Mobile Radar Observations of the Evolving Debris Field Compared with a Damage Survey of the Shawnee, Oklahoma Tornado

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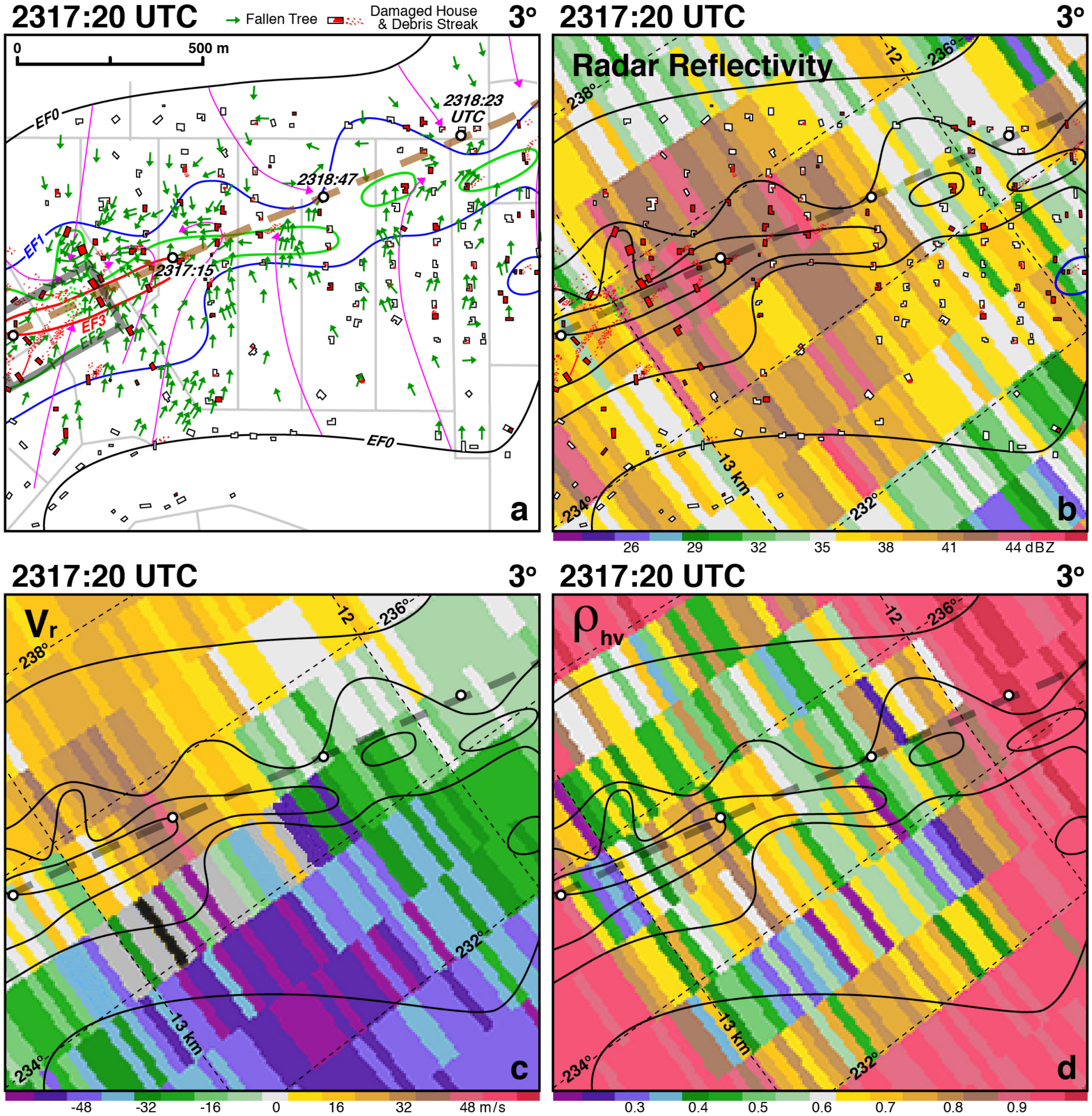
A detailed damage survey is combined with high-resolution mobile, rapid-scanning X-band polarimetric radar data collected on the Shawnee, OK tornado (example is shown in attached figure). The focus of this study is the radar data collected during a period when the tornado was producing damage rated EF3. The radar reflectivity increased as vast amounts of debris were lofted by the tornado. The tornadic debris signature (TDS) increased in size and there was a reduction in the cross correlation coefficient (Rho_{hv}) and differential radar reflectivity (Z_{DR}). There was an initial drop in the Doppler velocity differential accompanying the tornado at low levels as more debris became airborne. However, the magnitude of the velocity differential increased with time. In addition, an increase in vertical vorticity was also noted in the dual-Doppler analyses. The strengthening of the tornadic circulation after more debris was lofted suggests that either the amount of debris was insufficient to impact the wind speeds or that the storm/tornado-scale processes that increased the tornado’ s intensity had a greater influence that any changes attributed to the debris.

Vertical profiles of mobile radar data, centered on the tornado, revealed that the radar reflectivity was approximately uniform with height and increased in magnitude as more debris was lofted. The exception was near the surface where beam blockage by trees reduced the echo intensity. In contrast, the vertical profiles of r_{hv} and Z_{DR} at the lower levels were clustered into two groups. There was a large decrease in both variables immediately after the tornado exited the damaged area rated EF3 as might be expected. Low Rho_{hv} and Z_{DR} occurred near the surface where the debris loading was the greatest. The Rho_{hv} and Z_{DR} profiles increase slightly above the surface before decreasing above 1.5 km above radar level (ARL). The Rho_{hv} profile reaches a minimum at 2.5 km before increasing with height suggesting that debris is being centrifuged out of the circulation or has fallen to lower levels.
Range-height profiles of the dual-Doppler analyses that were azimuthally-averaged around the tornado were created to examine the mean evolution of the lofted debris. The leading edge of the lofted debris as depicted by low r_{hv} was located near the zero isopleth of radial divergence. Low-level inflow into the tornado encountering a positive bias in radial velocities could explain the transition from radial divergence to convergence. A ring of maximum radial convergence was noted to the rear of the leading edge of debris.

Keywords: Tornado, Debris


2317:20 UTC
Fallen Tree
Damaged House & Debris Streak
3°
0
500 m
2318:23 UTC
2318:47
2317:15
EF0
EF1
EF2
EF3
a
2317:20 UTC
3°
Radar Reflectivity
238°
236°
-12
-13 km
234°
232°
b
26
29
32
35
38
41
44 dBZ
2317:20 UTC
3°
V_r
238°
236°
-12
-13 km
234°
232°
c
-48
-32
-16
0
16
32
48 m/s
2317:20 UTC
3°
ρ_{hv}
236°
-12
-13 km
234°
232°
d
0.3
0.4
0.5
0.6
0.7
0.8
0.9