

# INTEGRATION OF THE TOTAL LIGHTNING JUMP ALGORITHM INTO CURRENT OPERATIONAL WARNING ENVIRONMENT CONCEPTUAL MODELS

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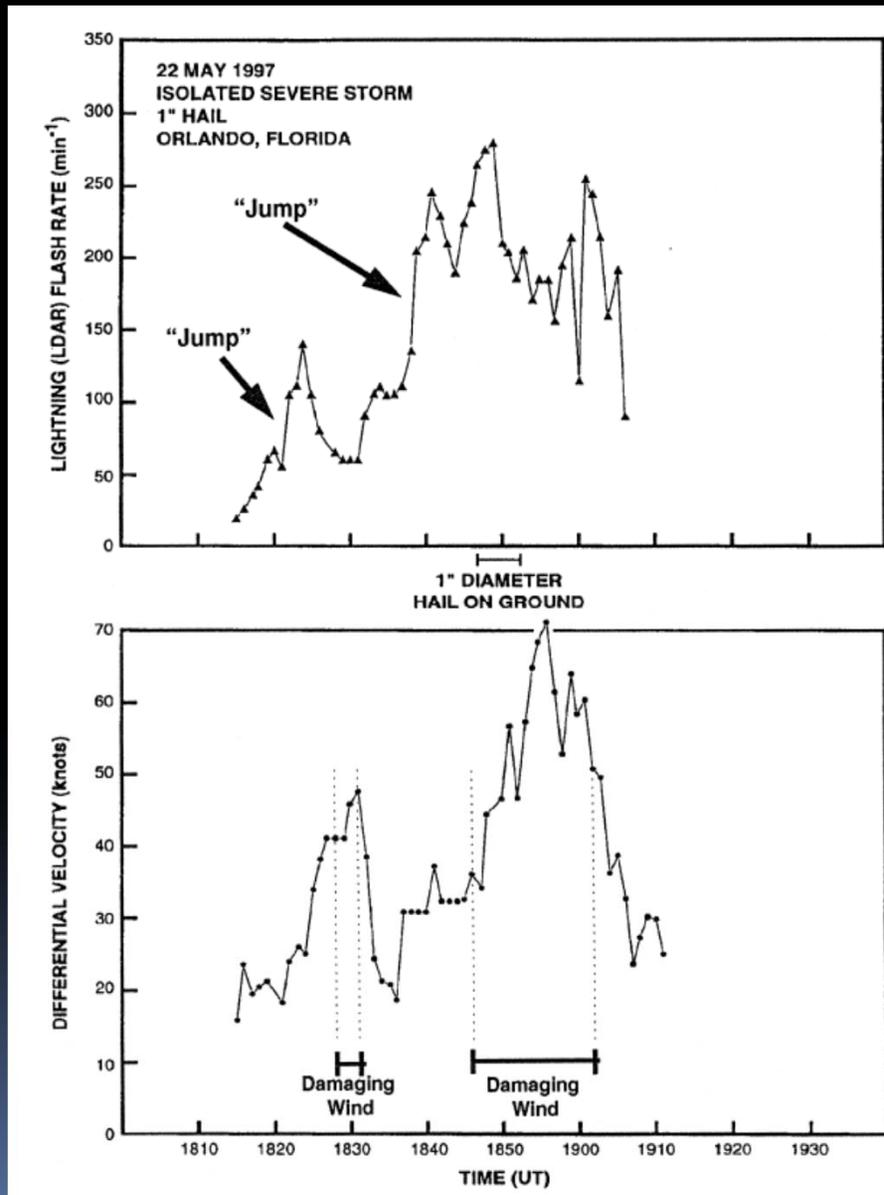
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# Goal of LJA Project

- Objective - To refine, adapt and demonstrate the LJA for transition to **GOES-R GLM (Geostationary Lightning Mapper)** readiness and to **establish a path to operations**
  - Ongoing work – reducing risk in GLM lightning proxy, cell tracking, LJA algorithm automation, and data fusion (e.g., satellite and radar + lightning).

# The Lightning Jump Concept



- Several studies in the past have correlated increases in total flash rates within a storm to severe weather occurrence, e.g.,
  - Goodman et al. 1988
  - Williams et al. 1989
  - Williams et al. 1999
  - Schultz et al. (2009)
  - Gatlin and Goodman (2010)
- The correlation is between the following
  - Updraft strength and modulation of electrification
  - Updraft strength and ability to produce severe and hazardous weather.

# Real Time Situation Awareness Utility

## ■ The LJA Can:

- Indicate when an updraft is strengthening or weakening on shorter timescales than current radar and satellite
- Identify when severe or hazardous weather potential has increased
- “Tip the scales” on whether or not to issue a severe warning

## ■ The LJA Cannot:

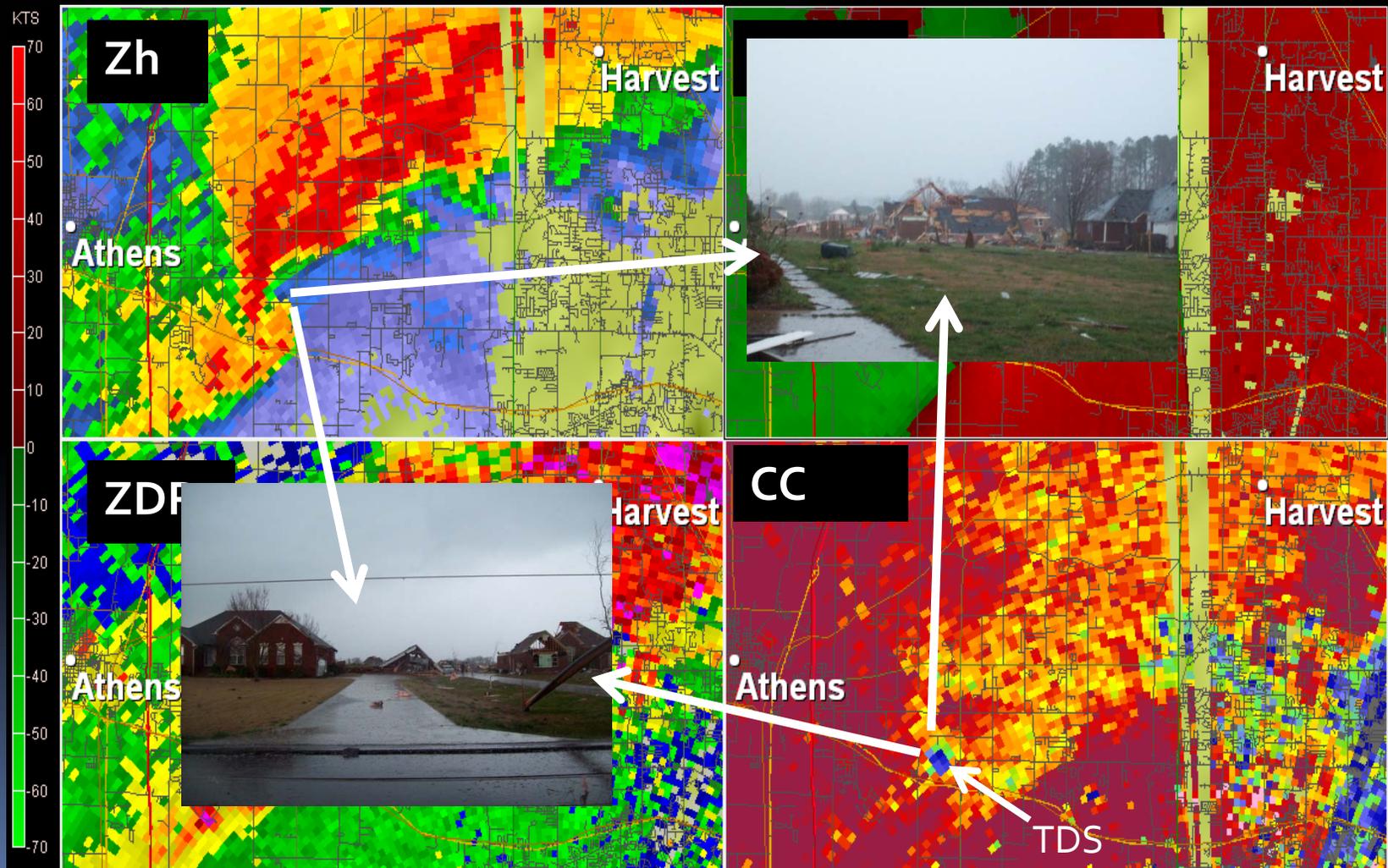
- Predict severe weather potential in every severe storm environment.
- Discern severe weather types
  - i.e., a certain jump does not mean there will be a certain type of severe weather
- Issue specific types of severe warnings

# Lightning jump “tips the scale”

March 2, 2012, morning severe weather episode

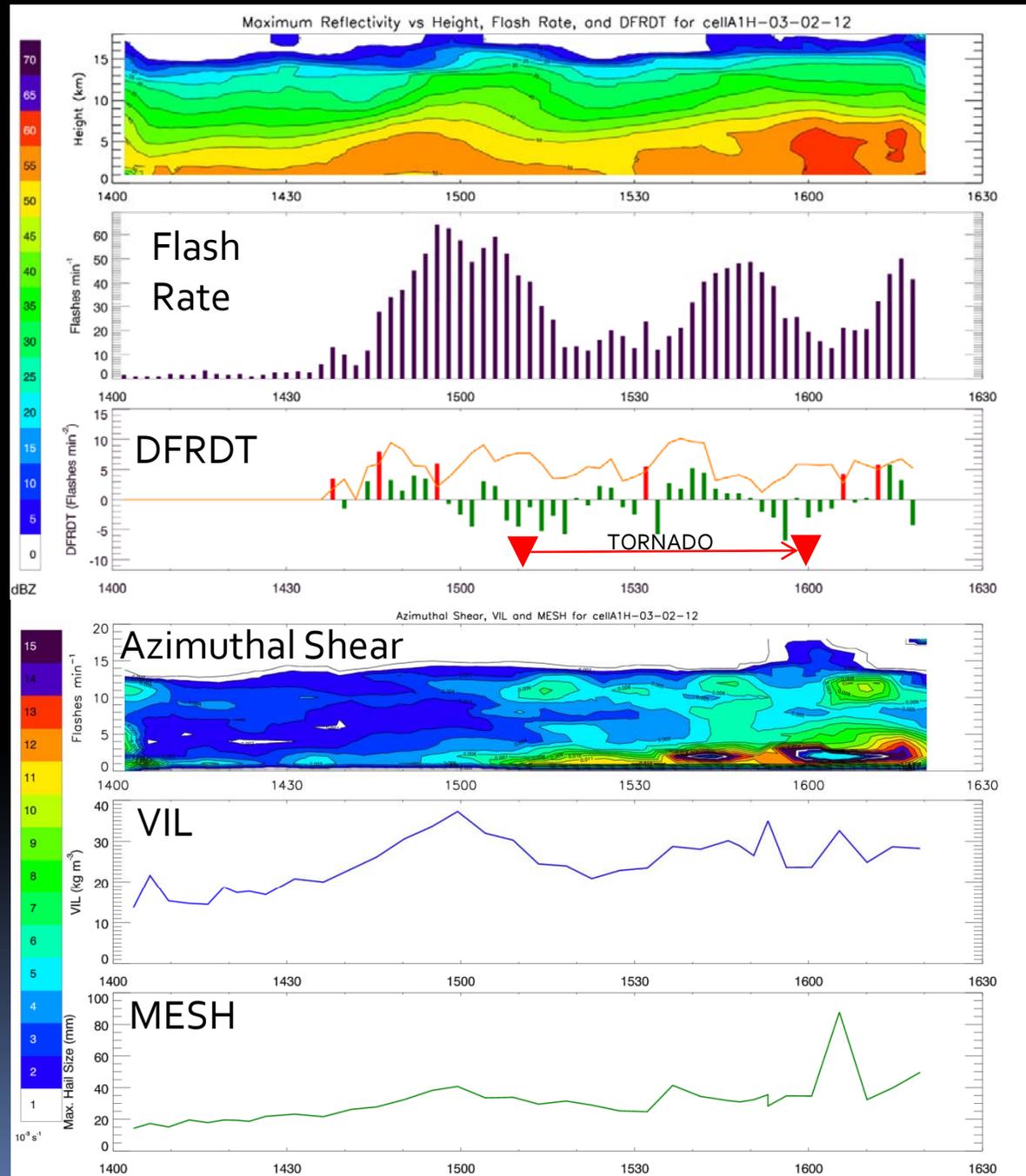
- 1451 UTC – NWS Huntsville Issues Warning
- Forecaster notes increase in lightning
- First reports of severe weather 1520 UTC
- Debris signature observed on ARMOR at 1513 UTC
- Lead time on event 19 minutes (touchdown 1510)

**ARMOR 1517 UTC 3/2/2012**



# Lightning Jump, lightning rates, and comparisons to radar derived products, March 2, 2012

Top – Reflectivity  
 2 down – total flash rate  
 Middle – DFRDT, LJ  
 4 down – VIL trend  
 Bottom – MESH trend



# The Next Step: Understanding the Physics Behind the Jump

## Key points this analysis will address:

- 1) What physically is going on in the cloud when there is a jump in lightning?
  - **Updraft variations, Ice fluxes**
- 2) How do these processes fit in with severe storm conceptual models?
- 3) What would this information provide an end user?
  - **Relate LJA to radar observations, like changes in reflectivity, MESH, VIL, etc. based multi-Doppler derived physical relationships**

KHTX-ARMOR dual-Doppler analysis July 19, 2006

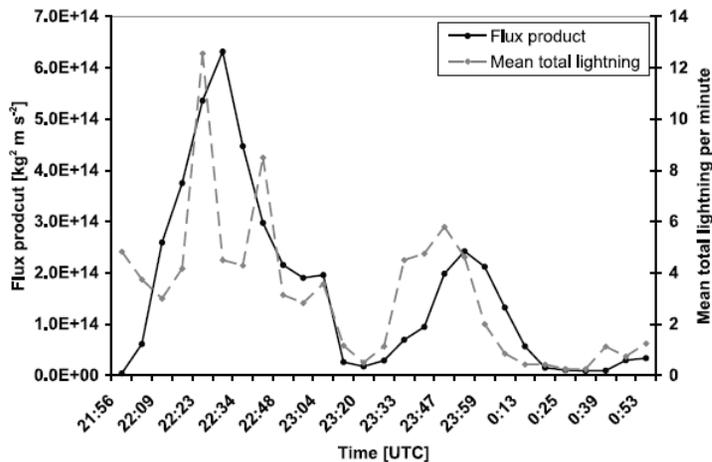
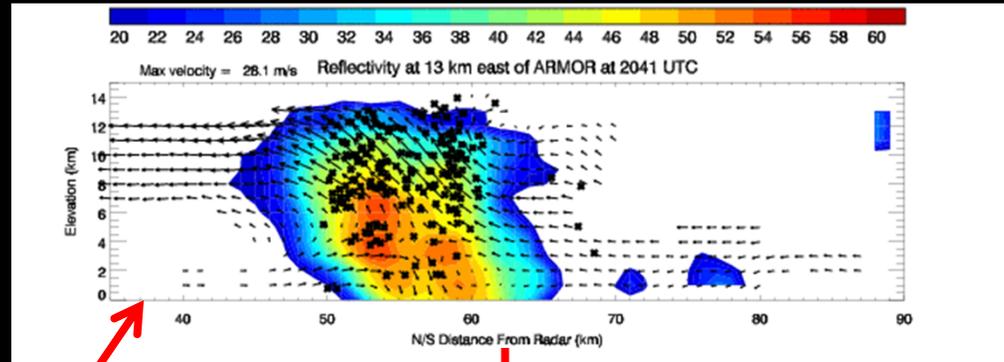
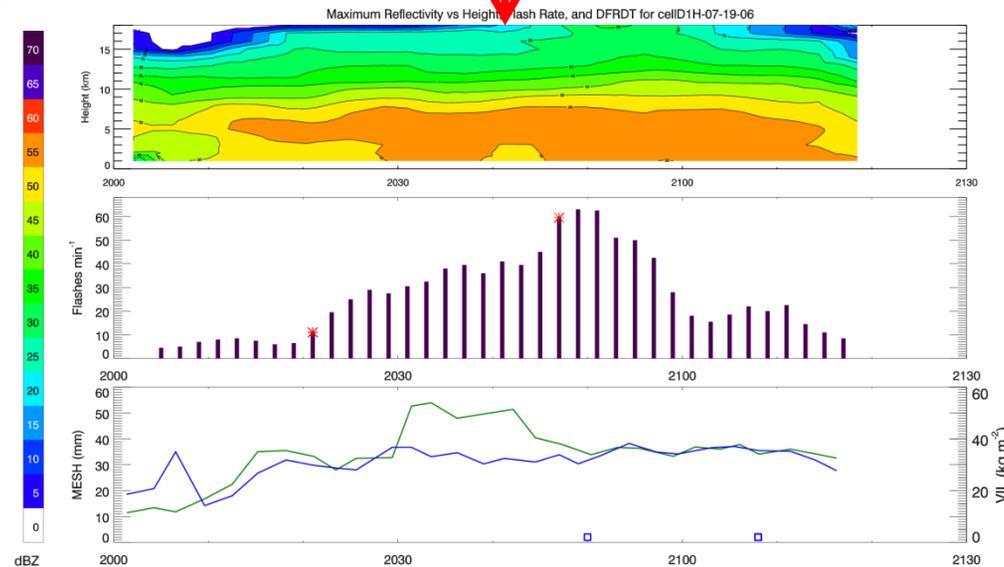


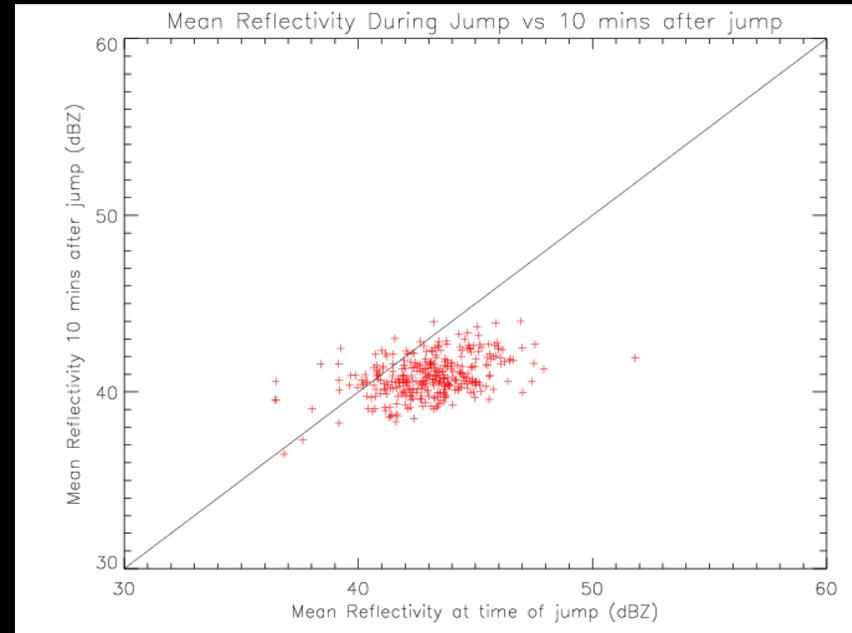
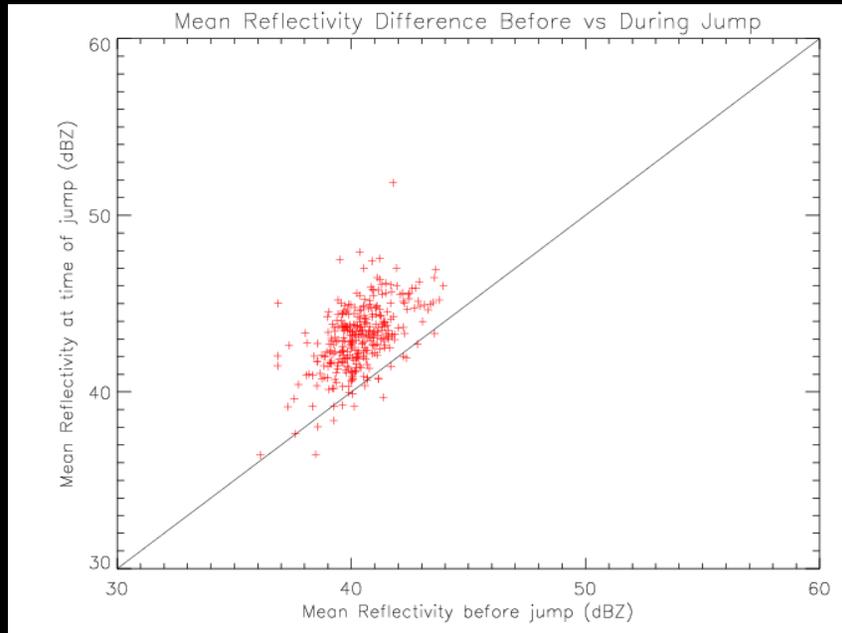
Figure 10. Mean total lightning rate per minute averaged over the radar volume time (gray dashed line) and the product of the fluxes of precipitation ice mass above the  $-5^{\circ}\text{C}$  level and nonprecipitation ice mass above the  $-5^{\circ}\text{C}$  level calculated with the divergence method (black solid line) of an ordinary single cell thunderstorm that occurred on 6 June 2000.



Time height of reflectivity (top) flash rate w/ lightning jumps (red asterisks; middle) and VIL (blue; bottom) and MESH (green; bottom)

Adapted from Deierling et al. 2008, JGR

# 1<sup>st</sup> Jump and Changes in Reflectivity Profiles



**Sample size:** 329 thunderstorms with at least 1 lightning jump using mean of all radar pixels above 35 dBZ

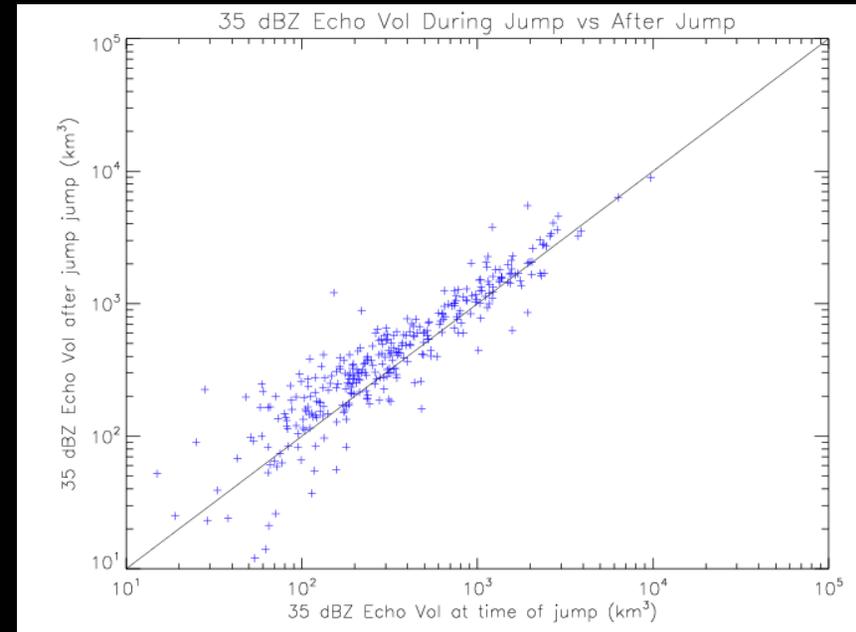
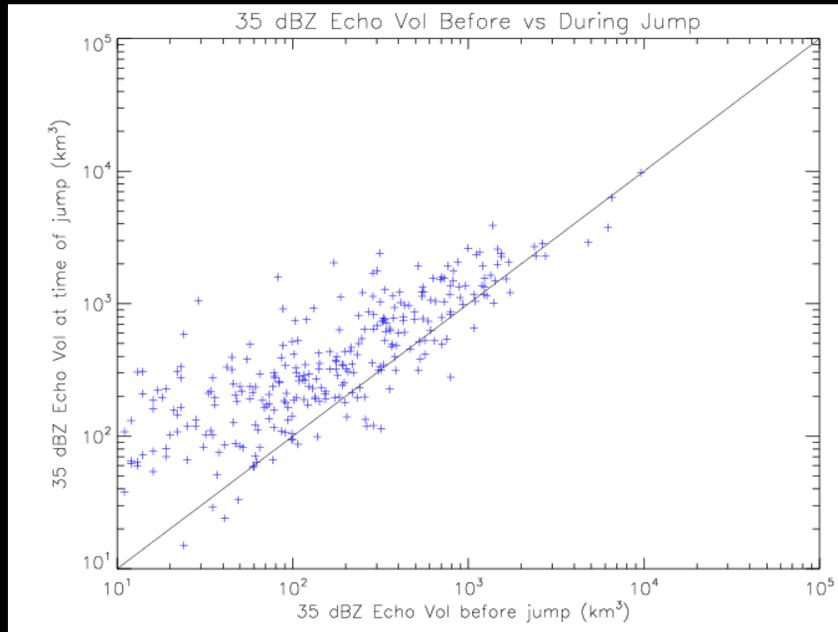
Mean reflectivity increases by an average of 2.72 dB during the 10 minutes prior to the first observed lightning jump

- Standard deviation (+/- 1.60 dB)

Then the reflectivity profile changes by an average of -2.19 dB during the 10 minute period after the jump

- Standard deviation (+/- 1.80 dB)

# 1<sup>st</sup> Jump and Changes in 35 dBZ Echo Volume



Sample size: 329 thunderstorms with at least 1 lightning jump.

Volume calculation using radar pixels above 35 dBZ at a temperature below -13° C

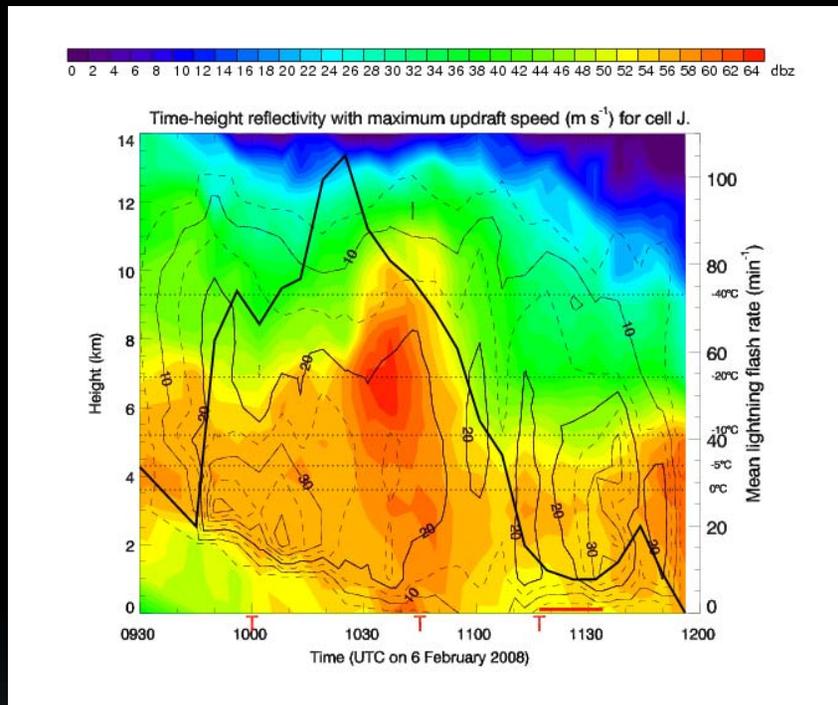
Average change in precipitation echo volume is 225 km<sup>3</sup> during the 10 minutes prior to the first lightning jump

- Standard deviation (+/- 413 km<sup>3</sup>)

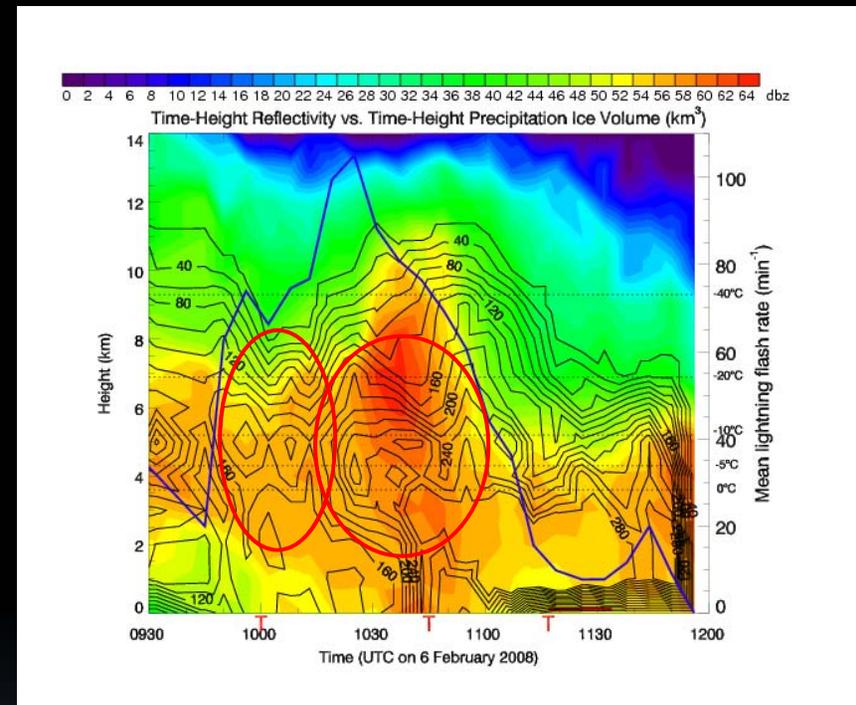
Then the precipitation echo volume continues to grow during the 10 minutes after the lightning jump by an average of 122 km<sup>3</sup>

- Standard deviation (+/- 356 km<sup>3</sup>)

# Kinematics/Microphysics and the Lightning Jump



Updraft speed vs total flash rate  
February 6, 2008



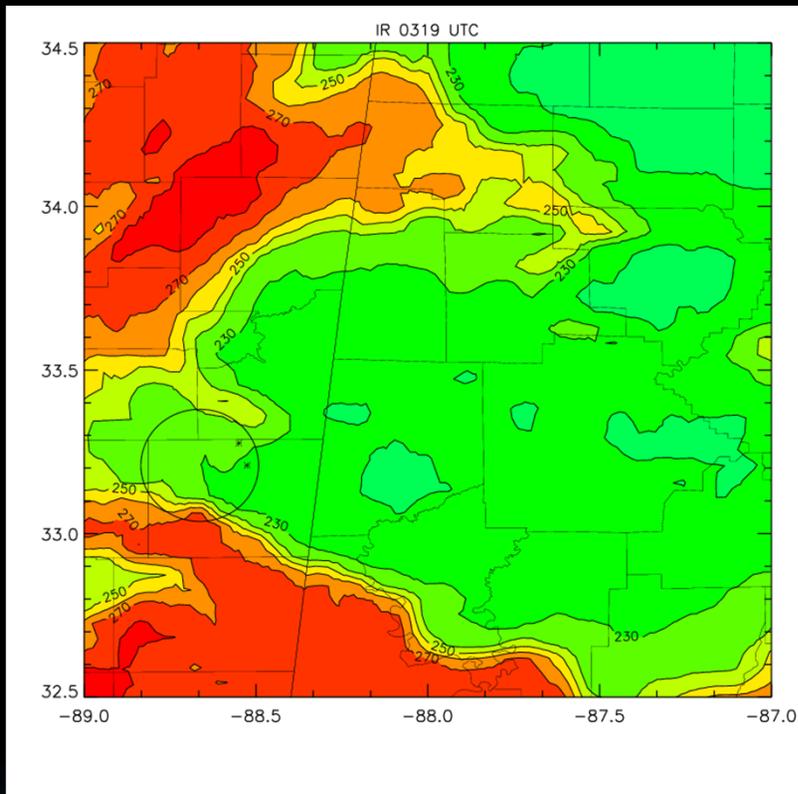
Precipitation Ice Volume vs total flash rate  
February 6, 2008

Large increases in updraft strength/volume and precipitation ice volume can correlate well with rapid increases in lightning (i.e., lightning jumps)

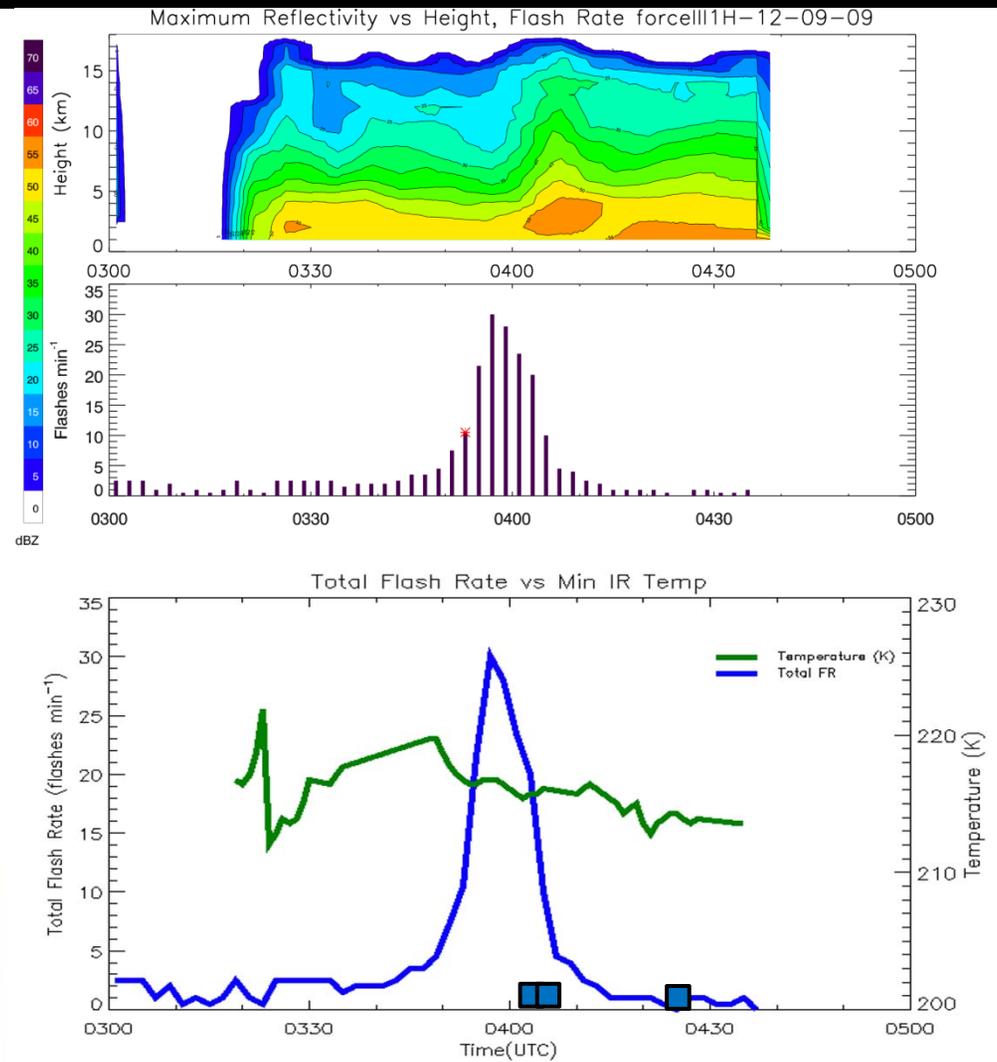
-In the case above two lightning jumps occur as large volume of strong updraft ( $>10 \text{ m s}^{-1}$ ) and large increases in precipitation ice volume occur (red circles).

-Note: a delay between radar observed quantities and LMA observed quantities exist because of differing temporal resolution of the measurements.

# Higher Temporal Satellite Information



Above - 1 minute temporal IR Brightness temperature (10.7  $\mu\text{m}$ ) from SRSO operations of GOES-O from December 9, 2009. Black asterisks represent lightning flash initiation points observed with the N. AL LMA. Black circle is the radar derived location of the storm.



Above – Time height section of reflectivity (top) total flash rate (purple bars; middle) and flash rate vs minimum brightness temperature (bottom). Red asterisk indicates time of lightning jump. Blue boxes represent wind reports.

# Summary

- Increases in the mean profiles of reflectivity are seen just prior to lightning jump occurrence followed by a decrease in the profile after the jump
  - Average increase 2.72 dB (+/- 1.60 dB)
  - Average decrease 2.19 (+/- 1.80 dB)
- Limited dual-Doppler assessment shows that increases in updraft volume and precipitation ice mass occur just prior to or during lightning jumps
- There is some evidence for cooling at cloud top just prior to a lightning jump occurrence in limited high temporal datasets
  - Need more datasets to corroborate this finding

# Looking forward

- The key will be to quantify the relationships between changes in updraft volume, precipitation ice mass, and other derived parameters on a number of cases to understand the physical mechanisms behind the jump.
- Inclusion of more rapid scan satellite information will be performed as a larger set of cases are collected to tie the LJ with satellite based quantities
- Ultimately, tying these relationships into the warning decision making process will be the key aspect to utilization of the lightning jump algorithm