Electrification signatures observed during the Lake Effect Electrification (LEE) Project

Vanna Chmielewski, Eric Bruning, Kristin Calhoun, Karen Kosiba, Geoffrey Stano, Scott Steiger, Michael Stock, John Trostel, Yonggang Wang, Sean Waugh, Joshua Wurman
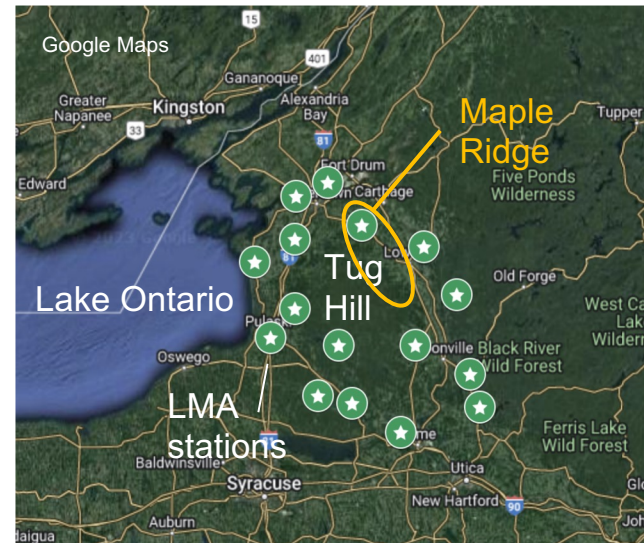
Image from Kaitlyn Jesmonth, SUNY Oswego
Oswego, NY, Nov 20, 2022

About LEE

- In the *lee* of Lake Ontario around the Tug Hill Plateau during winter 2022-2023
- Topics of interest:
  - Charge structures and the lightning produced
  - Microphysical environment
  - Interaction with the Maple Ridge Wind Farm
  - Minimum criteria for lightning
  - Contrast to other winter events

Observations

- Lightning Mapping Array (LMA): 8-16 stations
  - GTRI 09/26/22 - 04/02/23
  - NSSL 11/05/22 - 02/02/23
- DOW7
- Soundings
  - Environmental
  - Electric field meter (EFM)
  - Particle imager (PASIV)
- Snowfall measurements

Expectation:
- 9+ lake-effect events
- 3+ with lightning
- 7 IOPs

What did we get? The record **lowest** snowfall in Oswego, NY since 1926
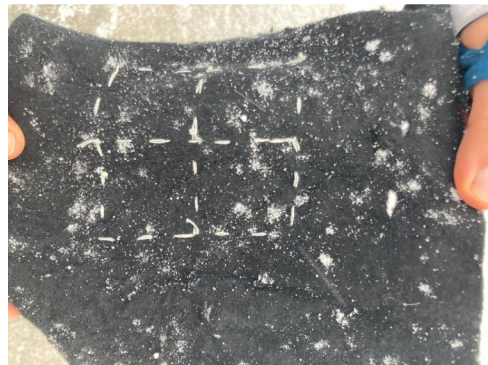

LMA sensor

EFM launch

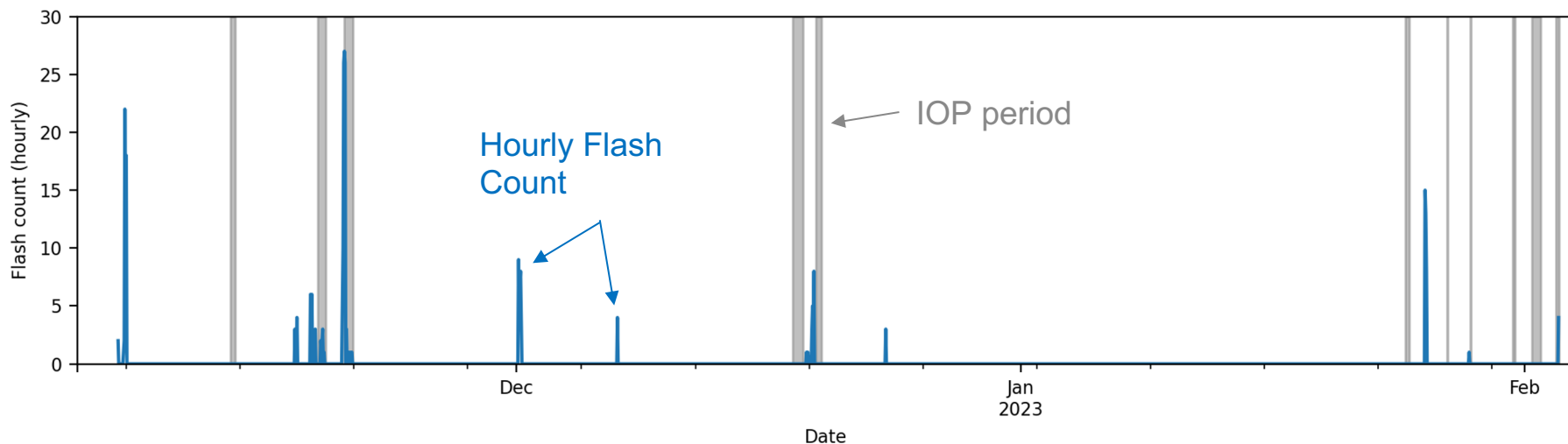DOW7

Imager launch

Graupel

Observation Summary

Complications to target observations:

- Component delays
- Harsh conditions
- Terrain

But still remarkably successful!

- 11 IOPs, 3 with lightning
- 6 other winter events
- 240 - 290 flashes from November to early February

Observation Summary

Complications to target observations:

- Component delays
- Harsh conditions
- Terrain

But still remarkably successful!

- 11 IOPs, 3 with lightning
- 6 other winter events
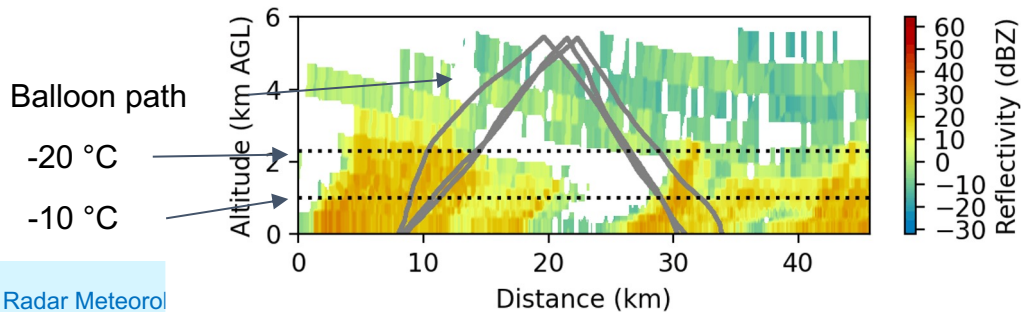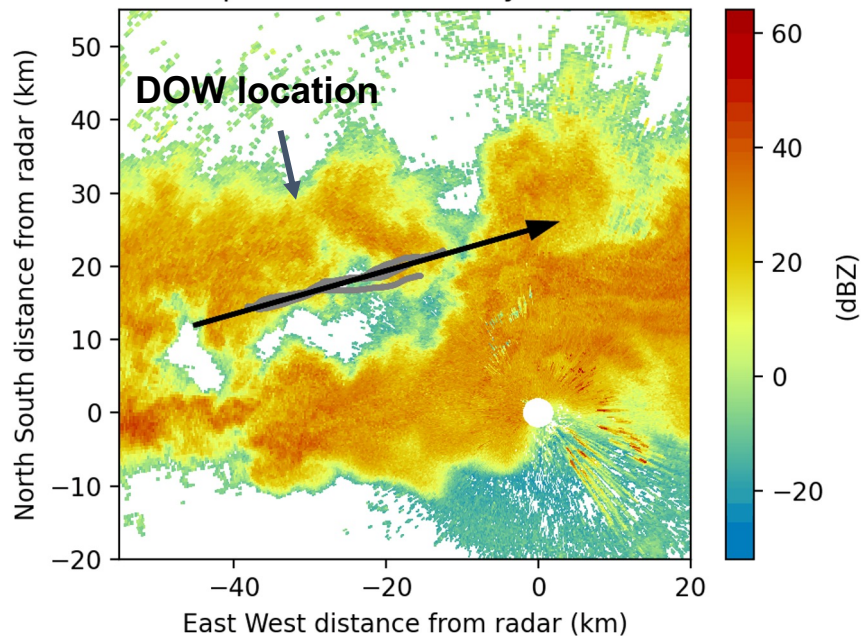- 240 - 290 flashes from November to early February
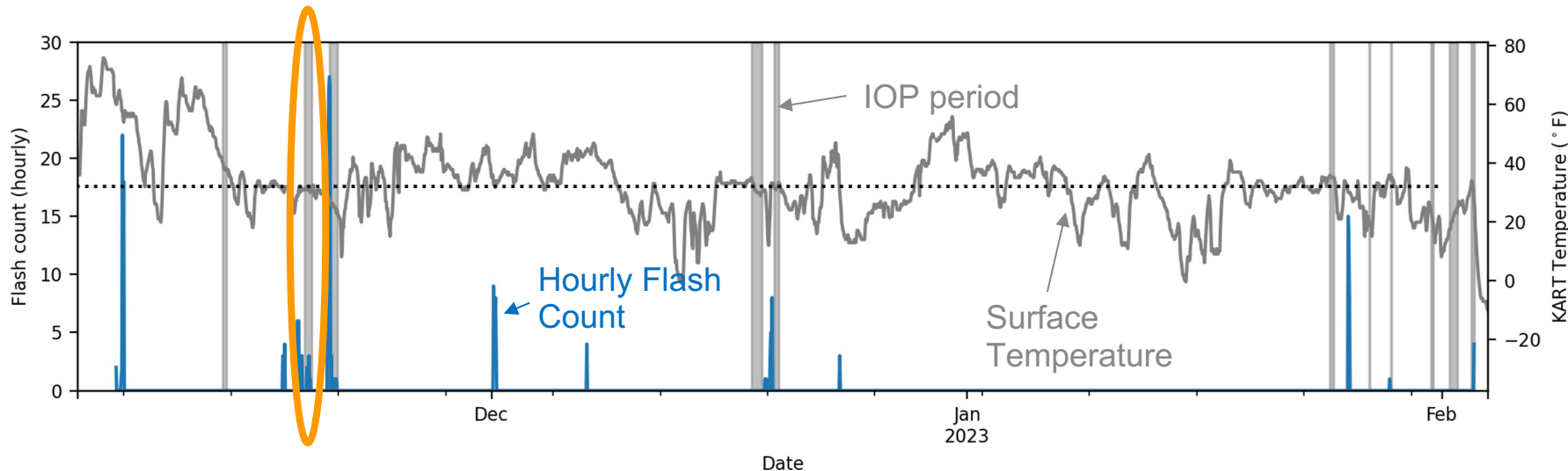
IOP2 Overview

- Three EFM launches from lake shore
  - 1st: North of the convective band
  - 2nd: In convective band
  - 3rd: In band immediately before it shifted south
- Flashes ~hourly
- >9 hrs DOW obs

KTYX 0.5 Deg. 2022-11-18T22:35:56.604000Z
Equivalent reflectivity factor

DOW location

Balloon path

-20 °C

-10 °C

Nearest neighbor interpolation to cross section grid

NSSL_Mobile   20221119/0139 (User Selected)

SHARPpy Beta v1.4.0 Andover

Lake surface temp (average): 10.5-11.1 °C
Land surface temp (at launch): 1.7 °C
Melting level: within 200 m of the surface.
Snow growth: 1.6 to 2.9 km MSL
Homogeneous freezing: 5.7 km
Cloud top in sounding: 5 km
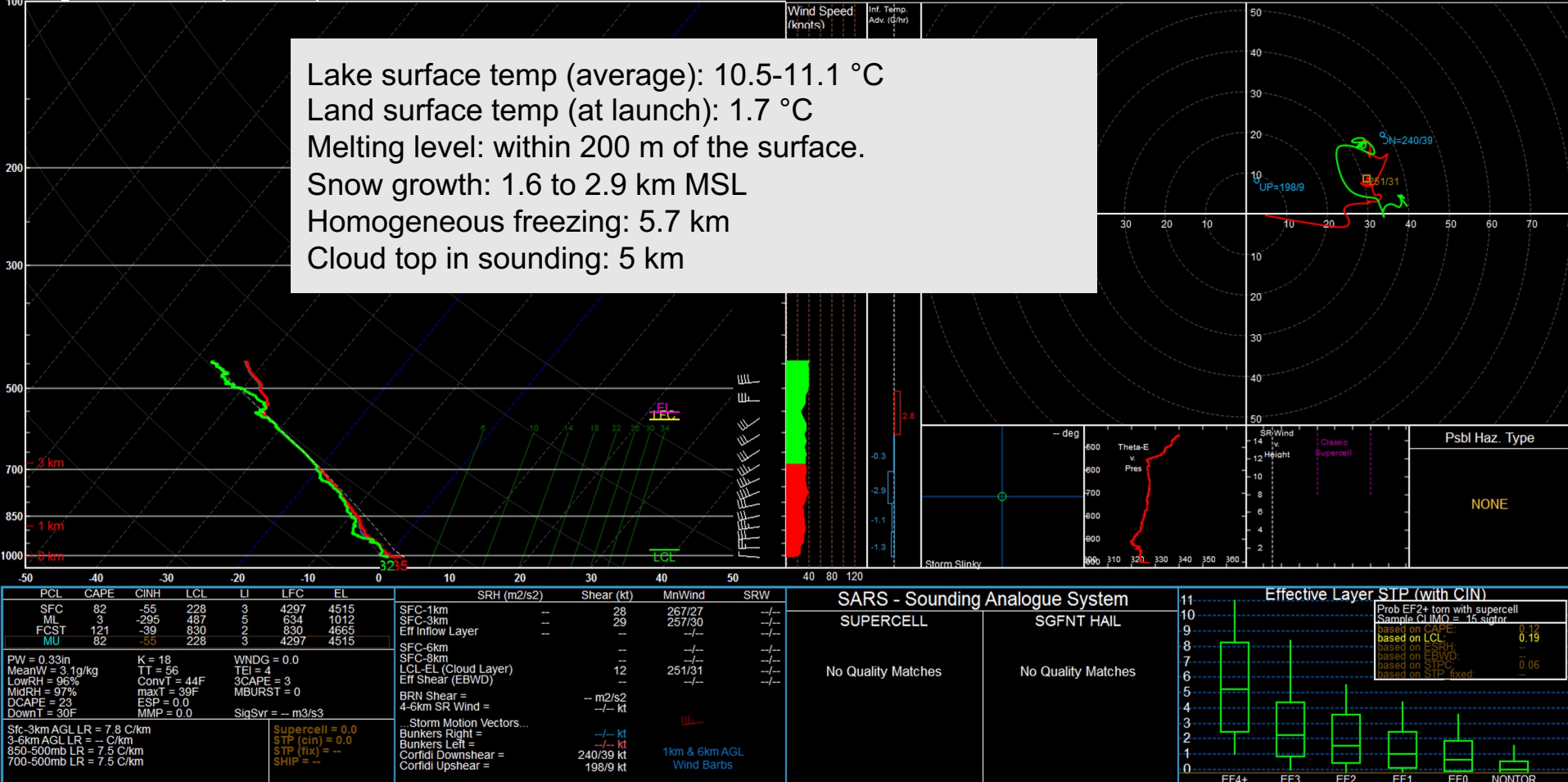
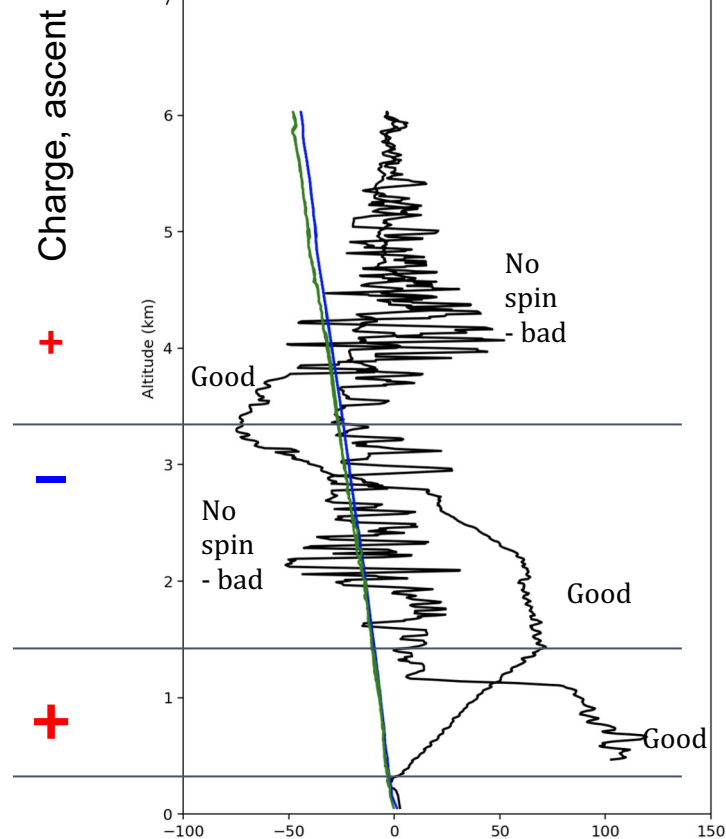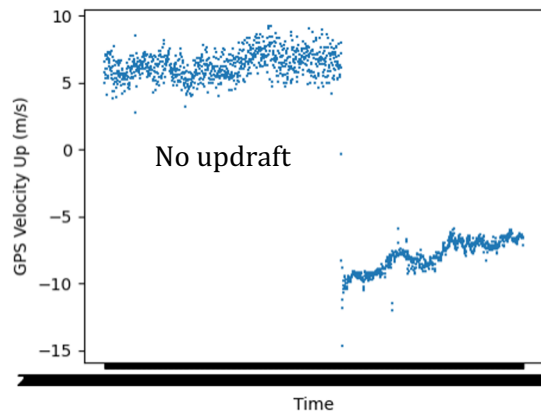# Launch 1 - preliminary

<u>QC still in progress</u>
Charge densities moderately large

Up:
- Positive charge to 1.3 km
- Negative charge from 2.0 to 3.2 km
- Positive charge above 3.5 km

Down:
- No spin for most of descent
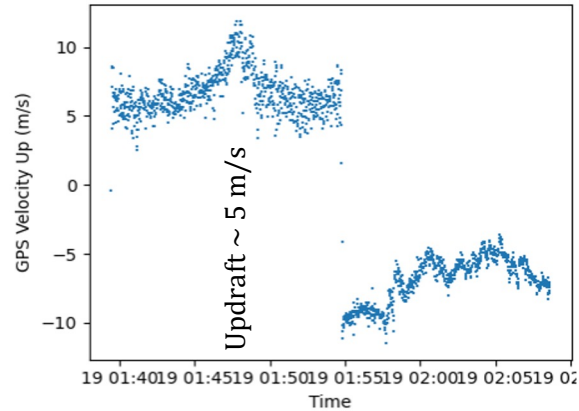- **We measured >100 kV/m at about 500 m MSL**!

Launch 2 - preliminary

Significant positive charge just above surface

Deep negative layer, larger charge density below 1 km
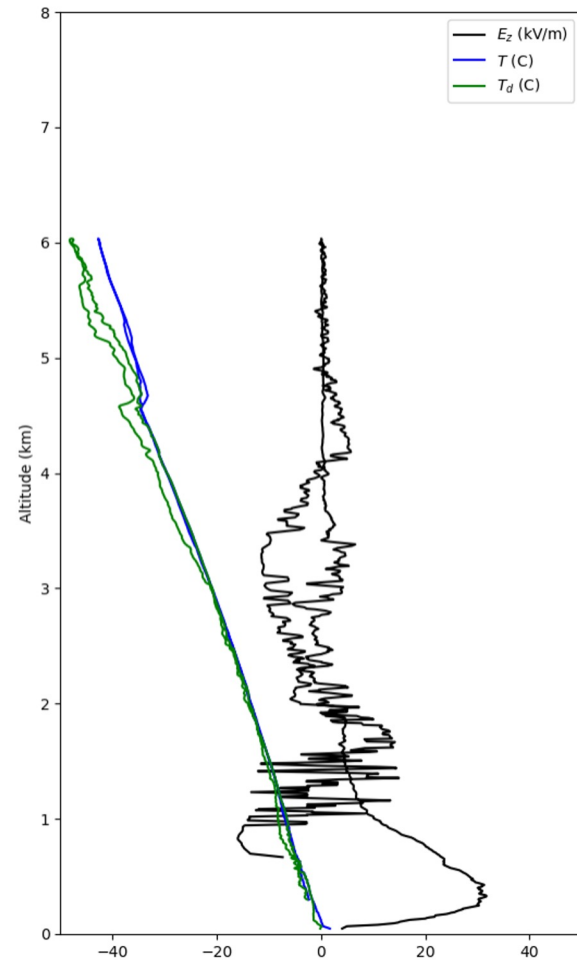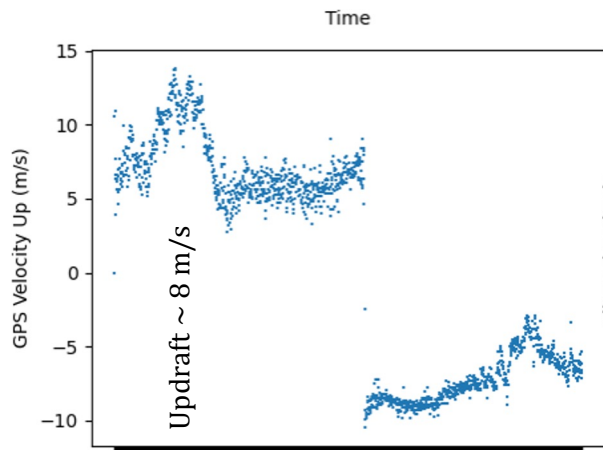
Probable upper positive layer

Launch 3 - preliminary

Significant positive charge just above surface

Deep negative layer

Probable upper positive layer

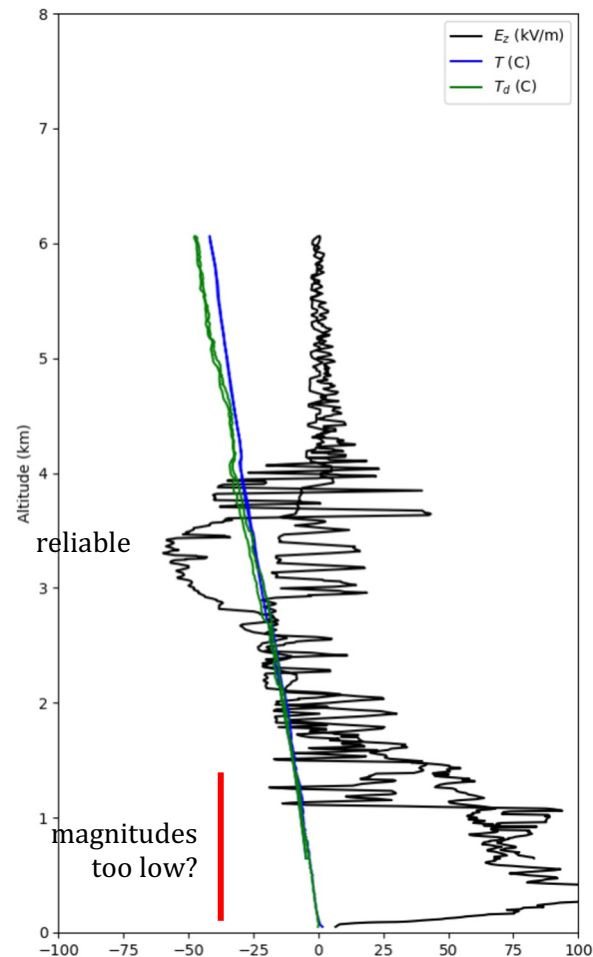Note: Clipped E due to accumulation of precip across spheres

Charge, ascent

IOP2 EFM Launch Summary

- Large electric fields in the lowest km
- Positive charge near the surface
    - Outside of updraft: positive charge below ~1.3 km or -10 °C
    - In updraft: positive charge below 500 m or close to 0 °C
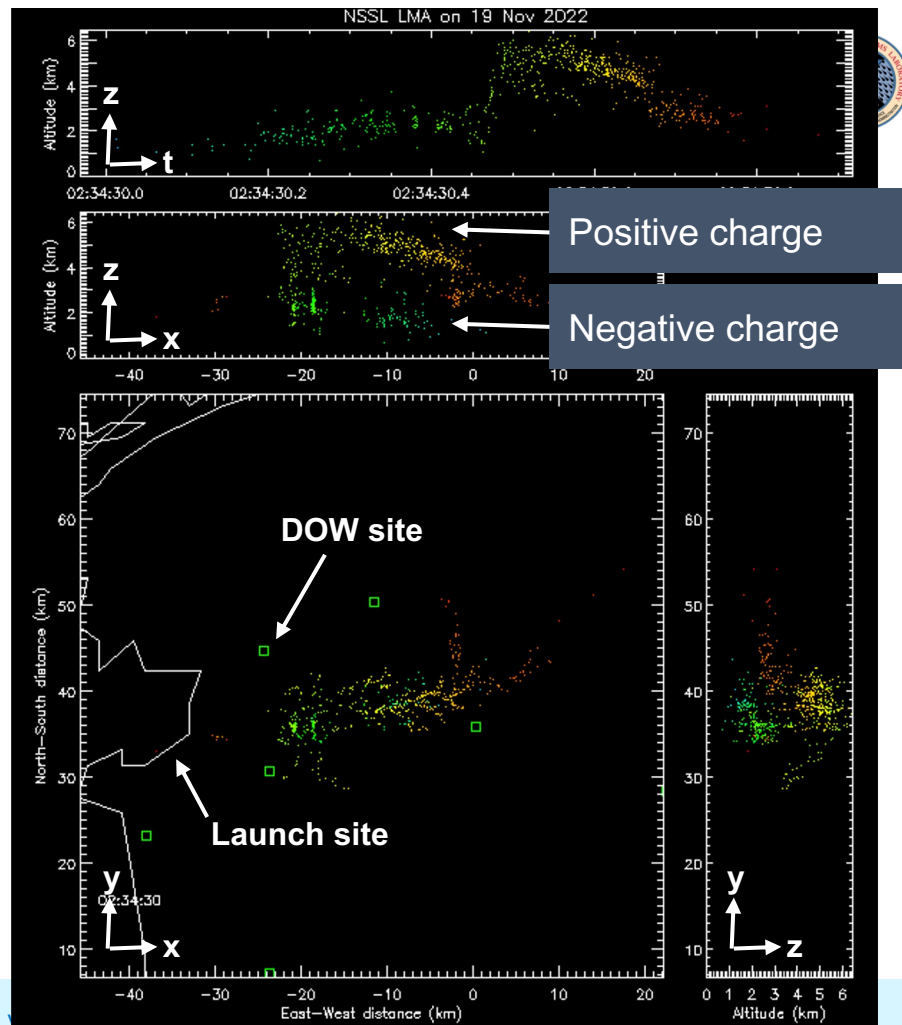- Negative charge until ~3.2 km or -20 °C
- Positive charge above ~3.5 km

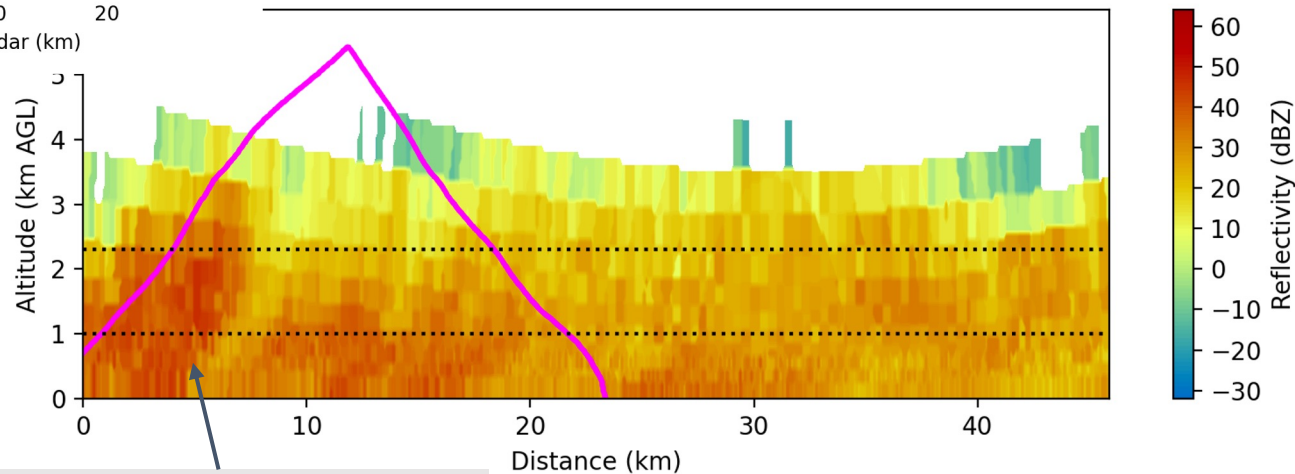# LMA agreement with the net charge structure

Most flashes were <3 km MSL

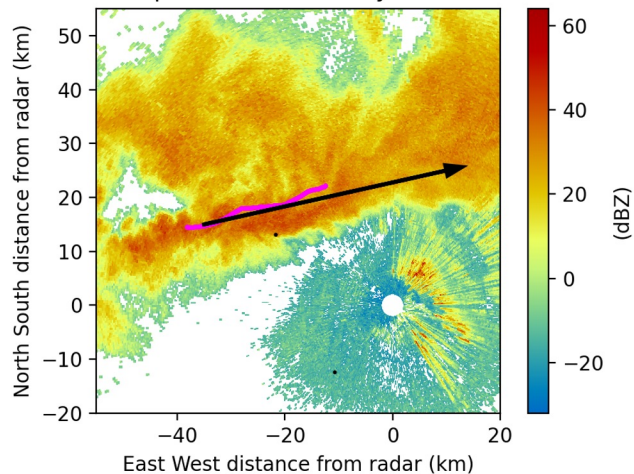This one/series approached 6 km MSL

~1 hr after EFM launch #2

~20 min before EFM launch #3

NSSL LMA on 19 Nov 2022

Positive charge

Negative charge

DOW site

Launch site

KTYX 0.5 Deg. 2022-11-19T02:26:29.702000Z
Equivalent reflectivity factor

KTYX perspective - 8 min prior

Nearest neighbor interpolation to cross section grid

Large graupel noted at 0219

KTYX 0.5 Deg. 2022-11-19T02:32:06.452000Z
Equivalent reflectivity factor
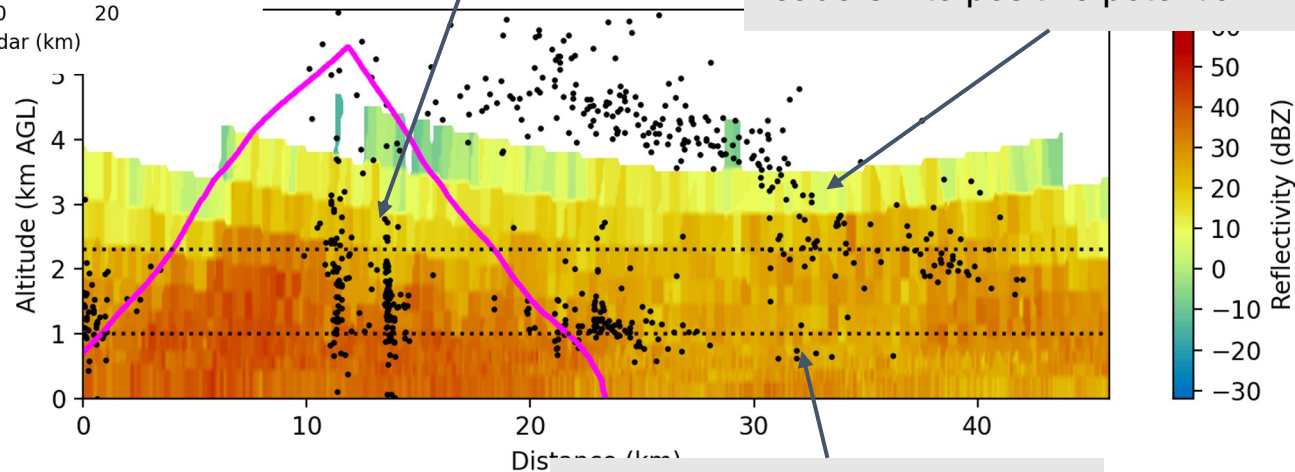
KTYX perspective - 2 min prior
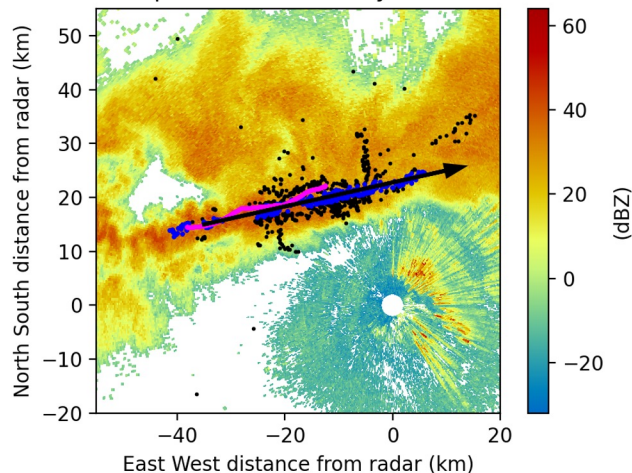
Upward development

Downward propagation of negative leaders into positive potential

Nearest neighbor interpolation to cross section grid

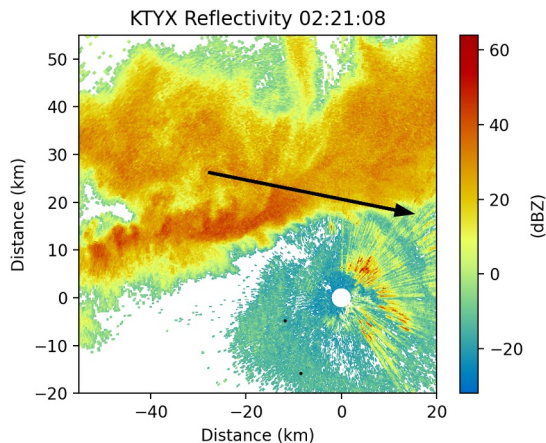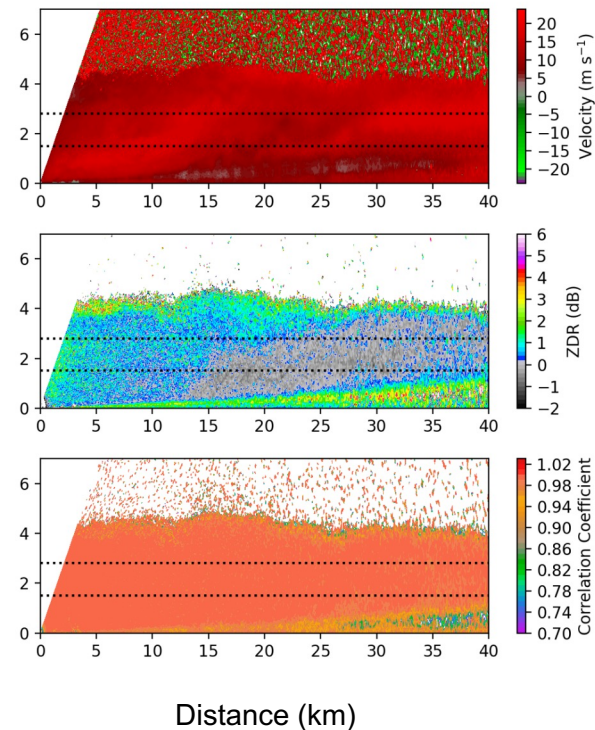Initiation area
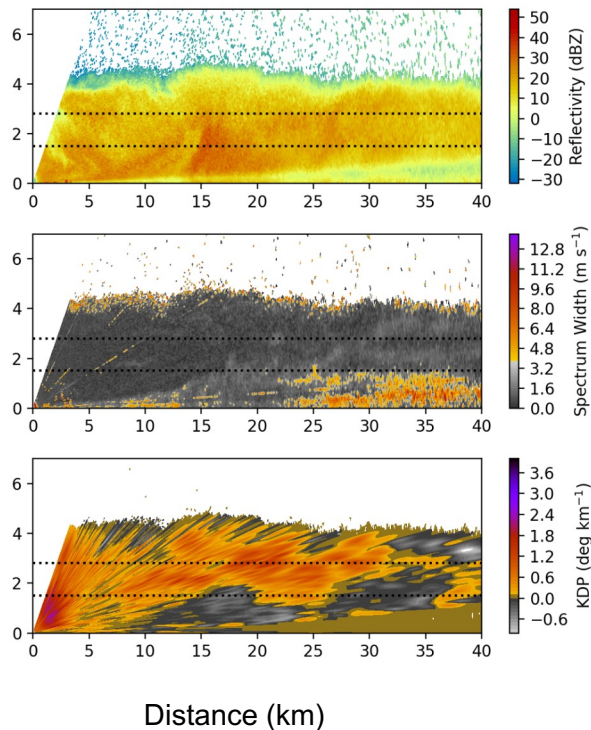Reduction of negative potential

DOW RHI perspective
02:22:02.1 - RHI
02:35:30 - Flash

KTYX Reflectivity 02:21:08

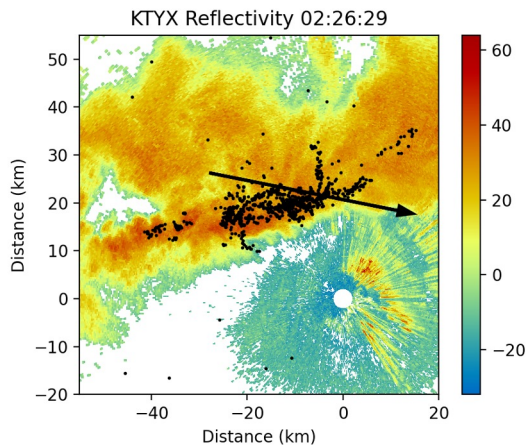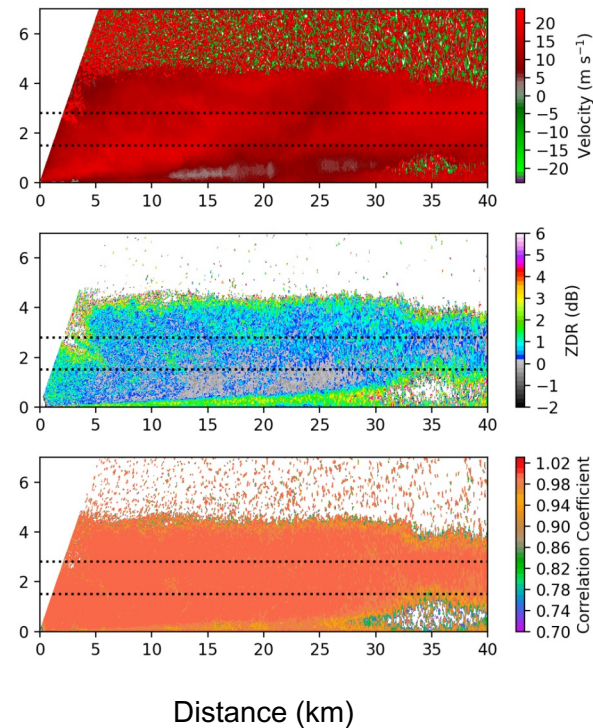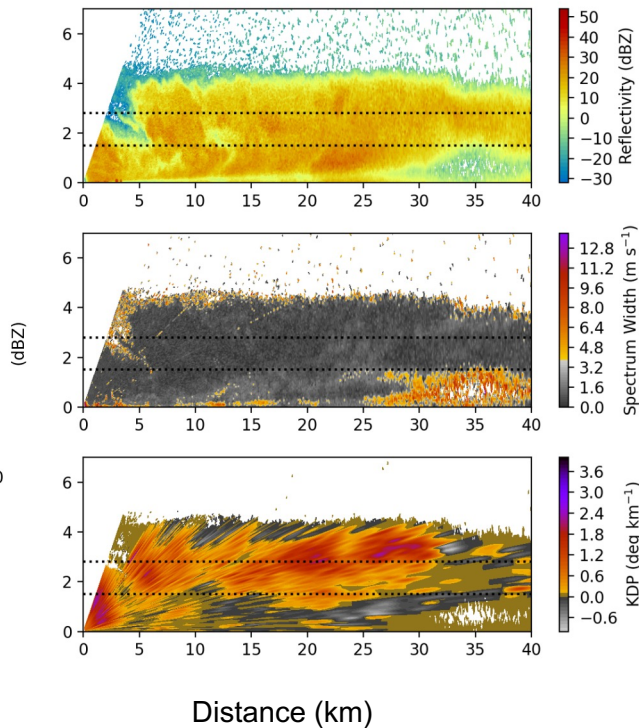KTYX PPI reference
DOW7 RHI at 101.3°

Distance (km)

Distance (km)

DOW RHI perspective
02:31:30.8 - RHI
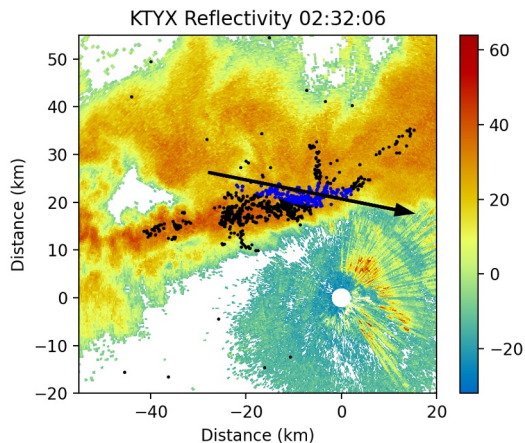# 02:35:30 - Flash

KTYX PPI reference
DOW7 RHI at 101.3°

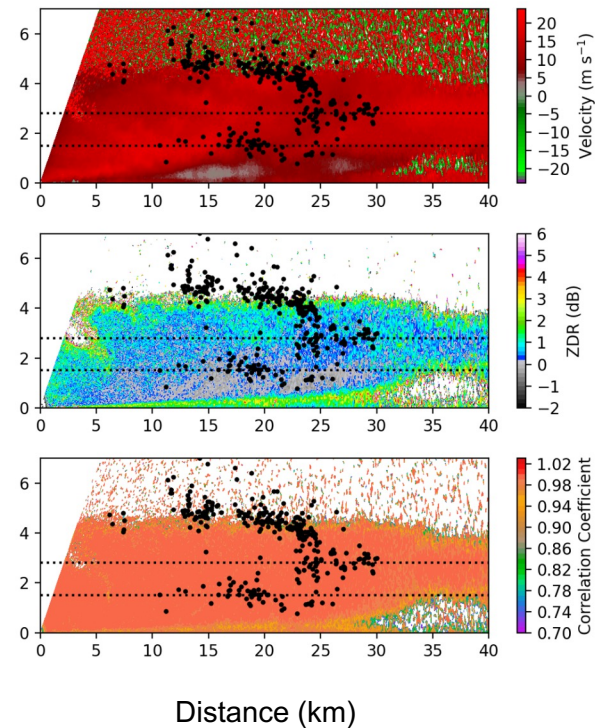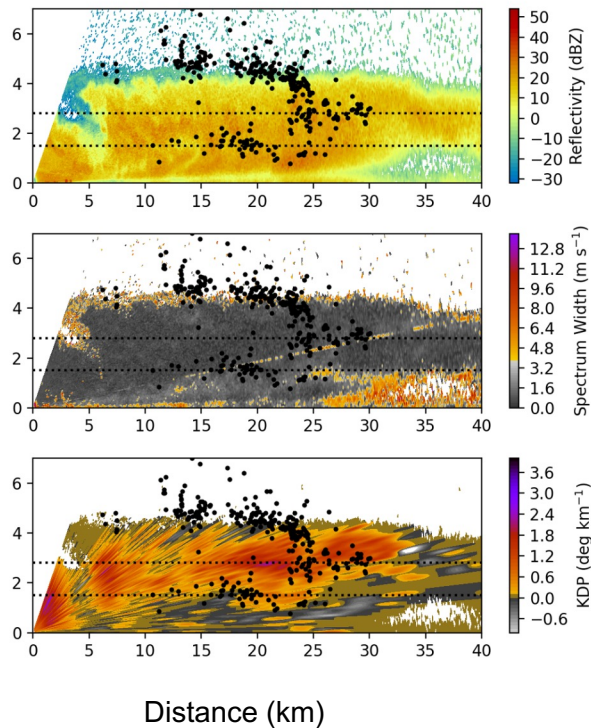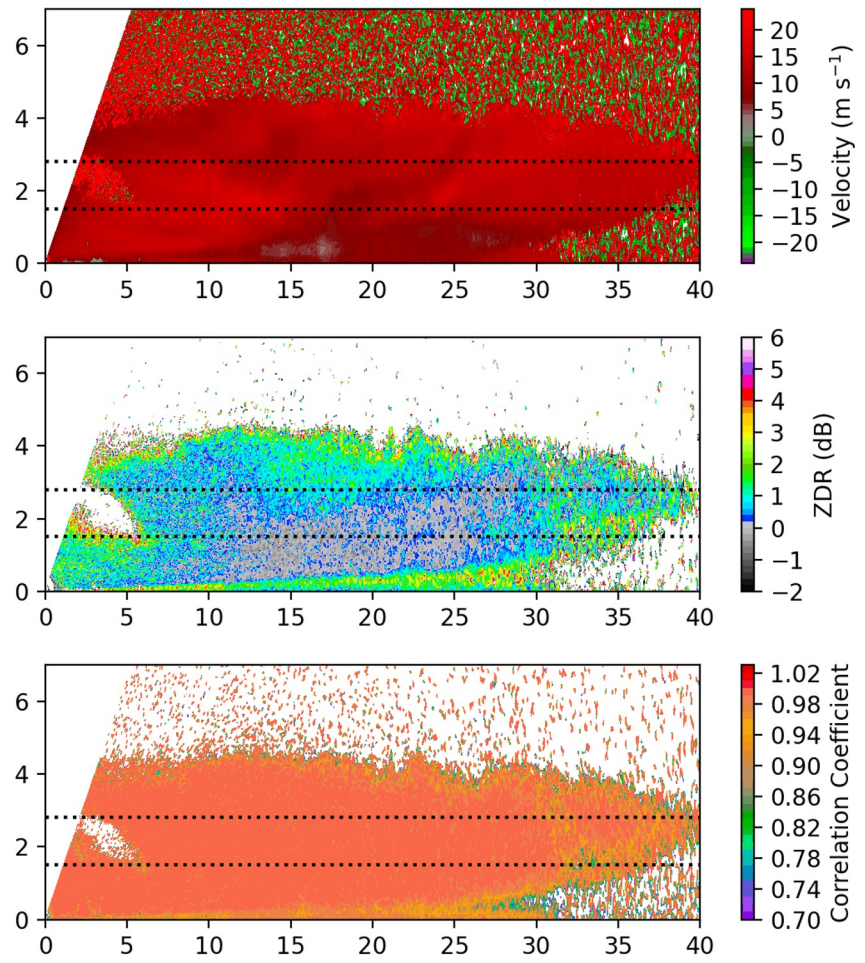# DOW RHI perspective
02:32:46.3 - RHI
02:35:30 - Flash

KTYX Reflectivity 02:32:06

KTYX PPI reference
DOW7 RHI at 101.3°

Distance (km)

Distance (km)

30 August 2023 // AMS 4   Animation covers 31 minutes leading up to the flash of interest
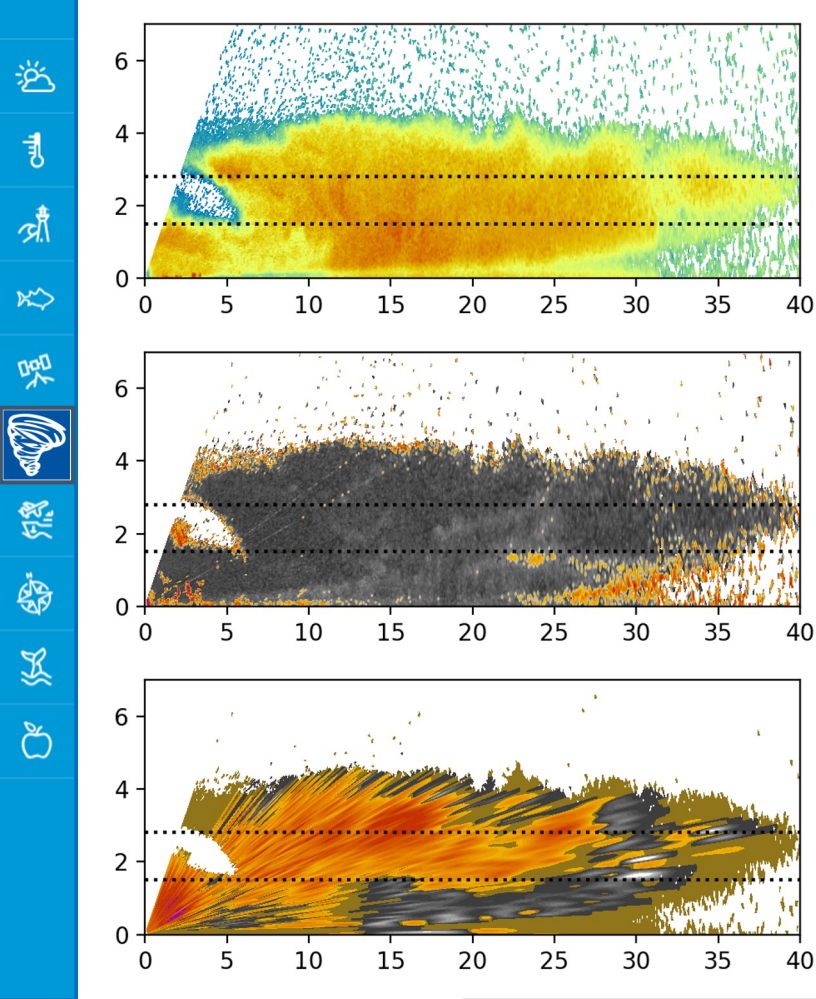
Ongoing work

- Electric field meter quality control
- Imager processing
- Integration of observations
- What do the radar characteristics look like in IOPs without lightning?
- How well can we duplicate observations in a simulation?
- Lightning characteristics throughout the season
  - Information from other networks
  - Typical areas, altitudes, propagations
  - Distance from a likely trigger
- What about the lightning in non-IOP periods?

Field catalog: https://catalog.eol.ucar.edu/lee