnik po klimatu Antarktidy 1976).

In contrast to Bellingshausen Station, early daily solar activity on Arctowski Station (Fig. 3) and early disappearance of daily solar activity on second one can be explained by making reference to differences in the configuration

*) The fact that the mean total radiation measured at Bellingshausen Station is consistent with the calculations of (Sasamori 1972), where the data on mean condition of atmosphere in these geographical lattitudes for a period of almost 100 years up to 1972 were used, makes it possible to consider the former one as a good point of reference.

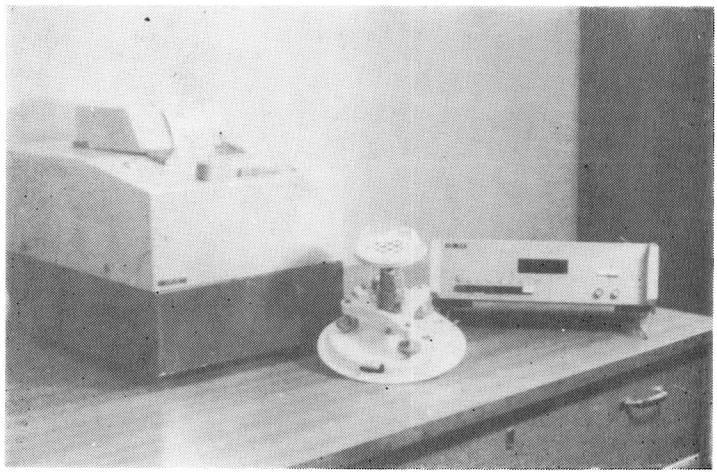

Fig. 1. Working set for measurements of solar radiation. Photo: K. Pęcherzewski

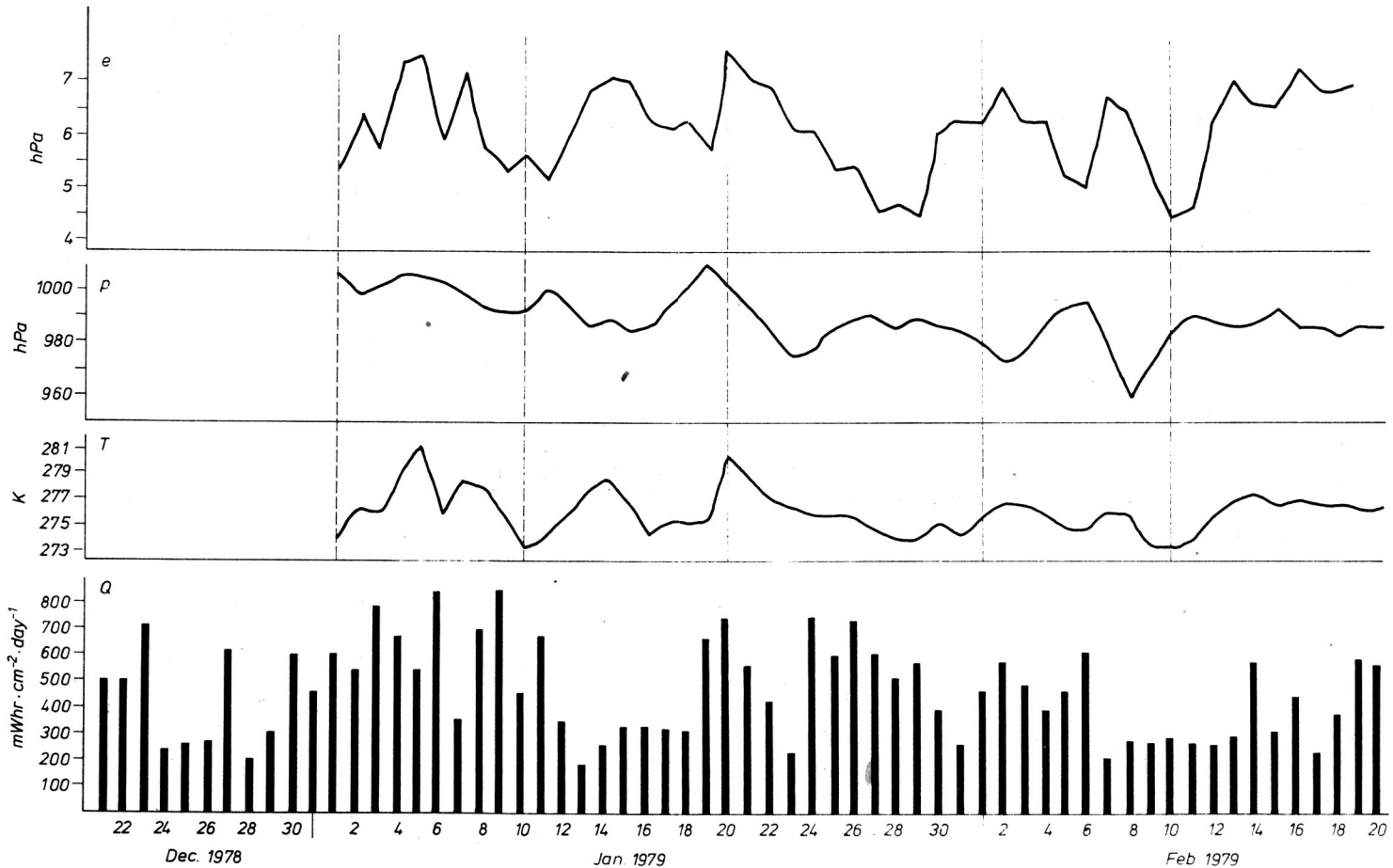

Fig. 2. Changes of daily sums of total solar radiation (Q) and mean daily temperatures (T), atmospheric pressure (p) and water vapour pressure (e) on Arctowski Station from December 20, 1978 to February 20, 1979

Table I

Decadal, mean daily totals of global radiation (mWhr·cm^{-2})

Region and period of investigation	Month	Decade	Daily values		Decadal mean daily values
			max	min	
	Dec.	3	710	168	405
	Jan.	1	834	316	606
Arctowski Station	Jan.	2	700	166	394
20. Dec.—78—20. Feb.—79	Jan.	3	739	192	479
	Feb.	1	598	175	384
	Feb.	2	599	201	365
	Dec.	3	981	213	606
	Jan.	1			442
Bellingshausen Station	Jan.	2	920*)	117*)	454
avg. 1968—1973	Jan.	3			370
(Sprav. po klimatu	Feb.	1			314
Antarktidy 1976)	Feb.	2	665**)	113**)	279
	Dec.	3	497	447	479
South Shetland Islands area	Jan.	1	—	—	—
Dec. 1974 — Feb. 1975	Jan.	2	—	—	—
(Franceschini 1977)	Jan.	3	450	212	336
	Feb.	1	—	—	—
	Feb.	2	352	212	283

*) whole January, **) whole February

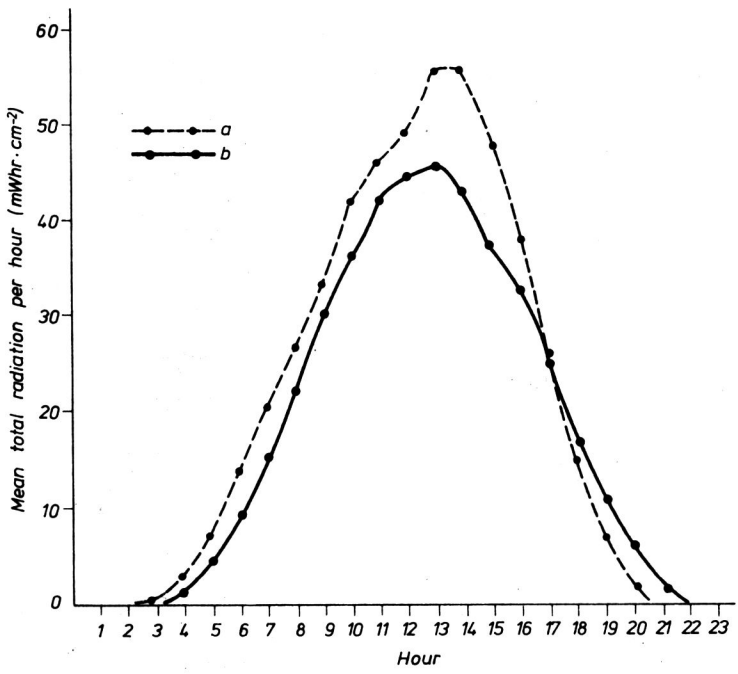

Fig. 3. Mean hourly total radiation in January 1979 on Arctowski Station (*a*) and mean values in January 1968—1973 for Bellingshausen Station (*b*)

of the landscape and the so-called horizon altitudes on both stations. Hence, the horizon line on Arctowski Station to the east is practically not intercepted, whereas to the east of Bellingshausen Station, there is a mountain range with an ice dome. The opposite situation occurs in the west of Arctowski Station where there are hills covered with lots of ice behind which the sun sets earlier, whereas on Bellingshausen Station the western area has a mild configuration, low horizon and thus daily solar activity in the afternoon lasts for almost one hour longer.

The data in Figure 3 show distinct asymmetry as regards solar radiation on both stations, both before and after the noon. This is also confirmed in Figure 4 with the mean hourly total radiation for Arctowski Station in successive decades of the austral-summer of 1978/1979. The data in Table II show that solar radiation on Arctowski Station reaches the surface for about 19 hours a day; mean values for a decade of hourly totals of

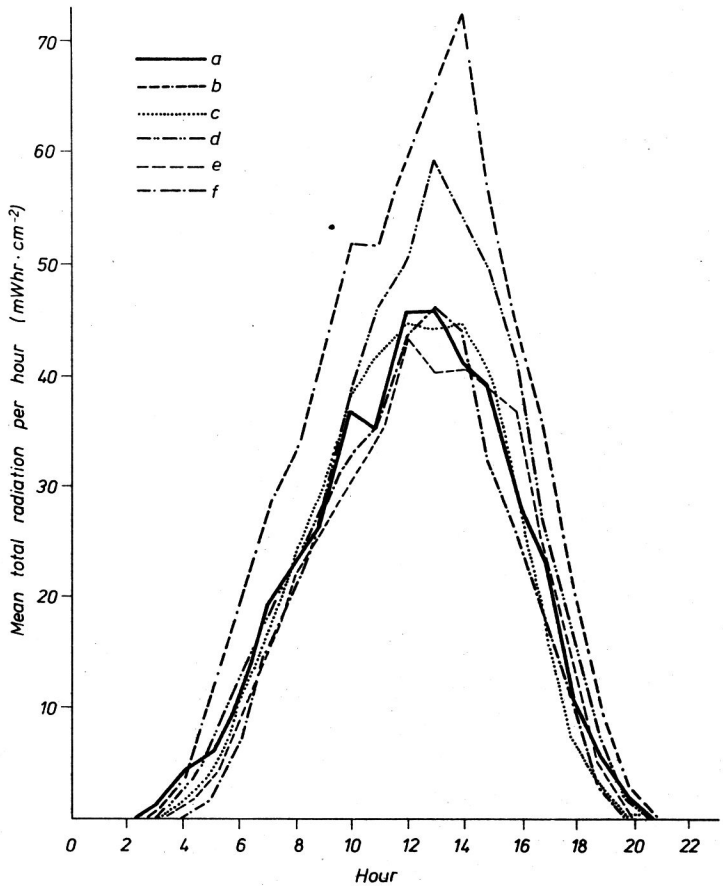

Fig. 4. Mean hourly total radiation on Arctowski Station for selected decades of the austral summer (December 20, 1978 — February 20, 1979): *a* — for 3rd decade of December 1978, *b* — for ist decade of January 1979, *c* — for 2nd decade of January 1979, *d* — for 3rd decade of January 1979, *e* — for 1st decade of February 1979, *f* — for 2-nd decade of February 1979

Table II.

Decadal, mean hourly totals of global radiation at stated hour in the day ($mWhr \cdot cm^{-2}$) Arctowski Station, 20. Dec. 1978 20. Feb. 1979

Month	De-cade	Hour																		day
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Dec.	3	1.3	4.2	5.7	9.9	18.0	22.8	27.0	36.6	35.5	45.4	45.6	41.4	38.1	29.7	23.7	11.6	5.9	2.0	0.2	404.6
Jan.	1	0.6	3.8	11.0	19.1	27.1	32.9	41.9	51.8	51.7	59.0	65.4	72.4	56.0	44.2	35.1	21.2	9.8	2.7	0.2	605.9
Jan.	2	0.1	1.3	4.1	10.6	16.3	24.0	29.8	38.4	42.0	39.7	44.3	44.6	40.2	29.7	18.3	7.3	3.0	0.6	0.0	394.3
Jan.	3	0.2	2.1	6.4	12.2	18.3	23.0	28.2	37.6	46.2	50.5	59.4	53.7	49.5	40.3	25.3	16.4	7.8	1.5	0.2	478.8
Feb.	1	0.5	1.2	3.5	9.2	14.9	21.9	25.8	30.2	34.3	42.5	40.1	40.5	38.7	36.9	24.1	14.0	4.8	1.1	0.0	384.2
Feb.	2	0.0	0.1	1.9	6.5	15.2	21.7	29.0	32.6	33.8	43.9	45.9	44.2	31.8	25.6	18.3	11.1	2.8	0.4	0.0	364.8

solar radiation attain their maximum in hours 12—14 and range between 39.7 and 72.4 mWhr·cm^{-2}. Distinct increase in solar energy reaching the region of Arctowski Station was recorded in the first and third decades of January.

Information about the energy of solar radiation in the whole spectrum allows to estimate approximately the corresponding amount of photosynthetically active radiation (PAR). According to the data of (Rusin 1979) in the range of inflowing energy 0.0—0.8 mWhr·cm^{-2}·min^{-1} PAR is equal to half of radiation in the whole spectrum, and at higher values its contribution decreases slightly. This information, compared with Table II allows to estimate PAR in the region of Arctowski Station in the summer of 1978/1979 as almost of the values presented in Table II.

Slightly lower PAR values in relation to total radiation should be expected only at noon hours of sunny days, when the energy in the whole spectrum may exceed 0.8 mWhr·cm^{-2}, min^{-1}. The above estimation makes it possible to calculate PAR with 10% accuracy. Real PAR data in the region adjacent to South Shetlands are given by (Franceschini 1977), i.e., mean daily PAR is 51—56% of total radiation (Q).

The data on energy of solar radiation during the austral-summer on Arctowski Station compared with the data for Bellingshausen Station (Spravočnik po klimatu Antarktidy 1976) and the shore of South Shetlands (Franceschini 1977) show that Arctowski Station can be considered as "privileged" as regards solar radiation. Further actinometric studies, which should be conducted systematically, will answer whether this is true or whether the summer of 1978/1979 should be considered as exceptionally sunny.

4. Summary

During the austral-summer of 1978/1979 total solar radiation was recorded within the spectrum 0.3—3.5 μm. Between December 20, 1978 and February 20, 1979 a discrete recording of (about 15 000 of data) five-minute sums of solar radiation were the initial material.

The data show that diurnal sums of total radiation ranged from 165.5 to 834.5 mWhr·cm^{-2}. Maximal mean hourly radiation was observed between 12 and 14 hours (39.7—72.4 mWhr·cm^{-2}). The asymmetry in the inflow of solar radiation was visible: less before noon and more after the noon (Fig. 3).

5. Резюме

В период антарктического лета 1978/1979 проводилась постоянная регистрация всей стоимости солнечного излучения в пространстве спектры 0,3—3,5 м. В днях от 20 декабря 1978 до 20 февраля 1979 получено запись (около 15 тыс. данных) пятиминутных сумм энергии солнечного излучения, которое становило исходный материал.

С полученых данных вытекает, что суточные суммы всего излучения колебались от 165.5 до 834.5 mWhr см$^{-2}$. Максимальные часовые средние стоимости изучения наблюдались в 12—14 часов (39.7 до 72.4 mWhr см$^{0-2}$).

Видна асимметрия в притоке солнечного излучения — меньшие количества в утренее время и большие количества в послеобеденное время (рис. 3).

6. Streszczenie

W okresie antarktycznego lata 1978/79, prowadzono ciągłą rejestrację wartości całkowitego promieniowania słonecznego w obszarze widma 0.3—3.5 μm. W dniach od 20 grudnia 1978 do 20 lutego 1979 uzyskano dyskretny zapis (około 15 tys. danych) pięciominutowych sum energii promieniowania słonecznego, które posłużyły jako materiał wyjściowy.

Z otrzymanych danych wynika, że dobowe sumy promieniowania całkowitego wahały się od 165.5 do 834.5 mWhr·cm^{-2}. Maksymalne średnie godzinne wartości promieniowania zaobserwówano w godz. 12—14 (39.7 do 72.4 mWhr·cm^{-2}). Widoczna jest asymetria w dopływie promieniowania słonecznego; — mniejsze ilości w godz. przedpołudniowych i większe ilości w godz. południowych (rys. 3).

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AUTHORS' ADDRESS:
Mgr Adam Krężel
Dr Kazimierz Pęcherzewski
Instytut Oceanografii
Uniwersytetu Gdańskiego,
Czołgistów 46,
81-378 Gdynia, Poland