

Study on the extratropical transition of typhoon 0310 (Etau) observed by wind profilers and weather radars

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Abstract. As the typhoon observation technique using a wind profiler is gradually developed, it became possible to see the detailed structures of wind behavior in the vicinity of the typhoon center these days. In this study, we examined the extratropical transition of Typhoon 0310 (Etau) in the aspects of wind behavior and precipitation observed with Wind profiler Network and Data Acquisition System (WINDAS) operated by Japan Meteorological Agency (JMA). There was a wide precipitating region in the front side, that is, in the north quadrant of the typhoon. As the typhoon was approaching to the main island of Japan, the precipitating region became gradually narrow. The convective precipitating clouds were observed in the vicinity of typhoon center. Strong cyclonic wind in the front side of the typhoon was observed. The cyclonic wind was getting weak and the strongest cyclonic wind region went away from typhoon center as the typhoon moved to the north-eastward. We observed inflow in lower altitude region (below 2 km) and outflow in higher altitude region (above 2 km). Both the inflow and outflow were getting stronger as the typhoon moved to north-eastward.

itation of the instruments. On the other hand, wind profilers are one of the most powerful instruments for typhoon observations, since they can obtain profiles of wind fields with the high time and height resolutions in any weather conditions. Recent years in Japan, as typhoon observational techniques using wind profilers gradually developed, the detailed structure of typhoon came to be seen and the researches of typhoon using wind profilers were begun these days. For example, Teshiba et al. (2001) and Shibagaki et al. (2003) examined the wind fields relative to typhoon center around the Japan Islands based on wind profiler observations. They showed intense cyclonic wind in the front side of typhoon and inflow and outflow in lower and in higher height, respectively. It seems that these characteristics in the vicinity of typhoon center are representative for the typhoon approached to the Japan Islands. However, as a few number of typhoon approaches to Japan every year and the typhoon observation technique using wind profiler developed recent year, there are few instance of typhoon observation using wind profiler. Therefore, we need further researches of typhoon approached to Japan Islands with wind profiler.

1 Introduction

There are several structural differences between tropical cyclone (typhoon) and extratropical cyclone. In spite of the existence of these differences, tropical cyclone gradually transits into extratropical cyclone in mid-latitudes. The process of the extratropical transition of tropical cyclone is not completely understood yet. In order to understand the structural variation accompanied with an extratropical transition, it is necessary to observe the detailed structure of typhoon, especially in the vicinity of typhoon center. However, this detailed structure cannot be seen by the conventional observation technique such as aircrafts, meteorological satellites, ground-based weather radars and so on, because of the lim-

In this study, we used observation data of typhoon 0310 (Etau) with wind profilers in plural sites from 7 to 10 August 2003, and examined wind fields of typhoon accompanied to extratropical transition. We show the analysis result of wind fields especially three WINDAS sites (Shimizu, Kochi and Takamatsu, see Fig. 1) in this paper. These sites are approximately located in the same distance from the closest point of approach of typhoon center and are the same azimuth angle relative to the typhoon center. Therefore, we consider that we can see not the nonaxi-symmetric structure of typhoon but the wind variation accompanied to the extratropical transition by the comparison to the wind fields of the three sites. In addition to three sites, we show the result at Naze where typhoon center passed just over the radar site.

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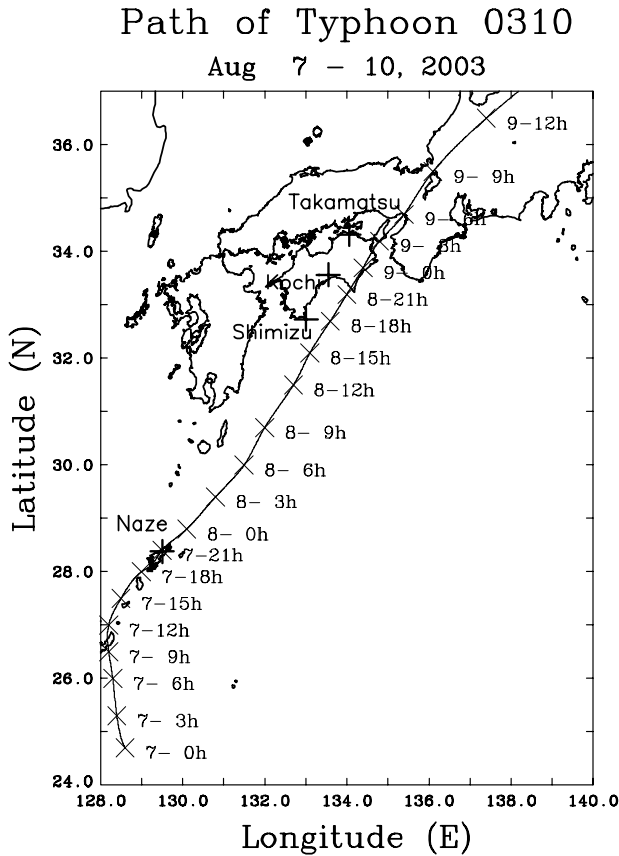


Fig. 1. Trajectory of typhoon 0310 (Etau) and WINDAS sites (represented + signs).

2 Instruments and analysis method

2.1 Observation instruments

Weather radars have the limitation for weather conditions. As they receive reflecting echo only from rain particles, weather radar cannot observe in the condition where no rain particle exist. Wind profilers, however, can obtain profiles of the wind in any weather conditions. Middle and upper atmosphere radar (MU radar) and lower troposphere radar (LTR) are representative of wind profilers in Japan. LTR was developed in Research Institute for Sustainable Humanosphere, Kyoto University (RISH) and was adopted for constituting radar of Wind Profiler Network and Data Acquisition System (WINDAS) in Japan. WINDAS is set up by 31 sites in Japan today. The radar frequency is 1.3 GHz and the time and height resolutions are 1 min and 300 m, respectively.

2.2 Analysis method

In this study, we apply the same assumptions as Teshiba et al. (2001). We assume that the typhoon is cylindrical and the moving speed of typhoon center does not change in height. Under the assumption, we examined wind fields by subtract-

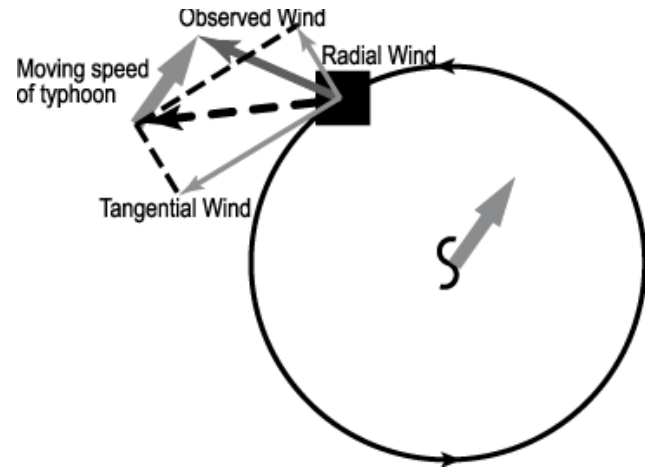


Fig. 2. Schematic illustration of analysis method. Black square shows radar site of WINDAS.

ing the moving speed of typhoon from observed wind and dividing into two components; radial and tangential component (see Fig. 2). The locations and moving speed of typhoon were estimated from the interpolation of the locations reported by JMA every 1–3 h. The positive values of radial and tangential wind are outflow and counterclockwise wind (cyclonic rotation), respectively.

3 Results

3.1 Characteristics of the precipitating distribution

We used two instruments for the analysis of precipitating distribution. One is weather radars and the other is WINDAS. Figure 3a and b show the results of the weather radar observation before and after the typhoon landed at the part of Japan Islands, respectively. Before landing, we can see typhoon eye clearly and precipitating clouds was distributed around the typhoon eye. After landing, however, the typhoon eye became ambiguous and the precipitating distributions which was seen before landing were broken.

Figure 4 is echo intensity observed by WINDAS. The positive and negative distance from typhoon center indicate the front and the rear sides of typhoon, respectively. The precipitating region in the front side of typhoon is wider than that in the rear side at each site. The precipitating region in the front side became narrower and narrower as the typhoon went north-eastward. Strong echoes do not exist around the melting layer (about 5 km), therefore the precipitating clouds are convective ones.

3.2 Characteristics of the wind field

We show the results of tangential wind (see Fig. 3). We can see strong cyclonic wind. The strongest region of cyclonic wind is the distance about 100–300 km from the typhoon center in the front side. The peak region went away from

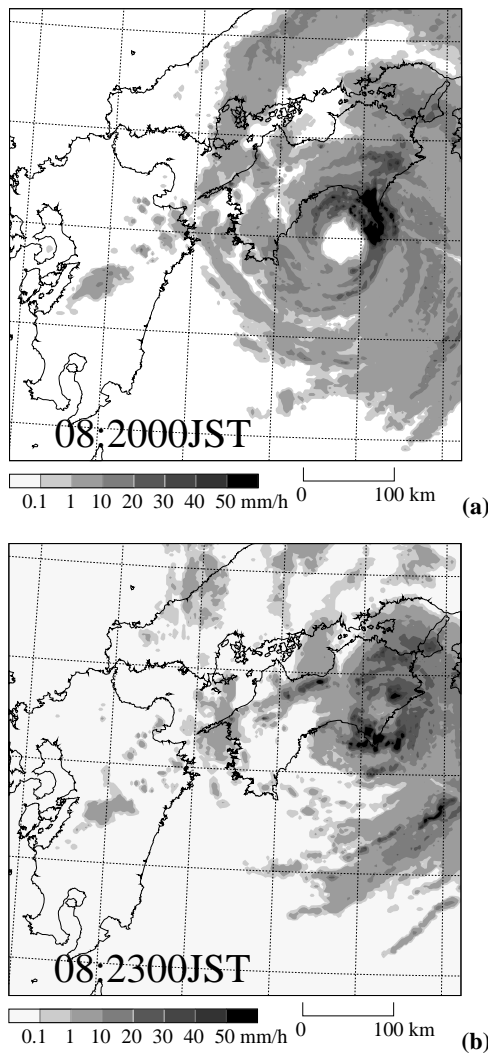


Fig. 3. Precipitating distributions observed by weather radars for 20:00 LT (a) and 23:00 LT (b) on 8 August 2003.

typhoon center and the strength of cyclonic rotation became weaker and weaker as typhoon moved north-eastward. We consider this feature is representative of typhoon in the extratropical transition. The anticyclonic wind can be seen in the region close to typhoon center within the distance of 30 km.

We show the results of radial wind (see Fig. 3). We can see inflow in lower altitude (below about 2 km) region both in front side and rear side of typhoon. We can see outflow in higher altitude (above about 2 km) region in the both side of typhoon. Especially, strong outflow is seen in the region of 300–500 m distance from typhoon center in the rear side. Inflow and outflow became stronger and stronger as typhoon went north-eastward (see Fig. 3b–d). Comparing the case before landing (Fig. 6a) with the case after landing (Fig. 3b–d), we can see the collapse of axis-symmetric structure of radial and tangential wind with respect to the typhoon center.

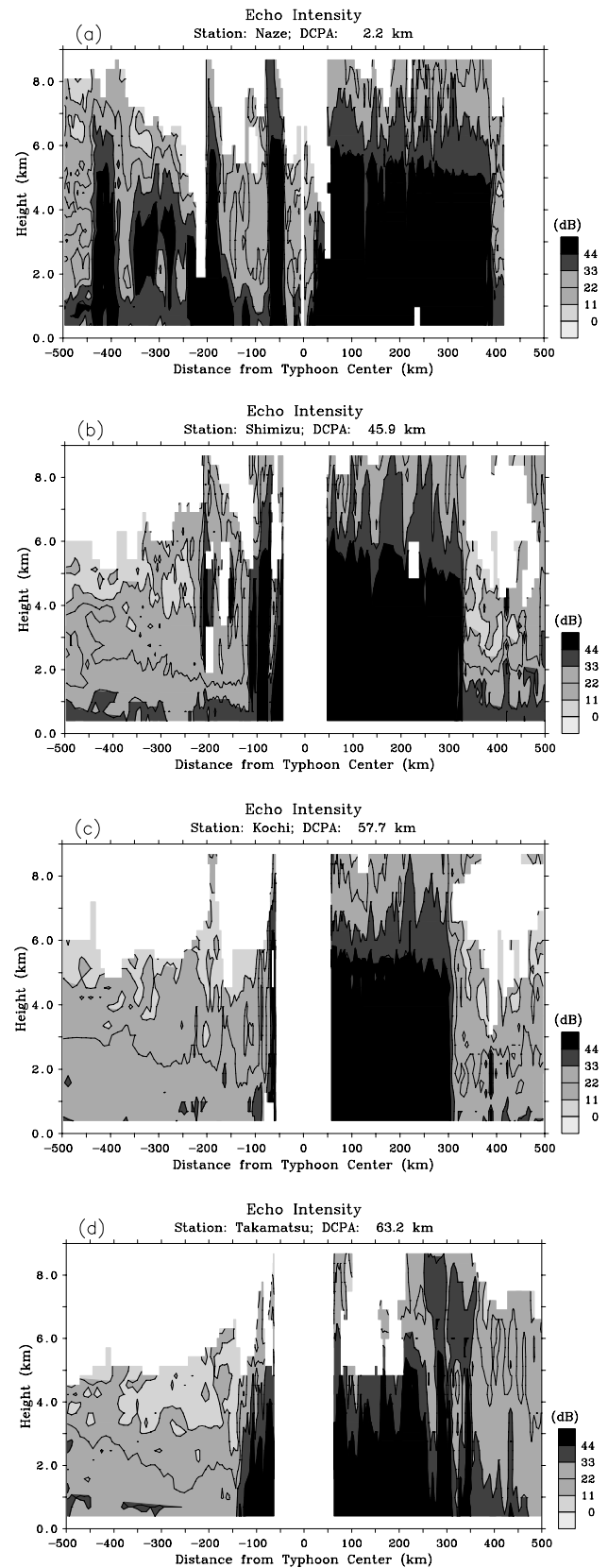


Fig. 4. Radius-height cross sections of echo intensity at (a) Naze, (b) Shimizu, (c) Kochi and (d) Takamatsu observed by WINDAS.

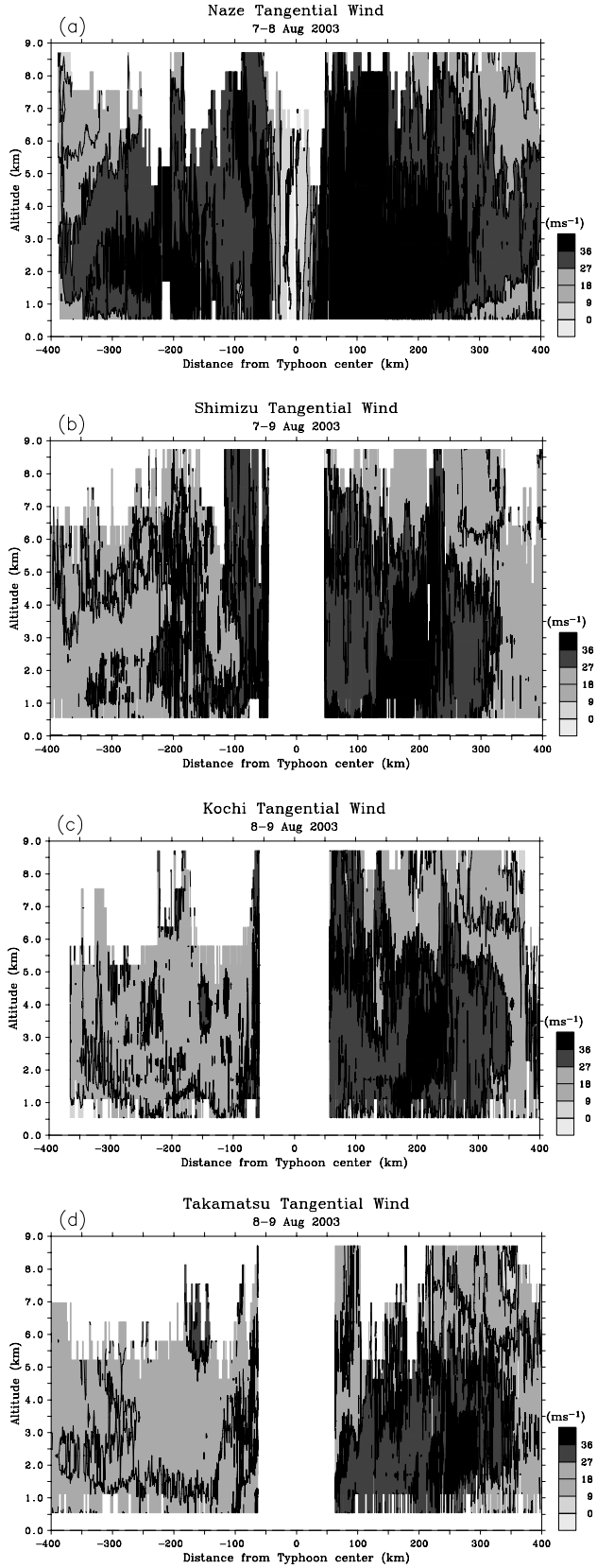


Fig. 5. Radius-height cross sections of tangential wind at (a) Naze, (b) Shimizu, (c) Kochi and (d) Takamatsu observed by WINDAS. The positive and negative value represent counterclockwise wind (cyclonic wind) and clockwise wind (anticyclonic wind), respectively.

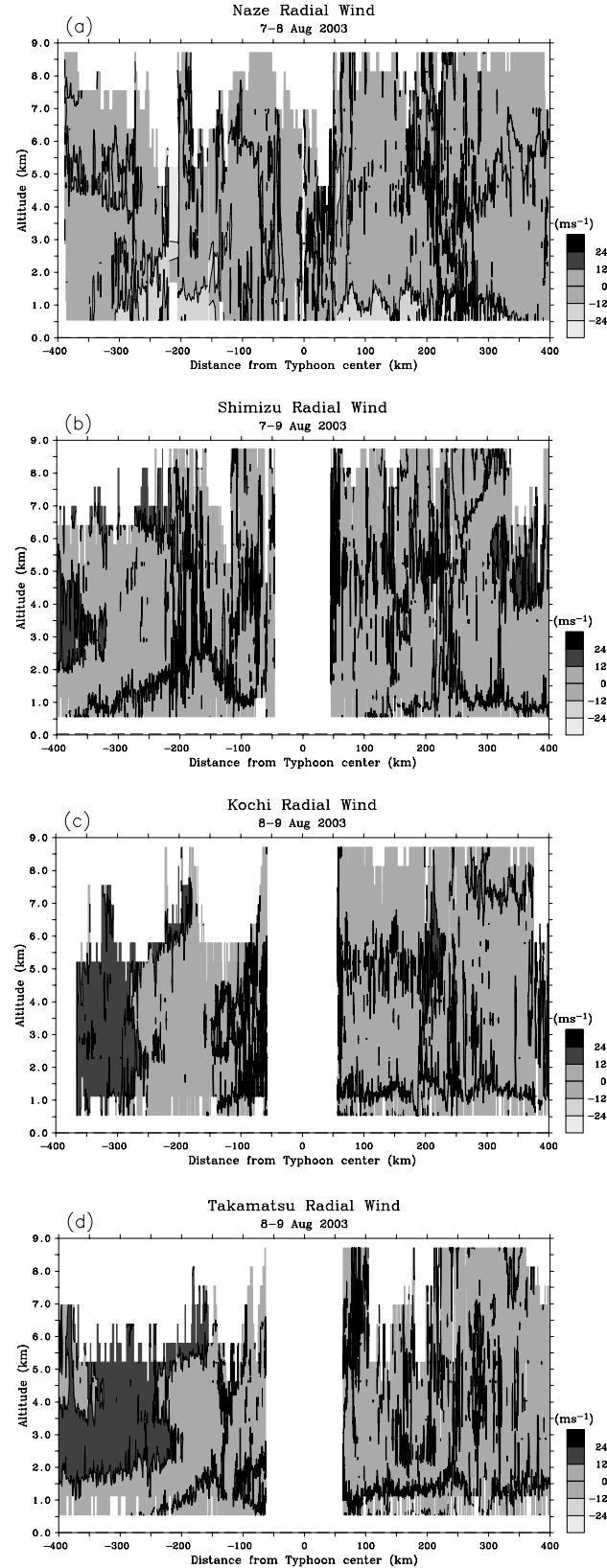


Fig. 6. Radius-height cross sections of radial wind at (a) Naze, (b) Shimizu, (c) Kochi and (d) Takamatsu observed by WINDAS. The positive and negative value represent outflow and inflow with respect to typhoon center, respectively.

4 Summary

Typhoon 0310 (Etau) passed over Japan Islands was successfully observed by WINDAS and weather radars. We got the detailed structure of precipitating distributions and wind profiles of typhoon in the vicinity of typhoon center. The precipitating distributions were quite different between the front and the rear side of typhoon. There was a wide precipitating region in the front side of typhoon, but was not in the rear side. The precipitating region became narrower and narrower as typhoon moved north-eastward. There were inflow and outflow in lower and higher altitude region, respectively. Inflow in front side of typhoon became stronger and wider as typhoon moved north-eastward. Simultaneously, the strength of outflow in the rear side became stronger. On the other hand, strong cyclonic wind in the front side of typhoon became weaker and weaker. These variation is due to the friction of surface of the earth.

References

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