



# The Relation Between Lightning and Wildfires in Florida

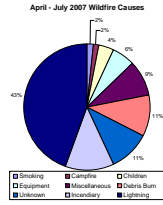
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## Motivation and Goals

- Lightning initiated approximately 43% of the wildfires in Florida during April, May, June, and July 2007.
- In addition to the property damage associated with wildfires, they also pose a safety risk to the general public as well as to firefighters on the front lines.
- The sea breeze produces almost daily lightning during the warm season in Florida.
- However, the amount, spatial location, and severity of lightning varies significantly from day to day.



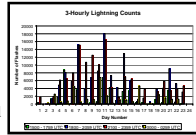
Month	Total Wildfires	Lightning Initiated Wildfires	Percentage Related to Lightning
March	85	0	0
April	218	20	9.6
May	669	193	28.8
June	532	275	51.8
July	424	342	80.6
Total	2218	940	42.4

## A Modeling Approach

- Dr. Phillip Shafer of Florida State University has developed a statistical guidance scheme for forecasting warm season cloud-to-ground (CG) lightning in Florida.
- The scheme was developed using data from the 13-km RUC model initialized at 12 UTC.
- During summer 2007 the Aegis/FSU fire weather group initialized a 4-km WRF model at 00 UTC.
- Major goal:** Determine whether the 4-km WRF can produce comparable results to the 13-km RUC and 12-km NAM models, which are initialized 12 h later (12 UTC).

## Analysis

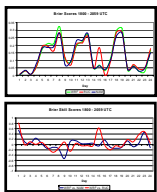
- The probability of one or more lightning flashes occurring during 3-hourly periods is computed on a 10x10 km grid from each of the three mesoscale models.
- The Brier Score (BS) and Brier Skill Score (BSS) are used to evaluate model performance.
- A Brier Score of 0.0 represents a perfect forecast.
- Results from the 4-km WRF model were used as the reference for comparison with those of the RUC and NAM.
- A positive BSS indicates that the WRF performed best.



Daily lightning counts for each time period for each of the 24 study days.

Time (UTC)	WRF	RUC	NAM
1800 - 1759	0.0548	0.0577	0.0544
1800 - 2059	0.0643	0.0669	0.0622
2100 - 2359	0.0475	0.0464	0.0482
0000 - 0259	0.0116	0.0118	0.0129

24-day composite Brier Scores for each time period and model.



Above Top: Daily BS for each of 24 June days.  
 Above Bottom: Daily BSS for each of 24 June days.  
 Both: 1800 - 2059 UTC

Time (UTC)	WRF vs. RUC	WRF vs. NAM
1800 - 1759	0.0003	-0.0074
1800 - 2059	0.0389	-0.0338
2100 - 2359	-0.0237	-0.0509
0000 - 0259	0.0169	0.1008

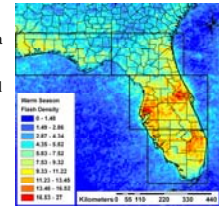
Left: Composite BSS for 24 June days.  
 Below: Probability of one or more flashes occurring between 2100 - 2359 UTC 19 June 2007, actual CG flashes are overlaid.



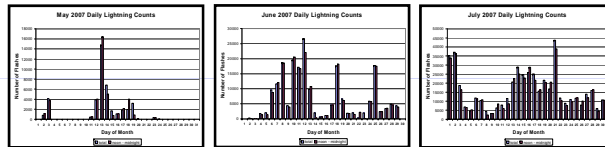
## Lightning, Wildfires and Precipitation

### Background and Goals

- In addition to initiating wildfires, lightning also poses a threat to firefighters on the front lines.
- The number of lightning initiated fires varies daily, and depends on the amount of moisture in the fuel layer as well as both synoptic and mesoscale weather patterns.
- During Florida's warm season synoptic scale patterns are very similar from day to day.
- Therefore, the daily variability in the number of wildfires is more a result of mesoscale features.
- Major goal:** Determine the mesoscale patterns and storm structure leading to a larger number of lightning initiated wildfires.

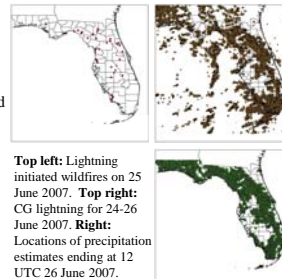


Above: Warm season (May - September) CG flash density with units of flashes km<sup>-2</sup> warm season<sup>-1</sup>.  
 Below: Daily lightning counts for 00 UTC - 00 UTC and counts between noon and midnight.



## Data

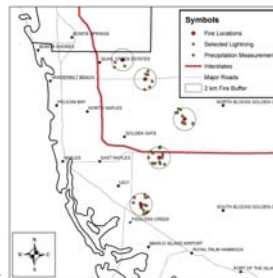
- The Florida Division of Forestry provided a detailed database of all wildfires reported during April - July 2007.
- Cloud-to-ground lightning data were obtained from the National Lightning Detection Network, operated by Vaisala Inc.
- The National Weather Service precipitation analysis combines radar and rain gauge measurements to produce daily precipitation estimates on a 4x4 km grid.



Top left: Lightning initiated wildfires on 25 June 2007. Top right: CG lightning for 24-26 June 2007. Right: Locations of precipitation estimates ending at 12 UTC 26 June 2007.

## Procedure

- Geographic Information System (GIS) techniques were used to physically relate wildfires with lightning and precipitation.
- Lightning is associated with a particular wildfire if it occurs **within 2 km and within one day of the wildfire report**.
- After determining the day and time of the lightning, the nearest 24-h precipitation measurement in both space and time is linked to the wildfire.
- This procedure was used to link wildfires with lightning and precipitation during May, June, and July 2007.
- The resulting database contains the location of each wildfire, statistics on the nearby lightning, and a precipitation estimate.
- The statistics include the number of flashes, precipitation amount, maximum peak current, mean peak current, maximum multiplicity, mean multiplicity, the distance from the precipitation estimate, and a ratio of the amount of precipitation per lightning flash.

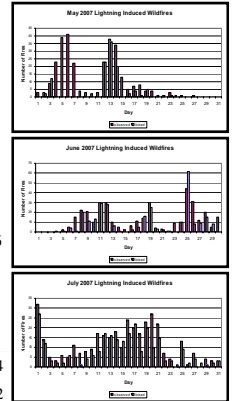


Example of the procedure used for combining the three datasets. These wildfires occurred in Southwest Florida on 25 June 2007.

## Results

- Omitted 4-6 May 2007 due to lack of lightning data.
- Only 7% of lightning initiated wildfires had any positive cloud-to-ground lightning within 2 km.
- Lightning Statistics (May, June, July 2007)**
  - Percentage Positive = 1.79%
  - Mean Peak Current = 20.4 kA
  - Mean Multiplicity = 2.95
- Fire Statistics (Wildfires linked with lightning)**
  - Number of flashes: Mean = 6.26, Median = 3
  - Precipitation (in): Mean = 0.539, Median = 0.36
  - Amount of precipitation (in) per lightning flash: Mean = 0.14, Median = 0.08
  - Maximum Peak Current (kA): Mean = 35.29, Median = 30
  - Maximum Multiplicity: Mean = 4.7, Median = 4
  - Average Multiplicity: Mean = 2.4, Median = 2.2

Month	Observed Lightning Initiated Wildfires	Physically Linked to Lightning	Percentage Linked
May	153	106	56.9
June	375	280	74.7
July	352	258	73.3
Total	920	644	70.0



- Daily counts of reported wildfires and those linked with lightning differ because the time that a fire is reported is an estimate, while our procedure searches 3 days for lightning that may have initiated them.

Daily counts of lightning initiated wildfires as reported by the DOF compared with those physically linked to lightning. Note: Wildfire reports are linked with lightning occurring on the day reported, the previous day, or the following day.

## Conclusions and Future Work

- Modeling Approach**
  - The increased spatial resolution of the WRF model (4 km) allows forecasts to be produced at 00 UTC that have comparable results to the NAM and RUC at 12 UTC.
  - Guidance prepared from the NAM was best, followed by the WRF and RUC.
  - Results still must be compared with climatology and/or persistence to determine the overall skill of the lightning guidance forecasts.
- Wildfires, Lightning, and Precipitation**
  - 70% of lightning initiated wildfires were physically linked with lightning.
  - Further work is needed to determine the source of the 30% difference between observed lightning initiated wildfires and those physically linked with lightning.
  - The average peak current among wildfires is greater than normal; however, the average multiplicity is smaller.
  - The majority of the wildfires can be associated with at least one high peak current or high multiplicity flash.
  - Additional analysis is needed to observe daily patterns in the fire statistics.
- Current Research**
  - The Warning Decision Support System - Integrated Information (WDSS-II) software is being used for the next phase of this research.
  - CG flash rates, precipitation rates, and other statistics are being computed along the paths of individual thunderstorms.
  - These storm tracks then will be compared to the locations of fires to more specifically determine which lightning flash initiated a particular wildfire.

References: See accompanying handout.