

# Analysis of Proximity Alerts Based on Total Lightning

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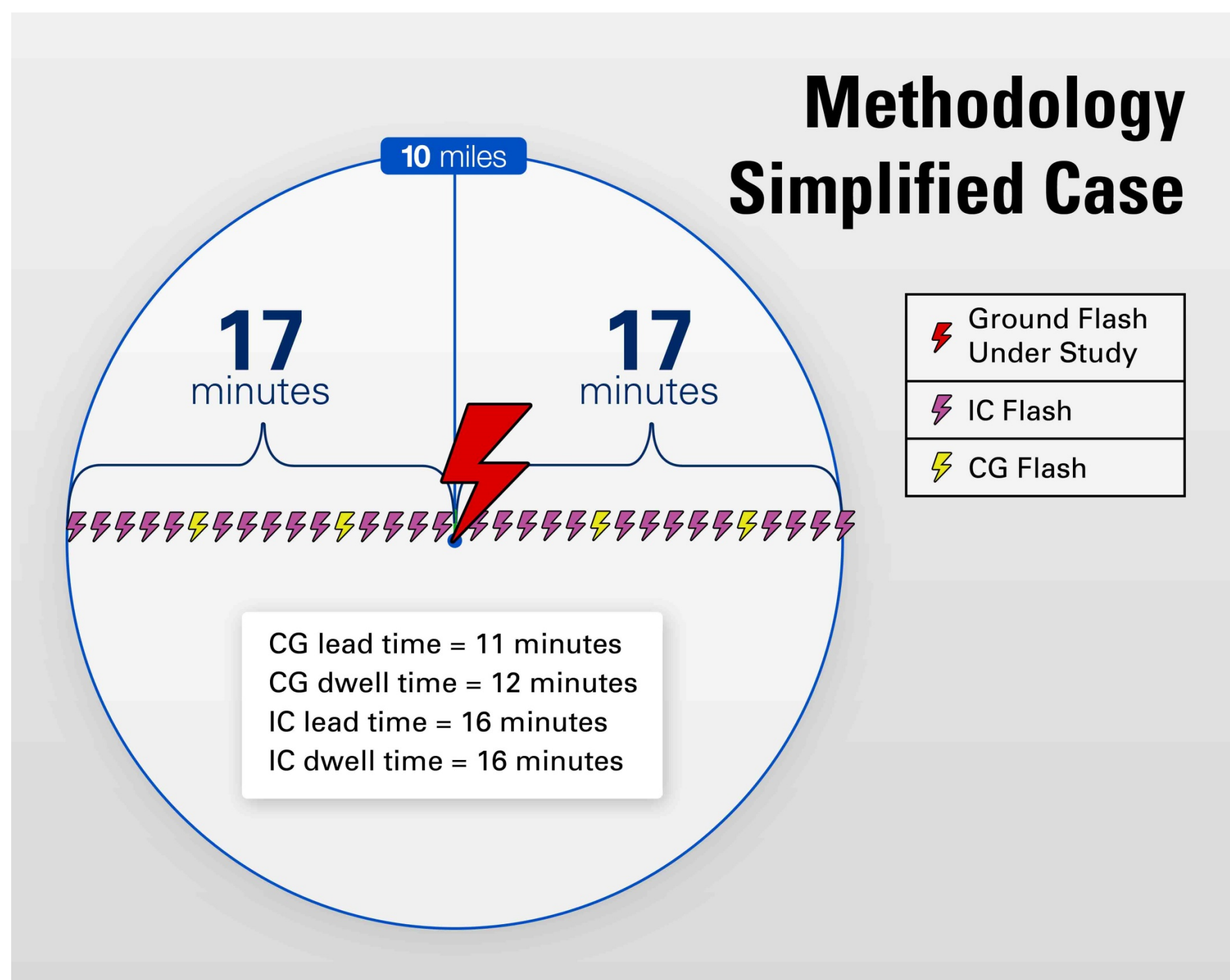
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## Abstract

Outdoor activities, from golfing to construction, are vulnerable to lightning strikes. Those responsible for safety of personnel and security of assets need the best possible information on which to base lightning hazard-warning decisions. Several past studies have suggested that in-cloud (IC) lightning often (but not always) precedes the first cloud-to-ground (CG) lightning flash in an area of concern (AoC) by several minutes. This suggests that use of total lightning for lightning hazard-warning decision support should often afford decision makers an opportunity to warn personnel earlier than if the data were limited to CG flashes only. This paper compares lead times before the first (CG) lightning flash in an AoC and alert duration using total lightning with the lead times and durations based on CG lightning only and provides an estimate of the percentage of first flashes in a storm that are IC and CG.

## Goals of the Research

- To compare lead time and alert duration provided by total lightning and CG lightning only for a simple proximity alert based on 10 mile/30 minutes rule
  - Comparing lead time
    - We consider each CG flash as an event of interest at the point of concern, that is, a person or venue where the ground flash occurred would have been struck by lightning
    - We examine the sequence of flashes leading up to the event
    - By considering every CG flash as an event of interest we achieve greater statistical significance than if we used only actual casualty events
  - Comparing alert duration
    - We determine the duration under alert for each event of interest using total lightning and using CG lightning only
- Assuming a desired lead time\*, to compare the percentage of events of interest for which the lead time was less than the desired value using total lightning and CG lightning only
  - By region and by season
- \*For example, a time of 5 minutes might be enough to clear a high-school playing field
- To determine the percentages of first flashes that are IC and CG, by region and by season
- To determine an advantage of total lightning over CG only by looking at ratios of percent unwarned



\*Simplified Example to Illustrate Method

The simplified case to the left shows lightning flashes occurring once per minute with each flash moving closer to the Point of Concern (PoC) (in red) as the lightning approaches and each flash getting further away from the PoC as lightning recedes from the area.

The first CG flash (yellow) occurs 11 minutes prior to the red flash, whereas the first IC flash (pink) occurs 16 minutes prior to the red flash. In this case, the IC flash provided a 5 minute lead time advantage over CG-only.

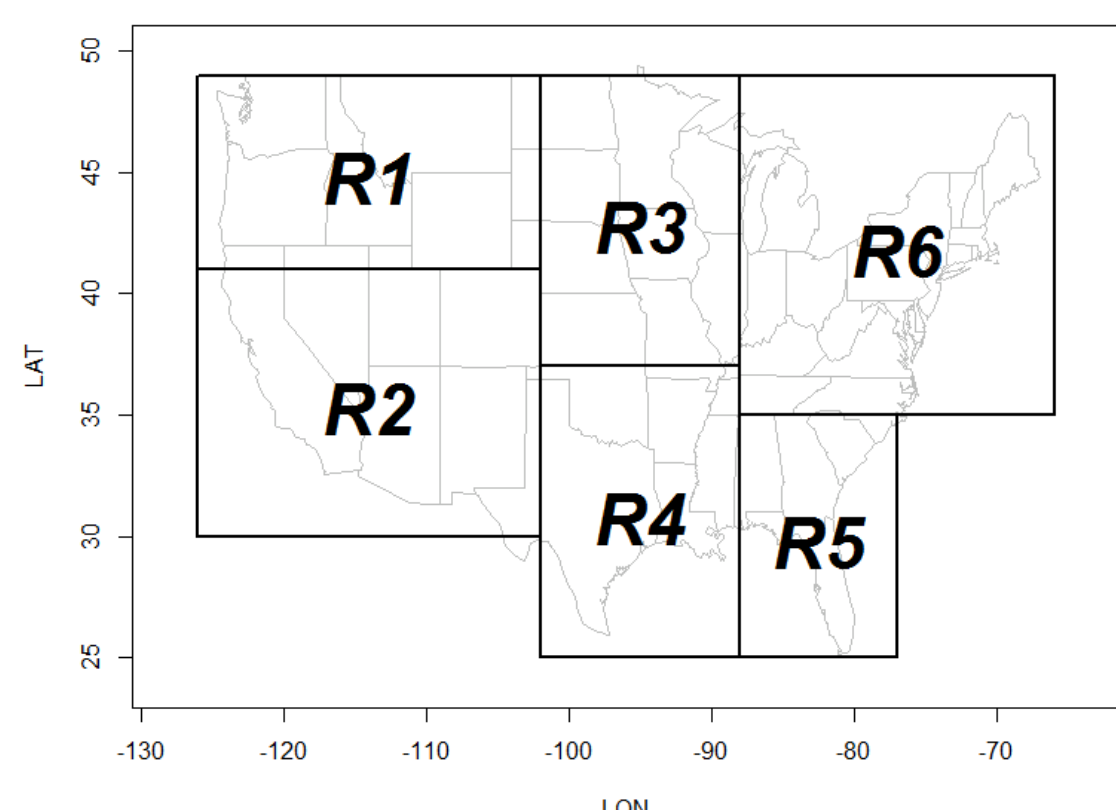
The last CG flash occurs 12 minutes after the red flash and the last IC flash occurs 16 minutes after the red flash. Dwell time relates to how long lightning keeps the location under alert.

## Details

To determine average lead times and percent of CG flashes for which lead time was less than a desired value, by total lightning and by CG-only, and for each CG lightning flash, all lightning events within 10 miles leading up to each CG flash at the Point of Concern (PoC) were identified and processed as follows:

- time, region, latitude, and longitude of the flash were recorded
- lead times for the flash based on total lightning and on CG only were recorded
- "dwell times" for the flash based on total lightning and on CG only were recorded
- the type of the first flash that provided the initial warning was recorded
- the number of total lightning events prior to the CG flash at the PoC were recorded
- the number of total lightning events after the CG flash at the PoC were recorded
- the number of CG lightning events prior to the CG flash at the PoC were recorded
- the number of CG lightning events after the CG flash at the PoC were recorded

## Regions of Study



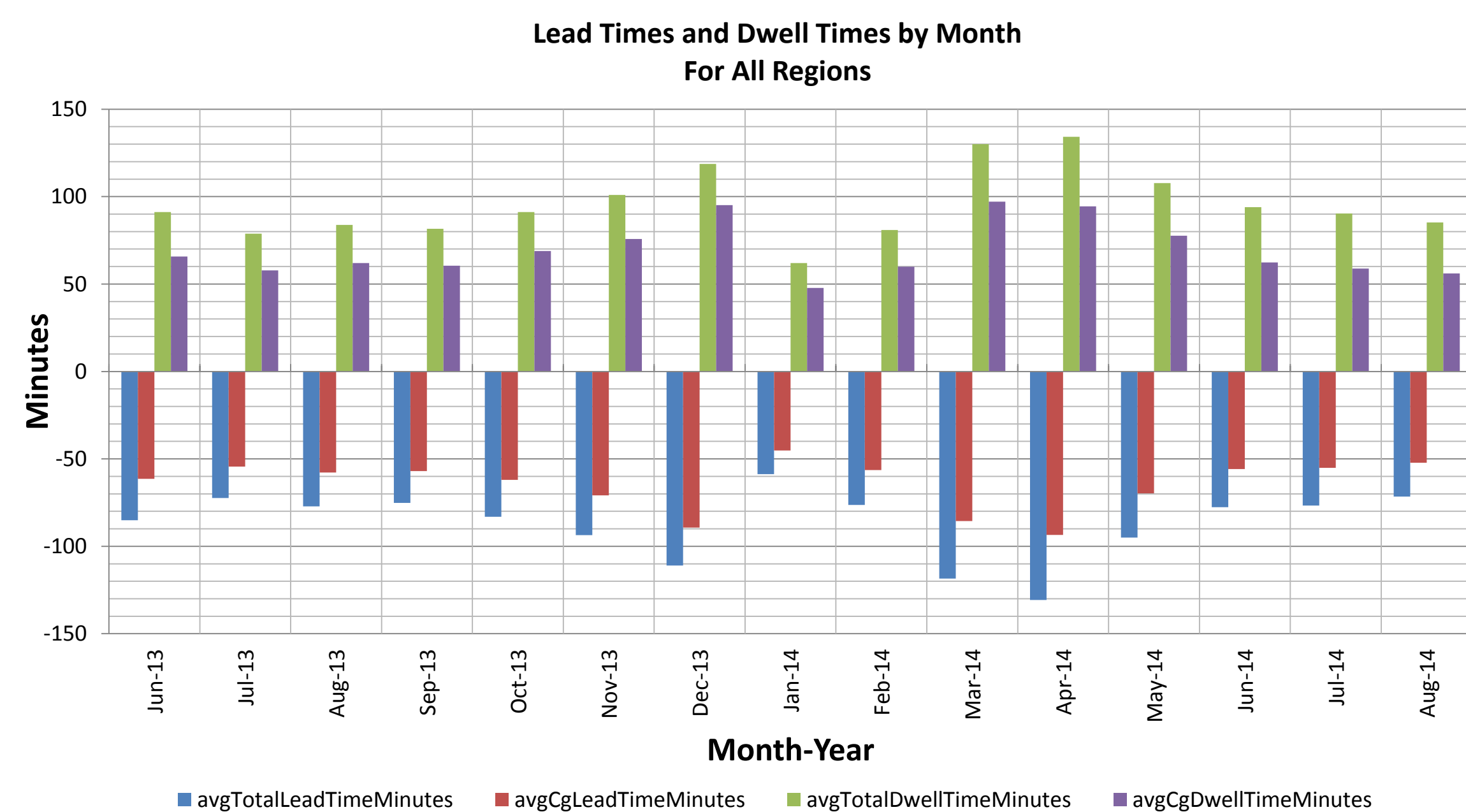
Location Latitude range

Longitude range

Region 1 41.0 to 49.0  
Region 2 30.0 to 41.0  
Region 3 37.0 to 49.0  
Region 4 25.0 to 37.0  
Region 5 25.0 to 35.0  
Region 6 35.0 to 49.0

North 102.0 to 126.0 West  
North 102.0 to 126.0 West  
North 88.0 to 102.0 West  
North 88.0 to 102.0 West  
North 77.0 to 88.0 West  
North 66.0 to 88.0 West

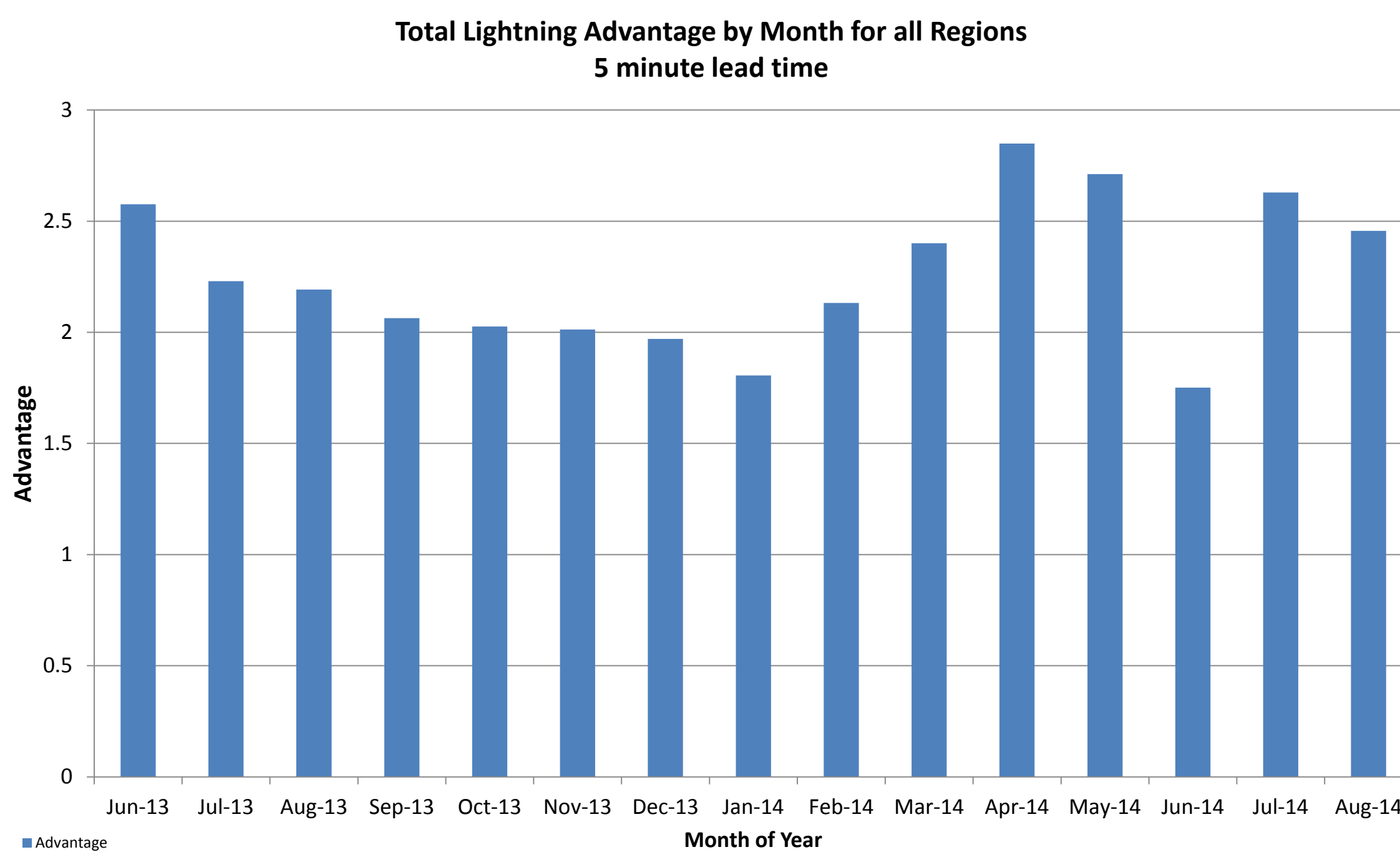
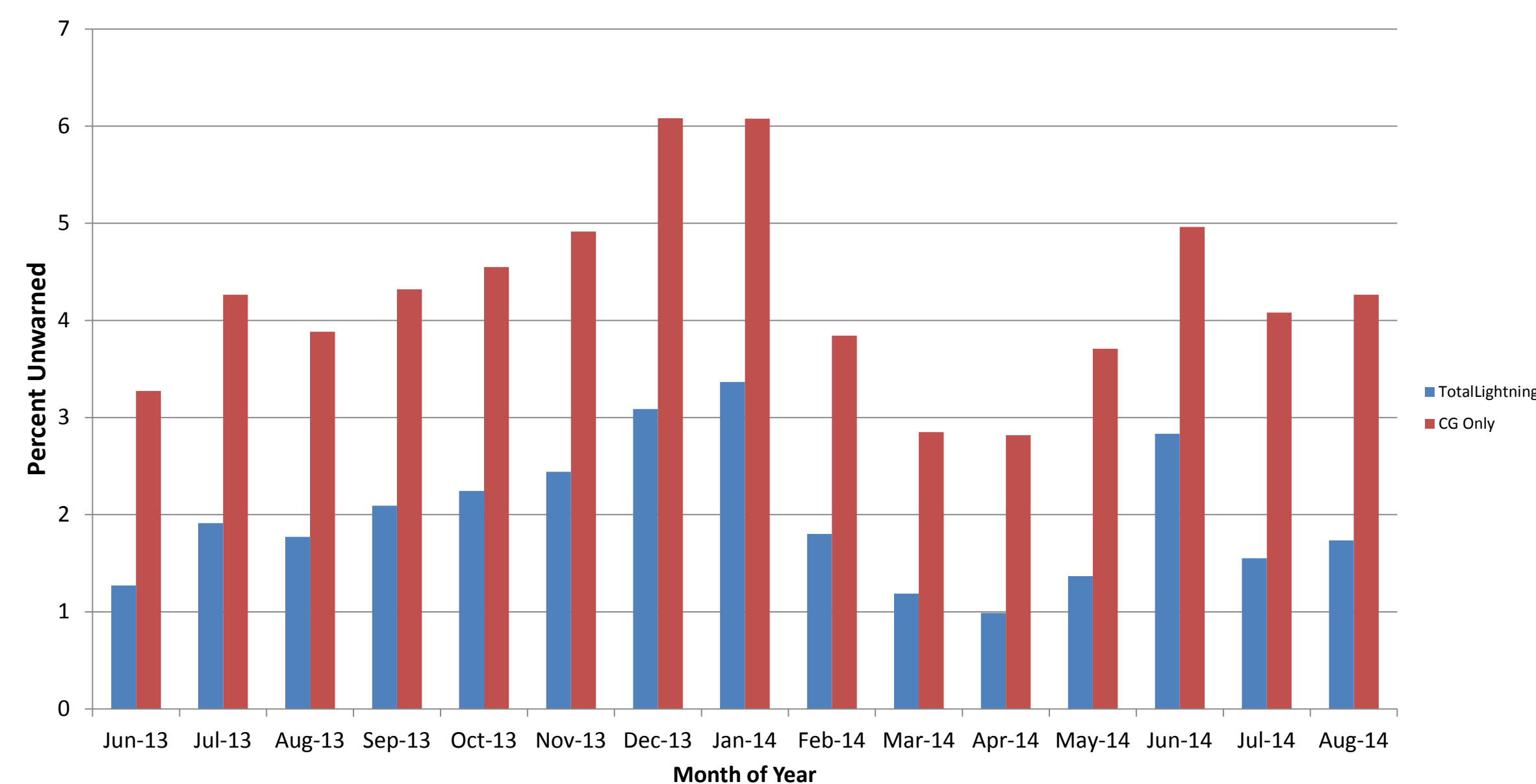
## Results



The graph to the left shows the lead time (negative number) for total lightning (IC+CG) and CG-only alerts. Total lightning has an advantage in additional lead time over CG-only alerts of ~22 minutes on average. Total lightning has a longer dwell time (positive number) than CG-only alerts of ~26 minutes on average.

Alerting on total lightning results in about 48 minutes of additional time under alert on average than CG-only.

The graph to the right shows the percent of CG flashes that go unwarned when a minimum of 5 minutes of lead time are required. In April of 2014, 0.98% of CG flashes were unwarned using total lightning versus 2.82% of flashes unwarned using only CG lightning. For a flash to be unwarned means there was no lightning in the warning area more than 5 minutes before the time of the ground flash under study.

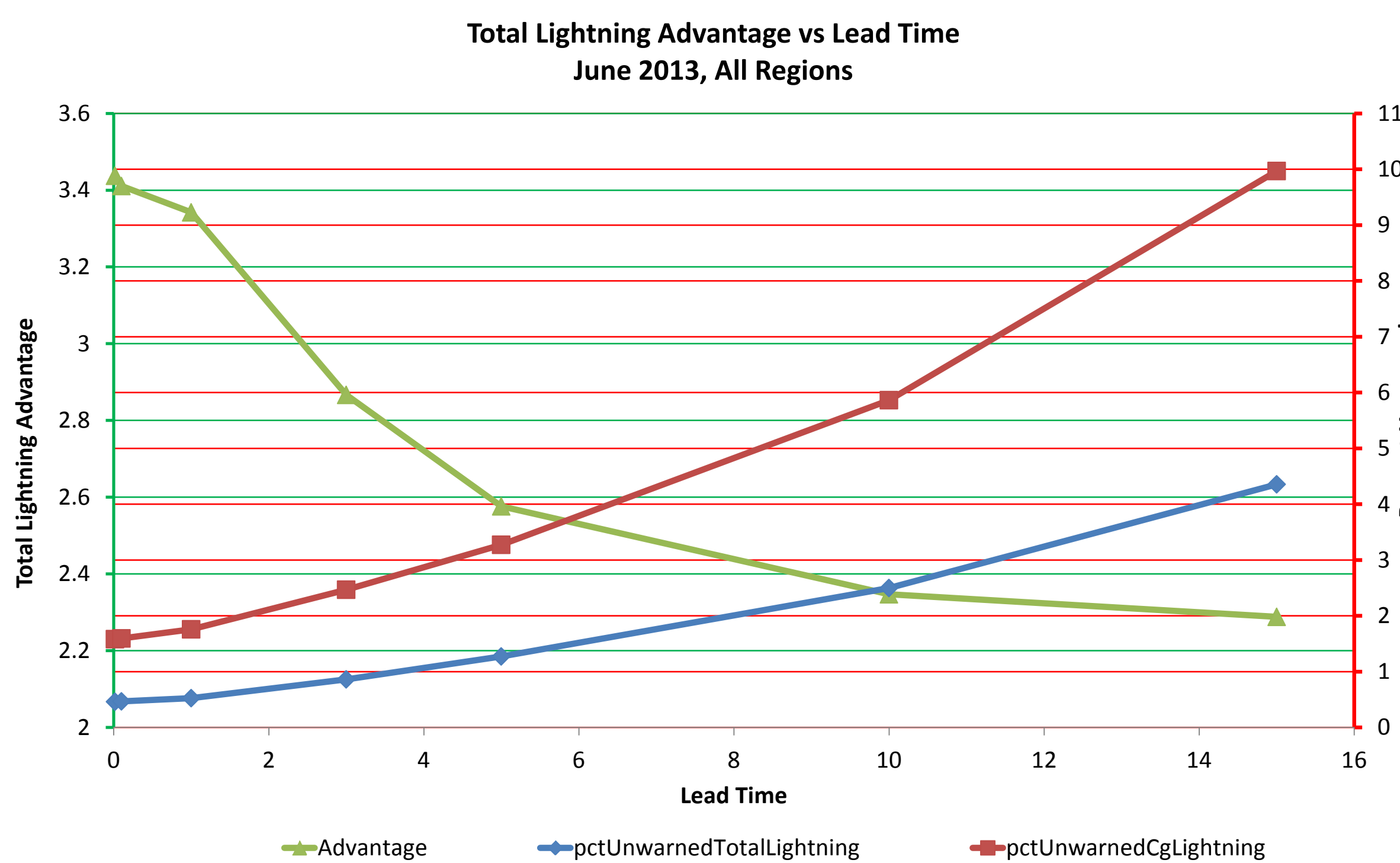


The advantage in using total lightning for proximity alerts is that the percentage of unwarned flashes is much lower for a given required time to evacuate an area. In April of 2014, the advantage was 2.85 times better (2.82%/0.99%) for total lightning.

The advantage for using total lightning is ~2.25 times better than CG-only for all time periods and all regions in this study.

The graph to the right shows the advantage of using total lightning vs CG-only lightning for proximity alerts which varies depending on your expected minimum lead time.

Data is shown for the month of June 2013 for all regions. Using total lightning increases your advantage of being alerted as the minimum lead time gets smaller and is expected to approach the average IC/CG ratio for a region.



## Conclusions

### Advantage of Total Lightning over Cloud-to-Ground Lightning Only

For all regions and all months from June 2013 through August 2014 (at 5 minute lead time): **225%**

For all regions and all months from June 2013 through August 2014 (at 3 minutes lead time): **245%**

Advantages are better in the summer months.

Summer months at 5 minutes: **227%**

Summer months (6,7,8,9) at 3 minutes: **250%**

| Number of First Flashes | Percent IC | IC/CG Ratio |
|-------------------------|------------|-------------|
| 3,472,971               | 79.8       | 3.94        |

In agreement with literature, approximately 80% of total flashes are IC.

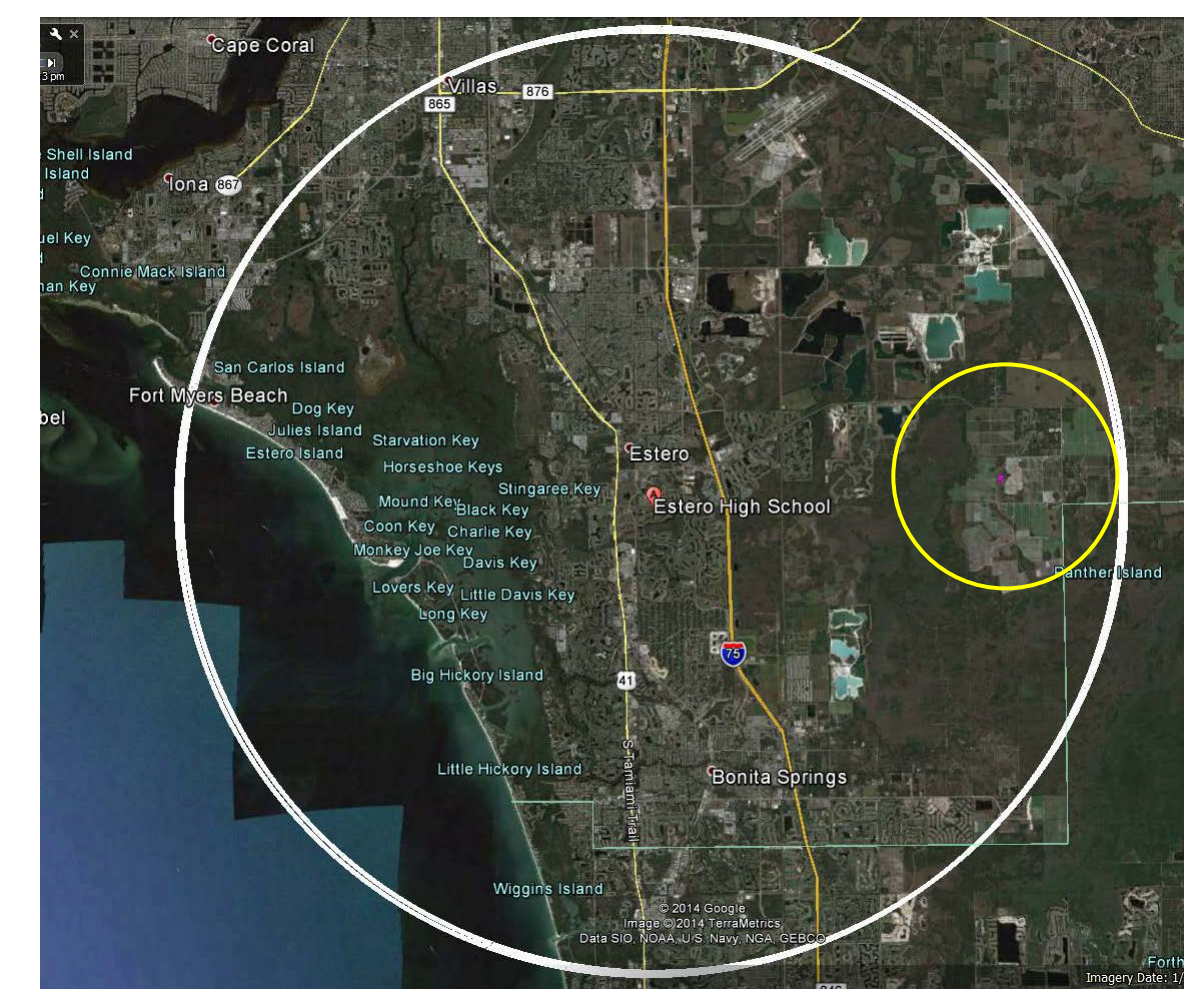
## Proximity Alert Case Study

### April 29, 2014 – Estero High School, Estero, Florida – Baseball Practice After School

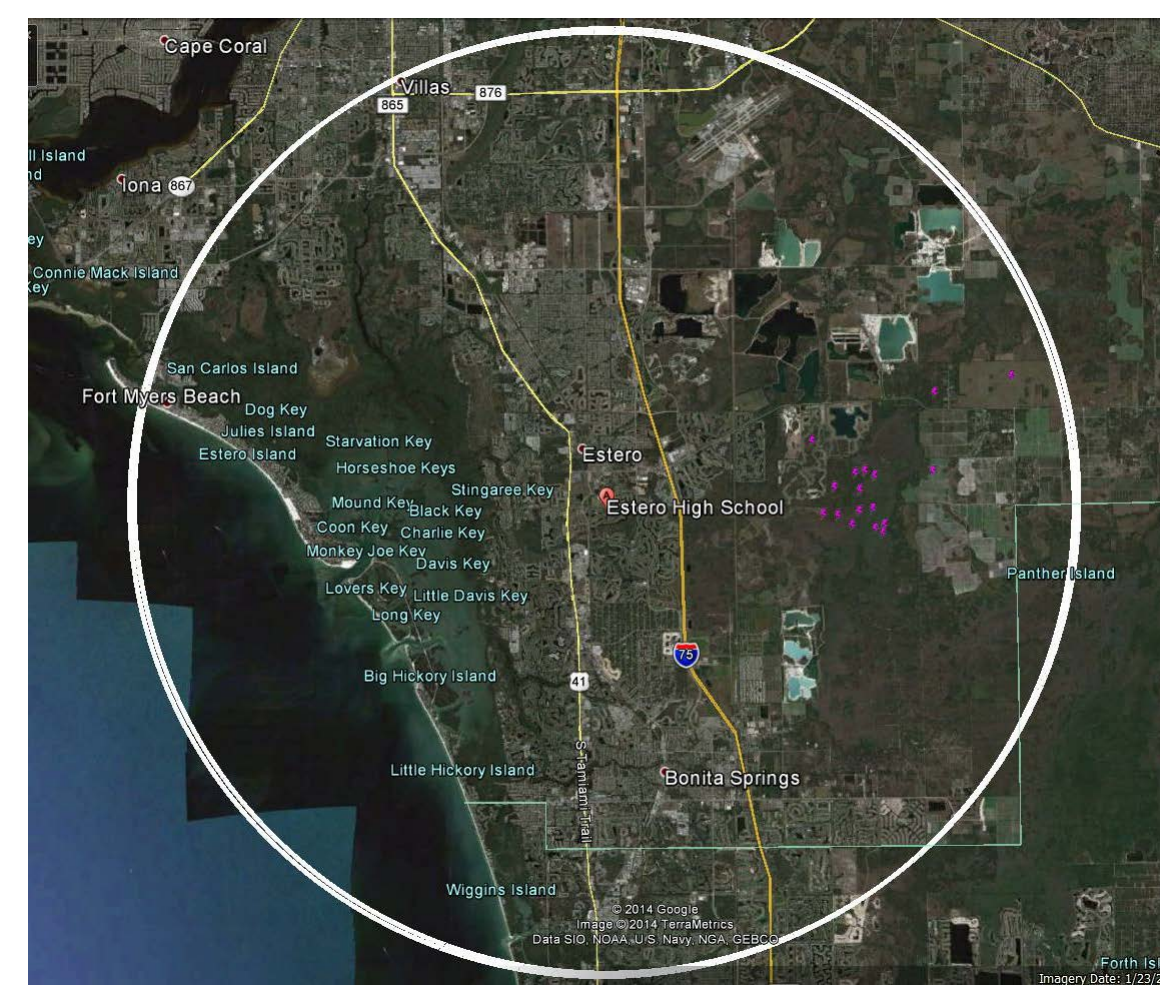
The team saw dark clouds off to the east, but the sun was shining over Estero High School's athletic fields on April 29, 2014. The Earth Networks (EN)/WeatherBug Outdoor Alerting System sounded at 3:09 PM EDT, so school officials cleared the athletic fields. Not long after the alarm, a direct lightning strike hit the batting cage where the baseball team had just been practicing.

Without the advanced warning, the team may have still been out in the elements and the outcome may have been very different. This storm and associated strike that impacted the school property was typical of a dangerous scenario. The most dangerous lightning strikes occur ahead or behind a storm when people believe they are not in danger because the storm is not directly overhead.

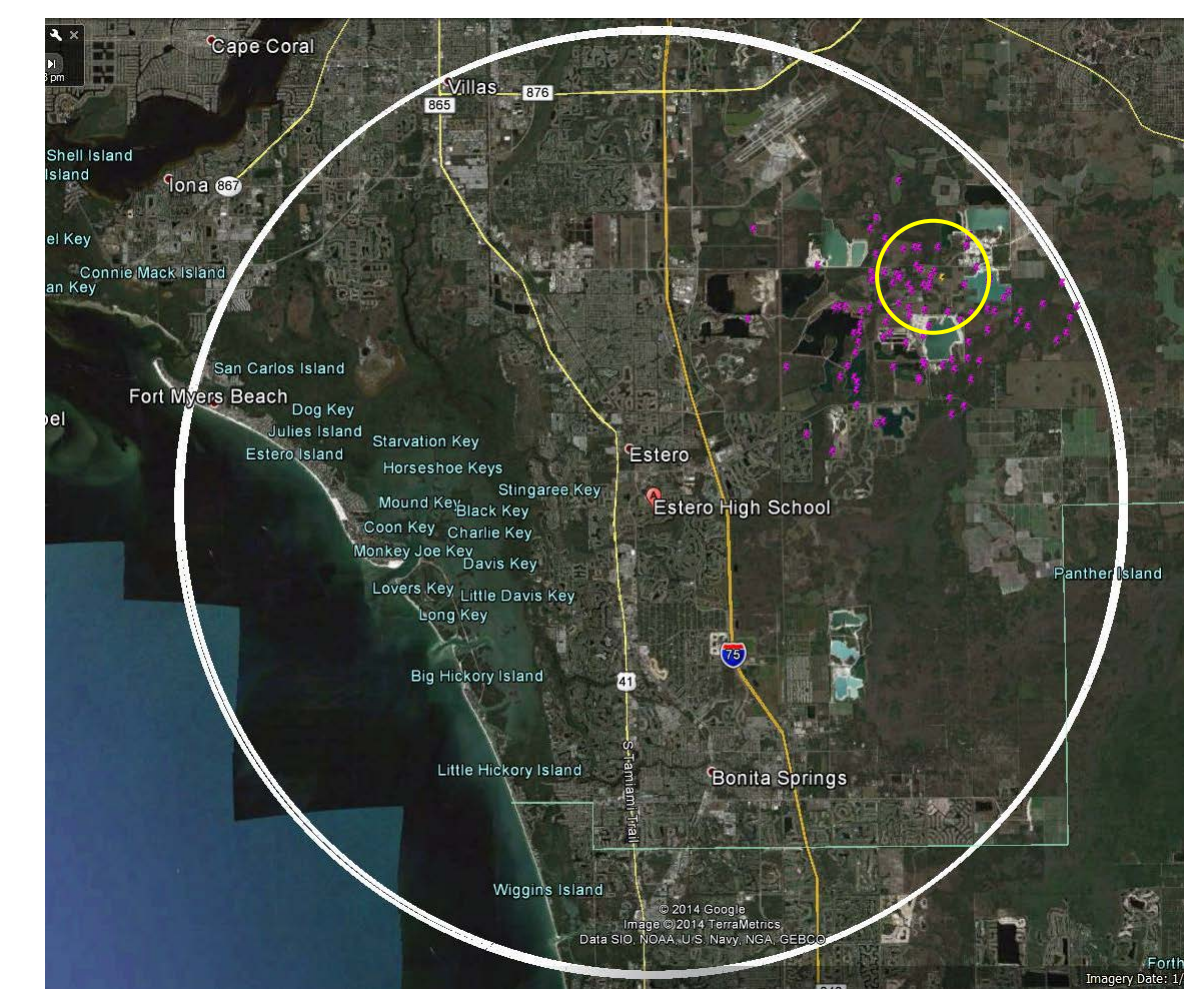
3:09 pm EDT – 26 minutes prior to Cloud-to-Ground (CG) strike – EN WeatherBug lightning safety solution detects in-Cloud (IC) lightning (magenta) within unsafe 10-mile radius of school. Students are moved to safety.



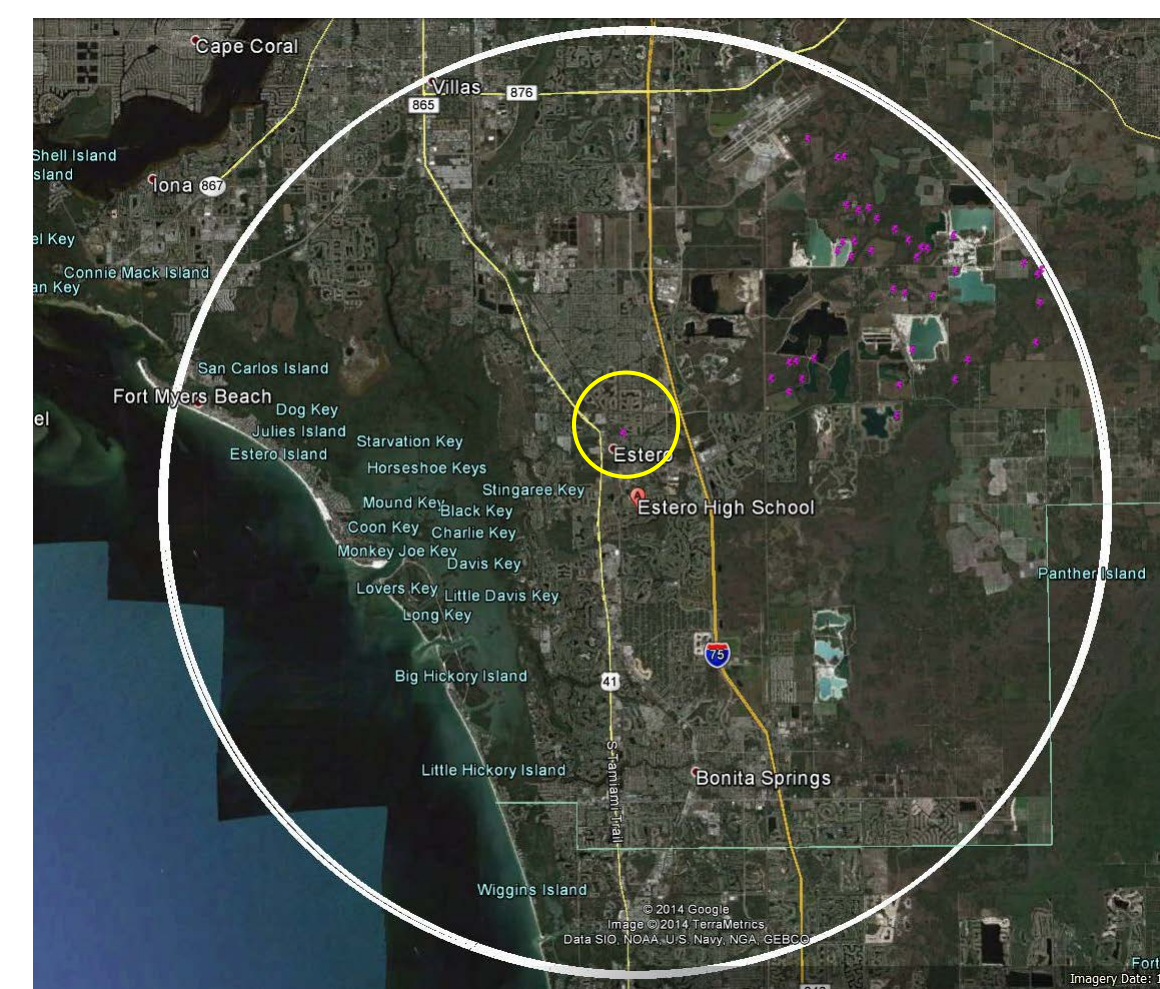
3:15 pm EDT – 20 minutes prior to CG strike – IC lightning intensifies east of the school.



3:25 pm EDT – 10 minutes prior to CG strike - IC lightning intensifies northeast of school. The system detects the first CG strike (yellow).



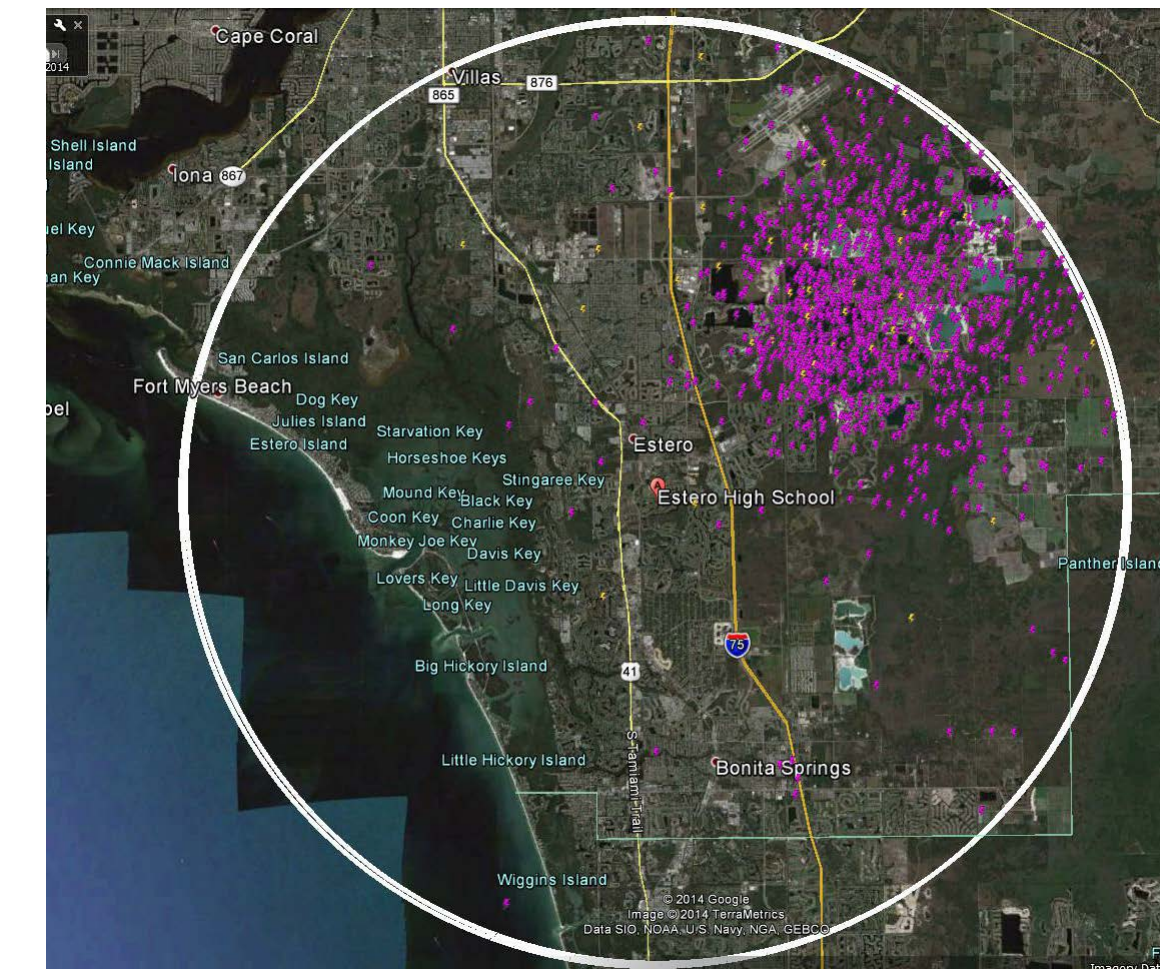
3:30 pm EDT – 5 minutes prior to CG strike - IC lightning (magenta) is detected less than two miles from school.



3:35 pm EDT – CLOUD TO GROUND LIGHTNING STRIKES SCHOOL GROUNDS – CG lightning strikes the batting cages where students had been playing baseball a short time earlier.



Total Lightning – Both CG and IC detected during this event by the Earth Networks-WeatherBug Total Lightning Network.



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