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YAMAGUCHI UNIVERSITY 山口大学

Retrieval of drop size distribution using both PR/TRMM and CPR/CloudSat data

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Abstract

Dual frequency precipitation radar (DPR) is widely used to estimate drop size distribution (DSD). The output of a radar or observed physical substance is the back-scattered cross section per unit volume (η). The rainfall rate is derived from η using empirical equation. If we have two observations of different frequencies, we can retrieve, assuming the DSD, both the averaged drop size and number of rain drop in unit volume from η. The simultaneous observation of rainfall from both Precipitation Radar (PR) of TRMM and Cloud profiling radar (CPR) of CloudSat is obtained in the month of January 2007. Using the two radar backscattering parameter, we tried to retrieve the drop size and number of particles. We also discuss a new method to calculate the attenuation without solving the Hitschfeld-Bordan equation.

Introduction

PR/TRMM has observed the rainfall in the tropic and subtropic regions for more than a decade. In TRMM retrieval algorithm, Surface Reference Technique (SRT) techniques is utilized. The radar reflectivity factors are corrected for attenuation, and the information on the DSD is inferred from the non-Rayleigh backscattering characteristics of the hydrometeors. The assessment of the reliability of SRT is difficult because the statistical properties of the surface echoes depend on surface type, angle of incidence, and surface winds. So we assumed the new method to calculate the attenuation without solving Hitschfeld-Bordan equation and SRT. To estimate the raindrop size distribution and number of particles, we must think of the scattering and the back-scattered cross section per unit volume. We calculated the Mie and Rayleigh scattering in order to get the scattering character and the back-scattered cross section per unit volume from radar equation. The back-scattered cross section per unit volume is corrected for attenuation. We evaluate the optical thickness of bin data and attenuate the bin data using recursion equation.

Satellite data

The simultaneous observation of PR/TRMM and CPR/CloudSat and their position on 25 January 2007 is shown on Table.1. Both the data were collected using orbit calculation of NASA's Two-line-element data sets.

Satellite	time [UTC]	Latitude [°]	Longitude[°]
CloudSat	10:40:25	-16.988	48.40302
TRMM	10:40:27	-16.987	48.40153

Table. 1. Observational time and location of satellites

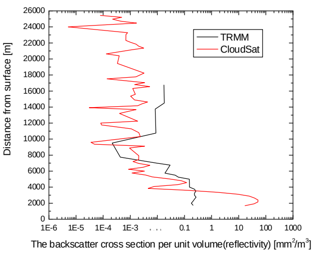


Fig.1. Scattering diagram shows the variation of backscattered reflectivity with reference to the distance from surface.

Methodology

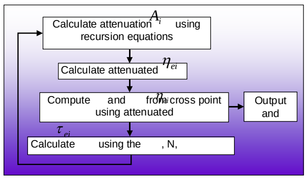
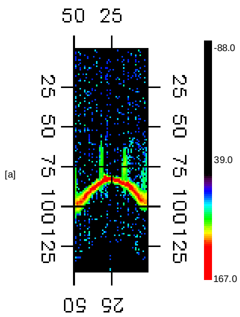


Fig. 2 Flowchart of the recursion equation method.

Results and Discussions

We assumed that water particle exist at 4560 [m] of the distance from surface, because of the bright band appearance as shown in Fig.1. Fig 3a and 3b shows the measured reflectivity of TRMM and CloudSat data. The simultaneous observation cross point is found at bin number 13 on TRMM and bin number 516 on the CloudSat data. These points observed the precipitation. These data were used to calculate the new back-scattered cross-section per unit volume η. Fig 4 shows the comparison of the observed back-scattered cross-section per unit volume η_{ei} and the apparent back-scattered cross-section per unit volume η_{mi} with reference to the distance from the surface without attenuation. In TRMM case, the observed back-scattered cross-section per unit volume η nearly unaffected by attenuation shown in Fig.4a. In other hand, the observed back-scattered cross-section per unit volume η_{mi} from CloudSat come under the influence of attenuation at 2880 [m] as shown in Fig.4b. This result indicates that there is an existing of the precipitation from 3200 [m] due to attenuation influence which appeared in the next range of the layers.



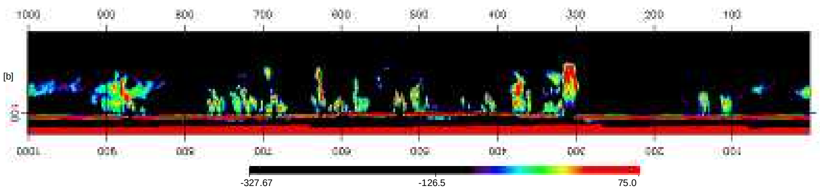


Fig. 3. The measured Reflectivity (dBZ) of PR/TRMM [a] and CPR/CloudSat [b]

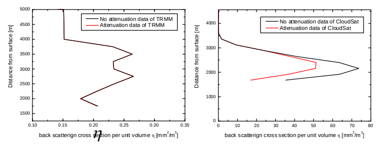


Fig.4 Comparison of η during attenuation influence (a: TRMM; b: CloudSat)

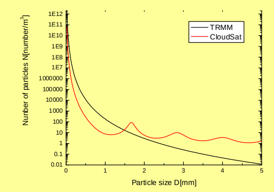


Fig 5 the relationship of the parameter D and N with reference to the distance from the surface.

Attenuation computed by recursion equation shown in equation (4). Using the sum of layers of optical thickness, the attenuation of layer is estimated. Substituting the total attenuation and back-scattered cross-section per unit volume into eq (6), subsequently incorporating σ in to equation (1), the raindrop size distribution D and number of the particle per unit volume N were computed. Fig 5 shows the relationship between raindrop size distribution D and number of the particle per unit volume N in 3200 [m]. The cross-section point determines the value of D and N.

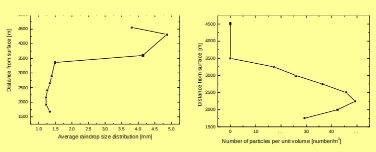


Fig. 6 Distribution of D and N in the atmosphere window.

However, in the total column of atmosphere window in the range from 1700 to 4560 m, there is wide distribution of D and N is computed and shown in Fig. 6.

The optical thickness is used for the attenuation. Fig. 7 shows the optical thickness with reference to the distance from the surface. The pattern of optical thickness at 4560m is identical for both data. The increase of optical thickness lies between 3200m to 4560m which is having an absolute value of 0.001 and 0.45 for TRMM and CloudSat respectively. This indicates that using the high frequency radar for observation, we must consider the attenuation by precipitation.

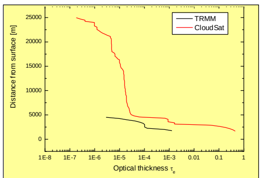


Fig 7. Optical thickness observed by TRMM and CloudSat data

Conclusions

We have developed a retrieval method of DSD for dual-frequency radar using two satellites. We have also discussed a method to calculate the attenuation, by not solving Hitchfeld-Bordan equation and SRT but using recursion equations.

References

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