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Remote estimation of cloud liquid and droplet size from radar and satellite measurements

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Depending on size, liquid droplets are classified into three categories: cloud droplets, drizzle, and rain drops. By definition, cloud droplet size is less than 50 μu, drizzle size is between 50 and 500 μu, and droplets greater than 500 μu belong to the raindrop category. Cloud liquid water contents (LWC) are commonly below 0.1 –0.2 g m^{-3}, but have been measured at >1 g m^{-3} over distances of several kilometers. Millimeter wave radar and microwave satellite observations show potential for estimating LWC and droplet size. However, the verification of estimated quantities using remote observations is confounded due to a lack of in situ observations. In the absence of suitable in situ observation, consistency between in dependent estimate of LWC and droplet size from radar and satellite observations can be used to improve confidence in remote estimation of cloud products.

In the case of spherical hydrometeors, such as cloud droplets, the utility of polarimetric measurements to estimate LWC and droplet size are limited since backscatter measurement is independent of polarization. A dual-wavelength radar method that makes use of absorption and Mie scattering is more attractive for estimating LWC and droplet size. Radar is capable of estimating range resolved measurements but its spatial coverage is limited. On the other hand, microwave satellite observations are suitable for estimating cloud microphysics both over and ocean. Even though satellite-based microwave methods for retrieving LWP (liquid water path) are well established for ocean backgrounds, problems with low thermal contrast and surface emissivity variability prevent the extension of such methods to land surfaces. A new dual-channel microwave method based on polarization-difference signals (combined with forecast or analyzed surface temperature and precipitable water vapor PWV) has been developed to retrieve LWP over both ocean and land. The theoretical basis of

the method lies in a new parameterization relating polarization-difference signals to surface temperature, LWP, PWV, and a single surface emissivity parameter.

This paper presents radar and satellite-based methods for estimating cloud microphysical properties. Examples of the application of the dual-wavelength radar and satellite techniques for estimating cloud microphysical properties are presented. Since it is almost impossible to verify the retrieval accuracy of cloud LWC, coincident ground-based radiometer-based observations are used to verify radar-based LWC.