RAPID-SCAN, POLARIMETRIC, MOBILE DOPPLER RADAR OBSERVATIONS AT X-BAND OF AN EF-5 TORNADO IN OKLAHOMA ON 24 MAY 2011

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ERAD 2012
28 June 2012

RCS 041
Toulouse, France

SW of El Reno, OK

MOTIVATION FOR POLARIMETRIC RAPID SCAN

• TORNADOES HAVE SHORT (~ 10 s) ADVECTIVE (ORBIT) TIME SCALES

• DUAL-DOPPLER ANALYSIS: ERRORS INTRODUCED WHEN RADAR VOLUMES SCANNED NOT AT THE SAME TIME

• IDENTIFY MICROPHYSICAL PROCESSES IN THEIR PARENT SUPERCELLS: CAN VARY RAPIDLY

• LOCATE DEBRIS SIGNATURES: CAN VARY RAPIDLY

PURPOSE OF PRESENTATION:

1. DEMONSTRATE THAT RaXPol COLLECTS POLARIMETRIC DATA SUCCESSFULLY IN RAPID-SCAN MODE

2. SHOW UNIQUE WIND, REFLECTIVITY, AND POLARIMETRIC MEASUREMENTS AT CLOSE RANGE IN AN EF-5 TORNADO AND ITS PARENT SUPERCELL

RaXPol SYSTEM PARAMETERS

Parameter	Value
Center Frequency	9.73 GHz +-20 MHz
Transmit Power	20 kW peak, 200 W ave.
Transmit Pulse Width	0.1 – 40 us
Transmit Waveform	RF Pulse, Linear or Custom Chirp
Transmit Polarization	Equal Power V&H
PRF	Uniform or Staggered
Antenna type	Dual-linear Polarized Parabolic Reflector
Antenna Diameter	2.4 m
Antenna Beamwidth	1.0^{o} Half-power
Antenna Gain	44.5 dB
Pedestal Type	Elevation over Azimuth
Pedestal Scan Rate	180 deg s^{-1} Az, 36 deg s^{-1} El
Receiver type	Dual-channel (V & H-pol)
Receiver Noise Figure	3 dB
Receiver Bandwidth	0.5 to 40 MHz, or Custom
Range Gate Spacing	7.5 to 75 m
IF Frequency	90 MHz
Digital Receiver	Dual-channel, 16 bit ADC
Dynamic Range	90 dB @ 1 MHz Bandwidth
Processor	Industrial PC, Dual Quad-core 2.66 GHz Xeon
Clutter Filter	Coherent, User Defined Bandwidth

DESIGNED BY
ANDY PAZMANY, PROSENSING, INC.

• RADAR TRANSMITS UNIFORMLY SPACED PULSE PAIRS, OR STAGGERED 3 PULSE GROUPS, WHILE SHIFTING THE FREQUENCY OF EACH GROUP BY THE PULSE BANDWIDTH NECESSARY TO ENSURE THE SAMPLES ARE INDEPENDENT

• AT 180^{0} s^{-1} SCAN SPEED, DATA ACQUISITION CONFIGURED TO AVERAGE FOR 5 ms, TO ACQUIRE DATA FROM 12 PULSE PAIRS, EACH SPACED 200 μs

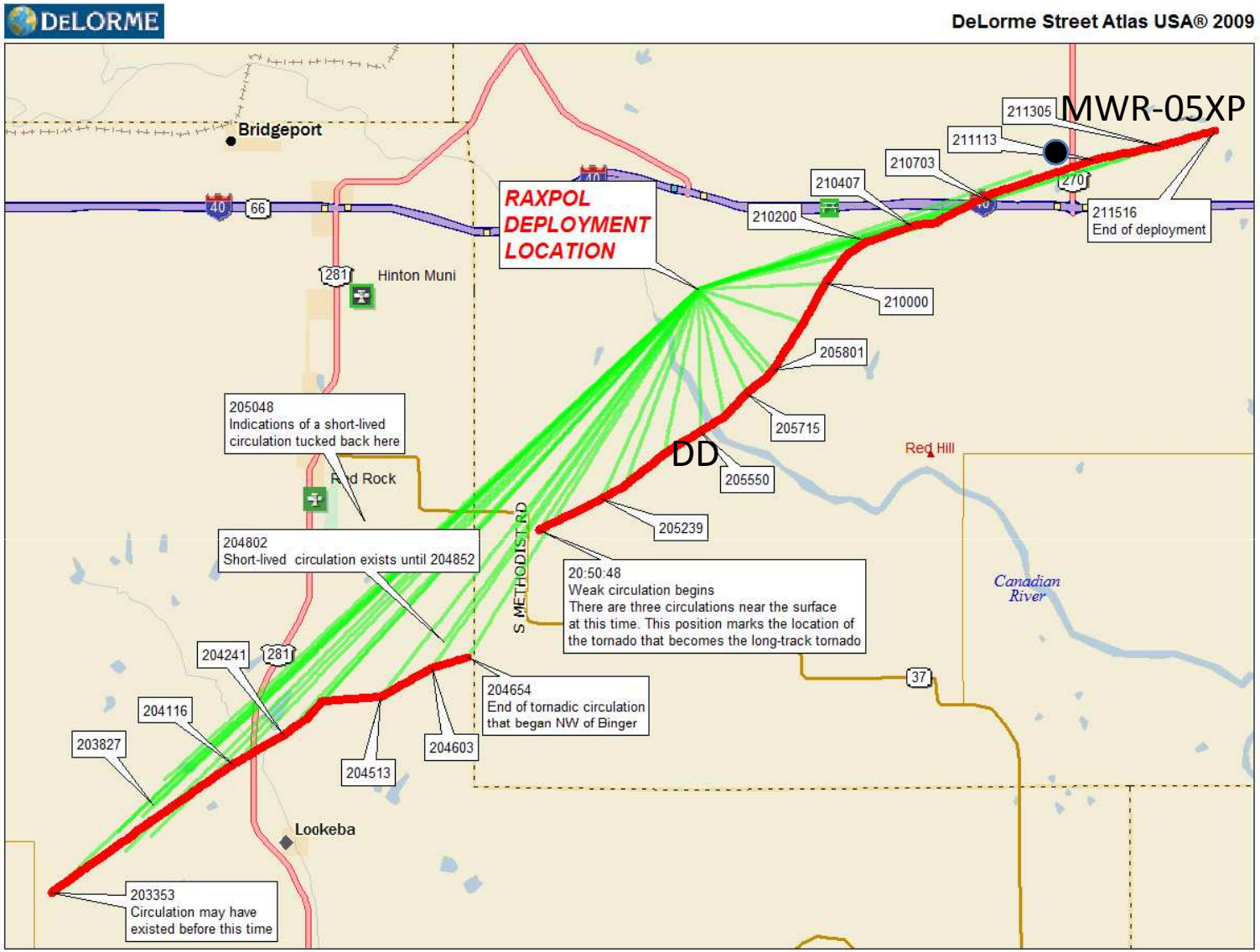
• FREQUENCY HOPPING SPEEDS THE CONVERGENCE OF THE AVERAGED RADAR PARAMETERS TO THE MEAN AND ALSO ENSURES THAT POWER AND V-H CROSS-CORRELATION DATA FROM THE 1^{ST} PULSE IN EACH GROUP ARE FREE FROM SECOND-TRIP CONTAMINATION

• SCAN 360^{0} (TOO MUCH HYSTERESIS TO DO SECTOR SCANS; LOSE TIME)

• e.g., AT ONE COMPLETE REVOLUTION EVERY 2 s, IT TAKES ~ 20 s TO SCAN VOLUME 1^{0} – 20^{0} WITH NO OVERLAPPING SCANS IN ELEVATION
(10 STEPS EVERY 2^{0})

RAPID X-POL (RaXPol)

22 May 2011


DeLORME
DeLorme Street Atlas USA® 2009
MWR-05XP
211305
211113
210703
210407
210200
211516
End of deployment
RAXPOL
DEPLOYMENT
LOCATION
210000
205801
205715
205550
205239
DD
Bridgeport
Hinton Muni
Red Rock
Red Hill
205048
Indications of a short-lived
circulation tucked back here
204802
Short-lived circulation exists until 204852
S METHODIST RD
20:50:48
Weak circulation begins
There are three circulations near the surface
at this time. This position marks the location of
the tornado that becomes the long-track tornado
Canadian
River
204241
204116
203827
204513
204603
204654
End of tornadic circulation
that began NW of Binger
Lookeba
203353
Circulation may have
existed before this time
Data use subject to license.
© DeLorme. DeLorme Street Atlas USA® 2009.
www.delorme.com
MN (4.9° E)
km
0 1 2 3 4 5 6 7 8 9
Data Zoom 10-0


24 May 2011
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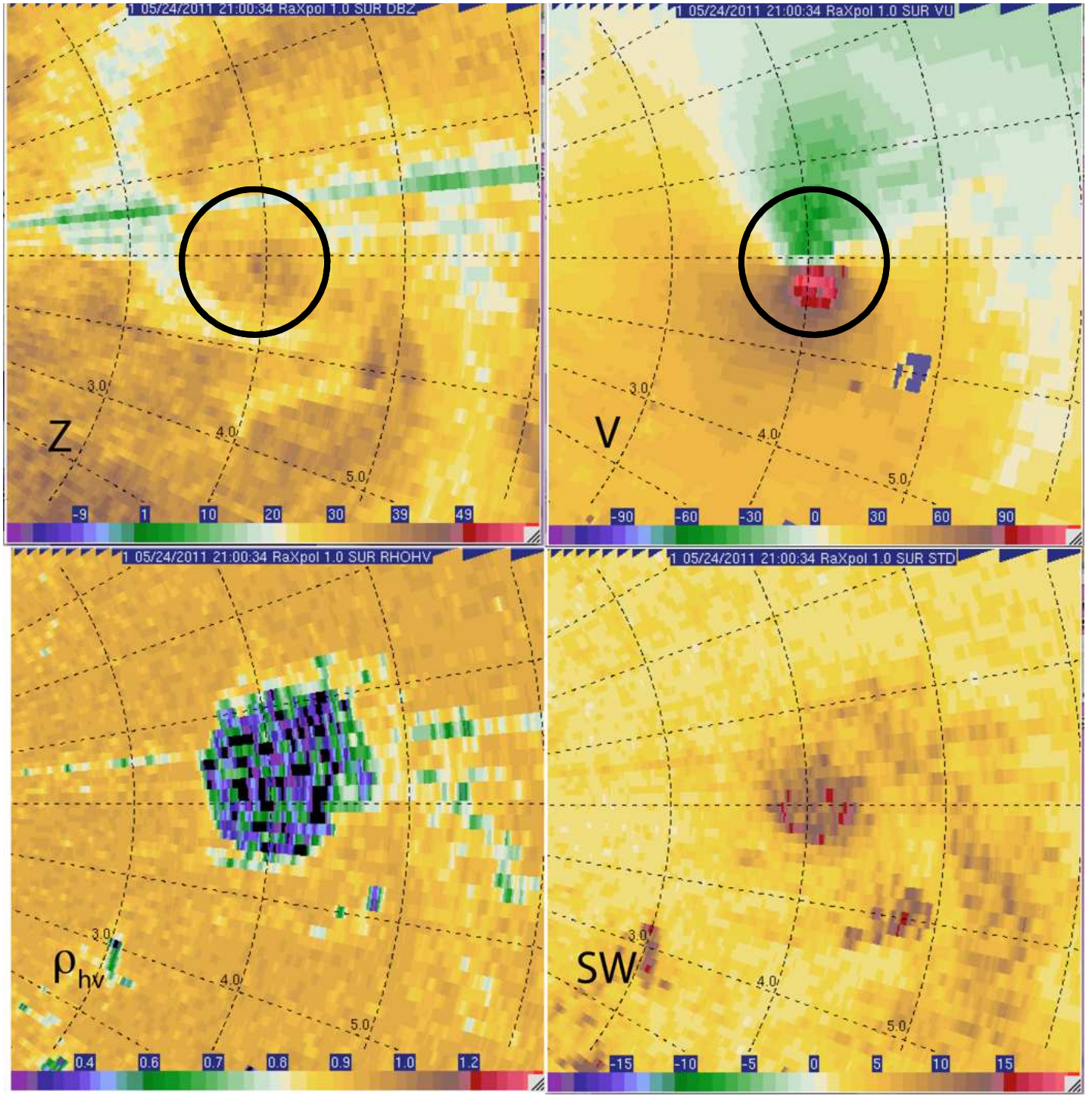
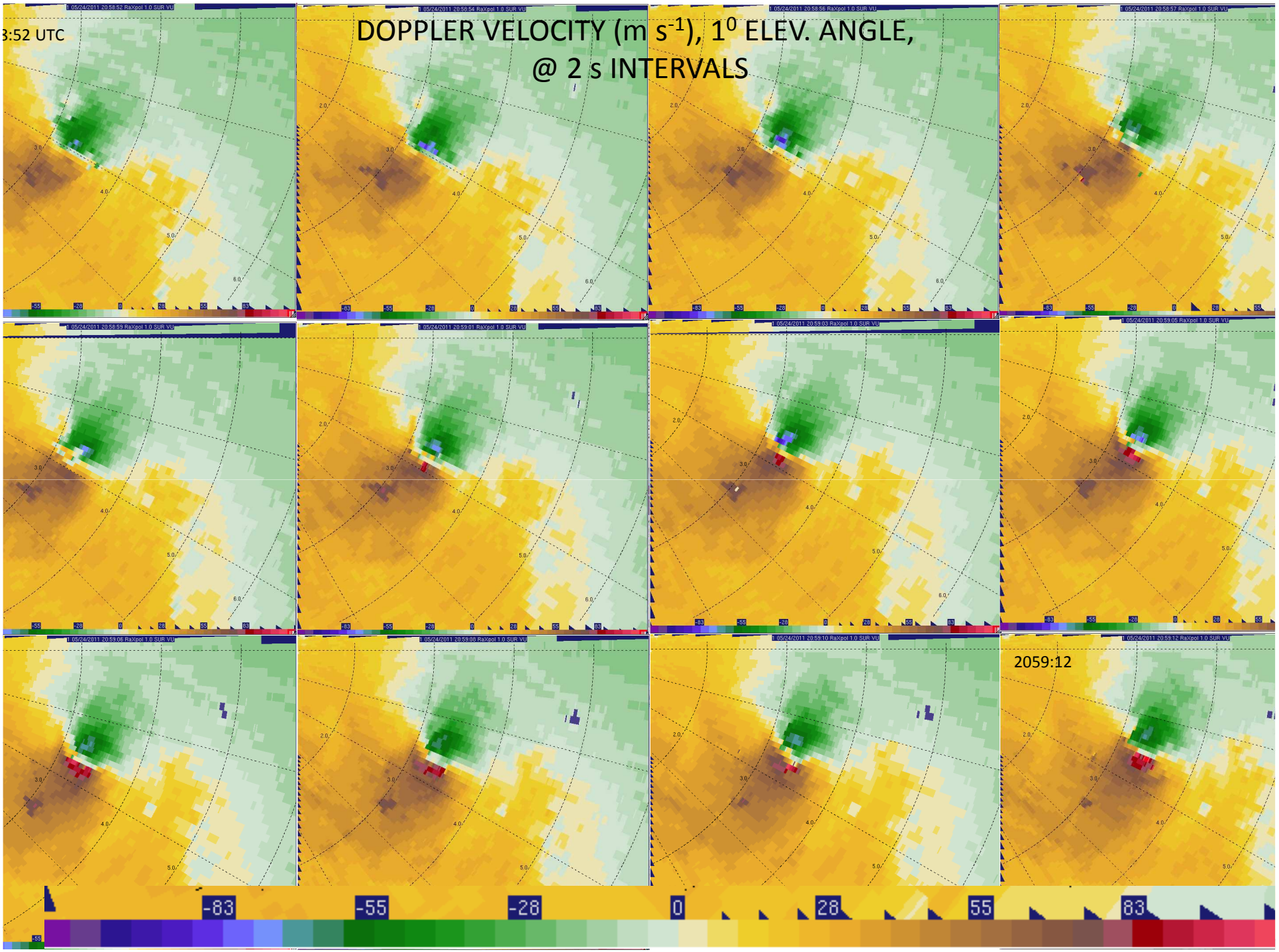
MULTIPLE-VORTEX STAGE
24 May 2011

24 May 2011

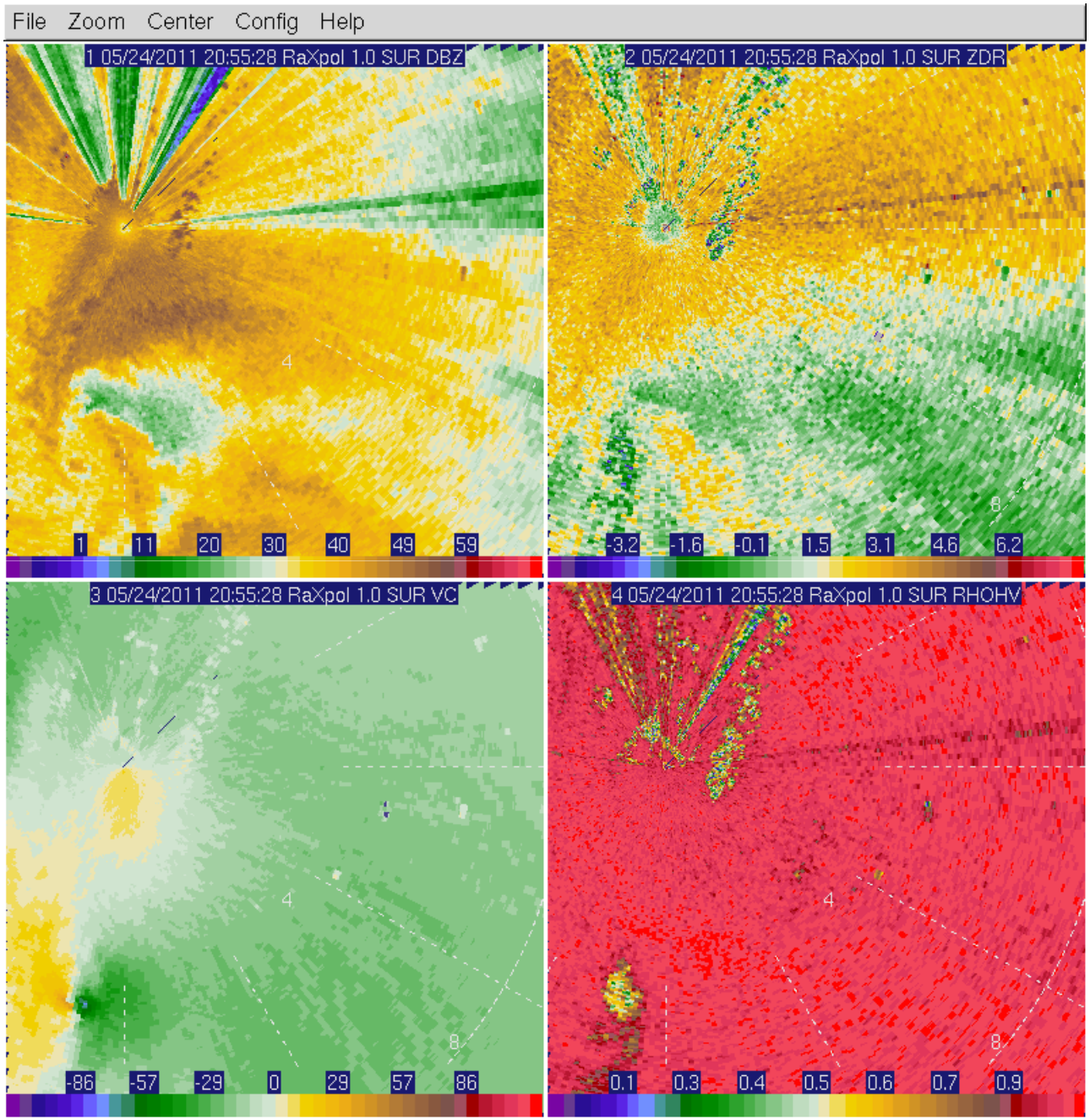

DAMAGE
© H. Bluestein

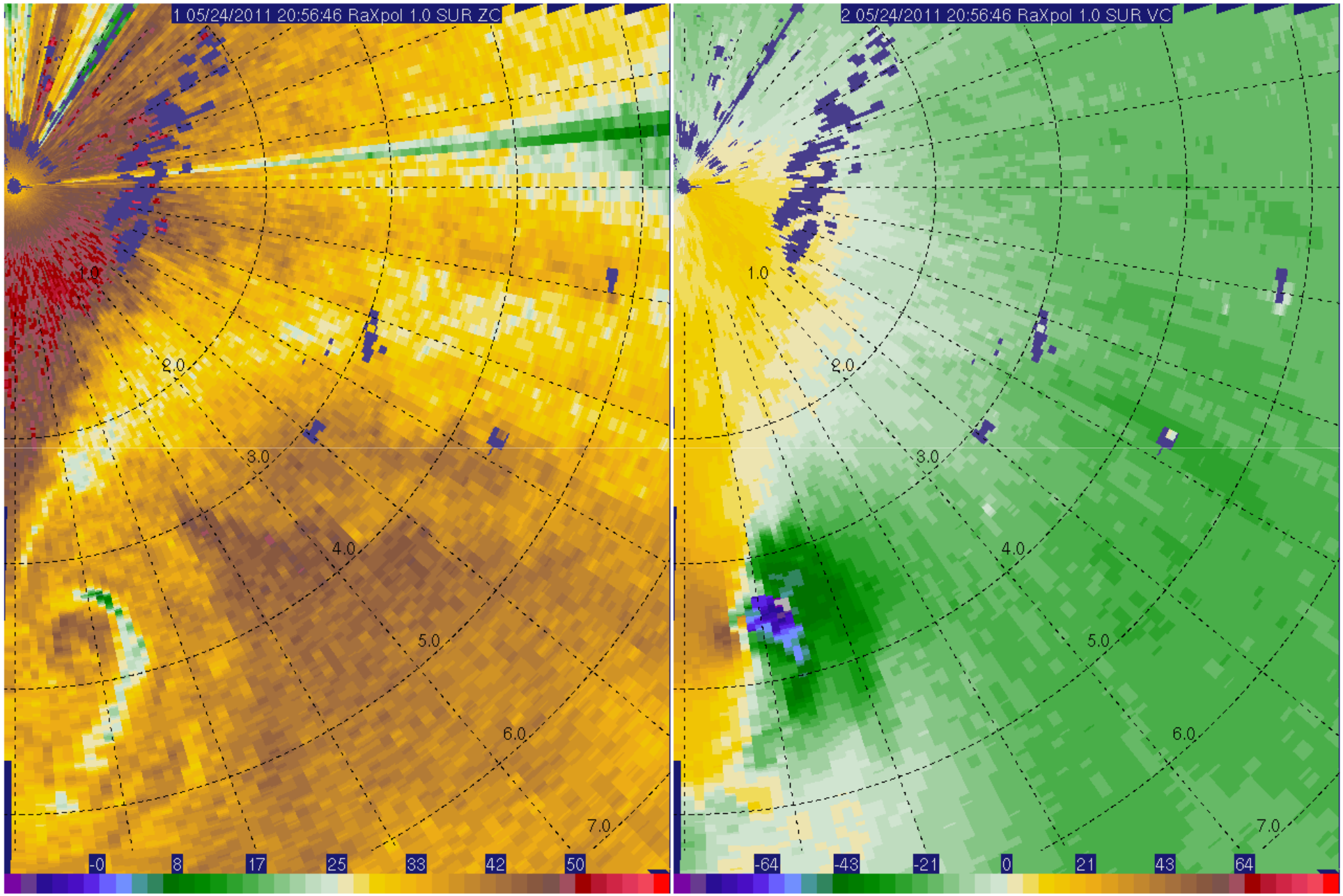


MAX V
125 m s^{-1}
@ 1^0 ELEV.
ANGLE,
~ 70 m ARL

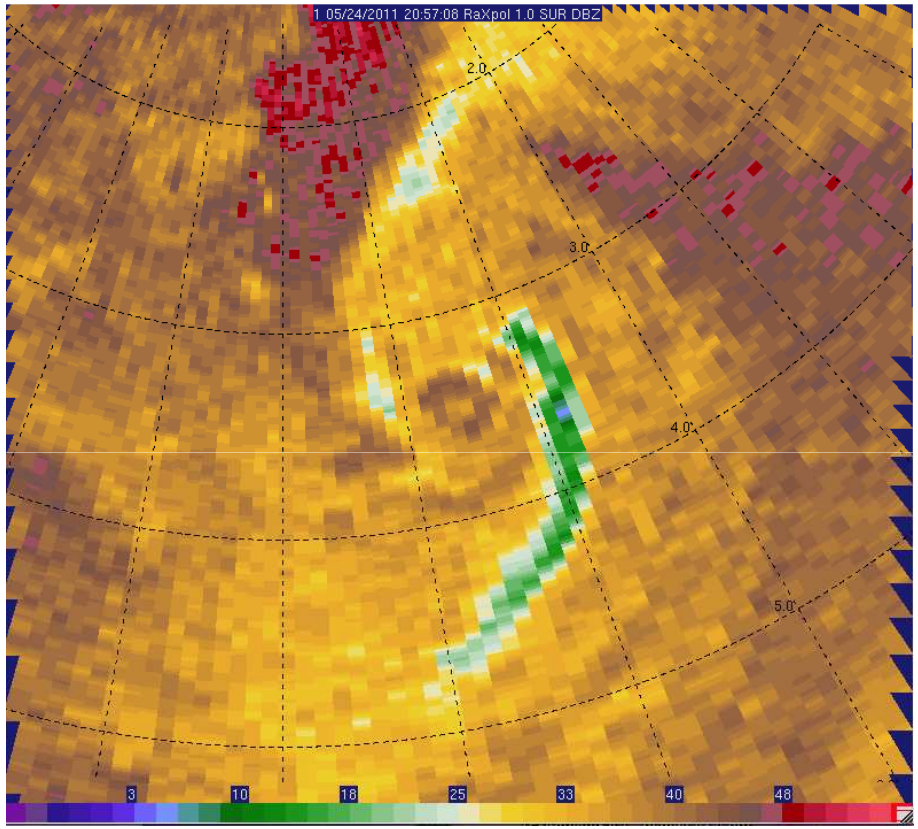

3:52 UTC
DOPPLER VELOCITY (m s-1), 10 ELEV. ANGLE,
@ 2 s INTERVALS
2059:12
-83
-55
-28
0
28
55
83

RaXPol
UPDATES
2056:46 –
2059:41 UTC

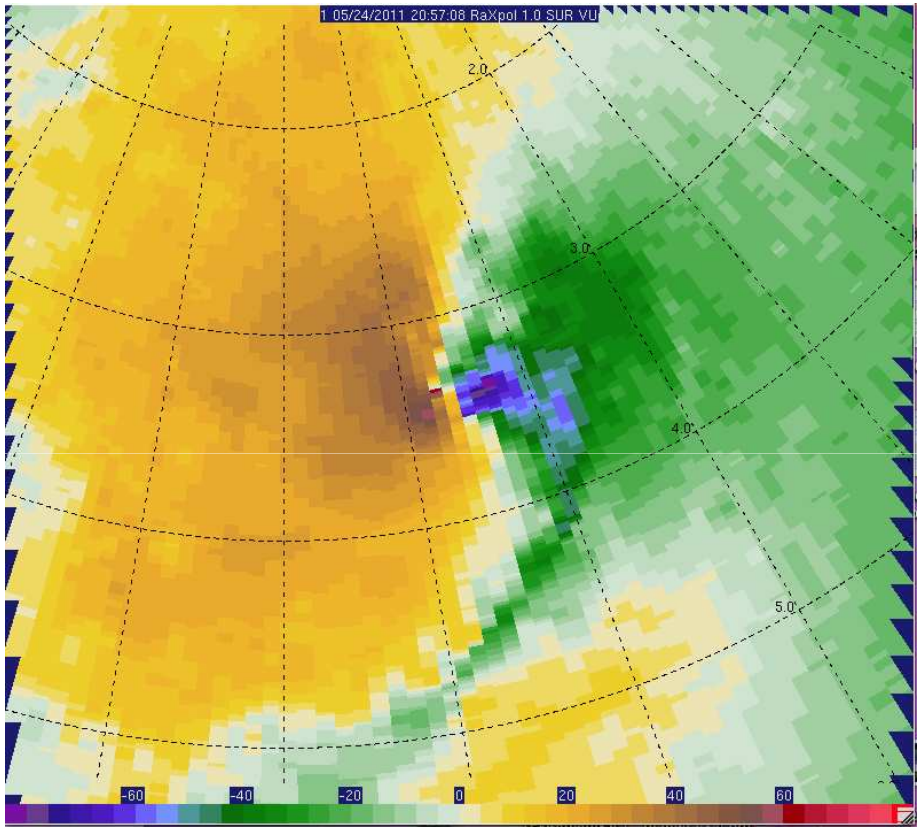



1 05/24/2011 20:56:46 RaXpol 1.0 SUR ZC
1.0
2.0
3.0
4.0
5.0
6.0
7.0
-0
8
17
25
33
42
50
2 05/24/2011 20:56:46 RaXpol 1.0 SUR VC
1.0
2.0
3.0
4.0
5.0
6.0
7.0
-64
-43
-21
0
21
43
64

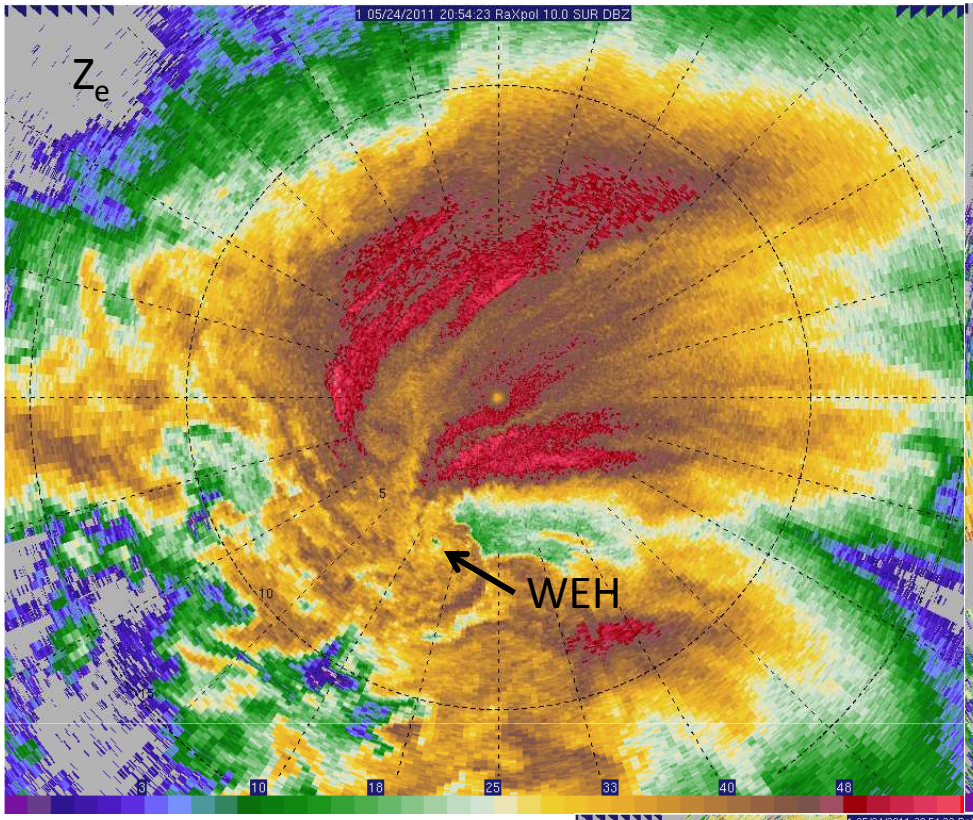
Z_e

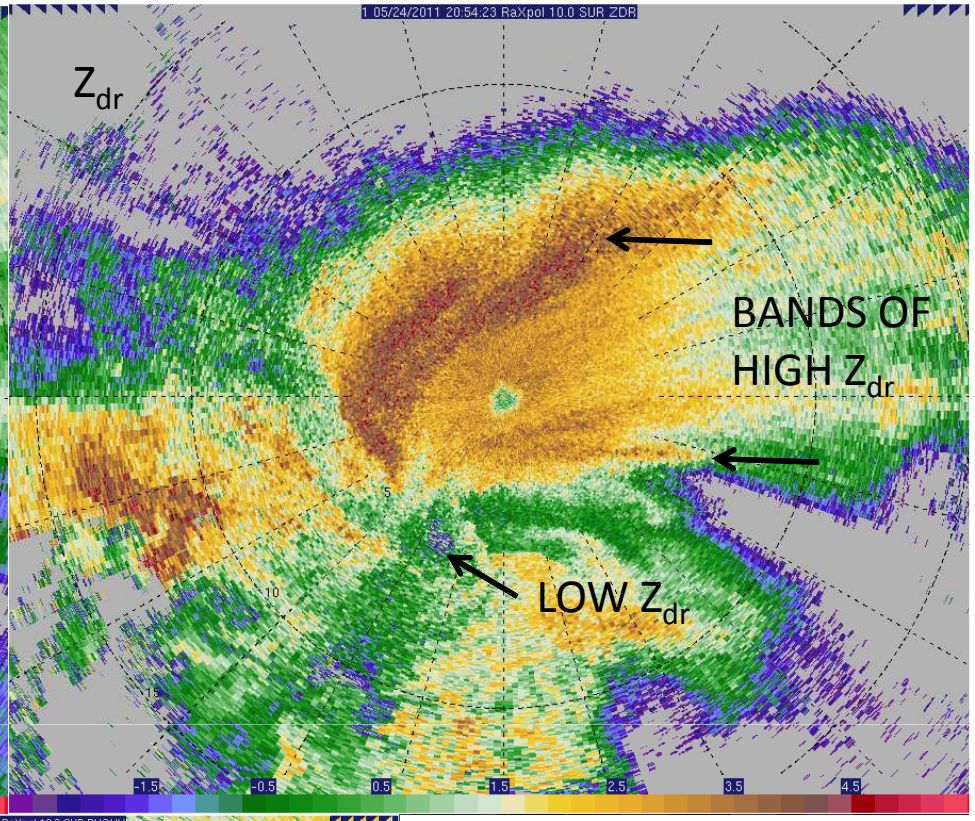


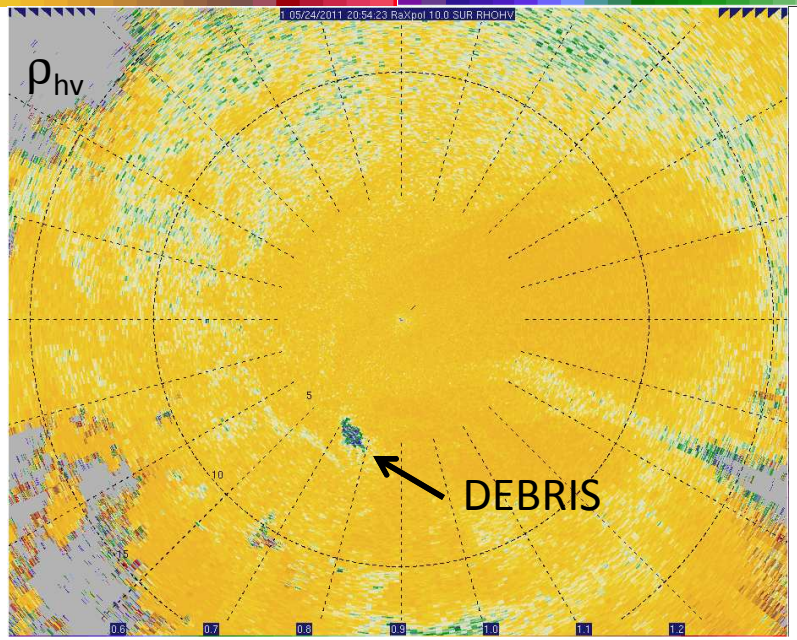
V



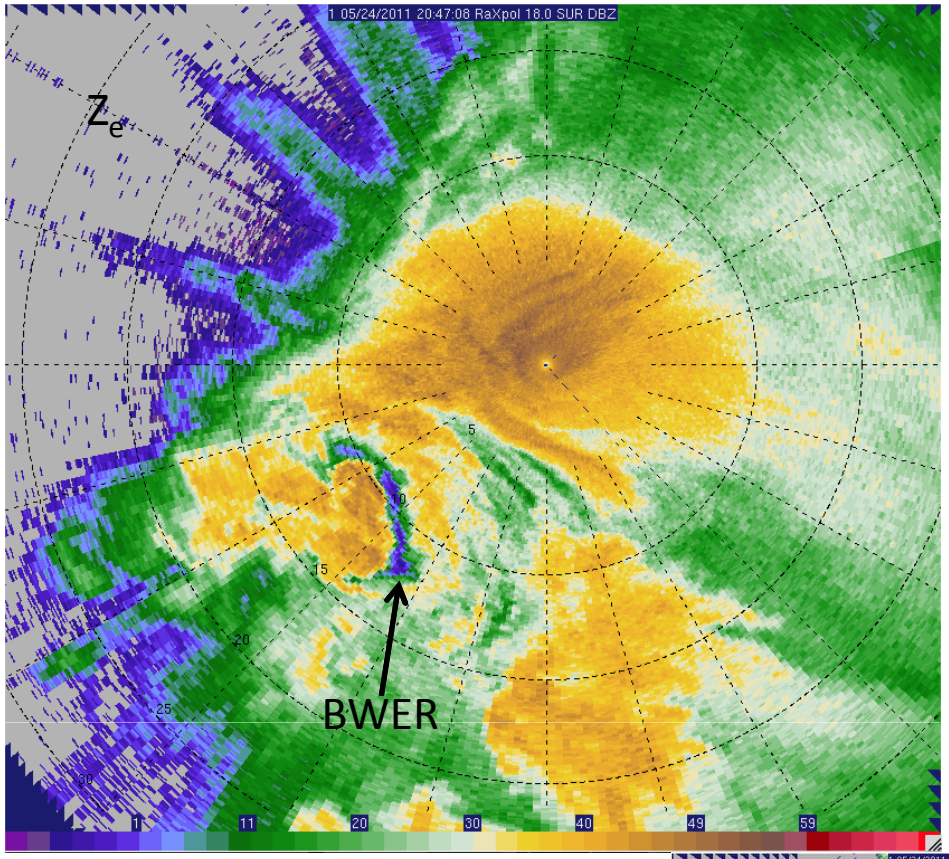
LOW-REFLECTIVITY ARC
2057:08 UTC 1^0 ELEV.

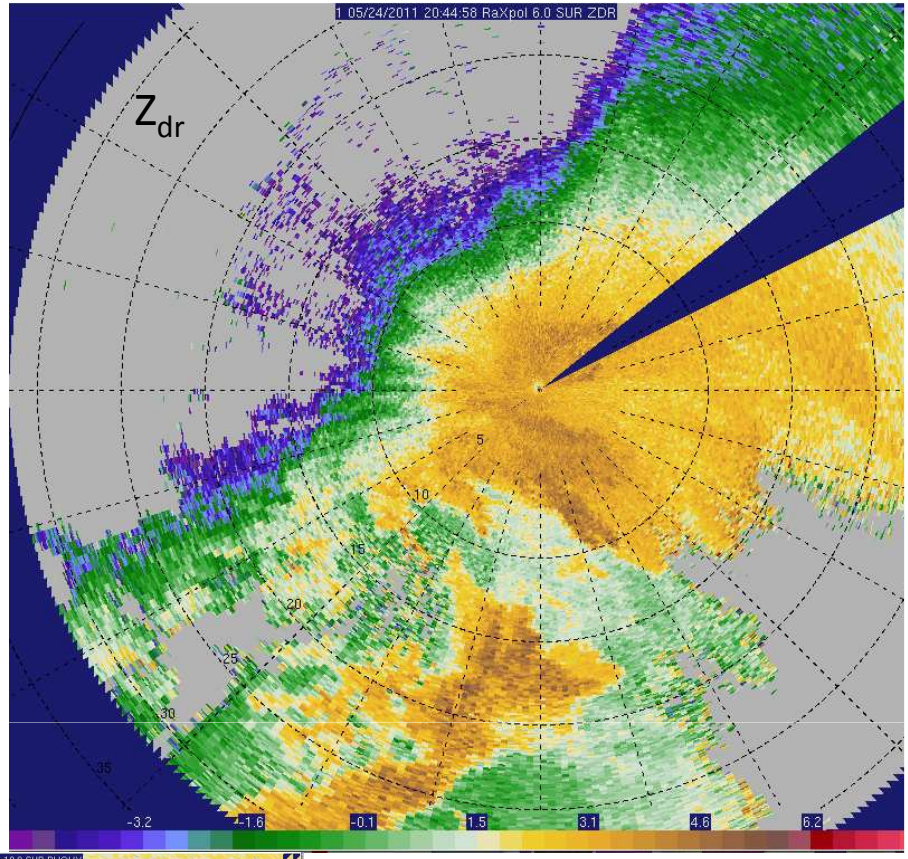


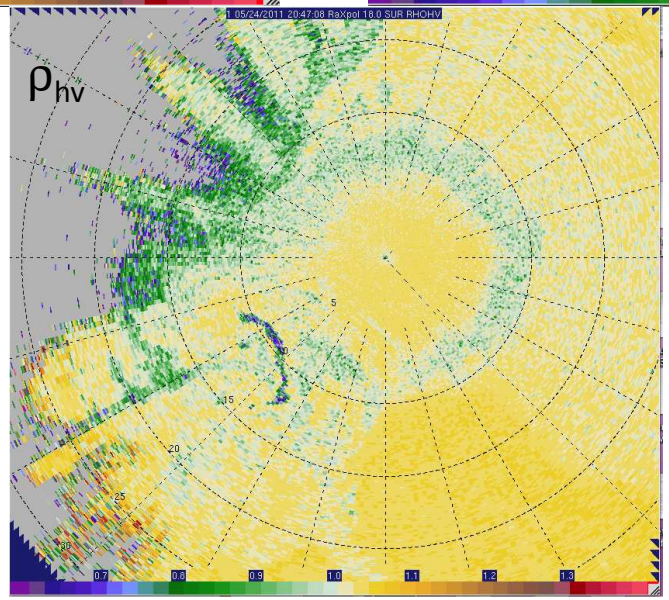




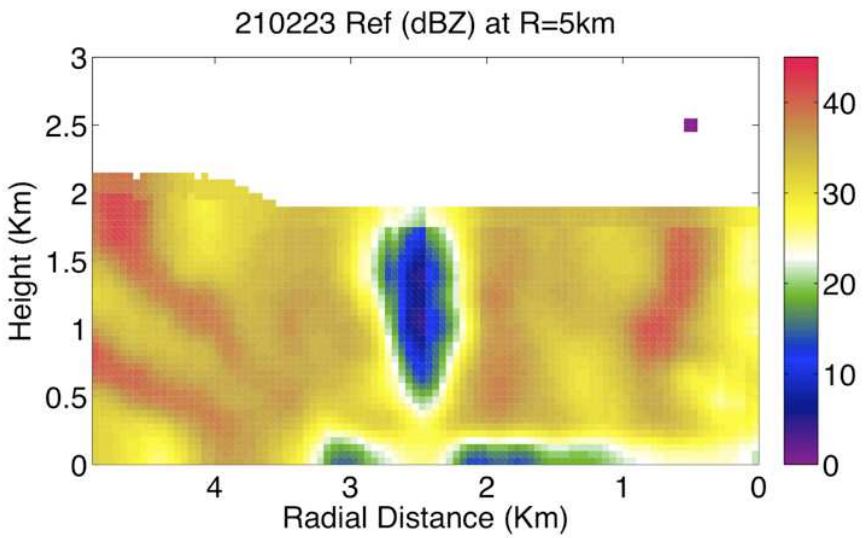
2054:23 UTC
5 km RANGE RINGS
10^0 ELEV. ANGLE

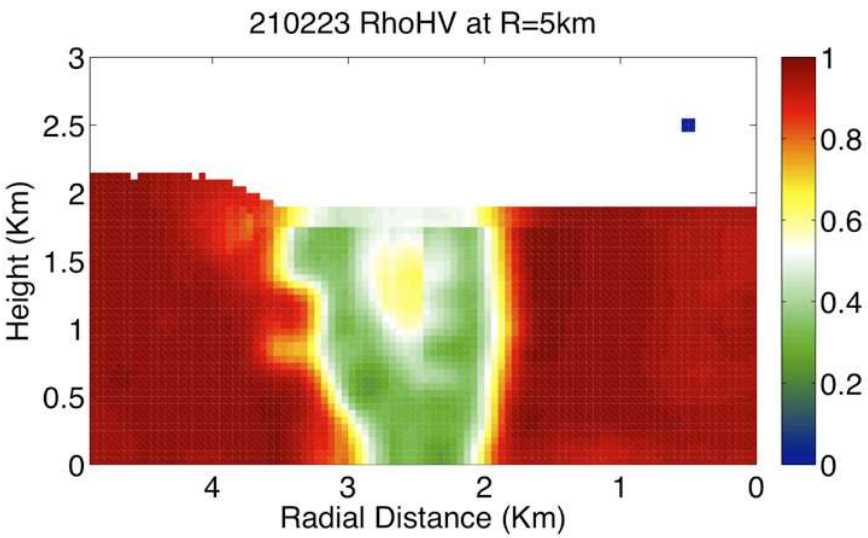


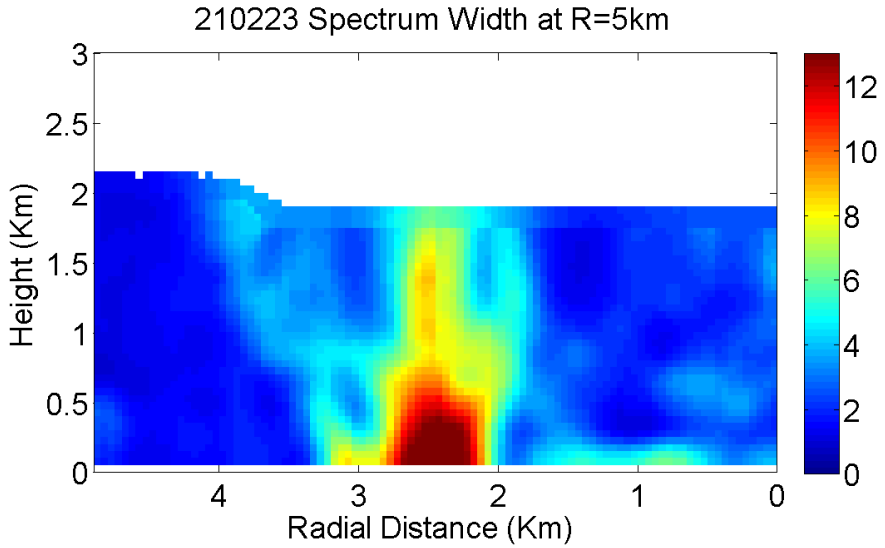


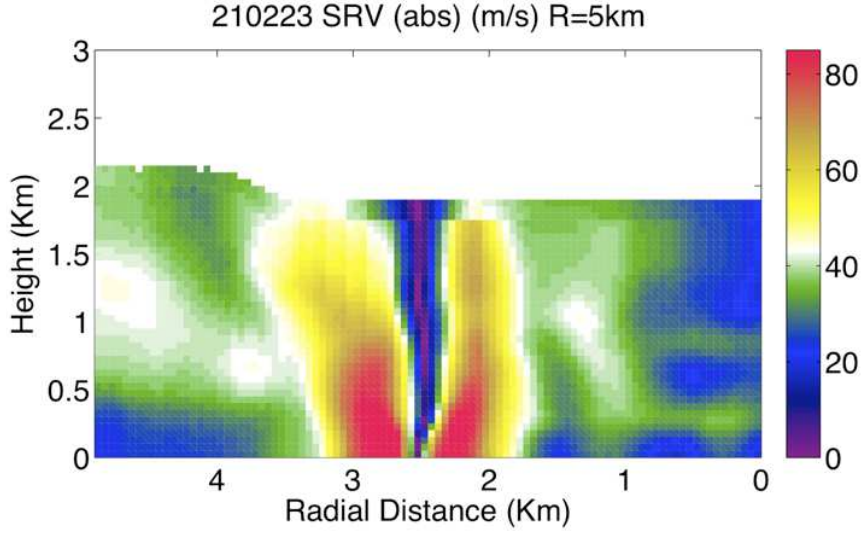


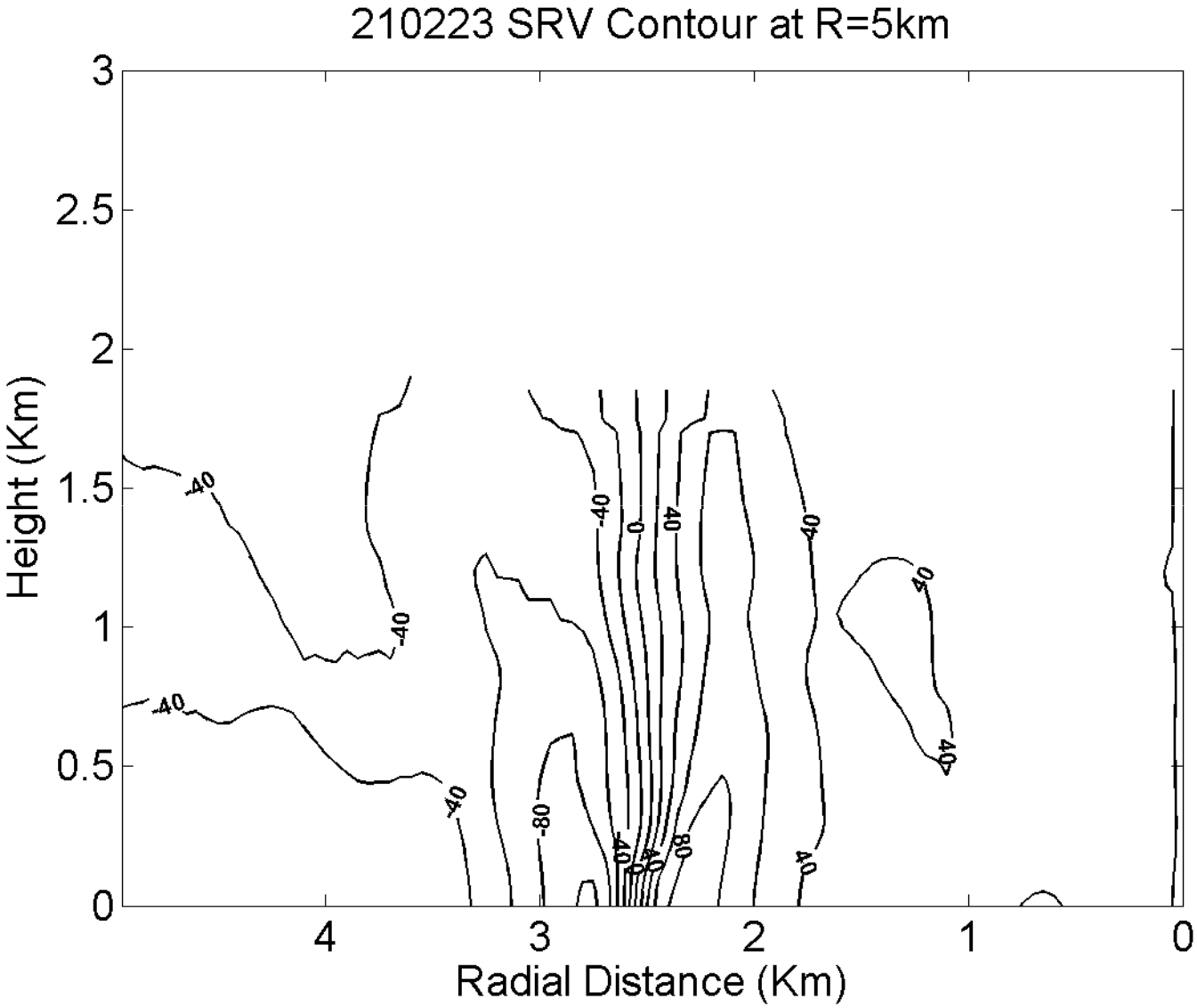
2047:08 UTC
18^0 ELEV. ANGLE
(~ 3 km ARL)

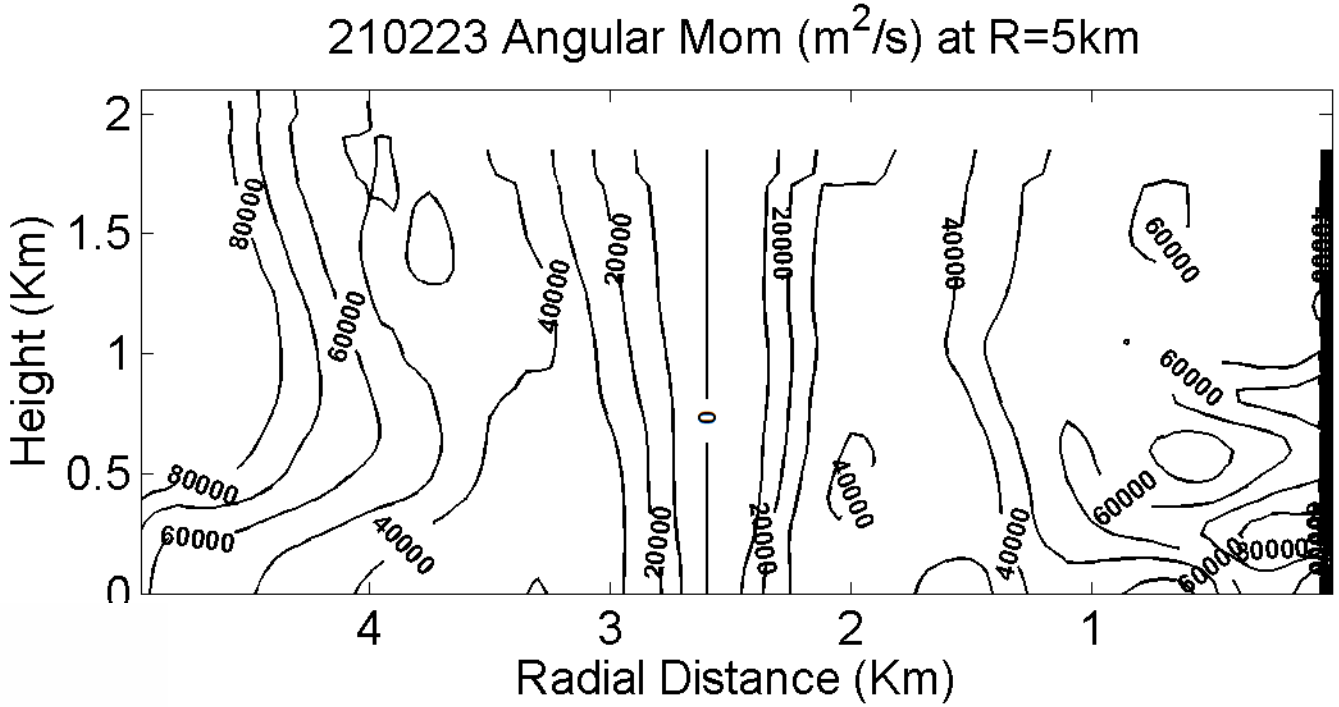

210223 Ref (dBZ) at R=5km
Height (Km)
Radial Distance (Km)
3
2.5
2
1.5
1
0.5
0
4
3
2
1
0
40
30
20
10
0


210223 RhoHV at R=5km
Height (Km)
Radial Distance (Km)
3
2.5
2
1.5
1
0.5
0
4
3
2
1
0
1
0.8
0.6
0.4
0.2
0

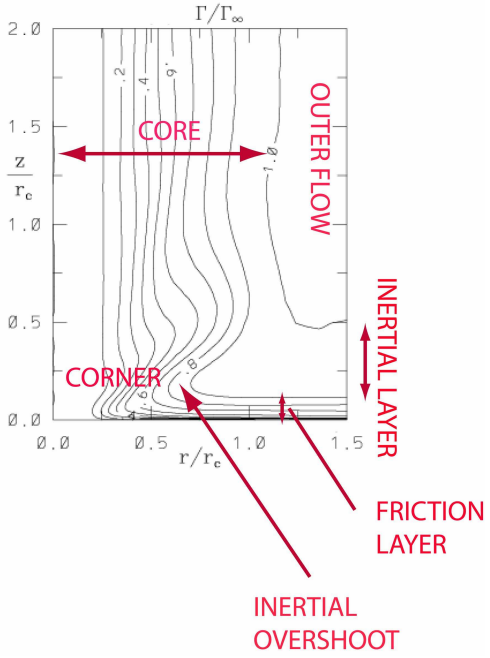

210223 Spectrum Width at R=5km
Height (Km)
Radial Distance (Km)
3
2.5
2
1.5
1
0.5
0
4
3
2
1
0
12
10
8
6
4
2
0


210223 SRV (abs) (m/s) R=5km
Height (Km)
Radial Distance (Km)
3
2.5
2
1.5
1
0.5
0
4
3
2
1
0
80
60
40
20
0


210223 SRV Contour at R=5km
Height (Km)
Radial Distance (Km)
3
2.5
2
1.5
1
0.5
0
4
3
2
1
0
-40
-80
0
40
80

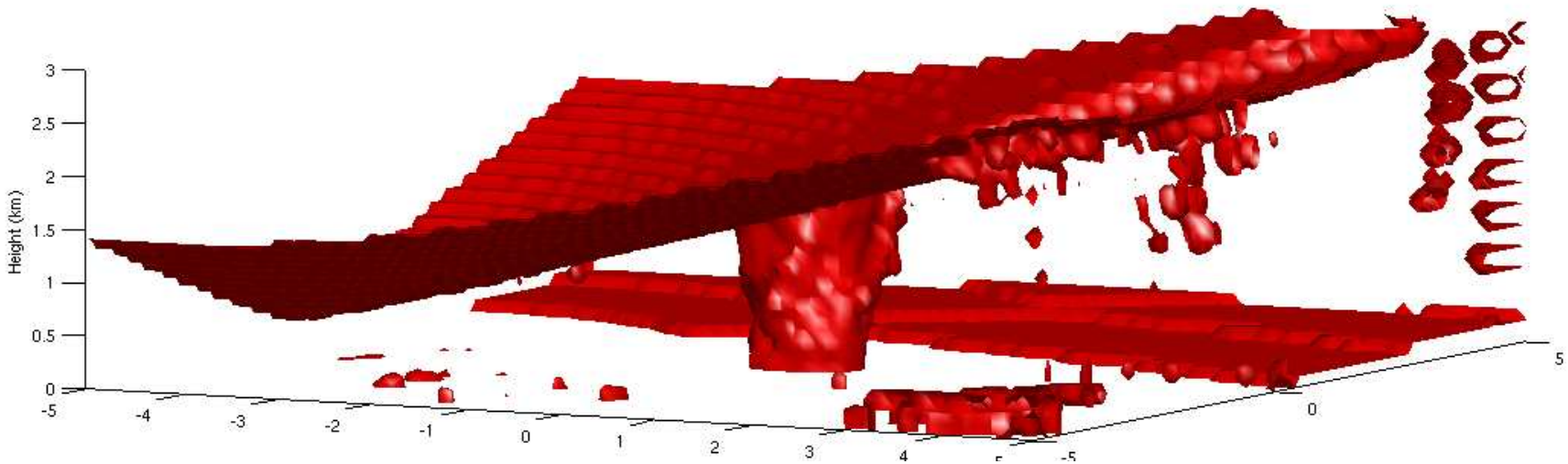


IDEALIZED
NUMERICAL
SIMULATION

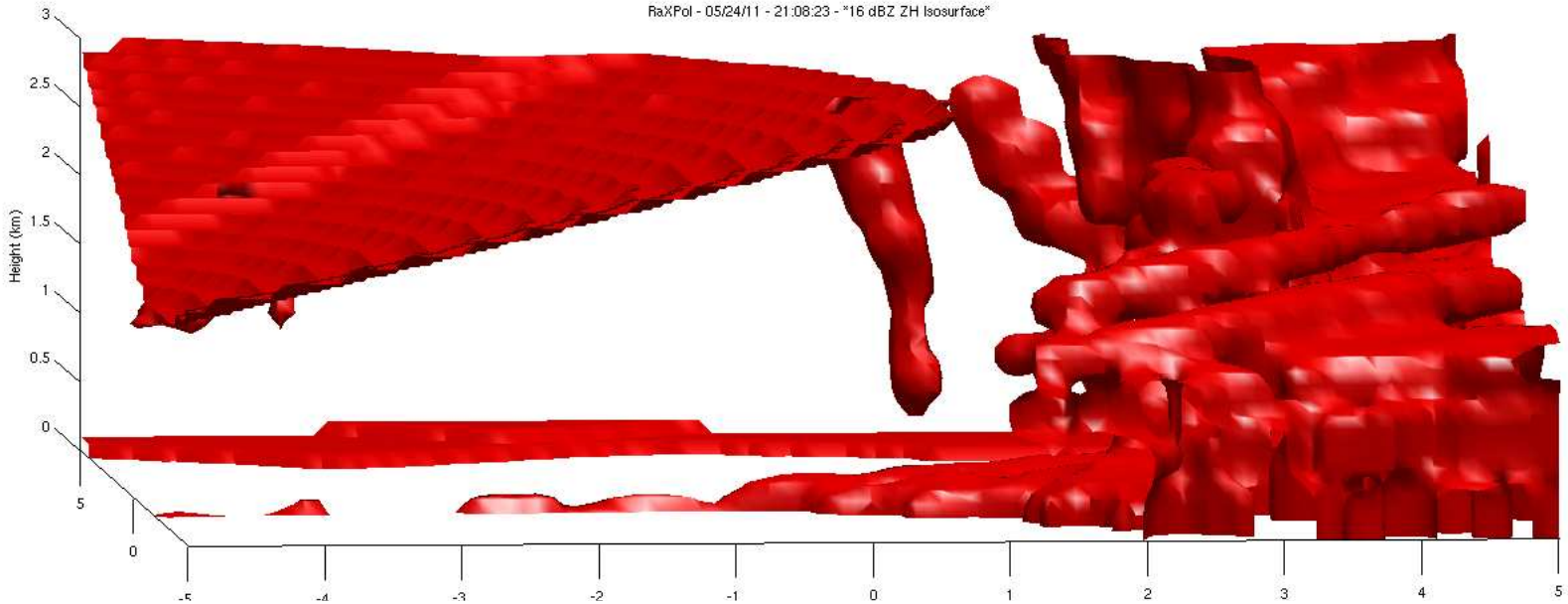


Based on an LES
by Lewellen et al. (2000)

RaXPol - El Reno Tornado - 21:02:22 UTC -- *0.80 RhoHV Isosurface*



RaXPol - 05/24/11 - 21:08:23 - *16 dBZ ZH Isosurface*



WORK IN PROGRESS:

- ANALYSIS OF DATA FROM RAXPOL AND MWR-05XP

  JANA HOUSER (DOPPLER WIND DATA)
  JEFF SYNDER (POLARIMETRIC DATA ONLY)

- DOCUMENT TORNADOGENESIS ON STORM SCALE:
  INNOVATIVE WAYS OF PROCESSING SINGLE-DOPPLER DATA

- DOCUMENT TORNADO STRUCTURE

- LOW-REFLECTIVITY ARC: NATURE OF?

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