7A.2 EVALUATION OF TRMM PR ESTIMATE USING WIND PROFILER EASUREMENTS OF RAINDROP SIZE DISTRIBUTION

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1. INTRODUCTION

The precipitation radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM) provides the 3-dimentional rain structures over the wide area of ocean and land. The derived rain rate from the PR is overall in good agreement with the surface measurement. However, there are still some discrepancies between the PR estimate and the rain rate derived from the microwave radiometer on the TRMM satellite. One of the key issues to validate the TRMM PR is a raindrop size distribution (DSD).

Raindrop size distributions have been measured with a disdrometer but are limited to the ground surface measurements. UHF/VHF wind profilers have primary been developed to measure wind but can also measure vertical profiles of DSD. A vertically pointing wind profiler can detect echoes scattered from both atmospheric refractive index irregularity and raindrops and thereby can measure both the vertical air motion and drop fall speeds. The measured Doppler spectrum is converted into the DSD assuming an appropriate relationship between the raindrop size and its fall speed.

We made simultaneous rain observations using the TRMM PR and a UHF wind profiler at the Communication Research Laboratory in Okinawa, Japan when the TRMM satellite passed over the observation site to evaluate the TRMM PR estimate of rain rate.

2. MEASUREMENTS

The Communication Research Laboratory developed a new 443 MHz wind profiler at the Ogimi wind profiler facility. site in Okinawa (128.09E, 26.40N). This profiler has unique capability of rotating antenna system for measurements of temperature with Radio Acoustic Sounding System (RASS). The vertical resolution is 200 m and the beam width is 3.3 deg.

Figure 1 shows the vertical profiles of reflectivity factor (Z) measured with the TRMM PR and that derived from DSD estimated from the wind profiler measurements at 2340 (JST) on 3 Jul 2002. Raindrop size distributions were derived from the Doppler spectrum measured with wind profiler using the iterative method. This method needs to assume no prior particular shape of DSD and can therefore provide a detailed structure, i.e., a small change in drop concentrations at particular drop size (Kobayashi and Adachi, 2001). Relative values of Z are plotted for the wind profiler measurements because the wind profiler used in the present comparisons has not been calibrated. The reflectivity factor measured with the TRMM PR has two peaks at altitudes of 4.5 and 5 km and has a sharp minimum between the two peaks. These changes agree well with Z derived from the wind profiler. This suggests that the both instruments measured the same precipitation.

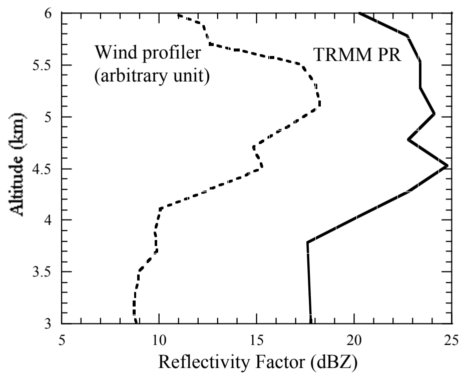

Fig.1 Reflectivity factor measured with the TRMM PR and wind profiler (relative value).

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Figure 2 shows comparisons of rain rate derived from the TRMM PR and the wind profiler. Vertical profiles of rain rate are derived using a Z-R relation (2A25) for the TRMM PR but are calculated from DSD for the wind profiler instead of using a Z-R relation.

The rain rate profile from the TRMM PR has peaks and dips at altitudes corresponding to those of the reflectivity factor as expected from the TRMM PR algorithm. For the wind profiler, however, no corresponding minimum of rain rate was observed at an altitude of 4.7 km. Rain rate increases with altitude from 4.5 to 4.7 km despite a decrease in Z. The reason of this discrepancy may be a change in DSD with altitude. The raindrop size distribution derived from the wind profiler shows increases in the drop concentration at ~0.5 mm in diameter and decreases around 0.9 mm at 4.7 km comparing with DSD at 4.5 km. An increase in rain rate due to the increased small drops exceeds a decrease due to decreased large drops at 4.7 km. The rain rate is approximately proportional to $\langle D\rangle^3$ ($\langle D\rangle$ the mean diameter) while the reflectivity factor is $\langle D\rangle^6$. The significant dependence of Z on drop size leads to an opposite result of Z to rain rate at 4.7 km. A decrease in Z due to decreased large drops dominates an increase in Z due to increased small drops.

A DSD change in small drops has large contributions to rain rate but has negligible contributions to Z in the present case. The TRMM PR could not detect the contribution of the increased small drops to Z. To examine this issue, we calculate rain rate from modified DSD by removing drops smaller than 0.5 mm in diameter. The modified DSD has little effect on Z (Fig.3), while a large effect on rain rate. The minimum value of rain rate appears at 4.7 km (Fig.4).

3. Conclusions

Simultaneous measurements of the TRMM PR and a wind profiler show that there was discrepancy in rain rate. This discrepancy arises from a change in DSD associated with the different sensitivity between Z and rain rate to drop size. Small drops have little contribution to Z but have large effects on rain rate. The contributions of small drops to rain rate are critical for accurate estimate of rain rate.

References

Kobayashi, T., and A. Adachi, 2001: Measurement of raindrop breakup by using UHF wind profilers. Geophys. Res. Lett., 28, 4071-4074.

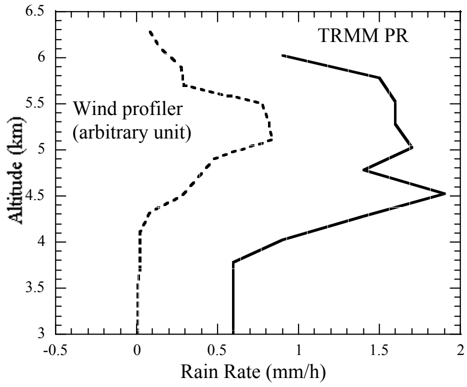

Fig.2 Same as Fig.1 except for rain rate.

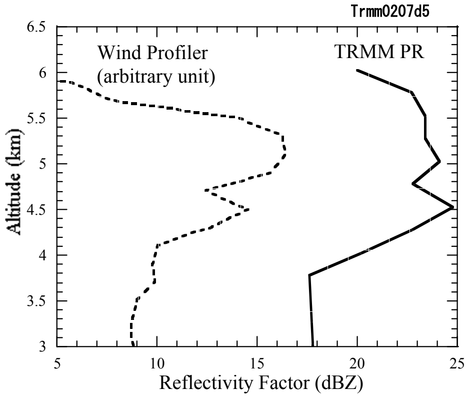

Fig.3 Reflectivity factor measured with the TRMM PR and wind profiler (relative value) using modified DSD.

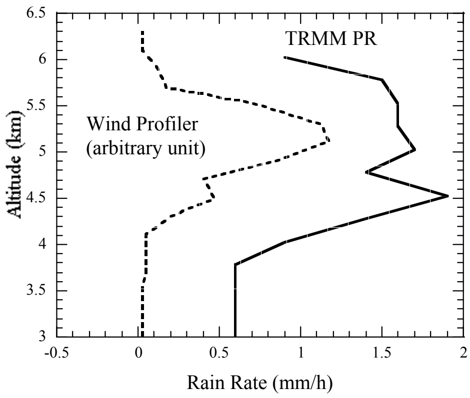

Fig.4 Same as Fig.3 except for rain rate.