Application of Upgraded HUCM Forward Operator to Simulated Updrafts with Varying CCN

Jeffrey Snyder, Alexander Ryzhkov, and Jacob Carlin

OU/CIMMS and NOAA/OAR/NSSL

Norman, OK

# Impacts of CCN on Convective Storms

- Highly complex and nonlinear
  - e.g., van den Heever and Cotton (2007)
- The effects of aerosols appears to be strongly affected by environmental parameters (moisture, shear, etc.)
  - Differences between "tropical" clouds (with high $0°$ C level) and more mid-latitude clouds (with lower $0°$ C level)
- The size distribution of CCN appears to modulate aerosol impacts (giant or ultra-giant aerosols)
- We are examining sensitivity of the polarimetric structure of convective storms to CCN characteristics (particularly at the early stage of development)

HUCM Microphysics and Forward Operator

▶ 43 mass-doubling bins

▶ 8 hydrometeor species (cloud/rain, freezing drops, hail, graupel, snow aggregates, dendrites, columns, and plates) and CCN

▶ Prognostic water fraction (freezing drops, graupel, hail, and snow) and rime fraction (snow)

▶ Time-dependent melting and freezing

▶ Recent addition: spontaneous drop breakup (essentially removes the 9-10 mm drops)

▶ Forward operator calculates Z_H, Z_{DR}, K_{DP}, ρ_{hv}, LDR, A_H, A_{DP}, δ, CDR using homogeneous-mixture or two-layer T-matrix scattering (both in real-time and using pre-computed scattering amplitudes as lookup tables)

Sensitivity of Initial Storm Development to CCN

▶ Mid-latitude convective storm (0°C ~3.3 km)

▶ In the most polluted case (3000 cm^{-3}), development is delayed, particularly when the PBL is very moist

▶ In general, as CCN ↑:

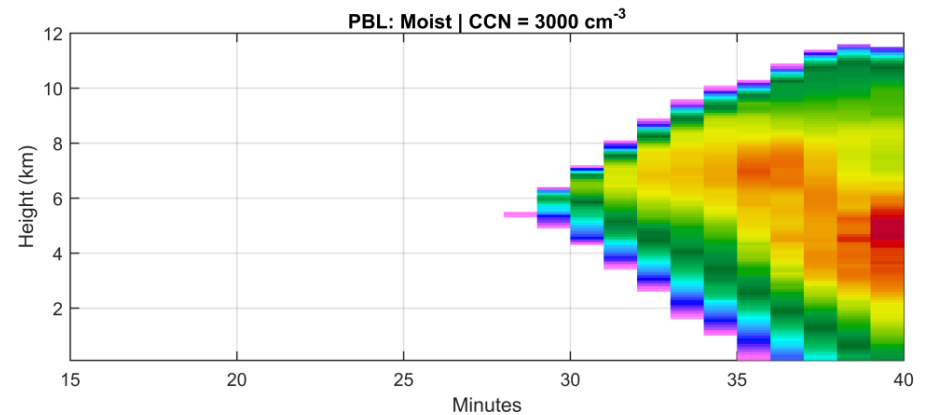 ▶ Z_{max} ↑
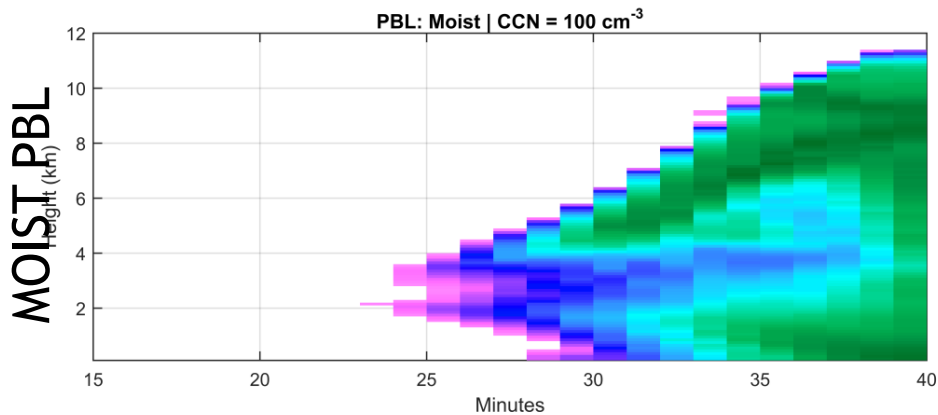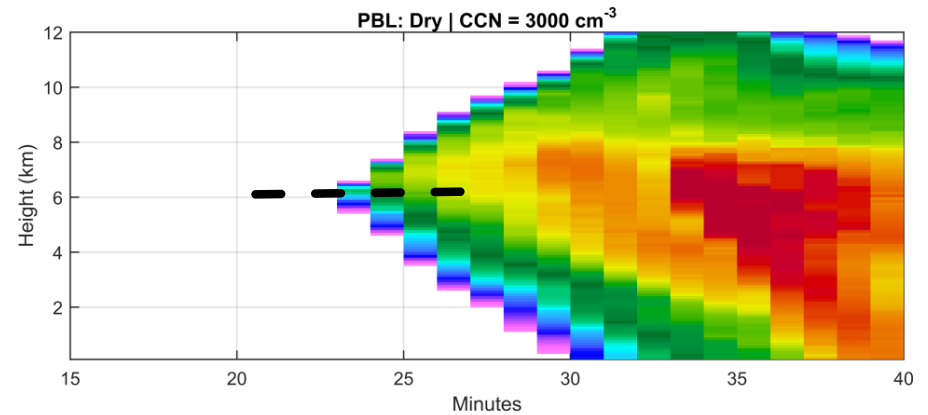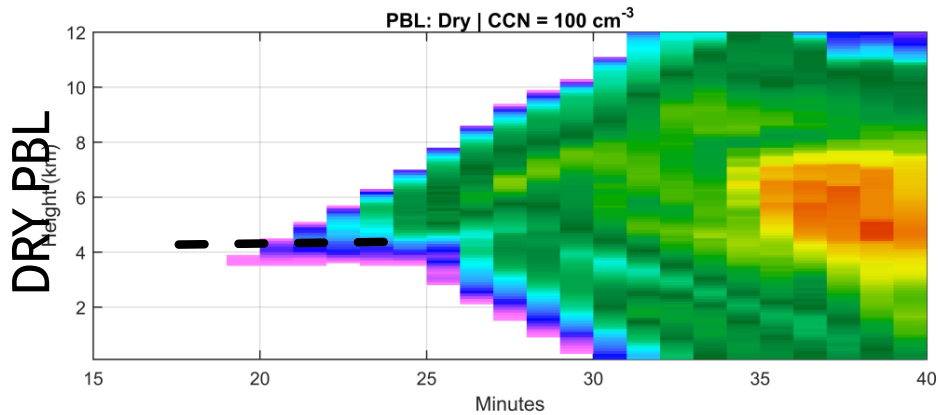
  ▶ dZ_{max}/dt ↑

  ▶ Height of Z_{max} ↑
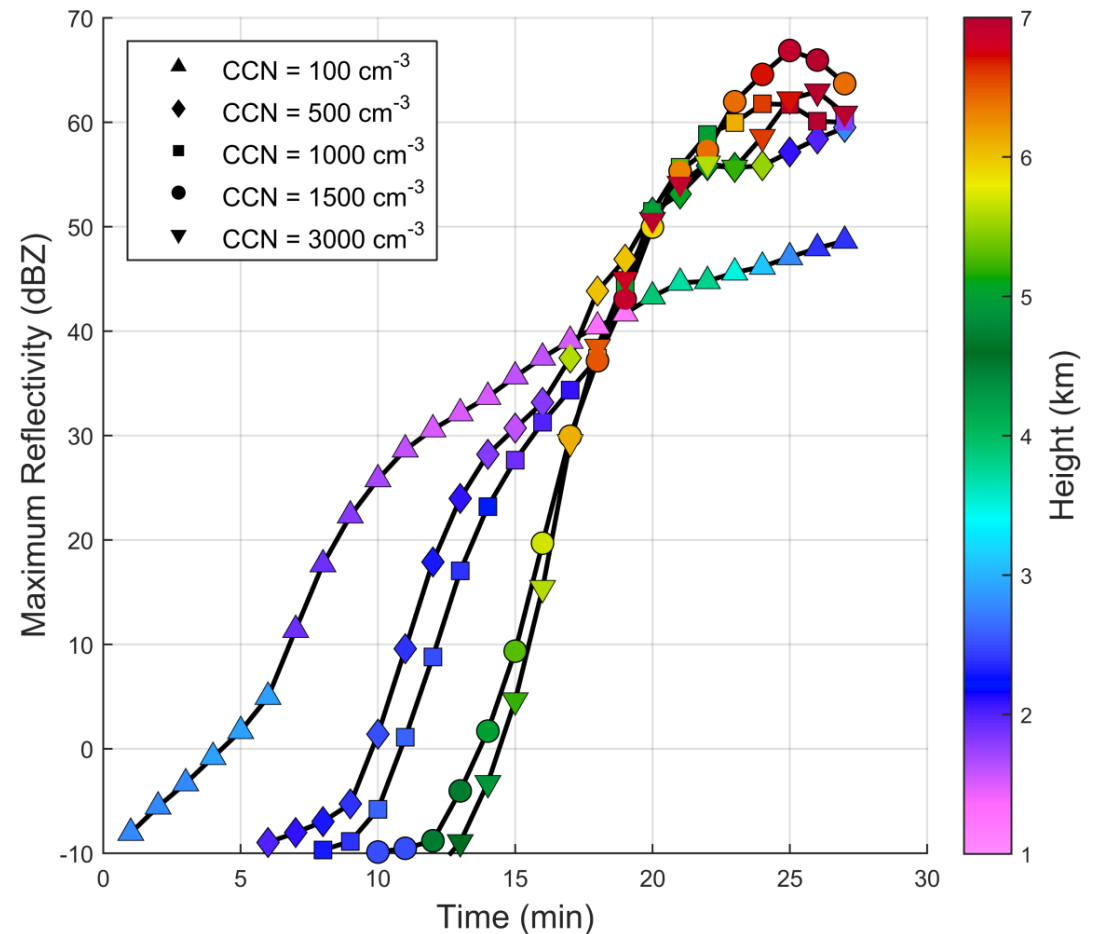
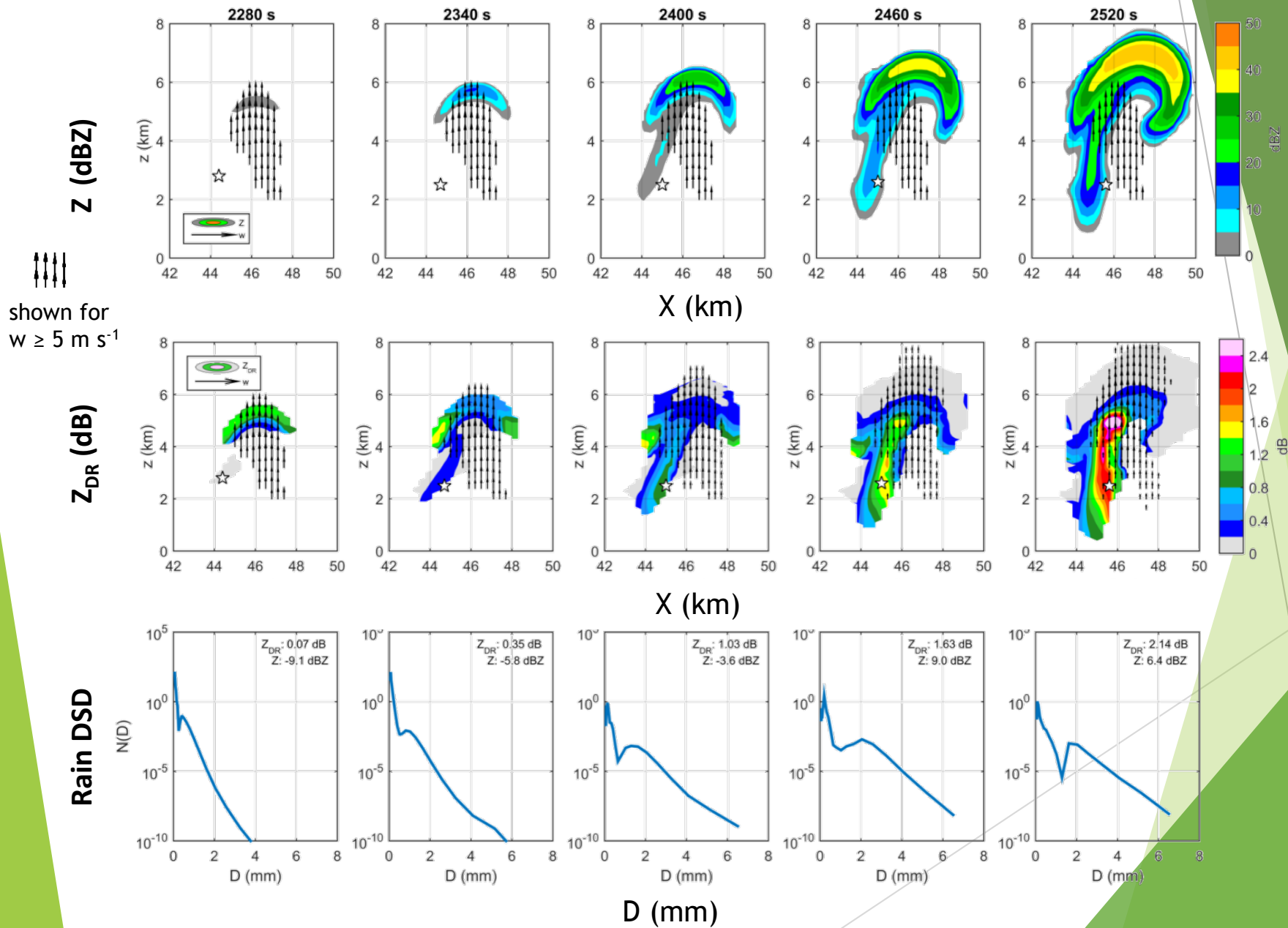# Sensitivity to CCN Concentrations and Low-Level Moisture

95th percentile of Z vs. time

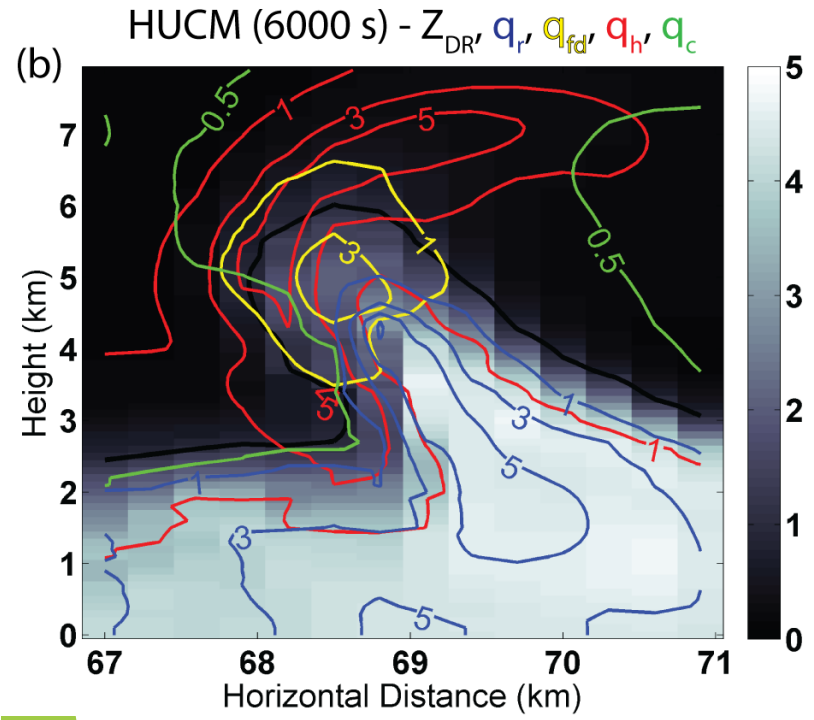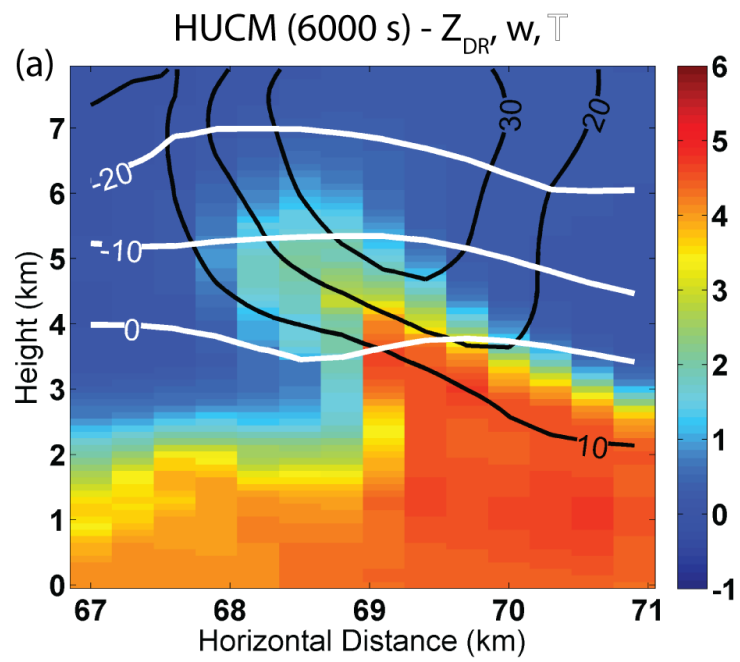
Same environment above PBL, wind profile, and total CAPE

HUCM Reproduces "Early Echo" High Z_{DR}... for *high CCN* cases

Z_{DR} Columns

(a) HUCM (6000 s) - Z_{DR}, w, $\mathbb{T}$

(b) HUCM (6000 s) - Z_{DR}, q_r, q_{fd}, q_h, q_c

From Snyder et al. (2015)

Height of Z_{DR}=1dB contours
Height of Z_{DR}=2dB contours
Z_{DR} volume (dB km)
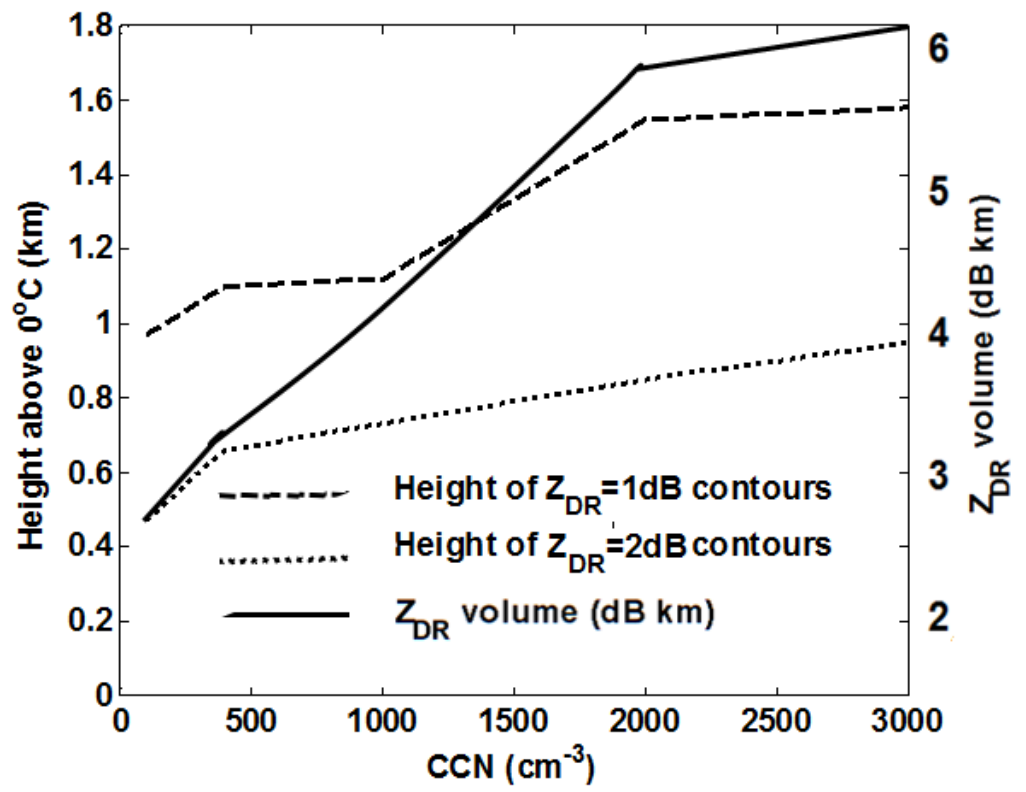
From Ilotoviz (2017, in preparation)

Conclusions

▶ Polarimetric radar has added considerably to our ability to observe convective storms, allowing us to infer microphysical processes and compositions not previously possible

▶ Polarimetric fields can be very sensitive to PSDs/DSDs, which in turn can be (extent unknown) sensitive to CCN concentrations (and presumably size distribution)

▶ There remains much work to do in the interaction between polarimetric radar and numerical modeling that will further allow for improved data assimilation, studies on other complications (e.g., role of CCN in polarimetric fields)

Contact:

Jeffrey.Snyder@noaa.gov or JSnyder@ou.edu