TEMPERATURE FLUCTUATIONS IN THE LOWER BOUNDARY LAYER AT MIZUHO STATION, EAST ANTARCTICA

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Abstract: Micrometeorological observations at Mizuho Station were carried out from February 1979 to January 1980 by the members of the 20th Japanese Antarctic Research Expedition (JARE-20), and will be continued until January 1982 by the other JARE members.

Characteristic profiles of the temperature and the wind speed measured simultaniously from a 30 m tower were analyzed. The temperature fluctuations at the level of 30 m or 16 m at Mizuho Station were observed. At that time, the wind speed at the 30 m level was often not stronger than that at a lower level. Fluctuations of the temperature are classified into three types by the level where the phenomena appeared. When these phenomena were observed at Mizuho Station, the strong inversion layer between the surface and the height of 1000 m which seemed to be caused by a large scale disturbance was observed at Syowa Station.

When the katabatic wind was disturbed on a large scale these peculiar phenomena were observed at Mizuho Station. It seems that the difference of the three types depends on the relation between the large scale disturbance and the katabatic wind.

1. Introduction

RIORDAN (1977) and LETTAU *et al.* (1977) described the temperature variation at Plateau Station, especially the connection of the temperature and the wind velocity and the stability in the lowest 32 m boundary layer were reported. Plateau Station is located at 79°15′S, 40°30′E at an elevation of 3625 m and is about 1000 km from the coast. This station is near the top of the East Antarctic ice sheet where a weak wind blows throughout the year.

Mizuho Station is located at 70°42′S, 44°20′E at an elevation of 2230 m, and is about 270 km inland from Syowa Station. As Mizuho Station is an inland station on the slope of the East Antarctic ice sheet, it is ordinarily subjected to the katabatic wind. Micrometeorological conditions at the station, such as the variations of the temperature, wind speed and net radiation when the strong katabatic wind was blowing continuously were described by WADA *et al.* (1981).

However, when a cyclone or a front approached Mizuho Station, this katabatic wind stopped for a while and then it began to blow again. This paper reports the fluctuations of the temperature and the wind speed under these conditions at Mizuho Station.

2. Instruments and Data Acquisition System

2.1. Thermometer

Platinum resistance thermometers were used with a Wheatstone Bridge to measure the air temperature at seven different heights. The temperature sensors were made by Toho Electric Co. in Japan. Their accuracy was ± 0.3°C in the range between 0°C and -40°C and ± 0.5°C in the range between -40°C and -70°C. The sensors, shielded by the stainless steel shelter from the direct radiation, were mounted on the arms of the 30 m tower at the heights of 30, 16, 8, 4, 2, 1 and 0.5 m.

2.2. Anemometer

Three cup anemometers were mounted on the aluminum pipe arms of the tower at the same heights as the air temperature sensors. The accuracy was ± 0.5 m/s in the range between 0 m/s and 5 m/s and $\pm 3\%$ in the range between 5 m/s and 40 m/s. These sensors were made by Makino Instrument Co.

2.3. Data acquisition system

The micrometeorological data acquisition system was constructed by Kaijo Denki Co. The system included a digital clock, a voltmeter, a scanner, a printer and two digital magnetic tape recorders. One-minute sampling data were given and recorded on the magnetic tape, and average, maximum and minimum values were calculated and printed with the printer every day.

The details of installation and performance of the measurement system in 1979 are described by MAE *et al.* (1981).

Readings of these data and statistical calculations were carried out with the electronic computer of M160-II at the National Institute of Polar Research.

3. Results of the Observations

3.1. Frequency distribution of temperature differences (G) between 30 m and 4 m

Figure 1 shows the frequency distribution of temperature gradients between 30 m and 4 m. The total number of observations is 1456 in May, 1428 in June, 1460 in July, 1472 in August and 1474 in December. Temperatures were observed every other minute and the data of temperature gradients are given by a 30 minute average

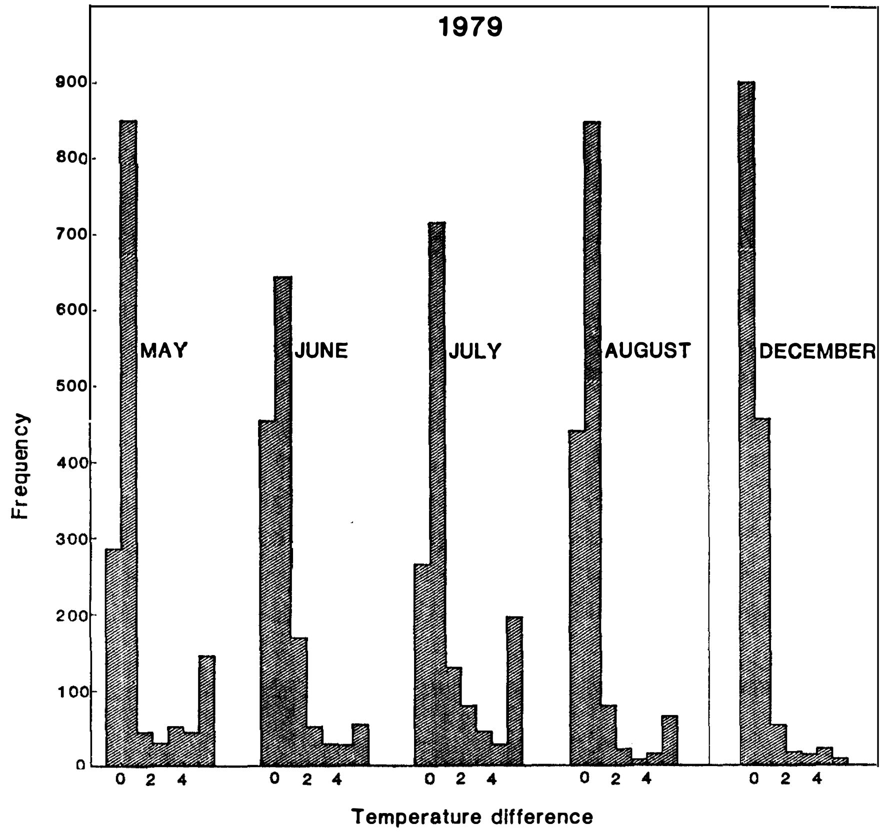

Fig. 1. Frequency distributions of temperature differences between 30 m and 4 m levels.

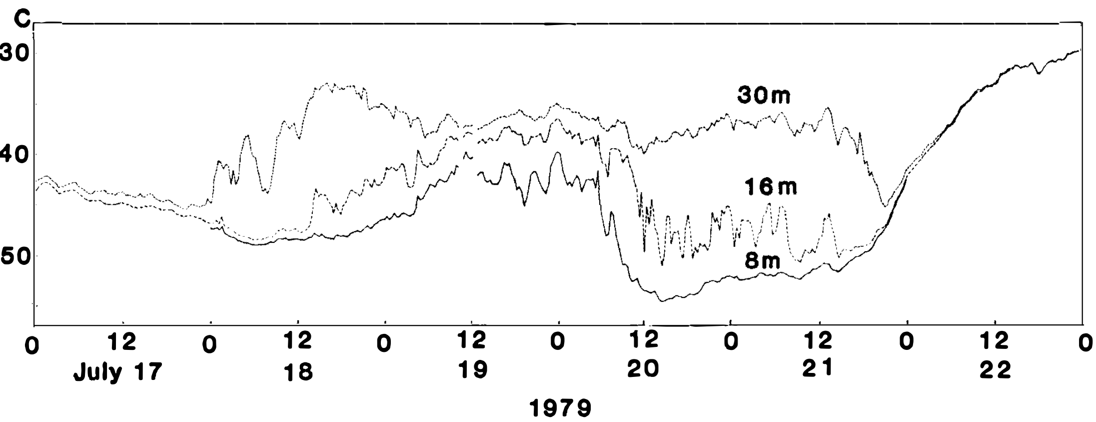

Fig. 2. Temperature variations at 30 m, 16 m and 8 m levels during the period from 17 to 22 July 1979.

in Fig. 1.

Comparing the frequency distribution of temperature differences in the winter season (May, June, July and August) with those in the summer season (December), it is found that most of the gradients are in the range of $0<G\leq 2$, followed by $5<G$, in the winter season, whereas in the summer season they are mostly in the range of $G<0$ and very few are of $5<G$. Namely, the strong inversion layer occurs much more frequently in winter than in summer. Some cases of occurrence of the strong inversion layer in winter are analyzed in this paper.

Figuie 2 shows a case of the variations of the air temperature at 30 m, 16 m, and 8 m heights. The strong inversion layer appeared during the period from 18 July to 21 July.

Twelve cases like the above were observed in May, June, July and August. These 12 cases were classified into two types by the difference in the level of temperature fluctuations. The type showing that the temperature variation at the only 30 m level are different from those at lower levels is defined as A, and the type showing that the temperature fluctuations at the 16 m or 8 m level are larger than those at the 30 m level is defined as B. Seven cases of the 12 cases are type A and three cases are type B. There are two cases showing the mixed type, one is the type which shifted from type A to type B and the other is the type which shifted from type B to type A. In the next section the characteristics of these types are described.

3.2. Relation between temperature fluctuation and wind speed of these types

3.2.1. Type A

The variations of the temperature and the wind speed which were measured during the period from 21 to 22 August 1979, by the sensors on the 30 m tower are shown in Fig. 3. The values in the figure are those at the 30 m, 16 m and 8 m levels. As for the temperature at the 30 m level, great fluctuations were observed from 2130 of 21 August to 2200 of 22 August. Temperature fluctuation at 15°C per hour was measured at about 2100 of 22 August. The temperature at lower levels than 16 m fell and recorded about −55°C at 0000 of 22 August.

The time variation of the wind speed at the 30 m level was different from that at lower levels during the period from 2300 of 21 August to 2300 of 22 August. The wind speed at 30 m was often weaker than that at 16 m or 8 m, but the wind speed at 16 m was usually stronger than that at 8 m. The local maximum of the wind speed at 30 m corresponded to the local minimum of the temperature at 30 m.

Figure 4 shows the variation of the temperature and the wind speed from 23 to 24 July. At the 30 m level the strong inversion layer and temperature fluctuation were observed from 0300 to 1700 of 24 July. The temperature at this level fluctuated remarkably in comparison with the former case (21–22 August). On the other hand, the variation of the wind speed at 30 m was almost similar to the variation at lower levels, differing from the former case. This case is defined as A′, having different wind stratification from that of type A.

3.2.2. Type B

The variations of the temperature and the wind speed during the period from

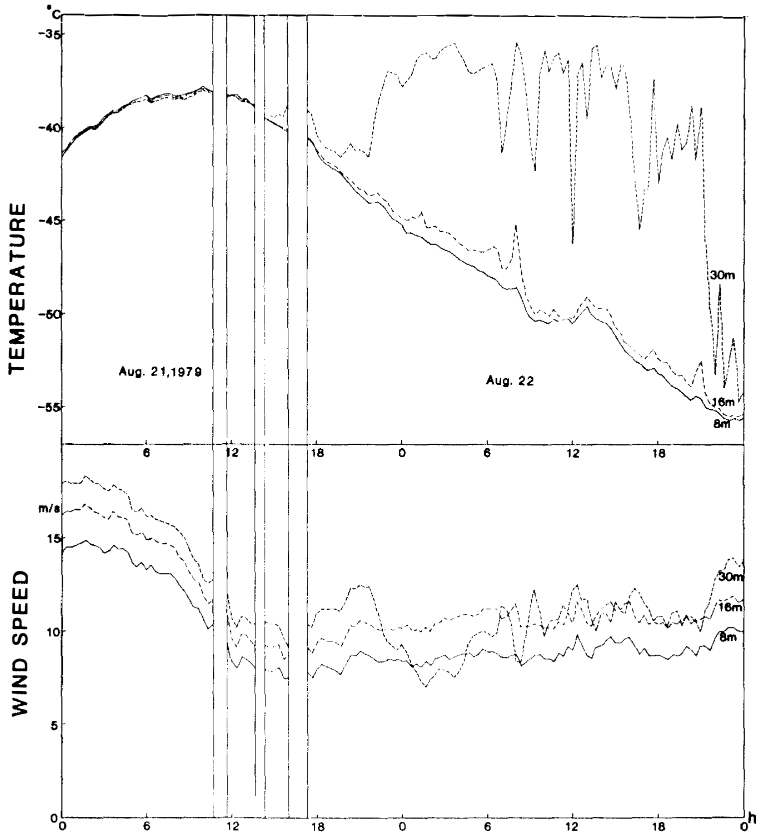

Fig. 3. The variations of temperature and wind speed in the period from 21 to 22 August 1979.

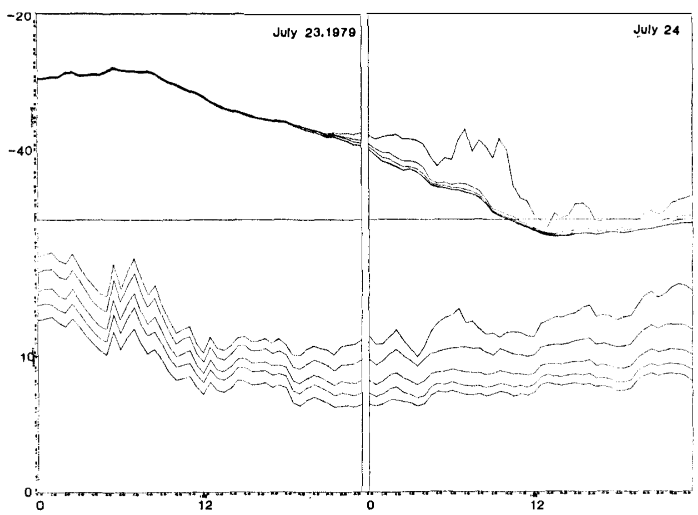

Fig. 4. The variations of temperature and wind speed in the period from 23 to 24 July 1979.

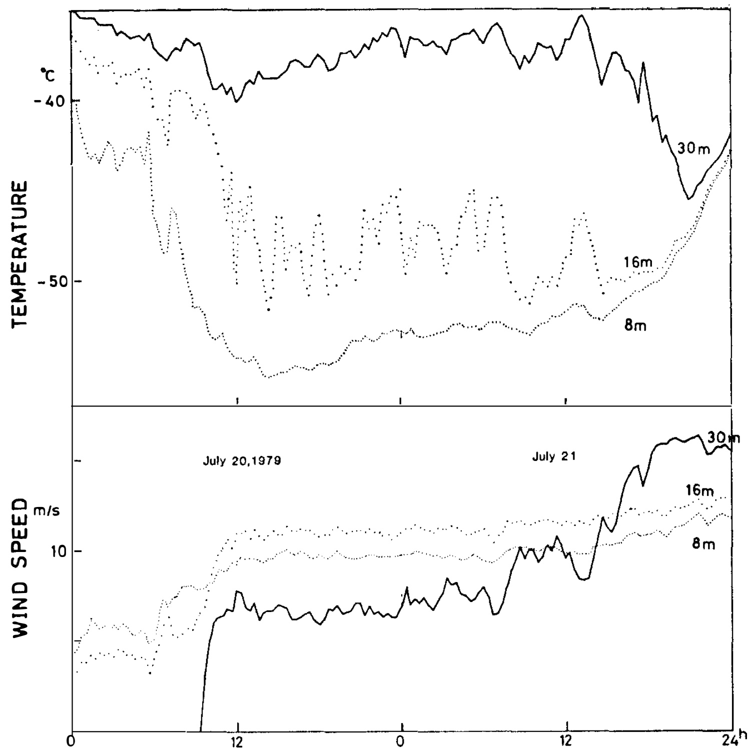

Fig. 5. The variations of temperature and wind speed in the period from 20 to 21 July 1979.

20 to 21 July are shown in Fig. 5. Temperature at the 30 m level did not vary much and large fluctuations as in type A were not observed. Temperature fluctuations at the 16 m level were larger than that at the 30 m level, and at lower levels they were much smaller than at the 16 m level.

The wind speed at the 30 m level was weaker than that at the 16 m or 8 m level during the period from 0000 of 20 July to 1600 of 21 July and the wind speed at 16 m was also weaker than that at 8 m from 0000 to 1000 of 20 July. Namely, the wind speed was stronger at lower levels than at upper levels. These abnormal wind profiles disappered at about 1600 of 21 July, and after 2100 the temperature fluctuation and the strong inversion layer also disappered.

This case is a part of the record shown in Fig. 2 and the phenomenon which was observed during the period from 0000 to 1300 of 18 July belonged to type A. This case is assigned to the mixed type which shifted from type A to type B.

3.3. Differences of temperature and wind profiles in the three types (A, A′, B)

Figure 6 shows the profiles of temperature and wind speed in three types. There is the layer in which maximum wind speed appeared and the temperature varied violently at the same time between 16 m and 30 m level in type A as shown in Fig. 6.

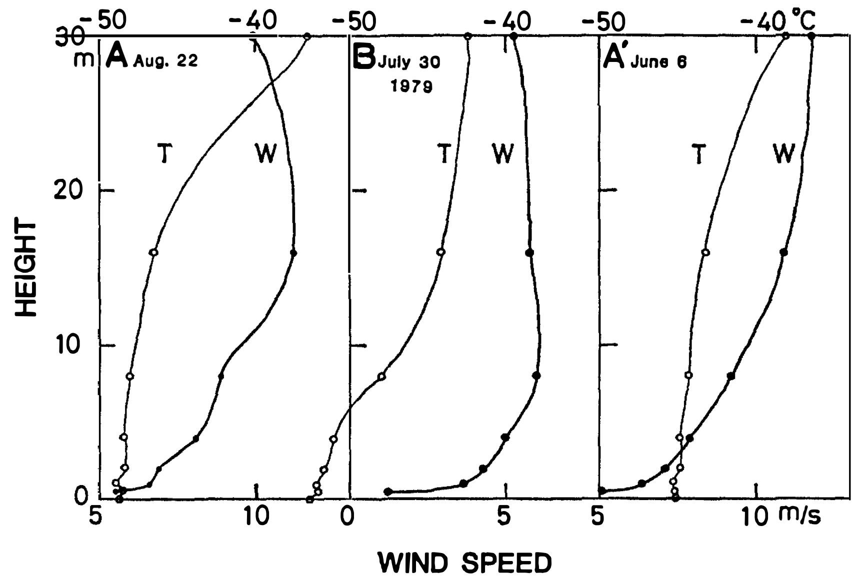

Fig. 6. Vertical profiles of temperature and wind speed in three types between the surface and the 30 m height at Mizuho Station.

In type B the maximum wind speed appeared at the 10 m level and at the almost same level the layer in which the temperature varied violently appeared. In type A′ maximum value of wind speed was not observed. However, as the temperature gradient of upper level was much larger than that between 30 m and 16 m and between 16 m and 8 m, it seemed that the layer in which the temperature varied violently appeared and the layer of the maximum wind speed appeared slightly above the 30 m level. The wind speed at this layer above the 30 m level was often smaller than that at the 30 m level.

3.4. Vertical profiles of air temperature at Syowa Station

Figure 7 shows the vertical profiles of air temperature between the surface and the 3000 m height at Syowa Station during the period from 19 to 25 August.

From 0300 of 19 August to 0300 of 20 August an inversion layer exists between the surface and the height of about 100 m and a higher inversion layer is seen at about 2000 m. At 1500 of 20 August the surface was warmed and the inversion layer disappeared owing to the large scale disturbance, *e.g.*, low pressure or front which passed near Syowa Station. As shown in the graph at 1500 of 22 August, the surface began to cool again because of the surface radiation. Later on, at 0300 of 25 August the profile became similar to that at 0300 of 21 August. In the profiles of 1500 of 22, 0300 and 1500 of 23 and 1500 of 24 August, the temperatures between the surface and 1000 m did not vary so much.

In the other cases the profiles of the temperature at Syowa Station changed in

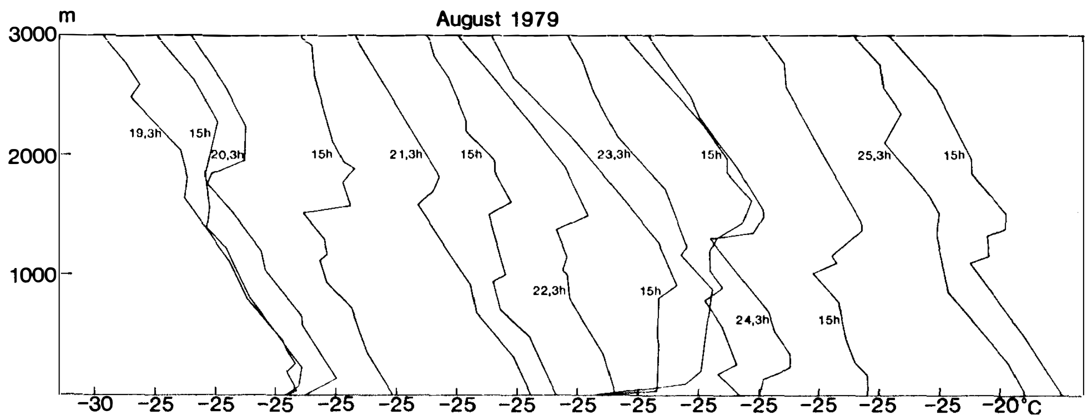

Fig. 7. Vertical profiles of air temperature between the surface and the 3000 m height in the period from 19 to 25 August 1979 at Syowa Station.

the almost same order, when the disturbance passed near Syowa Station.

4. Discussion

Figure 8 shows the variations of the 700 mb-temperature at Syowa Station and the surface temperature at Mizuho Station during from 10 July to 4 August.

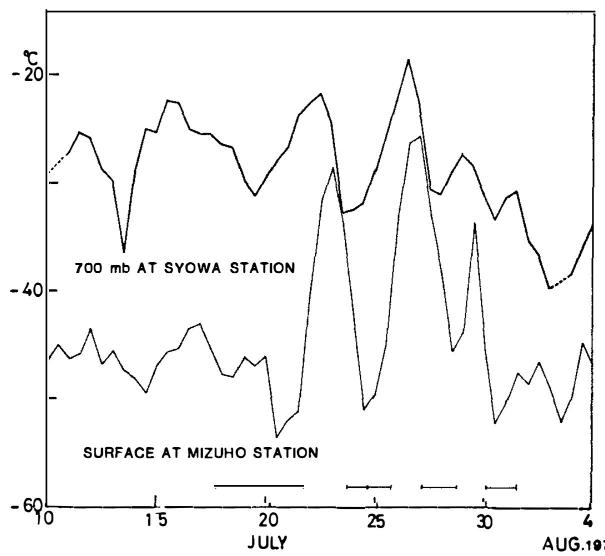

Fig. 8. The variations of the 700 mb-temperature at Syowa Station and the surface temperature at Mizuho Station in the period from July 10 to August 4, 1979.

Although the amplitude of the temperature variation at Syowa Station is different from that at Mizuho Station, the time of local maximum or minimum temperature at Syowa Station coincides well with that at Mizuho Station considering from the time lag with half a day or one day between two stations.

For the above reason, the vertical profiles of the temperature at Syowa Station in the periods of the 700 mb-temperature graph which corresponded to the periods when the temperature fluctuations described in Subsection 3.1 were observed at Mizuho Station are shown in Fig. 8.

Vertical profiles of temperature in three types which were described the preceding sections are shown in Fig. 9. The stratification in which the temperature at about 800 mb (1000 m) was similar to or higher than the surface temperature is found in each type. This stratification is also noticed in Fig. 7.

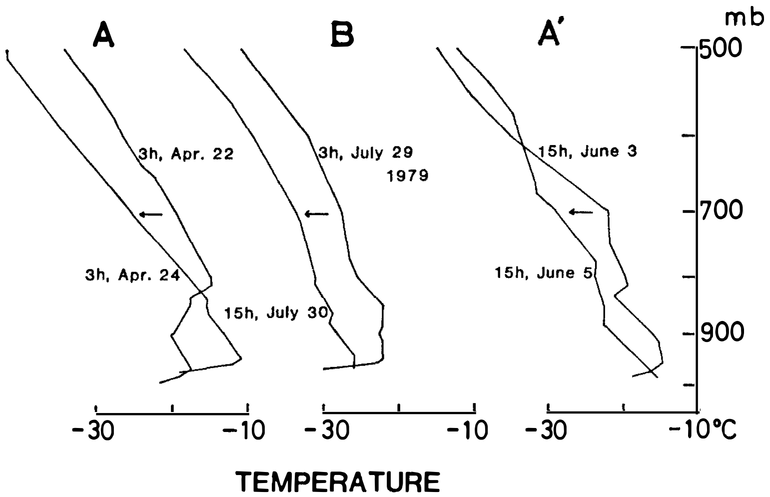

Fig. 9. Vertical temperature profiles in three types obtained at Syowa Station. The arrow shows the change in the profile.

The strong inversion layer between the surface and 1000 m at Syowa Station was formed when the temperature fluctuations were observed at Mizuho Station. Figure 9 shows the profiles of the three types. In each profile two patterns of transition are seen, as shown in Fig. 7, one pattern is found in the period from 0300 of 21 to 0300 of 23 August and the other in the period from 1500 of 23 to 0300 of 25 August, with the opposite tendency from each other. Temperature fluctuations of type A at Mizuho Station were observed in two periods which correspond to the above-mentioned periods. However, the strong inversion layer between the surface and 1000 m appeared in these periods.

In the katabatic wind area, especially at Mizuho Station, the katabatic wind of about 12 m/s usually blows and the profiles of the wind speed show the profiles of logarithmic distribution and the temperature difference between upper level and lower level is not so large (WADA *et al.*, 1981).

It seemed that the strong inversion layer between the surface and 1000 m appeared when the large scale disturbance, such as a cyclone or a front, passed near Syowa Station. The katabatic wind was disturbed by the large scale disturbance, so that peculiar phenomena were observed in the katabatic wind area. It seems that the difference of the three types depends on the relation between the scale of disturbance and the strength of katabatic wind.

As the available upper level data are only for 1979 at Syowa Station but not at Mizuho Station, with the results of observations, especially observations of low altitude radiosonde, at Mizuho Station in 1980, more detailed analysis will become possible.

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