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Retrievals of Stratocumulus Drop Size Distributions from Airborne Multiangle SpectroPolarimetric Imager (AirMSPI) Observations

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Data from the Polarization and Directionality of the Earth's Reflectances (POLDER) satellite instruments have been used for many years to retrieve information about the mean and dispersion of cloud droplet size distributions. The position of specific features in scattering angle space corresponding to supernumerary bows in the polarized phase function are extremely sensitive to the effective radius of the cloud droplets, while the amplitude of these features carries information on the dispersion of droplet sizes. Due to the relatively coarse angular sampling of POLDER multiangular views ($\sim 10^\circ$), variations in scattering angle from pixel to pixel are used instead to obtain fine sampling in angle, which requires the clouds to be homogeneous on scales of 150 km $\times$ 150 km in the POLDER retrievals.

We will describe high-resolution polarimetric observations of marine stratocumulus clouds made off the coast of California by the AirMSPI instrument, which files on the NASA ER-2 high-altitude research aircraft. AirMSPI is an eight-band pushbroom camera mounted on a controllable gimbal, which allows the instrument to make observations over a $\pm 67^\circ$ range in the direction of aircraft motion. AirMSPI's eight spectral bands are 355, 380, 445, 470, 555, 660, 865, and 935 nm in the ultraviolet to the near-infrared range. Polarimetric observations are made in the 470, 660, and 865 nm bands using photoelastic modulators (PEMs) to rapidly vary the orientation of the linearly polarized component (Stokes Q and U) of the incoming light, enabling measurement of the relative ratios of these parameters to intensity from individual pixels. From the nominal 20 km altitude of the aircraft, AirMSPI can provide imagery mapped to a 25 m grid using a sweep scanning strategy in which the gimbal controlling the pointing of the instrument is slewed back and forth along the direction of aircraft motion.

The AirMSPI observations of the polarimetric features of marine stratocumulus clouds have been used to derive cloud droplet effective radius and effective variance using a single scattering approach pioneered by the POLDER team. By focusing on observations made near the principal plane, measurements of Q at the three AirMSPI wavelengths were used to determine an effective polarized phase function, which was then compared with Mie theory calculations for a cloud composed of spherical droplets with a narrow size distribution. These results show that AirMSPI is capable of extremely sensitive retrievals of the cloud drop size distribution for marine stratocumulus clouds. Even small adjustments to the refractive index of liquid water at the AirMSPI wavelengths results in noticeable changes in the location the modeled polarimetric features.