# Fujiwhara effect; the interaction between T0917 and T0918

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**Abstract**

Typhoon No.17 in 2009 (T0917) caused severe damage to various parts of the Indochinese Peninsula, especially in the Philippines because it remained stagnant around Luzon for a very long time with complex movement due to interaction with Typhoon No. 18 in 2009 (T0918). The interaction between two typhoons is called the Fujiwhara effect. We clarified the process of the interaction between T0917 and T0918 by using satellite images and typhoon tracks. The southward movement of T0917, which is a typical consequence of the Fujiwhara effect, was observed.

**Key words** : Typhoon, Fujiwhara effect, Interaction, Southward movement

## 1. Introduction

Typhoon No.16 in 2009 (T0916) (Asian name: Ketsana, PAGASA*1) name: Ondoy) formed on September 26, 2009. It landed on Luzon island (the Philippines) and the Indochinese Peninsula, causing severe damage to the Philippines, Vietnam, Cambodia, and Laos. Eventually, it became a tropical depression around the Indochinese Peninsula on September 30. Almost 80 percent of metropolitan Manila (the Philippines) was left underwater. The total rainfall for the nine-hour deluge was 410.6 mm, breaking the previous single-day record of 334.0 mm in July 1967. The minimum pressure was 960 hPa*2), and the maximum wind speed was 35 m/s*2).

Subsequently, Typhoon No.17 in 2009 (T0917) (Asian name: Parma, PAGASA name: Pepeng) formed on September 29, 2009. After repetition of landing on and leaving from Luzon, it moved on into the South China Sea. After easing off into a tropical depression, it strengthened again into a typhoon. It then landed on Nanhai Island (China), and finally reverted back to a tropical depression around the Gulf of Tonkin on October 14. The minimum pressure was 930 hPa*2), and the maximum wind speed was 50 m/s*2).

Both typhoons caused severe damage to various parts of the Indochinese Peninsula, especially in the Philippines. There were three reasons for the large amount of damage. The first was that T0917 was a very strong typhoon. The second was that the two typhoons, T0916 and T0917, formed and landed on Luzon in succession. The third was that T0917 remained stagnant around Luzon for a very long time with complex movement due to its interaction with T0918 (See **Fig. 1**). The third reason is very interesting in terms of its physical characteristic. This is the so-called Fujiwhara effect, which was proposed by Dr. Sakuhei Fujiwhara, the then head of the Central Meteorological Observatory of Japan (Fujiwhara, 1921).

## 2. Fujiwhara Effect

The Fujiwhara effect was originally defined as an interaction between two typhoons (generally, two vortices with the same rotating direction) that are separated by up to around 1,000 km. It causes their centers to begin orbiting cyclonically (generally in the same rotating direction as the vortices themselves) about a point between the two systems. Recently, however, it is often used more generally to describe

***1)** PAGASA is the abbreviation for the Philippine Atmospheric, Geophysical and Astronomical Services Administration.

***2)** Minimum pressures and maximum wind speeds are values reported by the Japan Meteorological Agency. The rainfalls are values reported at the actual location. Dates are expressed using Greenwich Mean Time (GMT).

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**Fig. 1** Track of T0917 around Luzon (from the presentation by Ms. Olive Luces (Regional Director, Cordillera Administrative Region, Office of the Civil Defense, the Regional Disaster Coordinating Council of the Philippines) in Cordillera, Phillippines on 29 November, 2009).

the interactions among two or more nearby typhoons. Real typhoons not only exhibit simple rotation but also undergo complex movements governed by the distances between them, their intensity, and the surrounding winds. Their behavior patterns are classified into five types: complete merger (CM), partial merger (PM), complete straining out (CSO), partial straining out (PSO), and elastic interaction (EI) (Dritschel and Waugh, 1992, Prieto *et al*., 2003). The classification is based on a dynamic view and not a unique one. Another example of a classification can be found in Nyomura (1986). A series of typhoons can also exhibit multiple behavior types as they develop (Lander and Holland, 1993: see also the next section).

## 3. The interaction between T0917 and T0918

Satellite images of T0917 and T0918 showed a change of behavior from EI to PM, followed by PSO, and then their separation (EI). Specifically, T0917 and T0918 formed respectively in succession around the Caroline and Marshall islands around September 29, 2009. At that time, T0918 was situated to the east of T0917. Both typhoons were then moved westward by easterly winds. Around the time T0917 landed on Luzon, T0918 was approaching T0917 at high speed, and the Fujiwhara effect caused T0917 to stagnate around Luzon (EI; from about October 3-4; **Fig. 2a**). As T0918 approached Okinawa, T0917 was absorbed and rapidly weakened by T0918 (PM; from about October 5-6; **Fig. 2b**). The weakened T0917 was blown south by a combination of the prevailing wind and the northerly winds generated by T0918 (PSO; around October 7; **Fig. 2c**; see also **Fig. 1** for southward movement.). Once the southerly movement of T0917 and the north-easterly movement of T0918 had established a greater separation between them, T0917 regained its power and was moved west by an easterly wind (EI; around October 8; **Fig. 2d**). T0918 moved north-eastward and made landfall in Japan, becoming the only typhoon to do so in 2009.

## 4. Summary and Discussion

**Fig. 3** shows the track of T0917 by the Japan Meteorological Agency. The track in **Fig. 3**, as well as the track in **Fig. 1** by the Regional Disaster Coordinating Council of the Philippines, shows the southward movement of T0917 for October 5 through 8. The behaviors of T0917 after landing again on Luzon from about October 7 through 8 are different for both track data, although the reason is unknown. The track by the Japan Meteorological Agency shows a counterclockwise movement, but, the track by the Regional Disaster Coordinating Council of the Philippines shows a clockwise movement. In any case, track data show the southward movement of T0917.

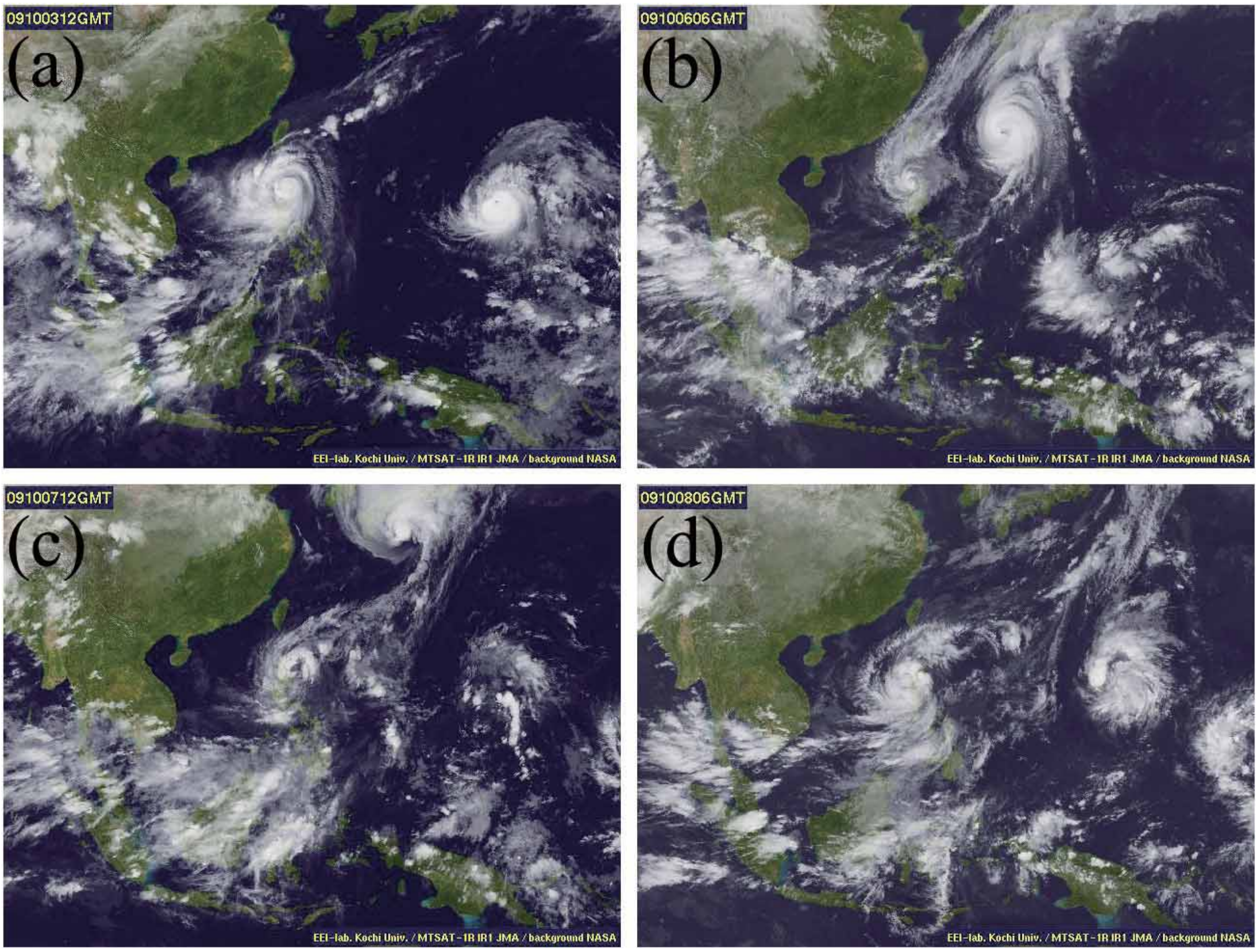


**Fig. 2** Infra-red satellite images of South-East Asia taken by the Multi-functional Transport Satellite (MTSAT-1R)(IR1: 10.3-11.3 μm) in 2009. (a) 12:00, 3 Oct., (b) 06:00, 6 Oct., (c) 12:00, 7 Oct., (d) 06:00, 8 Oct. In (c), T0918 is over the Japanese islands. In (d), T0918 is outside the frame of the image. These images were obtained from the Kochi University meteorology website (http://weather.is.kochi-u.ac.jp/).

Such a southward movement of a typhoon is a typical consequence of the Fujiwhara effect because a single typhoon does not usually move southward. Similar behavior was also observed in T0015 (Bopha), which formed on September 6, 2000, due to interaction with T0014 (Saomai), which formed just before T0015 (Wu *et al*., 2003).

## 5. Summary and Discussion

We clarified the detailed process of the interaction (Fujiwhara effect) between T0917 and T0918 by using satellite images and typhoon tracks. The types of interaction changed from EI to PM, followed by PSO, and then the two typhoons separated (EI). In the process, the southward movement of T0917, which is not observed in usual typhoons, was observed. With the repetition of landing on and leaving from Luzon due to this southward movement, T0917 remained stagnant around Luzon for a very long time, and caused severe damage to various parts of the Indochinese Peninsula.

Recently, global warming and its effects on natural disasters have become severe problems. By global warming, fewer yet stronger typhoons are expected to be generated (IPCC, 2007). However, there is large uncertainty towards these predicted results. Some recent studies show the opposite result; for example, a reduction in strong hurricane frequency under global warming conditions (Knutson, 2008). Therefore, predicting whether the phenomena described in this report will increase or not in the future is very difficult. However, from the viewpoint of disaster prevention, evaluating the changes in disaster with the changes in typhoon activity by global warming is important (e. g., Shimokawa *et al*., 2009, Murakami *et al*., 2011).

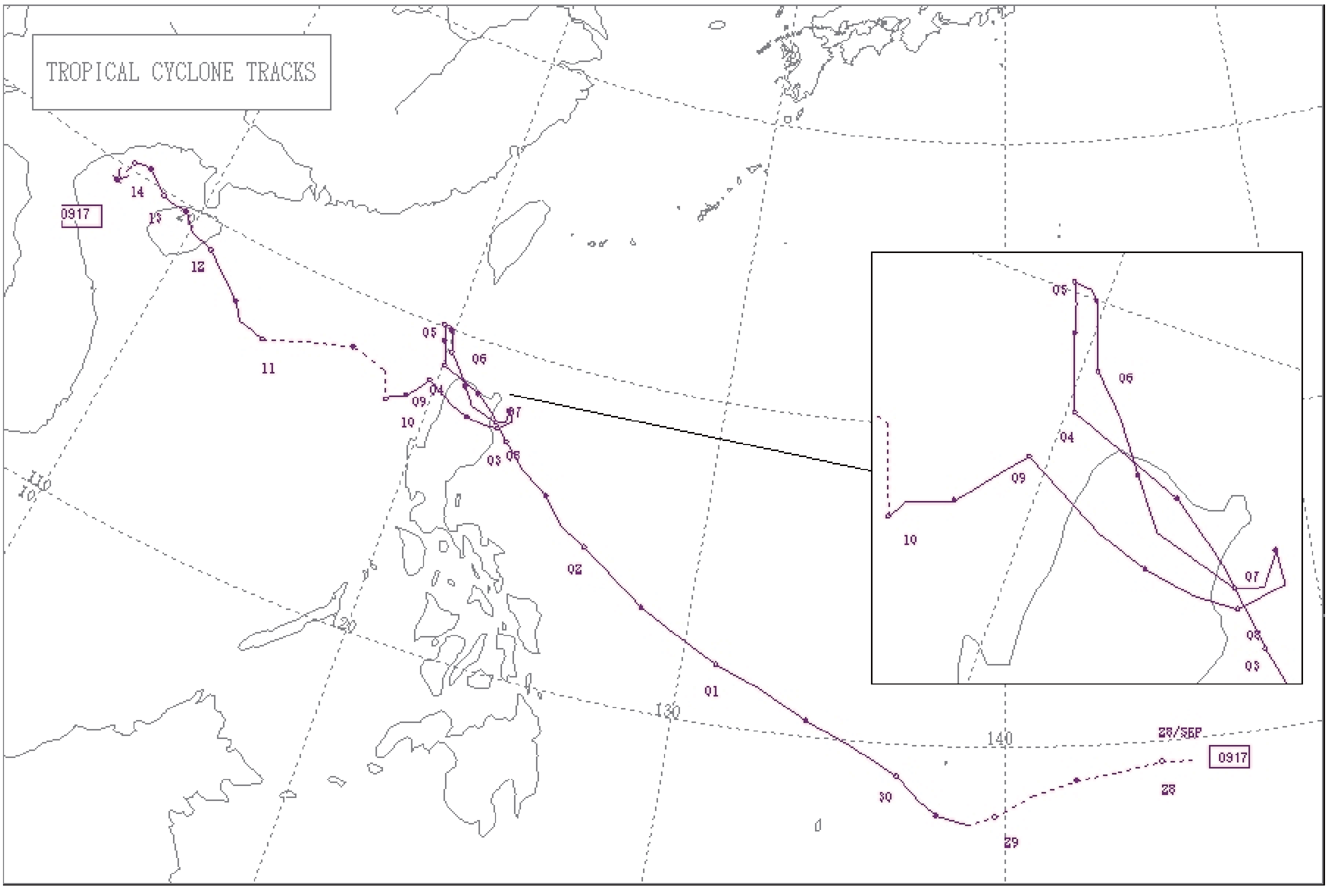


**Fig. 3** Track of T0917 by Japan Meteorological Agency (http://www.data.jma.go.jp/fcd/yoho/typhoon/route_map/index.html)..

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