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# SOME CHARACTERISTICS OF THE SURFACE RADIATION COMPONENTS AT ZHONGSHAN STATION[*]

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**Abstract** A preliminary analysis of some characteristics of the radiation components is made by using the surface radiation data obtained from February 1990 to January 1991 at Zhongshan Station. The result shows that the fluxes of direct radiation and global radiation are strong with higher atmospheric transparency, and the surface can absorb large amount of radiation energy in warm season. The surface loses heat energy in cold season due to the seasonal variations of the surface albedo and shortwave radiation. The variation of net longwave radiation is related to cloud amount and surface air temperature. The property of net radiation is similar to other Antarctic coastal stations but differs greatly from Antarctic inland area.

**Key words** Zhongshan Station, shortwave radiation, net longwave radiation, radiation balance

## Introduction

In recent years, some studies have been done on the short-term and long-term changes of radiation budget of Antarctica by Button *et al.* (1991), Stone and Deluisi (1990), Yamanouchi and Kawaguchi (1982), Ishikawa and Kobayashi (1982) and Bian *et al.* (1991), But radiation measurements were made only in few stations over Antarctic region, so it is necessary to carry out observation of radiation for furture understanding variation of Antarctic radiation budget. A measuremen project of the surface radiation components as a part of CHINARE—VI research program was carried out at Zhongshan Station (69° 22′S, 76° 22′E) February 1990 to January 1991. The fluxes of radiation components were measured with the pyranometers and pyrradiometers at height of 1.5m above the surface. These values were samples digitally and recorded every minute. The instruments used for the measurement were calibrated before and after in situ operation in Institute of Meteorological Instruments Calibration of CAMS. Detail specifications have already been reported and basis data of radiation balance components were published by Bian *et al.* (1991). In this paper

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some characteristics of the radiation components at Zhongshan Station are presented.

## Shortwave Radiation

Table. 1 gives the seasonal variations of the diurnal amplitude of direct radiation and atmospheric transparencies obtained in clear days. The transparency is calculated by

$$Pm = \sqrt[m]{\frac{Sm}{So}}$$

Where So is solar constant(1367 W/m$^2$),Sm the measured direct radiation flux and m is relative mass of atmosphere. There are 55 and 58 days in Larsman Hill area for the polar night and the polar day respectively.

*Table 1. Diurnal variations of the relative mass of atmosphere(mass),the direct radiation intensity(sm,W/m$^2$) and the transparent coefficients(pm,%).*

| | LT. | 06 | 08 | 10 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Jan. | mass | 2.93 | 1.98 | 1.60 | 1.50 | 1.60 | 1.98 | 2.93 | 5.49 |
| | Sm | 781 | 927 | 980 | 994 | 966 | 899 | 745 | 442 |
| | Pm | 0.834 | 0.836 | 0.830 | 0.825 | 0.822 | 0.823 | 0.822 | 0.819 |
| Apr. | mass | | | 6.47 | 5.04 | 6.47 | | | |
| | Sm | | | 432 | 526 | 439 | | | |
| | Pm | | | 0.836 | 0.828 | 0.838 | | | |
| Oct. | mass | | 4.21 | 2.77 | 2.45 | 2.77 | 4.21 | | |
| | Sm | | 594 | 809 | 850 | 804 | 580 | | |
| | Pm | | 0.819 | 0.826 | 0.822 | 0.824 | 0.815 | | |

As shown in the table 2 the intensity of direct solar radiation flux perpendicular to the incident ray is relative stronger due to the atmospheric transparency is higher during the polar day period. The intensity in April was about 60 percent of that in the polar day. Before or after the polar nights the intensity was very weak as low solar angle. Then the intensity is enhanced with increasing the solar altitude angle.

The monthly mean transparency values are given in table 2 for some months in three coastal stations of East Antarctic Continent. The variation argument of transparencies in different seasons was less in Larsman Hill area. This variation is fairly identical with that over all coastal stations of the Continent. It indicates that the transparency of Antarctica is better than that in Qinghai-Xizang area(Ji *et al.* ,1984), but it is not as good as inland area of Antarctica(Yin,1989).

*Table 2. Monthly mean atmospheric transparent coefficients at coastal stations in the East Antarctic Continent (%).*

| Month | Jan. | Feb. | Mar. | Apr. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| Zhongshan | 83 | 84 | 83 | 85 | 84 | 82 | 83 | 82 |
| Molodeznaya | 82 | 83 | 82 | 84 | 84 | 83 | 82 | 81 |
| Mirny | 81 | 82 | 83 | 84 | 83 | 82 | 81 | 81 |

*Table 3. Monthly mean, maximum and minimum values of global radiation($Q, W/m^2$) and surface albedo ($A$, %), monthly means of cloud amonut($CA$, 1/10) and percentage sunshine($SP$, %)*

| | Jan. | Feb. | Mar. | Apr. | Mar | Jun. | Jly. | Aug. | Sep. | Oct. | Nov. | Dec. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q | 280 | 155 | 85 | 35 | 4 | 0 | 1 | 23 | 77 | 166 | 281 | 324 | |
| Qmax | 372 | 212 | 199 | 72 | 19 | 0 | 4 | 61 | 144 | 257 | 358 | 412 | |
| Qmin | 185 | 84 | 35 | 11 | 0 | 0 | 0 | 3 | 27 | 90 | 160 | 191 | |
| A | 24 | 25 | 37 | 53 | 55 | / | 68 | 44 | 45 | 46 | 42 | 25 | |
| Amax | 27 | 72 | 98 | 85 | 86 | / | 91 | 88 | 92 | 89 | 93 | 30 | |
| Amin | 19 | 21 | 18 | 38 | 34 | / | 49 | 49 | 36 | 34 | 25 | 20 | |
| CA | 6.7 | 5.6 | 7.4 | 6.2 | 5.6 | 7.0 | 5.1 | 6.4 | 6.0 | 5.6 | 5.4 | 5.4 | |
| CP | 44 | 50 | 24 | 24 | 28 | 0 | 43 | 32 | 46 | 38 | 39 | 45 | |

Table 3 gives the monthly means of global radiation intensity(Q), and surface albedo (A), daily maximum and minimum values of global radiation (Qmax, Qmin) and albedo (Amax, Amin), monthly means of cloud amount(CA) and percentage sunshine(SP). The variation of radiation components at Zhongshan can be separated into two periods in context of the radiation condition. It is warm season from November to February and cold season from March to October. The mean intensity of global radiation is 260W/m$^2$ and its total amount is about 73% of the annual sum in warm season. The maximum intensity of global radiation(Qmax) appears in December of the polar day period. It can be seen from Fig. 1 that a large amount of solar energy can be received by the surface as the surface albedo becomes low during polar day. The sum of the surface absorbed(net shortwave) solar energy ($Q(1-A)$) is 45% of the annual amount. The mean intensity of absorbed radiation reached 300W/m$^2$ in January. So the polar day period is a main period for the surface to obtain solar energy. The intensities of global radiation and net shortwave radiation derease distinctly with means of 65W/m$^2$ and 27W/m$^2$ respectively except the polar nights in cold season because of more snow cover on the surface and albedo increasing as well as sunshine reduce.

As shown in Fig. 1 the relationships of global radiation and net shortwave with cloud amount and sunshine are very close. Their fluctuation cycle and intensity are associated with local weather conditions. The correlation coefficient between the daily mean of global radiation and cloud amount is $-0.73$ in warm season. The effects of cloud cover or type on the intensity of global radiation are complicated sometime. The increase of cloud probably strengthens scattered radiation as well as reduces direct radiation. When cloud cover is less than 6 tenths, its intensity was not susceptible with the increasing of cloud, but when it is up to 6 tenths, the gains of the scattered radiation were not enough to compensate the losses of direct radiation. Table 4 shows the peak flux of global radiation and sky conditions. It has been found that when it is cloudy near noon the instantaneous maximum intensity could be measured on occasion leading by the heavy scattered radiation of clouds and meanwhile added by the direct radiation reaching the surface and uneffected by clouds, Observed maximum instant value was over 1000 W/m$^2$ in the polar day period. Such instant value and the value beyond the solar constant have been measured is Qinghai-Xizang Plateau (Lu and Dai, 1979), They appeared in the conditions that almost all sky is covered by cumulus with sunny. Because of the low density of areosoles and small amount water vapor content on account of the high latitudes of the station as Ymanouchi *et al.* (1982) mentioned.

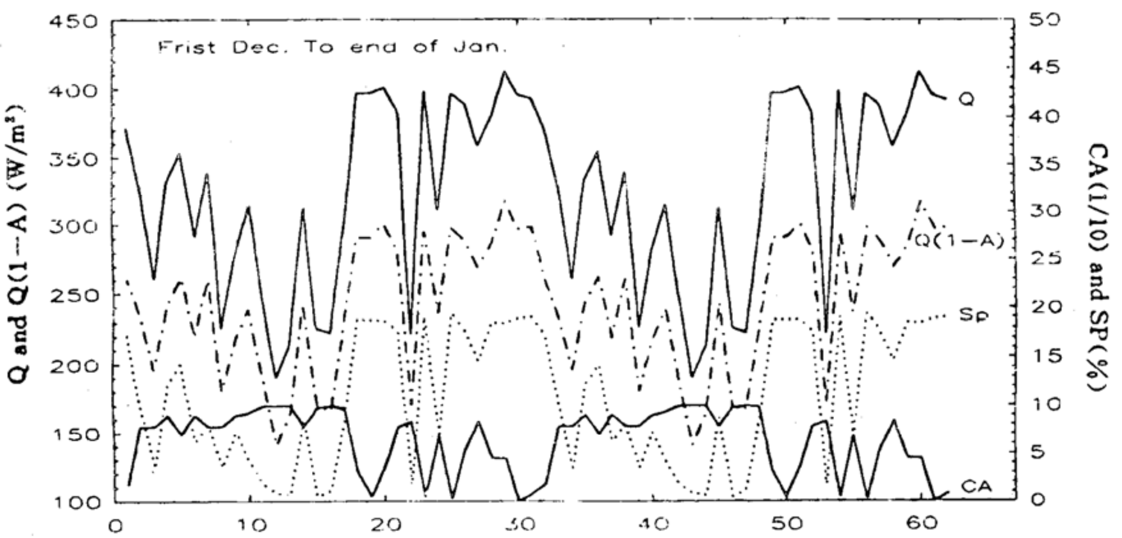

Fig. 1. Daily variations of global radiation (Q) and net shortwave radiation Q(1−A) and colud amount (CA) percentage sunshine (SP).

*Table 4. The peak flux of instantaneous global radiation* (*W/m*$^2$)

| Date | Flux | ACSD* | Cloud amount | cloud form |
|---|---|---|---|---|
| 6 Jan. | 1074 | ⊙ | $10^-/10^-$ | Sc |
| 2 Feb. | 996 | ⊙ | $10^-/0$ | Ac |
| 26 Oct. | 992 | ⊙ | $10^-/0$ | Ac |
| 12 Nov. | 1008 | ⊙ | $10^-/3$ | Sc |
| 5 Dec. | 1095 | ⊙ | $10^-/2$ | Sc Ac |

* ACSD: Apparent condition of sun dsic

## Net longwave radiation

Fig. 2 shows the daily variation of net longwave radiation(NLW) and air temperature (T) at the surface and cloud amount(CA) in January of the polar day period. The data of clouds and surface air temperature were taken by CHINARE Antarctic weather station at Zhongshan. The influence of cloud amount was very large, acting to incraeasing (or decraesing) the downward atmospheric longwave radiation and temperature. It is obvious from Fig. 2 that the daily variations of net longwave radiation are related to cloud amount and temperature in polar day, especially in the polar night period(Fig. 3). The correlation coefficient between the daily means of net longwave radiation and cloud amount is 0. 76 in polar day period and 0. 85 in polar night period. The net longwave radiation also can be expressed by air temperature and their correlation coefficient is 0. 75 in polar night period. It means that atmospheric longwave radiation is greater on cloudy day than that on cloudless day. The daily mean intensity of net longwave radiation remained negative and the range of variation was between $-40$ to $-109\mathrm{W/m^2}$ throughout the year. The seasonal variation of the radiation was proportional to that of the surface air temperature at the station within the pointed summer and coreless winter as described by Schwerdfeger(1984). The main reason of such phenomenon is stronger inversion at near surface in cold season and weak(or not inversion)in warm season.

## Radiation Balance

Radiation balance(net radiation) has a most significant meaning in terms meaning of climatology. In general the variation of net radiation may be restricted with changing of net shortwave radiation and net longwave radiation at the surface. But the net radiation is related only to longwave radiation during the polar night period as shortwave is negligible at the station. The characteristics of season variation of net radiation intensity is quite similar to that of global radiation. Table 5 shows the comparison of radiation balance between Zhongshan Station and Antarctic coastal Syowa Station(69°, 39° 35′E) and Antarctic inland Plateau Station (79° 15′S, 40° 30′E). Data for the last two stations are cited from Yamanouchi *et al.* (1982). The seasonal variation of net radation is fairly large(table 4). The high positive balance occurred in warm season and negative balance appeared in cold season.

Energy absorbed by the surface in the summer half year was more than that transported from the surface to air in the winter half year in the coastal area. The mean intensity of net radiation was $68\mathrm{W/m^2}$ in summer half year and $-41\mathrm{W/m^2}$ in rest time. It means that the surface heated the air in the form of sensible and latent heat transport as well as in the form of longwave radiation in summer half year. But the surface received energy from air due to the existence of inversion layer in the surface boundary in winter half year.

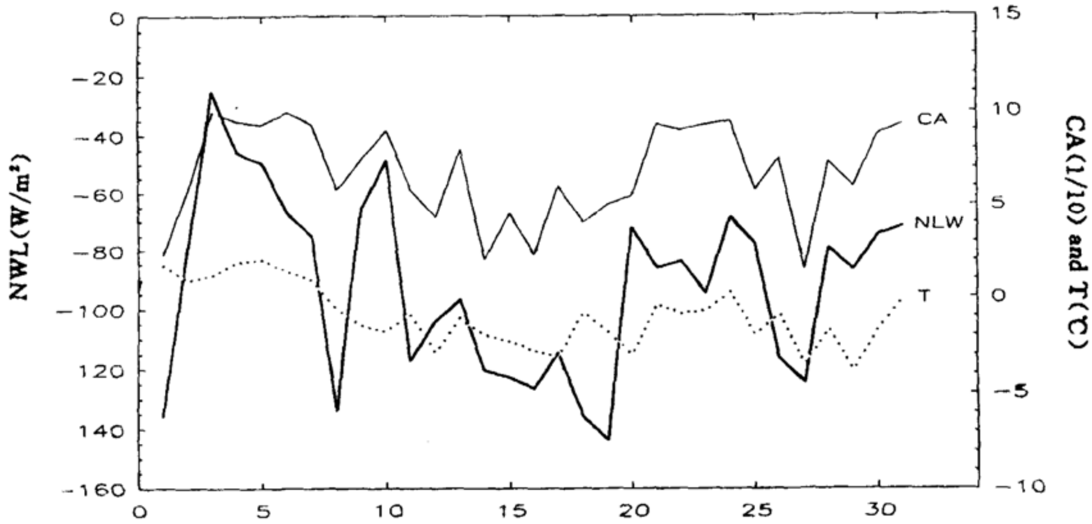

Fig. 2. Daily variations of net longwave radiation (NLW) and Cloud amount (CA) and air temperture(T) at the surface in January.

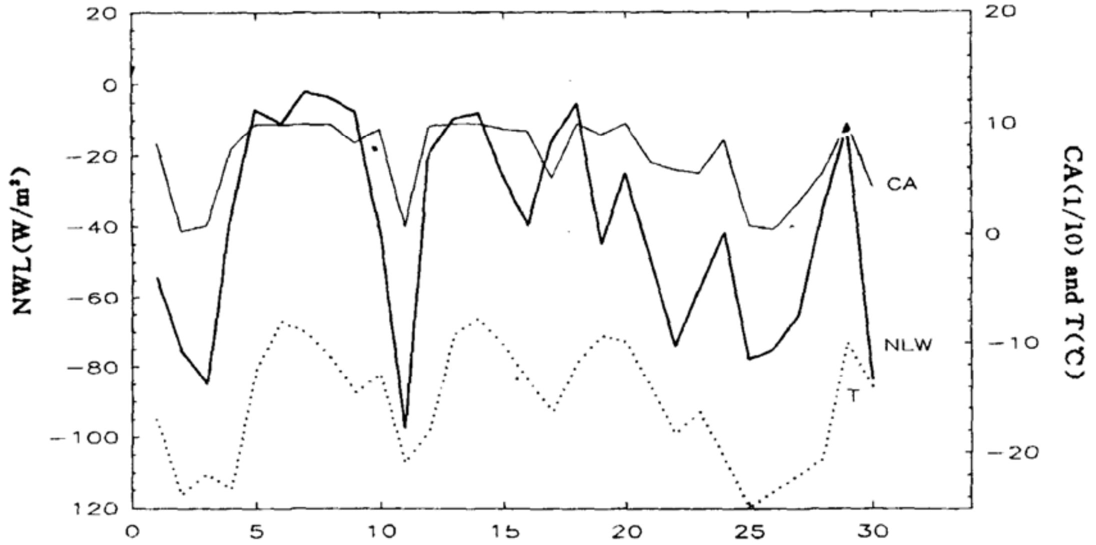

Fig. . Daily variations of net longwave radiation (NLW) and Cloud amount (CA) and air temperture(T) at the surface in

Therefore the budget of radiation over the coast region differt greatly from that in Antarctic inland area where energy absorbed by snow surface is less than that the surface give off. The mean net radiation is negative. It indicates that besides the geographical position the interior area is marked by low surface temperature and high surface albedo (Budd, 1986) in all seasons which play an important role in Antarctic radiation budget.

*Table 5. Monthly mean values of net shortwave radiation*($Q(1-a)$, $W/m^2$), *net longwave radiation*(*NLW*, $W/m^2$) *and net radiation*($B$, $W/m^2$)

| | Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zhongshan | Q(1−A) | 214 | 116 | 54 | 17 | 2 | 0 | 0 | 13 | 42 | 90 | 163 | 243 |
| | NLW | −92 | −66 | −53 | −58 | −50 | −40 | −55 | −55 | −61 | −73 | −102 | −109 |
| | B | 122 | 50 | 1 | −41 | −48 | −40 | −55 | −42 | −19 | 17 | 87 | 133 |
| Syowa | Q(1−a) | 212 | 140 | 55 | 18 | 2 | 0 | 0 | 11 | 21 | 67 | 150 | 198 |
| | NLW | −62 | −54 | −44 | −42 | −38 | −41 | −44 | −39 | −52 | −59 | −60 | −61 |
| | B | 150 | 86 | 11 | −24 | −36 | −41 | −44 | −28 | −31 | 8 | 90 | 137 |
| Plateau | Q(1−a) | 68 | 34 | 12 | 1 | 0 | 0 | 0 | 0 | 7 | 19 | 46 | 82 |
| | NLW | −55 | −36 | −23 | −17 | −16 | −13 | −16 | −16 | −22 | −34 | −45 | −69 |
| | B | 13 | −2 | −11 | −17 | −16 | −13 | −16 | −15 | −15 | −15 | 17 | 13 |

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