The Study on the Changes of the Three–dimensional Structure and the Movement Speed of the Typhoon through its Life Time.*

Typhoon Research Division

Teruo Muramatsu

ABSTRACT

In the report, we describe the change of the three-dimensional structure and the movement speed through a lifetime of typhoon 7916 (Owen) in autumn in 1979. The properties of the structure are analyzed for four stages; generation, development, mature and transformation to an extratropical cyclone (extratropical cyclogenesis) by using data from satellite, radar, rawinsonde, reconnaissace and AMeDAS.

In chapter 2, we discuss the generation of the typhoon from cloud cluster by analysis of the upper (250mb)- and lower (850mb)- level wind fields and time-longitude sections of GMS images in the equatorial western Pacific. The wind fields are composited from cloud tracked vector by geostationary meteorological satellite (GMS) and wind by RAWIN. It is found that the cloud cluster on the ITCZ along 10–13°N longitude has rapidly organized in the southern part of rigde area of upper the easterly wave disturbance which travels along 20–25°N with a period of 4–5 days and wavelength of 3000–4000km. The cloud cluster can be traced back 10 days before the typhoon formation. It possessed remarkable low- level circulation over 500km in a diameter before 4 days. The cloud cluster grows into the typhoon on September 23 at 13.2°N, 136.7°E west of Guam island. Including other cases of the generation of six typhoons through T7914 to T7920, it is common to all cases that cloud cluster on the ITCZ have organized in the ridge of westward traveling easterly wave along 20–25°N latitude.

In chapter 3, the three-dimensional structure of typhoon 7916 in the developing stage, minimum stage of centeral pressure and mature stage is investigated by using detailed data (radar, AMeDAS and rawinsonde) which are obtained when the typhoon passes slowly through in observation networks along near 130°E longitude. The observed structures are similar to those of mature hurricanes in the Caribean Sea; 1) good axisymmetry and steep gradient of temperature and wind fields in the central region, 2) existence of warm core in the central region in the middle and lower troposphere, and 3) gradient wind balance and weak vertical wind shear above the boundary. In addition to 1)–3), we obtained observational facts as follows: 4) The radius of maximum wind agrees with that of maximum precipitation and it displaces outward from 15km (26th, 56m/s, minimum stage of centeral pressure) to 80km radius (29th, 38m/s, mature stage) as the maximum wind velocity decreases. Kinetic energy within the 400km radius increases in spite of decrease of maximum wind speed and becomes maximum on 3 days after the centeral pressure becomes minimum. 5) Echo surrounding the eye has been organized with two distinct periods of 4–5 hours and about 12 hours. And also extent of low T_{BB} area shows semidiurnal and diurnal variations. 6) Asymmetrical distribution caused by cold and dry air advection in the western quad-

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rant becomes remarkable even at the mature stage when the typhoon is located south of 30°N.

In chapter 4, transformation process from mature typhoon into extratropical cyclone (extratropical cyclogenesis) in the westwerly zone is discussed in detail for the T7916. The results are surmmarized as follows: 1) Asymmetrical transformation in the temperature, humidity and height field occurs rapidly as the typhoon enters deeply the westerly zone. 2) Well organized deep convective clouds surrounding the eye disappear first and precipitation area displaces to forward direction or to polar side. 3) As the processes of 1) and 2) go on, steep gradients of height and temperature near the center become obscure, and temperature gradient is concentrated to low- level frontal zone. 4) In the final stage, middle tropospheric circulation (mainly 500mb–300mb level) disappears and, simultaneously, the dry area enter to low level circular center from the rear side. At this time (06z, lst), the typhoon has already lost all the properties and is transformed into an extratropical cyclone.

In the process of interaction with the westerly disturbance, the circulation of typhoon itself changes continiously to that of cyclone in the lower level below, 850mb, contrary to discontinous transformation in the middle troposphere.

In chapter 5, by using data of AMeDAS we analyzed the north- south cross section of precipitation associated with the Owen in mature stage and heavy precipitation enhanced by orographic features in the Japan islands.

The rainfall associated with the typhoon is classfied into four characteristic stage and is estimated quantitatively for each stages; 1) stage 1; rainfall at the stage when Cb cluster and frontal cloud band get close to each other and interact, 2) stage 2; rainfall due to Cb cluster within the typhoon circulation area, 3) stage 3; rainfall due to the spiral band, 4) stage 4; the heaviest rainfall in the central core region (including eyewall) from 40 to 150 kirometer radii. Mean and maximum values of precipitation in the stage 4 are 14–24mm/hr and 30–34mm/hr, respectively. Rainfall amount due to stage 4 exceeds over 300mm/day on the Amami island.

On the other hand, rainfall intensity is intensified by orographic effect when the typhoon approaches the slope of mountain, especially, Kyushu district and southwestern and southeastern parts of Shikoku district. The modification factor, which is defined as ratio of precipitation enhanced by orographic effect to that without effect, is 2.5–3 in the N- NE sector of the typhoon and 1.8–1.9 in the N- NNW sector when the direction of the slope agrees with that of low level wind.

In chapter 6, it is revealed that the characteristic change of typhoon speed takes place in the process of transformation into an extratropical cyclone when the typhoon enters southeast quadrant of the deep westerly trough. Characteristic features of the velocity change accompanied with extratropical cyclogenesis are shown as follows; 1) rapid acceleration stage when entering into the westerly zone, 2) the maximum speed stage immediately before full transformation into extratropical cyclone, 3) deceleration stage accompanied with final transformation and re-developement as an extratropical cyclone, 4) minimum speed stage, when the cyclone becomes mature as occulusion cyclone, and 5) stage of re-movement as migratory westerly disturbance. The rapid acceleration subsequent rapid deceleration in the process of extratropical cyclogenesis is emphasized in this study.

Such features in the movement speed are found when typhoons move NNE- NE-ward west of 150°E and enter southeast quadrant of the deep westerly trough. When the typhoon move NE-ward east of 150°E or ENE-ward in south of 30°N latitude the speed is constantly increased or constant after increasing, and the transformed extratropical cyclone does not develop, unlike the former case. It is also found that the former is about 30 percent and latter is 70 percent of all transformation cases. Both

cases are classified distinguishably.

In chapter 7, disasters caused by the typhoon are summarized.

In this report, we can reveal the changes of three-dimensional structure and movement speed on the typical autumu typhoon through a life time. Observation results are not only useful to understand the structure in detail but also helpful to develop the simulation of the three-dimensional dynamical model of typhoon.