A Multi-Case Analysis of GLM Detection Efficiency in Alabama, Colorado and West Texas

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Recent GLM Validation Studies

- **Marchand et al. 2019**
  - GOES-16 GLM achieves spec DE (~70%) in most locations except for High Plains
- **Zhang and Cummings 2020**
  - GOES-16 GLM effectively detects long duration flashes with large flash areas
  - Reduced detection of short duration flashes with small flash areas
- **Brunner and Bitzer 2020**
  - Satellite detection of optical emissions varies greatly with location in thunderstorm
- **Rutledge et al. 2020**
  - GOES-16 DE varies depending on thunderstorm microphysics, flash size, and flash height. Argued that reduced DE is caused by optical attenuation due to cloud ice particles and cloud droplets. DE lowest in so-called “inverted” storms


Washington
Montana
North Dakota
Minnesota
New Hampshire
Vermont
Massachusetts
Maine
Oregon
Idaho
Wisconsin
South Dakota
Wyoming
Michigan
New York
Rhode Island
Connecticut
Nevada
Utah
Nebraska
Iowa
Pennsylvania
Illinois
Ohio
New Jersey
Indiana
Delaware
Colorado
COLMA
G16/17
2018-2019
Kansas
Missouri
NALMA
G16 2020
Kentucky
Virginia
Maryland
California
Washington, D.C.
North Carolina
West Virginia
Tennessee
Oklahoma
Arkansas
Arizona
New Mexico
South Carolina
WTLMA
G16/17
2018-2019
Mississippi
Georgia
Alabama
Texas
Louisiana
Alaska
Florida
Hawaii

Methodology

- Only considered isolated convection within 100 km of LMA center
- CSU Lighting, Environment, Aerosols, and Radar (CLEAR)
  - CLEAR was used to track isolated convection in each of the three regions
  - 10 km^2 threshold employed for 35 dbz contour
  - 20 km^2 threshold employed for 45 dbz contour
- Minimum 10 source threshold used for COLMA and WTLMA
- 5 source threshold for NALMA
- NLDN flashes < 15 kA were considered intra-cloud and removed from the CG count
- ABI data used to estimate cloud water/cloud ice path (CTWP); radar used to estimate precipitation ice water path (IWP); radar also used to estimate graupel and hail echo volumes

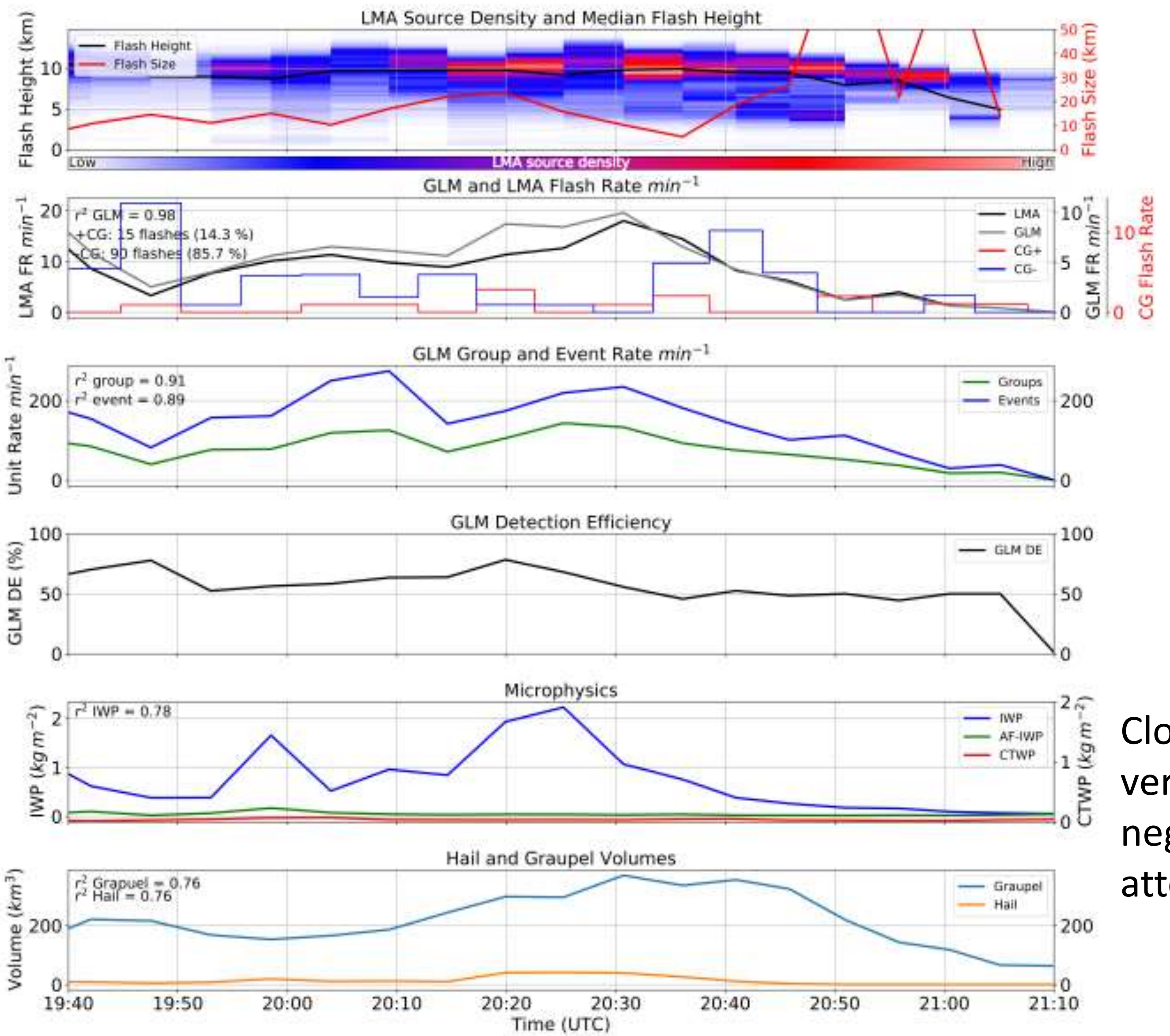
Case Date	Region	Time of Cell	Hail report	Wind report	Tornado report	Average DE(%)
20190715	CO	20:00-23:05 UTC	Yes	No	No	2.38
20190712	CO	1900-2100 UTC	No	No	No	2.48
20190701	CO	20:12-00:13 UTC	Yes	No	No	4.33
20180729	CO	19-2230 UTC	Yes	Yes	Yes	4.81
20190705	CO	02:56-04:14 UTC	Yes	No	No	5
20190520	WT	20:29-22:21 UTC	Yes	Yes	No	5.14
20190620	CO	20:37-23:22 UTC	No	No	No	5.55
20190704	CO	01:43-03:26 UTC	Yes	No	No	5.72
20190911	CO	22:08-00:08 UTC	Yes	No	No	7.02
20190625	WT	1:09-02:57 UTC	No	No	No	7.69
20180619	CO	18-2130 UTC	Yes	No	Yes	8.95
20190523	WT	23:00-02:47 UTC	Yes	No	No	10.25
20190526	CO	21:30-23:00 UTC	Yes	Yes	Yes	11.4
20180807	CO	22:24-01:54 UTC	No	No	No	12
20190608	CO	22:13-00:19 UTC	Yes	No	No	12.23
20190524	WT	00:34-3:55 UTC	No	No	No	12.55
20190525	WT	20:35-21:36 UTC	No	No	No	13.13
20180618	CO	0-2:30 UTC	Yes	No	No	14.08
20180605	WT	23:06-02:15 UTC	No	Yes	No	17.54
20190614	WT	00:59-3:10 UTC	Yes	No	No	18.76
20200524	AL	01:05-2:30 UTC	No	No	No	20.87
20190505	WT	20:20-21:56 UTC	No	No	No	23
20180517	WT	22:03-23:27 UTC	No	No	No	23.04
20180520	WT	0220-0430 UTC	No	No	No	23.28
20180601	WT	23:29-00:30 UTC	No	No	No	25.17
20200408	AL	2140-2340 UTC	Yes	Yes	No	26.8
20200523	AL	00:35-01:45 UTC	No	No	No	32.63
20200603	AL	20:25-2150 UTC	No	No	No	34.93
20200629	AL	17:35-18:15 UTC	No	No	No	35.88
20200627	AL	22:50-23:50 UTC	No	No	No	43.69
20190323	WT	00:31-04:57 UTC	Yes	No	No	46.21
20190423	WT	01:15-2:10 UTC	No	No	No	46.36
20200704	AL	17:50-19:02 UTC	No	No	No	49.2
20200517	AL	19:40-21:10 UTC	No	No	No	59.03

Cases are ranked from lowest to highest average Detection Efficiency

There is a tendency for more of the low DE cases to be severe, mainly hail

KHTX_20200517_storm_G16

Location of VHF sources are high and flash area is large



GLM flashes, groups, and events well correlated to LMA flash rate

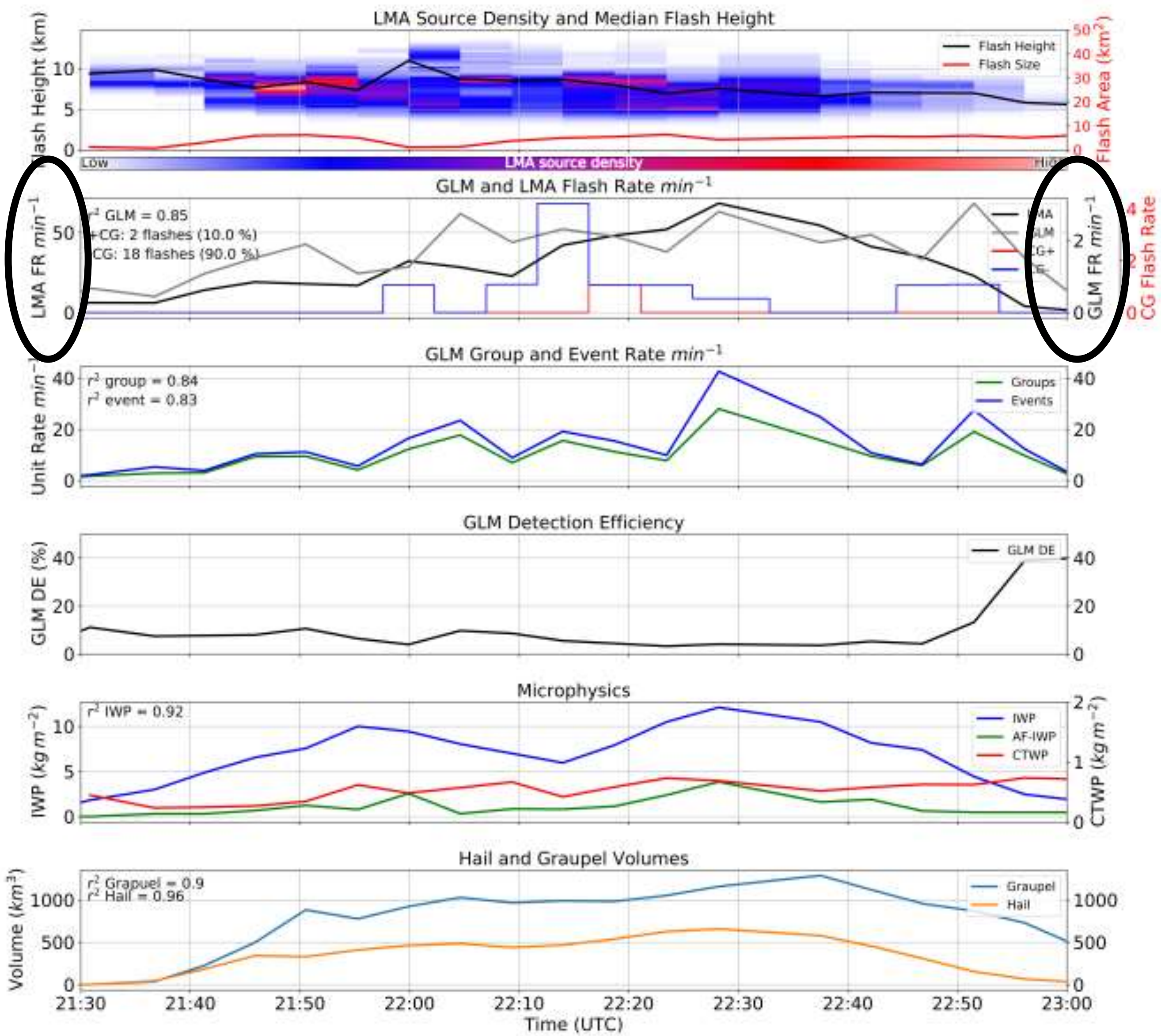
GLM DE mostly meets specs for this case

Cloud top water path is very small implying negligible optical attenuation

KCYS_20190526_storm_G17

Relatively low flash rate storm by Colorado standards

GLM DE is less than 10 percent for this storm



Flash area is very small <10 km^2

GLM correlated to LMA

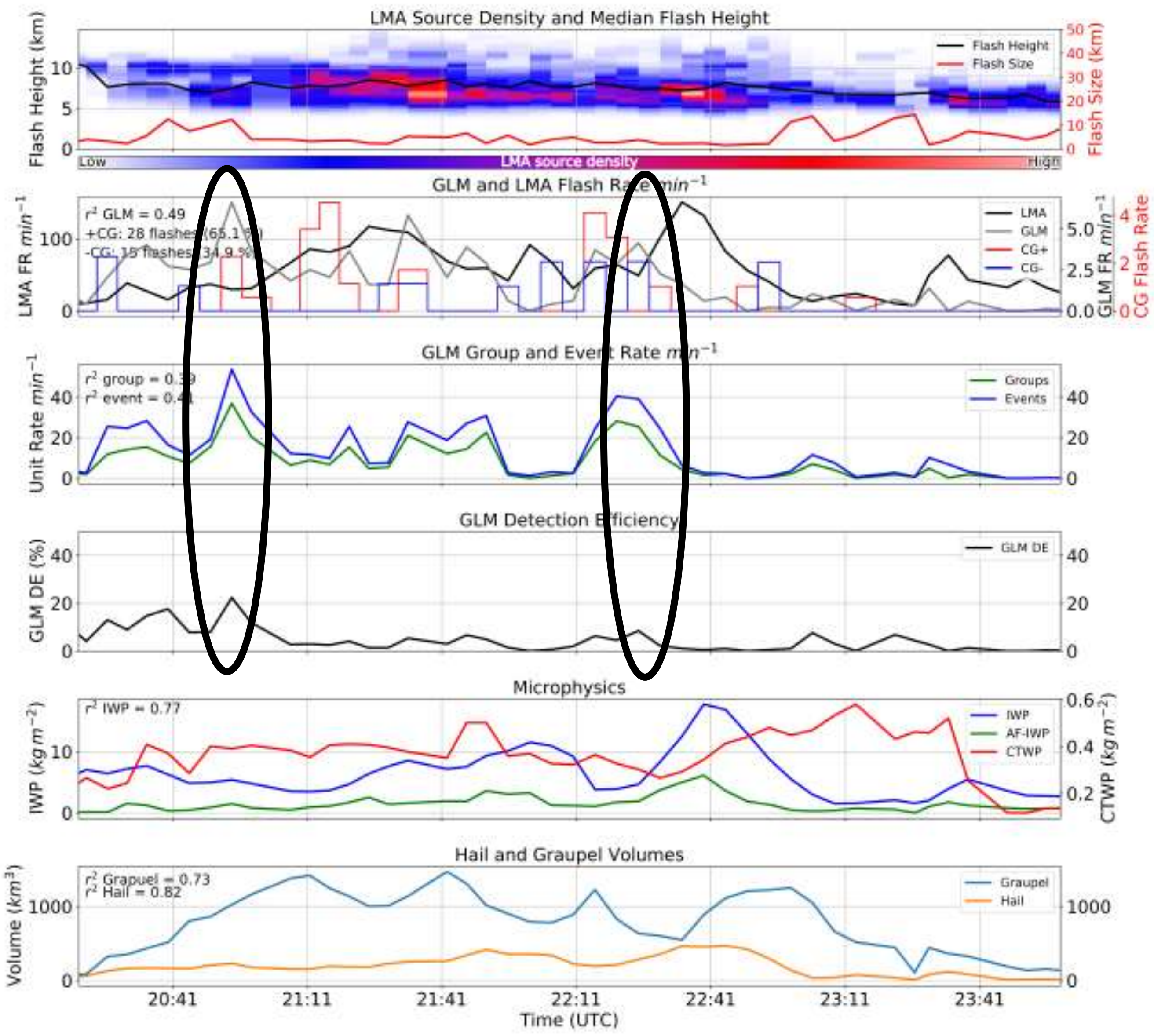
GLM flash rate is an order of magnitude less than LMA flash rate

CTWP larger than in high DE Alabama case

Low DE caused by small (dim) flashes and attenuation due to appreciable CTWP

KCYS_20190701_storm_G16

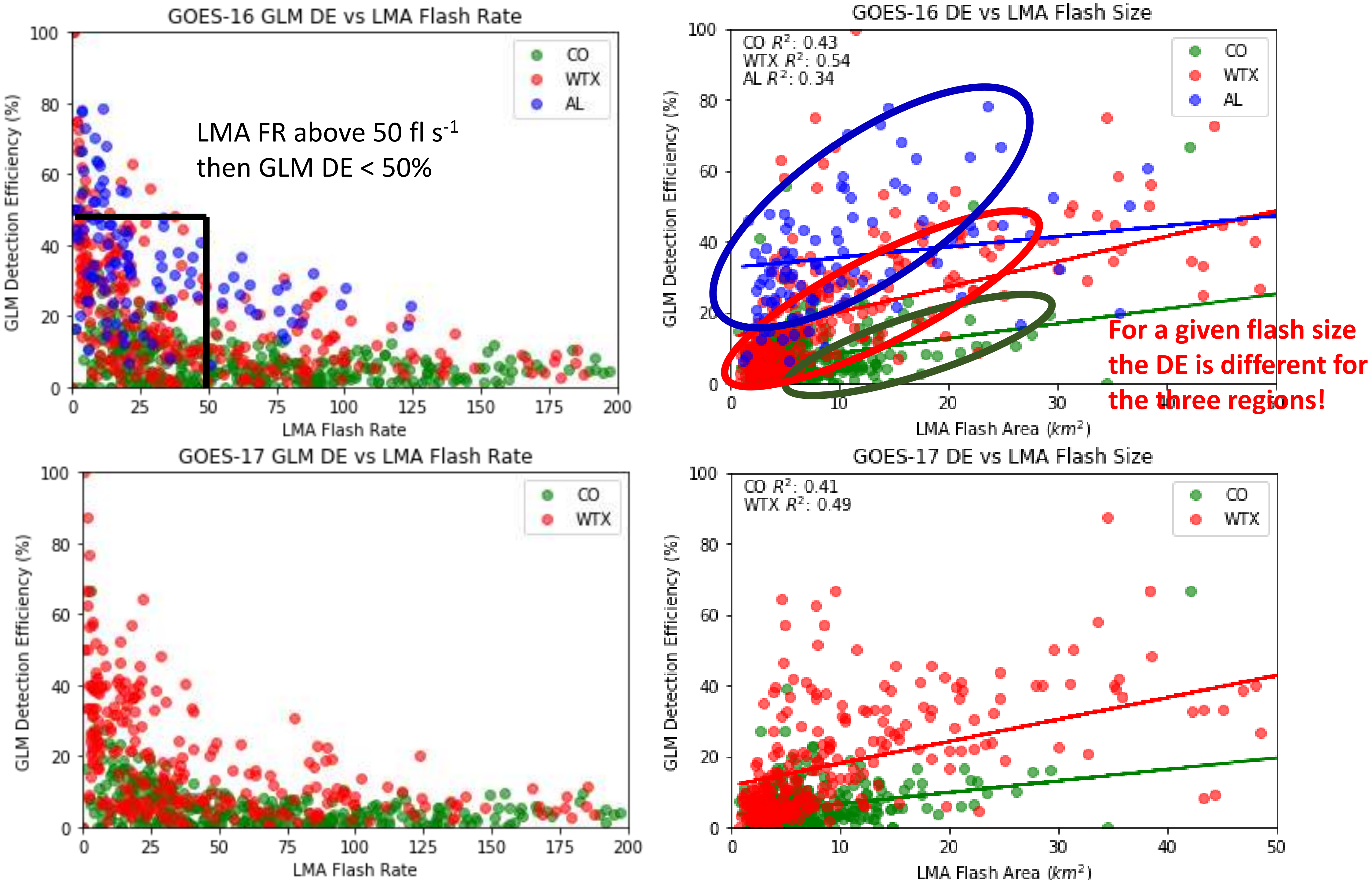
Low VHF source location and small flash areas = anomalous storm

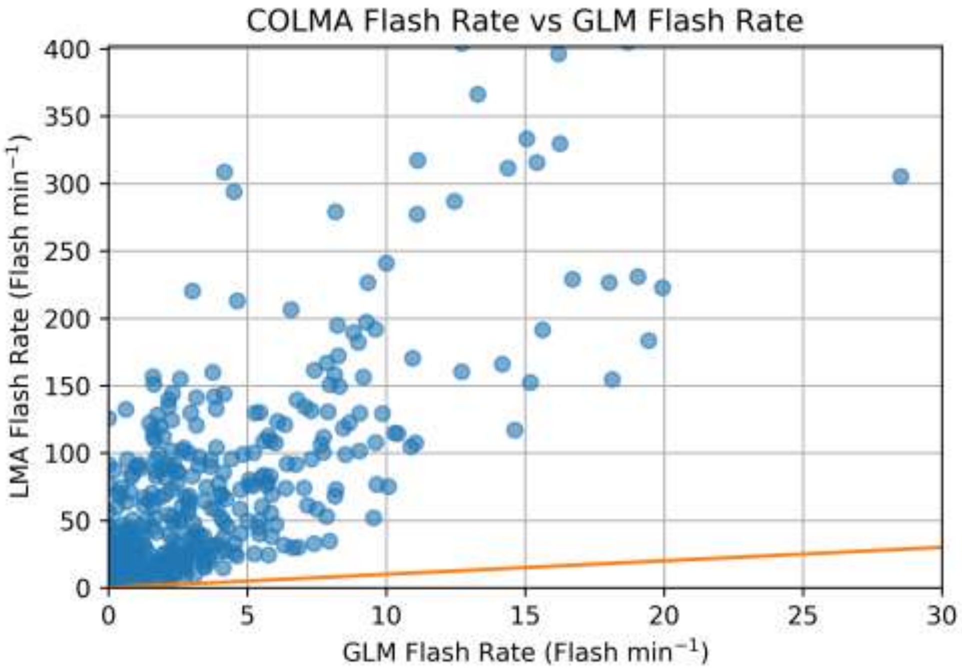


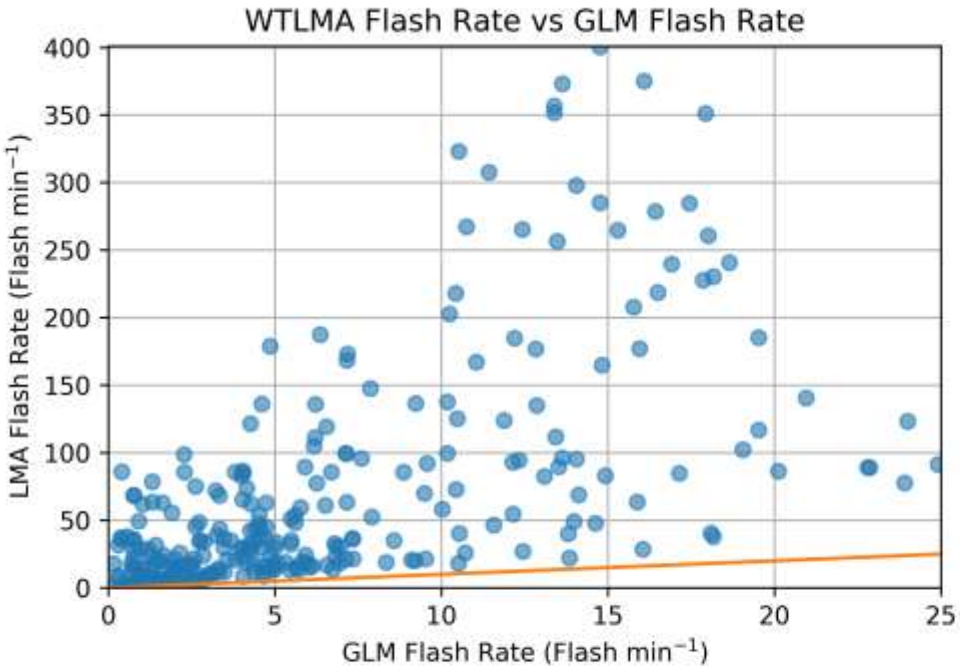
Higher count of +CG flashes especially early in time series consistent with inverted storm

DE is low for most of time series; DE increases with flash area (size)

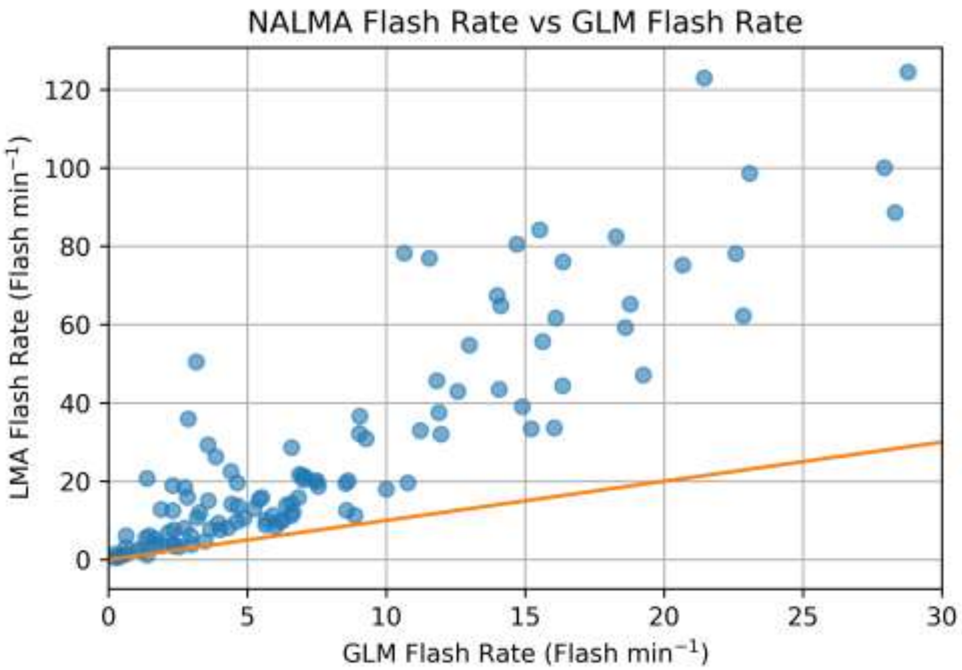
CTWP larger than the high DE Alabama case; role of optical attenuation again evident in explaining low DE


GOES-16 GLM DE vs LMA Flash Rate
GLM Detection Efficiency (%)
LMA Flash Rate
CO
WTX
AL
LMA FR above 50 fl s-1
then GLM DE < 50%
GOES-16 DE vs LMA Flash Size
CO R²: 0.43
WTX R²: 0.54
AL R²: 0.34
LMA Flash Area (km²)
For a given flash size
the DE is different for
the three regions!
GOES-17 GLM DE vs LMA Flash Rate
GOES-17 DE vs LMA Flash Size
CO R²: 0.41
WTX R²: 0.49





Orange line is the line of equal flashes for LMA and GLM



Largest discrepancy is in Colorado followed by West Texas and North Alabama

Conclusions

- Analyzed 34 isolated thunderstorms in Alabama, Colorado, and West Texas
- For a given flash area, the GLM DE varies greatly over the three regions
- Combination of low flash heights, small flash areas, cloud water path and GLM FOV act to reduce GLM DE
- Thunderstorms that produce severe hail are more likely to have a low DE
- Questions?