SOME CHARACTERISTICS OF WIND AND TEMPERATURE CHANGES IN THE SYOWA AREA, ANTARCTICA, IN TERMS OF KATABATIC WIND

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***Abstract*:** In order to investigate the characteristics of katabatic wind in the Syowa area, two unmanned weather stations were set up mainly along the flow line of katabatic wind on the coastal zone near Syowa Station (69°00′S, 39°35′E) of East Ongul Island in Lützow-Holm Bay. One station was installed at the foot of the coastal ice slope and the other on the ice slope 12 km inland. From August 1980 to January 1981, wind speed and air temperature were measured at those stations, and vertical soundings by rawinsonde were done at Syowa Station.

During the period of increasing of wind speed, a notable difference in wind direction was observed at Syowa Station, and besides, the vertical profiles of temperature and wind were classified into 2 types in terms of the height of inversion layer. When wind direction ranged from ENE to E at Syowa Station, and temperature inversion took place at about 300 m high, it was recognized to be a typical katabatic wind. Whereas, on the occasion of wind direction ranged from NNE to NE, inversion layer at 1000 m high, and cloudy condition, the wind was identified with that caused by large scale disturbances.

1. Introduction

BALL (1956, 1960) derived theoretically that various characteristics of the katabatic wind flow can be predicted in including the intensity of the hydrauric jump which occurs near the coast, and the deviation of the wind from lines of greatest slope is caused by the Earth's rotation.

MORITA (1968) reported some characteristics of katabatic winds at Syowa Station:

(1) During the night in the summer season (October to March), the katabatic flow of "type 3" in BALL's theory, in which a jump occurs over sea, reaches Syowa Station, but in the daytime it does not reach there because of the flow of "type 2" in which a jump occurs inland.

(2) In the winter season (April to September) persistent northeast-easterly

winds of katabatic origin blow day and night. These winds are, in most cases, associated with synoptic scale disturbances, and it is difficult to distinguish pure katabatic winds from the latter.

Morita's analysis has been done by the use of surface meteorological data obtained at Syowa Station. In order to define the katabatic winds in the Syowa area in their structure, vertical soundings by rawinsonde are required as well as observations of meteorological elements along the flow line of the katabatic wind.

In this paper, characteristics of wind and temperature changes in the Syowa area, Antarctica, are presented in terms of katabatic winds, based on the meteorological data obtained by vertical soundings and on the data of wind and temperature along the flow line.

2. Instruments and Observations

Two unmanned weather stations, developed by Mr. FUJISAWA who was a member of the meteorological party of JARE-18, were installed at the foot of the coastal ice slope (F0, 30 m a.s.l.) and on the ice slope 12 km inland (S16, 430 m a.s.l.) as shown in Fig. 1. The two stations were set up mainly along the flow line of katabatic wind deduced by AGETA (1971).

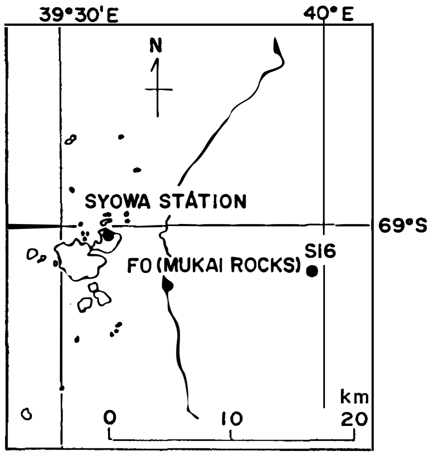


Fig. 1. The location of Syowa Station, F0 (Mukai Rocks) and S16.

Air temperature and wind speed at both stations were measured and telemetered to Syowa Station. Air temperature was measured by a thermister thermometer and wind speed by 3-cup anemometer.

Observations were done at 16 LT and occasionally at 04 LT. These observation times were decided from that the katabatic winds prevail from 18 to 09 LT as reported by MORITA (1968): the 16 LT observation was not influenced very much and the 04 LT observation was influenced significantly by katabatic wind. Measured data of each station were compiled and reported (KOBAYASHI *et al.*, 1982).

3. Results and Discussion

3.1. Variation of the air temperature and wind speed at S16, F0 and Syowa Station

Figure 2 shows the every ten-days variations of air temperature and wind

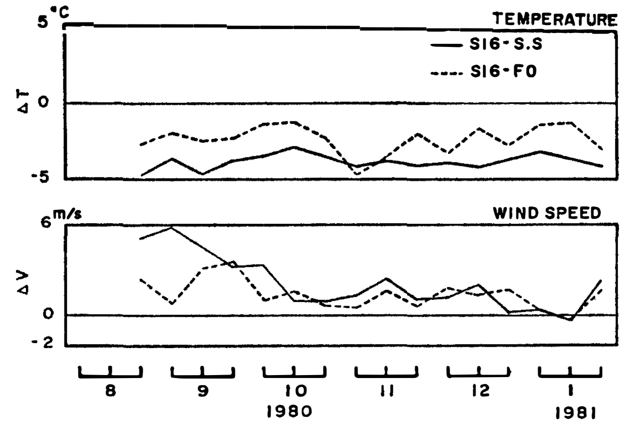


Fig. 2. Ten-days variation of air temperature and wind speed difference at 16 LT.

speed differences at 16 LT between Syowa Station and S16, and between F0 and S16.

Comparing the temperature differences between Syowa Station and S16 (ΔS) with those between F0 and S16 (ΔF), it was found that:

(1) The mean values of ΔS and ΔF were −3.9 and −2.4°C, respectively.

(2) Wind speed differences between Syowa Station and S16 showed large values (3.2–5.8 m/s) in the first ten days of October 1980. They showed a similar tendency between F0 and S16, but it is not remarkable compared with that between Syowa Station and S16.

3.2. The relation between wind directions at Syowa Station and wind speed differences between S16 and F0

Table 1 shows the frequency distributions of wind speed differences (ΔV) between S16 and F0 in each direction observed at Syowa Station. The 107 wind data were used out of 189 examples in which the wind speed of S16 was above 5 m/s.

Table 1. Frequency distribution of wind speed differences between S16 and F0 in each direction at Syowa Station.

ΔV	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	Calm
+	11	9	15	5	1									1			2
−	17	11	2	1	2	1	4	6	4			1		1			13

As is evident from Table 1, most of the frequencies of positive ΔV exist in the wind direction from NNE to E. The frequency of positive ΔV was lower than that of negative ΔV in the wind directions of NNE or NE; on the other hand the frequency of positive ΔV in the wind directions of ENE or E was higher than that of negative ΔV.

In the case of positive ΔV, vertical profiles obtained at Syowa Station can be classified into 3 types. The two types have an inversion layer at different height and the other has no one.

3.3. Characteristics of vertical profiles (A, B)

3.3.1. Type A

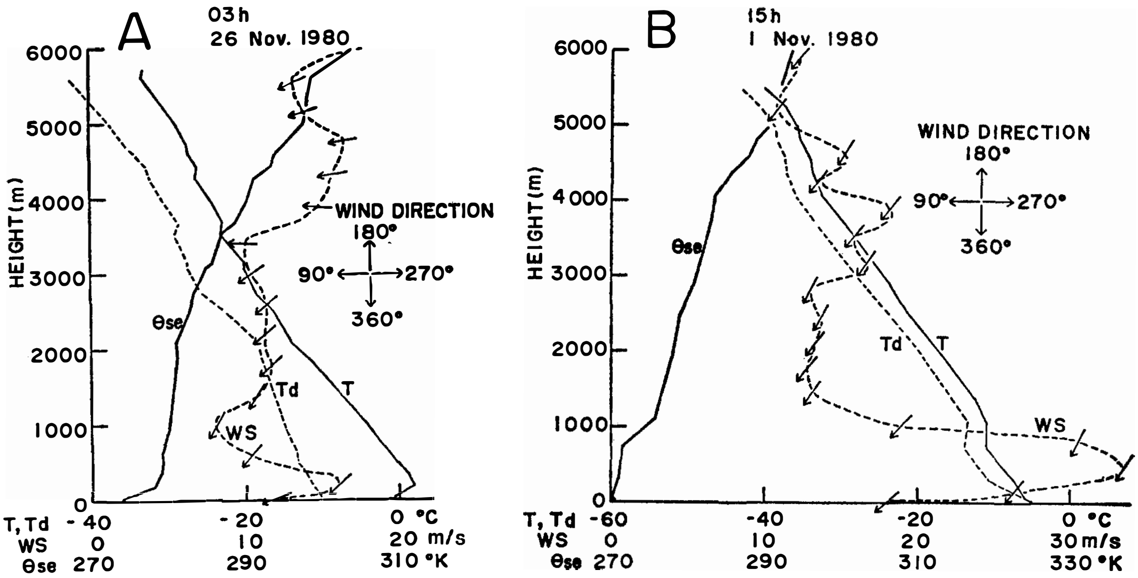
Figure 3a shows the profiles of sounding between surface and 6000 m high at Syowa Station at 03 LT (00 Z) of November 26, 1980. The surface wind speeds at S16 and F0 are 14.2 and 19.2 m/s, respectively, so ΔV is +5.0 m/s. Since the surface wind speed at Syowa Station is 13.4 m/s, this example shows that the katabatic wind reaches Syowa Station, though it is rather reduced compared with that of F0.

Characteristics of type A are as follows:

(1) An inversion layer exists between the surface and 300 m high, which will be referred to as the lower inversion layer. If the top of the inversion layer is higher than 500 m, wind speeds at Syowa Station are very weak.

(2) A strong wind layer exists between the surface and 1000 m height and the maximum wind speed appears near the top of the inversion layer.

(3) Constant pseudo-equivalent potential temperature layer exists above the inversion layer.



(a) (b)

Fig. 3. Vertical profiles of air temperature (T), dew point temperature (Td), wind speed (WS), pseudo-equivalent potential temperature (θ_{se}), and wind direction in two types (A, B) obtained at Syowa Station.

3.3.2. Type B

Figure 3b is an example of sounding at 15 LT (12 Z) of November 1, 1980. The wind speed at S16 and F0 are 18.3 and 22.5 m/s, respectively, so ΔV is +4.2 m/s; the wind speed at Syowa Station is 19.3 m/s.

Characteristics of type B are as follows:

(1) The lower inversion layer as seen in type A does not exist. However an inversion layer appears at about 1000 m height. The inversion layer usually accompanies a large scale disturbance, *e.g.*, low pressure system or front which passes near Syowa Station, and this inversion layer will be referred to the upper

inversion layer.

(2) A strong wind layer exists under the upper inversion layer.

3.4. *An appearing condition of each type*

Type A tends to appear at both 16 LT and 04 LT from late August to early September, but does not appear at 16 LT from the middle of September to late January. This means that there is a strong lower inversion layer on all clear days in the winter season, a lower inversion layer disappear in the day-time, so only in the nighttime on clear day katabatic wind blows.

Table 2 shows the frequency distributions of amount of low- and middle-level clouds at Syowa Station.

Type B takes place on the occasion of high cloudiness with snow; thus the large scale disturbance appears to cause the vertical profiles of type B.

Table 3 shows the frequency distribution of wind directions observed at Syowa Station in each type. As shown in the table, there are remarkable differences in

Table 2. Frequency distributions of cloud amount of low- and middle-level clouds at Syowa Station.

Type	10/10*	9/10	8/10	7/10	6/10	5/10	4/10	3/10	2/10	1/10	0/10**
A						1(0)				4(0)	5(0)
B	8(6)†				1(0)						3(0)

* Overcast. ** Clear.
† Bracketed number: Data accompanied with snow.

Table 3. The frequency distribution of wind directions observed at Syowa Station in each type.

W.D.	NNE	NE	ENE	E	ESE	NW	Calm	Total
Type A			7	2			1	10
Type B	9	3						12
Others	1	3	5	3	1	1		14

directions between type A and B. The wind direction of type A exists from ENE to E except in one case, and coincide with the direction of the flow line of the katabatic wind at the coastal ice slope reported by AGETA (1971). On the other hand, those of type B exists from NNE to NE.

3.5. *The example of daily variation*

The data of the unmanned station at H180 (1540 m a.s.l.) and that of Mizuho Station (70°42′S, 44°20′E at elevation 2230 m) were compared with those of S16, F0 and Syowa Station (locations are shown in Fig. 4). Figure 5 shows a daily variation of air temperature and wind speed on November 28, 1980 at those 5 points. This example shows the case of type A which appeared at night. The figure of air temperature change shows that the daily range of air temperature tends to be larger inland, and the abrupt fall of air temperature moves from inland to

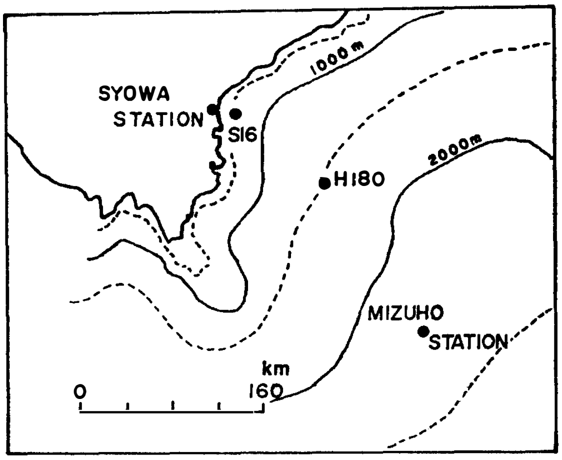


Fig. 4. The location of Syowa Station, S16, H180 and Mizuho Station.

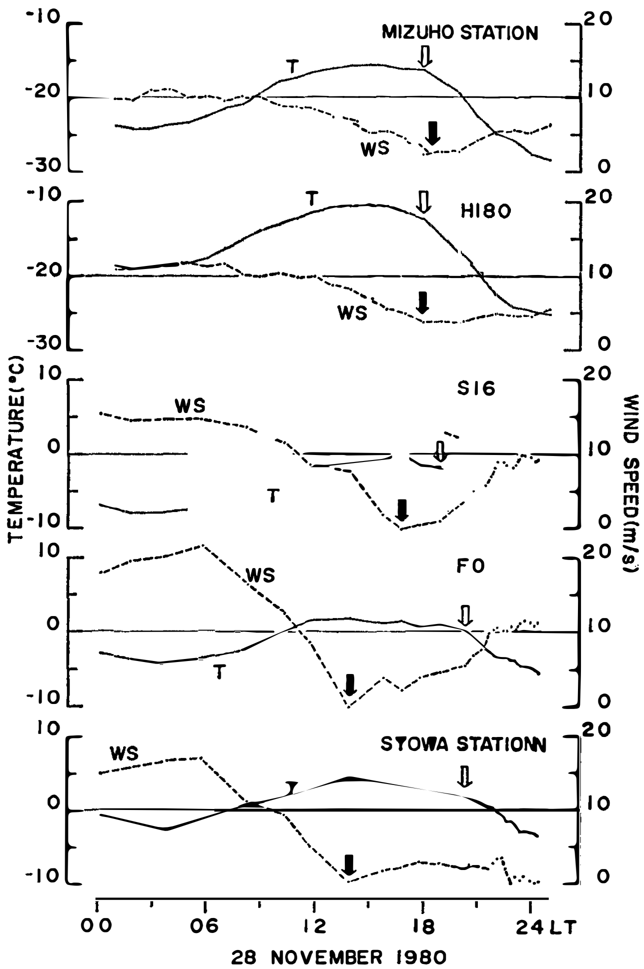


Fig. 5. The daily variation of the air temperature and wind speed observed at Syowa Station, F0, S16, H180 and Mizuho Station.

the coast as shown by the white arrows in the figure. The tendency of wind speed change shows that the wind speed is the strongest at the foot of the coastal ice slope (F0), and the minimum wind speed occurs earlier at the coast in contrast to the temperature fall, as shown by the black arrows in the figure. This example of daily variation of wind shows two cases of the katabatic wind. In the early morning of November 28 the katabatic wind reached Syowa Station and on the night of November 28 it did not.

4. Concluding Remarks

Two unmanned weather stations were installed on the foot of the coastal ice slope and on the ice slope along the flow line of the katabatic wind.

It was found that there were two types of vertical profiles of temperature and wind on the occasion of the strong down slope wind along the coastal ice slope: one type took place on the blowing of the katabatic wind and the other was followed by the large scale disturbance. Wind directions at Syowa Station when the strong down slope wind blows were mainly NNE, NE, ENE and E. In particular, the wind direction of katabatic wind was ENE or E which apparently differs from that (NNE or NE) caused by large-scale disturbances.

Characteristics of the wind directions and the vertical profiles observed by a rawinsonde at Syowa Station were classified into two types on the occasion of the strong down slope wind:

Type A: (1) Katabatic wind reaches Syowa Station.
(2) Strong inversion layer exists from the surface to about 300 m high.
(3) Wind direction ranges from ENE to E.

Type B: (1) Inversion layer associated with the large-scale disturbance exists at about 1000 m high.
(2) Wind direction ranges from NNE to NE.

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