6D.6 A STATISTICAL ANALYSIS OF STEADY EYEWALL SIZES ASSOCIATED WITH RAPIDLY INTENSIFYING HURRICANES

Nannan Qin[1,2] and Da-Lin Zhang[2,*]

[1]Key Laboratory of Meteorological Disaster of Ministry of Education,
Nanjing University of Information Science and Technology, Nanjing, Jiangsu Province 210044, China
[2]Department of Atmospheric and Oceanic Science, University of Maryland
College Park, Maryland 20742

1. Introduction

Despite considerable progress in tropical cyclone (TC) research, our understanding of TC structural and intensity changes is very limited, especially during its rapid intensification (RI) which is defined by Kaplan and DeMaria (2003, hereafter referred to as KD) as an intensification rate of larger than 15 m s^{-1} per day in the maximum sustained surface wind (V_{MAX}).

It is well known that intensifying TCs are often accompanied with continuous contraction of the radius of maximum wind (RMW) (Carrasco et al. 2014; Xu and Wang 2015). However, some recent studies show that intensifying TCs are not always accompanied with contracting RMWs. For example, Vigh (2010) and Stern et al. (2015) mentioned a few major hurricanes exhibiting rapid contraction of the RMWs during intensification, but most contraction was halted prior to the most intensification, i.e., showing nearly a steady state in RMWs (hereafter referred to as S-RMWs). Kieu (2012) documented the appearance of an S-RMW during RI from a series of ensemble simulations of Hurricane Katrina (2005). However, few observational studies have been performed to systematically confirm how frequently and significantly the S-RMW structure occurs in rapidly intensifying TCs.

2. Data description and processing

The extended best-track (EBT) dataset at 6-h intervals, developed by Demuth et al. (2006) for North Atlantic TCs, is used to examine the relationship between the S-RMW and rapidly intensifying hurricanes during a 25-year period of 1990-2014. The variables of our interest from the EBT dataset include V_{MAX}, discretized at 5 knots intervals, and the RMW, discretized at 5 n mi intervals. Nevertheless, to minimize the effects of data discretization, the unit of n mi recorded for the RMW will not be converted to the unit of kilometer, and any interpolation or smoothing is avoided. Since our hypothesis involves only hurricanes, any 6-h event, in which V_{MAX} is weaker than 33 m s^{-1}, and any landfalling storm, are excluded in our analysis.

* Corresponding Author address: Dr. Da-Lin Zhang, Department of Atmospheric and Oceanic Science, University of Maryland, College Park, MD 20742-2425. Email: dalin@atmos.umd.edu

3. Results

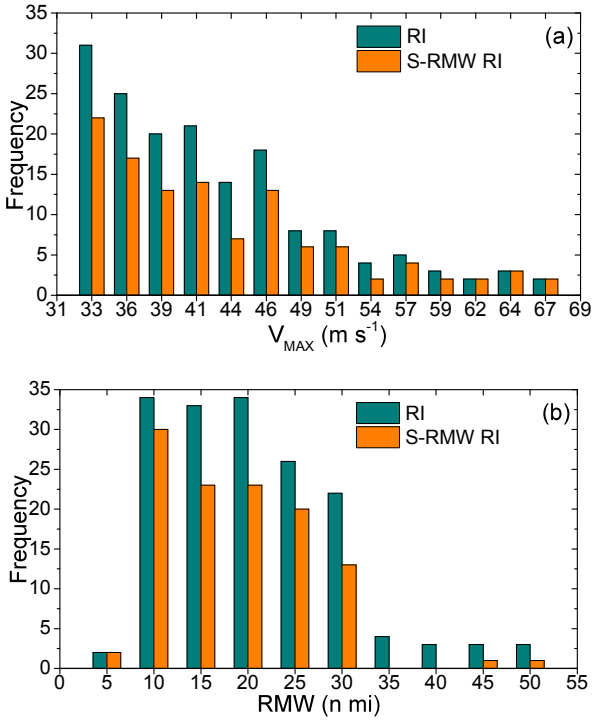

Figure 1 The frequency (number) distribution of the 12-h S-RMWs RI events (orange columns, added to 113) and the corresponding total RI events (green columns, added to 164) as a function of (a) V_{MAX} (m s^{-1}), and (b) RMW (n mi). There are 113 S-RMWs RI events out of a total of 164 RI events associated with 71 rapidly intensifying hurricanes.

a. S-RMW events at 24-h intervals

As a first step, we attempt to determine whether or not there exists a statistically significant relationship between S-RMWs and rapidly intensifying hurricanes that satisfy KD's RI criterion. By calculating the 24-h rates of V_{MAX} changes, we find that (i) 139 24-h events meet KD's RI criterion, and (ii) 53% of them, exhibit S-RMWs, hereafter referred to as the S-RMW RI events. A Student's *t*-test between the RI and S-RMW RI events indicates that the latter are significantly different at over 95% confidence from the former with contracting RMWs for all the 175 storms selected.

b. S-RMW events at 12-h intervals

The above results indicate that KD's criterion tends to skew toward the RI of category-1 hurricanes, partly because it was obtained by considering TCs at all intensities and with all intensity changes, even weakening ones. After some analysis of the RI storms at different time intervals, we find that much more cases would be included if 12-h interval is used with an RI rate of 10 m s^{-1} (12 h)$^{-1}$. By applying the new procedures, a total of 164 12-h RI events associated with 71 hurricanes are identified, and about 69% of them (i.e., 113 events) possess S-RMWs. This result also satisfies the significance *t*-test at over 95% confidence level.

Figure 1a shows the frequency distribution of the RI and the S-RMW RI events as a function of V_{MAX}. The frequency of the 12-h RI events decreases with increasing V_{MAX}; similarly for the corresponding S-RMW RI events. However, the percentages of S-RMWs at individual intensity ranges show significant increases. In particular, 75~100% of category-3 and 4 hurricanes possess S-RMWs.

The frequency distribution of the RI and S-RMW RI events as a function of the RMW is given in Fig. 1b, showing that S-RMW RI events occur frequently in the range of 5-30 n mi, with higher percentages toward much smaller-sized storms (e.g., at 5 and 10 n mi).

4. Summary and concluding remarks

In this study, a statistical analysis of S-RMWs associated with rapidly intensifying hurricanes is performed using the EBT dataset during the 25 years of 1990-2014. Results show that about 53% of 139 24-h RI events exhibit S-RMWs. This percentage increases to 69% when RI events are evaluated at 12-h intervals, based on a new RI definition. The Student's *t*-tests confirm that the S-RMW structure is a significant feature of rapidly intensifying TCs, especially after they reach category-3 intensity. Based on our analysis, we may state that S-RMWs tend to appear more frequently in more intense storms during their RI stage, and when the RMWs contract to less than 50 km. In a forthcoming study, diagnostic analyses will be performed to reveal how the S-RMW structure can be developed and maintained, and how RI can occur in the absence of the RMW contraction.

5. Reference

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