# Simulating Hail and Lightning

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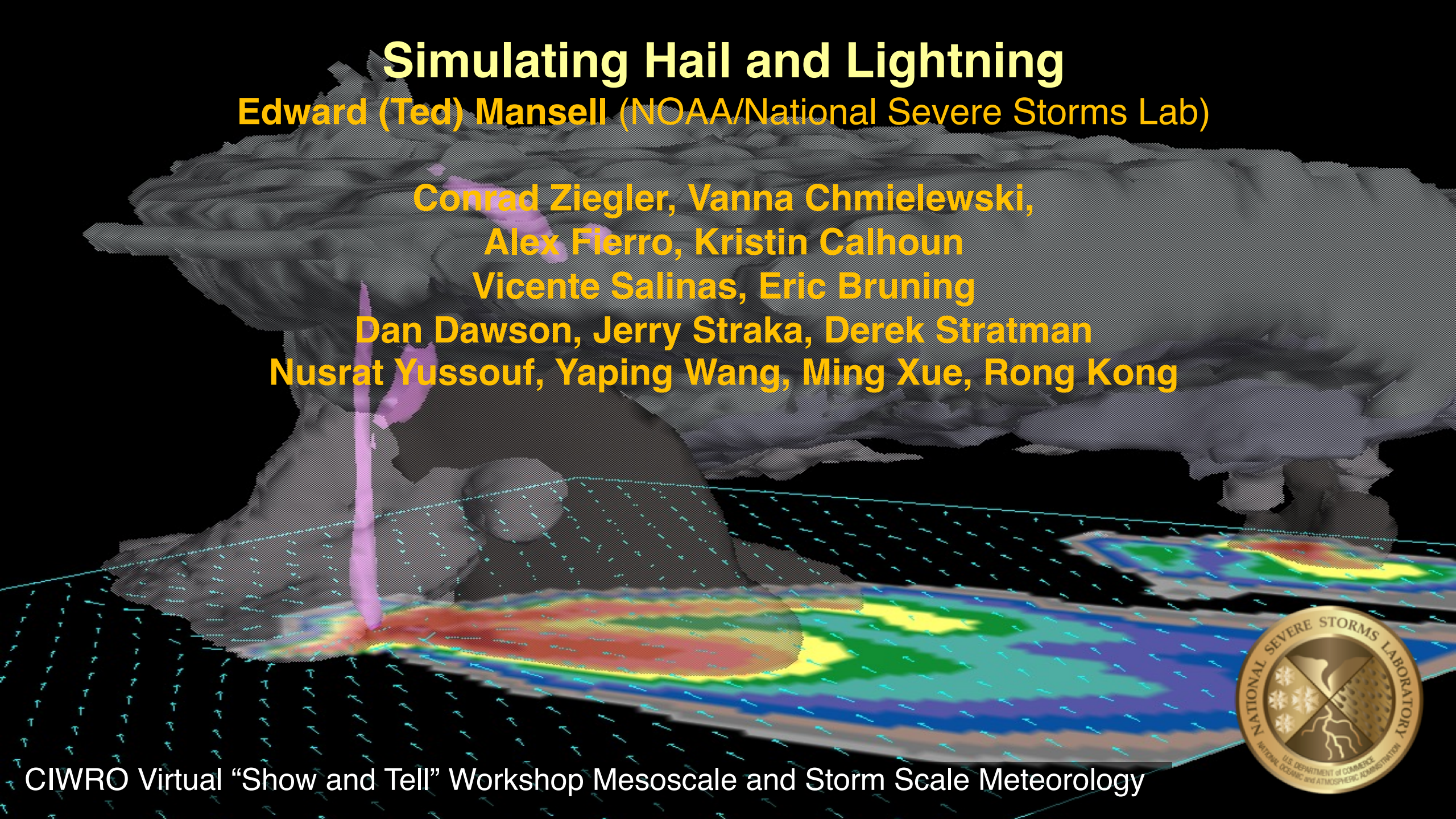


CIWRO Virtual “Show and Tell” Workshop Mesoscale and Storm Scale Meteorology

# What do I do?

- Cloud microphysics parameterization is central to research
- Main developer for "NSSL" bulk microphysics scheme:
  - Geared for severe convective storms, squall lines
  - CM1, COMMAS, WRF (NU-WRF), ARPS [Coming soon: UFS/CCPP]
- Electrification: All kinds of convection - relating lightning to storm features
  - Severe storms (of course) –[e.g., Geary, OK, case w/ Conrad Ziegler]
  - Ordinary storms
  - Tropical Cyclones (Fierro)
  - Tropical convection
  - Aerosol sensitivity
- Dabble in data assimilation (EnKF: lightning DA)
- Mobile radar data collection (NSSL's NOXP radar)

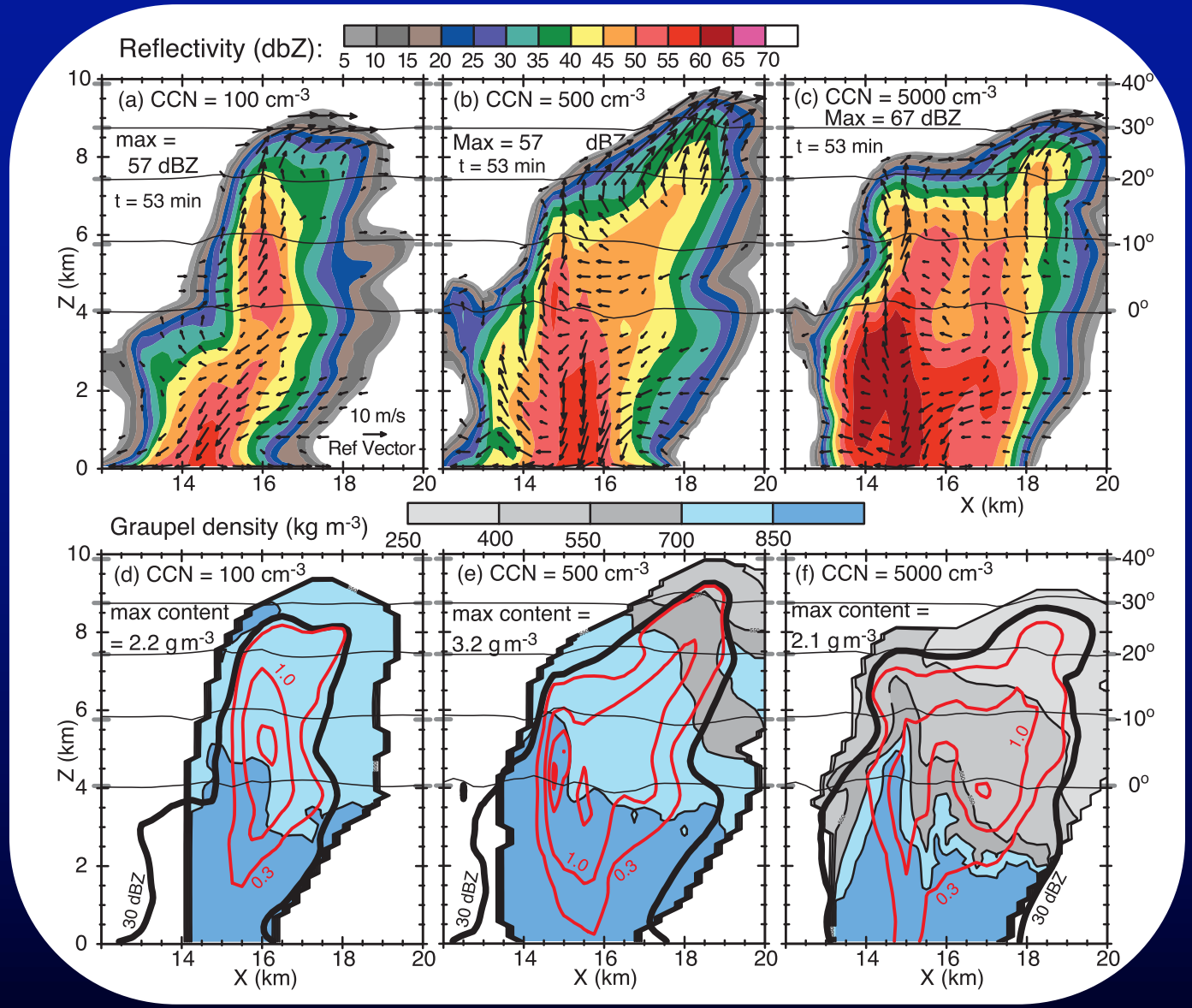
# NSSL Microphysics Key Features

- Fully 2-moment (mass and number), with 3-moment option for rain, graupel, hail (fast-falling species)
  - Can be run single moment, but why
- Specific attention to 2-moment sedimentation (adaptive limit on excessive size sorting). Important for dual-pol radar variables – better with 3-moment species
- Bulk CCNC prediction for aerosol sensitivity; explicit condensation (no saturation adjustment)
- Predicts bulk density of graupel and hail
- Hail species intended as "true" hail, characterized by size and source rather than simple density

# Graupel density example

Higher CCNC (droplet concentration) ->

- Lower rime and graupel density
- Also more graupel mass as more droplets persist into mixed-phase region and lower graupel fall speeds



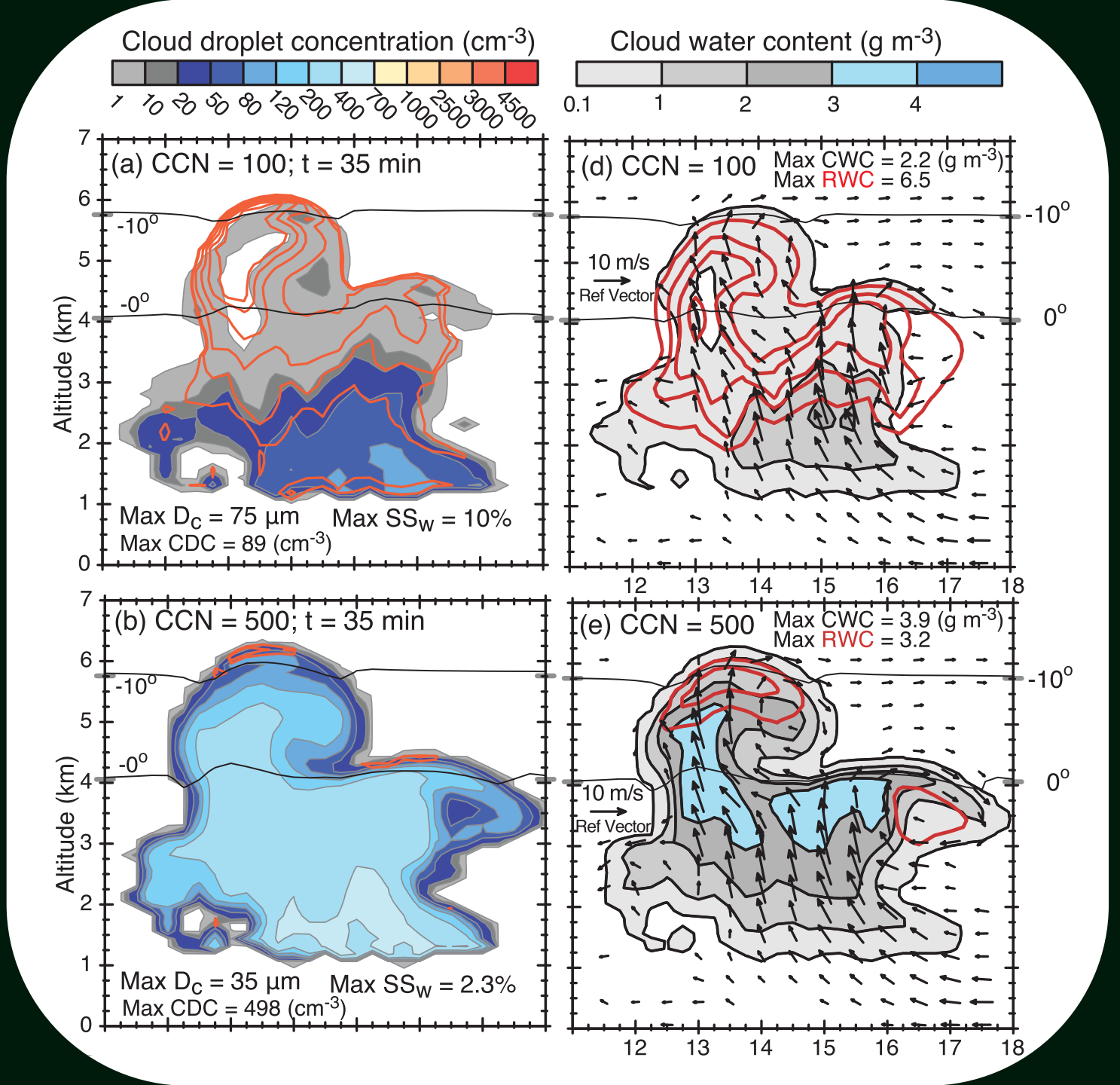

Mansell and Ziegler (2013)

# CCN example:

Low CCNC:
- Higher supersaturation
- Faster warm rain

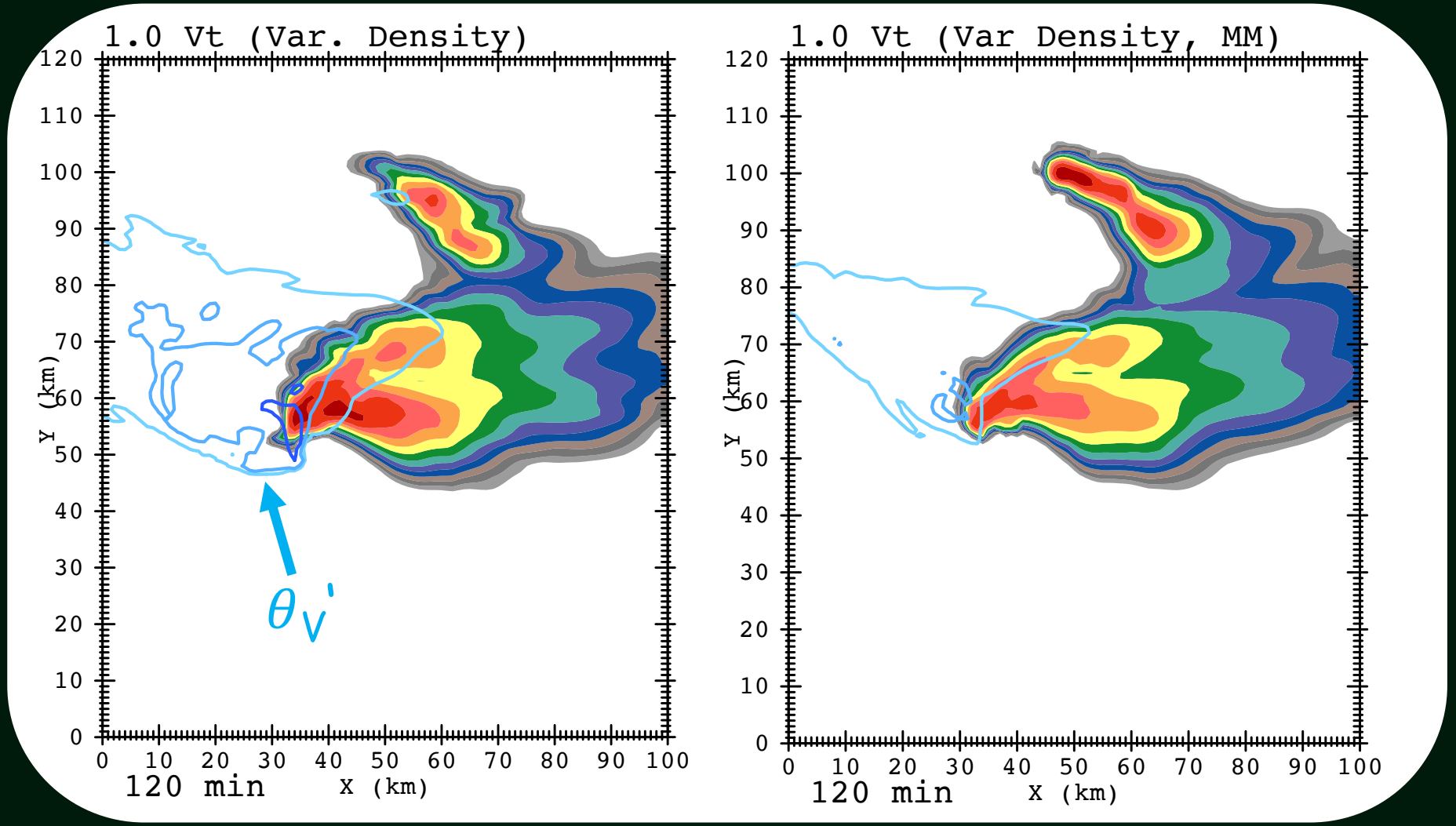
Higher CCNC:
- Lower supersaturation
- Slower warm rain

Mansell and Ziegler (2013)



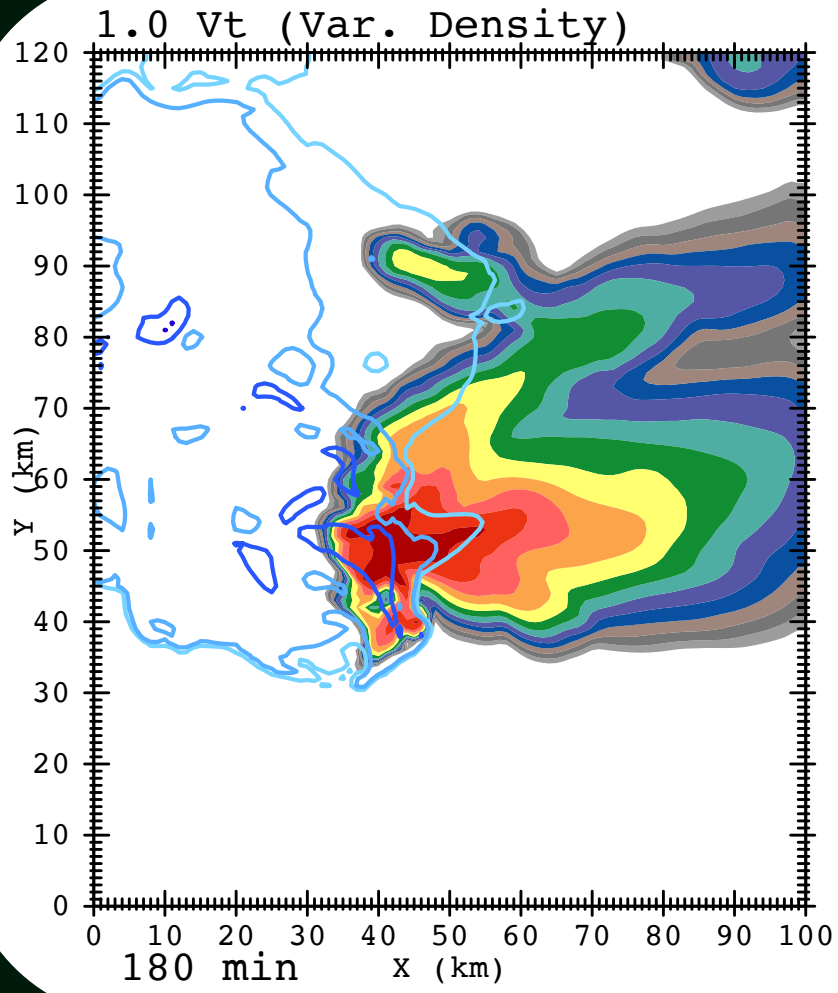
# Graupel/Hail Fall Speed Sensitivity

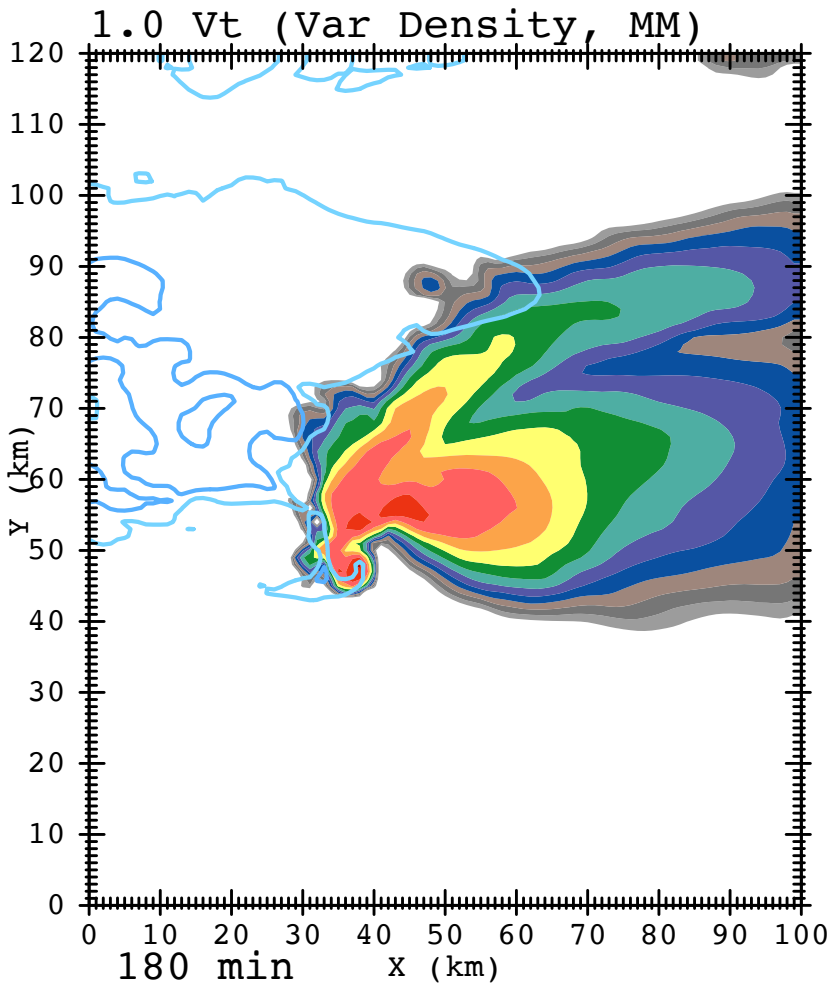
## Default vs. Milbrandt and Morrison (2013) (2hr)



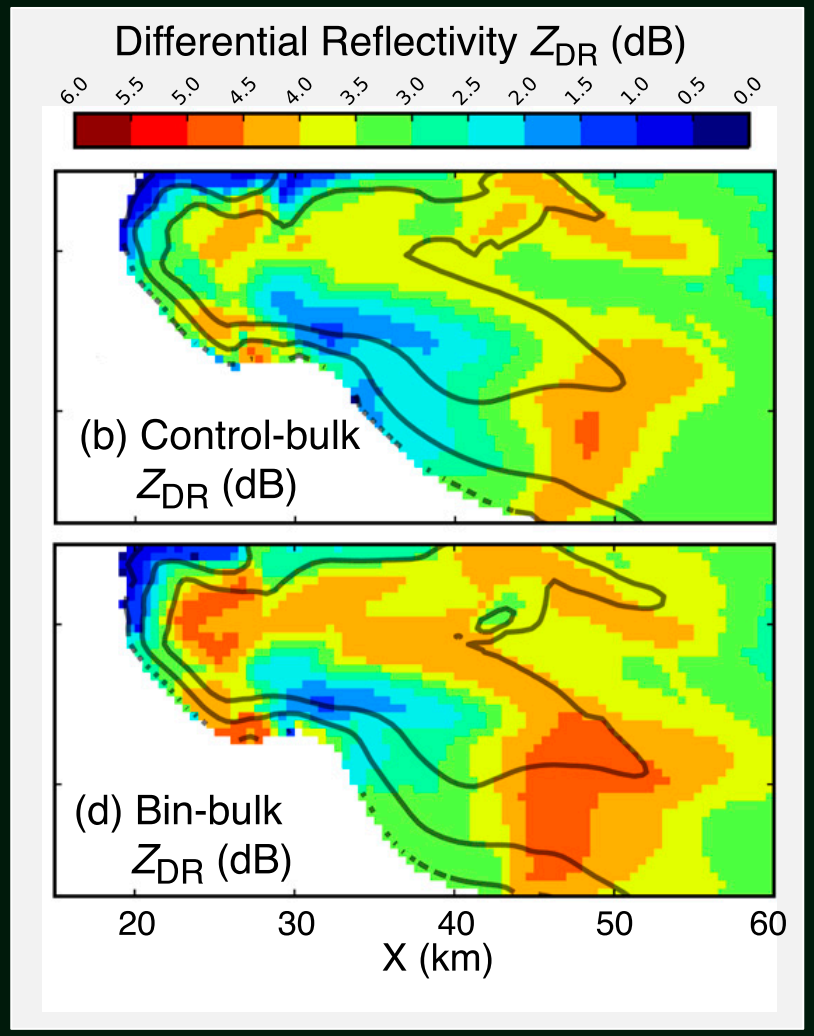
# Graupel/Hail Fall Speed Sensitivity

## Default vs. Milbrandt and Morrison (2013) (3hr)

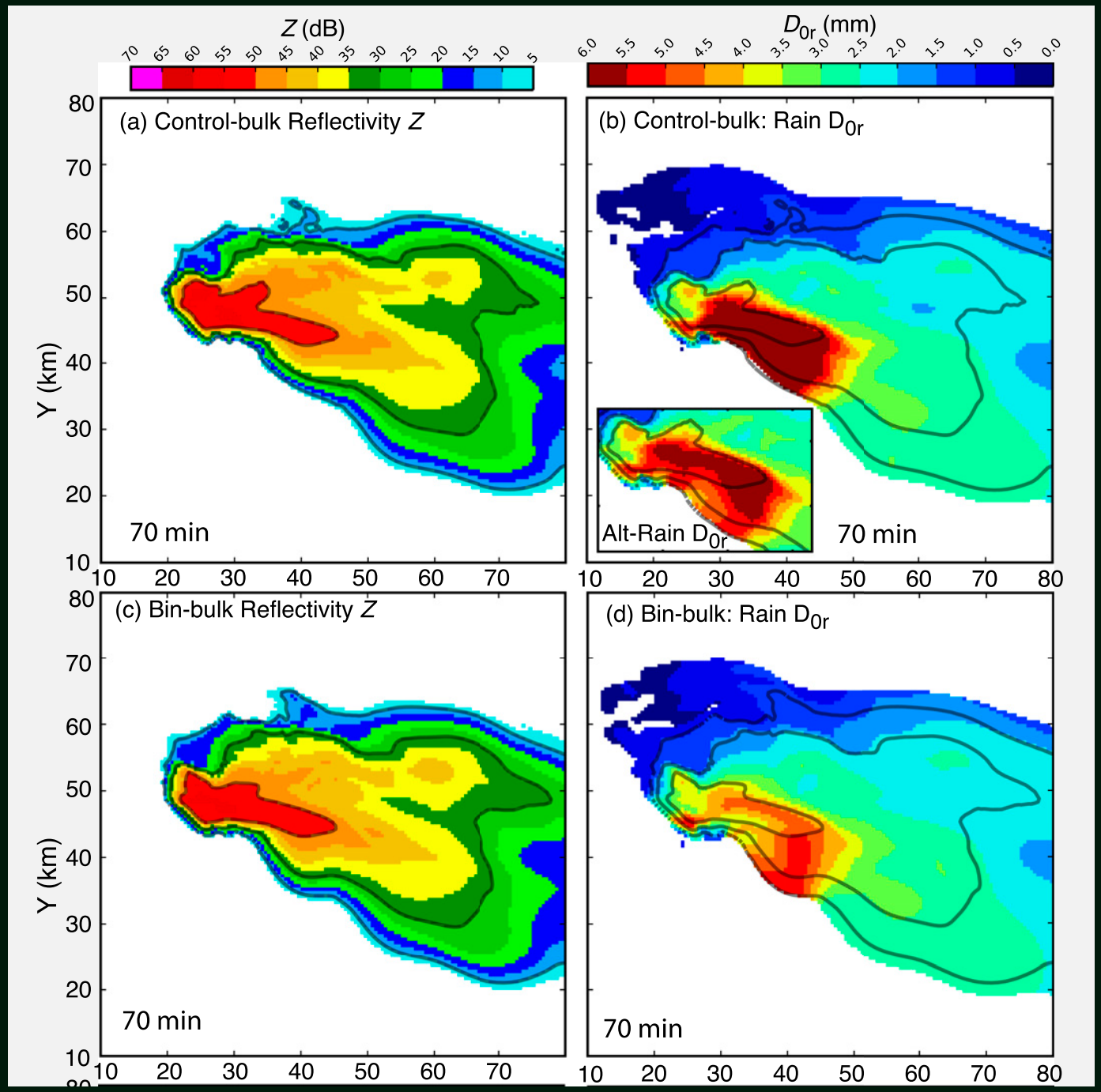



About 1/3 less rainfall for MM-2013




Mansell, Dawson, and Straka (2020)



# Dual-pol emulator (CAPS) (3-moment physics)

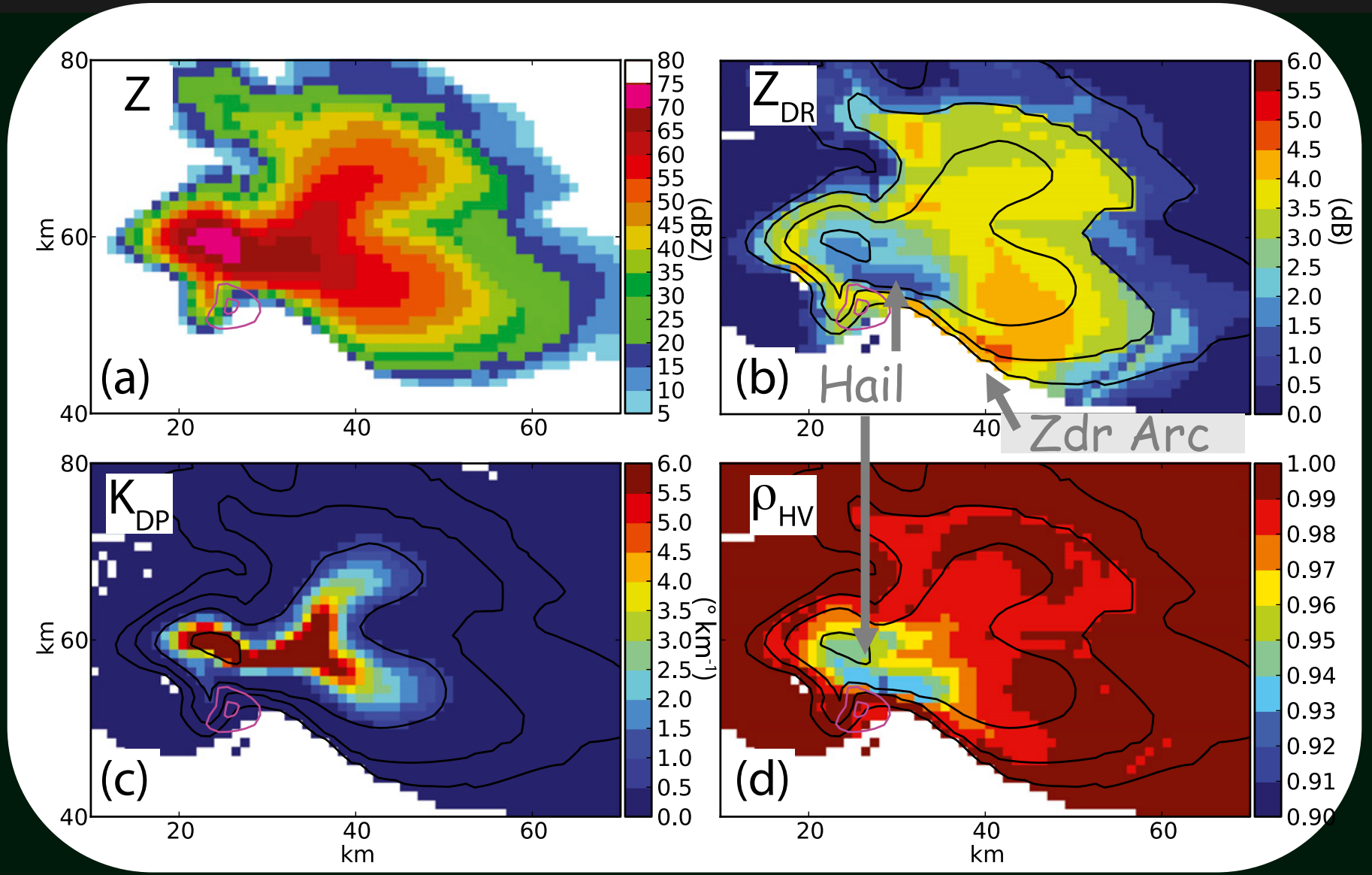



FIG. 6. As in Fig. 4, but for experiment SC3R3GLHVD, which includes separate variable-density graupel

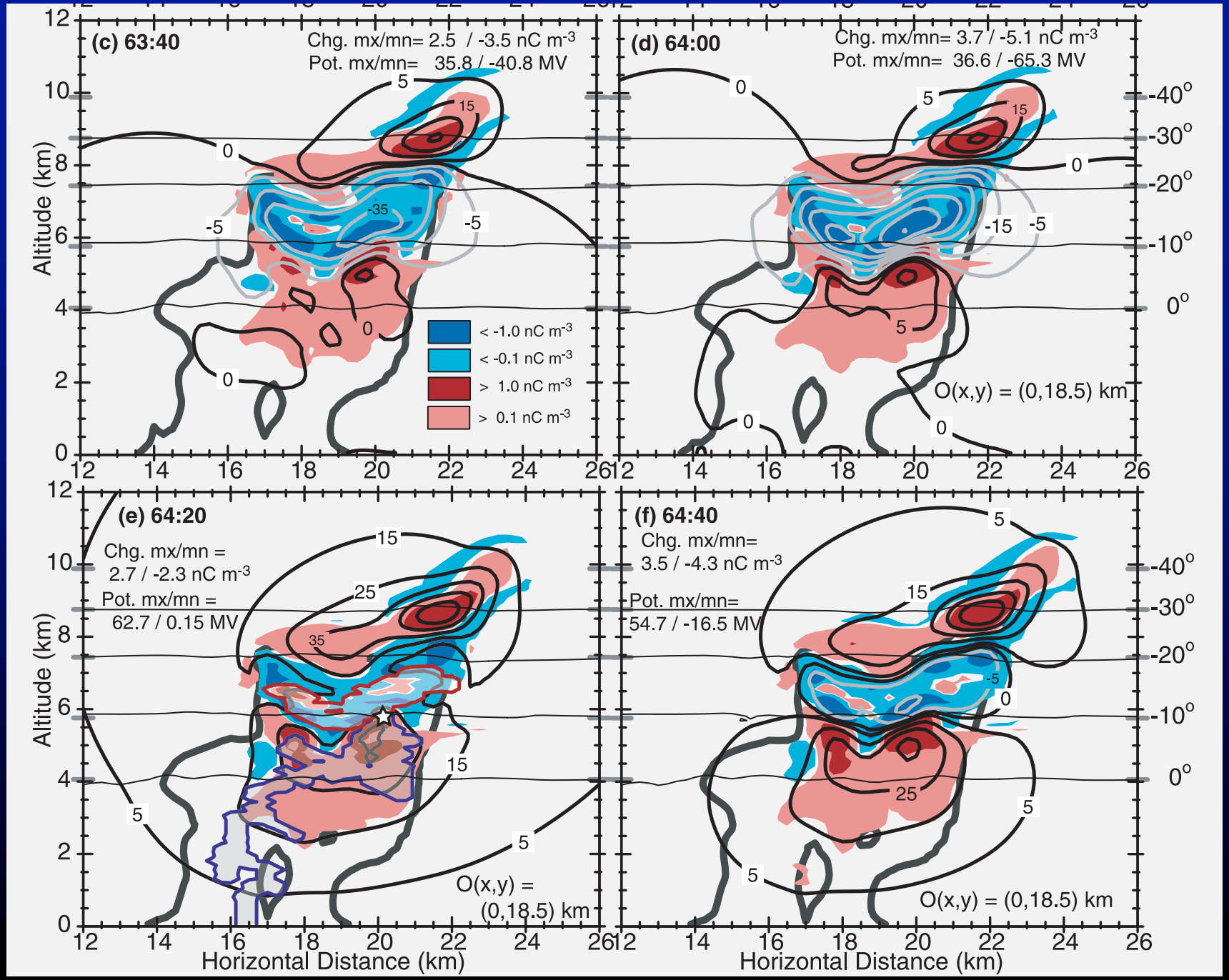
1 June 2008 supercell; Dawson et al. (2014)

# Small Thunderstorm electrification

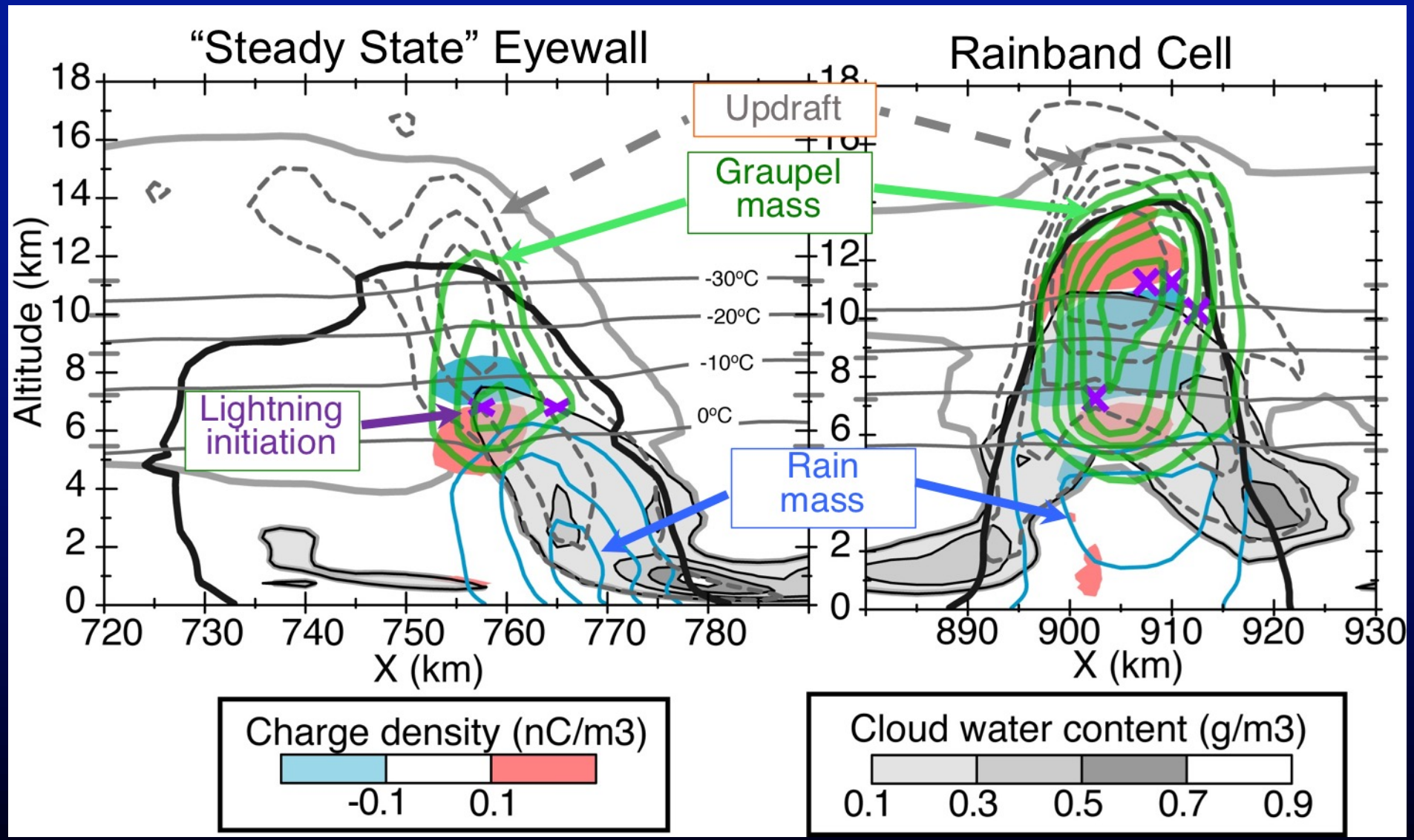
Charge and microphysical evolution

Can simulations help interpret observed behaviors?

Mansell, Ziegler, & Bruning (2010)



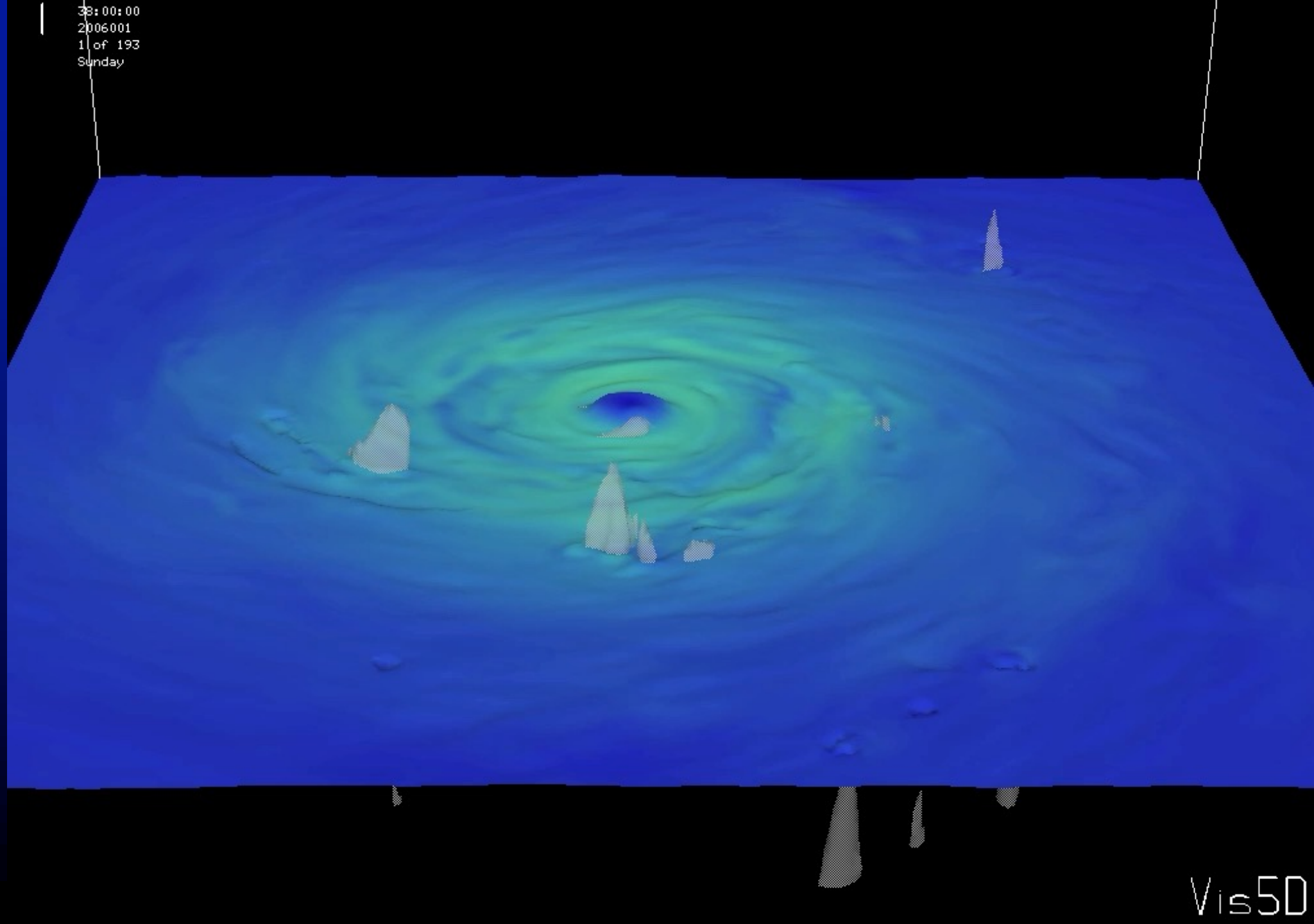
# Tropical Cyclone Electrification



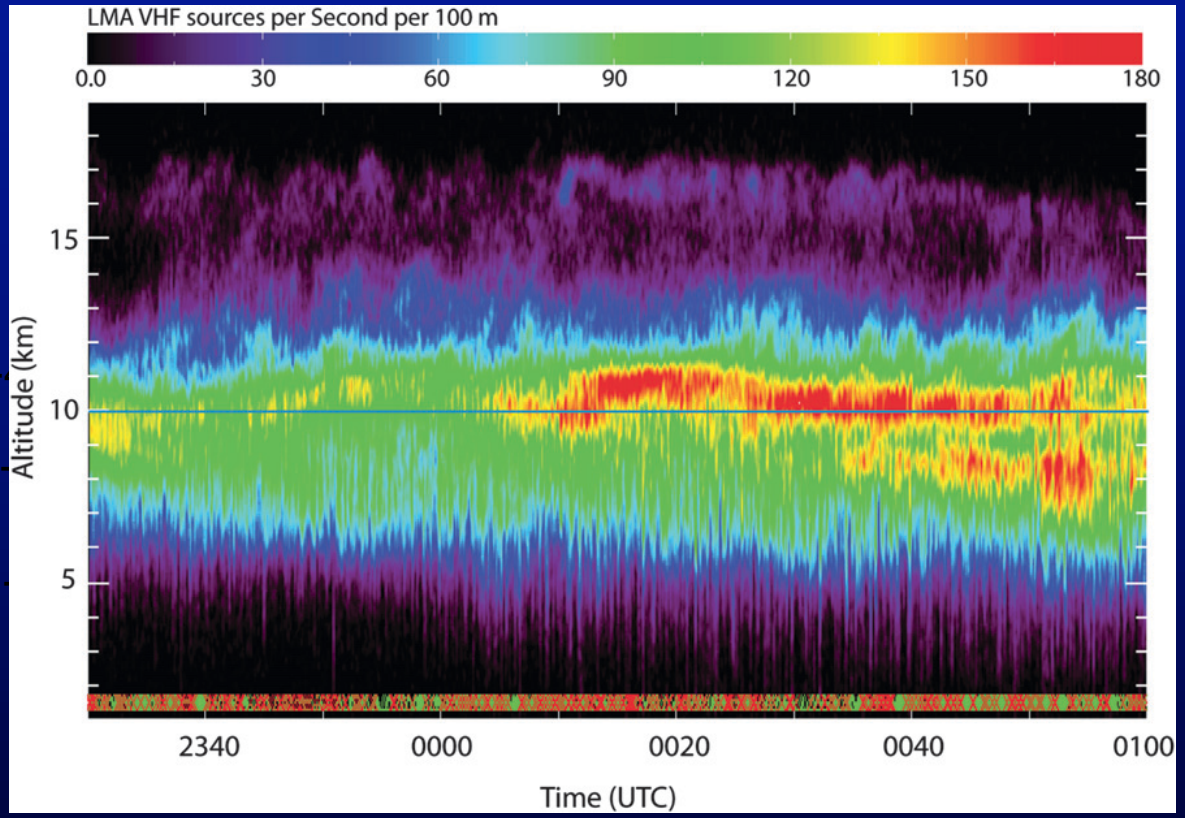

Fierro and Mansell (2017,2018)

# TC Rapid intensifi-cation

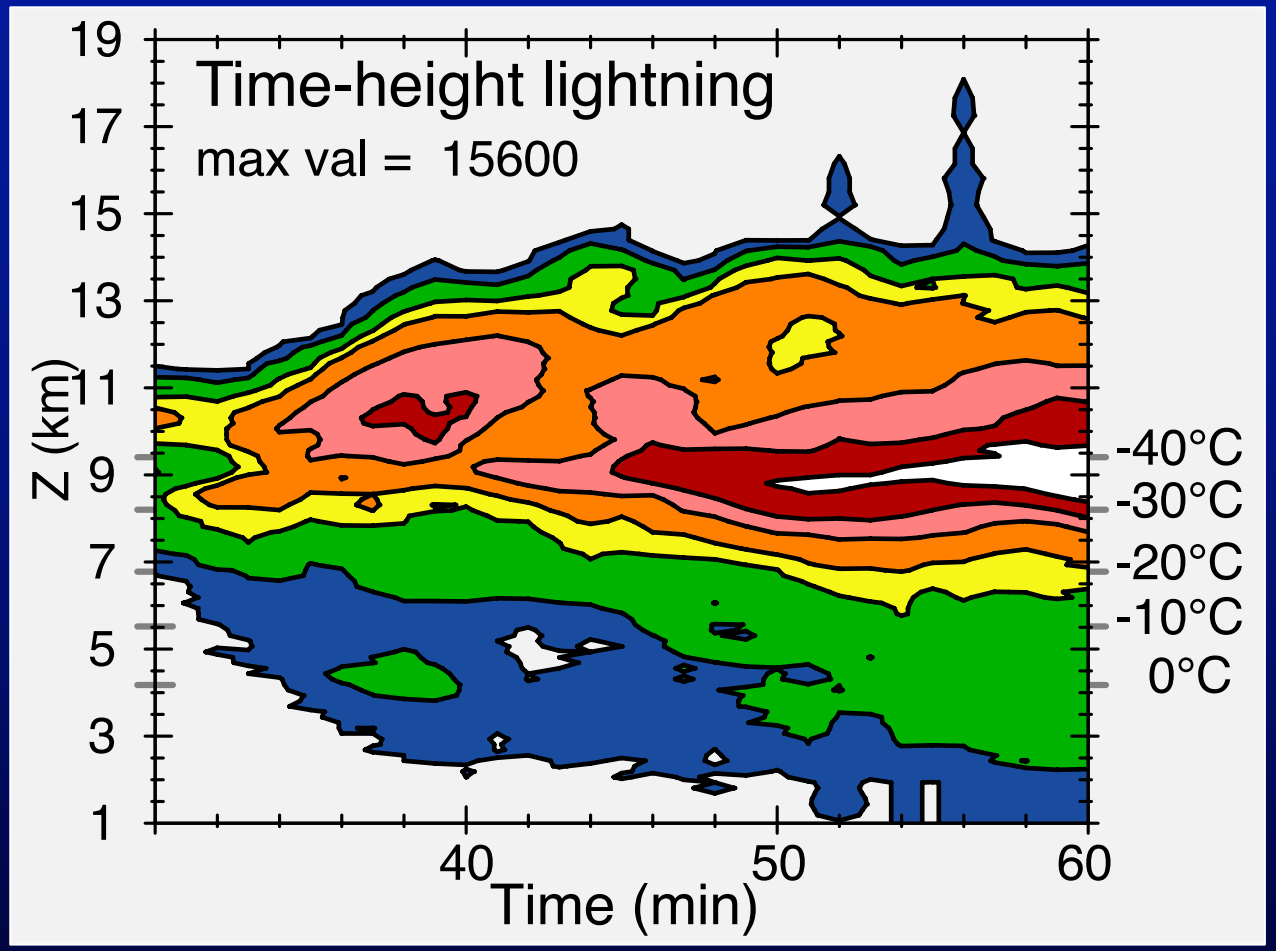
Color: wind speed at 0ºC level
Gray surfaces: 35 dBZ



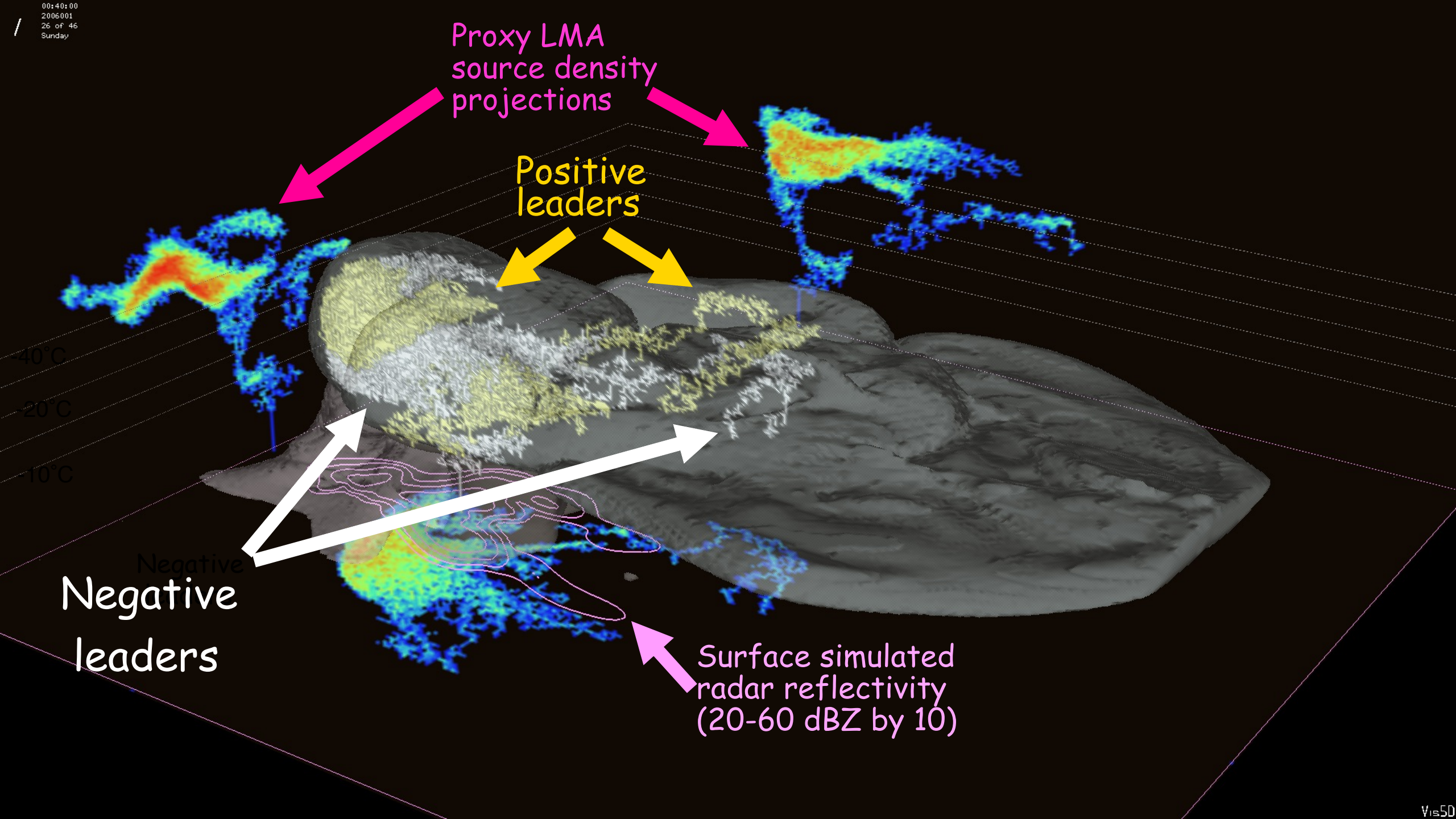
# Supercell lightning

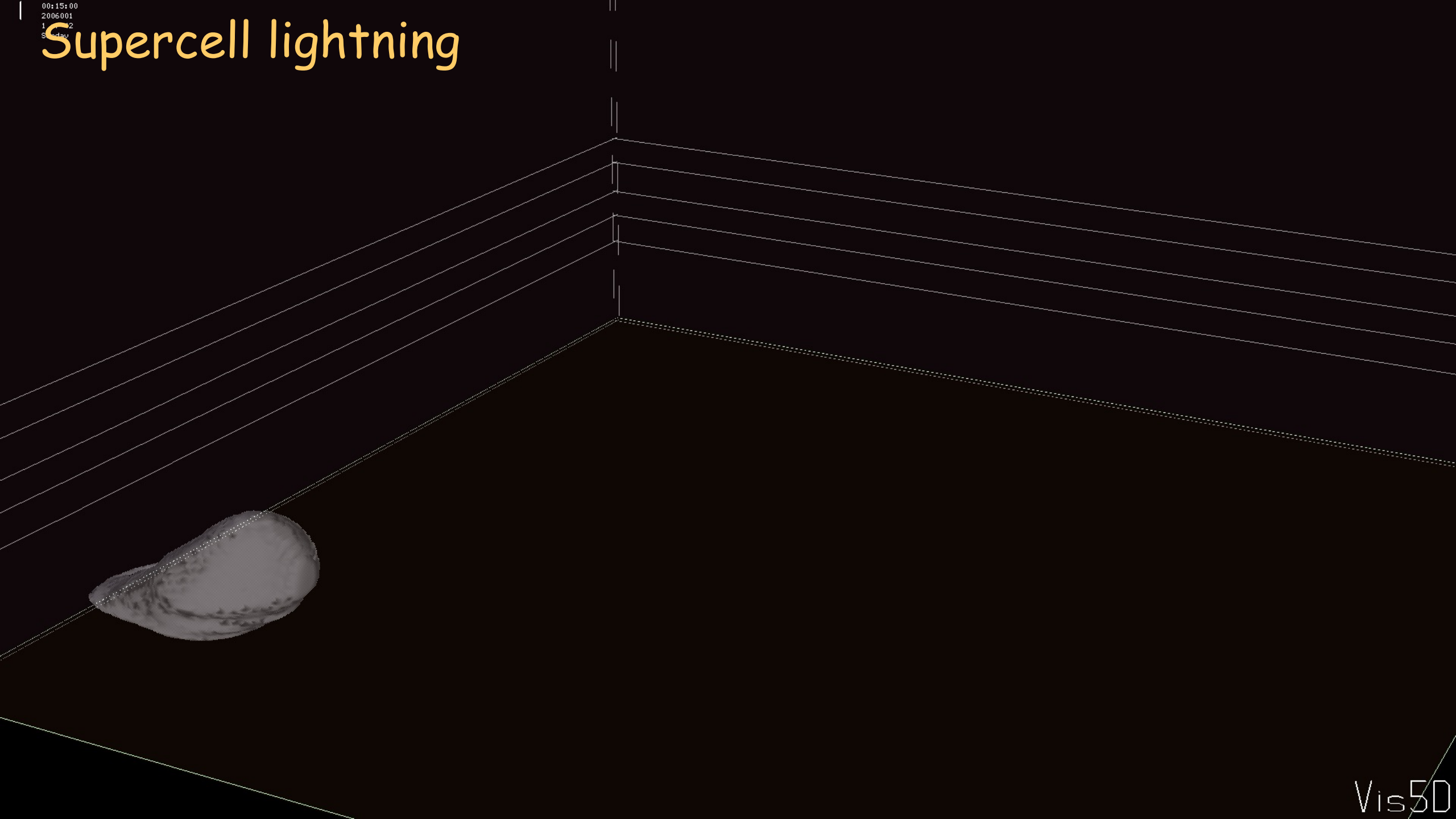



Flash VHF sources (time-height density) from 29 May 2004 supercell storm (Calhoun et al. 2013)




Simulated channel sources count (time-height density)


00:40:00
2006001
26 of 46
Sunday
Proxy LMA
source density
projections
Positive
leaders
-40°C
-20°C
-10°C
Negative
leaders
Surface simulated
radar reflectivity
(20-60 dBZ by 10)
Vis5D


00:15:00
2006001
Supercell lightning
Vis5D

# Current and “to do” list

- Hail embryo tracking (fraction of hail from frozen drops vs. from graupel – AGU talk)
  - Related to proposed ICECHIP field campaign
- Radiative Convective Equilibrium: Can aerosols affect lightning (spoiler: yes)
- Secondary ice production: Effects on microphysics and electrification
- Mixed phase particles (liquid fraction on ice)
- Bin microphysics: graupel density prediction
- Supercell sensitivity (evolution and lightning) to CCN conc. (J. Blair)

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