ENERGY BALANCE OF THE TUNDRA AT THE SPITSBERGEN ISLAND (SVALBARD) IN THE SUMMER SEASONS OF 1988 AND 1990

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SUMMARY

Measurements of the components of the energetic balance of the tundra at the slope position at Barentsburg and at the bottom of the Reindalen valley on the Isle of Spitsbergen (Svalbard) are compared in the course of warm and dry summers of 1988 and 1990. Peculiarities of the variations of the individual components are described in the average for the whole common period from 8 July to 9 Aug., and for the days with prevailing radiation and advection regimes of weather. The locality of Barentsburg exhibits - in comparison with Reindalen - higher values of the radiation balance and more than four times higher energy losses by means of evaporation in comparison with the turbulent heat flow. At Reindalen the shares of the two components are balanced. The differences can be explained by a higher water content in the tundra substrate at Barentsburg and more intense aeration of the station at Reindalen. The obtained results correlate with analogous measurements from the region of Werenskiold Glacier in 1985.

KEY WORDS

energy balance - active surface - Spitsbergen - tundra

INTRODUCTION

During the summer seasons of 1988 and 1990 a part of the expeditions of the Department of Geography, Faculty of Science, Masaryk University was, besides others, also the measurement of the energy balance of the active surface carried out on the glacier East Grönfjord and in the tundra near the settlement of Barentsburg (1988), and/or in the tundra in the upper part of Reindalen Valley (1990). By the above activities this research programme linked up with similar measurements carried out in 1985 on the surface of a moraine and the tundra (sorted circles) in the region of the glacier Werenskiold (Fig. 1).

Whereas the results of the foregoing energy measurements were either completely (for the year 1985 see Brázdil et al., 1988a,b, 1989) or partly (for the year 1988 see Brázdil et al., 1992) published, the present paper presents hitherto unpublished results of the analysis of the measurements of the energy balance of the tundra at Barentsburg (the year 1988) and at Reindalen (the year 1990). The fundamental processing of the respective data sets from the above two localities were carried out by Smrčková (1993).

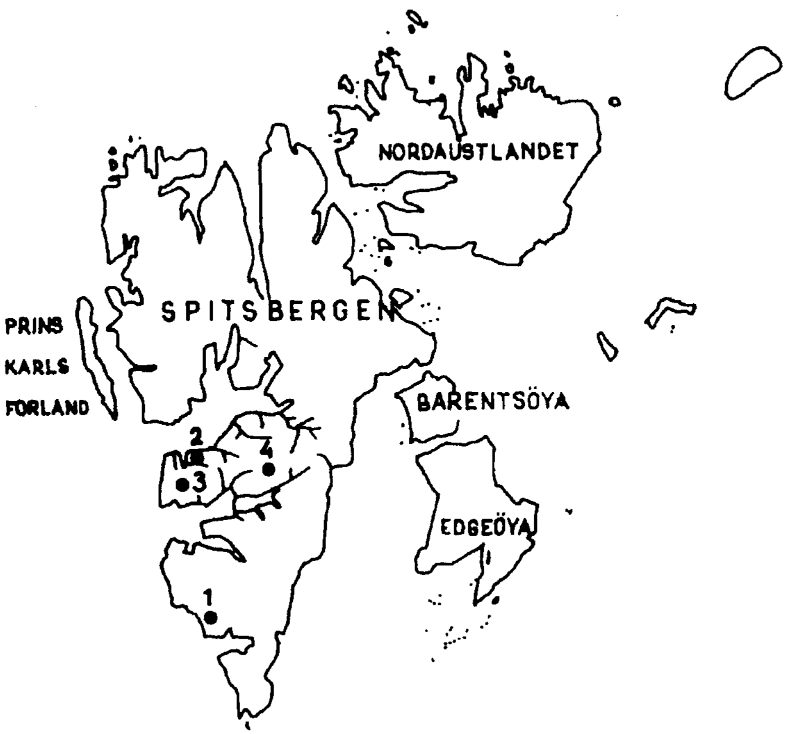

Fig. 1. A schematic map of Svalbard with marked localities of measurements of energy balance components of the active surface in 1985, 1988 and 1990 (1 - Werenskiold Glacier, 2 - Barentsburg, 3 - Eastern Grönfjord Glacier, 4 - Reindalen)

MEASUREMENTS OF THE COMPONENTS OF THE ENERGY BALANCE

The measurements of the components of the energy balance of active surface in the region of Barentsburg took place in the period of 20 June - 21 Aug., 1988, north-east of the settlement in the lower part of the slope of Mt. Grönfjordfjellet (522 m) (Fig. 2) at the elevation of 143 m on the surface of the tundra, consisting for the most part of mosses, with a sporadic representation of higher plants, mainly grasses. Under the vegetation there was a layer of raw humus, only 5-10 cm thick, passing into stony material of the slope debris which was filled with a finer grained admixture and strongly soaked and from the depth of 30-35 cm completely saturated with melt water running off under the surface.

The station for the energy measurements at Reindalen (Fig. 3) was situated in the lower part of the southern valley slope about 300 m east of a conspicuous mound of the terminal moraine of the glacier Martha at the height of 140 m above sea level. The active surface there consisted of a more or less stabilized sorted soil with tundra stand which prevailed in the area with the exception of the centres of soil polygons. That passed into a thin layer of raw humus (maximum 5 cm). Its substrate consisted of a layer of the active melting of permafrost, constituted mostly by solifluction stony

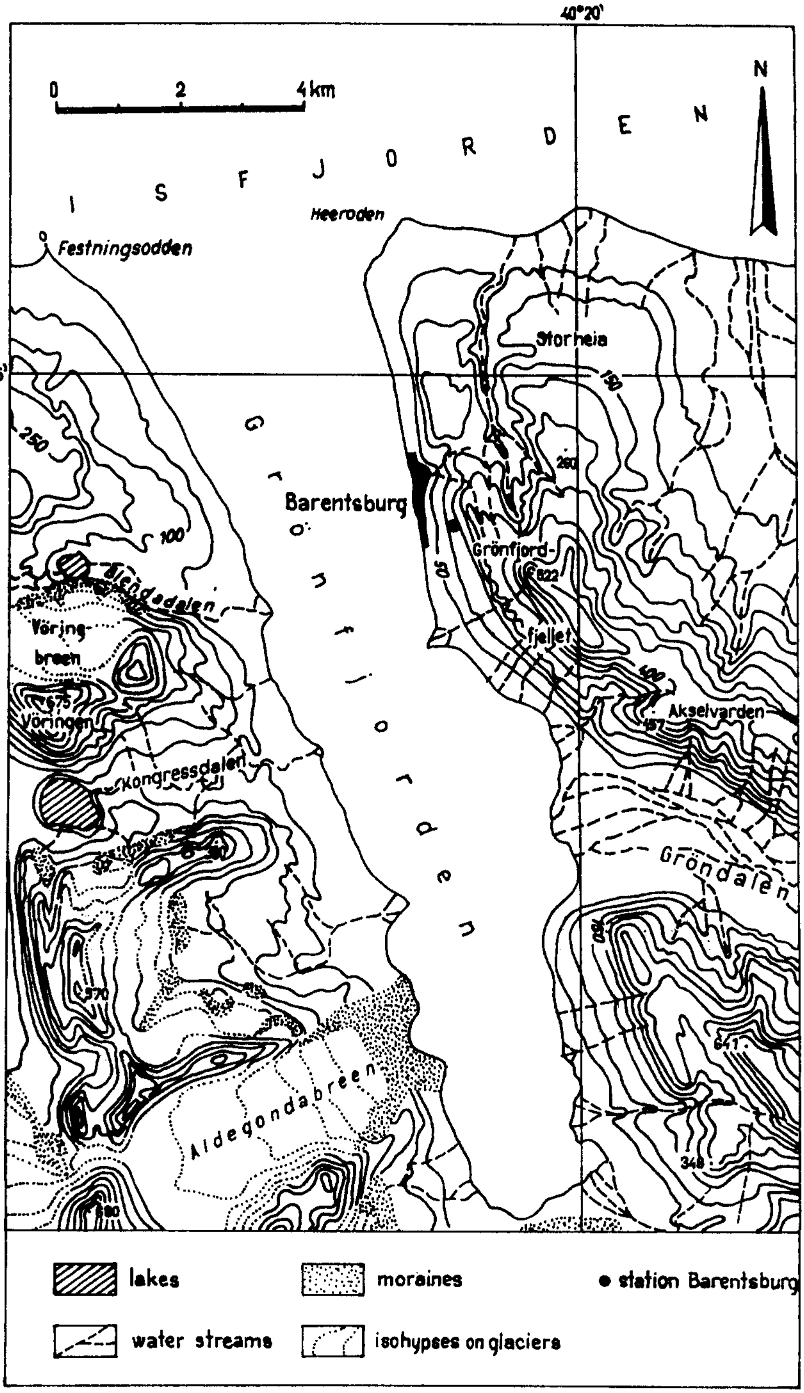

Fig. 2. Map of the area of Grönfjord with the marked position of the settlement of Barentsburg and the station for energy measurements

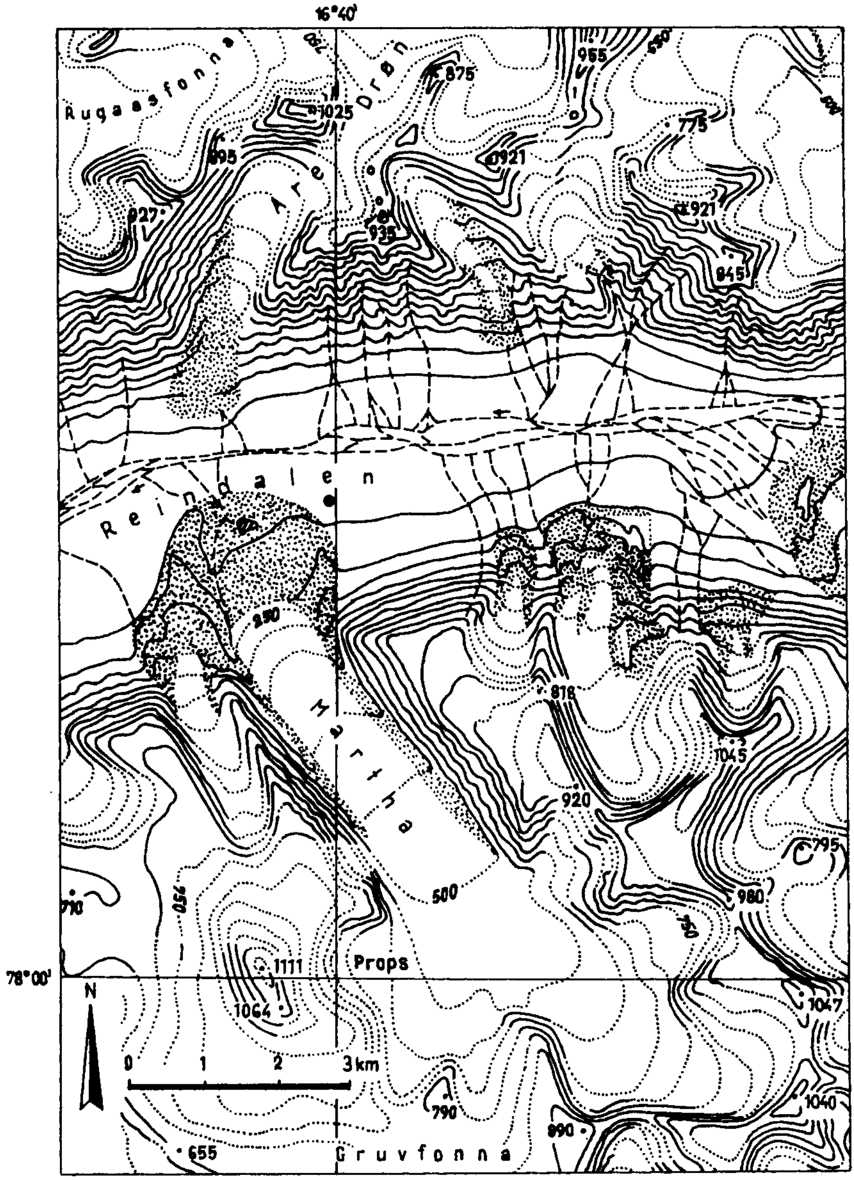

Fig. 3. Map of the area of the upper part of Reindalen Valley with the marked position of the station for energy measurements

stony material with finer grained filling, polygonally sorted. Measurements there were carried out from 8 July to 9 Aug., 1990.

The instrumental equipment of the two stations was identical (Table 1) and it was completed by the profile measurement of soil temperature down to the depth of 50 cm (Barentsburg) or 65

Measured balance component and/or parameter	Instrument	Position	Registration record
radiation balance	net radiometer Schenk	tripod height 1.5 m	clock-driven recording millivoltmeter Kipp & Zonen XR-4
air temperature	platinum resistance thermometer PT-100	tripod, height 0.5 and 2.0 m	clock-driven recording millivoltmeter 28/SK 120/6 (VEB Messgerätewerk E. Weinert Magdeburg)
wind speed	3-cup electrical anemometer with Robinson cross (VEB Anemometer-bau Dresden)	tripod, height 0.5 and 2.0 m	data-logger Vilog 2 (Vert-electronic Brno)
soil heat flux to (from) active surface	soil heat flux plates Alfametr type 112 (VDI Druteva Brno)	below active surface at depth of 0.01 m	clock-driven recording millivoltmeter Kipp & Zonen XR-4
active surface substrate temperature	glass soil thermometers and platinum resistance thermometers PT-100	at different depths	glass thermometers - normal reading, resistance thermometers- clock-driven recording millivoltmeter 28/SK 120/6 (VEB Messgerätewerk E.Weinert, Magdeburg)

Table 1. Instruments used for the measurement and recording of the radiation balance, of the soil heat flux and/or for measuring the input parameters necessary for the determination of the turbulent heat flux

(Reindalen). As follows from Table 1, the values of the radiation balance (R) and the soil heat flux into or out of the substrate of the active surface (G) were measured directly and further processed from the records of the clock-driven recording millivoltmeters. The turbulent heat flux (H) was determined by means of the profile measurement of air temperature and wind speed by the adapted method of turbulent diffusion (see Team of authors, 1977). The values of the latent energy flux (LE) were determined by the difference from the basic equation of the energy balance (LE = R - H - G).

ANALYSIS OF ENERGY BALANCE COMPONENTS

The summers of 1988 and 1990 at Svalbard were characterized, as against average ones, by a warmer weather. In 1988 all summer months at Barentsburg exhibited positive temperature anomalies (June 0.3 °C, July 0.8 °C, August 0.9 °C, summer 0.7 °C - reference period 1963-1987). Extraordinarily rich in precipitation was July (235 % of normal), whereas the remaining two months were substantially drier (51 % and 83 % of the normal, respectively, for the whole summer 110 % of the normal). From the circulation point of view cyclonal types of weather prevailed in June (73.3 % of all days), otherwise, however, anticyclonal types were more frequent (July 51.6 %, August 74.2 %, summer 51.5 %) (Brázdil et al., 1992). A document of the dry, warm summer of 1990 are measurements of Svea Gruber (the nearest meteorological station to the measuring post at Reindalen), where, in comparison with the reference period of 1980-1989 the summer was 0.8 °C above the normal (June 0.3 °C, July 1.5 °C, August 0.7 °C) and the summer precipitation reached only 47 % of the normal. All summer months were characterized by a marked prevalence of anticyclonal circulation types (June 76.6 %, July 58.0 %, August 67.8 %, summer 67.6 %) (Brázdil, Prošek, 1993).

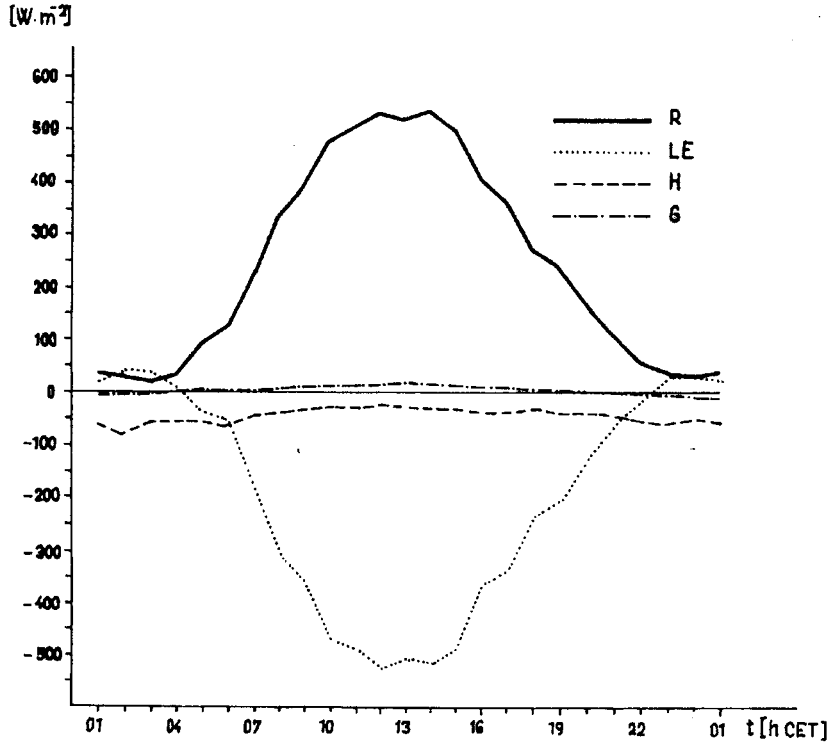

Fig. 4. Mean daily variation of the components of the energy balance of the active surface of the tundra (R, H, LE and G) in the period of 8 July - 9 Aug., 1988 at the station of Barentsburg

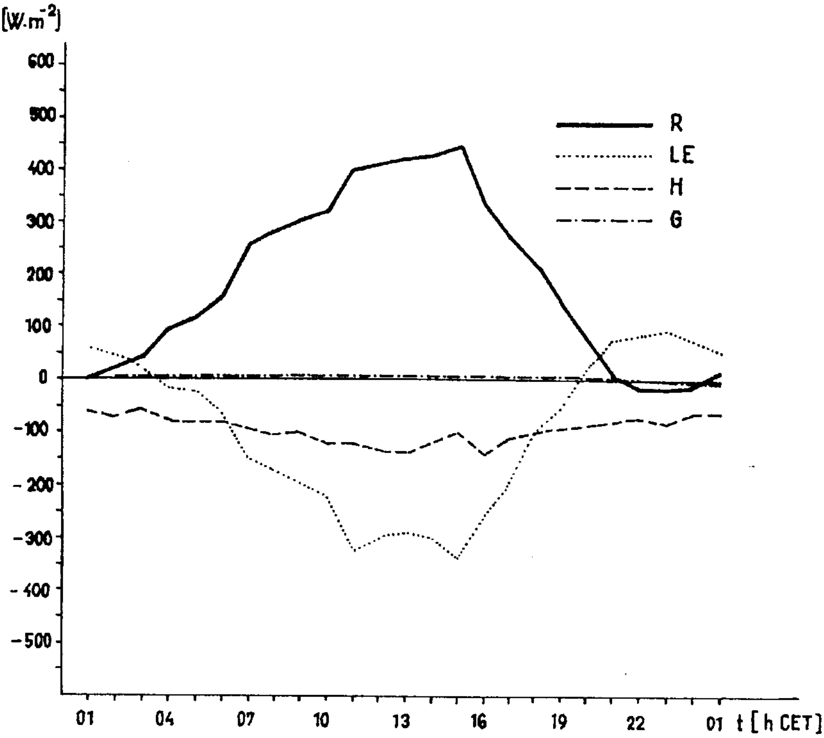

Fig. 5. Text see Fig. 4 - at the station of Reindalen

Station	01	04	07	10	13	16	19	22
Barentsburg (T)	7.0	6.8	6.8	7.2	7.7	8.0	7.9	7.0
Reindalen - a (T)	5.8	5.8	7.0	9.2	10.2	9.5	8.4	6.6
Reindalen - b (T)	4.9	5.0	5.7	6.8	7.4	7.1	6.6	5.6
Barentsburg (e)	9.3	9.2	9.7	9.8	10.0	9.9	9.8	9.6
Reindalen (e)	7.6	7.7	7.6	7.6	7.5	7.6	7.6	7.6

Table 2. Mean soil temperatures (T[°C]) at the depth of 1 cm and the mean water vapour pressure (e[hPa]) in the meteorological screen in synoptical terms of measurements [h CET] at the stations of Barentsburg and Reindalen (a - centre of the sorted circle without vegetation; b - periphery of the circle with a moss cover) in the period of 8 July to 9 Aug.

Despite certain differences in the circulation, temperature and precipitation characters of the summer seasons of 1988 and 1990, the results of the measurements of the energy balance of the active surface, under the justified assumption of conspicuous influences of different character of the active surface on the balance components at the two localities can be compared to each other. The time regime of the components of the energy balance was evaluated on the one hand from the point of view of their mean daily variation, on the other hand with respect to the time regime of their daily sums and sums for the whole period of measurements. With respect to the length of measurements at Reindalen the components of the energy balance were mostly processed for the longest common calendar interval in the two years, i.e. 8 July to 9 Aug.

The mean daily regime R is represented at the two stations (Figs. 4, 5) by a simple wave with peaks at 12 and 14 hrs CET at the station of Barentsburg (530 $W.m^{-2}$) and at 15 hrs CET at the station of Reindalen (440 $W.m^{-2}$). The reason of the above differences can be, with respect to a more anticyclonal character of the weather in the summer of 1990 as compared to the summer of 1988, with the greatest probability better reflexive properties of the active surface at Reindalen (partly bared soil polygons).

A low level of the mean daily minima R (Barentsburg 40 $W.m^{-2}$, Reindalen -20 $W.m^{-2}$) is the consequence of the absence of direct solar radiation during the night hours due to the overtopping of the horizon of the two stations in the northern quadrant (Figs. 2, 3). Differences in the level of the mean minima R are thus with greatest probability conditioned by the different intensity of long-wave radiation of the active surface at night, affected in the first place by the temperature of the soil surface and/or by the differences in the effective radiation of the active surface whose cause can, besides, be a lower content of water vapour in the atmosphere of the inland of the Isle of Spitsbergen (Reindalen) (Table 2).

Also in the case of the energy loss flux H of which a very inconspicuous daily variation is characteristic in both cases (Figs. 4, 5) there exist conspicuous differences between the stations of Barentsburg and Reindalen. Whereas at the former one in the daily period it varies between -80 to -20 $W.m^{-2}$ (the mean minimum is -81.3 $W.m^{-2}$), at the latter the mean daily change is delimited by the values of -140 and -55 $W.m^{-2}$. Heat losses via the dry turbulent way are thus significantly greater at the station of Reindalen than at Barentsburg. This is also confirmed by vertical differences in air temperature and wind speed. The mean differences in temperature between the levels of 0.5 and 2.0 m are thus at Reindalen 0.6 °C (extremes -0.5 and 1.9 °C), at Barentsburg 0.4 °C (extremes -0.7 and 1.5 °C). These values correspond to mean wind speed differences of -0.73 $m.s^{-1}$ (extremes 1.2 and -2.6 $m.s^{-1}$) and -0.32 $m.s^{-1}$, respectively (extremes 0.7 and -1.3 $m.s^{-1}$). Increased energy losses by way of H are linked up with a better aeration of the widely open valley of Reindalen on the one hand and with the position of the western slope of Grönfjordfjellet shaded towards the streaming with the north-east component on the other hand (see the position of the station of Barentsburg - Fig. 2). A certain role here is that of a lower moisture content of the substrate at Reindalen as compared with Barentsburg, which is reflected by the increase in dry, turbulence conditioned heat losses.

Marked differences can also be stated in then heat transfer connected with the changes in the state of water (LE). The mean LE minima in both cases exceed the minima of H, reaching the values of -525 and -340 $W.m^{-2}$, respectively. Also in the case of this mechanism of heat transfer, a significant effect on the level and extremity of its mean daily variation is that of the increased content of moisture in the substrate, and thus the increased evaporation at the station of Barentsburg in comparison with Reindalen. A certain role at Barentsburg is evidently that of the conspicuous slope inclination in the neighbourhood of the station (on the average 15.5°) and its western orientation conditioning an increase in solar radiation activity on its surface in the afternoon hours.

Only in the short interval of night hours (at Barentsburg between 22-04 hrs CET, at Reindalen between 19.30-03 hrs CET) the LE has the positive sign. Since the energy acquisition via LE is bound to the water vapour condensation on the active surface, at the station of Reindalen it is possible to state better conditions for this change in the state of water. This follows both from the mean length of the interval of positive values of LE, and from the level of the achieved energy gain (mean maxima of LE reach at Barentsburg and Reindalen 40 and 100 W.m^{-2}, respectively). In connection with what has been mentioned, in this case it is possible to take into consideration the positive effect of increased night radiation losses in the drier air of the inland of the Isle of Spitsbergen (at the station of Reindalen) on a more marked cooling of the boundary atmosphere, and thus also a more frequent temperature drop to the dew point. The least significant component of the energy balance is the molecular energy transfer from the active surface to the substrate, or vice versa (Figs. 4, 5). The mean daily regime of G is in both cases for the greatest part of the day typical by the minimum variation around the zero value. The mean maxima of G in the afternoon hours do not exceed 20 W.m^{-2}. Thus it is evident that at the two stations in summer there is minimum heat accumulation in the substrate of the active surface, the heat being transferred back to the atmosphere.

With the objective of discovering the influences of the weather character on the components of the energy balance also the daily regimes of R, H, LE and G were evaluated on days with increased radiation and/or advection weather character. With respect to the prevailing weather character of the summer in the region of Svalbard (great cloudiness, strong advection - see e.g. Brázdil et al., 1988b) it was possible to evaluate the effects of the radiation regime of weather only on the average of three days (Barentsburg 4, 18 and 21 July, 1988; Reindalen 21, 22 and 29 July, 1990) (Figs. 6, 7), for which as opposite also three days were chosen with the prevalence of advection effects (Barentsburg 15 July, 1 and 6 Aug., 1988; Reindalen 8, 23 and 28 July, 1990) (Figs. 8, 9). A more detailed characteristic of the above days is included in Table 3, from which it follows that even at such small samples it was impossible to respect the criterion of minimum advection in the radiation days and in their choice it was necessary to accent mainly the duration of sunshine.

The daily regime of R, with the prevalence of radiation effects (Fig. 6) at the station of Barentsburg is typical by a very rapid rise immediately after the morning change of the sign from - to + approximately until 11 h CET. After the culmination there follows a slow and regular drop which, after 23 h CET is replaced by a two-hour interval of positive values. It is then followed by a three-hour period of negative values. This regime is a clear consequence of the shading of the station against solar radiation by a considerably overtopping of the crest of Grönfjordfjellet (Fig. 2) in the

Weather character	radiation	advection
Station	Barentsburg	Barentsburg
Date	4 July 18 July 21 July	15 July 1 Aug. 6 Aug.
Mean cloudiness	3.7/10 3.5/10 1.3/10	10/10 9.5/10 9.8/10
Mean wind speed (m.s^{-1})	1.2 0.9 1.5	3.7 2.9 3.9
Station	Reindalen	Reindalen
Date	21 July 22 July 29 July	8 July 23 July 28 July
Mean cloudiness	4.4/10 3.9/10 4.9/10	10.0/10 9.0/10 9.8/10
Mean wind speed (m.s^{-1})	5.3 6.9 1.4	3.2 6.3 1.3

Table 3. The mean cloudiness and wind speed on selected days with prevailing radiation and advection weather characters at the stations of Barentsburg and Reindalen

northwest to northeast. That fact conditions, in the morning after the sunrise above the overtopped horizon, a rapid increase in the R value, and thus also the asymmetry of its daily variation and in the hours after the midnight the drop of R into the domain of negative values.

At the station of Reindalen (Fig. 7) the daily regime of R is less extreme and more symmetric. But also there there appear shadowing effects of the overtopping northern horizon, most conspicuously in the evening hours, when they condition a rapid drop in the values of R between 19 and 22 h.

Great differences between the two localities are evident in the two heat fluxes conditioned by the turbulence (H, LE). The daily regime of H at Barentsburg has a character similar to the mean one (Fig. 4), in the case of Reindalen it is more varied, chiefly due to a considerable variability of the vertical profile of wind speed during the radiation days, and like in Fig. 5 it documents increased energy losses in this way in comparison with Barentsburg.

The similarity of the mean daily course and the one conditioned by radiation at Barentsburg is also typical of the flux of LE, which is similarly unsteady at the station of Reindalen as H and even during the radiation weather it documents substantially higher energy losses through evaporation at Barentsburg in comparison with Reindalen.

At the prevalence of the advection weather the daily variations of all balance components are markedly suppressed (Figs. 8, 9), the unbalanced character of R and LE is, unlike the situation during the prevalence of radiation effects, typical of Barentsburg, where it is probably conditioned by a substantially greater variability of wind speed, direction and cloudiness at the contact of sea and land

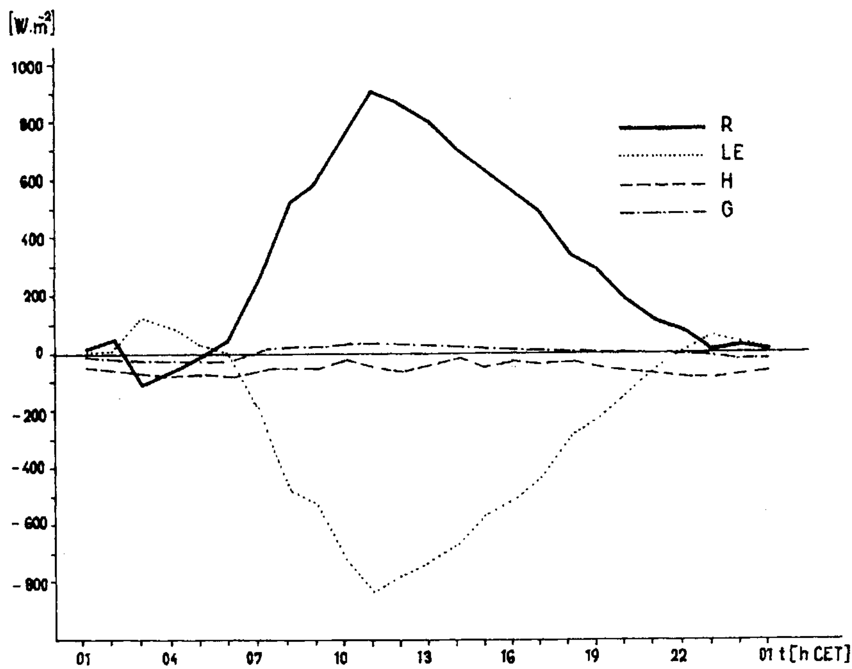

Fig. 6. Mean daily variation of the components of the energy balance of the active surface of the tundra (R, H, LE and G) during the prevailing radiation regime of weather (4, 18 and 21 July, 1988) at the station of Barentsburg

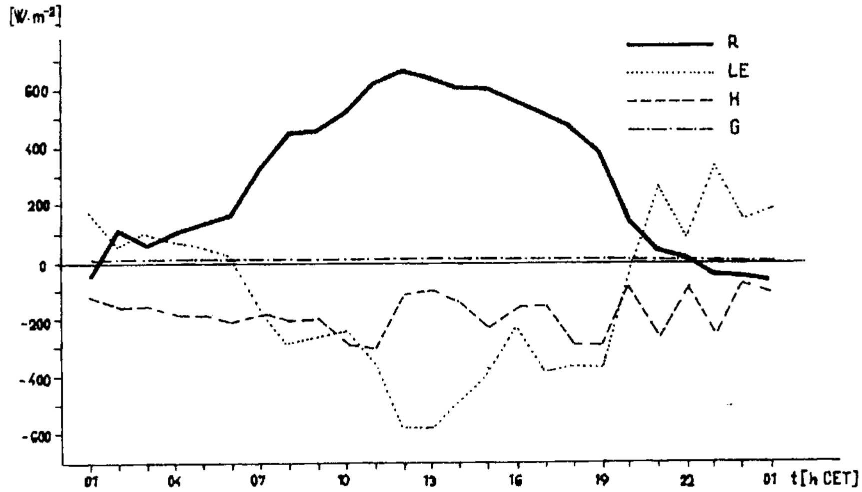

Fig. 7. Text see Fig. 6 - (21, 22 and 29 July, 1990) at the station of Reindalen

near the western coast of the Isle of Spitsbergen. At Reindalen, on the other hand, the variability of weather changes at advection is suppressed and the streaming of air in passing through the valley is more homogeneous as far as its speed is concerned, the consequence of which is a more smoothed regime of energy components R, H and LE.

An idea of the regime of energy fluxes at the two localities are yielded by Figs. 10 and 11. From them it follows that pentade sums of the radiation balance (ΣR_p) are influenced by the regime of the sunshine duration (S_r). At the station of Barentsburg pentade sums of the latent heat flux (LE_p) correlate besides with the values of ΣR_p in the period of 11 July - 10 Aug., 1988.

The same can no longer be stated about the station of Reindalen, where the relation of ΣR_p and ΣLE_p is considerably loose at the cost of a considerable variability of the pentade sums of the turbulent heat flux (ΣH_p).

The above facts demonstrate the information that at the station of Barentsburg with the radiation regime of weather (i.e. with the increase in the S_r values), unambiguously due to a sufficient moisture reserve of the substrate, the conditions for the latent heat transfer into the atmosphere improve, whereas at Reindalen, with the exception of the end of the processed period (1 to 10 Aug.) the prevalence of heat losses by the dry turbulent transfer over the moist one is evident.

On the basis of facts presented in Figs. 10 and 11, the next step was the verification of the dependence between the radiation balance and further nonradiation energy fluxes at the level of the daily sums. Whereas the dependence of the daily sums of the turbulent heat flux (ΣH) on the daily sums of the radiation balance (ΣR) was not confirmed at the station of Barentsburg according to expectation, there exists an extraordinary close dependence of the daily sums of the latent heat flux (ΣLE) on ΣR there (the correlation coefficient exceeds by its value of 0.948 the highly critical value at the level of significance 0.05) (Fig. 12) and significant is also the dependence of the daily sums of the heat flux into the substrate (ΣG) to ΣR at the value of the correlation coefficient 0.614 (Fig.

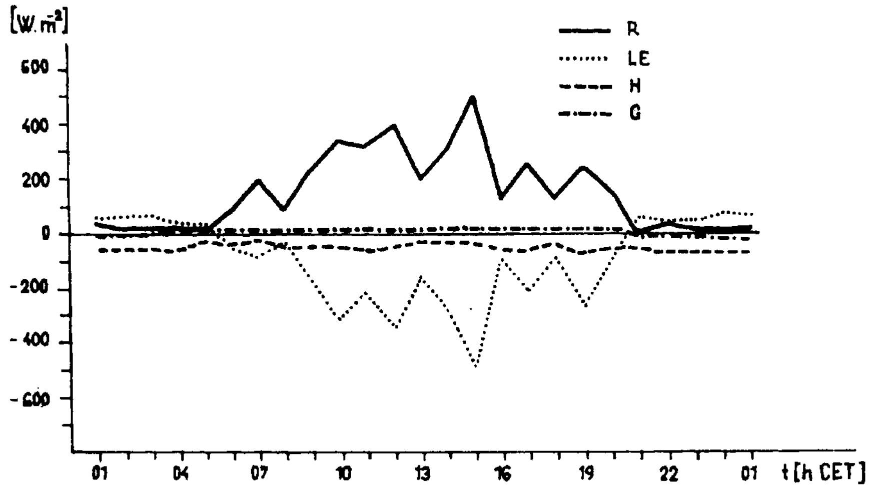

Fig. 8. Mean daily variation of the components of the energy balance of the active surface of the tundra (R, H, LE and G) during the prevailing advection regime of weather (15 July, 1 and 6 Aug., 1988) at the station of Barentsburg

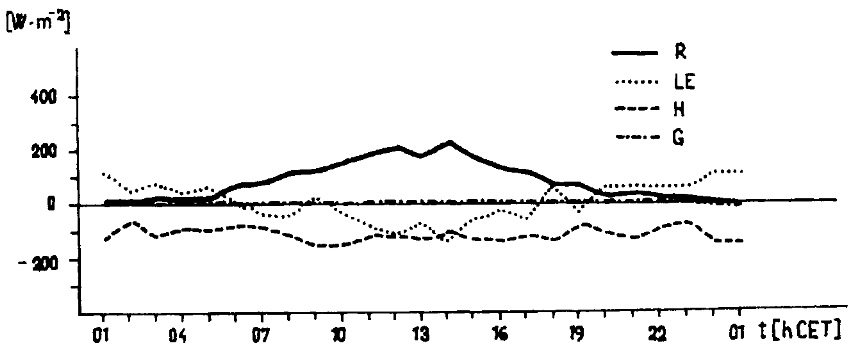

Fig. 9. Text see Fig. 8 - (8, 23 and 28 July, 1990) at the station of Reindalen

13). The correlation coefficient between ΣG and ΣR on the days with conspicuous radiation effects has a similar value (Fig. 13).

At the station of Reindalen the effects of ΣR on ΣH and ΣLE are substantially looser, and with respect to the respective correlation coefficients they cannot be evaluated as significant. A closer and statistically significant relation there can only be stated between ΣG and ΣR (Fig. 14). A somewhat higher value of this coefficient on days with more marked radiation effects demonstrates there to a certain extent more unambiguous consequences of the gain of radiation energy on the heat accumulation in the substrate.

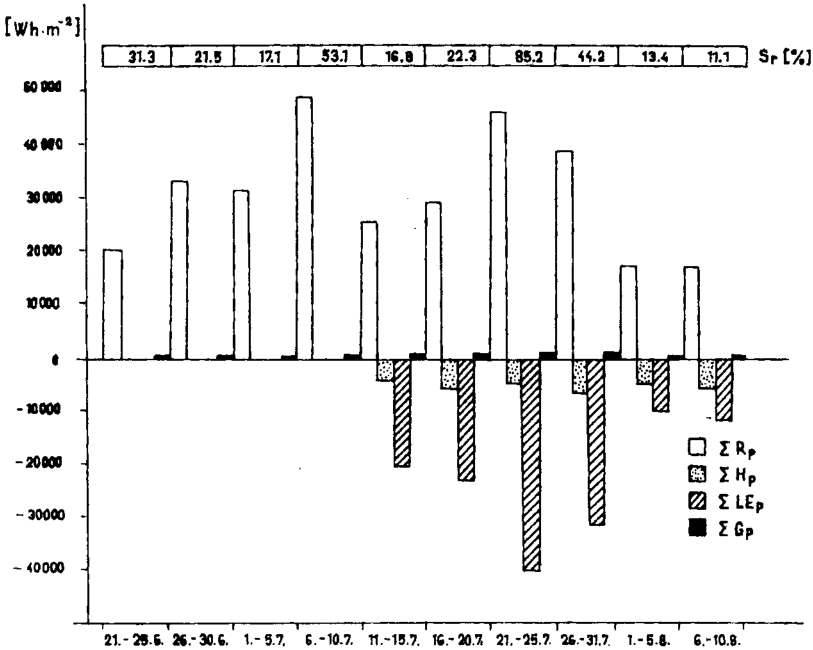

Fig. 10. Pentade sums of the radiation balance (ΣR_p), the turbulent (ΣH_p) and the latent (ΣLE_p) heat fluxes and the heat flux into the active surface substrate (ΣG_p) at the station of Barentsburg for the period of 21 June - 10 Aug., 1988, completed by the pentade means of the relative duration of sunshine (S_r)

A similar conclusion can also be drawn from the comparison of Figs. 13 and 14, from which there appears a closer connection of ΣG and ΣR at Reindalen with respect to Barentsburg where, despite the statistically demonstrated closeness of the above relation there is evidently a greater share of advection effects on the accumulation of heat in the underlier of the active surface than in the more continental climate of the inland of Spitsbergen Island.

An overall list of the sums of the individual components of the energy balance of the active surface for the whole common period of energy measurements at the two stations is presented in Table 4, completed by the percentual shares of sums of nonradiation energy fluxes in the sum R from measurements in the area of Werenskiold Glacier (Fig. 1), and/or similarly arranged results of the energy balance of the active surface of the tundra from the region of the North American Arctic.

From Table 4 it is evident that at three localities of measurements carried in the Isle of Spitsbergen (Barentsburg, Werenskiold - tundra and Werenskiold - moraine) energy losses bound to evaporation (LE) prevail over losses due to turbulent flux H. A more significant prevalence of LE over H can also be stated in the locality of Hudson Bay, to a lesser extent in the island of Axel Heiberg. Taking into consideration a high water content in the tundra vegetation as well as in its substrate at Barentsburg and similar conditions at the measurement localities at Axel Heiberg and Hudson Bay and/or a high soil moisture at the locality Werenskiold - tundra (at which inorganic material prevailed in area over vegetation), it is clear that the basic logical condition of increased heat losses due to

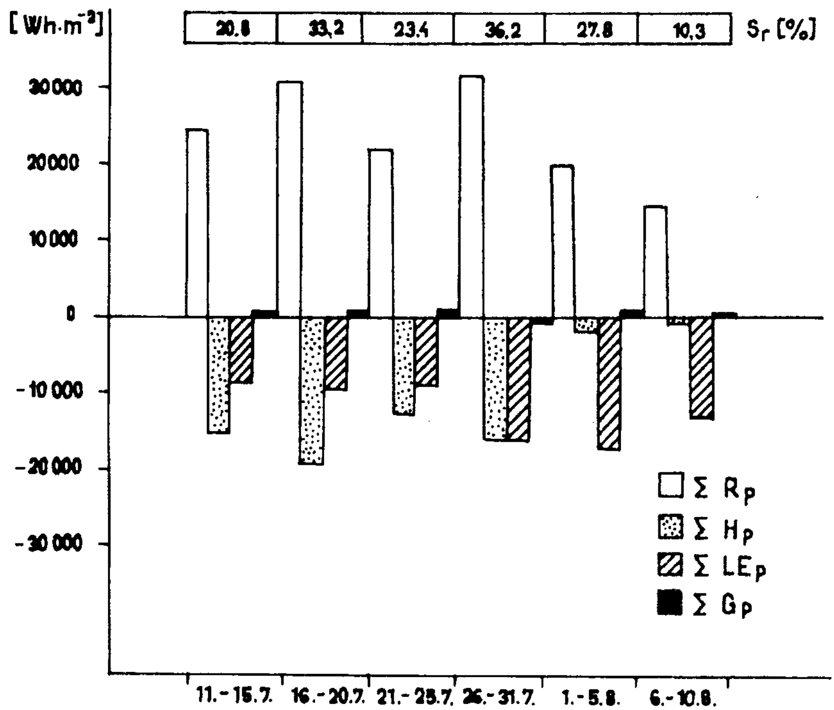

Fig. 11. Text see Fig. 10 - at the station of Reindalen for the period of 11 July - 10 Aug., 1990

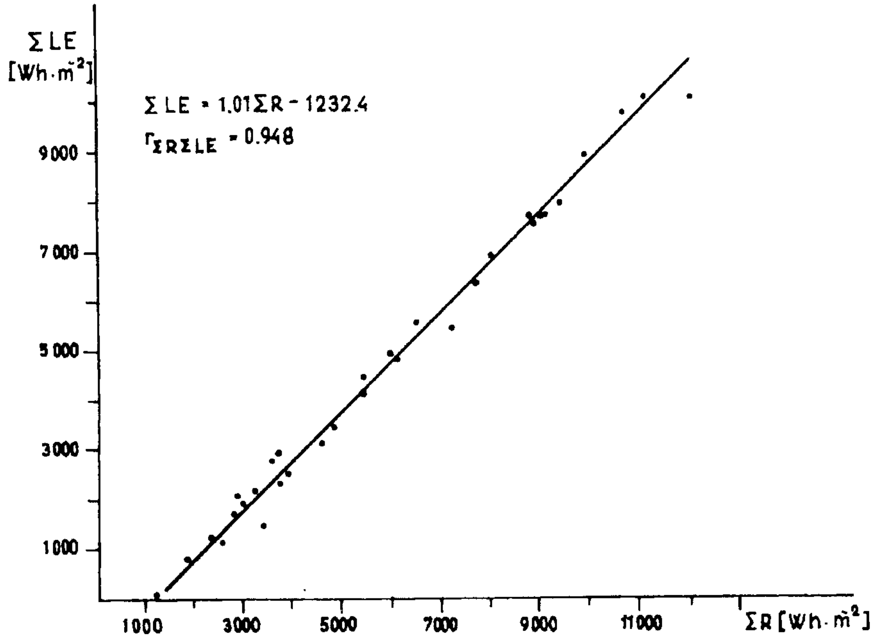

Fig. 12. Regression dependence of the daily sums of latent heat flux (ΣLE) on the daily sums of the radiation balance (ΣR) at Barentsburg for the period of 8 July - 10 Aug., 1988

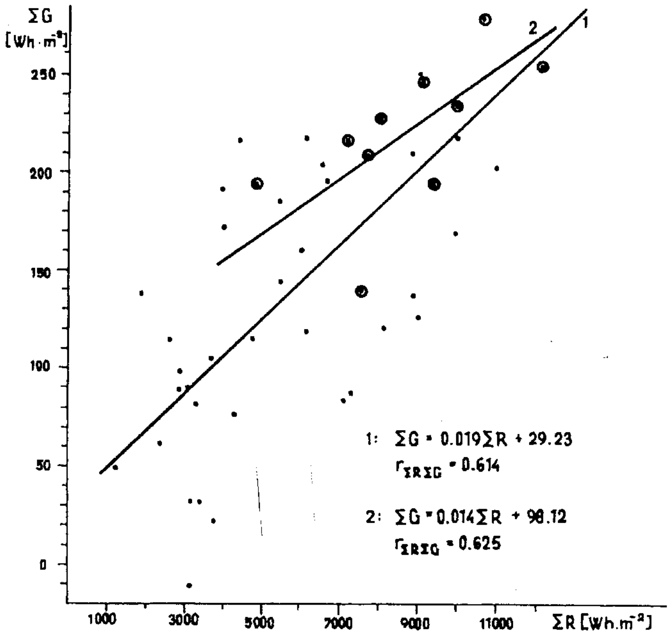

Fig. 13. Regression dependence of the daily sums of the heat flux into the substrate of the active surface (ΣG) on the daily sums of the radiation balance (ΣR) at Barentsburg for the period of 21 June - 10 Aug., 1988 (1) and on days with the radiation regime of weather (2) (points in circles)

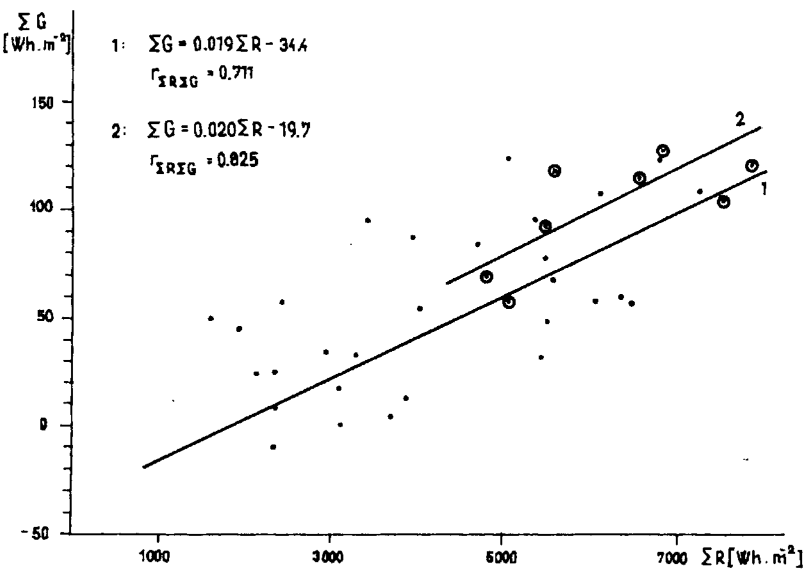

Fig. 14. Text see Fig. 13 - at Reindalen for the period of 8 July - 13 Aug., 1990 (1) and on days with the radiation regime of weather (2) (points in circles)

Energy balance components	Barentsburg (coastal upland tundra)		Reindalen (interior tundra)		Werenskiold[1)] (moraine)	Werenskiold[1)] (coastal tundra)
	$kWh.m^{-2}$	%	$kWh.m^{-2}$	%	%	%
ΣR	203.63	100.0	151.13	100.0	100.0	100.0
ΣH	-34.95	17.2	-74.48	49.3	30.4	13.9
ΣLE	-163.03	80.0	-74.99	49.6	62.5	72.5
ΣG	-5.65	2.8	-1.66	1.1	7.1	13.6
ΣA	-	-	-	-	-	-

Energy balance components	A.Heiberg, base camp[2)] (interior upland tundra)	Point Barrow, Alaska[3)] (coastal tundra)	Hudson Bay[4)] (SW-shore, tundra)
	%	%	%
ΣR	100.0	100.0	100.0
ΣH	37.5	44.2	35.8
ΣLE	46.9	49.6	50.4
ΣG	14.6	6.2	13.1
ΣA	1.4	-	0.8

[1)] Brázdil et al. (1988a); [2)] Ohmura (1982); [3)] Mather, Thornthwaite (1958), Maykut, Church (1973), Weller, Holmgren (1974) (in Ohmura, 1982); [4)] Rouse, Stewart (1972), Stewart, Rouse (1976)

Table 4. Sum values of the radiation balance (ΣR), the turbulent heat flux (ΣH), the latent heat flux (ΣLE), the heat flux into the substrate of the active surface (ΣG) and/or the heat consumption for the snow ablation (ΣA) and their percentual shares in ΣR at the stations of Barentsburg and Reindalen in the periods of 8 July - 9 Aug., 1988 and 1990, completed by relative values of energy fluxes from the region of Werenskiold (27 July - 10 Sept., 1985), the island of Axel Heiberg (July 1969-1970), Point Barrow (Alaska, July 1957-1971) and Hudson Bay (July - 15 days, August - 7 days, 1971)

evaporation is a sufficient amount of water in the substrate of the active surface. As another factor positively affecting losses by means of LE can, under lower moisture reserve in the substrate (the case of the locality Werenskiold - moraine), be considered advantageous exposition to the streaming of air, intensifying the evaporation.

With the condition of good ventilation, fulfilled also in the case of Reindalen and the locality Werenskiold - moraine, is evidently linked up also the greater share of H in energy losses at those two localities, compared with Barentsburg and the tundra in the region of Werenskiold. The percentual shares of ΣH in ΣR at the localities of measurement in North American Arctic correspond to similar conditions.

CONCLUSION

The presented results of measurements of components of the energy balance of the active surface represent - linking up with earlier publications (see quotations in the introduction) - a completion of the energy balance oriented research of the three above expeditions to Svalbard. In their course it was possible to obtain from the time point of view fragmentary, but from the point of view of fundamental types of the active surface substantially more comprehensive information about the differences in the energy economy of different types of the tundra, the glacier surface, the moraine and sorted soil, including some of their consequences (e.g. for the thermics of the soil or for the ablation of the snow cover on the glacier).

The information about the last mentioned localities (Barentsburg and Reindalen) is the content of another paper (Prošek, Brázdil, 1994).

REFERENCES:

BRÁZDIL, R., CHMAL, H., KIDA, J., KLEMENTOWSKI, J., KONEČNÝ, M., PEREYMA, J., PIASECKI, J., PROŠEK, P., SOBIK, M., SZCZEPANKIEWICZ-SZMYRKA, A. (1988a): Results of investigation of the geographical research expedition Spitsbergen 1985. Univerzita J. E. Purkyně, Brno, 337 pp.

BRÁZDIL, R., PIASECKI, J., PROŠEK, P., SZCZEPANKIEWICZ-SZMYRKA, A. (1988b): Variation of global and reflected radiation in the area of Werenskiold Glacier (SW Spitsbergen) in the summer to autumn season of 1985. Scripta Fac. Sci. Nat. Univ. Purk. Brun., 18, 1 (Geographia), 3-20.

BRÁZDIL, R., PIASECKI, J., PROŠEK, P., SZCZEPANKIEWICZ-SZMYRKA, A. (1989): Temperature conditions and energy balance of the active surface of a maritime terrace and a moraine in the Werenskiold area (Spitsbergen). In: Results of Investigations of the Polish Scientific Spitsbergen Expeditions, VII, Wrocław, 5-43.

BRÁZDIL, R., PROŠEK, P. (1993): Teplotní poměry oblasti Reindalen na ostrově Špicberk (Svalbard) v letním období roku 1990. Sborník ČGS, 98, 3, 156-169.

BRÁZDIL, R., PROŠEK, P., KONEČNÝ, M. (1992): Glyatsioklimatitcheskiye usloviya lednika Grenfjord Vostochnyy (Shpitsbergen). Materialy meteorol. issled., 15, Moskva, 136-151.

MATHER, J.R., THORNTHWAITE, C.W. (1958): Microclimatic investigations at Point Barrow, Alaska 1957-1958. Publications in Climatology 11. Drexel Institute of Technology, Centerton, N.J.

MAYKUT, G.A., CHURCH, P.E. (1973): Radiation climate of Barrow, Alaska, 1962-66. J. Appl. Meteorol., 12, 620-628.

OHMURA, A. (1982): A historical review of studies on the energy balance of Arctic tundra. J. Climatol., 2, 65-84.

PROŠEK, P., BRÁZDIL, R. (1994): Thermics of the tundra underlier and its conditioning by the energy balance at Barentsburg and Reindalen (Spitsbergen Island, Svalbard) in the summer seasons of 1988 and 1990. Scripta Fac. Sci. Nat. Univ. Masaryk. Brun., 24, Geographia, 61-80.

ROUSE, W.R., STEWART, R.B. (1972): A simple model for determining evaporation for high latitute upland sites. J. Appl. Meteorol., 11, 1063-1070.

SMRČKOVÁ, Z. (1993): Energetická bilance aktivního povrchu v Barentsburgu a v údolí Reindalen (Svalbard) a její důsledky na teplotní režim jeho podloží. M.Sc. thesis, Masaryk University, Brno, 76 pp.

STEWART, R.B., ROUSE, W.R. (1976): Simple models for calculating evaporation from dry and wet tundra surfaces. Arctic and Alpine Research, 8, 263-274.

TEAM OF AUTHORS (1977): Rukovodstvo po teplobalansovym nablyudeniyam. Gidrometeoizdat, Leningrad, 152 pp.

WELLER, G., HOLMGREN, B. (1974): The microclimates of the Arctic tundra. J. Appl. Meteorol., 13, 854-862.