



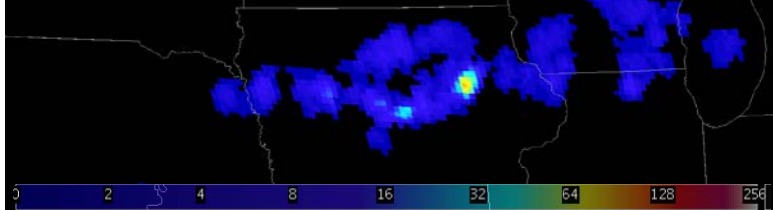
# Geostationary Lightning Mapper: Gridded Products: AFA and TOE Quick Guide



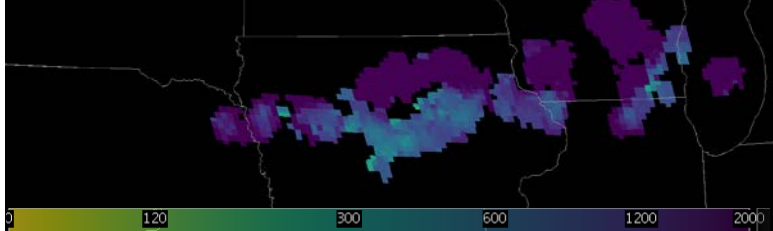
## AFA and TOE Background

- Average flash area (AFA) is the average area of all GLM flashes spatially coincident with each 2x2 km grid cell during a specified time period
- AFA has units of km<sup>2</sup>, with values ranging from a minimum of 1 pixel or ~64 km<sup>2</sup> to several thousand km<sup>2</sup> for regions with extensive stratiform flashes
- Total optical energy (TOE) is the sum of all optical energy that the GLM observes within each grid cell during a specified time period
- TOE has units of femtojoules (fJ; 10<sup>-15</sup> J), with values on the order of decimals for the dimmest flashes to over 1000 fJ for regions with many bright flashes
- AFA and TOE complement flash extent density (FED) to maximize the insights provided by the GLM
- AFA and TOE also provide context for understanding GLM data quality and the subtleties of space-based optical lightning observations

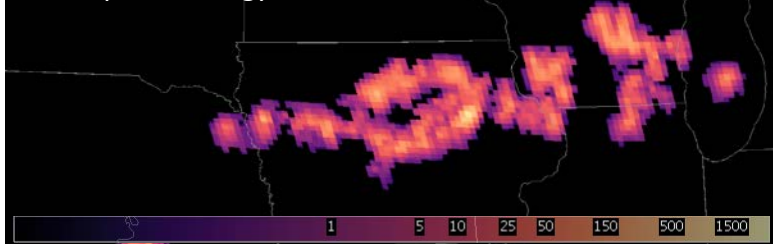
Flash Extent Density



Average Flash Area



Total Optical Energy



## Primary AFA Applications

- Detect/Monitor Thunderstorm Growth – the AFA color map accentuates small flashes to highlight the earliest flashes, AFA also provides a visual cue to help quantify subsequent storm growth
- Observe the areal lightning extent – the AFA indicates the occurrence of large/long flashes and helps differentiate anvil/stratiform flashes from embedded, newly-developing convection
- Monitor convective mode and storm evolution – the AFA trends are indicative of storm life cycles [e.g., frequent small flashes within the most intense convection (< 300 km<sup>2</sup>) and a tendency for larger flashes as storms weaken (> 600 km<sup>2</sup>)]

## Primary TOE Applications

- TOE directly depicts optical lightning observations – provides the most intuitive GLM portrayal
- Identify strengthening and weakening storms – forecasters have likened the use of TOE to watching a light bulb brighten/dim as the storms grow/decay
- Characterize convective scenes – the TOE helps make inferences regarding the surrounding cloud scene [e.g., the TOE helps distinguish between deep convection and the dimmer low level clouds it often illuminates (most common at night)]
- Analyze the cloud-to-ground lightning threat - TOE indicates lightning channel locations within extensive stratiform flashes, along which these flashes commonly strike ground [e.g., FED often illuminates large cloud areas (especially at night), TOE illustrates the actual lightning channel extent]

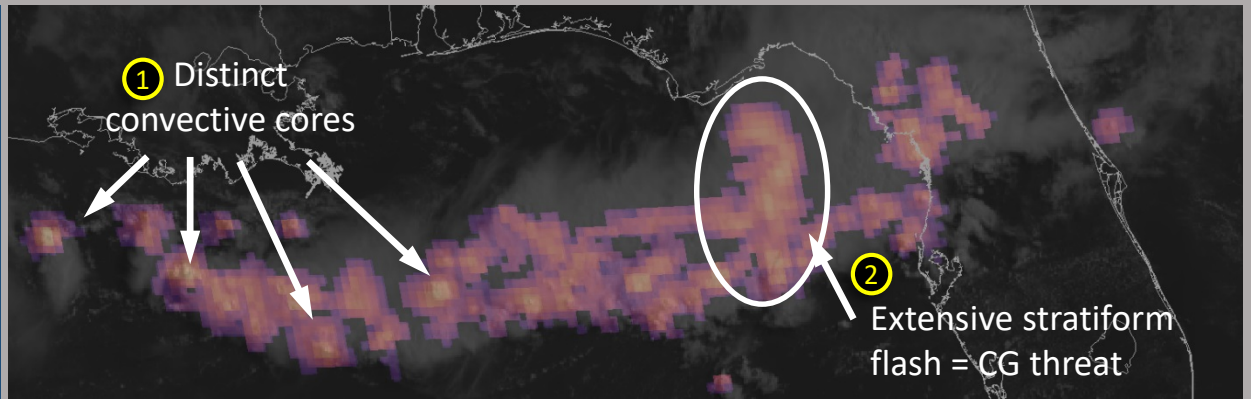


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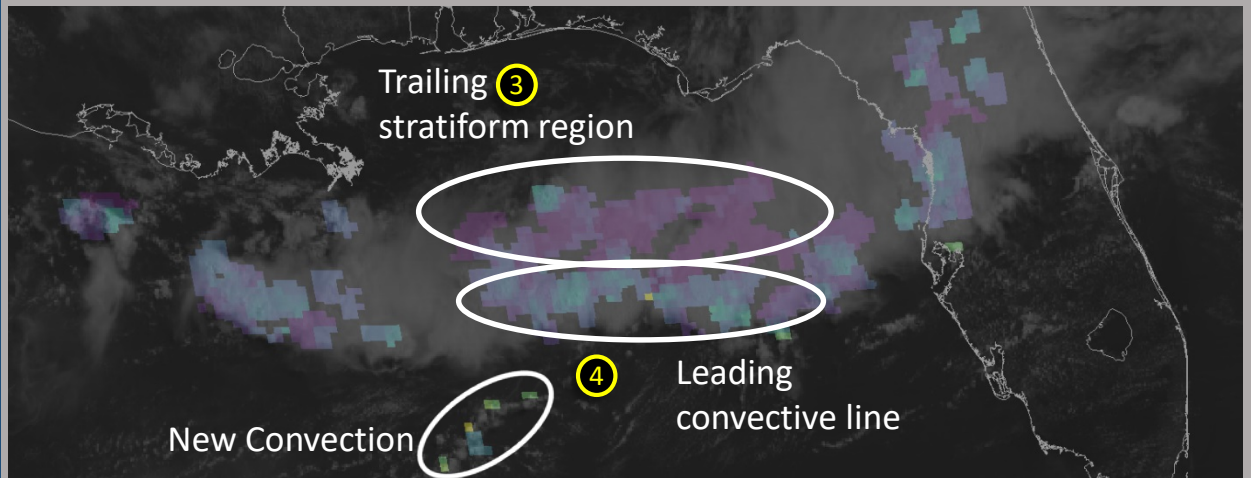
## Bright TOE regions indicate

- ① The most energetic convective cores
- ② Lightning channels within extensive flashes



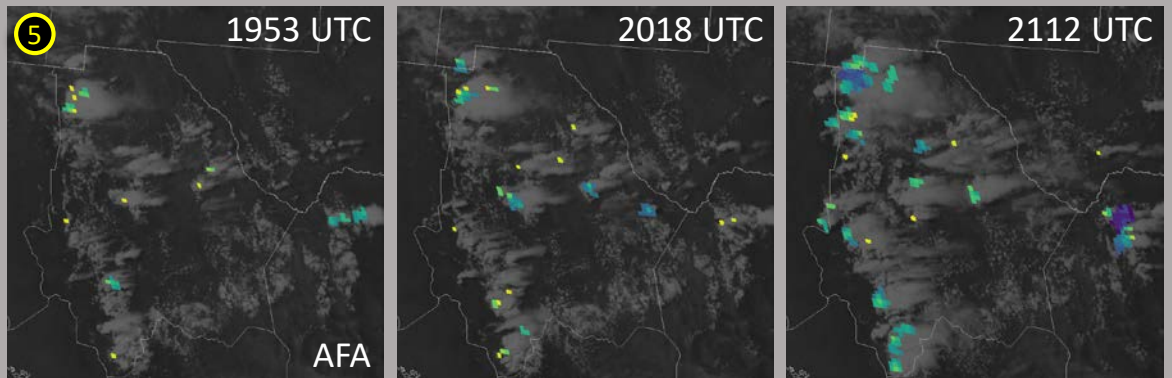
## AFA reveals

- ③ Large flashes in the stratiform / anvil regions and decaying storms
- ④ Small flashes in new convection (see below) and along the leading line



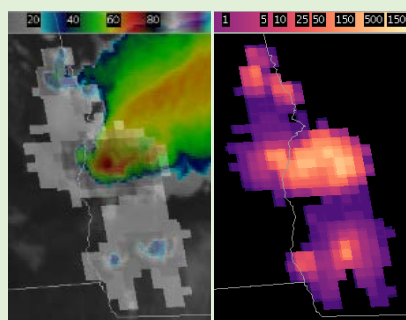
## Detect and Monitor Storm Growth

- ⑤ AFA accentuates small flashes to highlight earliest convection, also provides a visual cue to help quantify storm growth



## Understanding Optical Emissions

- AFA and TOE help understand how the optical lightning signals interact with the convective scene
- For example, TOE helps confirm when dim areas in nocturnal scenes represent illuminated low-level clouds rather than lightning channels ahead of the storm



## Additional Resources

- GLM VLab Community:  
<https://go.usa.gov/xU5MF>
- GLM Faculty Virtual Course  
<https://www.nasa.gov/science-research/nasas-geostationary-lightning-mapper>
- [NESDIS/STAR - CICS-MD](https://www.nasa.gov/science-research/nasas-geostationary-lightning-mapper)
- [NASA SPoRT Home Page](https://www.nasa.gov/science-research/nasas-geostationary-lightning-mapper)

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