Radiation Measurements
at the German Antarctic Station Neumayer
1982 - 1992

Torsten Schmidt and Gert König Langlo

Ber. Polarforsch. 146 (1994)
ISSN 0176 - 5027

List of Contents

I. INTRODUCTION

Since March 1981 meteorological measurements are carried out continuously at the German Antarctic research station Neumayer*. The programme of the meteorological observatory consists of

- routine synoptic observations,
- standard near surface measurements,
- surface radiation measurements,
- upper air soundings and
- air chemistry measurements.

The meteorological data are postprocessed and archived in the Meteorological Information System of the Alfred Wegener Institute (MISAWI).

This report covers a description of the surface radiation measurements obtained from 13th of March 1982 until 31st of December 1992.

This report is meant to roughly characterize the data set which is now available at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven and to describe the surface radiation components at Neumayer Station during the years 1982 to 1992.

---

* The station initially carried the official name "Georg-von-Neumayer". It was reconstructed and renamed to "Neumayer Station" in March 1992.

II. Observational Conditions at Neumayer Station

The first German Antarctic station "Georg-von-Neumayer" (GvN) was constructed at the position 70°37´S, 8°22´W in the beginning of 1981. Among others the station is serving since its opening as a meteorological observatory. The new station "Neumayer" (NM) at the position 70°39´S, 8°15´W continued these activities in an extended form since March 1992. Both stations are situated on the Ekström Ice Shelf which has a very homogeneous flat surface sloping gently upwards to the south. Fig. 1 shows the geographical location of both stations.

The meteorological sensors are exposed about 100 m south-east, i.e. upwind with respect to the prevailing wind direction of the station. Since most of the station buildings are covered with snow, perturbations of the measurements by superstructures are negligibly small.

The average air surface temperature for the years 1981 to 1991 was -15.8 °C (Pfaff, 1993). Large temperature variations occur during the winter months. In the coldest month (usually August) the minimum temperatures range between -36 and -46°C. Maximum temperatures during summer (December to February) exceed slightly the freezing point so that temporary minor melting of the snow surface may occur.

The dominat wind direction lies at 90 degrees. The catabatically influenced southerly winds occur cover a broad directional sector. Northerly winds are very rare. The annual average wind speed ranges between 8 and 11 m/s.

The surface weather situation is often governed by moderate to strong snow drift and snow fall. The station´s average snow accumulation rate was 84 cm per year during the period from 1981 to 1991 (Pfaff, 1993).

Detailed information on the meteorological conditions at the station is provided by Gube-Lenhardt and Obleitner (1986), Gube-Lenhardt (1987), Helmes (1989) and König-Langlo (1992).

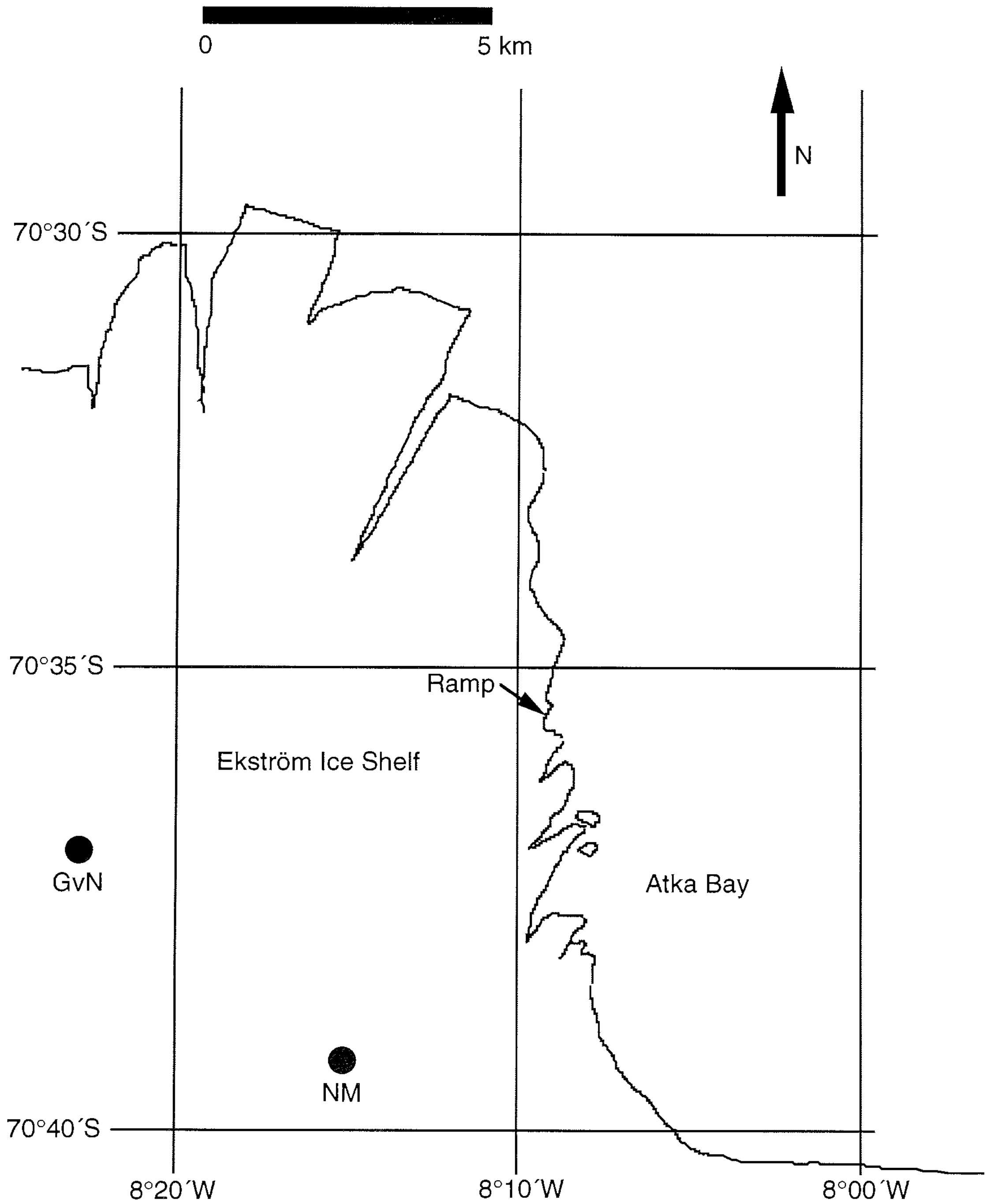


Fig. 1: The geographical location of the "Georg-von-Neumayer" (GvN) and "Neumayer" (NM) Station

The annual course of solar radiation at 70°37´S, 8°22´W with no refraction according to Iqbal (1983) is shown in Fig. 2. We find the maximum incidence angle of 42.8° at the 22nd of December. The sun stays permanently above the horizon from 19th of November to 24th of January (polar day) and permanently below the horizon from 19th of May to 27th of July (polar night).

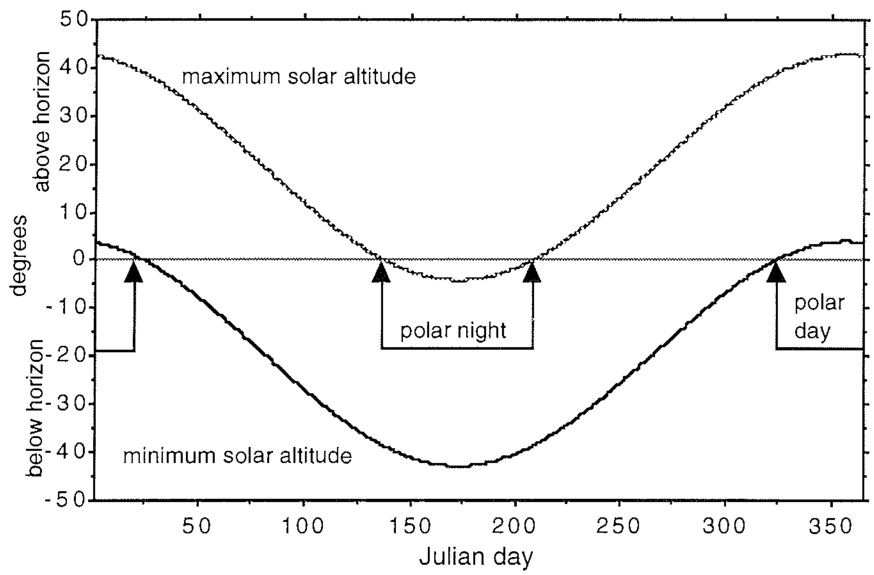


Fig. 2: Solar elevations at the "Georg-von-Neumayer" Station

From 13th of March 1982 until 15th of February 1992 the following radiation quantities were measured and stored as 10 minute averages:

- sunshine duration
- global solar radiation
- reflected solar radiation
- downward and upward total radiation.

From these measurements other radiation components, such as downward and upward long-wave radiation and surface albedo have been derived.

The measurements were carried out with

- a photoelectric sunshine recorder (Solar 111, Haenni and Cie.) for the sunshine duration,
- pyranometers (PSP, Eppley Laboratory and CM11, Kipp&Zonen) for the global and reflected solar radiation,
- pyrradiometers (Lange GmbH) for the downward and upward total radiation.

Since March 1992 the pyrradiometers were replaced by pyrgeometers (PIR, Eppley Laboratory).

Together with the radiation data 10 minute averages of the surface air pressure, relative humidity (2 m), air temperature (2 m and 10 m) and wind vector (2 m and 10 m) were stored as well.

The radiation instruments have been repeatedly calibrated at the German Weather Bureau (Deutscher Wetterdienst) in Hamburg according the World Radiometric Reference (WRR). Each sensor was exchanged after one year of operation.

III. THE DATA

3.1. Data Processing and Validation

The radiation signals were recorded in one minute intervals and stored as averages over 10 minutes on magnetic cassettes and on magnetic tapes. First these data have been subjectively inspected (visually by daily plots) and corrected or rejected before they were entered into the Meteorological Information System of the Alfred Wegener Institute (MISAWI). Poor data quality was often caused by

- hoar frost deposition on the radiation sensors,
- power failure of the observational system and
- interference with the local short-wave transmitter.

3.1.1. Data Validation

After the subjective quality check of the time series an objective data validation as listed in Tab. 1 was performed in the framework of MISAWI. All suspect data were flagged, manually examined, corrected if possible and otherwise rejected.

The validation procedures can be subdevided into two categories. The first 24 tests refer to accepted upper and lower limits of each quantity. The validation procedures No. 25-34 refer to the internal consistency between at least two values.

3.1.2. Derived Quantities

In addition to and partly on the basis of the measured quantities the following values have been derived

- solar elevation h according to Iqbal (1983),
- relative air mass m according to Kasten (1966):

$$m = 1 / (\sin(h) + 0.15\cdot(h+3.885)^{-1.253}) \qquad (1)$$

- extraterrestrial solar irradiance G_0 according to Iqbal (1983),
- surface albedo $a = K\uparrow / K\downarrow \quad [\%] \qquad (2)$
  with $K\downarrow$, $K\uparrow$ the global and reflected solar radiation, respectively

- surface temperature $T_0 = (L\uparrow/\sigma)^{(1/4)} - 273.15$ [°C] (3)
  with $L\uparrow$ being the upward long-wave radiation and the Stefan-Boltzmann constant $\sigma = 5.67 \cdot 10^{-8}$ W/m^2K^4.

The albedo is calculated only for $K\downarrow > 50$ W/m^2. For $K\downarrow < 50$ W/m^2 the relative error of $K\downarrow$ and $K\uparrow$ is too heigh to obtain reliable albedo values. Furthermore during night the global solar radiation is zero and no albedo is defined. A more detailed discussion of problems concerning the calculation of the albedo can be found in WCRP (1986).

No.	Error condition	No.	Error condition
1.	$K\downarrow < -5$ W/m^2	2.	$K\downarrow > 0.9 \cdot G_0 + 10$ W/m^2 and $h > 1°$
3.	$OG1 < -5$ W/m^2	4.	$OG1 > 0.666 \cdot G_0 + 10$ W/m^2 and $h > 1°$
5.	$RG8 < -5$ W/m^2	6.	$RG8 > 0.5 \cdot G_0 + 10$ W/m^2 and $h > 1°$
7.	$UV < -5$ W/m^2	8.	$UV > 0.05 \cdot G_0 + 10$ W/m^2 and $h > 1°$
9.	$K\uparrow < -5$ W/m^2	10.	$K\uparrow > 0.8 \cdot G_0 + 10$ W/m^2 and $h > 1°$
11.	$D < -5$ W/m^2	12.	$D > 0.9 \cdot G_0 + 10$ W/m^2 and $h > 1°$
13.	$DS < -5$ W/m^2	14.	$DS \cdot \sin(h) > 0.9 \cdot G_0 + 10$ W/m^2
15.	$L\downarrow < 100$ W/m^2	16.	$L\downarrow > 500$ W/m^2
17.	$Tp\downarrow < -50$ °C	18.	$Tp\downarrow > 30$ °C
19.	$L\uparrow < 100$ W/m^2	20.	$L\uparrow > 500$ W/m^2
21.	$T_p\uparrow < -50$ °C	22.	$T_p\uparrow > 30$ °C
23.	$0<S<5$ minutes or $0<S<10$ minutes	24.	$S > 0$ and $h \leq 0°$
25.	$OG1 > K\downarrow + 5$ W/m^2	26.	$RG8 > K\downarrow + 5$ W/m^2
27.	$RG8 > OG1 + 5$ W/m^2	28.	$UV > K\downarrow + 5$ W/m^2
29.	$UV > OG1 + 5$ W/m^2	30.	$UV > RG8 + 5$ W/m^2
31.	$K\uparrow > K\downarrow + 5$ W/m^2	32.	$D > K\downarrow + 5$ W/m^2
33.	$D + DS \cdot \sin(h) - K\downarrow < -0.2 \cdot K\downarrow$ W/m^2 and $h > 0°$	34.	$\lvert T_p\downarrow - T_p\uparrow \rvert > 2$ °C

Tab. 1: Validation procedures for radiation measurements which are applied in the framework of MISAWI

3.1.3. Daily Averages

In order to obtain daily averages each day was subdevided into eight 3-hourly intervals (0-3, 3-6,..., 21-24 UTC). For each 3-hourly interval an average was derived irrespectable of the number of measurements. This procedure was choosen in order to minimize problems resulting from incomplete datasets. If one or more 3-hourly averages were missing, no daily average was calculated.

Tab. 2 shows the number of the daily averages of each year for the period 13th of March 1982 until 15th of February 1992 in per cent.

Year	K↓	K↑	S	L↓	L↑
1982	98	95	100	95	90
1983	86	82	100	87	77
1984	86	85	100	75	68
1985	91	90	98	91	85
1986	87	73	98	68	71
1987	87	87	94	90	90
1988	73	44	88	41	22
1989	70	66	93	42	42
1990	79	79	37	80	80
1991	87	87	94	87	87
1992	91	91	100	91	91
all	84	79	90	75	71

Tab. 2: Daily averages of global solar radiation K↓, reflected solar radiation K↑, sunshine duration S, downward and upward long-wave radiation L↓, L↑ in per cent

3.1.4. Instrumental and Observational Peculiarities

Some changes of instruments and observational techniques during the years have to be considered. This refers especially to the pyrradiometer data. The pyrradiometer signals (PS↓ and PS↑) are composed of the incomming short-wave and long-wave radiation and the outgoing instrument´s long-wave radiation as described below by Eqs. (4a) and (5a).

downwards:

$$PS\downarrow = K\downarrow + L\downarrow - \sigma \cdot (Tp+273.15)^4 \quad [W/m^2] \qquad (4a)$$

$$Q\downarrow = K\downarrow + L\downarrow \quad [W/m^2] \qquad (4b)$$

$$LS\downarrow = L\downarrow - \sigma \cdot (Tp+273.15)^4 \quad [W/m^2] \qquad (4c)$$

upwards:

$$PS\uparrow = K\uparrow + L\uparrow - \sigma \cdot (Tp+273.15)^4 \quad [W/m^2] \qquad (5a)$$

$$Q\uparrow = K\uparrow + L\uparrow \quad [W/m^2] \qquad (5b)$$

$$LS\uparrow = L\uparrow - \sigma \cdot (Tp+273.15)^4 \quad [W/m^2] \qquad (5c)$$

The downward and upward total radiation Q↓ and Q↑ can be derived from the pyrradiometer signals PS↓, PS↑ and the instrument temperature T_P. Since the short-wave fluxes K↓ and K↑ are measured the long-wave radiation components L↓ and L↑ can be calculated as residuals.

In order to allow for later corrections only measured quantities such as LS↓, LS↑ (Eqs. 4c, 5c), T_P, K↓ and K↑ are archived in MISAWI. Such quantities as L↓, L↑, Q↓ and Q↑ can be derived from the observed data.

Between 1982 and 1986 only Q↓, Q↑, K↓ and K↑ were stored on magnetic tapes. We have recalculated LS↓ and LS↑ with the aid of Eqs. (4b,c) and (5b,c) applying the air temperature (2 m). This was done only to archive a formally consistent data set without any impact to the quality of the radiation measurements.

During the season 1989/90 the downward and upward total pyrradiometer signals PS↓, PS↑ as well as K↓ and K↑ were stored but not the instrument temperature T_P. In this case the air temperature (2 m) was taken again to recalculate LS↓, LS↑ from Eqs. (4c), (5c). Normally the difference between the instrument temperature and the air temperature (2 m) is less than 1°C leading to errors of less than 3 W/m^2 for L↓ and L↑. But during calm days with strong solar irradiance the error may increase to 15-20 W/m^2.

Since March 1992 pyrgeometers are applied, which measure the long-wave radiation signals LS↓, LS↑ and the instrument temperatures T_P↓, T_P↑ directly.

From 1982 to 1985 neither the global nor the reflected solar radiation were measured at night. Instead all values were taken to be zero. From 1986 to 1992 the pyranometer measurements were recorded also at night. The night values scatter around zero due to electronic noise which cannot be surpressed totally. Furthermore, a negative offset of a few W/m^2 occured mainly during calm wind and clear sky conditions. This offset results from a thermal unequilibrium within the instrument. The offset is also present in daytime, but then it is hidden in the solar radiation signal. In order to quantify the offset the night values of the short-wave radiation components are also archived.

3.2. Data Archiving

The radiation and mast measurements are archived in MISAWI in the radiation database called "StrahlungDB".

The "Meteorological Information System" MISAWI provides an unique user environment for storing, retrieving, changing and protecting the data. It provides a permanent access to different data independent of the structure of files etc.

The database "StrahlungDB" is structured according to Tabs. 3 to 5. The tables "Strahlung" (radiation) and "Mast" (mast) contain 10 minute averages from 1982 until March 1992, afterwards 5 minute averages.

name	explanation/remark
Strahlung_ID#	unique identification number
Messort_ID#	station identification number
DatumUhrzeit	date and time (UTC)
Global	global solar radiation K↓ (W/m^2)
Reflex	reflected solar radiation K↑ (W/m^2)
Diffus	diffuse solar radiation D (W/m^2)
Direkt	direct solar radiation DS (W/m^2)
OG1	global solar radiation 0.71-3.00 μm (W/m^2)
RG8	global solar radiation 0.53-3.00 μm (W/m^2)
UV	near UV radiation 0.30-0.37 μm (W/m^2)
GegenSignal	downward long-wave signal LS↓ (W/m^2)
GegenTemp	pyrradiometer temperature Tp↓ (°C)
AusSignal	upward long-wave signal LS↑ (W/m^2)
AusTemp	pyrradiometer temperature Tp↑ (°C)
Sonne	sunshine duration S (minutes)
Wolkenhoehe	cloudbase height cb (meters)
Sonnenhoehe	solar elevation h (degree) after Iqbal (1983)
Luftmasse	relative air mass m after Kasten (1966), Eq. (1)
AstroEin	extraterrestrial solar irradiance G_0 (W/m^2)
Albedo	surface albedo a (per cent), Eq. (2)
Temp0	calculated surface temperature T_0 (°C), Eq. (3)

Tab. 3: Contents of the table "Strahlung" of the MISAWI

name	explanation/remark
Messort_ID#	station identification number
DatumUhrzeit	date and time (UTC)
Tem10	air temperature 10 m (°C)
FF10	wind speed 10 m (m/s)
DD10	wind direction 10 m (degree)
Tem2	air temperature 2 m (°C)
FF2	wind speed 2 m (m/s)
DD2	wind direction 2 m (degree)
RelFeuchte1	first relative humidity 2 m (%)
RelFeuchte2	second relative humidity 2 m (%)
Stationsdruck	station air pressure (hPa)

Tab. 4: Contents of the table "Mast" of the MISAWI

The third table in the database "StrahlungDB" is the table "Tagesmittel" containing all the daily averages calculated according 3.1.3.

name	explanation/remark
Messort_ID#	station identification number
DatumUhrzeit	date and time (UTC)
Global	global solar radiation K↓ (W/m^2)
Reflex	reflected solar radiation K↑ (W/m^2)
Diffus	diffuse solar radiation D (W/m^2)
Direkt	direct solar radiation DS (W/m^2)
OG1	global solar radiation 0.71-3.00 µm (W/m^2)
RG8	global solar radiation 0.53-3.00 µm (W/m^2)
UV	near UV radiation 0.30-0.37 µm (W/m^2)
Gegen	downward long-wave radiation L↓ (W/m^2)
Aus	upward long-wave radiation L↑ (W/m^2)
Sonne	sunshine duration S (hours)
AstroEin	extraterrestrial solar irradiance G_o (W/m^2)
AstroSonne	astronomical sunshine duration S_o (hours)

Tab 5: Contents of the table "Tagesmittel" of the MISAWI

With the aid of the database language SQL (Structured Query Language) it is easy to access any archived data and to obtain derived quantities and all supplementary information.

With the attributes "DatumUhrzeit" and "Messort_ID#" the identification of each data point is possible. For example the command

```
select DatumUhrzeit, Global, Reflex from Tagesmittel where
Messort_ID#=1 and DatumUhrzeit between "1-1-84" and "1-1-85"
```

list all daily averages of global solar and reflected radiation for the year 1984.

Links between the different tables as well as to other databases (like synoptic database or upper air database) can be established easily.

For a description of the other meteorological databases which are also part of the MISAWI see König-Langlo (1992).

IV. RESULTS / PRODUCTS

This paragraph contains only examples of the radiation measurements since the other measurements of the meteorological observatory have been described already by Gube-Lenhardt and Obleitner (1986), Gube-Lenhardt (1987), Helmes (1989) and König-Langlo (1992).

4.1. Error Discussion

The accuracy of the calibration of the pyranometer is about 2 %. Due to high albedo values many errors occur rather similarly in both, the global solar radiation K↓ and in the reflected solar radiation K↑. Thus in the net short-wave radiation K^* a great deal of these influences is reduced again.

The calibration uncertainties of the pyrradiometer can be devided into three parts:

- The instrument temperature can be determined to an accuracy of better than 1 degree, leading to error the radiation fluxes of less than 3 W/m^2.

- The long-wave sensitivity of the thermopile can be calibrated to an accuracy of 10 %. Fortunately, at Neumayer Station the downward long-wave pyrradiometer signal LS↓ is mostly below ±100 W/m^2, so that the error becomes less than 10 W/m^2, while the upward long-wave pyrradiometer signal LS↑ seldom exceeds ±10 W/m^2, with an error of less than 1 W/m^2.

- The short-wave sensitivity of the thermopile can be calibrated to an accuracy of 5 %. Thus, during the night L↓ and L↑ can be determined by pyrradiometers with a higher accuracy than during daytime.

Similar to the short-wave balance K^* the long-wave balance L^* also benefits from compensatory effects on the measurements of the upward and downward fluxes.

The reliability of the data increases for daily, monthly and annual averages since the random errors are reduced. Since systematic calibration uncertainties affect all sensors similarly one may assume that balances such as K^*, L^*, Q^* are in general more accurate than the simple flux components.

4.2. Time Series based on 10 Minute Averages

For space reasons we will present only one example of the stored 10 minute averages. We have choosen the 27th of November 1991 which represents a cloudless summer day.

Fig. 3 shows the diurnal variation of the 10 minute averages of the extraterrestrial solar irradiance G_0, the global solar radiation $K\downarrow$ - i.e. the sum of direct solar radiation and diffuse solar radiation on an horizontal area - the reflected solar radiation $K\uparrow$ and the downward and upward long-wave radiation $L\downarrow$, $L\uparrow$.

Fig. 4 presents the net short-wave K^*, net long-wave L^* and net total surface radiation Q^* as specified by the following relationships:

$$K^* = K\downarrow - K\uparrow = K\downarrow \cdot (1 - a) \qquad (6)$$
$$L^* = L\downarrow - L\uparrow \qquad (7)$$
$$Q^* = K^* + L^* \qquad (8)$$

Fig. 5 portrays the albedo, the relative air mass and the solar elevation.

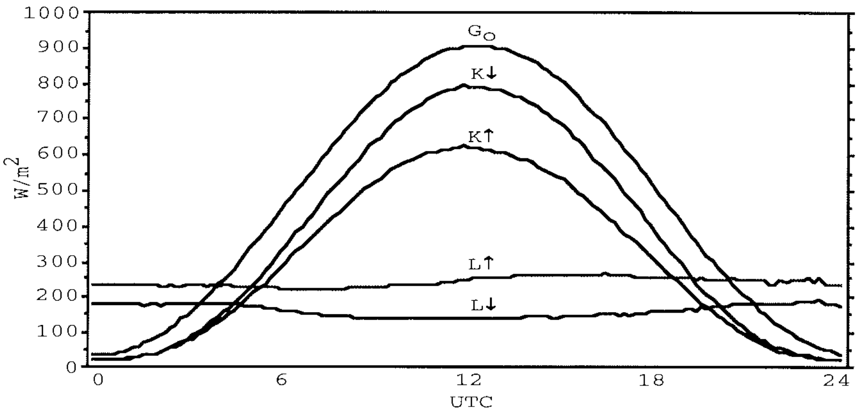


Fig. 3: Diurnal variation of the radiation quantities for the 27th of November 1991 based on 10 minute averages

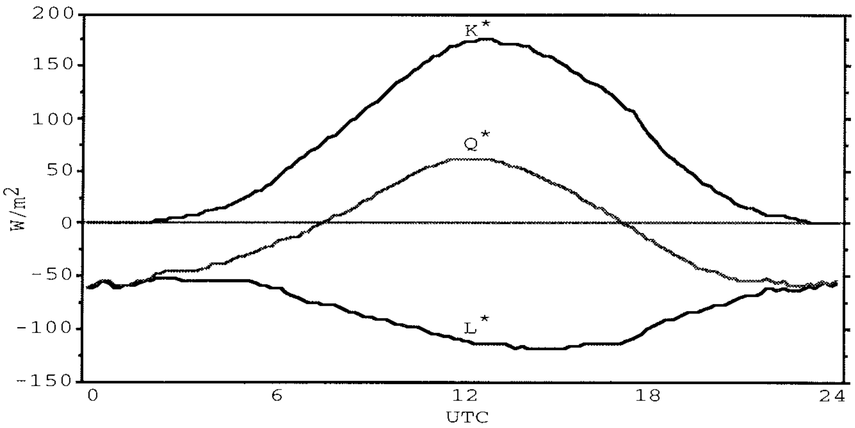


Fig. 4: Diurnal variation of the net short-wave, net long-wave and net total radiation K^*, L^*, Q^* for the 27th of November 1991 based on 10 minute averages

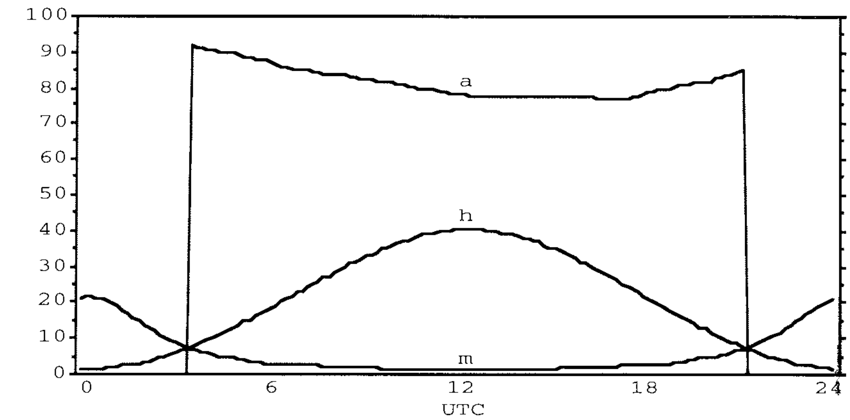


Fig. 5: Diurnal variation of the albedo (a) in per cent, the relative air mass (m) as a dimensionless value and the solar elevation (h) in degree for the 27th of November 1991 based on 10 minute averages

4.3. Time Series based on Daily Averages

4.3.1. Short-wave Radiation

Fig. 6 shows the daily averages of global solar radiation K↓ for the period 1982-1992. During summertime rather high values up to 450 W/m^2 are found.

Occasionally the observed sunshine duration S (Fig. 7) gets close to the astronomical value S_O.

Kuhn et. al. (1977) introduced the ratio of observed global solar radiation to the extraterrestrial solar irradiance $K{\downarrow}/G_O$ to demonstrate the effect of the atmosphere on the global radiation at the Earth´s surface. From Fig. 8 we conclude that the relative global radiation increases with increasing relative sunshine duration S/S_O (decreasing cloudiness). One can see in Fig. 8, that relatively heigh values of global solar radiation ($K{\downarrow}/G_O$>50%) also occur when the sun is obscured by clouds (S/S_O -> 0). This is caused by multiple reflection of short-wave radiation between the snow covered surface and the cloudbase which reduces the cloud influences on the global solar radiation remarkably.

According to Schwerdtfeger (1984) the ratio $K{\downarrow}/G_O$ near sea level ranges between 55 and 65 % over Antarctica. At Neumayer Station the average ratio for $K{\downarrow}/G_O$ of 58% falls well into that slot.

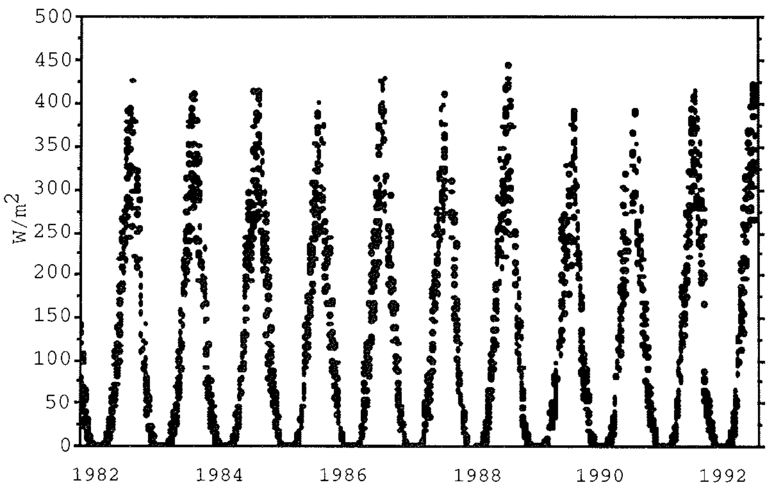


Fig. 6: Global radiation K↓, daily averages

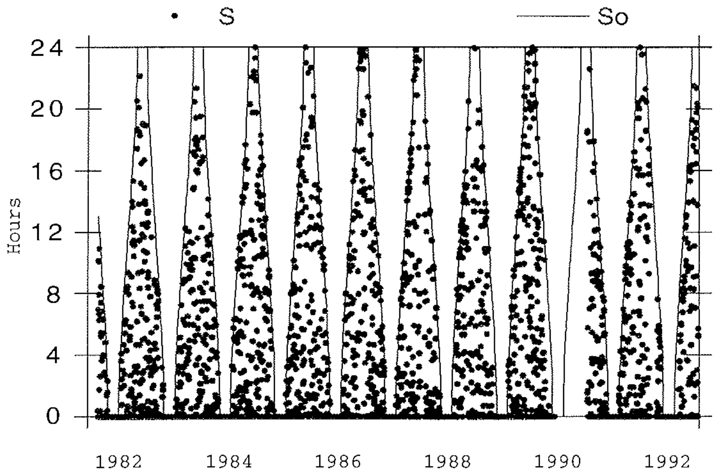


Fig. 7: Observed sunshine duration S and astronomical sunshine duration S_o in hours

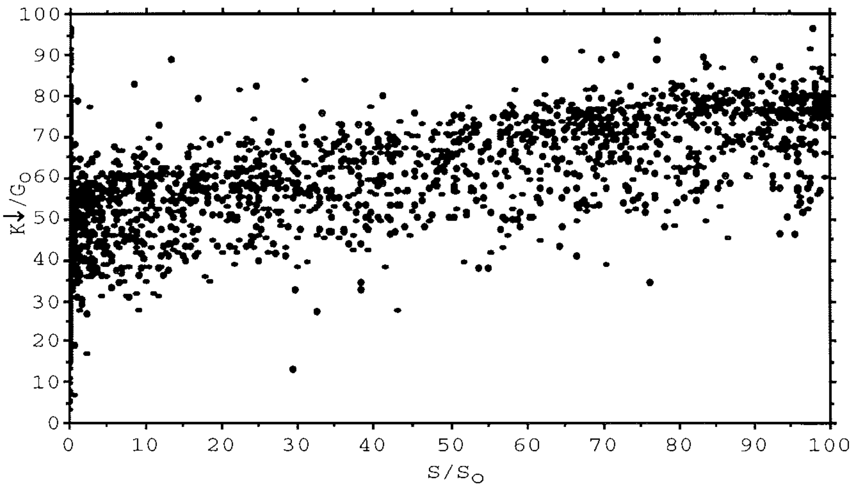


Fig. 8: Scattergram of $K\downarrow / G_o$ versus S/S_o in per cent, daily averages 1982-1992

Fig. 9 shows the surface albedo values as calculated from daily averages of reflected and global solar radiation for $K\downarrow > 50$ W/m^2. The extremes of a < 70 % and a > 95 % are obtained around the polar night where K↓ and K↑ are rather low and an albedo derivation is quite uncertain. For the Neumayer Station the average albedo is determined as 84 % in close agreement with Schwerdtfeger's (1984) value (85 %) for Antarctic ice shelf stations. Values above 90 % are common after snow fall while an albedo around 75 % is typical for the seldom cases with minor melting processes.

The well pronounced annual cycle of the net short-wave radiation K^* can be seen in Fig. 10. Also during summertime K^* rarely exceeds values of 100 W/m^2.

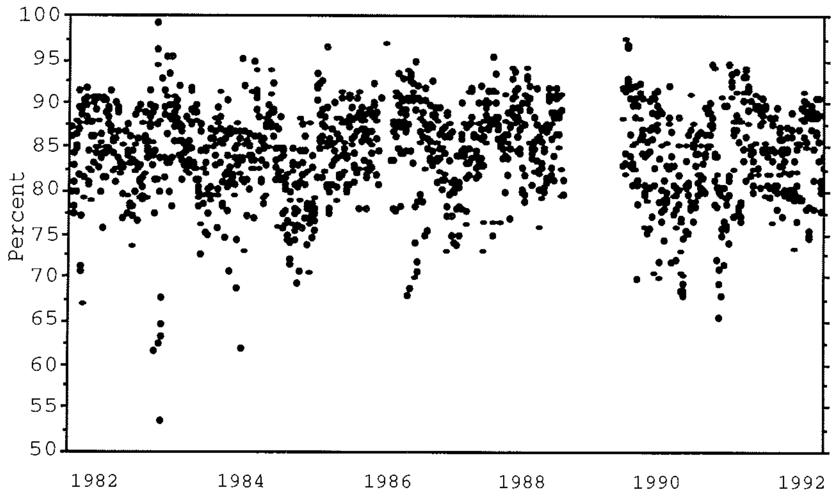


Fig. 9: Scattergram of surface albedo a (%) versus time for $K\downarrow > 50$ W/m^2, daily averages

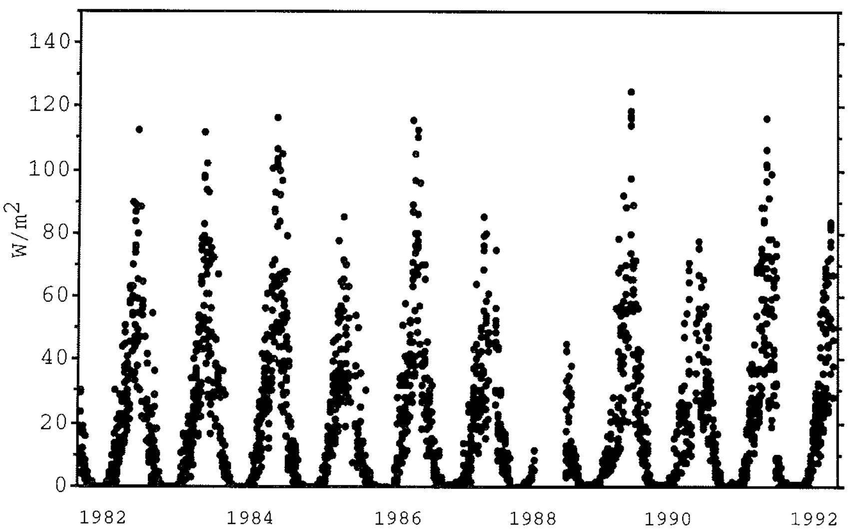


Fig. 10: Net short-wave radiation K^*, daily averages

4.3.2. Long-wave Radiation

The downward long-wave radiation L↓ on Fig. 11 is also governed by a distinct annual cycle with values above 300 W/m^2 in summer and minima of less than 150 W/m^2 in winter.

The so-called dimensionless Ångström ratio Å

$$Å = (L\uparrow - L\downarrow) / L\uparrow \tag{9}$$

with is occasionally used to characterize the long-wave surface radiation in polar regions (Schwerdtfeger, 1984) is reproduced on Fig. 12.

At about five per cent of all daily averages Å is negative, i.e. the net long-wave radiation L^* is positive. Such days are characterized by a cloud amount of $N \geq 7/8$ which result from low or medium level clouds and by a strong surface inversion layer.

For coastal Antarctic stations Schwerdtfeger (1984) derived monthly averages between 0.1 (winter) and 0.15 (summer) while equivalent values at Neumayer Station range from 0.09 (winter) to 0.11 (summer).

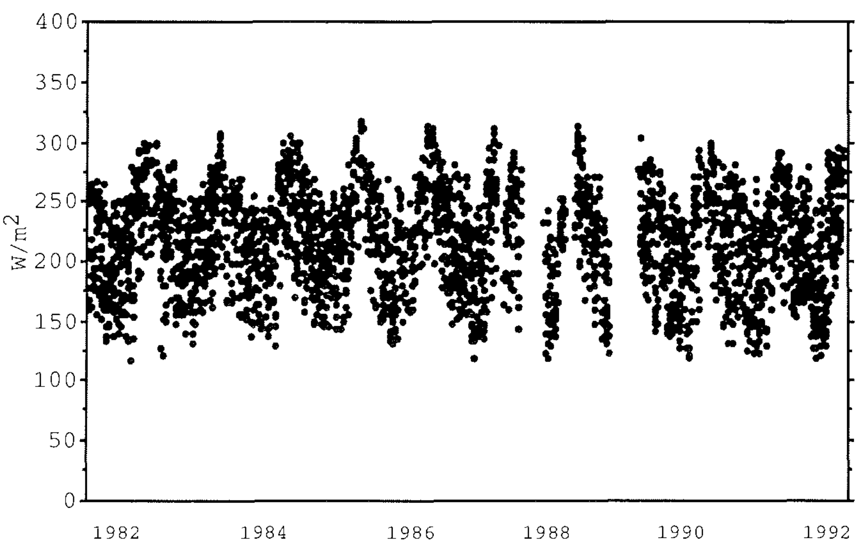


Fig. 11: Downward long-wave radiation L↓, daily averages

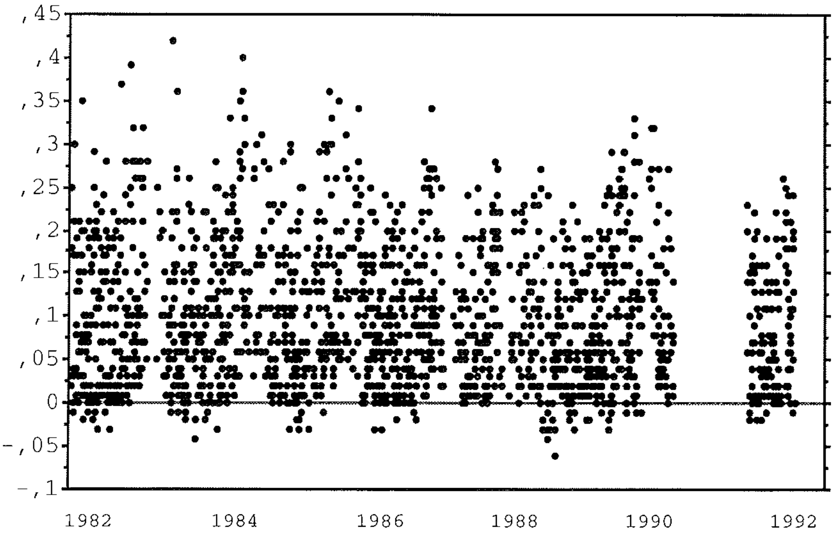


Fig. 12: Ångström ratio Å , daily averages

The net long-wave radiation L^* on Fig. 13 is mostly negative. An energy gain of the snow or ice due to long-wave radiation is basically restricted to situations with low level clouds and strong surface inversion.

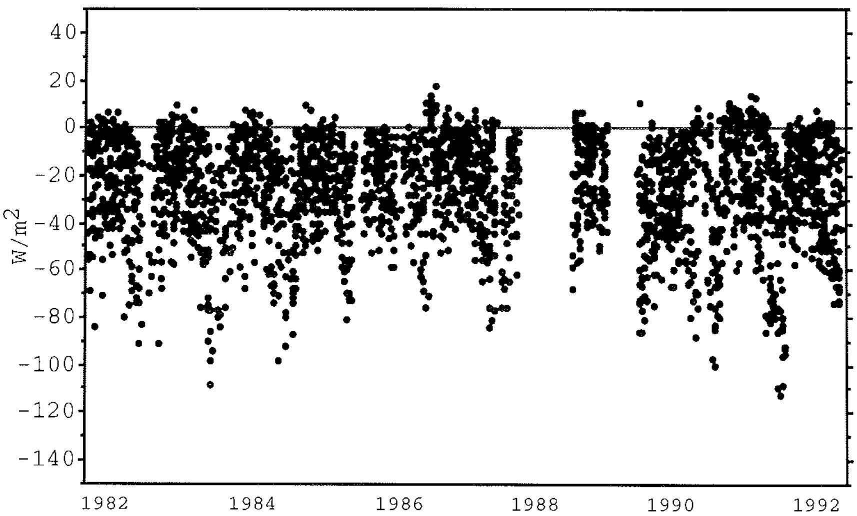


Fig. 13: Net long-wave radiation L^*, daily averages

4.3.3. Net Total Radiation

The net total radiation Q^* in Fig. 14 shows again a distinct annual cycle with a moderate energy gain of the underlying ice or snow in summer and a more pronounced energy loss in winter.

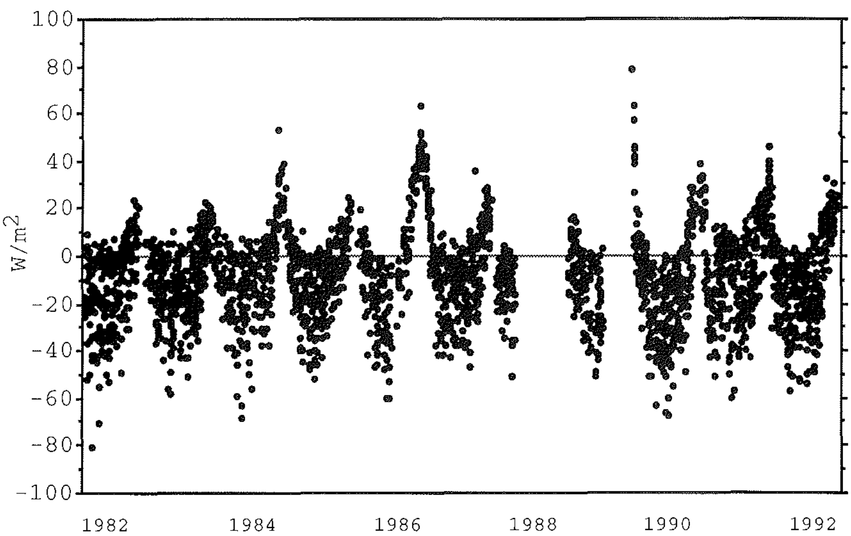


Fig. 14: Net total radiation Q^*, daily averages

4.4. Time Series based on Monthly Averages

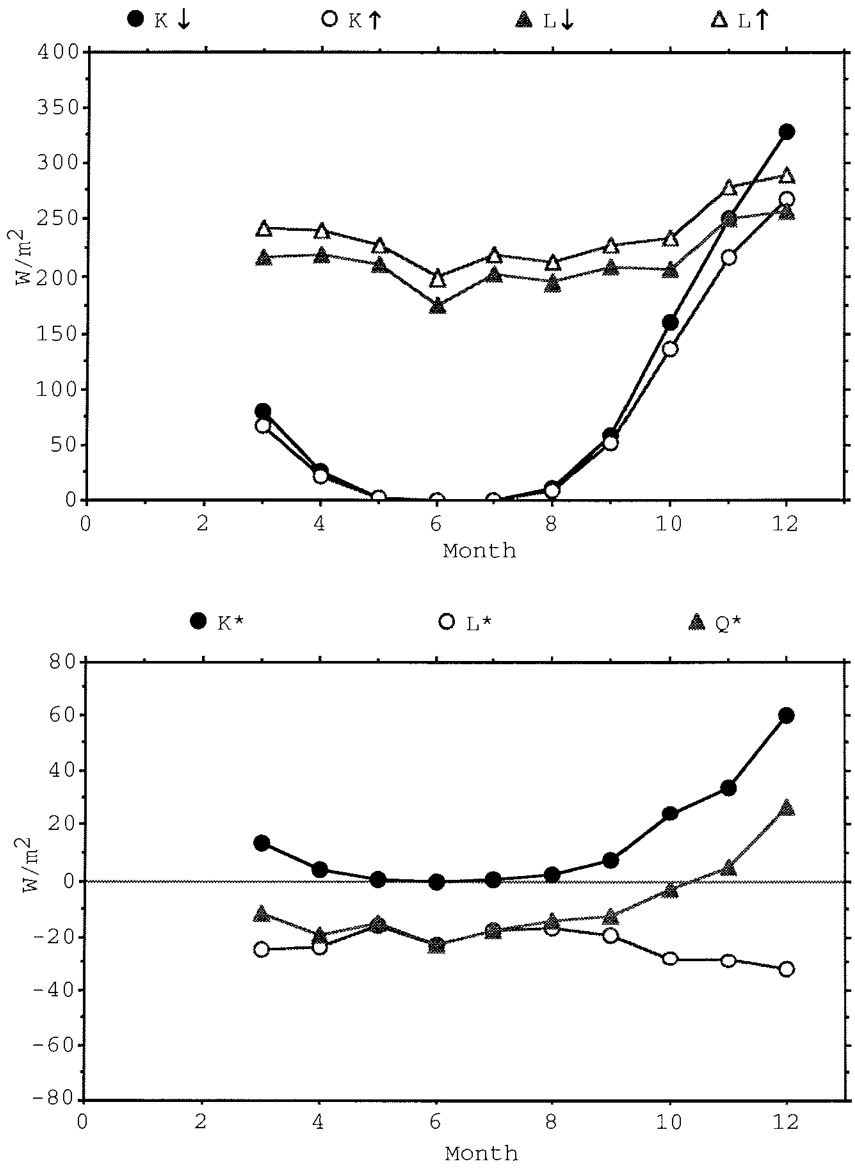
On the basis of the daily averages monthly averages were derived.

Data gaps present a particular problem for distinct seasonally varying quantities as the short-wave radiation components. A gap of a few days can cause a large bias in the resulting average. In Tab. 2 one can see that gaps occur especially in 1988-1990. A special treatment for missing daily averages has not been performed. Thus, some monthly averages may be rather uncertain while some could not be derived at all.

Subsequently the annual changes of the various radiation components are displayed for each year from 1982 to 1992 with the aid of plotted and tabulated monthly averages.

During summer when instruments were replaced and the crew changed the data aquisition suffered from a higher rate of missing values. These shortcomings have influenced particularly the monthly averages of February.

1982



Figs. 15a-15b: Monthly averages of short- and long-wave radiation components for 1982 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1982 (below)

1982

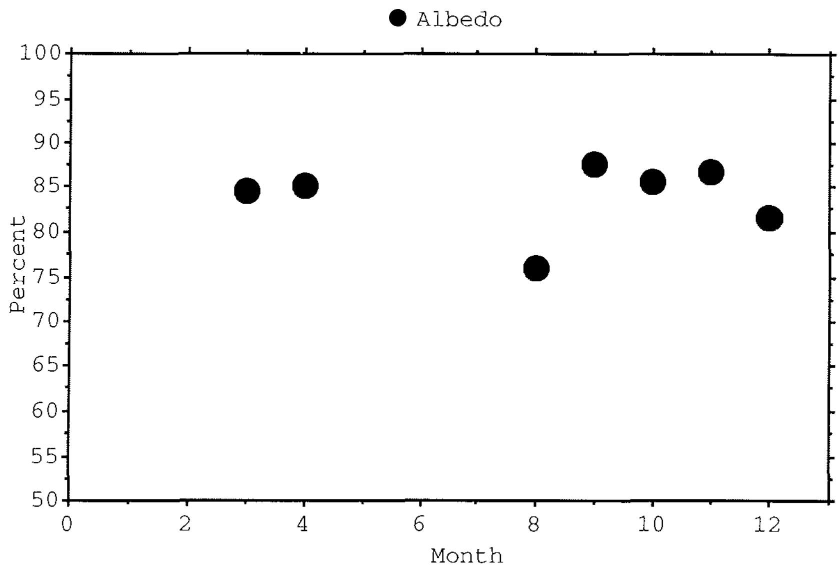
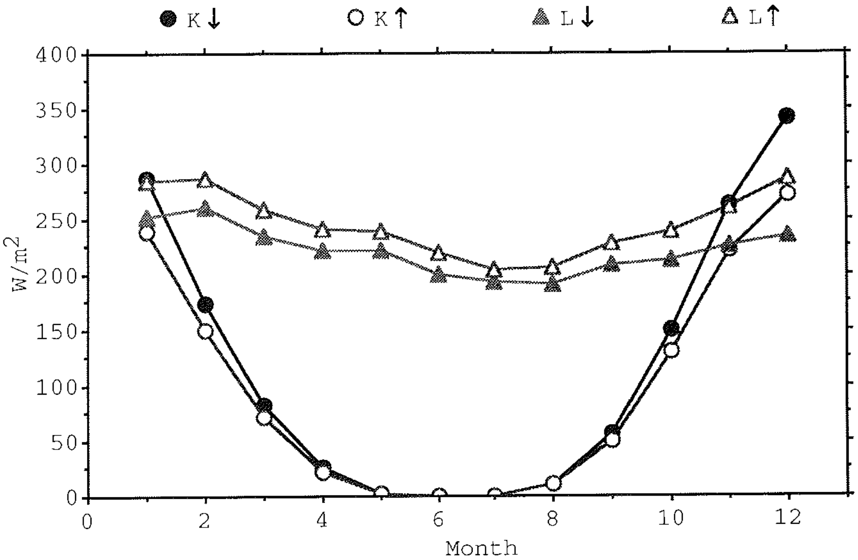


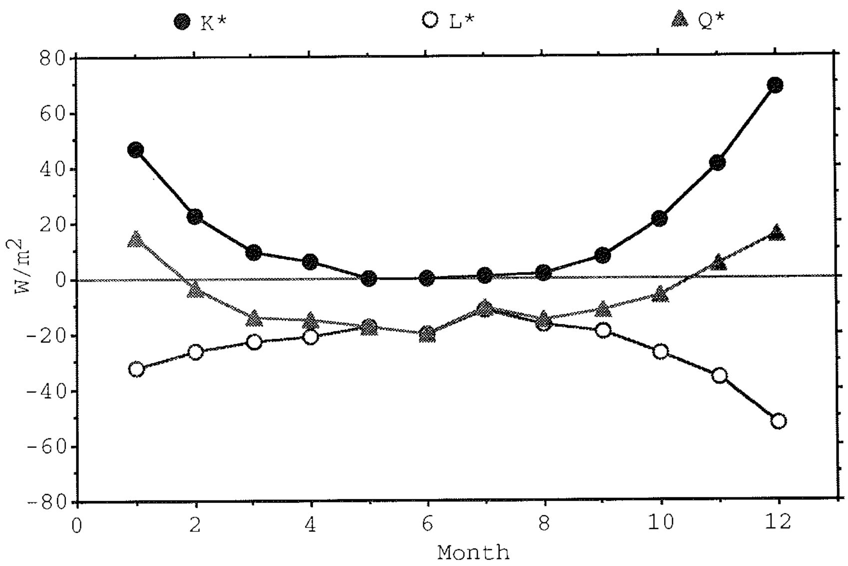
Fig. 15c: Monthly averages of surface albedo for 1982

Mon	K↓	K↓/G_o	K↑	L↓	L↑	S	S/S_o	a	K^*	L^*	Q^*
Jan	•	•	•	•	•	•	•	•	•	•	•
Feb	•	•	•	•	•	•	•	•	•	•	•
Mar	79	56	66	216	241	77	35	85	13	-25	-12
Apr	25	47	22	218	241	67	28	85	3	-23	-20
May	1	40	1	210	226	6	10	•	1	-16	-15
Jun	0	•	0	175	198	0	•	•	0	-23	-23
Jul	0	0	0	200	218	0	0	•	0	-18	-18
Aug	10	43	8	194	211	27	15	76	2	-17	-15
Sep	59	53	52	208	228	59	18	88	7	-20	-13
Oct	161	63	136	205	233	168	35	86	25	-28	-3
Nov	250	60	216	250	279	137	21	87	34	-29	5
Dec	328	63	268	257	289	216	29	82	60	-32	28

Tab. 6: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_o, S/S_o, a in % for 1982

1983





Figs. 16a-16b: Monthly averages of short- and long-wave radiation components for 1983 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1983 (below)

1983

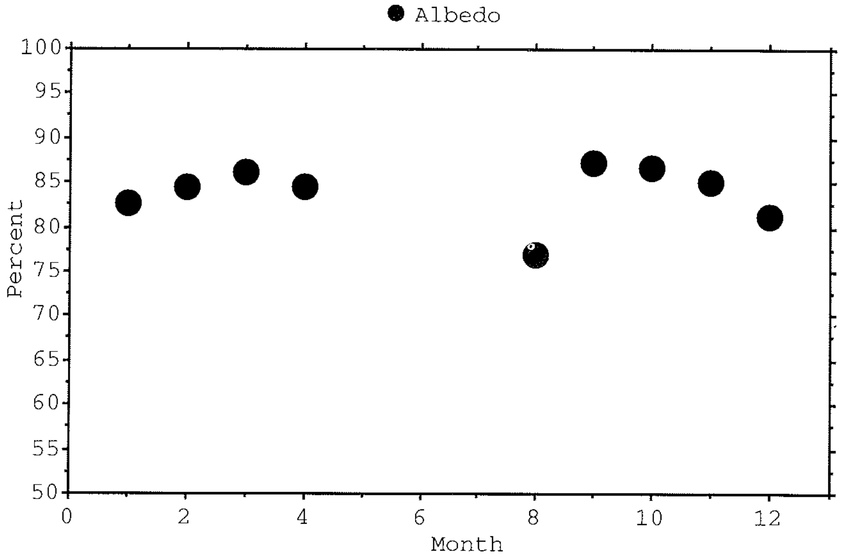
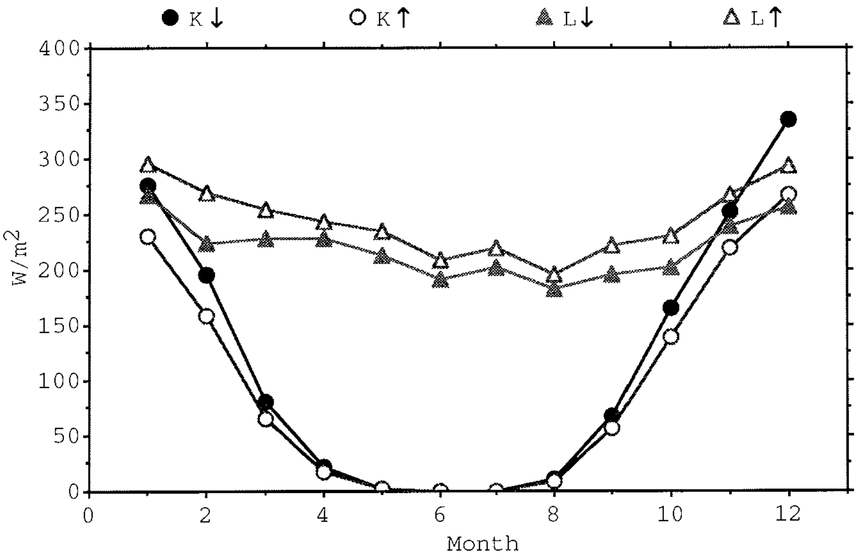


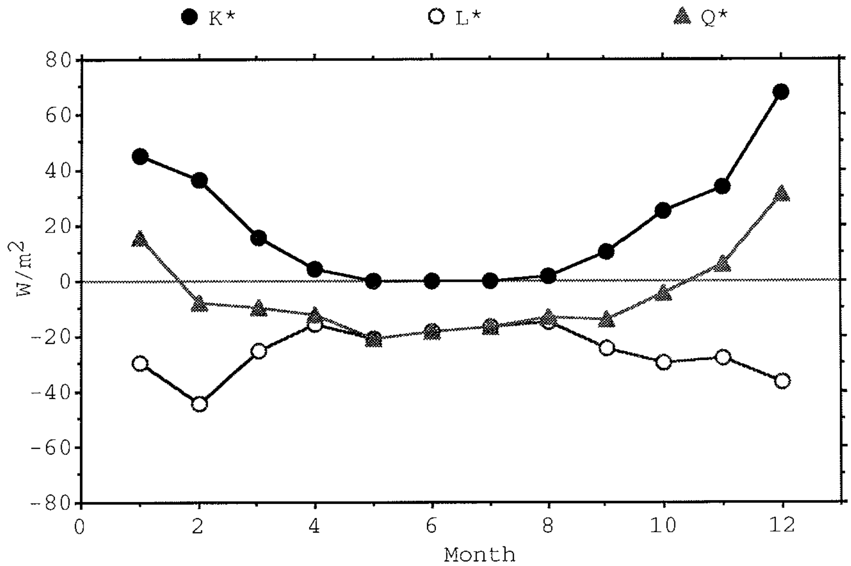
Fig. 16c: Monthly averages of surface albedo for 1983

Mon	K↓	K↓/G_o	K↑	L↓	L↑	S	S/S_o	a	K^*	L^*	Q^*
Jan	286	60	239	253	285	231	32	83	47	-32	15
Feb	173	53	151	260	286	65	13	85	22	-26	-4
Mar	82	47	72	235	258	70	18	86	10	-23	-13
Apr	27	51	21	221	242	59	25	85	6	-21	-15
May	1	30	1	222	240	8	14	•	0	-18	-18
Jun	0	•	0	199	219	0	•	•	0	-20	-20
Jul	0	0	0	194	205	0	0	•	0	-11	-11
Aug	12	50	10	191	208	39	21	77	2	-17	-15
Sep	57	51	50	209	228	67	20	87	7	-19	-12
Oct	150	59	129	212	239	144	30	87	21	-27	-6
Nov	262	63	221	226	261	196	30	85	41	-35	6
Dec	341	66	273	235	288	297	40	81	68	-53	15

Tab. 7: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_o, S/S_o, a in % for 1983

1984





Figs. 17a-17b: Monthly averages of short- and long-wave radiation components for 1984 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1984 (below)

1984

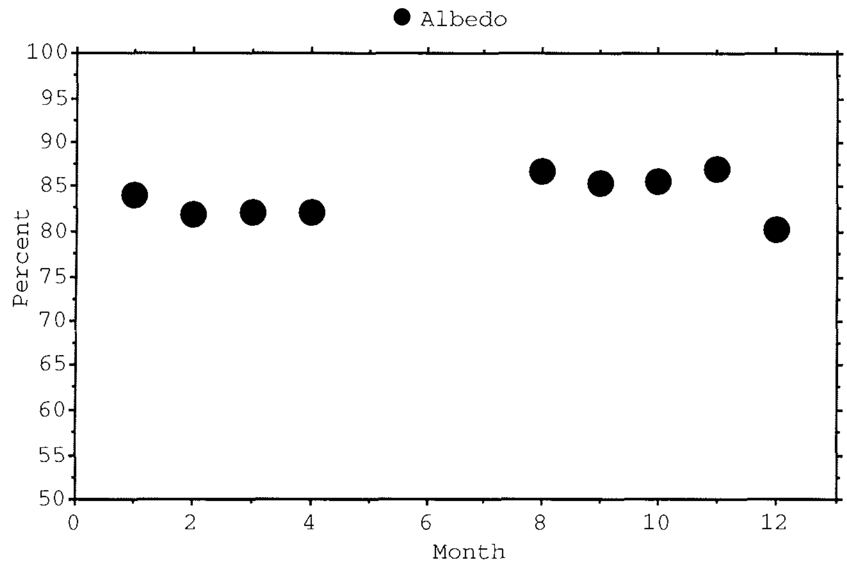
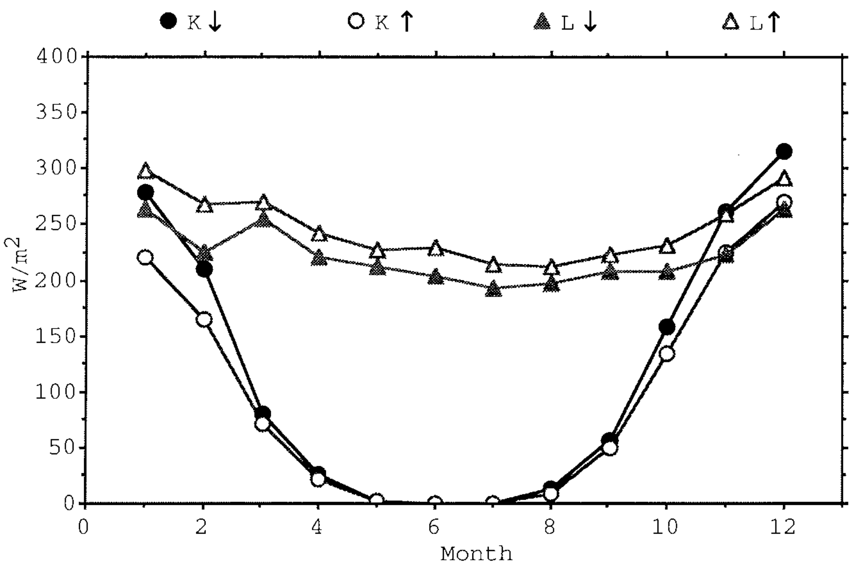


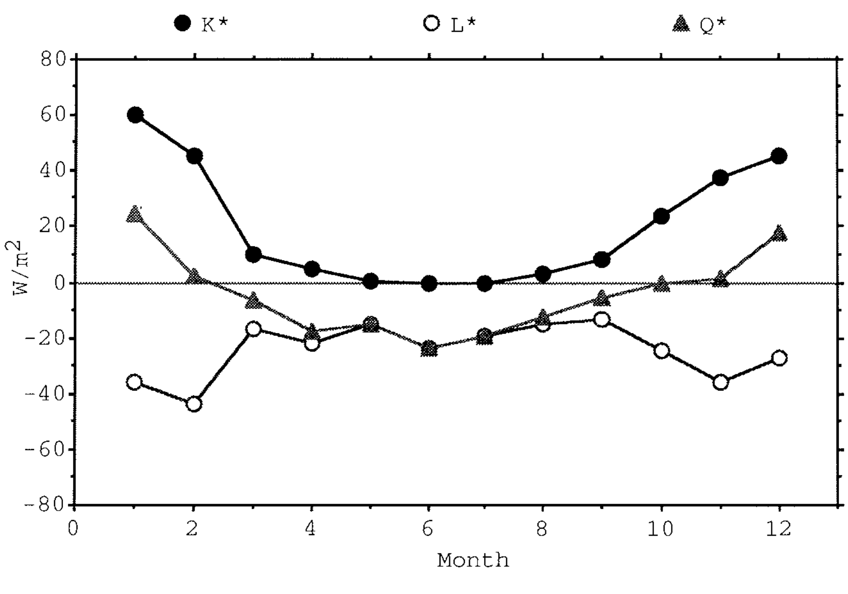
Fig. 17c: Monthly averages of surface albedo for 1984

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	276	58	231	267	297	153	21	84	45	-30	15
Feb	195	60	159	225	270	142	28	82	36	-45	-9
Mar	81	49	49	229	254	77	20	82	15	-25	-10
Apr	22	43	18	227	243	43	19	82	4	-16	-12
May	2	37	2	213	234	6	11	•	0	-21	-21
Jun	•	•	0	191	209	0	•	•	0	-18	-18
Jul	0	0	0	203	219	0	0	•	0	-16	-16
Aug	10	41	9	182	196	38	20	87	1	-14	-13
Sep	66	57	57	197	221	124	37	85	10	-24	-14
Oct	166	64	140	201	231	194	40	86	26	-30	-4
Nov	253	60	219	239	268	113	17	87	34	-29	5
Dec	334	64	267	257	293	244	33	80	67	-36	31

Tab. 8: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_0, S/S_0, a in % for 1984

1985





Figs. 18a-18b: Monthly averages of short- and long-wave radiation components for 1985 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1985 (below)

1985

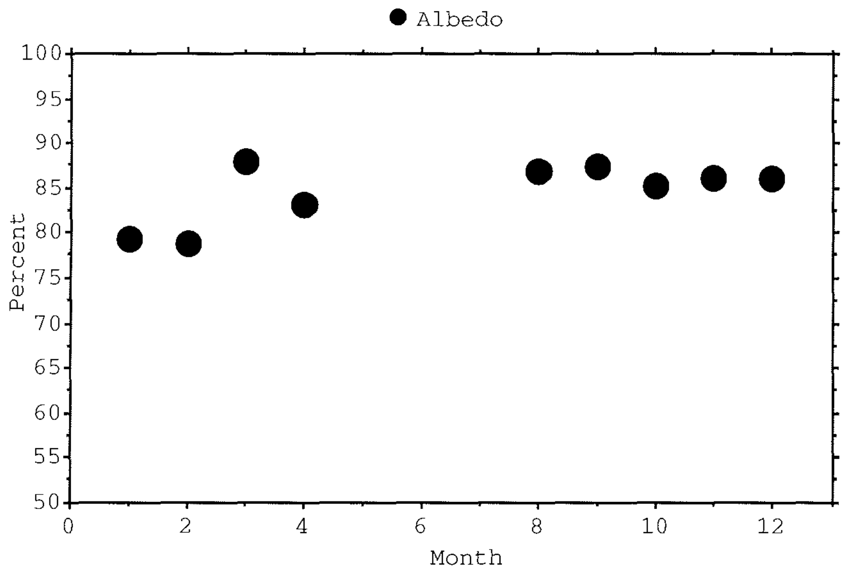
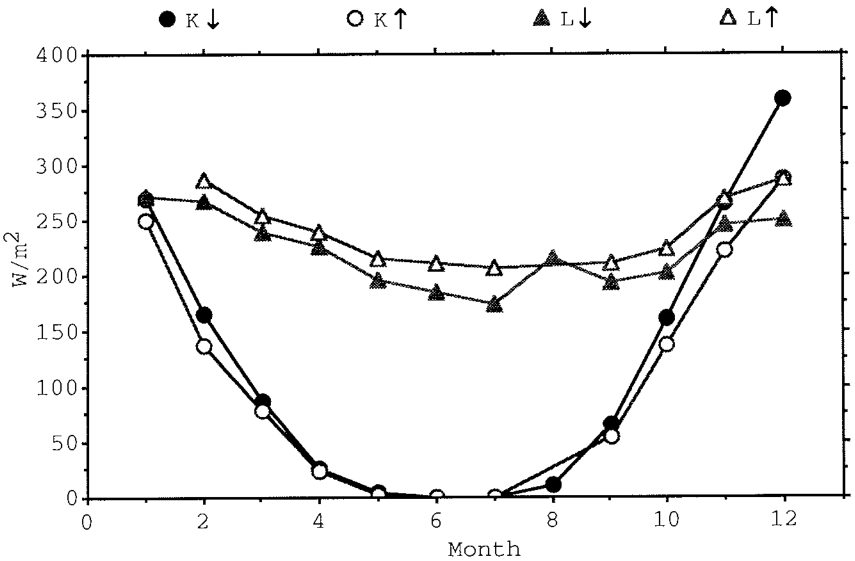


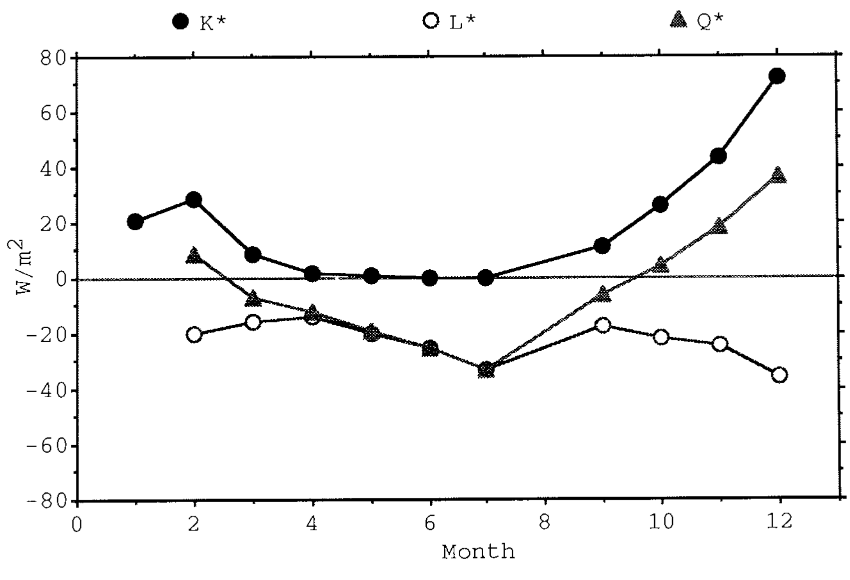
Fig. 18c: Monthly averages of surface albedo for 1985

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	279	59	220	264	299	210	29	79	59	-35	24
Feb	209	64	164	226	269	272	56	79	45	-43	2
Mar	81	47	71	254	271	94	24	88	10	-17	-7
Apr	25	47	21	220	243	87	36	83	4	-23	-19
May	1	41	1	211	226	0	1	•	1	-15	-14
Jun	0	•	0	204	228	0	•	•	0	-24	-24
Jul	0	0	0	193	213	2	23	•	0	-20	-20
Aug	12	52	9	197	213	51	27	87	3	-16	-13
Sep	57	51	49	209	222	86	26	87	8	-13	-5
Oct	157	62	134	207	231	176	36	85	23	-24	-1
Nov	262	63	225	223	258	181	28	86	37	-35	2
Dec	316	61	270	264	291	286	25	86	46	-27	19

Tab. 9: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_o, S/S_o, a in % for 1985

1986





Figs. 19a-19b: Monthly averages of short- and long-wave radiation components for 1986 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1986 (below)

1986

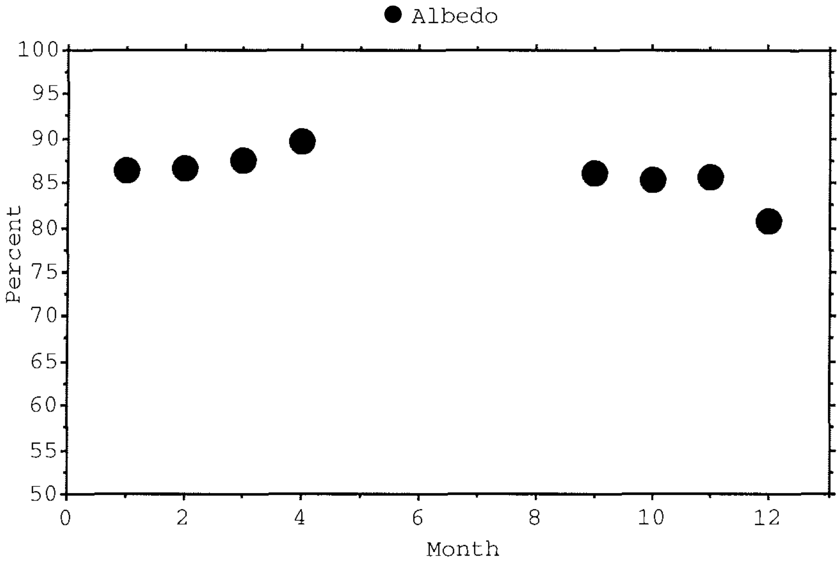
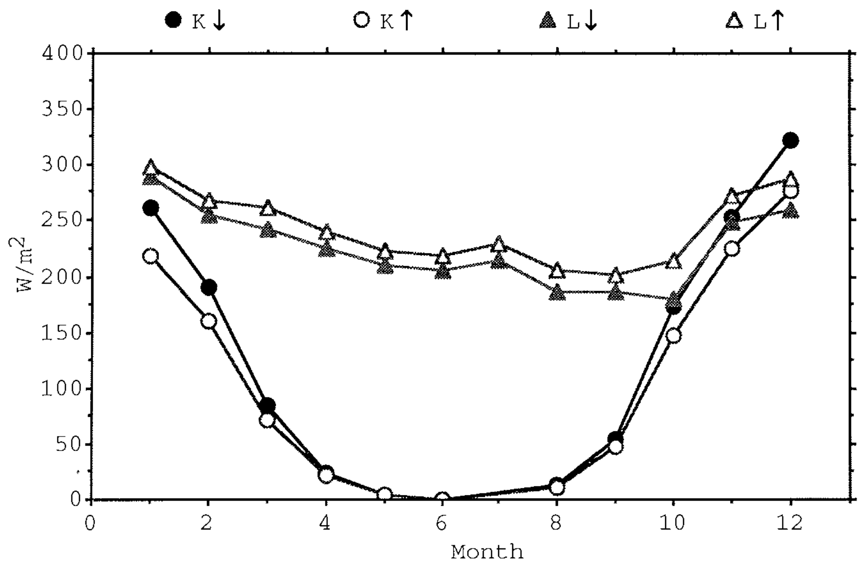


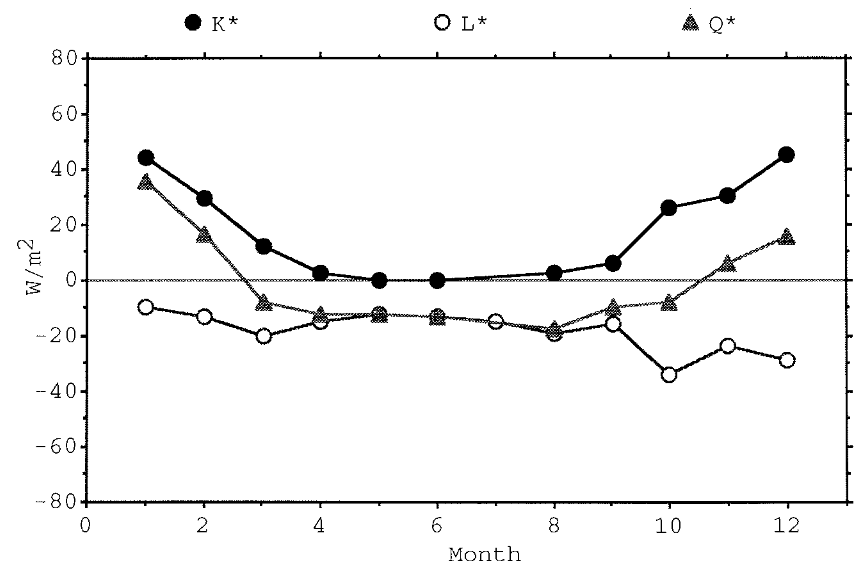
Fig. 19c: Monthly averages of surface albedo for 1986

Mon	$K\downarrow$	$K\downarrow/G_o$	$K\uparrow$	$L\downarrow$	$L\uparrow$	S	S/S_o	a	K^*	L^*	Q^*
Jan	270	57	249	272	•	248	34	87	21	•	•
Feb	166	51	138	266	287	93	19	87	28	-21	7
Mar	87	51	78	239	255	124	32	87	9	-16	-7
Apr	27	49	25	226	240	57	24	90	2	-14	-12
May	2	46	2	195	215	12	21	•	0	-20	-20
Jun	0	•	0	185	211	0	•	•	0	-26	-26
Jul	0	0	0	174	207	0	0	•	0	-33	-33
Aug	11	45	•	215	•	27	14	•	•	•	•
Sep	65	59	54	193	210	103	31	86	11	-17	-6
Oct	162	63	136	203	224	197	41	85	26	-21	5
Nov	266	64	223	245	270	174	27	86	43	-25	18
Dec	358	69	286	251	287	411	55	81	72	-36	36

Tab. 10: Monthly averages of $K\downarrow$, $K\uparrow$, $L\downarrow$, $L\uparrow$, K^*, L^*, Q^* in W/m^2, S in hours, $K\downarrow/G_o$, S/S_o, a in % for 1986

1987





Figs. 20a-20b: Monthly averages of short- and long-wave radiation components for 1987 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1987 (below)

1987

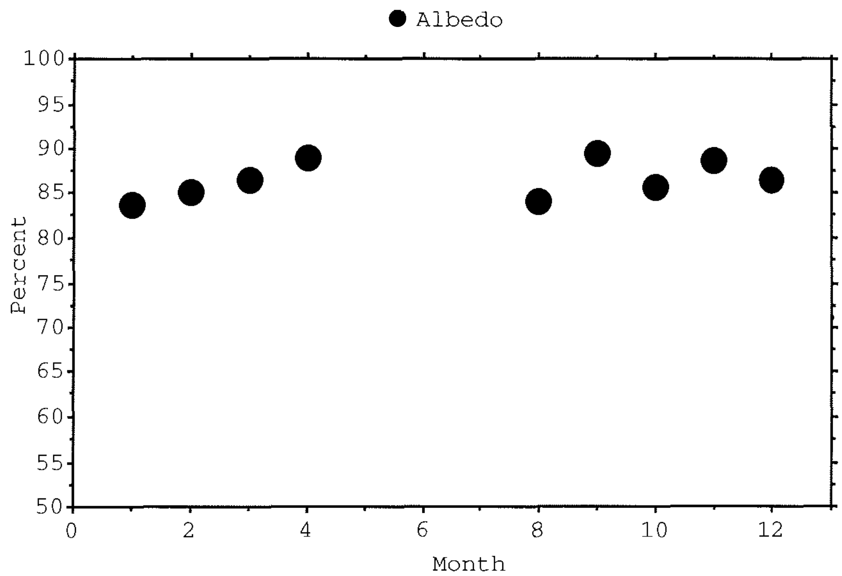
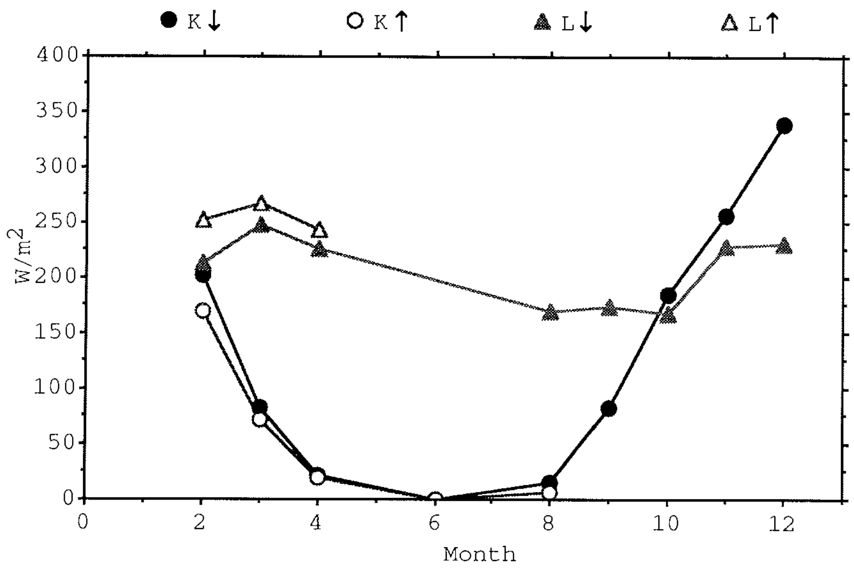


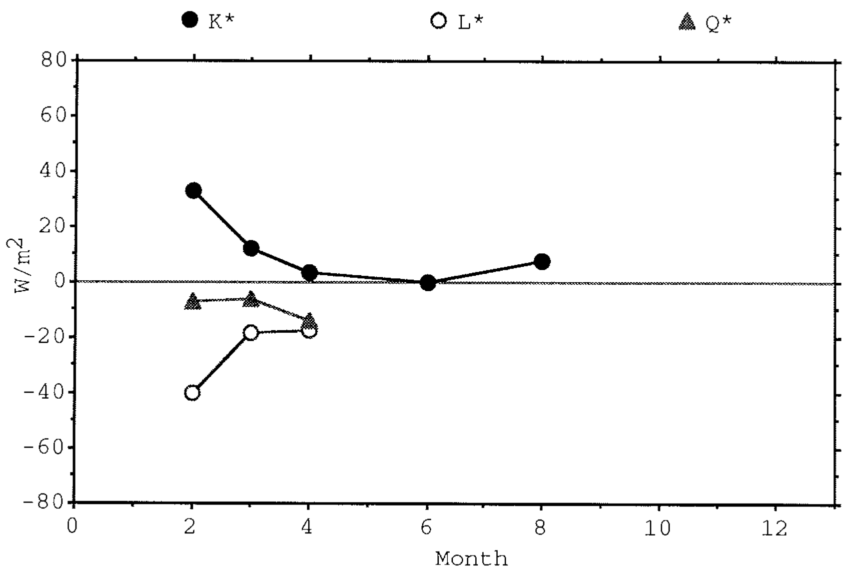
Fig. 20c: Monthly averages of surface albedo for 1987

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	262	55	218	289	299	98	14	84	44	-10	34
Feb	190	58	161	255	269	199	41	85	29	-14	-15
Mar	84	49	72	242	261	88	23	86	12	-19	-7
Apr	23	43	21	226	240	65	27	89	2	-14	-12
May	1	41	1	209	222	16	27	•	1	-13	-12
Jun	0	•	0	205	218	0	•	•	0	-13	-13
Jul	0	0	0	215	229	2	21	•	0	-14	-14
Aug	13	54	11	186	205	65	35	84	2	-19	-17
Sep	54	48	48	185	201	99	30	89	6	-16	-10
Oct	174	68	148	179	213	293	61	86	26	-34	-8
Nov	254	61	224	248	272	213	33	89	30	-24	6
Dec	322	62	277	259	288	239	32	87	45	-29	16

Tab. 11: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_0, S/S_0, a in % for 1987

1988





Figs. 21a-21b: Monthly averages of short- and long-wave radiation components for 1988 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1988 (below)

1988

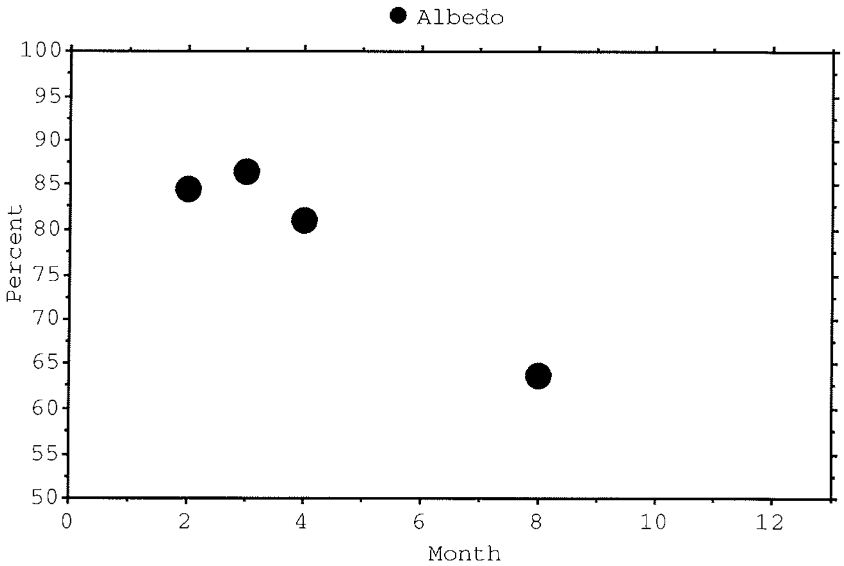
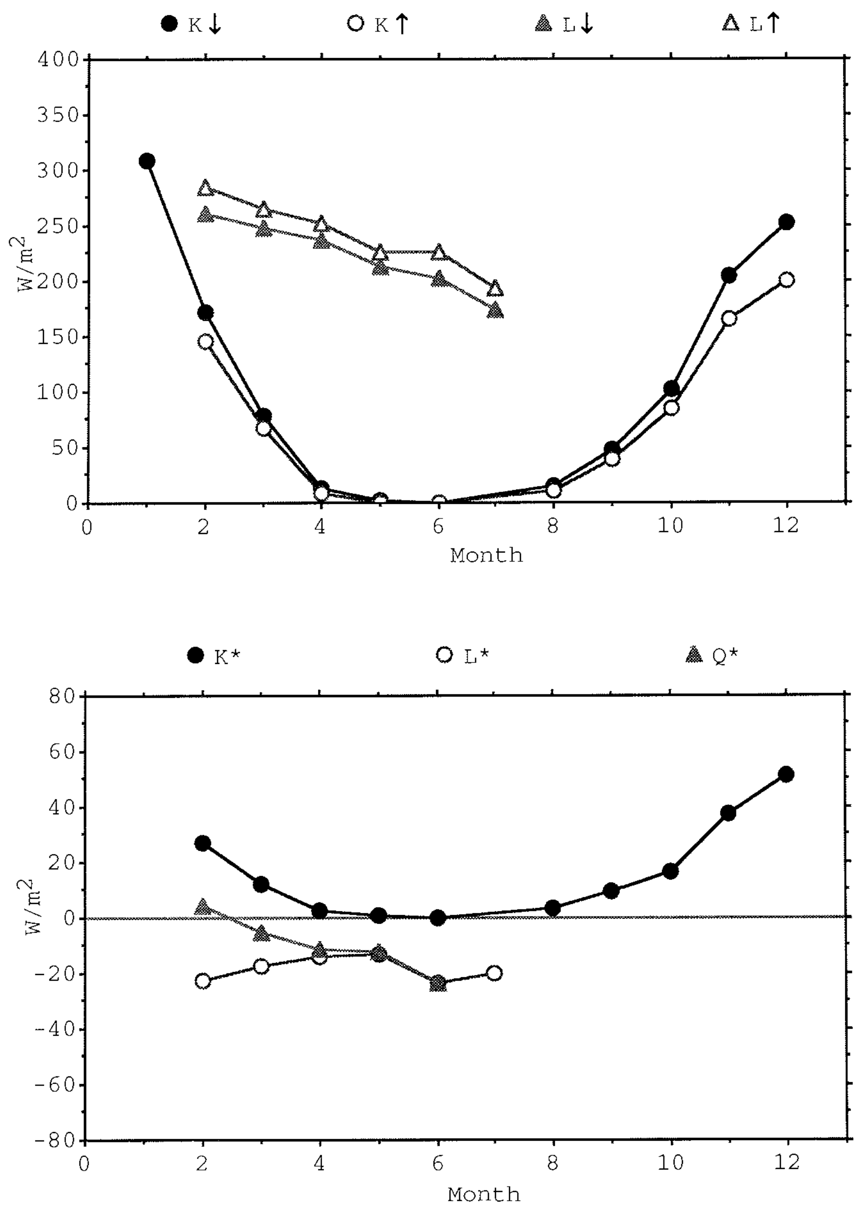


Fig. 21c: Monthly averages of surface albedo for 1988

Mon	K↓	K↓/G_o	K↑	L↓	L↑	S	S/S_o	a	K^*	L^*	Q^*
Jan	•	•	•	•	•	•	•	•	•	•	•
Feb	201	62	169	213	253	180	36	85	32	-40	-8
Mar	83	50	71	249	267	95	25	87	12	-18	-6
Apr	23	44	19	226	244	32	14	81	4	-18	-14
May	•	•	•	•	•	4	7	•	•	•	•
Jun	0	0	0	•	•	0	•	•	0	•	•
Jul	•	•	•	•	•	0	0	•	•	•	•
Aug	15	58	7	170	•	24	13	64	8	•	•
Sep	82	71	•	174	•	201	60	•	•	•	•
Oct	186	71	•	167	•	302	62	•	•	•	•
Nov	257	61	•	228	•	89	14	•	•	•	•
Dec	339	65	•	231	•	229	31	•	•	•	•

Tab. 12: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_o, S/S_o, a in % for 1988

1989



Figs. 22a-22b: Monthly averages of short- and long-wave radiation components for 1989 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1989 (below)

1989

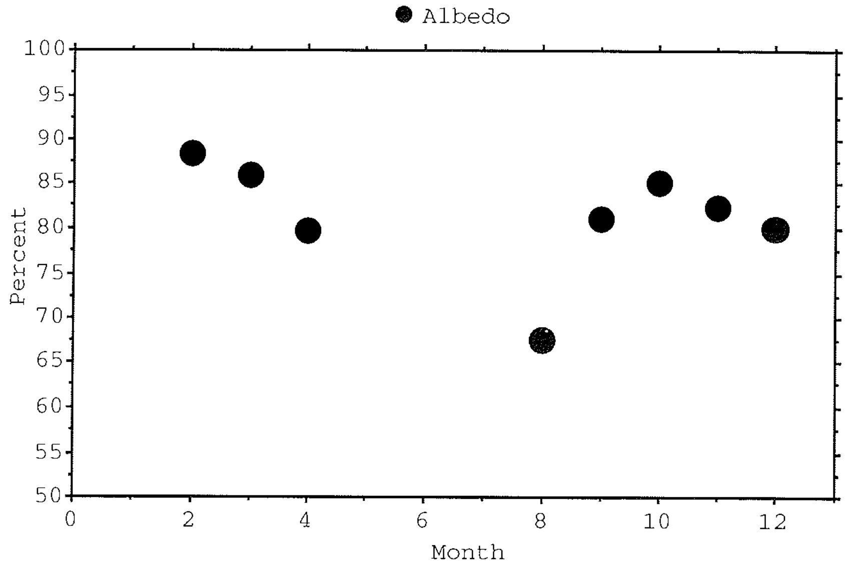
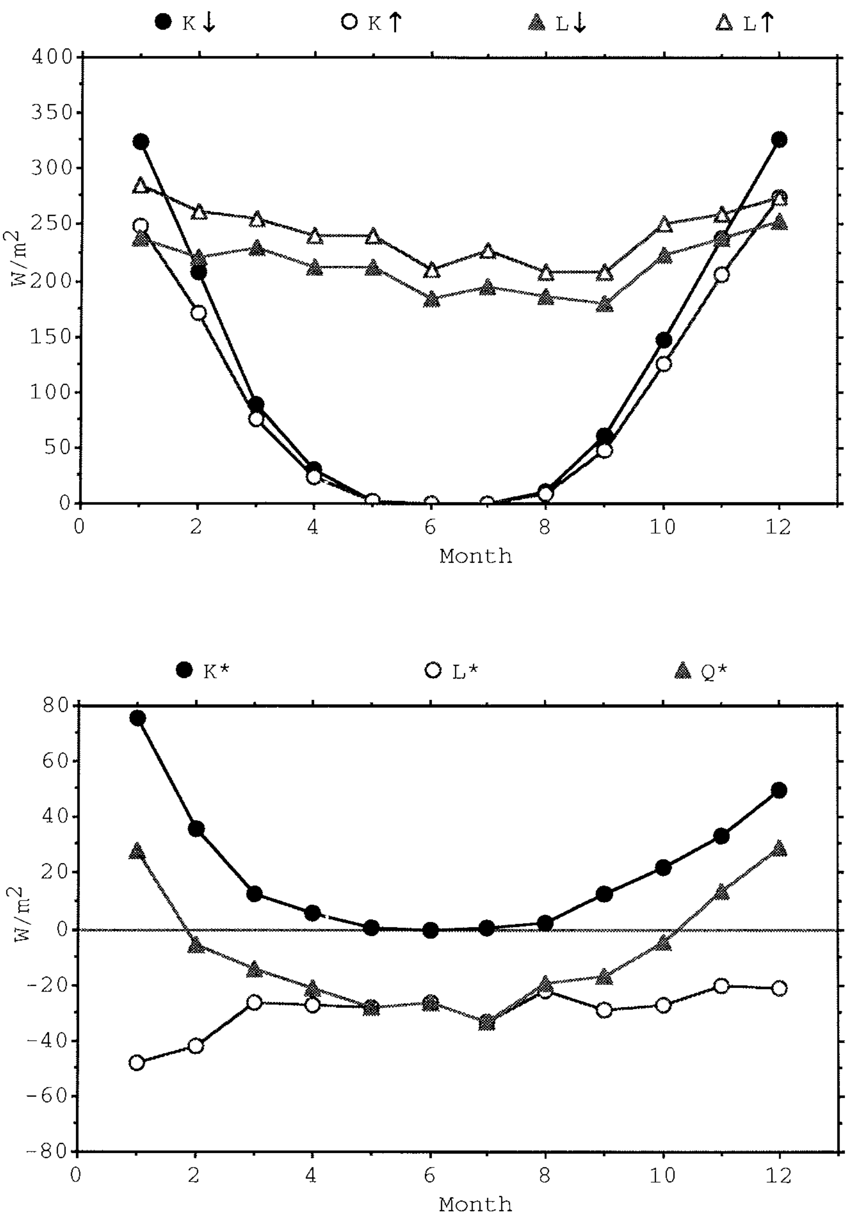


Fig. 22c: Monthly averages of surface albedo for 1989

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	308	65	•	•	•	147	20	•	•	•	•
Feb	172	52	145	261	284	185	38	88	27	-23	4
Mar	79	46	67	247	265	112	29	86	12	-18	-6
Apr	12	22	10	238	252	11	4	80	2	-14	-12
May	1	37	1	213	226	0	0	•	0	-13	-13
Jun	0	•	0	203	226	0	•	•	0	-23	-23
Jul	0	0	0	174	194	0	0	•	0	-20	-20
Aug	15	65	11	•	•	60	32	68	4	•	•
Sep	48	43	39	•	•	119	36	81	9	•	•
Oct	101	40	85	•	•	264	55	85	16	•	•
Nov	203	49	166	•	•	265	40	83	37	•	•
Dec	252	48	200	•	•	373	50	80	52	•	•

Tab. 13: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, $K↓/G_o$, S/S_o, a in % for 1989

1990



Figs. 23a-23b: Monthly averages of short- and long-wave radiation components for 1990 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1990 (below)

1990

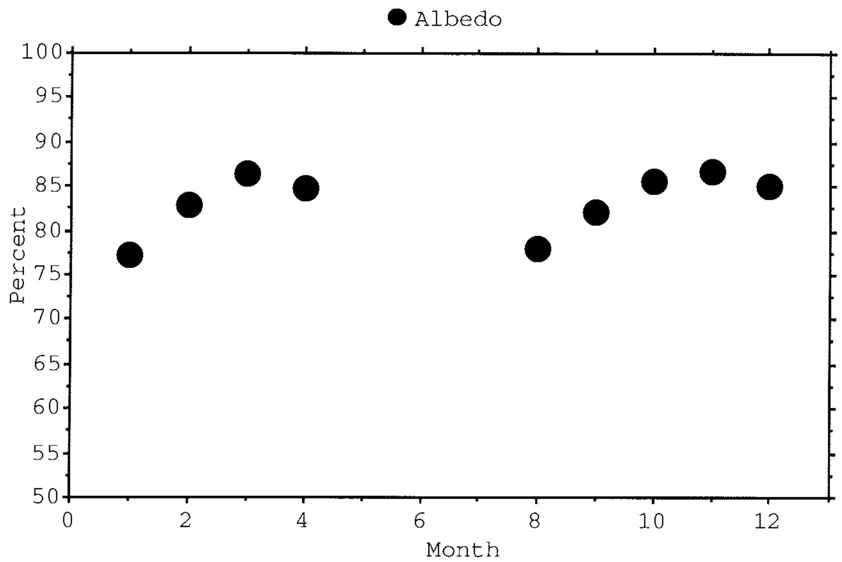
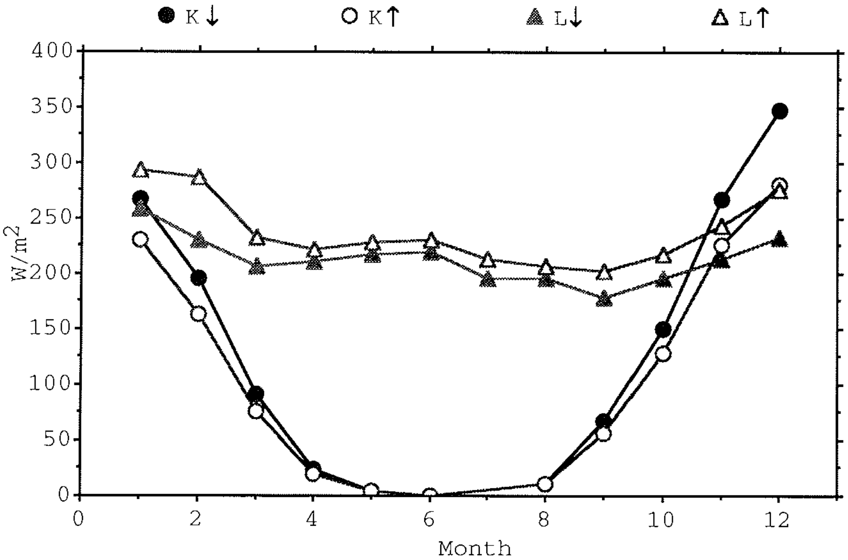


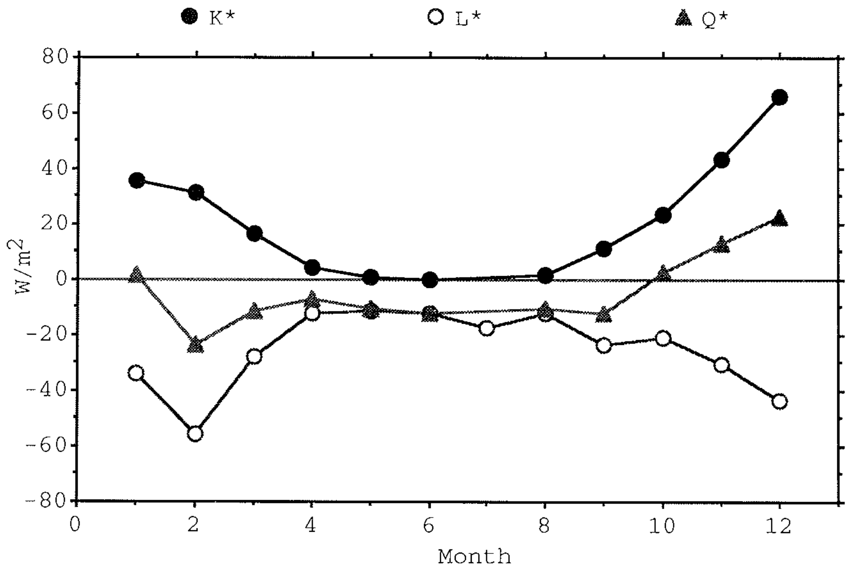
Fig. 23c: Monthly averages of surface albedo for 1990

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K^*	L^*	Q^*
Jan	324	68	248	239	286	344	48	77	76	-47	29
Feb	207	63	171	221	263	188	39	83	36	-42	-6
Mar	89	52	77	229	255	70	18	86	12	-26	-14
Apr	31	57	25	213	240	1	0	85	6	-27	-21
May	2	61	2	211	239	0	0	•	0	-28	-28
Jun	0	•	0	184	210	0	•	•	0	-26	-16
Jul	0	0	0	195	228	•	•	•	0	-33	-33
Aug	11	46	9	186	208	•	•	78	2	-22	-20
Sep	60	54	48	179	208	•	•	82	12	-29	-17
Oct	147	58	125	224	251	•	•	86	22	-27	-5
Nov	238	57	204	238	259	•	•	87	34	-21	13
Dec	326	63	276	253	275	21	3	85	50	-22	28

Tab. 14: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_O, S/S_O, a in % for 1990

1991





Figs. 24a-24b: Monthly averages of short- and long-wave radiation components for 1991 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1991 (below)

1991

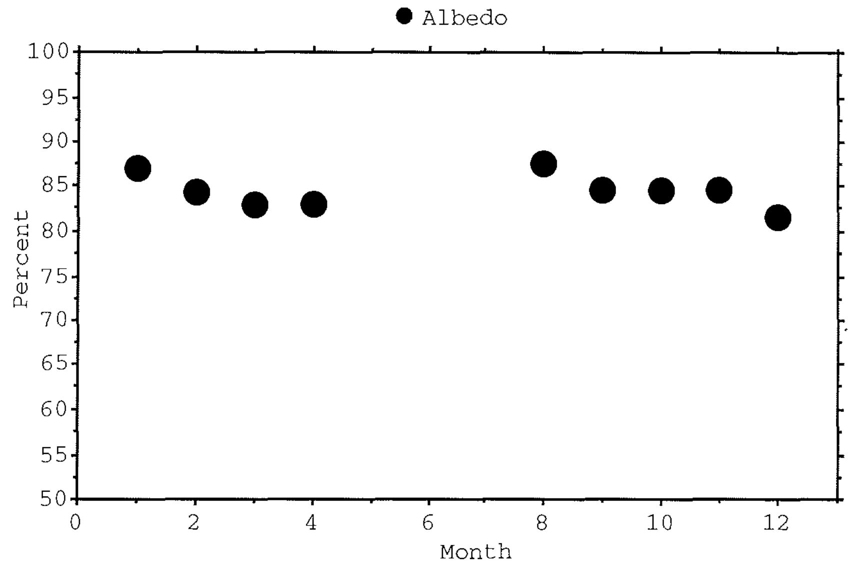
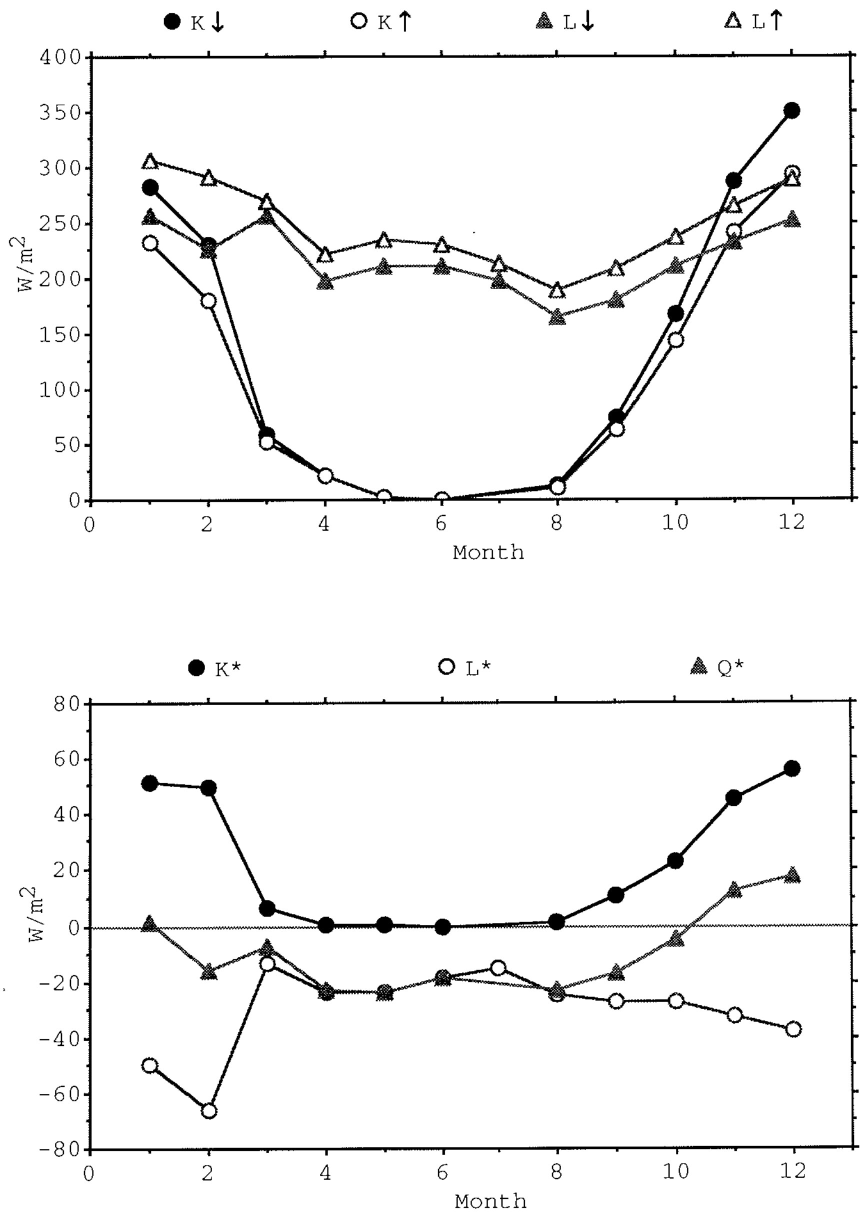


Fig. 24c: Monthly averages of surface albedo for 1991

Mon	K↓	K↓/G_o	K↑	L↓	L↑	S	S/S_o	a	K^*	L^*	Q^*
Jan	267	56	231	258	292	131	18	87	36	-34	2
Feb	195	60	164	231	286	164	34	84	31	-55	-24
Mar	92	54	76	205	234	151	39	83	16	-29	-13
Apr	25	46	20	210	222	68	29	83	5	-12	-7
May	2	59	2	217	228	2	4	•	0	-11	-11
Jun	0	•	0	219	231	0	•	•	0	-12	-12
Jul	0	0	0	195	213	4	43	•	0	-18	-18
Aug	12	50	10	196	207	47	25	88	2	-11	-9
Sep	68	61	57	179	202	154	47	85	11	-23	-12
Oct	151	59	128	197	217	150	31	85	23	-20	3
Nov	268	64	225	214	245	165	25	85	43	-31	12
Dec	347	67	281	233	276	284	38	82	66	-43	23

Tab. 15: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, K↓/G_o, S/S_o, a in % for 1991

1992



Figs. 25a-25b: Monthly averages of short- and long-wave radiation components for 1992 (above)
Monthly averages of net short-wave, net long-wave and net total radiation for 1992 (below)

1992

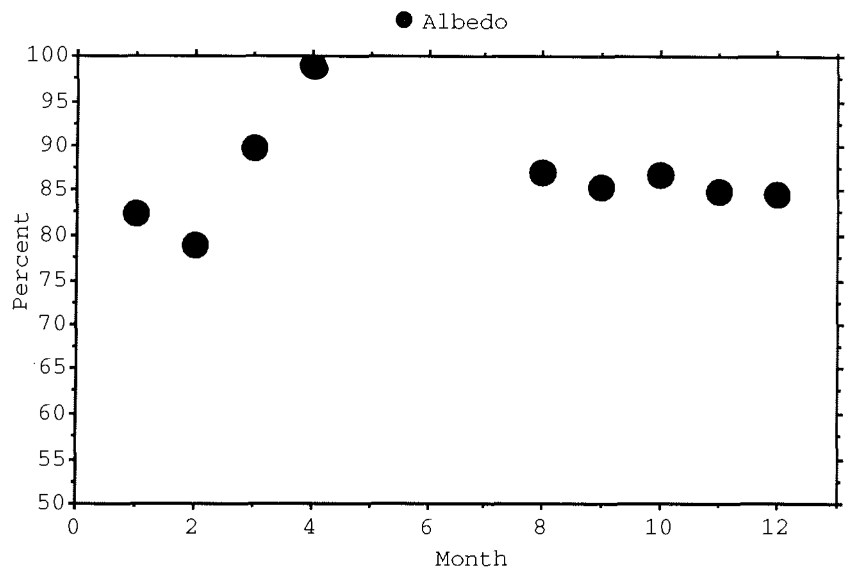


Fig. 25c: Monthly averages of surface albedo for 1992

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	283	60	232	257	307	173	24	82	51	-50	1
Feb	231	64	181	225	291	106	38	79	50	-66	-16
Mar	58	43	52	257	270	1	1	90	6	-13	-7
Apr	23	44	22	199	222	73	31	99	1	-23	-22
May	2	53	2	210	234	0	0	•	0	-24	-24
Jun	0	•	0	212	230	0	•	•	0	-18	-18
Jul	0	0	0	198	213	0	0	•	0	-15	-15
Aug	13	52	12	165	190	9	4	87	1	-25	-24
Sep	73	63	62	181	209	126	38	85	11	-28	-17
Oct	167	64	144	210	237	201	41	87	23	-27	-4
Nov	287	68	242	233	266	204	31	85	45	-33	12
Dec	349	67	293	251	289	268	36	84	56	-38	18

Tab. 16: Monthly averages of K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, $K↓/G_o$, S/S_o, a in % for 1992

4.5. Annual Averages

Based on the monthly averages in Tabs. 6-16 annual averages were calculated.

Years with less than 12 monthly averages (1982, 1988, 1989) were also considered. A comparison of single components such as K↓, K↑, L↓ and L↑ from such years with other annual averages should not be carried out while for budget values such as K^*, L^*, Q^* missing values have only a minor impact.

Annual averages of the various surface radiation components are shown for each year 1982 to 1992 in the following graphs (Figs. 26-36). Negative values denote that the surface loose energy due to radiation while positive values indicate an energy gain.

1982

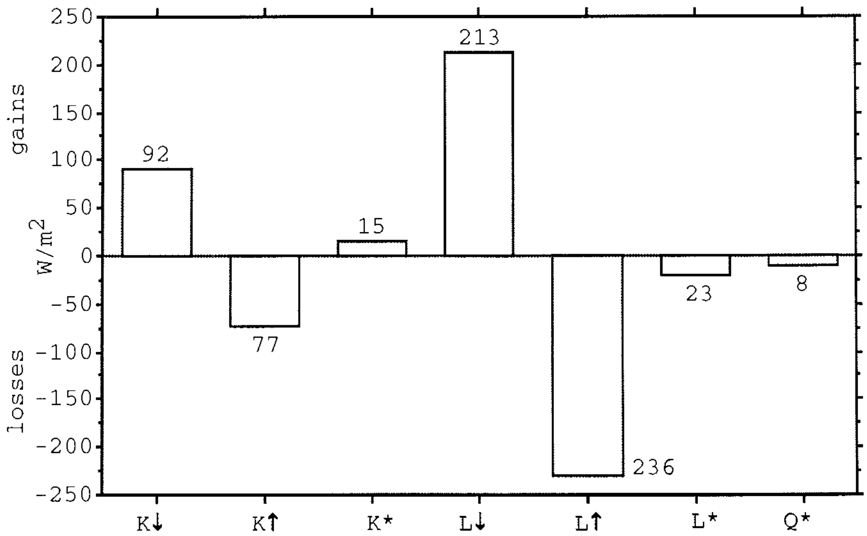
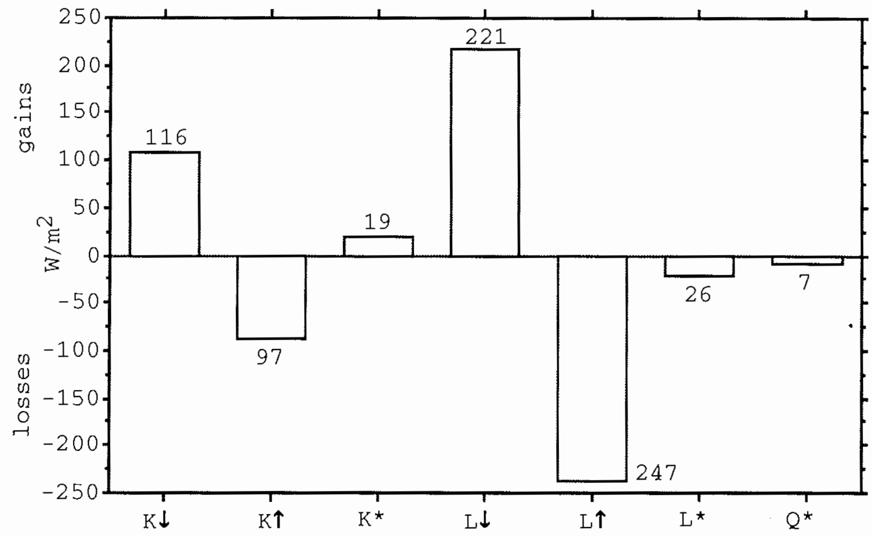
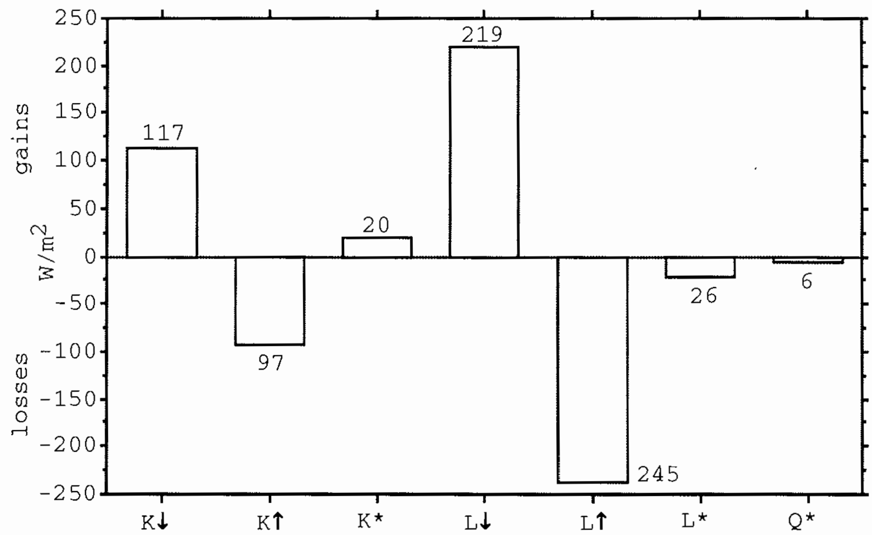


Fig. 26: Annual averages for 1982 (March-December only)

1983

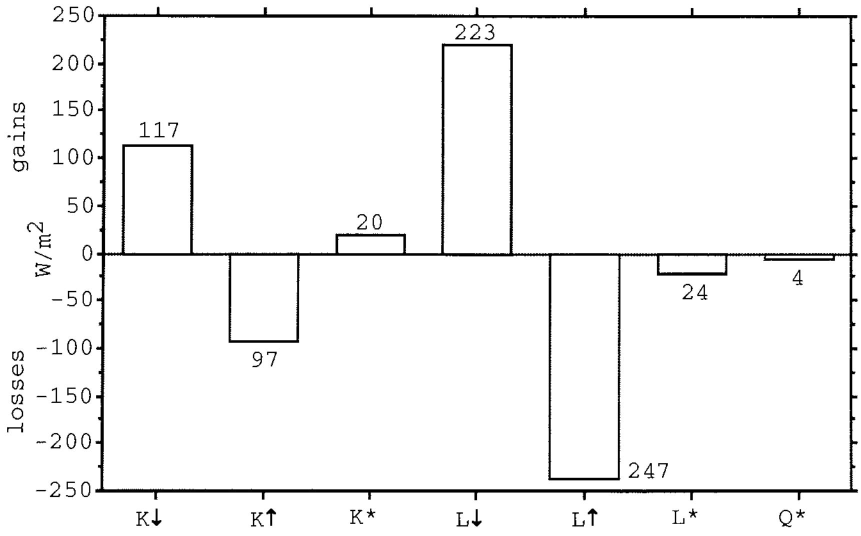


1984

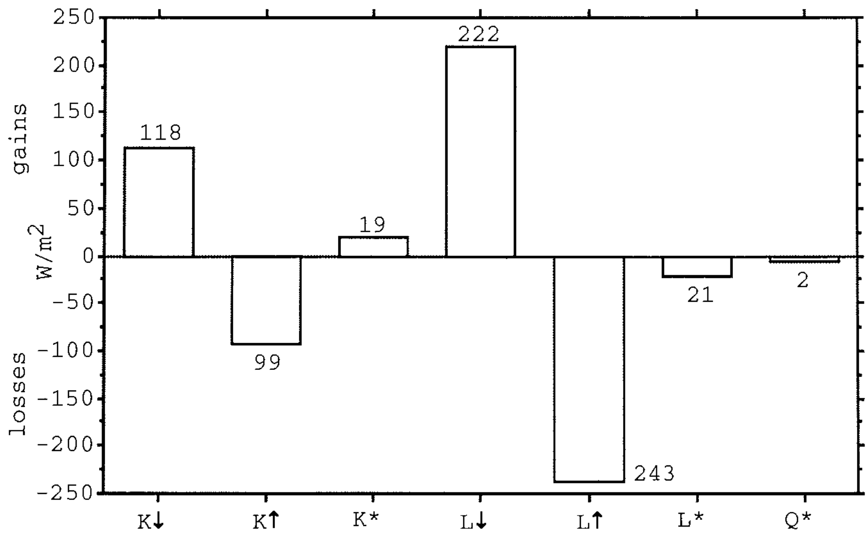


Figs. 27-28: Annual averages for 1983 (above) and 1984 (below)

1985

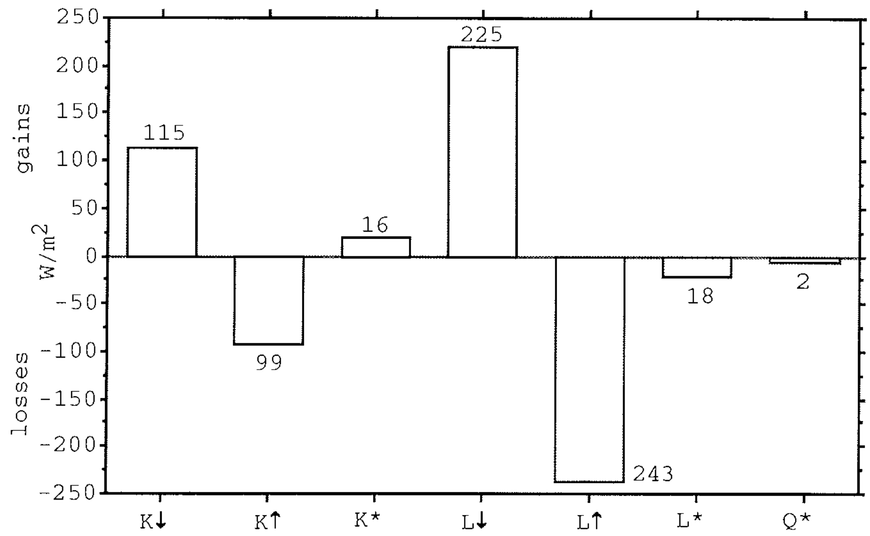


1986

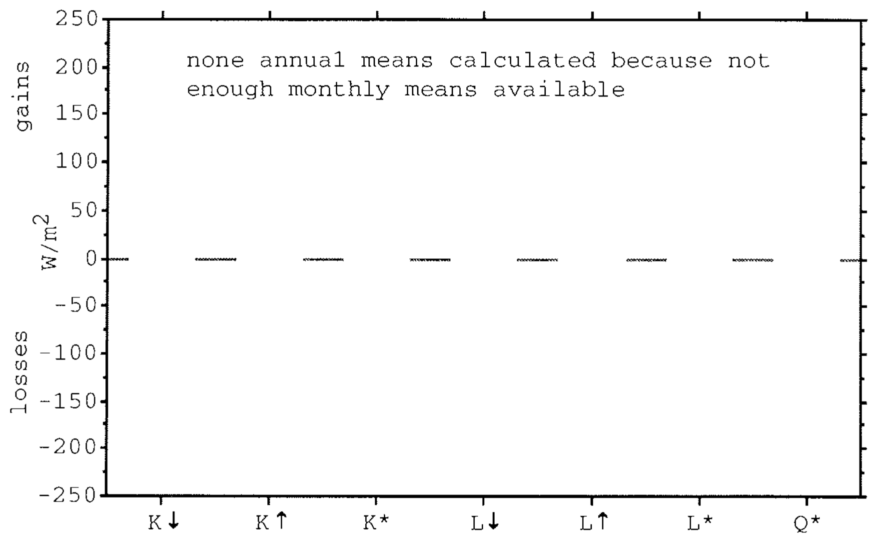


Figs. 29-30: Annual averages for 1985 (above) and 1986 (below)

1987

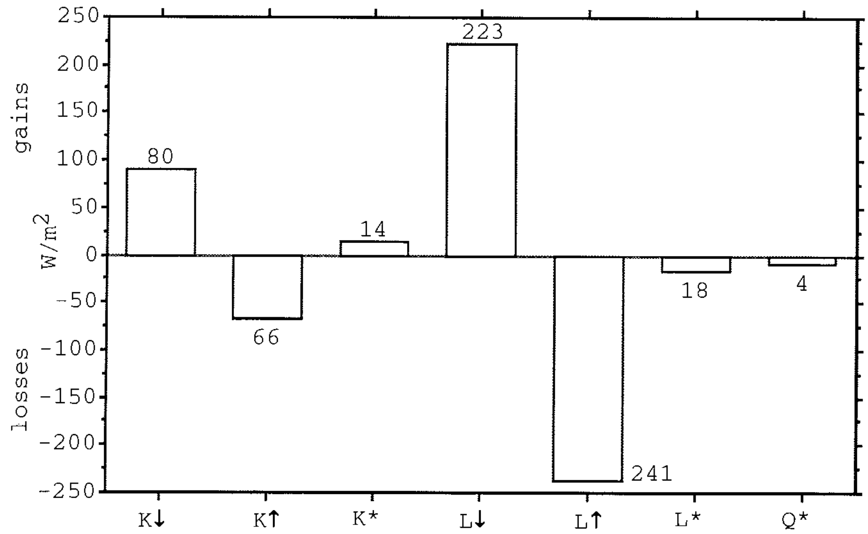


1988



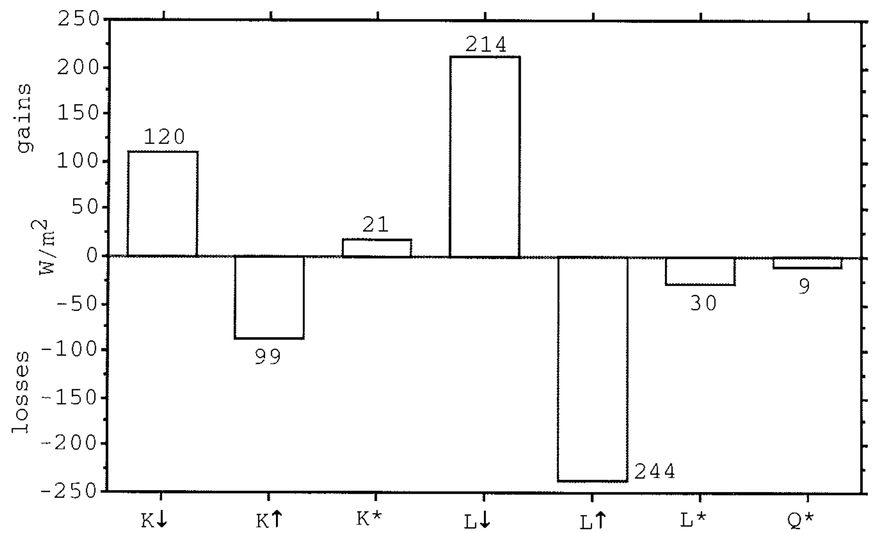
Figs. 31-32: Annual averages for 1987 (above) and 1988 (below)

1989



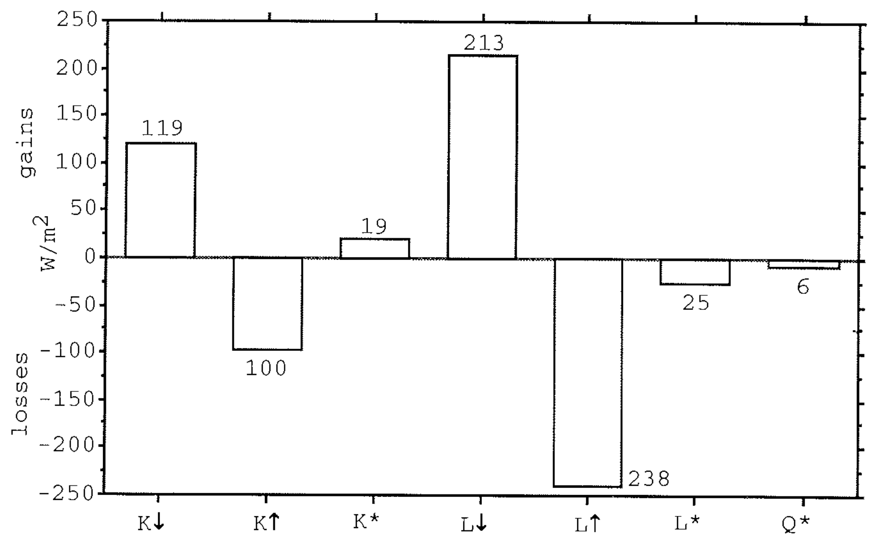
K↓, K↑: without January
L↓, L↑: February-July

1990

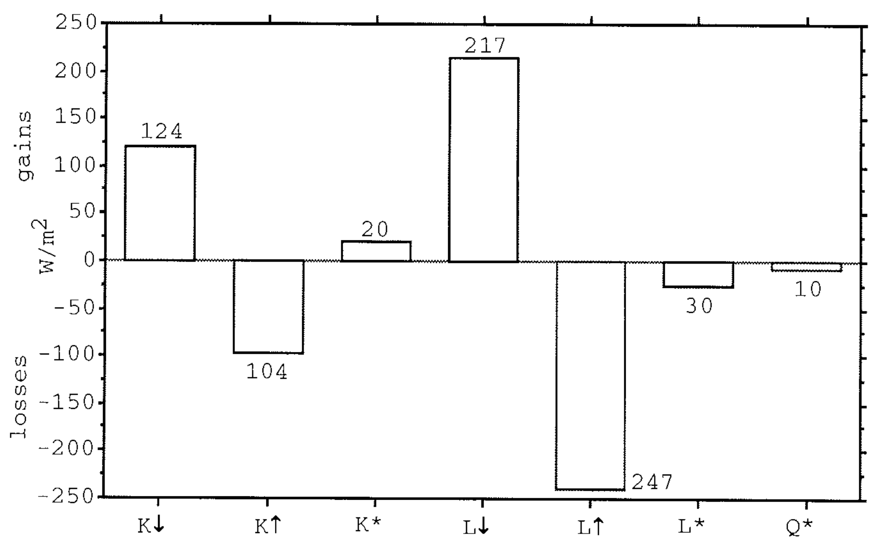


Figs. 33-34: Annual averages for 1989 (above) and 1990 (below)

1991



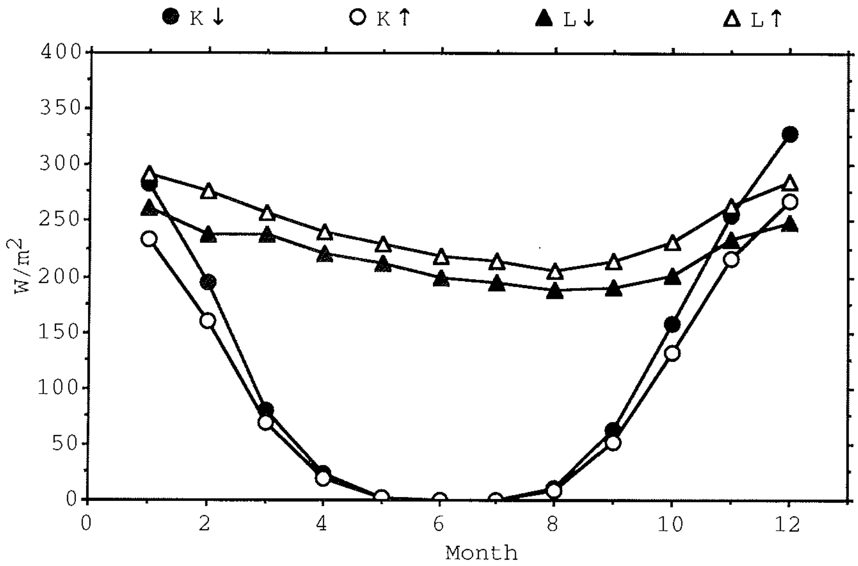
1992

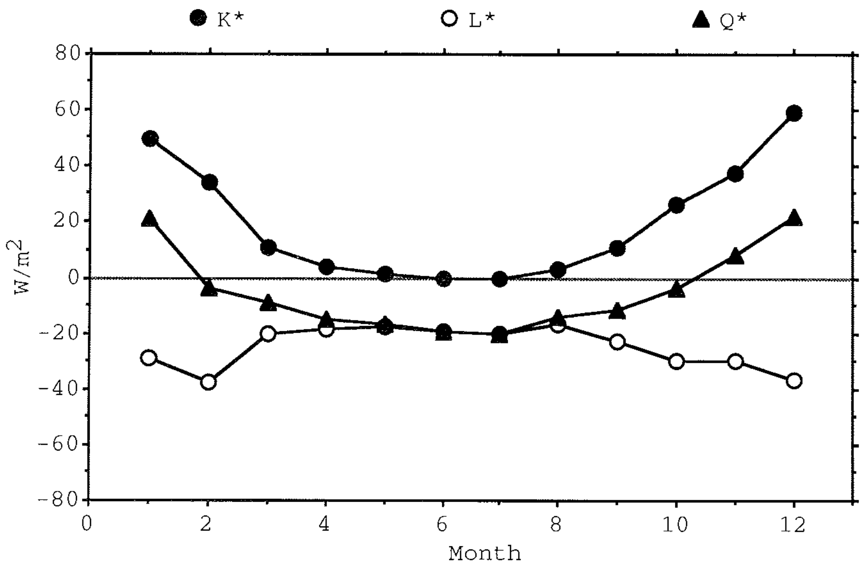


Figs. 35-36: Annual averages for 1991 (above) and 1992 (below)

4.6. Eleven Years Averages

On the basis of 11 monthly averages from 1982 to 1992 for each month an average shown in Fig. 37a-c and Tab. 17 was calculated.





Figs. 37a-37b: Monthly averages of short- and long-wave radiation components on the basis of the years 1982 to 1992

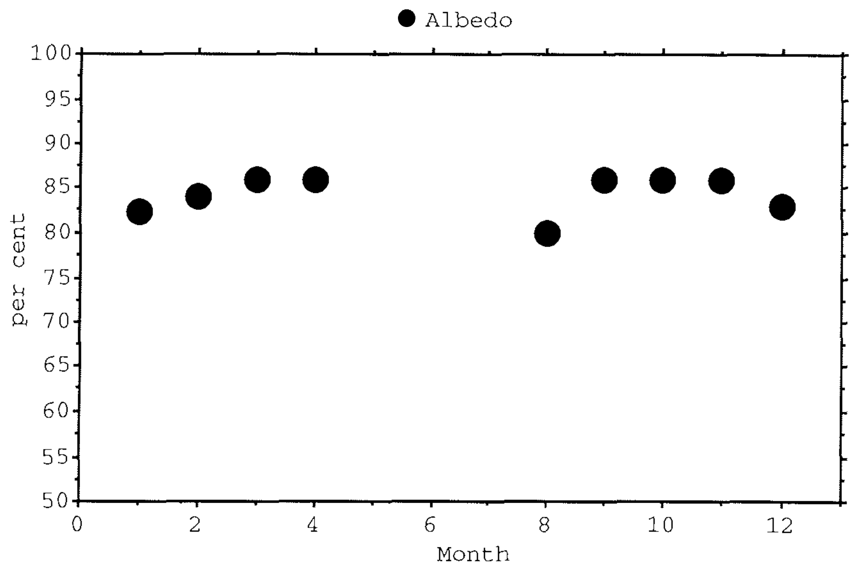


Fig.37c: Monthly averages of surface albedo on the basis of the years 1982 to 1992

Mon	K↓	K↓/Go	K↑	L↓	L↑	S	S/So	a	K*	L*	Q*
Jan	284	60	234	262	291	192	27	83	50	-29	21
Feb	194	59	160	238	276	159	32	84	34	-38	-4
Mar	81	47	70	237	257	87	22	86	11	-20	-9
Apr	24	45	20	220	239	51	22	86	4	-19	-15
May	2	49	2	211	229	5	10	•	1	-18	-17
Jun	0	•	0	198	218	0	•	•	•	-20	-20
Jul	<1	•	<1	194	214	1	8	•	0	-20	-20
Aug	12	48	9	188	205	50	26	80	3	-17	-14
Sep	63	56	52	191	214	114	34	86	11	-23	-12
Oct	157	62	131	201	231	209	43	86	26	-30	-4
Nov	255	61	217	234	264	174	26	86	38	-30	8
Dec	328	63	269	249	286	251	34	83	59	-37	22

Tab. 17: Monthly averages on the basis 1982 to 1992 for K↓, K↑, L↓, L↑, K^*, L^*, Q^* in W/m^2, S in hours, $K\downarrow/G_o$, S/S_o, a in %

Taking the results from Tab. 17 a 11 years average shown in Fig. 38 was determined.

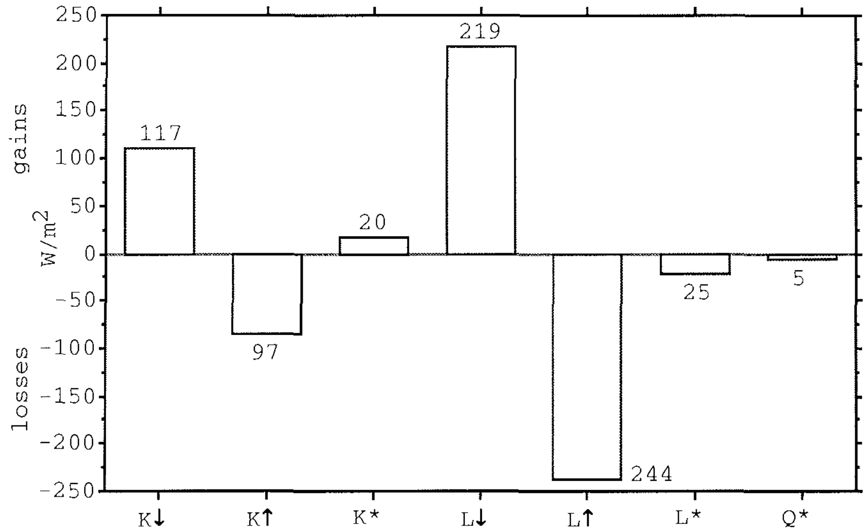


Fig. 38: 11 years averages on the basis of the years 1982 to 1992

The 11 years averages are in close agreement with climatological values of Budyko (1974). For the position 70°S and 10°W Budyko obtained a global radiation average of 285 W/m^2 for January (284 W/m^2 at Neumayer Station) and a annual average of 120 W/m^2 (117 W/m^2 at Neumayer Station). The net total radiation of -5 W/m^2 agrees well with Budyko´s result.

The correspondence between Budyko´s values and the measurements at Neumayer Station shows that the average surface radiation balance at this global position is well established.

Furthermore, there are no indication of any significant changes in any component of the discussed average radiation fluxes within the recent decades.

V. ACKNOWLEDGEMENTS

Thanks are due to all wintering teams at the "Georg-von-Neumayer" and "Neumayer" Station (see appendix A) for their careful performance of the radiation measurements, to Dr. S. El Naggar who is responsible for the maintance of the instrumentation and to B. Loose and S. Wyrwa for their help in programming and data processing.

VI. REFERENCES

Budyko, M.I. (1974): *Climate and Life* Academic Press, New York, 508 p.

Gube-Lenhardt, M. and Obleitner, F. (1986): *The meteorological data of the Georg-v.-Neumayer-Station for 1981 and 1982* Berichte zur Polarforschung 30

Gube-Lenhardt, M. (1987): *The meteorological data of the Georg-v.-Neumayer-Station for 1983 and 1984* Berichte zur Polarforschung 38

Helmes, L. (1989): *The meteorological data of the Georg-v.-Neumayer-Station for 1985, 1986 and 1987* Berichte zur Polarforschung 64

Iqbal, M. (1983): *An Introduction to Solar Radiation* Academic Press, Toronto 1983

Kasten, H. (1966): *A new table and approximation formula for the relative optical air mass* Arch. Met. Geophys. Biokl. B, 206-223

König-Langlo, G. (1992): *The meteorological data of the Georg-v.-Neumayer-Station for 1988, 1989, 1990 and 1981* Berichte zur Polarforschung 116

Kuhn, M., Kundla, M.S., Stroschein, L.A. (1977): *The radiation budget at Plateau Station, Antarctica* Antarctic Res. Series, Vol. 25

Pfaff, K. (1993): *^{2}H- und ^{18}O-Gehalte in den Niederschlägen in Abhängigkeit von der meteorologischen Situation der Georg-von-Neumayer-Station, Antarktis*
Dissertation, Leopold-Franzens-Universität Innsbruck

Schwerdtfeger, W. (1984): *Weather and Climate of the Antarctic*
Developments in Atmospheric Sci. 15, Elsevier, The Nederlands, 261 p.

WCRP (1986): *Revised instruction manual on radiation instruments and measurements*
WMO/TD-No. 149 World Climate Research Programme

LIST OF SYMBOLS

a	albedo [per cent]
cb	cloudbase hight [meter]
D	diffuse solar radiation [W/m^2]
DS	direct solar radiation [W/m^2]
G_0	extraterrestrial solar irradiance [W/m^2]
h	solar elevation [degree]
K↓	global solar radiation [W/m^2]
K↑	reflected solar radiation [W/m^2]
K^*	net short-wave radiation [W/m^2]
L↓	downward long-wave radiation [W/m^2]
L↑	upward long-wave radiation [W/m^2]
LS↓	downward long-wave pyrradiometer signal [W/m^2]
LS↑	upward long-wave pyrradiometer signal [W/m^2]
L^*	net long-wave radiation [W/m^2]
m	relative air mass [dimensionless]
OG1	global solar radiation between 0.71 and 3.00 μm [W/m^2]
PS↓	downward total pyrradiometer signal [W/m^2]
PS↑	upward total pyrradiometer signal [W/m^2]
Q↓	downward total radiation [W/m^2]
Q↑	upward total radiation [W/m^2]
Q^*	net total radiation [W/m^2]
RG8	global solar radiation between 0.53 and 3.00 μm [W/m^2]
S	sunshine duration [minutes, hours]
S_0	astronomical sunshine duration [hours]
σ	Stefan-Boltzmann constant $\sigma=5.67 \cdot 10^{-8}$ W/m^{2}K^4
T_0	derived surface temperature [°C]
T_P	pyrradiometer temperature [°C]
T_P↓	temperature of downward looking pyrgeometer [°C]
T_P↑	temperature of upward looking pyrgeometer [°C]
UV	near UV radiation between 0.30 and 0.37 μm [W/m^2]

APPENDIX

A. List of the wintering meteorologists in charge of the meteorological observatory:

1981/82	Friedrich Obleitner
1982/83	Gert König and Joseph Kipfstuhl
1983/84	Hans-Jürgen Belitz and Hans-Ulrich Stuckenberg
1984/85	Reinhard Beyer and Joachim Schug
1985/86	Peter Wachs and Bernd Wortmann
1986/87	Karl Bumke and Andreas Löbe
1987/88	Andreas Löbe and Klaus Sturm
1988/89	Heinrich A. Strunk and Guido Wolz
1989/90	Rudolf Mair and Karl-Heinz Pfaff
1990/91	Elisabeth Schlosser and Ulrike Wyputta
1991/92	Paul Rainer and Stephan Weber
1992/93	Christoph Kleefeld and Harald Rentsch

B. Description of the Data Set

The whole data set is archived in the Meteorological Information System of the Alfred Wegener Institute, MISAWI, see Tabs. 3-5. MISAWI offers several standard export formats for ASCII files. Each line contains measurements and derived quantities which belong to the same time. The colums are ordered according to the exported quantities, described by one head-line. As delimeter between the different columns [Tab] or [Space] can be used, depending on the demands of the individual user. The representation of missing values can be choosen as well according to the individual demands.

Some quantities are measured since 1982 while others like Diffus, Direkt, OG1, RG8, UV exists only after March 1992. Ten minute averages are available until March 1992 while 5 minute averages are stored since March 1992.

a) Export format: complete radiation data set

Head-line	Type	Format	Explanation/remark
Messort	char	5	Station name
Jahr	int	4	Year
Mon	int	2	Month
Tag	int	2	Day
JTag	int	3	Julian Day
UTC	float	5.2	UTC time
Global	float	6.1	Global solar radiation [W/m^2]
Reflex	float	6.1	Reflected solar radiation [W/m^2]
Diffus	float	6.1	Diffuse solar radiation [W/m^2]
Direkt	float	6.1	Direct solar radiation [W/m^2]
OGl	float	6.1	Global solar radiation 0.71-3.0 μm [W/m^2]
RG8	float	6.1	Global solar radiation 0.53-3.0 μm [W/m^2]
UV	float	7.2	UV radiation 0.3-0.37 μm [W/m^2]
Gegen	float	6.1	Downward long-wave radiation [W/m^2]
Aus	float	6.1	Upward long-wave radiation [W/m^2]
Sonne	float	7.2	Sunshine duration [minutes]
Wolken_H	int	5	Cloudbase height [meter]
Sonnen_H	float	8.3	Solar elevation [degree]
L_Masse	float	8.3	Relative air mass [dimensionless]
Astro_ein	float	6.1	Extraterrestrial solar irradiance [W/m^2]

This file contains lines much longer than 80 characters which might cause problems in editors, but normally this file format gets supported by common spread sheet software. About 20-40 kByte per day are needed.

b) Export format: reduced radiation data set

Head-line	Type	Format	Explanation/remark
Messort	char	5	Station name
Jahr	int	4	Year
JTag	int	3	Julian Day
UTC	float	5.2	UTC time
Global	float	6.1	Global solar radiation [W/m^2]
Reflex	float	6.1	Reflected solar radiation [W/m^2]
Gegen	float	6.1	Downward long-wave radiation [W/m^2]
Aus	float	6.1	Upward long-wave radiation [W/m^2]

This file contains only lines shorter than 80 characters and fits quite well into spread sheets and editors. Per day 7-15 kByte are needed.

c) Export format: complete radiation data set, daily averages

Head-line	Type	Format	Explanation/remark
Messort	char	5	Station name
Jahr	int	4	Year
Mon	int	2	Month
Tag	int	2	Day
JTag	int	3	Julian Day
UTC	float	5.2	UTC time
Global	float	6.1	Global solar radiation [W/m^2]
Reflex	float	6.1	Reflected solar radiation [W/m^2]
Diffus	float	6.1	Diffuse solar radiation [W/m^2]
Direkt	float	6.1	Direct solar radiation [W/m^2]
OG1	float	6.1	Global solar radiation 0.71-3.0 μm [W/m^2]
RG8	float	6.1	Global solar radiation 0.53-3.0 μm [W/m^2]
UV	float	7.2	UV radiation 0.3-0.37 μm [W/m^2]
Gegen	float	6.1	Downward long-wave radiation [W/m^2]
Aus	float	6.1	Upward long-wave radiation [W/m^2]
Sonne	float	7.2	Sunshine duration [hours]
Astro_ein	float	6.1	Extraterrestrial solar irradiance [W/m^2]
kw_bil	float	6.1	Net short-wave radiation [W/m^2]
lw_bil	float	6.1	Net long-wave radiation [W/m^2]
st_bil	float	6.1	Net total radiation [W/m^2]

Per year 4 kByte are needed.

d) Export format: reduced radiation data set, daily averages

Head-line	Type	Format	Explanation/remark
Messort	char	5	Station name
Jahr	int	4	Year
JTag	int	3	Julian Day
Global	float	6.1	Global solar radiation [W/m^2]
Reflex	float	6.1	Reflected solar radiation [W/m^2]
Gegen	float	6.1	Downward long-wave radiation [W/m^2]
Aus	float	6.1	Upward long-wave radiation [W/m^2]
Sonne	float	7.2	Sunshine duration [hours]

Per year 0.5 kByte are needed.

e) Further export formats are available on demand. Additional information can be obtained from similar ASCII file exported from other tables of MISAWI which archive the data of the meteorological mast measurements, the radiosonde soundings and the routine meteorological surface observations.

C Order Form

Data from Neumayer Station for scientific use can be obtained best with the aid of the attached Order Form. For information adress:

Dr. Gert König-Langlo
Alfred-Wegener-Institut für Polar- und Meeresforschung
Am Handelshafen 12
D-27570 Bremerhaven

Tel.: 0471/48 31 496
Fax: 0471/48 31 425
e-mail: gkoenig@awi-bremerhaven.de

The data can be obtained via Internet from an anonymous ftp-server at the Alfred Wegener Institute. Further information will be given individually.

Order Form
Radiation data from Neumayer

Restricted to scientific application

Name ____
(Last) (First) (M.I.)

Organization ______________________________________

Mailing Address ___________________________________

City ____________ State ______________ ZIP ____ County ____

Telefon____
(Voice) (FAX) (eMail:)

Time Interval _____________________________________

Export Format _____________________________________
(see Appendix B,a-e)

Delimeter _______________ Missing Value _______________

Research Topic ____________________________________

____

Comments ____

____

____

Date _______________ Signature ____________________