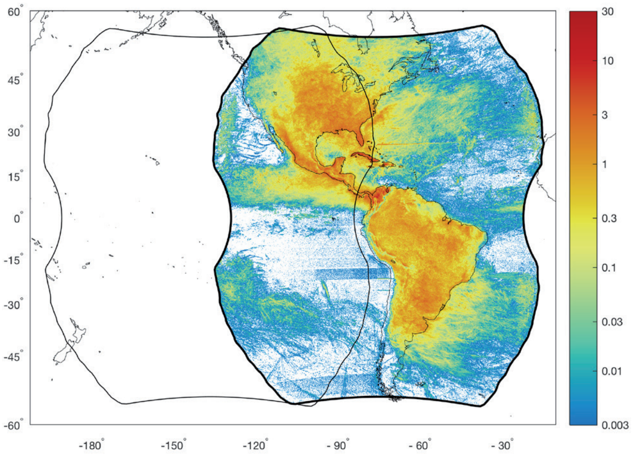
FACT SHEET

GOES-R
Lightning Detection

Why is it important to monitor lightning?

Rapid increases in total lightning (in-cloud and cloud-to-ground) activity often precede severe and tornadic thunderstorms. Characterizing lightning activity in storms allows forecasters to focus on intensifying storms before they produce damaging winds, hail or tornadoes. Lightning is a significant threat to life and property, and particularly hazardous for those working outdoors and participating in recreational activities (hiking, boating, golfing, etc.). Lightning is also a Global Climate Observing System essential climate variable, needed to understand and predict changes in climate. Using satellites, we can detect total lightning over vast geographic areas, both day and night, with near-uniform detection efficiency.


Lightning during a severe thunderstorm in Las Vegas, Nevada. Credit: David Lund



GLM coverage from the operational GOES East and GOES West positions, populated with the first nine months of lightning flash density observations from the GOES East GLM. The flash density is plotted for 2017 December – 2018 August within units of flashes per square km per month. Credit: NOAA

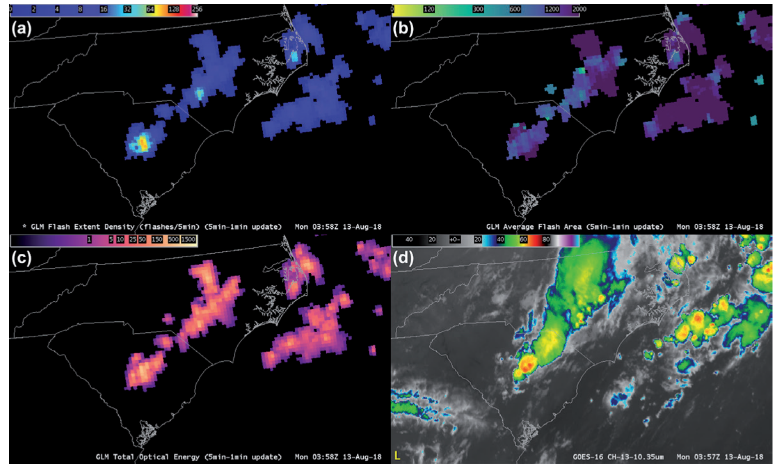
How do GOES-R Series satellites monitor lightning?

GOES-R Series satellites carry a **Geostationary Lightning Mapper (GLM)**, the first operational lightning mapper flown in geostationary orbit. GLM is an optical instrument operating at near-infrared wavelengths that detects and maps total lightning activity continuously over the Americas and adjacent ocean regions. GLM data reveal convective storm development and evolution throughout this broad coverage area. GLM provides insights beyond the presence of a lightning strike, revealing the spatial extent and distance lightning flashes travel.

GLM provides users with the time, location, areal extent, and radiant energy of individual lightning flashes and three gridded data products designed to help forecasters characterize convective storms. **Flash extent density (FED)** indicates the number of flashes that occur within a grid cell over a given time period. FED portrays the quantity and concentration of lightning flashes and their horizontal extent, sometimes traveling over hundreds of kilometers from the storm where the flash originates. The FED product indicates convective cores with warmer colors, while cooler colors depict the spatial extent of lightning flashes. FED illustrates convective processes on various scales with the strongest convective cores clearly distinguished from nearby convection. Rapidly increasing FED values are indicative of lightning "jumps," or rapid increases in lightning flash rates, which indicate rapidly intensifying storm updrafts that often precede severe wind, hail or tornados. Identifying lightning jumps provides forecasters with additional confidence when issuing severe thunderstorm or tornado warnings.

Average flash area (AFA) and **total optical energy (TOE)** complement FED to enhance insights provided by GLM and provide context when characterizing active convective scenes. AFA reports the average area of all flashes spatially coincident with each 2 by 2 km grid cell during a specified time period. This product indicates the occurrence of large/long lightning flashes often connected to the remnants of earlier convection and helps differentiate them from the small flashes in newly developing convection. AFA is particularly useful for diagnosing convective initiation and ensuing storm growth, evolution and decay, and for signaling the transition of a severe storm system to a heavy rain/flooding event.

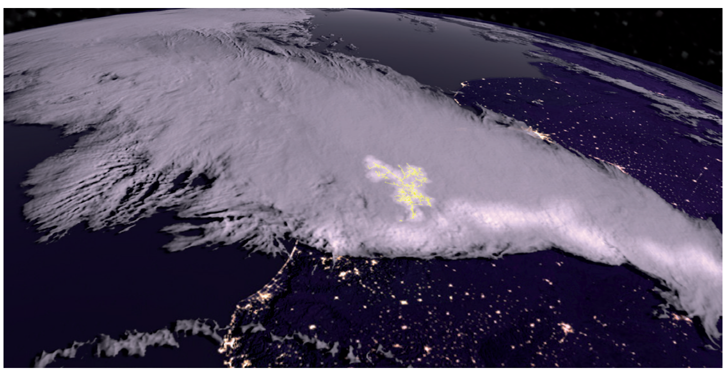
TOE is the sum of all optical energy observed within each grid cell during a specified time period. TOE directly depicts optical lightning observations and can help identify strengthening and weakening storms. This product frequently depicts the path and extent of lightning channels in these regions, making this product well suited for analyzing the cloud-to-ground lightning threat associated with large anvil or stratiform flashes.



GOES-16 gridded GLM (a) flash extent density, (b) average flash area, and (c) total optical energy, along with (d) Advanced Baseline Imager (ABI) infrared brightness temperatures. Combining GLM and ABI observations maximizes the insights they provide. Credit: NOAA

How is GLM different from ground-based lightning detection networks?

Ground-based networks monitor a range of radio frequencies to detect, locate and characterize lightning. The amount, intensity, propagation and type of lightning (in-cloud or cloud-to-ground) detected depend on the radio frequency and receiving station density, which constrains the geographical coverage and accuracy of certain networks. GLM provides complementary and additional total lightning attributes, including flash and group area, duration, optical energy, and the number of groups (events) per flash (group). The most fundamental difference between these technologies is that ground-based networks typically report strokes/flashes at discrete places and times, while GLM flashes have durations and areal extents.


GOES-16 GLM and ABI composite of lightning illuminating a mesoscale convective system over Uruguay. Credit: NOAA/CICS-MD

What benefits does GLM provide?

Trends in total lightning available from GLM provide critical information to forecasters, allowing them to identify initial thunderstorm development and focus on potentially severe storms before these storms produce damaging winds, hail or even tornadoes. In large, long-lived storm systems, lightning may travel hundreds of kilometers before striking the ground. GLM can show forecasters areas far from the main line of storms where the risk of lightning strikes to ground presents a public safety hazard.

GLM can aid with aviation route planning and the early recognition of conditions conducive to lightning-ignited wildfires. This instrument allows forecasters to detect electrically active storms, determine the areal extent of the lightning threat, track convective cells embedded in larger features, identify strengthening and weakening storms, monitor convective mode and storm evolution, and supplement radar data where coverage is poor. GLM has even been found useful in identifying meteors entering Earth's atmosphere.

Data from GLM is also used to produce a long-term database to track decadal changes in lightning activity. This is important due to lightning's role in maintaining the electrical balance between Earth and its atmosphere and potential changes in extreme weather and severe storms under a changing climate.

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Related links:

GLM operational applications quick guide: http://bit.ly/GLMApps

GLM FED quick guide: http://bit.ly/FEDquickguide

GLM AFA and TOE quick guide: http://bit.ly/AFATOEquickguide

GLM detection methods quick guide: http://bit.ly/GLMDetMethods

GLM validation and data access: https://go.usa.gov/xmvyW