SCIENCE

Polarimetric Radar and VHF Lightning Observations in a Significantly Tornadic Supercell

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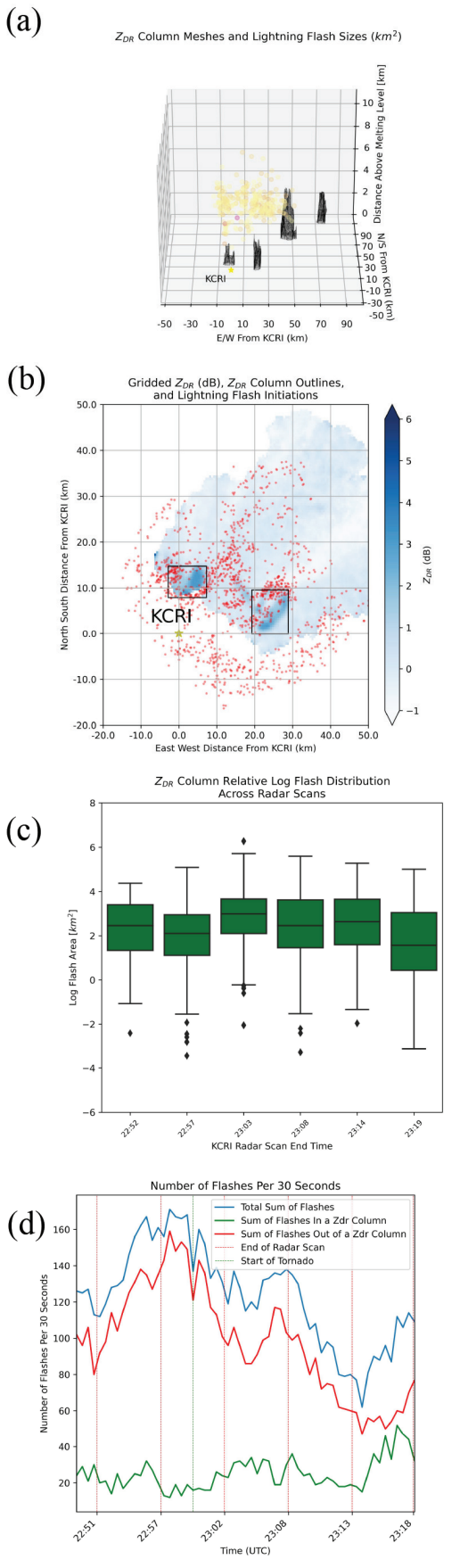
Mature thunderstorms contain updrafts, which can be detected by polarimetric radar via a feature called a differential reflectivity (Z_{DR}) column. As in Sharma et al.'s 2021 article, "Polarimetric and Electrical Structure of the 19 May 2013 Edmond–Carney, Oklahoma, Tornadic Supercell," we discerned relationships between Z_{DR} columns and lightning in a supercell thunderstorm. We applied similar analysis to a different tornadic supercell to see if their conclusions hold.

On May 19, 2013, a supercell thunderstorm produced an EF-4 tornado that tracked between Norman and Shawnee, Oklahoma. As in Sharma et al.'s 2021 research, we used data from the KCRI radar in Norman and the Oklahoma Lightning Mapping Array to study this supercell. Radar data were objectively analyzed and filtered using Barnes' 1964 "A Technique for Maximizing Details in Numerical Weather Map Analysis." A marching cubes algorithm based on Lorenson and Cline's 1987 "Marching Cubes: A High Resolution 3D Surface Construction Algorithm" was utilized to create a series of 1-dB Z_{DR} isosurface meshes (see figure 1a). Lightning data was then converted from ECEF to Cartesian coordinates using a local tangent plane conversion relative to the radar. The mesh footprint bounding boxes were then used to classify flashes as inside or outside the Z_{DR} column (see figure 1b).

Variable changes in flash sizes within the columns were observed (see figure 1c). The number of flashes outside of the columns were significantly higher than within the columns (see figure 1d), in contrast with the findings of Sharma et al. This result suggests at least two different modes of lightning behavior above supercell updrafts.



(a) 1-dB isosurface meshes (black) and lightning flash sizes (yellow) at 2303 UTC while the tornado was mature. (b) Plan view of Z_{DR} (blue shading, in dB), 1-dB bounding boxes (black), and lightning flash locations (red) at 2303 UTC. (c) Logarithmic distribution of flash sizes within the Z_{DR} columns across six radar scans taken from 2251 to 2318 UTC. (d) Time series of the number of flashes relative to Z_{DR} column footprints.

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We look forward to analyses of additional cases, and the emergence of a generalized relationship for Z_{DR} column-relative flash size distributions in supercell thunderstorms.

Research advisor Robin Tanamachi writes: "This work shows that lightning behavior above updrafts in tornadic supercells may be storm-dependent, which is a valuable added insight to the work of graduate student Sharma. Bruss performed analyses independently, writing much of the Python code himself. The results will motivate further observations of lightning behavior in storms."