Relationships between Lightning and Radar Parameters in the Mid-Atlantic Region

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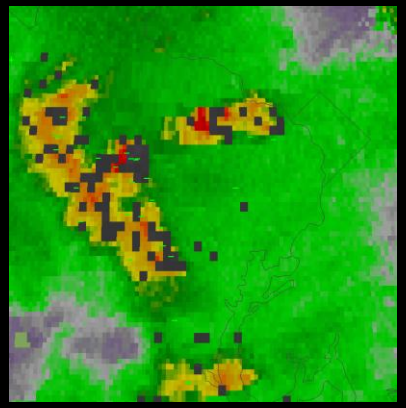
Research Objectives

- Determine relationships between lightning and radar to better differentiate between severe and non-severe storms
- Examine environmental influences on storm structure, severity, and lightning production in the Mid-Atlantic region
- Compute correlations between CG and IC characteristics, and also between lightning and radar parameters
- Investigate how storm structure (isolated vs. line/multicell) influences lightning production and its relation to storm severity
- Compare IC products at 2×2 and 8×8 km resolutions with both CG lightning and radar-derived parameters to investigate the suitability of the coarser GLM resolution

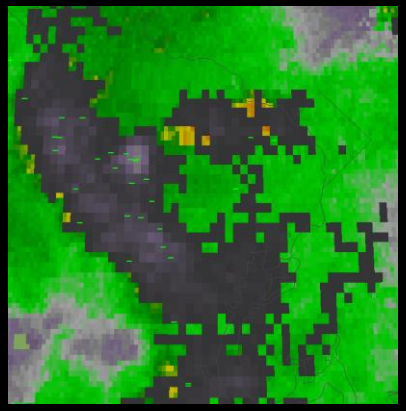
Warning Decision Support System

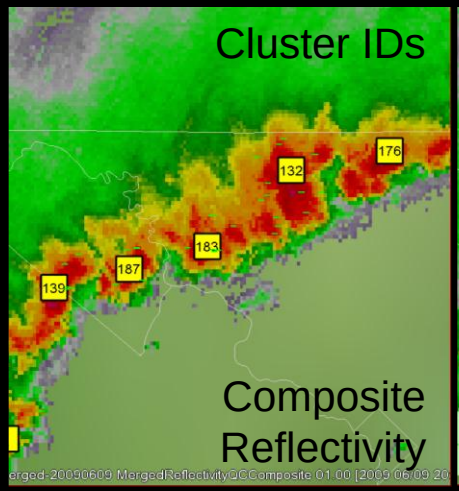
- Generate lightning and radar products
  - NLDN, LDAR/LMA, GLM-FED
  - RUC-derived near-storm environment
  - WSR-88D, plus *merged* parameters
- Identify and track individual storm cells
  - Track total lightning and radar parameters within individual storms
  - Many variations of parameters
- Prepare storm database
  - Automated procedures
  - Statistical analyses of many lightning and radar-derived parameters

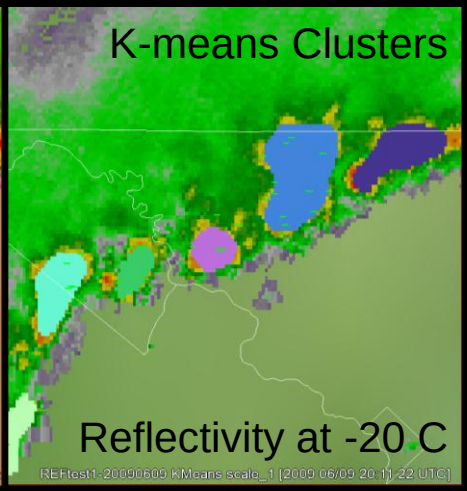
Flash Initiation Density



Flash Extent Density



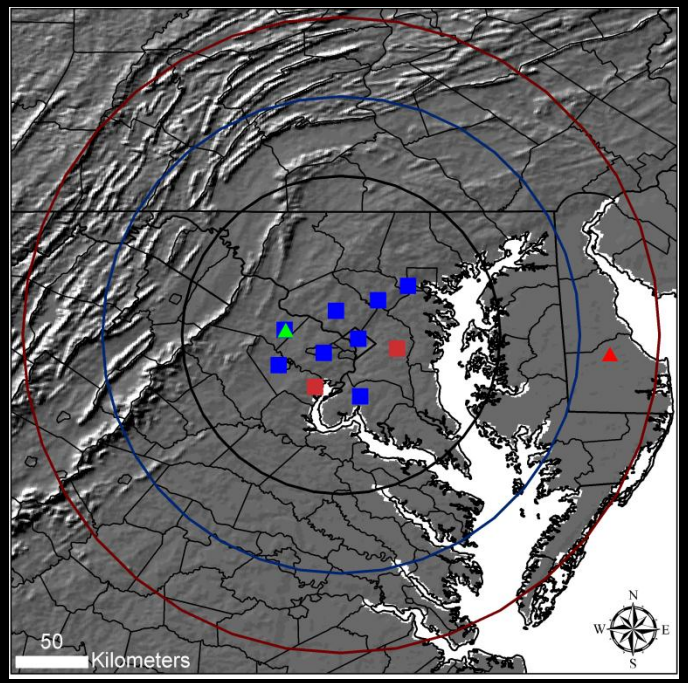




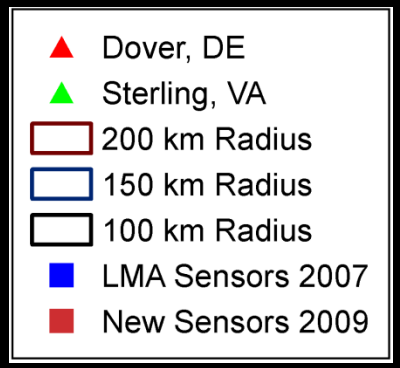
Study Overview

- Introduces our analysis methods and the resulting storm database
- Many storms on 61 case study days
- Compare and Contrast
  - Severe versus Non-Severe
  - Isolated versus Line/Multicell
- Total Storms = 1667 (1245)
  - 58,969 (34,953) 2-min points = 1966 h
  - Average duration = ~71 min
  - 460 Severe
  - 1207 Non-Severe

Mid-Atlantic Study Domain

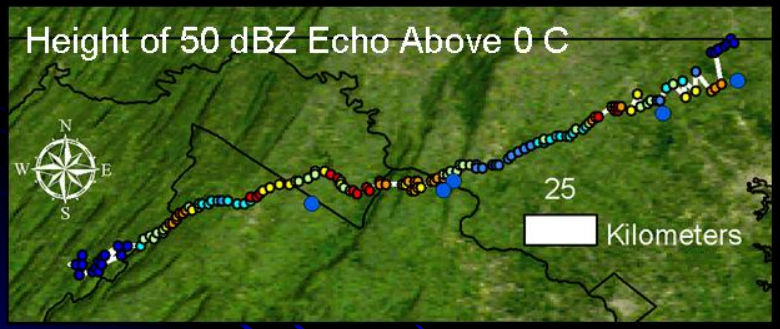


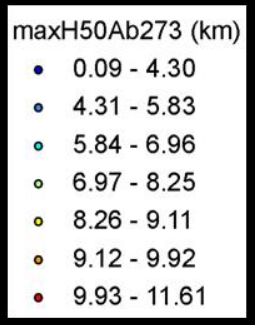
- Sample size (N) strongly influences our statistical results

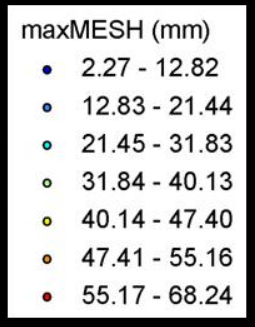


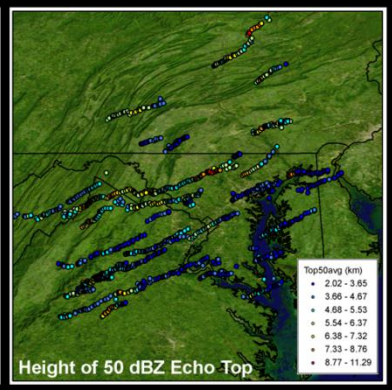
Additional Details

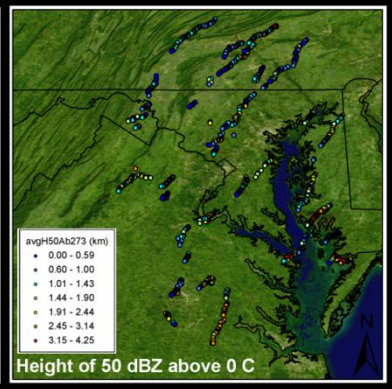
- Storms were selected based on their duration and relative location
- Storms were defined as 1) severe or non-severe and 2) isolated or line/multicell throughout their entirety
- Study only examines the maximum values for each storm time/location (vs. average values)







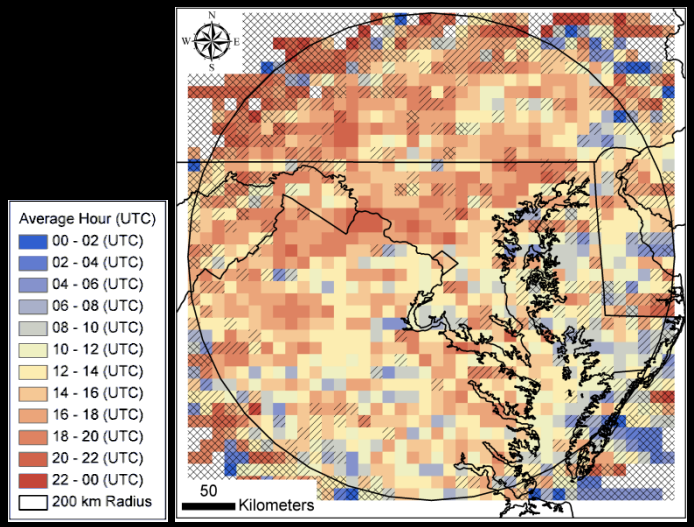




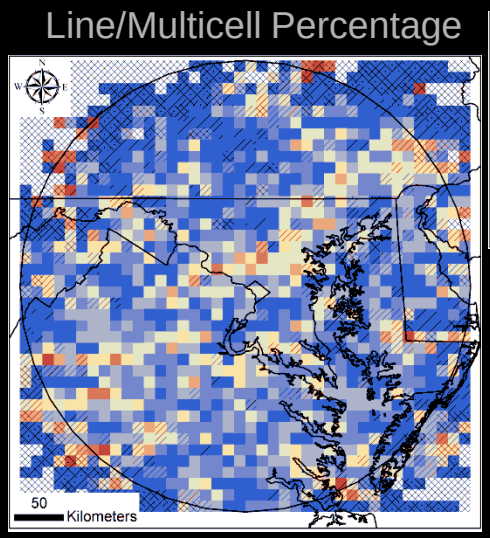
Synoptic and mesoscale systems influence storm-scale distributions

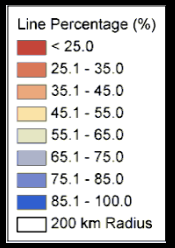
- Manual inspection of all 1667 storms revealed several recurring features
- Spatial GIS plots illustrate these features
  - Display average values for each grid cell
- Average hour shows the importance of diurnal heating in this region
- Line/multicell storms are more numerous and typically last longer
- Isolated (severe) storms occur most frequently over central Maryland

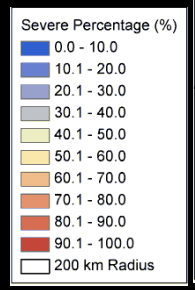
Average Hour (UTC)



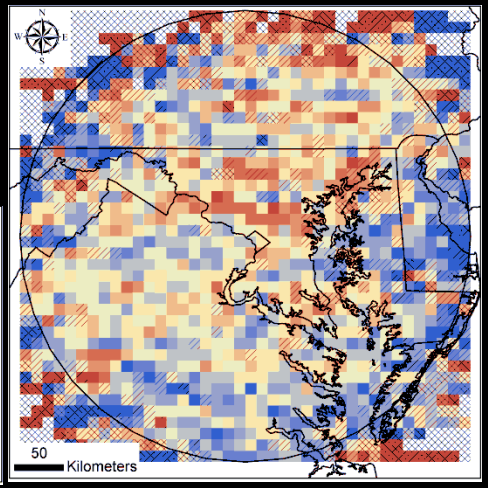
Line/Multicell Percentage







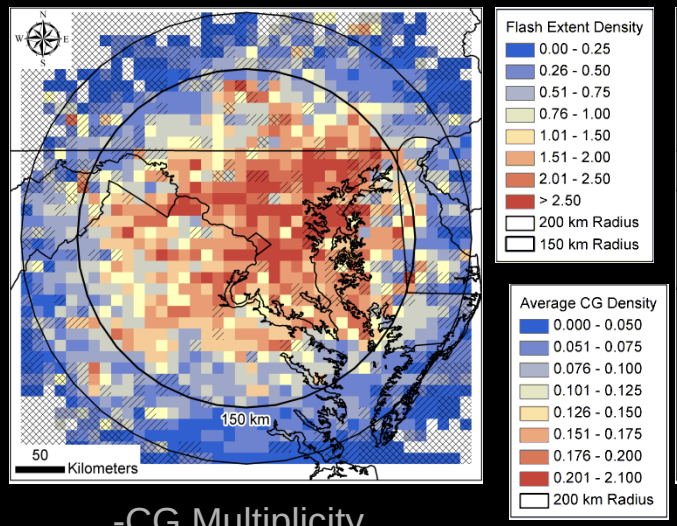
Severe Percentage



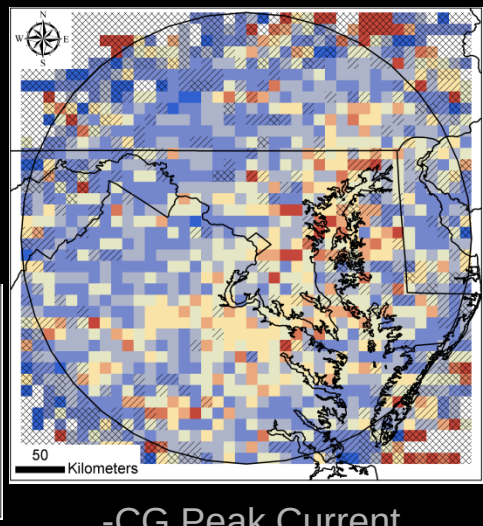
Storms exhibit considerable variability within the Mid-Atlantic Region

- IC-FED illustrates the decreasing LMA DE with increasing range
- This limitation restricted our intercomparison of lightning and radar to within 150 km of the LMA
- -CG Characteristics
  - Flash density exhibits no clear maximum
  - Multiplicity and estimated peak current are greatest in the coastal regions and line/multicell storms

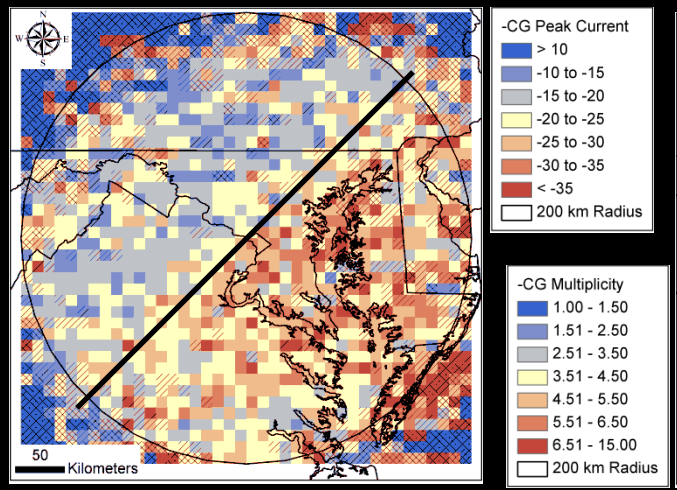
IC Flash Extent Density



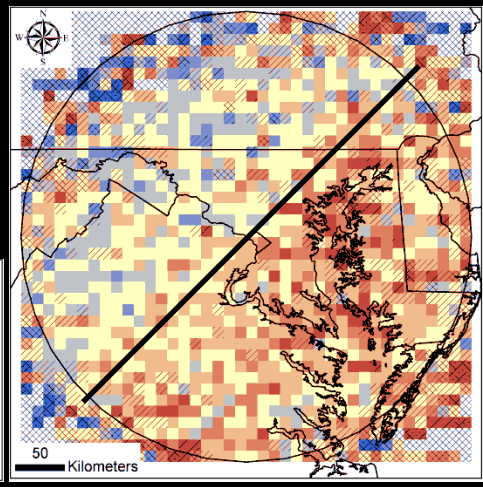
-CG Flash Density



-CG Multiplicity

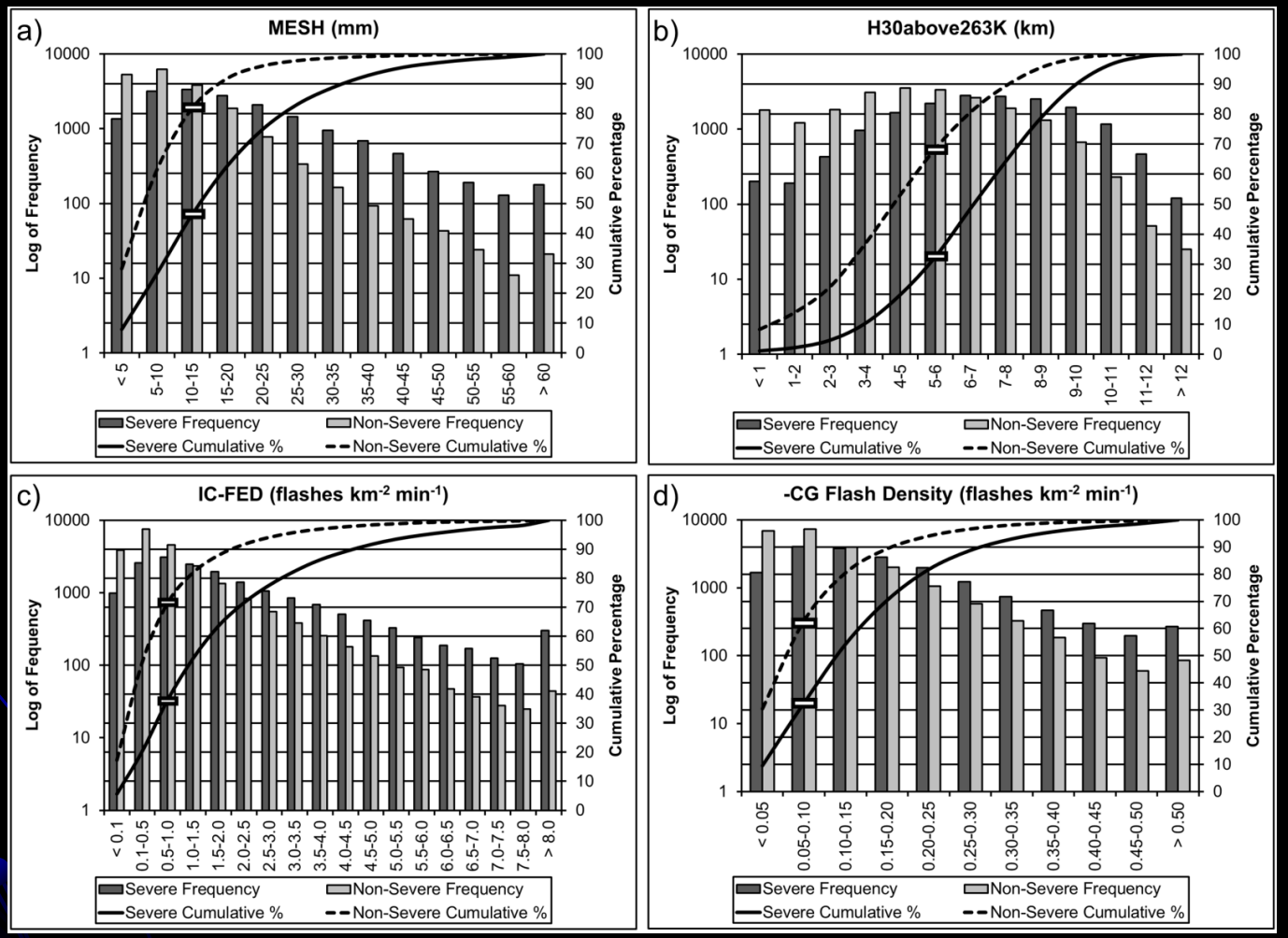


-CG Peak Current



Values of individual lightning and radar parameters can describe the likelihood that a given storm is severe or non-severe

- MESH > 15 mm
  - 53.7% vs. 18.2%
- H30above263K > 6 km
  - 67.5% vs. 24%
- IC-FED > 1
  - 61.9% vs. 28.5%
- -CG Density > 0.1
  - 67.4% vs. 37.3%
- Flash density units are flashes km^{-2} min^{-1}

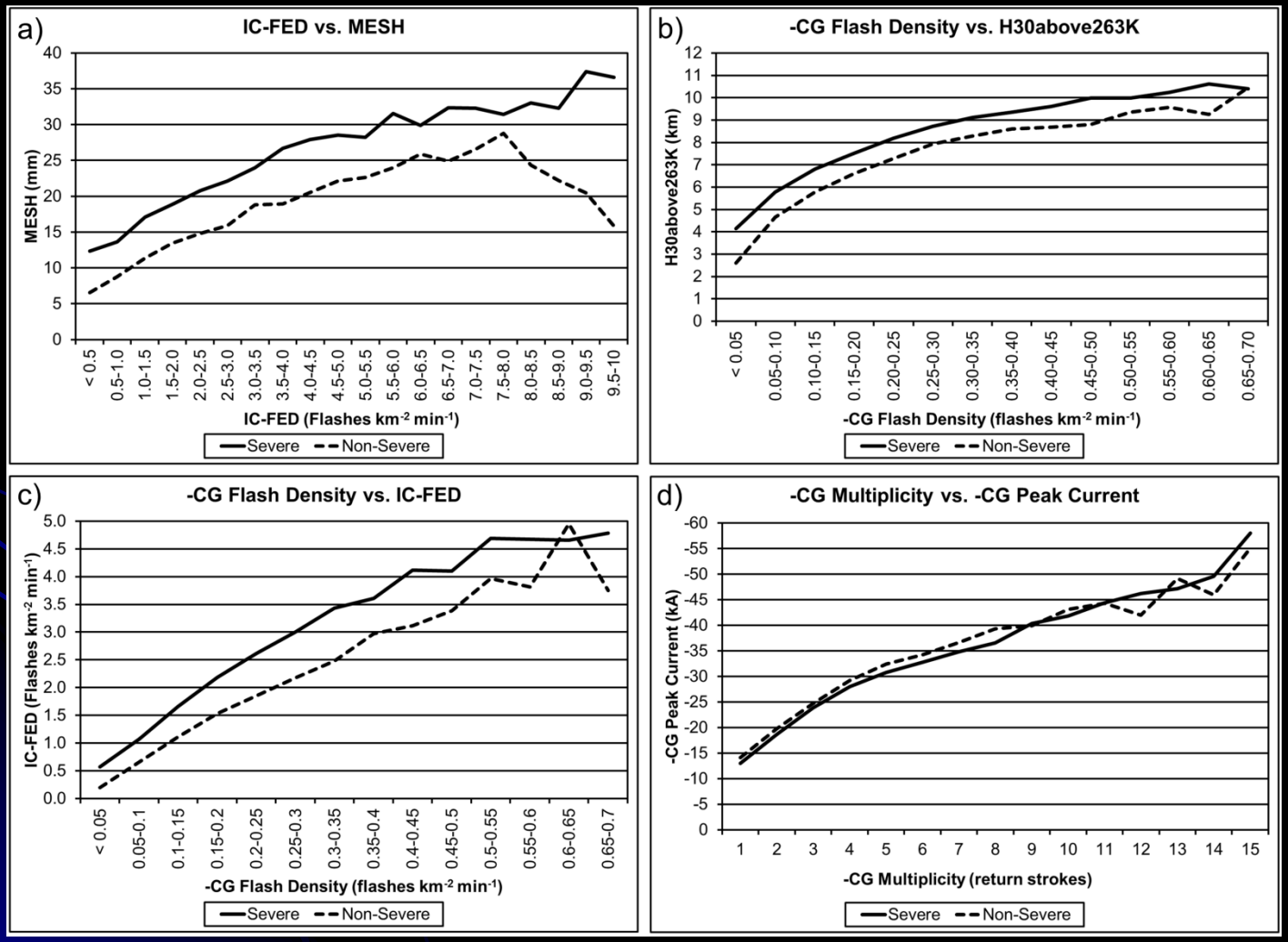


Correlations help identify relationships between lightning and radar parameters

- Confirmed several relationships that previously had only been documented in relatively few storms
- Flash-based IC products are better correlated with CG lightning and radar-derived parameters than are source-based products
- MESH, a composite of several radar parameters, is better correlated with IC–FED (0.542) than –CG flash density (0.482)
- Strong correlation between 2×2 km and 8×8 km IC-FED (0.935)
  - Both resolutions are similarly correlated with CG and radar parameters
  - Suggests that the GLM will provide valuable storm-scale IC information comparable to the 2–D information provided by local LMA networks

Profile histograms illustrate relationships between lightning and radar parameters

- Relationships are similar in both severe and non-severe storms



Additional Results

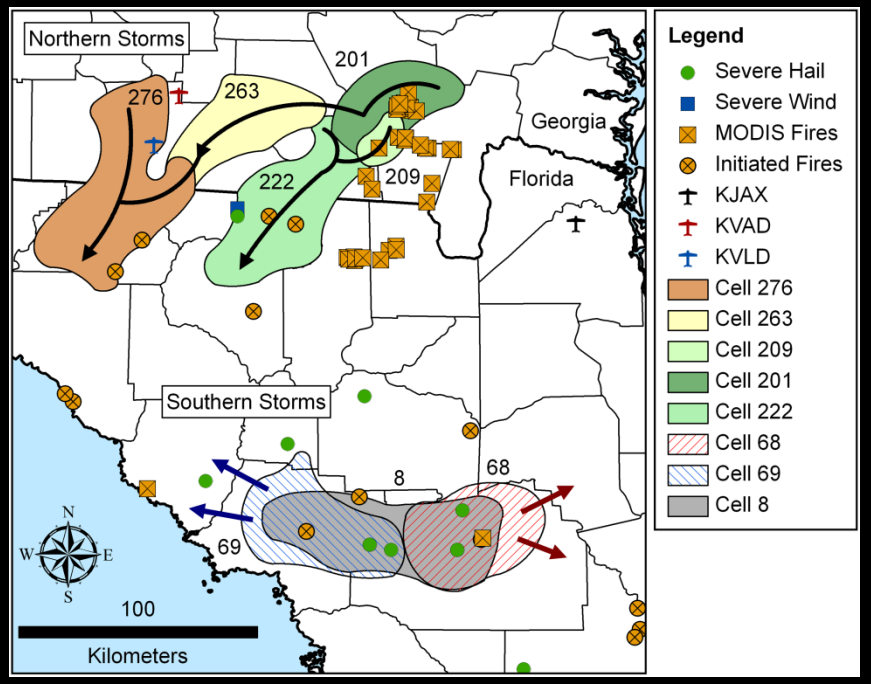
- -CG flash density, multiplicity, and peak current are intercorrelated and directly related to the height of 30 dBZ above -10˚C
- -CG multiplicity and I_p are inversely related on the storm scale, and are greatest in deep (line/multicell) storms
- Line/multicell storms were more intense than isolated storms in our database (i.e., greater flash rates and stronger radar-derived parameters)
- +CG peak current is inversely correlated with IC lightning and radar-derived measures of storm intensity

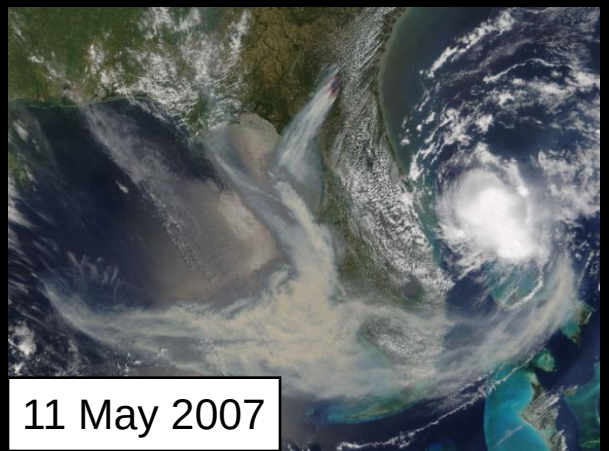
Summary

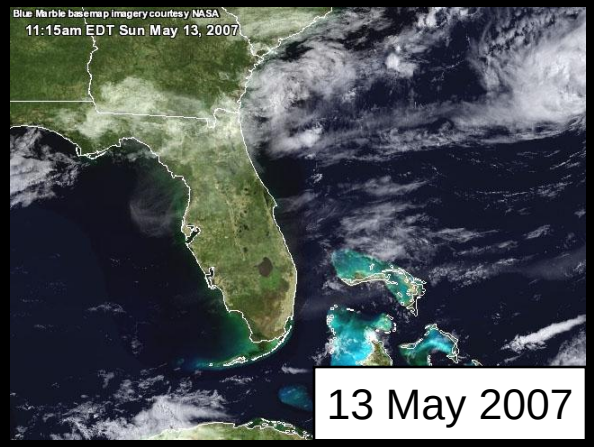
- Demonstrated our ability to examine many lightning and radar parameters in a large number of storms
- Revealed storm-scale relationships between CG and IC characteristics, and also between lightning and radar parameters
- Identified differences between isolated and line/multicell storms
- Showed that individual lightning and radar parameters can help determine the likelihood that a given storm is severe
- Combinations of CG and IC datasets will ensure that these data are used to best advantage both now and in the future

Case Study 13-14 May 2007

- Much of Florida was experiencing a severe drought as a surface cold front approached the area
- Okefenokee wildfires were producing widespread smoke
- Two distinct regions of storms
  - Drier environment to the north
  - Sea-breeze induced convergence to the south
- Both regions initiate wildfires and produce severe weather





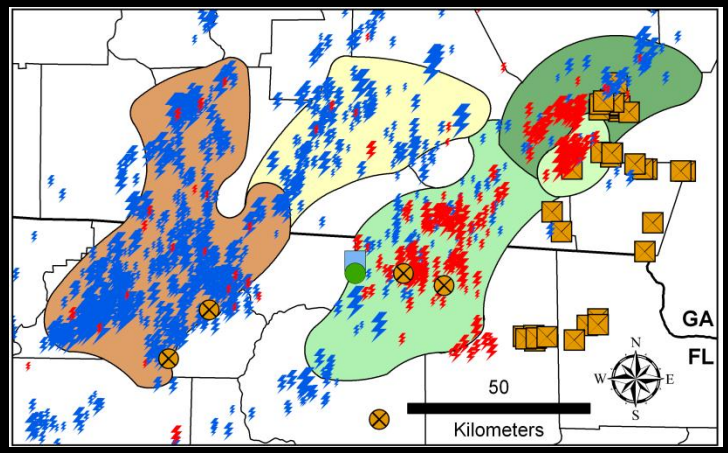


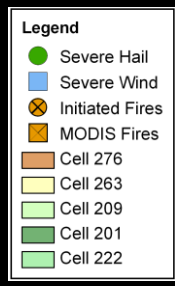
Storms nearest the active wildfires produce predominately +CG flashes

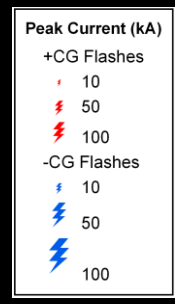
- Smoke-enhanced +CG production
  - Observed in storms directly associated with the source fires, and also in storms at long distances down wind
- Reversed polarity charging likely is related to…
  - Strong updrafts (less entrainment)
  - Smoke-related CCN (larger, but fewer) increased competition
  - Greater supercooled water content in the mixed phase region
- Strong +CG flashes often exhibit both large I_p and LCC

Red = +CG
Blue = -CG

Northern Storms







Southern Storms