Relationships Between Flash Rates and Radiosonde Temperatures in Supercell Environments.

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Introduction

In May of 2024, a *student-led research initiative* by Millerville Meteorology students, named **Project TILTTING**, (Thermodynamic Investigation into LCL Thresholds during Tornadogenesis and its Influence in the Northeast and Great Plains), deployed to the Southern Great Plains to collect environmental data targeting tornadogenesis.

On May 19th, 2024 , three tornadoes touched down in Custer City, Oklahoma (NWS).

- 00:28-00:44 UTC, EF2
- 00:39-01:02 UTC, EF1
- 01:05-01:14 UTC, EF1

Given the established roles of lightning during tornadogenesis, this study aims to explore potential thermodynamic relationships that may contribute to this phenomenon.

Motivation

In a separate deployment, we observed an increase in temperature and subsequent increase in lighting flash rates. This observation motivates this question:

What kind of relationships exist between the storm inflow characteristics, storm behavior, and lightning flash rates?

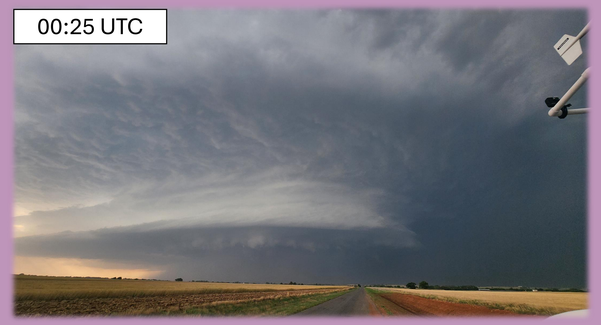
Datasets and Method

The data we are using is of the May 19th, 2024, Custer City, Oklahoma supercell, given the reliability of Oklahoma Lightning Mapping Array on that day.

- Project TILTTING released two Windsonds into the Custer City storm to characterize the supercell inflow at 23:07 UTC and 00:26 UTC.
- Total flash rate and lightning jump data from the Oklahoma Lightning Mapping Array (OKLMA) between 23-01 UTC.
- Nearby Oklahoma Mesonet surface observations.
- Tobac Python package for cell tracking.



Formation of the mothership supercell during our first balloon launch. 18:05 (CDT)



Mothership Supercell during our second weather balloon launch. 19:25 (CDT)



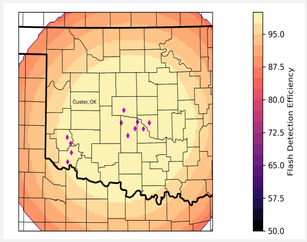
Team members preparing for the second launch. 19:24 (CDT)



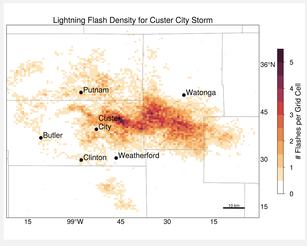
Southwest of the Custer City, OK. Tornado 20:24 (CDT)

Results

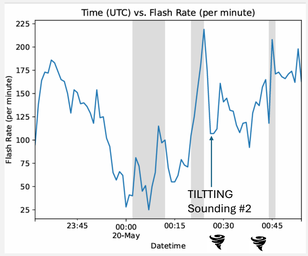
Lightning Trends from OKLMA



An estimate of the flash detection efficiency of the LMAs during this case. The purple diamonds represent the stations which were operating at the time.



Analysis of lightning flash extent density during the Custer City supercell. The colored dots represent different cell tracks, and the blue circle represents area of interest. The darker colors represent a higher flash extent density.

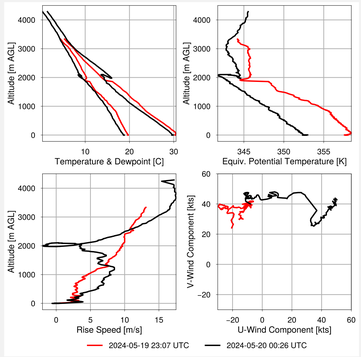


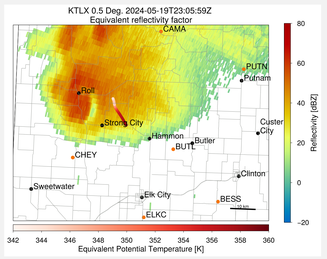
Analysis of lightning flash rates during the Custer City supercell. Three lightning jumps occurred at approximately 00:02-00:12 UTC, 00:20-00:25 UTC, and 00:43-00:47 UTC.

TILTTING Inflow Soundings

The sounding collected by Project TILTTING's Windsond on May 19th, 23:07 (UTC) is indicated by the red lines. Though we are interested in the data near tornadogenesis, it is still useful to understand atmospheric conditions before the storm matured.

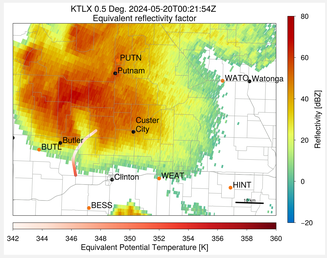
The inflow sounding collected by Project TILTTING's Windsond on May 19th, 00:26 (UTC) is indicated by the black lines. The Windsond was released two minutes prior to the first Custer City tornado formation.





This reflectivity plot compares the storm placement to the direction of the first released Windsond.

The red line northeast of Strong City indicates the Windsond direction and equivalent potential temperature.

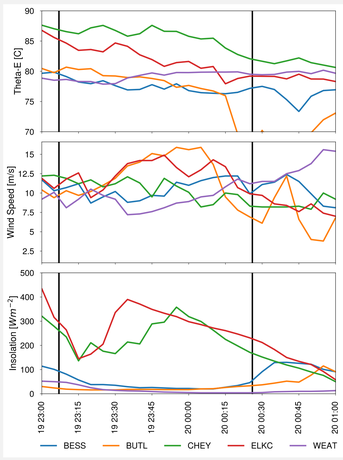


This reflectivity plot compares the storm placement to the direction of the second released Windsond.

The red line southeast of Butler indicates the Windsond direction and equivalent potential temperature.

The curve of the line, as well as it's direction towards the hook echo, indicate this was an inflow sounding.

Inflow Trends from Oklahoma Mesonet



These three charts represent data collected from the Oklahoma Mesonet between the times of 23:00 (UTC) – 01:00 (UTC).

Theta-E represents the equivalent potential temperature. This is useful as theta-E combines both temperature and moisture, making it easier to assess stability and potential for convection.

Insolation represents the solar radiation received per unit area. This is useful to understand if the storm anvil and sunset had any effect on the thermodynamics.

Summary

This study analyzed the relationship between lightning flash rates and inflow characteristics. By comparing temporal trends, wind speed, and lightning activity, we can try to identify patterns. Though the data is useful to create a bigger picture of the storm environment, we cannot find a conclusive answer to our question. This project is a great start for future research objectives. In the future, we'd like Project TILTTING's Mesonet to collect thermodynamic properties like temperature and dewpoint at the surface. We'd also like to switch from Windsonds to Vaisala Radiosondes, to increase our data reliability.

Acknowledgements

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