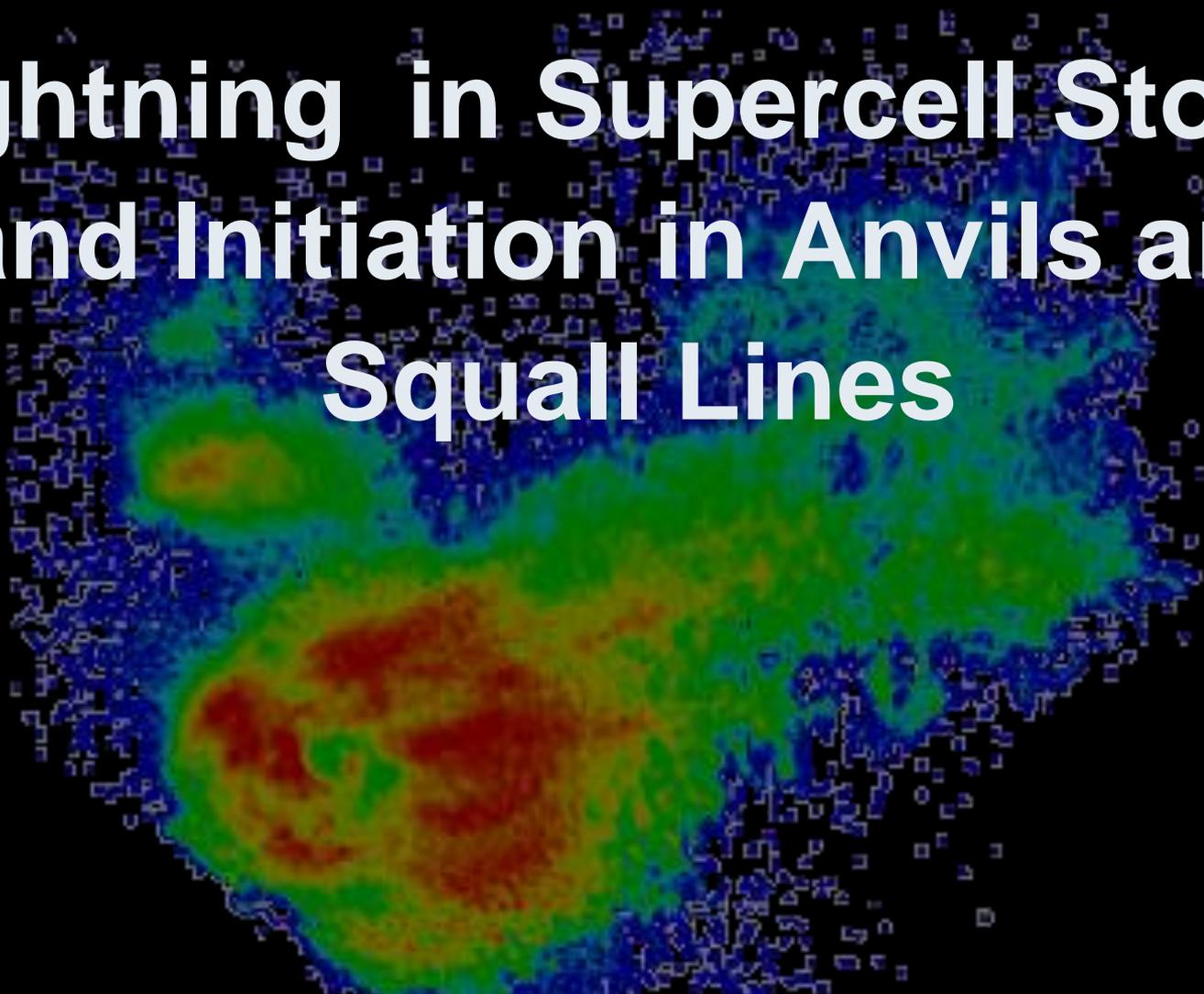


# Lightning in Supercell Storms and Initiation in Anvils and Squall Lines

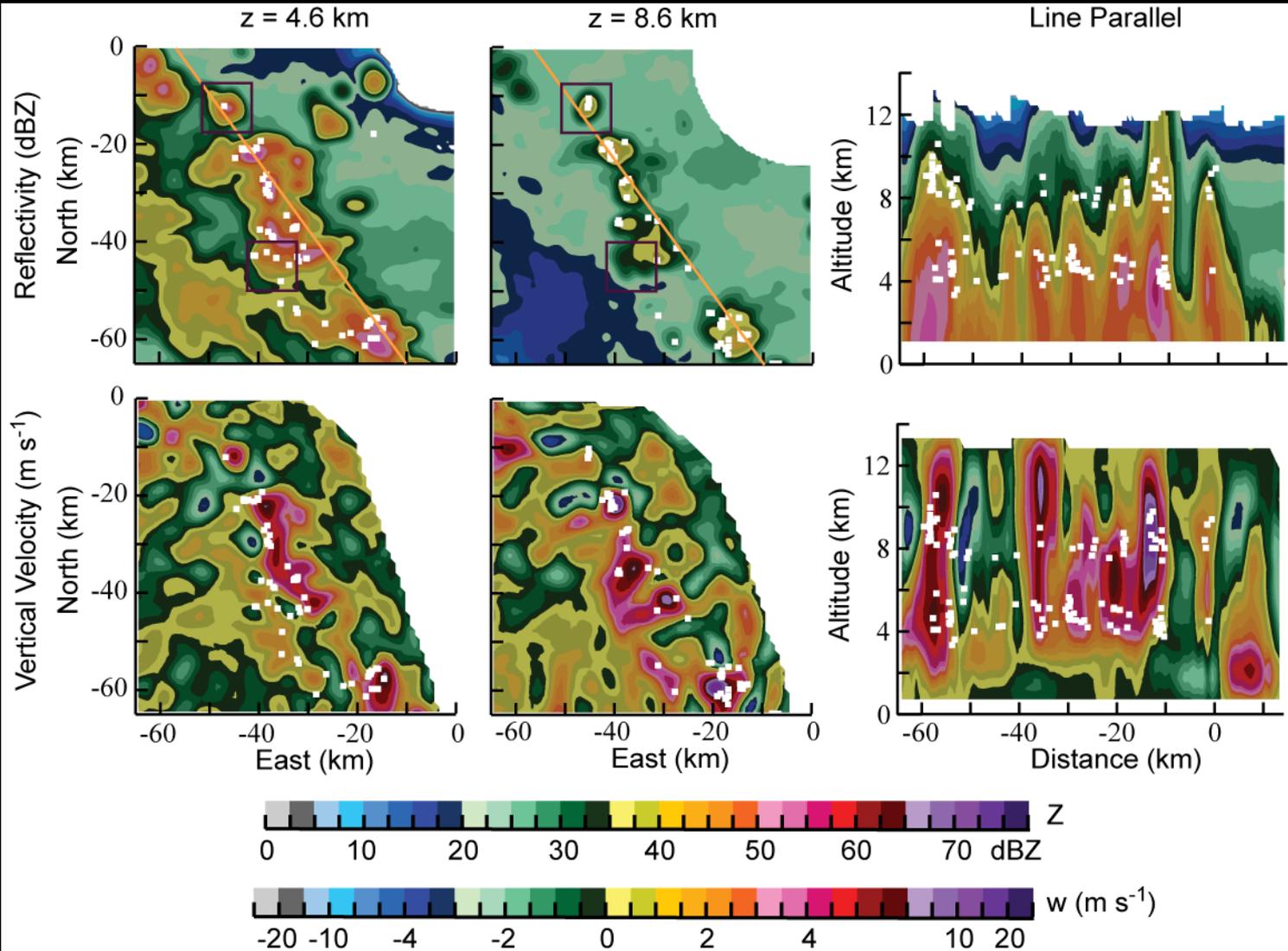


Don MacGorman

National Severe Storms Laboratory

# 19 June 2004

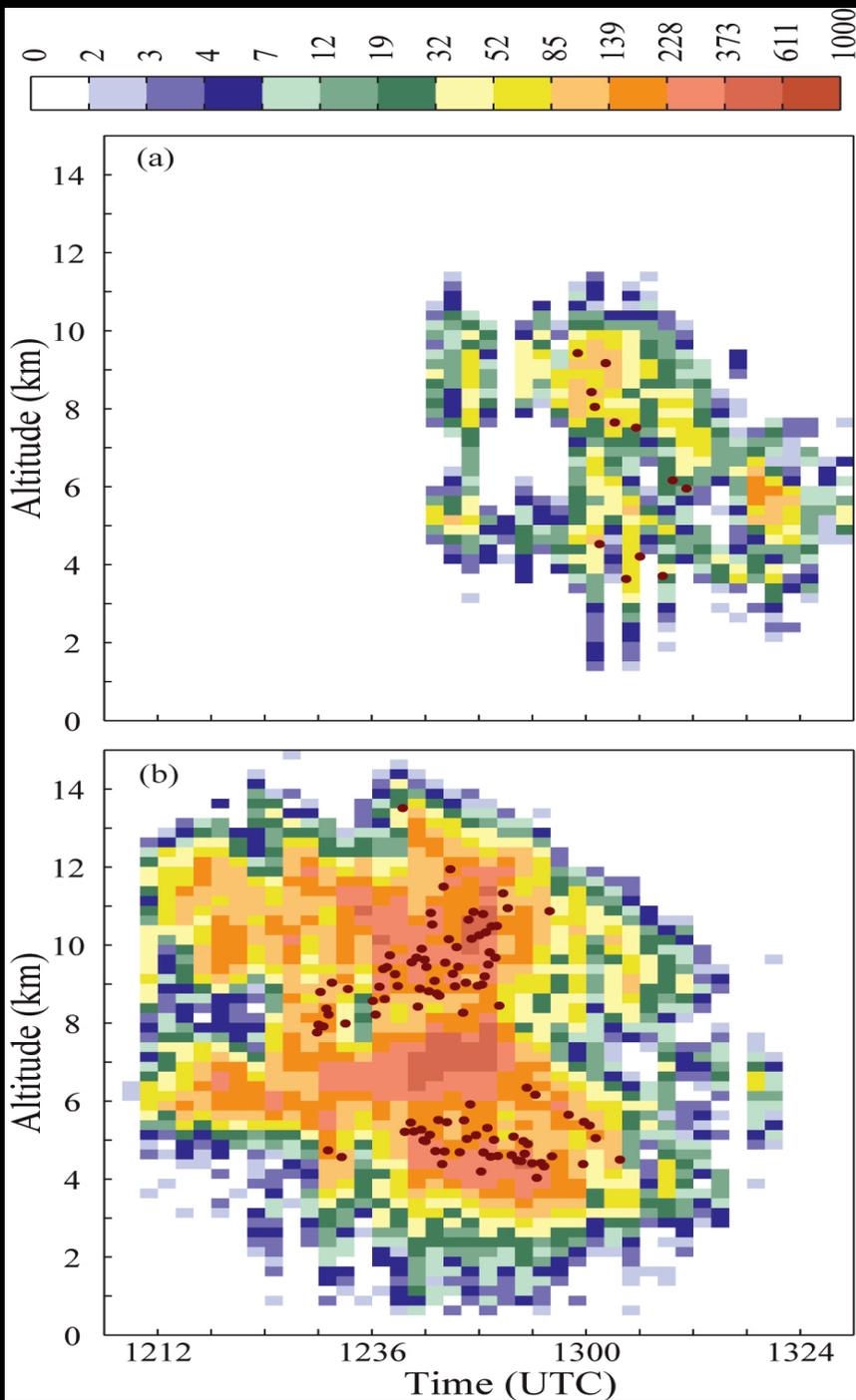
## 1256 UTC



# VHF Density & Flash Initiations in Two Cells

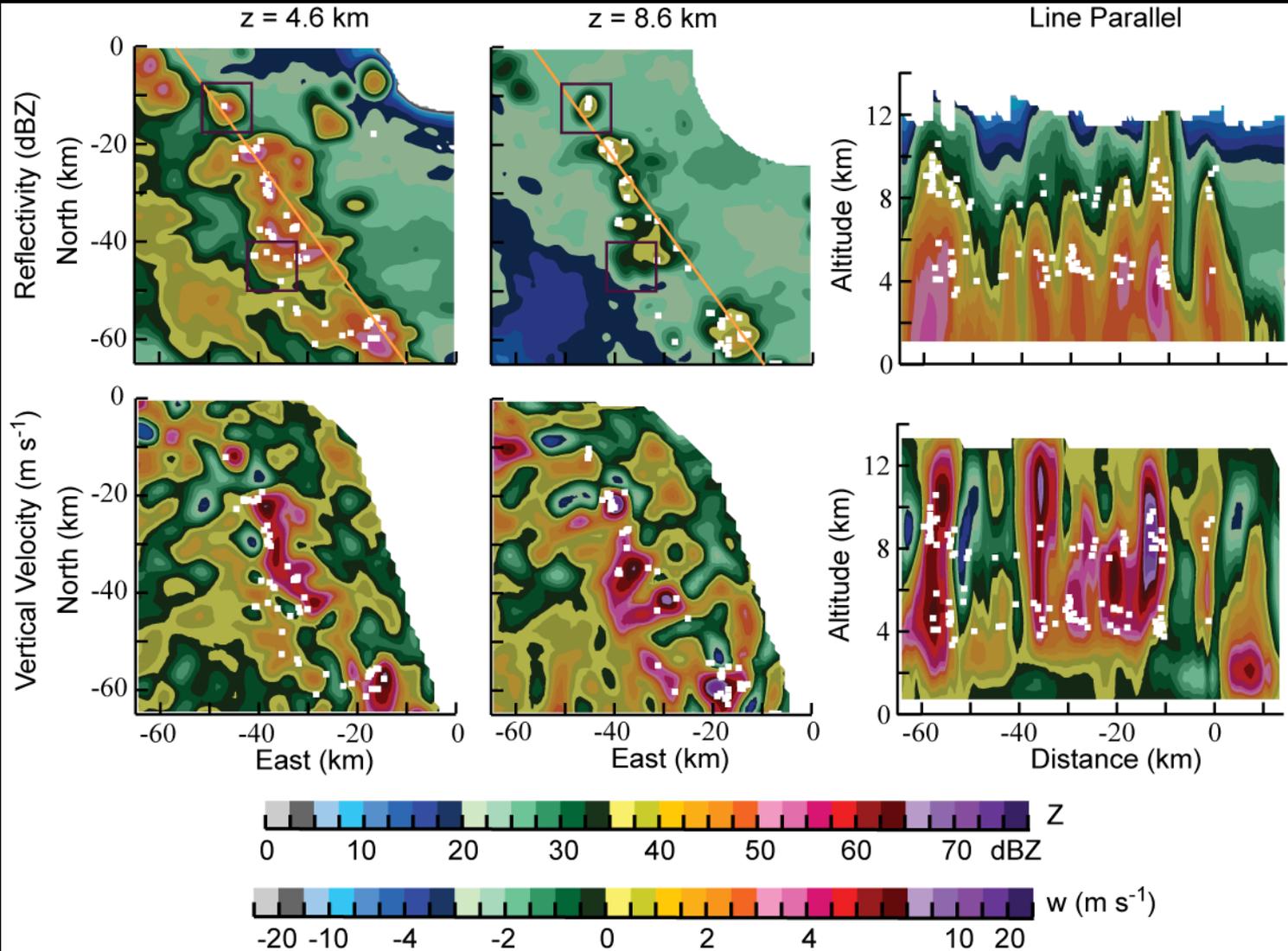
19 June 2004

MCS



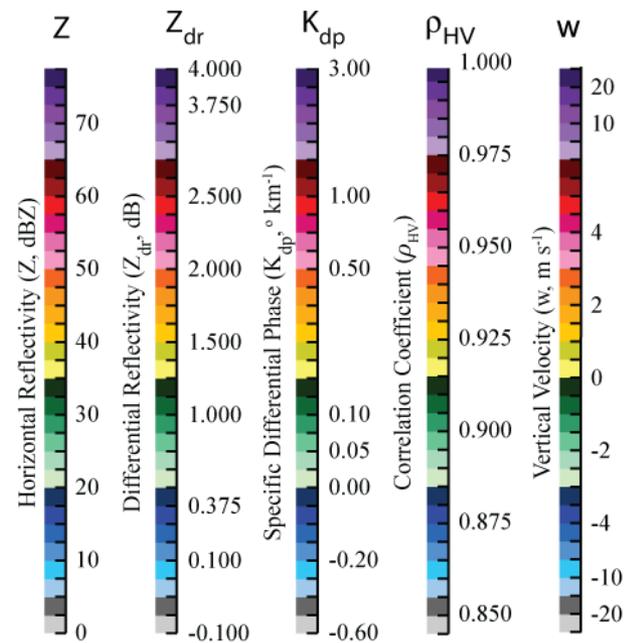
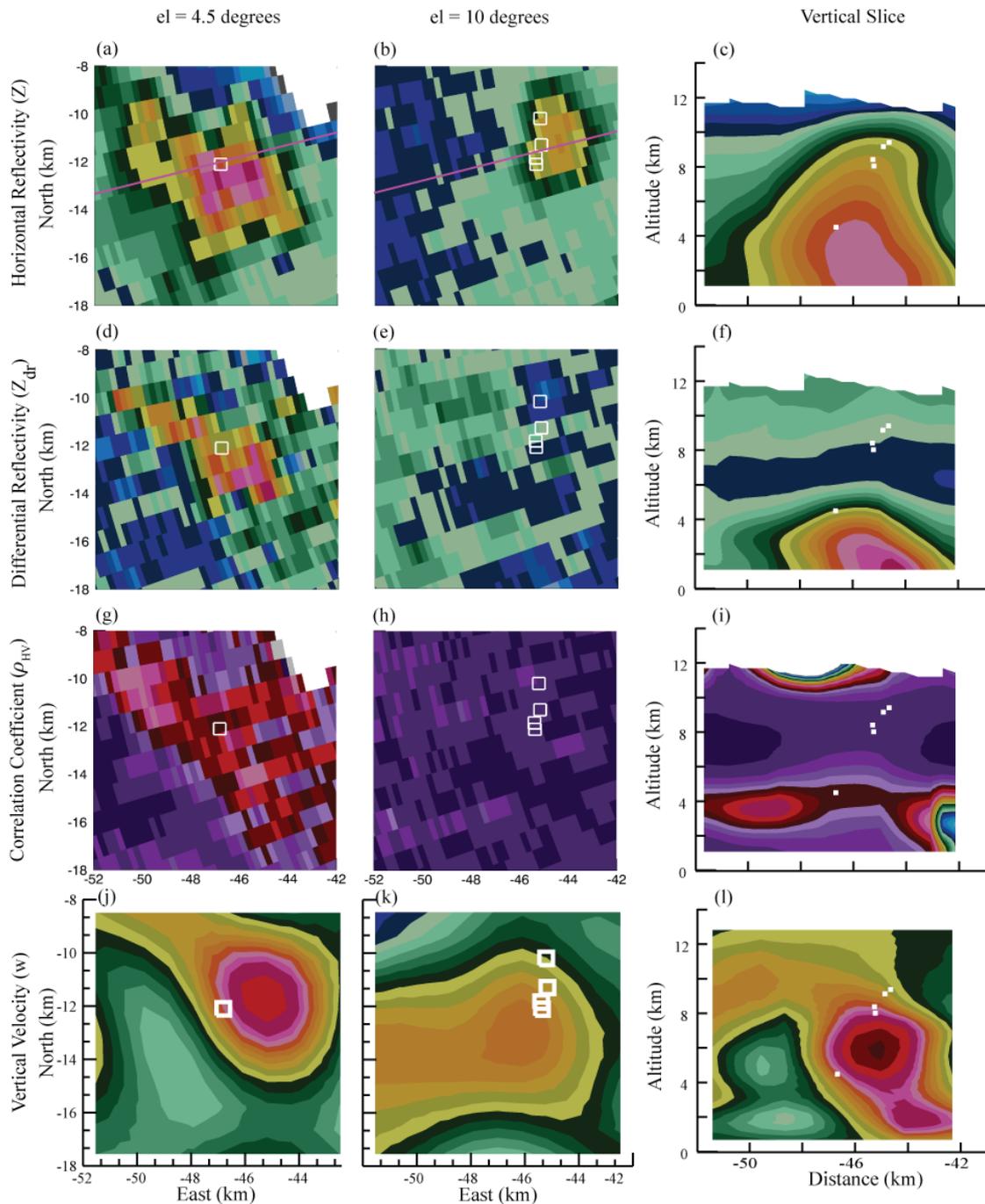
# 19 June 2004

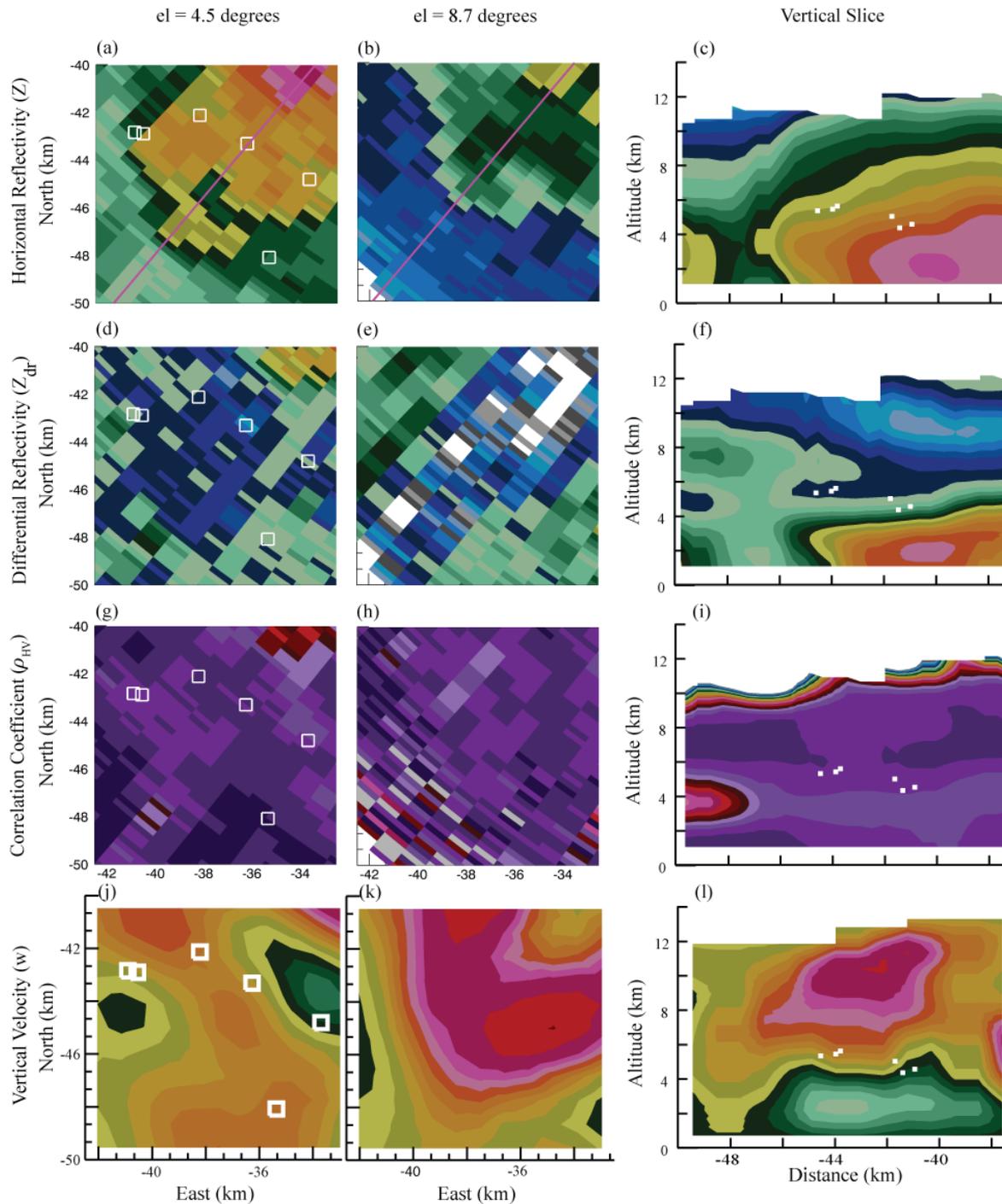
## 1256 UTC



# Lightning vs. Radar Data in a Growing Cell

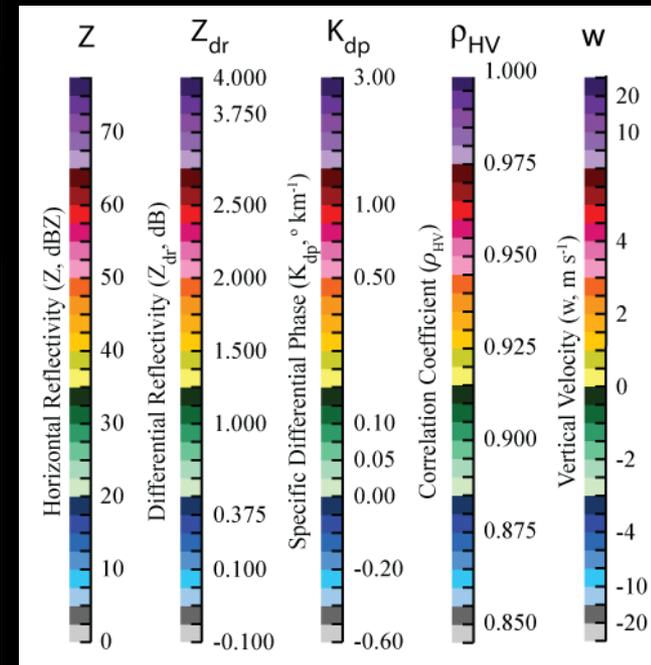
MCS at 1256 UTC on 19 June 2004





# Lightning vs. Radar Data in a Dissipating Cell

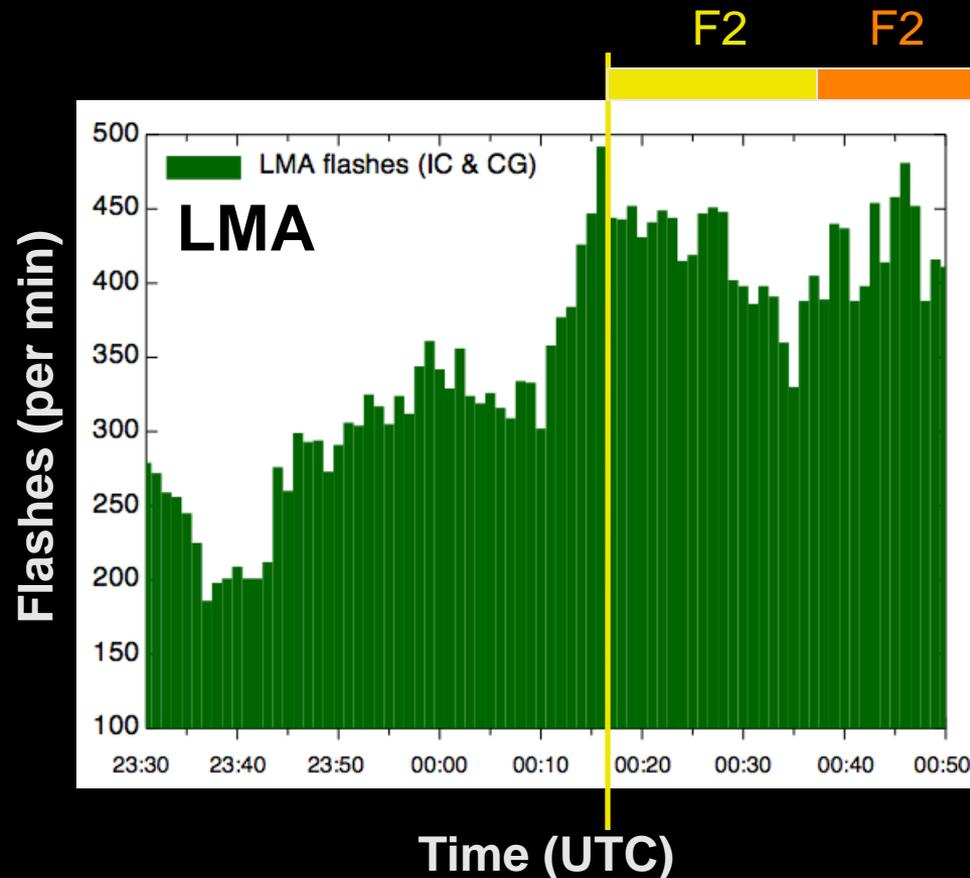
MCS at 1256 UTC on  
19 June 2004



# 29-30 May 2004

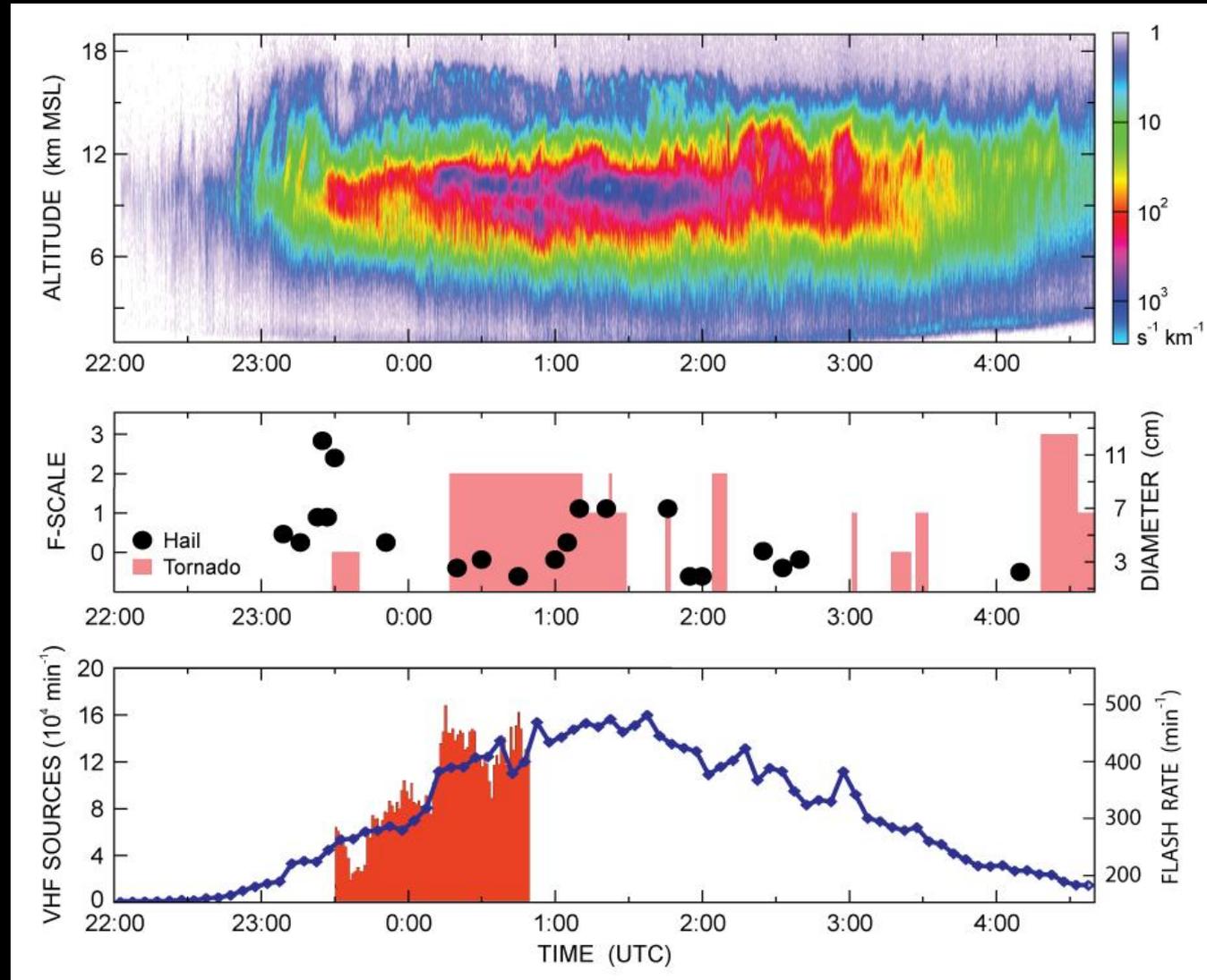
## Flash Rates

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



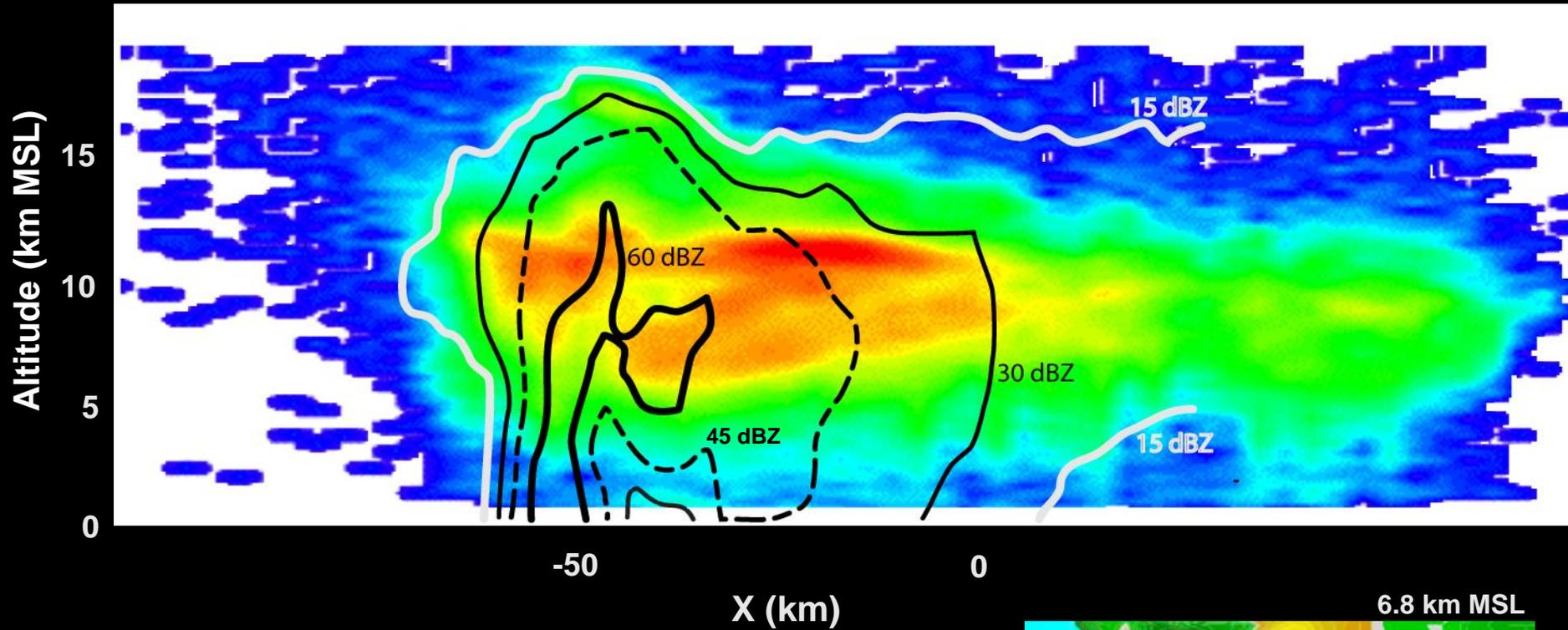
# 29-30 May 2004

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



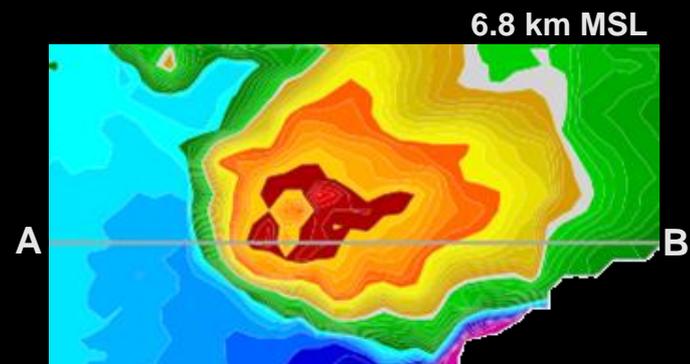
\*number of mapped VHF sources in whole storm per unit altitude

# Reflectivity and LMA Event Density



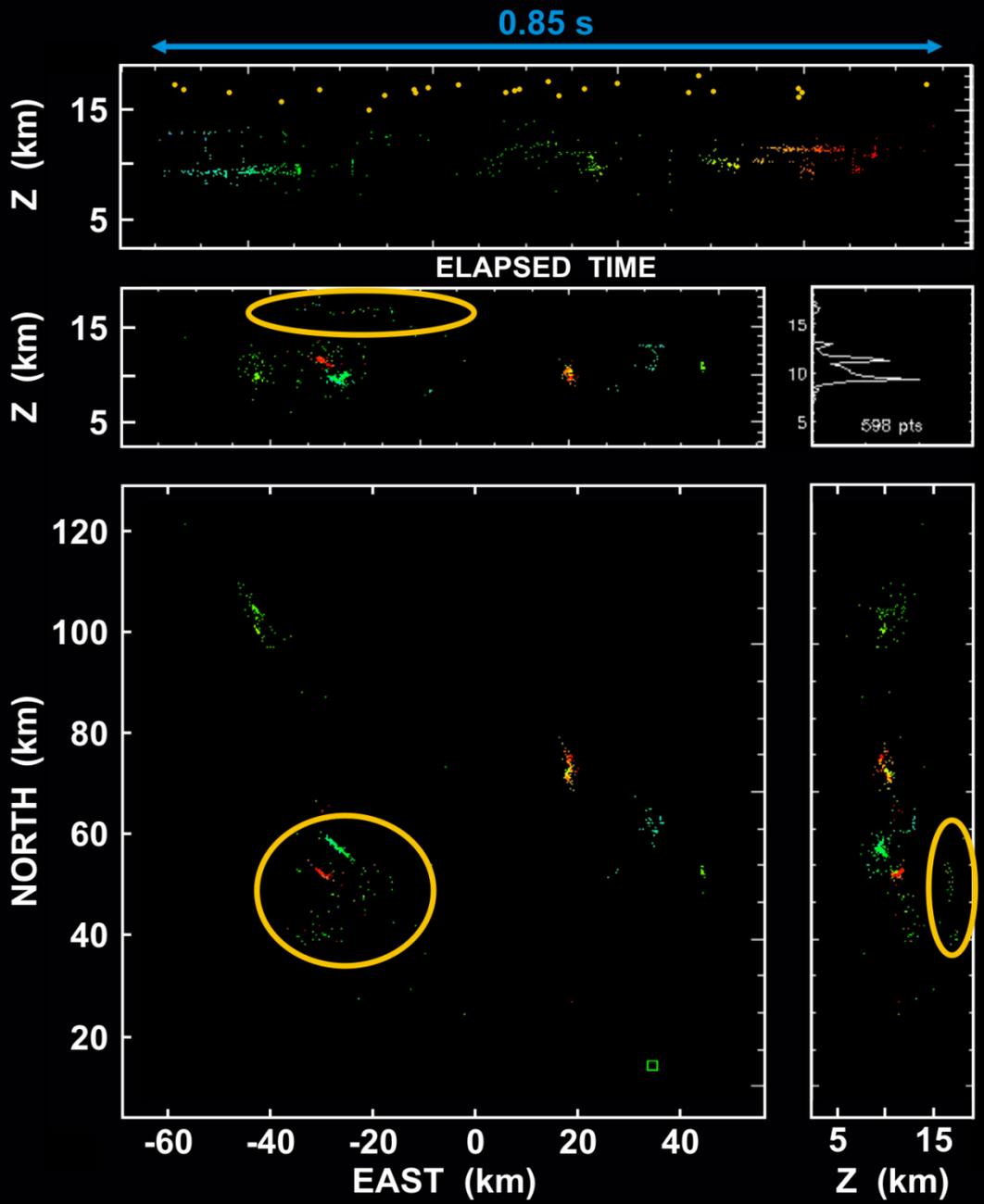
Radar: 0016:45 – 0018:32 UTC

LMA Data: 0015 – 0020 UTC

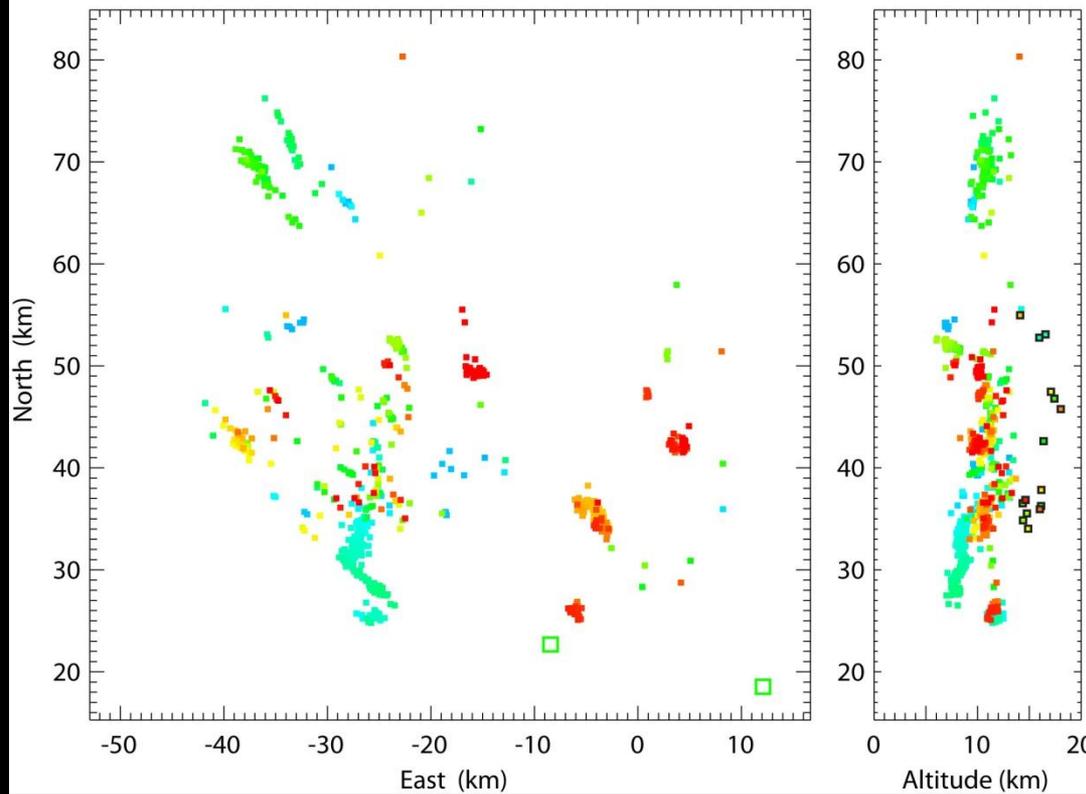
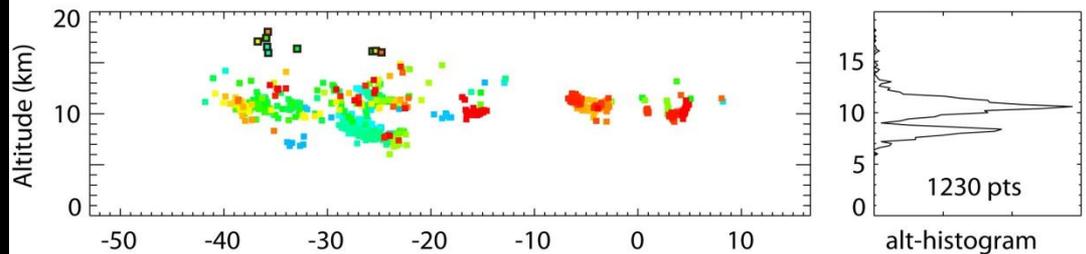
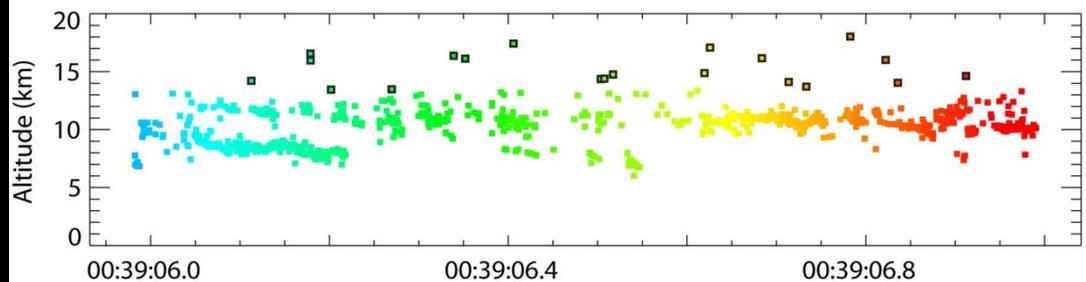


# LMA Mapped Points

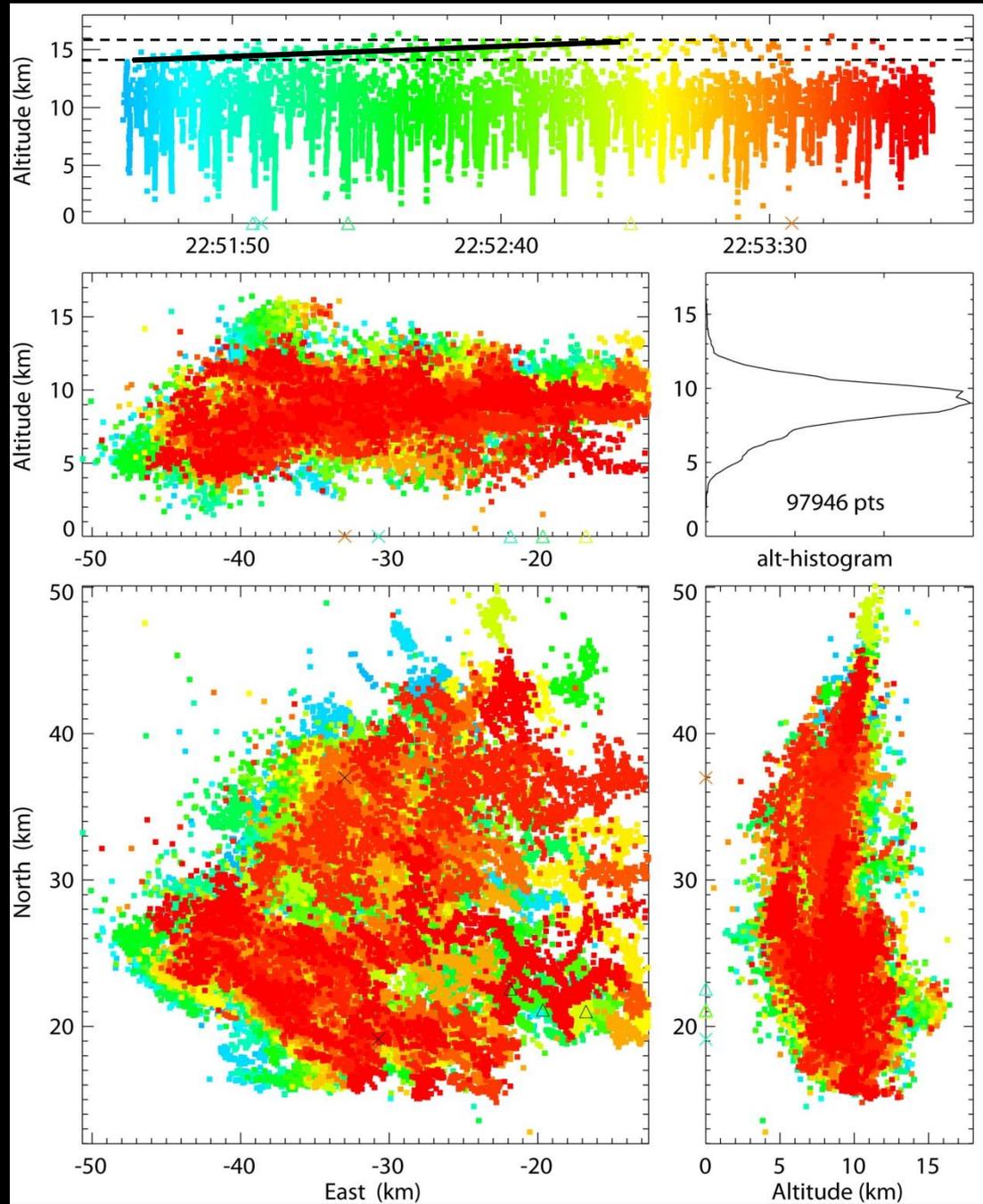
30 May 2004  
0010:21 UTC



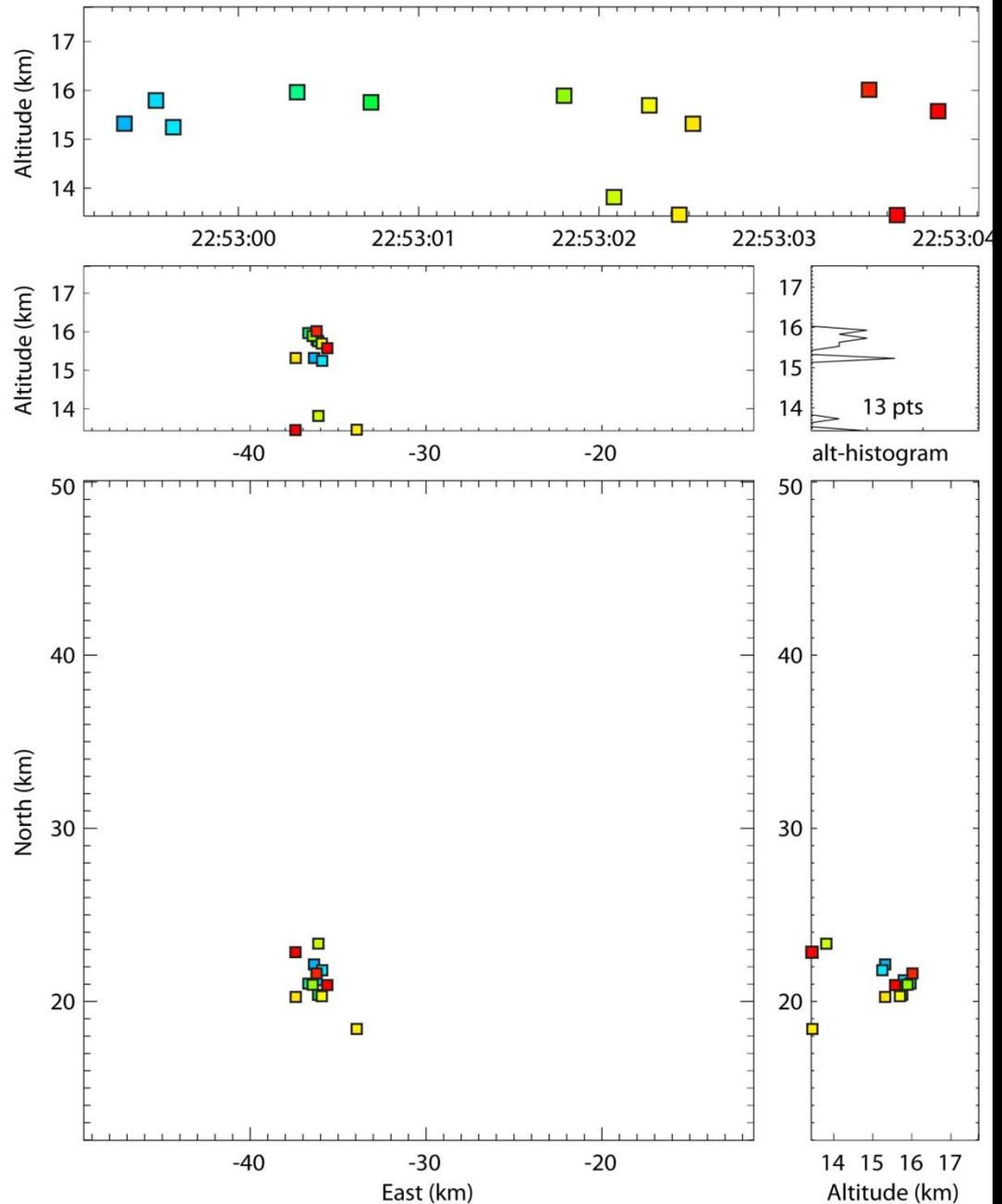
**30 May 2004**  
**00:39:06 UTC**  
**1 second**



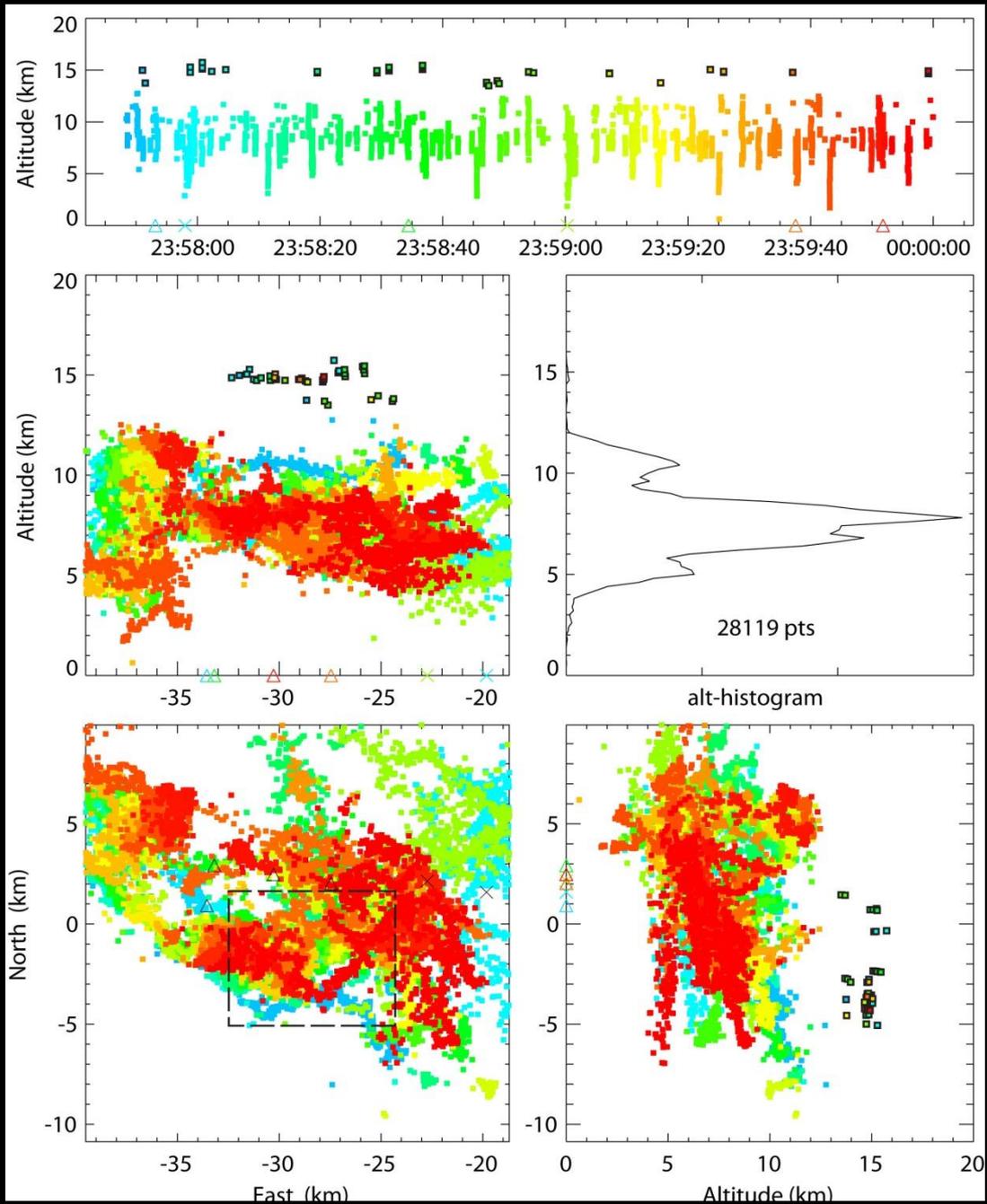
**26 May 2004**  
**22:51:30 – 54:00**  
**2.5 minutes**



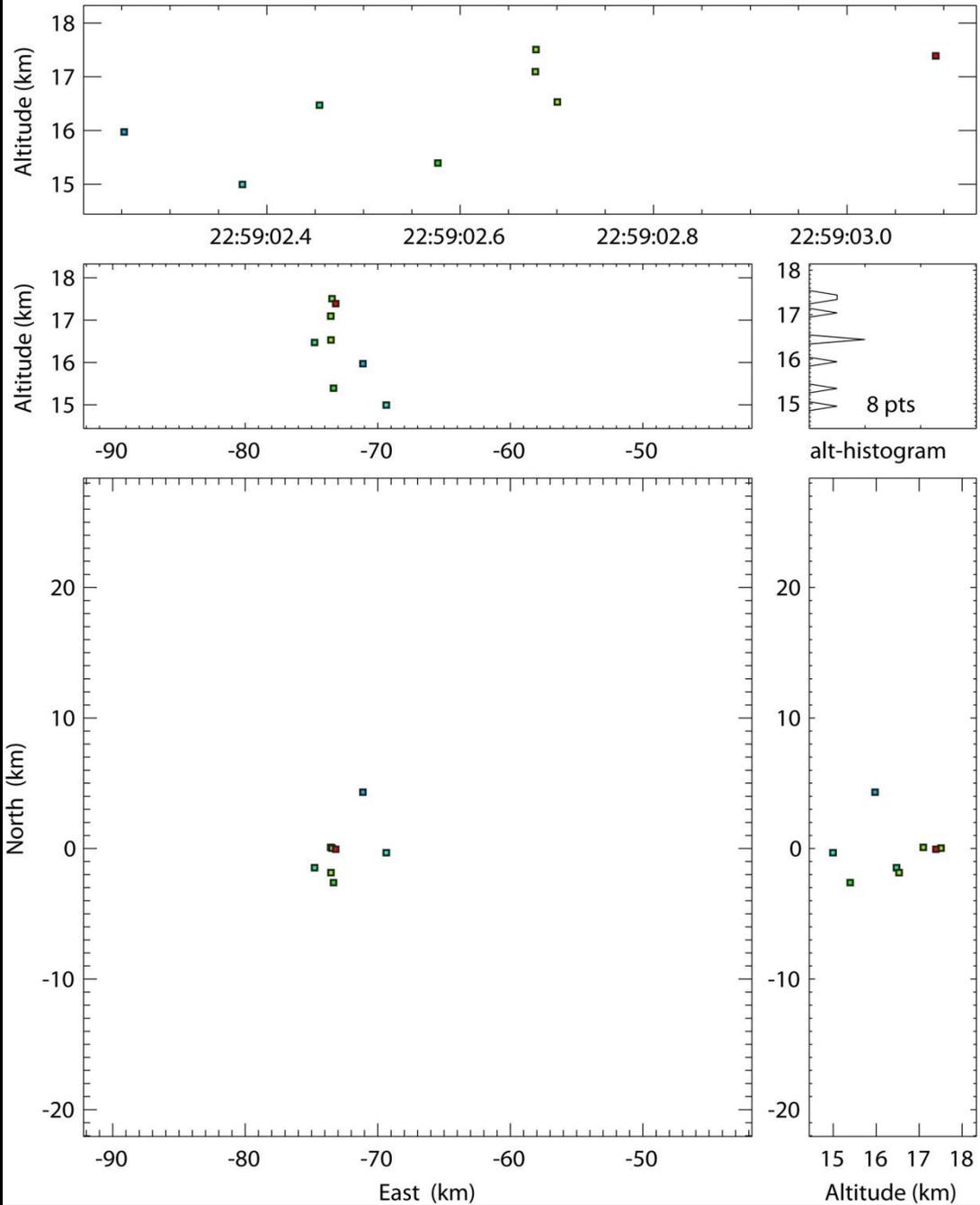
**26 May 2004**  
**22:53 UTC**  
**5 seconds**  
**13 – 17 km MSL**



**24 May 2004**  
**23:58 UTC**  
**2.2 minutes**

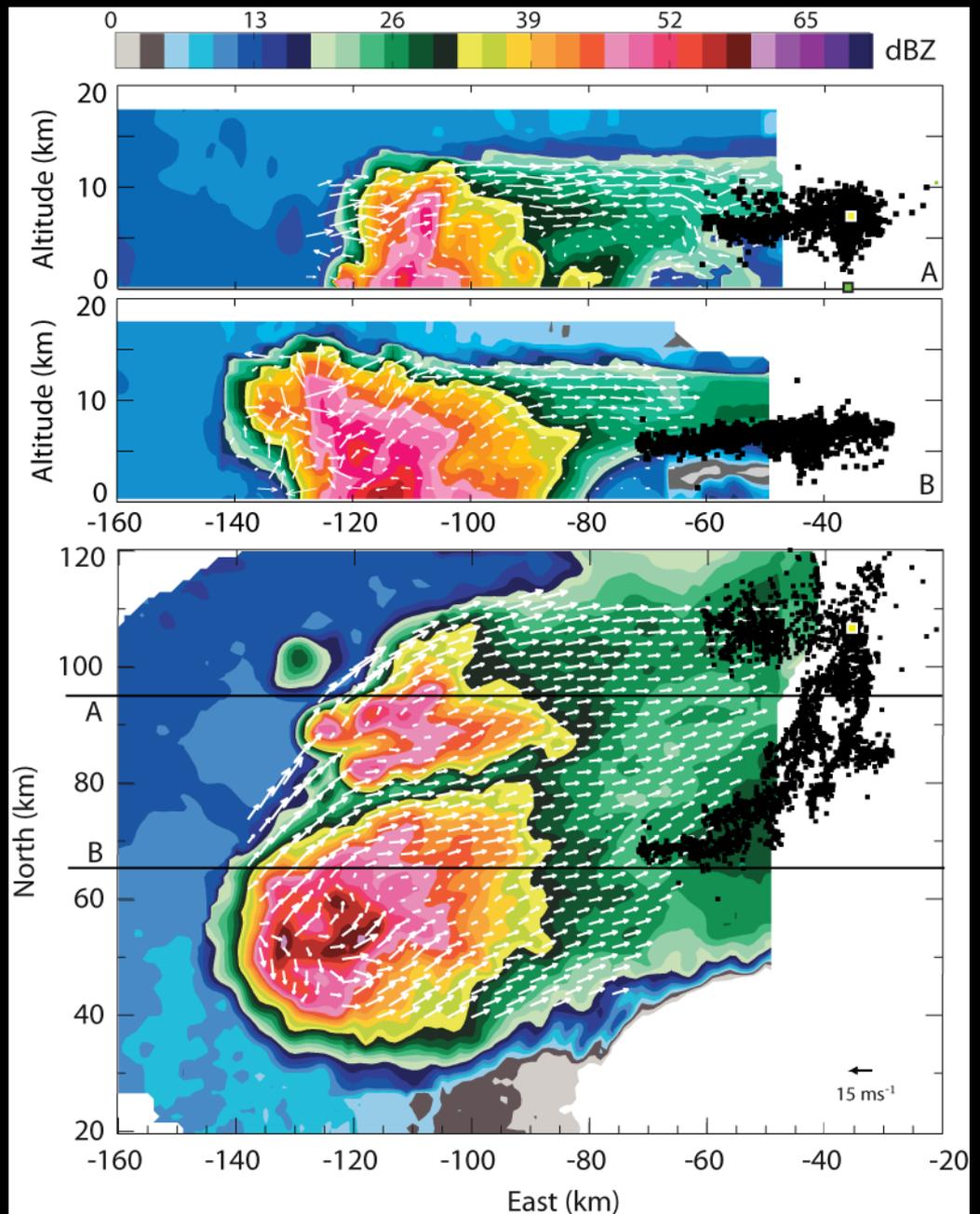


**24 May 2004**  
**22:59 UTC**  
**1 second**



# Lightning Initiation in a Supercell Anvil

29-30 May 2004  
2321:45.2-46.9 UTC

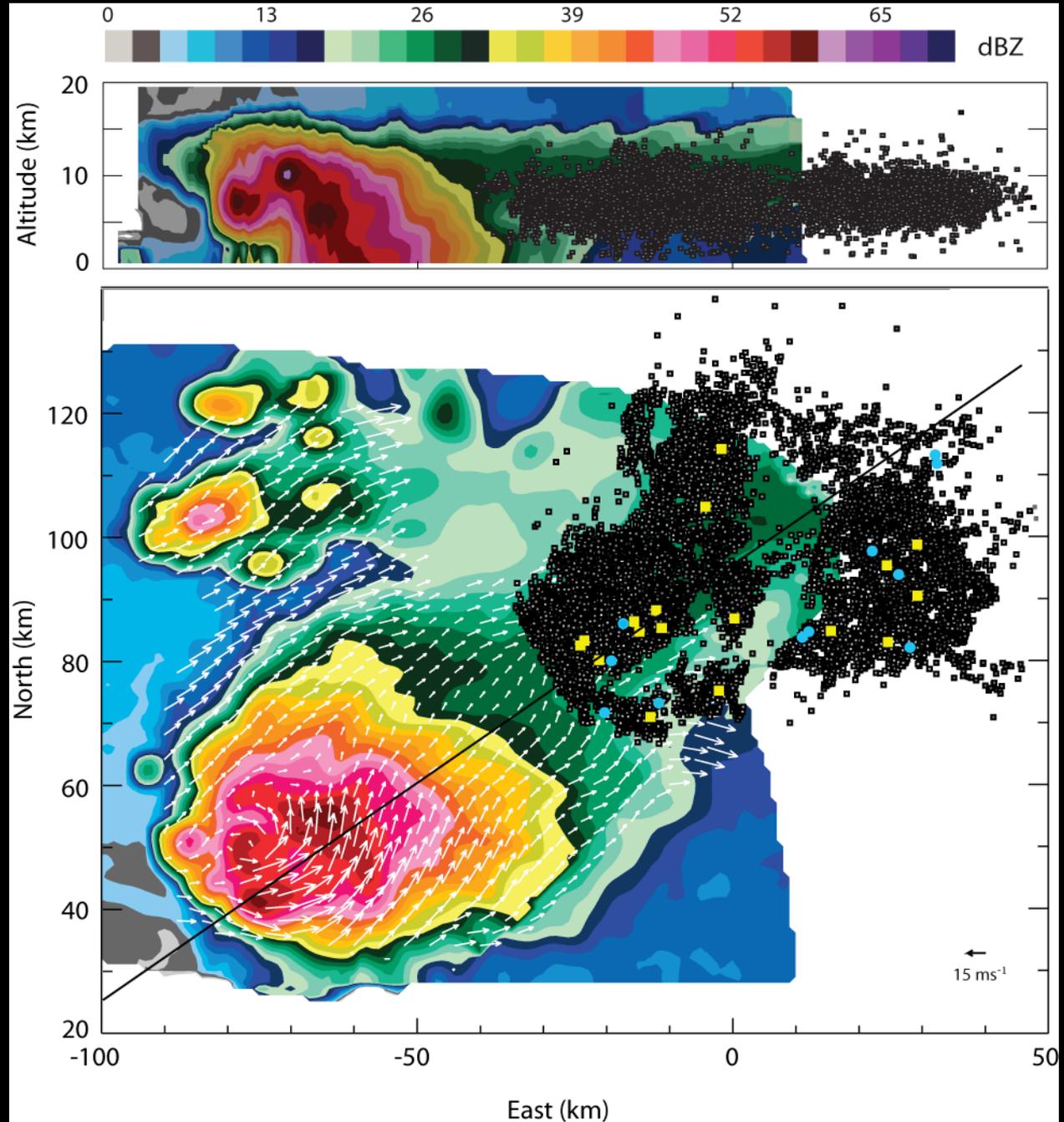


# Lightning in a Supercell Anvil

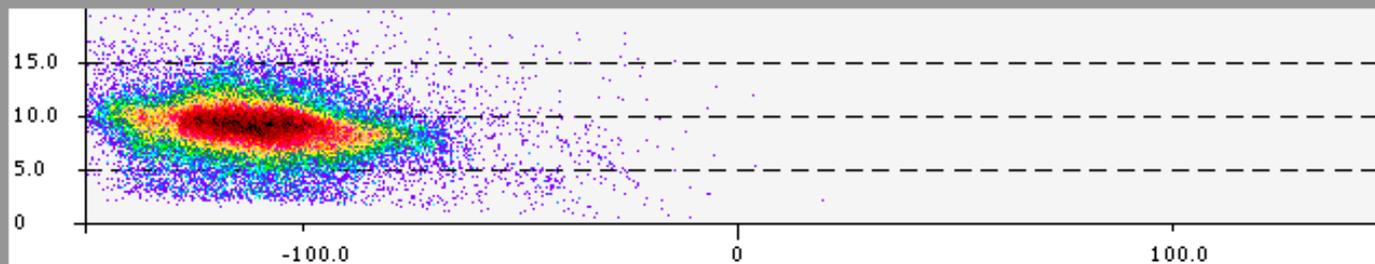
29-30 May 2004

LMA:  
2 min beginning  
0030:30 UTC

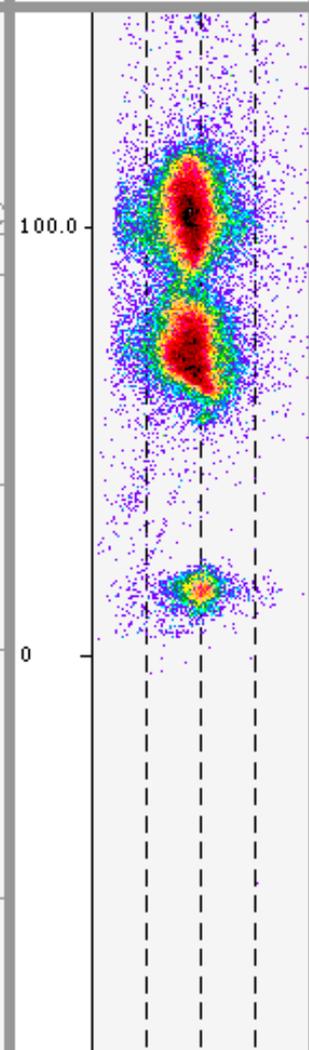
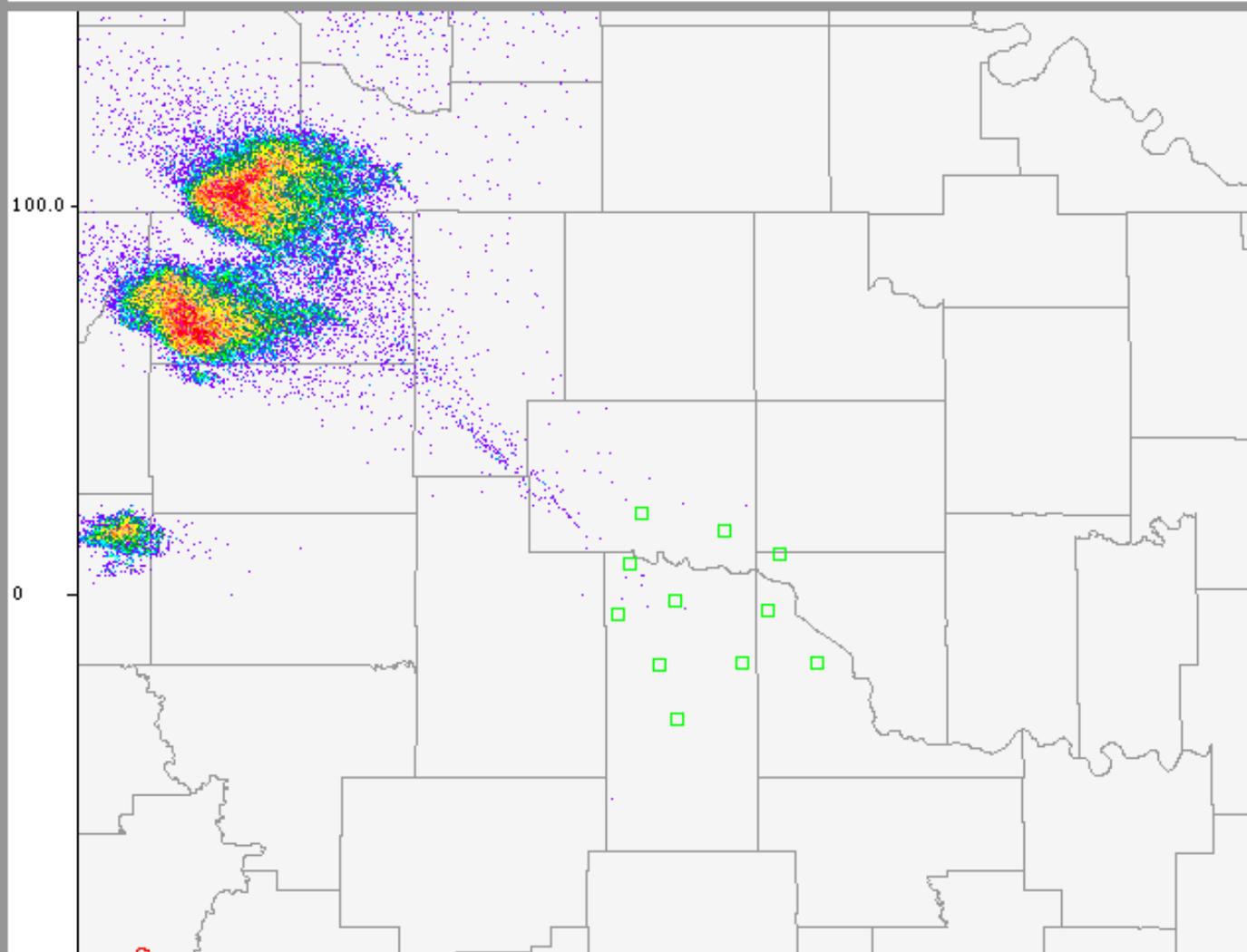
Radar:  
Beginning 0038 UTC



# Oklahoma Lightning Mapping Array 2200 UTC May 29, 2004



72081 pts



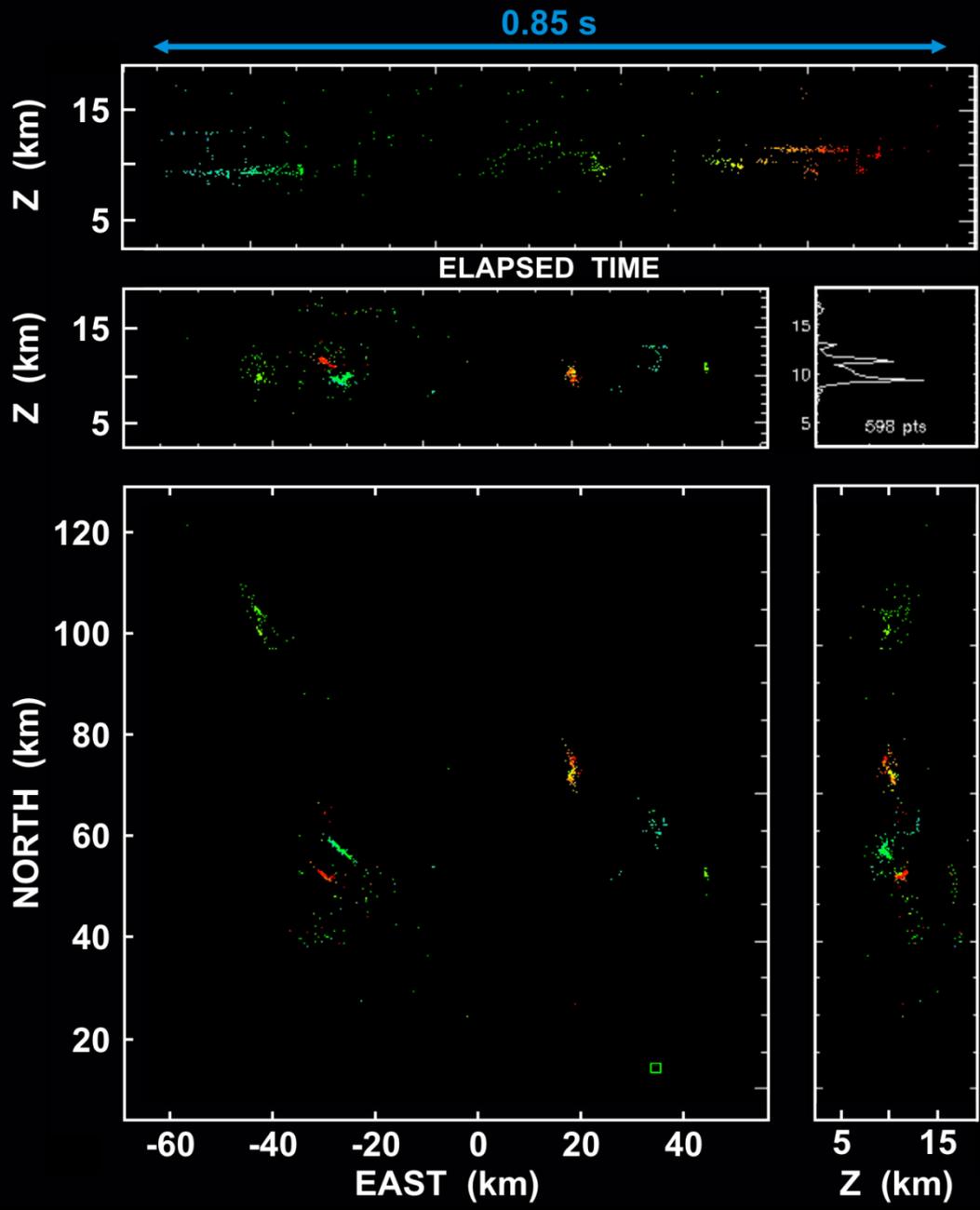
# Acknowledgments

## Other 2004 TELEX PI's and Field Investigators

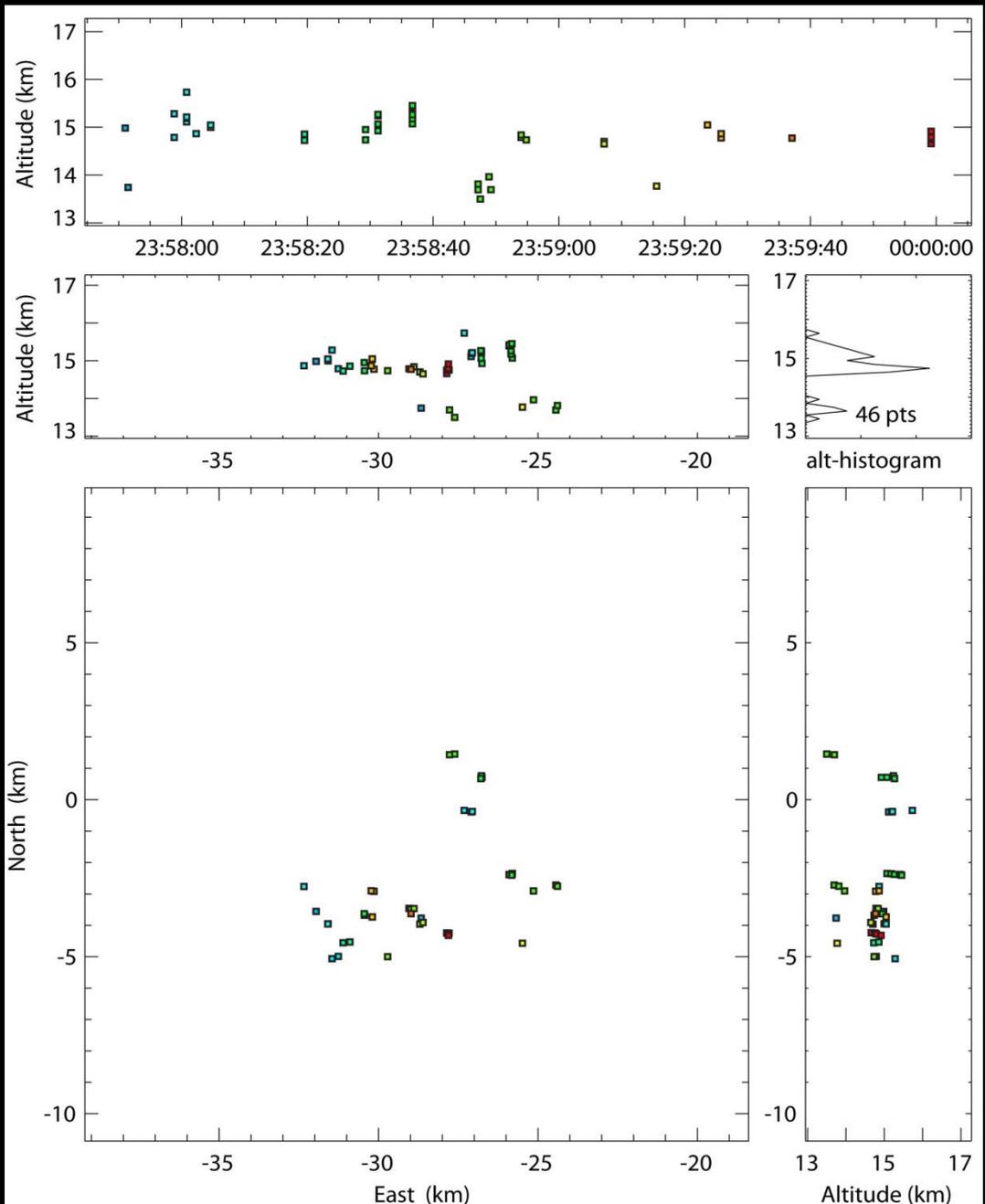
- New Mexico Tech: Bill Rison, Ken Eack
- NSSL: Conrad Ziegler
- CIMMS: Terry Schuur, Ted Mansell
- Univ. of Oklahoma/Meteorology: Jerry Straka, Bill Beasley, Nick Biermann, Gordon Carrie, Nicole Lund, Clark Payne, Stephanie Weiss, Scott Giangrande, and many undergraduate students

National Science Foundation: Grant # ATM-0233268

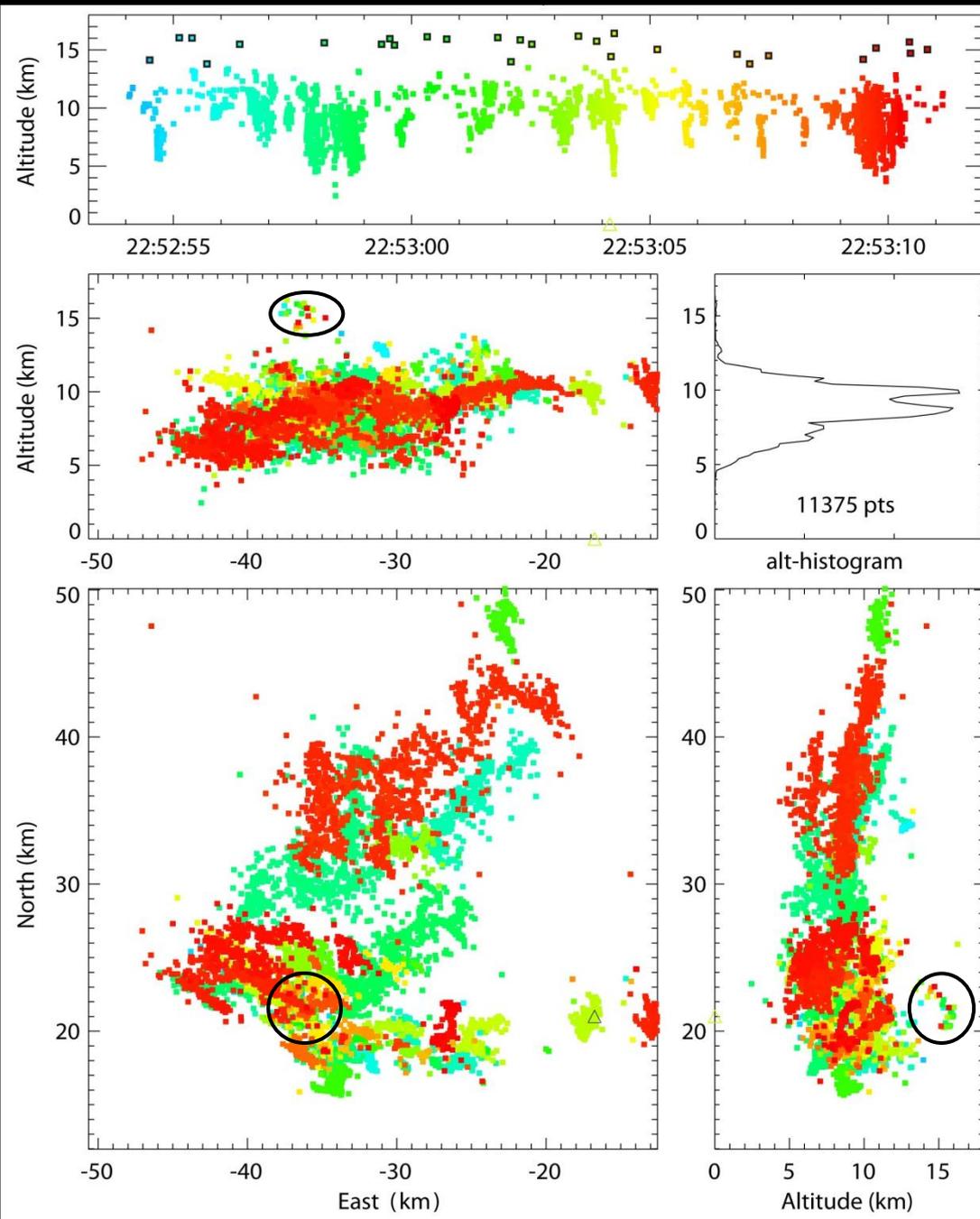
**LMA Mapped Points**  
**30 May 2004**  
**0010:21 UTC**



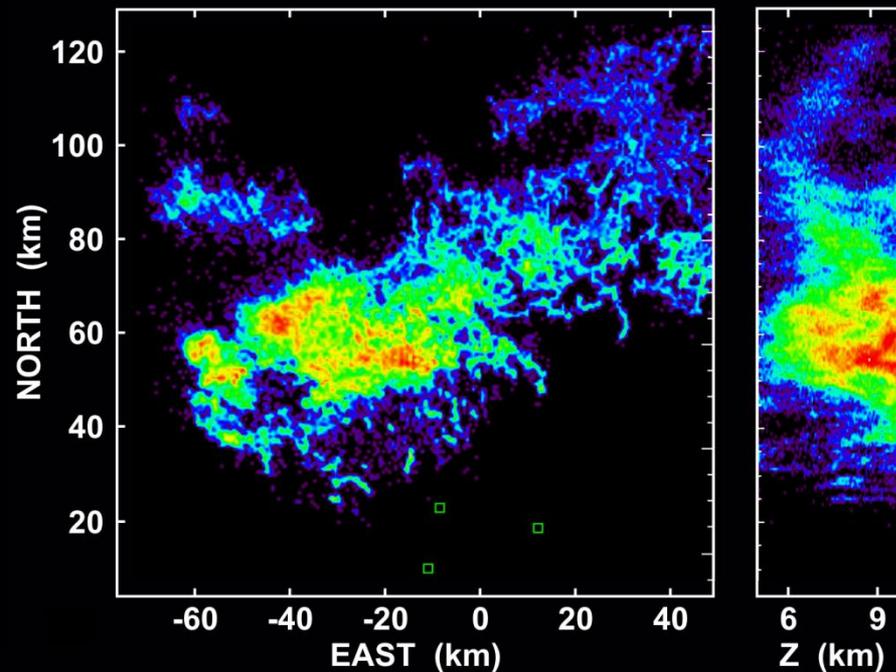
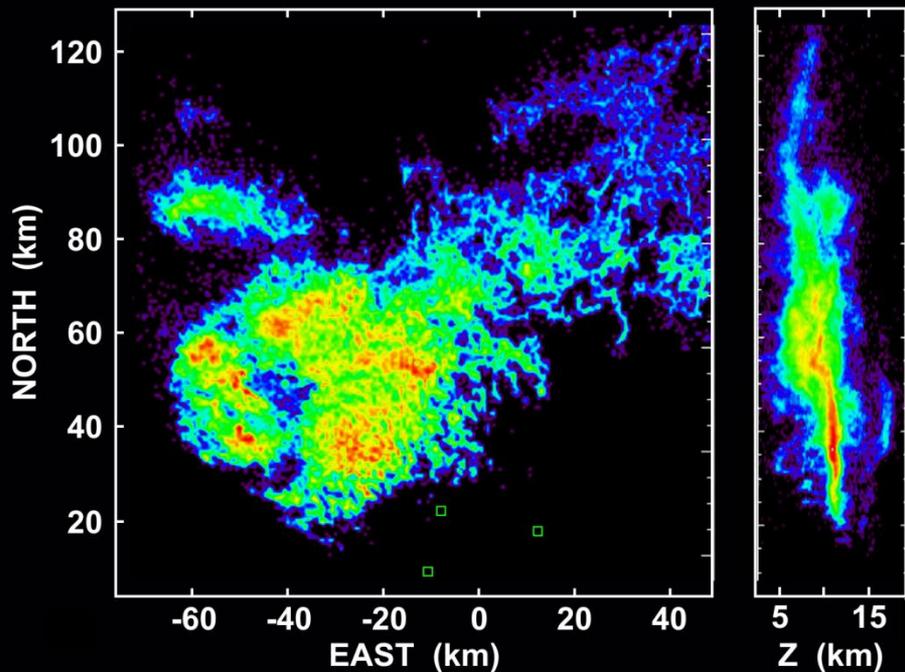
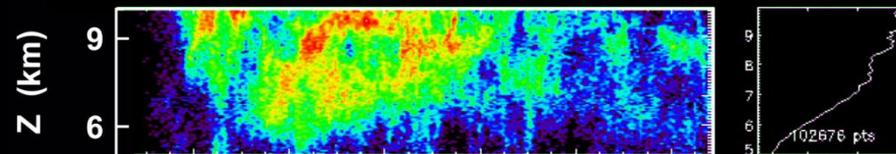
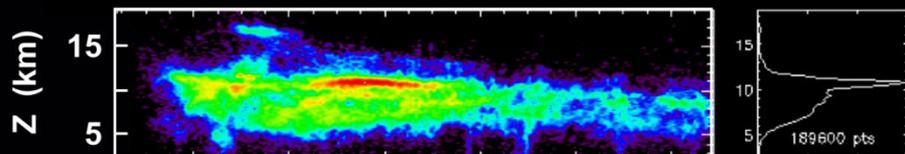
**24 May 2004**  
**23:58 UTC**  
**2.2 minutes**



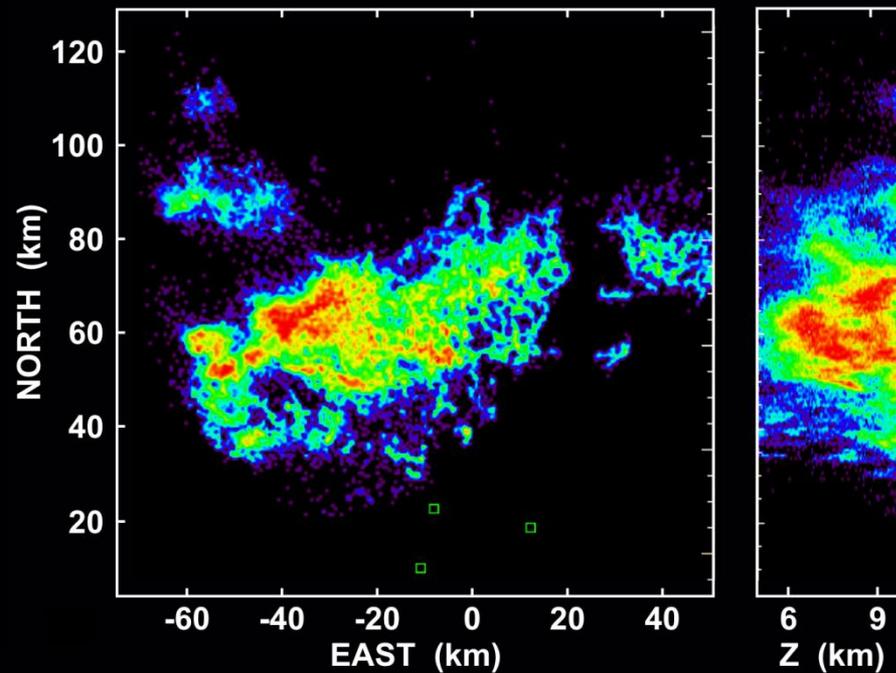
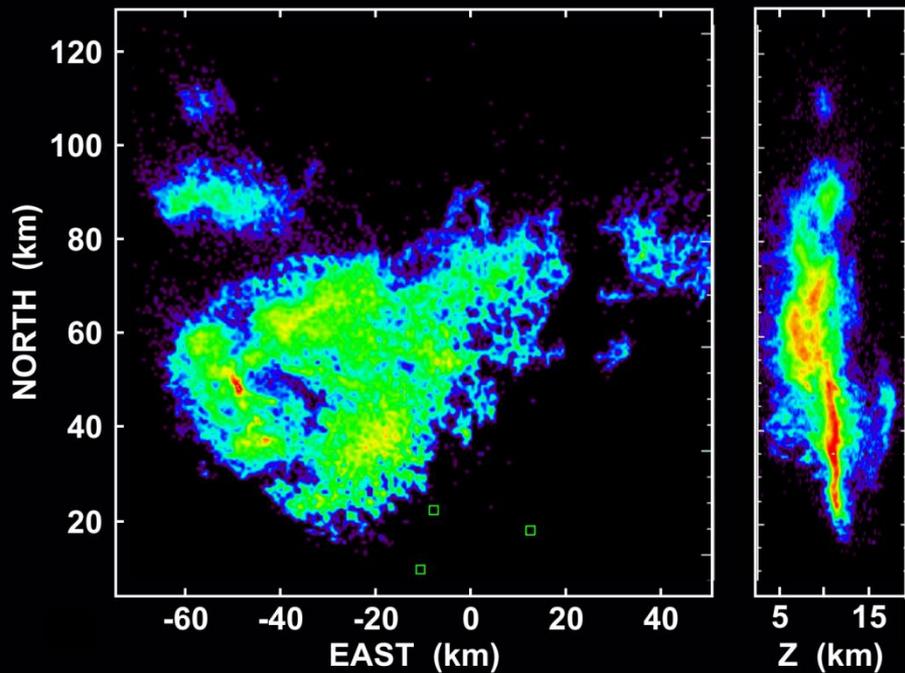
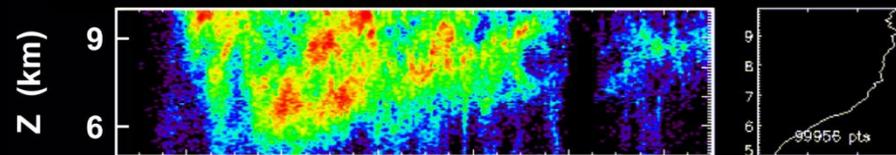
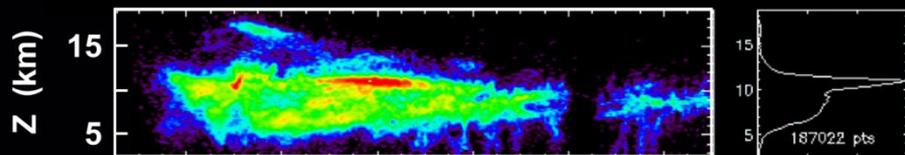
**26 May 2004**  
**22:53 UTC**  
**17 seconds**



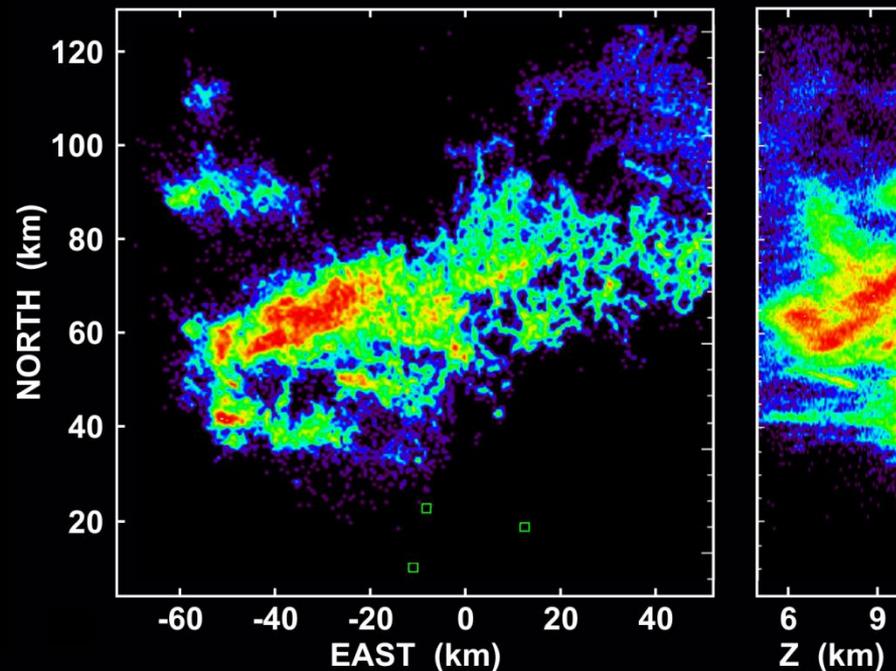
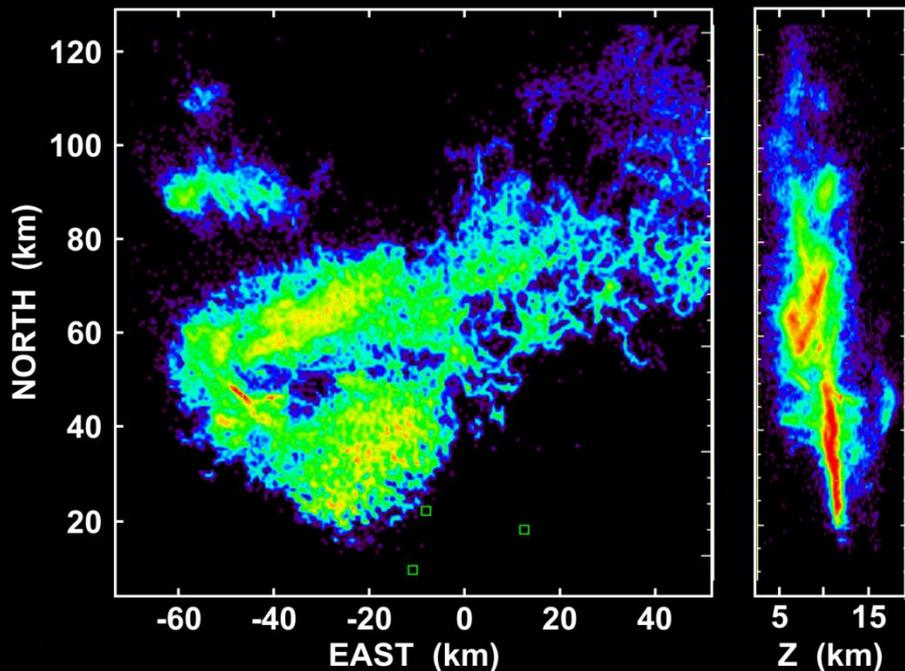
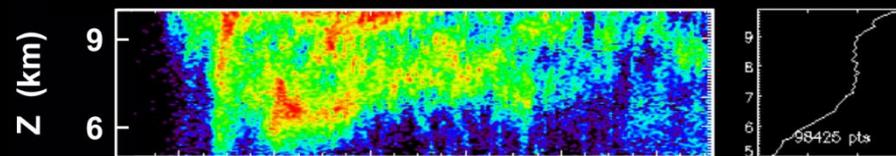
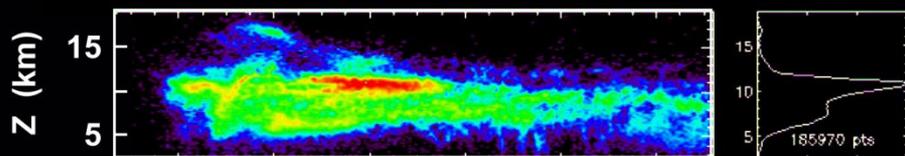
00:15:00 – 00:17:30 UTC



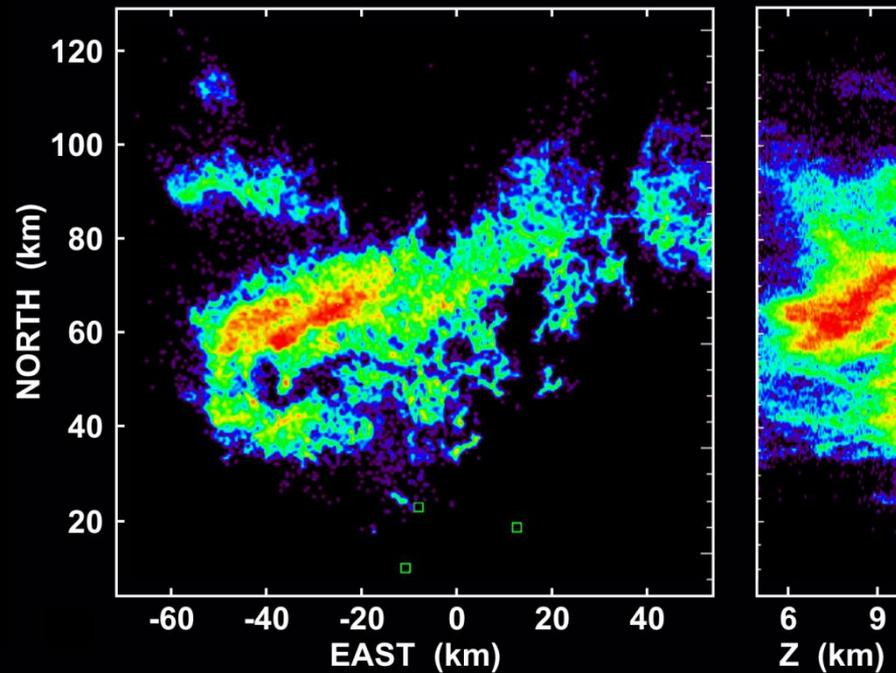
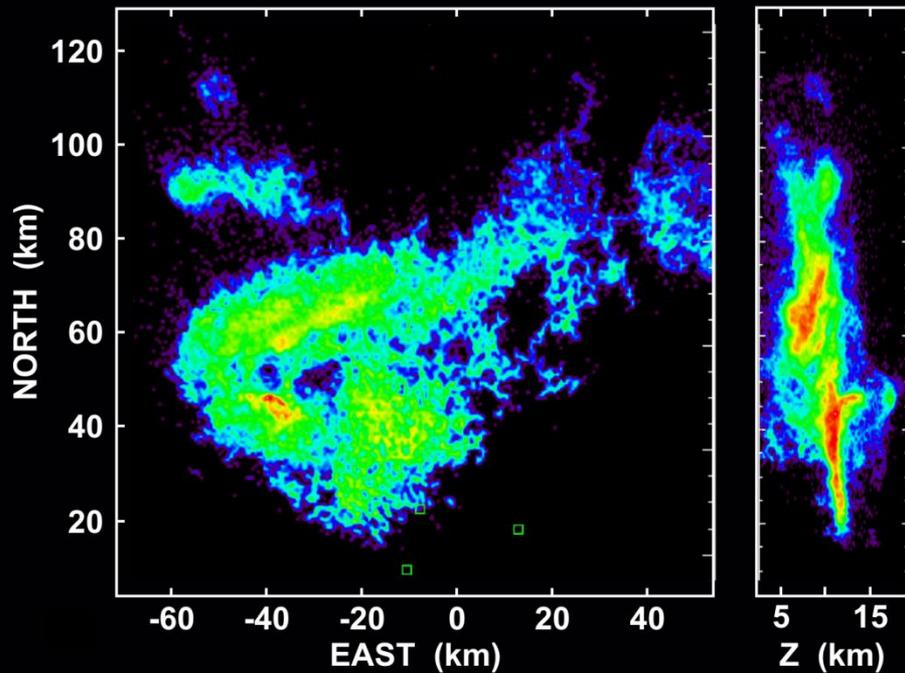
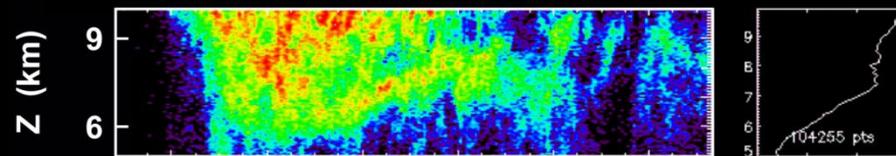
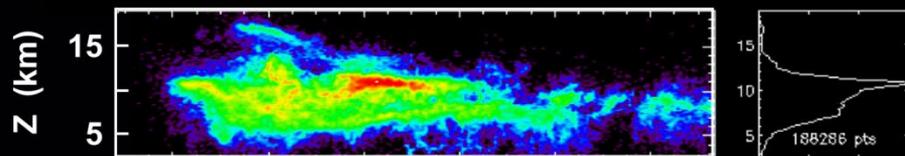
00:17:30 – 00:20:00 UTC



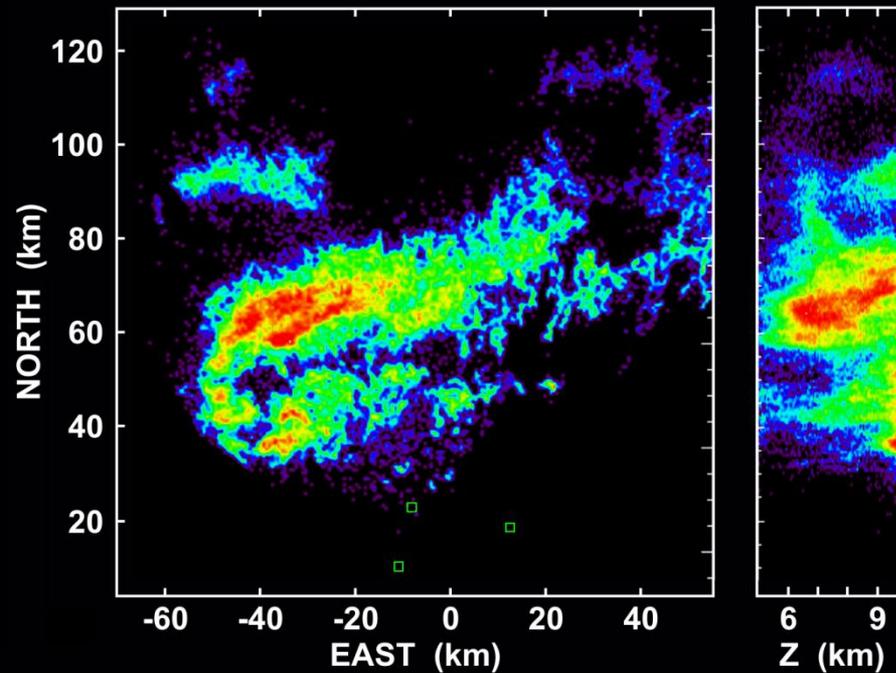
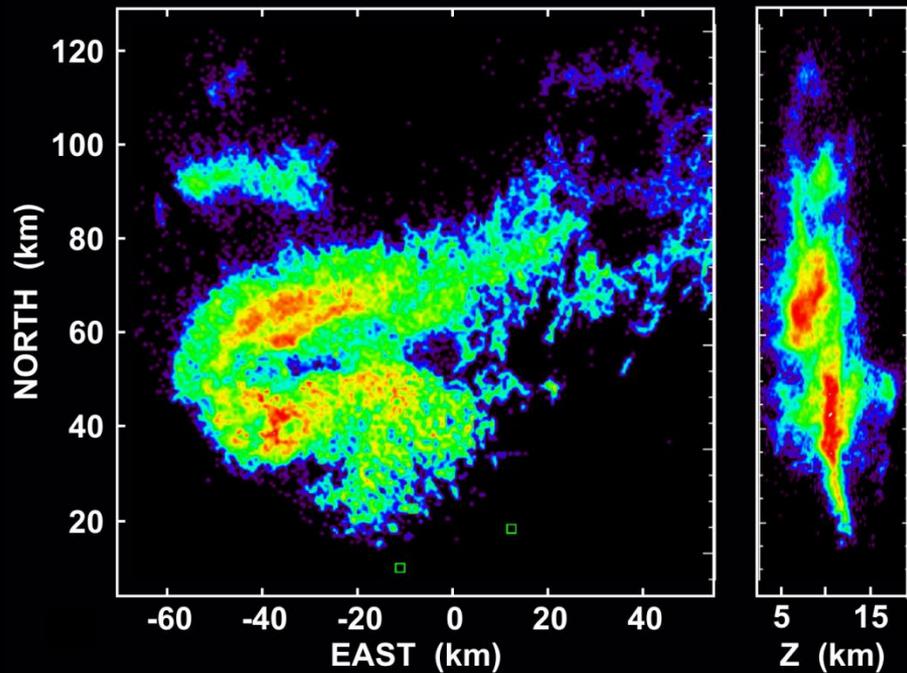
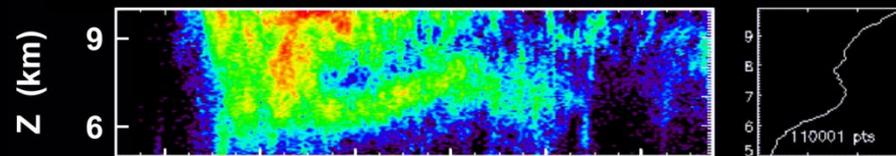
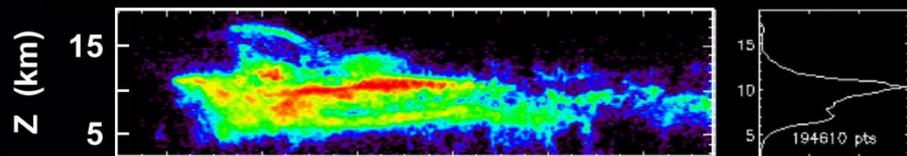
00:20:00 – 00:22:30 UTC



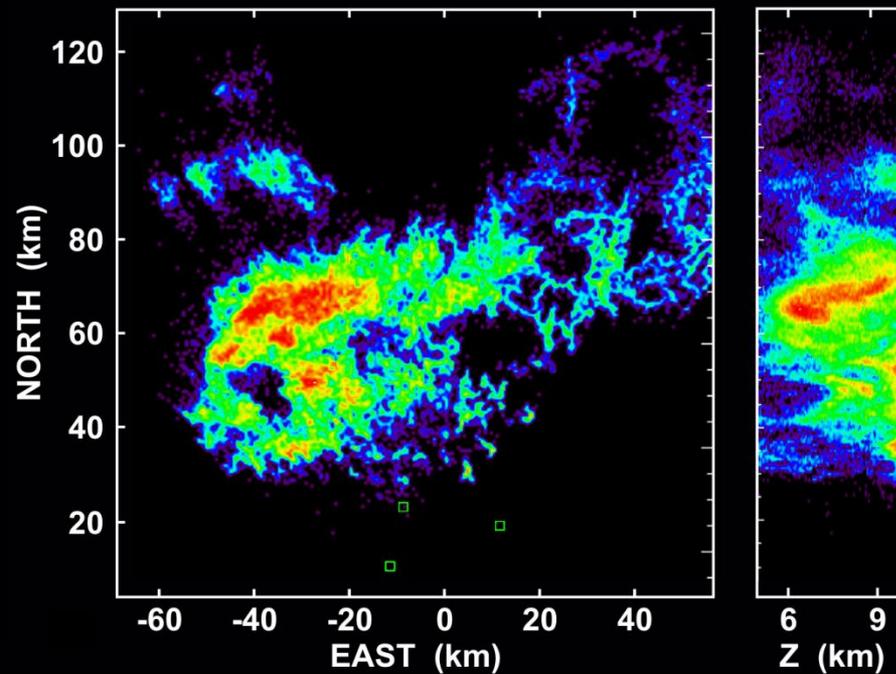
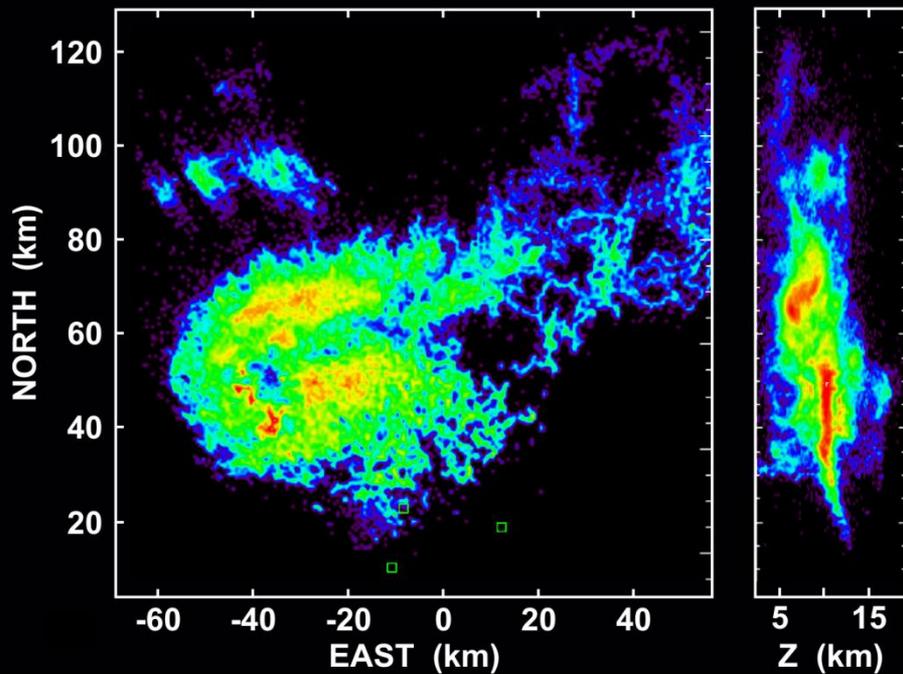
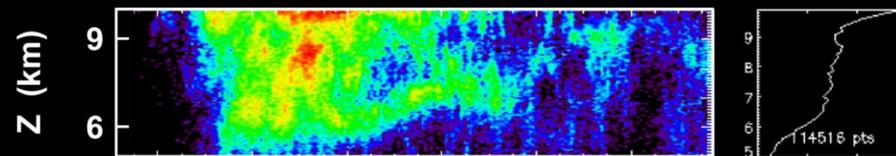
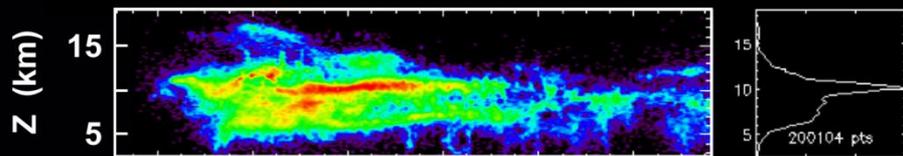
00:22:30 – 00:25:00 UTC



**00:25:00 – 00:27:30 UTC**

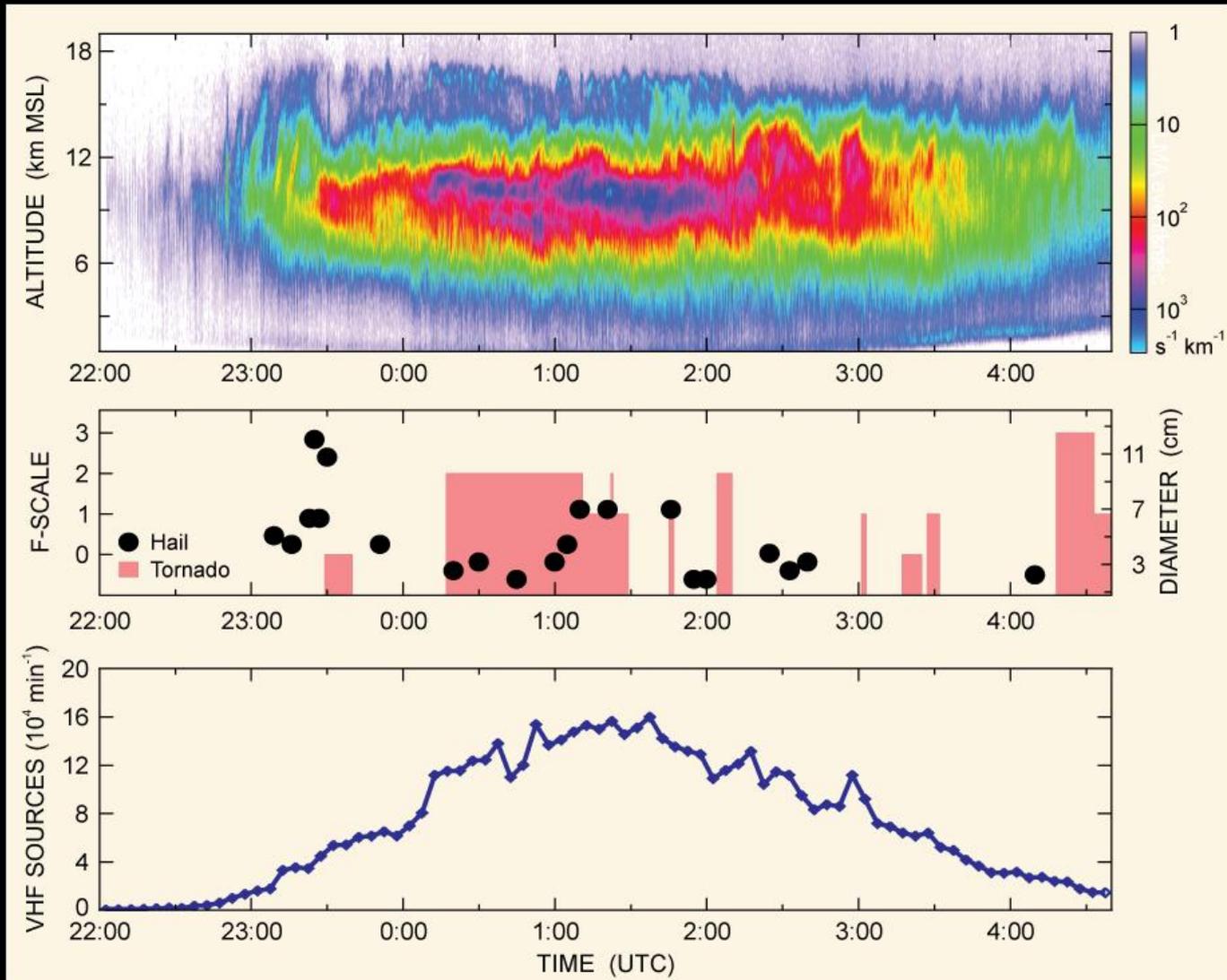


00:15:00 – 00:17:30 UTC

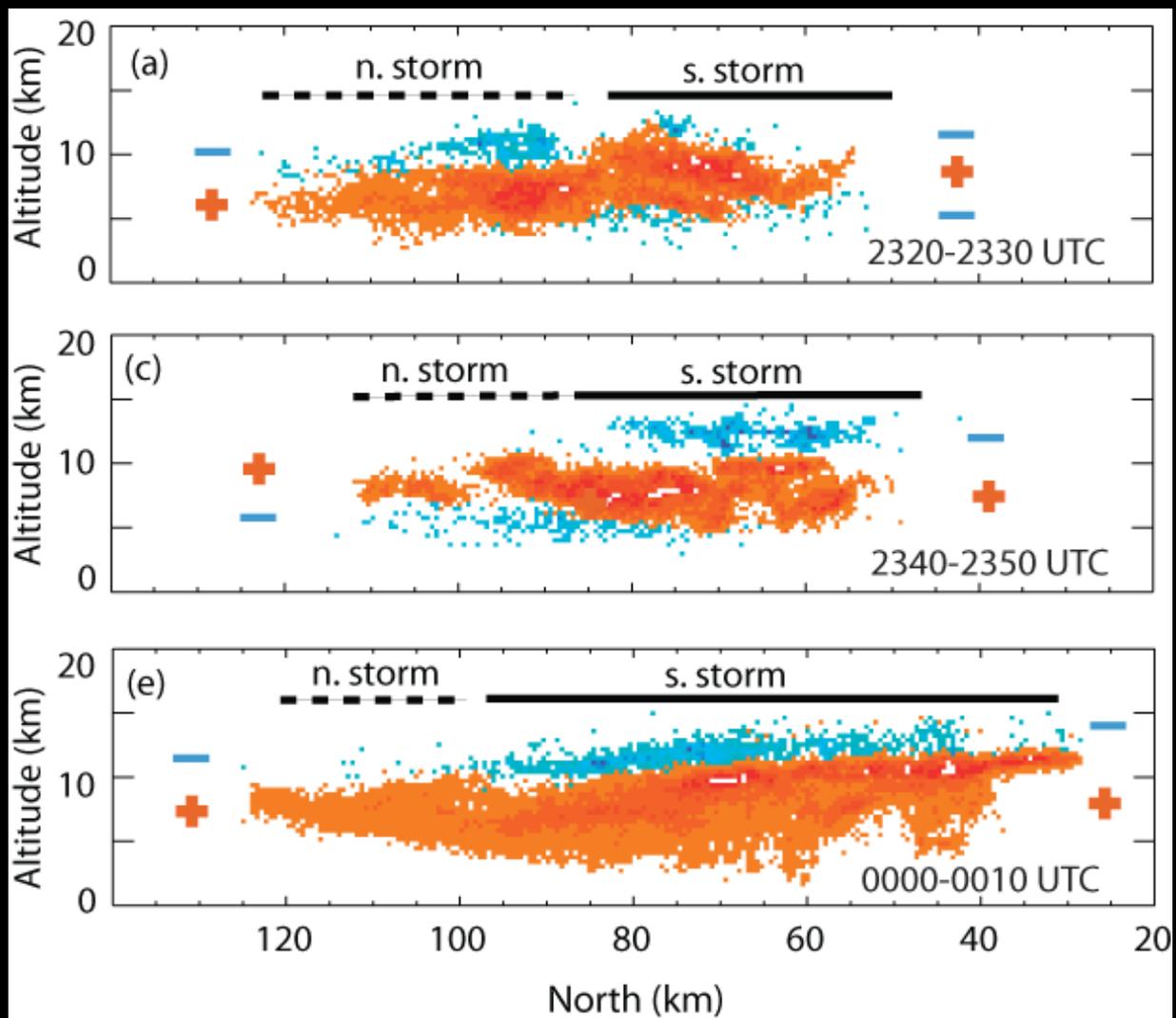


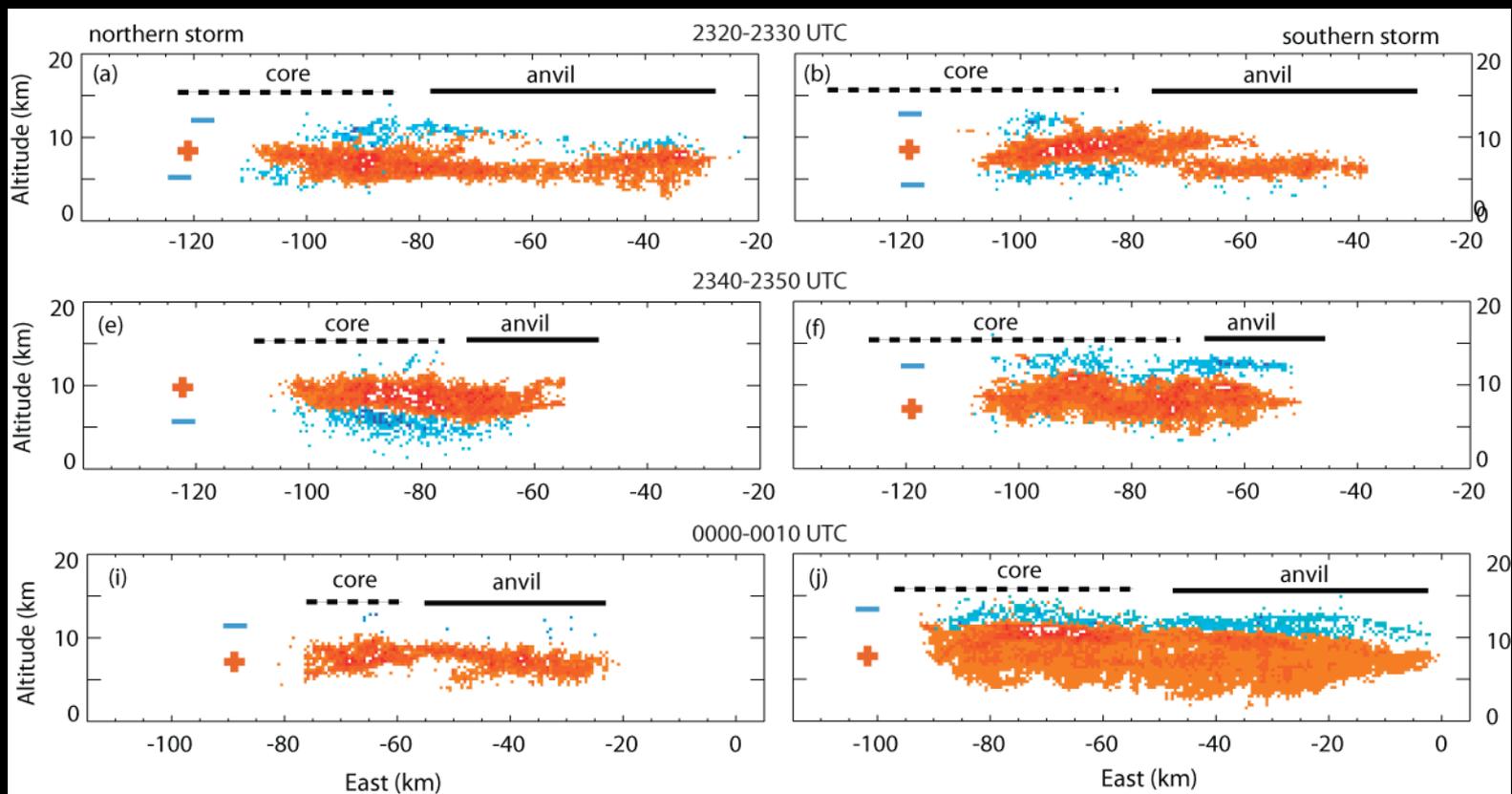
# 29-30 May 2004

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



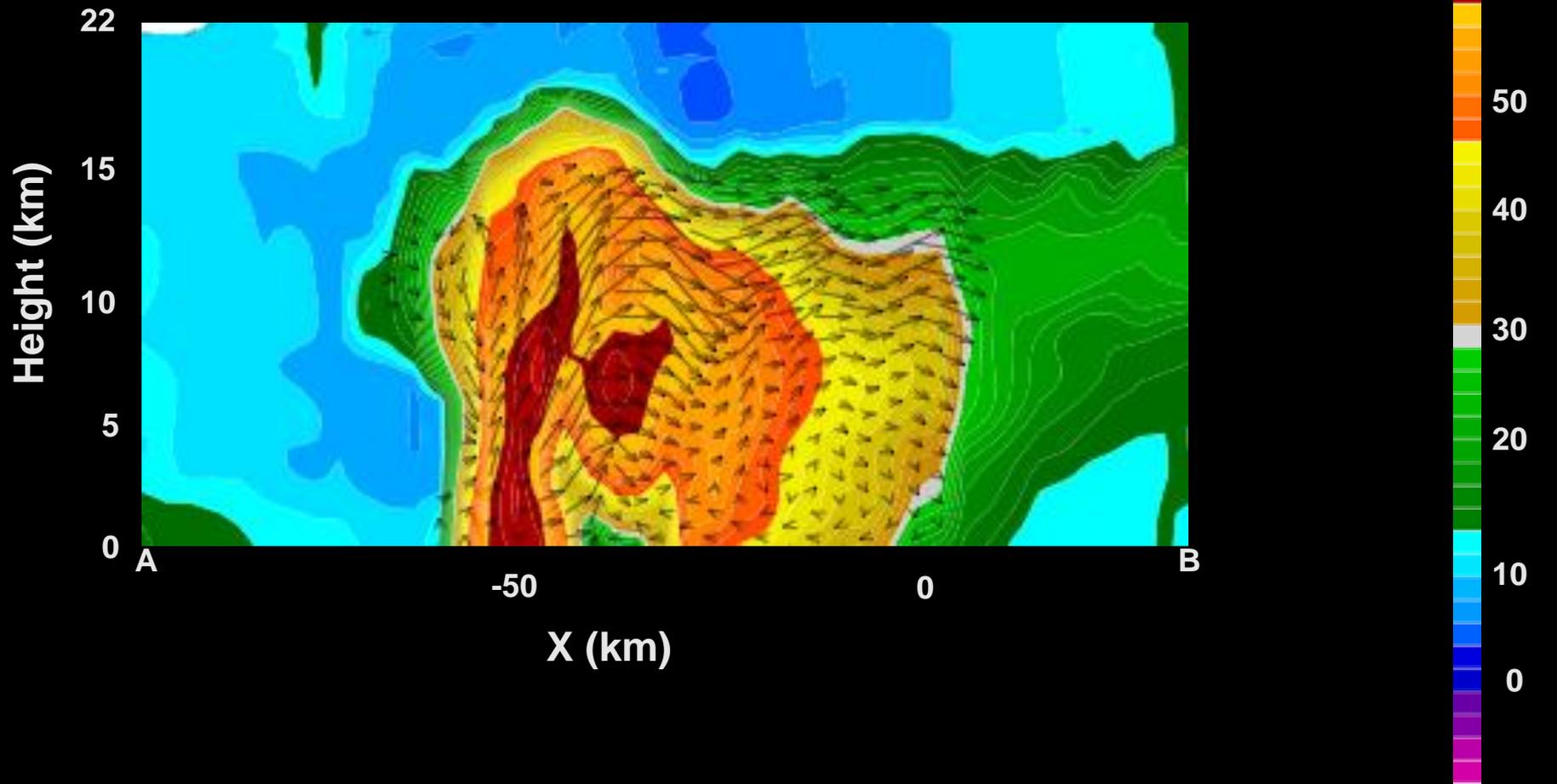
\*number of mapped VHF sources in whole storm per unit altitude





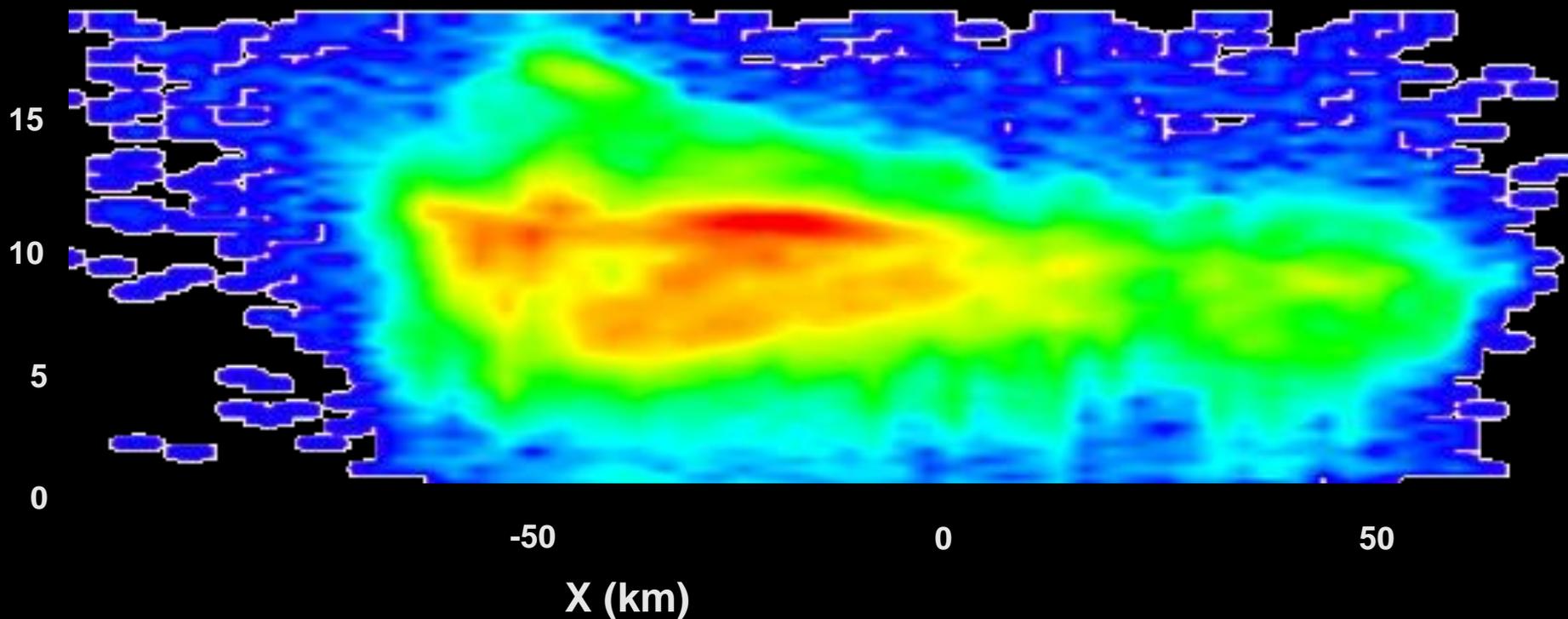
# Dual-Doppler (X-Z)

0016:45 - 0018:32 UTC

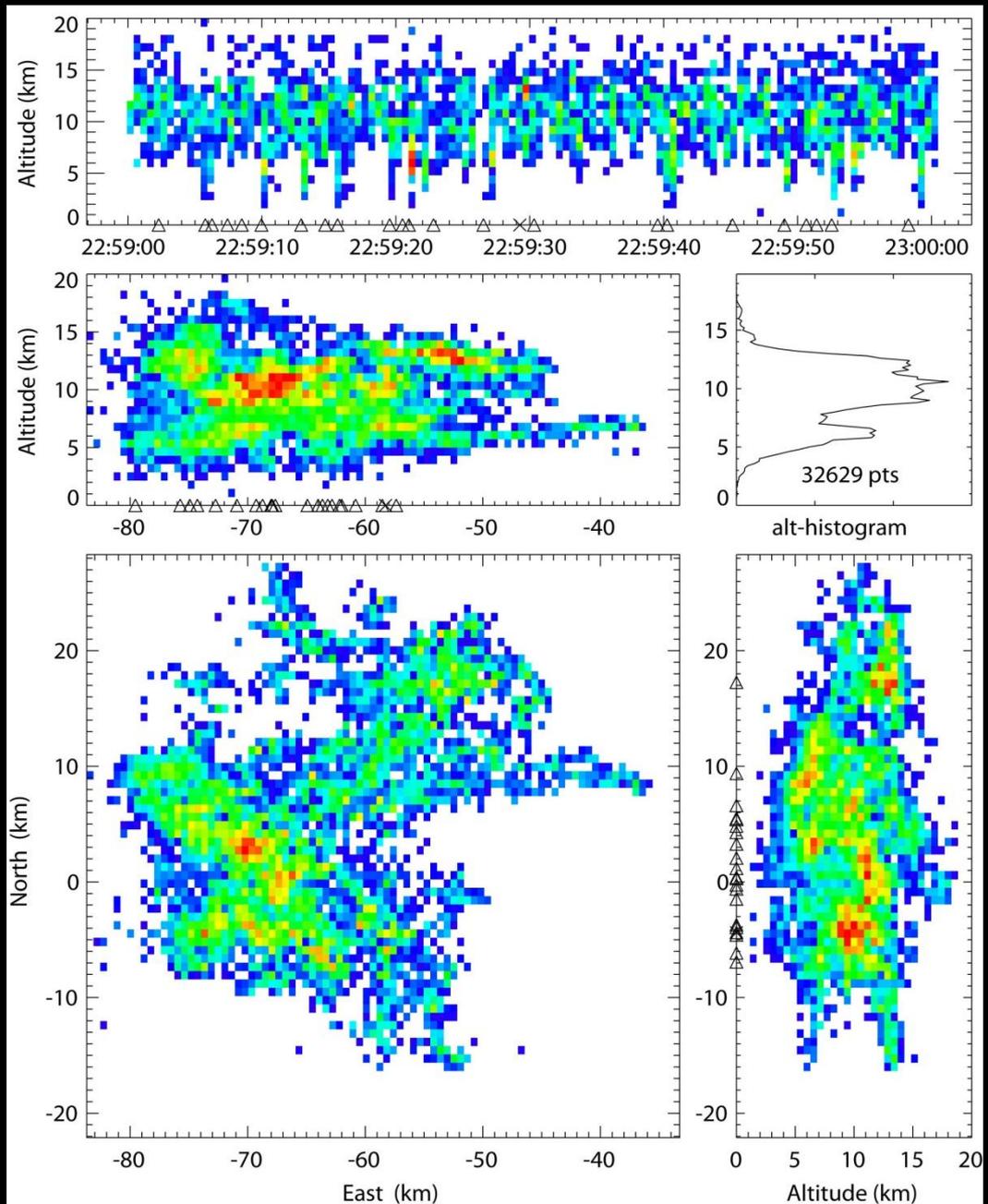


# LMA Event Density

0015 - 0020 UTC



**24 May 2004**  
**VHF source density**  
**22:59 UTC**  
**1 minute**

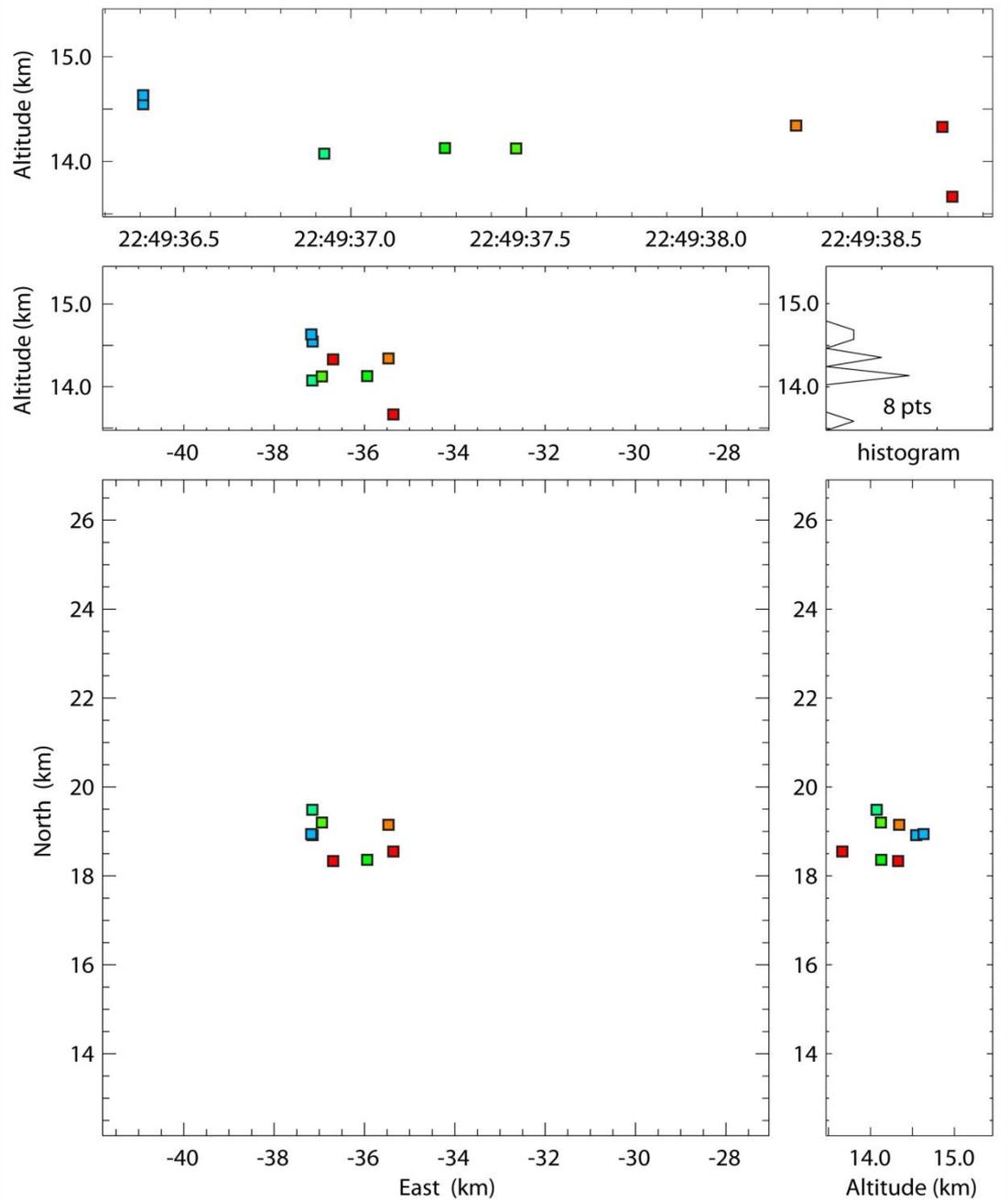


**26 May 2008**

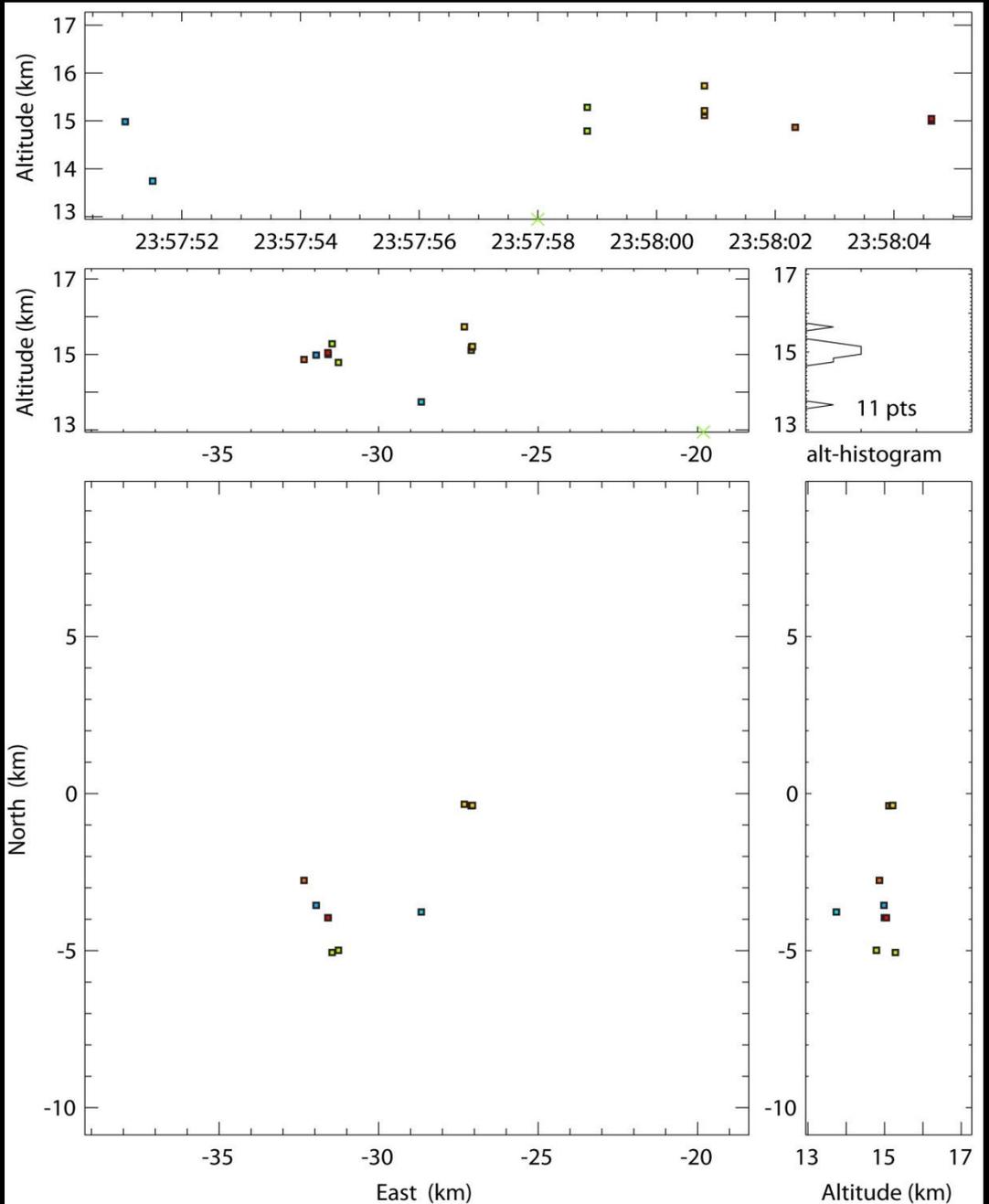
**22:49 UTC**

**5 seconds**

**High Points Only**



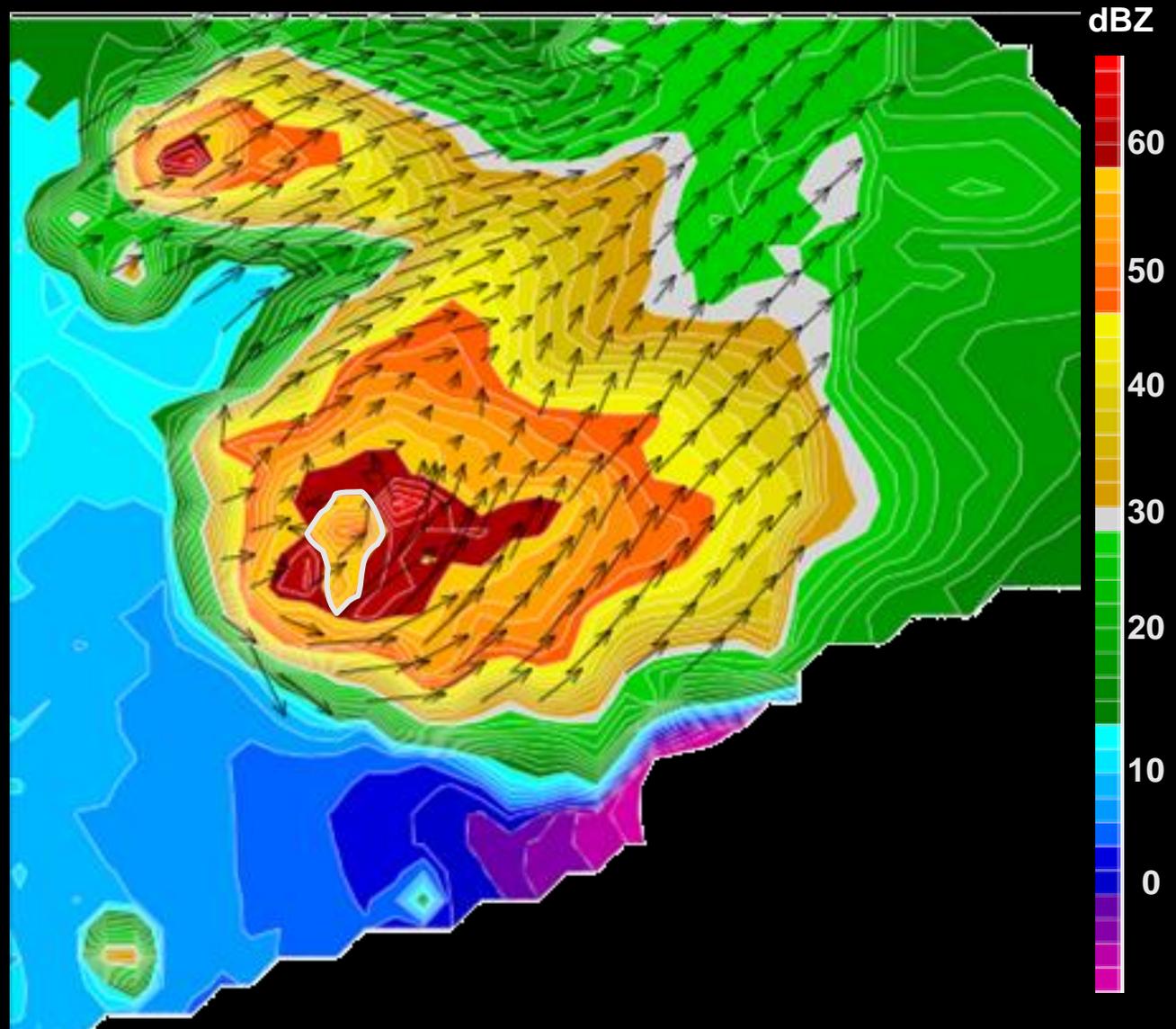
**24 May 2004**  
**23:57:52 UTC**  
**14 seconds**



# Dual-Doppler Analysis

0016:45 -  
0018:32 UTC

Height: 6.8 km

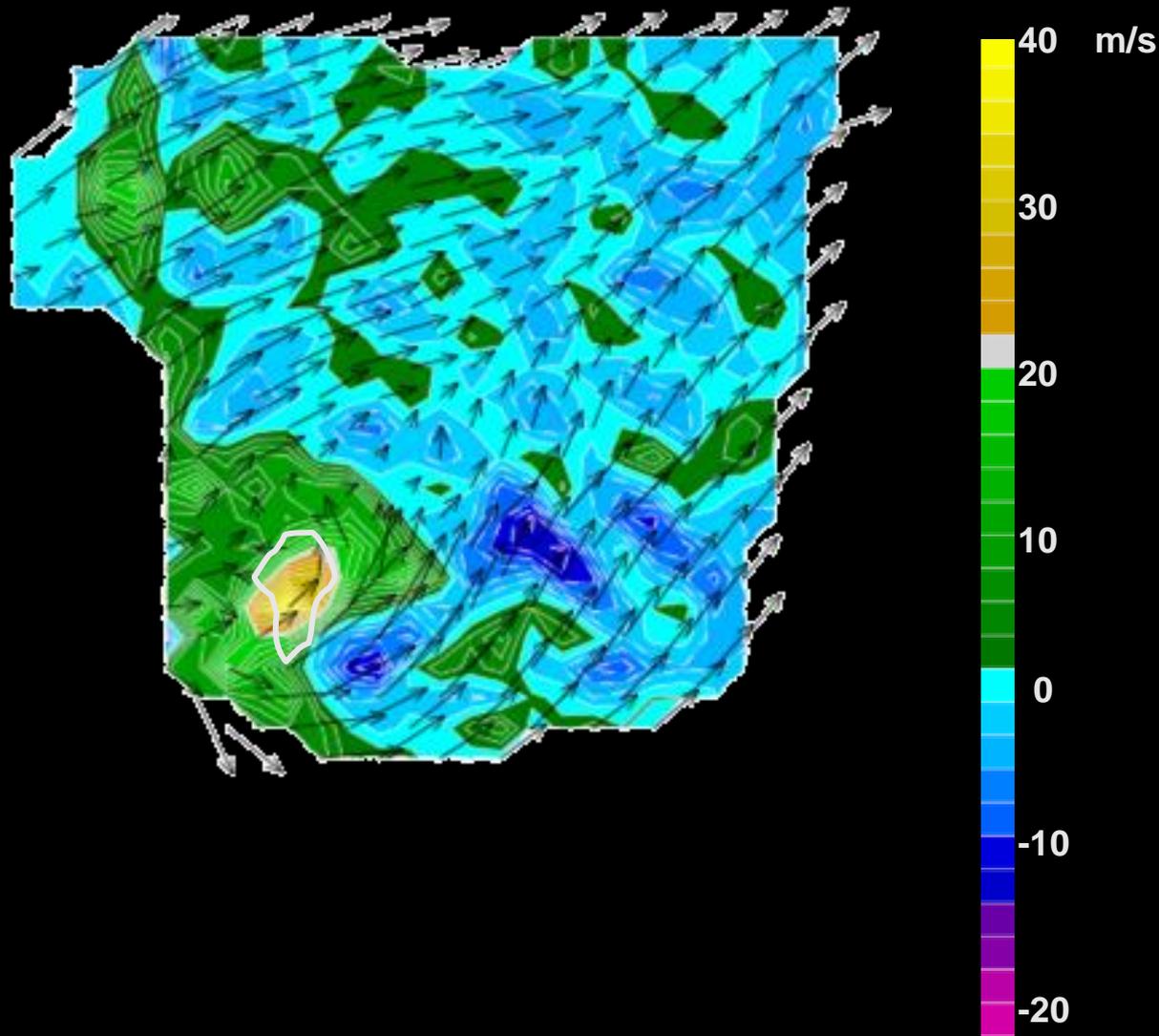


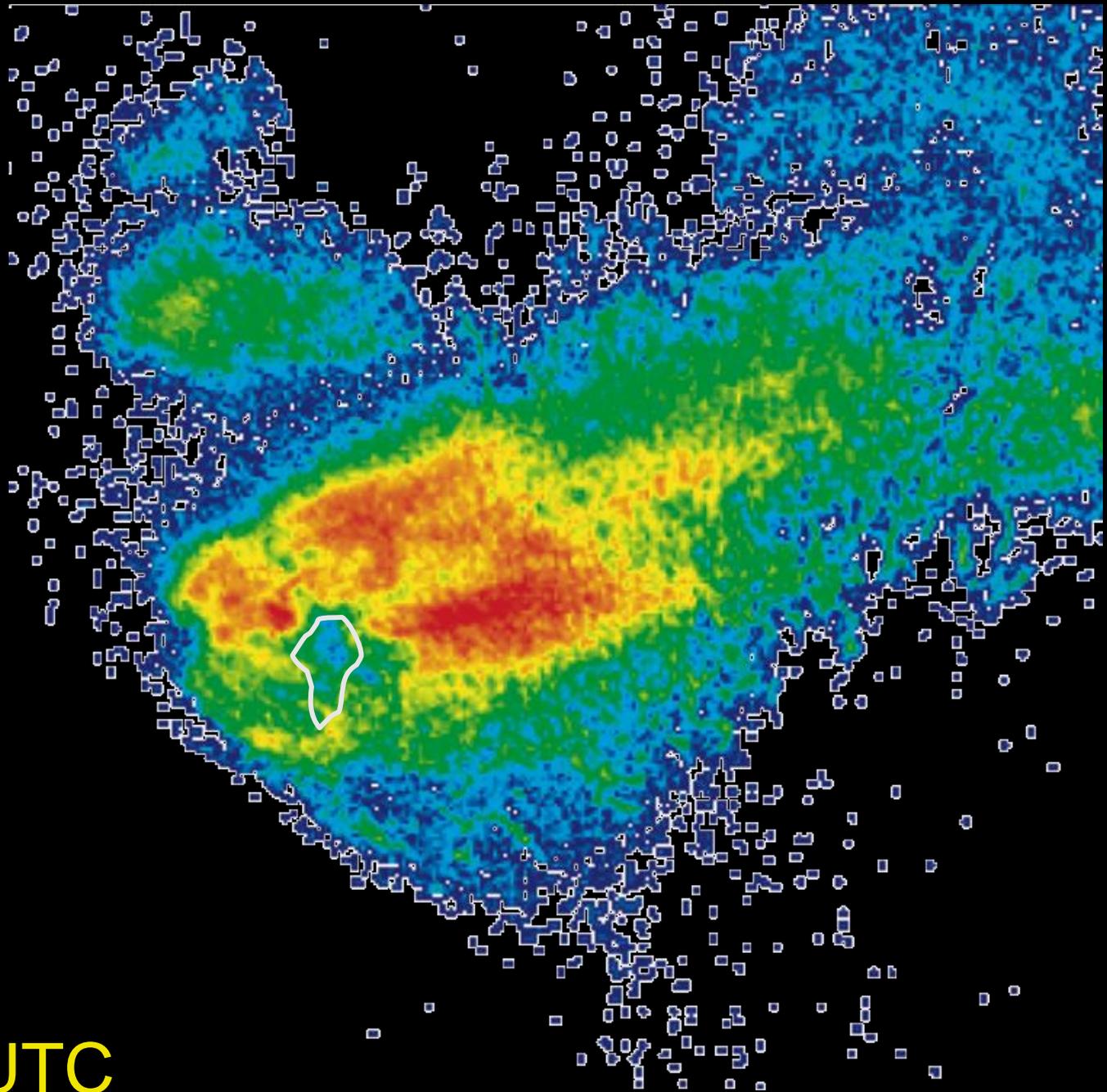
# Dual-Doppler Analysis

0016:45 -  
0018:32 UTC

Height: 6.8 km

max w = 39 m/s





# LMA Event Density

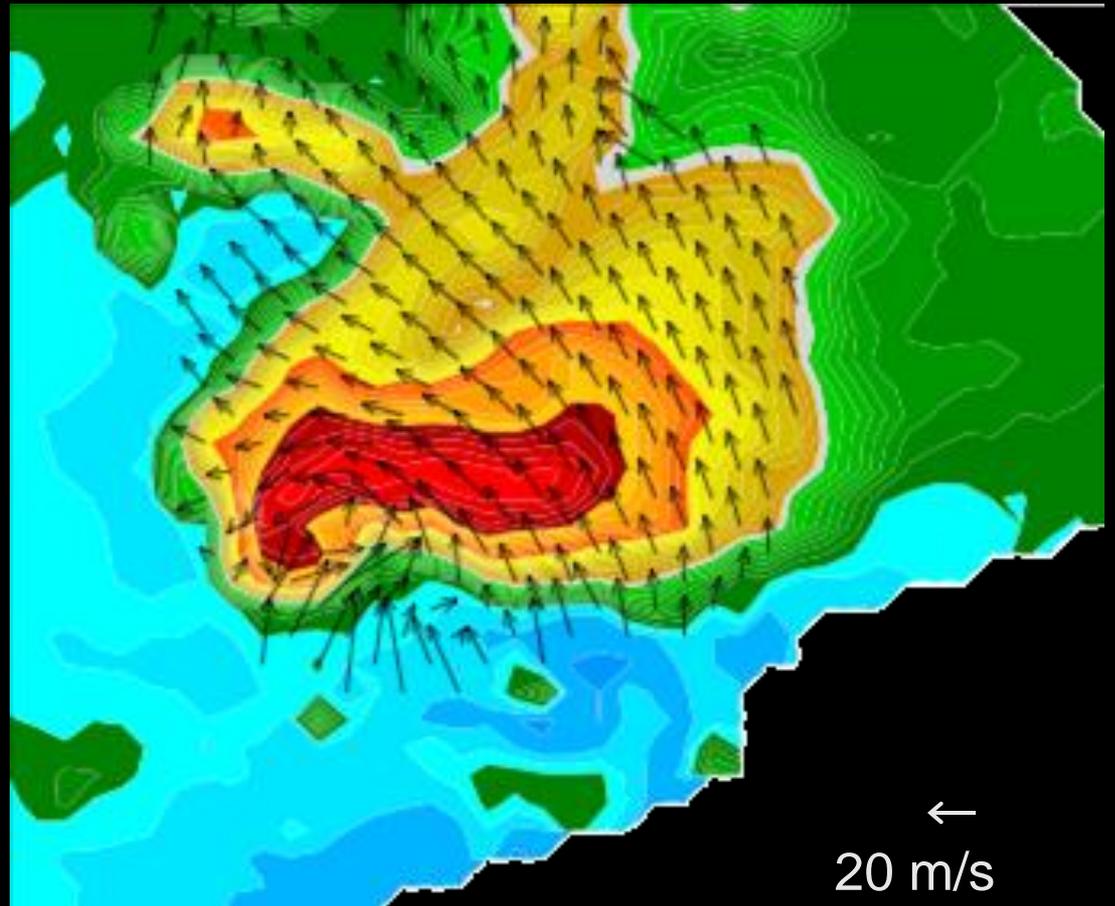
6-10 km

0015 - 0020 UTC

# Dual-Doppler Analysis

0016:45 - 0018:32 UTC

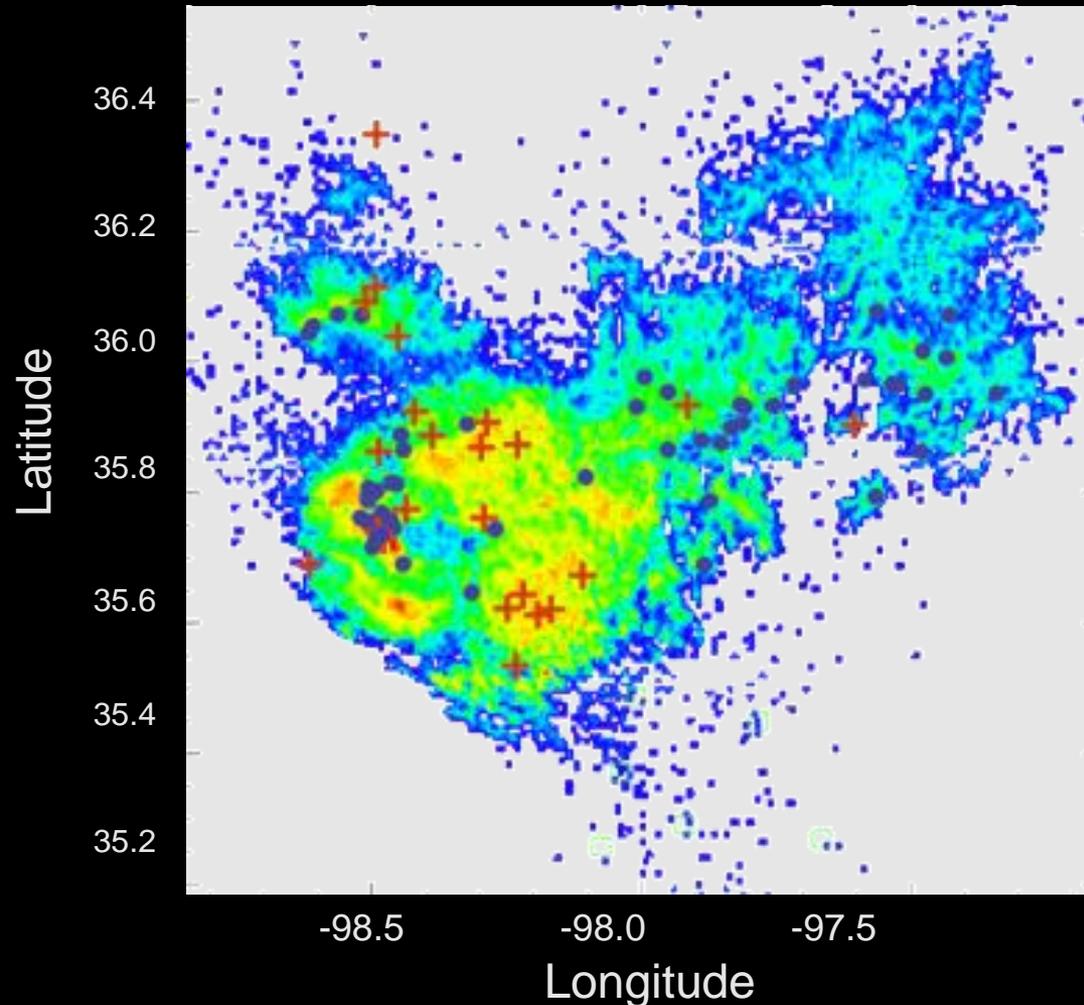
- Height = 0.8 km
- Strong inflow into the storm from the south (> 30 m/s)
- Pronounced circulation, hook echo
- Reflectivity greater than 65 dBZ
- Analysis at the time of tornadogenesis



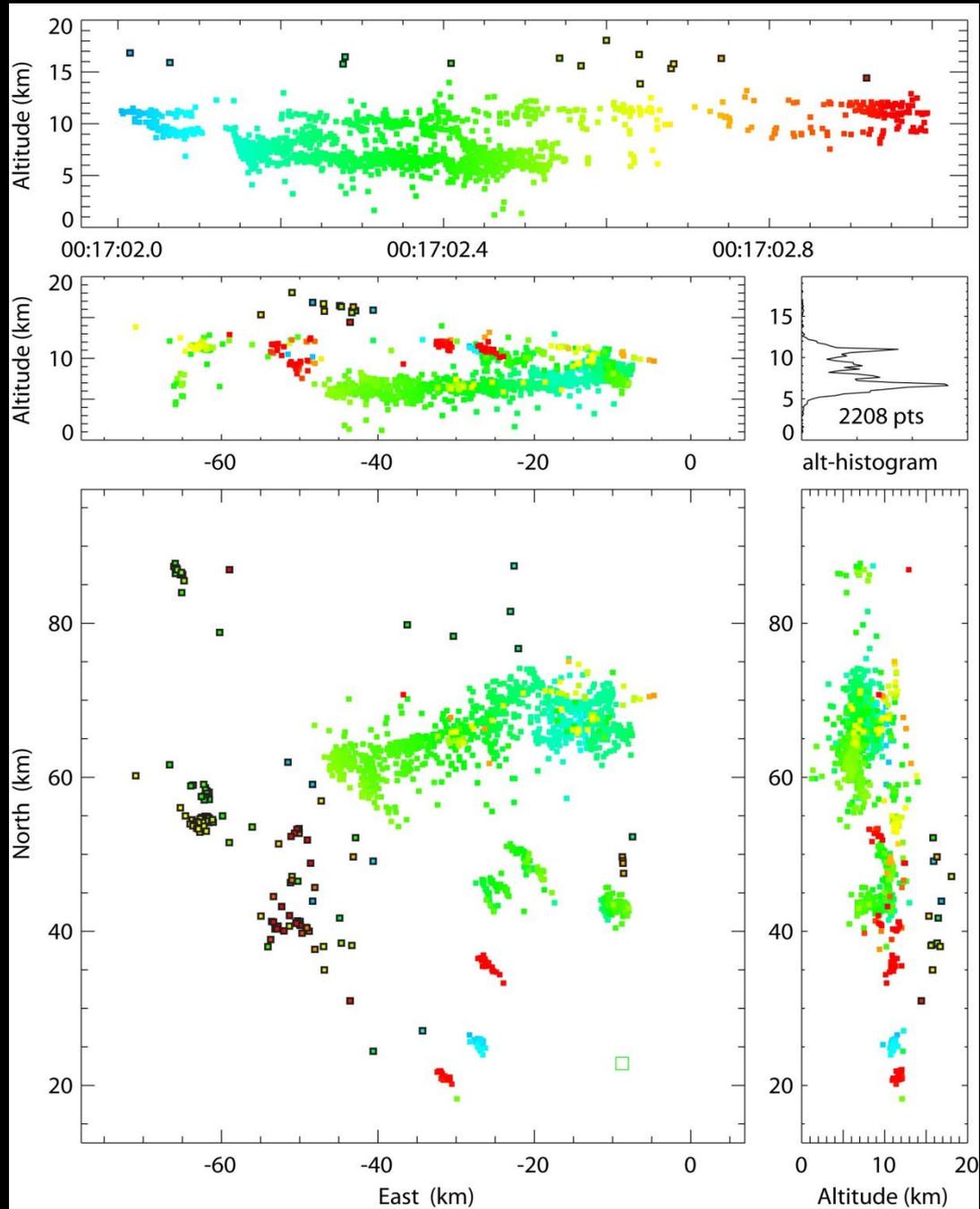
# LMA Density & NLDN CG strike locations

## 0015-0020 UTC

- CG's cluster in areas of peak activity in LMA
- -CG's in anvil
- +CG dominate in southern part of storm and in hook echo region
- No CG's in lightning weak region which is coincident with the updraft core

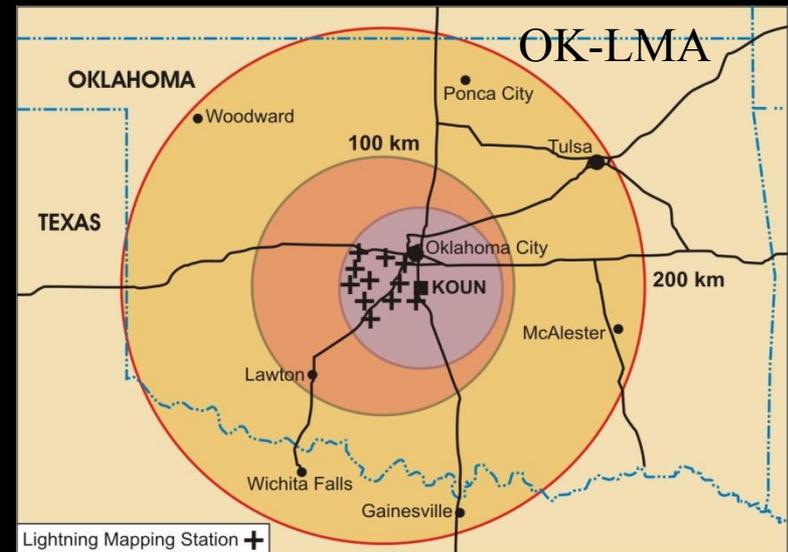


**30 May 2004**  
**00:17:02 UTC**  
**1 second**



# Thunderstorm Electrification & Lightning Experiment (TELEX)

- Spring 2003 / 2004 in central Oklahoma
- Instrumentation:
  - Lightning Mapping Array
  - Balloon-borne Electric Field Meter
  - Polarimetric 10-cm Radar
  - Two Mobile 5-cm Radars (SMART-R)
- Determine how lightning relates to storm's evolving microphysics, winds, and structure
- Supercell storms and mesoscale convective systems were two main subjects



# Dual-Doppler Analysis

0016:45 - 0018:32 UTC

- SMART (Shared Mobile Atmospheric Research and Teaching) Radars
  - 5 cm wavelength
  - ~ 2 min to scan through all elevation angles ( $0.5^\circ$  -  $33.5^\circ$ )
  - 20 m/s Nyquist velocity
- Used Barnes objective analysis scheme to grid radar data using reorder (Trapp and Doswell, 2000)
- NWS: F-2 tornado began at 0017 UTC near Geary, OK

