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A Radar Investigation of Precipitation Properties during Discrepancies between GOES-16 GLM and LMA Observed Flash Rates in the Skyline Alabama Supercell of 22 April 2017

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Lawrence D. Carey[1], Nathan L. Curtis[1], Sarah M. Stough[1], and Christopher J. Schultz[2]

[1]UAH, Department of Atmospheric Science, Huntsville, Alabama; [2]NASA Marshall Space Flight Center (MSFC), Huntsville, Alabama

GOES-16 GLM AND LMA LIGHTNING

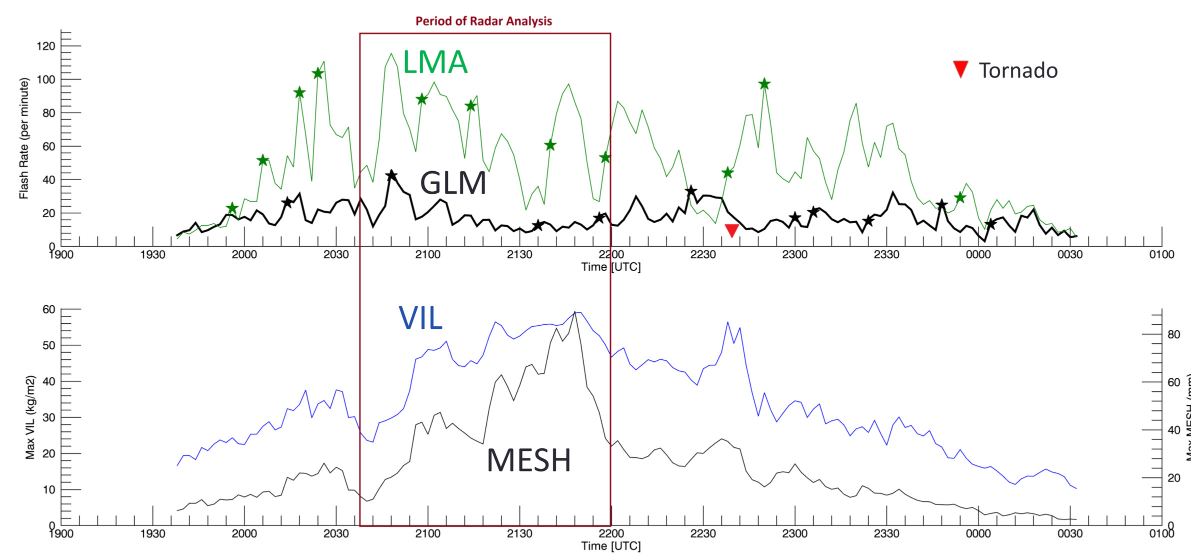

Figure 1 – Top: Geostationary Lightning Mapper (GLM) and Lightning Mapping Array (LMA) flash rates and lightning jumps (★, ★)
Bottom: radar maximum Vertically Integrated Liquid (VIL) and Maximum Expected Size of Hail (MESH)

- During severe supercell phase and period of radar analysis (red box in Fig. 1)
  - LMA flash rate typically 2 to 5 times larger than GLM flash rate for GLM+VIL tracked storm
  - LMA detected 4 jumps to GLM's 3 jumps. GLM & LMA jumps within 10 minutes.
  - LMA flash area small when (LMA-GLM) flash rate difference large (Fig. 2). Impact of GLM 8 km x 8 km spatial resolution on detectability and/or flash clustering algorithm?
  - With most LMA flashes at 8-9 km (Fig. 3), altitude does not appear to play a large role in (LMA-GLM)
- During developing phase < 2040 UTC, more LMA (than GLM) jumps; during weakening and decaying phases > 2200 UTC, more GLM (than LMA) jumps (Fig. 1)

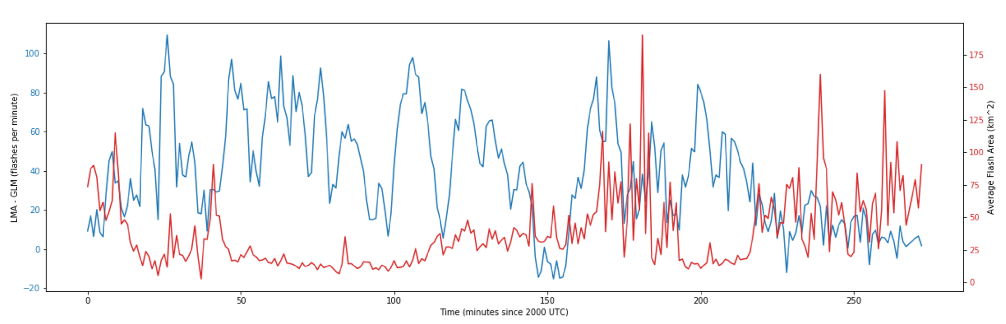

Figure 2 – LMA – GLM flash rate and LMA observed storm average flash area (km^2)

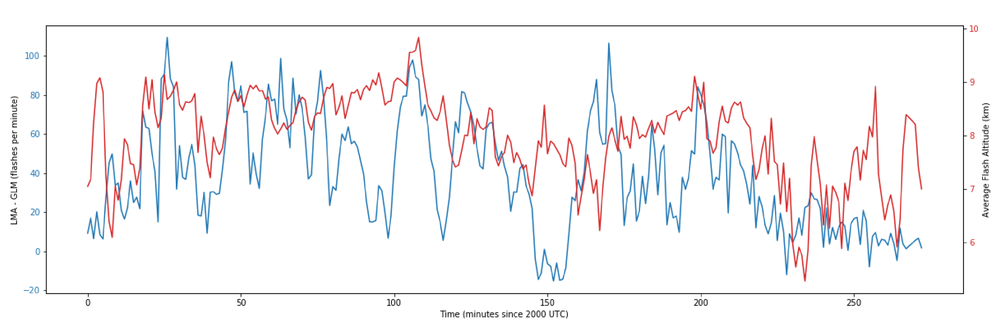

Figure 3 - LMA – GLM flash rate and LMA observed storm average flash initiation altitude (km)

HID VOLUMES

- Early (2038-2043 UTC), graupel was dominant riming ice with moderate flash rates
- Lightning jump and larger flash rates in GLM and LMA associated with large increase in hail relative to graupel (2043-2102 UTC)
- Graupel volume and % of total ice increases while hail decreases slightly from 2102 to 2115 UTC. Flash rate decreases slightly.
- Graupel volume and % of total decreases from 2115 to 2133 UTC while flash rate decreasing. Hail decreasing more slowly.
- Graupel and hail volumes increases from 2133 to 2146 UTC associated with GLM/LMA jumps and increase in flash rates.
- Decrease in graupel and especially hail volume from 2145 to 2159 UTC consistent with decrease in GLM/LMA flash rates. Aggregates & ice increase with weaker storm.

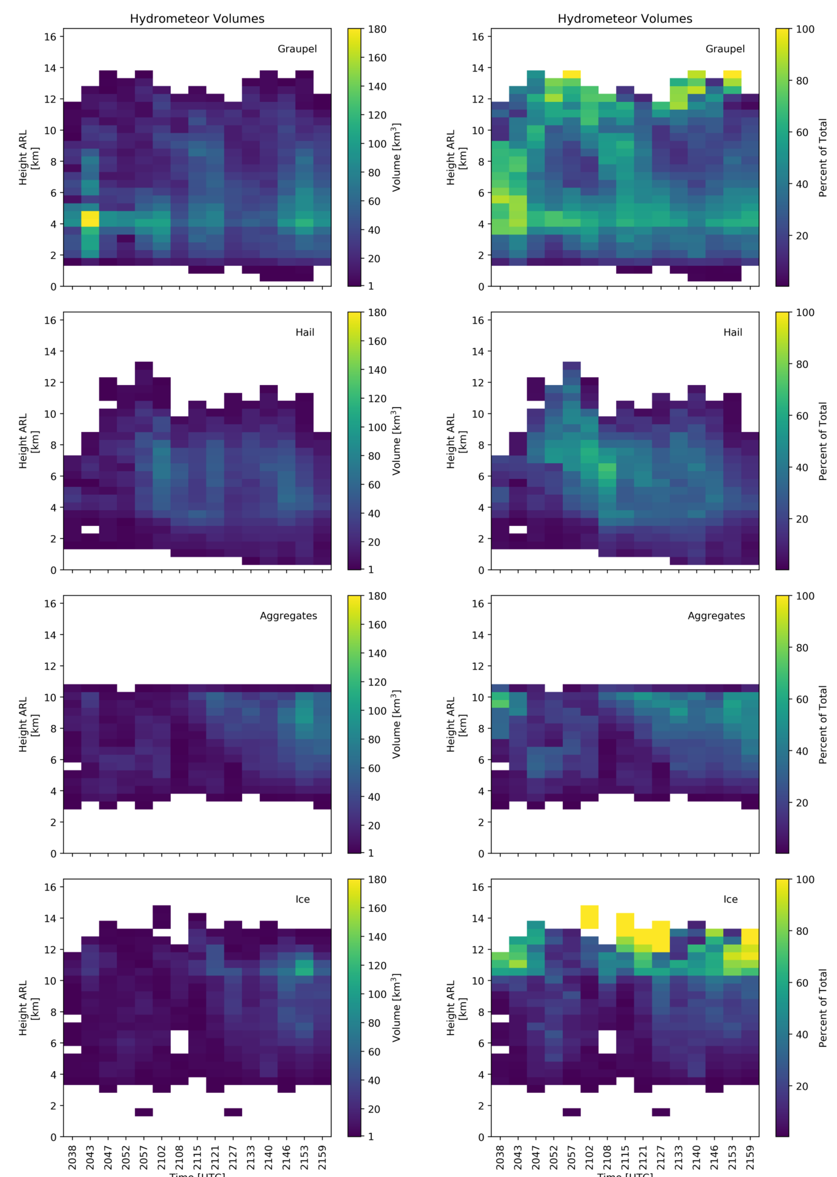

Figure 5 – Time-height cross-sections of HID volume. From top to bottom: graupel, hail, aggregates, and ice. Left: km^3, Right: % of total.

RADAR REFLECTIVITY AND HYDROMETEOR IDENTIFICATION (HID)

- 2043 UTC:
  - Moderate LMA/GLM (37/10 fpm) flash rates
  - Low MESH (8 mm), moderate VIL (23 kg m^{-2})
  - Narrow, rapidly developing supercell
  - Ample graupel for lightning; some hail
- 2102 UTC:
  - Lightning jump in LMA and GLM 10 min earlier
  - High LMA/GLM (86/32 fpm) flash rates
  - High MESH (41 mm) and VIL (52 kg m^{-2})
  - Big increase in hail volume aloft.
- 2115 UTC:
  - Decrease in LMA/GLM flash rate = 59/18 fpm
  - Decrease in MESH (34 mm) and VIL (44 kg m^{-2})
  - Decrease hail but graupel and Z_{max} increasing
  - Bounded Weak Echo Region (BWER) formed
- 2133 UTC:
  - Decrease in LMA/GLM flash rate = 28/12 fpm
  - Increase in MESH (60 mm) and VIL (57 kg m^{-2})
  - Graupel volume decreasing but hail less so.
  - Lightning jumps in GLM/LMA 4/7 minutes later
- 2146 UTC
  - Increase+ in LMA/GLM flash rate = 105/20 fpm
  - High MESH (80 mm) and VIL (59 kg m^{-2})
  - Increase in graupel and hail in HID consistent
- 2159UTC
  - Decrease in LMA/GLM flash rate = 30/21 fpm
  - Decrease in MESH (33 mm) and VIL (47 kg m^{-2})
  - Decrease in graupel and especially hail aloft

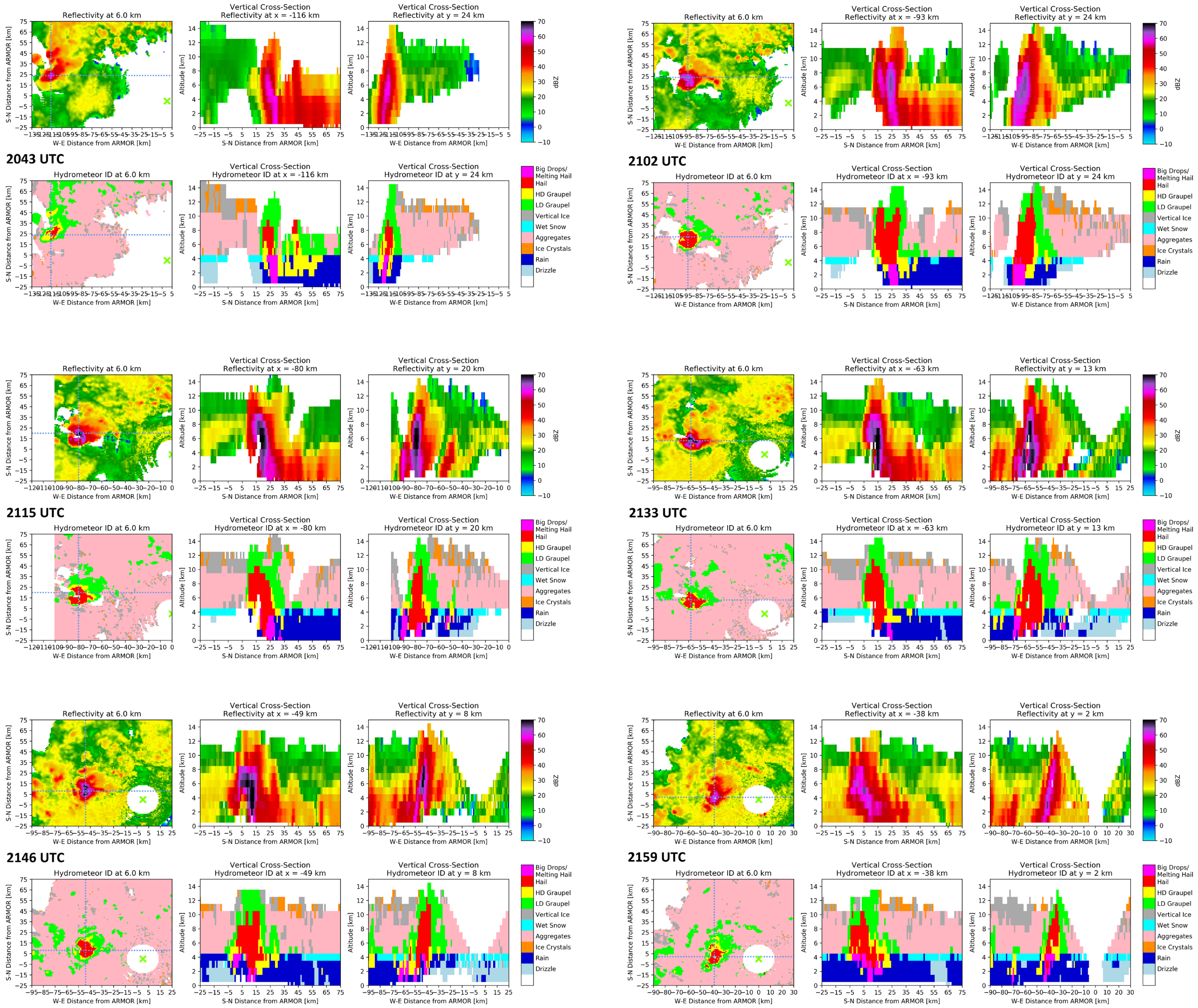

Figure 4 – Six-panel horizontal (at 6 km altitude) and vertical (in N-S and E-W planes shown in horizontal) cross-sections of radar reflectivity (top panels) and HID (bottom panels) for 2043, 2102, 2115, 2133, 2146 and 2159 UTC (left to right and top to bottom).

CONCLUSIONS

- GLM flash rates were 2 to 5 times lower than LMA in an Alabama supercell that was tracked using a combination of GLM flash initiation density and VIL
- Since most lightning was initiating at 8-9 km (and not at low levels) according to LMA, flash height does not appear to be a primary factor in low GLM flash rates
- When (LMA-GLM) flash rate differences were largest, the LMA observed flash areas were relatively small (and vice versa).
- Flash size may be a primary factor in low GLM flash rates due to detectability and/or flash clustering issues with small flashes within the coarse 8 km x 8 km resolution.
- High cloud liquid water droplet concentrations were inferred indirectly from riming necessary for large radar MESH, VIL and hail/graupel volumes. High cloud water droplet concentrations in supercells may decrease GLM detection efficiency due to optical extinction of near IR emitted by lightning as it moves through cloud.
- Despite large flash rate differences, GLM & LMA lightning jumps during robust supercell generally agreed with each other and radar trends in HID, MESH and VIL.
- However, more LMA jumps (than GLM) in developing supercell and more GLM jumps (than LMA) in weak to decaying supercell. Future work: improve GLM tracking.

ACKNOWLEDGEMENT

This project was supported by the NOAA GOES-R Series Risk Reduction Research (R3) program and NASA MSFC through the NASA MSFC and UAH Cooperative Agreement (NNM11AA01A).