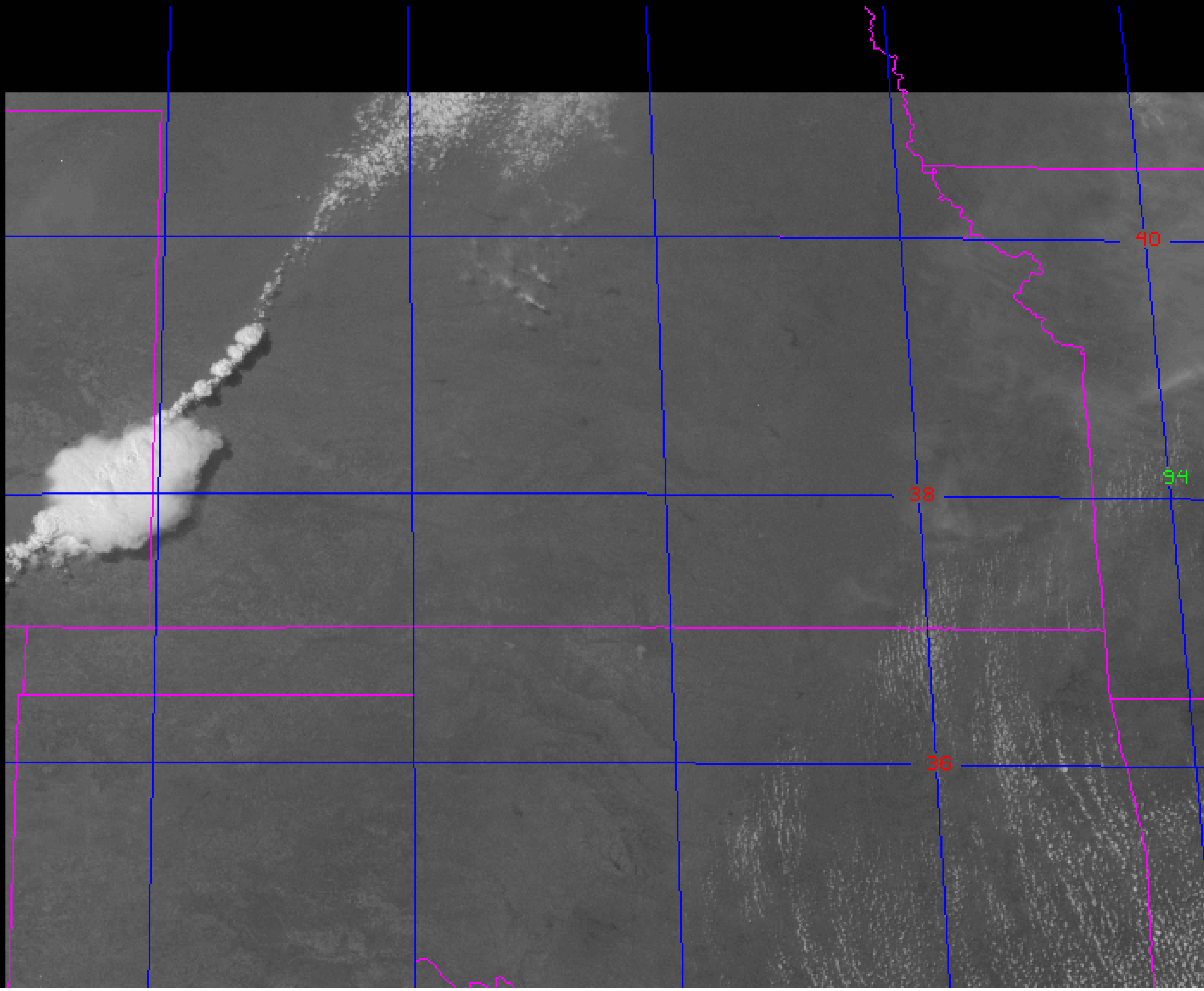
The 19 June 2002 “Mantle Echo” Case:
Microphysics and Initiation

Robert Fovell and Axel Seifert

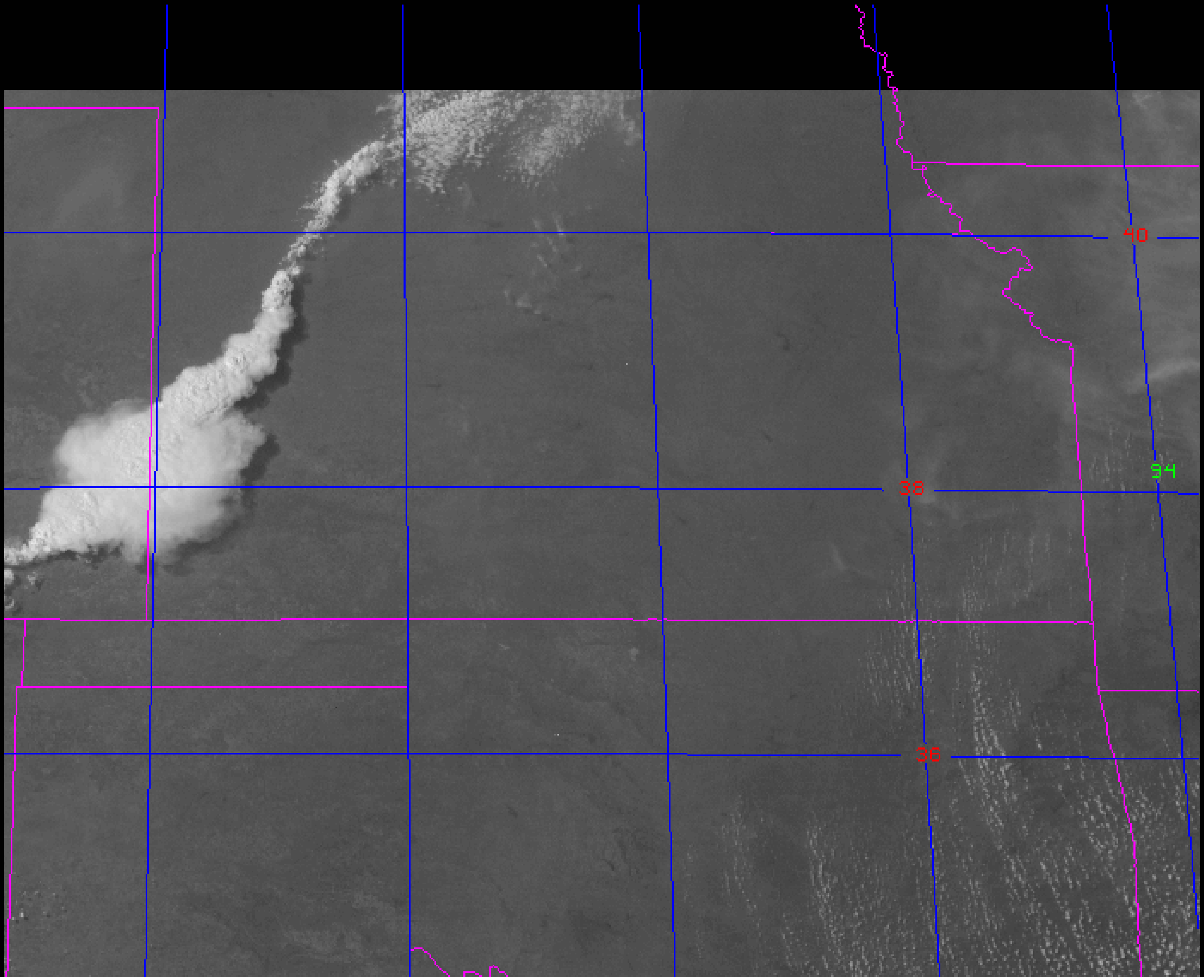
Overview

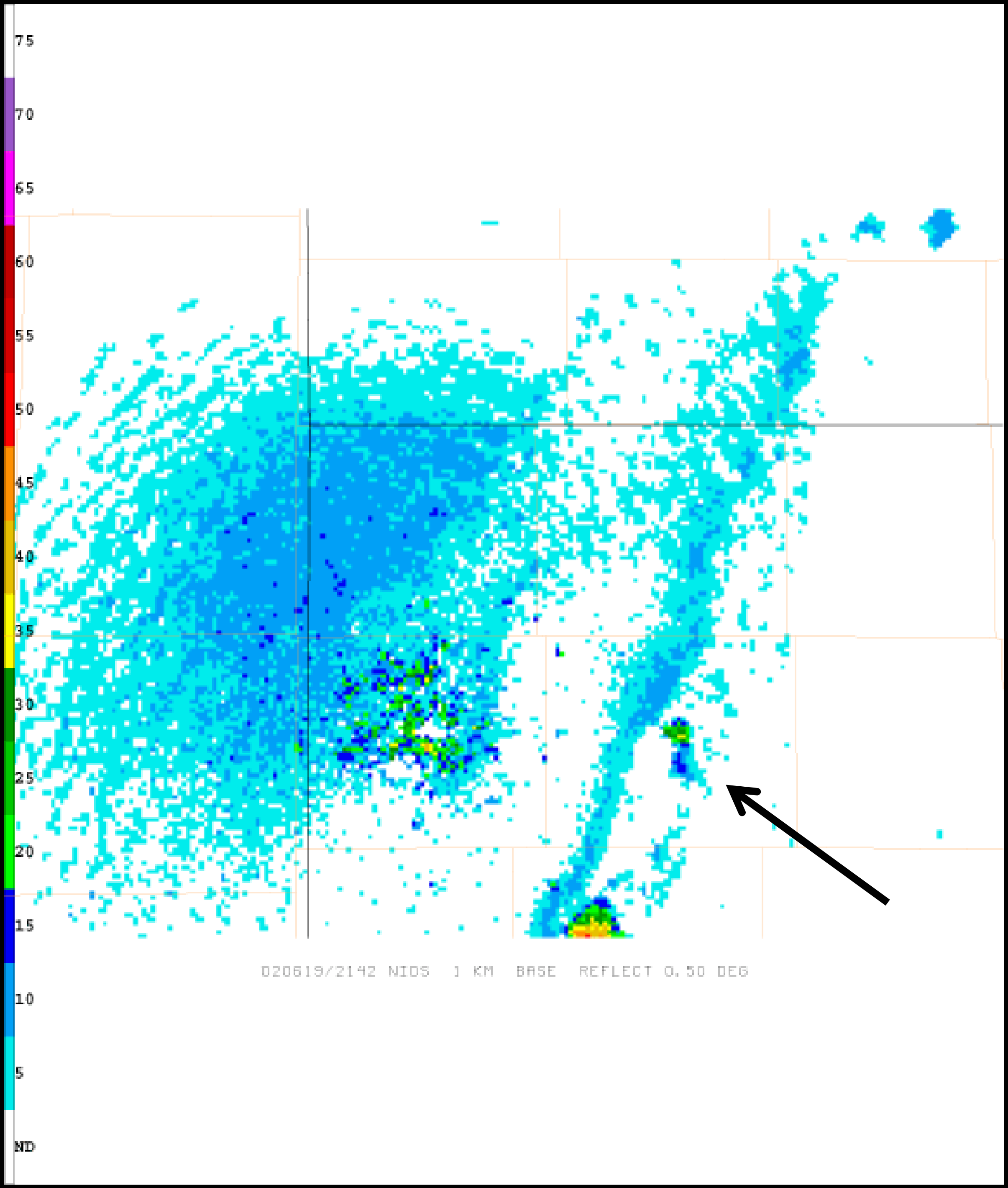
- 19 June 2002 case during IHOP
- ELDORA radar observed very early history of a strong, isolated, hail-producing storm
  - Wakimoto et al. (2004)
- Opportunity and challenge for modeling
  - Early evolution of storm insensitive to microphysics
  - …but sensitive to initiation mechanism

GOES-11 visible 2103 UTC



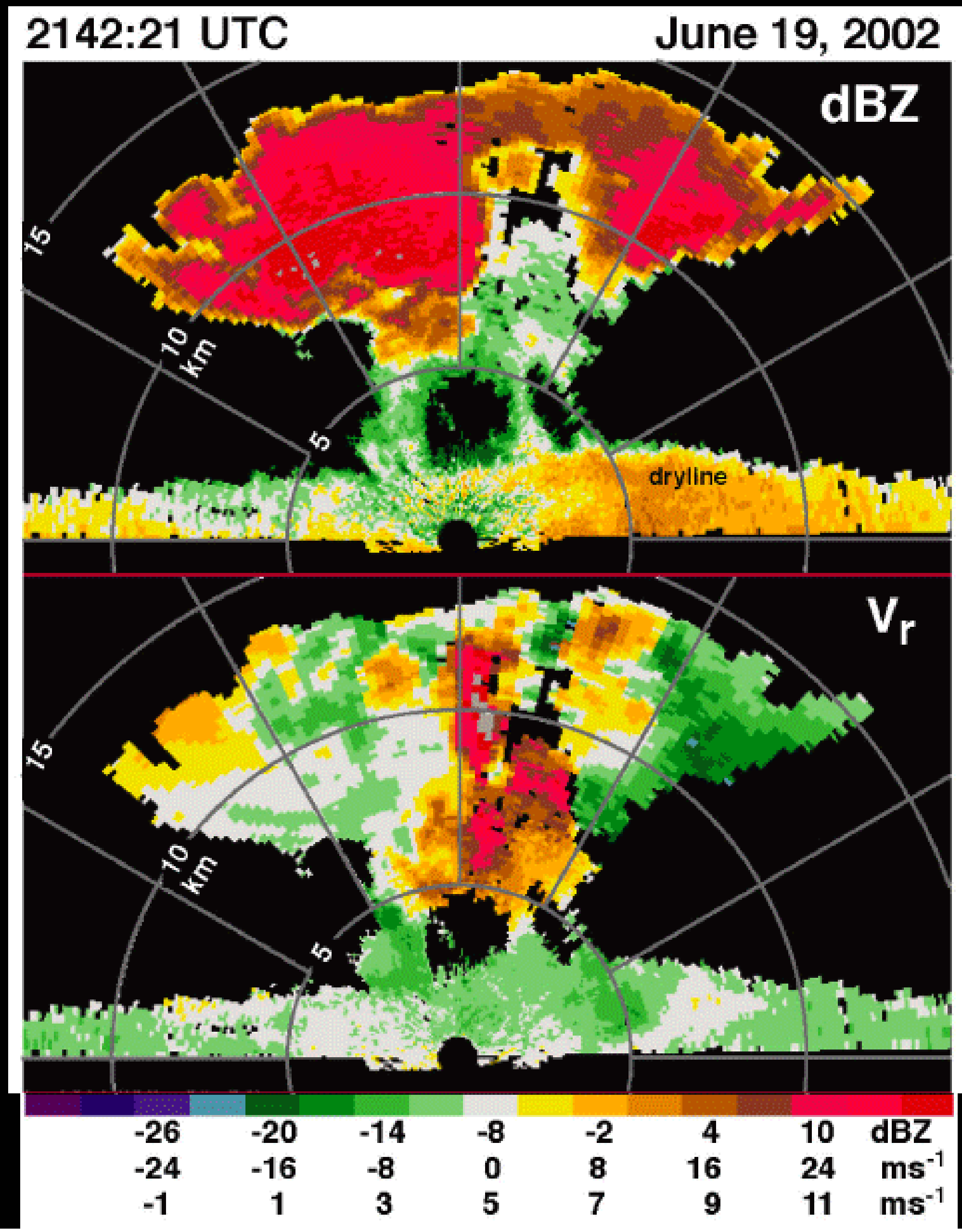
GOES-11 visible 2139 UTC





Goodland, KS radar
2142 UTC

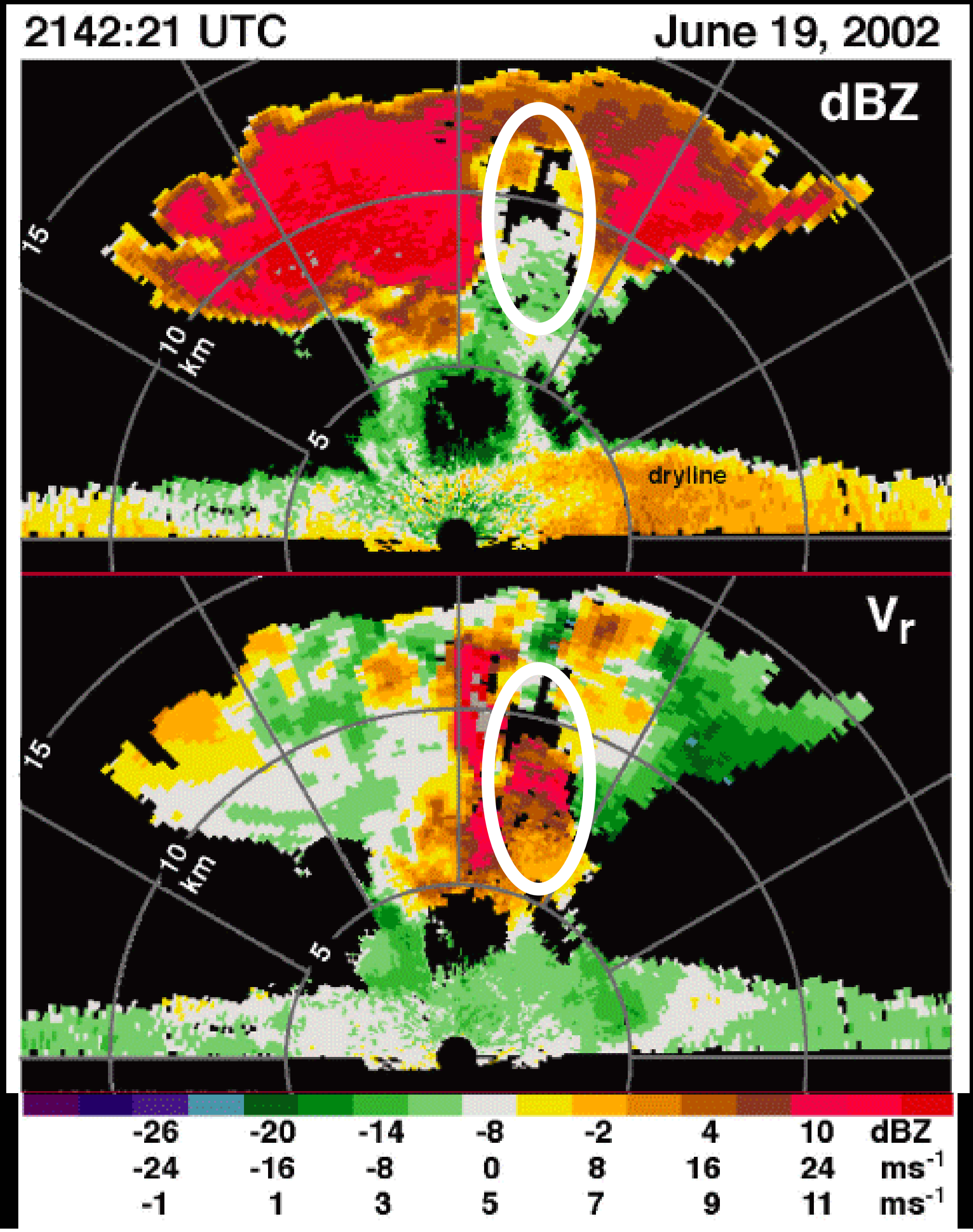
ELDORA observations



~15 km deep
~30 km wide

Wakimoto et al. (2004)

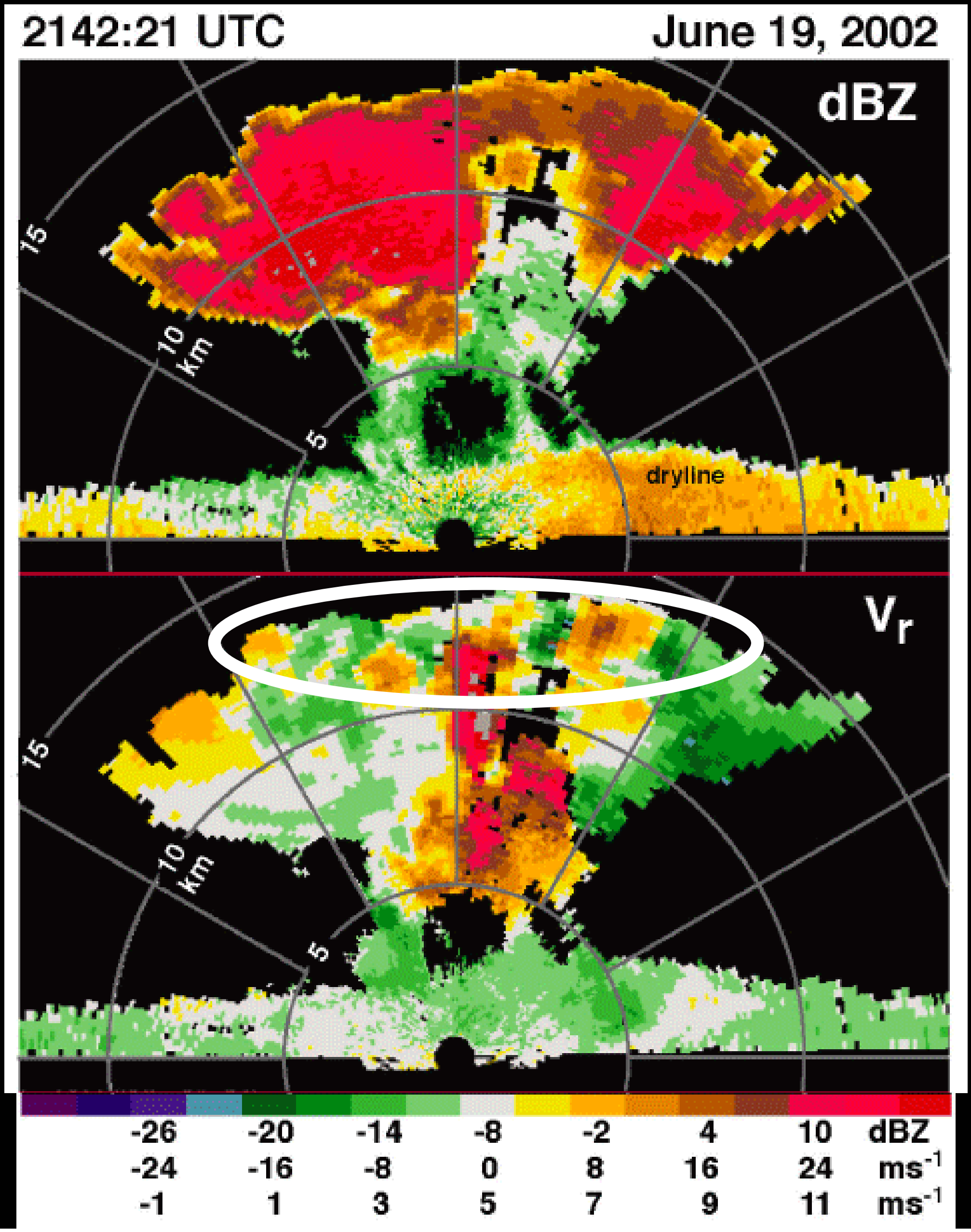
ELDORA observations



weak echo vault

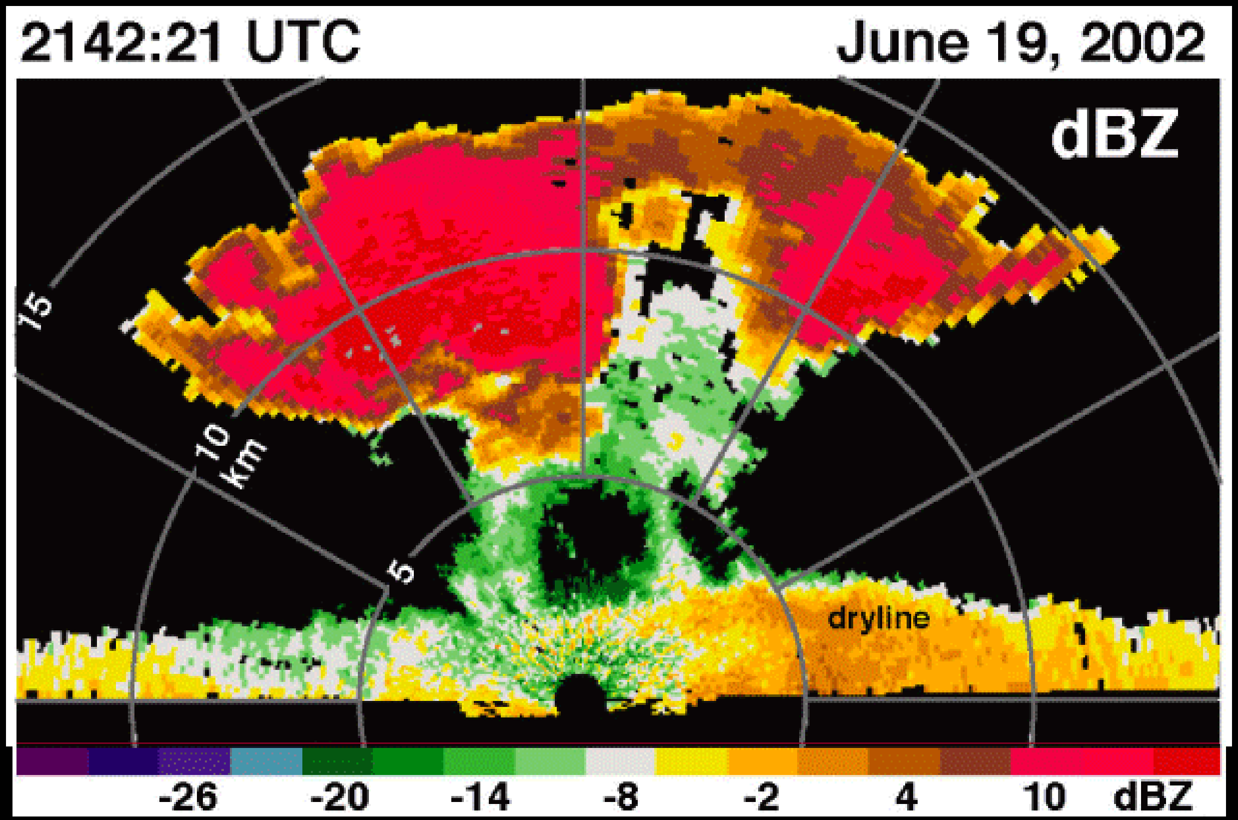
Max updraft ~40 m/s

ELDORA observations



Rotational couplets

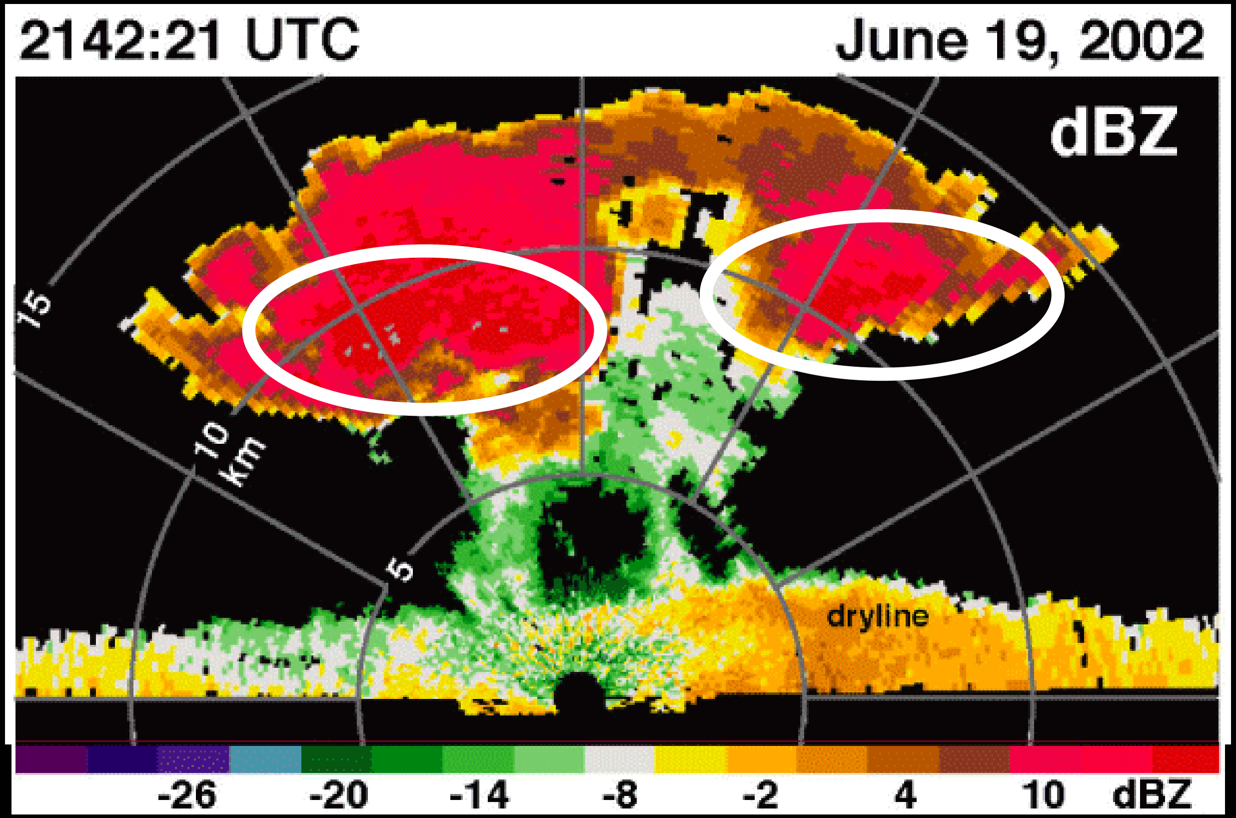
ELDORA observations



Note reflectivities < 20 dBZ

Echo above 7 km level

ELDORA observations



Greatest echo brightness at lower portion of echo “horns”

Wakimoto et al. (2004)

Mon. Wea. Rev.

- Simulations
  - 2D using ARPS model
  - Lin-Farley-Orville (1983; “LFO”) single moment microphysics [seriously tweaked]
- Goal: simulate echo structure
  - Height of echo (above 7 km)
  - Echo brightness (or lack of it…)
  - Weak echo vault
  - Larger reflectivity at bottom of “horns”
  - Rotational signatures

Wakimoto et al. (2004)

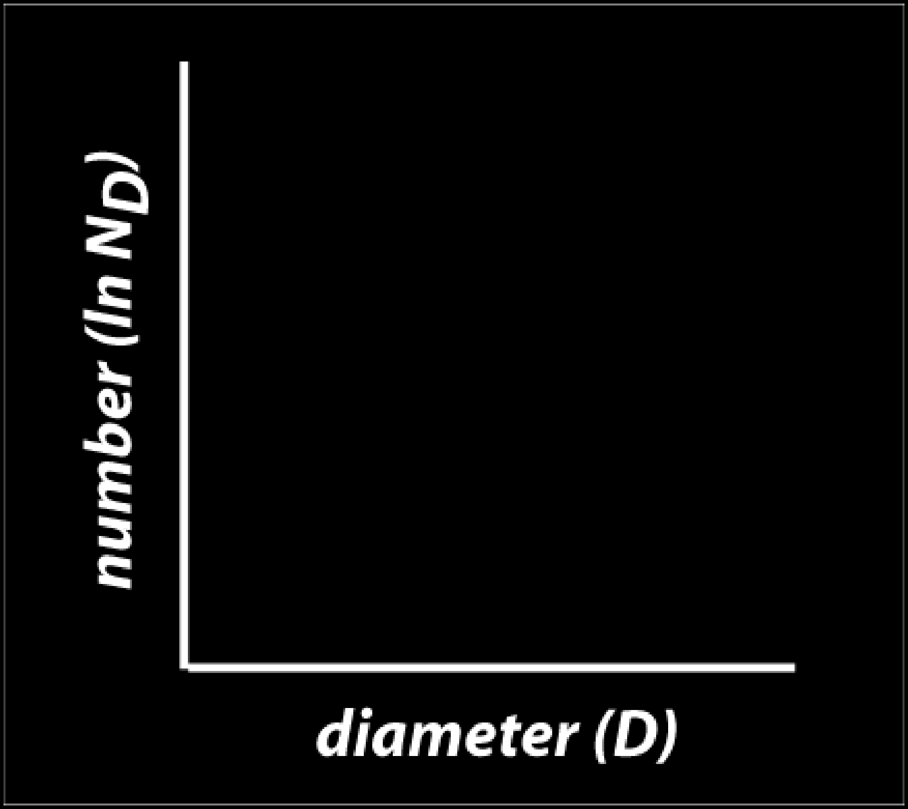
Results

- Default single-moment microphysics schemes rapidly produce very bright echoes
  - Echo magnitude too large
  - Echo height too low
  - No weak echo vault
- Tweaked LFO scheme produced good results
  - Slowed down conversion rates
- Microphysics and/or initialization to blame?
  - Were snow/graupel masses too large or mean particle diameters too big in default scheme?
  - Was initial perturbation too large?

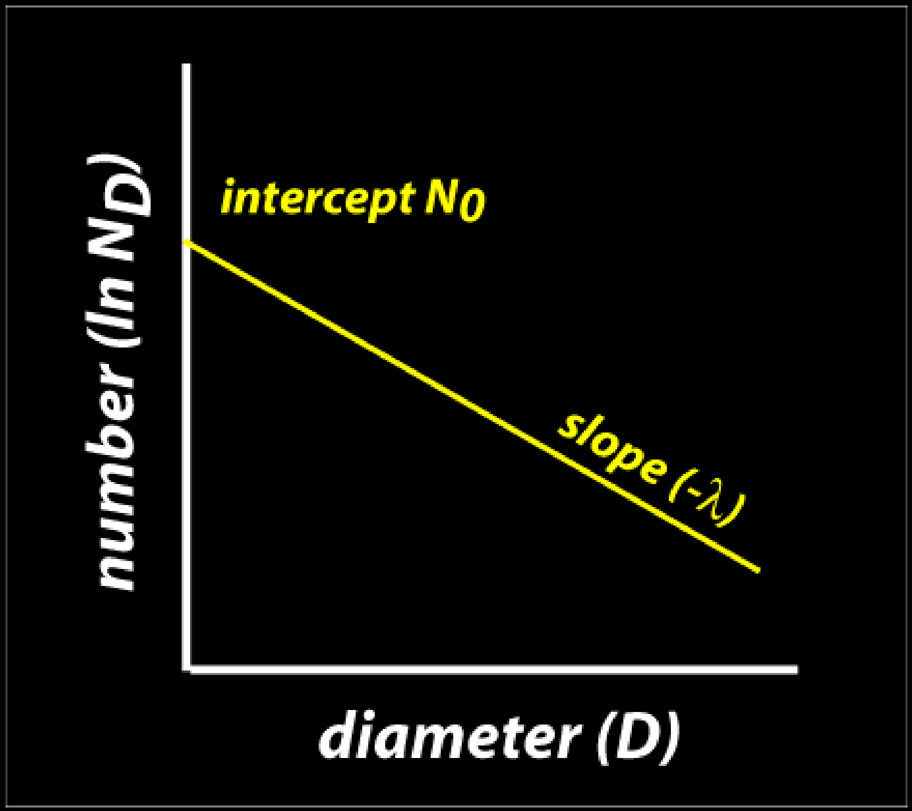
Revisit the 19 June case

- WRF model (v2.0.3.1), 250 m resolution
- Seifert-Beheng (SB) two-moment microphysics
  - 5 condensate categories
    - Cloud, rain, ice, snow and graupel
  - Prognoses mass and number concentration
- Different initiation mechanism

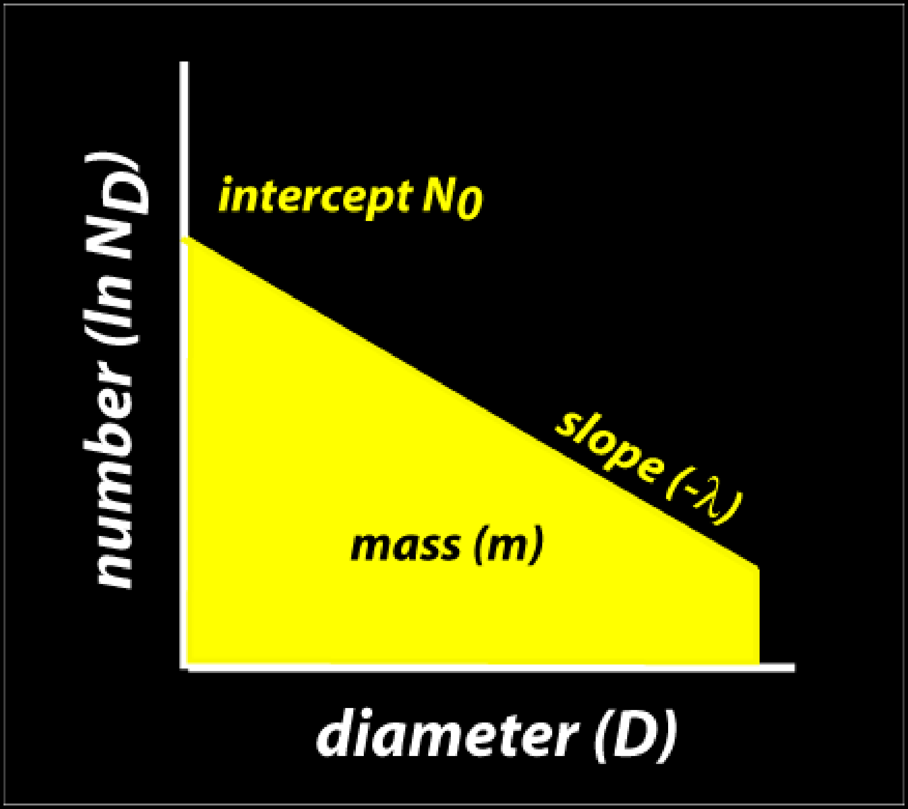
Single-moment microphysics



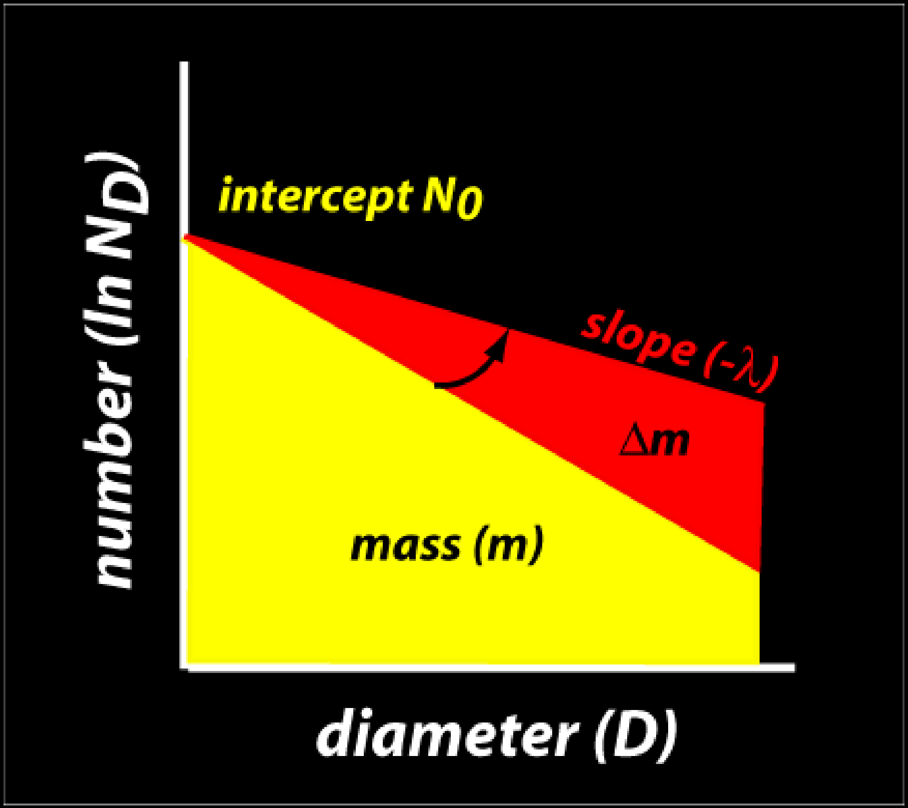
Single-moment microphysics



Single-moment microphysics



Single-moment microphysics



Overly rapid appearance of large particles,
affecting collection rates and echo brightness

Two-moment microphysics

- Predicts mass (m) and number (N) separately

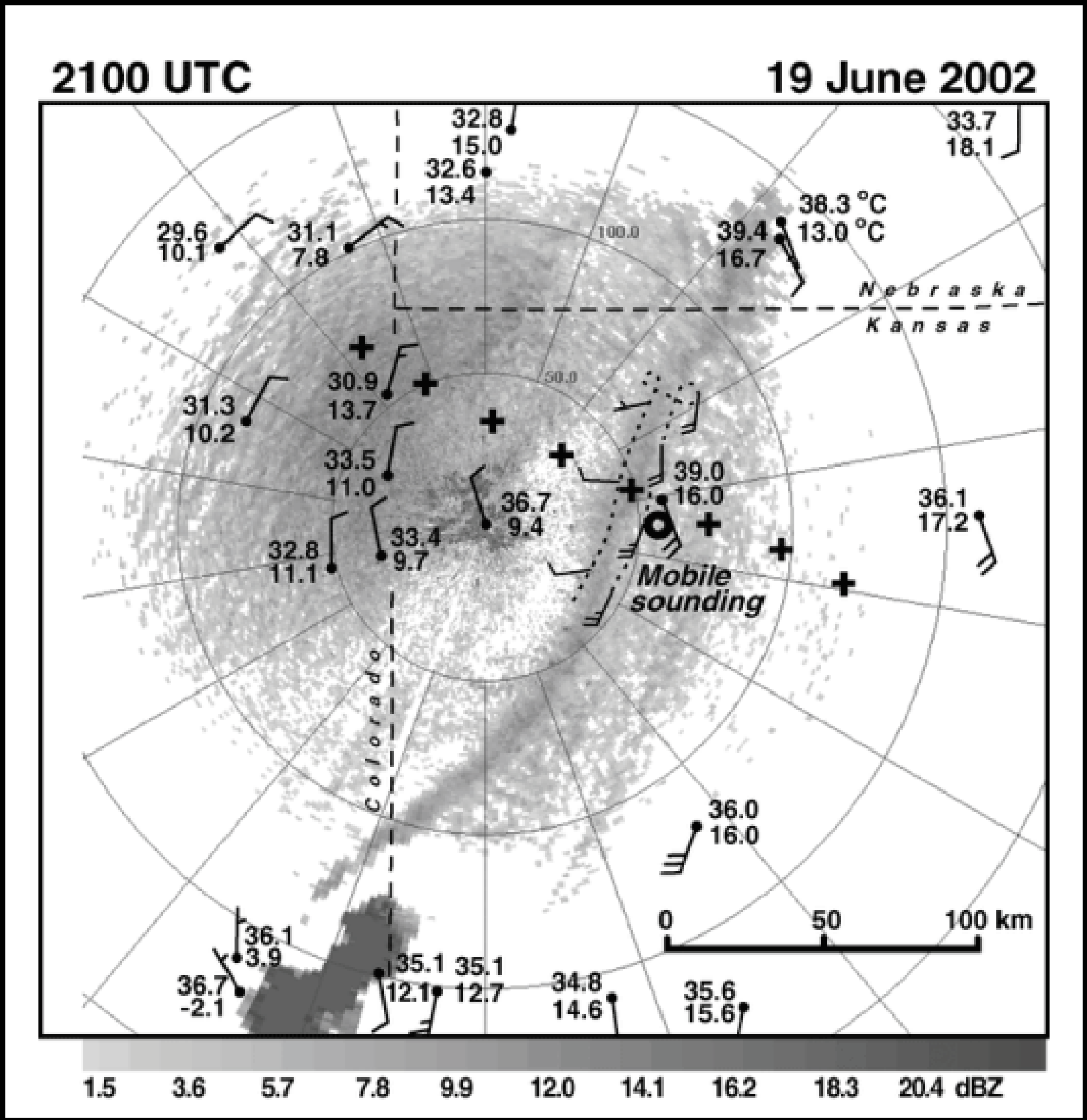
$$\bar{m} = \frac{m}{N}$$

- Can have large … small particles

Initialization

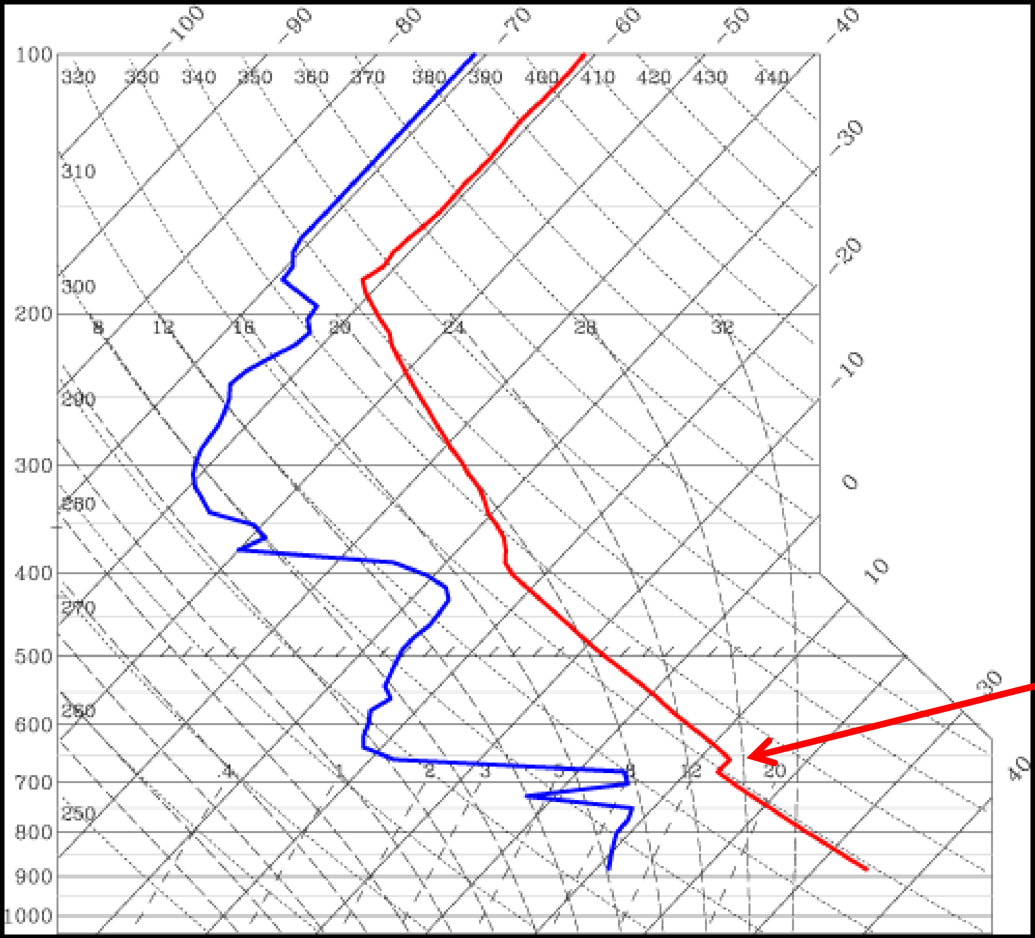
- Mobile sounding launched 2003 UTC close to dryline
- Dropsondes deployed across dryline ~1 hour later, just prior to convective initiation in NW Kansas

Sounding locations



Wakimoto et al. (2004)

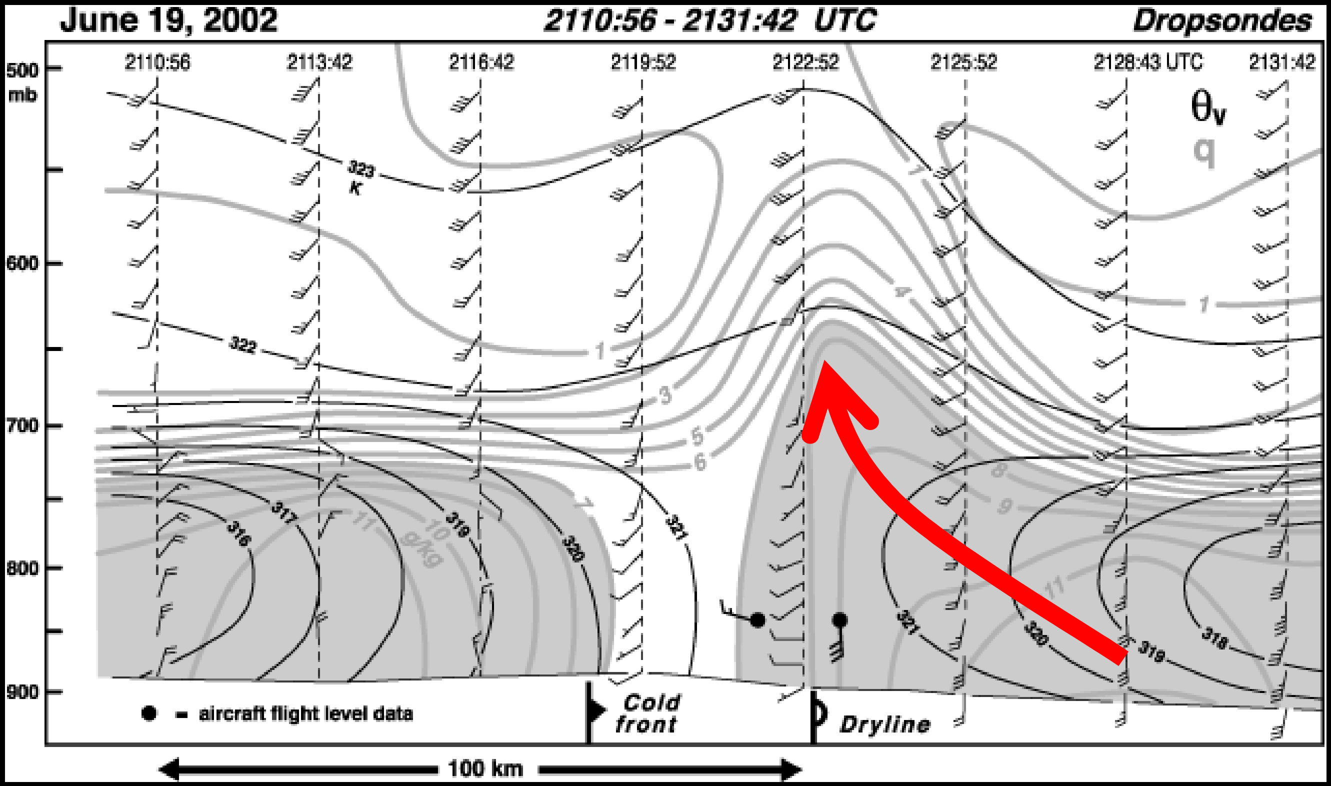
Mobile sounding launched 2003 UTC



Inversion

~9 g/kg

Dropsonde-based x-section

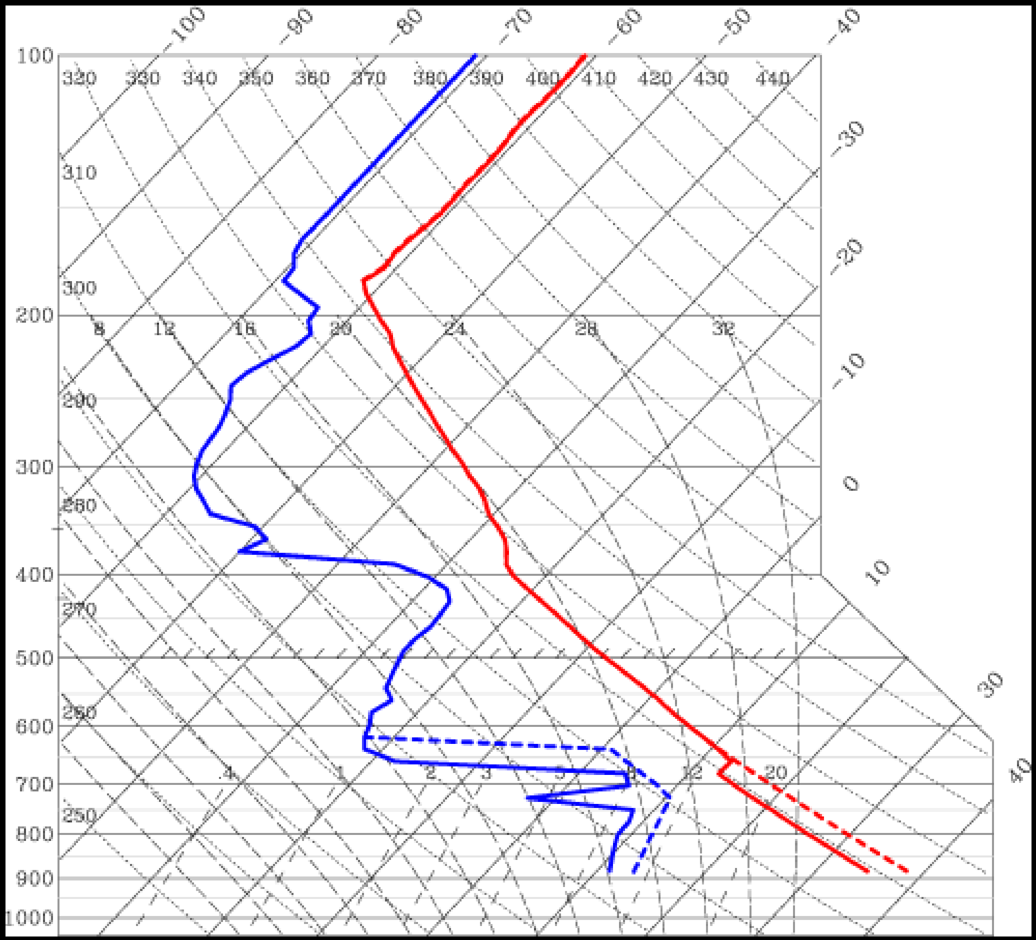


Inversion vanishes near dryline

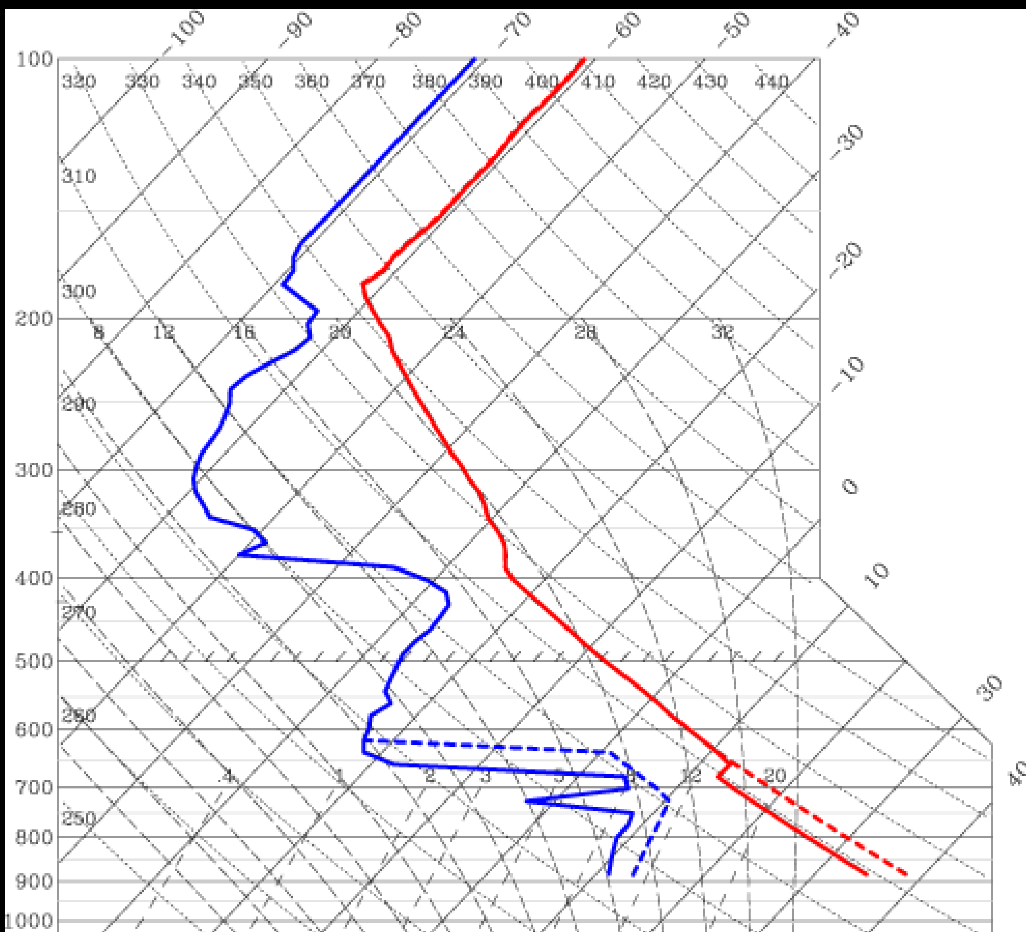
Convection probably taps higher moisture to east

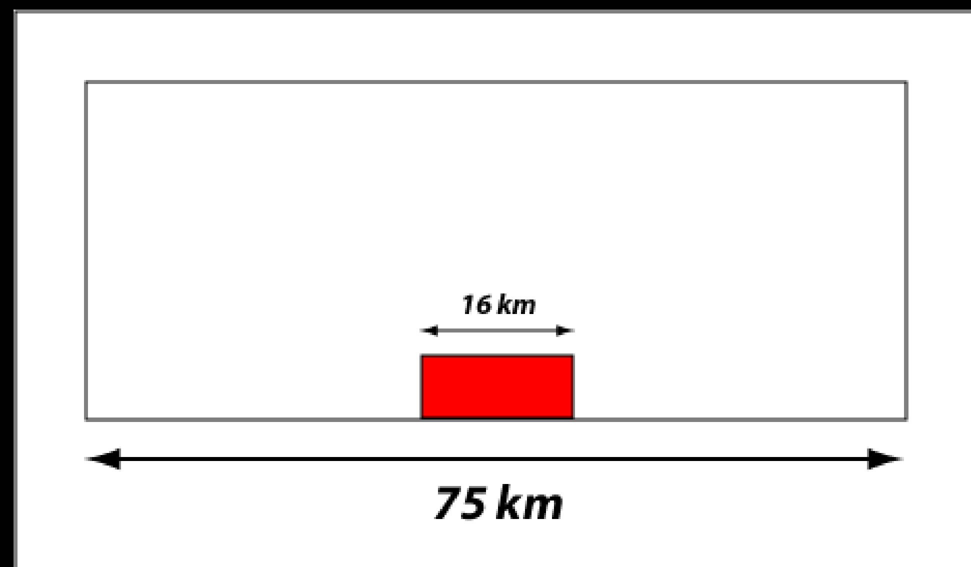
Wakimoto et al. (2004)

Sounding modification for "augmented environment"

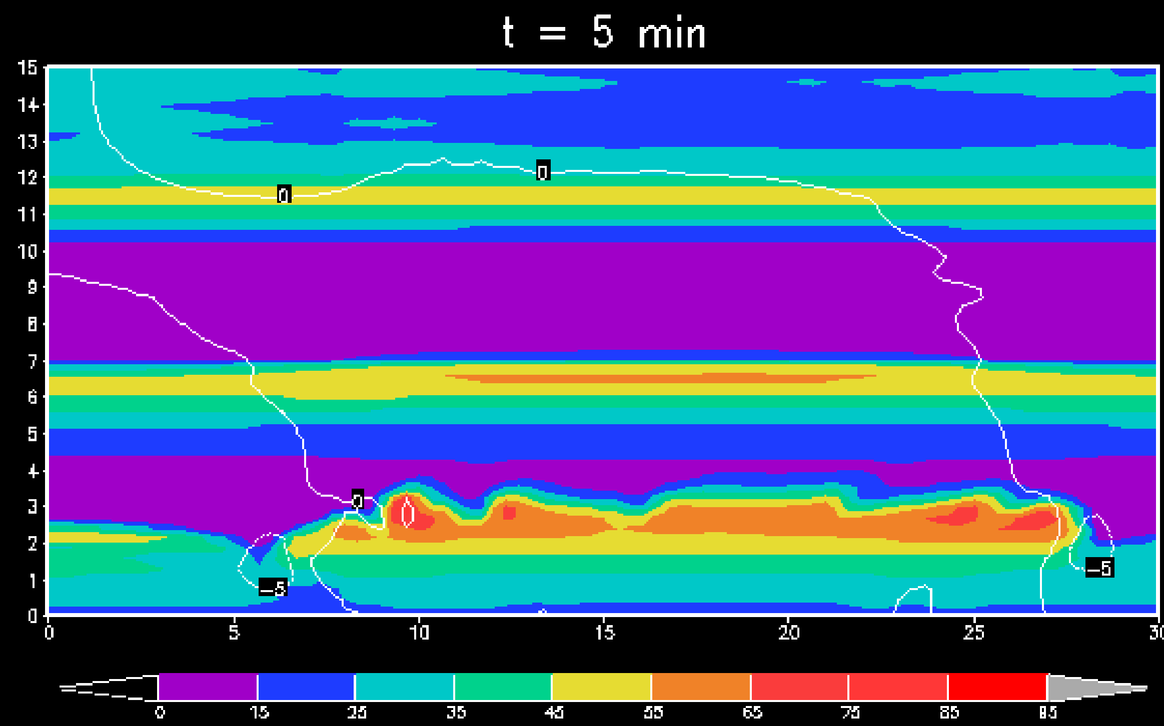


“Thermal” mimics effect of sustained dryline lifting

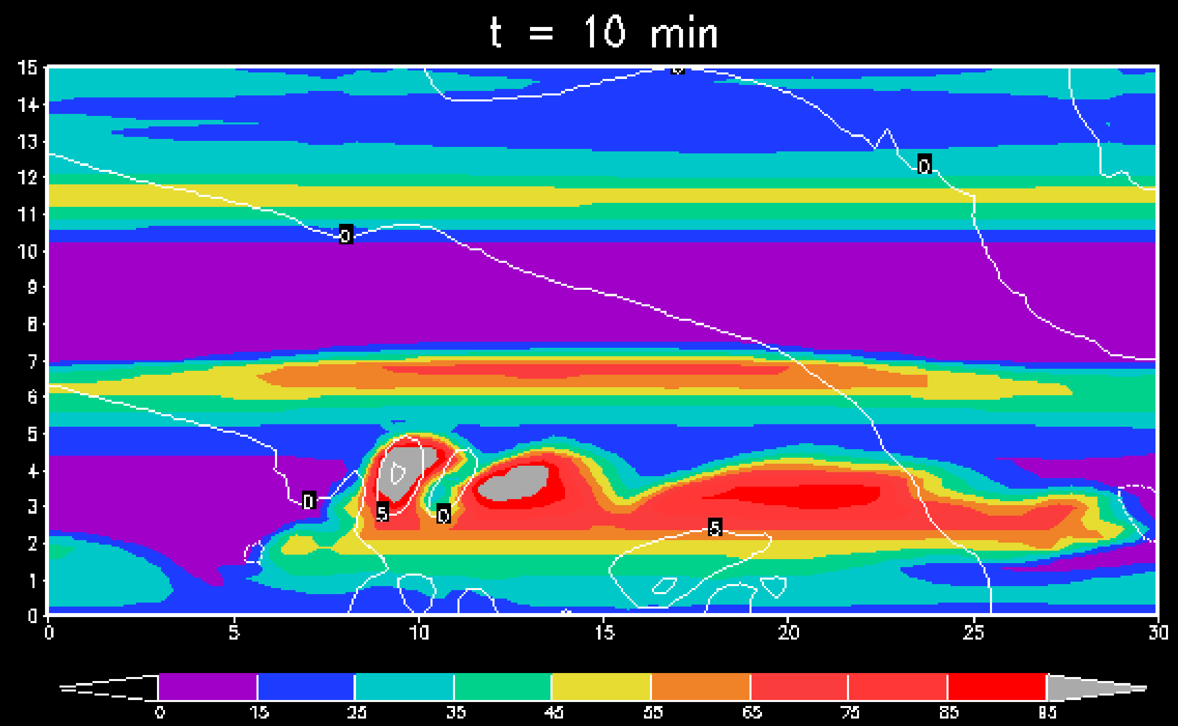




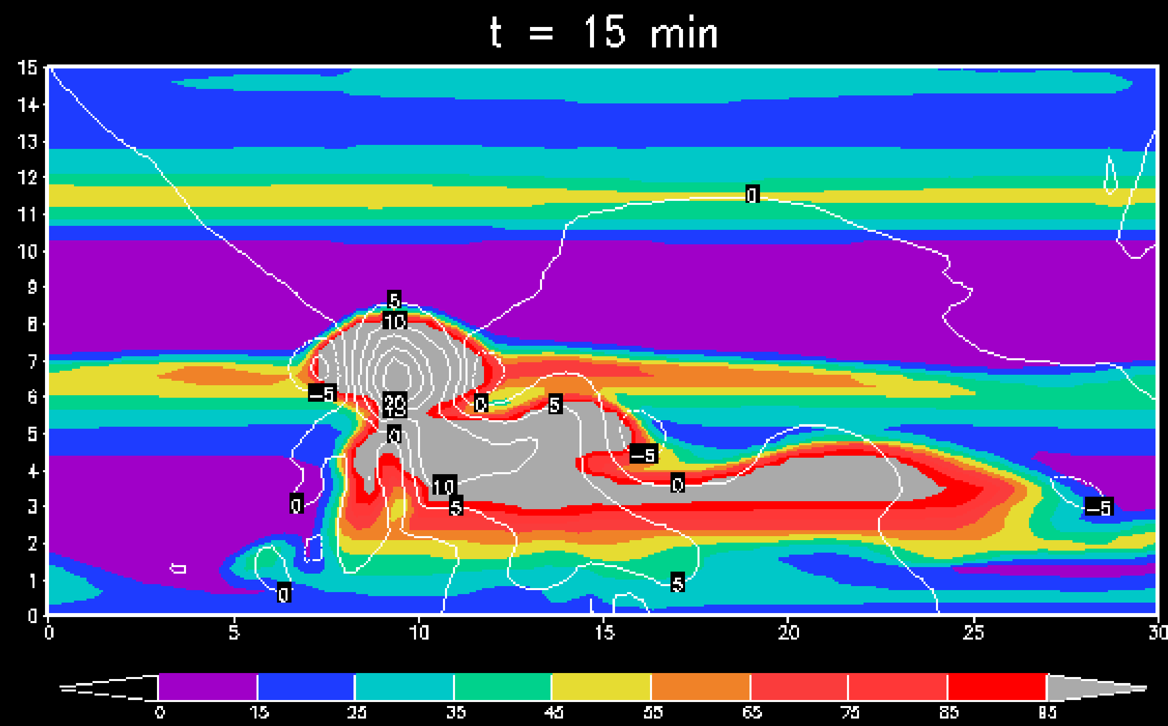
Relative humidity t = 5 min



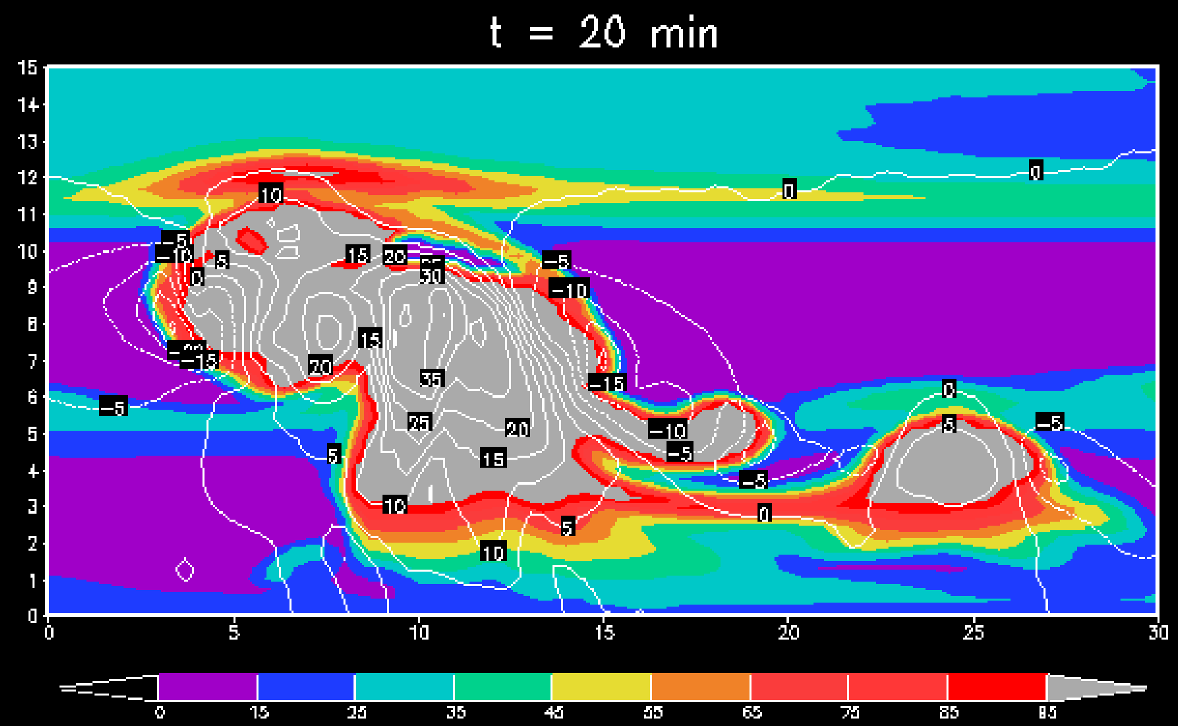
Relative humidity t = 10 min



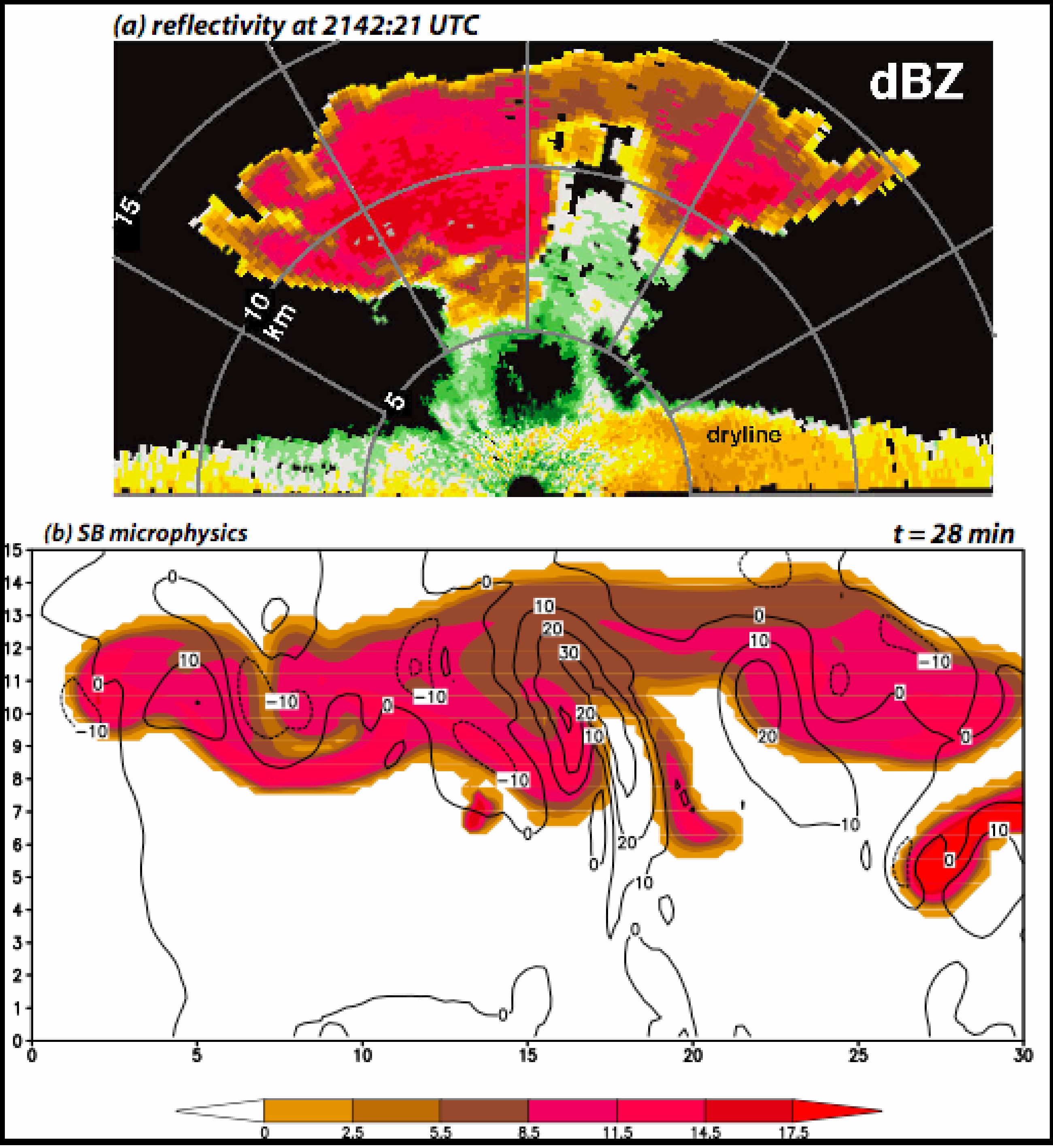
Relative humidity t = 15 min



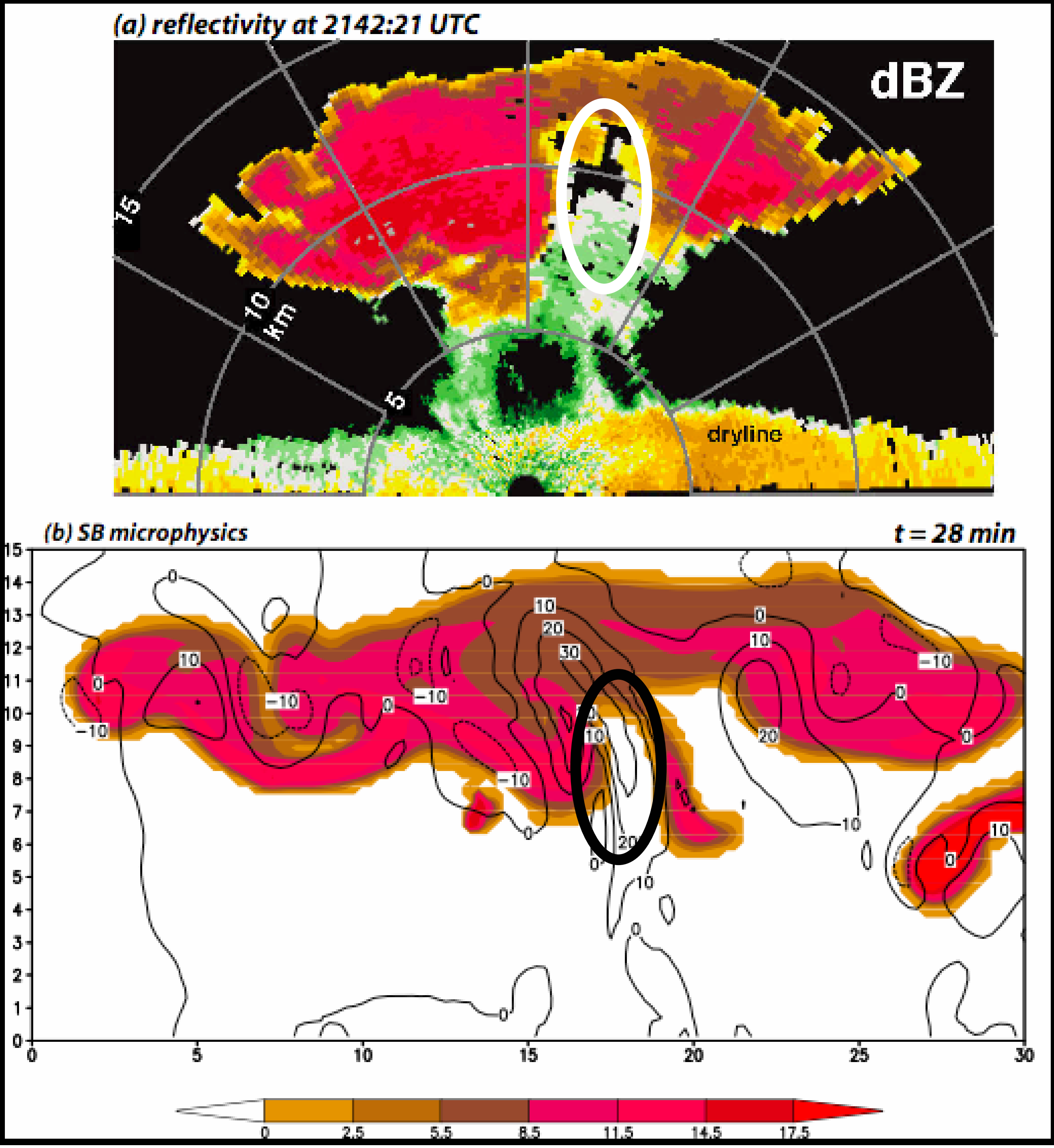
Relative humidity t = 20 min



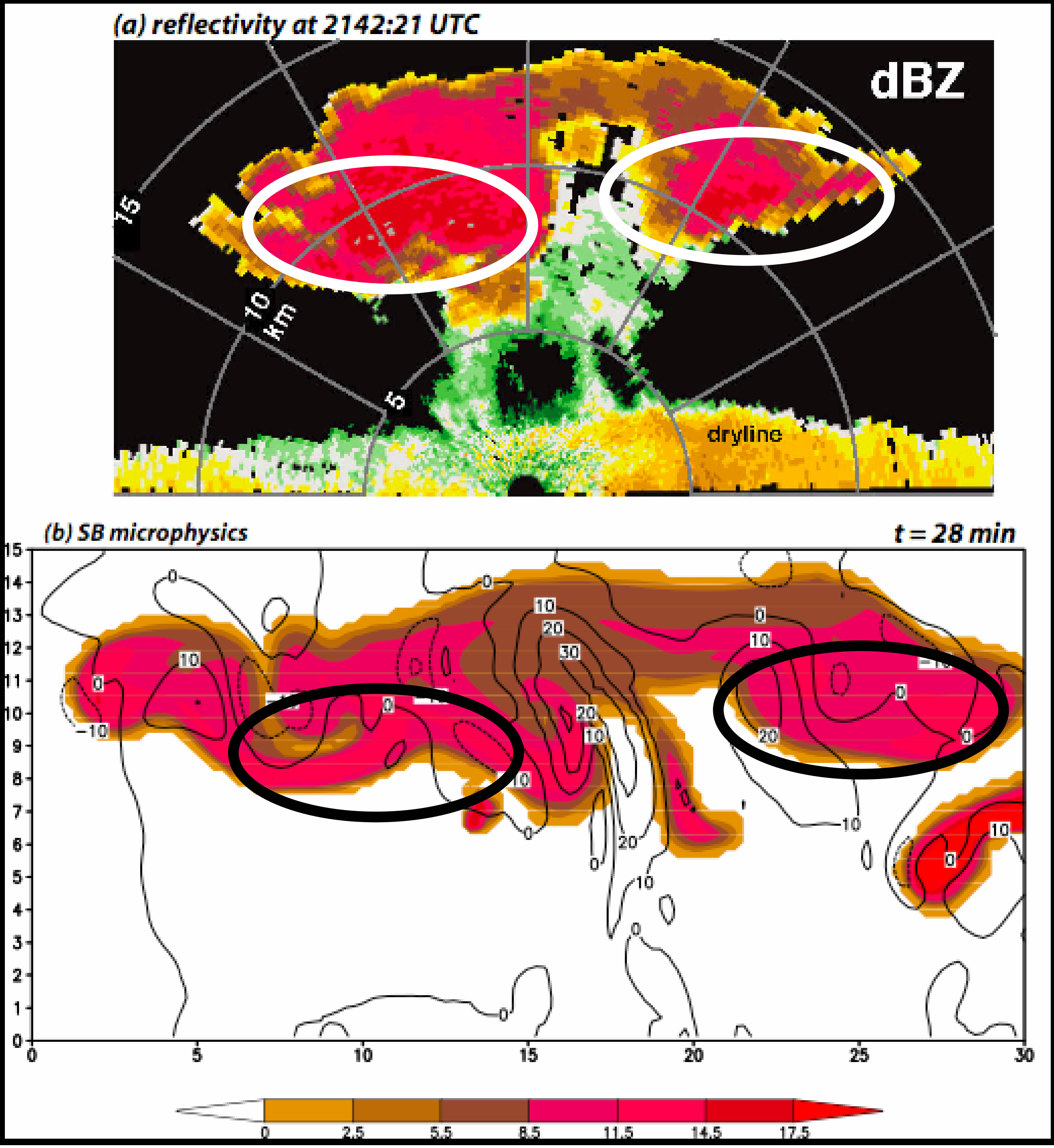
Observed and SB simulated reflectivity



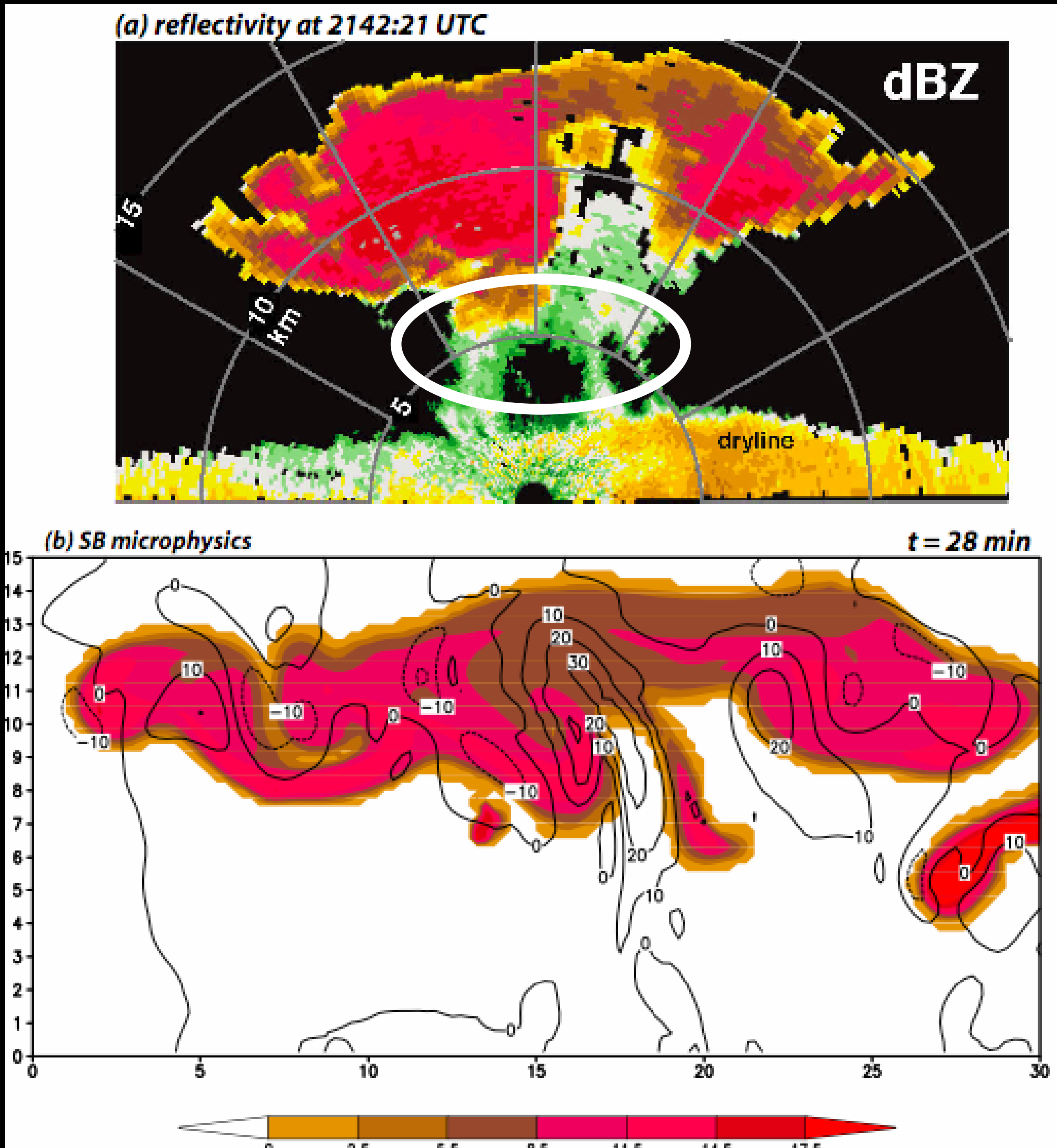
Observed and SB simulated reflectivity



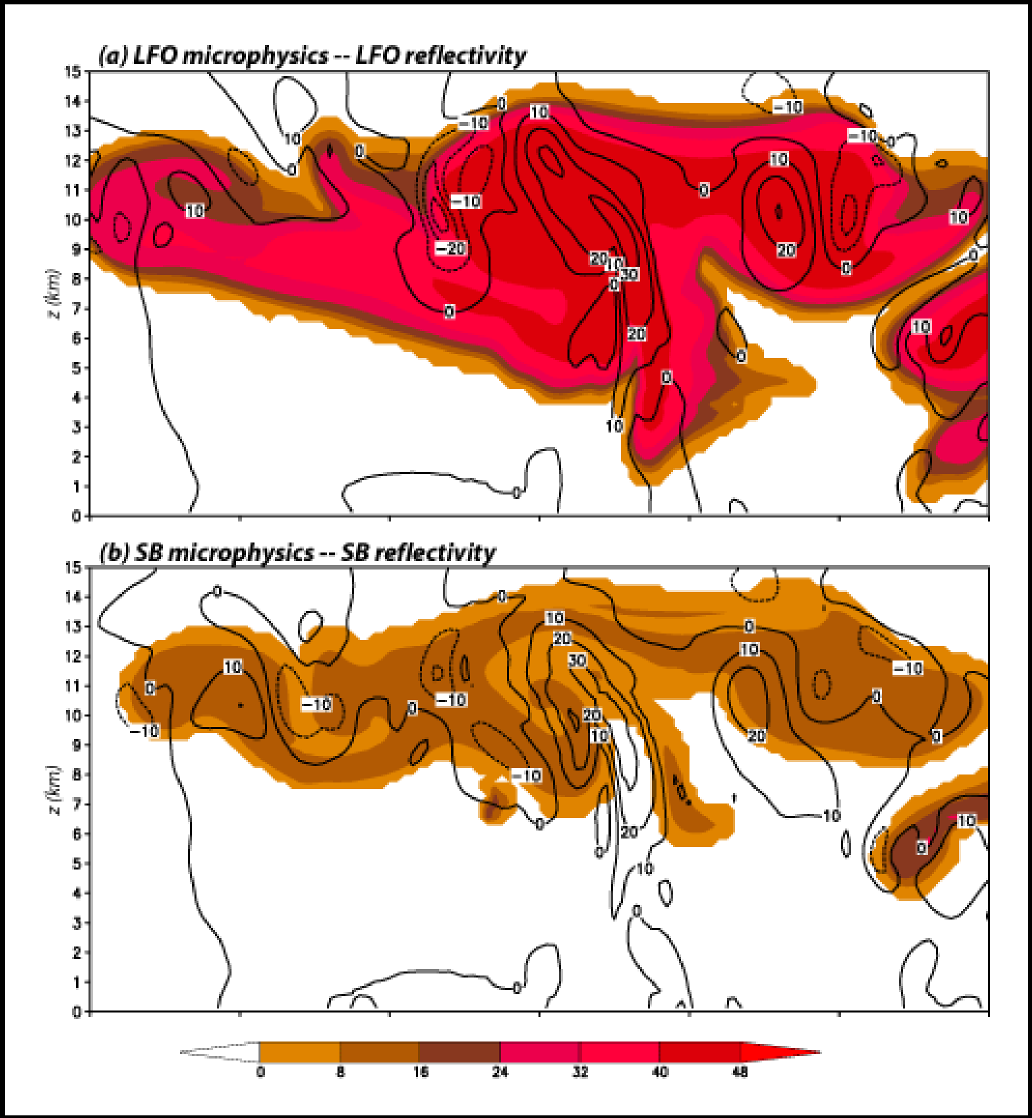
Observed and SB simulated reflectivity



Observed and SB simulated reflectivity



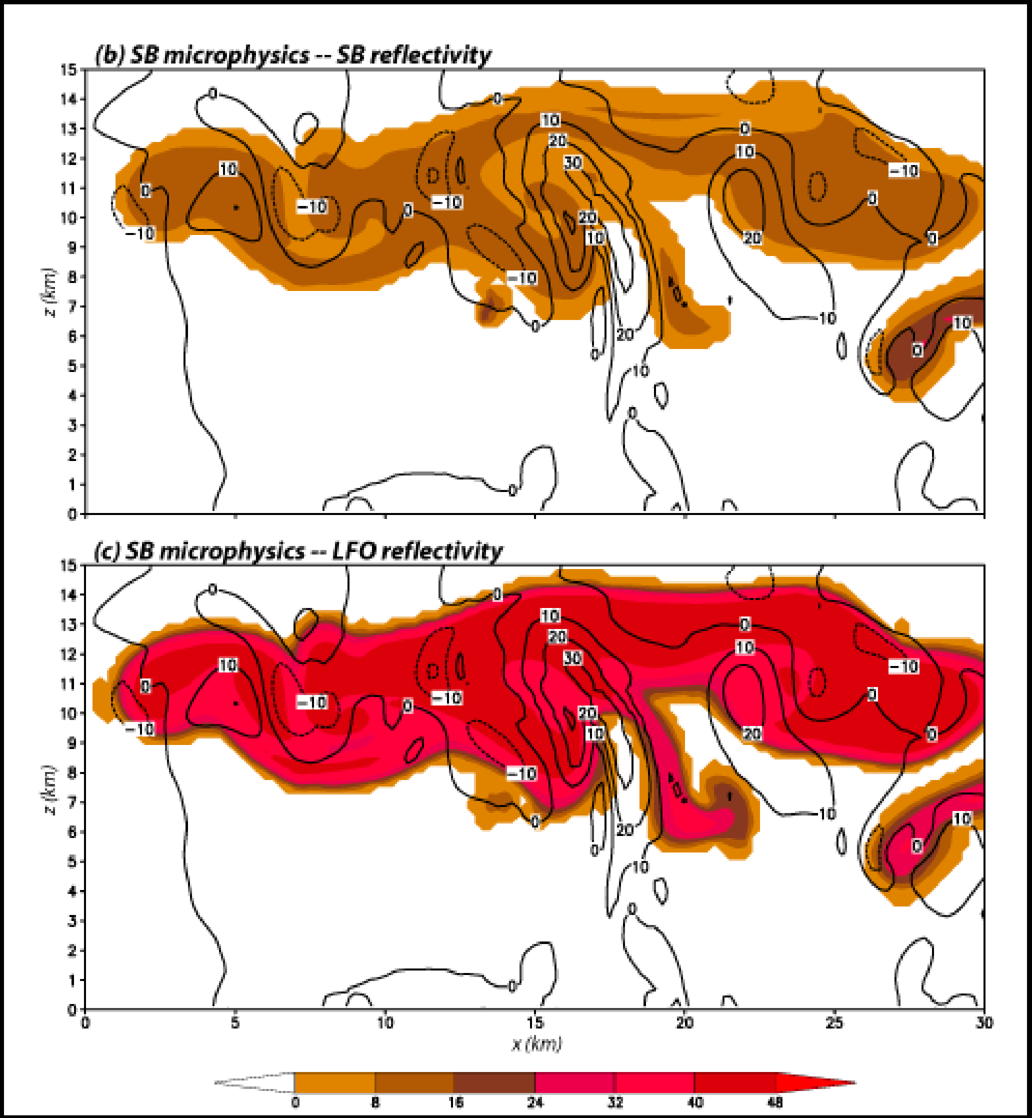
LFO vs. SB microphysics



Effect of particle size assumption

SB

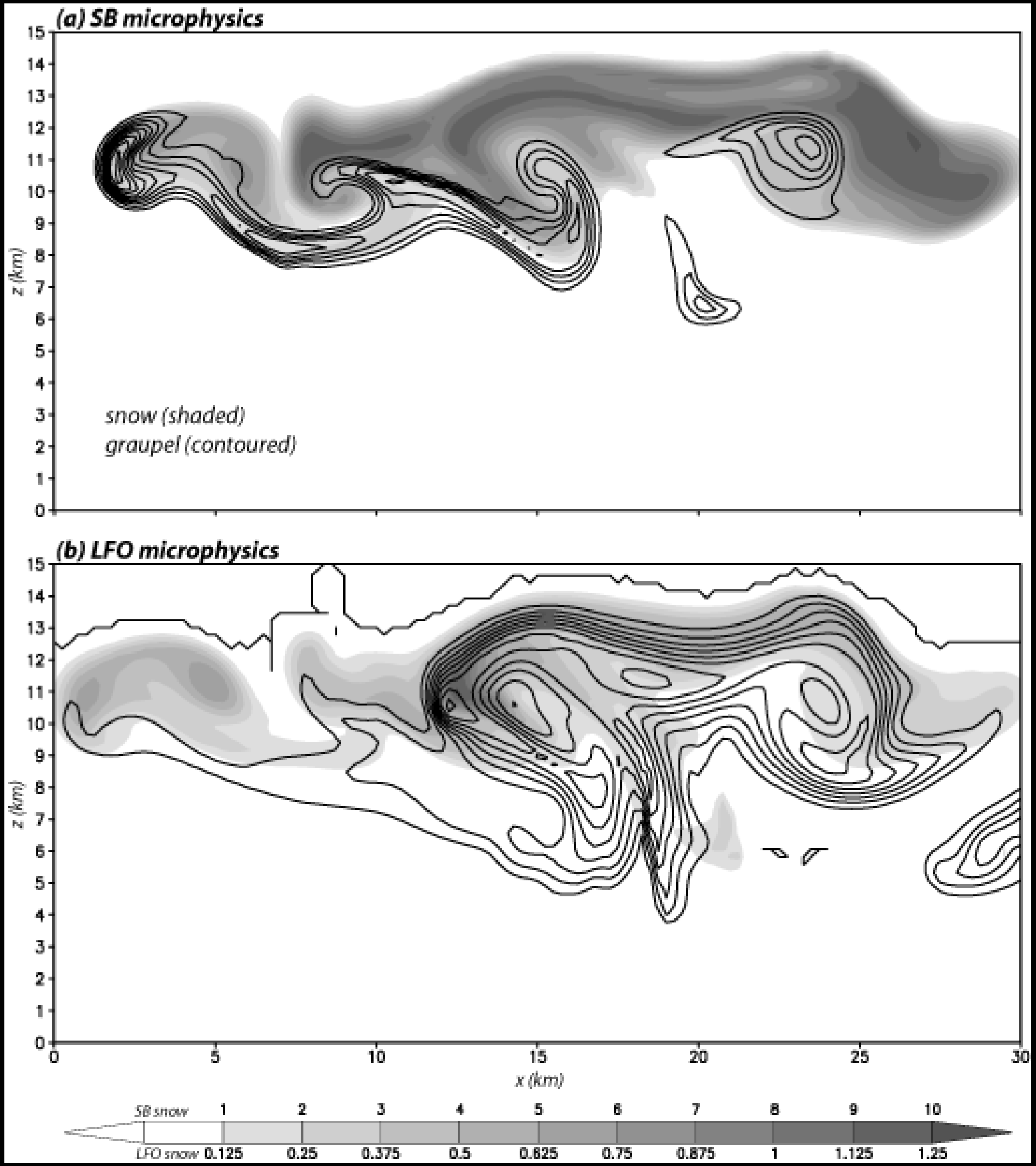
SB with LFO particle size



Snow and graupel

SB

LFO

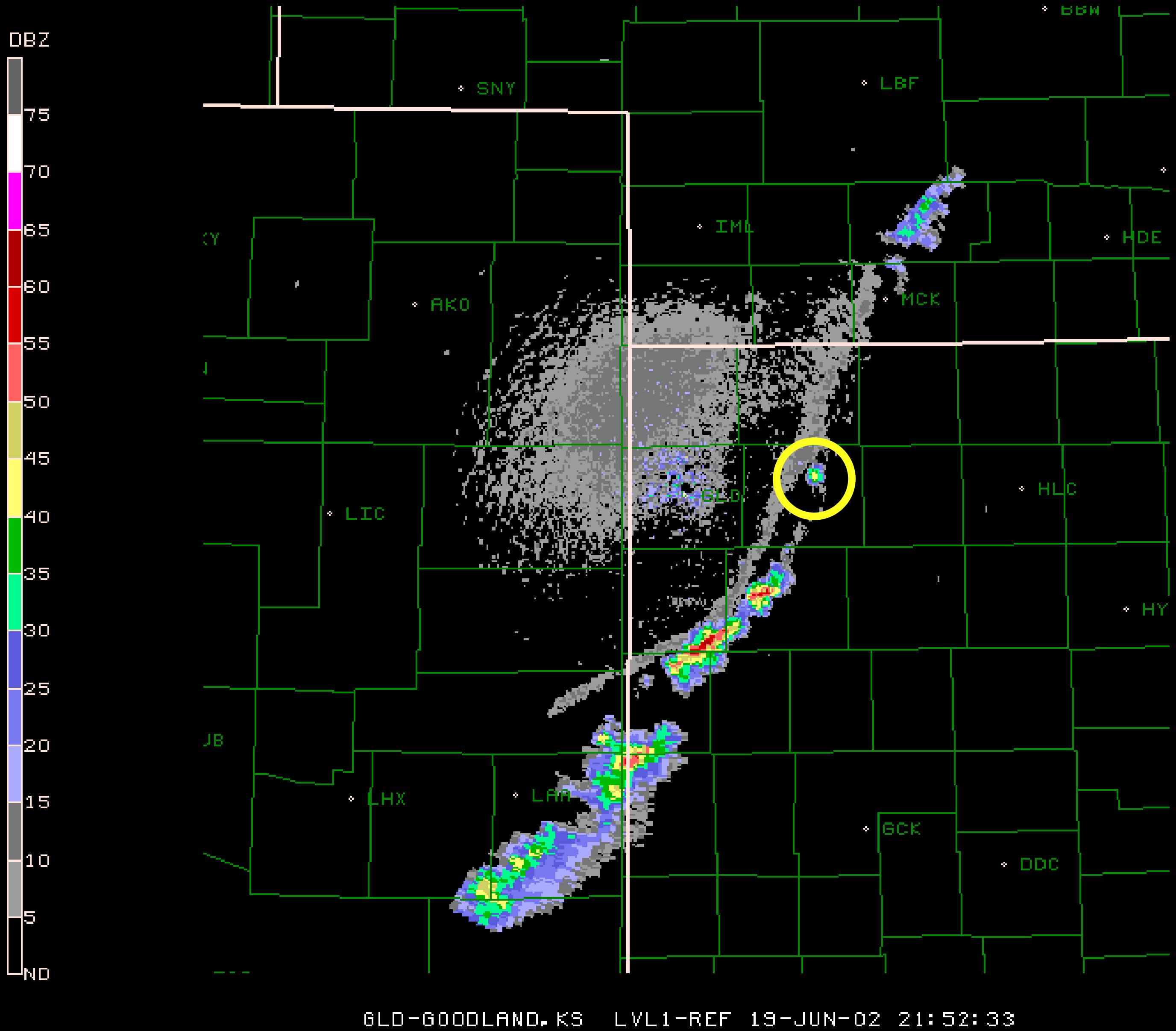


SB vs. LFO comparison

- SB microphysics produces a large quantity of small particles
  - Small reflectivities despite large masses
- Tweaked LFO “worked” by reducing snow, graupel mass contents
  - Single moment scheme large mass content implies large average particle size

Issues

- Neither SB nor LFO storms precipitate with this initialization
  - WSM6 case *does*
  - No scheme yields surface hail like actual storm
- Actual storm stays near dryline, continually forced
  - May not be a microphysics problem…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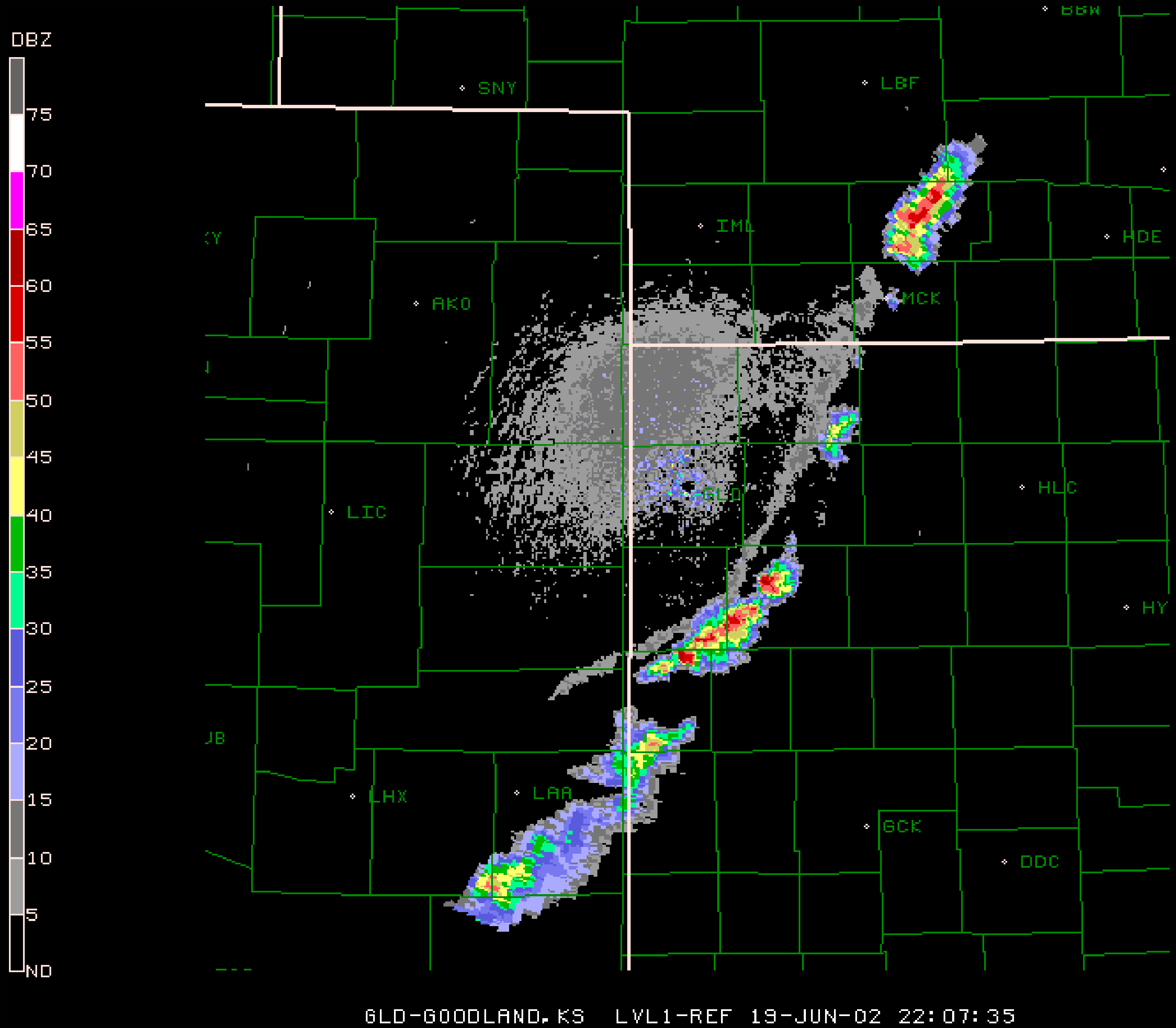
21:52 UTC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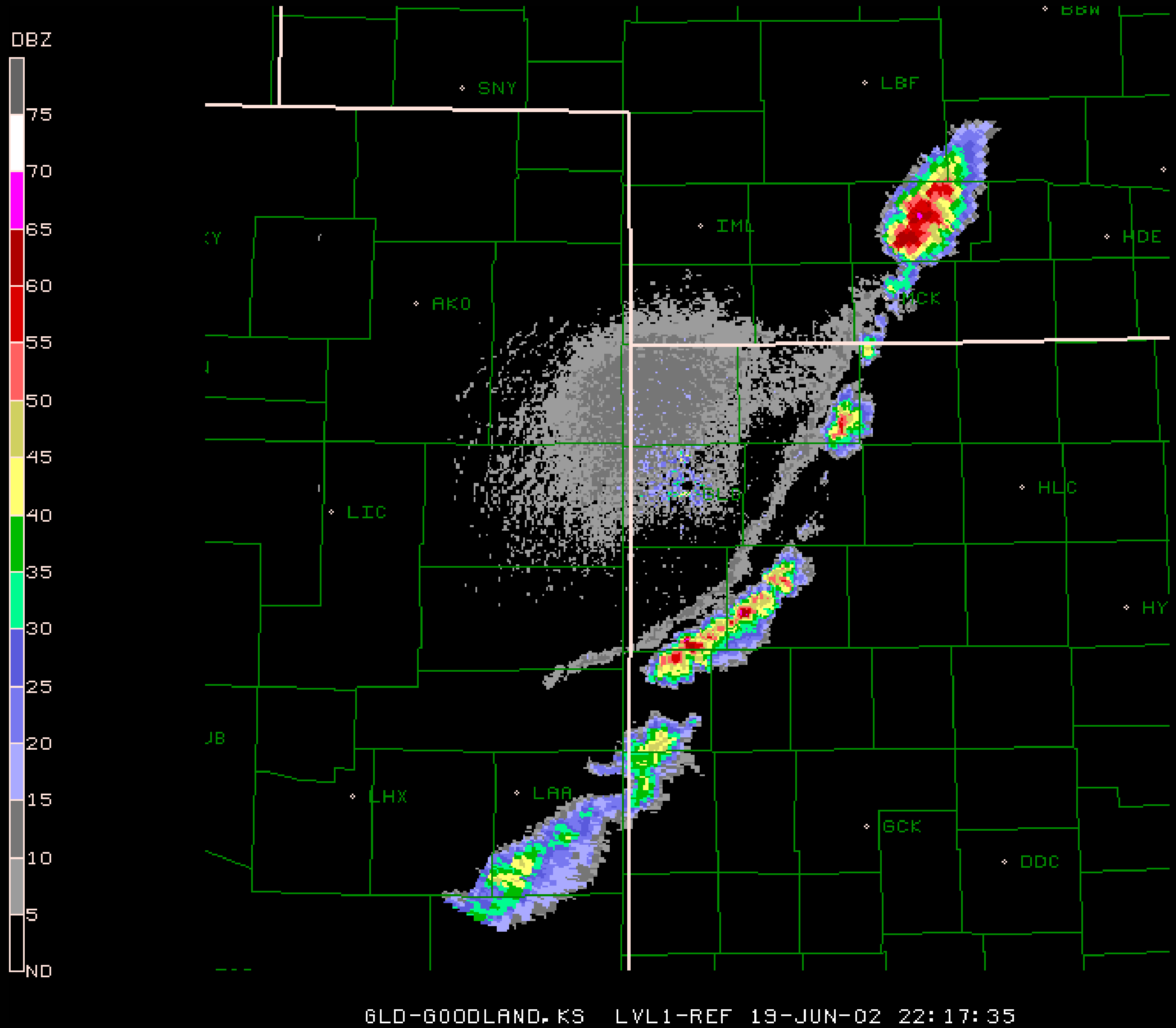
22:07 UTC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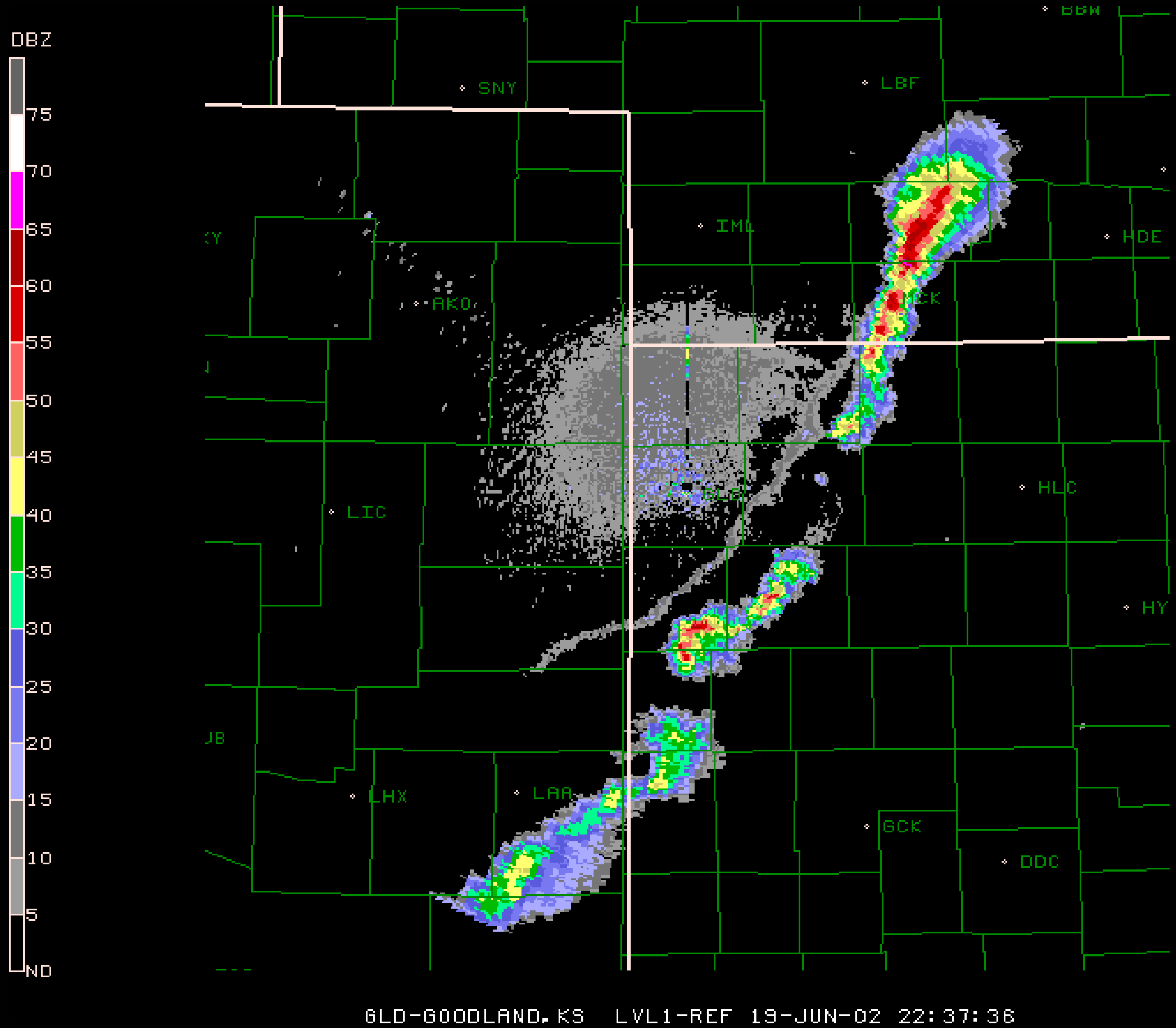
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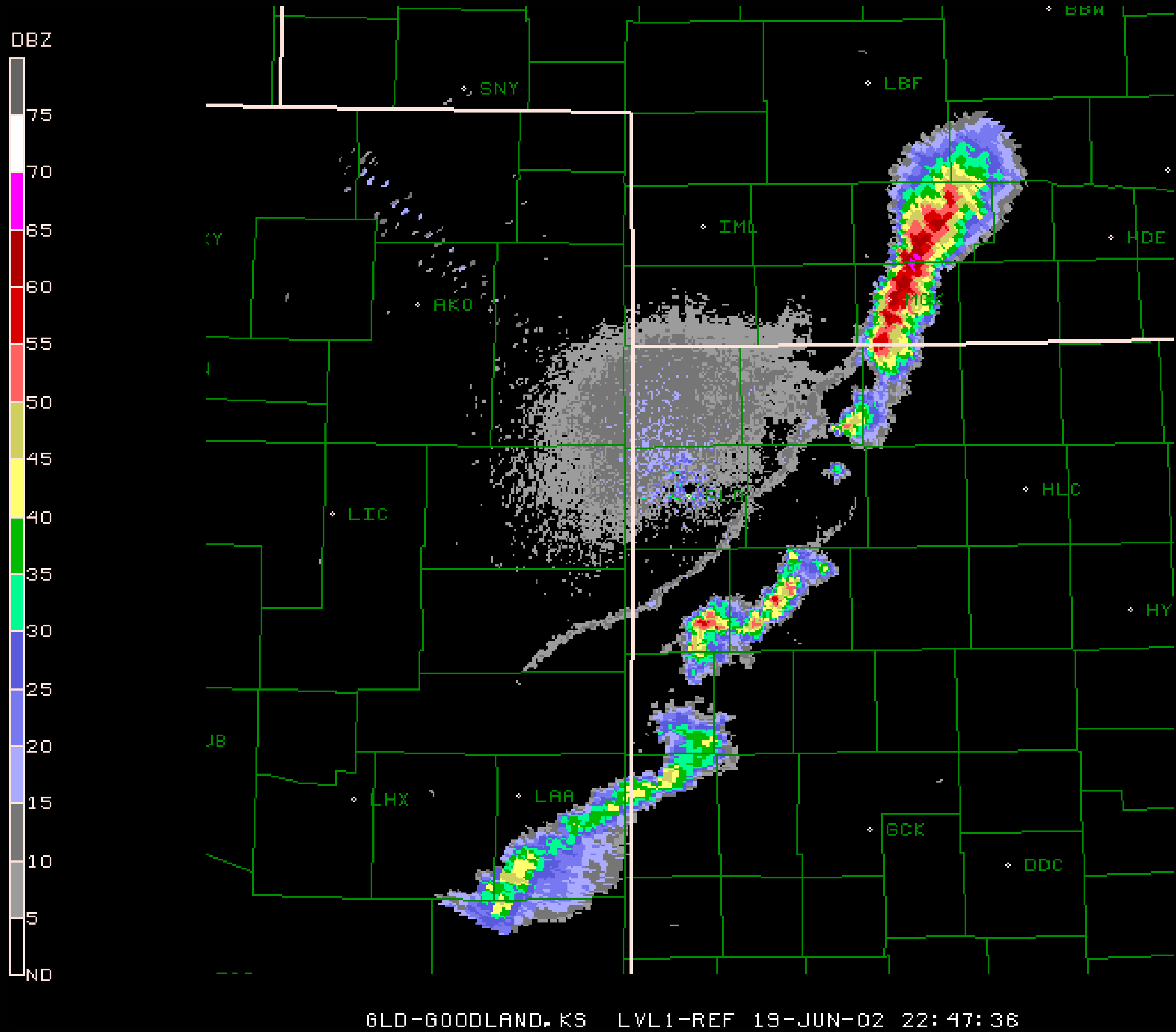
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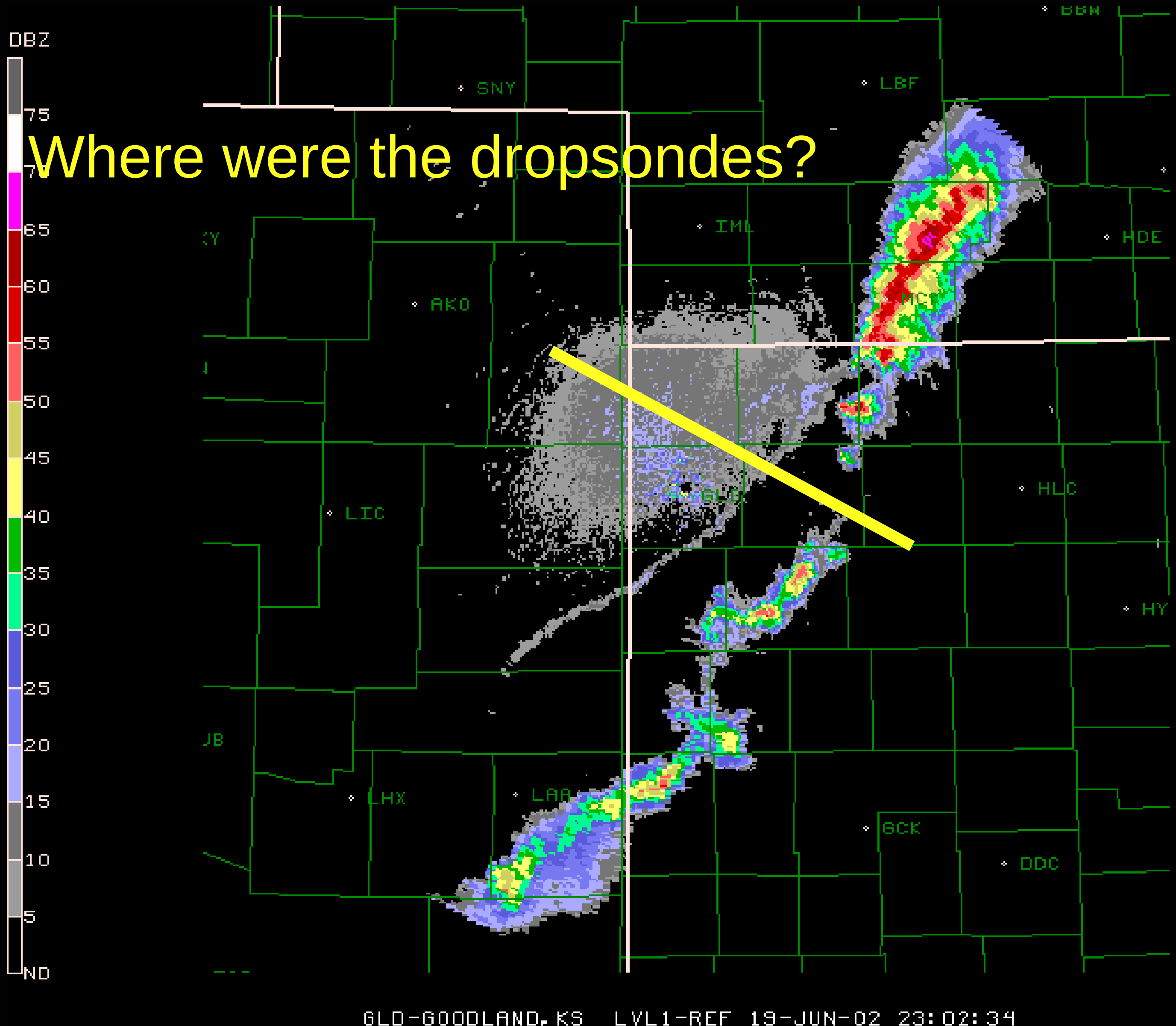
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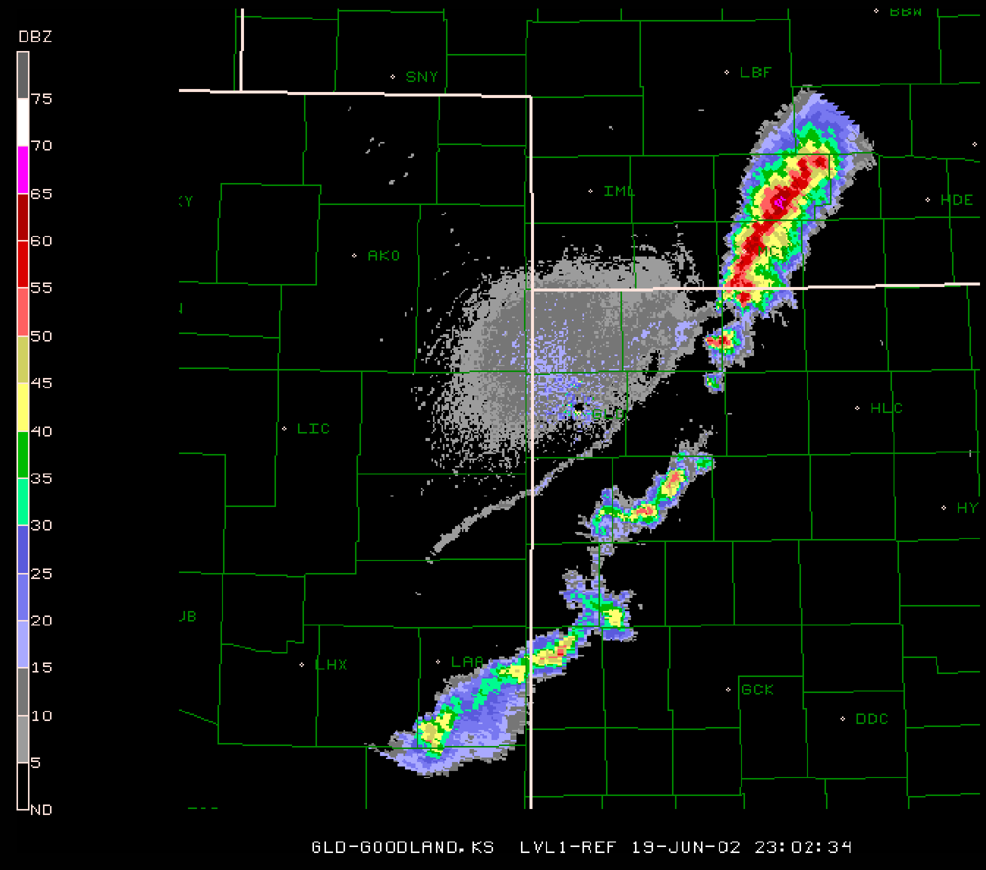
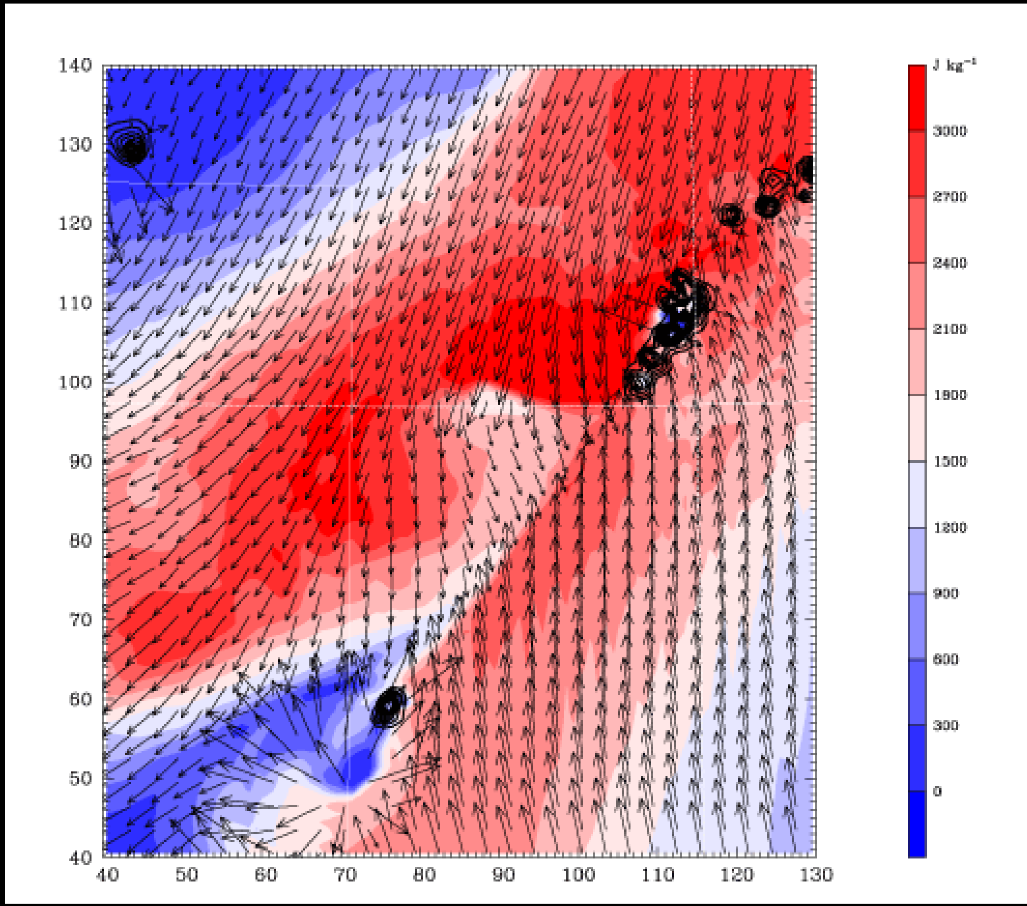
23:02 UTC

“Do dropsondes suppress convection?”



WRF real-data run
4 km
CAPE, 10 m winds, precip



Conclusions

- “Mantle echo” cases provide a good test for microphysical schemes
  - Early dynamical evolution insensitive to microphysics
- Sophisticated two-moment scheme yields realistic results
- Convective initiation mechanism more than usually important