Estimation of Liquid Droplet Size and Liquid Water Content in Clouds and Drizzle Using Remote Sensing Measurements

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Presence of a few drizzle or larger cloud droplets is ubiquitous in stratocumulus clouds. Larger droplets often minimally contribute to the liquid water content (LWC), but due to their larger sizes, they tend to dominate the reflectivity. Reflectivity and liquid water LWC are not linearly related. Thus, LWC cannot be estimated accurately using reflectivity measurements alone Radar measurements of reflectivity and lidar backscatter of cloud and drizzle are in general, proportional to one of the moments of the drop size distribution (DSD). For example, the radar reflectivity is proportional to the 6th moment of the DSD in Rayleigh scattering regime and lidar backscatter to the 2nd moment of the DSD in the case of optical scattering.

This paper describes a technique for estimating LWC and characteristic particle diameter in stratocumulus clouds using radar and lidar observations. The proposed technique is independent of DSD. Partitioning or detection of cloud and drizzle are not required based on an arbitrary threshold of reflectivity. The knowledge of characteristic particle size significantly reduces uncertainty in liquid water content estimate. It is applicable for a broad range of W-band reflectivity between -30 and 0 dBZ and all values of lidar backscatter observations. The Cloud Systems Evolution in the Lidar and radar measurements in the Cloud Systems Evolution in the Trades (CSET) are analyzed using the proposed technique. The retrieved LWC from radar and lidar measurements is validated qualitatively using the concurrent G-band radiometer estimates of the liquid water path.

Keywords: W-band radar, Lidar, Stratocumulus cloud