Features of the wind fields associated with Typhoon 0418 (Songda) compared with those of Typhoon 9119 (Mireille)

by

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ABSTRACT

The wind fields in T0418 (Songda), which caused extensive wind disaster in western and northern Japan on 7-8 September 2004, were examined through comparison with T9119 (Mireille) which attacked Japan on 27-28 September 1991. The two typhoons passed northeastward through the northern Kyushu on almost the same track, with an area of strongest winds in their southeastern sectors. However, T9119 was accompanied by a strong cold-air surge in the western sector, where intrusion of dry air into a rainband is likely to have caused evaporative cooling, while such feature was lacking in T0418 for which convective clouds in the western sector had almost disappeared after landfall. The two typhoons subsequently caused severe winds in the northern Japan, although they had almost transformed to extretropical cyclones in the Sea of Japan. T9119 had nearly uniform pressure and weak wind in an area within 100km of the center, with steep pressure gradient and strong southwest winds on its southeastern side, while T0418 had a sharp pressure center with the area of strong wind located nearer the center.

KEYWORDS: Strong wind, Typhoon, Typhoon 0418 (Songda), Wind disaster

1. INTRODUCTION

In 2004, the main islands of Japan were attacked by ten tropical storms, including six storms which had typhoon intensity (max. wind ≧ 64kt) at landfall. T0418 (Songda) reached the west coast of Kyushu on 7 September with central pressure of 945hPa, which is the lowest among the six typhoons. It then moved northeastward through northern Kyushu and the Sea of Japan, and passed the western coast of Hokkaido on 8 September. T0418, and T0423 (Tokage) which caused floods and landslides on 20 October 2004, brought the worst typhoon disaster in Japan after the attack of T9119 (Mireille) on 27-28 September (Table 1). The tracks of T0418 and T9119 were very close to each other (Fig.1). Both typhoons moved northward from the western Pacific to the East China Sea along the western side of the Pacific high, and then they turned northeast and gradually transformed into extratropical cyclones as they passed the Sea of

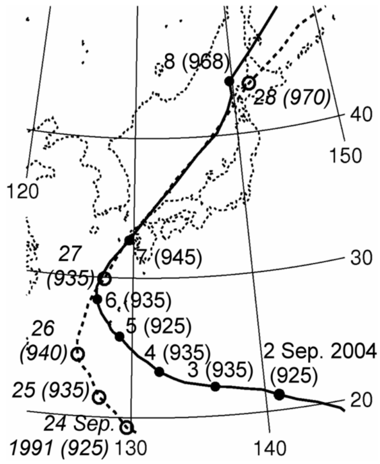

Fig.1 Tracks of T0418 (Songda, solid line) and T9119 (Mireille, dotted line). Circles indicate daily positions of the typhoon center at 09 JST (=00 UTC).

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Japan (Figs.2-3). Fujibe and Fujitani analyzed the wind fields of T9119 with attention to the asymmetric wind fields as it passed Kyushu [1]. In this article we compare the wind distribution of these typhoons in search for the characteristic features of the wind fields in T0418.

2. DATA

Fig.4 shows the tracks of T0418 and T9119 in western Japan, and the locations of observation stations. The tracks were based on three-hourly positions and pressure of each typhoon center on

Table 1 Damage due to each typhoon.

	T0418 (Songda)	T9119 (Mireille)
Human damage		
Dead or missing	45	62
Injured	1365	1499
House damage		
Totally collapsed	132	506
Partly damaged	66461	169941
Flooded	8196	22965

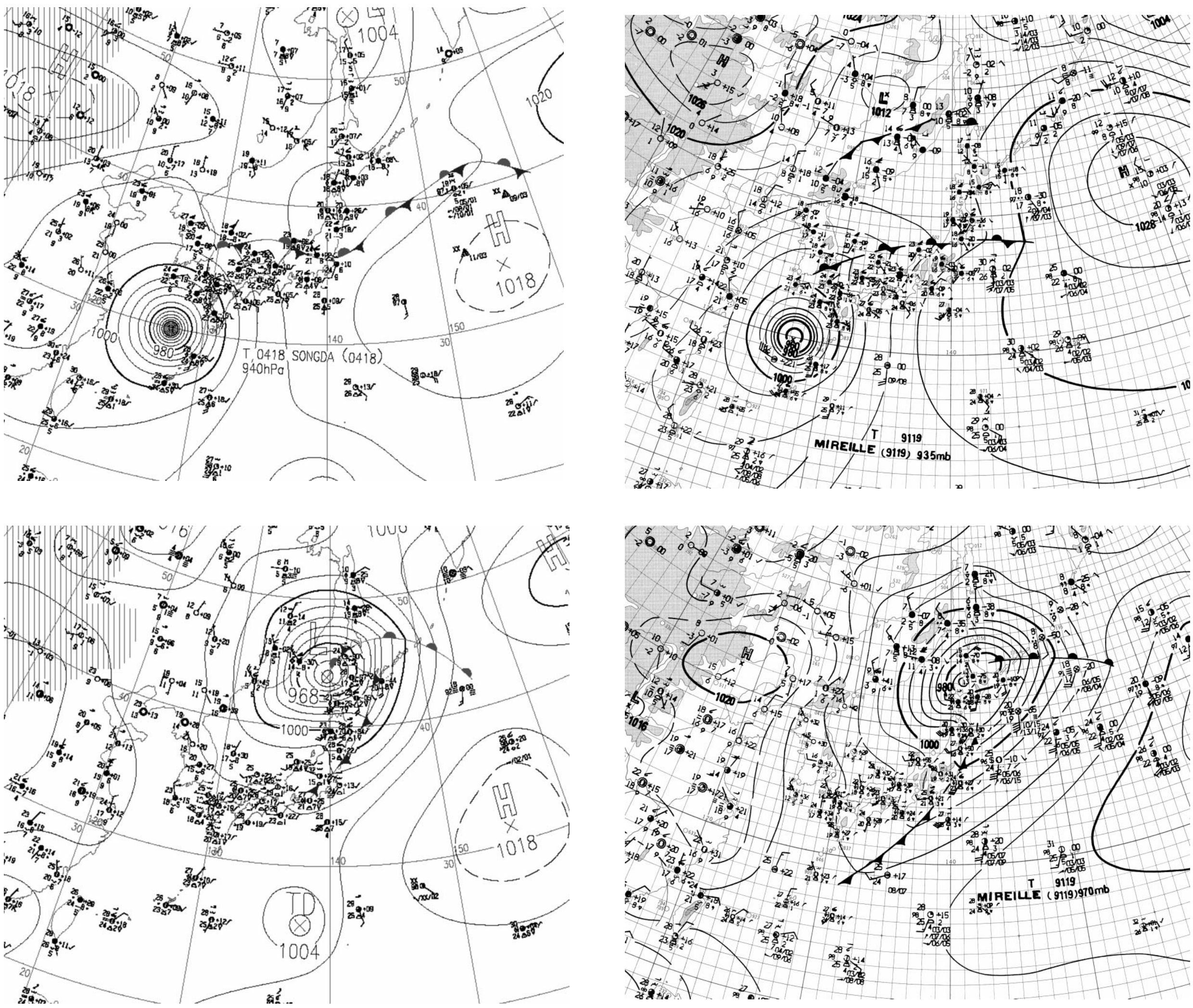

Fig.2 Surface analysis for each typhoon according to the JMA.

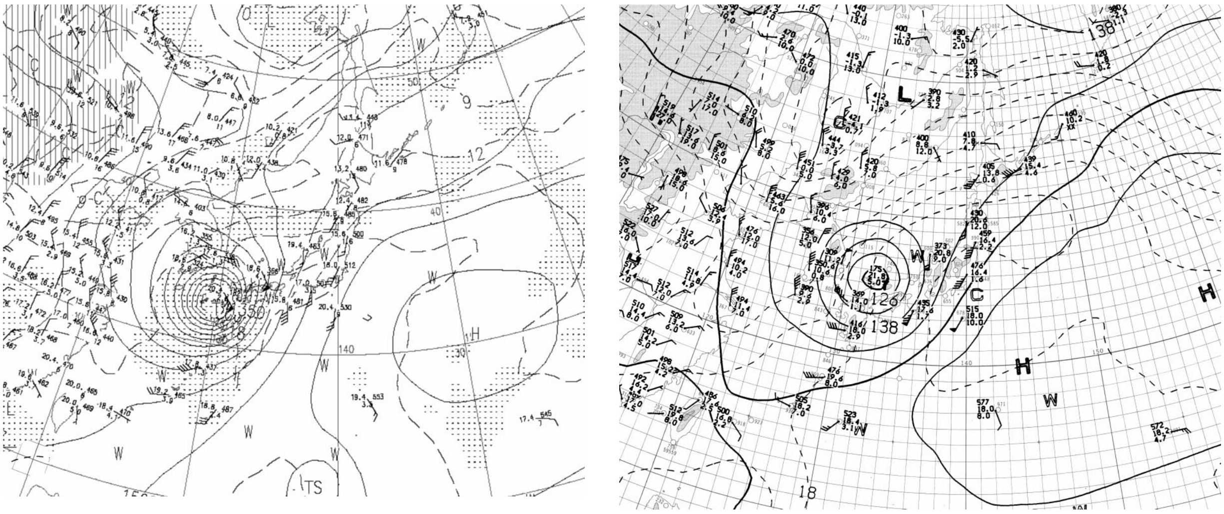

Fig.3 The 850hPa analysis for each typhoon according to the JMA.

the best track analyzed by the Japan Meteorological Agency (JMA). The cubic spline functions of Akima [2] were used to interpolate the latitude and longitude of the center as functions of time.

Data of surface wind, temperature, and rainfall were available on the network of the Automated Meteorological Data Acquisition System (AMeDAS) which provides data of every ten minutes for 2004 and every hour for 1991. Hourly and minimum sea-level pressure and peak gust are recorded at meteorological observatories of the JMA. Some of them are equipped with a wind profiler, which have provided ten-minute data of upper-level wind since June 2001 with a vertical resolution of about 300m.

3. Wind fields in western japan

The two typhoons moved northeastward across the northern part of Kyushu at a speed of 50-60 km/h (Fig.4). They were in an early stage of extratropical transformation, corresponding to the frontal zone from the Sea of Japan to the Yellow Sea, so that the convective clouds surrounding the eyewall began to decay after landfall. Nevertheless, they retained central pressure below 950hPa while passing Kyushu, and caused severe wind damage in regions from

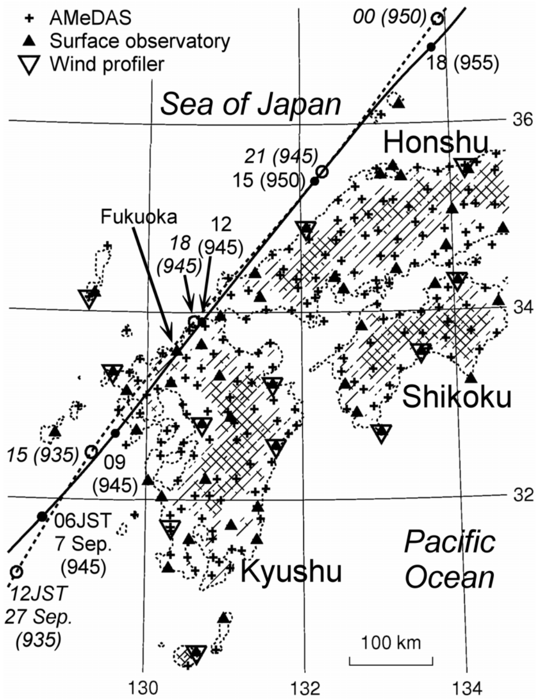

Fig.4 Tracks of T0418 (Songda, solid line) and T9119 (Mireille, dotted line) in western Japan. Circles indicate three-hourly positions of the typhoon center. Hatching indicates the area higher than 300m, 600m, and 1200m above the m.s.l. with increasing tones.

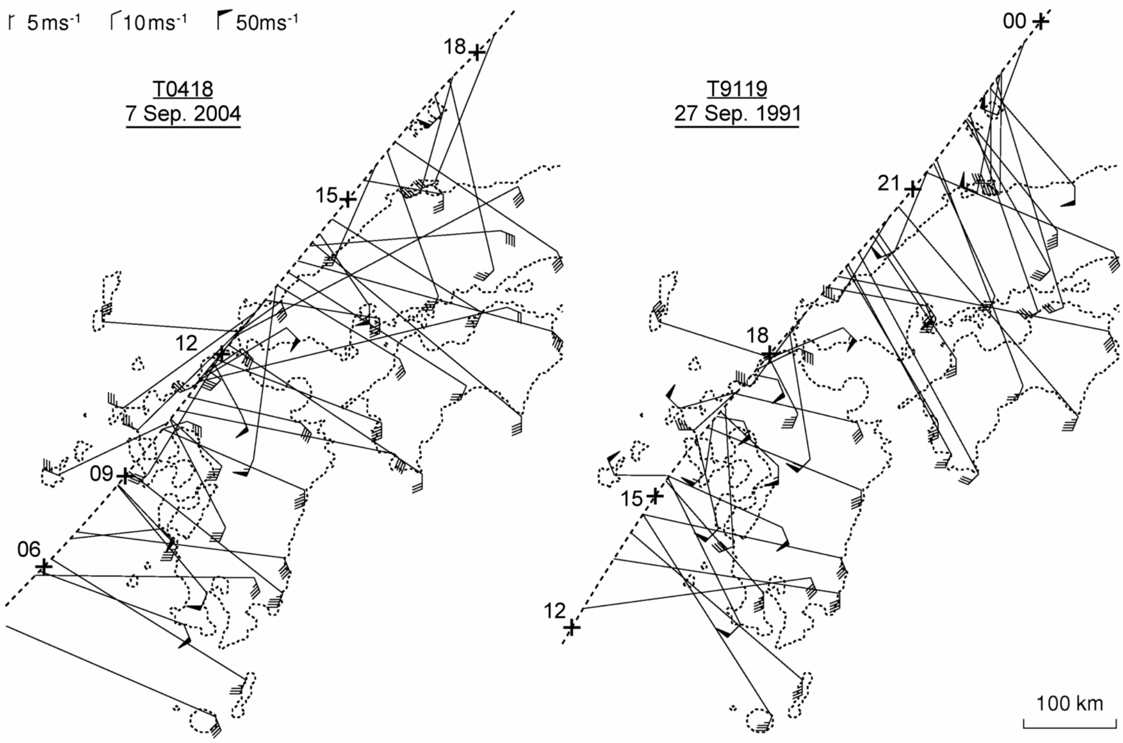

Fig.5 Peak gusts at JMA observatories, with the corresponding positions of the typhoon center.

Kyushu to western Honshu.

Figure 5 shows the distribution of peak gust due to each typhoon. In Fig.6, the peak gust at each station is plotted against the distance from each typhoon track. In both cases the strongest gust of ~ 60ms^{-1} was observed at about 50km southeastward of the tracks. On the northwestern side and near the track, the peak gust of T9119 had the intensity of 40-50ms^{-1}, while that of T0418 was less than 40ms^{-1}. As seen from Fig.5, the peak gusts along the track of T9119 were from the northwest at many stations, while they were from the southwest in the case of T0418 .

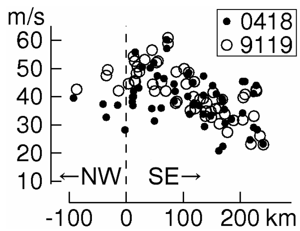

Fig.6 Peak gusts at JMA observatories in western Japan (Kinki, Chugoku, Shikoku, and Kyushu districts except Mie prefecture) plotted with respect to the distance from the typhoon track.

Figure 7 shows the composite fields of surface wind, temperature, and rainfall intensity around each typhoon center. The analysis was made by superimposing the AMeDAS data for four hours with respect to the center. There is rough similarity in the wind fields in the southern and eastern sectors. On the western side of the center, the wind in T0418 was relatively weak, while T9119 was characterized by strong northwesterly winds and low temperature, coinciding with an area of heavy rain. This feature of T9119 became conspicuous after its landfall on Kyushu [1].

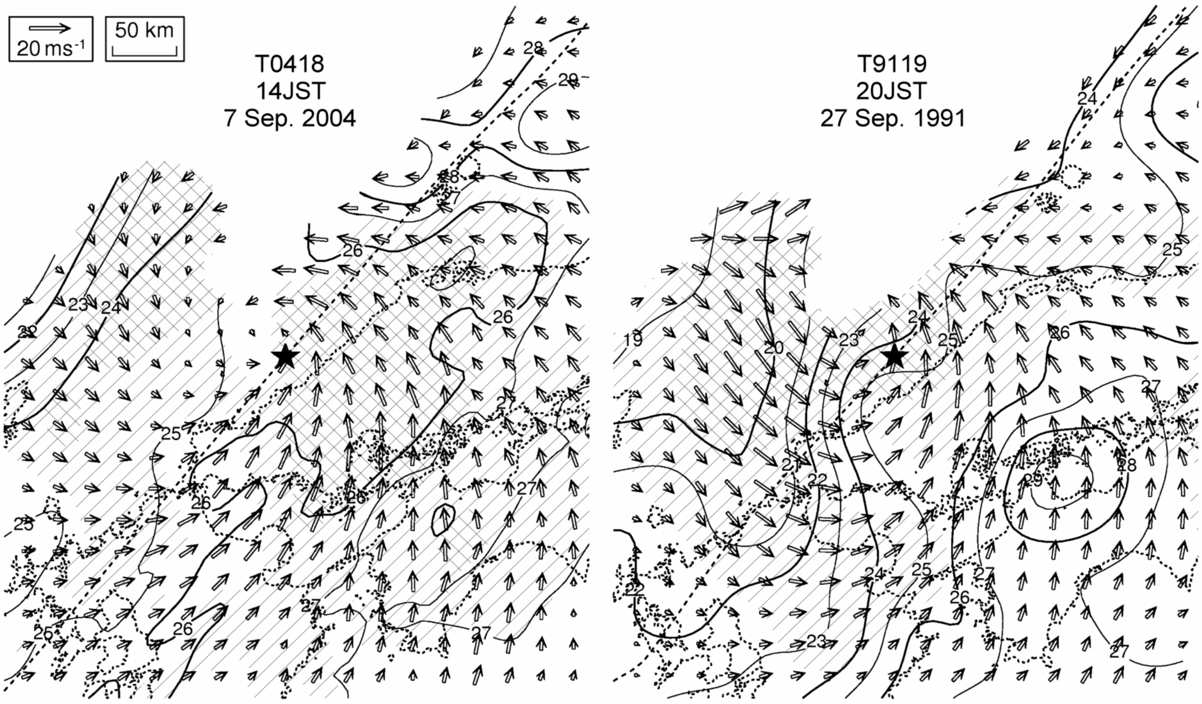

Fig.7 Composite fields of wind vector (arrows), temperature (isotherms), and rainfall intensity (hatching). For T0418, the ten-minute AMeDAS data from 1140 JST to 1530 JST were superimposed after adjusting the deviation of the typhoon position from that at 1400 JST. For T9119, hourly AMeDAS data from 1800 JST to 2100 JST were superimposed after adjusting the deviation of the typhoon position from that at 2000 JST. Hatching indicates the area of rainfall exceeding 2mm/h and 8mm/h with increasing tones.

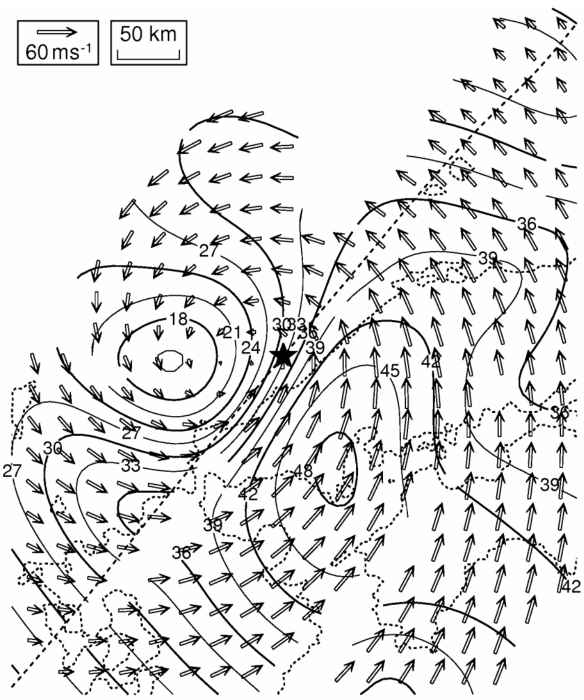

Fig.8 Composite fields of wind vector (arrows) and wind speed (isotachs) for T0418 at 1km above the m.s.l. The ten-minute wind profiler data from 0900 JST to 1500 JST were superimposed after adjusting the deviation of the typhoon position from

Figure 8 shows the composite fields of horizontal wind vector and wind speed at 1km above m.s.l. for T0418. The analysis was made by superimposing the wind profiler data for six hours with respect to the center. The main feature of the wind field roughly agrees with that at surface (Fig.7), with respect to the maximum wind speed (～50ms^{-1}) to the southeast of the center and the minimum wind speed (～20ms^{-1}) to the northwest. The wind speed difference is 30-35 ms^{-1}, which is about twice the moving speed of the typhoon (60km/h   17ms^{-1}).

As shown by Fujibe [3], the wind field near the center of a moving typhoon is given by the summation of the gradient wind for the stationary typhoon and the translation velocity. Figure 9 shows the composite wind fields relative to the storm motion, which was northeastward (38.8deg) at a speed of 64km/h on the average for 09-15 JST. The difference of wind speed between each side of the track almost vanishes in Fig.9, although the vortex core deviates behind the

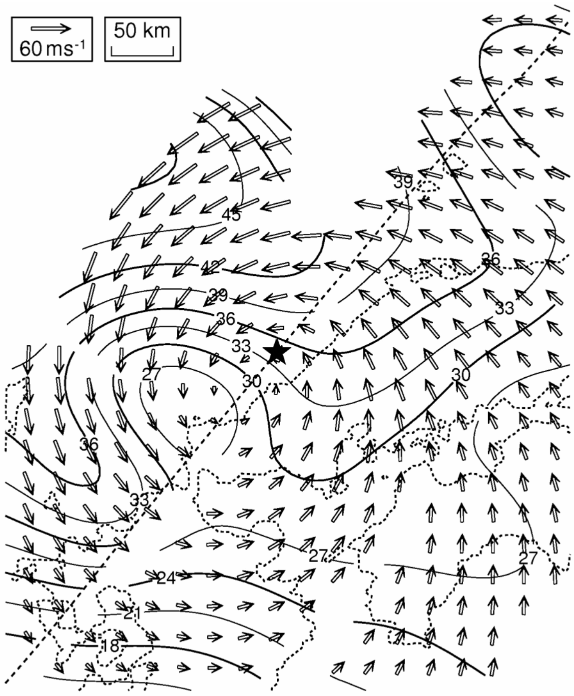

Fig.9 Same as Fig.8 but for the storm relative wind.

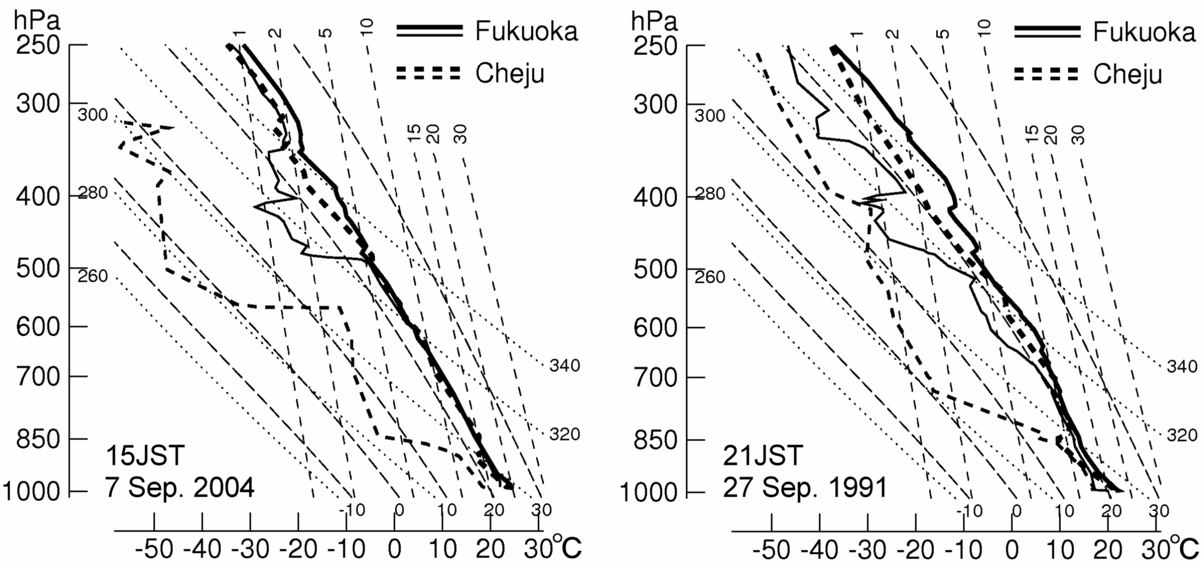

Fig.10 Emagrams at Fukuoka and Cheju Island (see Fig.1) at 15 JST 7 Sep. 2004 and 21 JST 27 Sep. 1991, at which the typhoons were offshore the western Honshu (see Fig.4).

center. Thus the wind difference across the track of T0418 can be roughly explained by the translation of an axisymmetric typhoon. In other words, the strong northwest winds behind the center of T9119 are a highly asymmetric feature which had an appearance of a cold air surge.

The frontal zones in southern Sea of Japan were accompanied by very dry air in the middle troposphere on its northern side (Fig.10). This fact implies that the dry air entrained in the rainband behind T9119 caused evaporative cooling and a consequent cold-air surge. This process did not work in T0418 because convective clouds behind the center had almost disappeared after the landfall.

Figure 11 shows the sea-level pressure distribution for the two typhoons. In both typhoons, the pressure gradient is stronger behind the center than in the front. This asymmetry may be explained by the orographic effect of the mountains in Honshu and Kyushu having peak height of 1-2km, characterized by ridging on the upstream side and troughing on the downstream side [4]. However, the pressure gradient behind the center of T9119 is much stronger (about twice) than that of T0418. This difference implies the role of cold air in generating the strong pressure gradient behind T9119. It is plausible that the cold air surge blocked by the mountains induced a strong ridging effect and intensified the pressure gradient.

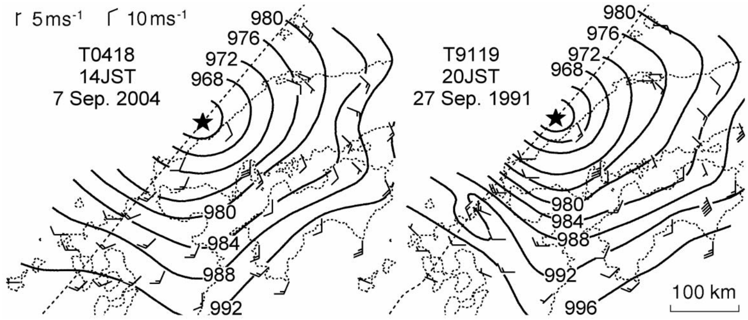

Fig.11 Sea-level pressure fields for each typhoon.

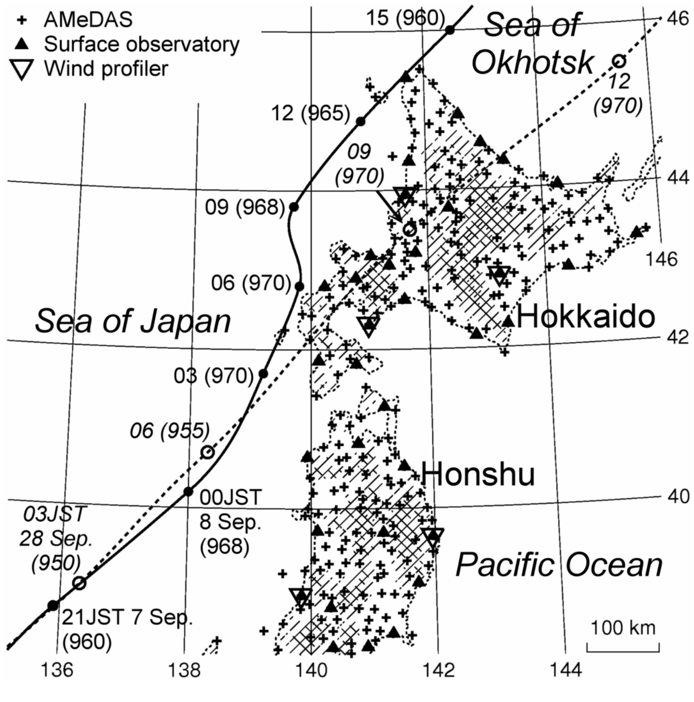

Fig.12 Storm treaks in northern Japan (same as Fig.4).

4. WIND FIELDS IN NORTHERN JAPAN

After passing Kyushu, the two typhoons rapidly lost the structure of tropical storms characterized by axially symmetric structure with eye wall clouds. However, they still had the intensity of

960-970hPa and peak gusts exceeding 50ms-1 as they hit the northern Japan, which rarely experiences severe winds due to typhoons. T0418, which transformed to an extratropical cyclone at 0900 JST 8 September according to the best track of the JMA, moved northward along the west coast of Hokkaido at a speed of 40-50km/h, while T9119 passed northeastward through Hokkaido at a very high speed of 120-130 km/h (Fig.12).

Figure 13 shows the peak gust at each station with respect to the distance from the track. Figure 14 shows the composite fields of wind and temperature around the center of each typhoon (cyclone) obtained in the same way as Fig.7. Both T0418 and T9119 were accompanied by strong south or southwest winds in their eastern and southern sectors. However, the area of strong winds was located

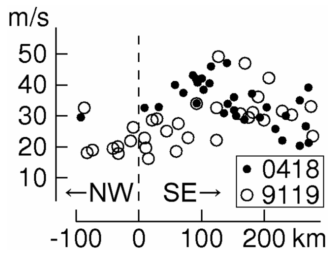

Fig.13 Same as Fig.6 but for observatories in northern Japan (Hokkaido and Tohoku districts).

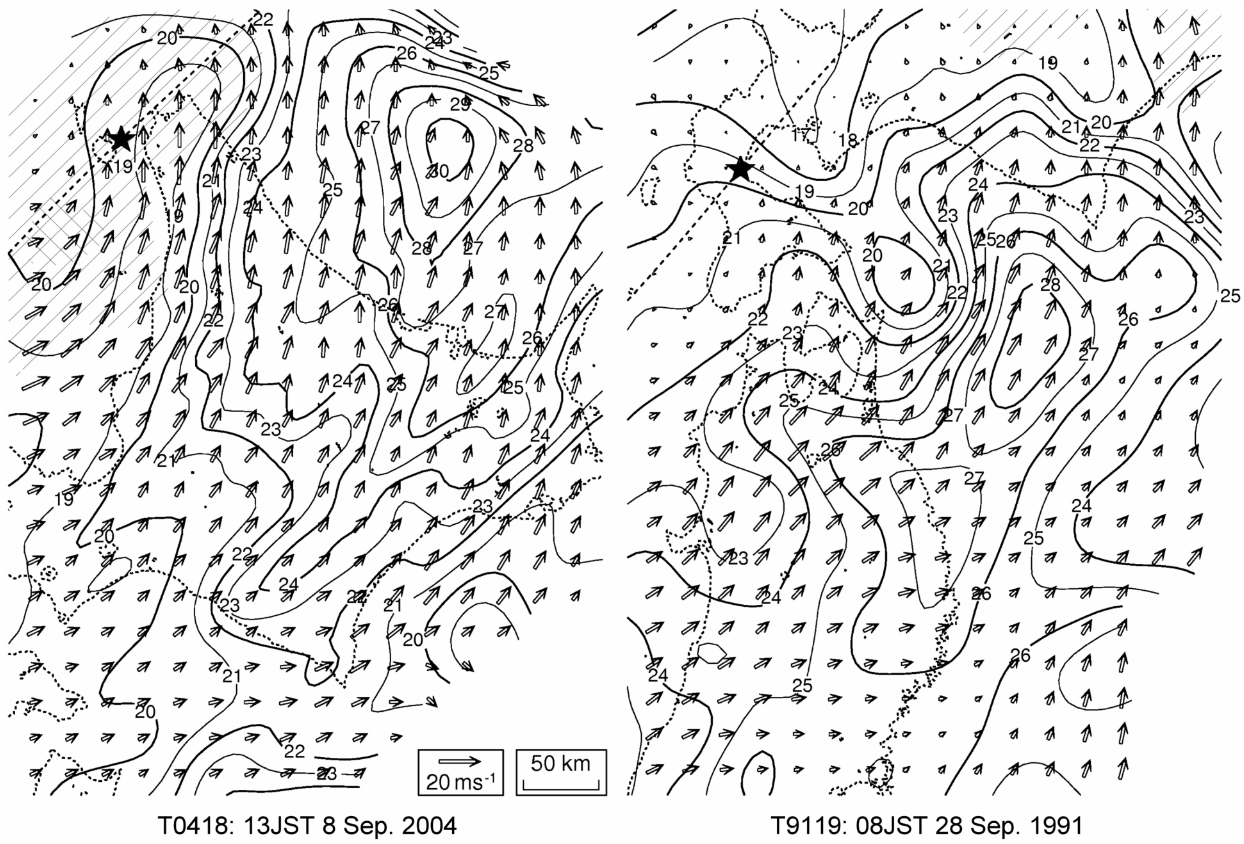

Fig.14 Same as Fig.7, but for 1040-1430 JST for T0418, and 0600-0900 JST for T9119.

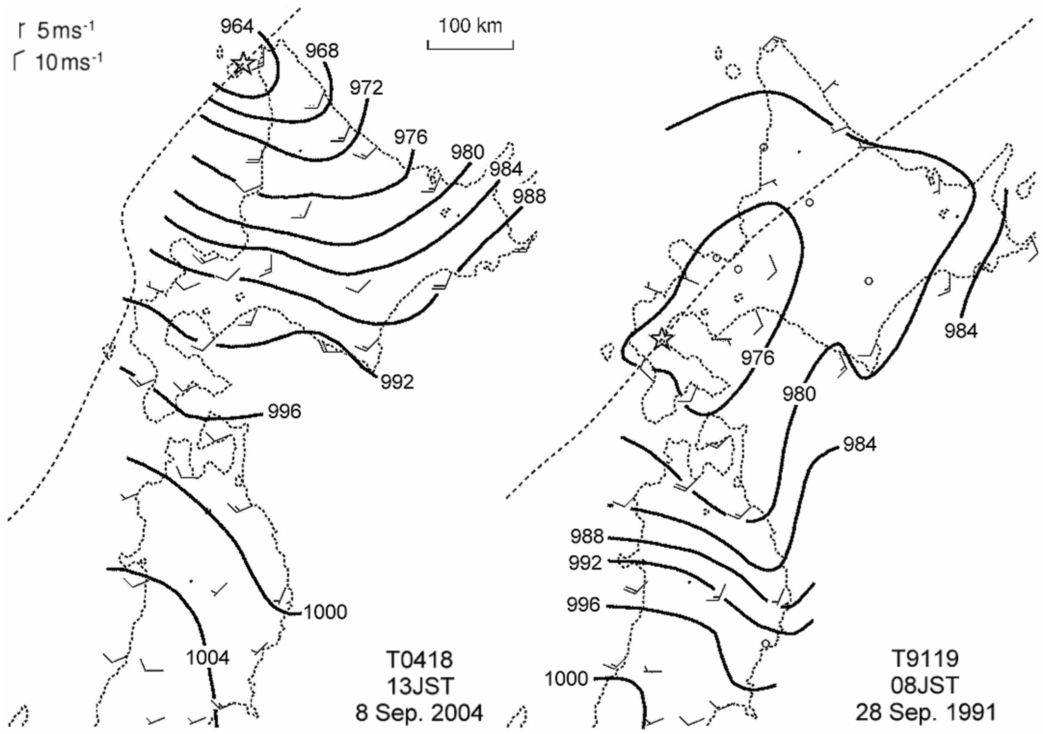

Fig.15 Sea-level pressure fields for each typhoon (cyclone).

nearer the center in the case of T0418 than in T9119, which had a weak wind region within 100km of the center. Due to this difference, the wind damage of T0418 was severest in the northwestern part of Hokkaido, while that of T9119 was most serious in the northern part of Honshu rather than in Hokkaido. In both cases the severe winds were accompanied by no or little rain.

Figure 15 shows the sea-level pressure fields. Corresponding to the difference in the wind distribution, T0418 had a relatively sharp pressure center, while T9119 had nearly uniform pressure within 100km of the center.

More detailed analysis indicates that the west or southwest winds in the southern sector of T0418 were colder and somewhat stronger than the south winds in the eastern sector. In the GOES-9 IR image, the region of cold westerly winds can be traced back to a low T_{BB} area which became recognizable in the late evening of 7 September on the southwestern sector of the typhoon. This feature implies the intrusion of cold air spreading from the southwestern to the eastern side of the center as a factor intensifying the surface wind.

5. REFERENCES

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