Modeling Rain Medium for Weather Radar and Propagation

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Practices established in sectors such as radar meteorology or telecommunication system make use of approximate equations (algorithms) relating meteorological quantities characterizing precipitation or clouds properties to scattering and propagation measurements. Important cases are those relating rain rate (*R*) to volume radar cross section or specific attenuation. Examples in radar meteorology are those using radar measurements such as the radar reflectivity factor (*Z*) to estimate rain rate from equations of the form $Z=aR^b$. In case of dual-polarization radar [1], which nowadays are common among weather services, equations of the form $R=aZ_h^bZ_{dr}^c$ or $R=aK_{dp}^b$, are used, where Z_{dr} and K_{dp} are the radar measurements of differential reflectivity and specific differential phase shift. In propagation studies, standard models make use of equations expressed through a power law to relate rain rate with specific attenuation for a wide range of frequency [2]. These algorithms are approximations and have an error structure influenced by different factors, such as the variability of microphysical properties of precipitation. Modeling rain microphysics for weather radar and propagation applications is generally accomplished through modelling the drop size distribution (DSD) and the drop shapes. The DSD is defined to be the number of drops per unit volume of air and per unit of drop diameter interval and has been modeled with two (such as the exponential distribution) or three three-parameter distribution. Among the different proposed DSD models, the one based on the Gamma distribution has become the most popular, although different models can be appropriate in specific precipitation event [3]. The instruments called disdrometers can measure the diameter distribution of drops reaching the ground, from which volume DSD are derived through assumptions on ground velocity, or measurements, also obtainable from some kind of disdrometers. They differ each other with respect to the measurement principles (impact, laser, or visual) and each one is characterized by different instrumental errors and limitations, like the minimum detectable drop diameter [4]. In addition, active instruments, such as vertical profilers [5] or dual-polarization weather radar [6] are also useful because they can estimate DSD aloft. Using measured or theoretical distributions of DSDs and electromagnetic simulation models, radar and propagation variables can be obtained. From the same DSDs, rain characteristics (*R* in particular) can be computed, and the algorithm described above can be found via fitting techniques. Measured distributions can be considered as more representative of the natural variability of rain in a given location than the theoretically derived distributions. However, disdrometer-derived DSDs are affected by different sources of errors that will have an impact on the algorithms that are derived. The impact of DSDs, as estimated by different instruments, on weather radar retrievals or in predicting propagation effects will be analyzed and discussed.

References

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