Statistical validation of drop size distribution estimated by GPM/DPR

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The dual-frequency precipitation radar (DPR) onboard Global Precipitation Measurement (GPM) core satellite provides the information of the model parameter of the drop size distribution (DSD) assuming the Gamma type DSD model by using Ku-band (KuPR) and Ka-band (KaPR) radar observations. In the current DPR algorithm introduces ε (epsilon) as a DSD parameter that is constant in the vertical profile. The ε is defined as a control parameter in k-Z relationship as *k=ε α Z^β*, where k is specific attenuation in (dB/km) and, α and β is constant value, respectively. Therefore, once ε and Z are determined, DSD (and then R) and Z(Ku) - Z (Ka) relationship are determined.

The purpose of this study is to evaluate ε estimated from DPR algorithm by statistical approach. In this study, two methods are implemented: 1) Histogram matching between Z from KuPR and KaPR, and 2) Estimation of ε from PIA-zeta relationship that can be calculated both KuPR and KaPR individually (single frequency method).

Data used in this study are DPR level-2 (Matched swath) in 2015, 2016 and 2017. Before applying the methods, backscattering database for Ku, Ka and W band using Mie theory and Z(Ku)-Z(Ka), Z(Ku)-Z(W) table for various ε ranging from 0.3 to 2.0 with 0.05 intervals, are prepared.

The histogram method compares histograms of Z (Ku) and Z (Ka). In this analysis, the average ε at a certain area (e.g. 10 x 10 degrees box in latitude and longitude) represent the typical value of the area. Since the difference in the histograms of Z both from the KuPR and KaPR reflects the difference in Mie effect between KuPR and KaPR and therefore ε represents the corresponding DSD model. In other words, if we know the ε, we can reproduce the KaPR histogram from KuPR histogram. In this analysis, starting from KuPR histogram, the most appropriate KaPR histogram is tried to find by changing the ε. The advantage of this approach is that ε can be estimated various height (e.g. 1 km, 2 km) if the both KuPR and KaPR data exist. This method, however, is not independent estimation of ε from the standard algorithm of DPR because this method uses the attenuation corrected Z by the standard algorithm that implicitly include the ε. For the calculation of ε, exceedance probability of Z histogram is used. This method can be utilized for different orbital sensors such as the comparison between CloudSat and TRMM/PR.

The next method is to utilize the path integrated attenuation (PIA)- zeta(ζ) relationship (regression method). According to Iguchi et al. (2000),
1-10^(-PIAβ/10)=ε ζ, where ζ is the integral of specific attenuation using the observed Z(Zm) instead of attenuation corrected Z multiplied by 0.2ln(10)β. PIA is estimated by the observation of the surface echo (surface reference method). By making a scatter plot of *1-10^(-PIAβ/10)* and ζ, ε corresponds to the slope of this plot. The slope in Ku-band corresponds to the ε in this study. Ka-band epsilon is calculated using the same k-Z relationship with Ku-band.

The ε estimated by these two methods are compared with the average value of ε from standard algorithm. Basically ε from both methods correlate well with the ε from the standard algorithm. Note that the variance ε from the regression method is twice large as the standard algorithm. This result may be caused by that the standard algorithm not to determine the ε under less attenuated situation. The regression method can be utilized to assess the k-Z relationship between Ku and Ka and the histogram method of various height indicates the constant ε of the throughout the profile may not be valid.

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