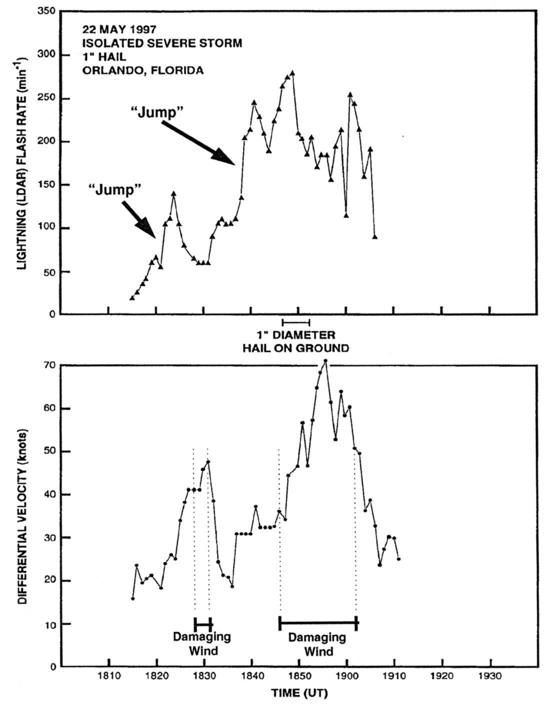
Precipitation Properties and Processes Linking Vertical Motion, Lightning, and Severe Weather

Sarah M. Stough[1], Lawrence D. Carey[1], Christopher J. Schultz[2], and Daniel J. Cecil[2]
1. Department of Atmospheric Science, University of Alabama in Huntsville, Huntsville, AL, USA
2. Earth Science Office, NASA Marshall Space Flight Center, Huntsville, AL, USA

Introduction

Better understanding of the relationship between lightning characteristics and thunderstorm kinematics and microphysics is needed to advance lightning meteorology research.

- Rapid increases in lightning flash rates (lightning jumps) shown to precede severe phenomena, connected by updraft-driven processes (Williams et al. 1999; Gatlin and Goodman 2008; Schultz et al. 2009, 2011, 2015, 2016, etc.)
- Refining the relationship between updraft-driven lightning properties and downdraft-influenced severe weather necessitates further investigation
  1. Spatial characterization of hydrometeor fields corresponding to flash regions during lightning jump development
  2. Evolution of hydrometeor fields in flash regions following lightning jumps



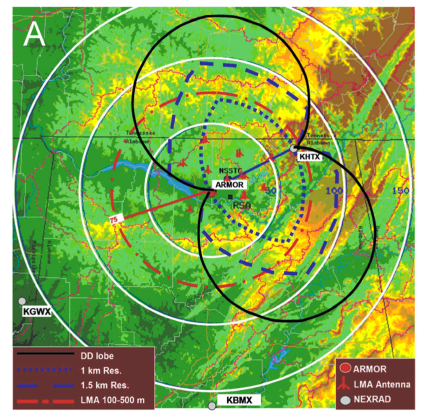
Williams et al. 1999 Fig. 5

Data and Methods

- Total lightning data from the North Alabama Lightning Mapping Array (NALMA) (Koshak et al. 2004)
  - Network sensors detect emitted lightning VHF radiation sources
  - Sources clustered into flashes using spatial and temporal thresholds (McCaul et al. 2005, 2009)
  - 2-sigma lightning jump algorithm used to identify and quantify a lightning jump when change in flash rate exceeds the recent average by ≥ 2.0 sigma (Schultz et al. 2009, 2017)

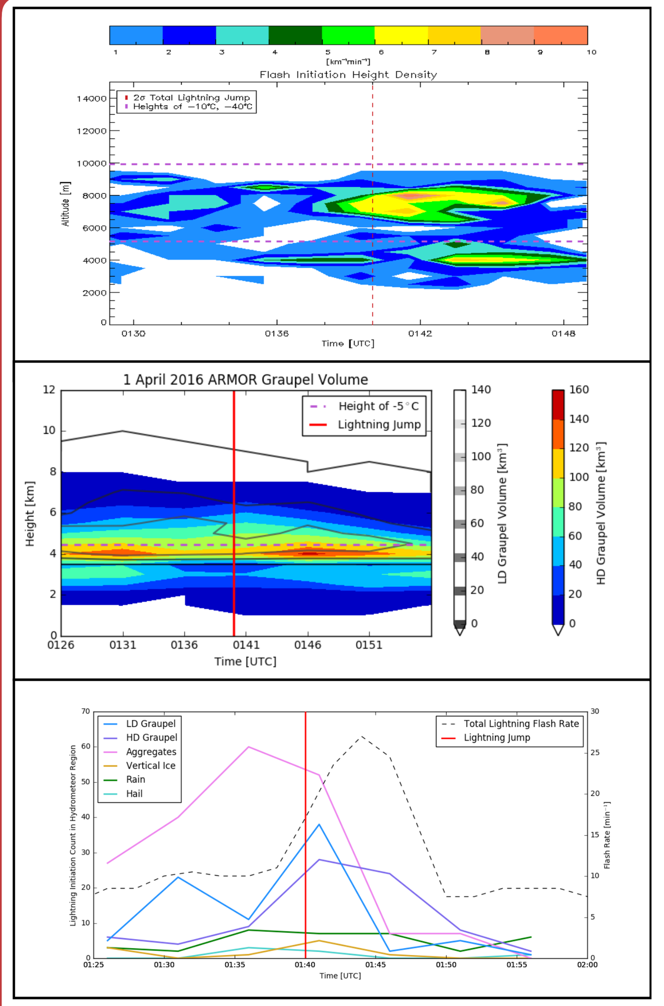
SPoRT 2017 Fig. 2

- C-Band radar data from the Advanced Radar for Meteorological and Operational Research (ARMOR) gridded with 0.5 km spacing using Py-ART software (Helmus and Collis 2016)
  - Dolan and Rutledge (2009), Dolan et al. (2013) method used for hydrometeor identification
  - Precipitation ice volume computed above the height of the -5°C level



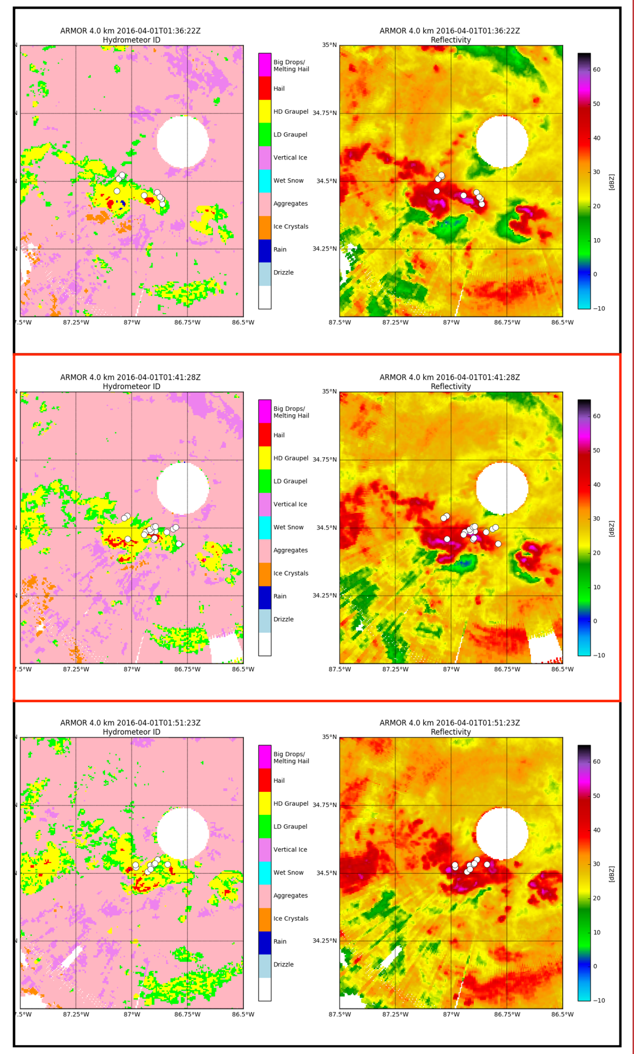
Schultz et al. 2015 Fig. 4a

Results



1 April 2016 supercell

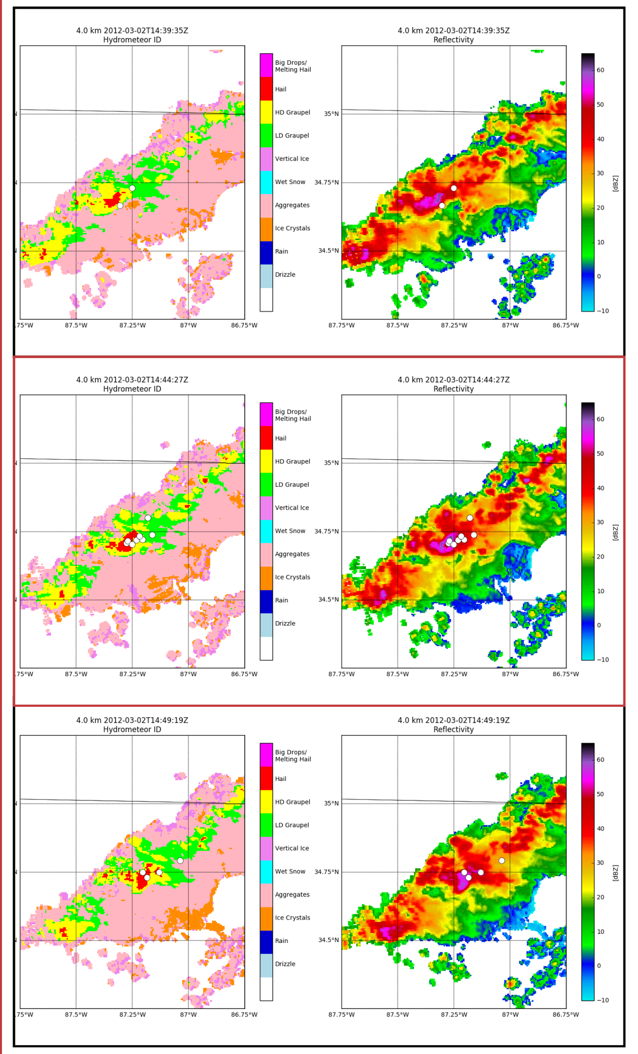
- Single lightning jump at 0140 UTC (7.6-sigma)



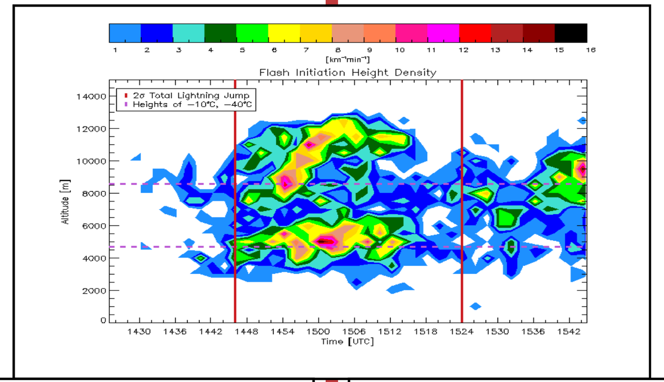
- Most initiations (init.) near 8 km leading up to jump
- Most increase in init. in graupel-dominant regions

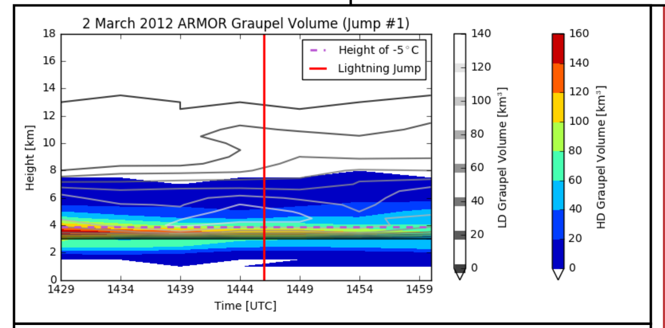
2 March 2012 supercell

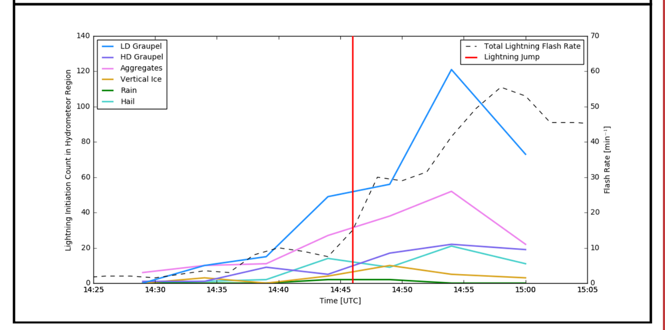
- First lightning jump at 1446 UTC (2.8-sigma; subsequent increase of 3.9-sigma at 1448 UTC)



- Increasing init. near 3-5 km prior to jump
- Increasing aggregate and graupel init. prior to jump

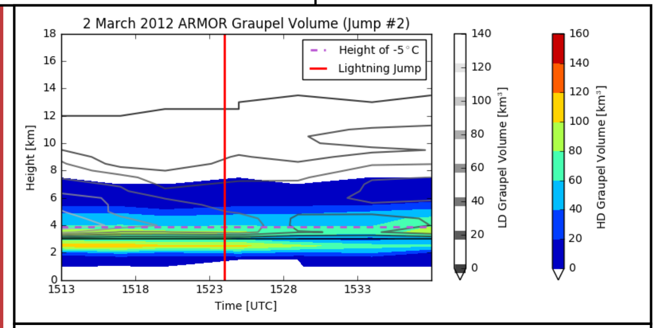


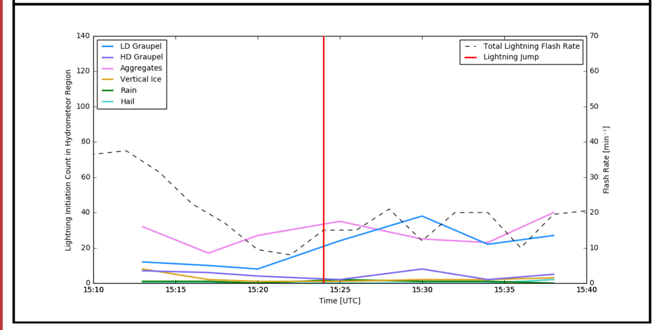


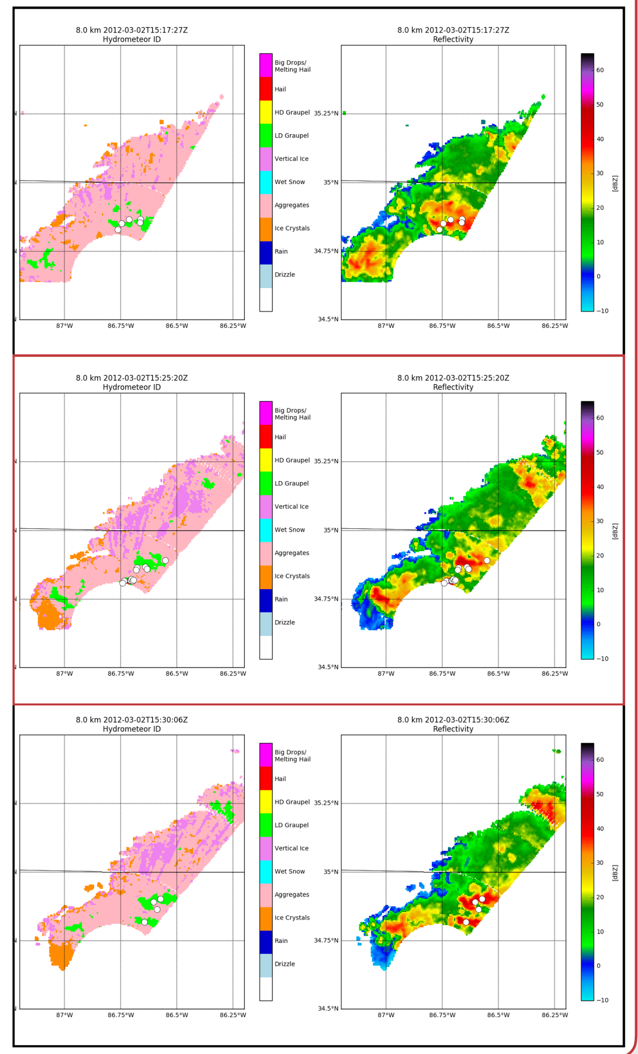


2 March 2012 supercell

- Second lightning jump at 1542 UTC (2.5-sigma)
  - Fewer init; inc. init. near 8 km prior to jump
  - Dec. in graupel volume; slight inc. of graupel init.







Summary and Discussion

- HID analysis of lightning contributing to 3 lightning jumps of varying intensity; subsequent trends in HID characteristics of storm post jump
- Lightning initiations within jumps predominantly associated with aggregate regions, though graupel-associated initiations (particularly LD graupel) showed greatest increase leading to lightning jump
  - Increases in LD+HD graupel associations were greater during the two more substantial jumps of the three
- Lightning initiation points most commonly observed at periphery of graupel/hail regions
- Observed bi-level contribution of lightning flashes during jump periods; most initiations observed aloft while greatest graupel concentrations in lower 4.0-4.5 km regions also exhibited numerous initiations
- Observed minor decrease in height and/or concentration of HD graupel volume concentration following lightning jumps

Ongoing and Future Work

- Add case studies to examine more diverse storm microphysics
- Expand analysis to include characterization of flash propagation
- Research requires radar data with higher temporal resolution to better relate microphysics to flash-scale processes

Acknowledgments

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