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Combined High Spectral Resolution Lidar and Radar Measurement of Drizzle

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Marine stratus clouds are an important feature of the global climate system. Cloud lifetime is sensitive to drizzle rates. Drizzle not only removes water from the cloud but it's evaporation cools the sub-cloud layer acting to suppress convection. Accurate measurements of drizzle rates will improve our understanding of cloud maintenance.

Simultaneous lidar measurements of extinction and radar backscatter allow determination of drizzle droplet particle size, liquid water content, fall velocity and water flux. However, drizzle measurements with conventional lidar are hampered by: 1)changes in the transmission of the output window caused by water accumulation on the lidar output window, 2)the difficulty of correcting the backscatter signal for atmospheric extinction and, 3)the effects of multiple scattering. High spectral resolution lidar avoids problems with window transmission and atmospheric attenuation because the backscatter is referenced to the known molecular scattering cross section at each point in the profile. Although multiple scattering degrades the direct measurement of extinction with the HSRL, it has little effect the HSRL measurement of backscatter cross section. We have developed an iterative solution that begins by estimating the extinction cross in drizzle using an assumed lidar ratio and the backscatter measurement. This is combined with the radar backscatter to make a first estimate of the particle size distribution. Mie scattering theory is then used to compute an improved lidar ratio for this particle size distribution and the new lidar ratio provides an improved extinction cross section. The calculation assumes a modified gamma distribution of sizes. The mode diameter of the distribution is fixed by the lidar-radar cross section ratio, while the width of the distribution is determined by matching the computed fall velocity of the drizzle with the observed radar Doppler velocity.

The strengths and limitations of the this approach are examined using HSRL and millimeter radar acquired during the MAGIC deployment of the DOE ARM mobile facility on the 'Spirit Horizon' container ship. Marine stratus observations were acquired as the ship made repeated weekly trips between Long Beach CA and Honolulu, HI. This paper will compared derived precipitation rates with conventional rain gauge and distressed data. The sensitivity of the retrieval precipitation rates to assumptions will also be presented.