SCRIPTA FAC. SCI. NAT. UNIV. PURK. BRUN.
Vol. 18 (1988), No. 1 (Geographia), p. 3—20

VARIATION OF GLOBAL AND REFLECTED RADIATION IN THE AREA OF WERENSKIOLD GLACIER (SW SPITSBERGEN) IN THE SUMMER TO AUTUMN SEASON OF 1985

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Received for publication: August 1987

SUMMARY

Variations of global and reflected radiation were studied on the basis of measuring conducted at the meteorological station of Wrocław University on the lateral moraine of Werenskiold Glacier (SW Spitsbergen) during the "Spitsbergen '85" expedition in the period of 28th July—10th September 1985. Daily course of global radiation with reference to its typical features and peculiarities is reported for individual decades. Daily course of reflected radiation is presented for two localities with different character of the active surface, namely, the moraine and the marine terrace with sorted circles. The values of reflected radiation intensity are greater on sorted circles because of the brighter colouring of the surface. Daily sums of global radiation in the period under study were highest at the turn of July and August, when they exceeded markedly the values measured during previous Wrocław expeditions. They went especially to circulation types SE_a, E_a and K_a (classification after Niedźwiedź, 1986), mostly at the advection of continental polar air. The magnitude of sums of global radiation in a given synoptical type depends closely on the size of cloudiness, with possibly striking differences between the sums obtained. On the basis of sums of extraterrestrial insolation calculated for particular days transmissivity of the atmosphere was determined for each day of the period of observation. Its mean value for the period of measuring was 36.1 %, varying between 66.1—9.9 %. Further, regression relationship was established between the atmospheric transmissivity and the values of mean daily cloudiness, having the character of a parabola. The study of daily sums of reflected radiation on the moraine and sorted circles confirmed the differences between the two localities reported earlier, as well as the course of mean daily values of the albedo. Regressive relationships of the values of reflected radiation to sums of global radiation were established. In continuation of the measuring work performed by previous Wrocław University expeditions, the period under investigation (especially July and August) was marked with substantially more favourable radiation conditions with a conspicuously higher proportion of anticyclonic situations.

1. INTRODUCTION

Besides the processes of advection (circulation), the radiation conditions are an important factor influencing the formation of weather and climate in the area of Southwest Spitsbergen (Svalbard). The proportion of radiation fluxes amounts on Spitsbergen to about 50 % of the total annual energy supply, increasing in the summer season (polar day) to as much as 80 % (Orvig and Vowinckel, 1970) — Tab. 1.

Tab. 1. Proportion of non-radiation processes (in %) in the turnover of energy (Orvig and Vowinckel, 1970)

	January	February	March	April	May	June	July	August	September	October	November	December	Mean
65 °N 0 °E	100	73	36	4	8	15	10	20	32	62	92	100	46
North Pole	100	100	100	48	10	9	22	25	79	100	100	100	58

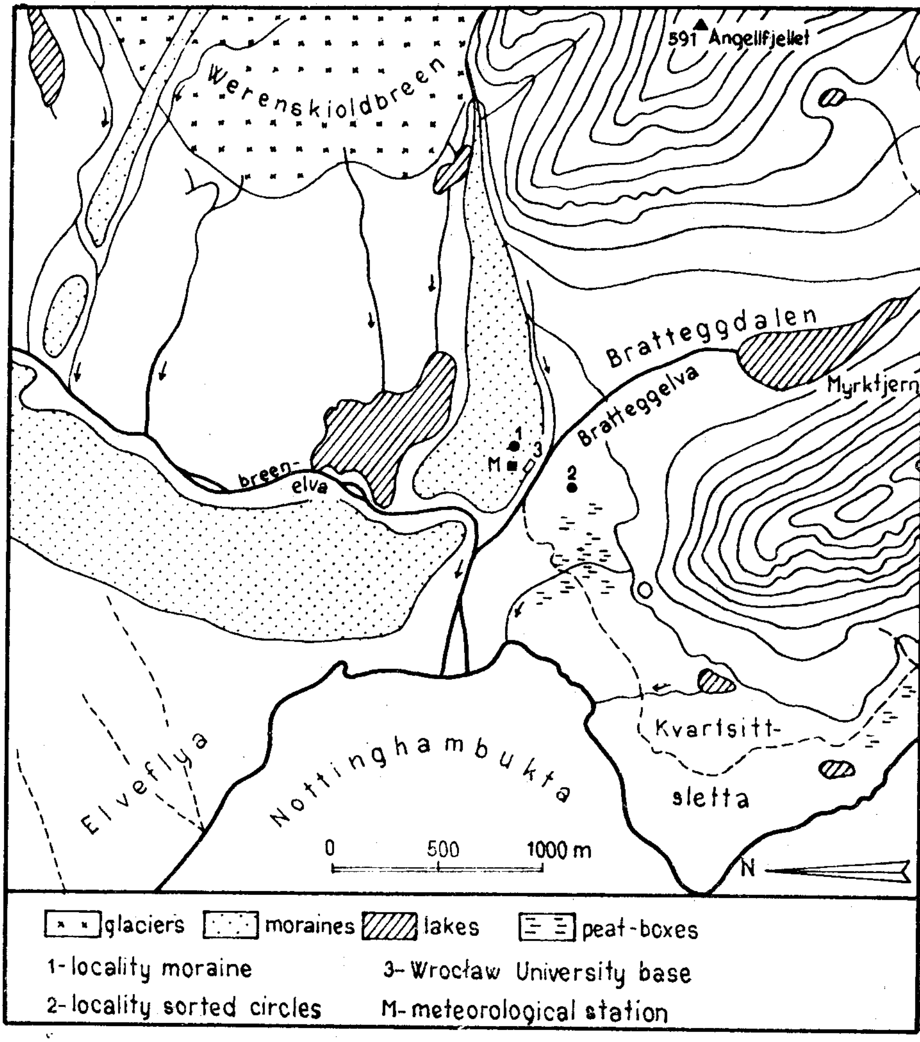
Their main component is global radiation which belongs, by its records in the Hornsund fjord area and especially in its narrow coastal section, to the lowest on the Earth (less than 581.5 kWh . m^{-2} . year^{-1}). This is due to its absorption by frequently forming stratified clouds, mainly of St and Sc type, which in the course of a year absorb about 40 % of the incoming global radiation. The cloudiness-induced reduction of global radiation manifests itself in May—July, that is, in the months of the potentially greatest radiation intensity. Higher on the glaciers the sums of the intensity of incident radiation are greater by about 232.6 kWh . m^{-2}. As a result of the high albedo (as much as 80 %), of course, the annual values of radiation balance are here negative, slightly below zero, while on the coast the annual value ranges round 69.8 kWh . m^{-2} (Baranowski, 1968, 1977; Pereyma, 1983).

Research into radiation conditions of the Polar Bear Bay (Isbjörnhamna) in Hornsund, chiefly global radiation, was carried out in the summer months of 1957 to 1960 and 1970—1974, and throughout the year in the season 1957/1958. Another period of radiation measurements is connected with the establishment of a meteorological station as a part of the scientific base of the Polish Academy of Sciences (PAS) in Hornsund in 1978 ($\varphi = 77°00'04''$ N, $\lambda = 15°33'36''$ E, $H = 10$ m a.s.l.). Radiation conditions in this area have so far been analysed in the works of Baranowski (1968, 1977), Baranowski and Głowicki (1974, 1975), Pereyma (1983), Głowicki (1985).

Many of these studies were concerned also with the radiation conditions of Werenskiold Glacier (about 12 km north of Hornsund) and its forefield, at the lateral moraine of which a research base of the Geographical Institute of Wrocław University and its meteorological station are situated ($\varphi = 77°04'20''$ N, $\lambda = 15°11'30''$ E, $H = 18$ m a.s.l.) — Fig. 1. This station and the glacier were the sites of measurig global radiation, and the basic findings for different summer seasons have been reported and analysed, for example, by Kosiba (1960), Baranowski and Głowicki (1974, 1975), Pereyma (1983), Pereyma and Piasecki (1983, 1986).

The present paper offers an analysis of the radiation conditions of the above-mentioned area based on measurements performed during the geographical expedition "Spitsbergen '85", organized in the period of 17th July—18th September 1985 by the Geographical Institute of Wrocław University under the direction of Professor Dr. Hab. Alfred Jahn (for more information on the expedition and its scientific programme see Brázdil et al., 1988).

Fig. 1. Schematic map of the Werenskiold Glacier area with the scientific base of Wrocław University and localities of measuring components of active surface energy balance, and the position of the studied area on the Spitsbergen Island →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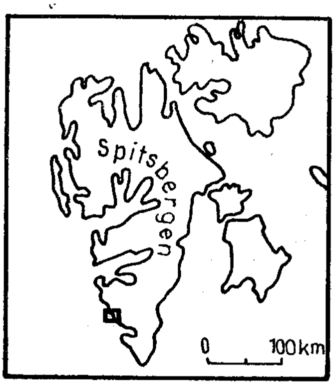
2- locality sorted circles
3- Wrocław University base
M- meteorological station


Spitsbergen
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2. CIRCULATION PATTERN AND METEOROLOGICAL CONDITIONS IN JULY—SEPTEMBER 1985 IN THE SPITSBERGEN AREA

The circulation pattern in the Southwest Spitsbergen area during the expedition can be characterized by means of a typification of synoptic situations according to Niedźwiedź (1986). Niedźwiedź has determined 20 circulation types depending on the position of pressure formations and the direction of advection in the Svalbard area delimited by 74—81° North latitude and 0—30° East longitude. The individual types are denoted by capital letters according to the direction of advection and further by index letters *a* and *c* according to the anticyclonic or cyclonic character of the situation. In the case of the 4 following types advection is absent or its direction changes:

1. C_a — central anticyclone, without advection, centre of high pressure over Spitsbergen
2. K_a — anticyclonic wedge, occasionally several not very marked centres or a diffused area of high pressure, axis of ridge
3. C_c — central low, centre of low pressure over Spitsbergen
4. B_c — trough, a not marked area of low pressure or axis of the trough with different advection directions and a front system separating different air masses.

In addition, the symbol X denotes partly situations characteristic of the baric saddle, partly those which could not be classed with the foregoing types.

The circulation conditions of July and August in 1985 observed in the area under investigation differed markedly from the average as a result of the prevailing anticyclonic circulation. In July 79.4 % of all days were classified as the anticyclonic type (the July average in 1971—1984 was 38.8 %), with a predominance of advection from the eastern and southeastern directions (anticyclone travelling from the Arctic in the direction of northeastern Europe or a ridge of high pressure from northern Europe across the Atlantic Ocean towards Greenland) and from the southwestern direction (high pressure over Scandinavia) — Fig. 2. Also, relatively rare cyclonic situations produced advection from the eastern sector (SE, E). In August anticyclonic situations were observed in 61.3 % of all days (the August average in 1971—1984 being 39.7 %). The activization of cyclones in the area of the Iceland-Cara trough manifested itself, apart from the predominating circulation of types E and SE, through an increased advection of warmer masses of the continental polar air. In September the anticyclonic situations already occurred only in 20 % of all days (the September average in 1971—1984 was 26.4 %). They were connected with a growth of the Greenland High and were characterized by an advection of the cold Arctic air from the north. In the prevailing cyclonic circulation in this month the northeastern (1/3 of all days) and the northern directions of advection, connected with an activization of the Iceland-Cara trough, were predominant. Besides that, of course, cyclones moved forward also along the Spitsbergen-Greenland trajectory, which caused an advection of warm and moist sea air from the south.

In the particular period of performing comprehensive measurements of global radiation (that is 28th July—10th September 1985) there prevailed situations with the eastern type of circulation (E_a 15.6 %, E_c 13.3 %, SE_a 11.1 %), even trough the situation K_a (20 %) occurred most frequently — Fig. 2. On the whole, situations of anticyclonic character predominated in this period of time over the cyclonic ones (53.4 : 42.2 %).

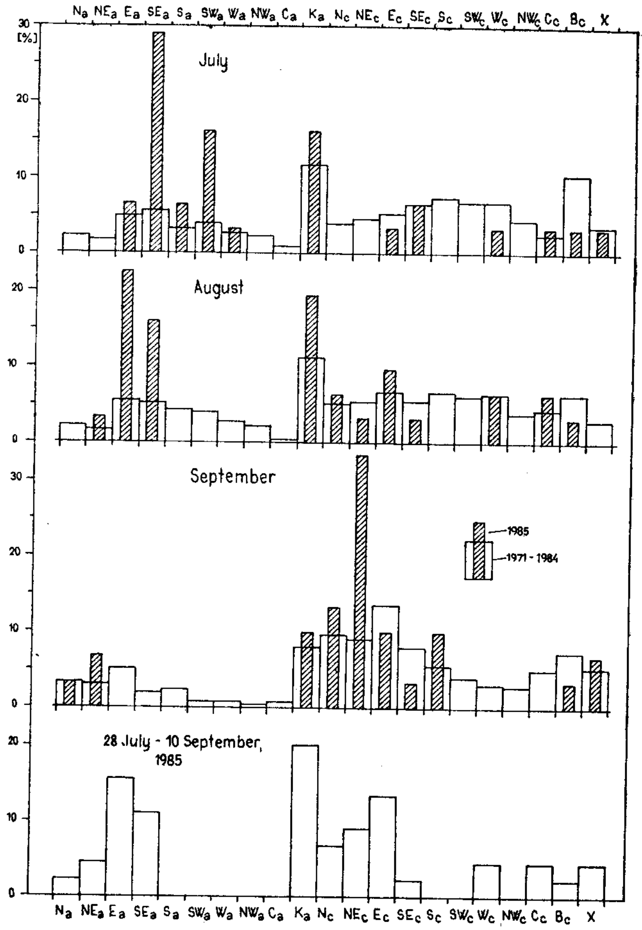

Fig. 2. Relative frequencies of occurrence of synoptic types of the Niedźwiedź classification (Niedźwiedź, 1986) for the Svalbard area in July—September 1985 and the years 1971—1984, and in the period of measurements of global and reflected radiation during the expedition (28th July—10th September 1985)

Circulation relations modified the meteorological regime of the Werenskiold Glacier area in the period of observations. During the period of measuring (21st July—10th September 1985) the mean daily temperature reached 4.7 °C with a maximum daily mean of 11.8 °C recorded on 26th July at an advection of warmer continental polar air masses from the southeast. About 58 % of days had mean daily air temperatures between 0.1 and 5.0 °C, and about 35 % between 5.1 and 10.0 °C. The relative air humidity varied from 61 to 70 %. According to the criterion of Baranowski (1968) (mean daily air temperature ≤ 2.5 °C) the thermal autumn began already on 22nd August. The total precipitation for the whole period of observations was 38.7 mm only, of which 20.4 mm went to precipitation connected with the occluded front on 9th September. Precipitation probability reached 44 %, but a half of the cases involved days with precipitation with a sum ≤ 0.1 mm, and in

83 % of days with precipitation the sums were ≤ 1.0 mm. Snowfalls appeared already on 17th August and later formed a changeable snow cover. More than a half of days under observation had a cloudiness greater than 8/10, these days concentrating on the period of 4th—18th August, the beginning of September and its 2nd pentad (see Fig. 9). The cloudiness was the very element on which the radiation conditions of the Werenskiold Glacier area closely depended (fore more see Part 4).

3. METHODS OF MEASURING AND EVALUATION OF THE MATERIAL MEASURED

The measuring of global radiation intensity was carried out at the basic meteorological station of the expedition, located on the lateral moraine of Werenskiold Glacier, by means of a Soviet thermoelectric pyranometer M-80 connected to a six-track clockdriven recording millivoltmeter with drop bar system (Fig. 3).

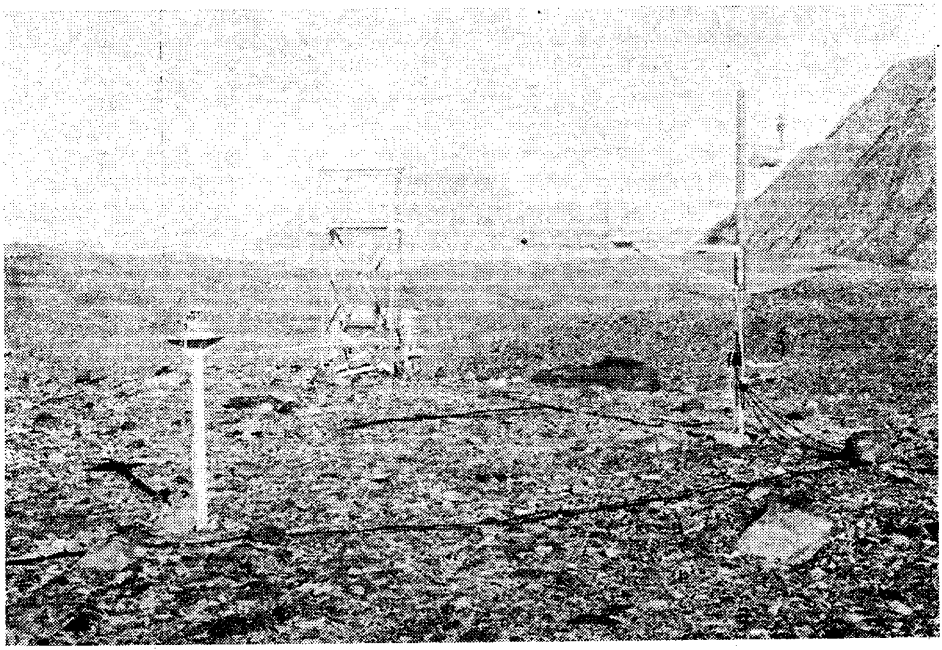

Fig. 3. View of part of the expedition's basic meteorological station on the lateral moraine of Werenskiold Glacier. In foreground, left, stand with M-80 pyranometer, right, M-80 albedometer on the long transversal arm of the stand

Apart from the locality just mentioned, measurements of reflected radiation intensity were performed also above the surface of the marine terrace (Fig. 1) formed by sorted circles, at a distance of roughly 150 m from the basic station at an altitude of 12 m a.s.l., using the same instrument, this time functioning as an albedometer, the manner of registration being the same.

Both kinds of measurement were part of a comprehensive programme of measuring the energy balance of the active surface of the moraine and sorted circles, and its thermal effect, that is, rate and depth of thawing or freezing of the surface active layer of permafrost (for more details see the work by Brázdil et al., 1988).

The evaluation of instantaneous intensities of global and reflected radiation ($W \cdot m^{-2}$) was performed on the basis of registrations of clockdriven recording millivoltmeters with drop bar system hourly (CET = GMT + 1 h), and the determination of daily total intensities of both fluxes of radiation was based on the hourly values determined from five instantaneous intensities within an hour's interval and multiplied by the length of the hour interval. These were then summed up in the period of a day and converted into $Wh \cdot m^{-2} \cdot d^{-1}$. The measuring activities proceeded incessantly from 24th July to 10th September 1985, but this study presents the results from a shorter period (28th July—10th September 1985), during which the comprehensive project of measuring all the components of the active surface energy balance was being implemented.

In view of the short distance of the two localities of measuring albedo was determined using the records of global radiation obtained from the basic meteorological station.

4. ANALYSIS OF THE RESULTS OF MEASURING

In the average daily regime of global radiation ($K\downarrow$) in the period of measuring (Fig. 4) there was a typical maximum at the time of the Sun culmination reaching

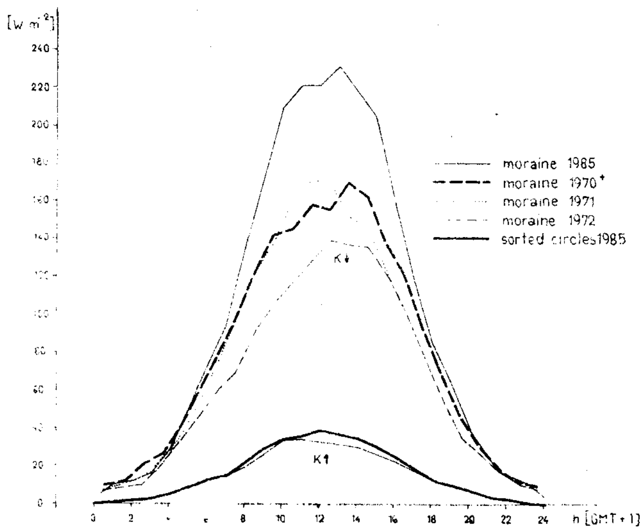

Fig. 4. Mean daily courses of intensity of global radiation ($K\downarrow$) and reflected radiation ($K\uparrow$) at the basic meteorological station of the expedition (locality moraine) and on the sorted circles over the period of 28th July—10th September 1985, compared with data on global radiation from the same part of year obtained by previous expeditions (+ data only from the period 28th July—4th September)

230.3 W.m^{-2}. Round midnight the value $K\downarrow$ decreased to inconspicuous positive values (minimum 3.44 W.m^{-2}). With regard to the more marked proportion of anticyclonic situations in 1985 as compared with the previous years (see Part 2) the mean daily hourly maximum was substantially higher in this year then in the previous ones. The mean daily courses in the individual decades (Fig. 5) are understandably less levelled and their maxima are conditioned partly by a decrease in radiation intensity associated with the diminishing height of the Sun over the horizon (cf.

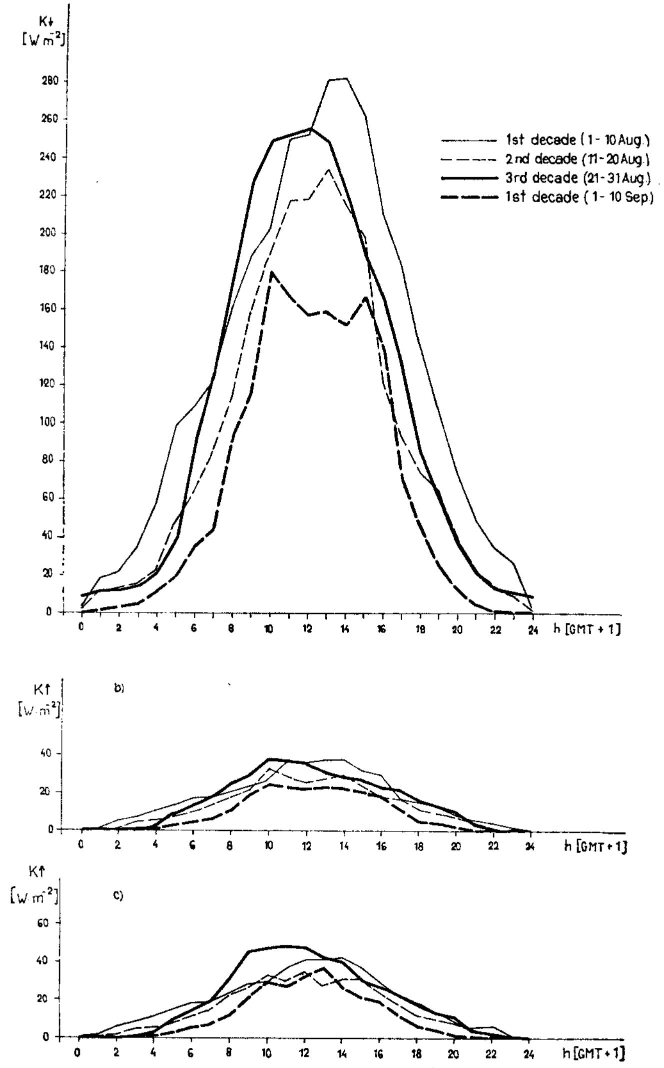

Fig. 5. Mean daily courses in decades (a) of global radiation ($K\downarrow$) and reflected radiation ($K\uparrow$) on moraine (b) and sorted circles (c) in August and September 1985

the decreasing maxima of $K\downarrow$ from the 1st to the 2nd decade of August and the 1st decade of September), partly by the cloudiness whose increased value in the 2nd decade of August (Tab. 2) compared with the 3rd decade of this month conditioned a higher level of the mean $K\downarrow$ maximum in the 3rd decade.

Tab. 2. Mean 3-hourly and mean daily cloudiness in decades and in the whole period of measuring 28th July—10th September 1985

Period	Time of measurement (GMT + 1h)								Mean
	01	04	07	10	13	16	19	22	
1—10 August	7.8	7.2	7.4	7.1	7.1	7.2	7.3	7.5	7.3
11—20 August	8.7	7.5	8.0	7.6	7.7	8.1	8.7	8.4	8.1
21—31 August	6.3	7.2	7.4	7.2	7.4	7.9	6.7	7.0	7.1
1—10 September	8.7	8.6	8.6	7.9	8.2	9.0	8.7	9.1	8.6
28 July—10 September	7.9	7.6	7.6	7.3	7.5	8.0	7.9	8.0	7.7

The characteristic pattern of the vertex of the curve of the mean daily course of $K\downarrow$ in the 1st decade of September is apparently due to an increased formation of convective clouds in the noontime hours associated with an increasing lability

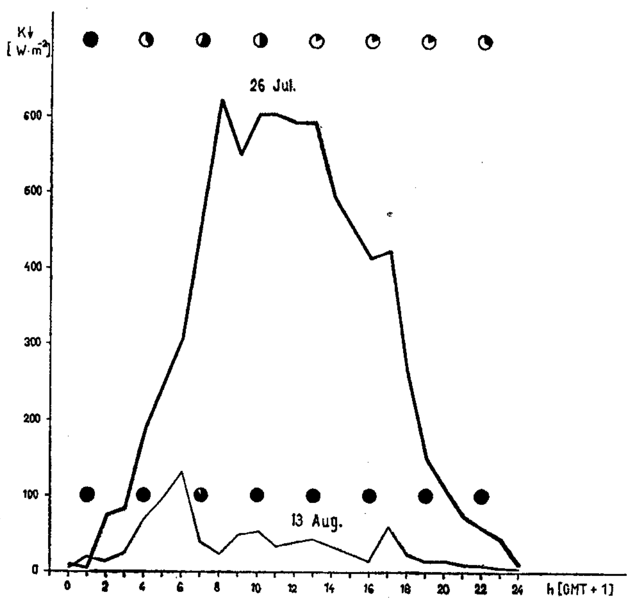

Fig. 6. Daily course of global radiation intensity ($K\downarrow$) on 26th July 1985 (type SE_a — typical radiation weather, mean daily cloudiness 4.3/10, highest daily sum of $K\downarrow$ over the period of measuring) and on 13th August 1985 (type SE_c — typical advection weather, mean daily cloudiness 9.9/10). Sectors of circle mark 3-hourly cloudiness on the given day

of the air advected from the ice-covered ocean of higher latitudes above the free water surface during the predominanting circulation from the northern or northeastern component (in 3rd—8th September the prevailing direction of advection was N-NE).

The minimum decade mean values of $K\downarrow$ differ only slightly, partly practically dropping under the sensitivity threshold of the apparatus used in the 3rd decade of August and the 1st decade of September (after the period of polar day the astronomical sunset begins for the given latitude on 26th August).

Fig. 6 illustrates the marked influences of radiation and advection factors on the daily variations of $K\downarrow$.

The mean daily course of reflected radiation ($K\uparrow$) for the whole period of measuring (Fig. 4) is somewhat more marked on the sorted circles than on the moraine (the difference of the daily maximum of $K\uparrow$ is 5.56 W . m^{-2} in favour of the sorted circles), but these differences get blurred in morning and evening hours. A similar conclusion follows also from the mean daily courses of $K\uparrow$ in the individual decades. The increased reflexivity of the sorted circles surface is conditioned by a brighter colouring of the active surface partly due to the dry moss cover, as compared with the darker material of the moraine, which is subsequently manifest in different values of radiation balance of the two localities (see Brázdil et al., 1988).

In our analysis further attention was given to the daily sums of global radiation (henceforth only $\Sigma K\downarrow$) and reflected radiation (henceforth $\Sigma K\uparrow$).

Temporal changes of $\Sigma K\downarrow$ are illustrated by Fig. 7 which also presents the variation of daily sums of the extraterrestrial insolation in the given period (ΣK_e), which served, together with the $K\downarrow$ values, for the determination of the transmissivity of the atmosphere (P).

The ΣK_e values were established by way of calculating the hourly K_e values for the day in question using the formula

$$K_e = K_s \left(\frac{r_m}{r} \right) \cos z,$$

where K_s = the solar constant ($K_s = 1\,367$ W . m^{-2}), r_m/r = the ratio of mean and instantaneous distance of the Earth from the Sun for the given date, and z = the zenith distance of the Sun for the given day and hour. The r_m/r values were taken over from the Astronomicheskiy yezhegodnik SSSR na 1985 god (1982) (Astronomical Yearbook of the USSR for 1985) and the parameters necessary, apart from the latitude φ ($\varphi = 77°04'20''$ N), for the calculation of cos z, i.e. declination and hour angle, were borrowed from the Hvězdářská ročenka 1985 (1984) (Astronomical Yearbook 1985). The values of K_e thus determined were converted into hourly sums (Wh . m^{-2}. h^{-1}), their summation giving the daily sum of ΣK_e.

As can be seen from Fig. 7, the $\Sigma K\downarrow$ values follow the trend of variation of ΣK_e only very approximately because of the changeability of the absorption potentialities of the atmosphere, and their temporal changes are evidently influenced in a greater measure by the character of the advected air masses, whose absorption and dispersion properties are affected mainly by the formation of clouds and their amount. The conditions of condensation are frequently influenced by the transfer of air over the glaciated mountain ranges of the archipelago, conditioning meso-spatial and local modifications of circulation (for example, giving rise to the foehn, anabatic or catabatic winds, etc.).

Tab. 3. Pentad sums of global radiation (Wh . m^{-2}) in summer seasons of 1985 and of 1970, 1971, 1972, 1973 and 1983 (after Baranowski and Głowicki, 1974, 1975; Pereyma and Piasecki, 1983, 1986; Pereyma and Lucerska, 1987)

Month, pentad		1970	1971	1972	1973	1983	1985
July	5	20,121.1	11,426.5	13,175.0	13,897.2	—	—
	6	18,438.2	14,188.6	12,325.0	15,088.9	—	27,765.7
August	1	8,496.9	7,329.2	16,863.9	18,191.7	—	25,636.8
	2	13,136.1	11,635.8	9,105.6	12,605.6	11,963.9	8,859.4
	3	9,261.0	13,966.5	7,097.2	14,300.0	10,083.3	6,512.1
	4	6,240.7	8,088.7	6,425.0	17,578.3	11,836.1	15,371.5
	5	10,104.1	7,428.1	7,411.1	16,380.6	10,005.6	12,829.3
	6	8,658.5	11,780.0	6,247.2	12,644.4	10,261.1	18,678.1
September	1	6,262.8	8,701.6	4,886.1	8,461.1	6,750.0	9,564.6
	2	—	4,942.8	4,791.7	7,194.4	4,641.7	7,717.4

Tab. 3 has been designed for the purpose of comparing the sums of the global radiation in the period of 1985 under analysis with the previous summer seasons. It shows that, in comparison with the previous summer seasons, considerably high sums of global radiation occurred in the summer of 1985, especially at the turn of July and August. Higher pentad sums occurred also in late August and the first third of September. The maximum daily sum of global radiation was recorded on 26th July (7421.3 Wh.m^{-2}.d^{-1}) still before the comprehensive measuring operations were started, at the time of polar continental air advection (circulation of type SE_a), accompanied with the rise of the foehn from the free atmosphere. The days with radiation weather, on which the highest daily sums of global radiation (over 4 000 Wh.m^{-2}.d^{-1}) occurred, were associated with the circulation types SE_a and E_a (advection of polar continental air — 1st—3rd August and 26th August) and the situation K_a (for characteristics see Part 2 — 29th and 31st July, 20th and 22nd August). In one case only (19th August) was the increased daily sum of global radiation linked with advection from the north (situation N_c).

Except the days 29th and 31st July the given high daily sums of $K\downarrow$ were conditioned by a minimal cloudiness (Fig. 9). On 29th and 31st July they occurred despite an increased cloudiness, the skies, however, occurring only in a layer of little thickness.

Although the situations just discussed exhibit generally the highest $\Sigma K\downarrow$ values, there may occur even cases, during a great cloudiness (depending on the character of air masses being advected), of the $\Sigma K\downarrow$ records ranking among the lowest. As an example we can take the situation SE_a, in which a daily sum of merely 855.3 Wh.m^{-2}. d^{-1} occurred (11th August) next to an extremely high $\Sigma K\downarrow$ values.

The great changeability of $\Sigma K\downarrow$ values, of course, is reflected also in the variance of the values of transmissivity P (Fig. 7, bottom). The mean transmissivity value for the period of measuring was 36.1 %. Pereyma (1983) reports, for the station of Isfjord Radio, P values for the summer season ranging round 50 %. This difference in transmissivity is apparently conditioned by an increased formation of clouds in the southern part of the Spitsbergen Island, affected also, among others, by the warm current of the North Atlantic Drift washing the southwest coast of the island. For the sake of comparison we present the data on cloudiness from the Isfjord Radio station just mentioned ($\varphi = 78°04'$ N, $\lambda = 13°38'$ E, $H = 5$ m a.s.l.)

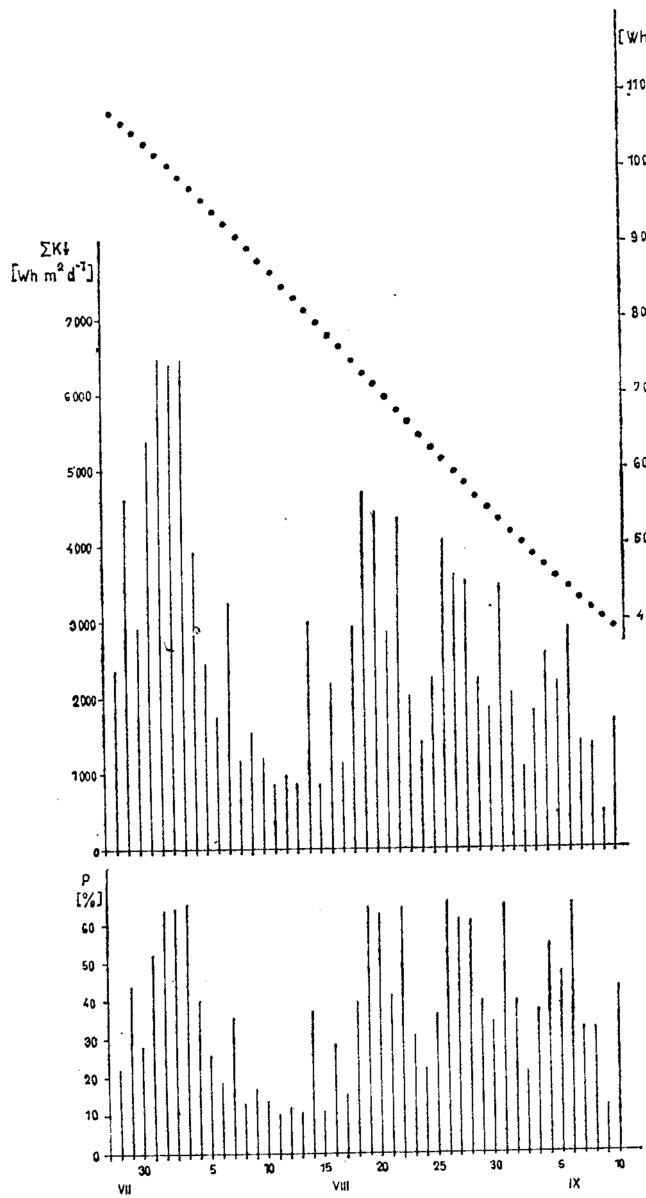

Fig. 7. Daily sums of intensity of extraterrestrial radiation (ΣK_e), global radiation ($\Sigma K\downarrow$) and atmospheric transmissivity (P) in the period of 28th July—10th September 1985 on the moraine

and from the PAS station in Hornsund, about 12 km away from the base of Wrocław University (Tab. 4).

The aim of Tab. 5 is to clarify the influence of the character of circulation and the associated cloudiness on the P values. It shows that the highest values of trans-

Tab. 4. Mean monthly cloudiness (in tenths of sky cover) at the Isfjord Radio station (1951—1975) and at the PAS base in Hornsund (1978—1983) (after Steffensen, 1982; Rodzik and Stepko, 1985)

Station	Month												Mean
	January	February	March	April	May	June	July	August	September	October	November	December	
Isfjord Radio	4.9	5.3	5.2	4.6	5.5	6.2	6.5	6.4	6.3	6.0	5.4	5.0	5.6
Hornsund	6.0	7.2	6.2	6.8	7.2	8.1	7.6	8.6	7.8	7.5	6.6	5.6	7.1

Tab. 5. Daily sums of atmospheric transmissivity P (%) and mean daily cloudiness C (in tenths of sky cover) according to synoptic types after the typification by Niedźwiedź (1986) on the moraine and sorted circles in the period of 28th July—10th September 1985

K_a			E_a			E_c		
Date	P	C	Date	P	C	Date	P	C
29 July	43.6	8.5	3 August	65.3	1.1	28 July	21.8	9.9
30 July	27.9	9.8	4 August	40.0	8.8	5 August	25.6	9.8
31 July	52.2	7.5	24 August	21.7	9.4	29 August	39.3	7.6
8 August	12.8	10.0	25 August	35.6	9.1	30 August	34.0	9.8
9 August	17.1	10.0	26 August	66.1	4.6	2 September	20.6	9.9
10 August	13.6	9.9	27 August	60.5	4.2	9 September	11.5	10.0
20 August	62.3	3.6	31 August	64.9	3.9			
22 August	64.2	1.8						
23 August	30.2	8.4						
Mean	36.0	7.7		50.6	5.9		25.5	5.9

NE_a			NE_c			SE_a		
Date	P	C	Date	P	C	Date	P	C
7 August	35.1	9.5	6 August	18.4	10.0	1 August	63.4	2.8
8 September	32.0	9.8	3 September	36.7	9.1	2 August	63.9	1.5
			5 September	47.5	7.2	11 August	9.9	10.0
			6 September	65.1	6.2	12 August	11.3	9.2
						28 August	60.4	4.2
Mean	33.6	9.6		41.9	8.1		41.8	5.5

SE_c			N_a			N_c		
Date	P	C	Date	P	C	Date	P	C
13 August	10.2	9.9	7 September	31.9	9.1	18 August 19 August 4 September	39.2 64.6 54.0	8.4 2.0 6.6
Mean	10.2	9.9		31.9	9.1		52.6	5.7

C_c			W_c			B_c		
Date	P	C	Date	P	C	Date	P	C
14 August 15 August	37.1 10.6	8.1 10.0	16 August 21 August	28.0 41.0	9.6 8.4	17 August	14.8	10.0
Mean	23.9	9.0		34.5	9.0		14.8	10.0

X		
Date	P	C
1 September 10 September	39.2 42.8	9.8 8.2
Mean	41.0	9.0

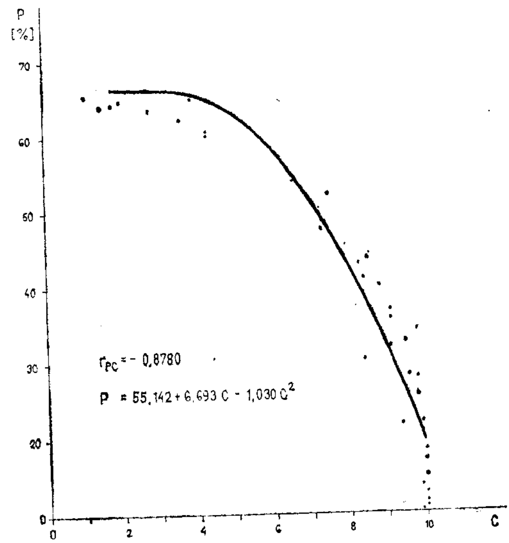

Fig. 8. Dependence of atmospheric transmissivity P on cloudiness C (in tenths of sky cover) on the moraine in the period of 28th July—10th September 1985

missivity occur in situations N_c, E_a, SE_a, NE_c, K_a, W_c, NE_a and in situations X, with a relatively small cloudiness being typical expecially of the first three of them. However, the results presented in this table are to be evaluated with some caution in view of the small frequency of occurrence.

With regard to certain links of the P values with the values of mean daily cloudiness we have attempted to solve the relationship of correlation and regression for the two variables (Fig. 8). The second-degree polynomial proved to be the most convenient for this dependence. The correlation field in Fig. 8 and the corresponding curve are evidence of the growth of absorption with the increasing C whose inten-

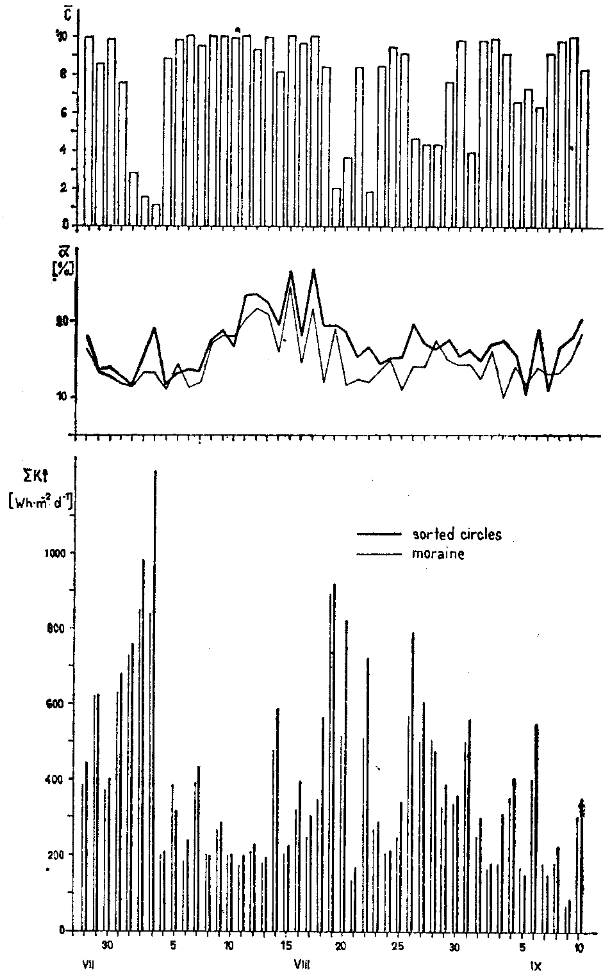

Fig. 9. Daily sums of reflected radiation $\Sigma K\uparrow$ and mean daily albedo $\bar{\alpha}$ on the moraine and sorted circles, supplemented by mean daily cloudiness C (in tenths of sky cover) determined from 3-hourly obervation times 01, 04, 07, 10, 13, 16, 19 and 22 h (GMT + 1h) from the period of 28th July—10th September 1985

sity increases nonlinearly with the values of cloudiness. The greater variance of points of the correlation field at high C values (9—10/10) demonstrates different absorptive abilities of different types of clouds and manifests other factors, such as their different thickness, water content, or further properties affecting the absorption of radiation in the case of overcast skies. It is only natural that this variance diminishes with the C decreasing.

The radiation reflected by the surface is conditioned, besides the character of the active surface, chiefly by the of global radiation. By the way, this follows also from the comparison of daily sums of $\Sigma K\downarrow$ (Fig. 7) with the daily sums of reflected radiation $\Sigma K\uparrow$ given in Fig. 9, which, like Fig. 5, illustrates the increased reflectivity of the sorted circles surface compared with the moraine, which is further seen also in the differences in the active surface radiation balance of the two localities as presented in the work by Brázdil et al. (1988).

The mean and extreme values of $\Sigma K\uparrow$ and albedo $\bar{\alpha}$ of both localities of measuring are given in Tab. 6.

Tab. 6. Mean and extreme values of daily sums of reflected radiation $\Sigma K\uparrow$ ($Wh.m^{-2}$) and mean daily albedo $\bar{\alpha}$ (%) on the moraine and sorted circles in the period of 28th July—10th September 1985

Locality	Mean		Maximum		Minimum	
	$\Sigma K\uparrow$	$\bar{\alpha}$	$\Sigma K\uparrow$	$\bar{\alpha}$	$\Sigma K\uparrow$	$\bar{\alpha}$
moraine	357.5	14.7	890.8	24.6	68.9	9.9
sorted circles	420.1	16.9	1,216.7	26.7	81.1	10.3

The dependence of $\Sigma K\uparrow$ values on $\Sigma K\downarrow$ was evaluated for both localities, again by means of the calculus of correlation and regression (Fig. 10). The relationship between $\Sigma K\uparrow$ and $\Sigma K\downarrow$ proved to be somewhat closer on the moraine than on the sorted circles, which was apparently connected with a lesser variability of shades of colour of the moist and dry surface of the moraine as compared with the sorted circle. Also, both correlation coefficients in Fig. 10 are statistically significant at the level of significance $p = 0.05$ (at the critical value $r = 0.2875$). Practically, the linear dependence of $\Sigma K\uparrow$ on $\Sigma K\downarrow$ (see the regression lines and their equations in Fig. 10) shows the growth of the intensity of reflected radiation to be more marked on the sorted circle than on the moraine.

On the basis of the above facts, the trend of variation of $\Sigma K\uparrow$ daily sums in both localities must influence also the temporal changes of the mean daily albedo $\bar{\alpha}$, which are graphically represented in Fig. 9 and corroborate the facts described earlier. Unlike $\Sigma K\uparrow$, however, $\bar{\alpha}$ is not closely related to cloudiness whose daily means are also given in Fig. 9. The loose relationship of $\bar{\alpha}$ values to cloudiness is easily understood if we consider the fact that in the case of overcast skies we have only rough characteristics of the absorptive and dispersive potentialities of the atmosphere for solar radiation, which depend, besides the degree of cloud cover, on a number of further factors, for example, the type, variety and form of clouds and their distribution at particular heights, thickness, zenith distance of the Sun, etc. Also, the value of albedo is in some degree influenced by the proportion of diffused and direct radiation in global radiation (at the same intensity of global radiation the albedo value increases with the growing proportion of diffused radiation — Munn, 1966).

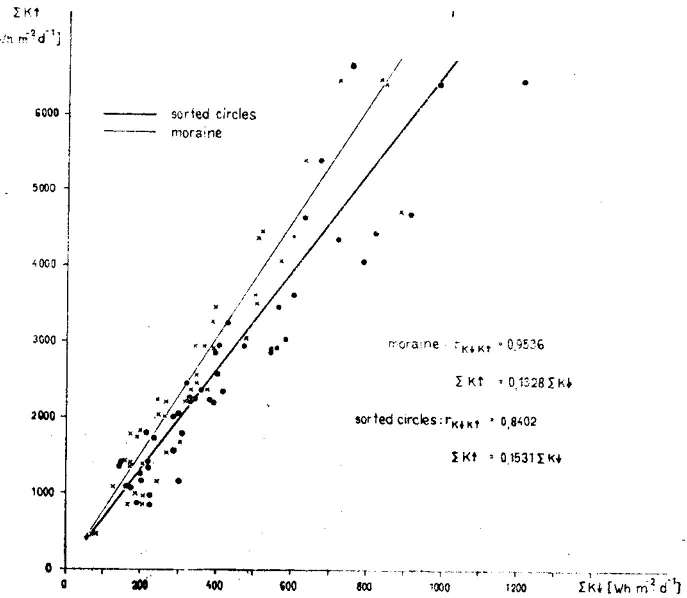

Fig. 10. Dependence of daily sums of reflected radiation intensity $\Sigma K\uparrow$ on daily sums of global radiation $\Sigma K\downarrow$ on the moraine and sorted circles in the period of 28th July—10th September 1985

5. CONCLUSION

The measuring of radiation at the meteorological station of Wrocław University carried out during the expedition in 1985 was motivated by aims somewhat different from earlier activities of that kind (in this case they served for a study of active surface energy balance and its effects on the development of the surface active layer of permafrost), yet the results themselves represent a continuation of measurements conducted by previous expeditions. In contrast to them, however, more attention was paid by this expedition to the reflective properties of the two different kinds of active surface, characteristic of the wider environs of the base of Wrocław University, and to the transmissivity of the atmosphere, whose evaluation made it possible, for the period of operations of the "Spitsbergen '85" expedition, to quantify at least some of the relations between atmospheric transmissivity and cloudiness, global radiation received by the active surface and reflected from it, and to estimate the influence of circulation weather types on the ability of the atmosphere to transmit solar radiation.

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