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Use of QuikScat Data in Studying the Evolution of Tropical Cyclone Structure

Johnny C.L. Chan* and Cleo K.M Yip
Department of Physics and Materials Science, City University of Hong Kong

1.Introduction

In the past, the capability for studying the evolution of tropical cyclone (TC) structure and its size was low due to the lack of data over the ocean. But with the advance of technology, higher resolution and wider coverage of meteorological satellites, more data are available for investigating the problem of TC structural changes. In this study, TC size and the evolution of TC structure over the Western North Pacific (WNP) are investigated using the QuikScat surface wind data during the period June 1999 to December 2001.

2. Data

The scatterometer wind data from the QuikScat satellite from June 1999 to December 2001 are used. The Seawinds scatterometer is a microwave radar designed specifically to estimate ocean near-surface wind speed and direction. The satellite has an 1800-km wide continuous swath, with 900 km wide on both sides. It provides sea-surface winds with a resolution of 25 km. In this study, only those TCs with more than half of its circulation covered by the swaths are chosen.

3. TC size

a. Seasonal variation of R-15

Following Liu and Chan (1999), the size of a TC is defined as the azimuthally-averaged radius of 15 m s^{-1} surface winds (R-15). This is done by first averaging the winds within each 0.1°latitude radial band and fitting the averaged winds to a Rankine vortex profile:

$$V = Cr^{--x} \qquad (1)$$

**Corresponding author address:* Johnny Chan, Dept. of Physics & Mat. Sci., City University of Hong Kong, Tat Chee Ave., Kowloon, Hong Kong, China. Email: johnny.chan@cityu.edu.hk

where V is the tangential wind speed, r the radius from the TC center, C a constant and x the exponent that determines the rate of decrease of V. In fitting this profile, it is assumed that the measured wind is equal to the tangential wind. The radius at which V = 15 m s^{-1} is then R-15.

Since the number of TCs from January to June is small, these TCs are not considered. The mean values of R-15 in the other months show a peak in October (Fig.1), a result generally consistent with that obtained by Liu and Chan (1999). That is, large TCs tend to occur more often in the late season. Brand (1972) and Merrill (1984) have also found similar results.

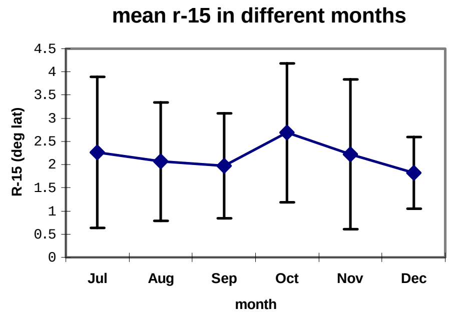


Fig 1. Monthly variations of mean R-15 values. Error bars are the standard deviations.

b. Mean R-15 during 1999-2001

The mean value of R-15 obtained in this study using the QuikScat data is 2.17 °lat (Table 1), which is smaller than those obtained from previous studies. To determine if the smaller value obtained in this study is due to the different data sources used, another set of scatterometer data from the European Remote-Sensing 2 (ERS-2) was used to verify the results. The R-15 value during the period from June 1999 to December 2000 estimated using the ERS-2 data is 1.84 °lat, while that for the same period for the same TCs using the QuikScat data is 1.88 °lat, with a correlation coefficient between the two data sets being 0.78. This result suggests that the average size of TC occurred during June 1999 to December 2001 is indeed generally smaller than that in other years.

TABLE 1. Comparison of mean TC size (°lat) obtained from various studies. ROCI is defined as the average radius from the center to the outermost-closed surface isobar.

	This study	Liu's study (1999)	Merrill (1984)
Method	R-15	R-15	ROCI
Mean	2.17	2.9	4.4
Standard deviation	1.3	1.1	2.0

The years 1999 to 2001 are La Niña (LN) years, and Chan (2000) has found that during LN years, TCs tend to form further west with less recurvature. It is therefore likely that more TCs would be under the influence of a strong subtropical ridge, which Liu and Chan (2002) have found to favor small TCs. This is indeed what is observed during this period.

4. Evolution of TC wind profile

The wind profile of each TC is the azimuthally-averaged winds between 1 to 15 °lat from the TC center. Again, only those cases in which at least half of the TC circulation was covered by the swath are included. A detailed examination of the temporal variation of the profiles in individual TCs suggests six evolution patterns. These are described as follows:

Pattern 1a: Entire profile increases with time; intensity of TC increases (Fig. 2a)

Pattern 1b: Entire profile decreases with time; intensity of TC decreases (Fig. 2b)

Pattern 2a: Outer (beyond 4.2 °lat) wind increases with time but inner wind strength (within 2.2–4.2) °lat does not change (Fig. 2c)

Pattern 2b: Outer (beyond 4.2 °lat) wind decreases with time but inner wind strength (within 2.2–4.2) °lat does not change (Fig. 2d)

Pattern 3a: Wind strength increases with time inside 3.2±1 °lat but decreases beyond this interval. (Fig. 2e)

Pattern 3b: Wind strength decreases with time inside 3.2±1 °lat but increases beyond this interval. (Fig. 2f)

The number of cases in each category is given in Table 2.

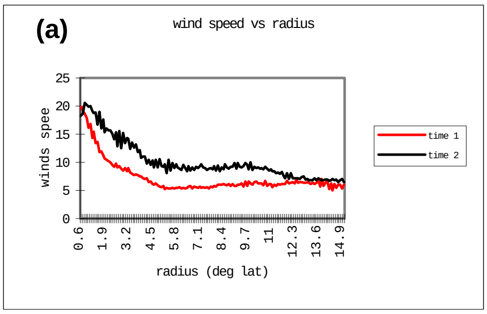
TABLE 2: Statistics for each category of wind profile change.

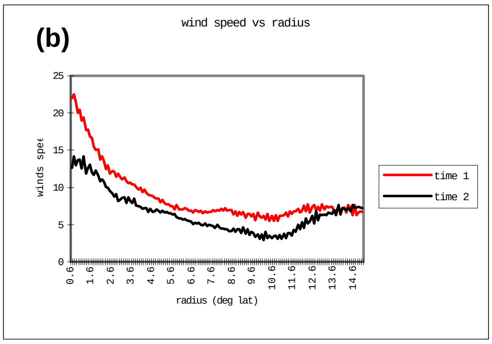
Pattern	No. of cases	No. of cases with R-15 increase	No. of cases with R-15 decrease
1a	27	24	3
1b	21	14	7
2a	9	4	5
2b	7	2	4
3a	30	21	9
3b	16	6	10

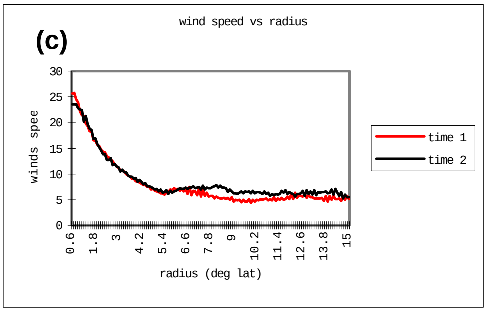
Table 2 suggests that several patterns of wind profile changes have a higher frequency of occurrence, like Patterns 1a (entire profile increase), 1b (entire profile decrease), and 3a (inner wind increase but outer wind decrease). On the other hand, the number of cases for Patterns 2a and 2b is smaller. Further, for Patterns 1a and 3a, the wind profile changes have a large proportion of cases with a corresponding increase in R-15, which suggests that in some cases, the temporal evolution of the wind profile is related to the TC size change.

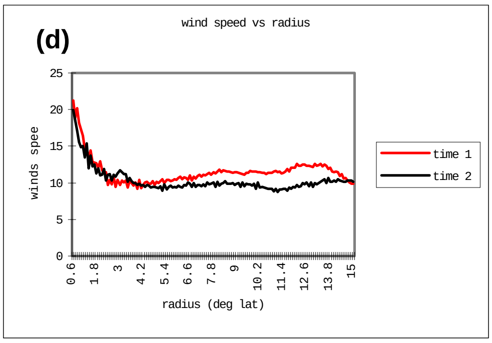
5. Summary

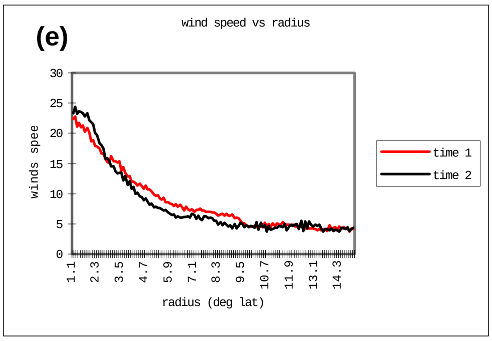
In this study, TC size and the evolution of TC structure are investigated using the QuikScat data. It is found that the seasonal variations of TCs sizes are consistent with those found in previous studies. The smaller average TC size found in this study is expected because the TCs were present during La Niña years. An examination of the evolution of the TC wind structure suggests six different patterns, some of which have similar size variations as well. Reasons for the different types of variations will be discussed at the conference.











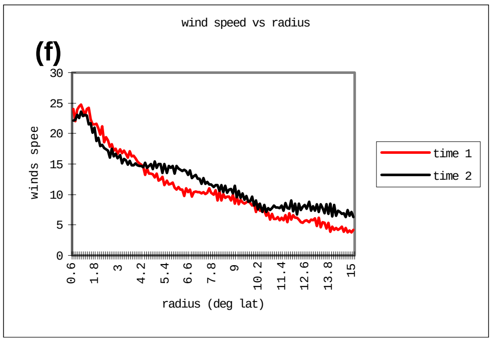


Fig. 2. Examples of the six patterns of temporal variations of TC wind profile. See text for the definition of each pattern. The difference between the two periods is less than 24 h.

References

Brand, S., 1972: Very large and very small typhoons of the Western North Pacific Ocean. *J. App. Meteor.*, **9**, 433-441.

Chan, J. C. L., 2000: Tropical cyclone activity over the Western North Pacific associated with El Niño and La Niña events. *J. Climate*, **13**,1517-1536.

Liu, K. S., and J. C. L. Chan, 1999: Size of tropical cyclones as inferred from ERS-1 and ERS-2 data. *Mon. Wea. Rev.*, **127**, 2992-3001.

—, and J. C. L. Chan, 2002: Synoptic flow patterns associated with small and large tropical cyclones over the Western North Pacific. *Mon. Wea. Rev.*, **130**, 2134-2142.

Merrill, R.T., 1984: A comparison of large and small tropical cyclones. *Mon. Wea. Rev.*, **112**,1408-1418.