Bayesian Absolute Detection Efficiency of the GLMs

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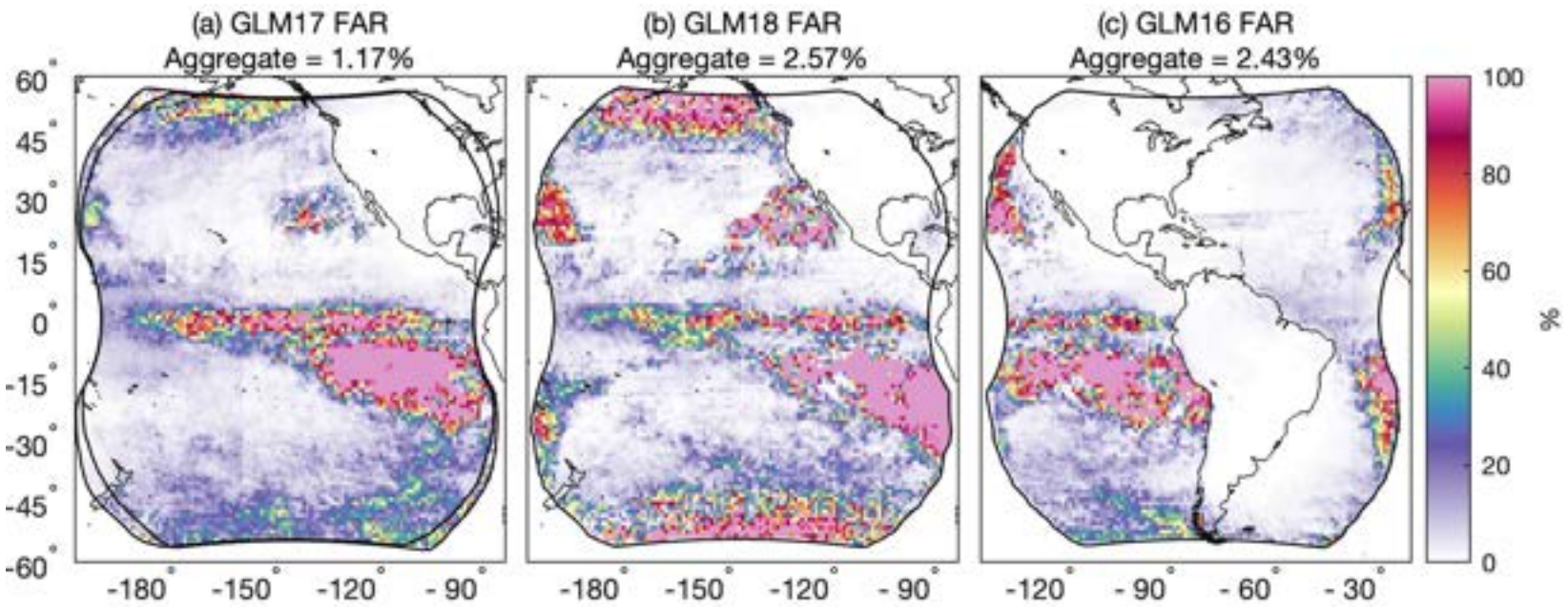
Calculating GLM's detection performance

- Detection efficiency (DE) = % of true lightning flashes a sensor detects
- Most studies calculate relative DE
  - Probability that sensor A detects a discharge given that sensor B detected the same discharge
  - Assumes that the reference sensor (B) detects all lightning
- Bitzer et al. (2016) introduced a Bayesian method for absolute DE (ADE)
  - Does not assume that either sensor detects all lightning
  - Calculated with respect to the larger universe of detected lightning
  - Provides an upper estimate of ADE for each sensor being analyzed
- Bitzer and Burchfield (2016) applied the Bayesian method to ground network pulses/strokes: ENTLN (56.8% ADE), GLD360/NLDN (59.8%), and WWLLN (7.9%)
- Virts et al. (in review) applied the Bayesian method to TRMM and ISS LIS ground networks, and GLM16

Caveat: GLM artifacts



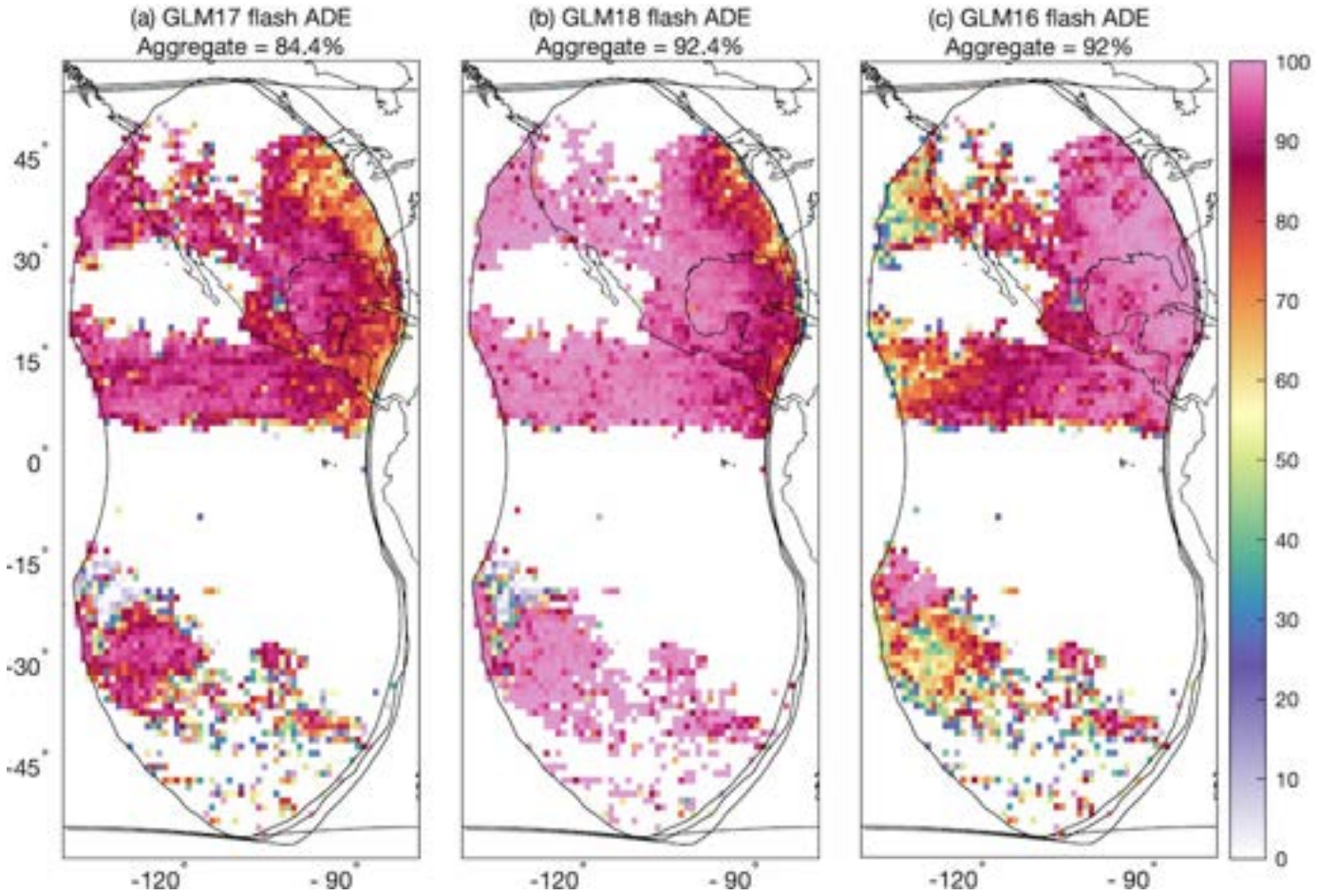
- False alarms are counted as missed flashes for other sensors
- ~1-3% of GLM reported flashes cannot be matched to *any* reference flash (within ±10 min, 50 km)
- FAR is higher when averaging over all grid boxes (e.g., weighting each **location** instead of each **flash** the same)

Lightning data available for Bayesian analysis

Source	Lightning data	Time period	Domain
Satellite optical sensors			
GLM16	Flash	Aug 2019 – Jul 2023	Western Hemisphere
GLM17		Aug 2019 – 10 Jan 2023	Central/Eastern Pacific
GLM18		Nov 2022 – Jul 2023	Central/Eastern Pacific
Ground-based RF networks			
ENGLN	Pulse -> flash	Aug 2019 – Jul 2023	Global
GLD360	Stroke -> flash	Aug 2019 – Jul 2023	Western Hemisphere (through 2020) Extended Western Hemisphere (2021 and later)

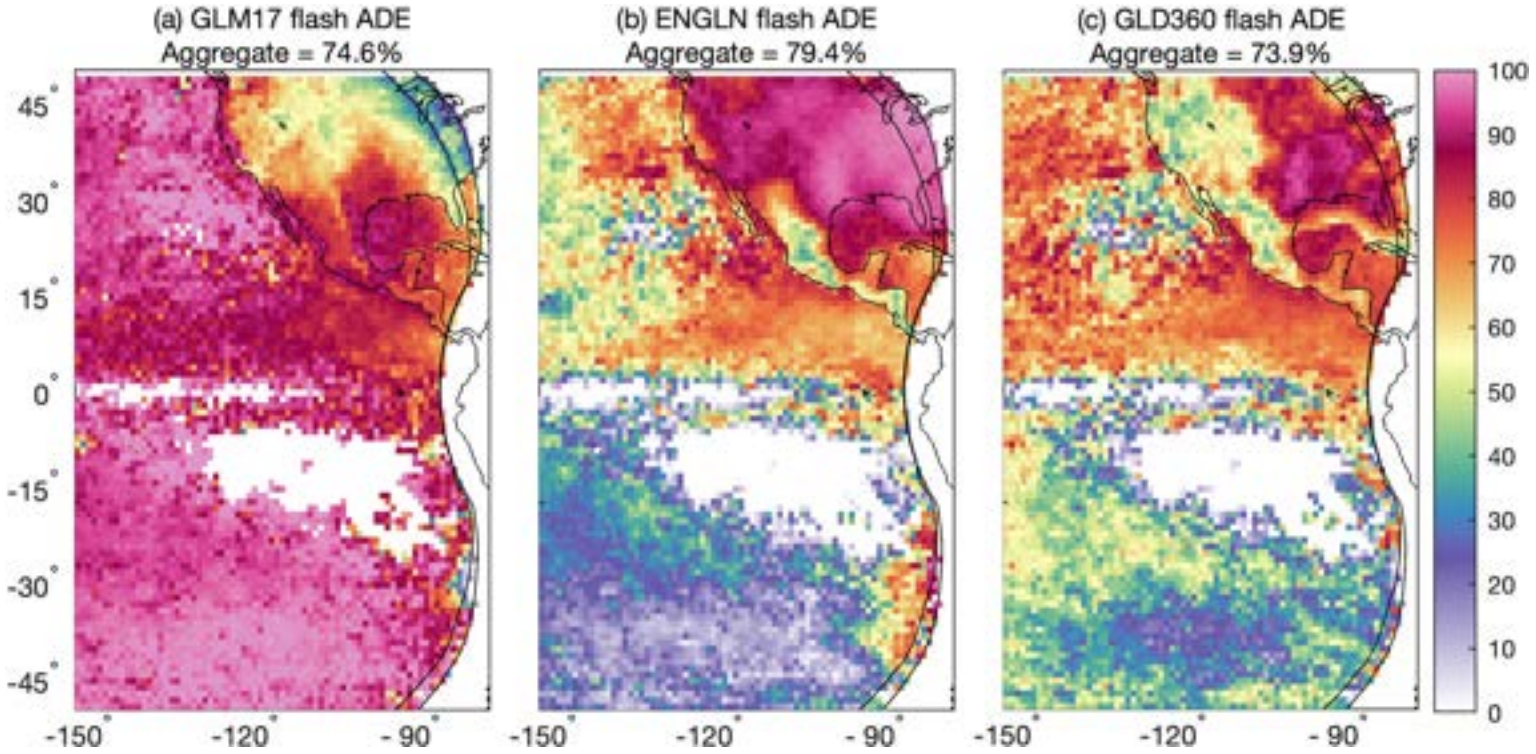
- Begin analysis after the blooming filter was implemented
- ENGLN and GLD360 stroke/pulse data clustered into flashes using Weighted Euclidean Distance (parameters ±330 ms and 5.5 km)
- Flash matching criteria: ±1 s and 50 km

Three-GLM comparison



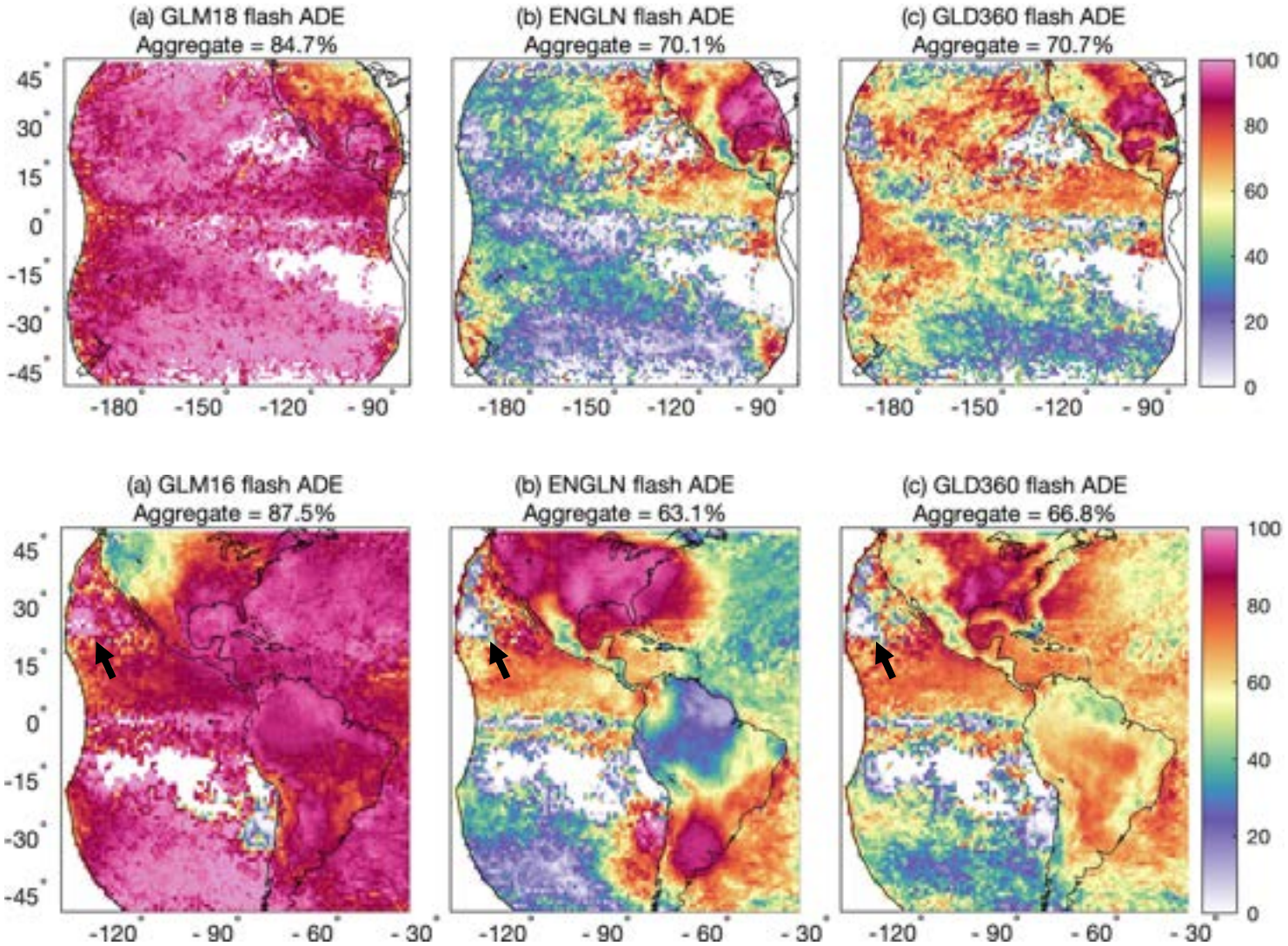
- Three-GLM comparison possible from 1 Nov 2022 – 10 Jan 2023
  - ~4.5-5.0 million flashes
- GLM16/18 aggregate ADE 92% over all flashes
  - GLM17 ADE was ~8% lower
- Lower ADE near FOV edges, western US (GLM16), and southern Pacific

GLM17 performance



- GLM17 aggregate ADE ~75% is comparable to the ground networks for this domain
- ENGLN has largest spatial ADE variations and performs best over CONUS
- GLD360 has fewer spatial variations than ENGLN and lower ADE for this domain
  - Artifact visible at the boundary between NLDN and GLD coverage

GLM18/16 performance



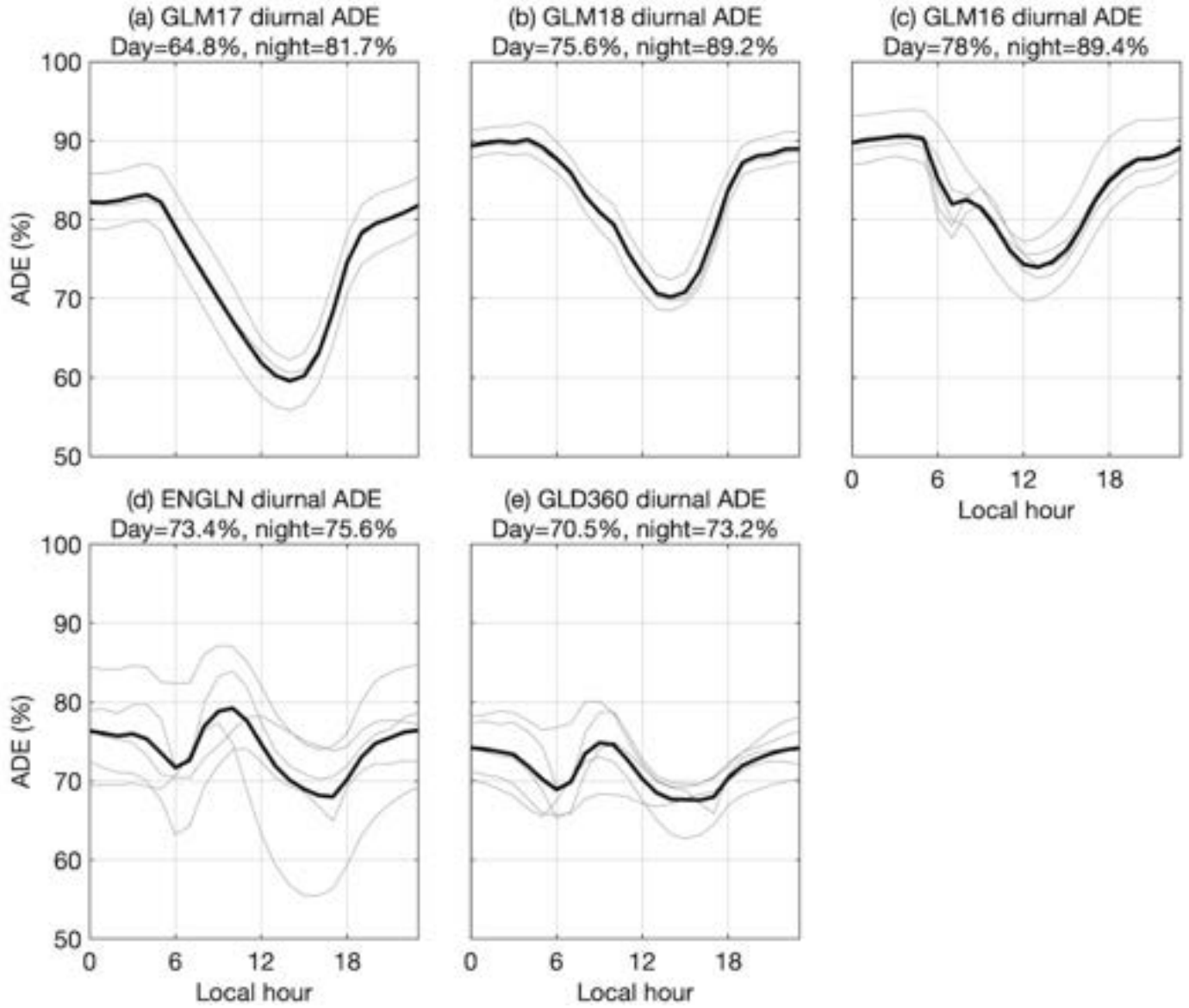
- GLM18/16 out-perform both reference networks (ADE=85-88%)
- GLM blooming artifacts produce locally low reference network ADE

GLM flash ADE in the overlap region

GLM17		GLM18		GLM16	
Analyzed With	*ADE*	*Analyzed With*	*ADE*	*Analyzed With*	*ADE*
GLM16, ENGLN	68.7%	GLM16, ENGLN	80.6%	GLM17, ENGLN	79.5%
GLM16, GLD360	73.1%	GLM16, GLD360	82.3%	GLM17, GLD360	84.4%
GLM16, GLM18	84.8%	GLM16, GLM17	92.7%	GLM17, GLM18	92.3%
ENGLN, GLD360	74.4%	ENGLN, GLD360	84.1%	ENGLN, GLD360	84.8%
				GLM18, ENGLN	82.0%
				GLM18, GLD360	83.6%
Median	**73.8%**	**Median**	**83.2%**	**Median**	**84.0%**

GLM18 ADE is ~10% higher than GLM17, and similar to GLM16

Diurnal variability of GLM ADE



- Gray lines = hourly ADE from 3-way comparisons involving at least one GLM and one ground network
- GLM16/18 ADE:
  - Remains above 70% throughout the diurnal cycle
  - Diurnal amplitude is ~11-14%
- GLM17 has larger diurnal amplitude and is as low as 60% during the afternoon
- Maxima in GLM false flashes around 06-07 and 16-17 LT create semi-diurnal cycle in reference network ADE

Conclusions

- GLM and reference network ADE largely follow expected geographical patterns
- GLM16/18 aggregate flash ADE is 83-84%
  - GLM17 flash ADE is 10% lower
  - Each GLM has ~100% ADE over some oceanic areas
- Diurnal amplitude of GLM16/18 ADE is 11-14%, minimizing ~13-14 LT
- GLM16/18 aggregate ADE is >70% throughout the diurnal cycle

Thank You!

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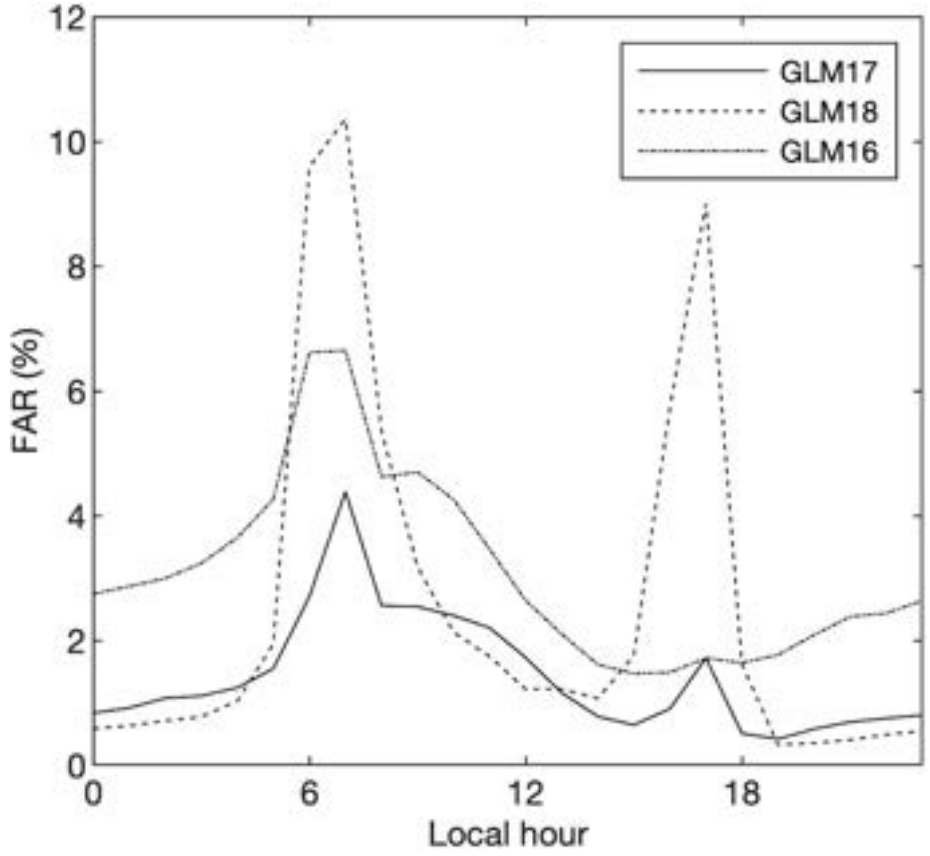
Diurnal variability of GLM false alarms



- GLM false alarms spike around 06-07 and 16-17 LT due to solar intrusion and blooming
- These artifacts artificially decrease the ground network ADE