Three-Dimensional Lightning Mapping Observations of Supercell Storms

Don MacGorman, Kristin Kuhlman, Paul Krehbiel, Mike Biggerstaff, and Dan Betten

NOAA/National Severe Storms Laboratory

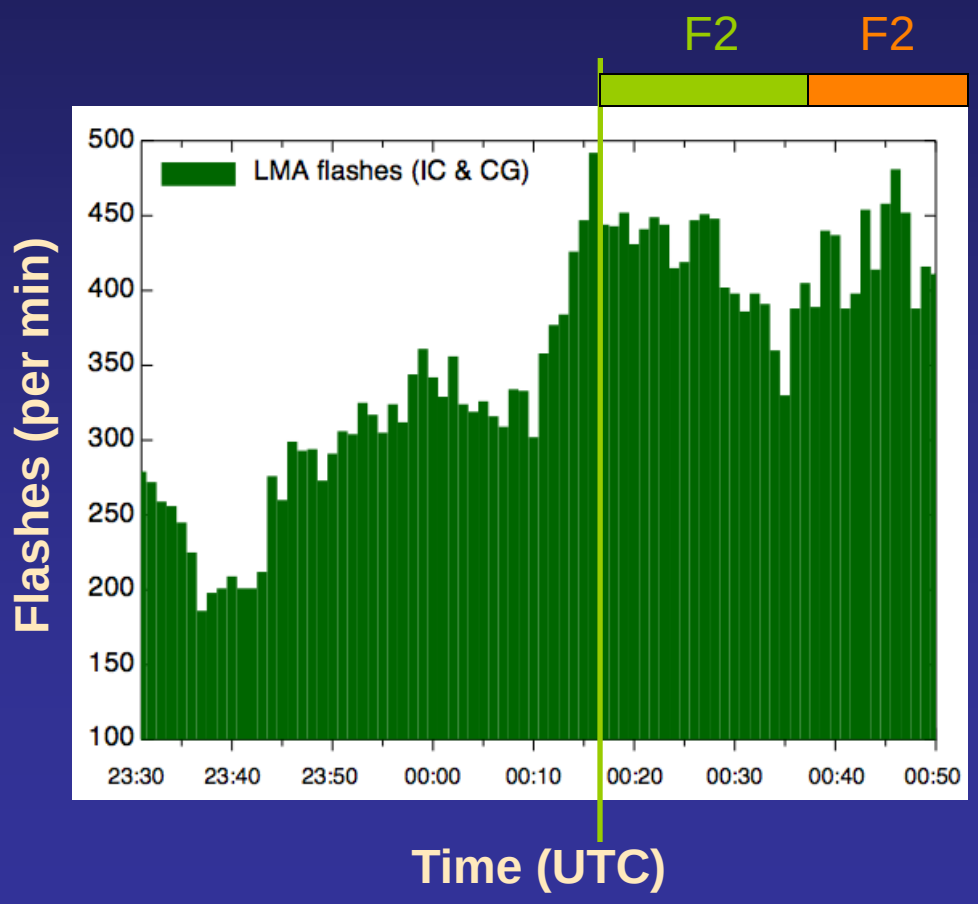
CIMMS/Univ. of Oklahoma & NOAA

New Mexico Institute of Mining and Technology

School of Meteorology, University of Oklahoma

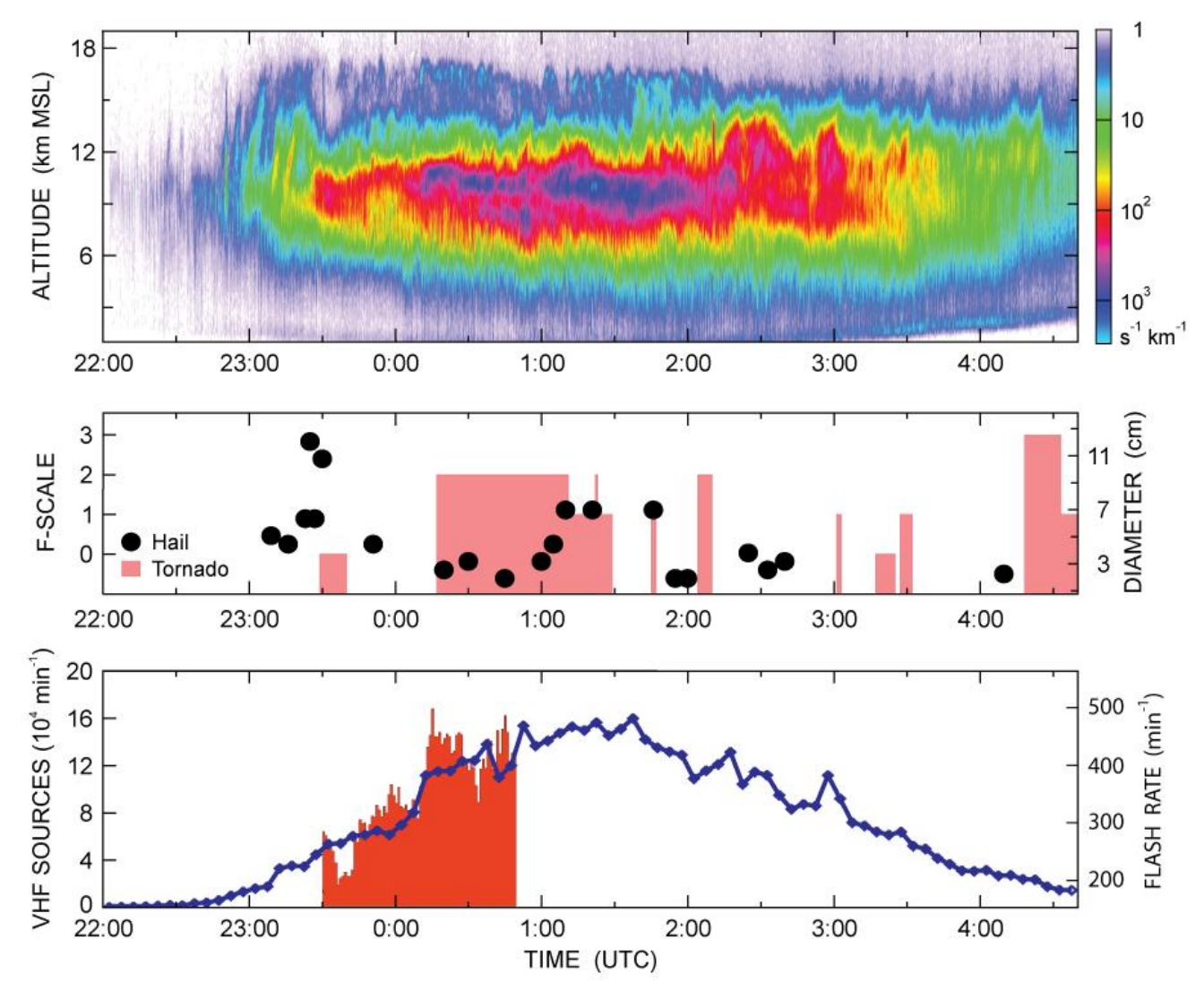
29-30 May 2004
Flash Rates

- Sudden jump in flash rates just before first F-2 tornado
- Estimated peak flash rate of 8/second



29-30 May 2004

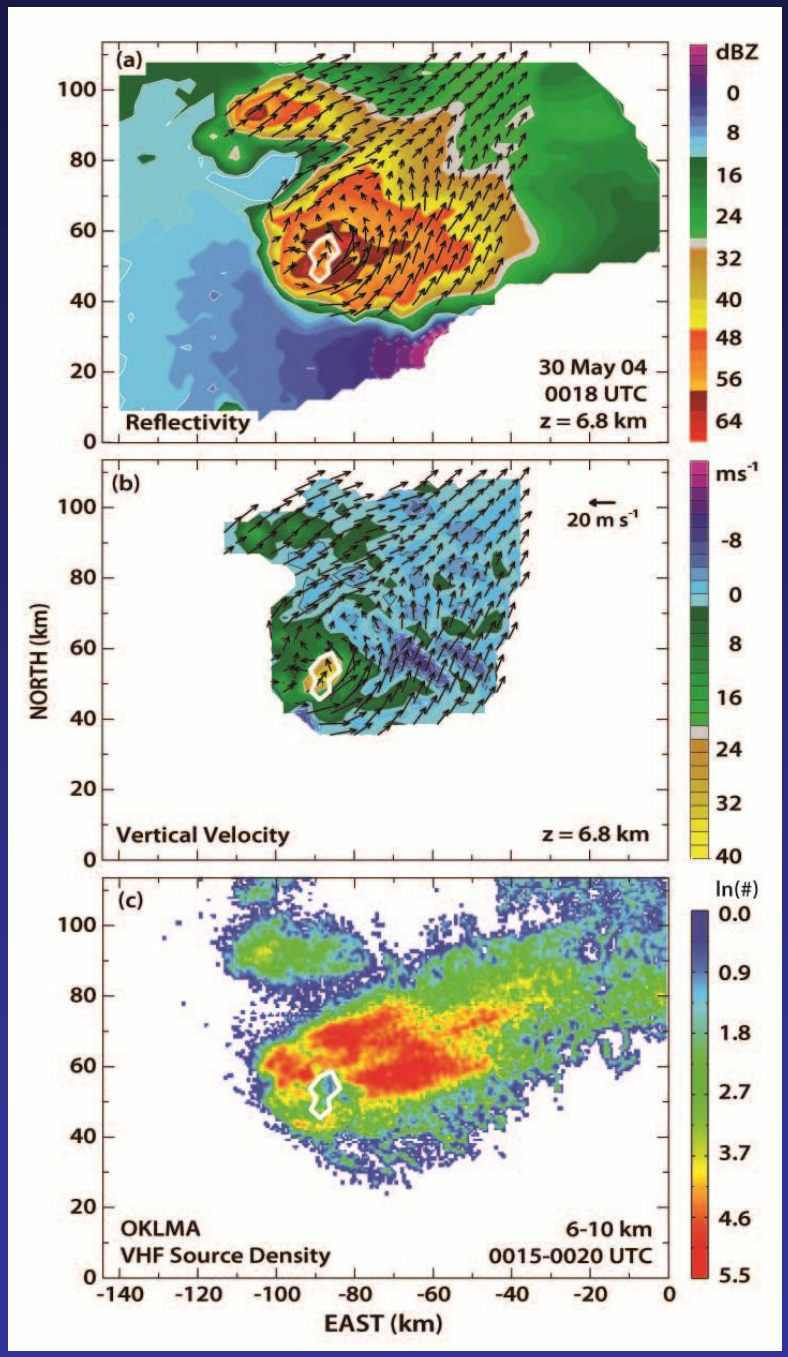
Evolution of VHF Source Density,* Hail Diameter, and Tornadoes



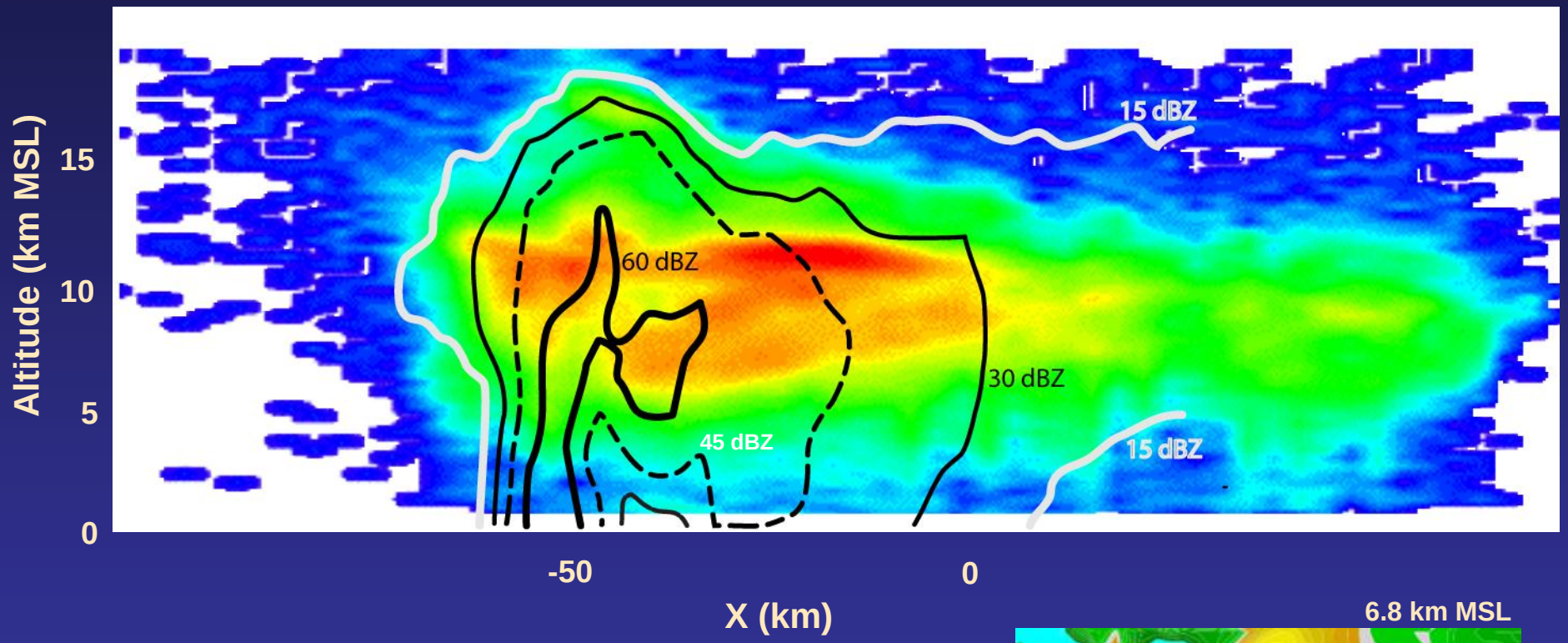
*number of mapped VHF sources in whole storm per unit altitude

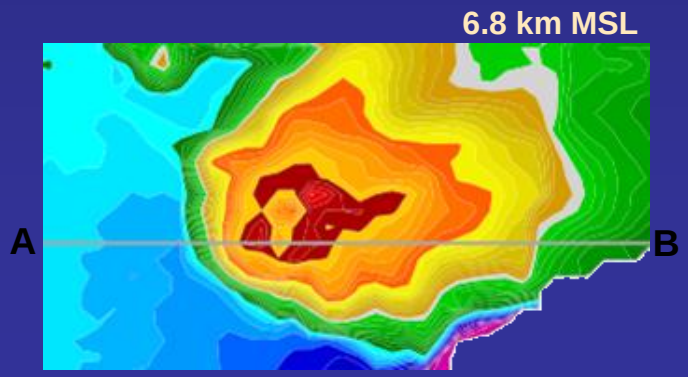
Lightning Hole or Ring

Relative minimum in lightning density corresponds to bounded weak echo region and core of strong updraft



Reflectivity and LMA Event Density





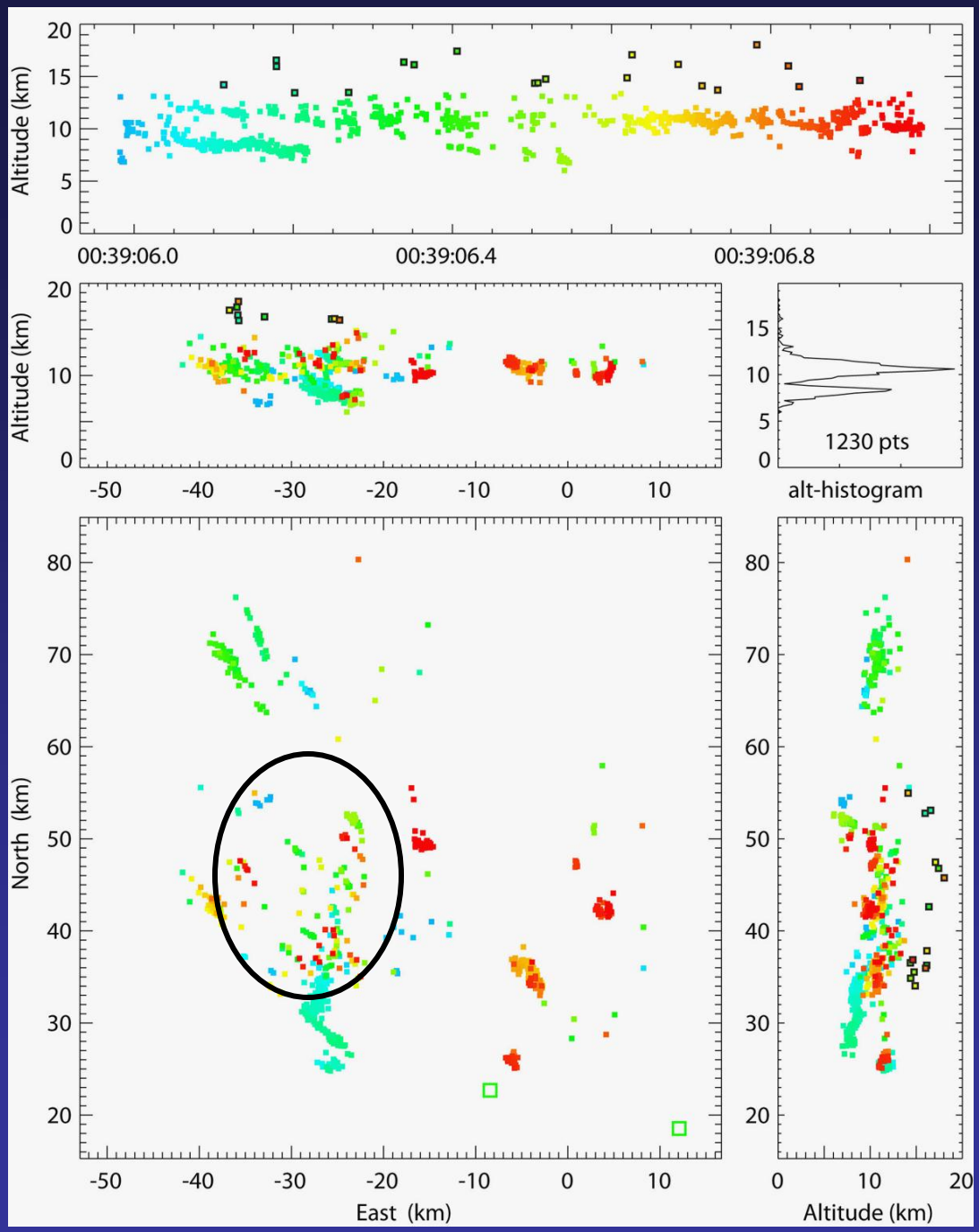
Radar: 0016:45 – 0018:32 UTC

LMA Data: 0015 – 0020 UTC

30 May 2004

00:39:06 UTC

1 second



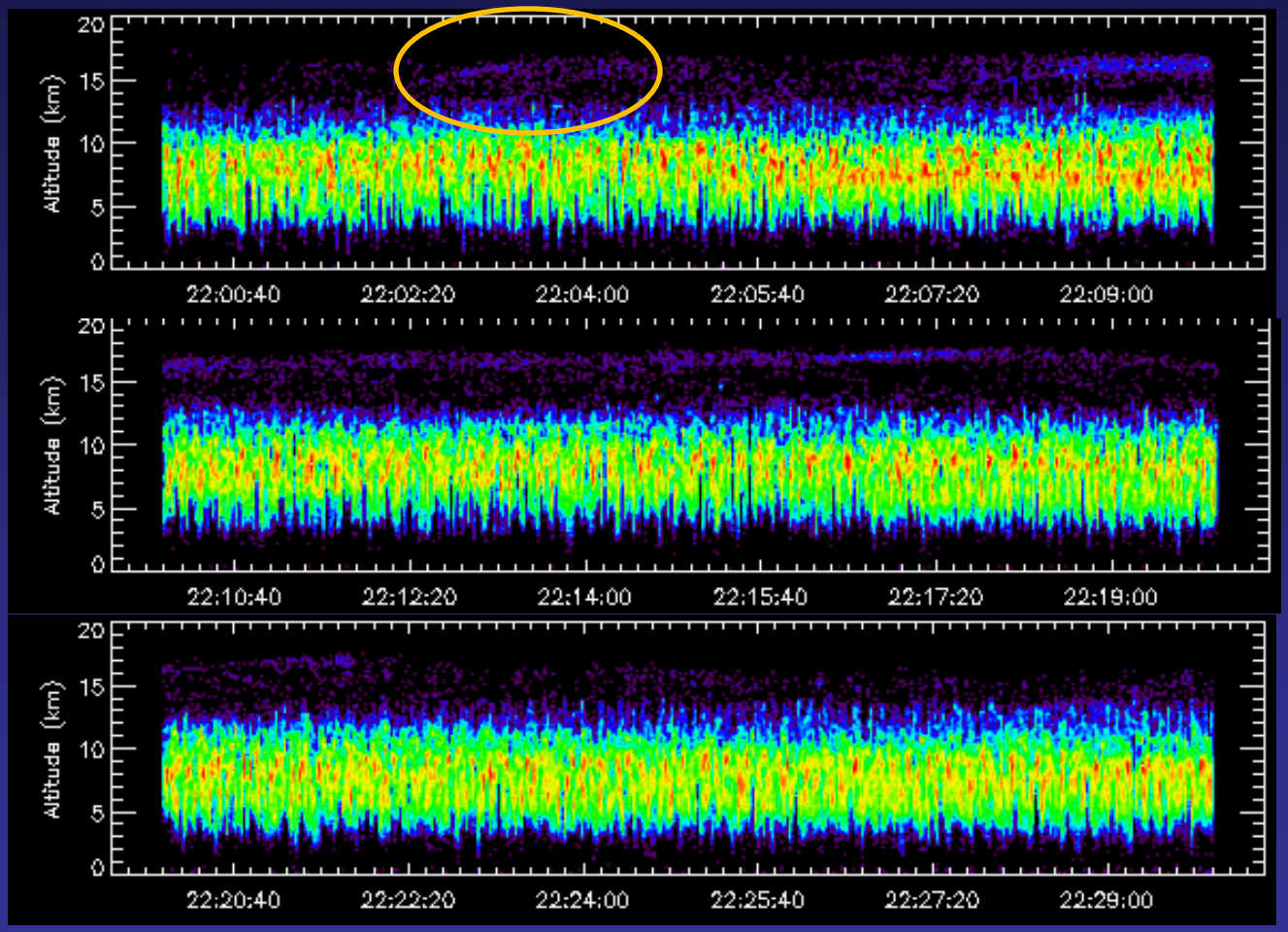
Mesocyclone Collapse

Notice a decrease in the height of the storm

Part of the collapse of the supercell or the beginning of a replacement cycle

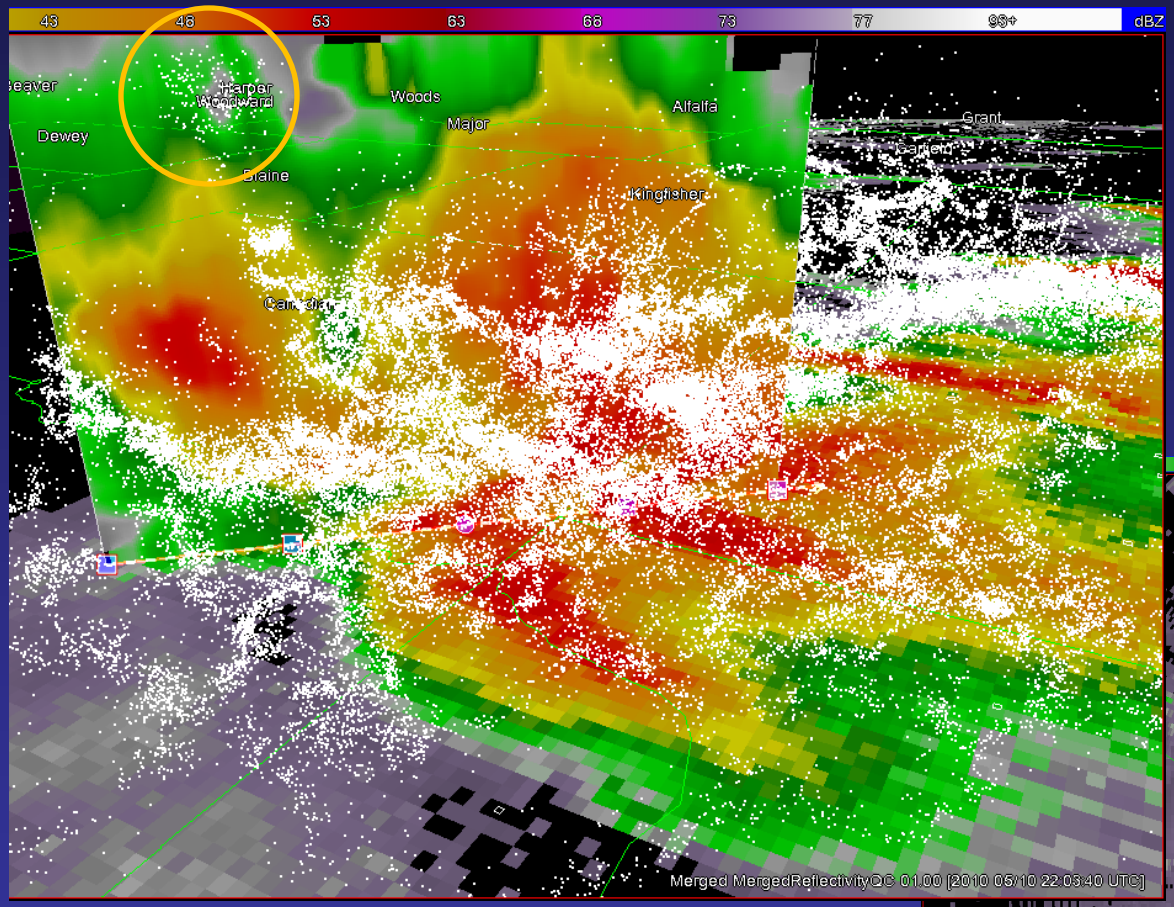
Tornadogenesis or the strengthening of a pre-existing tornado are possible

10 May 2010: Moore Storm

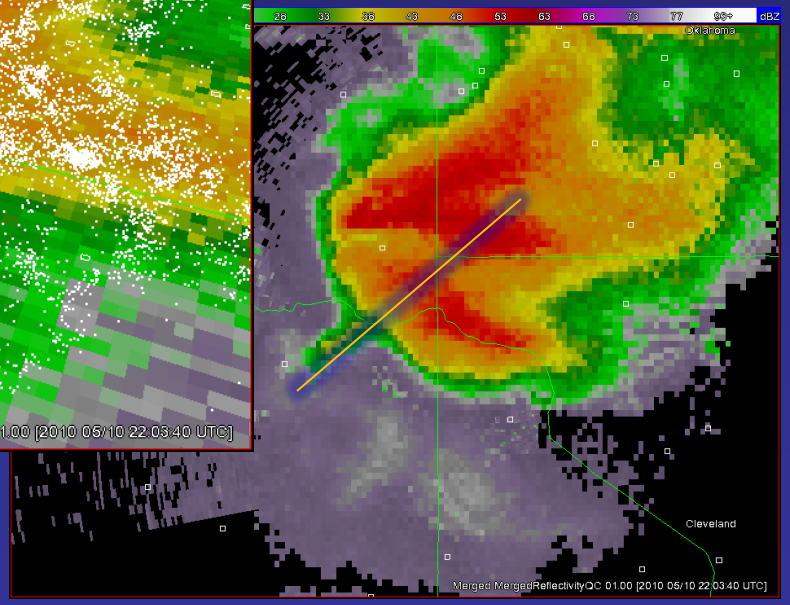


Altitude of VHF sources (by log event density) versus time plots for 22:00-22:10 UTC, 22:10-22:20 UTC, 22:20-22:30 UTC

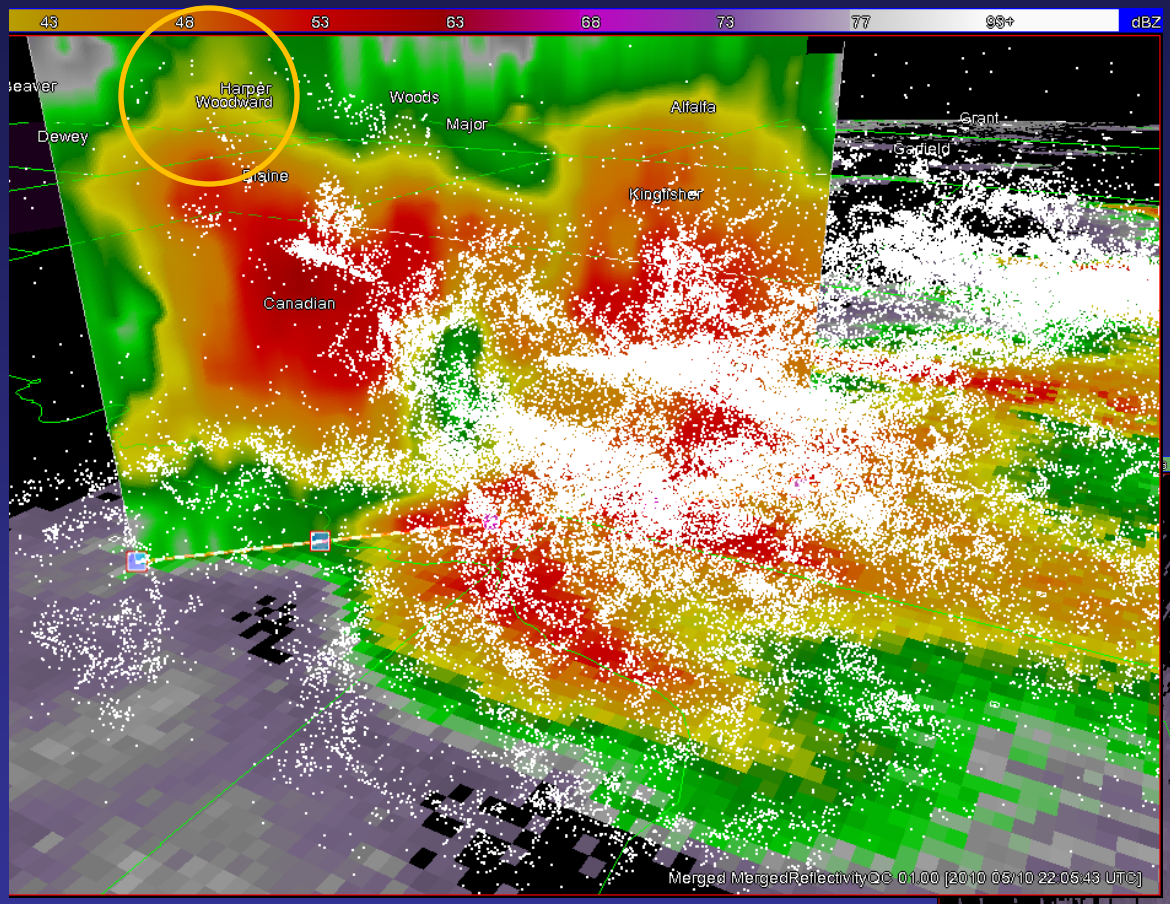
10 May 2010: Moore Storm

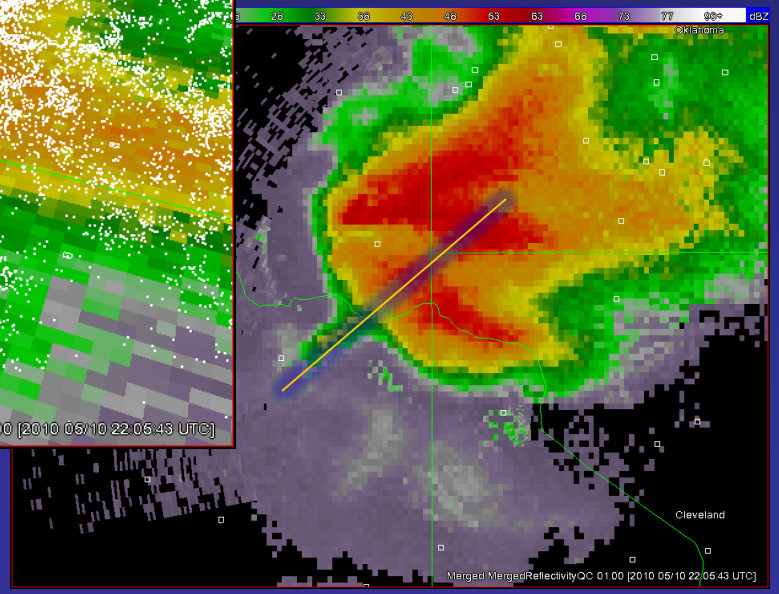


22:03 UTC



10 May 2010: Moore Storm





2205 UTC

27 July 2010

Supercell Data Set:

25 April 2006 0000—0050 UTC

2 F1 tornadoes in El Reno

7 May 2007 0200—0240 UTC

2 EF0 in Seminole Co. from a supercell ahead of a squall line

31 March 2008 0600—0655 UTC

EF0, EF1 in Edmond

24 May 2008 1900—2005 UTC

EF1, EF2 in Lacey with more tornadoes produced afterwards

10 May 2010 2130—2155 UTC

Unrated in Yukon (short lived storm)

10 May 2010 2155—2240 UTC

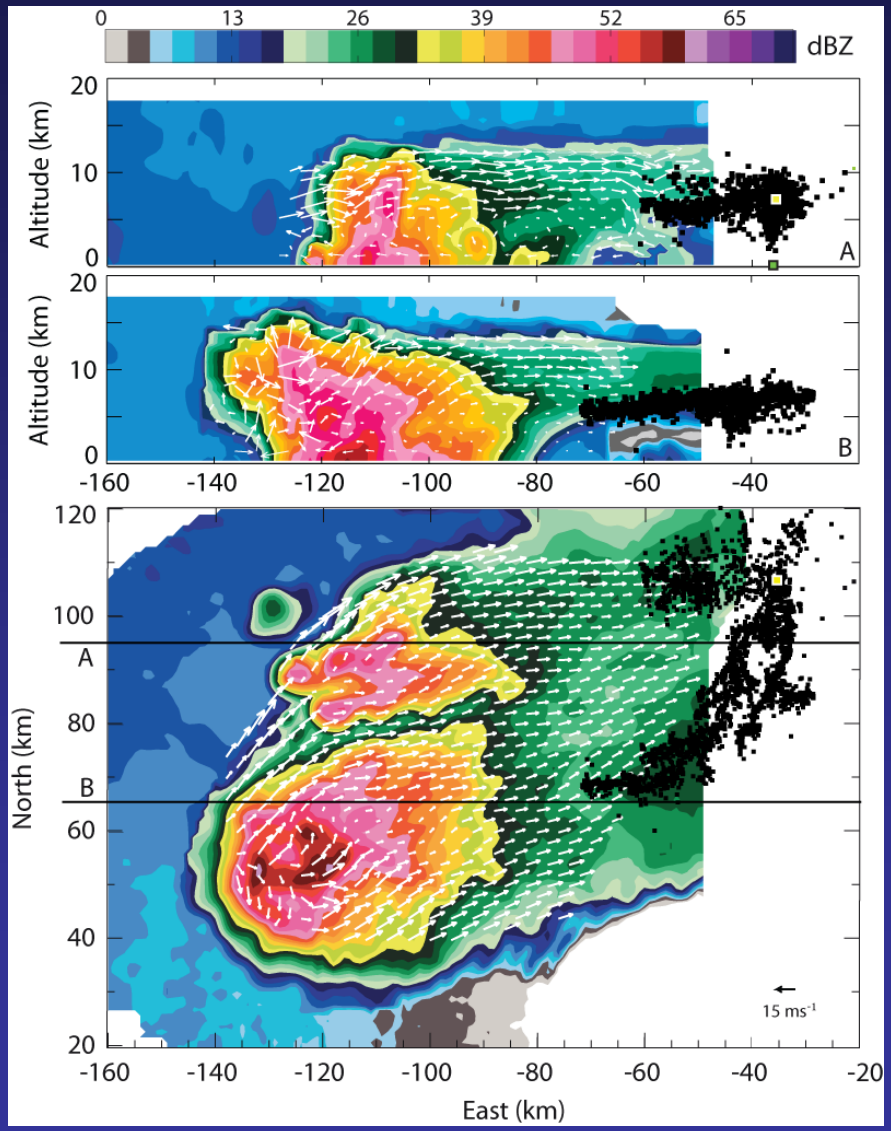
EF4, Unrated in Moore

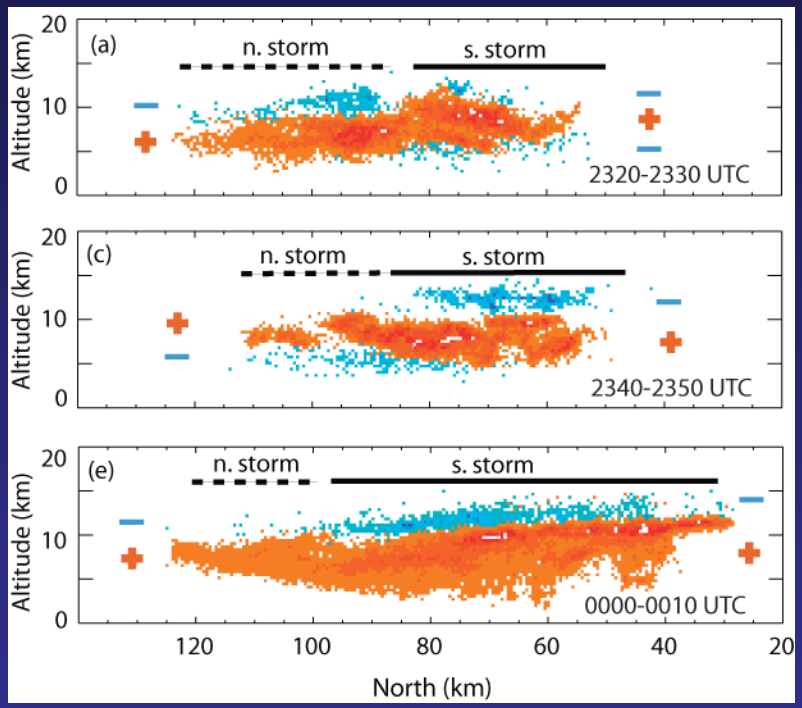
10 May 2010 2225—2305 UTC

EF4, EF1, EF2 in Norman

Anvil Flash

29 May 2004, 2321:45 UTC



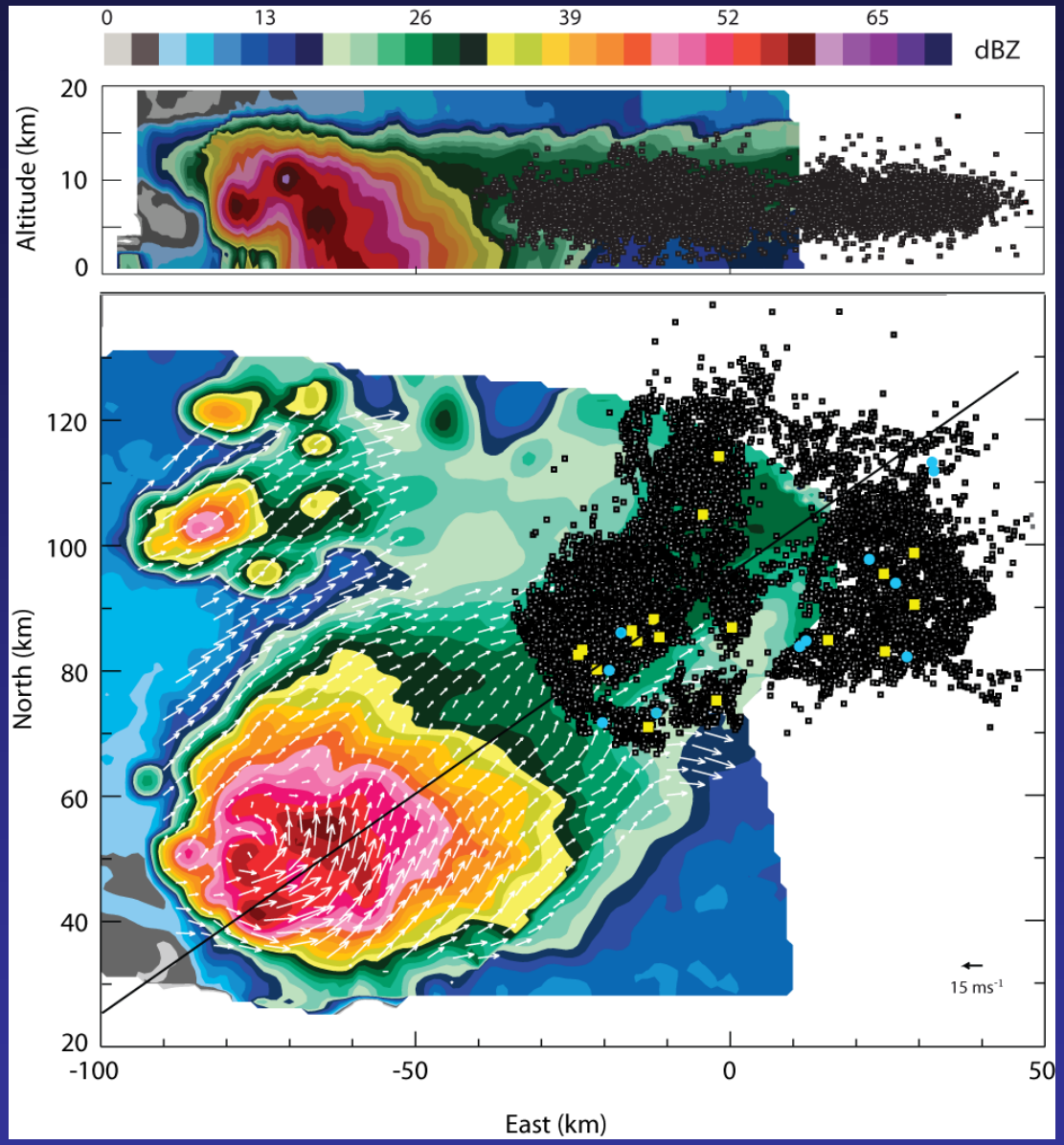


Anvil-Initiated Flashes 5/30/04

LMA data
0030:30-0032:30 UTC

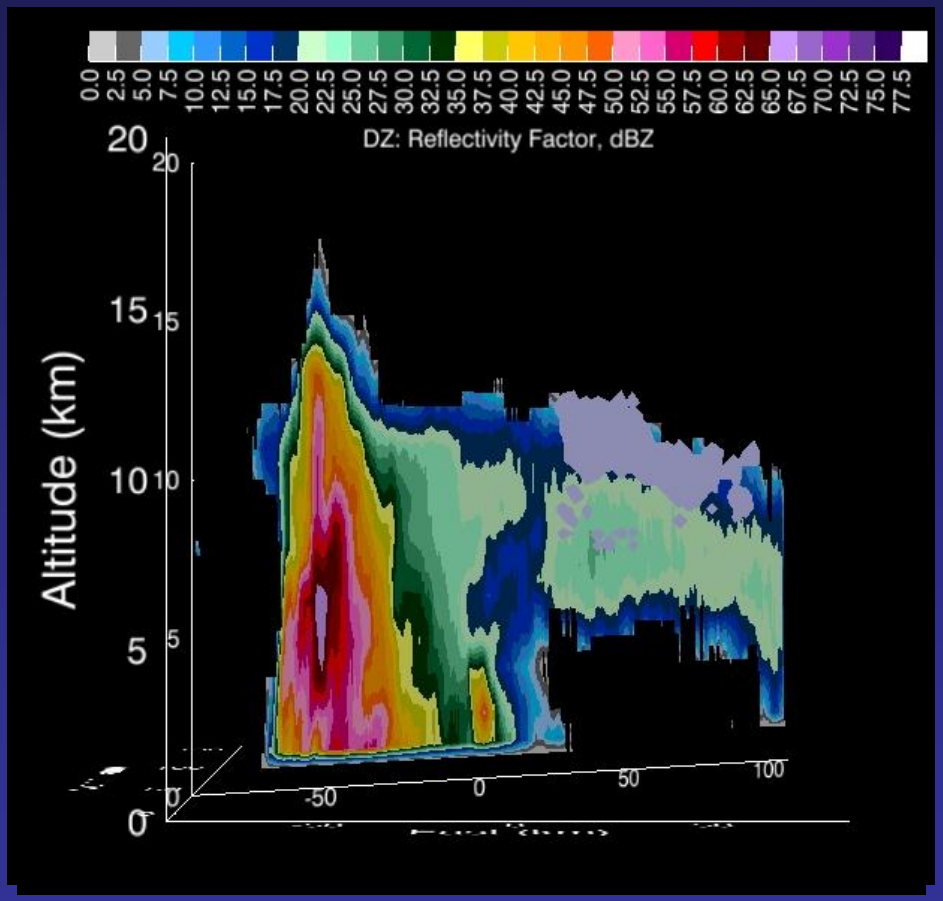
Radar data
0038-0043 UTC

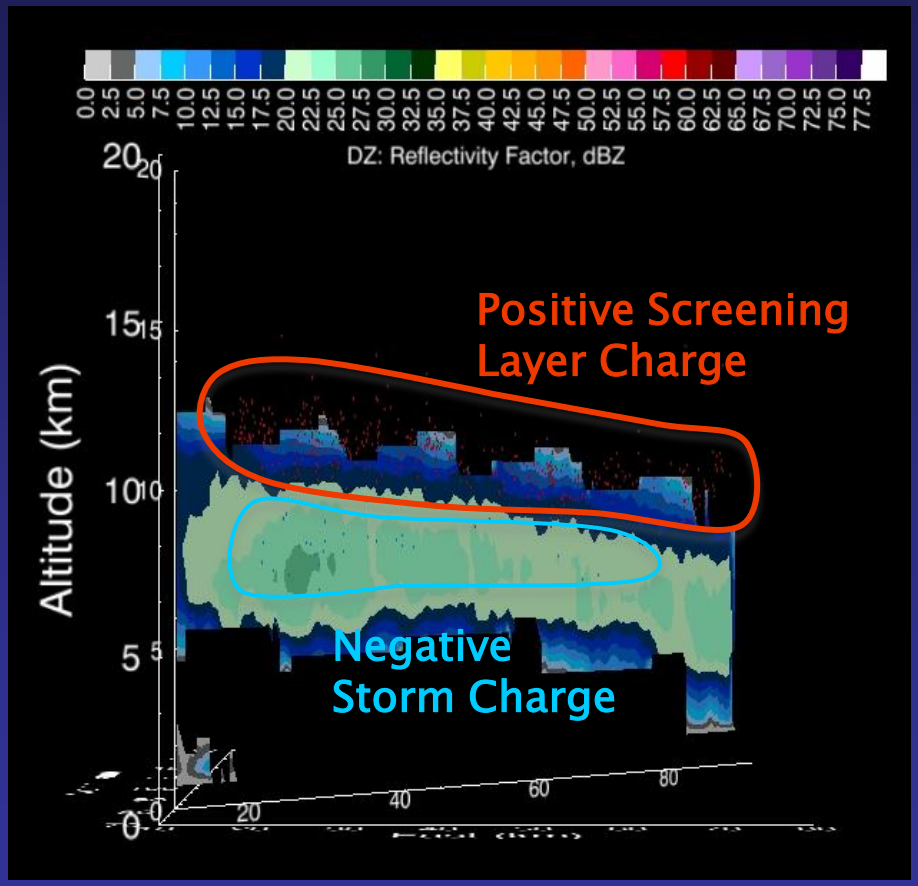
8 flashes / min in anvil



Flash Initiation in Anvil: Screening Layer

0107:48 UTC 30 May 2004





Preliminary Findings

- Initiation of Anvil flashes in or near
  - Screening layer charge
  - Reflectivity maximum
  - Anvil-anvil interaction

- Ground Flashes beneath Anvil with
  - Rain
  - Virga
  - Anvil below melting/freezing height

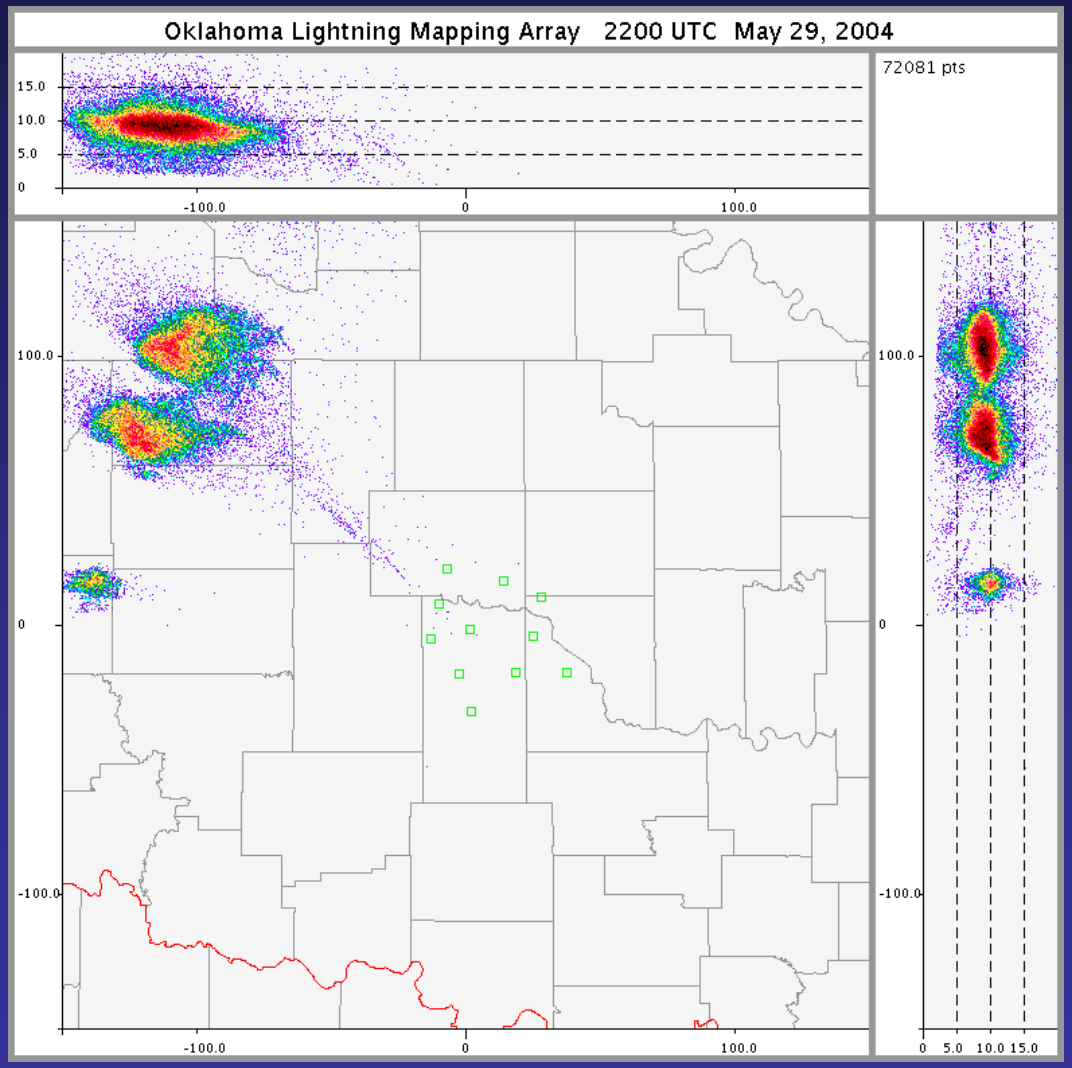
- No anvil flashes in shallower winter supercells

3-D LIGHTNING MAPPING ANIMATION OF SUPERCELL

Start:
2200 UTC
29 May 2004

Z, 20 km

NORTH, 300 km



Animation Time

End:
0240 UTC
30 May 2004

Density of mapped points every 10 min

EAST, 300 km

Z, 20 km

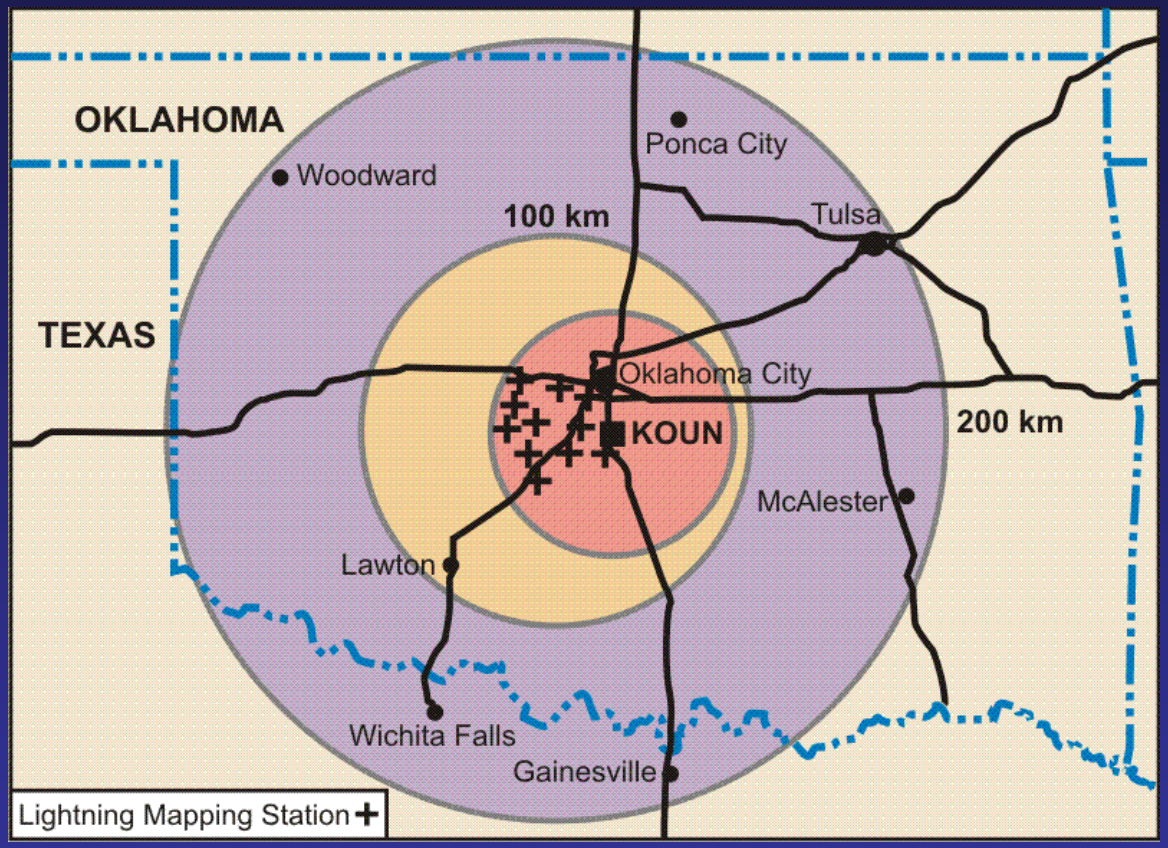
A Few Issues Concerning Nowcasting Applications Based on Oklahoma Lightning Mapping Array Data

Don MacGorman
NOAA/National Severe Storms Laboratory
CIMMS/University of Oklahoma and NOAA

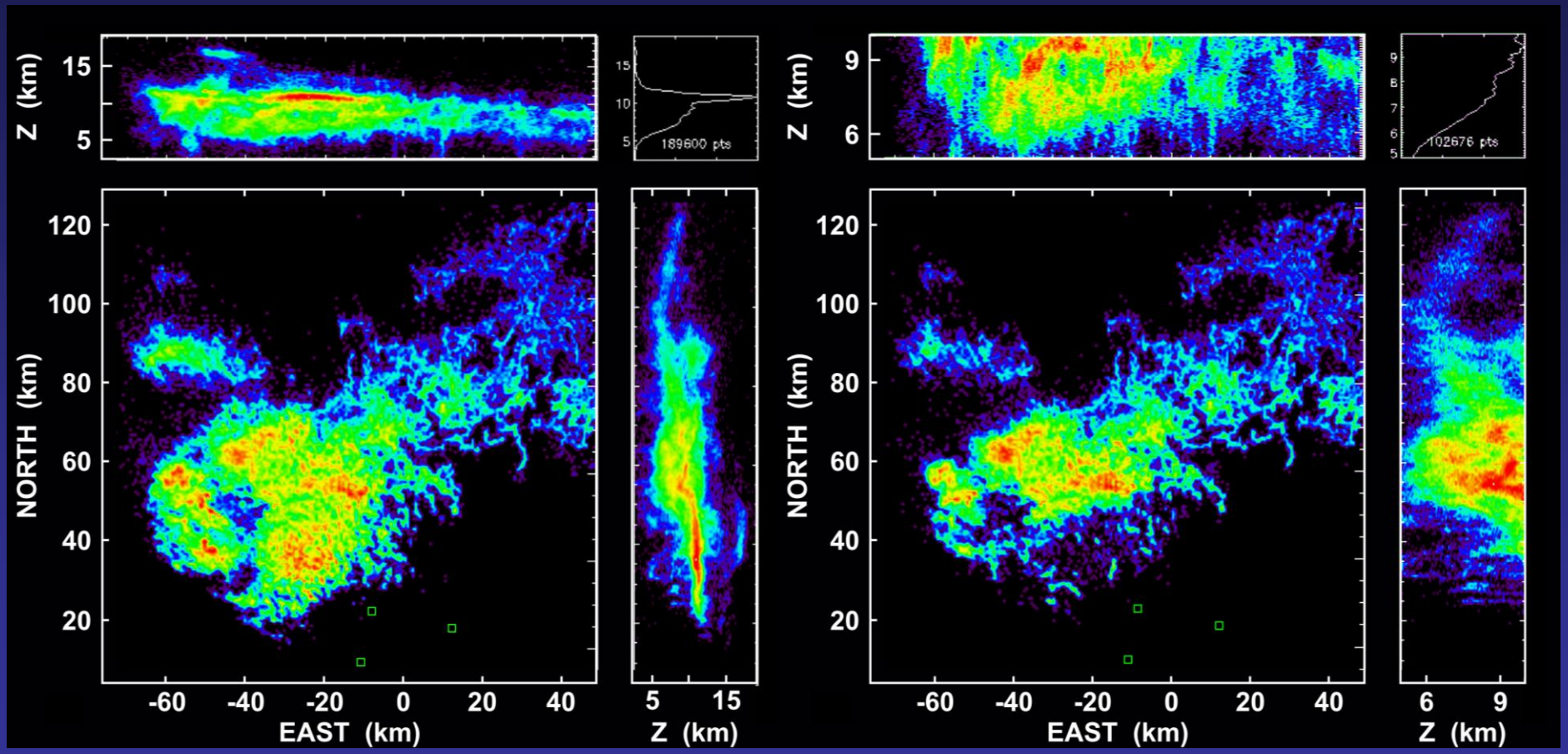
Copyright C. Doswell

Oklahoma Lightning Mapping Array

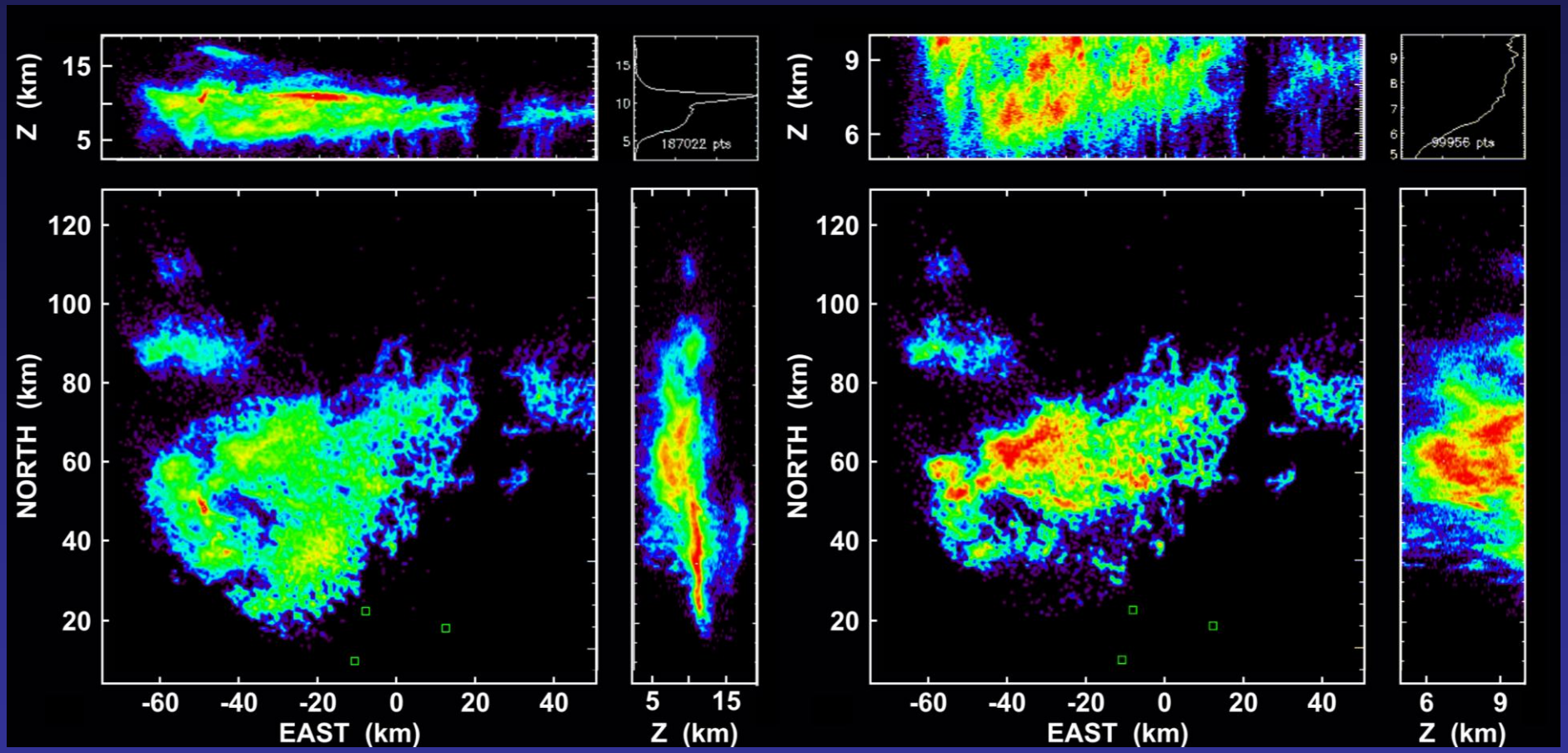
- 11 stations
- Uses open VHF television channel
- Maps signals in time and 3-D space



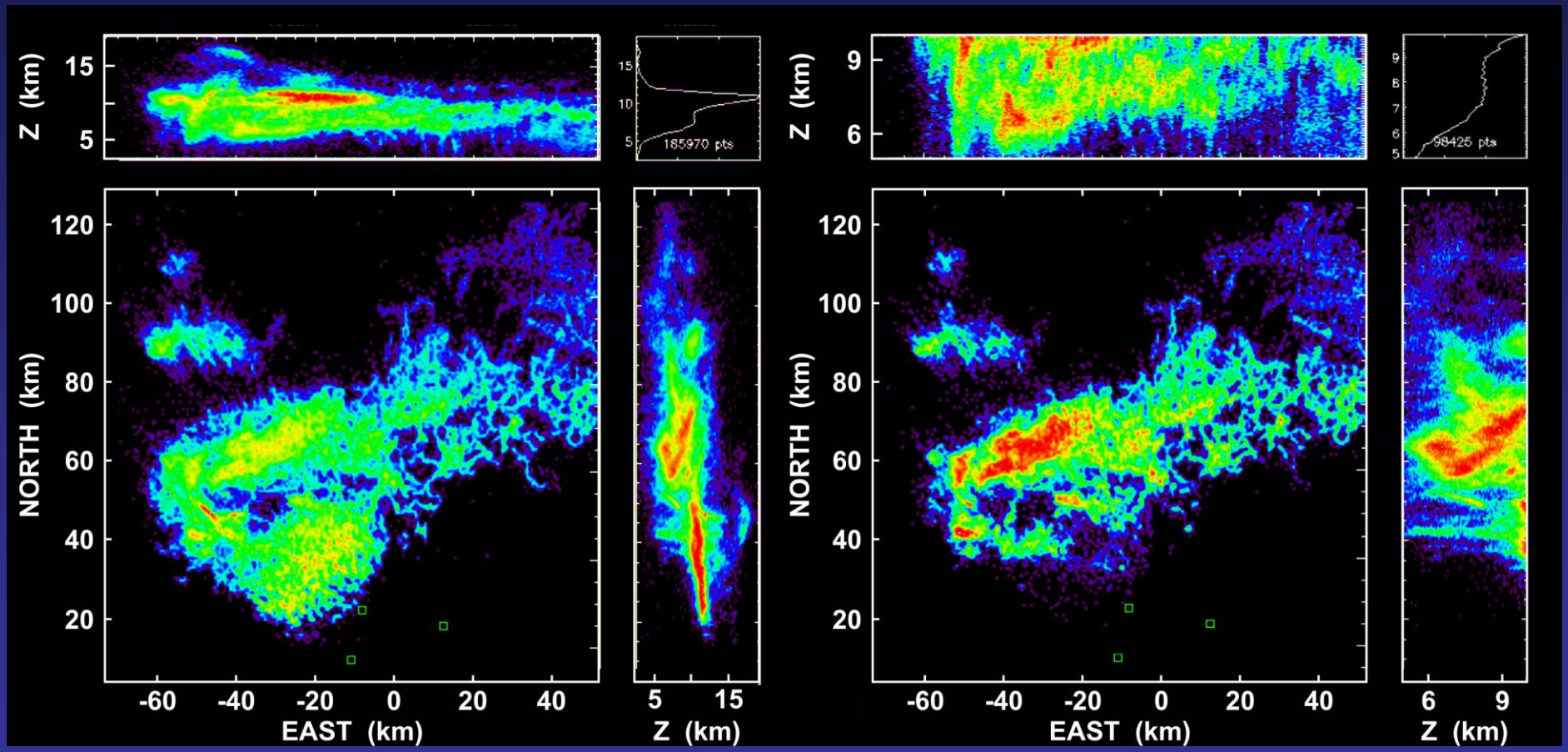
00:15:00 – 00:17:30 UTC



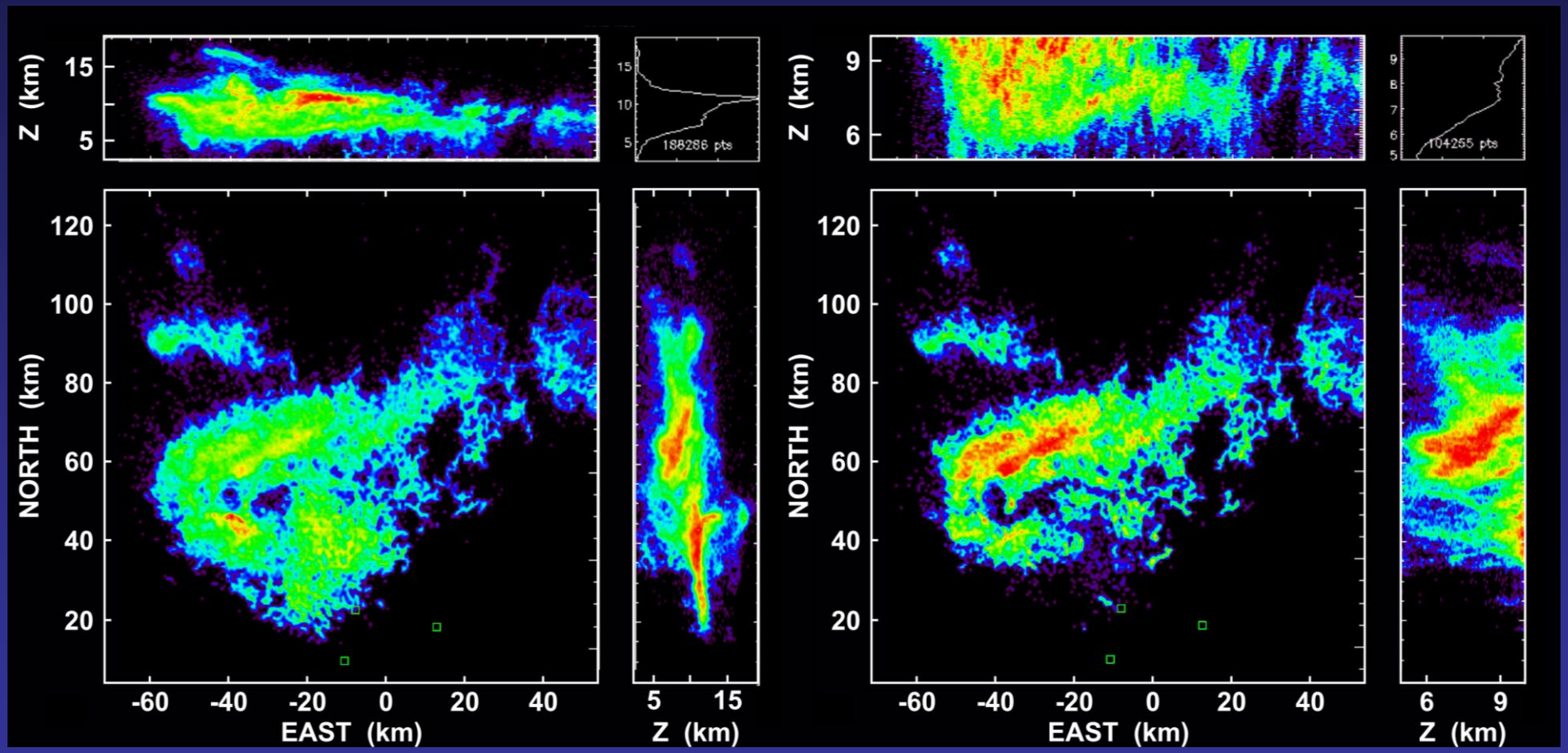
00:17:30 – 00:20:00 UTC



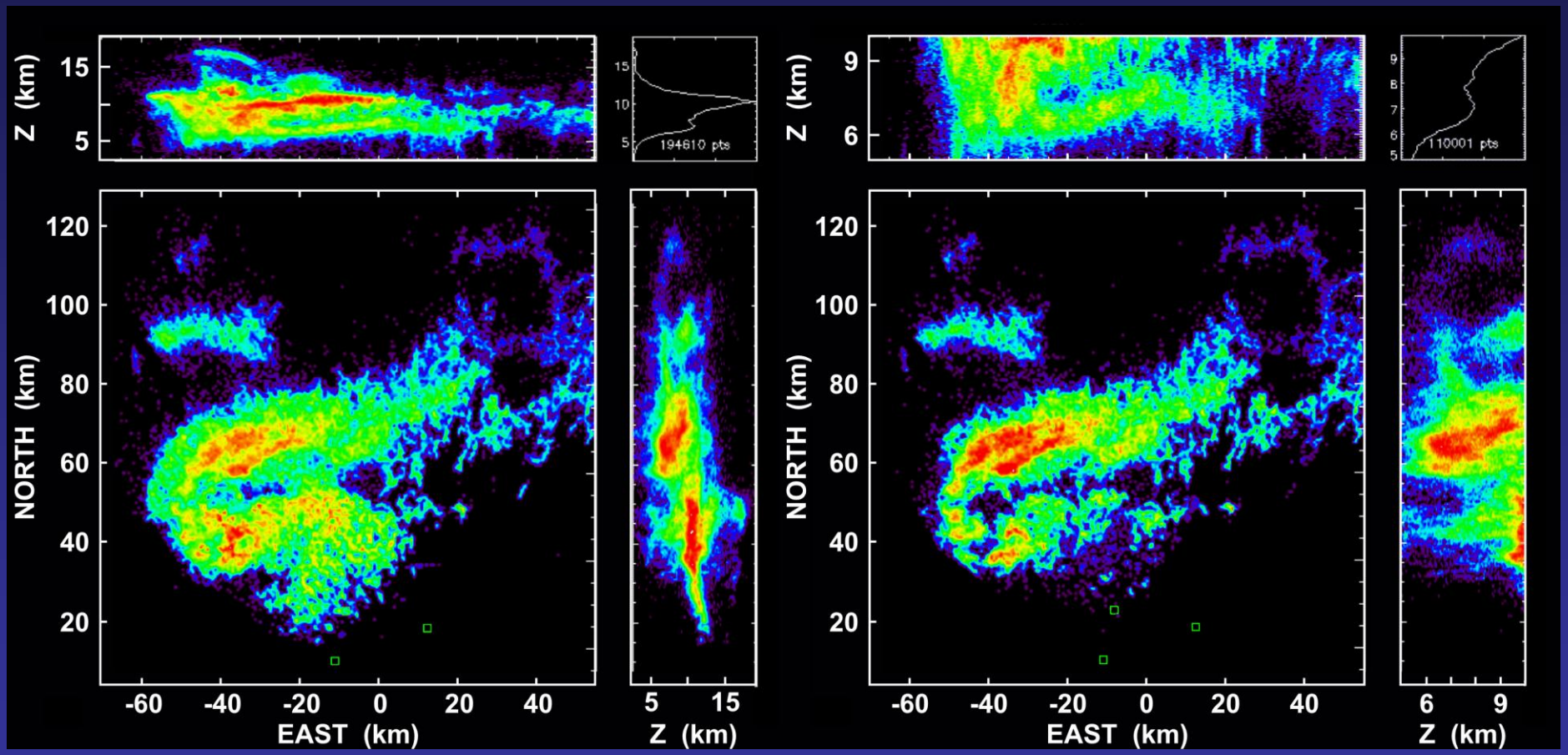
00:20:00 – 00:22:30 UTC



00:22:30 – 00:25:00 UTC



00:25:00 – 00:27:30 UTC



Summary of Observations

Relationship with Tornadogenesis

- In 12 of 14 cases, noticeable impulses in the lightning signature of the overshooting top preceded tornadogenesis by 3-25 minutes.

- In 11 of 14 cases, tornadogenesis coincided with both a drop in radar top height and a decrease in either the height or occurrence of lightning in the overshooting top.

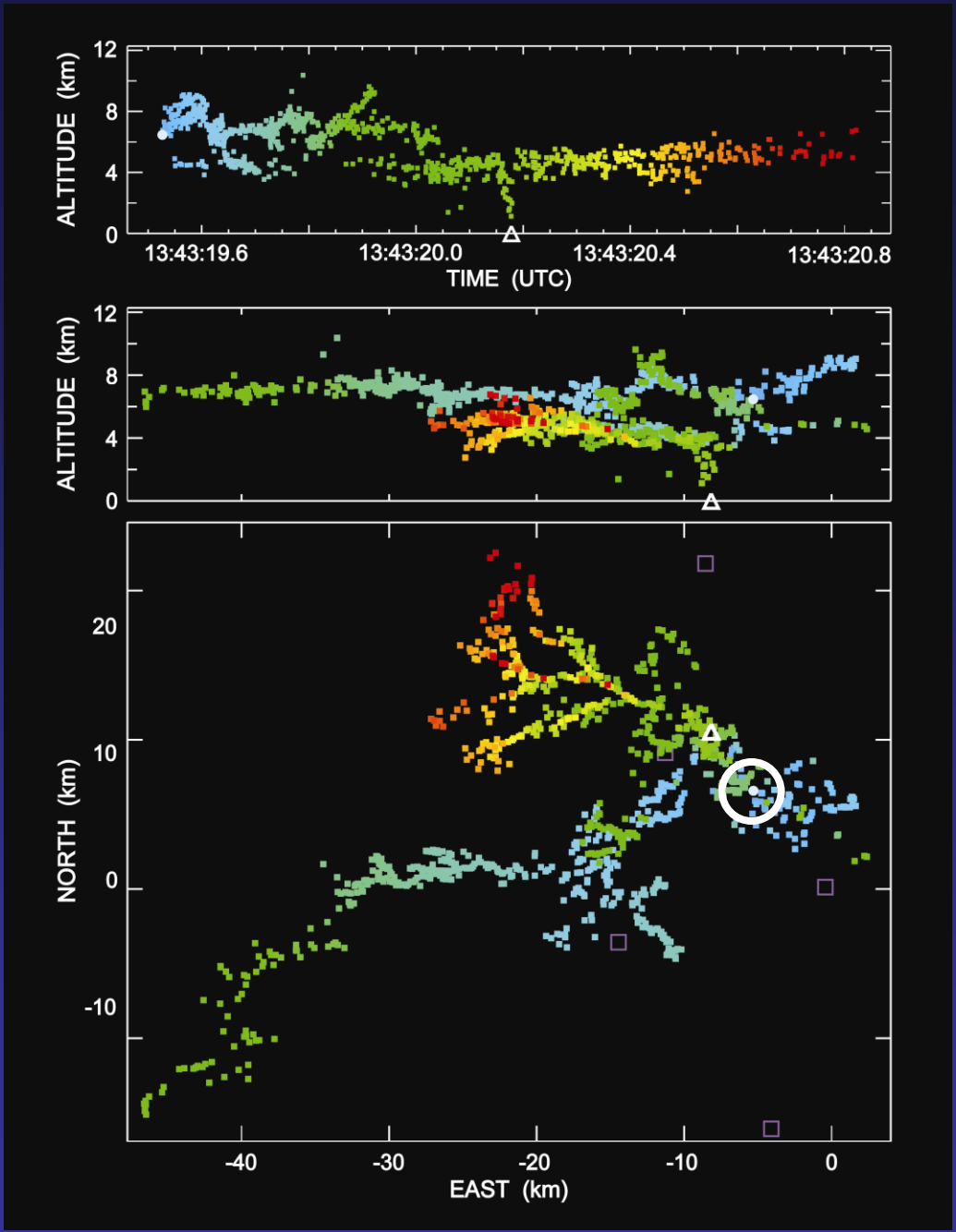
Summary of Observations

Lightning Characteristics

- Much smaller rate of VHF sources in the region of the overshooting top than elsewhere in the storm

- Usually independent of flashes lower in the storm and occasionally contain larger flashes with more than one VHF source point

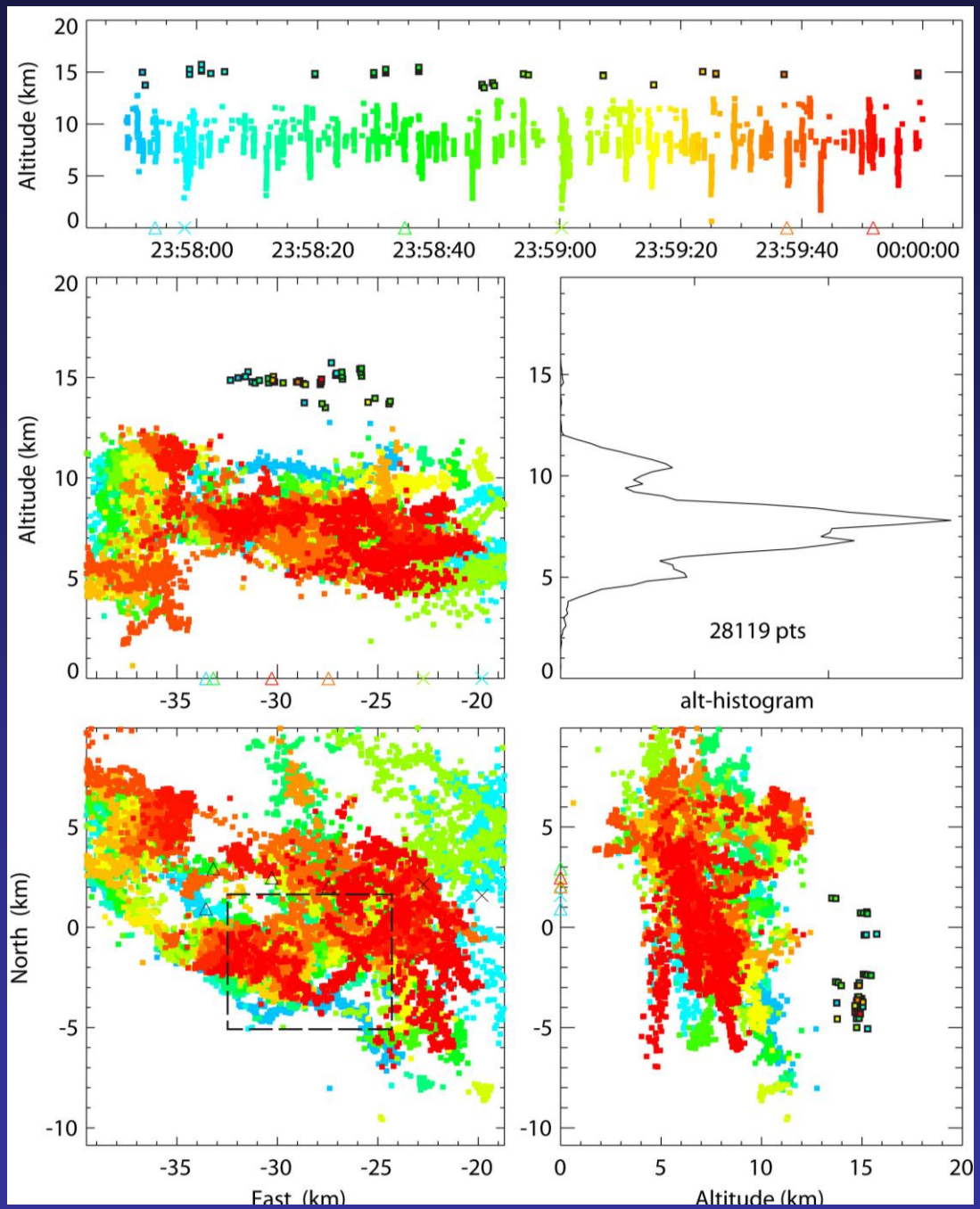
A Cloud-to-Ground Flash

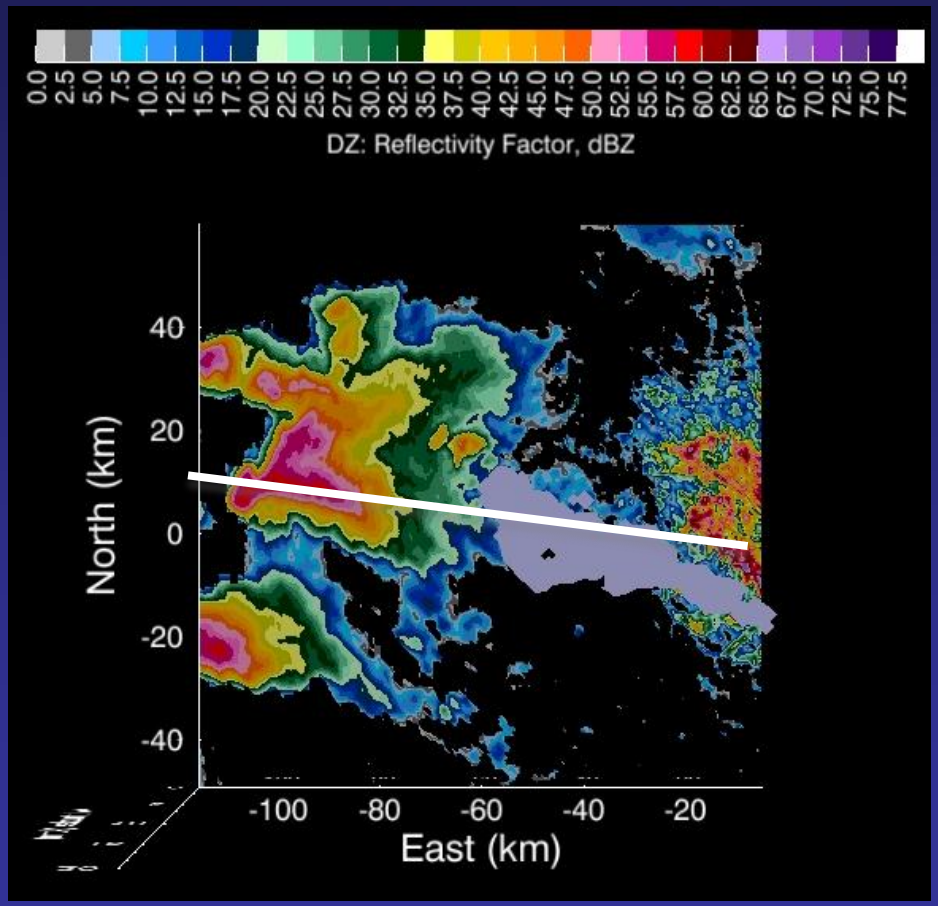
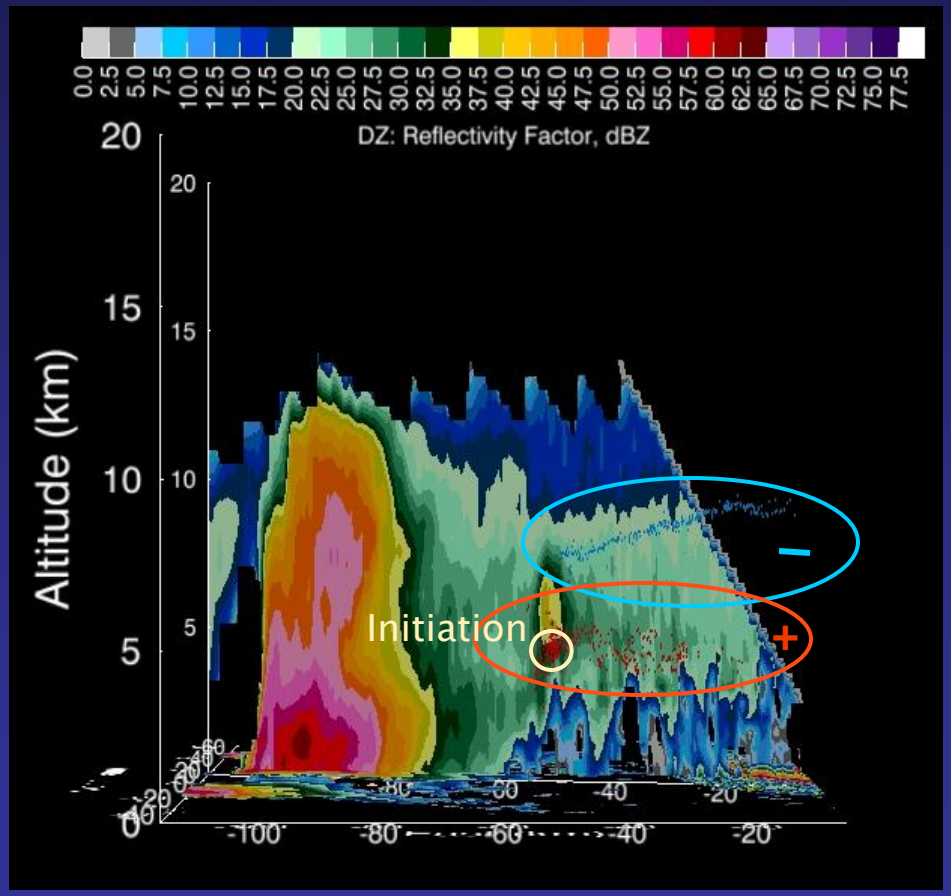


24 May 2004

23:58 UTC

2.2 minutes



Flash Initiation in Anvil: Reflectivity Max

2328:43 UTC 24 May 2004