Comparisons between Supercell Kinematics and Lightning Optical Energy Output from GLM

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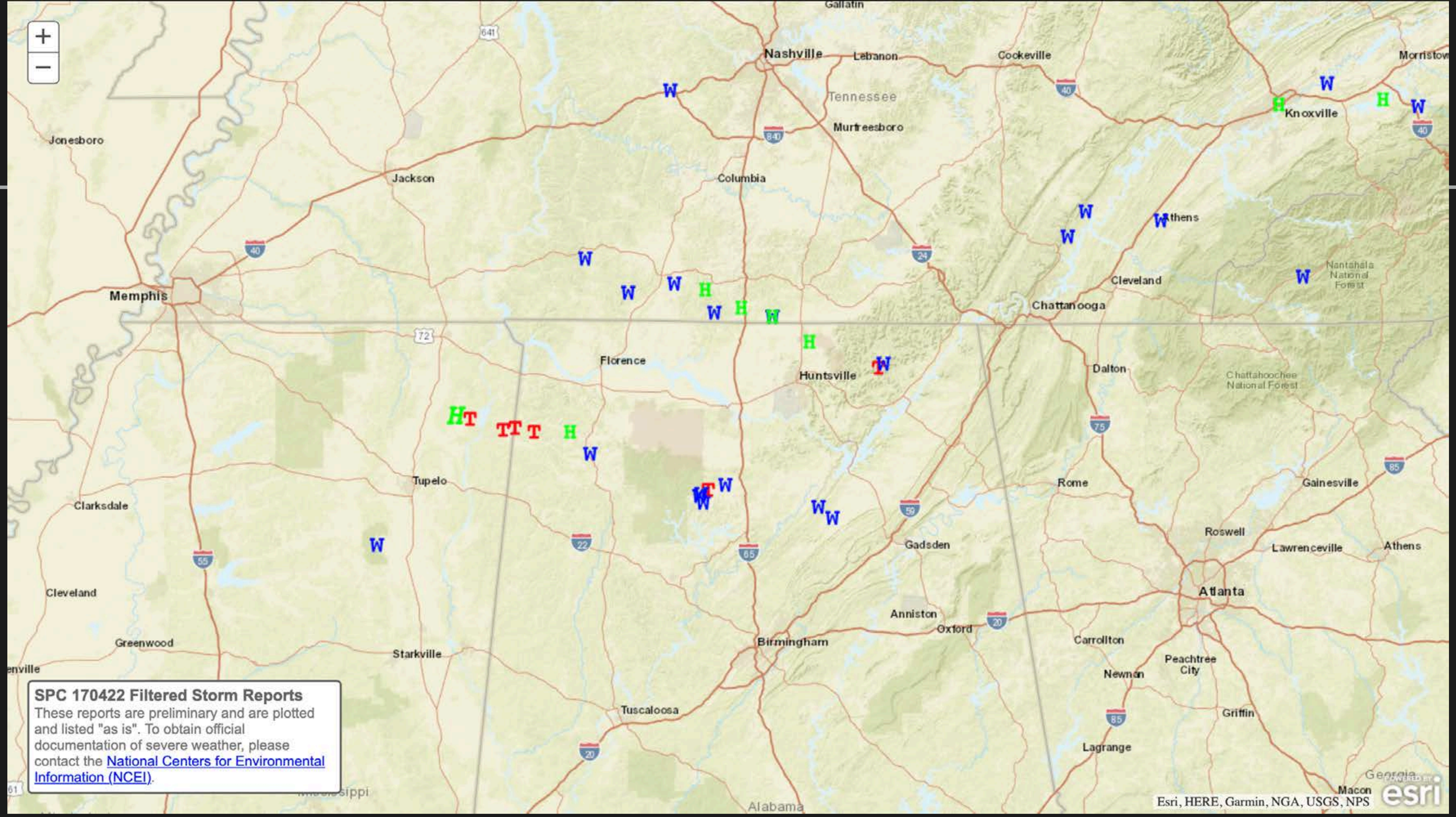
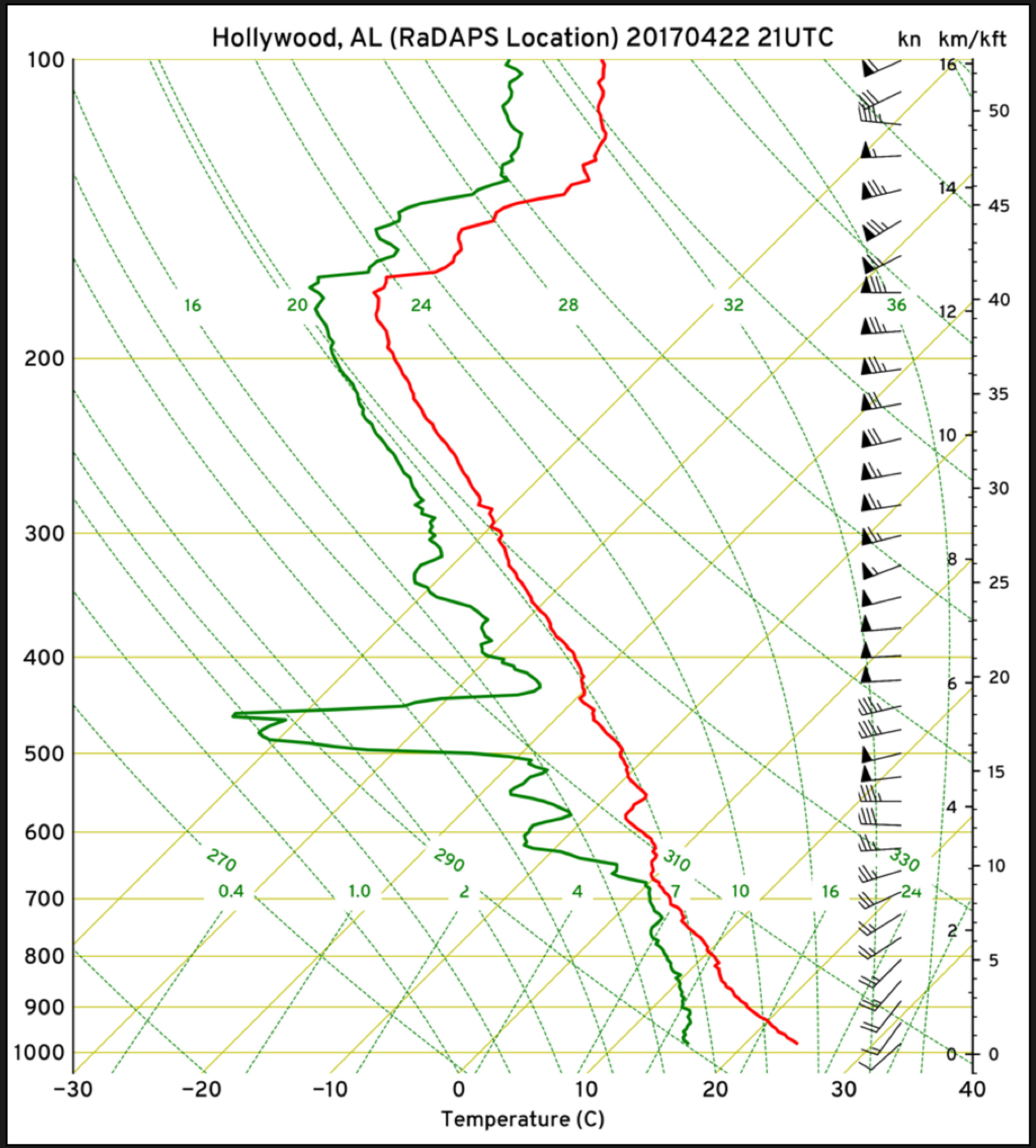
Motivation

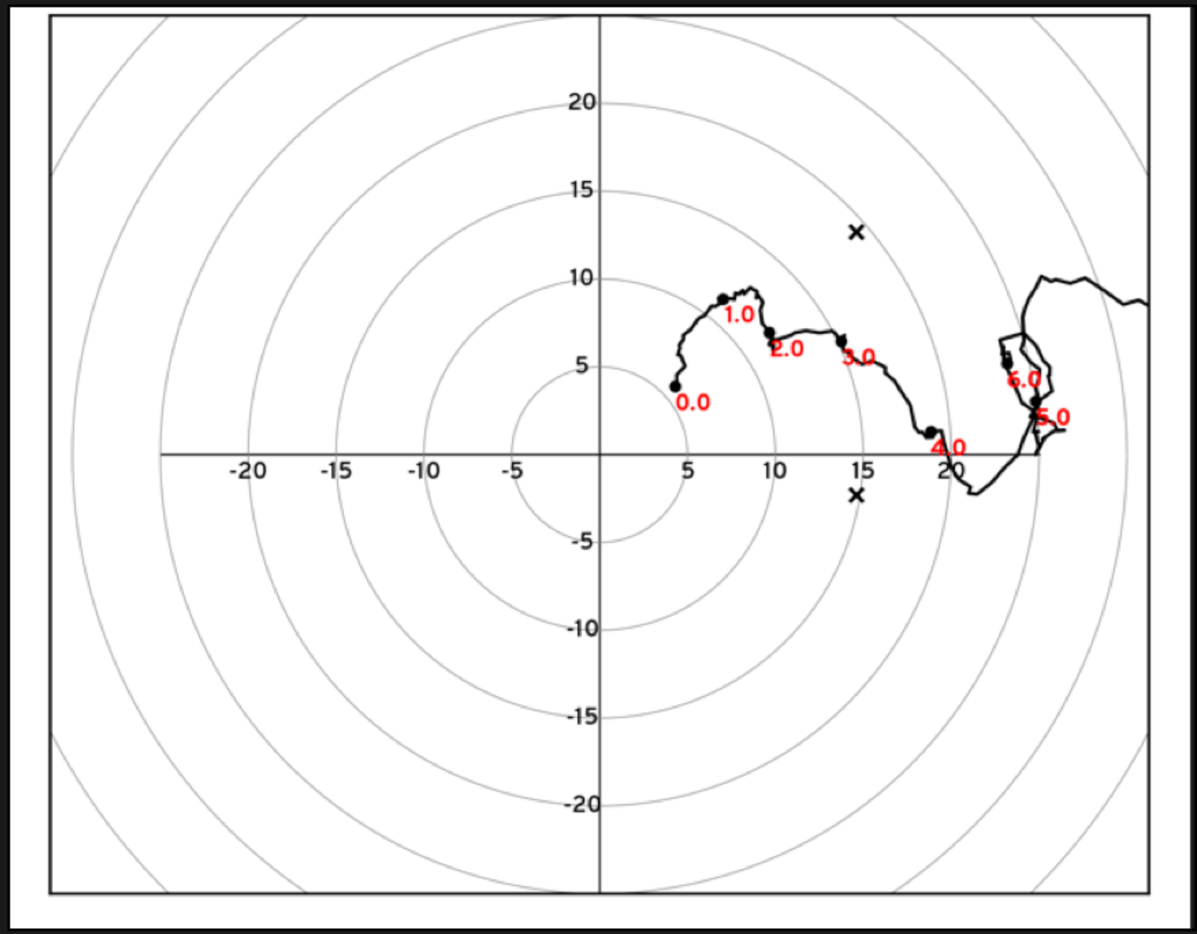
- With the launch of the Geostationary Lightning Mapper (GLM) in Nov 2016, continuous lightning observations of the Western Hemisphere from space are now available
- Launches of additional and future lightning mappers on GOES-17 (Mar. 2018), Meteosat (2020s), and other geostationary satellites will allow continuous lightning measurements from +- 55° latitude
- In addition to climatology, lightning activity can be used as an aid in nowcasting severe weather in regions with poor radar or LMA coverage
- Before being applied on a global scale, need to understand lightning trends with severe weather using space based measurements coincident with ground based measurements

22 Apr 2017

- Supercells across the North Alabama mesoscale domain
- EF-1 and EF-0 tornadoes, along with multiple hail and wind reports, associated with two supercells
- 552 J/kg of mixed layer CAPE with 37 kts of 0-6 km shear
- Occurred during the VORTEX-SE and GOES-R Validation field campaigns







500 m Mixed Layer Parcel

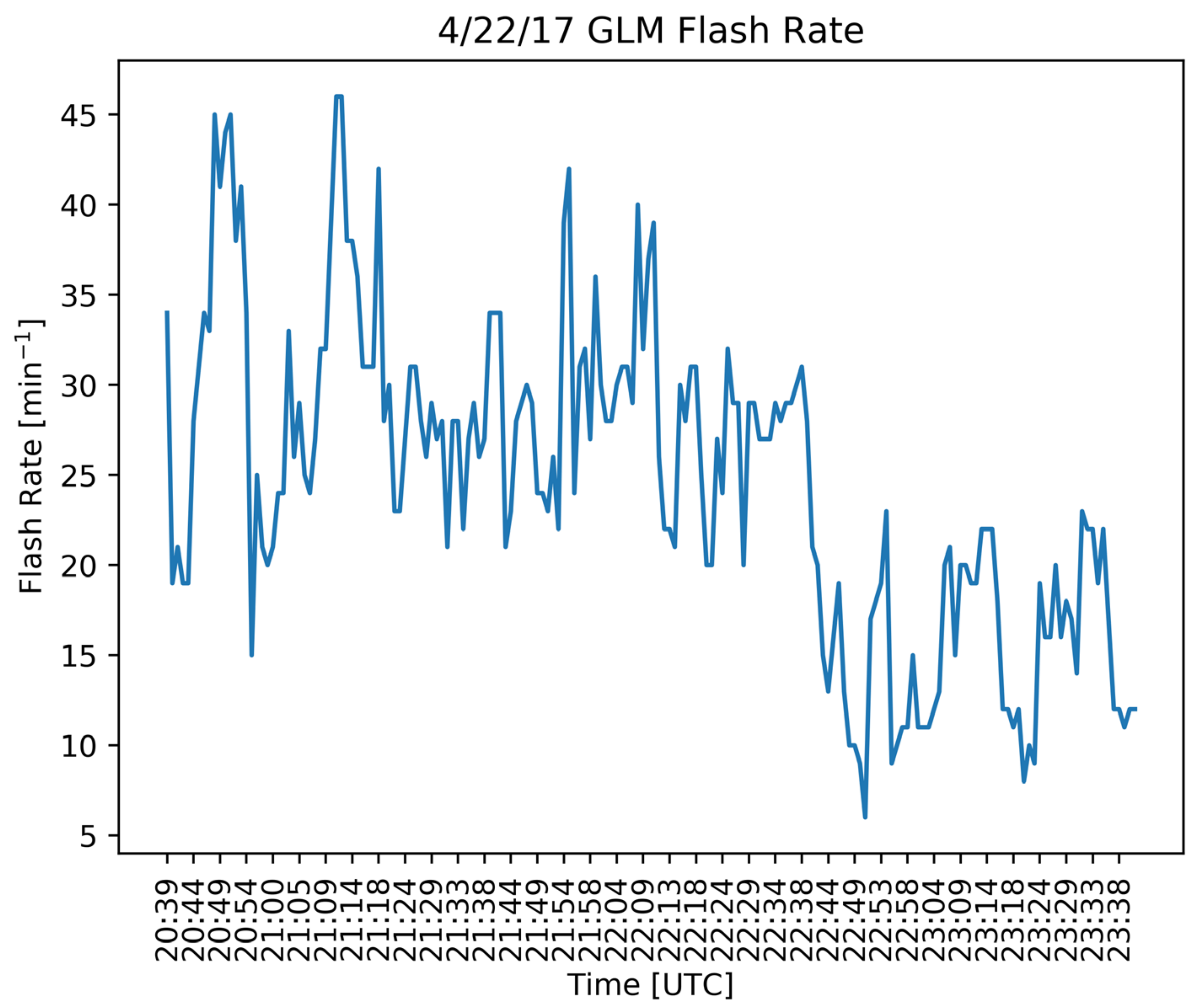
CAPE	552	$J\,kg^{-1}$
CIN	15	$J\,kg^{-1}$
TOPS	1651.73	km
θ_e	330.1	K
LI_{MAX}	-4.6	C
LI_{500}	-2.2	C
LI_{300}	0.3	C
Parcel	979	mb

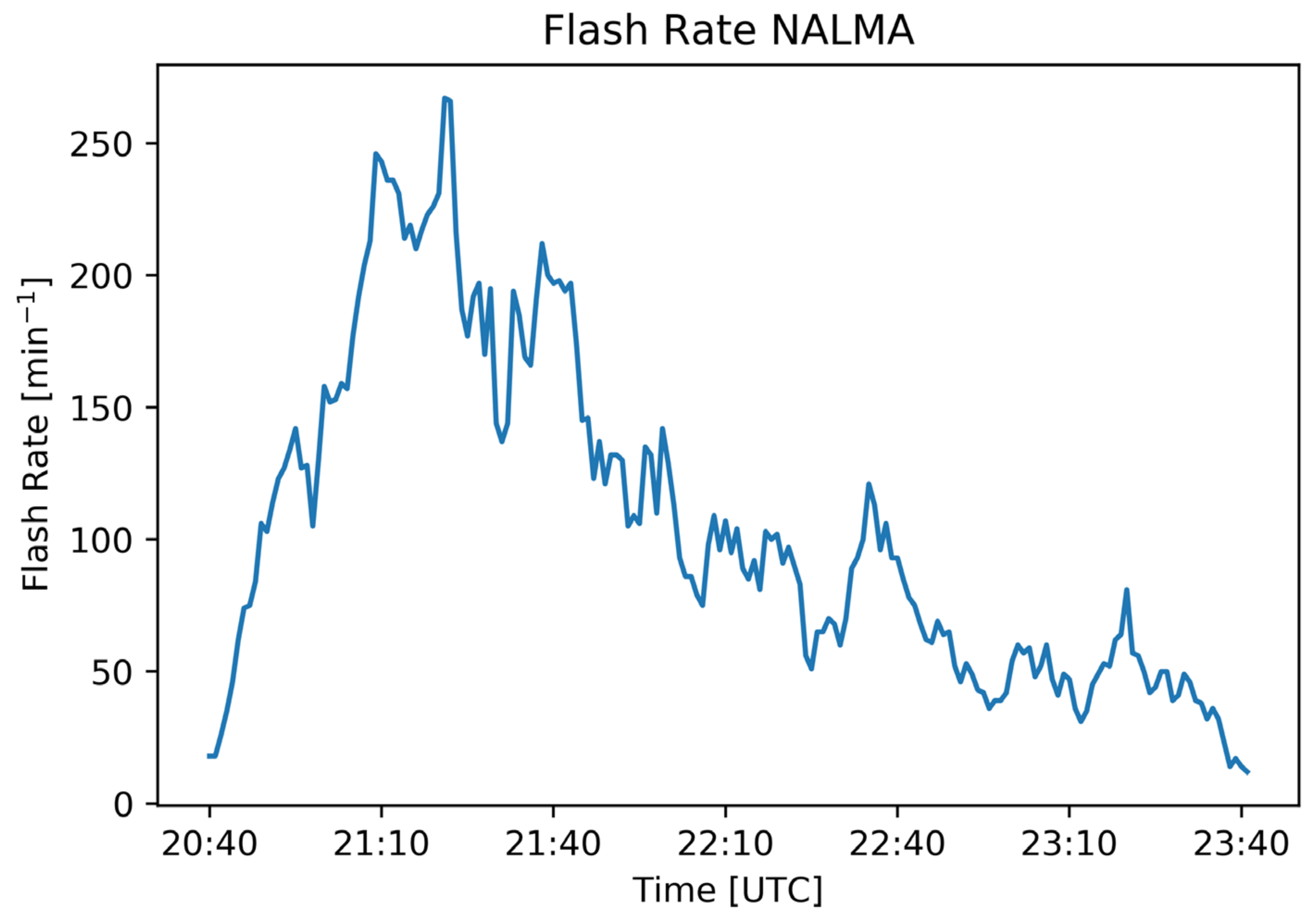
Hodograph

0-1 km shear 28° 11.0 kts
0-3 km shear 74° 19.0 kts
0-6 km shear 86° 36.8 kts
SRH 0-1 : 73 m2/s2
SRH 0-3 : 129 m2/s2
BRN : 10
0-1 km shear 54° 5.7 kts
1-2 km shear 244° 3.3 kts
2-3 km shear 188° 4.1 kts
3-4 km shear 262° 7.3 kts
4-5 km shear 143° 6.2 kts
5-6 km shear -72° 2.7 kts

LMA vs GLM Flash Rates

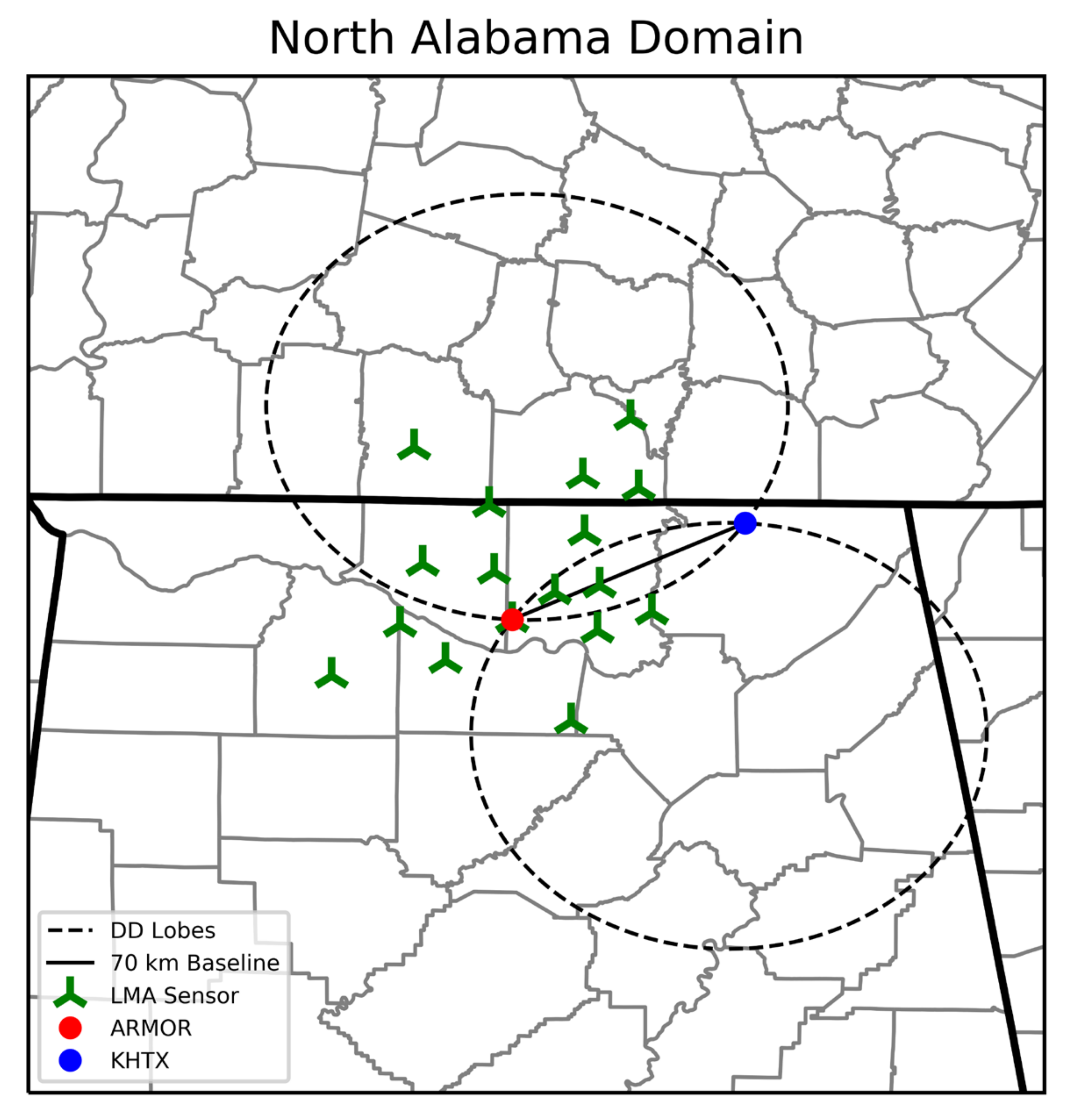
- GLM flash rates much lower than flash rates from LMA
  - GLM max flash rate around 45 flashes per minute, LMA near 275 flashes per minute
  - This trend seen with different LMA clustering thresholds and algorithms
  - Implications with lightning jump (poster 1018 Wed. 4-6pm)
- Cause of this difference?
  - Resolution?
  - Optical extinction?
  - Flash clustering?
- Goal of using optical energy is to remove the flash clustering process

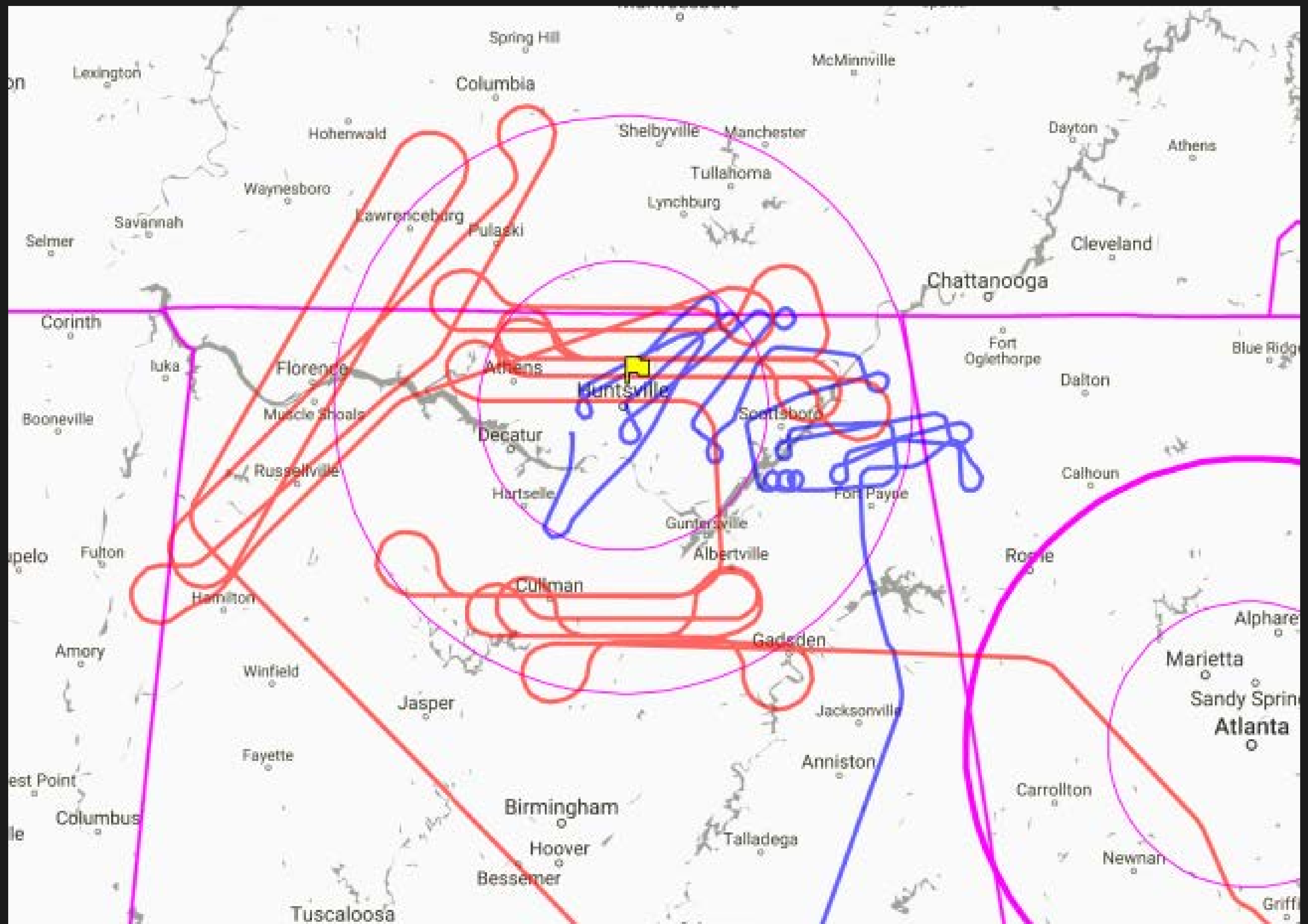




Data and Methodology

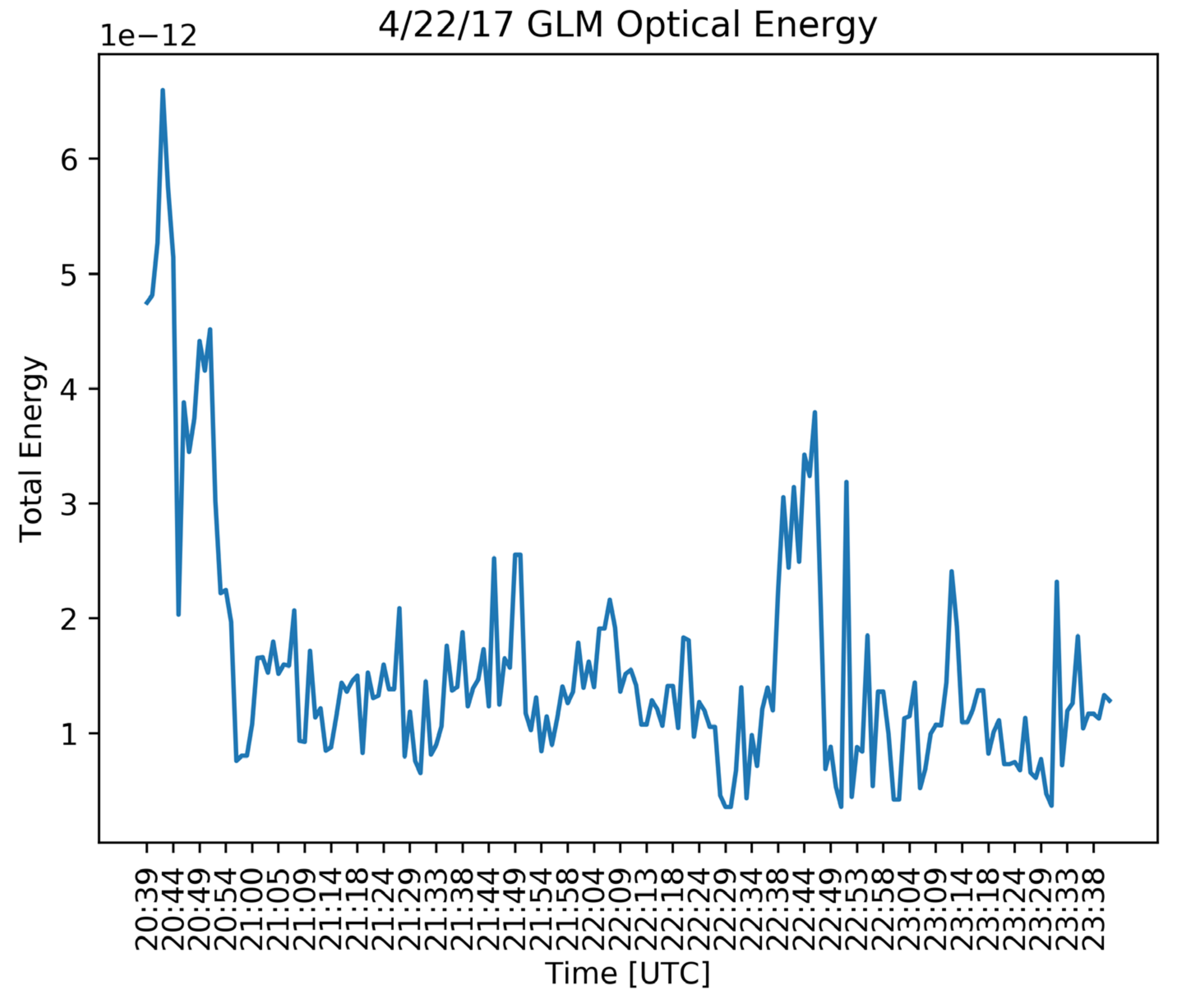
- Lockheed-Martin reprocessed GLM data
- Undecimated LMA data from the North Alabama LMA (NALMA)
- LMATools flash clustering
  - 0.3 s time threshold
  - 3 km distance threshold
  - Chi square value of 1
  - 6 station minimum
- Radar data from KHTX and ARMOR manually unfolded and quality controlled
- Data gridded to a 1 km x 1 km x 0.5 km grid
- Multi-Doppler winds found using PyART Multidop package which uses a 3DVAR approach (Shapiro et al. 2009, Potvin et al. 2012)
- HID using CSURadartools (Dolan et al. 09, Dolan et al. 13)

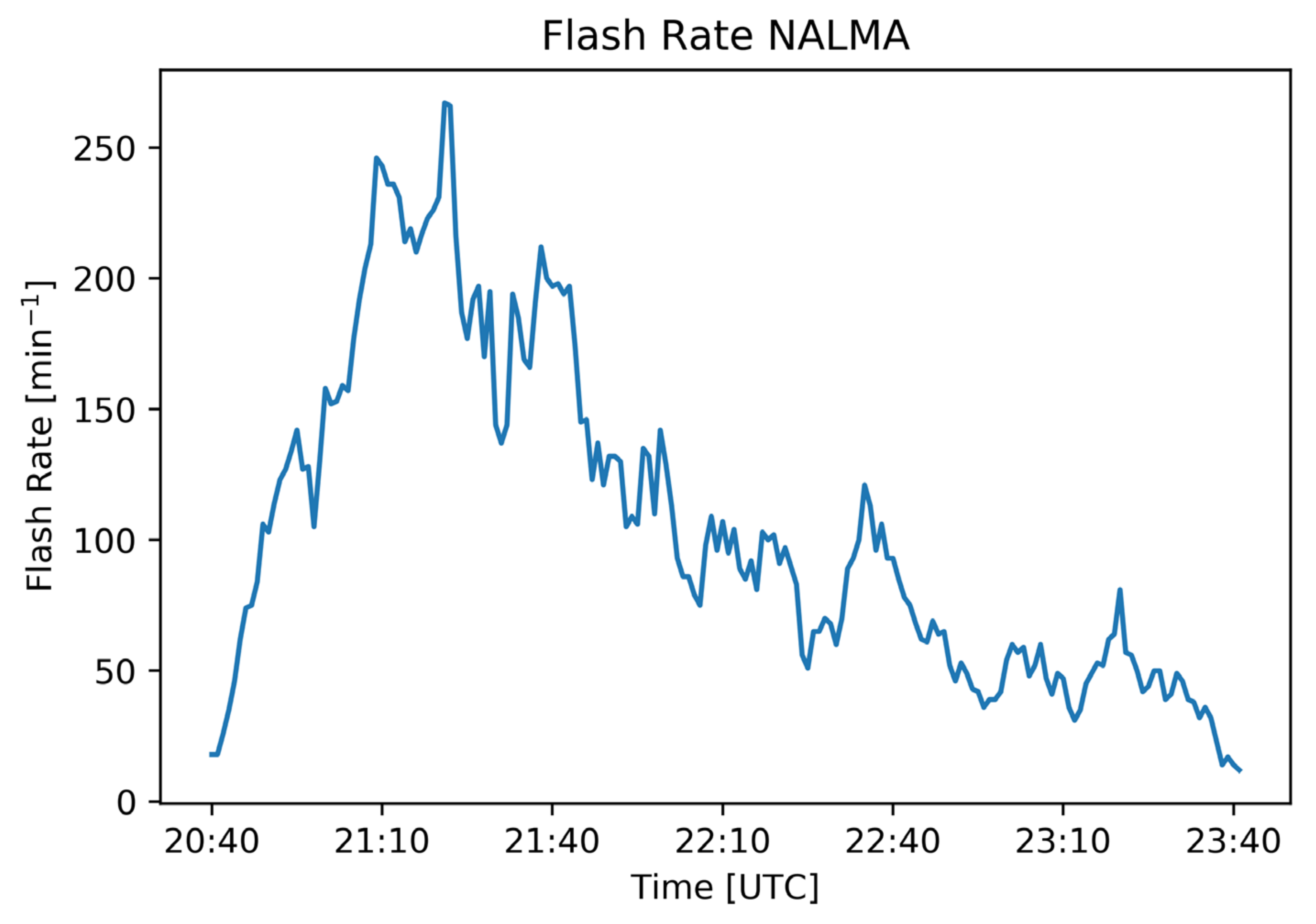




Optical Energy

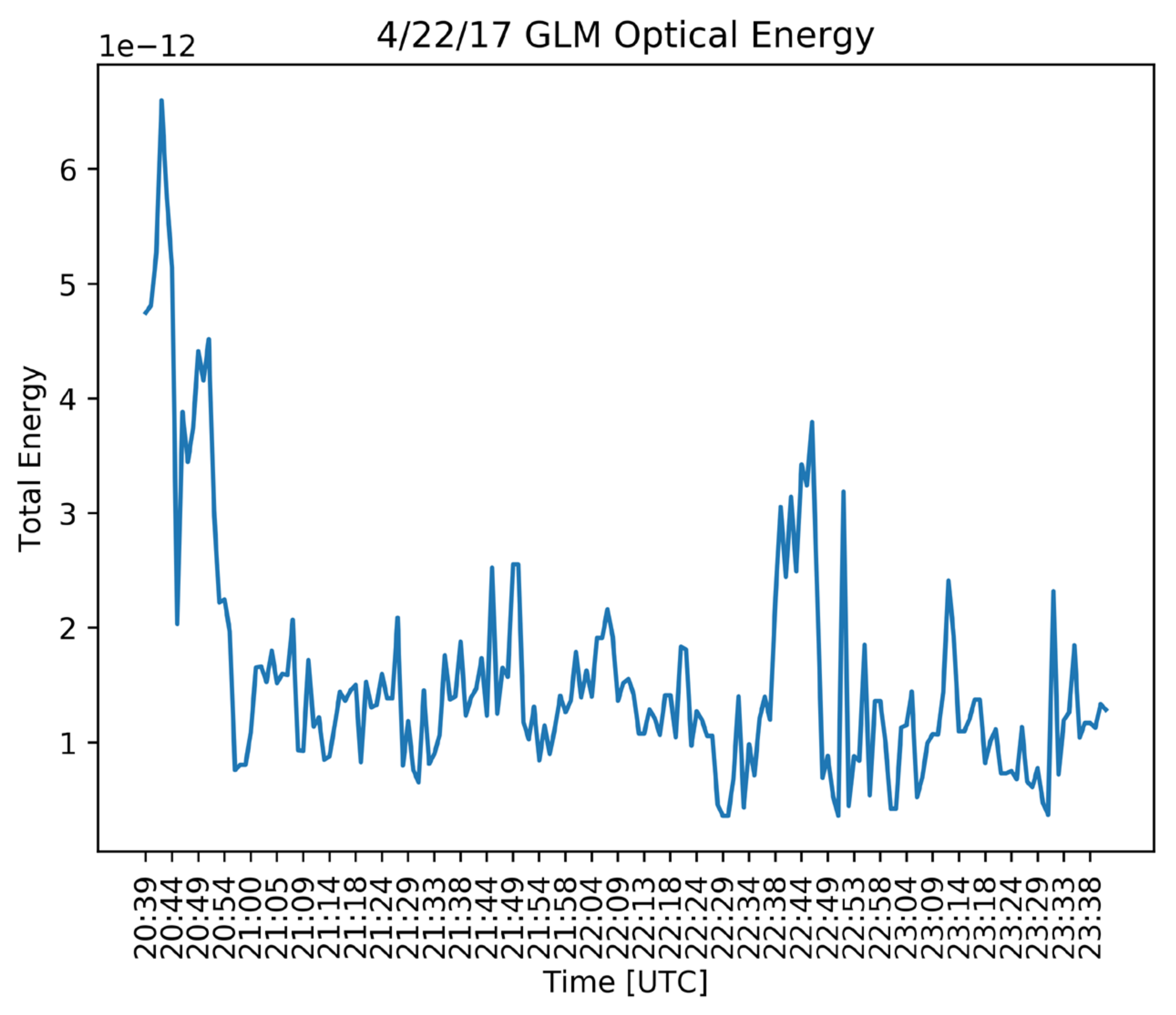
- Optical energy high as storm enters range of NALMA, then dives down to a minimum for an extended period of time
- Optical energy remains low even during times of high flash rates in NALMA during period of severe hail
- Increase in optical energy associated with increase in flash rate around 2240 UTC, coincident with time of the EF-0 tornado

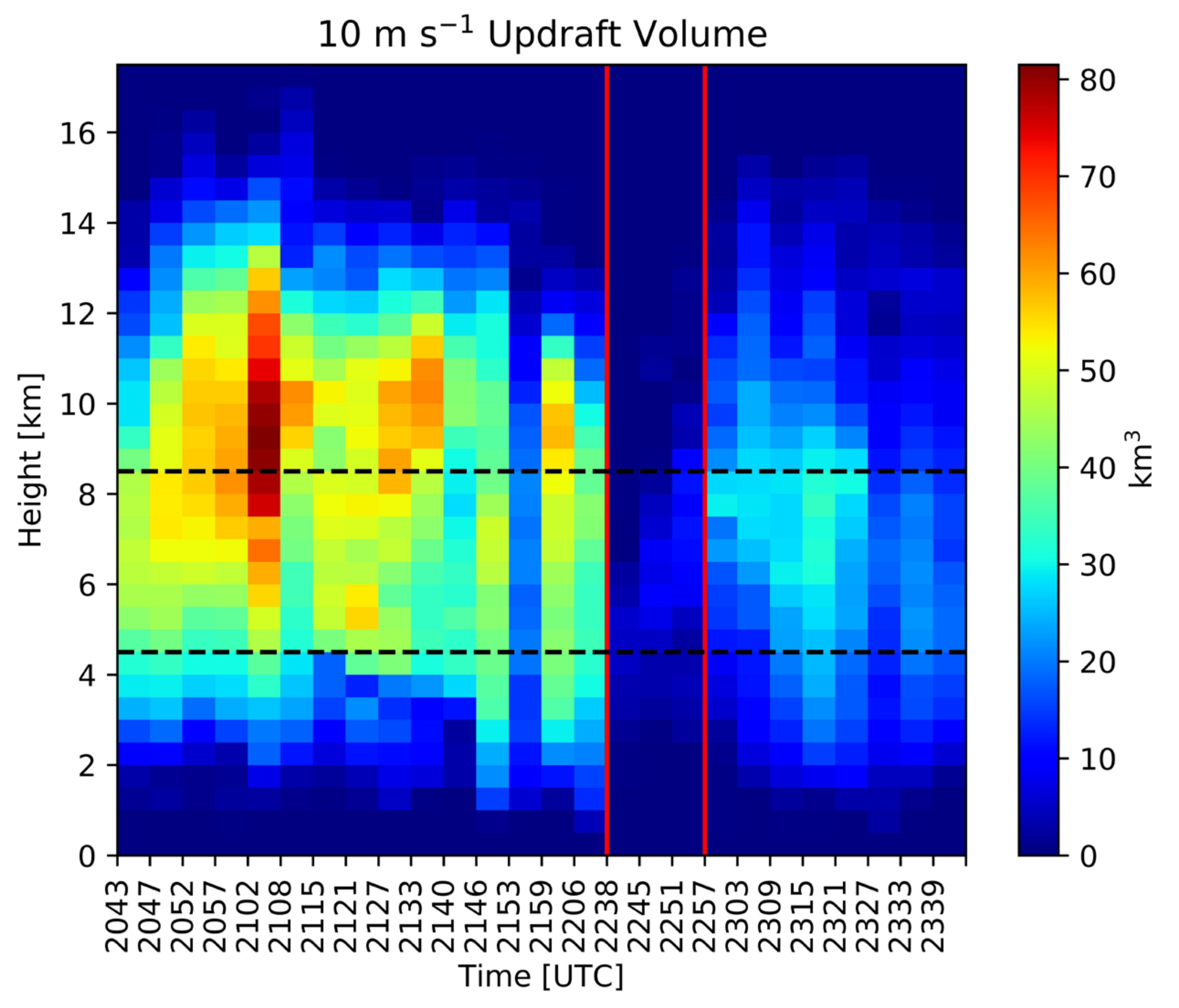




Updraft Volume vs Optical Energy

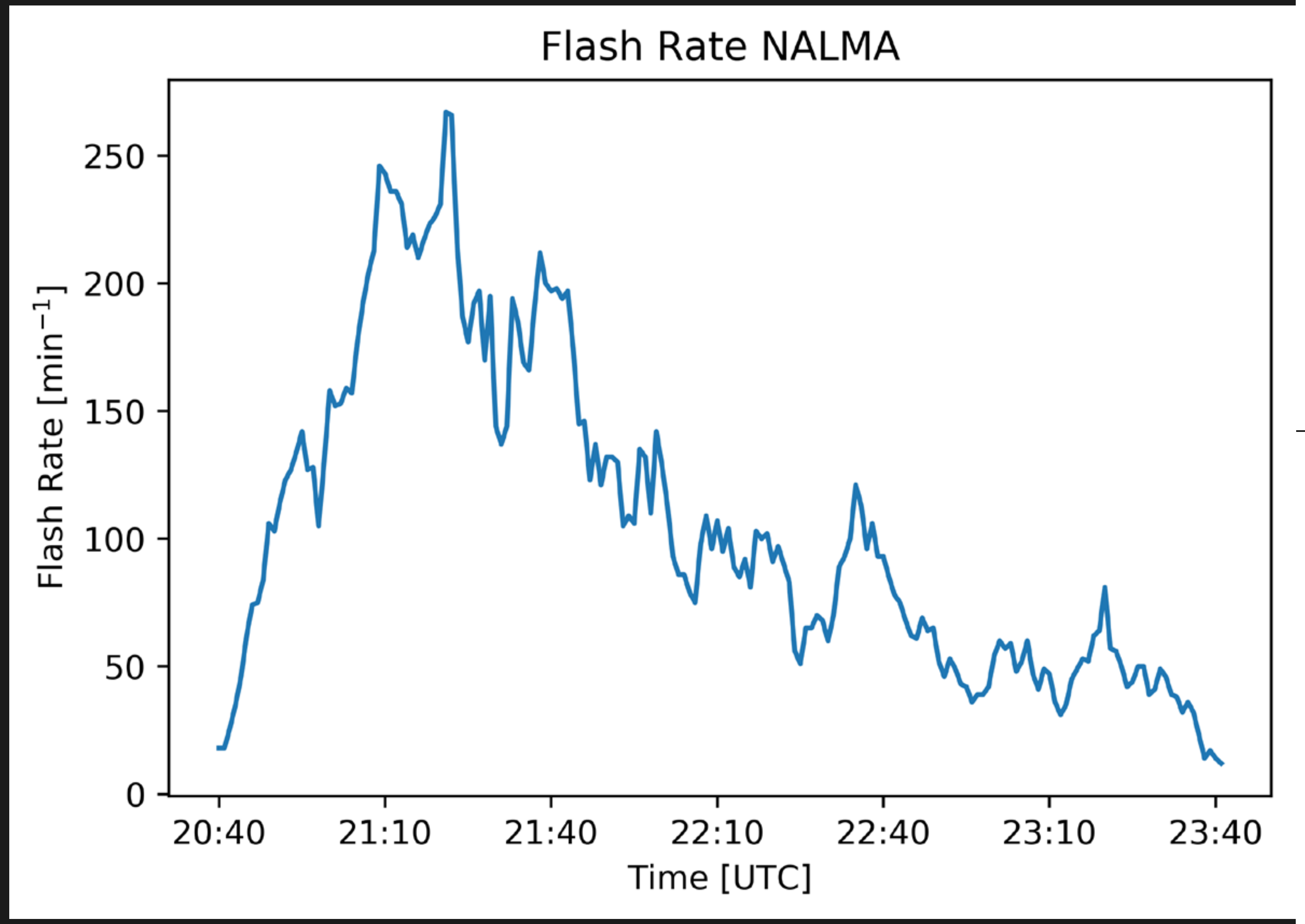
- Updraft volume larger during production of severe hail then tapers down near the end
  - Tornado occurred when storm was within the baseline
- Rise of optical energy at 2238 UTC occurs as the storm enters the dual-Doppler baseline
- Optical energy decreases as updraft volume increases
  - Rapid increase in cloud/precipitation hydrometeors

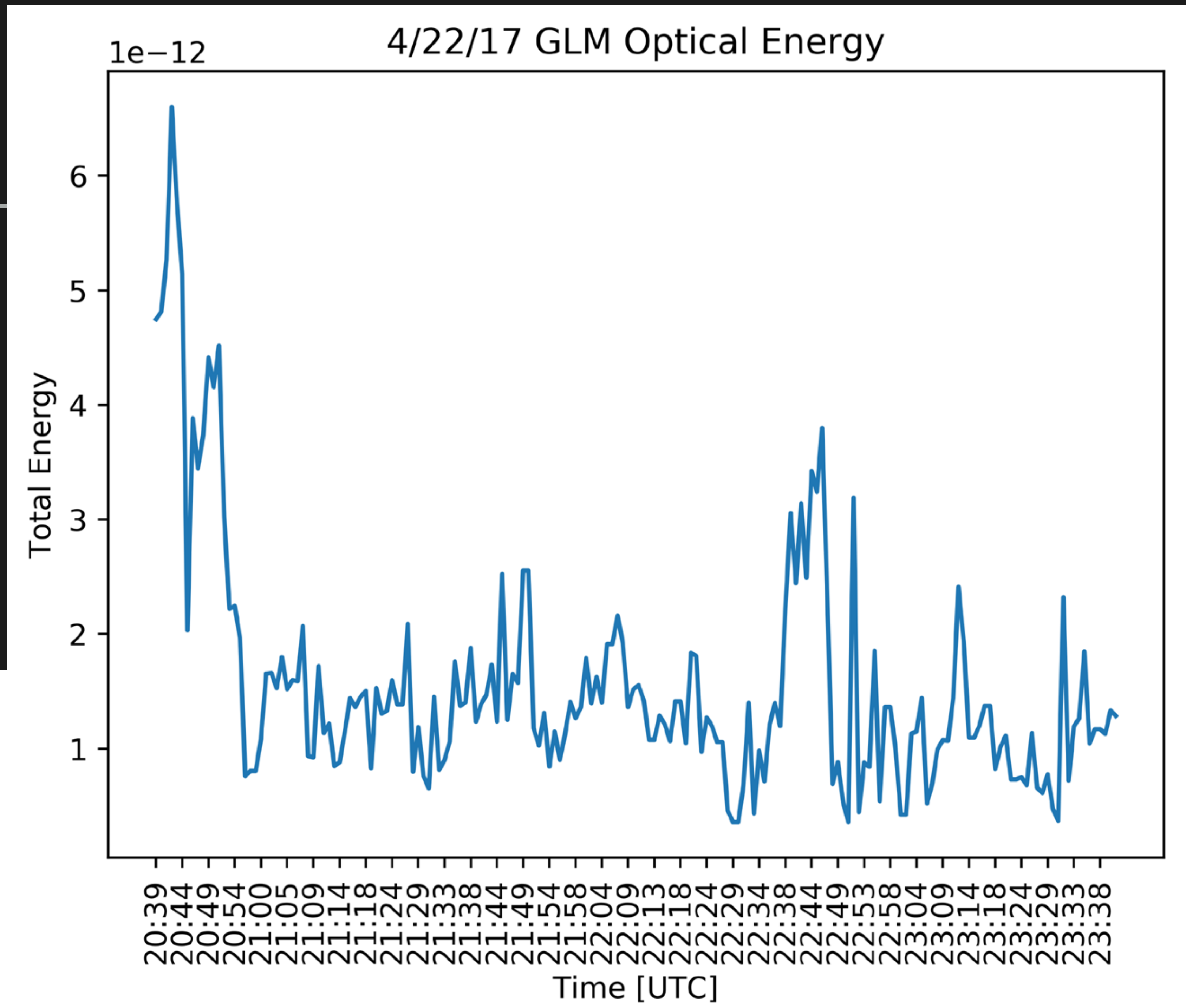


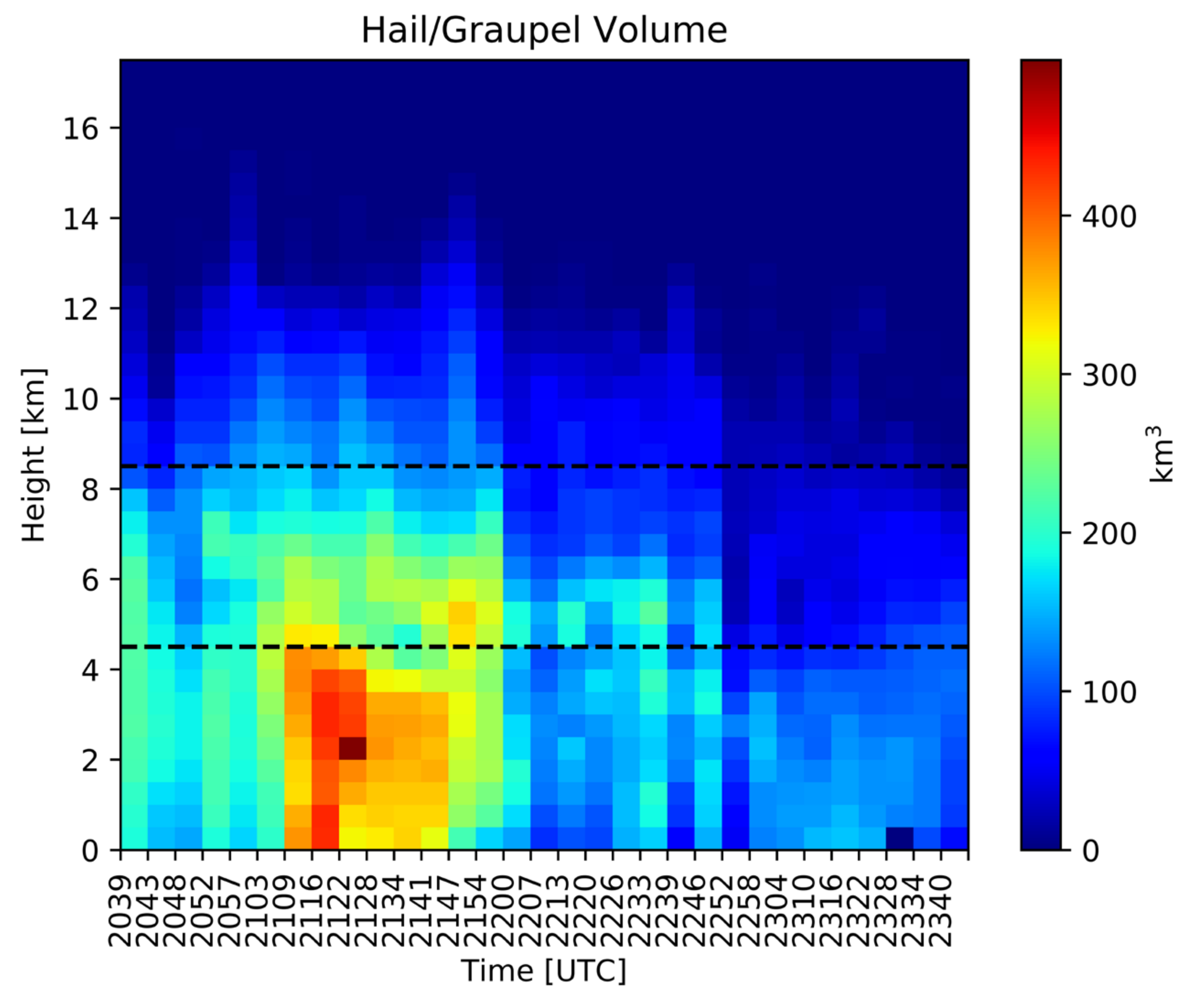


Graupel Volume vs Optical Energy

- Period of lowest optical energy from 2054-2234 UTC associated with highest hail/graupel volumes
- Peak of optical energy at 2238 UTC occurred with less hail/graupel
- However, optical energy does not increase as the hail/graupel volume decreases starting at 2200 UTC

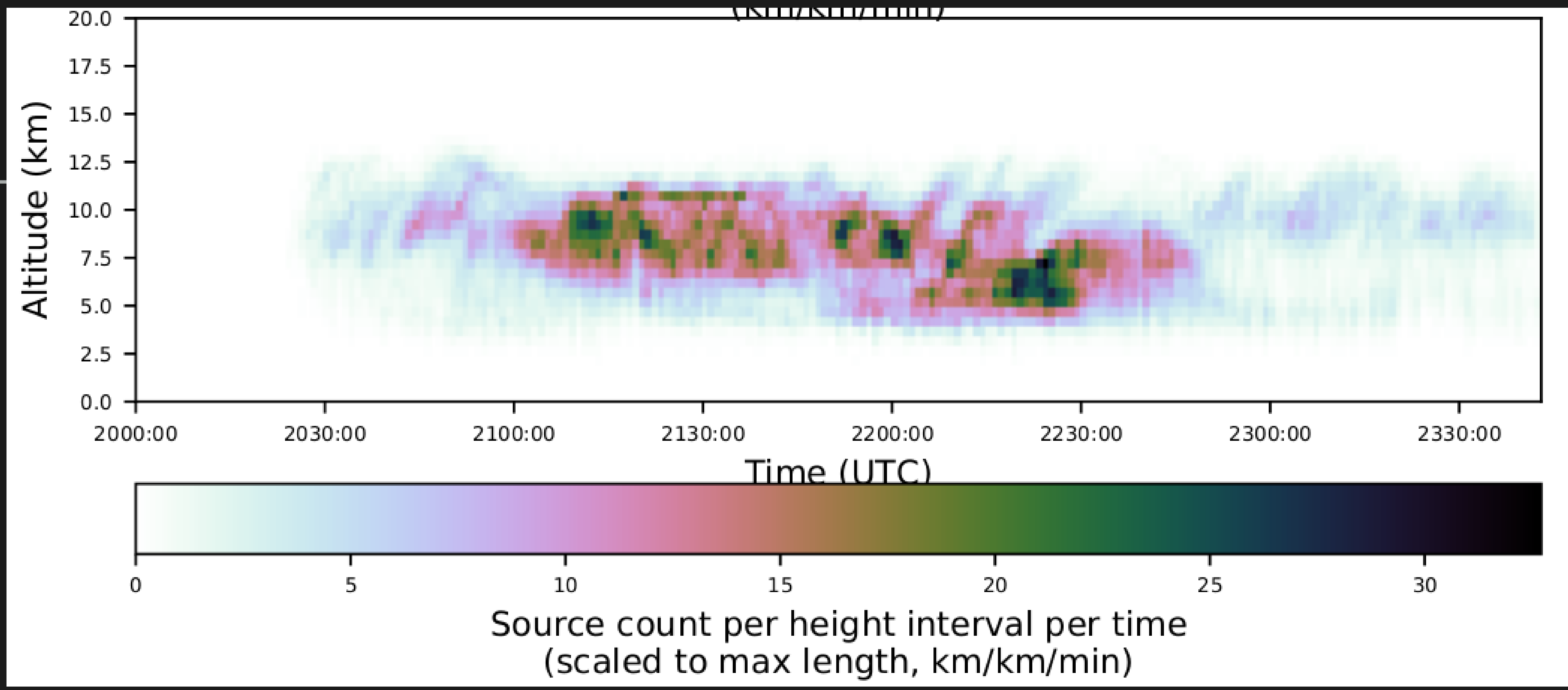


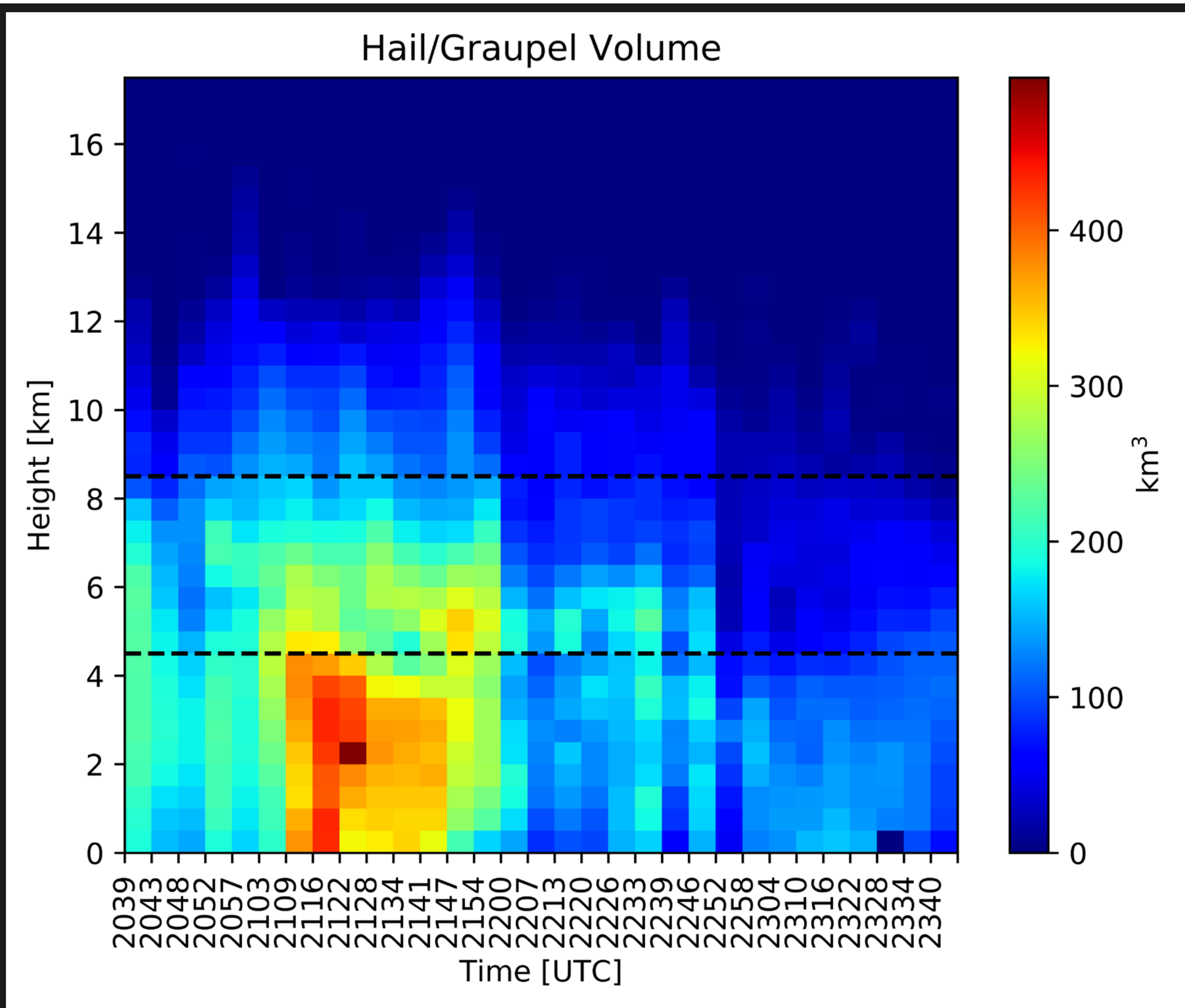




Lightning Height

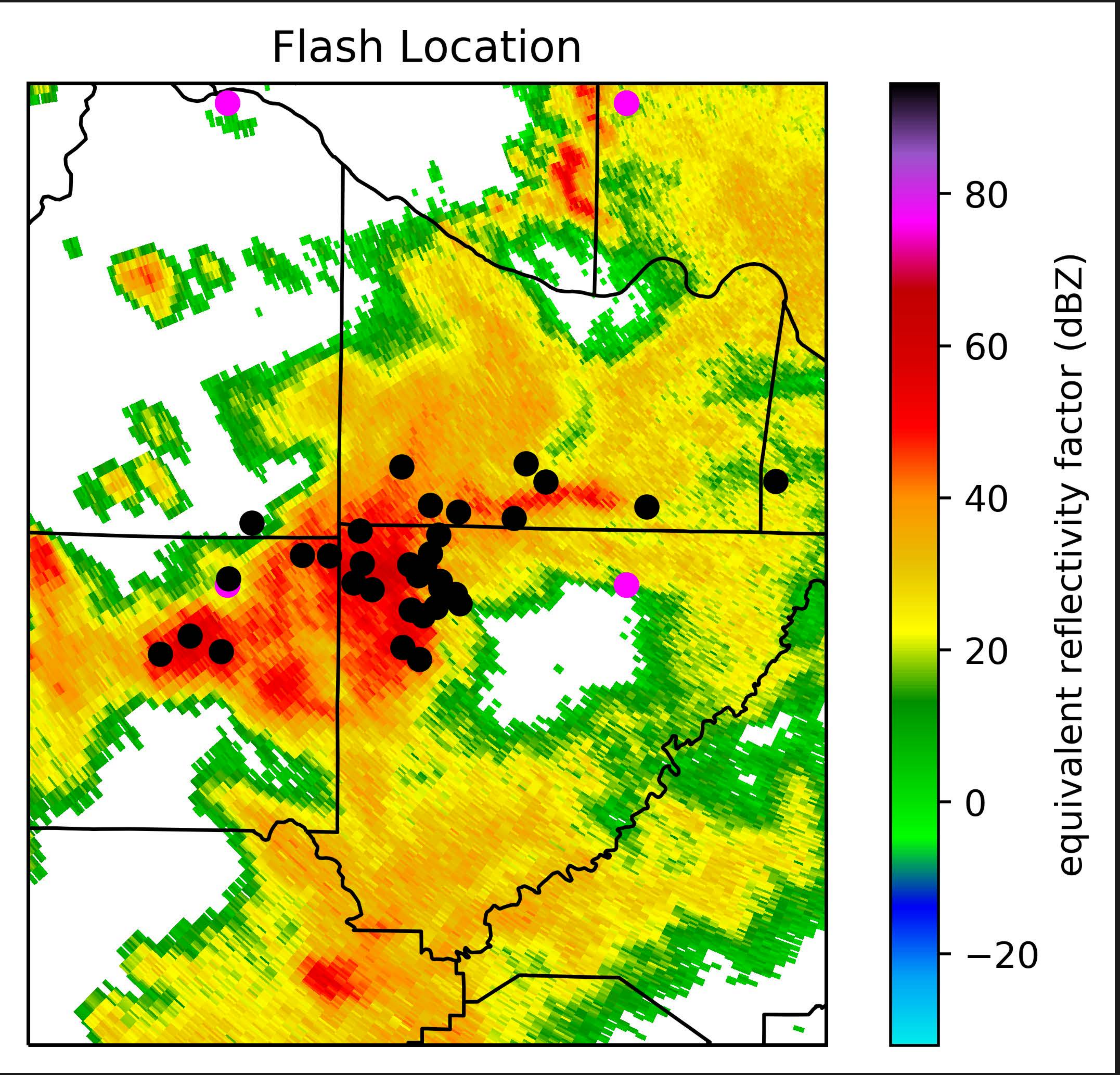
- Majority of sources are located above higher regions of hail/graupel
- LMA sources descend prior to tornadogenesis, when optical energy and flash rate both increase
- Hail and graupel are not the only hydrometeors that may be contributing to optical extinction -> cloud water/ice have an impact





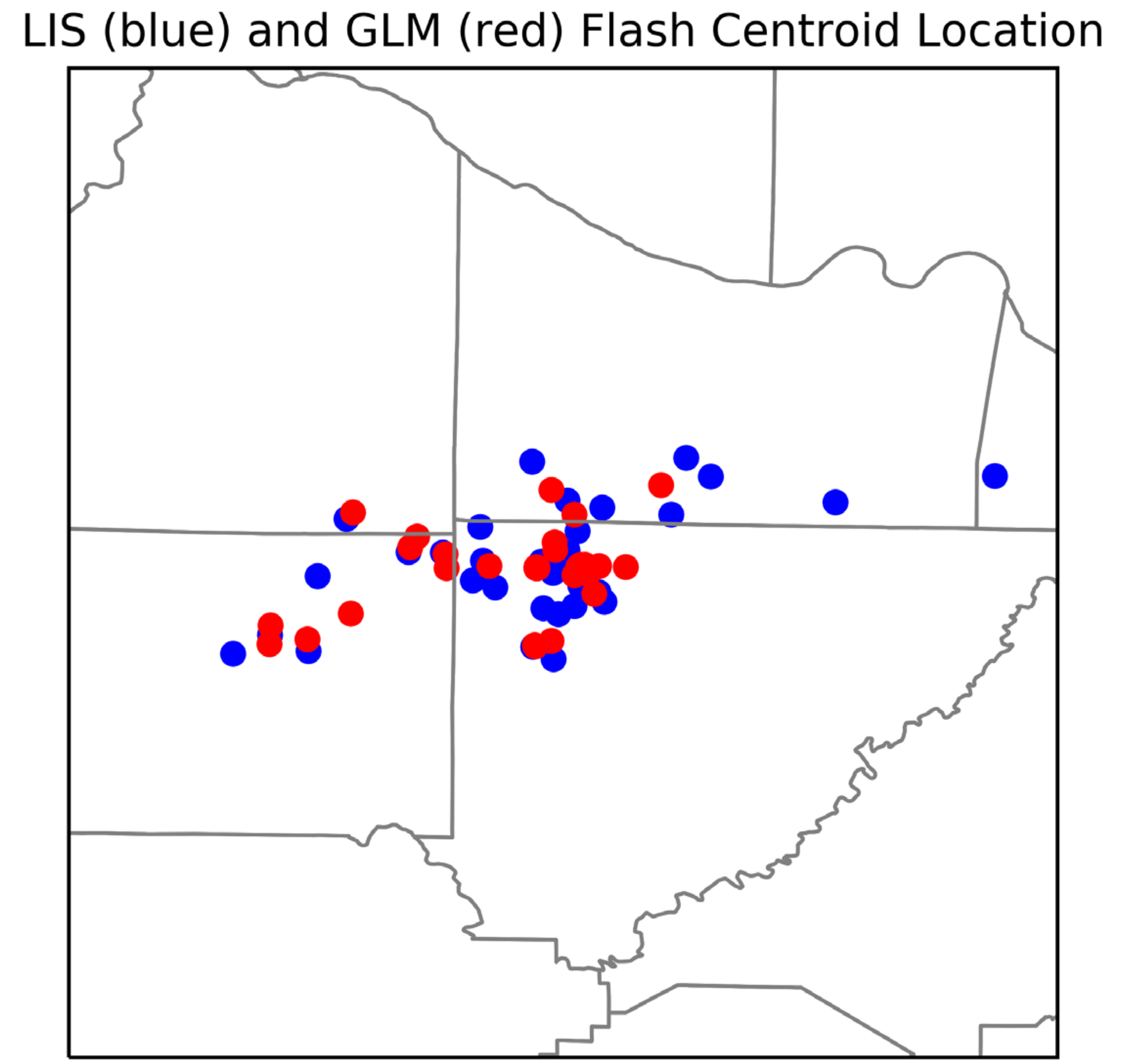
ISS LIS - Cullman Supercell

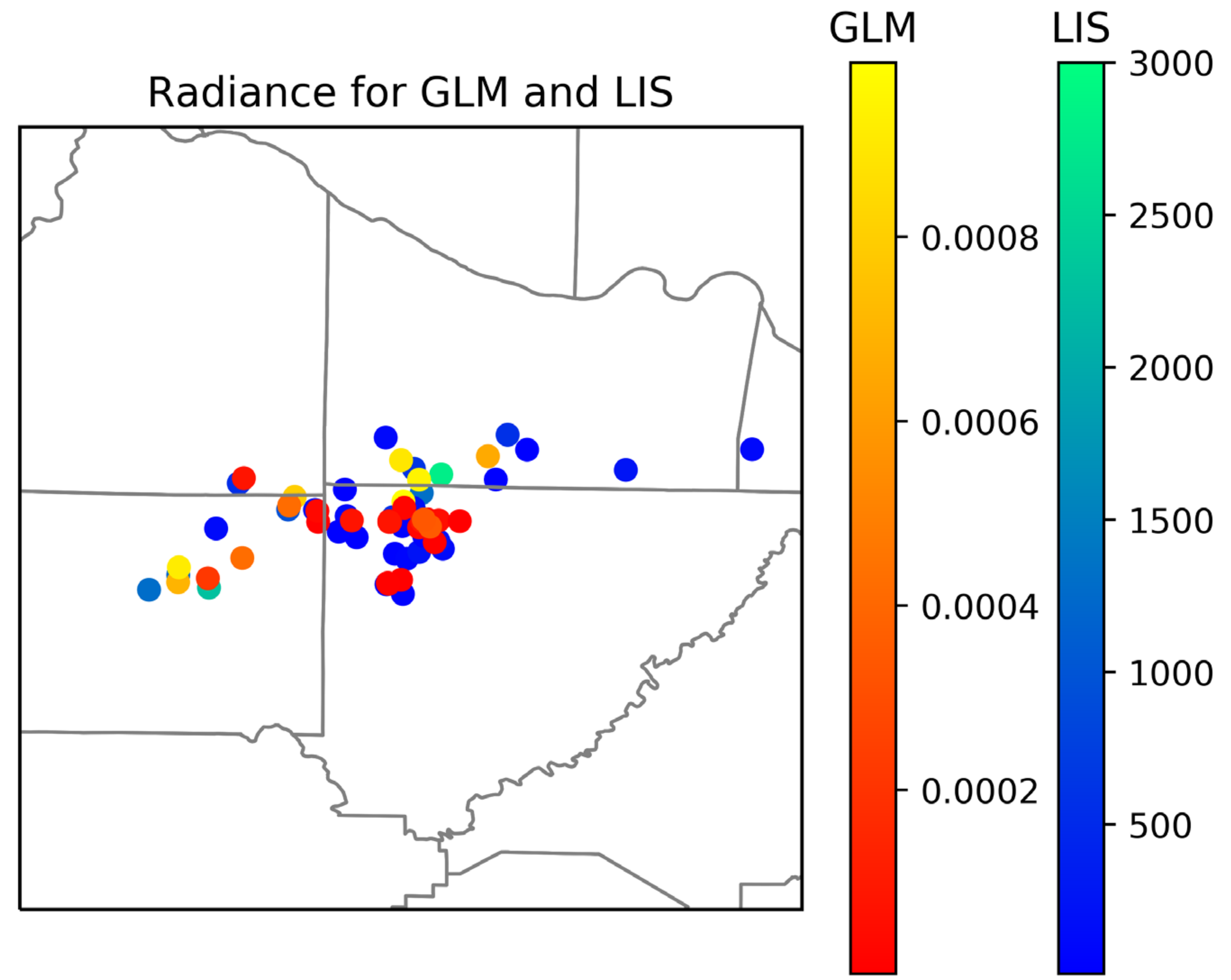
- ISS LIS overpass around 2245 UTC over supercell near Cullman County
- ISS LIS had 33 flashes during the 1 minute overpass, while GLM had 31 flashes; LMA showed 86 flashes
- Low Earth Orbit and Geostationary orbit showing similar flash rates, eliminating distance to the satellite as a possible means of error in underestimating flash rates for this case



ISS LIS - Cullman Supercell

- GLM and LIS flashes located in similar regions of the storm, with similar flash rates
- LIS did show 2 flashes east of the storm, where GLM did not
- LIS and GLM energies for each flash show similar trends, with higher optical energies located in similar areas



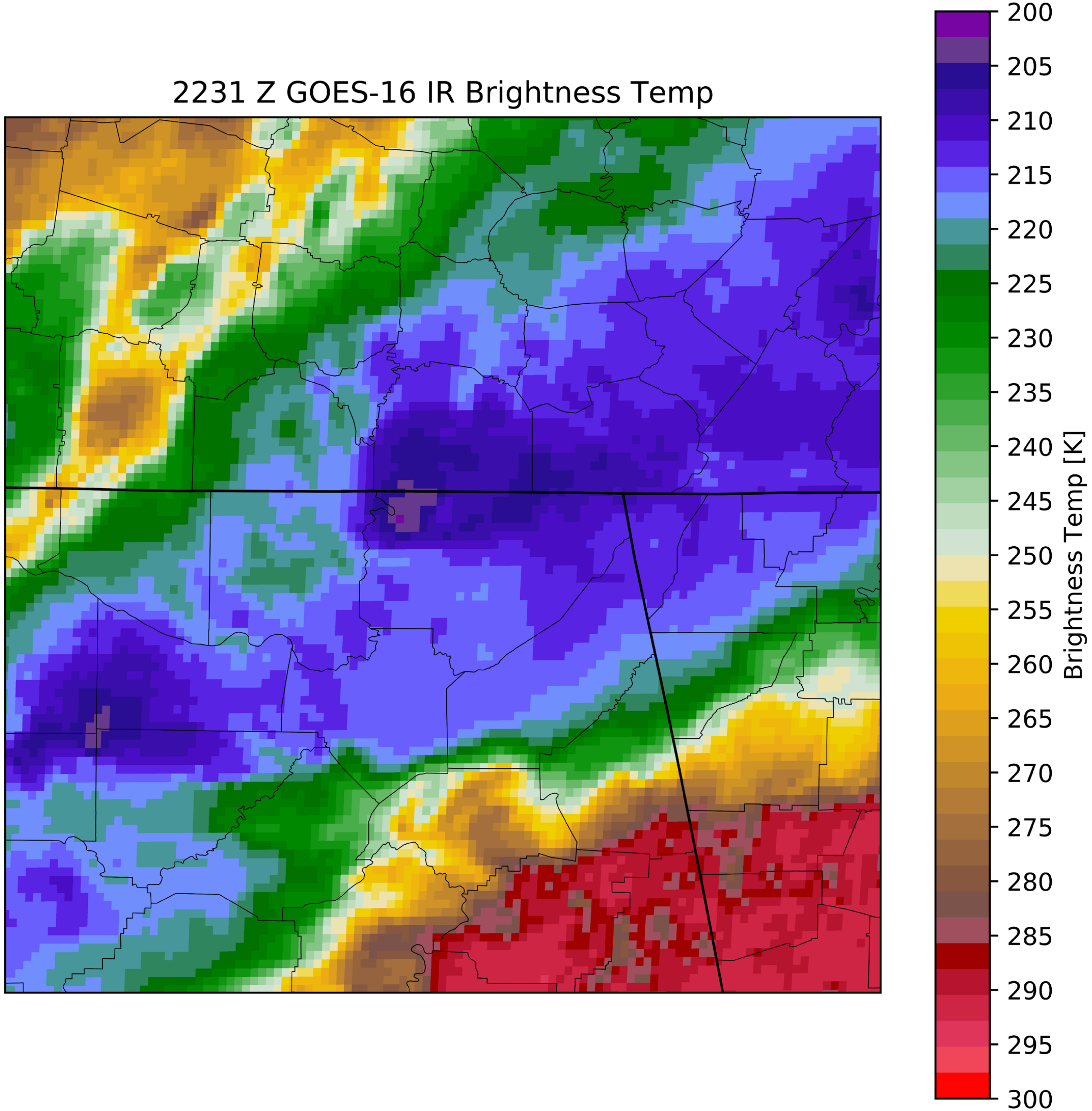


Conclusions

- Flash rates between LMA and space based observations differ, with satellite observations showing lower flash rates than LMA
- Updraft volume and optical energy may be inversely related, however it can not be confidently stated due to storm passing through dual-Doppler baseline
- Optical energy from GLM does not appear to be correlated with flash rates, from either LMA or GLM
- Optical energy remains low after hail/graupel volume decreases, however LMA sources are located above most of the hail/graupel
- ISS LIS and GLM both show reduced radiances within heavy precipitation, however further investigation into the flash properties of that storm is needed

Future Work

- Flash properties
- Cloud properties from GOES-16 ABI
- ER-2 Data
  - Electric field changes
  - FEGS
- Further investigation with ISS LIS
- P3 tail radar



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