THE WRF LIGHTNING FORECAST ALGORITHM: RECENT UPDATES AND EXTENSION TO FORECASTS OF CG LIGHTNING

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Background

- WRF-based Lightning Forecast Algorithm (LFA) was developed based on observed robust relationships between LTG flash rates and large precipitating ice in storms
  - LFA was designed to be entirely empirical, easy to implement
  - LFA uses two proxy fields:
    - Threat 1: Graupel flux at -15°C (GFX)
    - Threat 2: Vertical ice integral (VII)
  - GFX represents amplitude / time variability of LTG; VII represents amplitude / areal coverage of LTG Weighted average blend (Threat 3) gives best overall results
  - Original LFA study (McCaul et al. 2009; WAF) developed on 2-km mesh with WSM6 microphysics, calibrated on storm cases from North Alabama Lightning Mapping Array (NALMA); recent efforts have used 4-km CONUS mesh, varying microphysics
  - Objectives:
    - (1) Assess accuracy of LFA threat to define areal coverage,
    - (2) Examine the sensitivities of LFA output to microphysics & PBL physics in a matrix of simulations,
    - (3) Examine behavior of CG flash rates as a function of bulk storm properties; add CG flash rate prognoses to LFA.

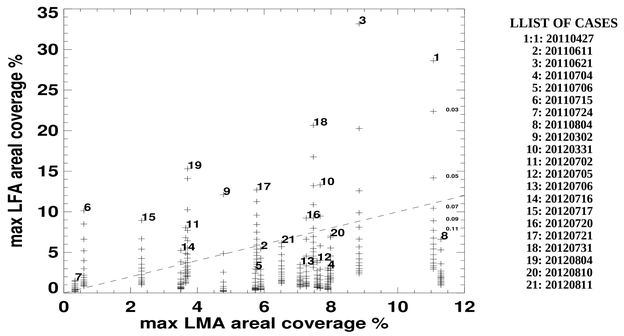
Methodology

- Applied varying LTG threat thresholds to 21 cases and compared peak LFA threat coverage to peak coverage of flash extent density from LMA; tally thresholds that match LMA.
- Assessed sensitivity of LFA to microphysics and PBL physics within a matrix of 8 x 3 runs, allowing attributability.
- Evaluate sensitivity at Gulf Coast sites such as KMOB, for selected dates in summer 2012. Objective is to intercompare LFA output across WRF configurations, not validate with LMA.
- Study large database of storm attributes, including radar properties and **Earth Networks Total Lightning Network (ENTLN; plot at right)** statistics, to see which attributes might predict storm CG flash rate fraction.
- Develop method of adding CG prognoses to LFA, and apply to case studies to demonstrate feasibility.

Preliminary Results

- LFA areal threat best matches LMA threat area when using a threat threshold of 0.08 fl km-2 (5 min)-1.
- LFA output is sensitive to microphysics, PBL physics, and initialization data .
- For HRRR-WRF, need to boost LFA calibration by more than 2.0 to match WRF runs made by the National Severe Storms Laboratory (NSSL).
- Study of observed storms on a 1-min timescale shows that storm CG fraction is strongly related to storm peak VIL.
- Shape of CG fraction vs. VIL curve suggests a Gaussian exponential fit might serve to convert VIL to CG fraction.
- Since LFA already prognoses total flash rate density (FRD), we can obtain actual CG FRD by multiplying LFA total FRD field by CG fraction field.
- Application of proposed CG algorithm to a test case gives peak CG FRD values within 5% of NLDN observations. These early results are very encouraging.

LFA threat areal coverage vs threshold



LLIST OF CASES
1:1: 20110427
2: 20110611
3: 20110621
4: 20110704
5: 20110706
6: 20110715
7: 20110724
8: 20110804
9: 20120302
10: 20120331
11: 20120702
12: 20120705
13: 20120706
14: 20120716
15: 20120717
16: 20120720
17: 20120721
18: 20120731
19: 20120804
20: 20120810
21: 20120811

Acknowledgments

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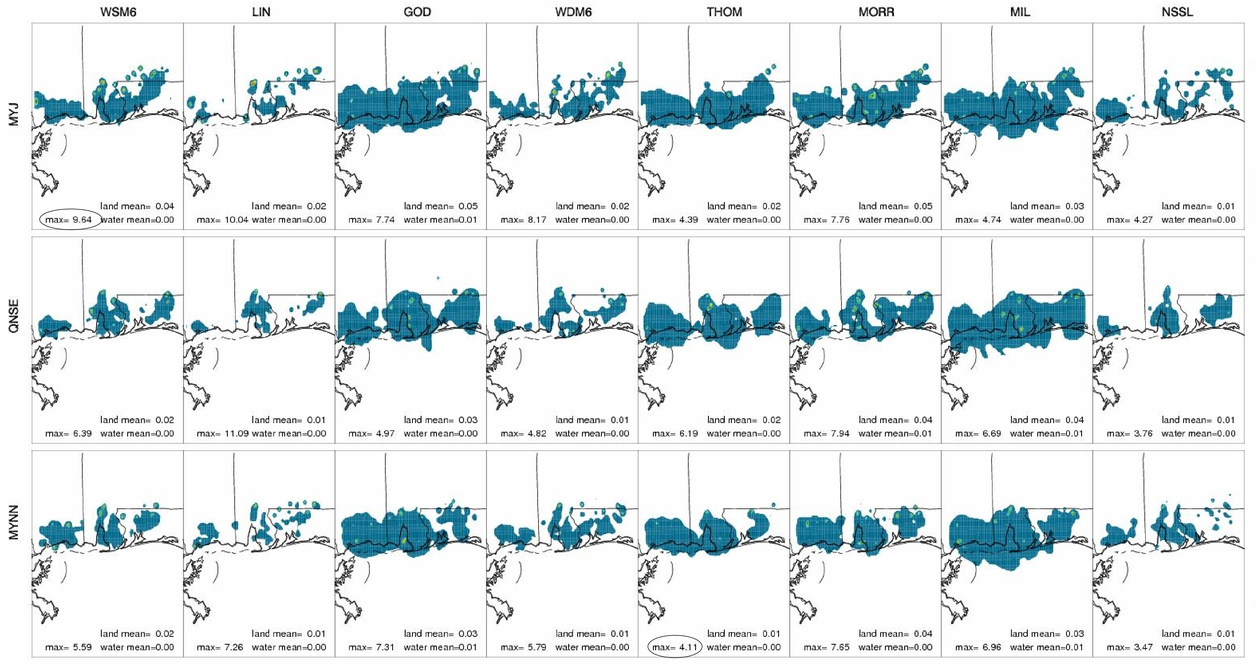
- Kristin Calhoun provided the OU/NSSL storm database used in studying behavior of CG fraction as a function of peak VIL
- NASA/SPoRT provided the matrix of WRF simulations used for study of sensitivity of the LFA to microphysics and PBL physics

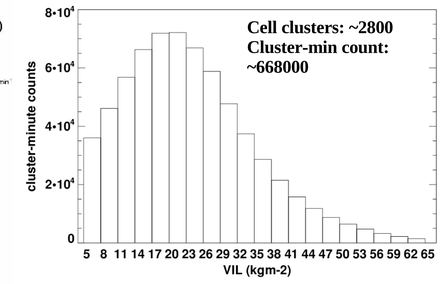
Future Work

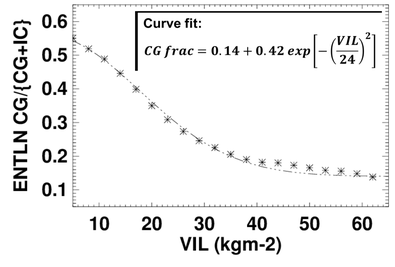
- Assess performance of revised LFA areal coverage thresholds in new NSSL, CAPS, SPoRT, and HRRR WRF runs.
  - Assess performance of LFA CG prognoses.
  - Compare LFA prognoses of CG threat as applied to wildfires from dry western storms to NLDN observations.
  - Examine LFA behavior in hurricane HWRF and other TC simulations to assess realism and ability to predict rapid intensification of TCs.

Sensitivity of LFA to 8 microphysics / 3 PBL physics choices; 2200 UTC 3 July 2012 (centered on KMOB)

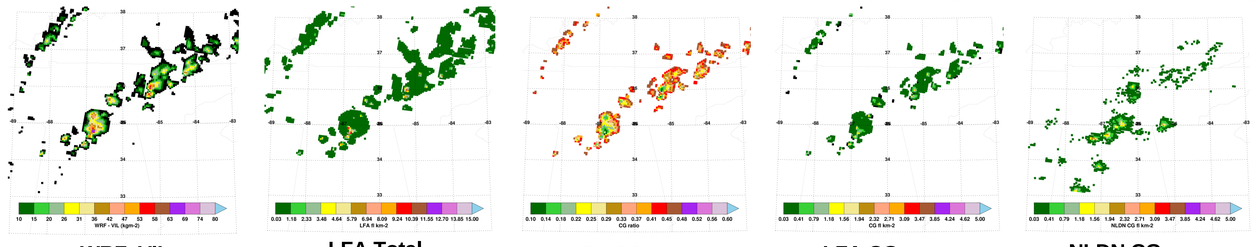


Statistics of storm peak VIL, ENTLN CG fraction, using OU/NSSL storm database:

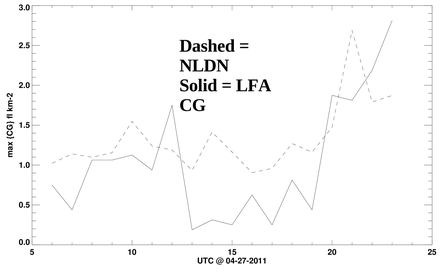




Test of LFA CG algorithm on NSSL WRF data from 2200 UTC 27 April 2011 (centered over Alabama)



WRF VIL | LFA Total Flash rate density (FRD) | LFA CG Fraction | LFA CG FRD | NLDN CG FRD



PEAK LFA CG FRD vs NLDN