



# Update on (GLM and) LMX

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NWS Office of Observations  
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*NOAA's Satellite Applications Symposium Series: Weather*

# GLM and LMX Outline

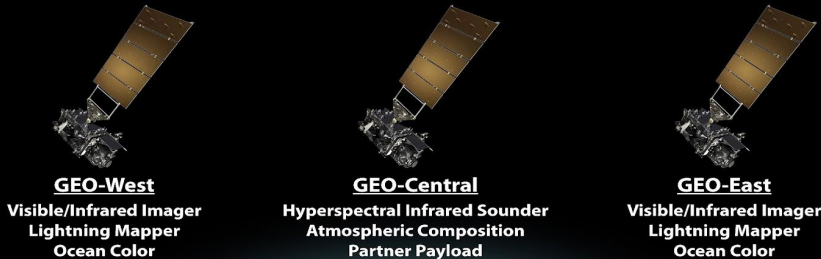
- What is GeoXO LMX?
- GLM and LMX - Sampling of Requirements (potential improvements)
- Applications - Current GOES-R Series GLM products, GLM into Tools/Utilities, and Newer GLM Products
- MTG-LI
- Steps Toward GeoXO Integration
  - MTG-LI data coming soon (Atlantic+ Coverage)
  - Prototyping products and techniques, proving ground, simulation
  - Development, Testing and T2O

# What is GeoXO LMX?

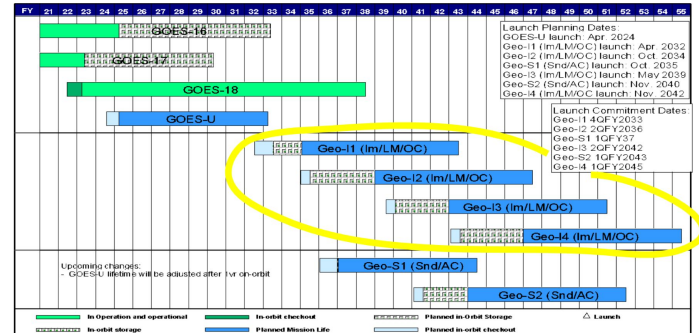
The Geostationary Extended Observations (GeoXO) Lightning Mapper (LMX) will be a single spectral channel instrument used to measure the location and intensity of optical transients produced by lightning:

- hosted on GEO-West and GEO-East - two flight models (FMs), with two additional optional FMs
- detect other phenomenon (like bolides)
- integrated into NWS operations
- provide continuity (and potential improvements) beyond the GOES-R Geostationary Lightning Mapper, GLM

## GeoXO Constellation



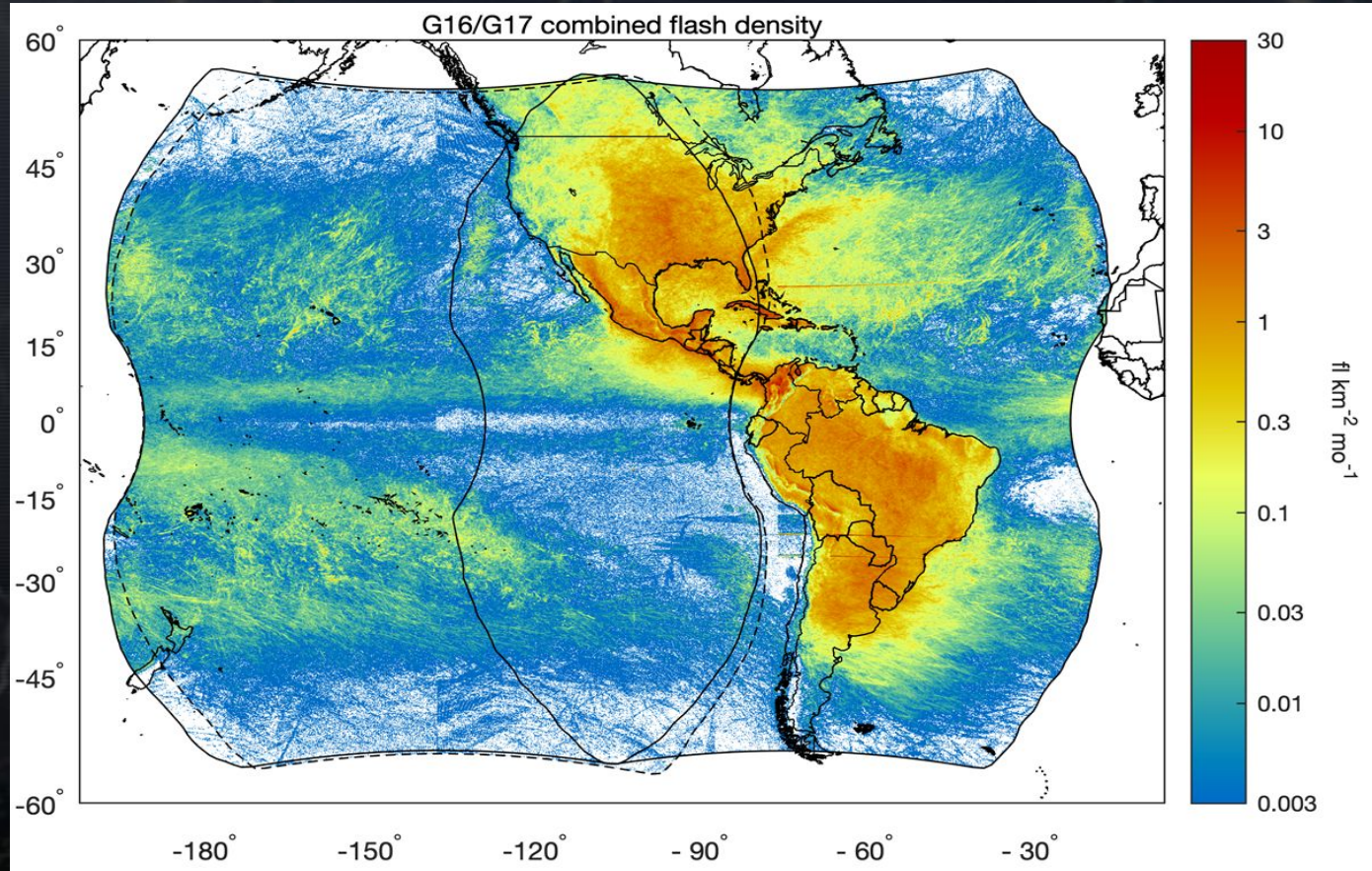
## LMX Planned for Geo-I1, Geo-I2, Geo-I3 and Geo-I4



# GLM and LMX - Sampling of Requirements

Parameter	GLM	LMX Targets
Resolution/GSD	8 km (FED family at 2 km)	$\leq 8$ km (224 $\mu$ rad)
Detection Efficiency	Requirement: detection efficiency > 70%, averaged over full disk and 24hrs (actual performance is in range 70-90% range)	event detection probability over the coverage area shall be greater than 70% after Level 1b processing
Frame Rate	2 msec	$\leq 2$ msec
Downlink Rate	7.7 Mbps	$\leq 75$ Mbps when averaged over any 5 sec period
Coverage	coverage up to $\sim 54$ deg N/S lat or roughly $\sim 75\%$ of the Earth as seen from geostationary orbit	$\geq 84\%$ of the Earth as seen from geostationary orbit with no internal gaps in coverage.
Product Latency	<20 sec latency in L1b (FED family updated every minute)	<10 seconds ...from event detection through generation of Level 1b products.
Navigation (INR)	Navigation error within $\pm 112$ $\mu$ rad ( $\sim 1/2$ pixel or $\sim 4$ km)	LMX navigation error shall not exceed 98 $\mu$ rad, 3-sigma, per axis, except during eclipse periods.
FAR	< 5% averaged over 24 hours	<5% averaged over 24 hours after Level 1b processing

# GLM Coverage (West and East)



# Geostationary Lightning Data Applications

## GLM and LMX:

- essential tools for NWS and partner decision services
- critical measure of life- and property-threatening lightning hazard
- stand-alone datasets *and* as part of decision-assistance tools, aids forecaster situational awareness in severe wx scenarios (and adds confidence to forecasts)
- intersects many NWS and partner mission service areas: aviation, marine, fire, public, severe, tropical, such as:
  - helps identify the location of potential wildfire ignitions and provides guidance to early responders
  - aids diagnosis and warning for tropical cyclones
  - climate - lightning is indicator of inter-annual to decadal change, and key variable to validate climate models (GLM, and later LMX): major contributors to global lightning databases
- potential to improve weather model forecasts (e.g., improvement in short-term precipitation forecasts)

# GLM Base and Derived Products

Base Level-2 data - Events, Groups and Flashes available from PDA (NCCF?), NODD and in GRB (20 sec batches)

## Derived Products -

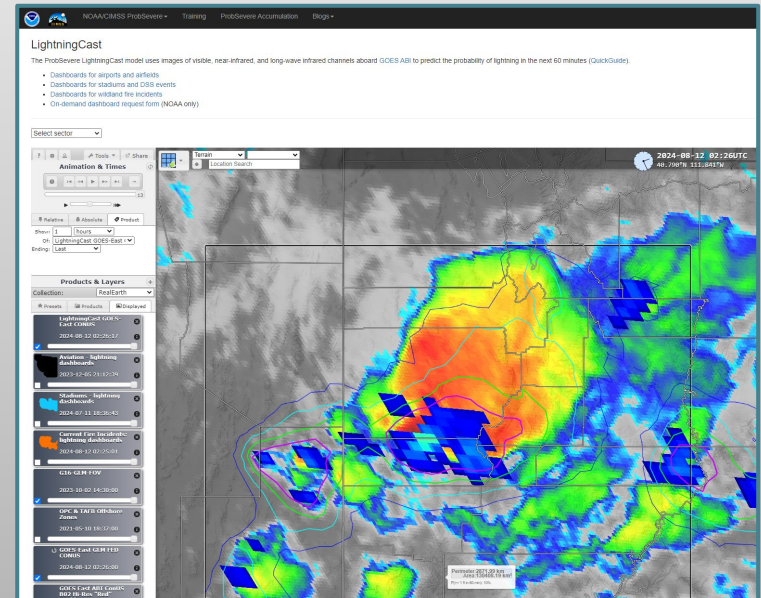


- Flash Extent Density Product Family

- Flash Extent Density (FED), Minimum Flash Area (MFA), and Total Optical Energy (TOA) - (all at one 1-min refresh)
- Time averages of the FED family (e.g., 5 min and 30 min averages)

- GLM into Blended Products and Decision-Assistance Tools

- MRMS
- [ProbSevere - LightningCast](#)



# GLM Products - Newer Arrivals

**Data Quality Product** - real-time per pixel detection efficiency (generally better near satellite subpoint)

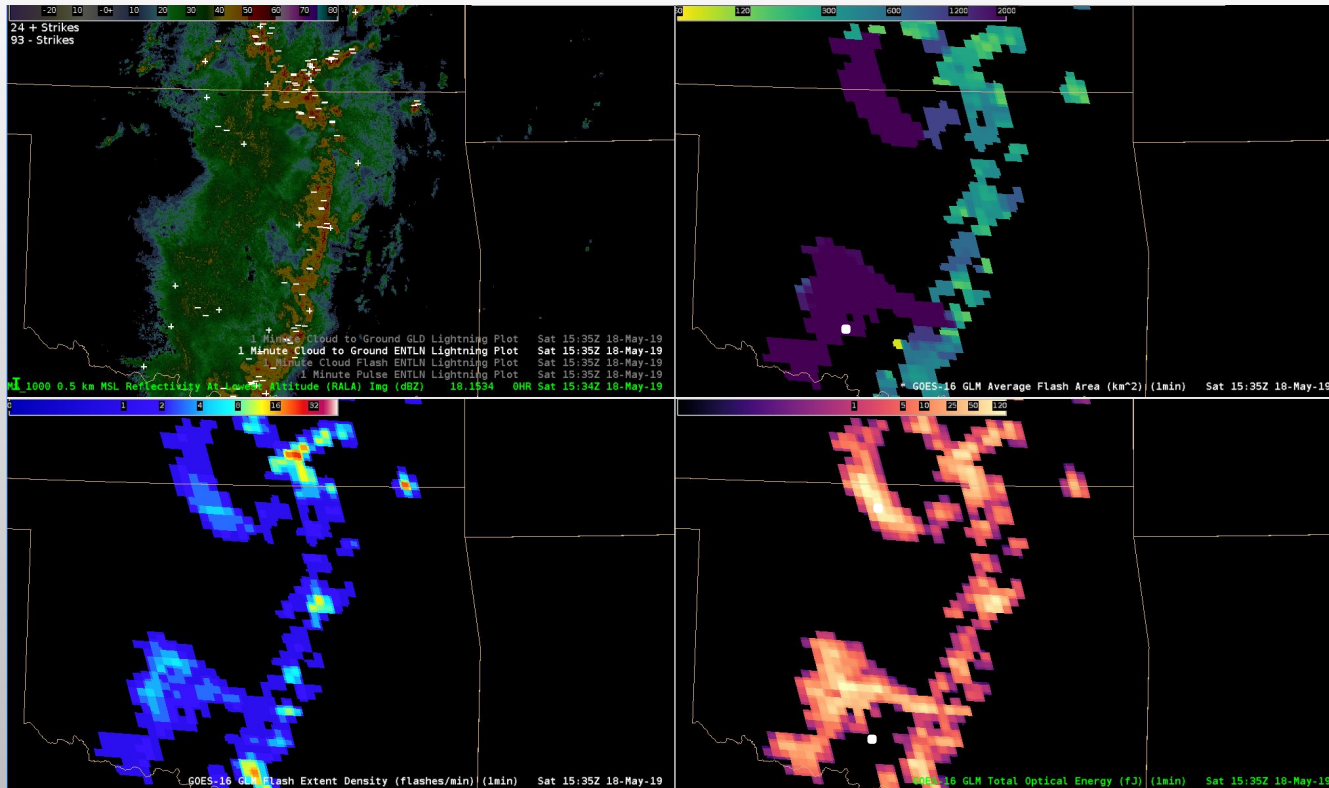
**Background Product** (~8km resolution near-IR GLM 'Full Disk')



*Credit E. Bruning, Texas Tech, J. Patton, CISESS, and K. Thiel, CIWRO/SPC)*



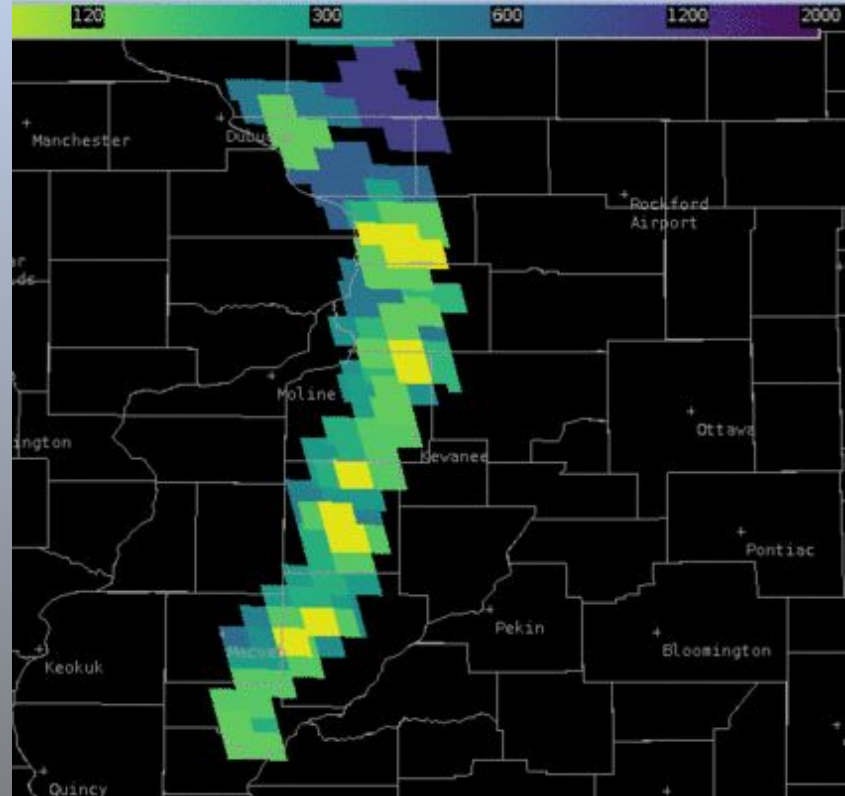
# ENTLN and GLM Products in AWIPS



Credit Joseph Patton (CISS) and Steve Cobb (NWS WFO Tulsa) - Nov. 2020

# GLM Minimum Flash Area

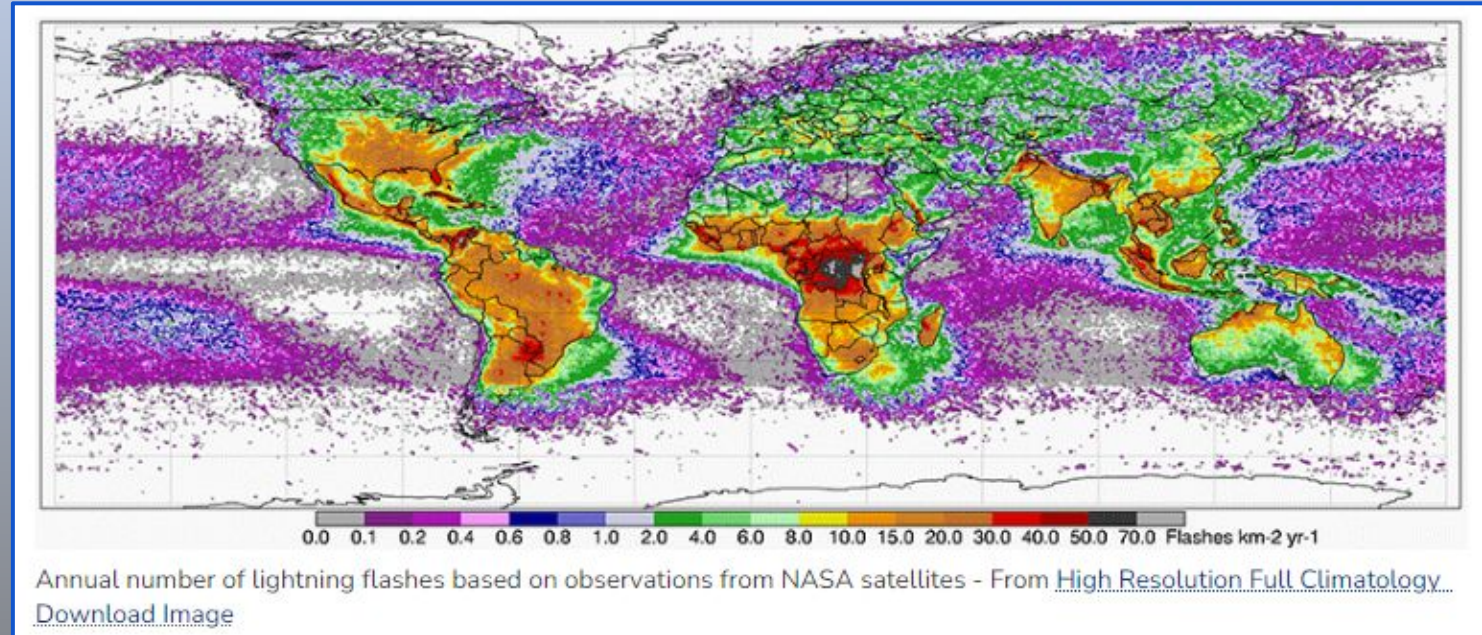
- MFA replaced Average Flash Area since it more clearly accentuates the flash size differential = more operationally useful
- Frequent, small flashes typically indicate intense or strengthening convection
- Larger flashes can indicate well-defined storm systems or weakening convection
- Occurrence and relative position of large GLM flashes is indicative of the path charged particles travel outside updrafts
- Robustness and displacement of lightning within anvil and stratiform regions is descriptive of storm system evolution and severe weather potential



Slide/loop from Joseph Patton, CISS

# Lightning Climatology

(from <https://www.noaa.gov/jetstream/lightning>)



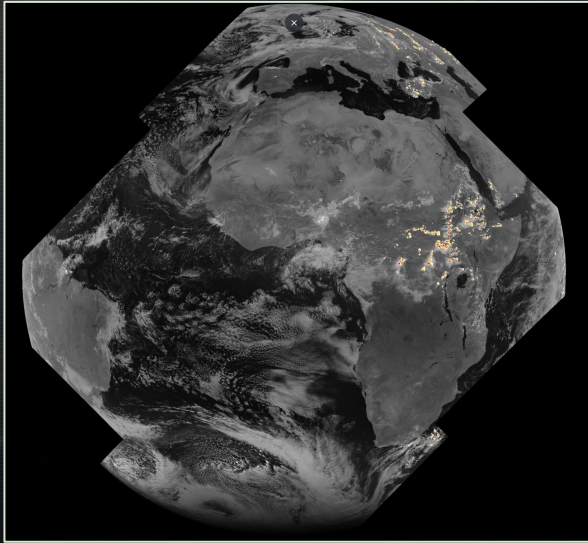
*Lightning is most prevalent natural hazard on Earth: millions of flashes per year.*

# NWP Model Assimilation Plans

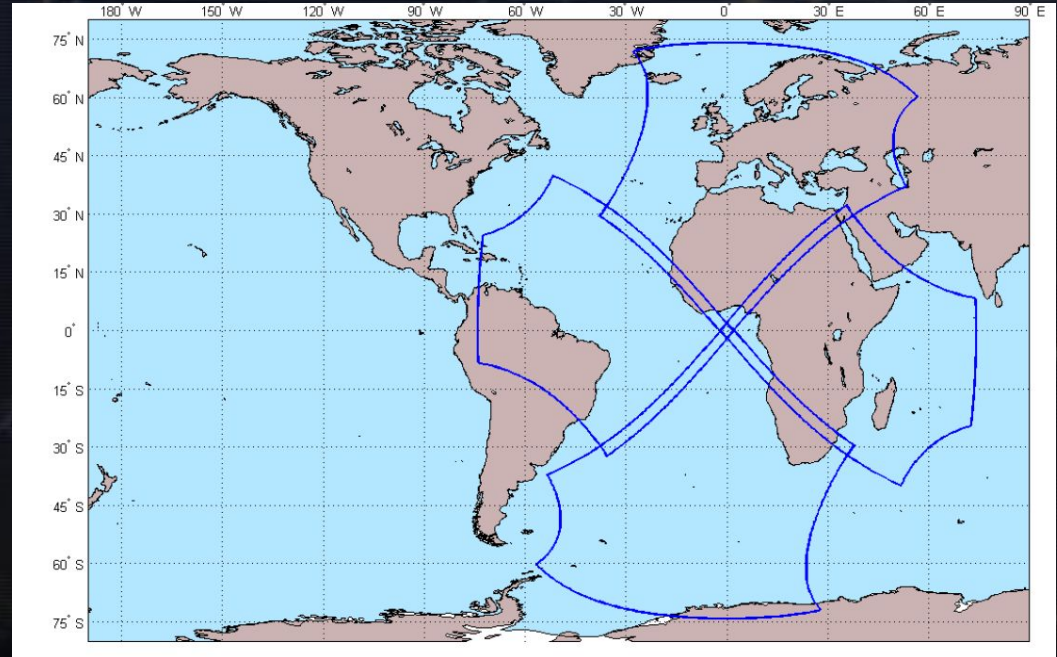
- GLM data is being assimilated in the prototype Rapid Refresh Forecast System (RRFS-A) running at NCEP, which is under evaluation for implementation
- Global Systems Laboratory continues developing GLM assimilation for future RRFS versions, with recent tests taking place in JEDI. While this development lays groundwork for the eventual use of data from MTG-LI, NCEP does not have any tasks focused specifically on that instrument yet.
- NWP assimilation of LMX will build upon experience gained from GLM and MTG-LI assimilation

# EUMETSAT MTG Lightning Imager

Sample data from the Lightning Imager on MTG-I1 became available this year, with near-real-time data expected later this year.



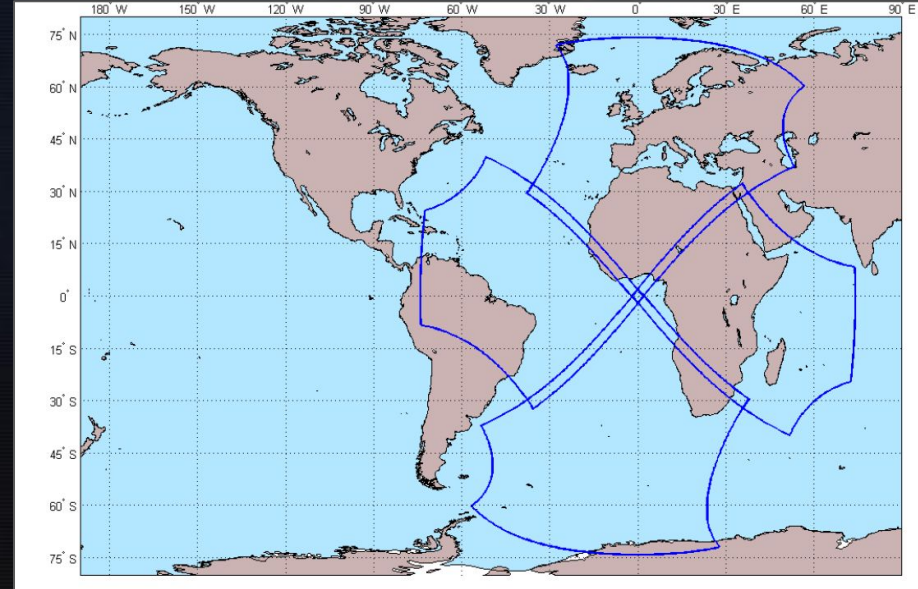
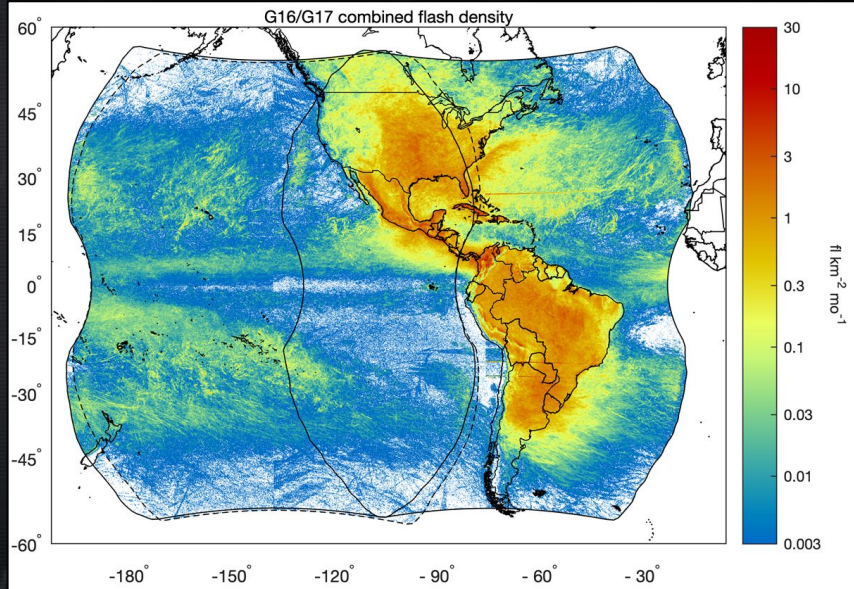
Source: [EUMETSAT media](#).



Credit [Jochen Grandell \(EUMETSAT\)](#)

# Coverage Overlap of GLM and MTG-LI

(and of LMX and MTG-LI)



*Exploring options for multi-sensor exploitation (GLM, MTG-LI, LMX, and ground based).*

*Ensuring smooth transition from GLM to LMX.*

# The Road to GeoXO/LMX - Looking Ahead

## Further Leveraging of GLM

- GOES-19 and New Product/Tools Integration
- Performance improvements will continue where needed through instrument setting adjustments and software modifications (e.g., advanced filtering). Continued efforts to remove or further reduce any residual artifacts such as Sun glint, solar intrusion, subarray boundary inconsistencies, any platform stability effects, FED splitting.

## MTG-LI Exploitation by NOAA and Partners

## User Feedback

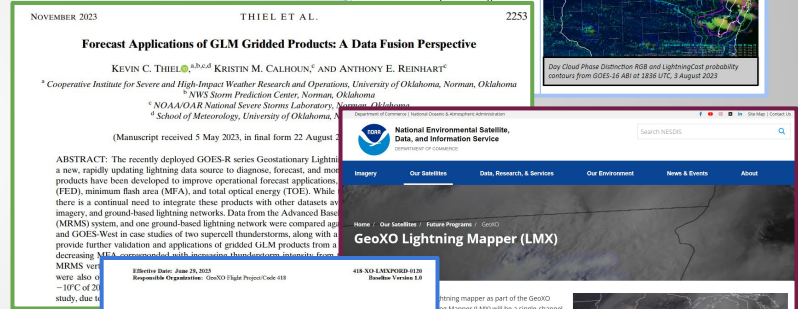
## Prototyping and Pathfinders with Simulated LMX Data

- LMX User Team, helping to chart the course



# Some References

- [GLM Quick Guide](#)
- [GLM on VLab](#)
- [NOAA/GOES-R GLM Page](#) and [GLM Fact Sheet](#)
- [ProbSevere - LightningCast](#)
- [Forecast Applications of GLM Gridded Products: A Data Fusion Perspective \(Thiel et al.\)](#)
- [NOAA/NESDIS LMX Page](#)
- [LMX Technical and Other Documents on sam.gov](#)



## Geostationary Extended Observations (GeoXO) Lightning Mapper (LMX) Performance and Operational Requirements (LMXPORD)

June 29, 2023



Coddard Space Flight Center  
Greenbelt, Maryland

Lightning mapper as part of the GeoXO Lightning Mapper (LMX) will be a single-channel, high-resolution sensor used to detect, locate, and measure the extent of lightning flashes. LMX will use imagery provided by the GOES-R Data Mapper (GLM) and potentially other sensors from geostationary orbit (GEO) and increases lead time to detect lightning. It also improves lightning hazard prediction, wildfire detection and mitigation, and aviation hazard mitigation. LMX is available where other sensors are not available and in mountainous and rural areas that local radar does not cover. It is an essential climate variable needed to improve climate modeling. GOES-16 imagery of a convective system over the Midwest on Dec. 16, 2017, shows lightning activity within the system. Credit: NOAA/NESDIS/Space Weather Prediction Center



When the shocking truth strikes...IT'S TOO LATE!



# FLASH RIPROCK

and the  
Bolt from the Blue

# Thanks!

# Questions/Discussion

"POSITIVE" LIGHTNING BOLTS COME FROM THE UPPER PARTS OF THUNDERSTORMS, STRIKING MANY MILES AWAY FROM THE PARENT STORM.

IF YOU HEAR THUNDER, THE LIGHTNING IS NEAR. THERE IS NO SAFE PLACE OUTSIDE. FOLLOW THESE SAFETY RULES: 1. IMMEDIATELY MOVE TO SAFE SHELTER, A SUBSTANTIAL BUILDING WITH ELECTRICITY OR PLUMBING OR AN ENCLOSED METAL-TOPPED VEHICLE WITH WINDOWS UP. 2. STAY IN SAFE SHELTER AT LEAST 30 MINUTES AFTER THE LAST SOUND OF THUNDER. 3. STAY OFF CUBBED PHONES, COMPUTERS AND OTHER ELECTRICAL EQUIPMENT. 4. AVOID PLUMBING, INCLUDING SINKS, BATHS AND FAUCETS. 5. STAY AWAY FROM WINDOWS AND DOORS, AND STAY OFF PORCHES. 6. IF OUTDOORS, NEVER LIE FLAT ON THE GROUND. NEVER SHELTER UNDER AN ISOLATED TREE, AND NEVER USE A CLIFF OR ROCKY OVERHANG FOR SHELTER. IMMEDIATELY GET AWAY FROM PONDS, LAKES AND OTHER BODIES OF WATER. STAY AWAY FROM OBJECTS THAT CONDUCT ELECTRICITY (BARBED WIRE FENCES, POWER LINES, WINDMILLS, ETC.)

SOME COMMON LIGHTNING MYTHS: A. BENJAMIN FRANKLIN'S KITE WAS NEVER STRUCK BY LIGHTNING. B. LIGHTNING DOES NOT ALWAYS STRIKE THE TALLEST OBJECT, ONLY THE TALLEST OBJECT IN A PARTICULAR AREA. C. LIGHTNING CAN STRIKE ANY OBJECT IN ITS PATH, NOT JUST METAL. D. JUST BECAUSE IT'S NOT RAINING DOESN'T MEAN YOU CANNOT BE STRUCK BY LIGHTNING. IF YOU HEAR THUNDER, TAKE SHELTER. IN FACT, MOST PEOPLE STRUCK BY LIGHTNING EACH YEAR ARE IN RAIN-FREE AREAS MILES AWAY FROM A THUNDERSTORM. E. RUBBER SOLES OF SHOES (OR RUBBER TREES) ARE NOT INSULATORS FROM LIGHTNING; THEY OFFER ZERO LIGHTNING PROTECTION.

IN 3D, REALLY 3D AND eyeMax'd 3D (We're serious, seek shelter!)