COMPARISON OF THE SEASONAL METEOROLOGICAL VARIATIONS BETWEEN MIZUHO AND SYOWA STATIONS, ANTARCTICA IN 1977

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Abstract: On the basis of surface meteorological records obtained at Mizuho Station (44°20′E, 70°42′S, 2230 m a.s.l.) and Syowa Station (39°35′E, 69°00′S, 20.7 m a.s.l.) in 1977, a preliminary study is done on the comparison of seasonal meteorological variations between those stations. Similar tendencies are seen in the surface pressure variations at both stations throughout the year, indicating that both stations are under the same air pressure field. The most obvious difference of meteorological conditions between both stations appears in the wind speed variation, that is, a yearlong, especially in winter, strong cold katabatic wind at Mizuho Station and the prevailing wind from the NE, which is strengthened under the influence of synoptic scale disturbance, at Syowa Station. From the spectrum analysis of wind speed and air temperature records, the period of 15 days is predominant in the air temperature variation at Syowa Station and in the wind speed variation at both stations. The periodicities correspond to these of the predominant synoptic scale disturbances. From the viewpoint of synoptic meteorological conditions at both stations, the seasons are classified into summer from November to February, winter from May to August and the intermediate seasons. The summer season is characterized by less disturbed conditions and regular daily variations of wind speed and air temperature. In the intermediate seasons, synoptic scale disturbances prevail and the influences appear in the variations of wind speed at Syowa Station and air temperature at both stations, being much more at Mizuho than at Syowa, that is, the increase of both elements. The number of snowfall days also increases in the intermediate seasons. In winter, regular daily variations completely disappear and weekly to semi-monthly periods are predominant in the synoptic scale disturbances.

1. Introduction

Meteorological observations have been carried out intermittently at Mizuho Station since its establishment at 44°20′E, 70°42′S and 2230 m a.s.l., about 270 km

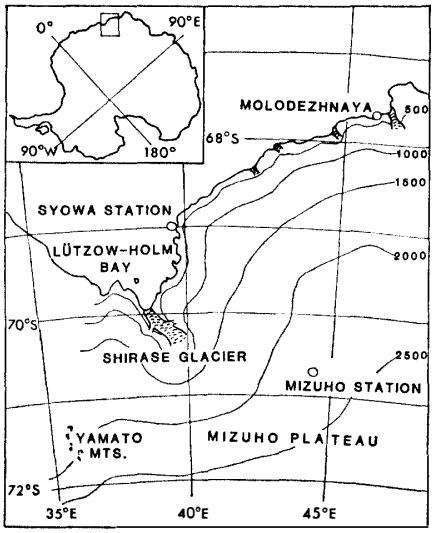

Fig. 1. Location of Mizuho and Syowa Stations.

southeast of Syowa Station (located at 39°35′E, 69°00′S and 20.7 m a.s.l. on East Ongul Island) (Fig. 1), in July 1970. Routine observations started in May 1976, and the surface synoptic reports have been sent to the World Meteorological Center, Melbourne through Syowa Station on international code forms, FM11-C-SYNOP and FM71-CLIMAT, for the monthly summaries since November 15, 1971. The international index number is 89544.

Many studies have been done on the various meteorological problems at Syowa and Mizuho Stations but only few studies have been done on the comparison of meteorological conditions at these two stations. These were by WATANABE and YOSHIMURA (1972), SASAKI (1974), YAMADA (1974) and INOUE *et al.* (1978).

The present paper describes the preliminary results of a study of the differences and seasonal variations of the meteorological conditions between Mizuho and Syowa Stations during the period from February 1977 to December 1977, when one of the authors, Yoshiyuki FUJII, wintered at Mizuho Station, on the basis of the observational results reported by FUJII and KAWAGUCHI (1978) for Mizuho Station and by the JAPAN METEOROLOGICAL AGENCY (1979) for Syowa Station.

2. Annual Variations of Wind Speed and Air Temperature at Mizuho and Syowa Stations in 1977

In order to make clear the general characteristics and fundamental difference of meteorological conditions at Mizuho and Syowa Stations, the annual variations of 3-hourly wind speeds and air temperatures at both stations in 1977 are shown in Fig. 2 and Fig. 3 respectively.

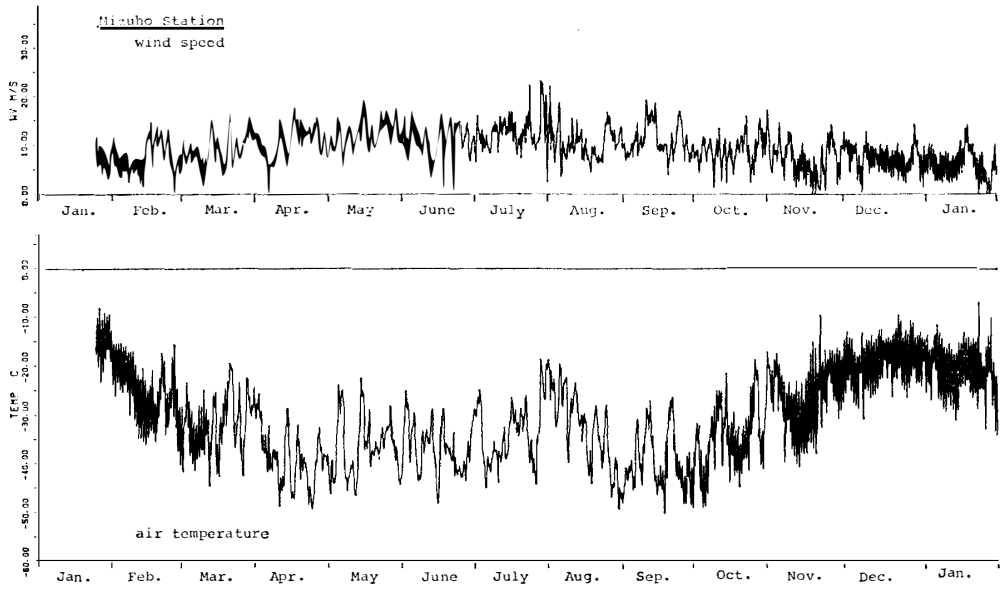

Fig. 2. Variation of 3-hourly wind speed and air temperature at Mizuho Station in 1977.

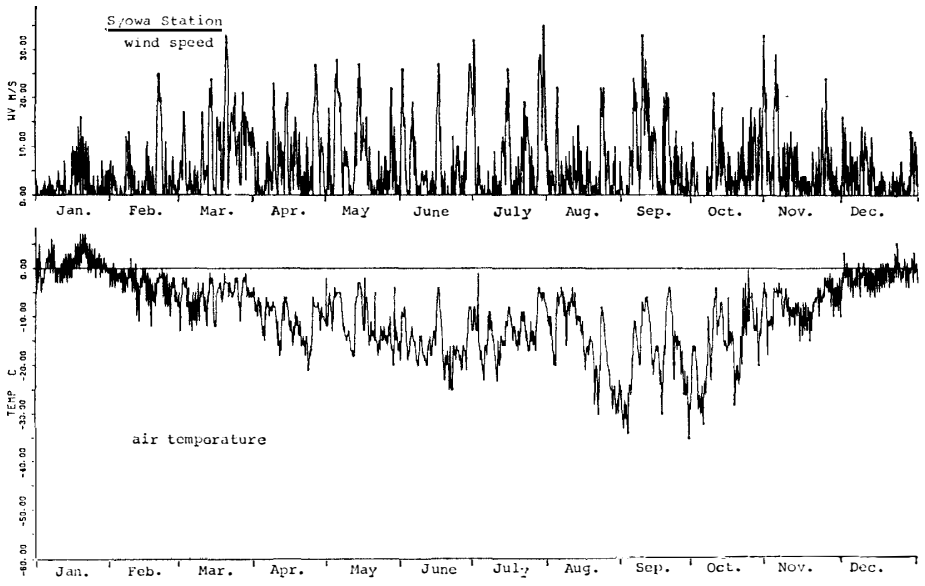

Fig. 3. Variation of 3-hourly wind speed and air temperature at Syowa Station in 1977.

The tendency of the seasonal variation of wind speed and air temperature at Mizuho shows the typical conditions of a "Cold Katabatic" climatic region according to the classification proposed by DALRYMPLE (1966). Katabatic wind prevails throughout the year, having an annual average of 9.5 m/s and being higher in winter.

The seasonal variation of air temperature has a tendency to follow the pattern of a so-called "coreless winter" (*i.e.* POLLOG, 1924), having a minimum of −50.3°C on September 17, 1977.

Regular daily variations of air temperature and wind speed are predominant at Mizuho Station in the summer season from mid-November to mid-February. The regularity is shown more clearly in the variation of air temperature than in that of wind speed.

On the other hand, the tendency of seasonal variation of wind speed and air temperature at Syowa Station differs greatly from those at Mizuho Station.

As reported by MORITA (1968) and MAKI (1972), Syowa Station is characterized meteorologically by the absence of steady katabatic wind and the presence of a prevailing wind from the NE, which is strengthened under the influence of synoptic scale disturbances. Wind speed varies greatly, from more than 30 m/s in a cyclone to several meters per second in a quiet period. The monthly mean is generally high in winter but especially high in March (9.6 m/s) and September (8.1 m/s).

Air temperature shows a minimum in September, being −36.2°C of the annual extreme value on the 28th. A regular daily variation was also observed at Syowa Station in summer. Air temperature is high during strong wind periods due to the synoptic scale disturbances.

Figure 4 shows the 24-hour (8 measurement intervals) running mean of the same data as Figs. 2 and 3, solid and dashed lines indicating the cases of Mizuho and

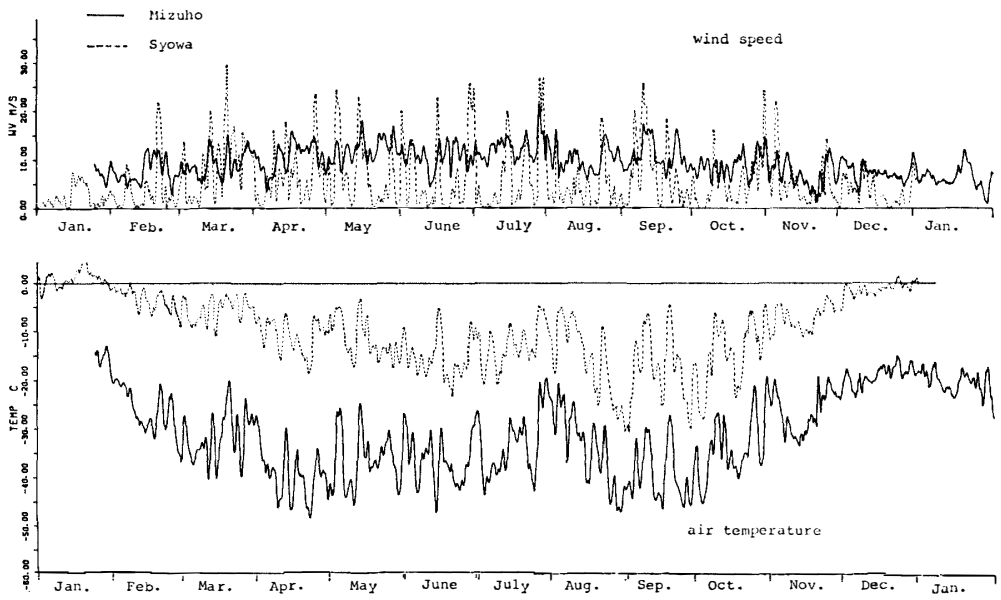

Fig. 4. 24-hour running means of wind speed and air temperature observed at Mizuho Station (solid line) and Syowa Station (dashed line) in 1977.

Syowa Stations, respectively. Since the general tendencies and the shorter variations of air temperature are similar at both stations, Mizuho and Syowa Stations are thought to be located in the region influenced by the same synoptic scale disturbances.

A spectral analysis was done using the 3-hourly data for 372 days from January 1977 to January 1978 at Mizuho Station and for 365 days in 1977 at Syowa Station.

The power spectra of the air temperature variation at Mizuho and Syowa Stations are shown in Fig. 5. The same analysis for the wind speed variation at both stations is shown in Fig. 6. In general, conspicuous periodicity is not seen in the variations of air temperature and wind speed at these stations.

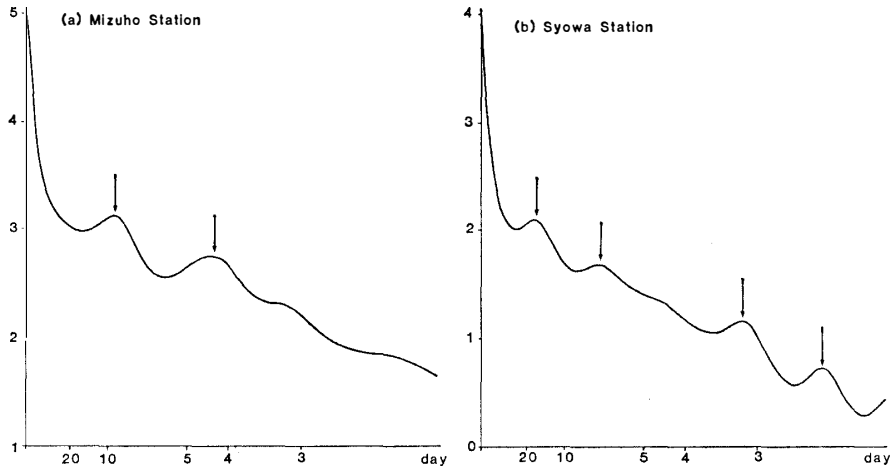

Fig. 5. Power spectra of air temperature at Mizuho and Syowa Stations in 1977.

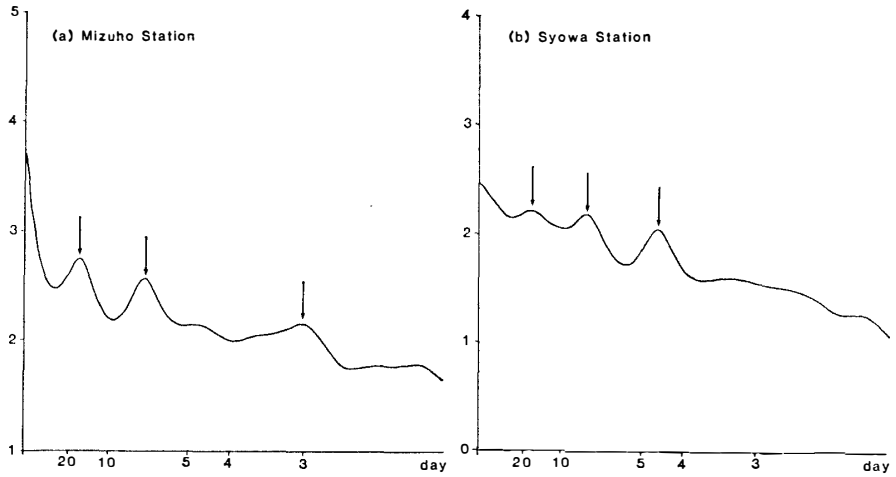

Fig. 6. Power spectra of wind speed at Mizuho and Syowa Stations in 1977.

Relatively distinct periodicities in the air temperature variation of about 4 and 9 days are obtained at Mizuho Station and of about 2.4, 3, 7 and 15 days at Syowa Station. No common periodicity is seen for the air temperature variation at both stations. As for the periodicity of the wind speed variation, about 3, 7 and 15 days are seen at Mizuho Station and about 4.5, 9 and 15 days at Syowa Station.

According to INOUE *et al.* (1978), katabatic wind speed and air temperature at Mizuho Station each had a good correlation with surface pressure at Syowa Station in a cycle of about four days in September of 1972, and had predominant periods of three to eight days in the winter months of 1972. The shorter periods of three to nine days as were also seen in the variations of air temperature and wind speed at Mizuho in 1977 may indicate the periodicity of synoptic scale disturbances.

The periodicity of 15 days which is commonly seen in the air temperature variation at Syowa Station and in the wind speed variation at both stations may correspond to that of the predominant synoptic scale disturbances.

3. Seasonal Meteorological Conditions in 1977

From the viewpoint of synoptic meteorological conditions at Mizuho and Syowa Stations, the seasons at both stations are roughly classified into summer, from November to February, winter, from May to August, and the intermediate seasons, consisting of March, April, September and October.

These seasons are characterized by the following meteorological conditions which are shown in the Figs. 7, 8 and 10 of the 3-hourly variations of surface pressure, wind speed, cloud amount and wind direction at 15 LT (12 GMT).

Owing to the altitudinal difference between the locations of both stations, the scales of surface pressure are given on both sides of the figures. Vertical lines in the figures indicate the hour of 3 LT (0 GMT) every 48 hours.

3.1. Summer season

Figure 7 shows the 3-hourly variations of some meteorological elements at Mizuho and Syowa Stations in the summer season of February, November and December in 1977.

Similar tendencies are seen in the surface pressure variations at both stations, not only in summer but also throughout the year, indicating that both stations are under the same air pressure field as is pointed out by SASAKI (1974) and INOUE *et al.* (1978). The difference of the surface pressure between Syowa and Mizuho Stations is about 240 mb.

Less disturbed conditions appear in this season, though synoptic scale disturbances are seen in this figure on February 20–22 and November 2–4, 22 and 24 when the surface pressure decreased and the wind speed increased at Syowa and Mizuho Stations. Corresponding to the inflow of warm wet air masses by the disturbances,

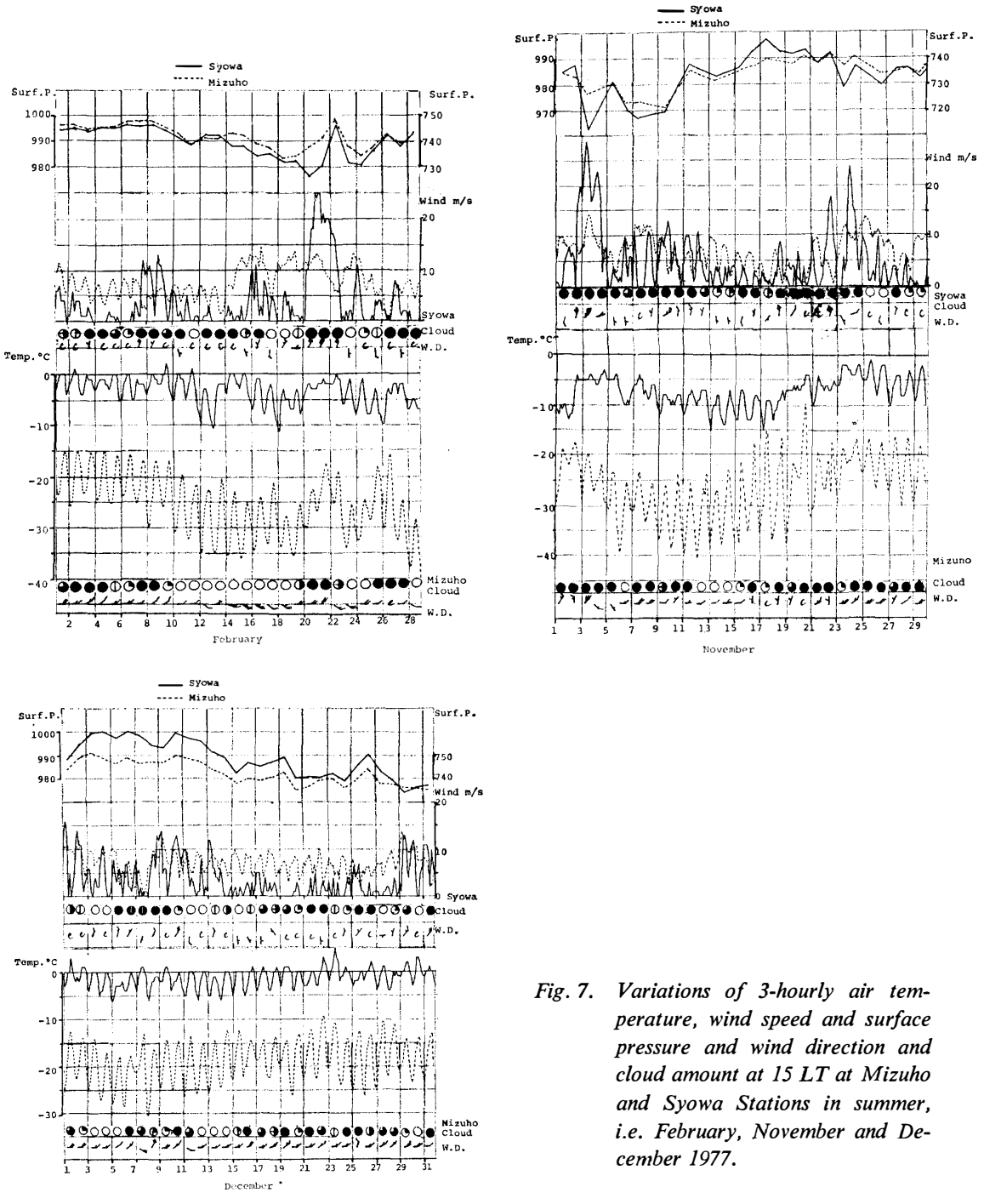

Fig. 7. Variations of 3-hourly air temperature, wind speed and surface pressure and wind direction and cloud amount at 15 LT at Mizuho and Syowa Stations in summer, i.e. February, November and December 1977.

cloud amount and air temperature increases.

The summer season is characterized by the regular daily variations of air temperature and wind speed at Mizuho Station, as was pointed out by YAMADA (1974)

and by INOUE *et al.* (1978), and at Syowa Station where the regularity is less clear than that at Mizuho Station. The minimum and the maximum of air temperature appear at 3–6 and about 15 LT respectively, those of wind speed being observed at 18–21 and 6–9 LT respectively at Mizuho Station. The phase lag between the maxima in the time series of wind speed and air temperature is six to nine hours at Mizuho Station. This phase lag roughly coincides with about nine hours estimated by cross spectrum analyses using the consolidated data of the periods from April to May 1974, from June to December 1972 and January 1975 (INOUE *et al.*, 1978).

3.2. Intermediate seasons

Meteorological conditions during the periods around the equinoxes, are much different from those in summer and winter. Figure 8 shows the variation of the meteorological elements at Mizuho and Syowa Stations in March–April and September–October.

Surface pressure is low in the intermediate seasons at both stations. The extreme minima in 1977 were 711.9 mb and 953.7 mb at Mizuho and Syowa Stations, respectively, on October 12. This confirms the theory developed by SHWERDTFEGER (1960) that the strength of the circumpolar vortex in the troposphere increases in intensity at about equinoxes, resulting in a decrease of pressure in the coastal region of the Antarctica.

Synoptic scale disturbances prevail in the intermediate seasons. The influence of the disturbances appears in the variations of wind speed at Syowa Station and of air temperature at both stations, that is, in the increase of both elements. The influence on the air temperature is much more at Mizuho than at Syowa Stations.

The tendency of wind speed variation at Mizuho Station occasionally shows a negative correlation with that of air temperature during the synoptic scale disturbances, as were seen on April 7, 14, 27 and so on and September 19. SASAKI (1974) described a similar tendency in the relation between wind speed and air temperature at Mizuho Station from June to December, except in August, in 1972. This is explained by assuming that the inflow of warm air masses corresponding to the disturbances weakens or destroys the surface inversion. Two maxima of the number of snowfall days appear in both intermediate seasons at Mizuho and Syowa Stations (Fig. 9). A similar tendency to the seasonal variation of snowfall days is seen in that of monthly mean cloud amount, which was larger than 6.5 (15 LT) and 7.0, in March and July to November, at Mizuho and Syowa Stations, respectively.

Judging from the seasonal variation of snowfall days, cloud amount and other meteorological elements, weather is generally bad in the intermediate seasons between summer and winter, being worst in March and September–October, owing to the considerable cyclonic activity in those seasons.

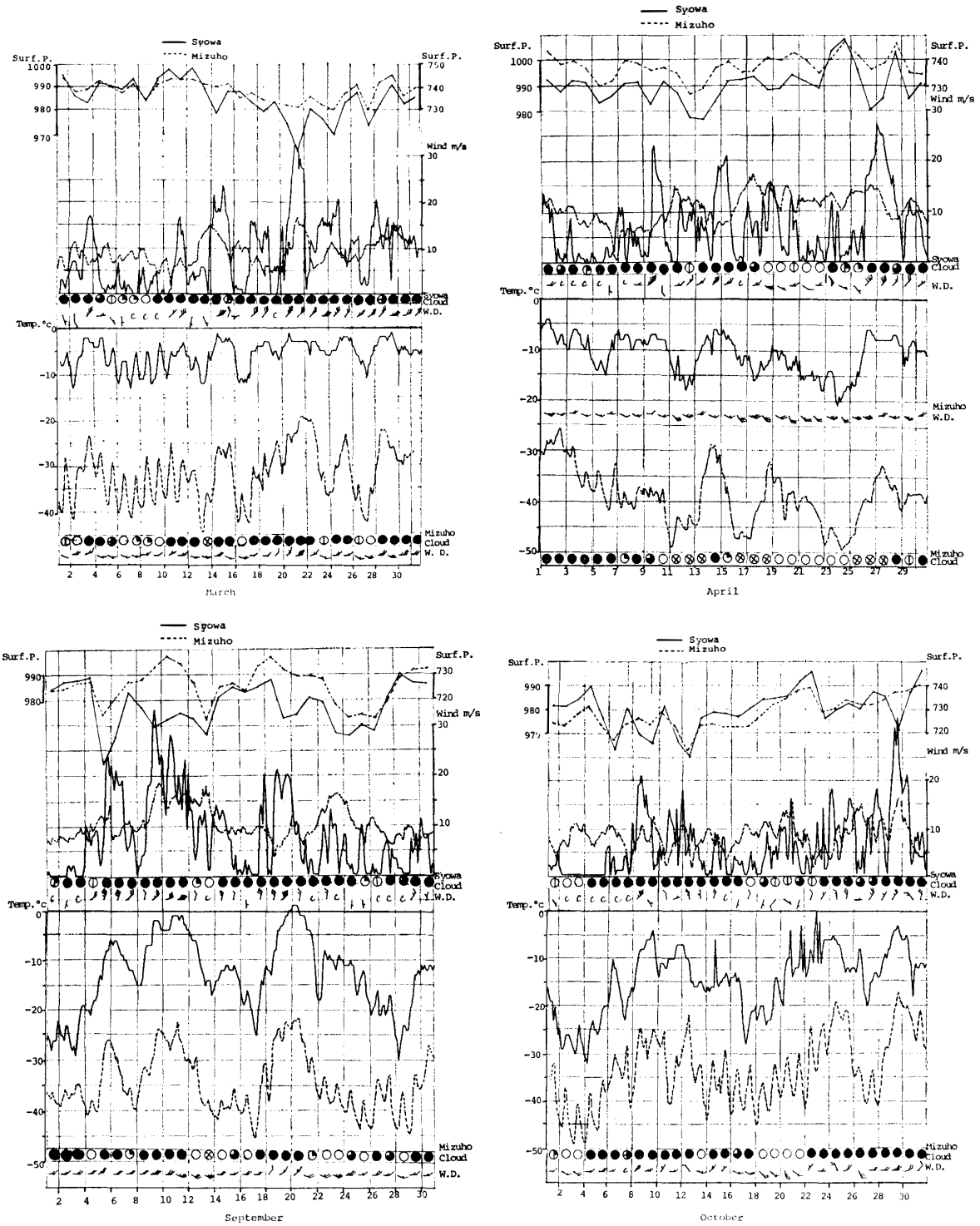

Fig. 8. Same as Fig. 7 in the intermediate seasons, i.e. March–April and September–October, 1977.

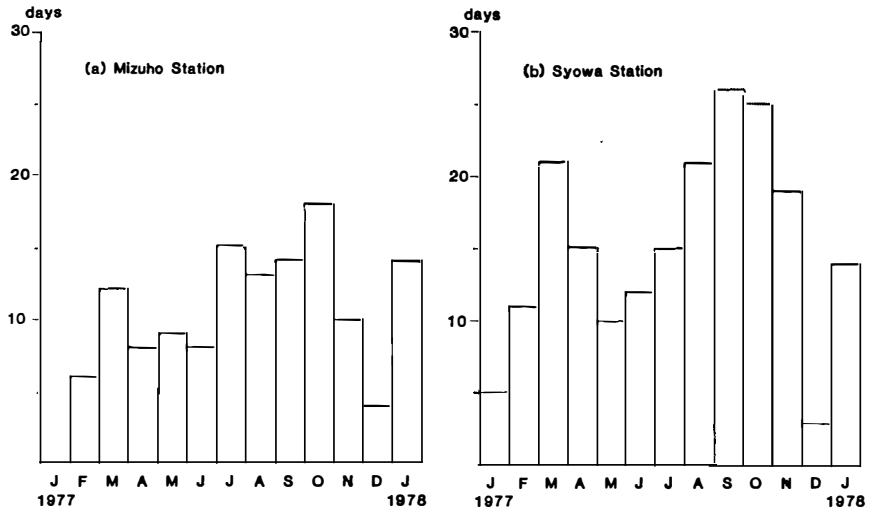

Fig. 9. Monthly variation of the number of snowfall days at Mizuho and Syowa Stations in 1977.

3.3. Winter season

Regular daily variations completely disappeared and a longer periodicity appeared in the variations of meteorological elements in winter from May to August, as is shown in Fig. 10. Weekly to semi-monthly periods were especially predominant in the variations of wind speed at Syowa Station and of air temperature at both stations. As the periodicity is that of a combination of high wind speed and high air temperature, the synoptic scale disturbance corresponding to the oscillation of long waves is said to occur weekly to semi-monthly in the winter season.

Surface pressure is generally high in this season; extreme maxima in 1977 of 761.6 mb and 1014.6 mb were observed at Mizuho and Syowa Stations, respectively, on the same day, August 1.

The difference in the variation of wind speed between Mizuho and Syowa Stations was greatest in winter. Corresponding to the development of a surface inversion in winter, the cold katabatic wind was strengthened at Mizuho Station, so that the mean wind speed was highest, 11.5 m/s on the average, in winter at Mizuho Station. As for Syowa Station, the wind speed was generally high in the intermediate seasons, the monthly mean being highest, 9.8 m/s, in March, and second highest, 8.1 m/s, in September of 1977, owing to the frequent synoptic scale disturbances.

Cloud amounts were small in early winter, May and June 1977, and on the days of low air temperature at Mizuho and Syowa Stations. The winter season was favored in general with good weather, especially in early winter, which was less disturbed by the cyclonical activities.

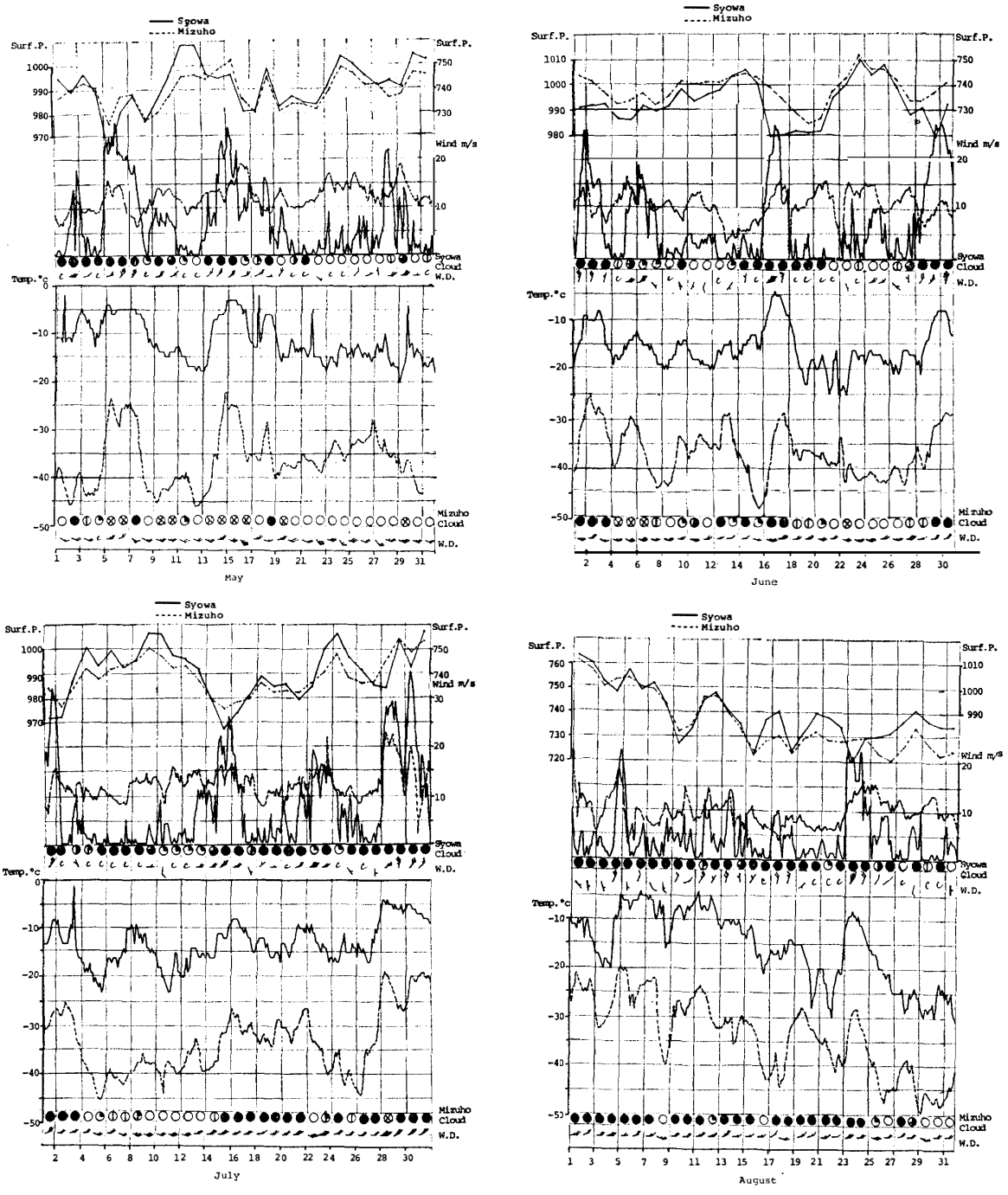

Fig. 10. Same as Fig. 7 in winter from May to August in 1977.

4. Concluding Remarks

The present paper describes the preliminary results of a synoptic analysis done

on the meteorological data obtained in 1977 at Mizuho Station, which is located at 2230 m a.s.l. on the Mizuho Plateau, and at Syowa Station, located on East Ongul Island, in order to clarify the differences and the similarities in the meteorological variations between Mizuho and Syowa Stations.

Further studies, such as weather chart analysis, study of the relation of surface meteorological conditions to upper air conditions and so on, are needed to obtain a clear understanding of the effects of synoptic scale disturbances on the meteorological conditions at Mizuho and Syowa Stations, and of the atmospheric circulation over both stations.

Acknowledgments

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