Lightning Jump Algorithm for Proxy GOES-R Lightning Mapper Data

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Introduction

- Lightning Jump Algorithm (LJA) developed by Schultz et al. (2009, 2012) uses Lightning Mapping Array (LMA) data to suggest likelihood of subsequent severe weather

- Geostationary Lightning Mapper (GLM) on GOES-R will see flashes differently than LMA, yielding different flash counts and locations

- Full automation of LJA using GLM-like data needed before operational implementation

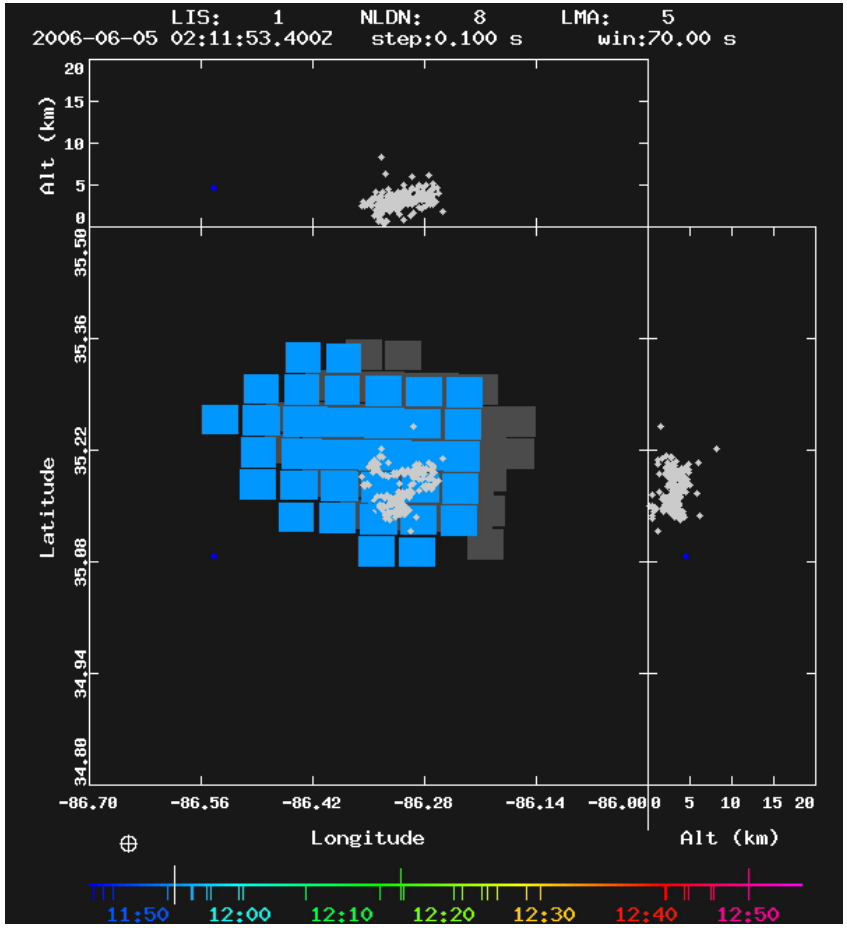
- *Robust storm cell tracking needed in order to compute flash rate history / tendency*

Lightning Jump Algorithm

More info in Schultz et al. TJ30.4 (6MALD)

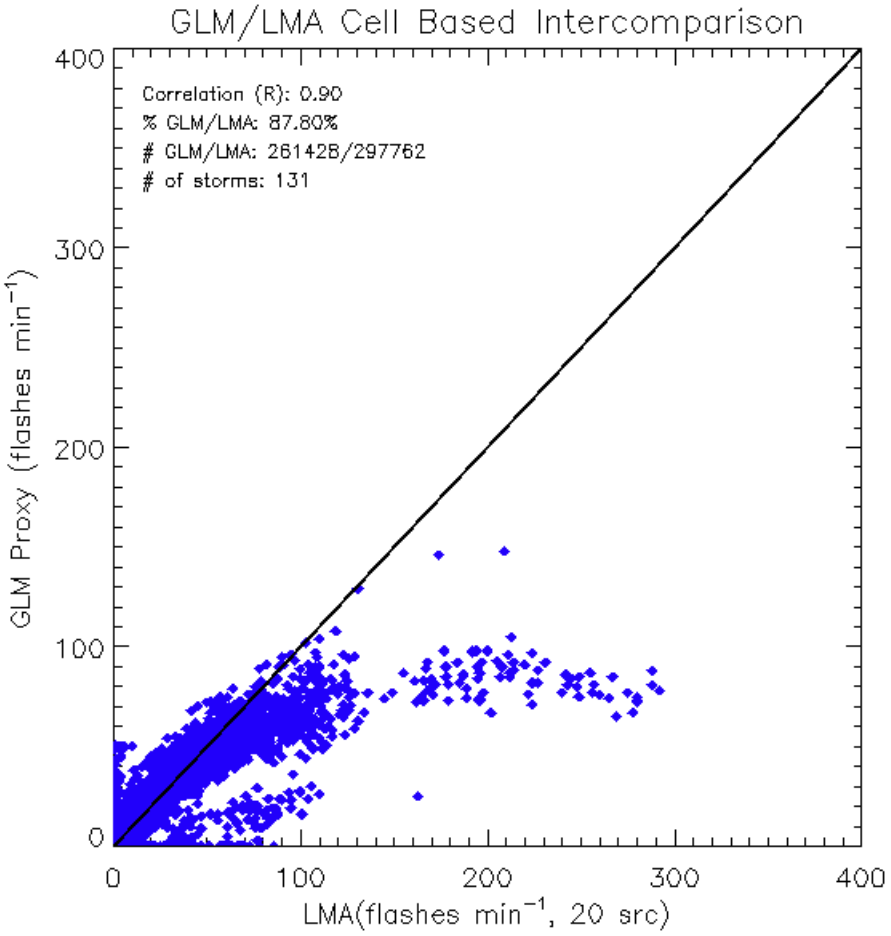
- The LJA Can:
  - Indicate when an updraft is strengthening or weakening on shorter timescales than current radar and satellite
  - Identify when severe or hazardous weather potential has increased
  - “Tip the scales” on whether or not to issue a severe warning
- The LJA Cannot:
  - Predict severe weather potential in every severe storm environment.
  - Discern severe weather types
    - i.e., a certain jump does not mean there will be a certain type of severe weather
  - Issue specific types of severe warnings

Transition from LMA to GLM Proxy



- Observations from LMA ≠ GLM
  - Different instrument
  - Different frequency
  - Different part of flash (RF sources along the channel, vs illuminated cloud top)
- Must transition product from LMA to GLM proxy data stream
- First step, using current GLM Proxy (***see Bateman poster 725, Wednesday 2:30-4:00***)

Transition from LMA to GLM Proxy



- Compared 1-minute flash rates in LMA and GLM for 131 storms
  - 20+ sources per flash threshold
- GLM Proxy flash count is ~88% of the LMA flash count
- Correlation in the trends are strong
  - R= 0.9
- GLM flash rates have a ceiling at ~100 flashes per minute

Fields Used for Cell Tracking

2002-11-11 00:58 UTC

Flct5: 5-minute GLM proxy flash count, updated every minute

VIL: Vertically Integrated Liquid (radar)

VILFRD: VIL combined with 5-minute Flash Rate Density

$$VILFRD = 100 * (((VIL/45) \le 1) + (sqrt(Flct5/45) \le 1))$$

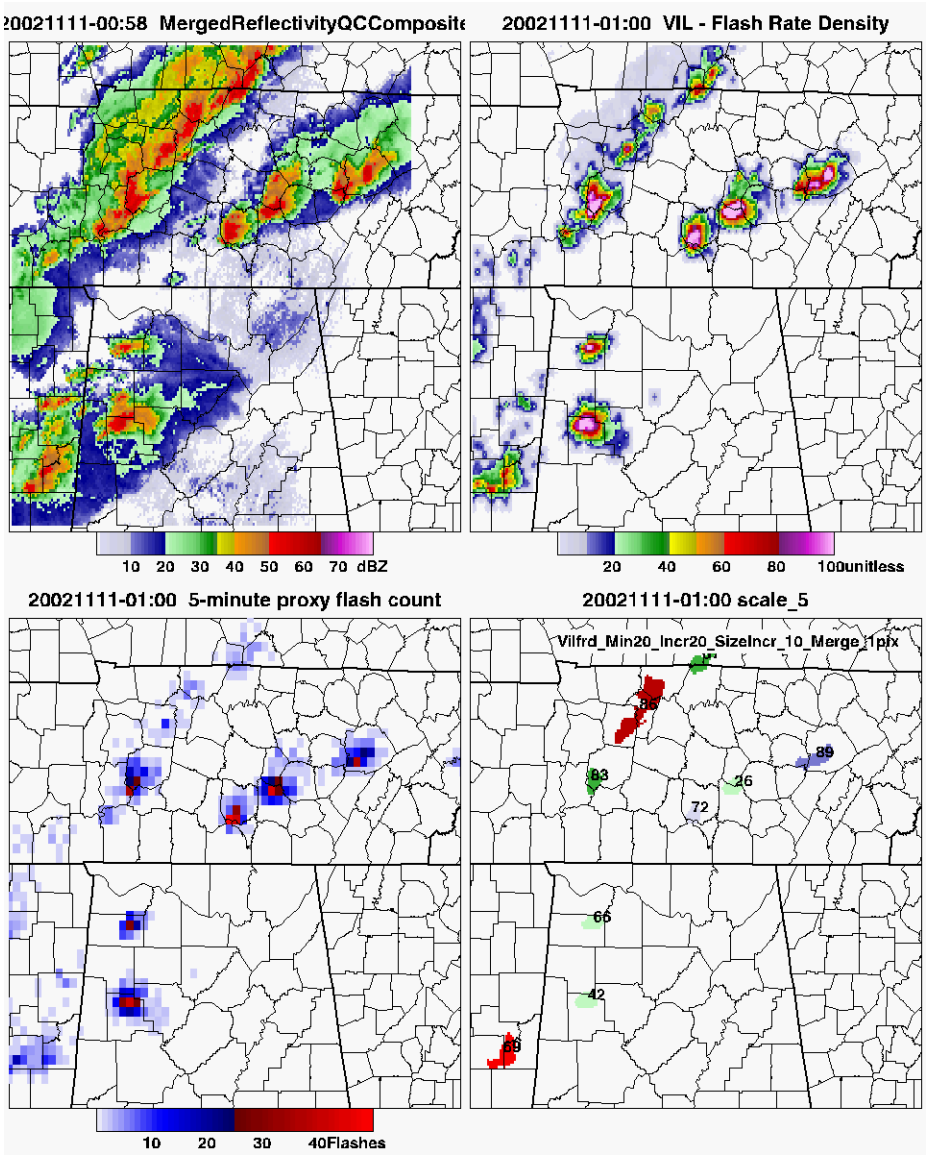
Track values where VILFRD ≥ 20, using increments of 20, with anything over 100 set to 100.

Tracker (**WDSSII *w2segmotionll***) builds cells until a minimum size threshold is met. Several sizes tested; we use ~200 km^2 for large storms, ~80 km^2 for smaller storms.

First see if values exceeding 100 cover large enough area (e.g., cells 26, 42, 72, 83)

If not, include values exceeding 80 (e.g., cells 66, 89)

If not, include values exceeding 60 (e.g., cell 66, 89), 40 (e.g., cell 69), or 20 (e.g., cell 36).

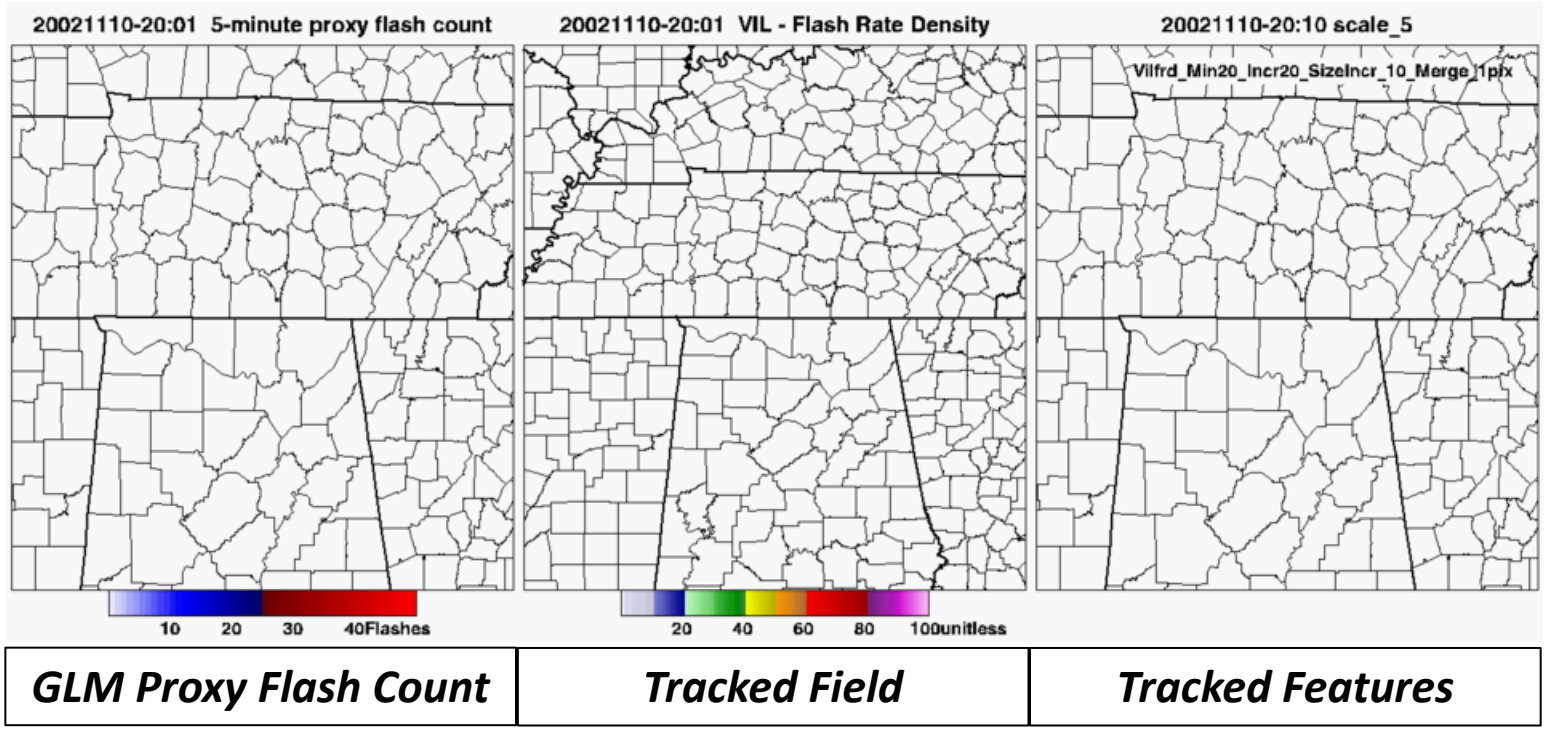


Cell Tracking

Left: *GLM Proxy Flash Count*

Middle: *Combined VIL-Flash Density Field*

Right: *Tracked Features*



Tracking uses WDSSII *w2segmotionll*, with **maximum overlap** approach for associating cells from one time step to the next.

Cells are projected forward from time *t* to *t+1* (1-minute increments, so projected motion has very little effect)

If an observed cell at *t+1* matches a cell location projected forward from *t*, within (5 km) or (1 x Size of Cell), then it is associated with that previously identified cell's history.

If a cell disappears in one time step, it cannot re-appear later.

Outside WDSSII, "broken tracks" are objectively merged. If WDSSII has a new cell begin at *t+1* within 20 km of where a previous cell track ended at time *t*, those cell histories are tied together. (This last step is not reflected in animation, but is in flash rate time series .)

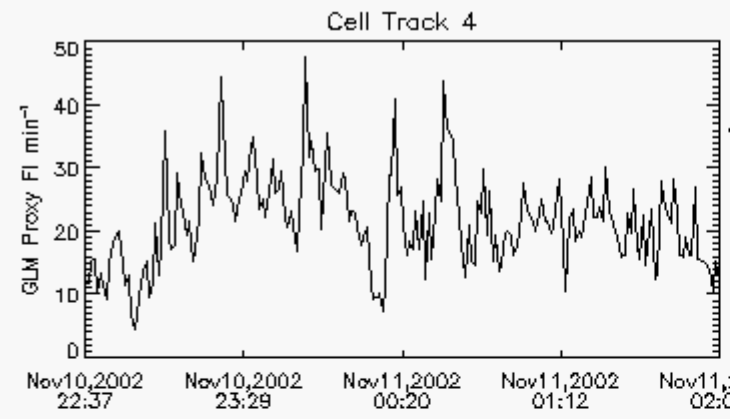
In example above, Cell 7 becomes 14, becomes 27…

Integration of LJA algorithm with WDSSII Cell Tracking of GLM Proxy + Radar VIL

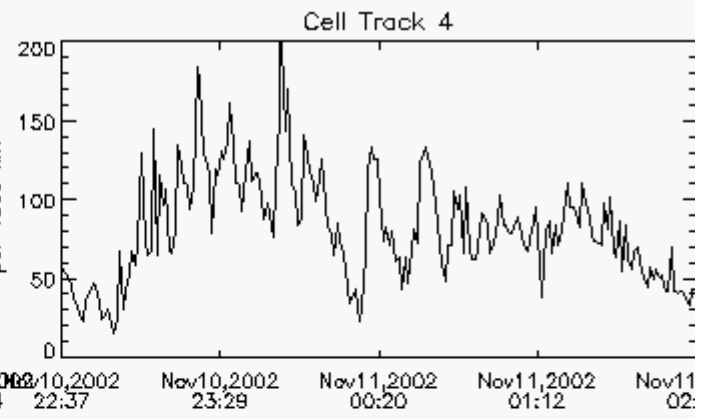
Time Series of Cell #4 (#26 in animation)

2002-11-10/22:37 – 2002-11-11/02:04 UTC

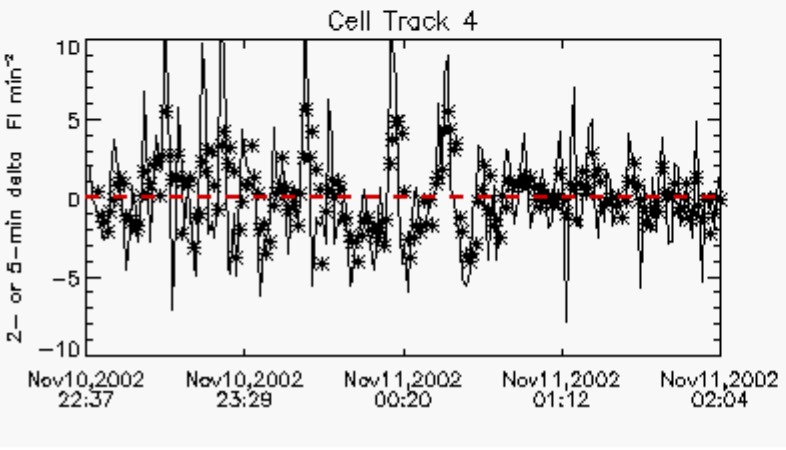
GLM Proxy Flash Rate



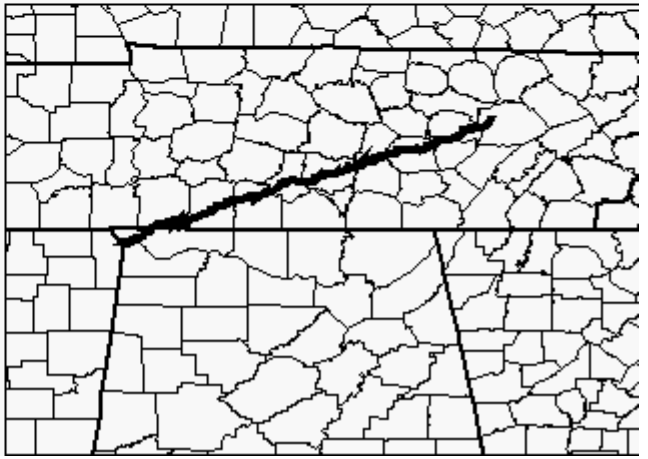
GLM Proxy Flash Density



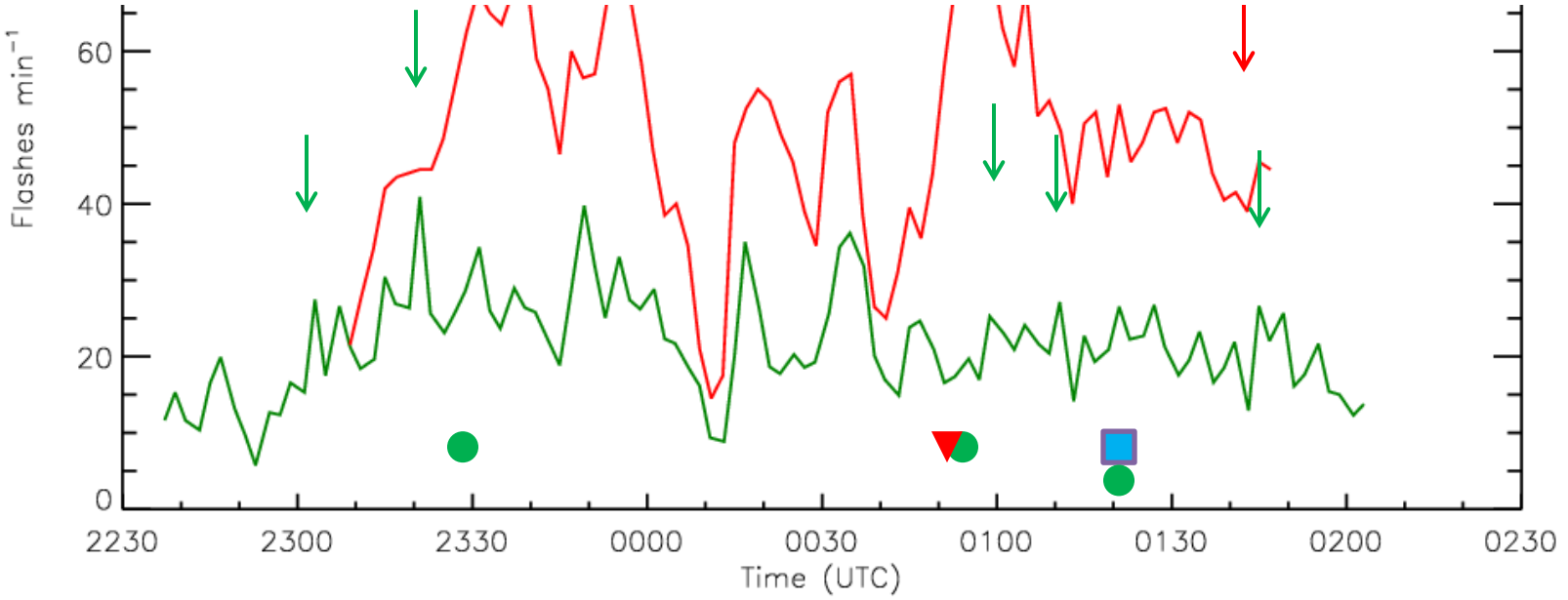
GLM Proxy Flash Rate DELTA



Cell #26 Track



- Tendency for more jumps in GLM proxy data while using original 2σ LJA settings (i.e., based on LMA flashes)
- Unmodified 2σ LJA implemented on ***small*** sample (so far, 19 storms) with tracked GLM proxy objects results in
  - Higher POD (24 hits/27 severe = 89%) than Schultz et al. (2011) (79%)
  - Higher FAR (49%) than Schultz et al. (2011) (36%)
  - Lower CSI (48%) than Schultz et al. (2011) (55%)
  - Similar lead time (21.5 ± 12.8 min) to Schultz et al. (2011) (20.7 ± 15.1 min)
- Working on ***increasing sample size*** of tested GLM proxy-based storms
  - More robust statistics
  - Assess if and what kind of required modifications to GLM proxy-based LJA

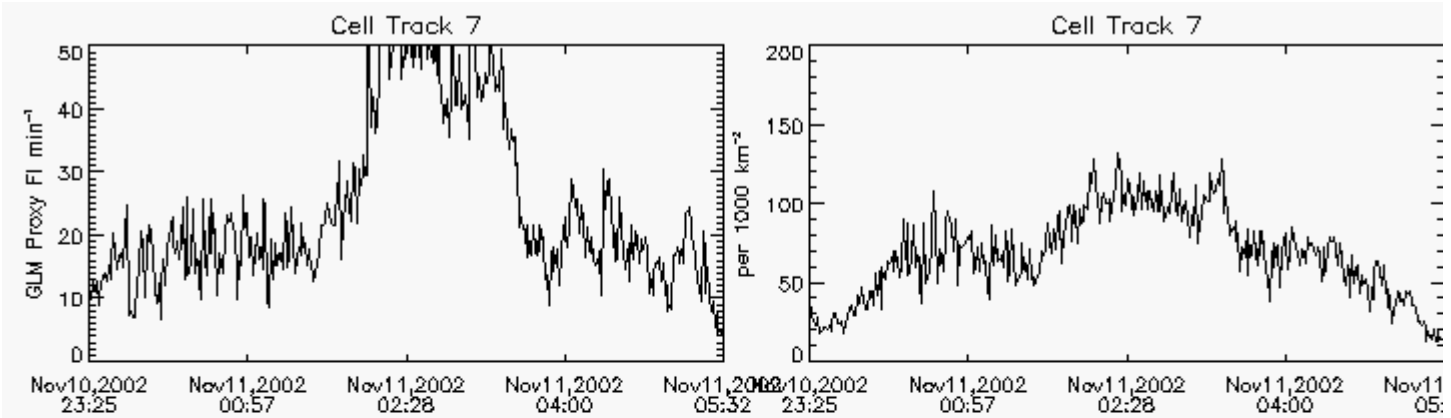


Integration of LJA algorithm with WDSSII Cell Tracking of GLM Proxy + Radar VIL

Time Series of Cell #7 (#42 in animation)

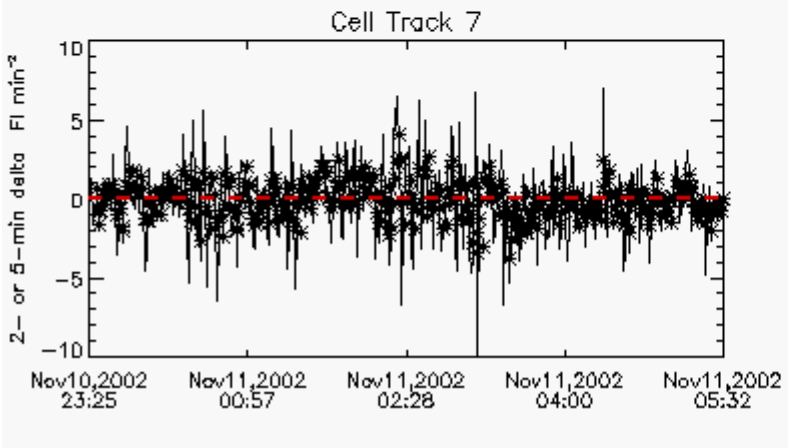
2002-11-10/23:25 – 2002-11-11/05:32 UTC

GLM Proxy Flash Rate

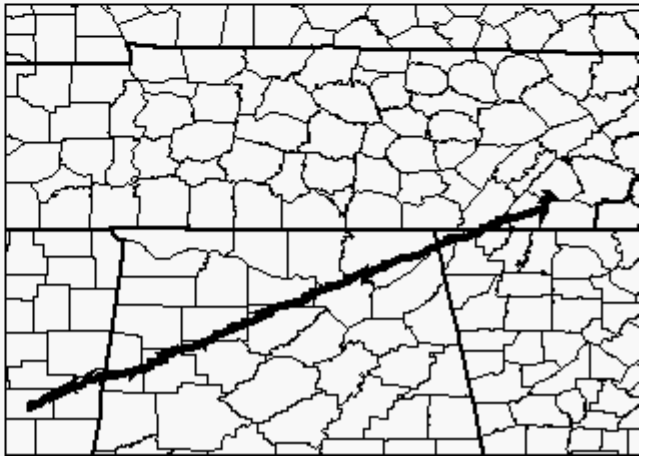


GLM Proxy Flash Density

GLM Proxy Flash Rate DELTA

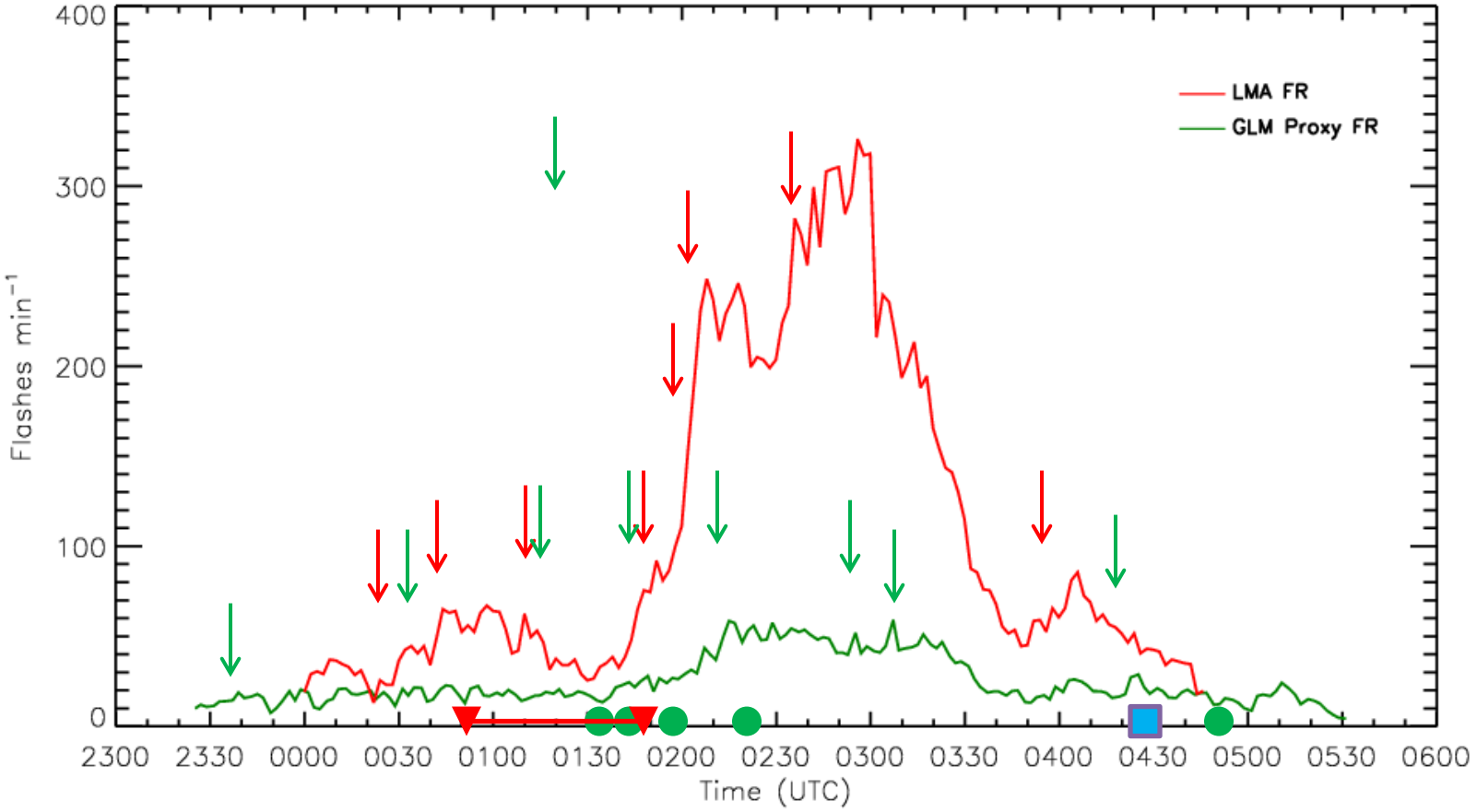


Cell #26 Track



LMA vs. GLM Proxy Flash Rate and Jumps

Cell 7 / Cell H 11-11-02



GLM Jump: ↓ LMA Jump: ↓

Tornado: ▼ Hail: ● Wind: ■

Summary of Ongoing Work

- **Refining and developing GLM lightning proxy database (M. Bateman)**
  - Transformed VHF-based NA-LMA to optical lightning proxy using LIS and statistical-physical methods
  - Developed representative proxy lightning (e.g., GLM resolution, 8 km) for 37 events (100's of cells) from 2002-2010 over NA-LMA. Turn-key for new cases, as needed.
- **Improving multi-sensor (GLM proxy, radar) cell (object)-oriented tracking**
  - Optimized current WDSS-II/K-means cell tracking algorithm to reduce tracking ambiguity for LJA
- **Developing LJA as an automated objective system**
  - Began adaptation of LJA (rules, thresholds) to GLM proxy and multi-sensor object tracking improvements

Summary of Potential Future Work:

- **Test LJA/Cell-tracker/GLM proxy system in Proving Ground (PG) and local WFO's**
  - Make improvements to *LJA and verification methods* based on direct user feedback
  - Leverage NASA SPoRT's capability in transitioning NASA products to the NWS/PG
  - Merge GLM proxy work into the LJ National Demonstration and Evaluation at PG in Norman
- **Develop LJA training materials**
  - To educate end users on LJA theoretical basis, methods, expected algorithm performance, strengths/limitations, optimal uses in situational awareness
- **Explore LJA in multi-sensor/multi-parameter forecaster methods and algorithms**
  - Investigate optimal synthesis of LJA with WSR-88D radar and GOES-R ABI algorithms for improved situational awareness