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The Characteristic of the Surface Wind Speeds over Taiwan Area During the Invasion of Tropical Cyclone

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1. Introduction

The island of Taiwan is situated in one of the main paths of the north Western Pacific tropical cyclones. As Central Mountain Range is in center of the isolated island with a pick higher than 3,900 meters, therefore many interesting weather-topography interaction phenomena have been observed and documented (e.g. Wang 1980; Chang et al. 1993). The forecast of the tropical cyclone's track and the rainfall and surface wind distribution are also complicated by the topography.

In addition to the academic studies, the forecasting of the destructive tropical cyclones also is one of the most important operational tasks of the local weather services. Shieh (1986) reported that the majority of economic losses due to weather related events in Taiwan have been caused by the strong winds, heavy rains and sometimes storm surges associated with tropical cyclones. For example, near 2,000 mm rains were observed in a 48-hour period on the central mountain area during the invasion of typhoon Herb in 1996. The heavy rains induced severe flooding and massive debris flow. The strong winds caused serious agricultural damages. Understanding and achieving better forecasts of the track, rainfall, and wind distributions over Taiwan have become one of the highest priority tasks of the local weather services and the meteorology community.

In the past few years, the improvements on the numerical prediction and the ensemble techniques have reduced the track forecasting errors significantly in the Central Weather Bureau (CWB), Taiwan, and in other operational Centers. For the rainfall forecast associating with tropical cyclones, some statistical rainfall forecast models also have been examined (e.g., Yeh 2002; and others). Those climatological[1] models have provided basic guidance for the rainfall forecast of the tropical cyclone forecast operation of CWB. To improve our understanding and the forecast of the distribution of the surface wind speeds over Taiwan during the invasion of tropical cyclone are the major purpose of this study.

2. Data and analysis

The hourly 10 minutes mean wind speeds of all the 25 stations over Taiwan were collected. The historic data set covers the period from 1961 to 2000. The hourly peak gust recorded from selected stations in northern Taiwan (Taipei station) and southern Taiwan (Kaohsiung station) were also collected. However, the data set of the peak gust only covers the period from 1988 to 2000 and 1993 to 2000, for station in Taipei and in Kaohsiung, respectively. The data were analyzed when a tropical cyclone was inside the region of 18^{O}N to 28^{O}N and 117^{O}E to 127^{O}E. The boundaries of the region are about 5 degrees to the east of Taiwan and three degrees to the south of Taiwan. Since we have focused on the tropical cyclones that have made impact on Taiwan, therefore only the cyclones that have invaded Taiwan were selected. Here we defined invaded Taiwan as the cyclone center made landfall or passed by Taiwan within 1.5 degrees.

Chang et al. (1993) showed that the relative position of the tropical cyclone center is a dominated factor to the surface pressure, rainfall, and wind distributions over Taiwan. The climatological mean wind speeds based on the cyclone center position were calculated for all the 25 stations. Similar is for the climatological means of the gust speed of at Taipei and at Kaohsiung.

3. Results

For the climatological mean wind speeds (based on the cyclone center position) of Taipei, two centers of the maximum are found (figure not shown). One locates about 150km to the northeast of Taipei; the other locates in southwestern Taiwan. Similar distributions of two maximum centers are found for the neighbor

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stations over northwestern Taiwan. But that is different for the mean wind distribution contains only one maximum center locating right over the station (figure no shown), for a neighbor station Pengayi that in a small island about one degree north of Taiwan. Topography effect is a clear indication for the difference. As the cyclone intensity dropped when the center moved further inland, therefore the maximum winds for station such as Taipei were generally found prior to the cyclone center moved over. The shielding effect of the mountains is also shown as that the winds are relatively small when the stations are in the leeside of the mountain of the cyclonic flow. Comparing the climatological mean wind speeds for different stations shows that the surface winds are very different among stations in different locations relative to the mountain. For example, the strong winds at Hualien station were observed mainly during the cyclone centers were in a band region with axis perpendicular to the axis of the Central Mountain Range. Leeside effect or ridging effect cause the surface wind speed decreases significantly when the center moves away from the zone to the north or to the south.

The relationship between the peak gust speeds (Vg) and the 10-minute mean wind speeds (Vm) observed at Taipei were shown in Figure 1. A least square fit obtains Vg=0.45+2.38Vm. Where Vg and Vm are in units of m/sec. A similar relationship (not shown) was found for the winds at Kaohsiung, except that the factor is 2.15. As Taipei is in northern Taiwan, more of the cyclonic flow can directly affect the city than that of at Kaohsiung, stronger gust were observed. The difference between the gust and the mean wind at Taipei can reach 6 Beaufort wind scale. Many cases of gust of storm scale occurred with mean winds of moderate breeze. The forecast of the peak gust speeds seems to be more important and more challenging than the forecast of the mean wind speeds. From the distribution of the climatological mean of the gust speeds (based on the cyclone center position), we found that local smaller scale topography also affect the gust winds. Stronger gust winds were observed when the centers were in the favorable region with the cyclonic flow can flow along the valley to reach the city.

Based on the climatological means, several statistical methods that Yeh (2002) used were examined to forecast the surface winds in Taiwan when tropical cyclone in nearby. The results show that those statistical forecast methods can provide basic guidance for the wind forecast.

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References

Chang C.-P., T.-C. Yeh, and J. M. Chen, 1993: Effects of terrain on the surface structure of typhoons over Taiwan. *Mon. Wea. Rev.*, 121, 734-752.

Shieh, S.-L, 1986: A survey of meteorological disasters over Taiwan area. *Atmospheric Sciences*, 13, 89-108. (in Chinese)

Wang, S.-T., 1980: Prediction of the behavior and strength of typhoons in Taiwan and its vicinity, Research Report No. 108, 100pp. (in Chinese)

Yeh, T.-C., 2002: Typhoon rainfall over Taiwan area: The empirical orthogonal function modes and their applications on the rainfall forecasting. *Terr., Atmos., and Ocenic Sci.*, 13, 449-468.

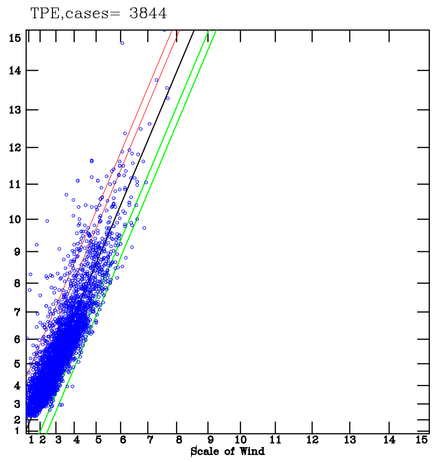

Figure 1. The distribution of the surface 10-minute mean speeds (horizontal, in Beaufort wind scale) and the gust wind speeds (vertical) at Taipei during the invasion of typical cyclone.