An Overview of the Total Lightning Jump Algorithm: Past, present and future work

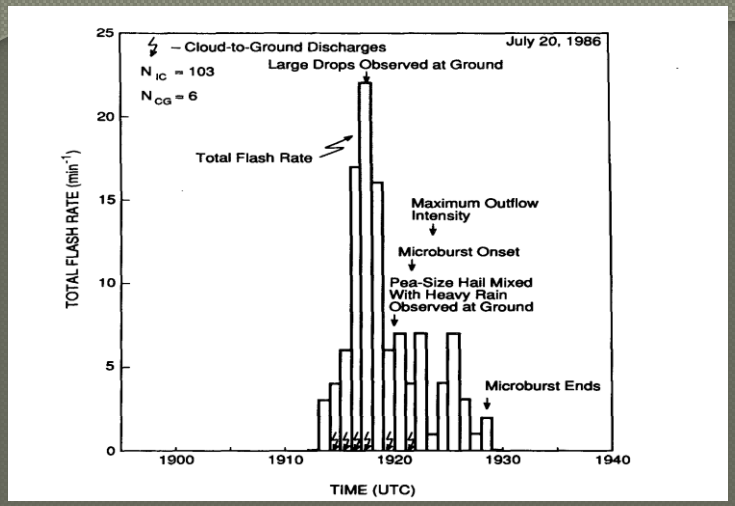
Christopher J. Schultz[1], Walter A. Petersen[2], Lawrence D. Carey[3*]

1 - Department of Atmospheric Science, UAHuntsville, Huntsville, AL

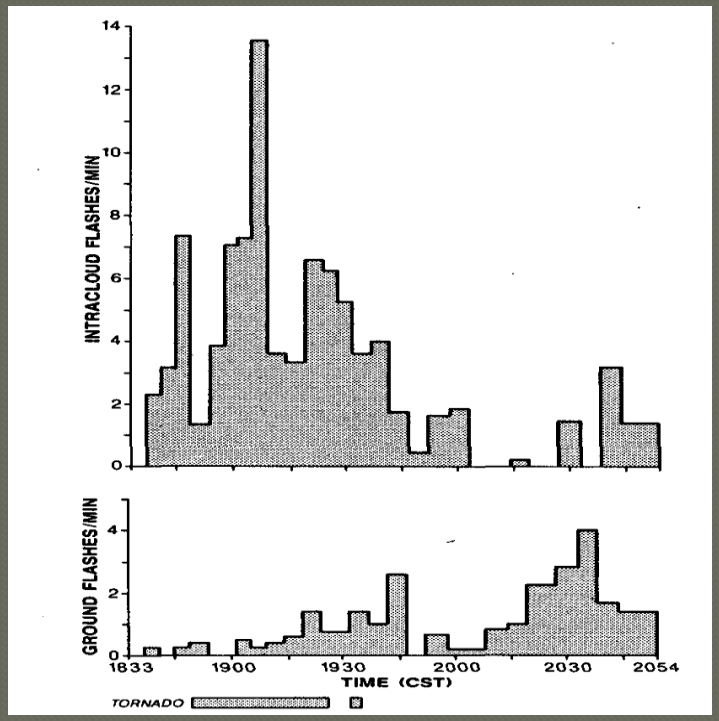
2 – NASA Marshall Space Flight Center, Huntsville, AL

3 – Earth System Science Center, UAHuntsville, Huntsville, AL

The Foundation



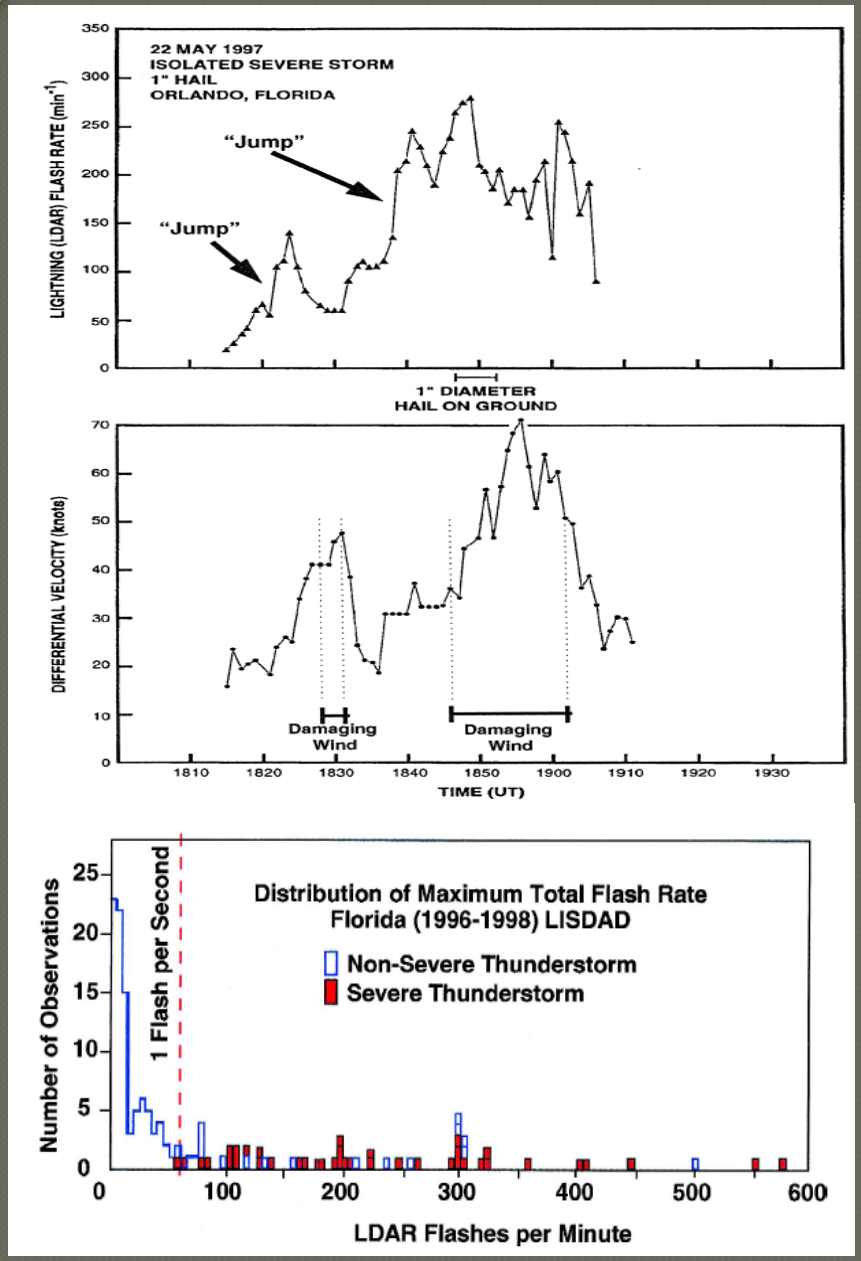
Adapted from Goodman et al. (1988)



Adapted from MacGorman et al. (1989)

- **Goodman et al. (1988) demonstrated that total lightning peaked prior to the onset of a microburst.**
- **Williams et al. (1989) showed that the peak total flash rate correlated with the maximum vertical extent of pulse thunderstorms, and preceded maximum outflow velocity by several minutes.**
- **MacGorman et al. (1989) showed that the total flash rate peaked 5 minutes prior to a tornado touchdown, while the cloud-to-ground (CG) flash rate peaked 15 minutes after the peak in intra cloud flash rate.**

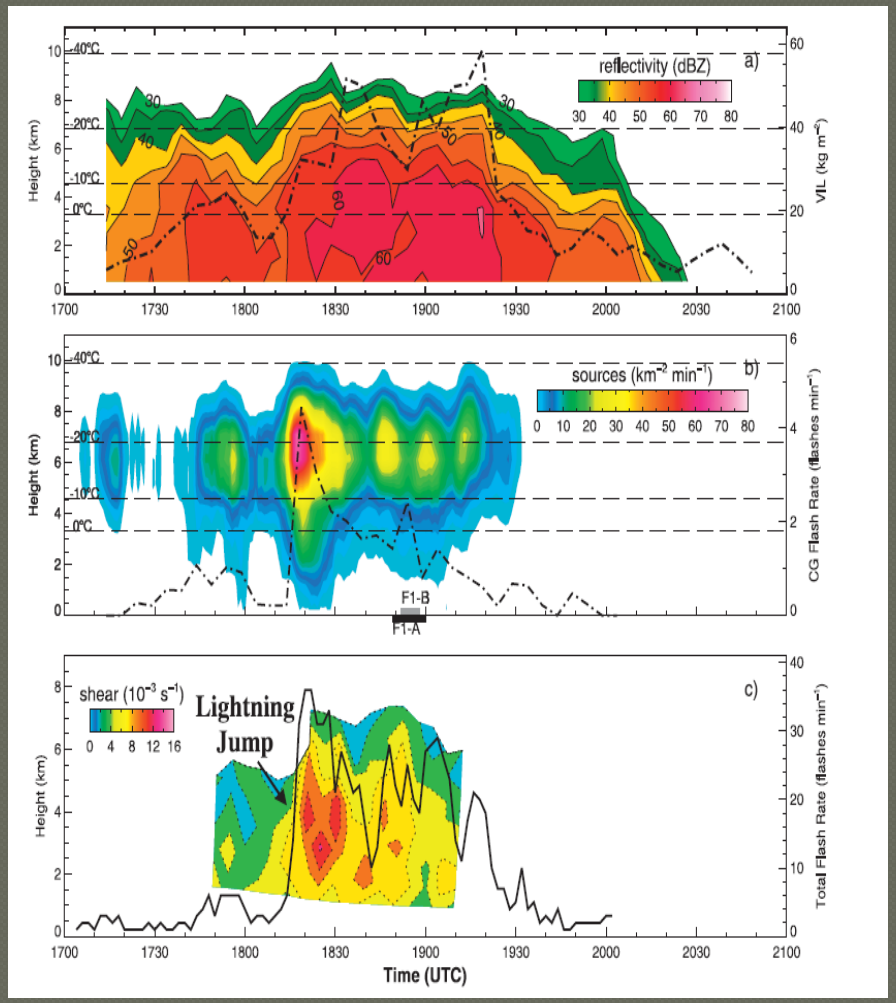
Previous work: lightning jumps



Adapted from Williams et al. (1999) (above)

- Williams et al. (1999) examined a large number of severe storms in Central FL
- Noticed that the total flash rate "jumped" prior to the onset of severe weather.
- Williams also proposed 60 flashes min^{-1} or greater for separation between severe and non-severe thunderstorms.

The Lightning Jump Framework



- Gatlin and Goodman (2010) , JTECH; developed the first lightning jump algorithm
- Study proved that it was indeed possible to develop an operational algorithm for severe weather detection
- Mainly studied severe thunderstorms
  - Only 1 non severe storm in a sample of 26 storms

Adapted from Gatlin and Goodman (2010)

Schultz et al. (2009), JAMC

- Six separate lightning jump configurations tested
- Case study expansion:
  - 107 T-storms analyzed
    - 38 severe
    - 69 non-severe
- The "2σ" configuration yielded best results
  - POD beats NWS performance statistics (80-90%);
  - FAR even better i.e.,15% lower (Barnes et al. 2007)
    - Caveat: Large difference in sample sizes, more cases are needed to finalize result.

Thunderstorm breakdown:

North Alabama – 83 storms

Washington D.C. – 2 storms

Houston TX – 13 storms

Dallas – 9 storms

Algorithm	POD	FAR	CSI	HSS
Gatlin	90%	66%	33%	0.49
Gatlin 45	97%	64%	35%	0.52
2σ	87%	33%	61%	0.75
3σ	56%	29%	45%	0.65
Threshold 10	72%	40%	49%	0.66
Threshold 8	83%	42%	50%	0.67

Schultz et al. 2011, WAF

- Expanded to 711 thunderstorms
  - 255 severe, 456 non severe
  - Primarily from N. Alabama (555)
  - Also included
    - Washington D.C. (109)
    - Oklahoma (25)
    - STEPS (22)

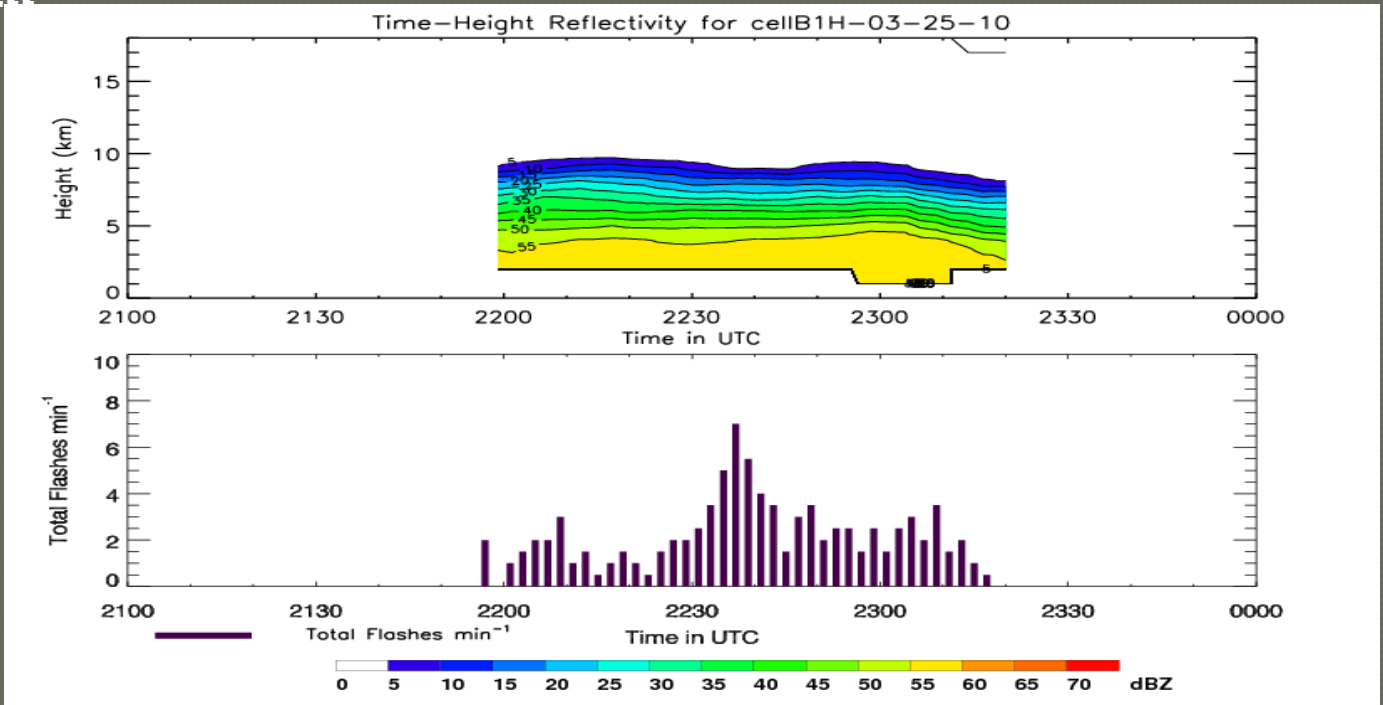
TABLE 3. Skill scores and average lead times using the sample set of 711 thunderstorms for both total lightning and CG lightning, correlating trends in lightning to severe weather.

	POD	FAR	CSI	HSS	lead time (all)	lead time (tornado)
Total lightning	79%	36%	55%	0.71	21.22 mins	20.94 mins
CG lightning	66%	53%	38%	0.55	13.54 mins	15.24 mins

Understanding Limitations

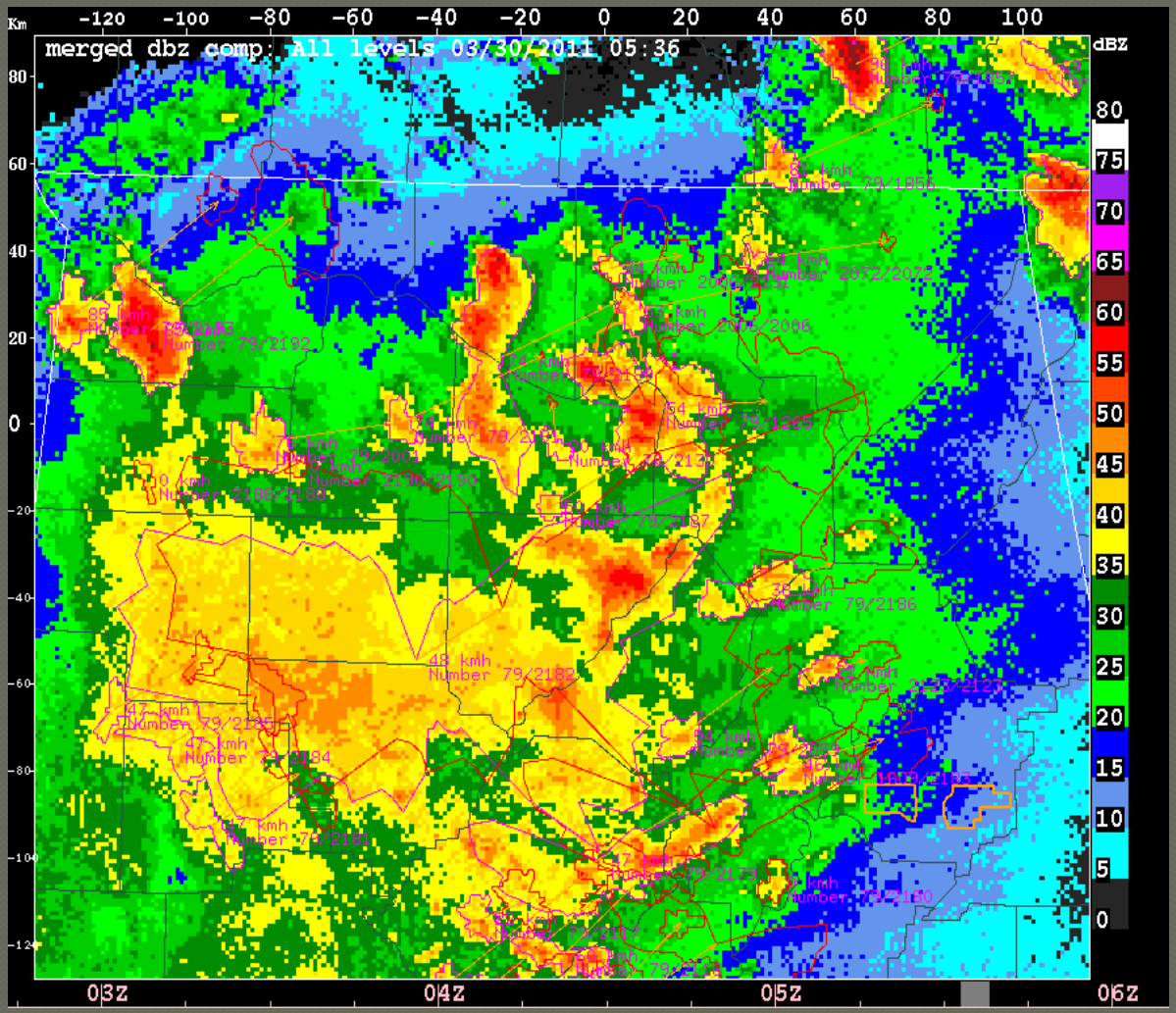
Nearly 40% of misses in Schultz et al. (2011) came from low topped supercells, TC rainband storms, and cold season events

- Lack of lightning activity inhibited the performance of the algorithm

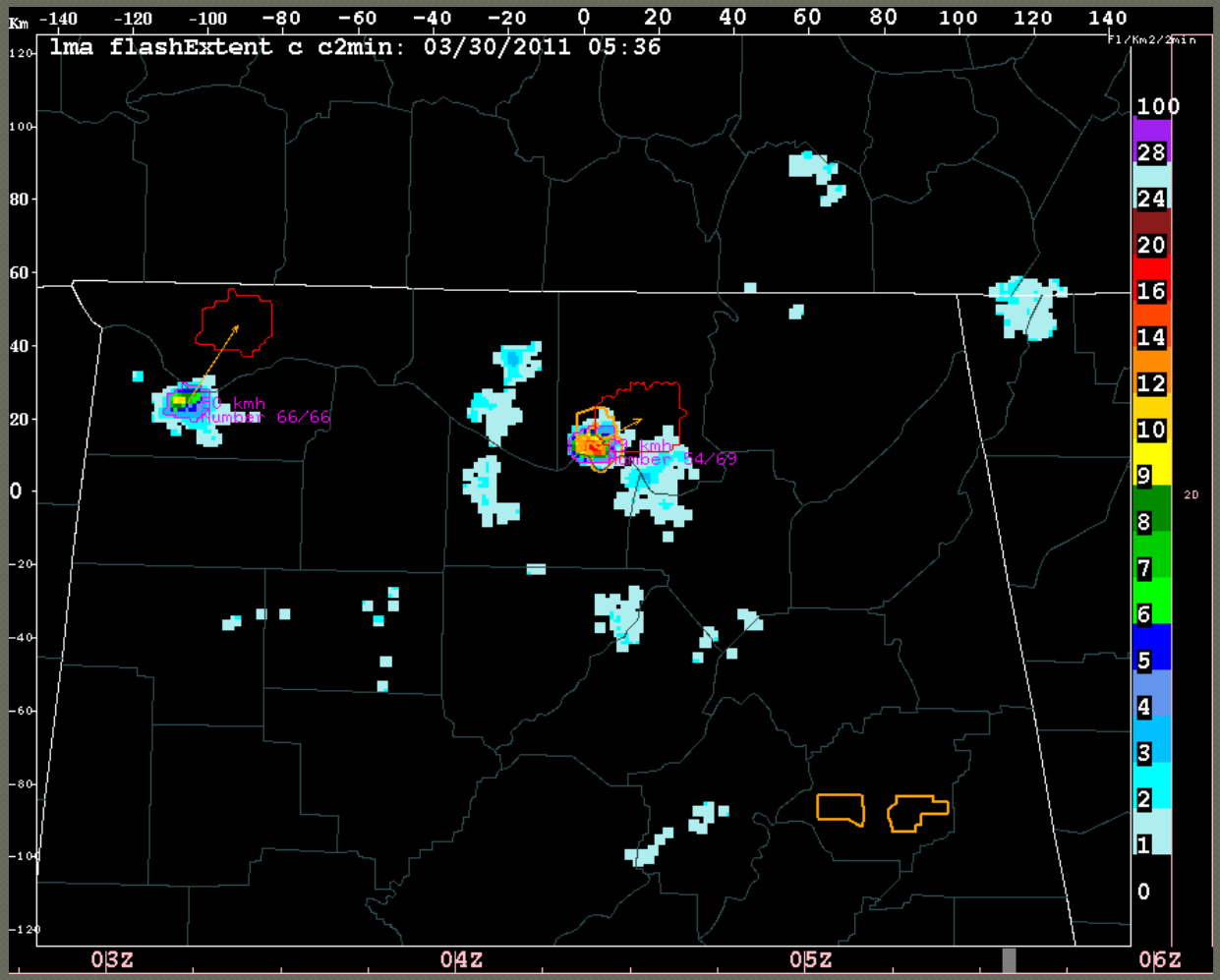


Time-height plot of reflectivity (top) and total flash rate (bot) for an EF-1 producing tornadic storm on March 25, 2010. Tornado touchdown time ~2240 UTC.

Current work: Tracking utilizing lightning data



Current work: Utilizing lightning data

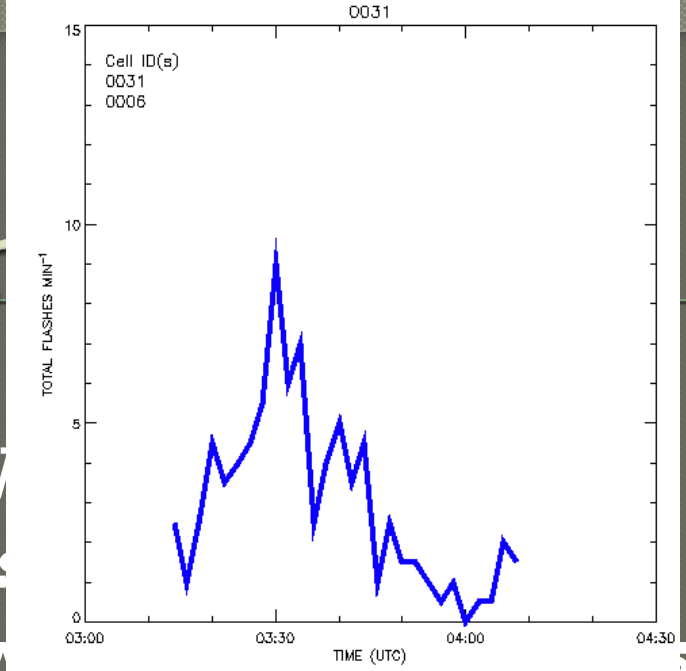


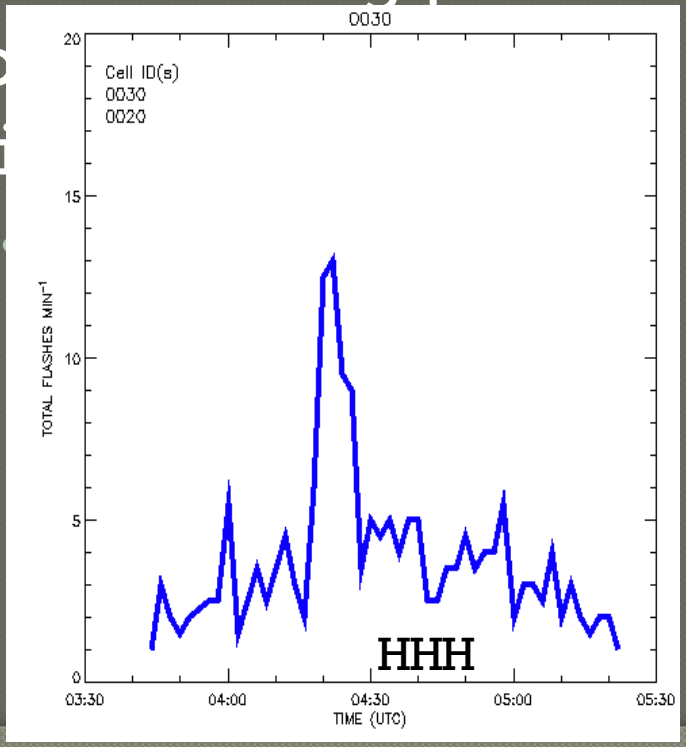
Examined Several Methods

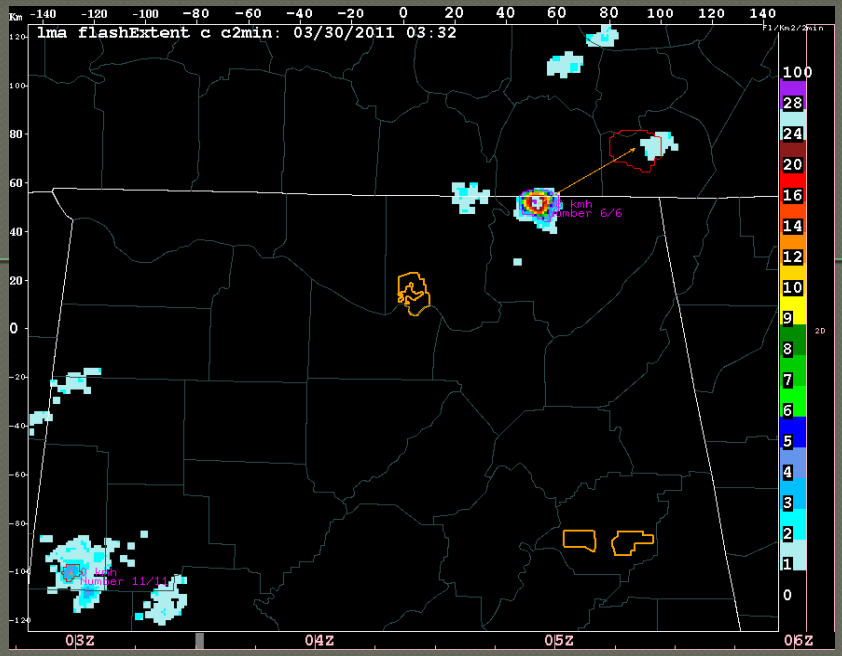
- Radar based
  - 35 dBZ at 6 km
  - 35 dbZ and 45 dBZ at 3 km
  - 35 dBZ and 50 dBZ at 3 km
  - 35 dBZ at 0°C
- Lightning based (flash extent density)
  - 3 flashes km^2
  - 3 and 5 flashes km^2 dual threshold
  - 3 and 6 flashes km^2 dual threshold
    - Have also tested different area thresholds as, temporal periods, and have utilized smoothing and clumping, and tested at GLM resolution
- Several more planned, as well as combinations of lightning, radar and satellite.

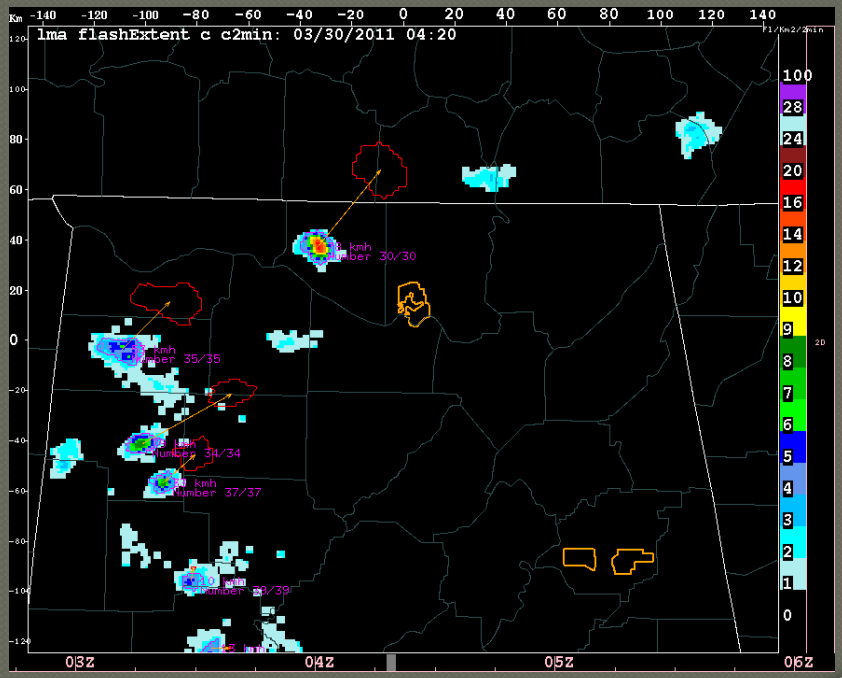
Th

- W
  i
  v
  C
  li

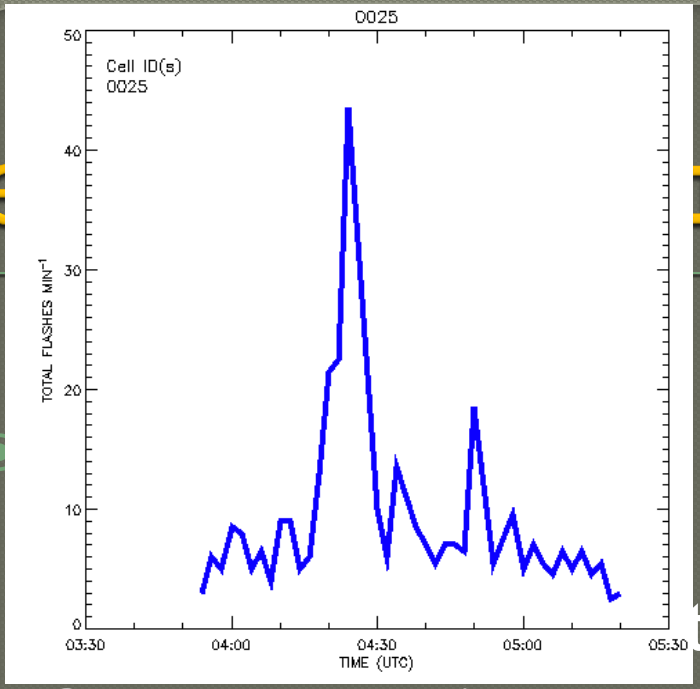

0031
Cell ID(s)
0031
0006
TOTAL FLASHES MIN-1
TIME (UTC)
03:00
03:30
04:00
04:30

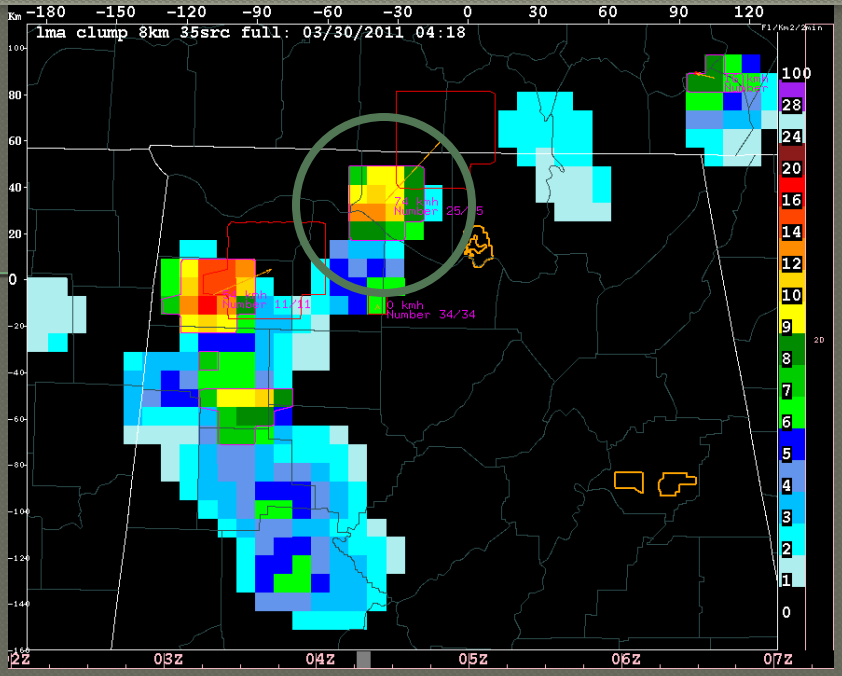

0030
Cell ID(s)
0030
0020
TOTAL FLASHES MIN-1
TIME (UTC)
03:30
04:00
04:30
05:00
05:30
HHH

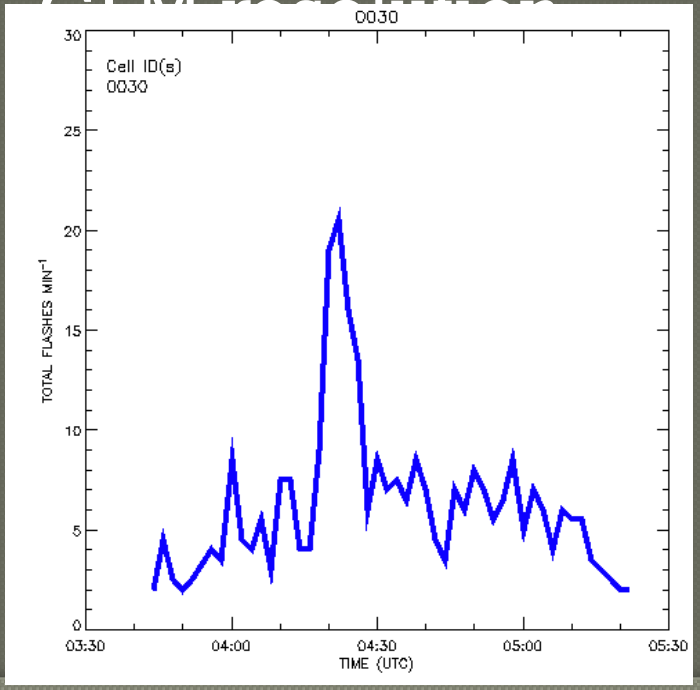

lma flashExtent c c2min: 03/30/2011 03:32
03Z
04Z
05Z
06Z

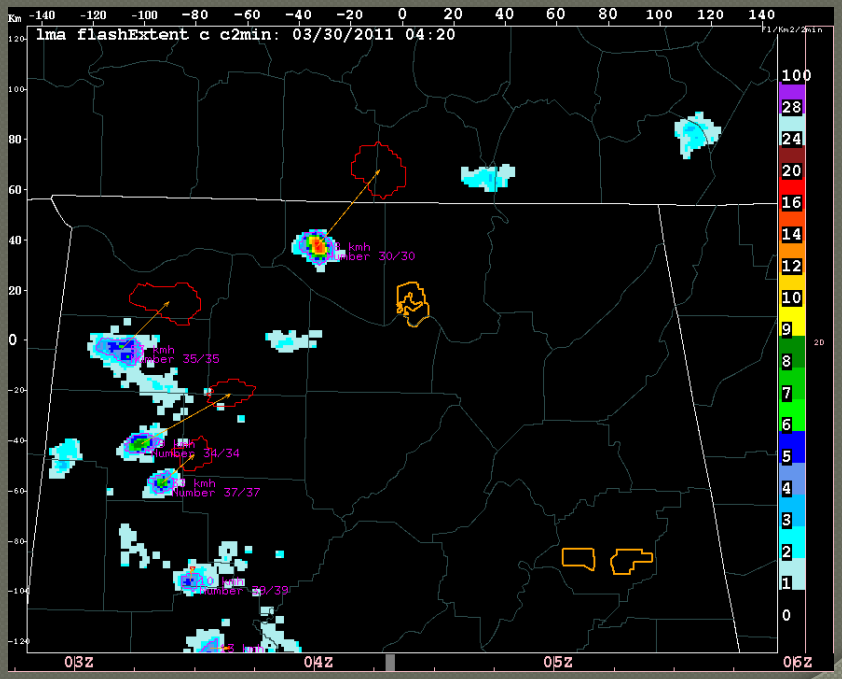

lma flashExtent c c2min: 03/30/2011 04:20
03Z
04Z
05Z
06Z

Tre re

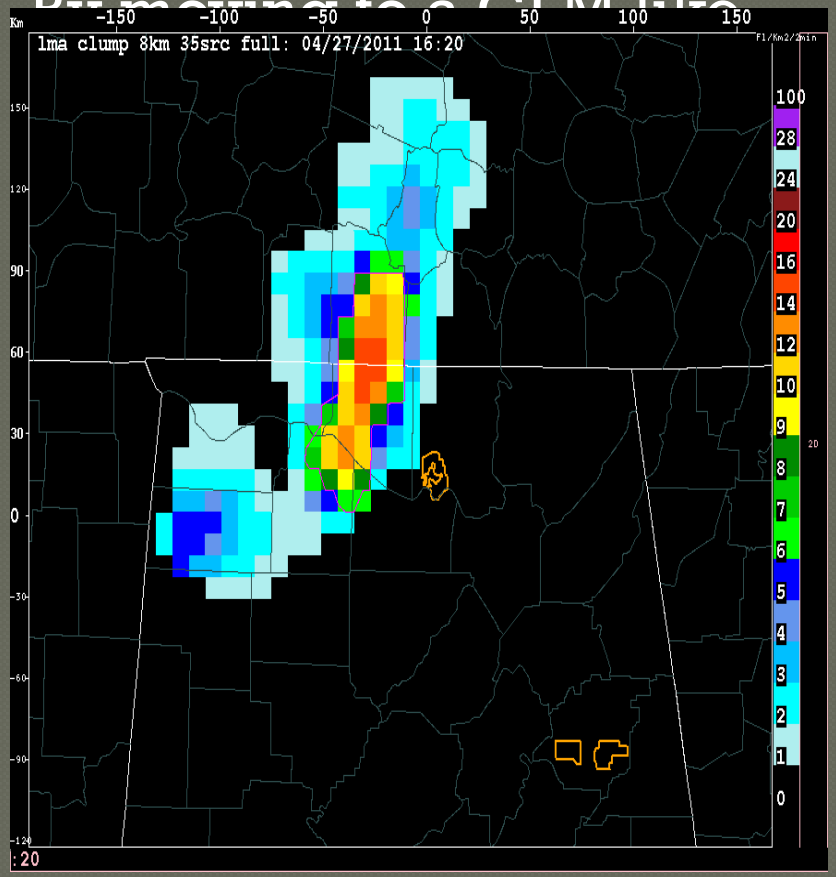

0025
Cell ID(s)
0025
TOTAL FLASHES MIN-1
TIME (UTC)
03:30
04:00
04:30
05:00
05:30


lma clump 8km 35src full: 03/30/2011 04:18
03z
04z
05z
06z
07z

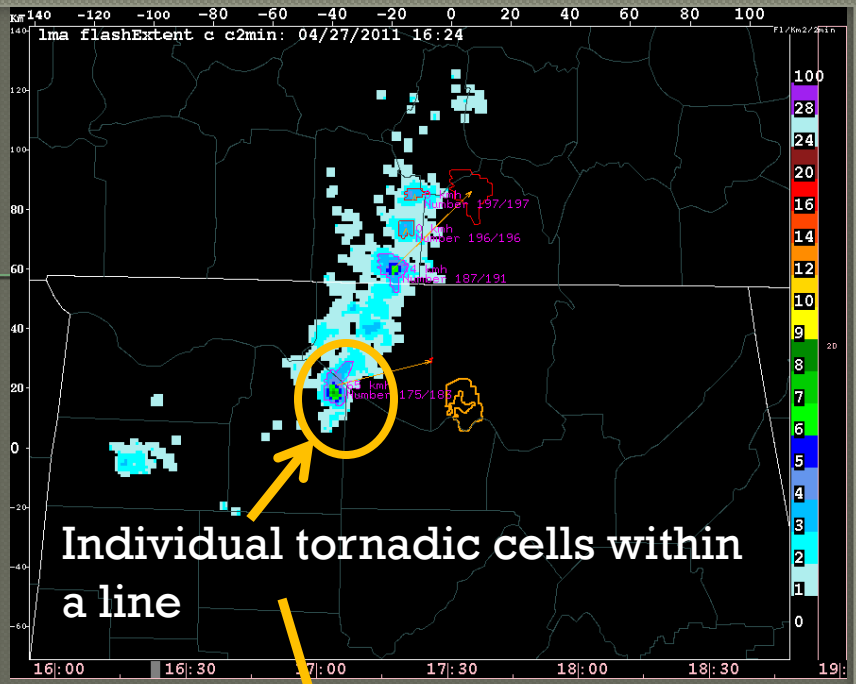

0030
Cell ID(s)
0030
TOTAL FLASHES MIN-1
TIME (UTC)
03:30
04:00
04:30
05:00
05:30

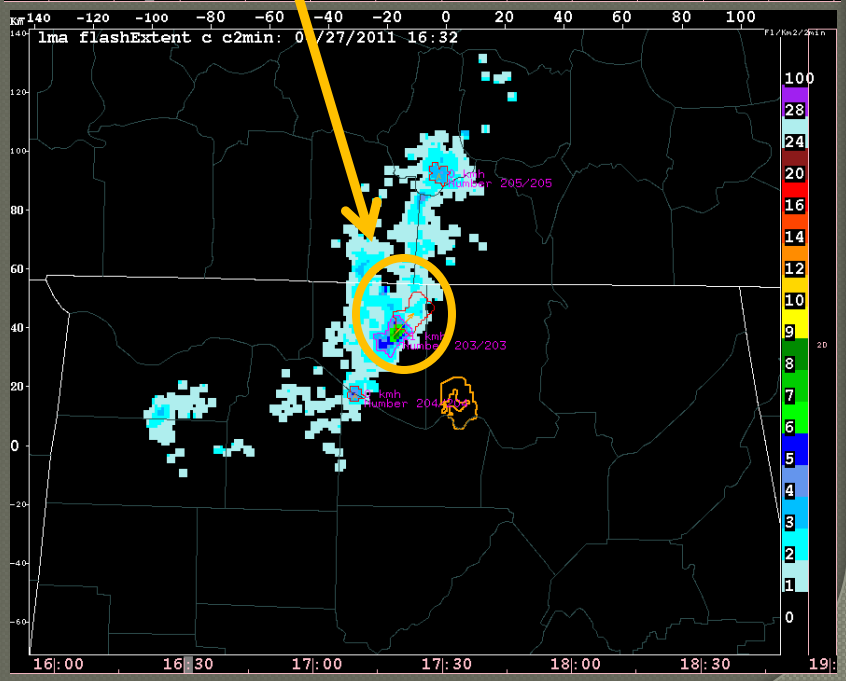

lma flashExtent c c2min: 03/30/2011 04:20
03z
04z
05z
06z

Obviously we lose smaller features

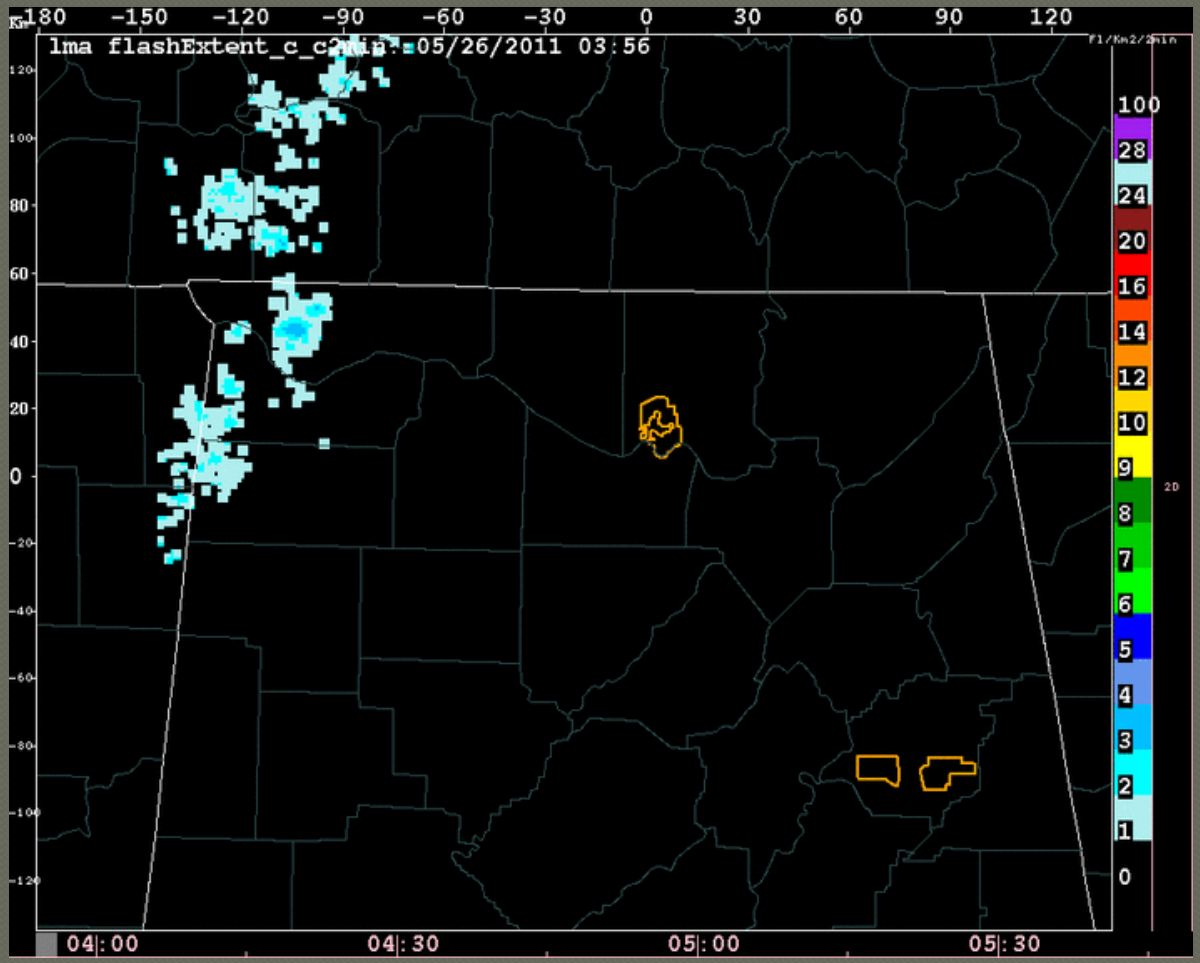


Midday tornadic QLCS, 27 April, 2011





System Issues
May 26, 2011, 0356-0554 UTC



Number of stations contributing to the flash extent density can cause a "blooming" effect which would affect the FED thresholds used to track storms.

What still needs to be done

- Develop an accurate cell tracking method
  - Several proposals to explore this, work already being undertaken
- Test in an operational setting
  - Spring experiment proposal
- Develop algorithm for Geostationary Lightning Mapper datastream
  - i.e., transition from LMA tailored product to a GLM tailored product
- Get operational forecasters to buy in!
  - Show timing of lightning jumps to radar and satellite parameters (e.g., Deierling et al. 2008, Johnson 2008).