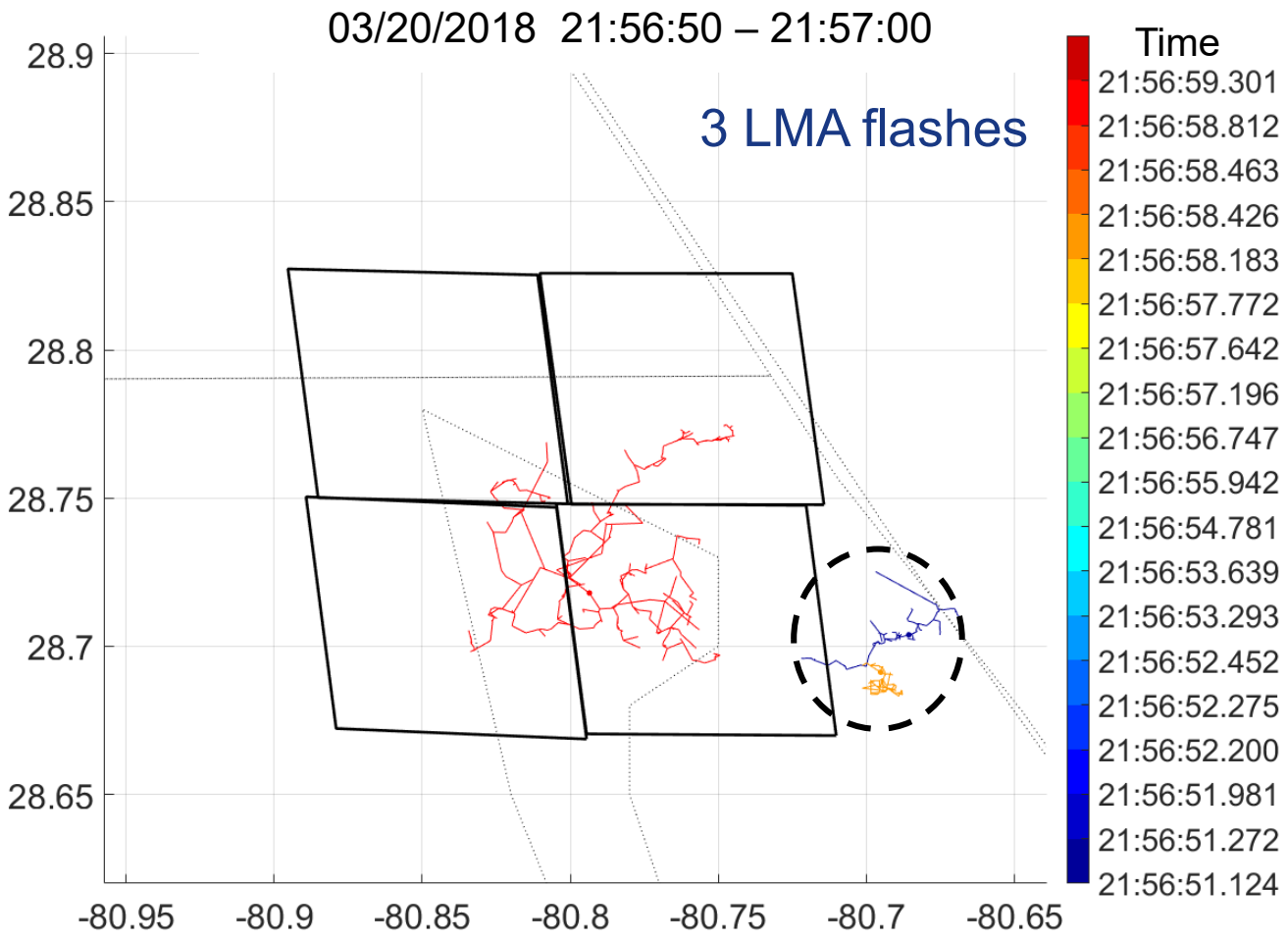
Why is Geostationary Lightning Mapper (GLM) unlikely to detect small flashes?

Daile Zhang and Ken Cummins

Thanks to Bill Koshak, Scott Rudlosky and Mason Quick

A GLM Detection Behavior: Miss smaller flashes

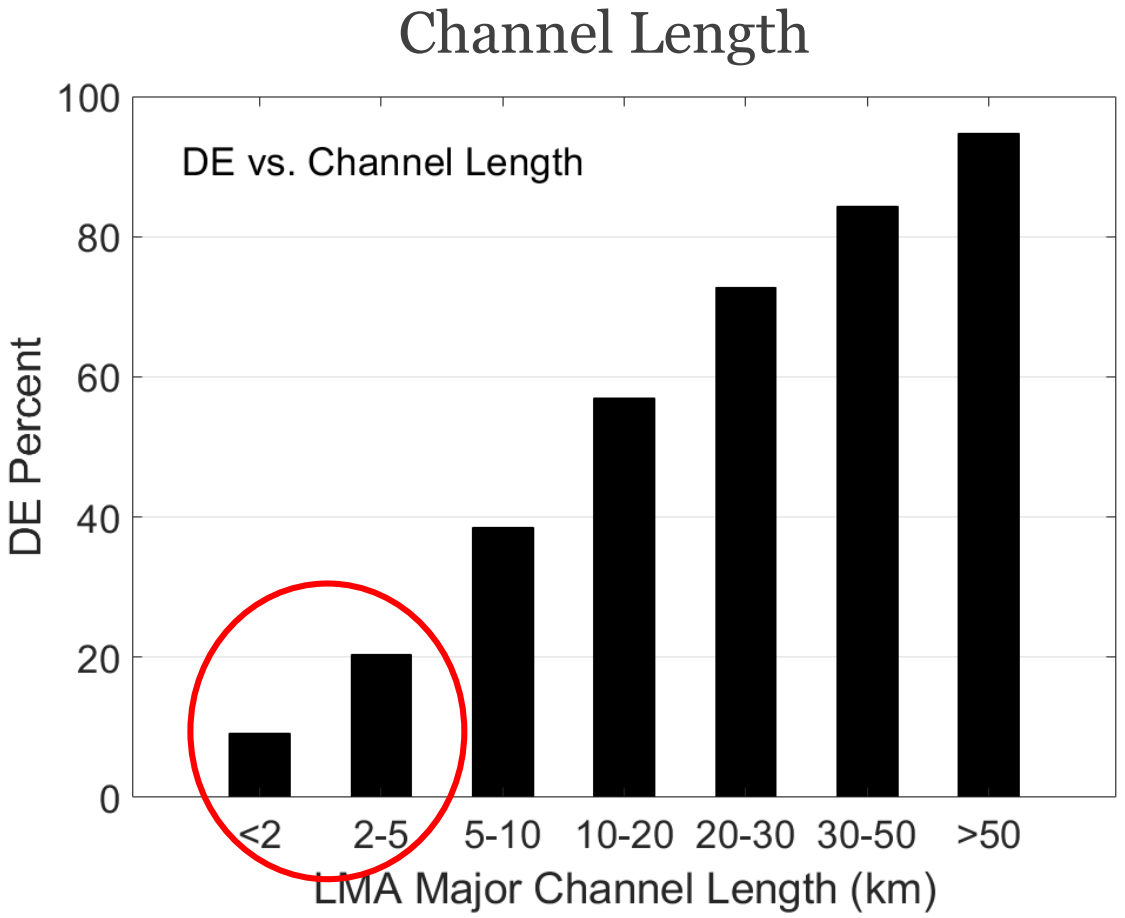
Detected 1 larger flash



Missed 2 smaller flashes

Lightning Mapping Array (LMA)

GLM Flash Detection Efficiency (DE)

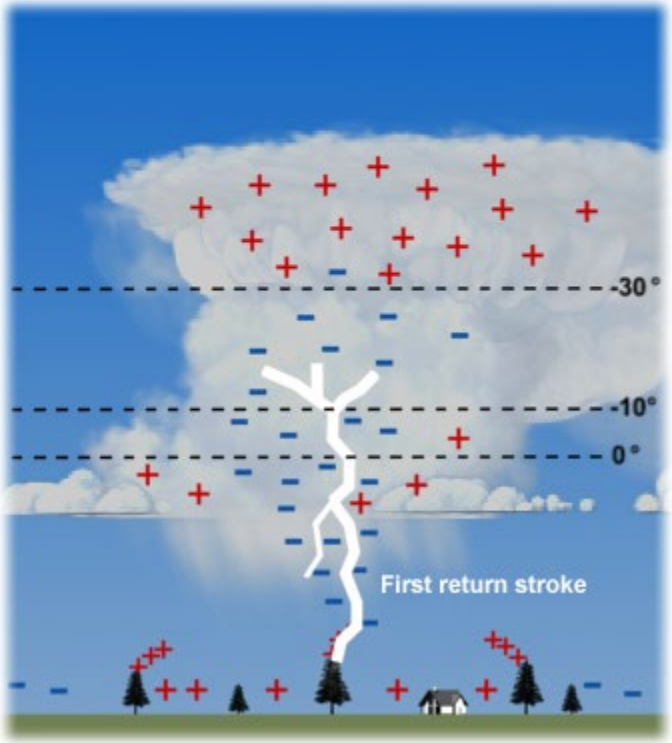


(2018-03-20 19:00-19:59
Kennedy Space Center)

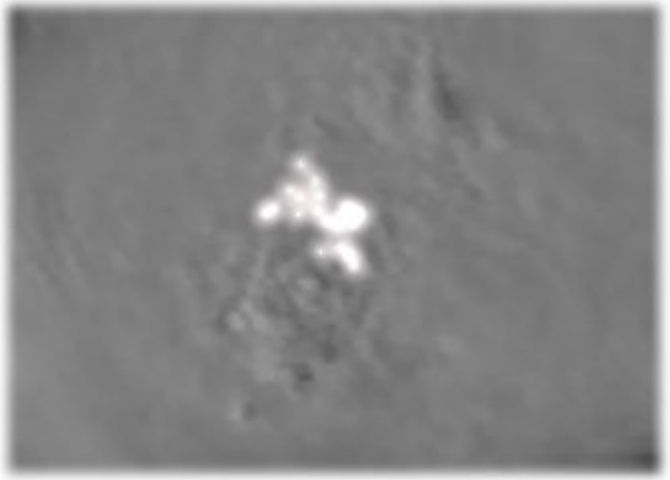
What does GLM see?

Satellites detect **cloud-top** optical sources

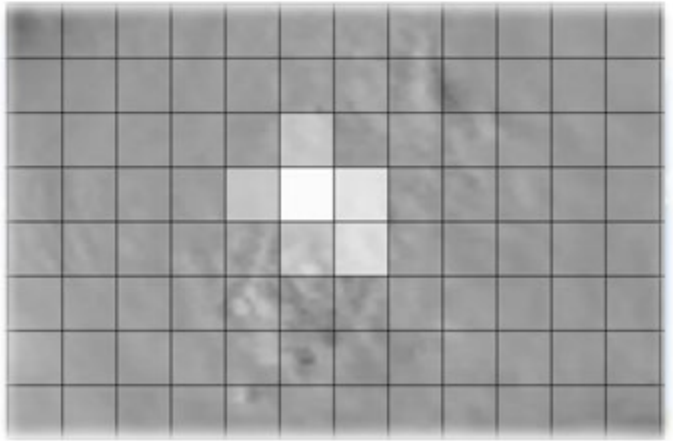
1 Conceptual View of Cloud-to-Ground Lightning Discharge Process



3 Cloud-Top View



2 GLM Observed Optical Pulse



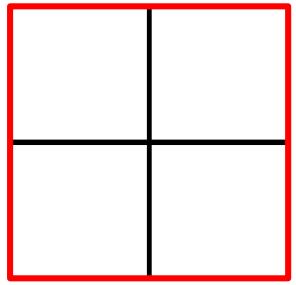
What determines detection?

- Cloud-top source size → What fraction of sub-pixel size sources does lightning produce?
- Cloud-top energy and threshold → What is the GLM minimum detectable cloud-top energy?

Lightning Imaging Sensor (LIS)

LIS has about 4 times higher spatial resolution than GLM

(Low-earth orbit – limited view time)

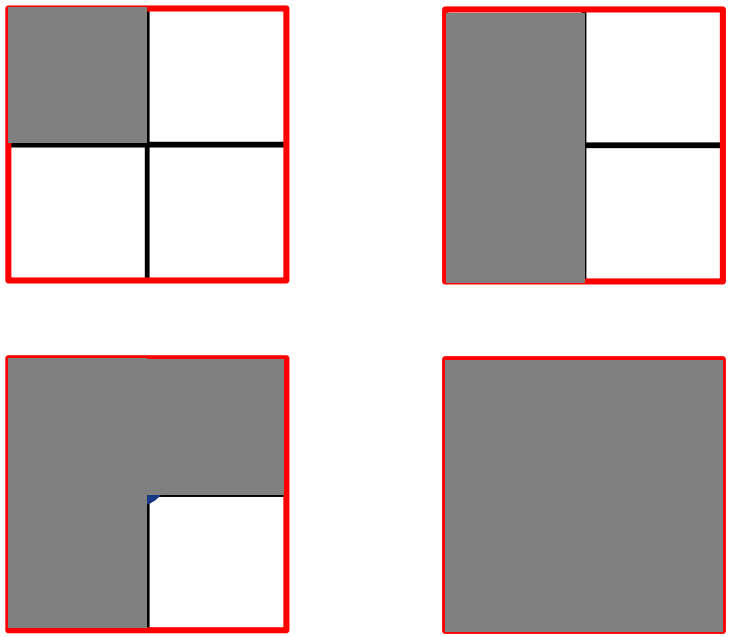


Black: LIS pixels
(4 km × 4 km at nadir)

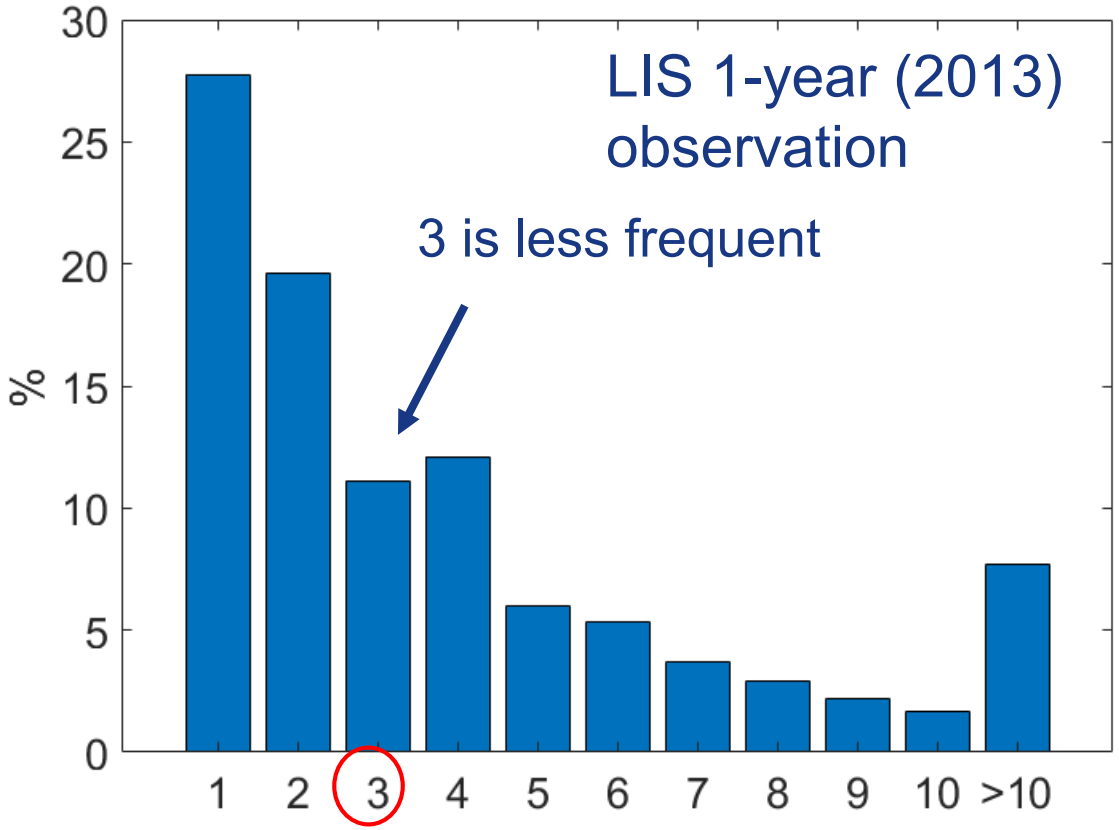
Red: GLM pixel
(8 km × 8 km at nadir)

What fraction of sub-pixel size sources does lightning produce?

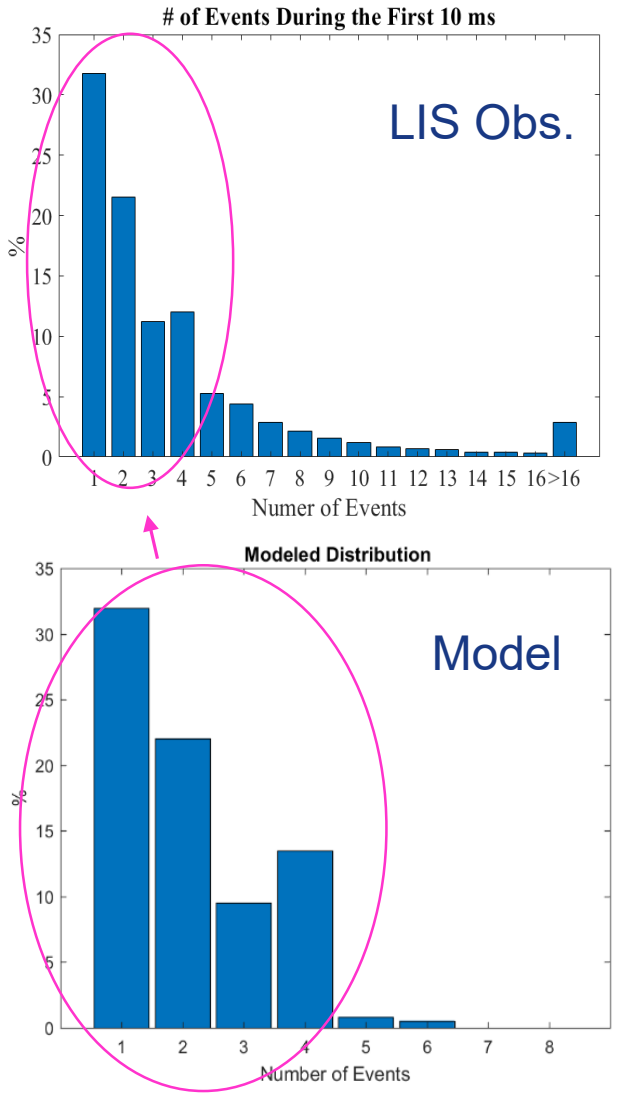
Our hypothesis is that the cloud-top sources are smaller than a LIS pixel.

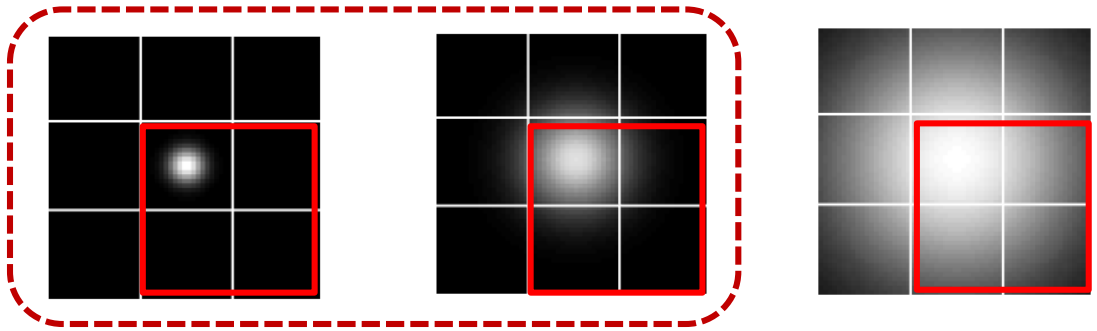


Black: LIS pixels Red: GLM pixels



LIS Modeling Cloud-top Light Source Size





More than 50% of the cloud-top sources are smaller than a GLM pixel (sub-pixel)

The Minimum Detectable Cloud-top Energy

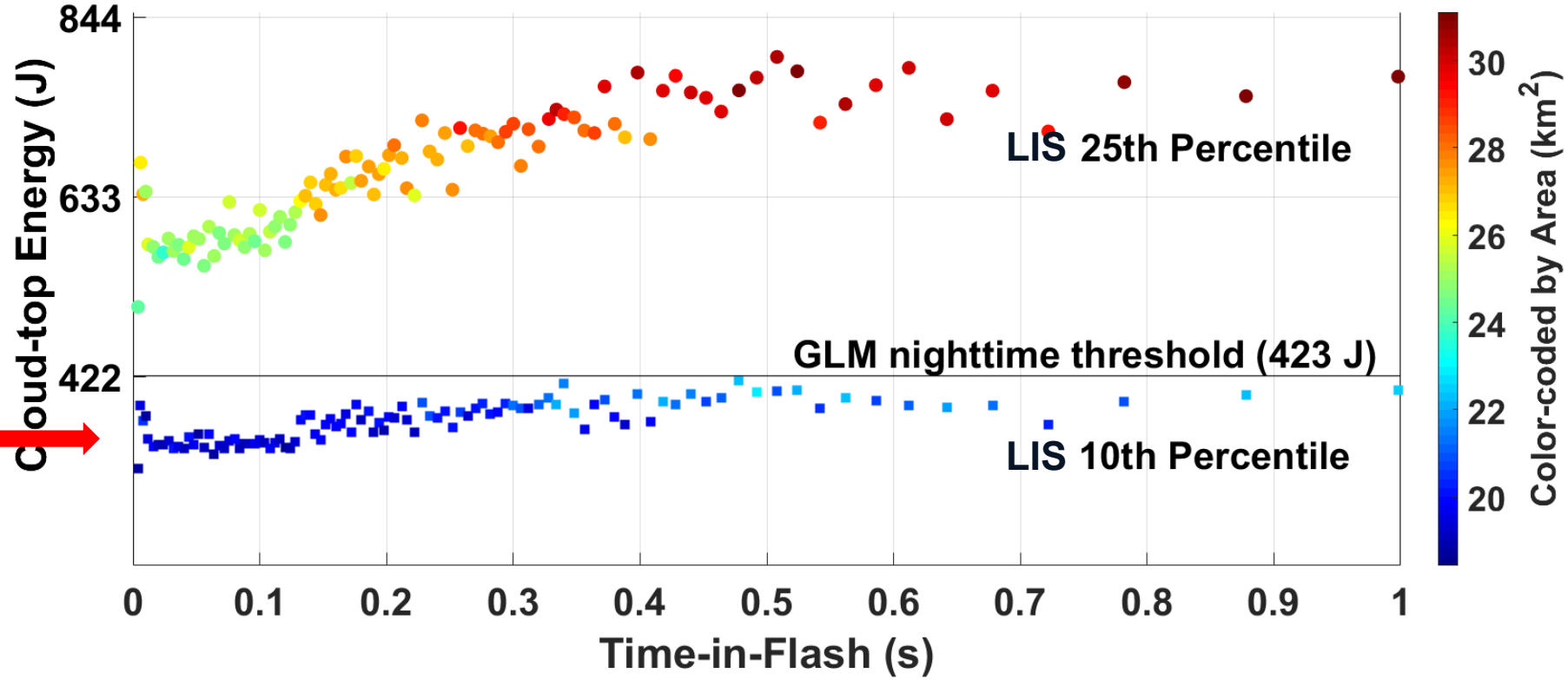
LIS $$E = \frac{\pi \Delta \lambda \hat{\xi} A}{n} = 164 \text{ J}$$

GLM $$E = \frac{6.61 A \hat{q}}{n} = 423 \text{ J}$$

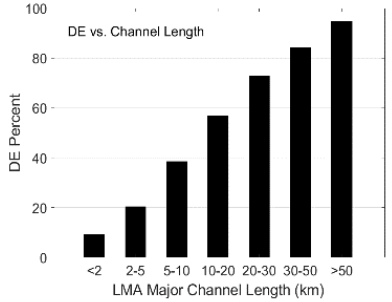
The minimum detectable cloud-top energy for a GLM pixel is (423/164) = 2.58 times higher than for a LIS pixel

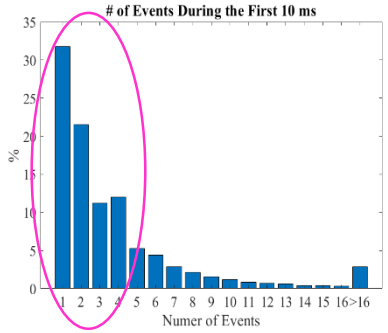
Within-Flash Time Evolution of Cloud-top Energy

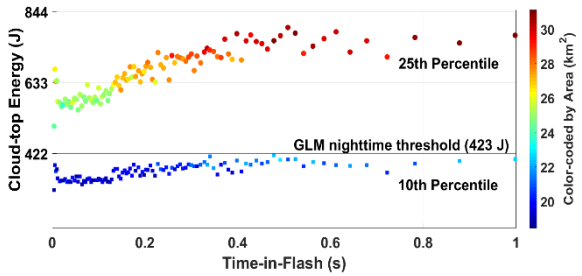
GLM won't detect these



Summary







- GLM low detection efficiency for smaller flashes
- More than 50% cloud-top light sources are sub-pixel sizes
- The minimum detectable cloud-top energy of GLM is 2.58 times higher than LIS

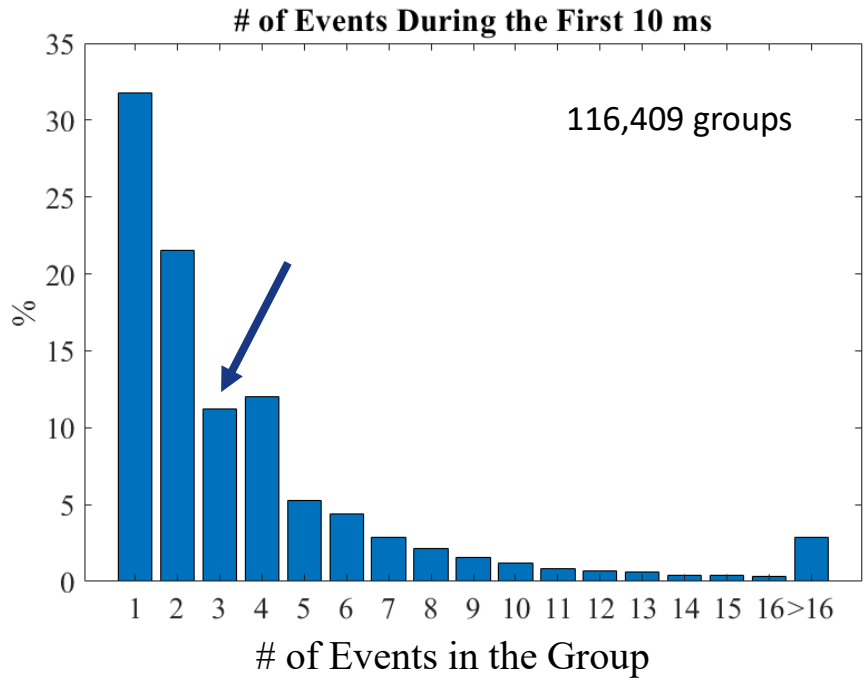
Thank you!

dlzhang@umd.edu

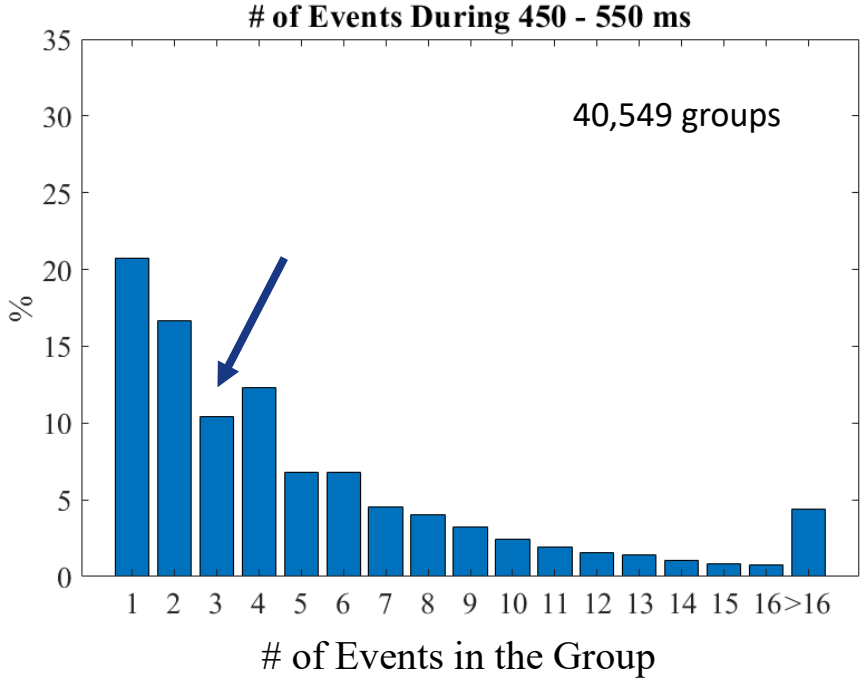
07/08/2018 Tucson, AZ

Histograms of # of Events in the Group

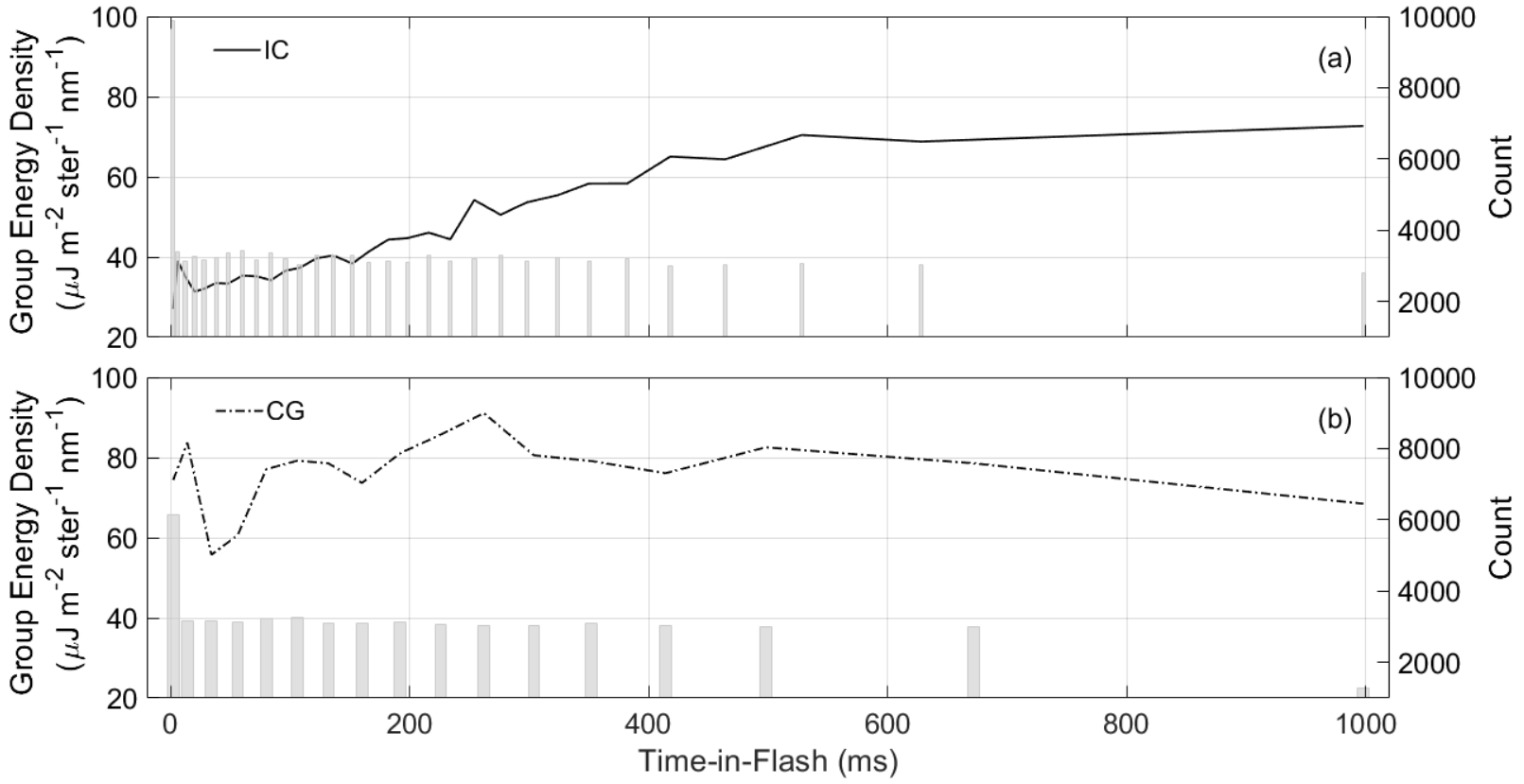
Beginning of the flashes



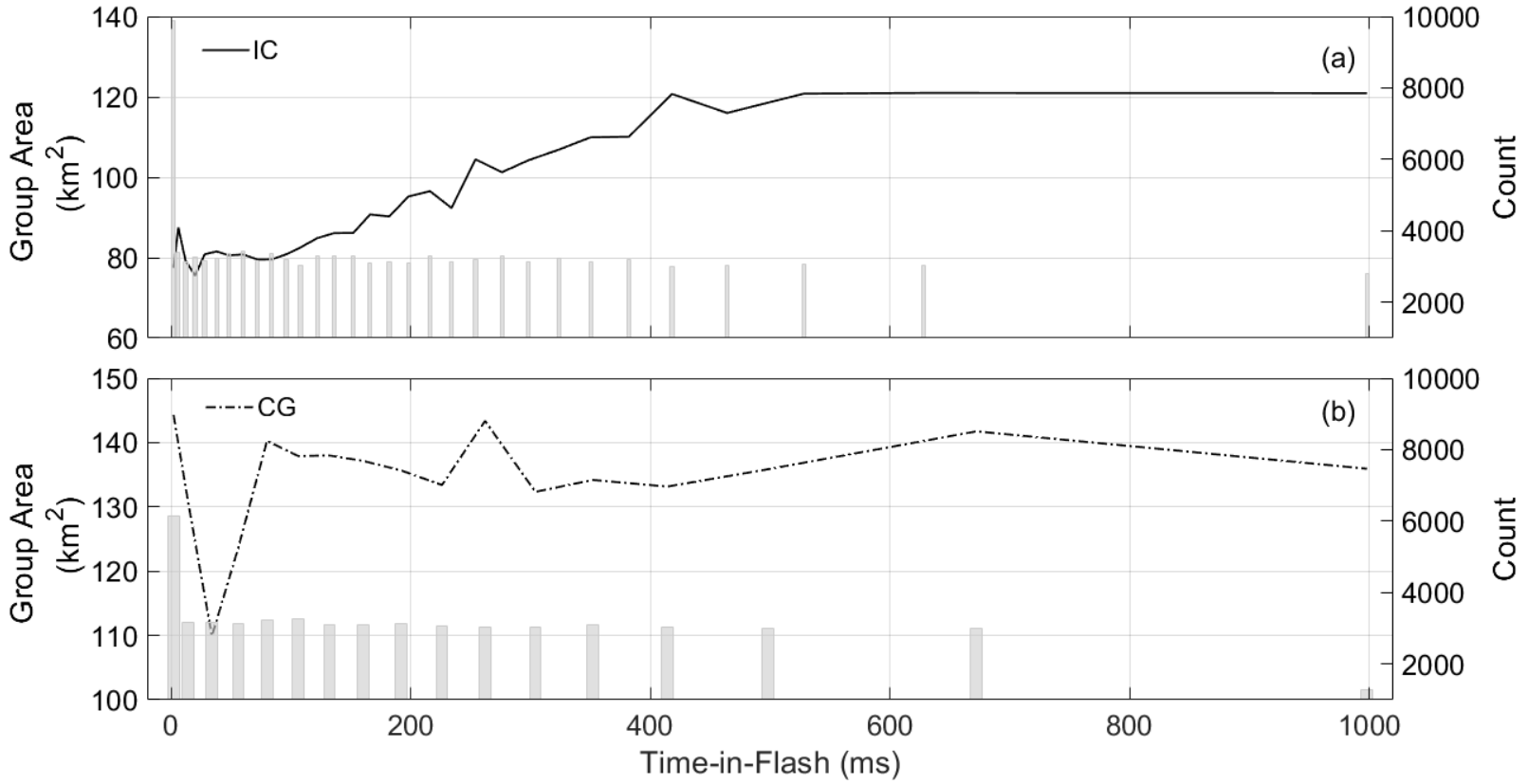
Later in the flashes



IC vs. CG group energy density



IC vs. CG group area



Average LIS Flash Evolution with Different Flash Durations