Z-R RELATIONS OBTAINED FROM WIND PROFILER-DERIVED DSD FOR TRMM PR EVALUATION

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1. Introduction

Raindrop size distributions are crucial for understanding rain formation processes. The relations of reflectivity factor (Z) and rain rate R significantly change with DSD. Therefore, accurate estimates of rain rate from the precipitation radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM) needs statistics of DSD to determine typical Z-R relations. However, most studies have used disdrometers to measure DSD and have shown only surface measurements. Many processes affect raindrop size as drops fall, i.e., coalescence, nucleation, diffusion growth or evaporation, sedimentation, and breakup. Observations and numerical modeling results show significant changes in the DSD during rainfall (e.g., List and McFarquhar 1990; Kobayashi and Adachi, 2001). Continuous measurements of vertical profiles of DSD are needed both for the accurate measurements of the TRMM PR and improvement of our understanding of the rain process.

The present study uses an iterative retrieval method for arbitrary shaped raindrop size distribution (ITRAN) from wind profiler measurements; no particular DSD shape is assumed and the DSD is fully derived automatically (Kobayashi and Adachi, 2005 ,Rajopadhyaya et al 1993).

2. Observations

We have derived many DSD from 400MHz band wind profilers at Tsukuba and Okinawa. Here we show results at Tsukuba. On 20 June 1997, typhoon 9707 moved over the Japan. Precipitation associated with typhoon rain bands was measured with a 404 MHz profiler at the Meteorological Research Institute inTsukuba where is located about 100 km east of the typhoon center. The rain rate was ranging from 1 to 30 mm/h at the ground. In total 365 Doppler spectra of a distinct peak were selected and were applied to the ITRAN to derive DSD.

Figure 1 shows profiler-derived integral parameters (a) Z, (b) total number of raindrops N_T, (c) second moment S_a, and (d) median volume diameter D_0 plotted versus the rain rate (R). Note that integrated rainfall parameters, except for D_0 are approximate values because the wind profiler was not accurately calibrated. Reflectivity factor correlates well with R, which is in agreement with previous studies. However, the slope b in the Z-R relation of Z=R^b is 1.1. This value is smaller than that reported in previous studies.

The total number of raindrops increases as R increases (Fig. 7 b), which contrasts with previous studies that show a weak dependence of the intercept parameter on rain rate (Bringi et al., 2002, Testud et al., 2001). Although there is considerable variability, the rain rate can be determined from N_T in the present case. The second moment S_a, depends strongly on R (Fig. 7c) and is also linearly related to N_T (not shown). Physically, S_a is related to the surface area of raindrops. The probability of drop collision is proportion to the square of the drop size. This may lead to the strong relation between R and S_a.

Figure 7 (d) shows no apparent correlation between R and D_0, as in studies by Bringi et al. (2002). During fall of raindrops, small and

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large drops, respectively, increase and decrease in number when collision-induced breakup occurs. These changes cause D_0 to decrease and N_T to increase. The opposite also occurs through the collision-induced coalescence. Therefore, an inverse relation between N_T and D_0 is expected. However, not even a weak relation between R to D_0 is present in Fig. 7(d) despite the apparent relation between R and N_T present in Fig.7 (b). Median volume diameter characterizes the shape of DSD but is mathematically independent on N_T. Similar values of D_0 are observed during precipitation events with similar DSD and different R.

Figure 2 shows vertical profiles of LWC, D_0 and N_T at 13:09. Rain rate was 10 mm/h at the ground. The values of LWC and N_T were normalized by the maximum values in the profile. The inverse relation between D_0 and N_T is clear. Although most changes in LWC are in hase with change in N_T, there are some examples of inverse relationships between N_T and LWC. For example, at 4 km, LWC increases but N_T decreases. At this altitude, D_0 increases significantly, which leads to an increase in LWC.

3. Conclusions

The iterative method was applied to 365 spectra measured with a 404 MHz wind profiler, in precipitation associated with typhoon rain bands. Results show interesting relationships between LWC and integral rainfall parameters. We have also observed DSD derived from a wind profiler at the Okinawa Subtropical Environment Remote-Sensing Center of the National Institute of Information and Communications Technology in Okinawa. These studies will contribute the accurate measurements of the TRMM PR and the GPM.

Acknowledgement

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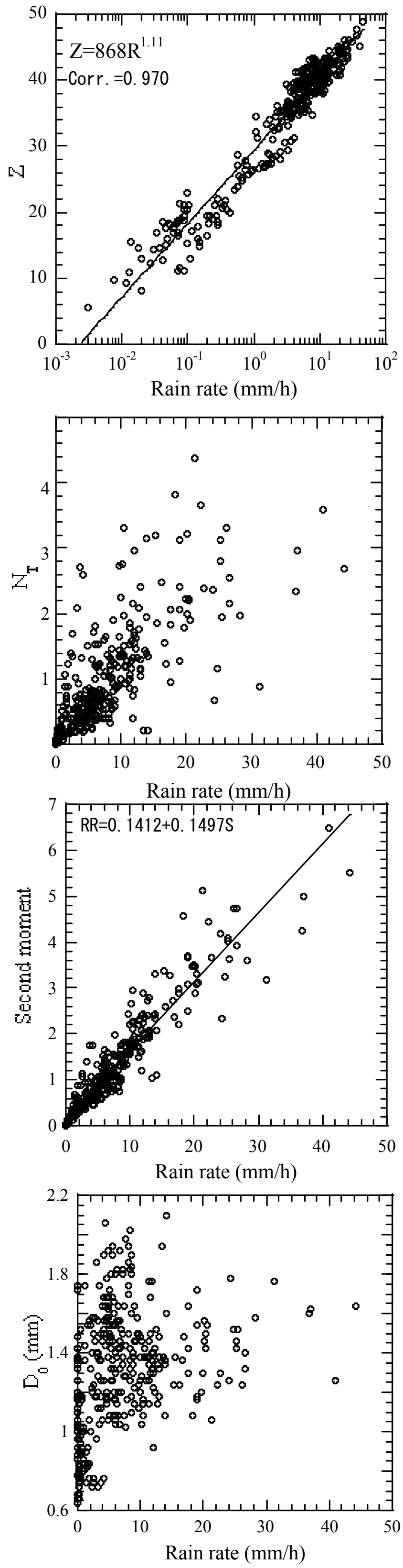

Fig.1 A scatterplot of the profiler derived parameters (a) Z, (b) N_T, (c) S, and (d) D_0 versus LWC

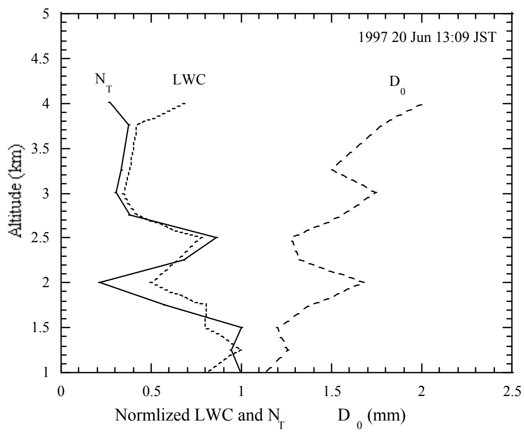

Fig.2 Vertical profiles of LWC, D_0,and N_t at 13:09. The Values LWC andN_t are normalized by the maximum values in the profile. The inverse relation between D_0 and N_t is clearly seen.

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