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Investigation of Lightning and Storm Electrification Processes Using a Phased Array Radar and Lightning Mapping Array

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Link to Poster

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Introduction

Motivation:

Current radar scan times, on the order of 5 minutes per full volume scan, are **too slow to pick up on storm electrification signatures** which change on the order of seconds

Solution:

- Using the **Horus Phased Array Radar (PAR)**, which allows for scan rates potentially fast enough to capture the build-up and breakdown of electric fields within ice crystals
- Analyzing negative **signatures** of Specific Differential Phase (K_{DP}) and near-zero signatures of Differential Reflectivity (Z_{DR}) may indicate ice crystal alignment and electric fields
- Along with Horus, the **Oklahoma Lightning Mapping Array (OKLMA)** may increase certainty in ice crystal orientation location and flash intensity

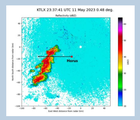
Research Objectives

- Investigate how effective are PARs higher temporal resolution for **analyzing ice crystal alignment** within thunderstorms
- Determining a **correlation between K_{DP} and Z_{DR}** signatures and the three-dimensional flash locations
- Advancing our understanding of **electrification signatures** and how important the temporal scale is to that process

Methods

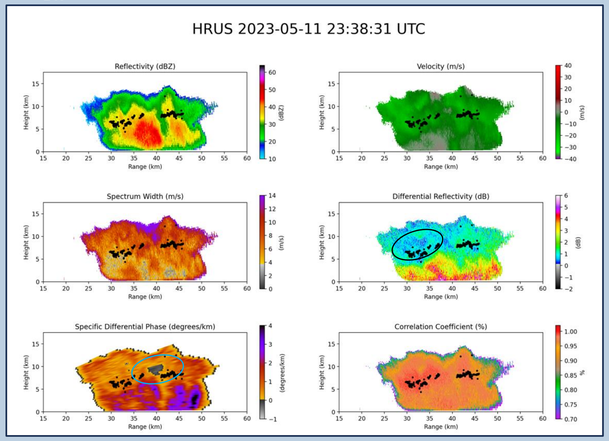
- **Horus radar scans and OKLMA data displayed together** to determine if repetitive ice crystal alignments were captured
- The `Lmatools` method for **flash-sorting** was used to determine the number of flashes
- The focus of this research is for the period from **11 May 2023 at 23:38 UTC to 12 May 2023 at 00:00 UTC**

View a video of the storm-scale and timing.



Vertical Ice Crystal Alignment

Looked for negative **K_{DP} values (blue oval)** and near-zero **Z_{DR} values (black oval)** which can indicate ice crystal

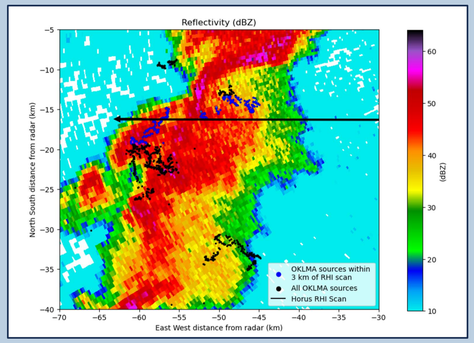


Horus and OKLMA data from May 11, 2023

Video of Horus RHI and OKLMA data →

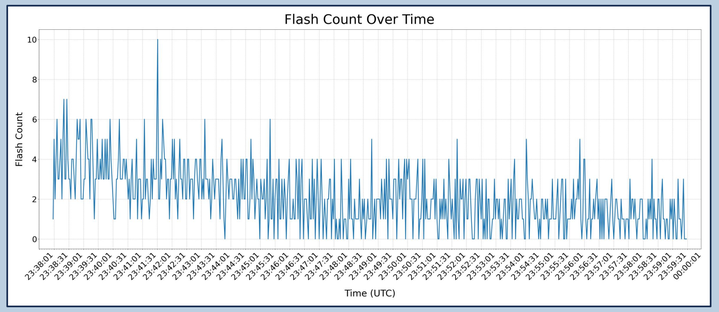
Flash Propagation

Flash propagation was **well documented by the OKLMA** due to the storm's position over the central Oklahoma



Horus and OKLMA data from May 11, 2023, at 23:38:31 UTC with KTLX reflectivity

Flash Intensity



LMA flash count per 2 second period (approximate RHI scan time) within 5 km of the RHI during the 22-minute study period

1,311 unique flashes were recorded during the 22-minute study period

Findings and Limitations

- K_{DP} values **were not representing the build-up/breakdown** of electric fields that cause ice crystal orientation, likely due to
  - Horus's scan times
  - High flash rates
  - Horus's beam width at the time (12° in azimuth and 3.5° in elevation), with a 5-panel array
- **Z_{DR} showed some promise** in determining regions favorable for lightning propagation
- OKLMA flash source data provided us with a **very detailed three-dimensional map** of the storm's flash propagation and intensity

Future Work

- Collect data with the **fully populated Horus array** and using a different beam configurations (e.g., spoiling)
- Compare results from multiple cases with **varying flash rates**

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