Variability of cloud microphysical properties in context of thermodynamic and radar-derived structure of mesoscale convective systems: results from PECAN

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Temperature, relative humidity, cloud particle concentration, number distribution function, and mass content were obtained measured by instruments on the NOAA P-3 during 37 spiral profiles of 5 mesoscale convective systems (MCSs) during the 2015 Plains Elevated Convection at Night (PECAN) project. Using multiple-Doppler syntheses of the wind and reflectivity fields from the NOAA TDR (a 3.22 cm wavelength X-band Doppler radar) and several NWS WSR-88D 10-cm wavelength S-band operational radars, each MCS was identified as one of various archetypes (classic leading-line/trailing-stratiform mode, parallel stratiform and nonlinear system modes, frontal squall line) and the location of each spiral assigned to one of three primary MCS regions: the transition zone (TZ), enhanced stratiform rain region (ESR), and anvil region (AR). The importance of different microphysical processes in each region was then hypothesized from the cloud microphysical properties derived from in-situ probes.

Aggregation was common within all three MCS regions, with increases in particle size with increasing temperature greatest in the predominantly ice saturated environment of the ESR. Here, the fractional decrease with increasing temperature in total particle number concentration (N_t) of 21% $^\circ C^{-1}$ exceeded the fractional decrease in total water content (TWC) of 14% $^\circ C^{-1}$, consistent with the changes expected with aggregation. Progressively smaller changes in particle sizes, shapes, and concentrations due to aggregation were coincident with decreases in the average relative humidity above the melting layer in the TZ and AR. The impacts of sublimation were greatest in the AR, where on average, subsaturated conditions were present for temperatures greater than −11°C, with a larger fractional decrease in TWC of 50% $^\circ C^{-1}$ with increasing temperature compared to that in N_t of 41% $^\circ C^{-1}$ consistent with a reduced importance of aggregation. Sublimation similarly limited the effectiveness of aggregation within the TZ. The latent cooling imparted by sublimation is thus expected to have been the greatest within the AR, where the descent of the rear inflow jet (if present) would likely be initiated.

Two spirals within the stratiform region trailing a frontal squall line exhibited increasing N_t and TWC with increasing temperature along with a high incidence of pristine ice crystals, characteristics absent within all other PECAN spirals. Mesoscale ascent in this region likely contributed to the notably different microphysical characteristics observed therein.