Identifying Insects and Clouds in the Vertical Column using 35-GHz Radar Polarimetric Doppler Velocity Spectra

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This study presents an algorithm to identify and distinguish insects from clouds in the boundary layer in 35-GHz (Ka-band) vertically pointing radar polarimetric Doppler velocity power spectra. Without this discrimination, the Ka-band radar insect observations may be incorrectly interpreted as meteorological phenomena. In Northern Oklahoma, the insects extend from the ground to over 4 km AGL with their maximum height in the afternoon after long periods of solar heating.

The algorithm is based on two fundamental scattering processes: polarimetric diversity and point targets versus distributed targets. First, insects have a polarimeteric signal due to their asymmetric shape. The incident linear polarized wave reflects off of asymmetric insects producing a backscattered wave with both co-polarized (Co-Pol) and cross-polarized (X-Pol) components. The radar receiver detects both polarizations and generates Co-Pol and X-Pol Doppler velocity power spectra. Conversely, cloud droplets are symmetric and have small radar cross sections such that the cross-polarized return wave is too small for the radar to detect. (Note that falling raindrops are detected in the X-Pol channel due to their larger radar cross-sections.) The second scattering process utilized in the algorithm is that the few insects in the small radar resolution volume (approximately 300 m^3) appear as individual point targets. The power return from point targets produce large power fluctuations across the Doppler velocity spectra. In contrast, clouds consist of many distributed targets filling the radar resolution volume which produce a smoother power spectrum.

The proposed insect-cloud algorithm uses the Doppler velocity spectra texture to discriminate whether the return signal is from insects or cloud droplets. Spectral regions with larger texture indicate scattering from insects and regions with smoother spectra indicate scattering from cloud droplets. Artificial Intelligence (AI) techniques are used to develop spectra texture statistics for both insects and cloud droplets. First, the the polarimetric information is used as a training set to identify insects and develop the Co-Pol spectra texture statistics associated with insects. Cloud droplet Co-Pol spectra texture statistics are determined from the observations without any X-Pol observations. After producing clusters of insect and cloud droplet texture statistics, a membership test is used to distinguish insect from cloud droplet scattering for every profile and every Doppler velocity spectra. These spectral classifications are simplified into a single value at each range gate indicating the presence of cloud and/or insect. The cloud masks are available for meteorological studies to study the daily evolution of boundary layer clouds.