

Understanding and Utilizing the Geostationary Lightning Mappers (GLMs) for Operational Meteorology & Lightning Safety

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UNIVERSITY OF
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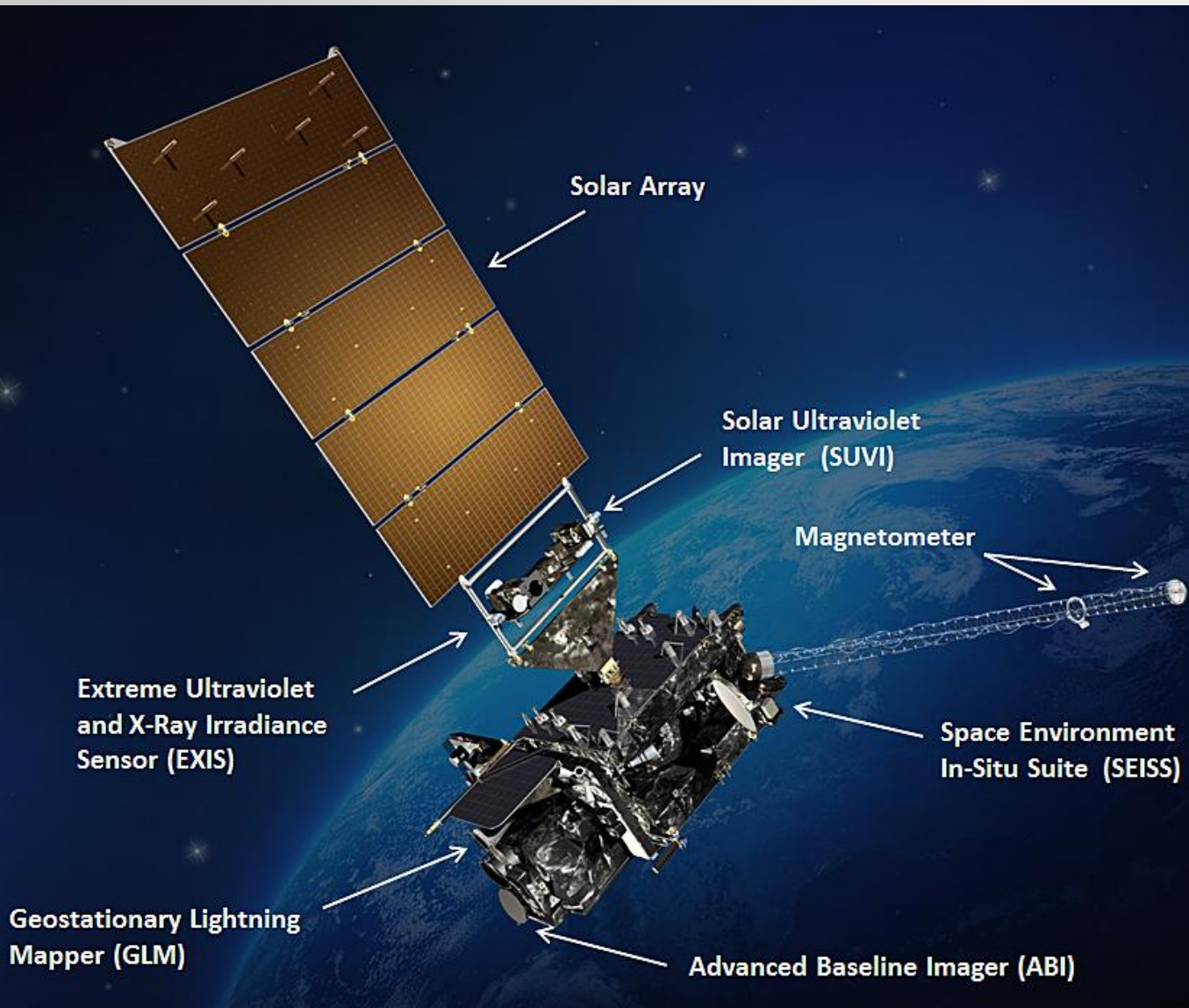
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What Is the GLM?

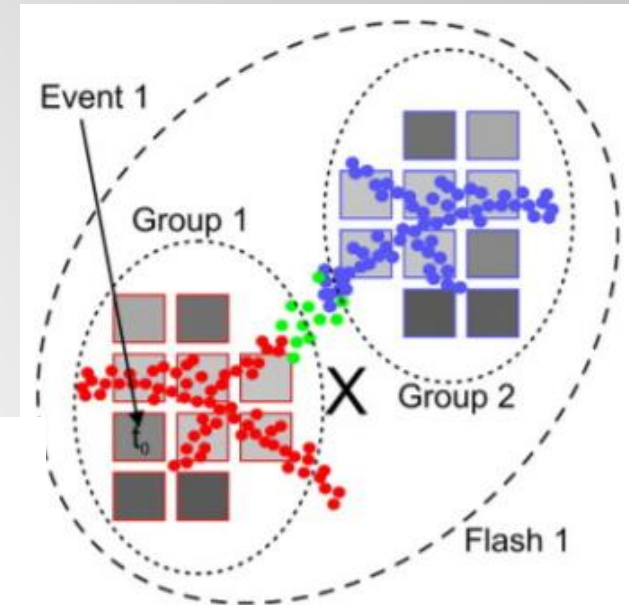
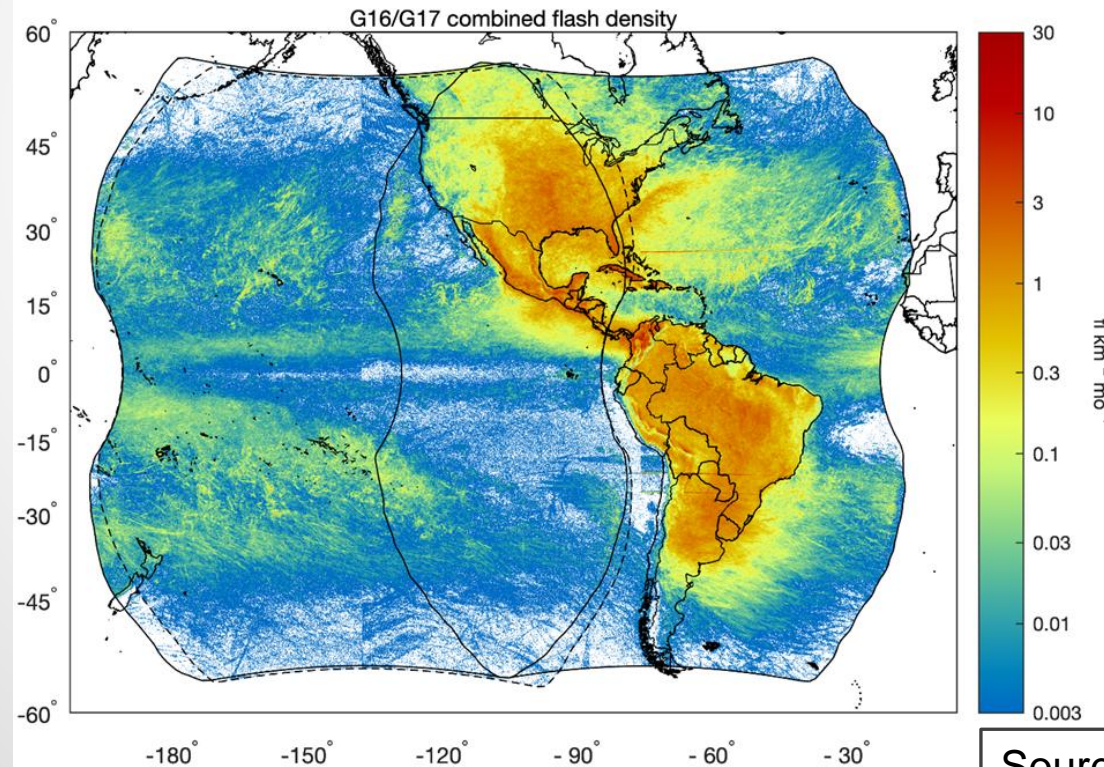
- GLM is a single-channel, near-infrared imager that monitors for short-lived sources of light emitted by lightning, both cloud-to-ground and cloud-to-cloud
- Sources of light are compared to a continuously updating background image to detect lightning
- Coverage is provided across most of the Western Hemisphere by GOES-16 and GOES-17



GOES satellite with GLM. Source:

Flash Processing by the GLM

- Individual point sources of lightning are collected into “flashes” when groups of point sources occur near each other in space and time
- Gridded products quickly convey lightning characteristics such as the areal lightning extent and number of flashes

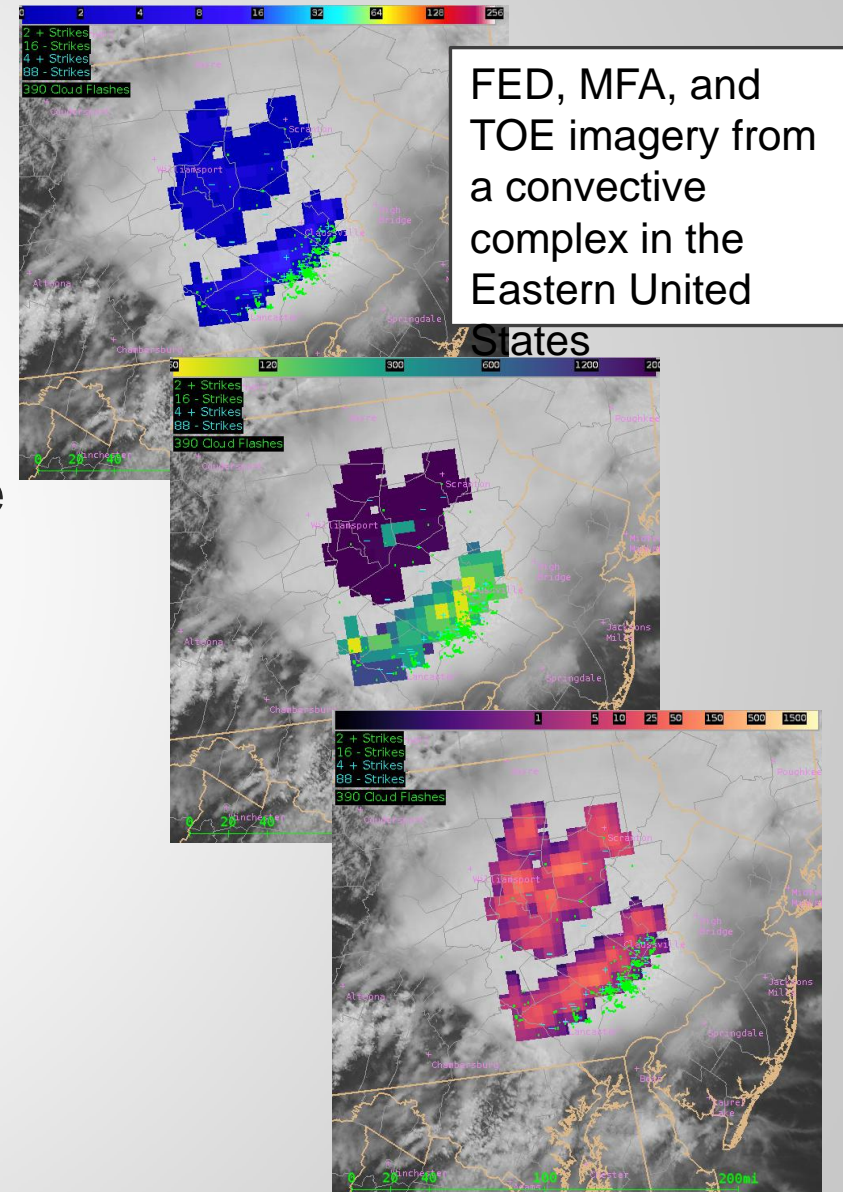


Source: Bruning et al.
(2019)

Source: Rudlosky and Virts
(2021)

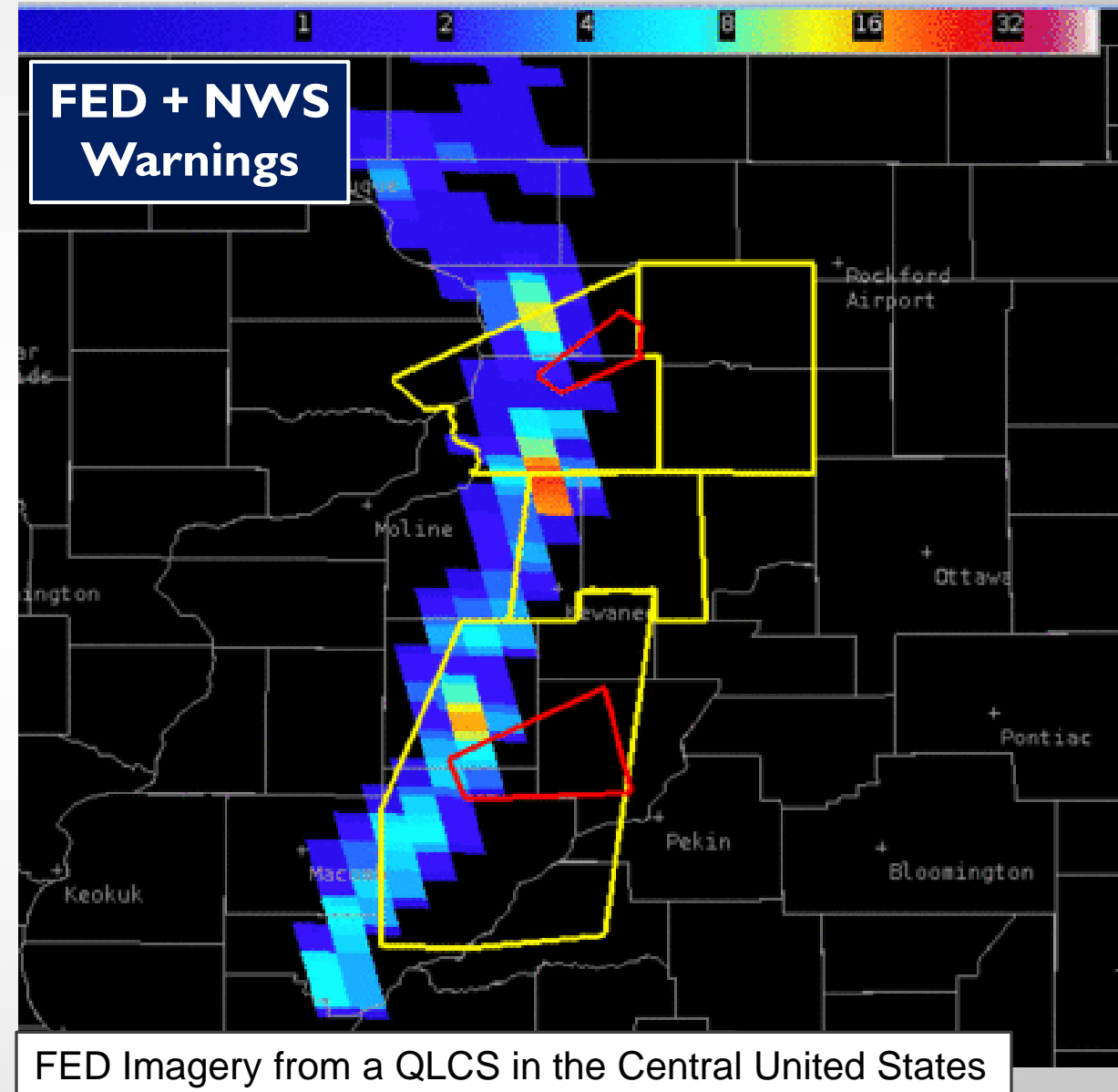
GLM Gridded Products

- **Flash Extent Density (FED)** – total number of flashes spatially coincident with each grid cell over a given period of time. Ranges from one to hundreds of flashes
- **Minimum Flash Area (MFA)** – smallest area of any flash observed with each grid cell in km². Smallest MFA values are less than 100 km² while the largest MFA values can be 1000s of km²
- **Total Optical Energy (TOE)** – total amount of optical brightness observed by the GLM instrument in femtoJoules (J x 10⁻¹⁵). Ranges from 0.1 fJ to hundreds of fJ



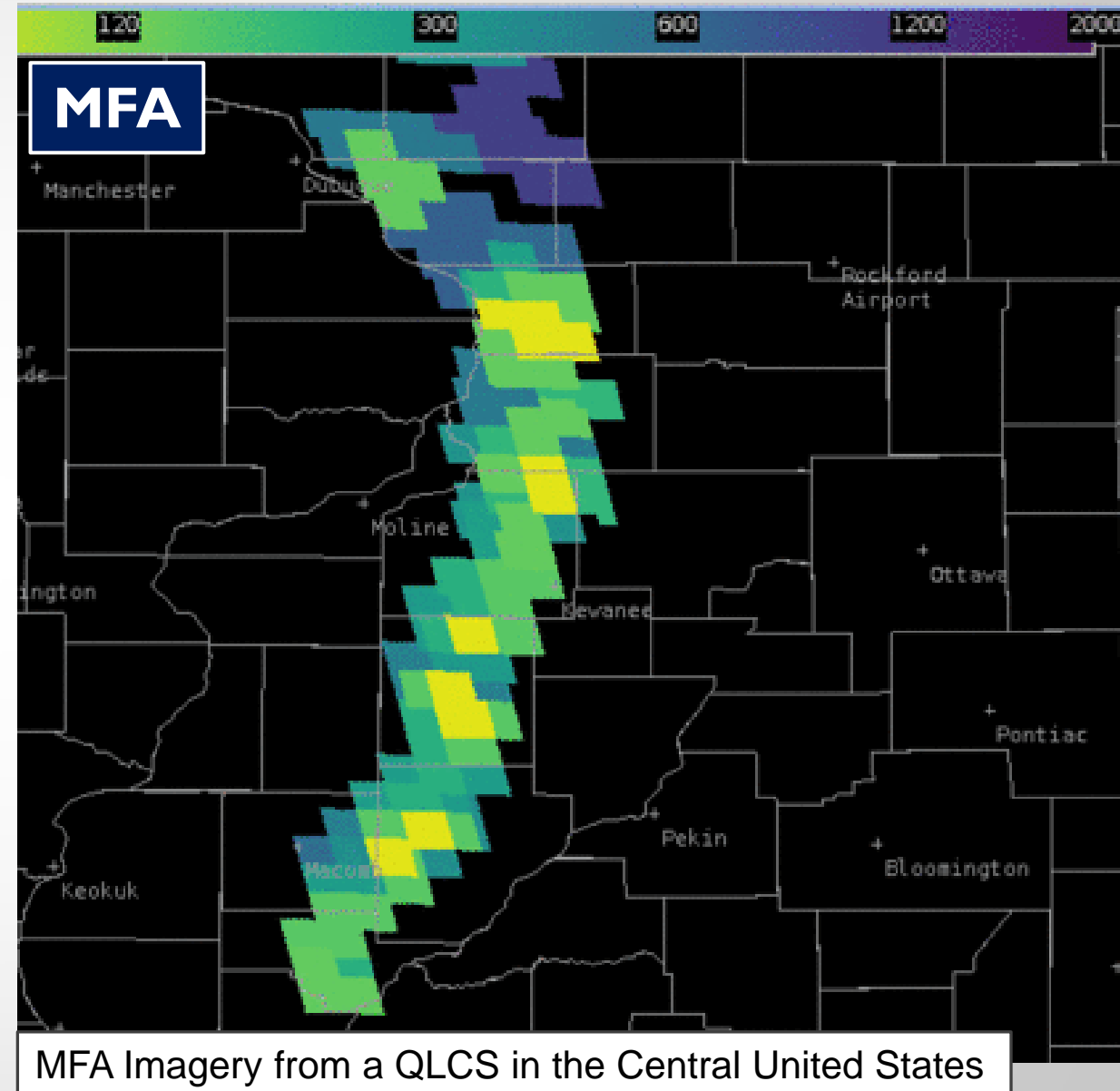
GLM Products – Flash Extent Density (FED)

- Total flash counts with each grid cell over a given period of time
- Cool colors indicate fewer flashes while warmer colors indicate more flashes
- Large FED not necessary for severe storms, but larger FED may be indicative of strengthening convective activity which may show a greater potential for severe weather
- “Jumps” in lightning activity have been correlated with a higher likelihood of the occurrence of severe weather



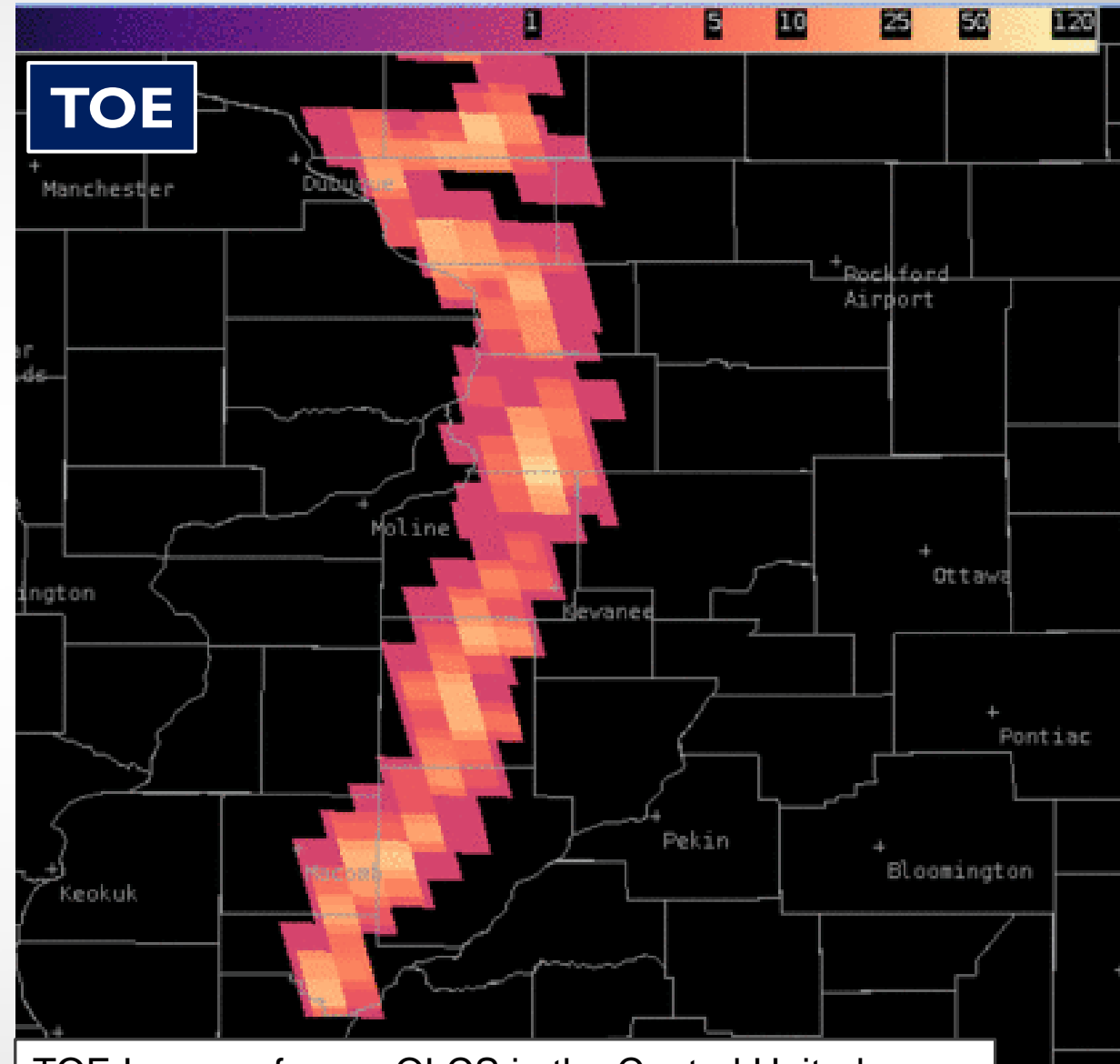
GLM Products – Minimum Flash Area (MFA)

- Area of the smallest flash spatially coincident with each grid cell over a given period of time
- Smaller MFA values ($< 300 \text{ km}^2$) represented by yellow/green grid cells often indicate strengthening convection and/or mature updrafts
- Larger MFA values ($> 900 \text{ km}^2$) represented by dark blue/purple grid cells often indicate either weakening convection or large flashes in anvil/stratiform regions of mature storms



GLM Products – Total Optical Energy (TOE)

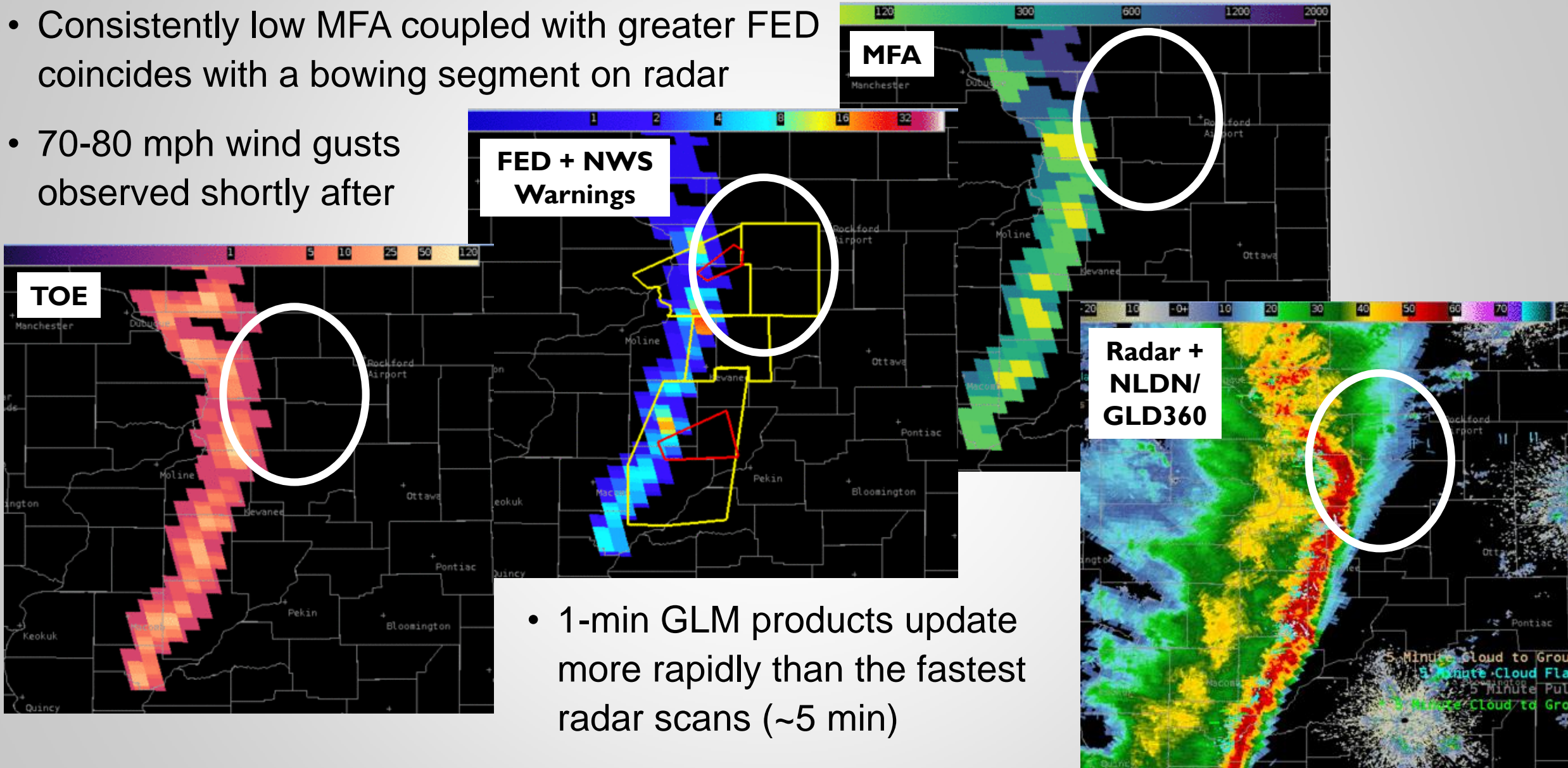
- Amount of optical brightness/energy observed with each grid cell over a given period of time
- More energetic lightning flashes will likely be observed by the GLM as higher TOE values
- Higher TOE values may indicate brighter flashes from strengthening convection or fewer hydrometeors preventing light from reaching the GLM instruments



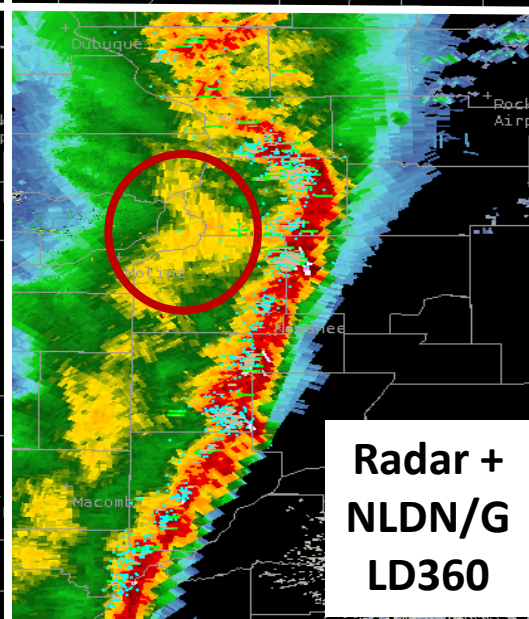
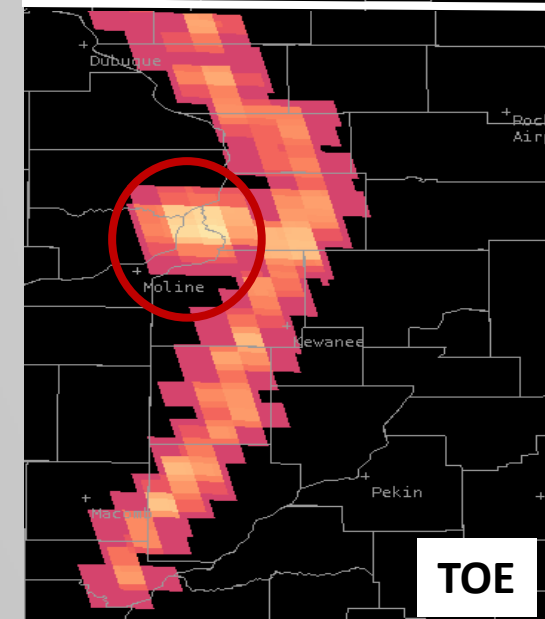
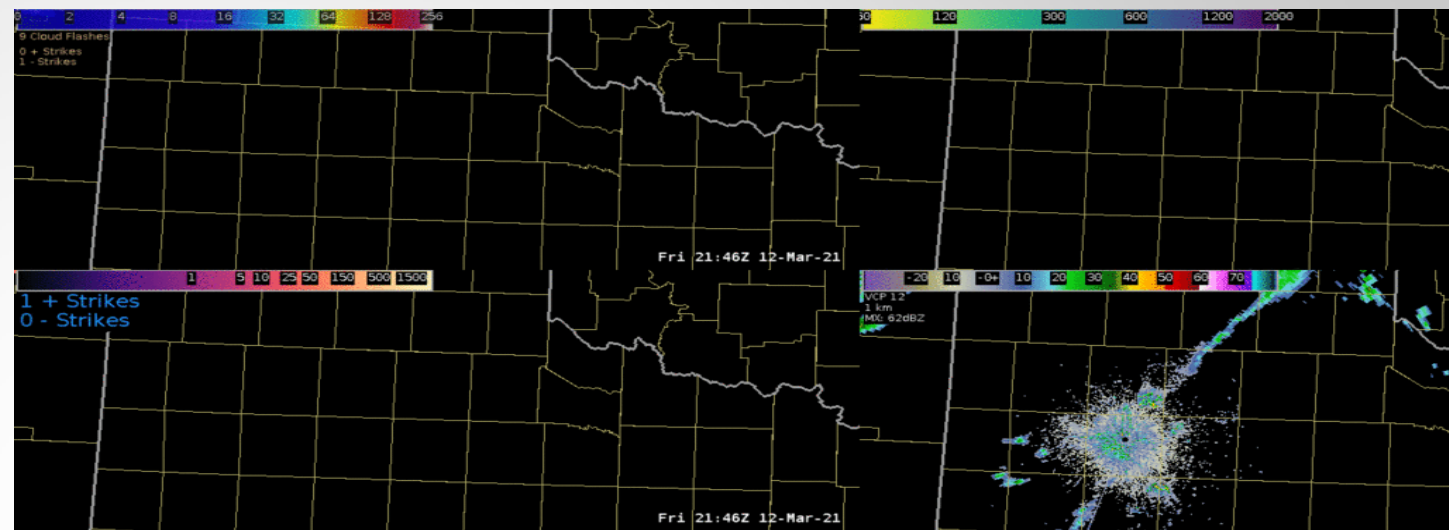
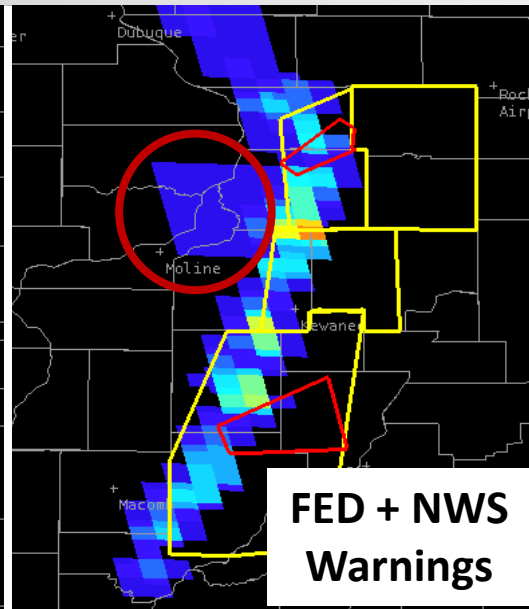
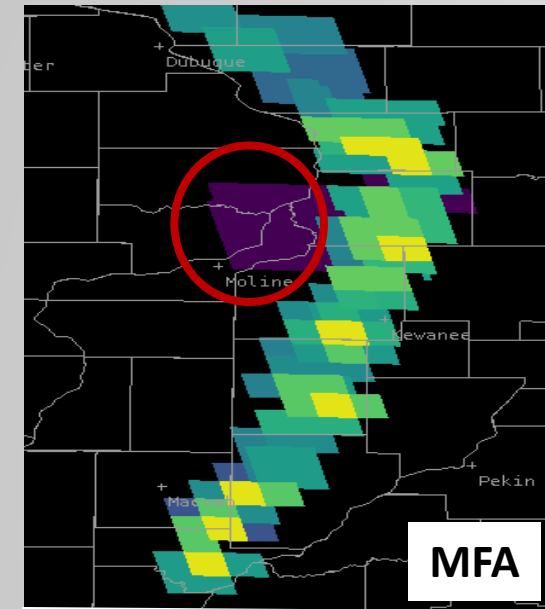
TOE Imagery from a QLCS in the Central United States

Case Study – QLCS

- Consistently low MFA coupled with greater FED coincides with a bowing segment on radar
- 70-80 mph wind gusts observed shortly after



Lightning Safety



- Convective initiation (above) is highlighted with low MFA values as first lightning occurs
- Large stratiform region flashes (left, red ovals) are clearly visible with high MFA/low FED/high TOE values; highlight a less obvious risk for cloud-to-ground flashes which threaten life and property

Operational and Training Resources

Operational GLM Product Sources

- CSPP Geo software allows forecasters to visualize GLM grids in real-time (<https://cimss.ssec.wisc.edu/csppgeo/>)
- Software is compatible with 64-bit CentOS7 Linux platforms and is free to download and use
- CSPP Geo supports all GOES-16 instruments
- Some near real-time GLM imagery can also be seen in some online resources such as College of DuPage (<https://weather.cod.edu/>) and Weathernerds (<https://www.weathernerds.org/>)

GLM Training Resources

- Several quick guides (2-page reference materials) detailing GLM products and uses are hosted here: https://rammb.cira.colostate.edu/training/visit/quick_guides/ (just look for GLM)
- Quick briefs (4 to 5 minute training videos) concerning the GLM are hosted here: https://rammb.cira.colostate.edu/training/visit/quick_briefs/
- COMET provides GLM/GOES-R training here: <https://www.goes-r.gov/users/training/comet.html>

Summary & References

- GLM gridded products include Flash Extent Density (flash counts), Minimum Flash Area (area of smallest flash), and Total Optical Energy (total optical brightness)
- Using the GLM gridded products in addition to ground-based networks is important to fully understand the lightning and convective activity within thunderstorms
- Initial flashes and stratiform flashes, both of which pose a risk to safety, are highlighted by the GLM
- Several training resources are available for better understanding how to use the GLM

References

- Bruning, E., Tillier, C. E., Edgington, S. F., Rudlosky, S. D., Zajic, J., Gravelle, C., et al. (2019). Meteorological imagery for the geostationary lightning mapper. *Journal of Geophysical Research: Atmospheres*, 2019; 124: 14285– 14309. <https://doi.org/10.1029/2019JD030874>
- Rudlosky, S. D., and Virts, K. S. (2021). Dual Geostationary Lightning Mapper Observations. *Monthly Weather Review*, 2021; 149-4: 979-998. <https://doi.org/10.1175/MWR-D-20-0242.1>