Inter-comparison of Lightning Trends from Ground-based Networks during Severe Weather: Applications toward GLM

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Motivation

- Total lightning flash rate trends have demonstrated value for forecasting high impact weather.
- Total lightning trends are well observed by VHF systems like the Northern Alabama Lightning Mapping Array (NALMA)
  - > 90% flash detection efficiency within about 100-150 km
  - Fine spatial resolution (< 1 km) at those ranges.
- To expand GOES-R GLM (Geostationary Lightning Mapper) proxy applications for high impact convective weather (e.g., severe, aviation hazards) research, it is desirable to investigate utility of additional sources of *continuous* (total) lightning
  - that can serve as suitable GLM proxy over **large** spatial scales (order 100's to 1000 km or more)
  - including typically data denied regions such as the oceans.

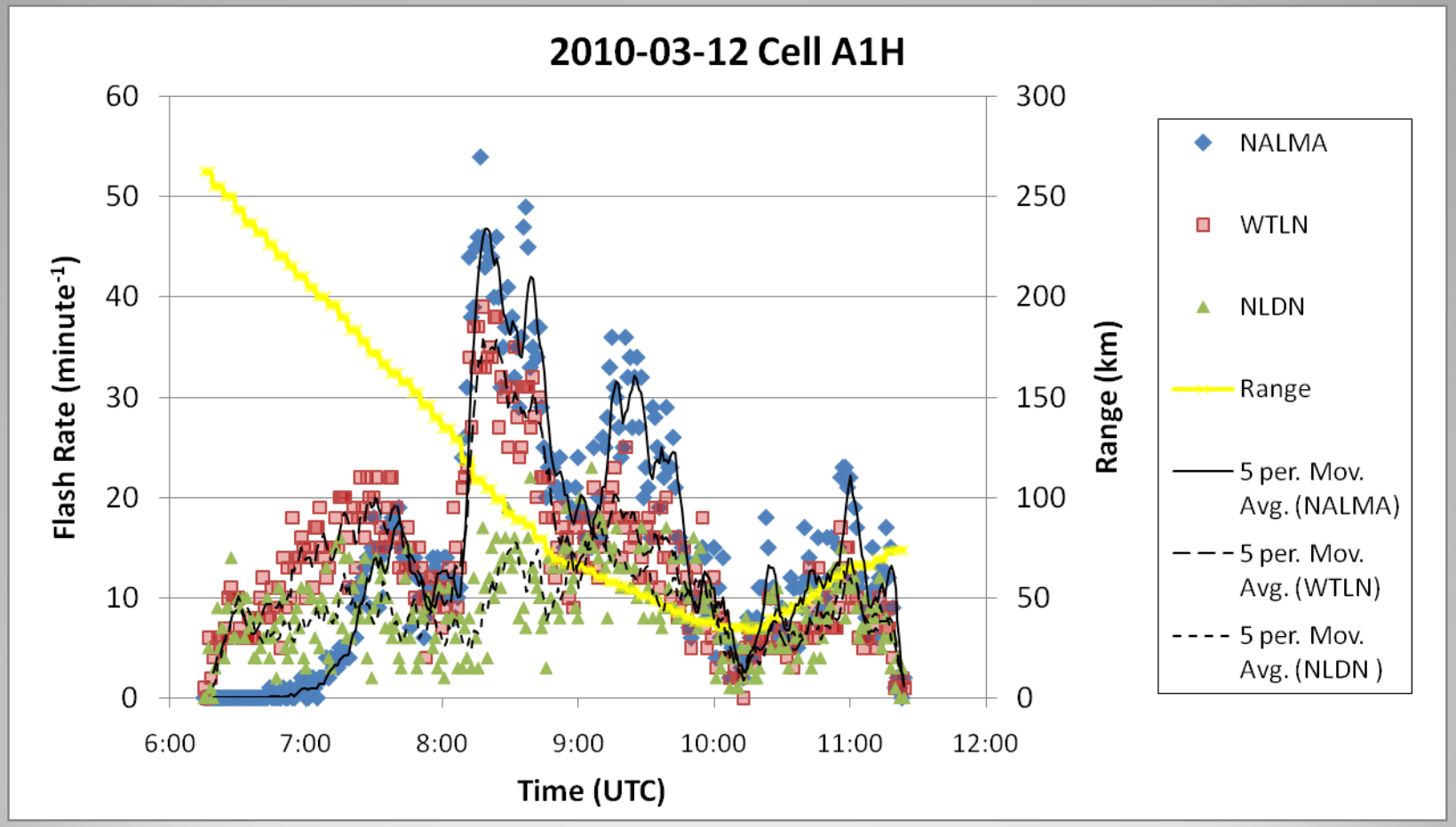
Data and Methodology

- Potential sources of GLM proxy include ground-based long-range regional VLF/LF lightning networks such as **Weatherbug Total Lightning Network (WTLN)**
  - For comparison, consider Vaisala **National Lightning Detection Network (NLDN)** all flash data (CG+IC)
- Use NALMA as a reference source of total lightning
  - Consider effect of range on NALMA flash detection efficiency (0-50, 50-100, 100-150, 150-200 km range bins)
- Approach: **Convective-cell** based total lightning flash *rates* and *trends*
  - Tailored to test directly the efficacy of total lightning data sources in potential weather applications and algorithms like lightning jump (LJ)
  - Integrates both detection efficiency and location accuracy effects

Data and Methodology

- Cell identification and tracking using NCAR's Thunderstorm Identification, Tracking and Nowcasting (TITAN) algorithm (Dixon and Weiner 1993)
  - WSR-88D data (e.g., KHTX Hytop radar in N. Alabama)
  - Tracking > 35 dBZ features at -13° C (5-7 km) following LJ algorithm by Schultz et al. (2009, 2011)
- Locations and major axes of tracked radar echo ellipsoids used to bin NALMA, WTLN and NLDN total lightning flashes every 1-minute into "cells".
  - Compare cell-based total flash rates and trends from each lightning network for sample of severe and non-severe cells.
- 70 tracked cells for 6188 minutes on 8 days in N. Alabama
  - 3/12/2010, 4/25/2010, 7/26/2010, 8/5/2010, 9/11/2010*, 10/26/2010, 3/30/2011, 4/27/2011 (*non-severe)

Severe supercell storm: large hail (some over 2”), winds



Results – Cell A1H, 3/12/2010

Ratio of mean cell flash rates by range (km) of cell from NALMA center

Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
WTLN/NALMA	0.70	0.71	0.83	1.53
NLDN/NALMA	0.66	0.50	0.31	0.79

Mean temporal correlation of cell flash rate (2 minute average) by range (km) of cell from NALMA center

Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
(WTLN,NALMA)	0.88	0.85	0.98	0.12
(NLDN,NALMA)	0.60	-0.08	0.33	-0.28

Results – Cell A1H, 3/12/2010

Ratio of mean (median) cell flash rates* by range (km) of cell from NALMA center

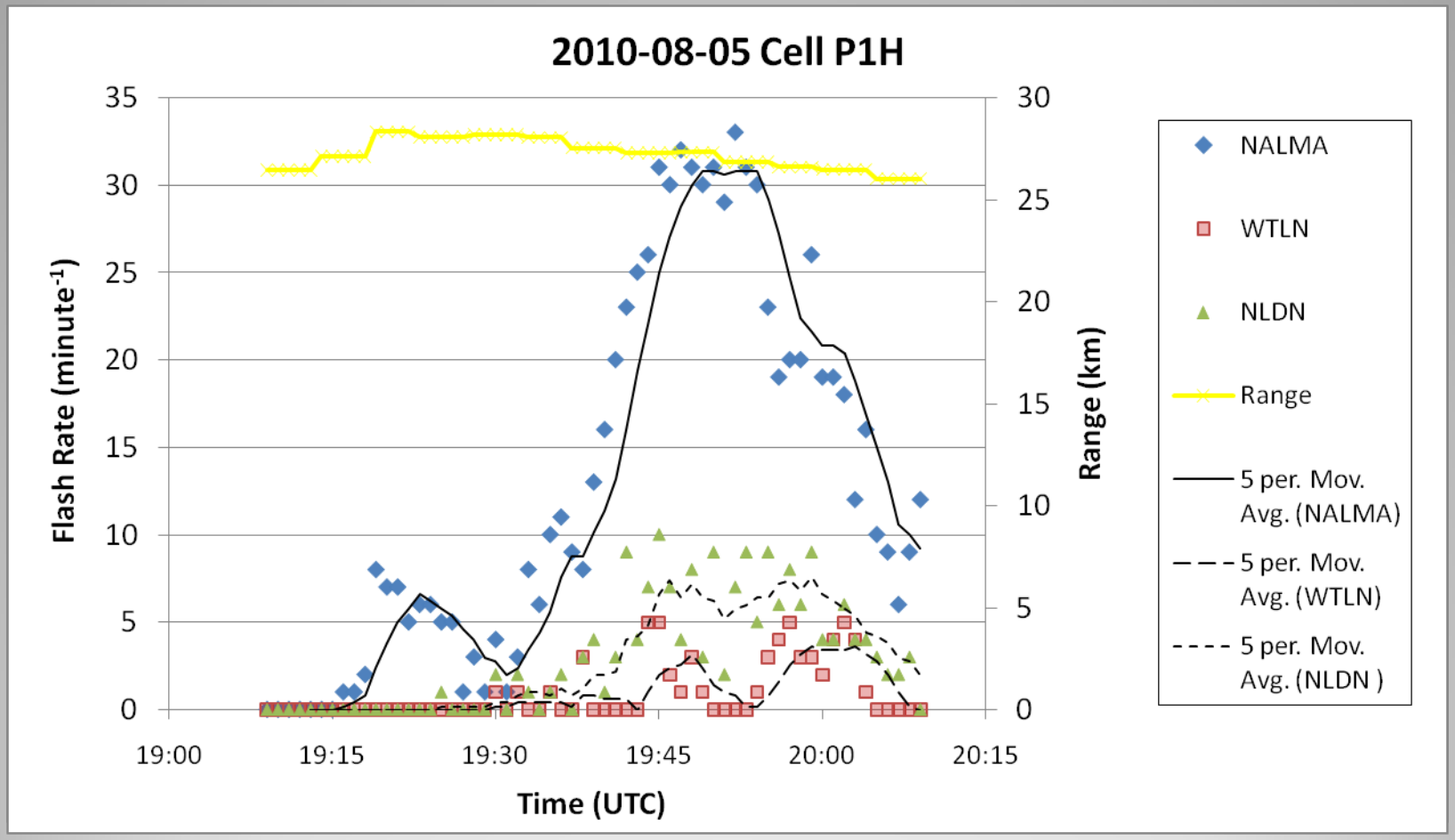
Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
WTLN/NALMA	0.50 (0.44)	0.80 (0.63)	1.12 (1.0)	1.63 (1.43)
NLDN/NALMA	0.41 (0.33)	0.57 (0.38)	1.03 (0.63)	1.16 (0.71)

Mean temporal correlation of cell flash rate* (2 minute average) by range (km) of cell from NALMA center

Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
(WTLN,NALMA)	0.77	0.66	0.65	0.60
(NLDN,NALMA)	0.46	0.45	0.30	0.30

Results – All 70 cells

* Conditional – eliminated consensus non-lightning periods



Results – 8/5/2010, different

Ratio of mean (median) cell flash rates* by range (km) of cell from NALMA center

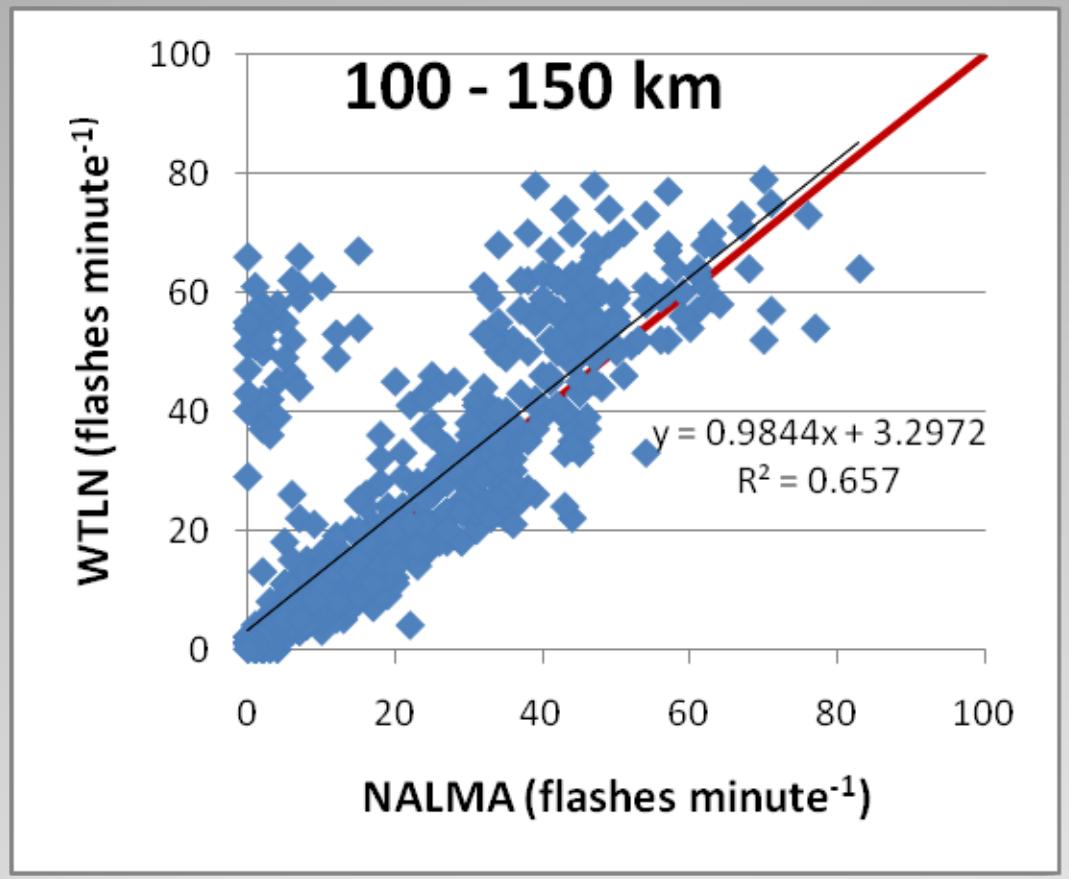
Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
WTLN/NALMA	0.58 (0.63)	0.90 (0.73)	1.19 (1.13)	1.63 (1.43)
NLDN/NALMA	0.43 (0.38)	0.48 (0.36)	0.83 (0.63)	1.16 (0.71)

Mean temporal correlation of cell flash rate* (2 minute average) by range (km) of cell from NALMA center

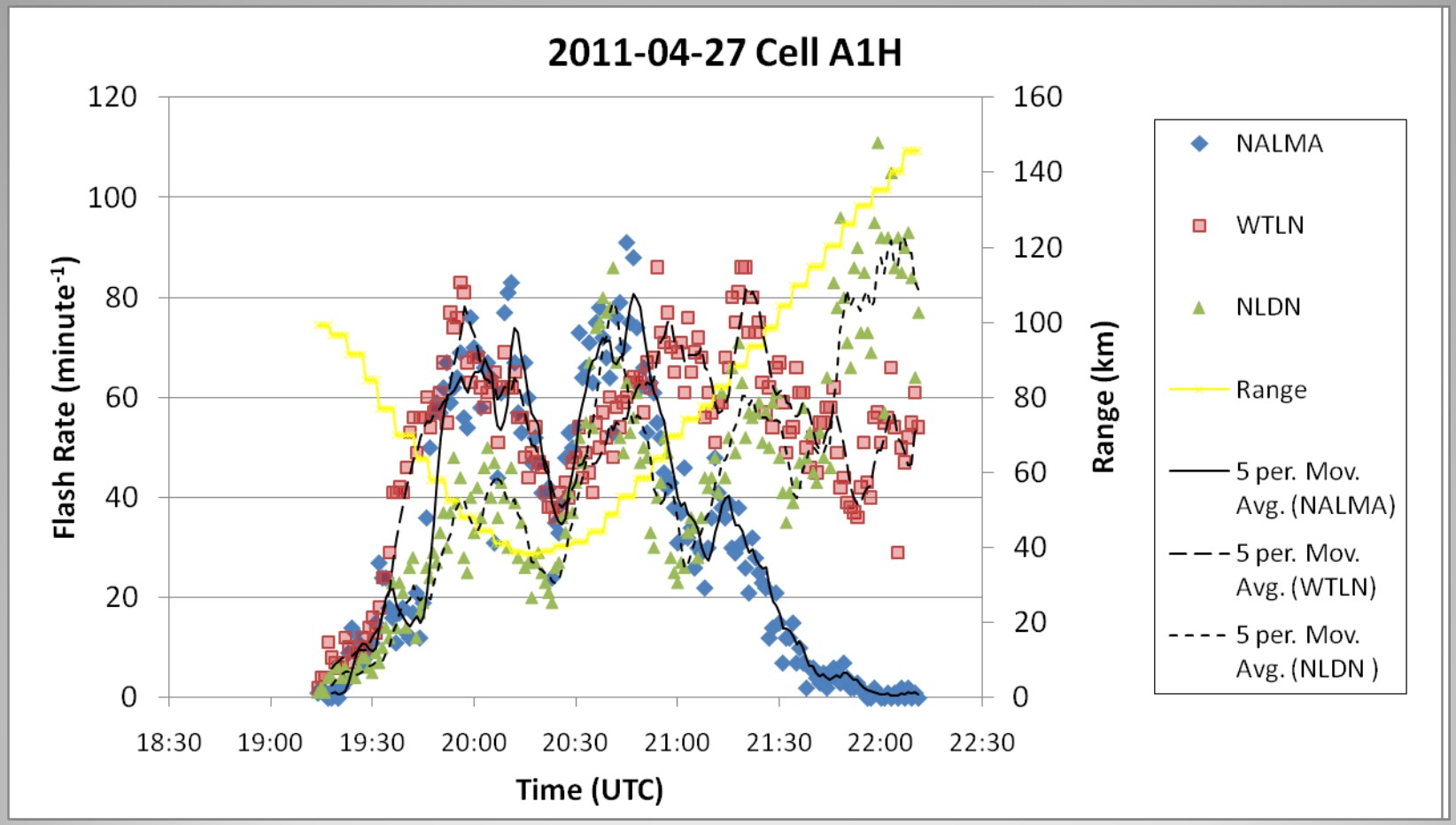
Range (km)	0 - 50	50 – 100	100 – 150	150 – 200
(WTLN,NALMA)	0.81	0.82	0.75	0.60
(NLDN,NALMA)	0.43	0.43	0.27	0.30

Results – All cells except 8/5/2010

* Conditional – eliminated consensus non-lightning periods



Results – WTLN vs. NALMA cell flash rates by range



Results – Some more examples

Summary

- Comparison between NALMA and WTLN total lightning flash rates are reasonable
  - WTLN cell flash rates are 45% to 60% (60% to 90%) of NALMA cell flash rates at 0–50 km (50–100 km) range, in the mean/median
  - By 100-150 km range, mean WTLN and NALMA cell flash rates are comparable
- Importantly for Lightning Jump, the temporal trend of the WTLN cell flash rate is reasonably correlated to NALMA cell flash rate ($\rho \approx 0.8$ at 0-150 km range, in the mean)
- Evaluation of proxy data is ongoing and being accomplished in a holistic fashion, focusing on both the lightning measurement and the meteorological application
  - Stroke/flash matching, gridded products, cell-based
- Evaluating a variety of VLF/LF lightning network data sources by inter-comparison with NALMA and TRMM LIS
  - GLD-360, NLDN, WTLN, WWLLN