5A.5 The radar rainfall estimate for torrential rain during typhoon Nair (2001)

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1. Introduction

On 16 Sep. 2001, Typhoon Nari (2001) landed on Taiwan. The warmer ocean temperature and unique track sustained the convection and circulation of this typhoon. The slow motion of Nari and the orographic effects brought record breaking rainfall and caused flood in Taipei basin , taking 92 lives (Sui et al., 2002). The disdrometer, rain gauge network and dual-Doppler radar data were collected during Nari's landfall. Based on the Drop size distribution , the relations of Z-R are calculated through the Gamma distribution fit of DSD. The radar reflectivity field was compared to the reflectivity calculated from the observed DSD. Then the radar rainfall estimate was derived through the DSD derived Z-R relations. The area rainfall from rain gauge network were used as verification of radar estimate.

2. Radar Rainfall estimate and DSD

A quality control sequence was applied to the raw disdrometer data, the vertical velocity of the drops with unreasonable fall velocity and oblateness was changed to the empirical fall speed formula. Through these steps, the peculiar spike in the DSD was diminished. The accumulated rainfall was also agreed with the tipping bucket rain gauge at the same location after the vertical velocity correction (Fig. 1). Through the calculation of different moments of DSD, the No, m, Λ of Gamma distribution $N(D)=N_0D^m\exp(-\Lambda D)$ were calculated. The total drops number Nt and median volume diameter D0 were also calculated in every six minute intervals of 12 hours analysis time period.

Between 0200-0300 Sep. 17th, the rainfall accumulation was 44mm, the largest rainfall rate for every six minutes interval was 96mm/hr. The analysis of N0, m, Λ indicated the smaller m is associated with larger rainfall rate. In the same time, the smaller Λ was associated with the heavier rainfall rate (Fig. 2). In the statistics of these parameters in 12 hours, the coefficient m and Λ have the same tendency. The Nt had very good correlation with the rainfall rate. The major reason for this result is in the typhoon situation the large increase of the total drops number are responsible for the decrease of Λ and greater rainfall rate.

We also apply the disdrometer derived Z-R relations to the radar reflectivity (Fig. 3). Before this calculation, the correlation between the disdrometer derived reflectivity and the radar observed reflectivity is checked. During the heavy rain period, radar reflectivity is about three dBZ less than the disdrometer. The smoothing in horizontal area and the difference of reflectivity between 1.75km and surface may both cause the underestimate. During the weak rainfall period there are very small difference between disdrometer and radar. The area rainfall accumulation are quite satisfactory by using the disdrometer derived Z-R relation and corrected radar reflectivity.

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3. DSD and Vertical Velocity Distribution

The detailed velocity distribution associated with the convective systems of Typhoon Nari were revealed by the UHF radar Figure 4 illustrates the two-dimensional histograms of vertical velocity observed by ISS during a period of high rainfall rate, 11-12 LST, September 17 (Fig. 4a) and a period of low rainrate, 21-22 LST, September 17 (Fig. 4b). Because the radar reflectivity is sensitive to hydrometers, return echoes of the UHF radar are mainly contributed by the precipitation particles. In high-rainrate period, the histogram shows a clear separation around 4.5 km. Above 4.5 km, vertical velocities occur most frequently within the range of -2 ms-1 to 2 ms-1 with much more downward velocities than upward velocities, indicating the existence of prevailing frozen precipitating clouds and sporadic updrafts. Below 4.5 km, downward speed in the range of 5 – 8 ms-1 is dominant due to melting of solid particles to raindrops.

Comparing the histograms in low rainrate period (Fig. 4b) and high rainrate period (Fig.4a), a major difference is found below 5 km where downward motions in low rainrate period spread over a wider range with weaker magnitudes, implying that shallow convection and stratiform-type precipitation are dominant. There also exists clear-air echoes below 4.5 km in the low-rainrate period (Fig. 4b) as represented by higher counts of near zero velocity. It is also important to recognize that upward velocities above 5 km can reach about 2 ms-1 during light rainfall period (Fig. 4b) and exceed 2 ms-1 during high rainfall period (Fig. 4a).

The corresponding raindrop distribution measured by a 2-D video disdrometer is presented in Fig. 4c and 4d. During the high (low) rainfall period, the average raindrop size is 2 mm (1 mm) derived from the raindrop distribution in Fig. 4c (Fig. 4d) with maximum size about 4 mm (6 mm). However the number of raindrops during high rainfall period is one order of magnitude higher than that during light rainfall period. Since the terminal velocity of 2 mm and 1 mm raindrop is about 6.5 and 4 ms-1, respectively , the disdrometer measurements are consistent with the vertical velocity measurements in the lower troposphere by UHF radar measurements.

Reference

Sui, C.-H., C.-Y. Huang, Y.-B. Tsai, C.-S. Chen, Pay-Liam Lin, S.-L. Shieh, M.-H. Li, Y.-A. Liou, T.-C. Chen Wang, R.-C. Wu, G.-R. Liu, Y.-H. Chu et al., 2002: Typhoon Nari and Taipei Flood- A Pilot Meteorology-Hydrology Study. EOS, Transcations.

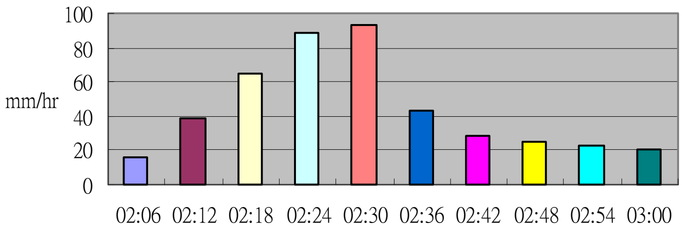

Fig. 1 Rainfall rate of disdrometer Sep 17th 0200-0300 in six minute interval.

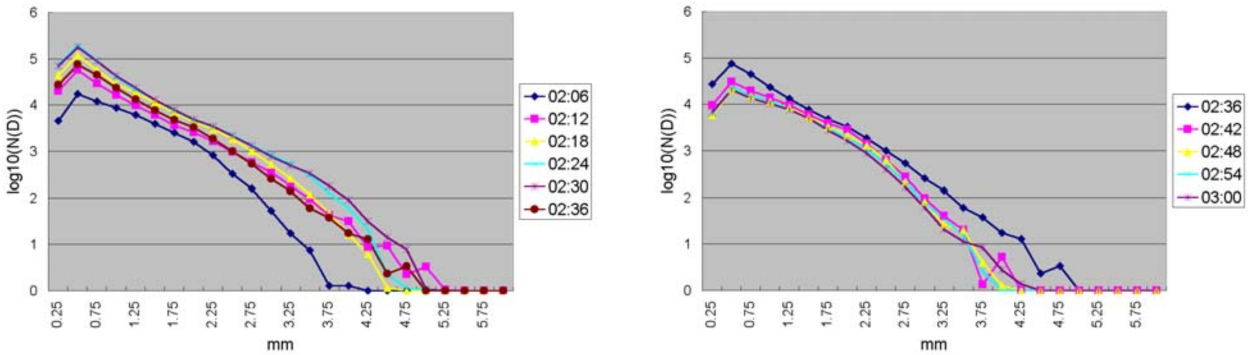

Fig. 2 The DSD distribution between 02:00-02:36 and 02:36-03:00

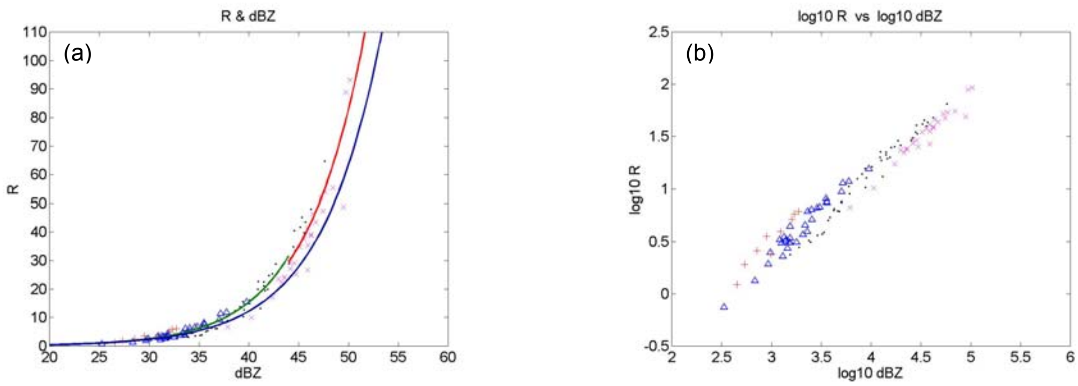

Fig. 3 (a) The scatter diagram of R versus dBZ , every mark represent for six minutes interval, the blue line is the, the red line is the average Z-R relation for reflectivity greater than 44 dBZ, and the green line is for the reflectivity smaller than 44 dBZ.

(b) The scatter diagram of log 10 R versus log 10 Z, different colors for D0 categories for 12 hour analysis time.

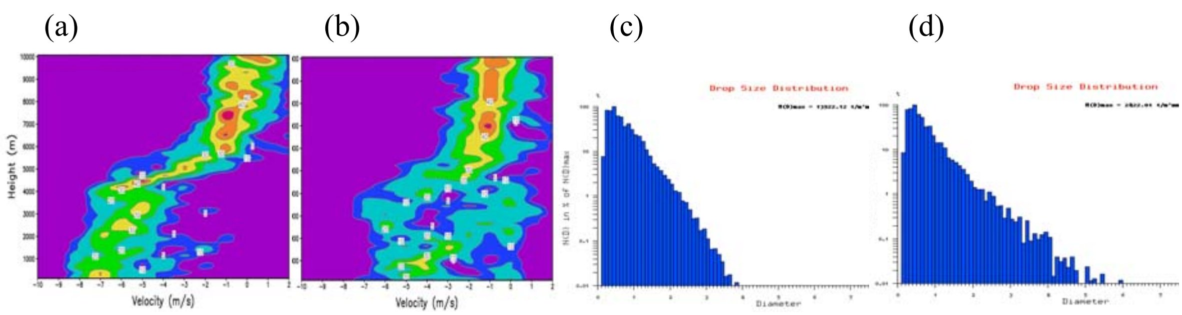

Fig. 4 Histograms of vertical velocity observed by ISS at NCU for (a) 11-12 LST, and (b) 21-22 LST, September 17, and the corresponding raindrop size distribution in (c) and (d) using a 2-D video. disdrometer.