An Operational Overview of the Geostationary Lightning Mapper

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Many thanks to U.S. National Weather Service forecasters and SPoRT colleagues for their input and recommendations!

52nd Canadian Meteorological and Oceanographic Society Congress – GOES-R Short Course

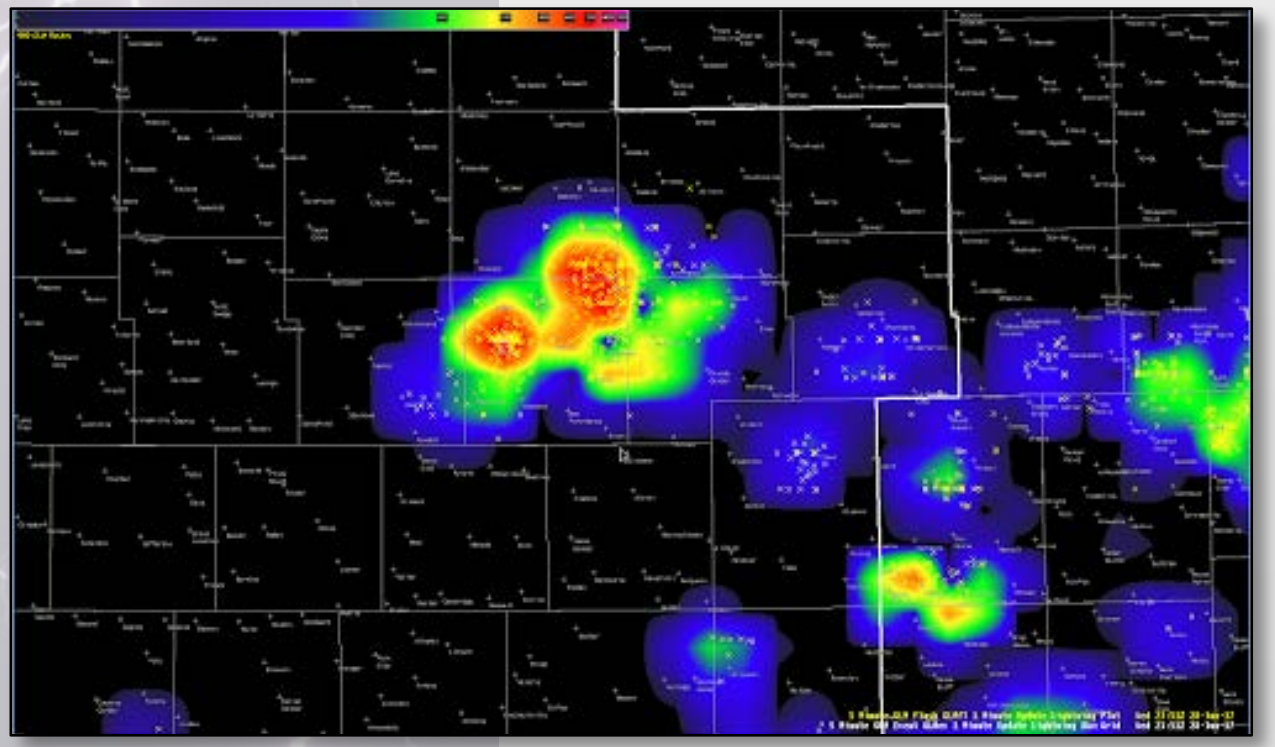
Halifax, Nova Scotia

10 June 2018

A Short Outline

- Role with the GOES-R Proving Ground
- The Geostationary Lightning Mapper
- Physical reasoning of GLM observations
- Basic differences with ground networks
- Early, potential uses (examples)
- Future Work

Role With the GOES-R Proving Ground



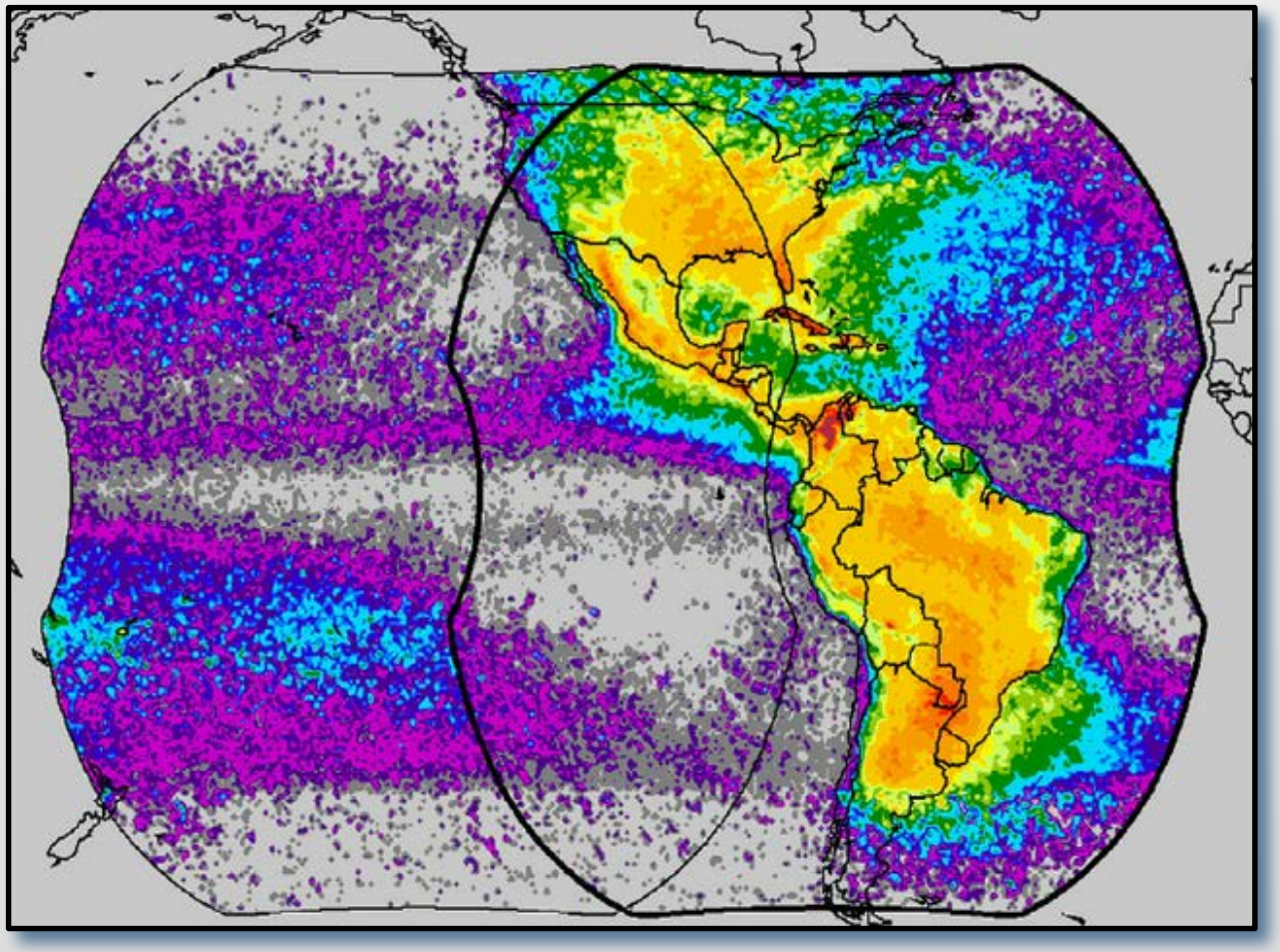
Sample of GLM event density with flash centroid points. (Preliminary, non-operational)

- Liaison to the U.S. National Weather Service for NASA SPoRT
  - Work with multiple operational partners
- Serve as GLM liaison for GOES-R
  - Focus on training
  - Focus on operational applications
- Work to advocate for operational needs
- Greatly supported by colleagues and collaborating forecasters in developing quality training material

The Geostationary Lightning Mapper

Geostationary Lightning Mapper (GLM)

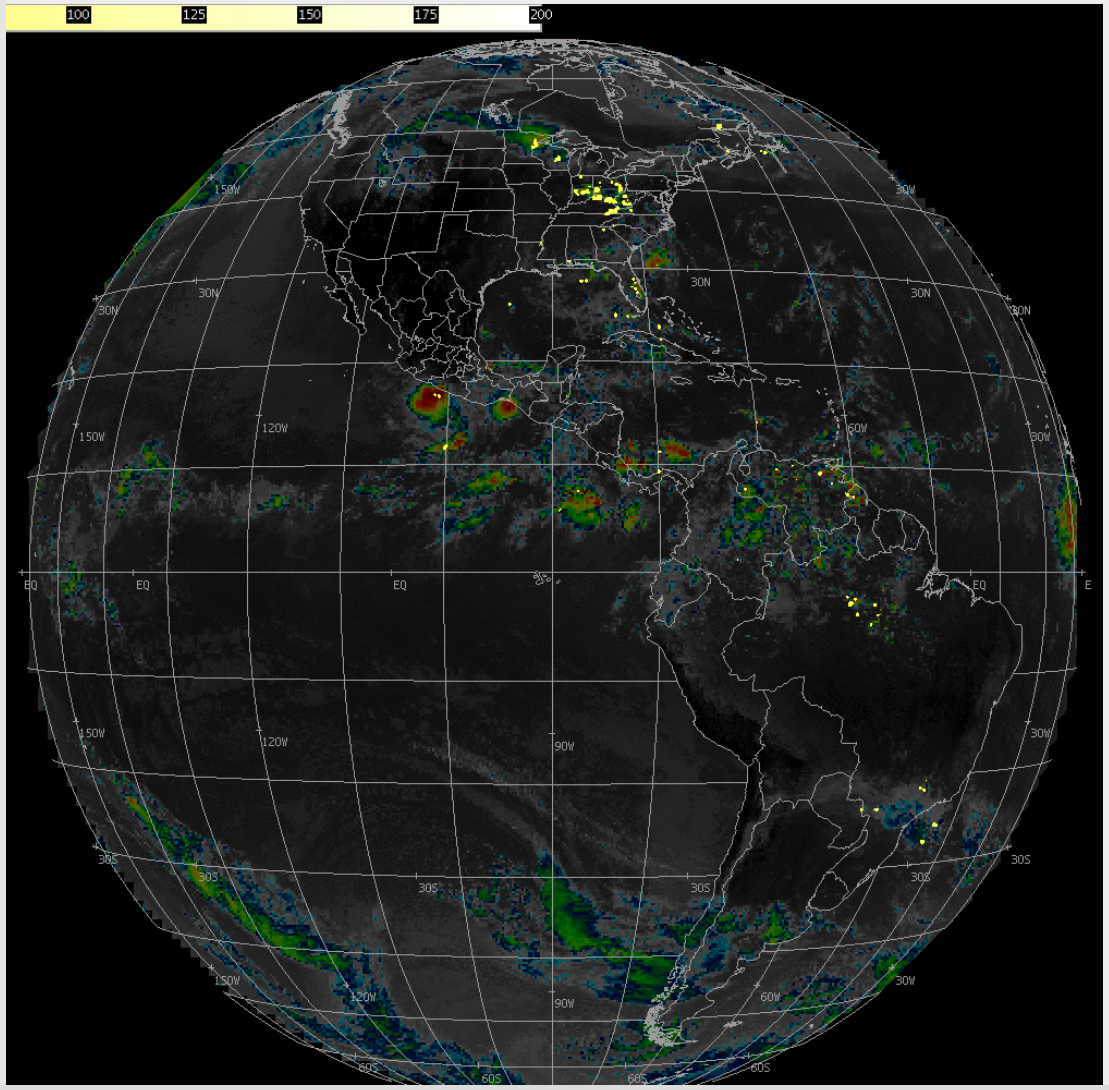
- Large digital camera to detect cloud top brightness differences
- Covers 54˚ N/S
  - Not all of Canada, but most of population
- Observes both intra-cloud and cloud-to-ground lightning – Does not distinguish the difference
- Specifications: >70% detection over the full disk over 24 hours (>90% at night)
  - Initial review exceeding specifications



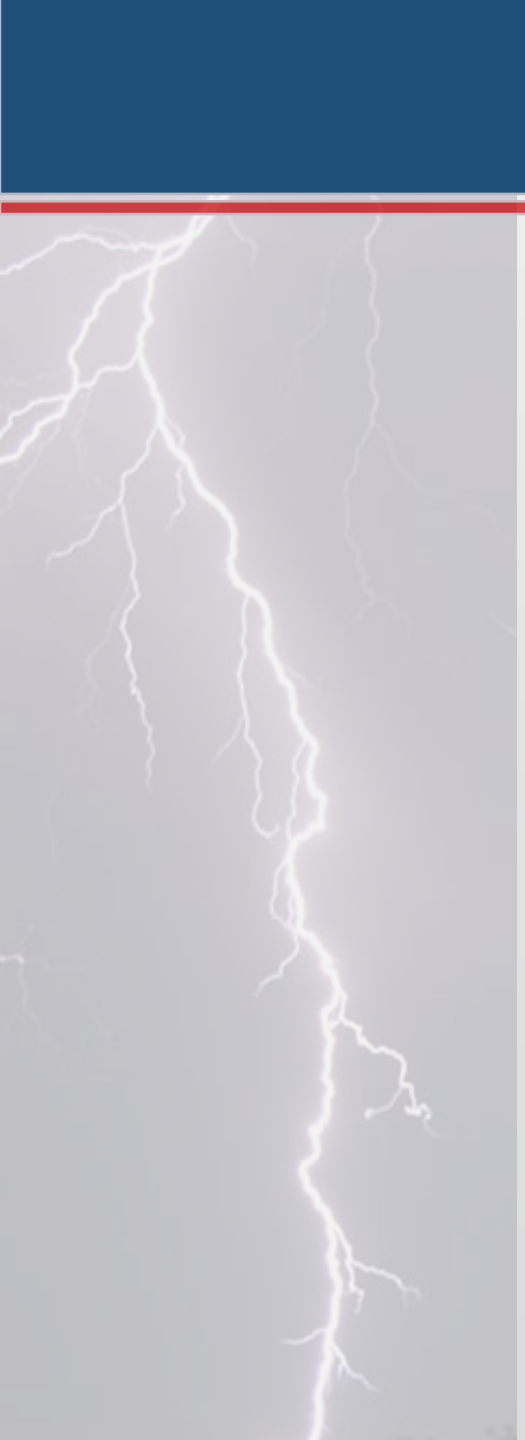
GLM field of view for GOES-16 and -17

Geostationary Lightning Mapper (GLM)

- The GLM provides near hemispheric coverage
  - Generally consistent detection efficiency over most of the field of view
  - Available in data spare regions
  - 1 minute updates
  - Not proprietary (can show in real-time)
- Compared to traditional ground networks
  - GLM observes total lightning
  - GLM provides spatial extent
  - GLM detections consistent over land and water
- GOES-16 GLM preliminary test data now
- GOES-16/17 GLM full availability late 2018/early 2019

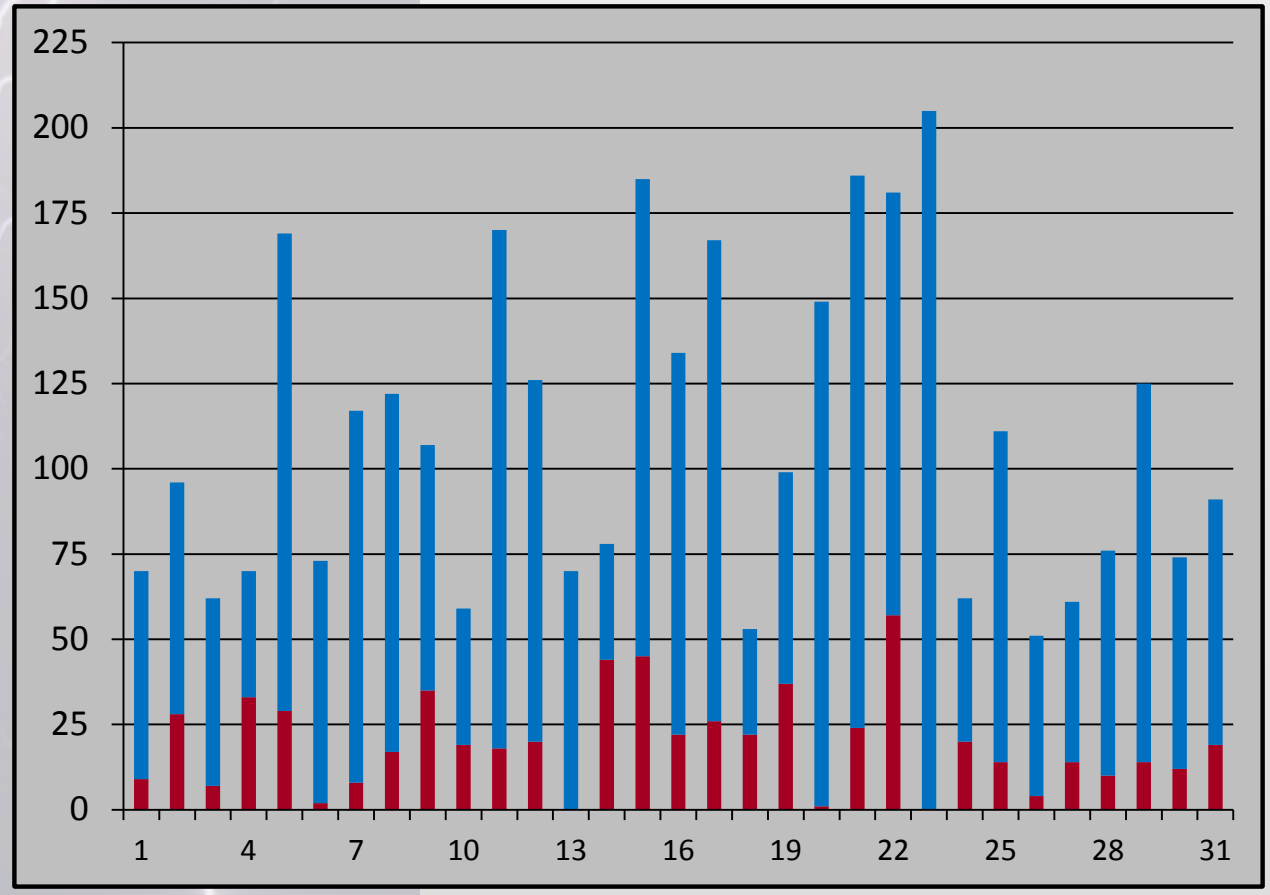


13 June 2017 from 1719-1819 UTC (Preliminary, non-operational)



Physical Reasoning

What Is Total Lightning



Total Lightning

- Combination of cloud-to-ground and intra-cloud observations
- Intra-cloud typically far outnumbers cloud-to-ground in any given storm
- Reminder: GLM observes total lightning, but does not distinguish between the two

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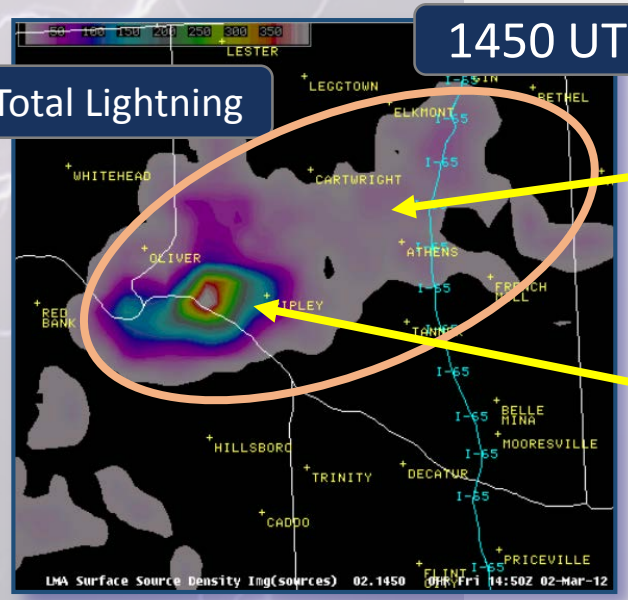
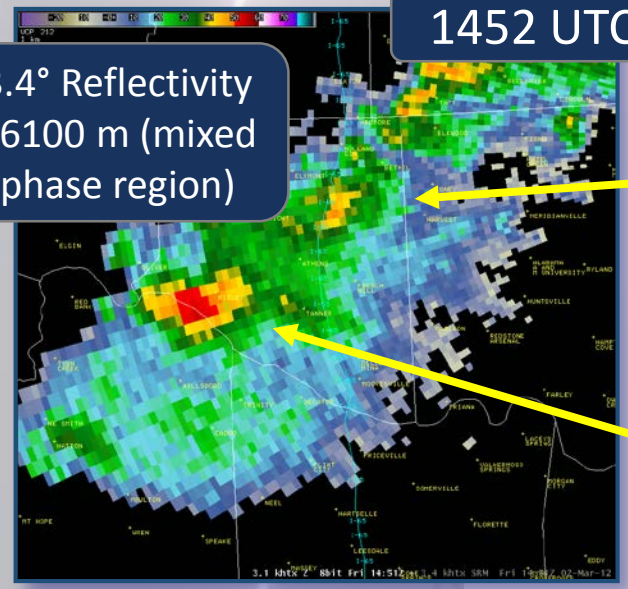
Total Lightning





- Total lighting = cloud-to-ground **and** intra-cloud
- Physical reasoning for total lightning
  - Charging occurs in mixed phase region
  - Larger, stronger updrafts = more total lightning
- Advantages
  - Intra-cloud often precedes first cloud-to-ground
  - Total lightning proxy for storm strength
  - Monitor convective development / weakening
  - Observe the spatial extent
- Early training matches GLM to forecaster conceptual model
  - Builds trust in GLM, particularly for data sparse areas

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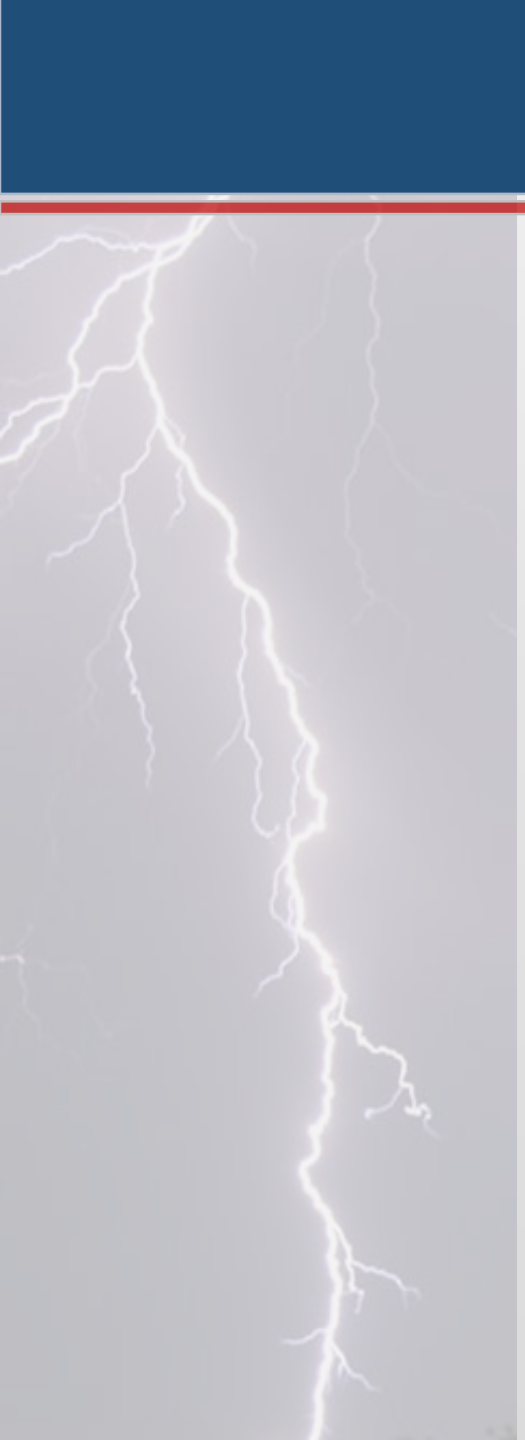


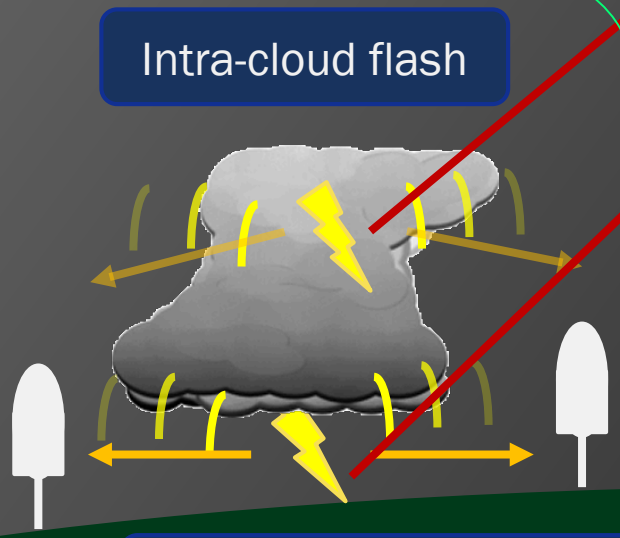
Comparison with Ground Networks

Distinguishing GLM, NLDN, and ENTLN

- Very Low Frequency (VLF) – Earth Networks, GLD360
- Best for long-range (>500 miles)
- Only observes strongest flashes (mostly cloud-to-ground)
- Dependent on Ionosphere (best at night)

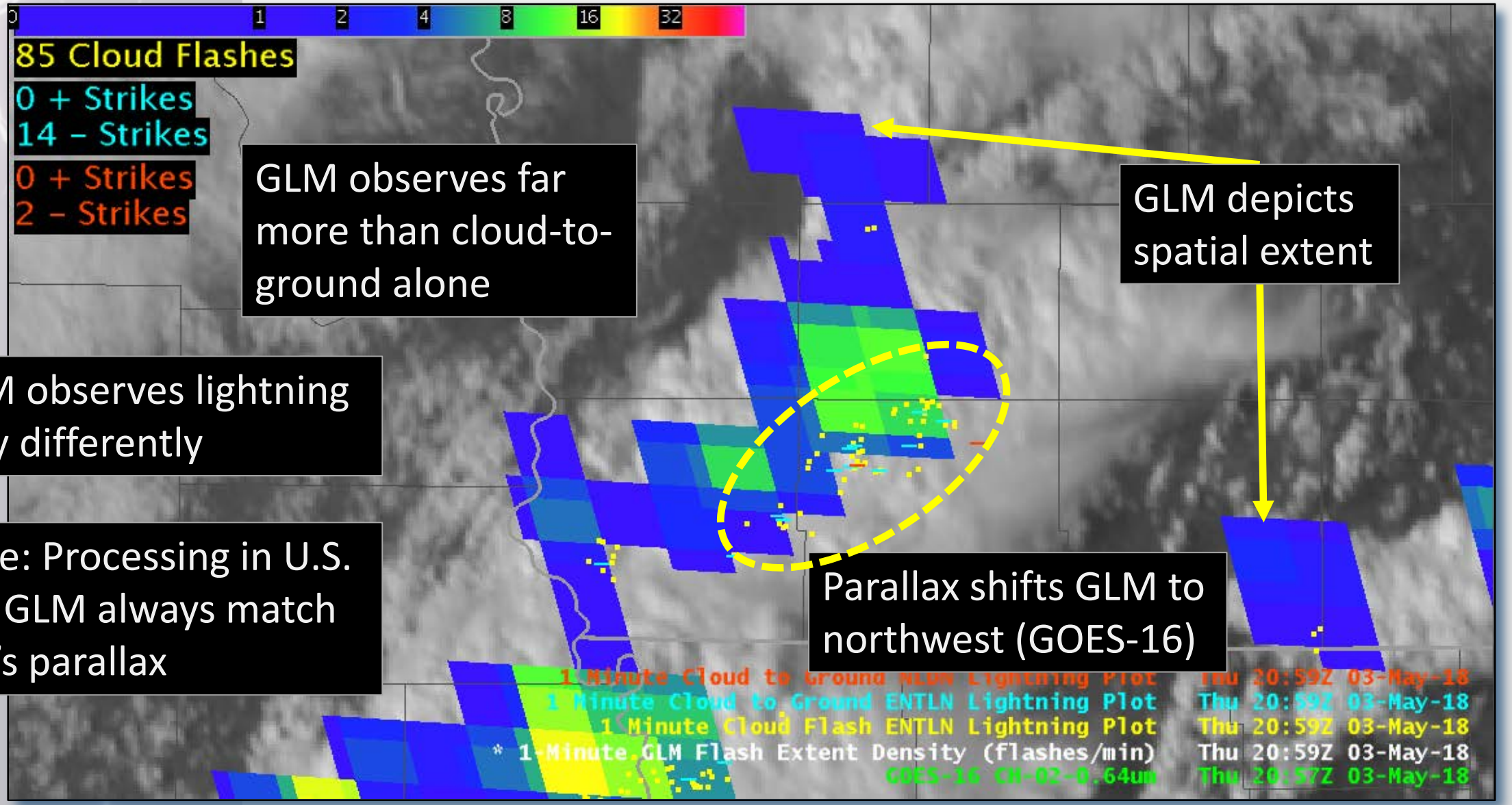
22,200 miles up

Ionosphere



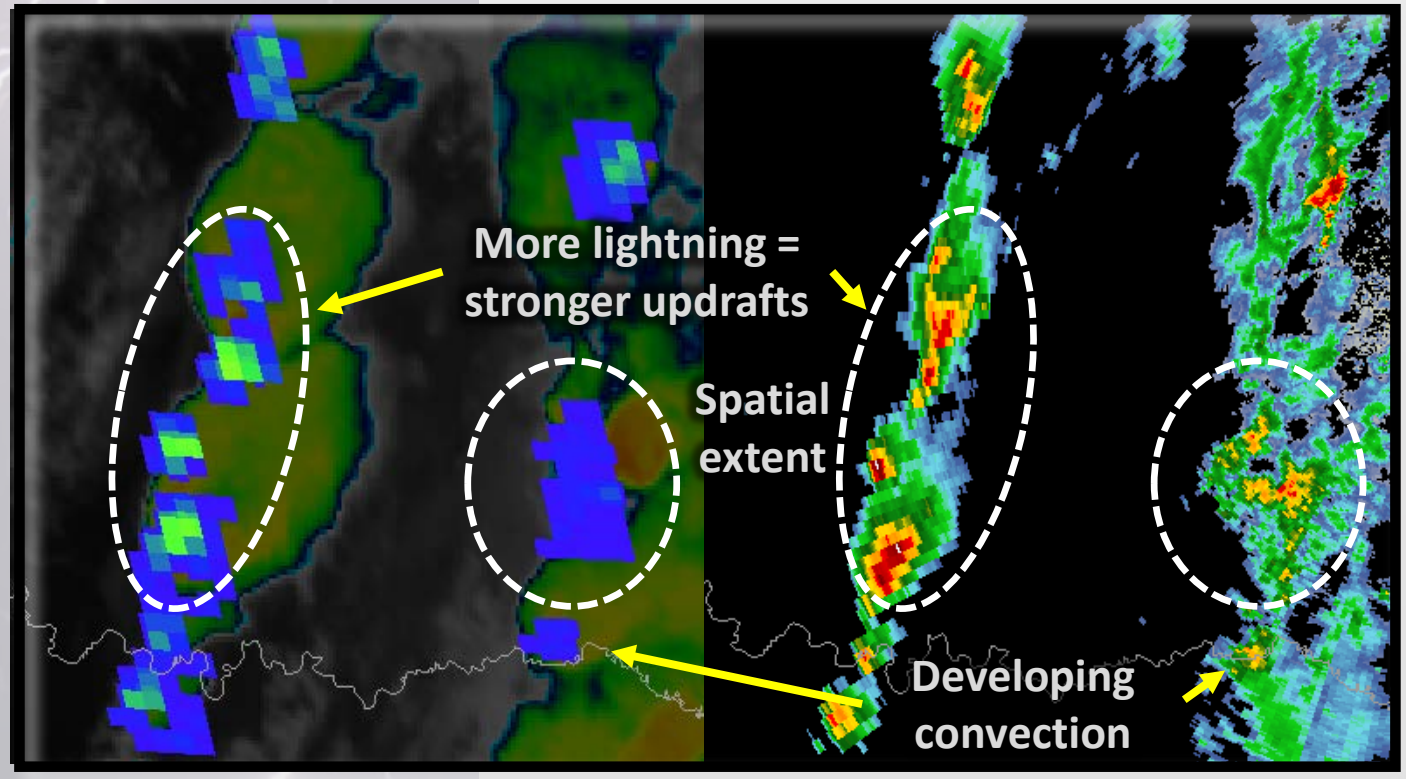
- Low to Very Low Frequency (LF, VLF) – Earth Networks, GLD360, NLDN
- Good range and accuracy with a sensor network
- Signal distinguishes ground versus intra-cloud
- Intra-cloud generally weaker than cloud-to-ground and harder to observe

Simple GLM and Ground Network Comparisons



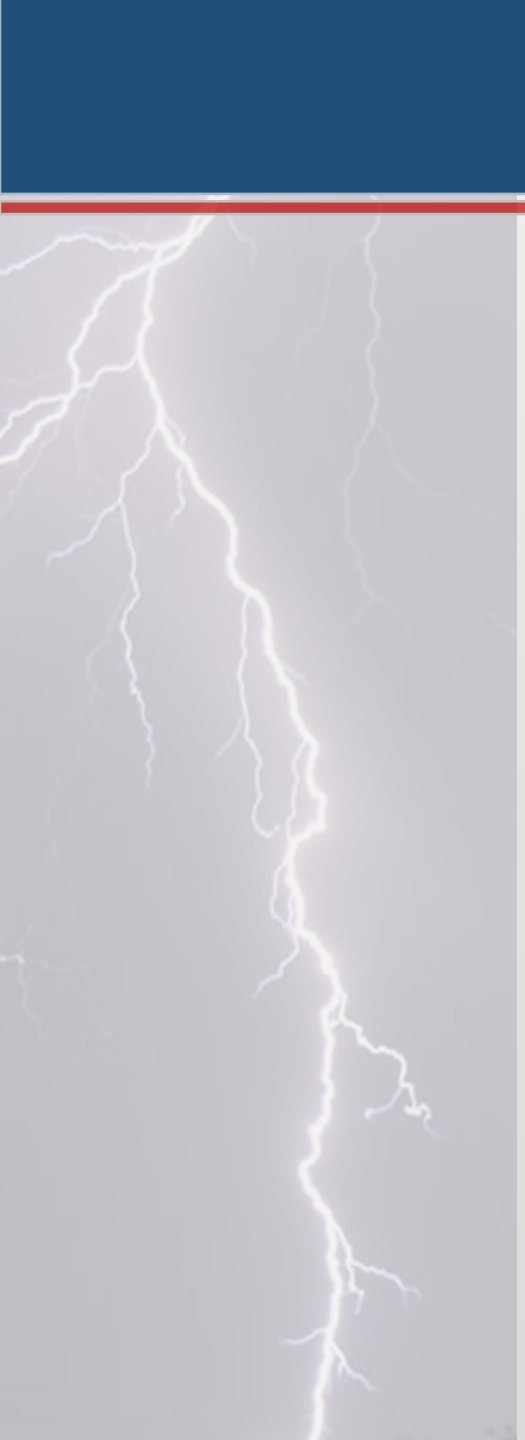
Potential Operational Uses

GLM Capabilities: Monitor Convection



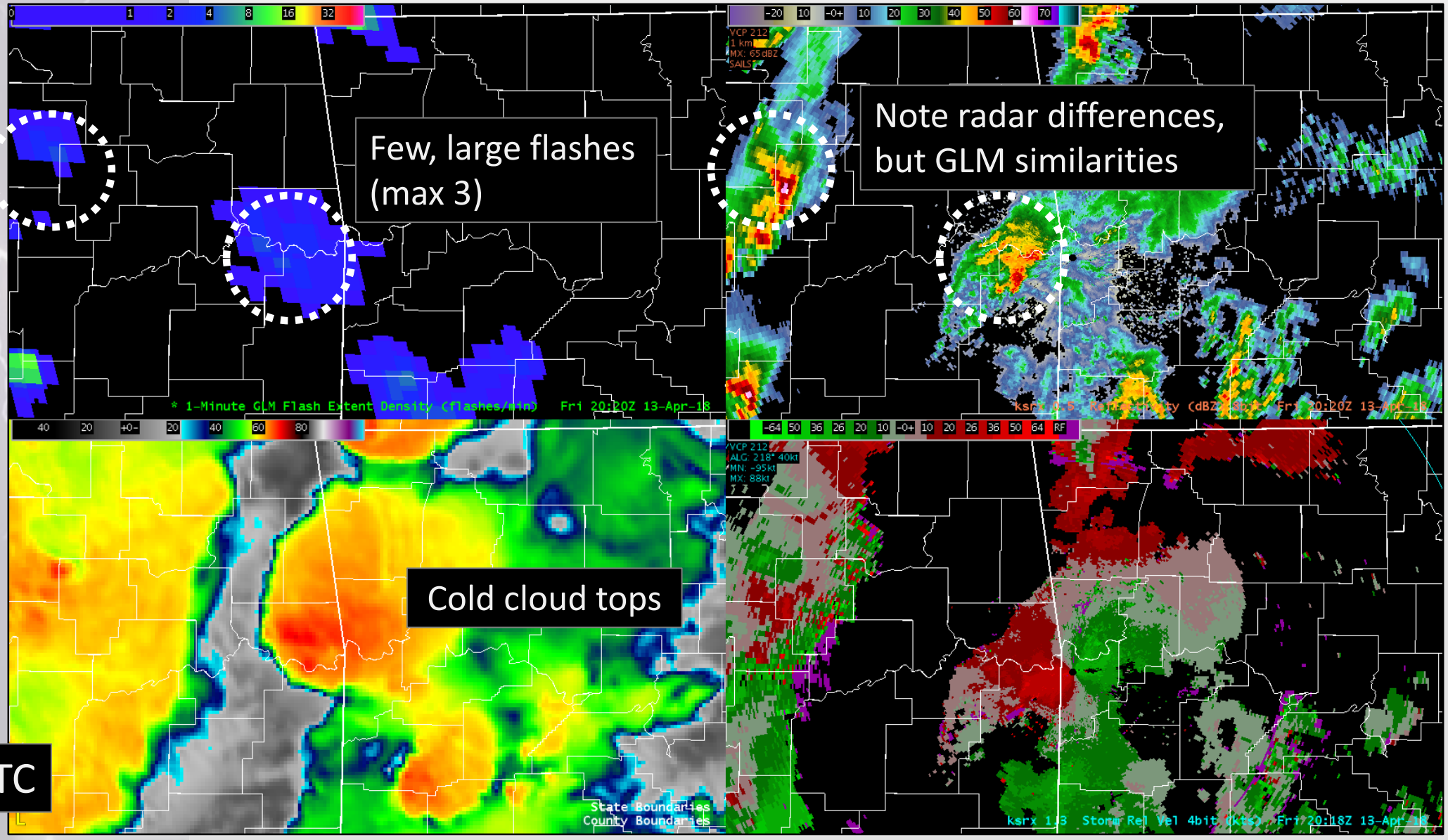
Example of GLM flash extent density overlaid on 10.3 micron ABI IR (left) compared to radar reflectivity (right)

- Identify spatial extent of lightning
  - Can extend well into the stratiform region
  - Signify possible updates to convective SIGMETs?
- Monitor convective updrafts
  - Train in regions with radar to earn trust
  - Use GLM alone in data sparse regions
  - Identify convective / non-convective
  - Monitor development

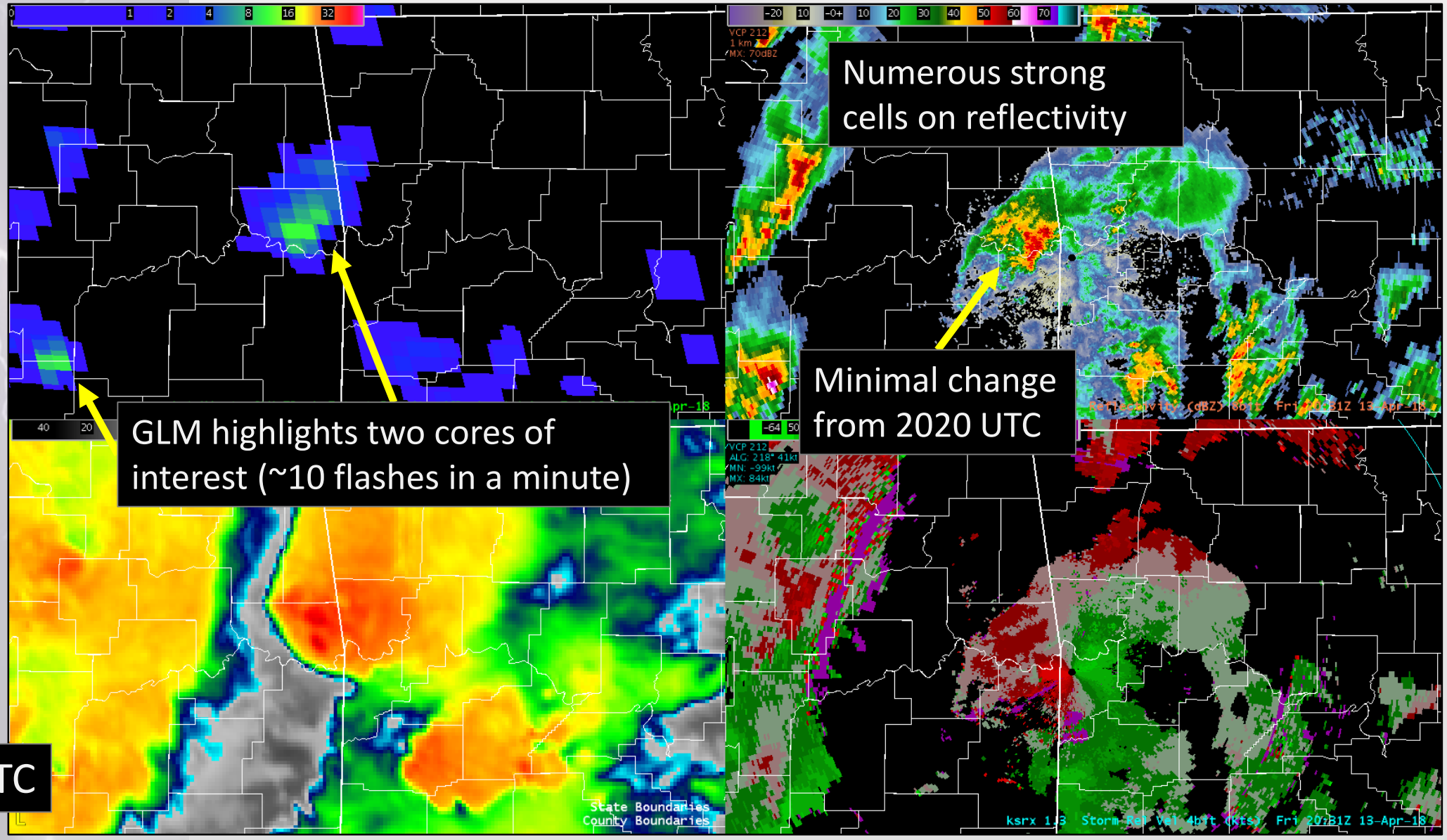


Severe Weather Decision Support

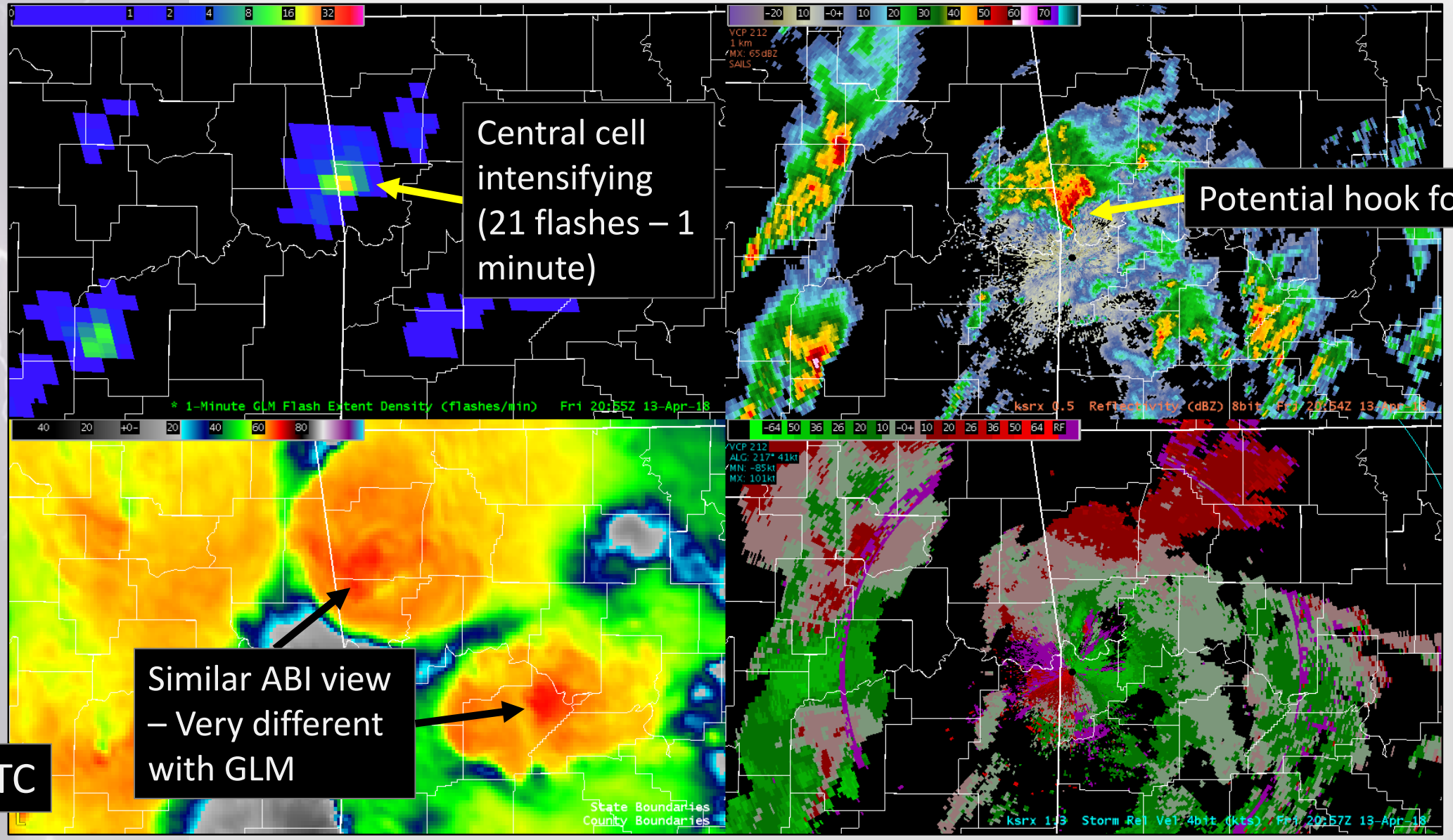
Severe Weather Decision Support (1)



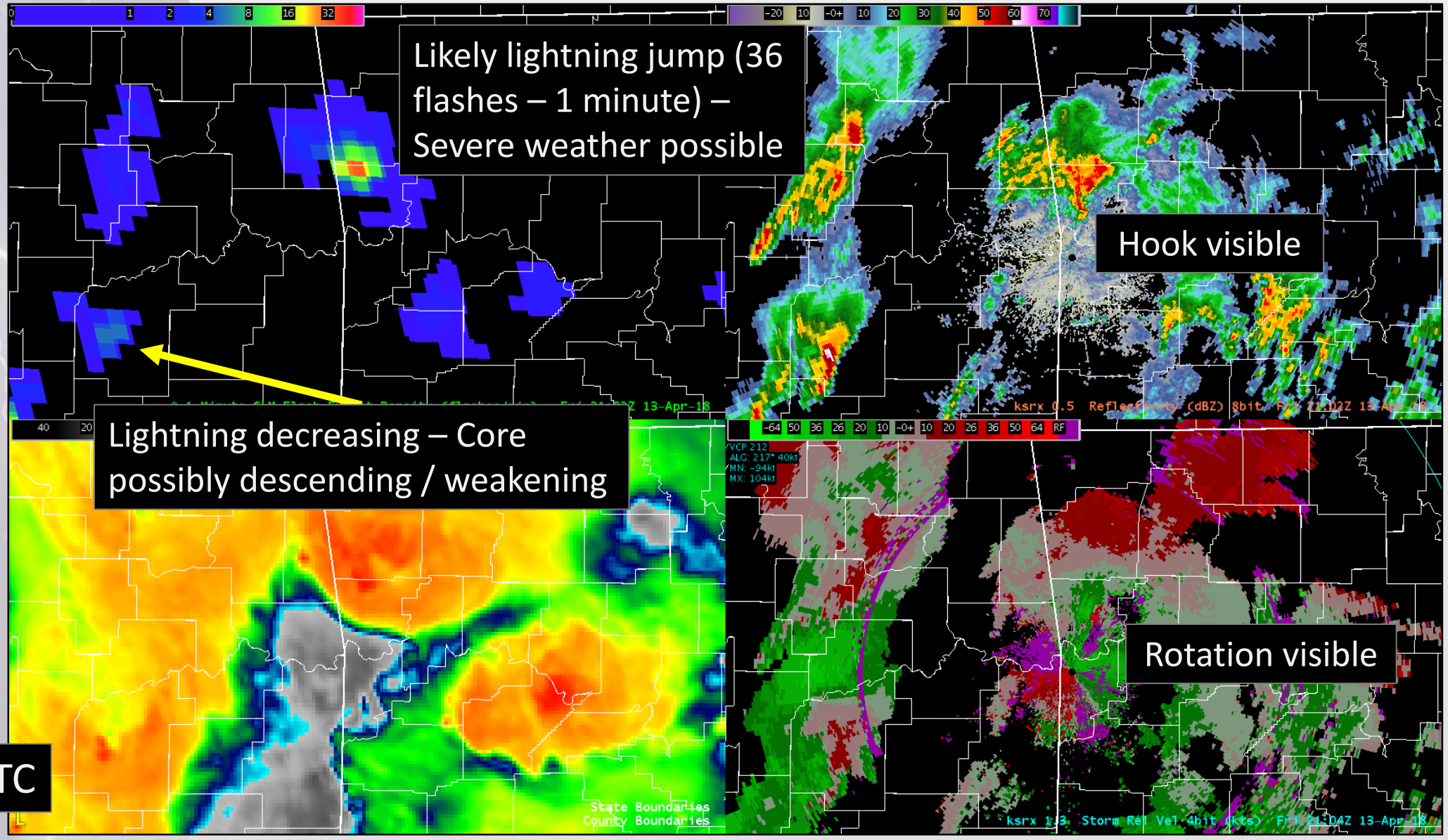
Severe Weather Decision Support (2)



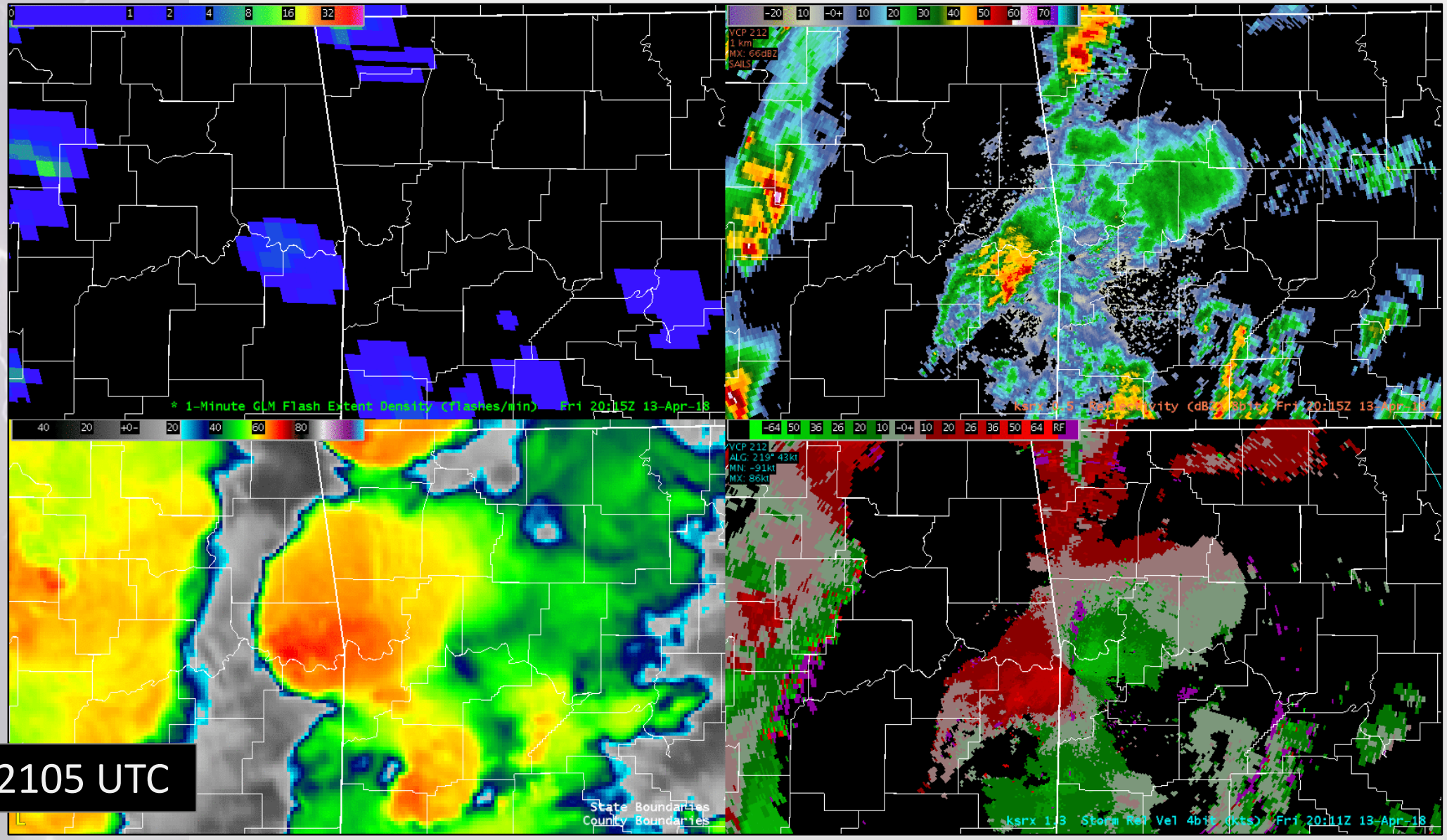
Severe Weather Decision Support (3)



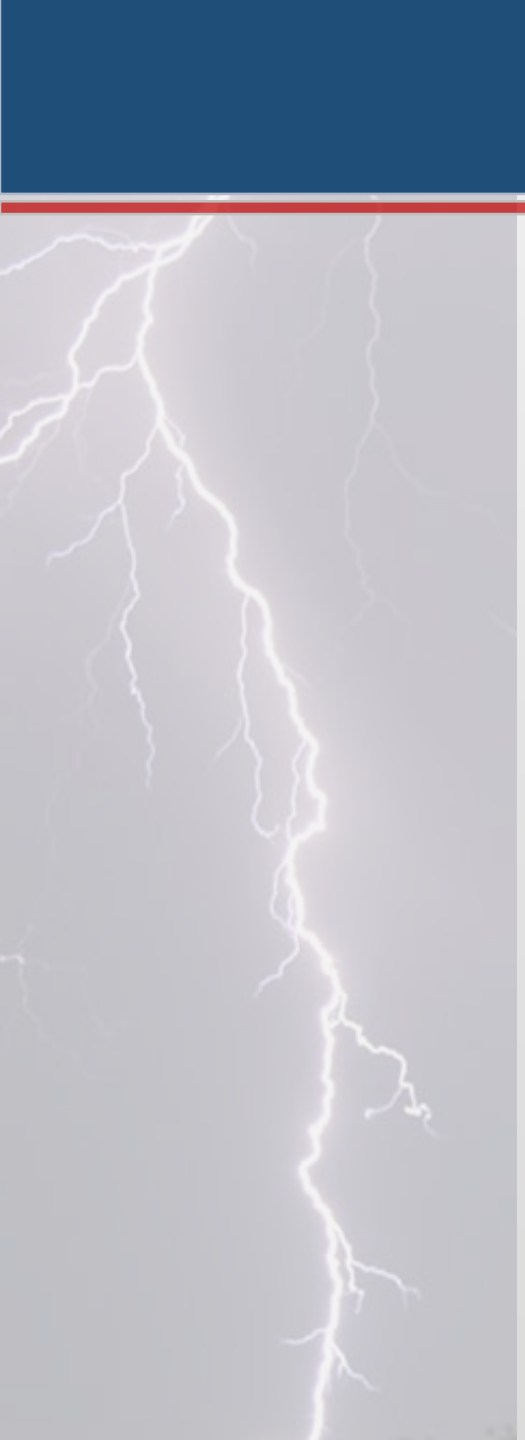
Severe Weather Decision Support (4)



Severe Weather Decision Support (Animation)



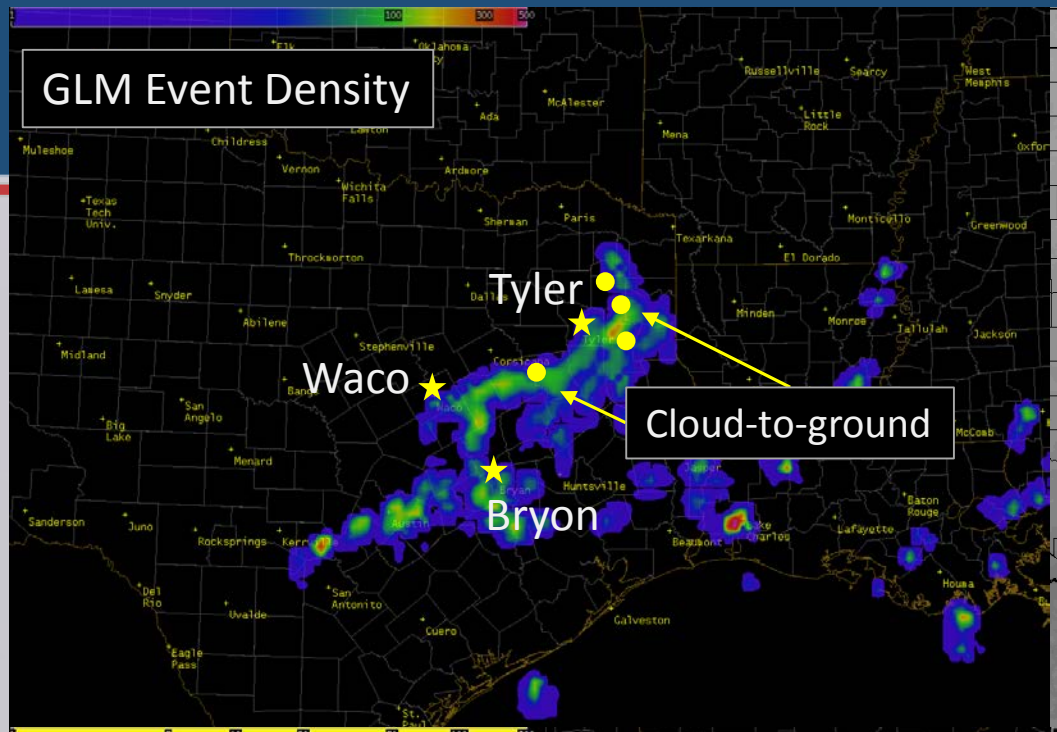
2015 – 2105 UTC

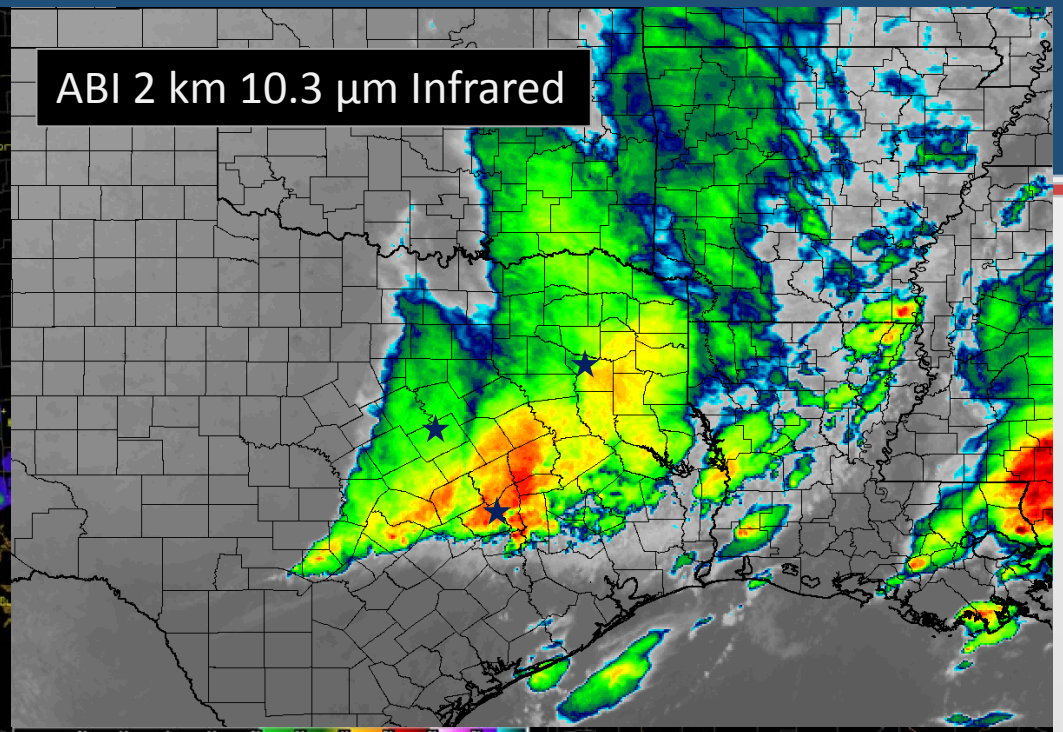


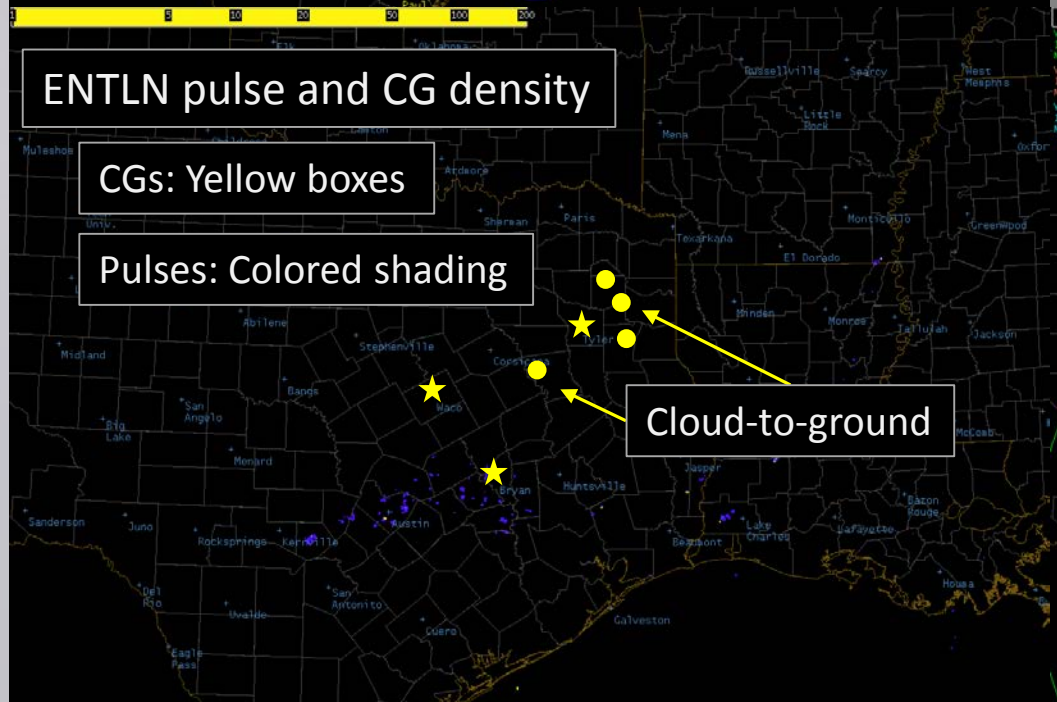
Lightning Safety
(Including case from Quebec)

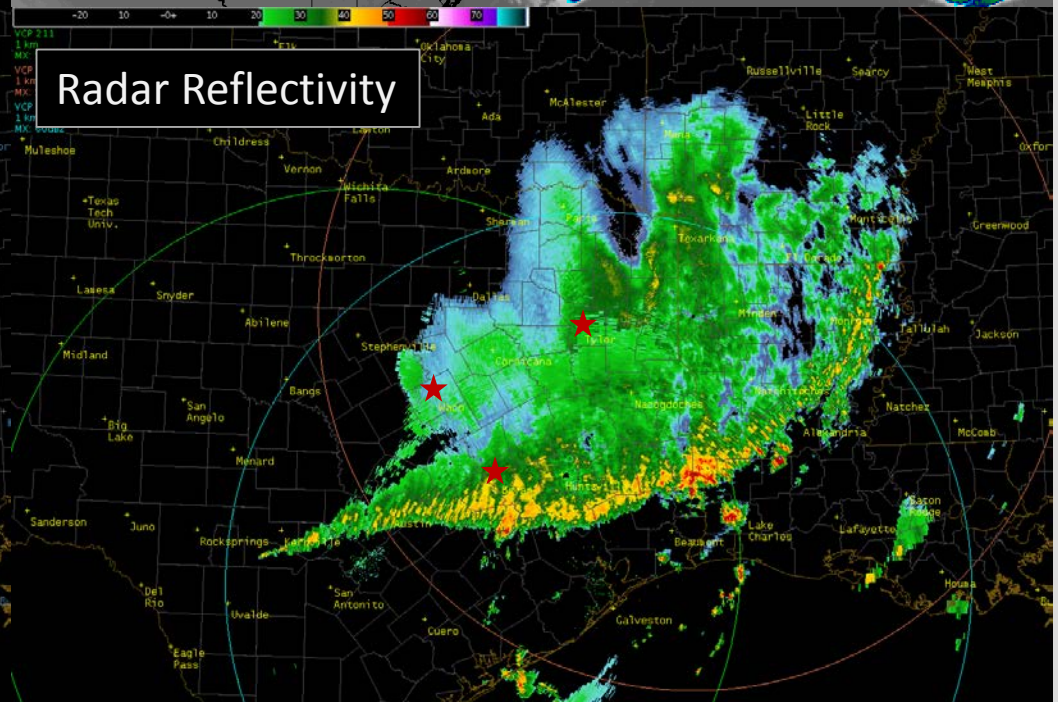
Lightning Safety

- Flash extended 200+ kilometers
- GLM "connects the dots" – Earth Networks individual obs part of 1 contiguous flash

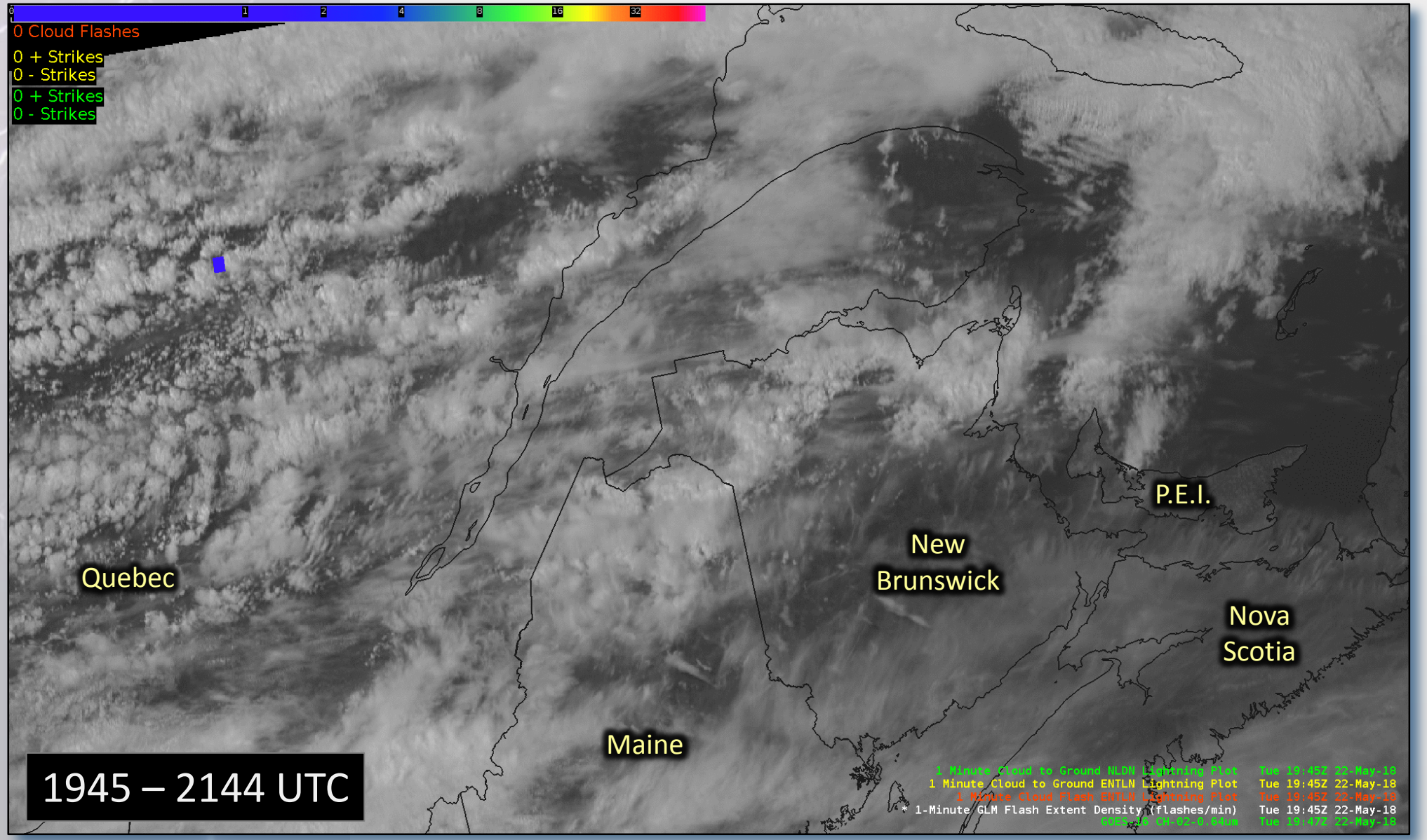








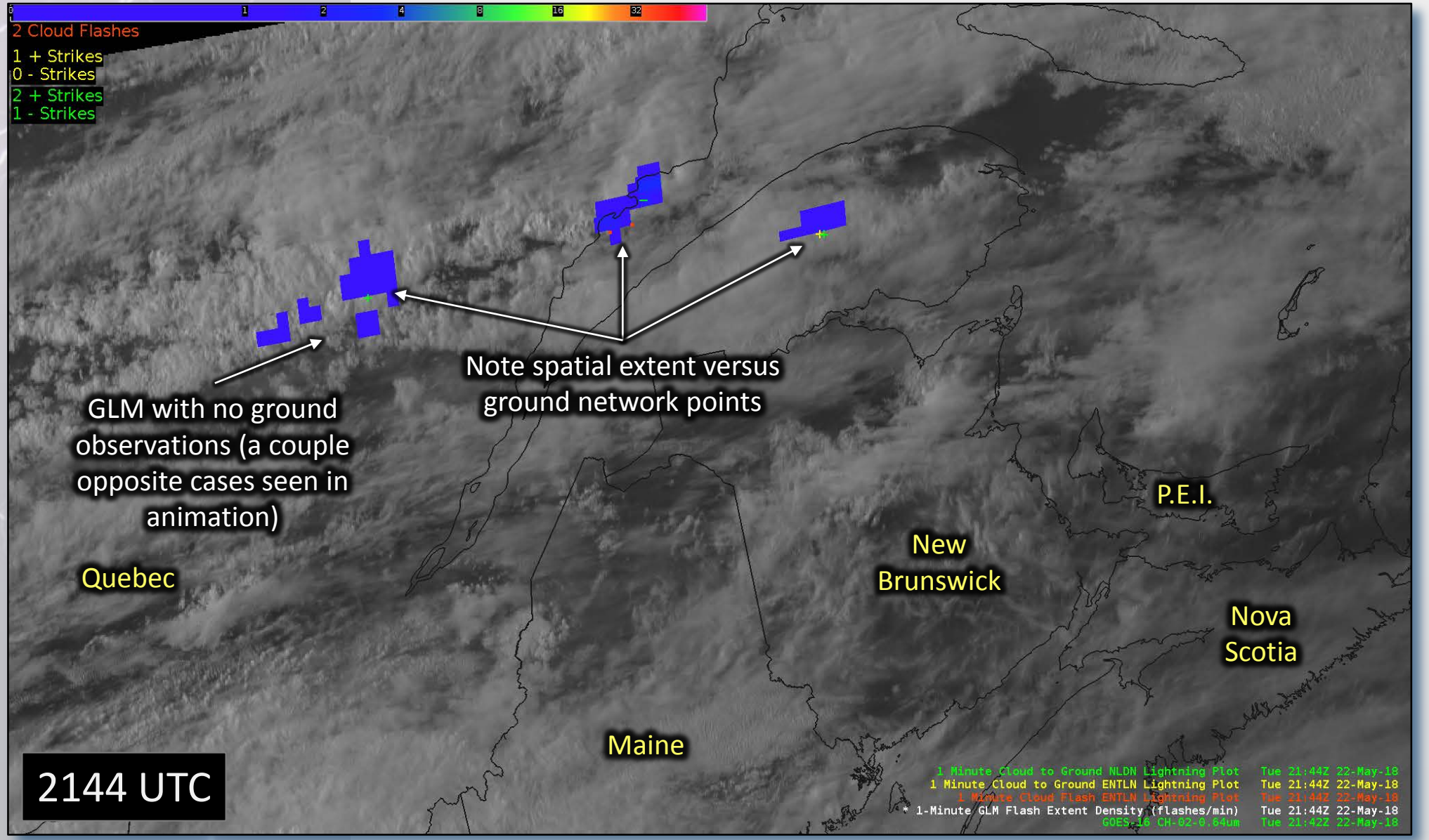
Lightning Safety: Example from Quebec



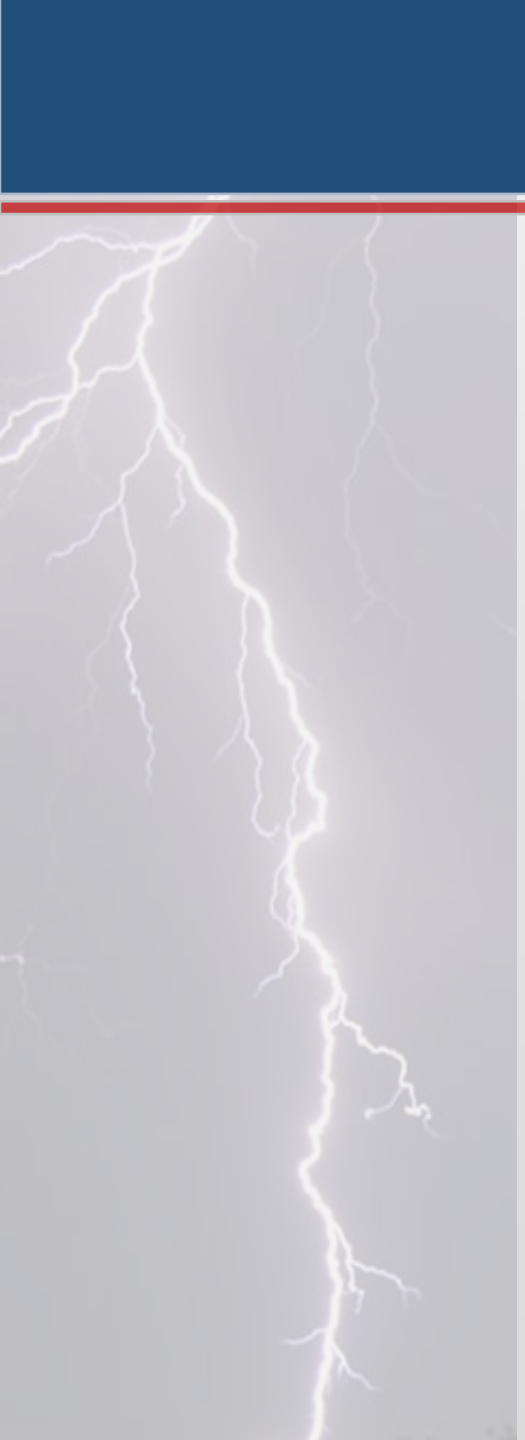
Lightning Safety

- Non-severe storms in east-central Quebec
- Note spatial extent versus ground networks
- Note GLM activity versus ground networks

Lightning Safety: Example from Quebec, 1 Frame

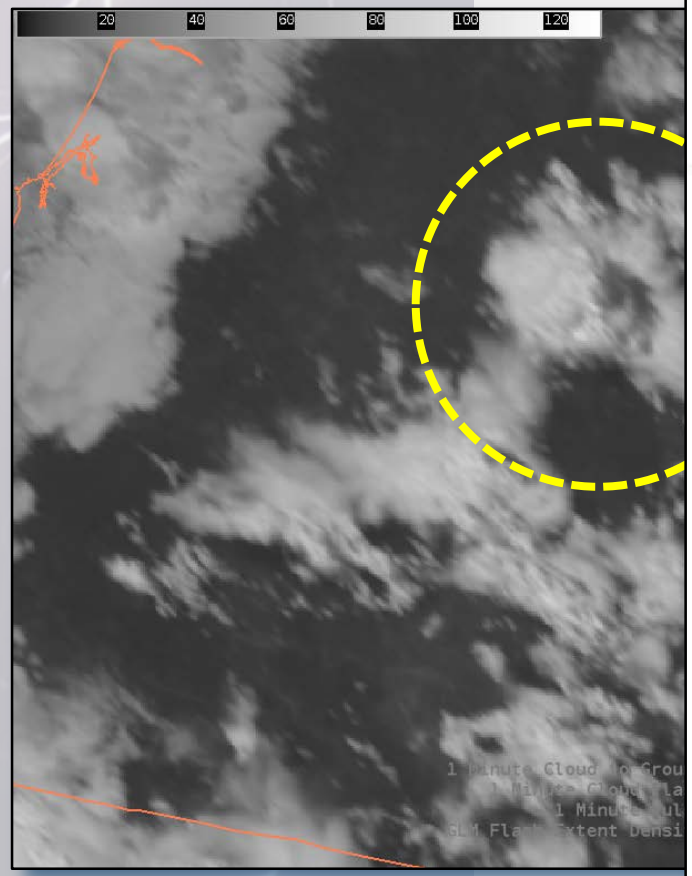


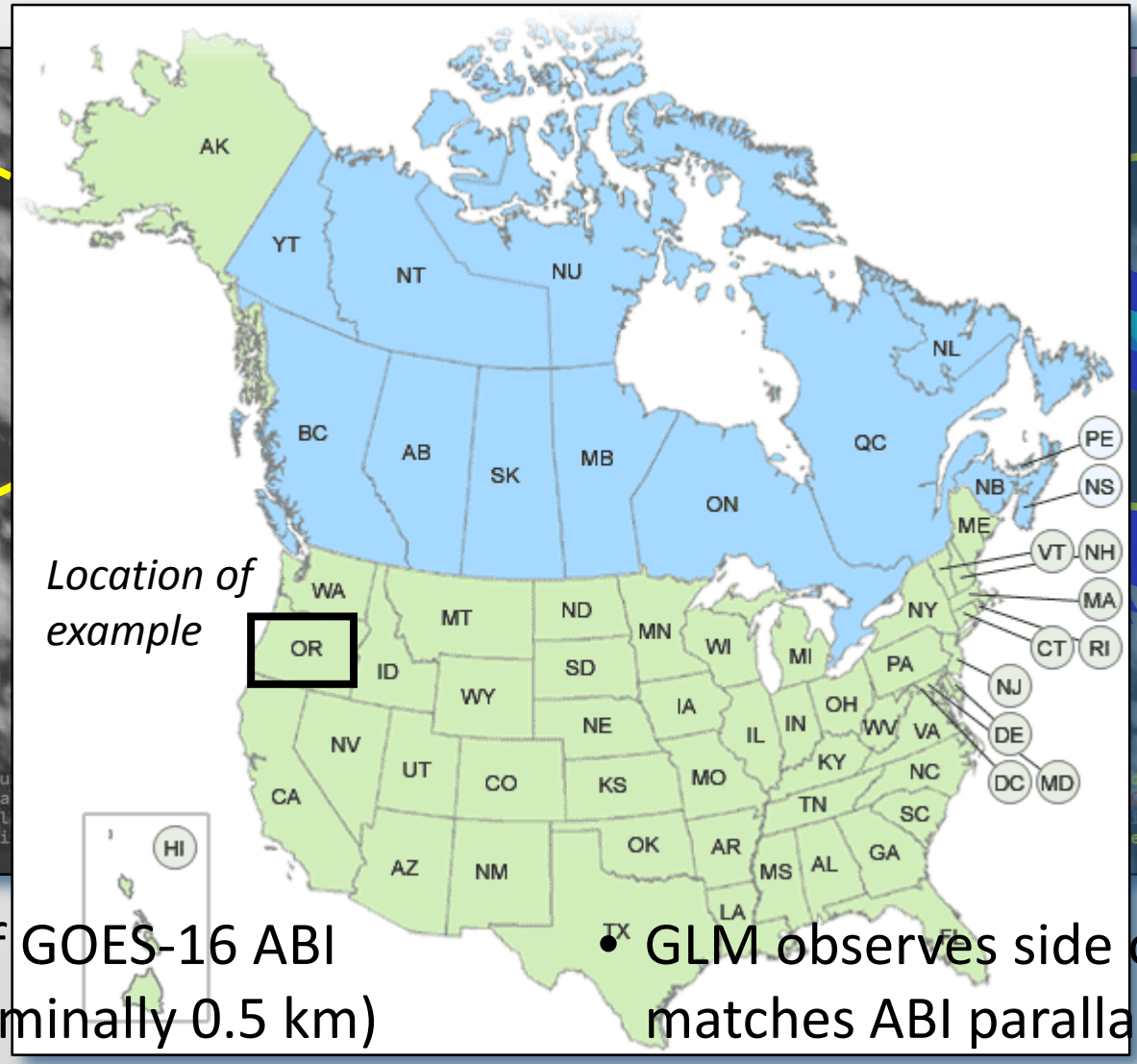
- Note: Using U.S. purchased data, which may not fully represent ground networks in Canada
- GLM mostly observing 1-3 flashes at any given location

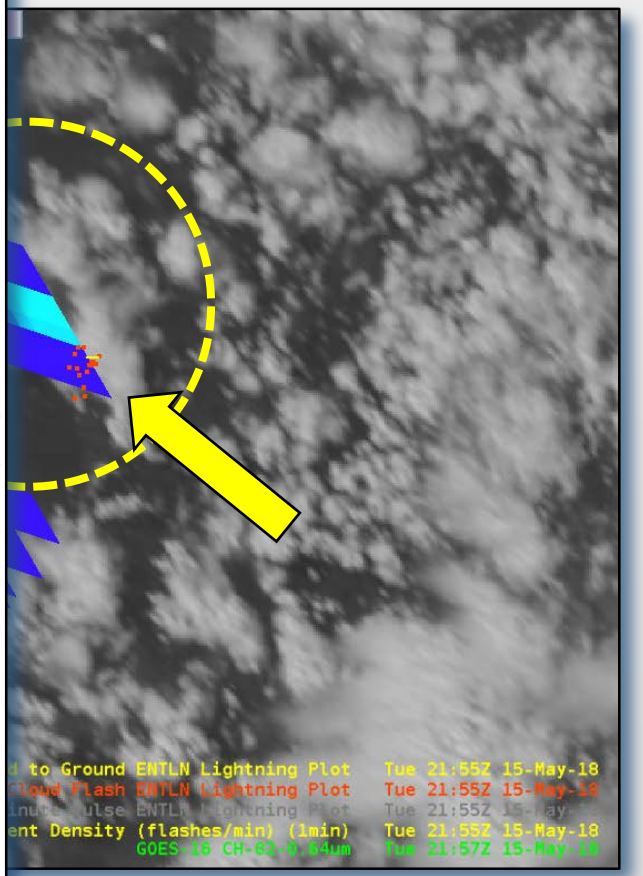


Issues With Parallax

Parallax with GLM (GOES-16 example)



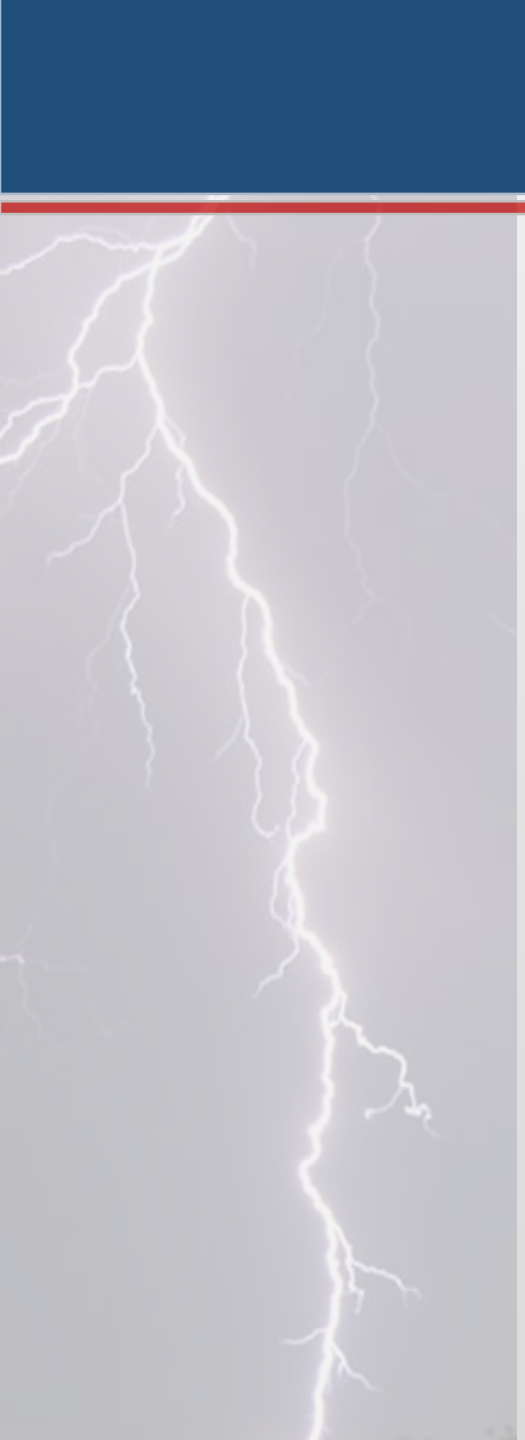




- Near western extent of GOES-16 ABI
- 0.64 micron visible (nominally 0.5 km)
- Circle highlights storm of interest

- GLM observes side of storm - display matches ABI parallax intentionally
- Ground data location more representative

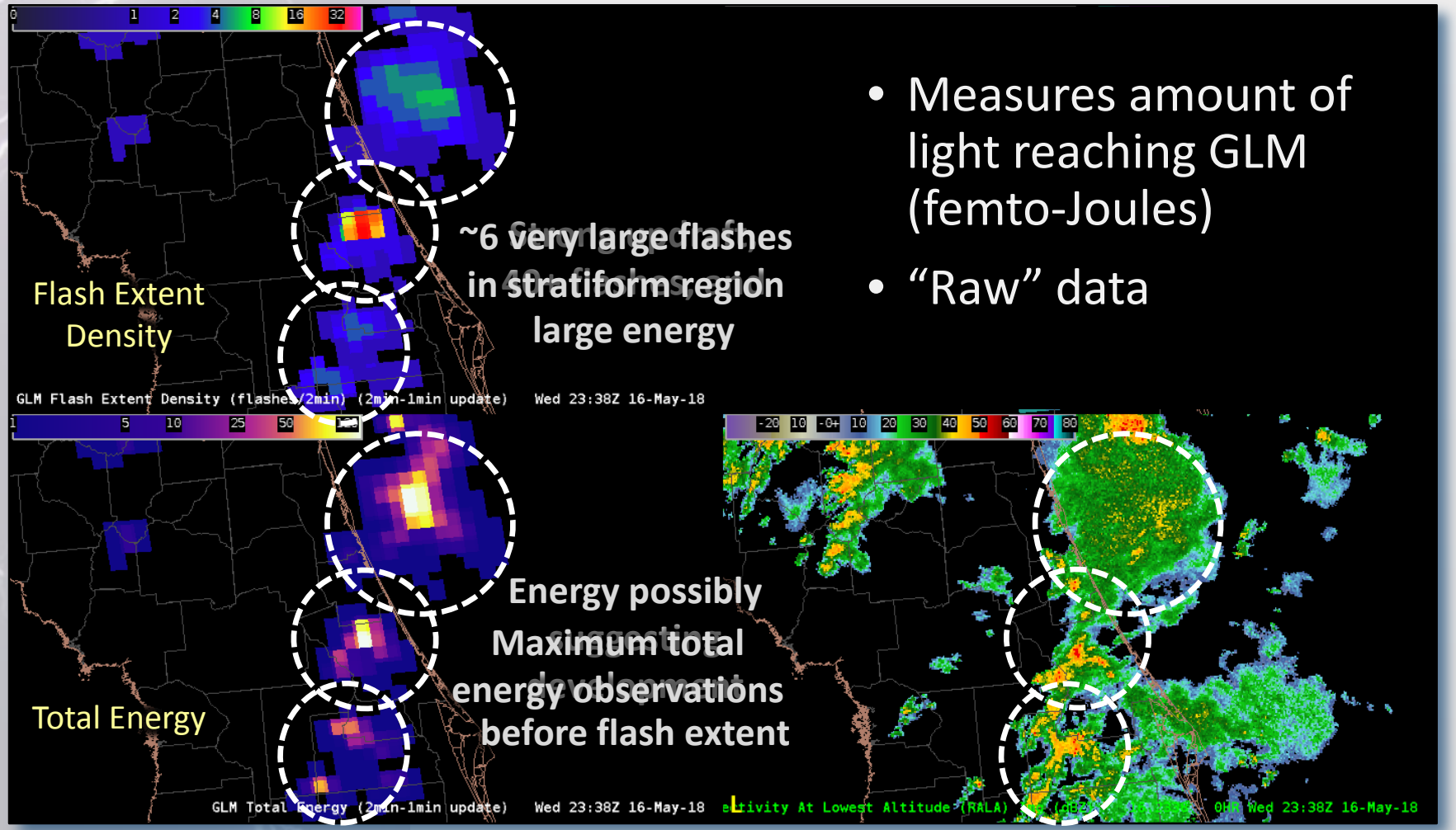
Map created by Kathryn Lenihan



Additional, Near-term Products

- Average flash area
- Total energy
- Lightning safety stoplight product

Additional Products: Total Energy



GLM flash extent density (upper left) with total energy (lower left) and radar reflectivity (lower right)

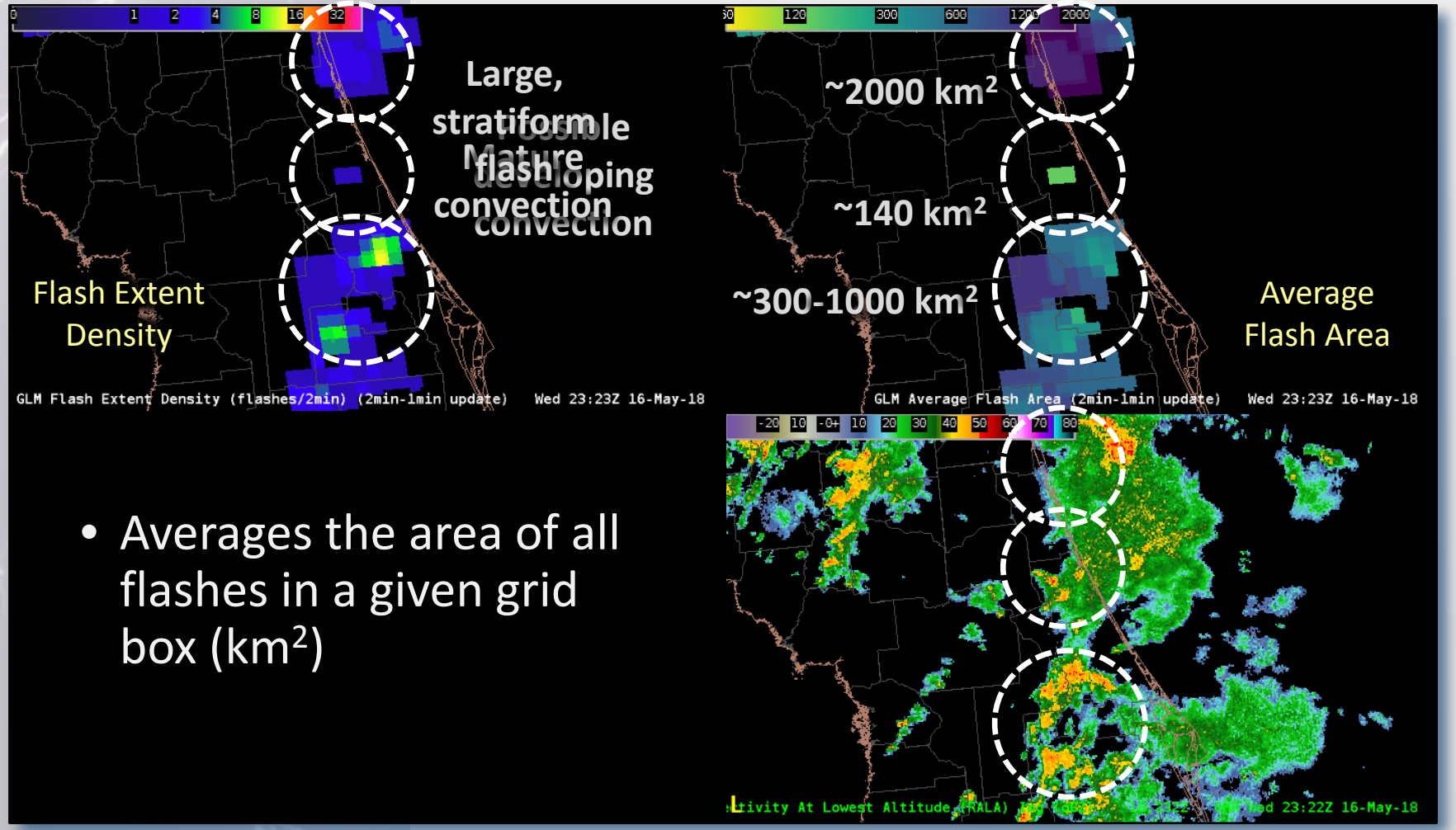
ADVANTAGES

- Identify energetics
- More energy likely is a stronger storm
- Reinforce flash extent observations

DISADVANTAGES

- More work needed to identify "significant" values
- Large area flashes can look like storm cores (less cloud for light to be attenuated in stratiform)

Additional Products: Average Flash Area



- Averages the area of all flashes in a given grid box (km^2)

GLM flash extent density (upper left) with average flash area (upper right) and radar reflectivity (lower right)

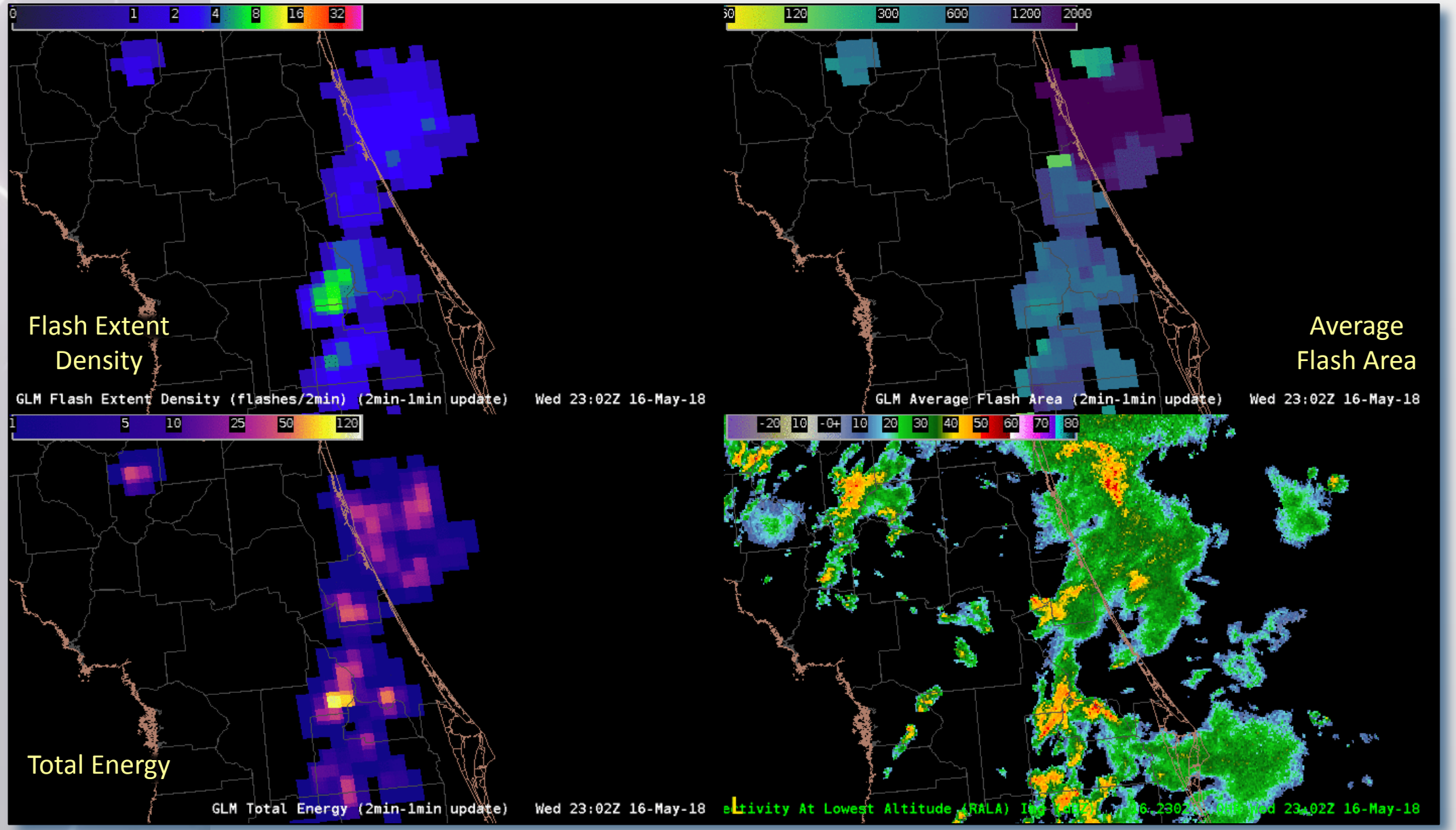
ADVANTAGES

- Developing convection – More, smaller flashes
- Weakening convection – Fewer, larger flashes

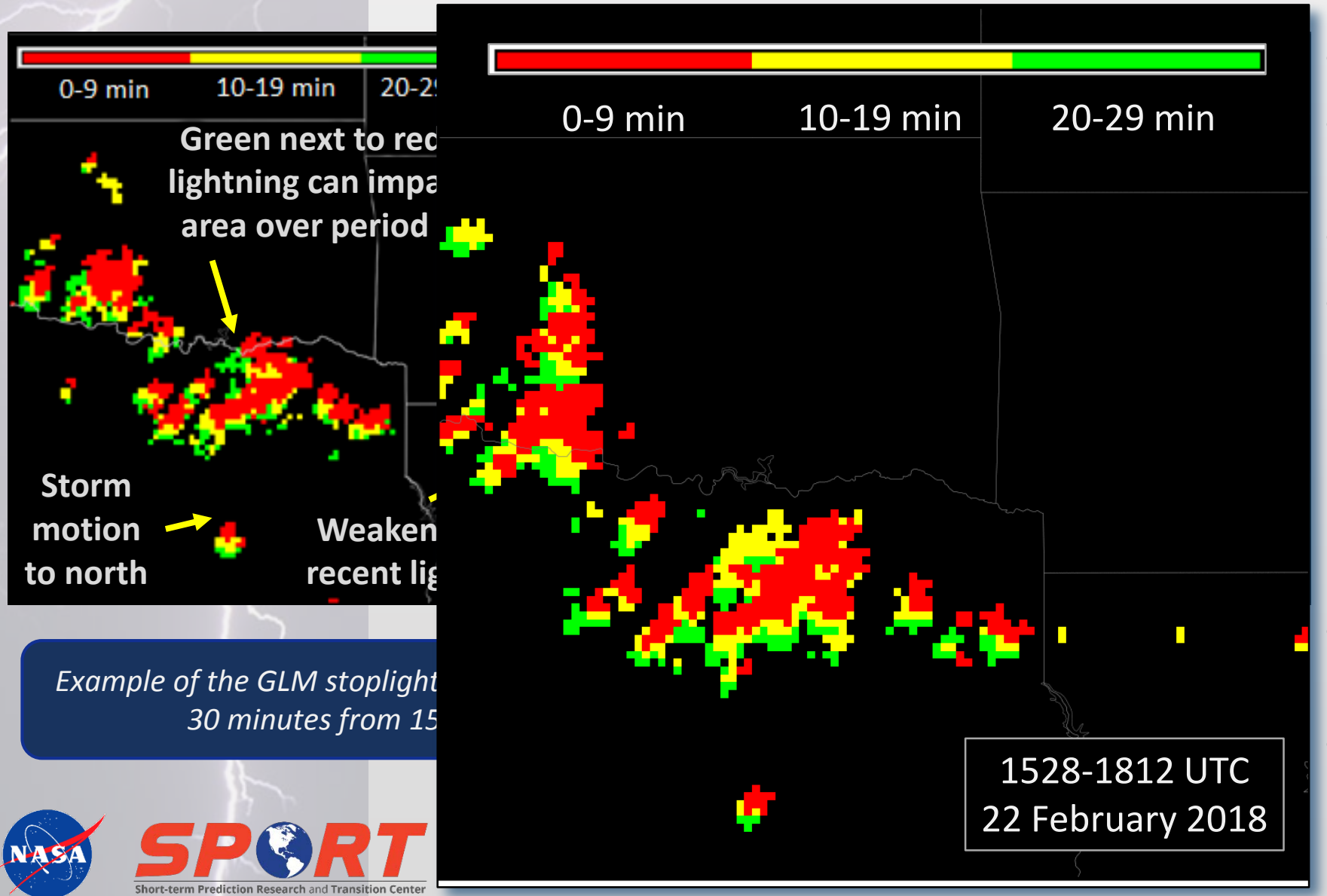
DISADVANTAGES

- Averaging can mask the desired signal – Very true if using a 5 minute summation
- Additional work needed for “significant” values of “small” flashes

Additional Products: Combined Animation



Additional Products: The “stoplight” product



Example of the GLM stoplight
30 minutes from 15

- New SPoRT ability
- Collaboration with local emergency managers
- Based on 30 min rule
- Show location and age of lightning obs in a single image
  - 0-9 min (red)
  - 10-19 min (yellow)
  - 20-29 min (green)
- Greater sense of activity over time than 1 min data
- Early reviews suggest not using green (may suggest safe)

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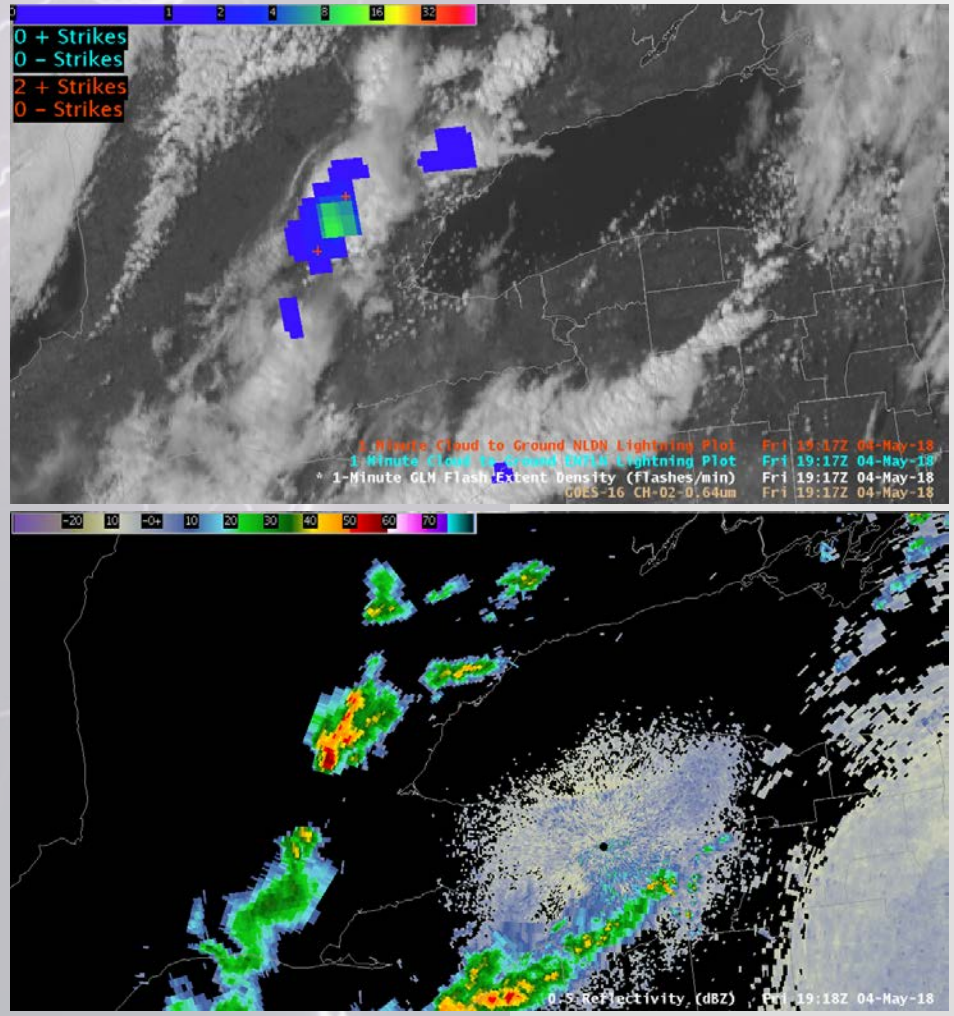
Future Activities / Acknowledgements



GLM flash extent density (top) and radar reflectivity (bottom) in the vicinity of Toronto at 1917 UTC on May 4, 2018

- Continue developing GLM training
- Conduct GLM assessment (Summer 2018)
- Conduct assessment with local emergency managers
- Collaborate on GLM uses with aviation partners
- Develop GLM applications library examples (from forecasters!)
- New visualizations (GLM stoplight)
- Investigate using optical energy observations
- Many thanks to the GOES-R Proving Ground for funding

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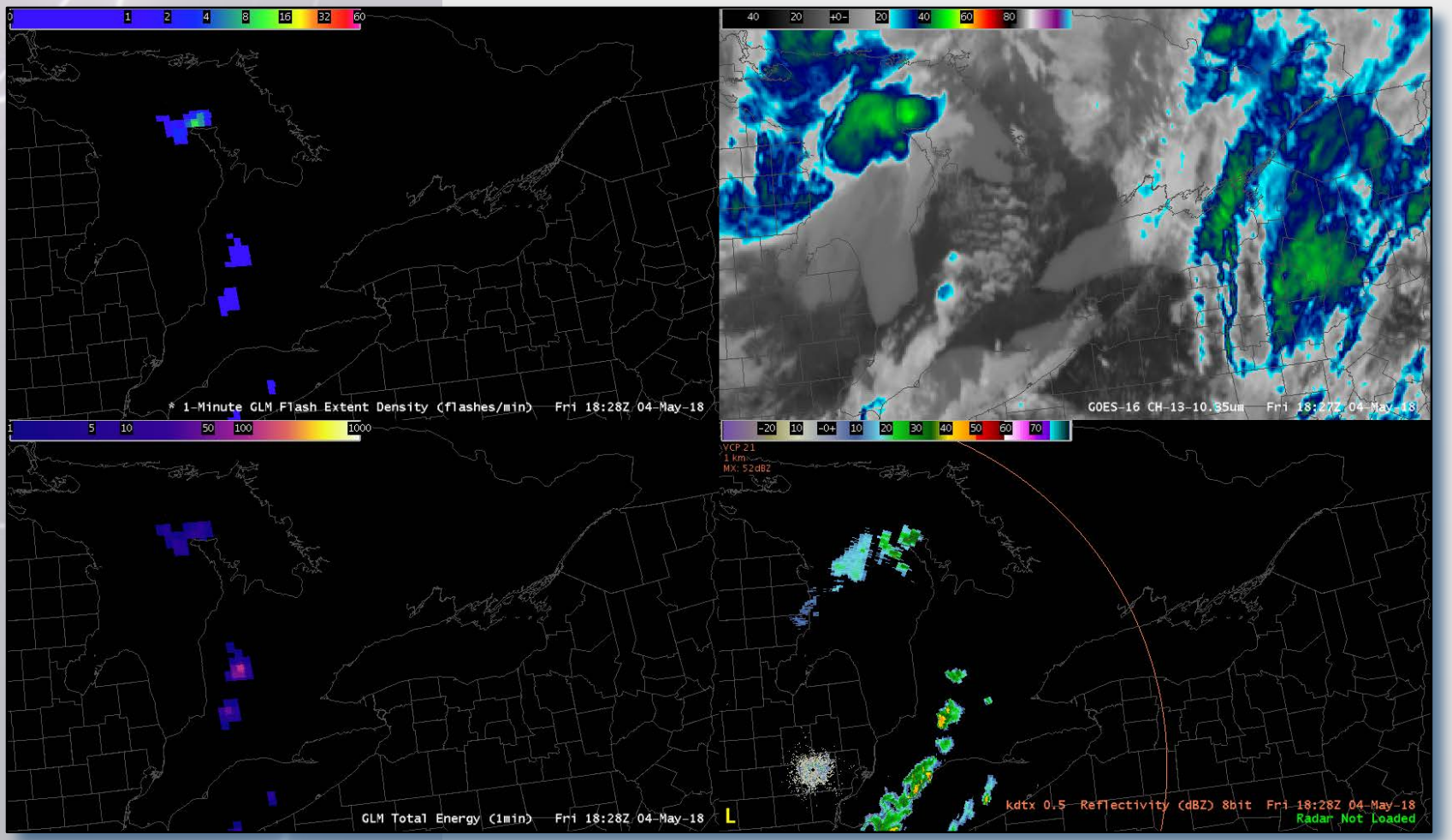
Questions?



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NASA SPoRT

https://weather.msfc.nasa.gov/sport

NASA SPoRT Blog

https://nasasport.wordpress.com

GOES-R

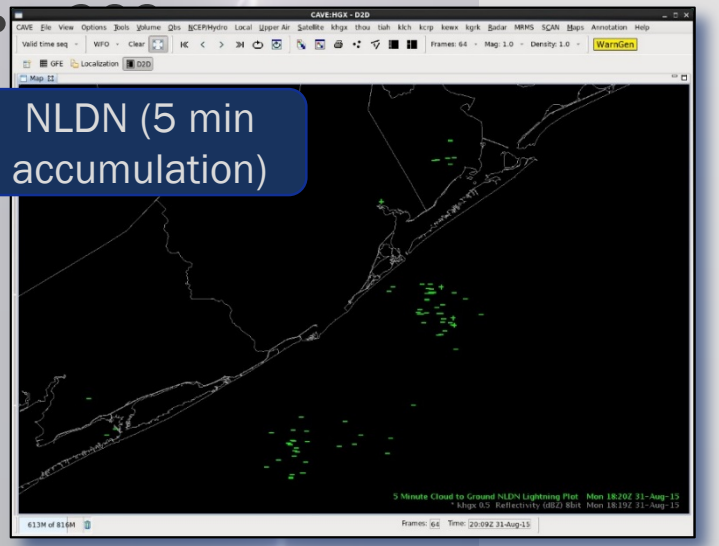
http://www.goes-r.gov/

Extra Slides

Basic Differences Between Observation Systems

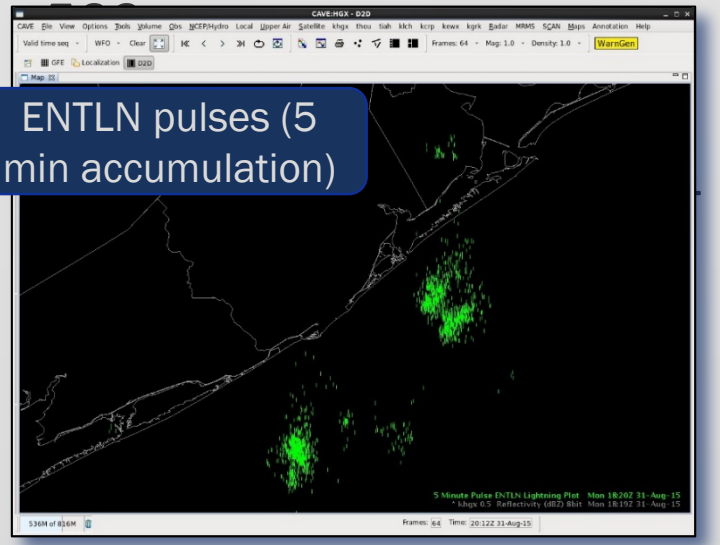
National Lightning Detection Network (NLDN)

- CONUS and near-shore
- DE: >95% of cloud-to-ground within 200 km of CONUS
- 1 min update



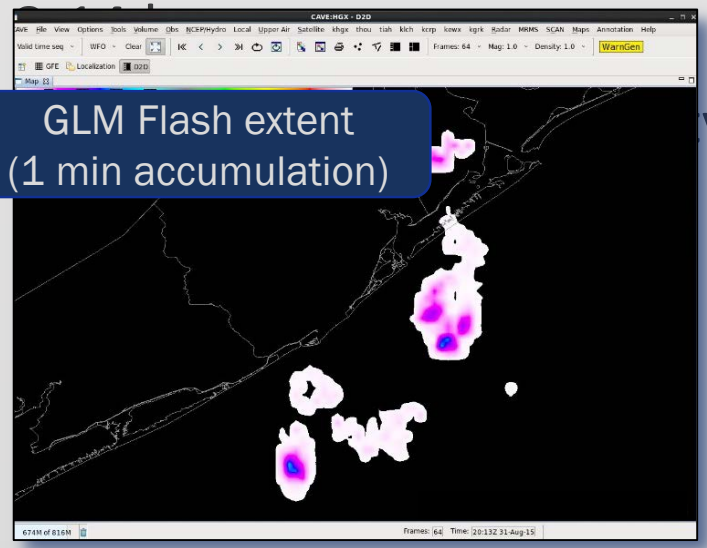
Earth Networks Total Lightning Network (ENTLN)

- Near global, but best over CONUS
- DE: 90% cloud-to-ground, >50% intra-cloud
- 1 min update



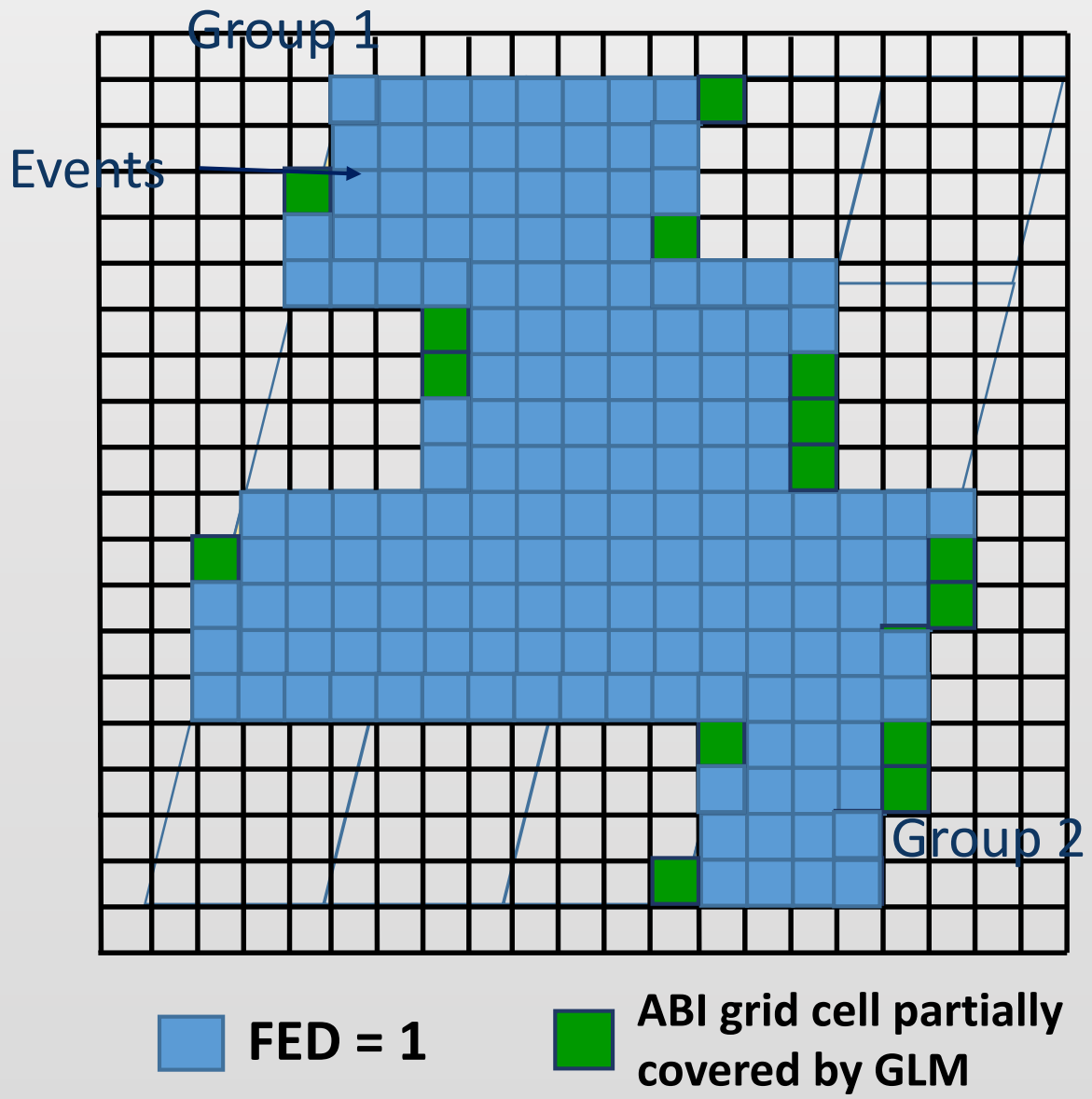
Geostationary Lightning Mapper (GLM)

- 55˚N/S in GOES field of view
- DE: ~70% (daytime) and 90+% (nighttime) of total lightning
- 20 s update (1 min AWIPS)

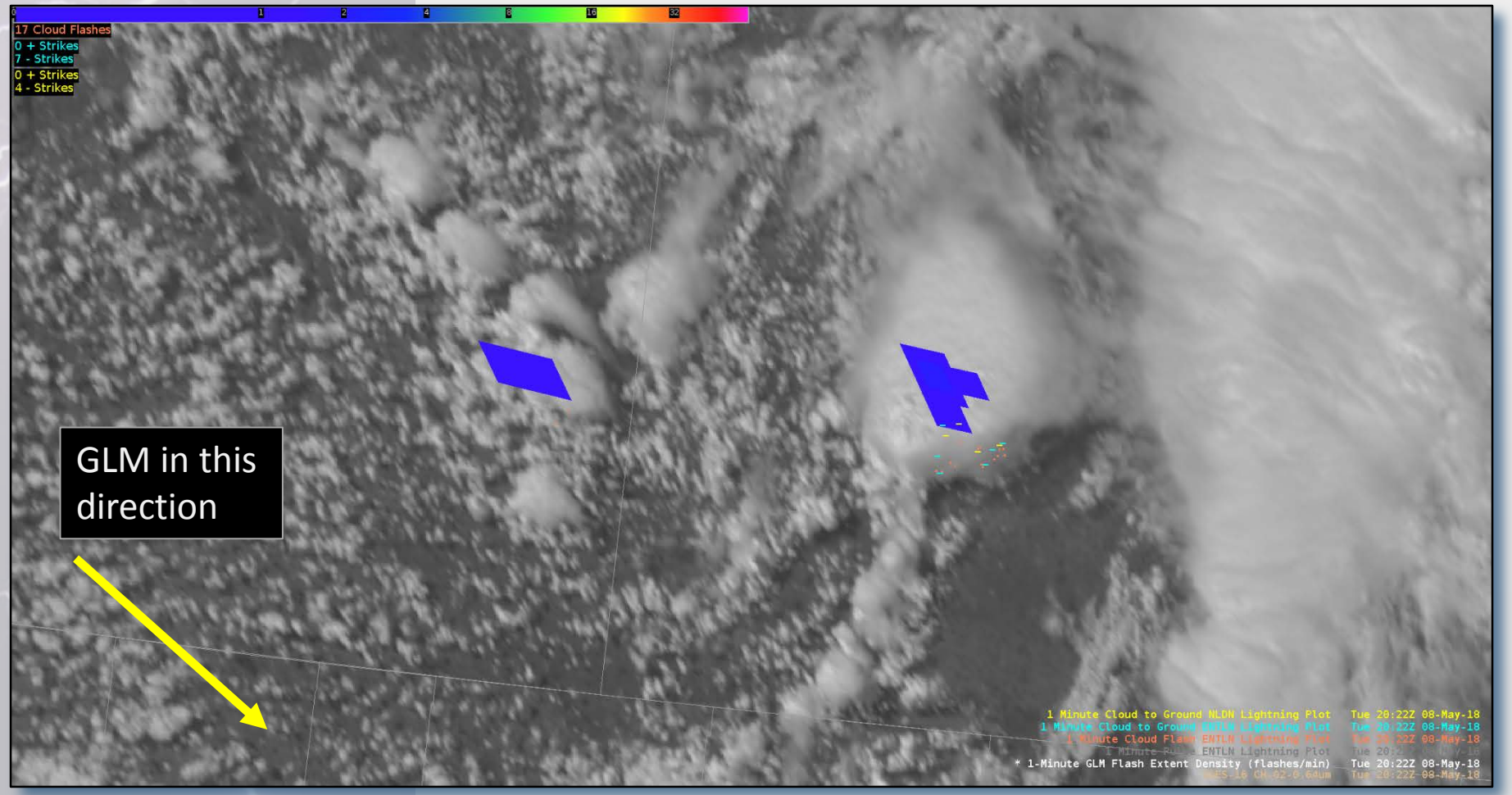


Creating the GLM Flash Extent Density Product

- Events (any detections per pixel in 2 ms) assigned to GLM polygon
- Events combined into groups (like return strokes)
- Groups combined into a flash (within 330 ms and 16.5 km)
- GLM polygons sliced by ABI 2×2 km grid
- ABI grids fully covered by GLM assigned value (+1 for each flash)
- Partially covered grids rounded to the nearest integer
- Similar approach for other products
- Grids necessary – Raw GLM data are points and lack spatial information



Dealing with Parallax



One minute GLM observations with NLDN and Earth Networks over southeast Alberta and southwest Saskatchewan

Will need to note the difference over Ontario and Nova Scotia