Understanding Frequent Lightning Environments Across the National Weather Service Albany, NY County Warning Area

Christina Speciale (NOAA/National Weather Service, Albany, NY)
Brittany C. Connelly and Ian A. Anderson (State University of New York at Albany)

Motivation

- National Weather Service (NWS) forecasters in Albany, NY provide frequent weather briefings to emergency manager partners across eastern New York and western New England during the warm season when large public outdoor events are planned or ongoing.
- Partner briefings are focused around potential hazards and impacts from both severe thunderstorms and lightning. Partners will take action when either severe thunderstorms or lightning are expected.
- Local office research on damaging winds and hail is well-documented and has improved operations. This study aims to improve local expertise in predicting excessive lightning environments.
- Enhancing our understanding of key environmental parameters tailored toward lightning production will hopefully allow forecasters to anticipate frequent lightning events. Thus, services provided to emergency manager partners as they make life saving decisions will also be improved.
- NWS Raleigh, NC conducted a lightning study as part of a COMET project. It proved successful in improving the understanding of prolific lightning events across North Carolina.

Student Participation

- NWS Albany offers internships to undergraduate atmospheric science students. Participating in a research project with an NWS forecaster is part of their internship.
- Two undergraduate students assisted with this lightning research.

Methodology

- Studied 10-yr period between Jan 1, 2008 - Dec 31, 2017 bounded by NWS Albany CWA
- Python script collected lightning data from the National Center for Environmental Information (NCEI)'s archive of Vaisala's National Lightning Detection Network (NLDN)
- Definition of a "Frequent Lightning" day:
  - A 24-hr period (00z – 00z) with **5,000** or more cloud-to-ground (CG) lightning strikes
  - Lightning fatality in the NWS Albany CWA.
- **Found a total of 53 "frequent lightning" days** (included 3 lightning fatalities days)
- Ranked all days from lowest to highest based on total strikes. Divided into two bins based on the median value of **9,176**:
  - "Low End" days: _Under_ Median Value
  - "High End" days: _At or Over_ Median Value
- Mapped lightning strikes from each frequent lightning day in Google Earth. Overlaid BUFKIT sites to determine which soundings from the NAM would best represent the frequent lightning environment.
- Used Excel to determine the time window in which the majority of the lightning strikes occurred and thus which model run would be most useful.
- Analyzed archived soundings from each frequent lightning day and documented values for specific parameters in spreadsheet.
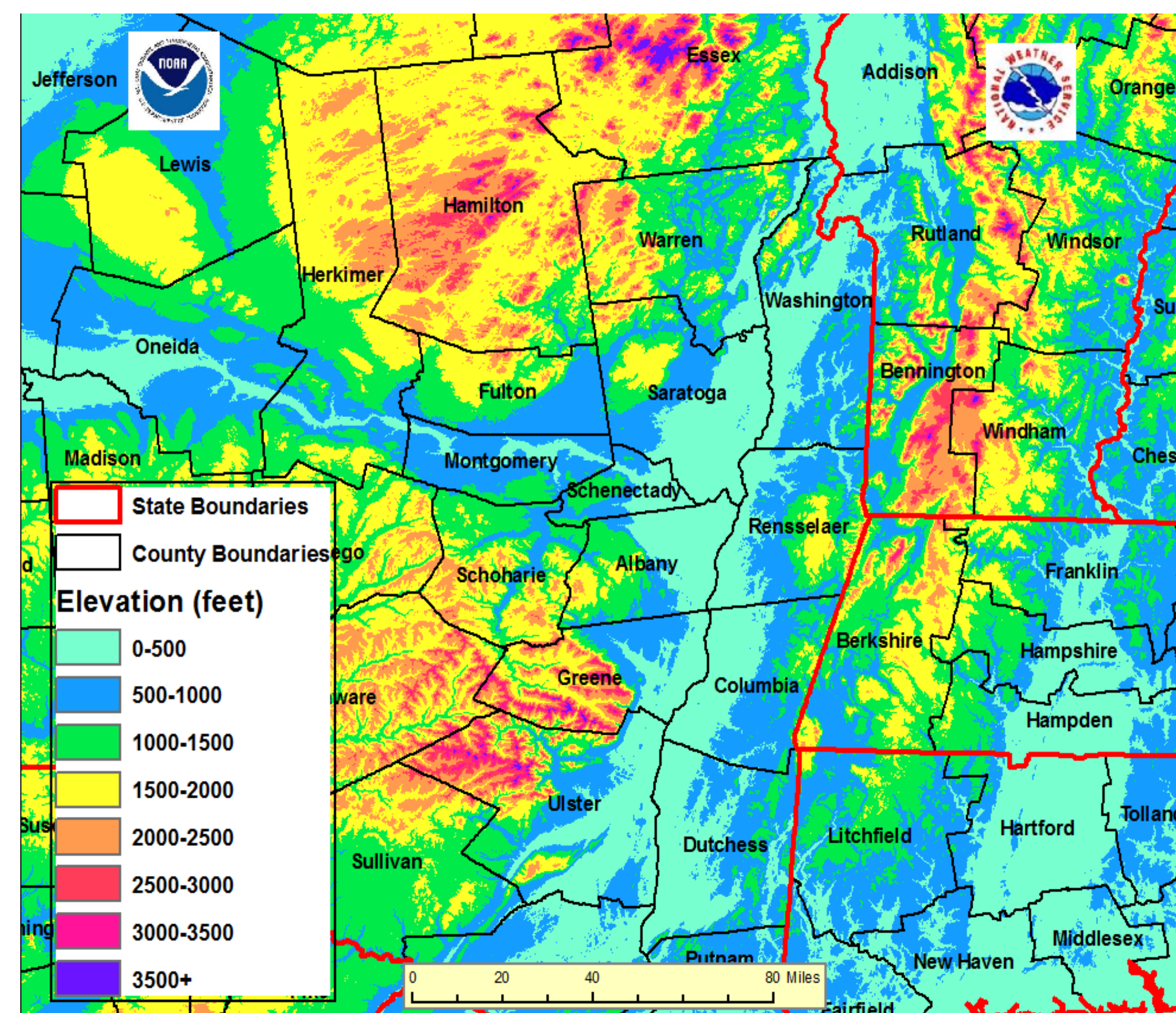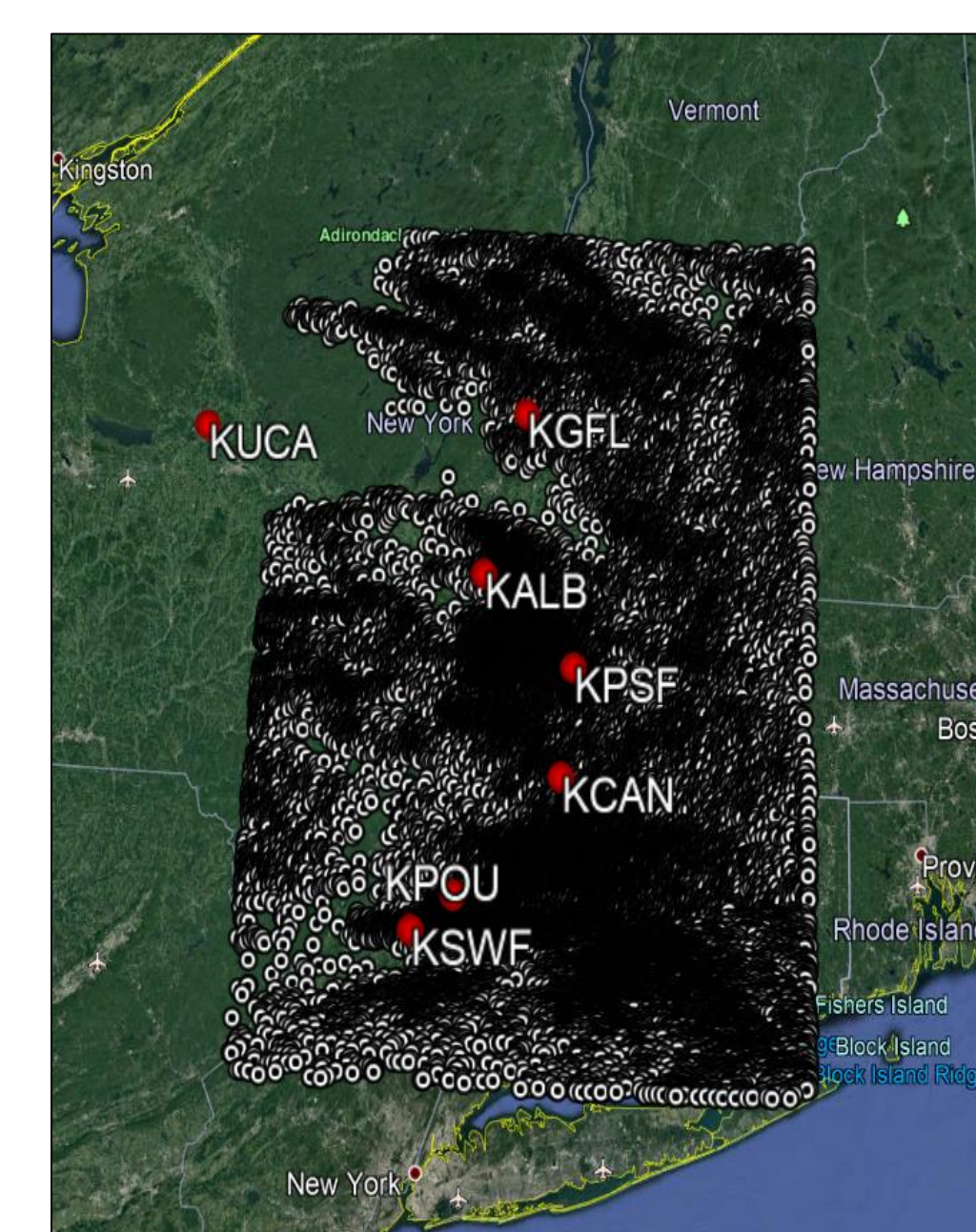
NWS Albany, NY County Warning Area (CWA)
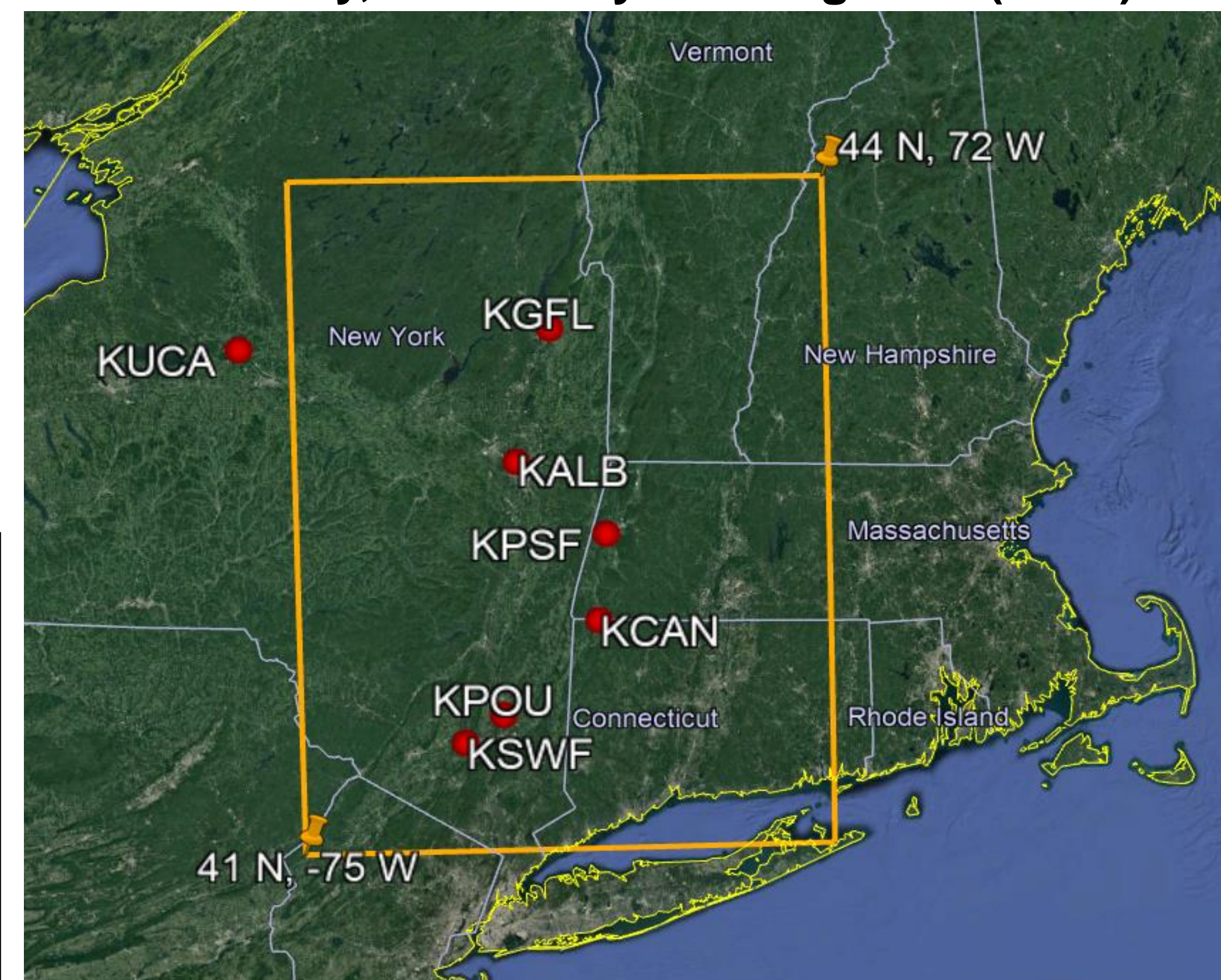
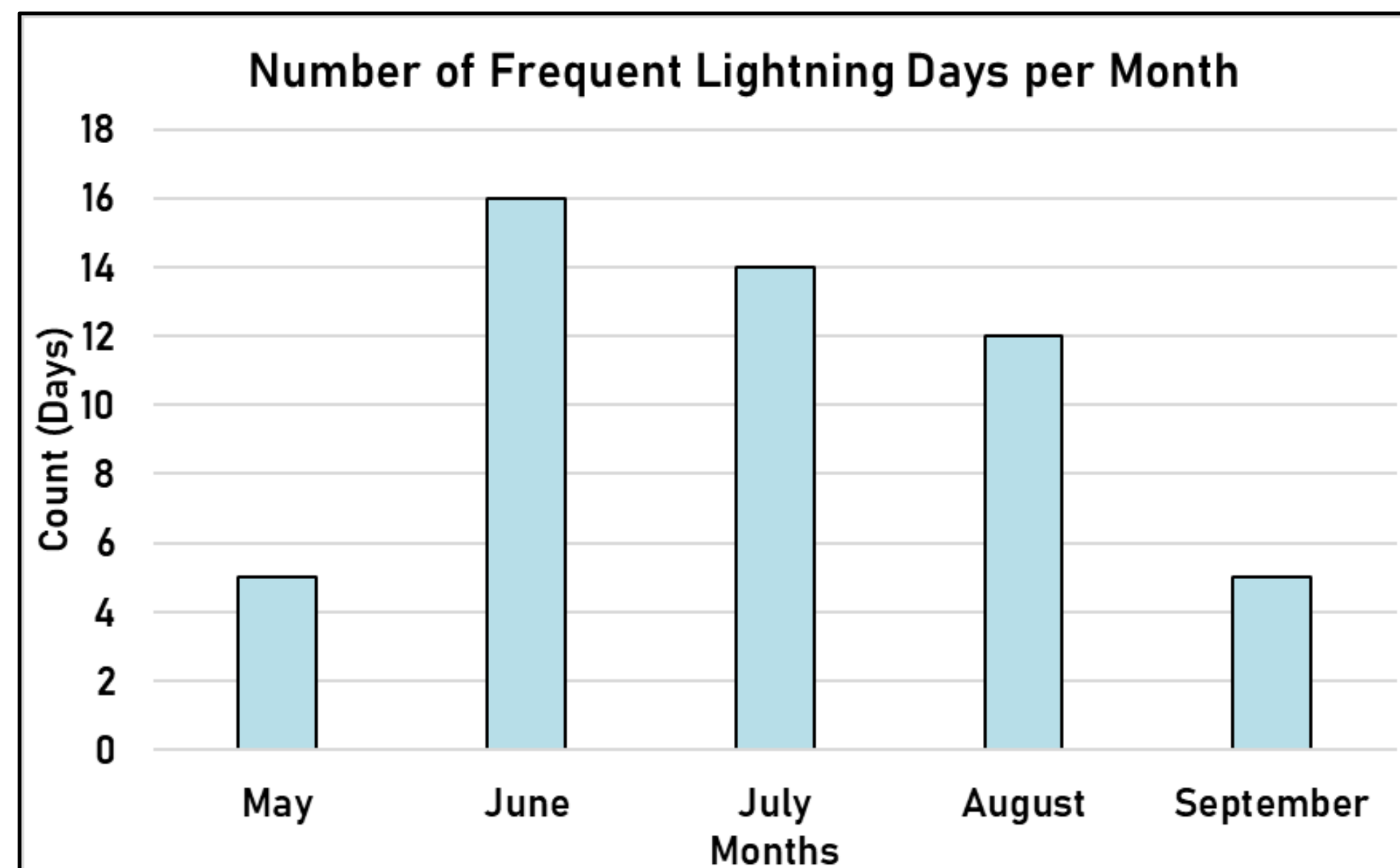### Bounding Box Used to Gather Archived CG Lightning Strikes overlaid with chosen BUFKIT sites
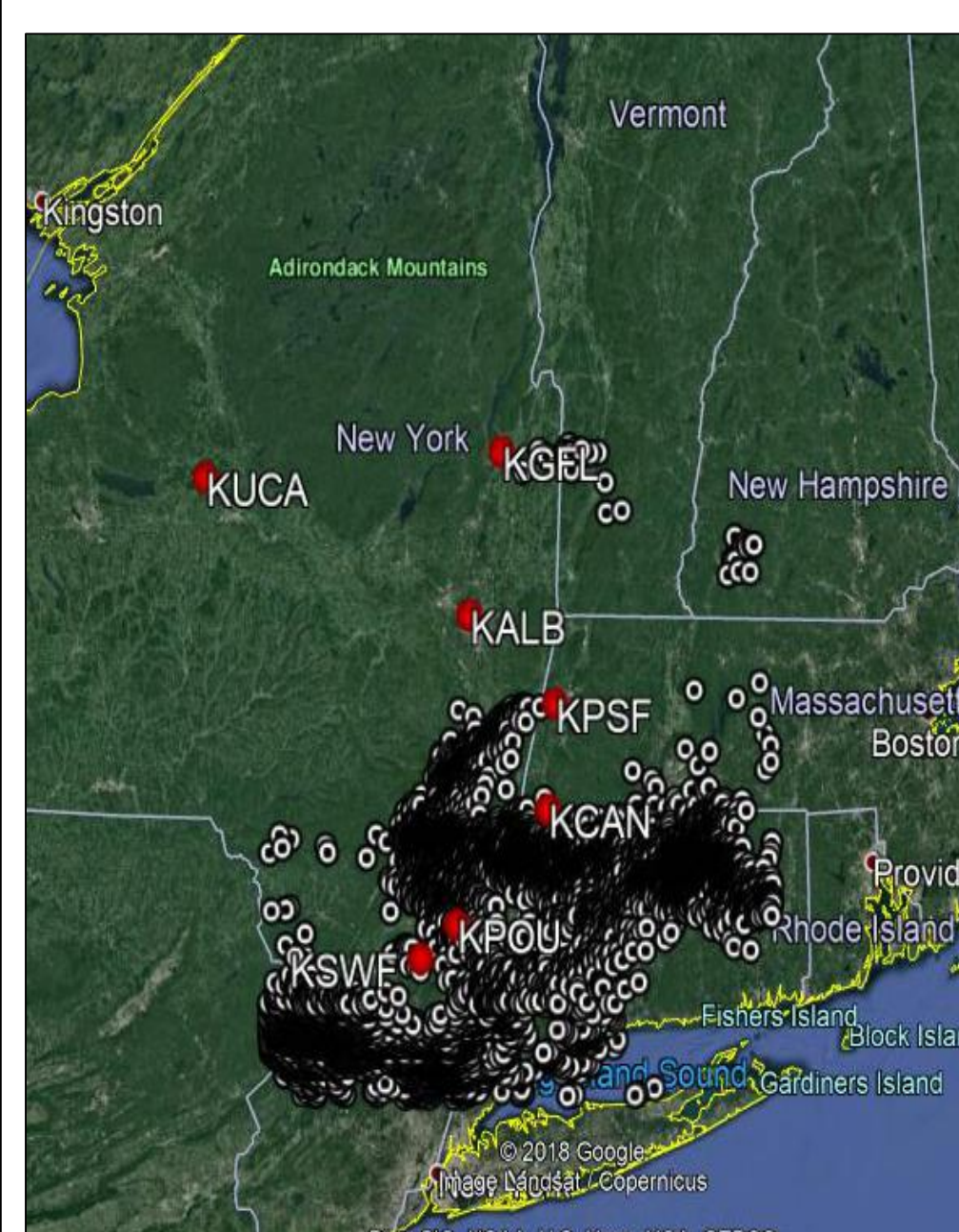
Example of a *"low end"* frequent lightning day
June 22-23, 2012 | 5,916 strikes.

Example of a *"high end"* frequent lightning day
June 9-10, 2011 | 34,790 strikes.

Results

### Number of Frequent Lightning Days per Month

Common Environmental Characteristics of Frequent Lightning Days

- Warm, moist air masses but PWAT mainly < 2"
- Deep buoyancy layers with NCAPE ~ 0.15 J/kgm
- Sufficient Surface Based Instability
  - Tall, Skinny CAPE
  - Hail Cape (-10°C to -30°C) ~ 500J/kg
- Steep Lapse Rates
  - 850 – 700mb lapse rates: 6.5 – 7.5°C/km
  - 700 – 300mb lapse rates: 6.5 – 7.0°C/km
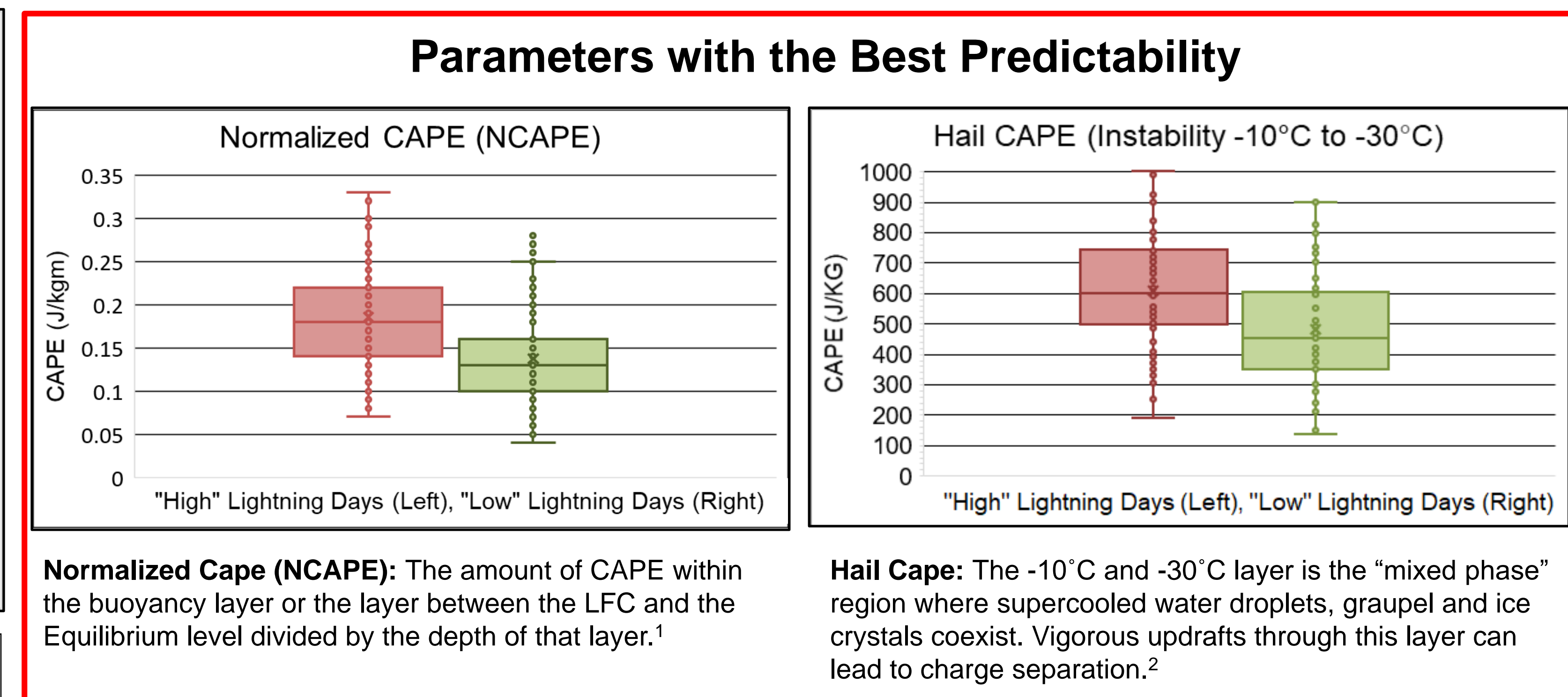- Sufficient Effective Shear
  - 25 to 35 knots
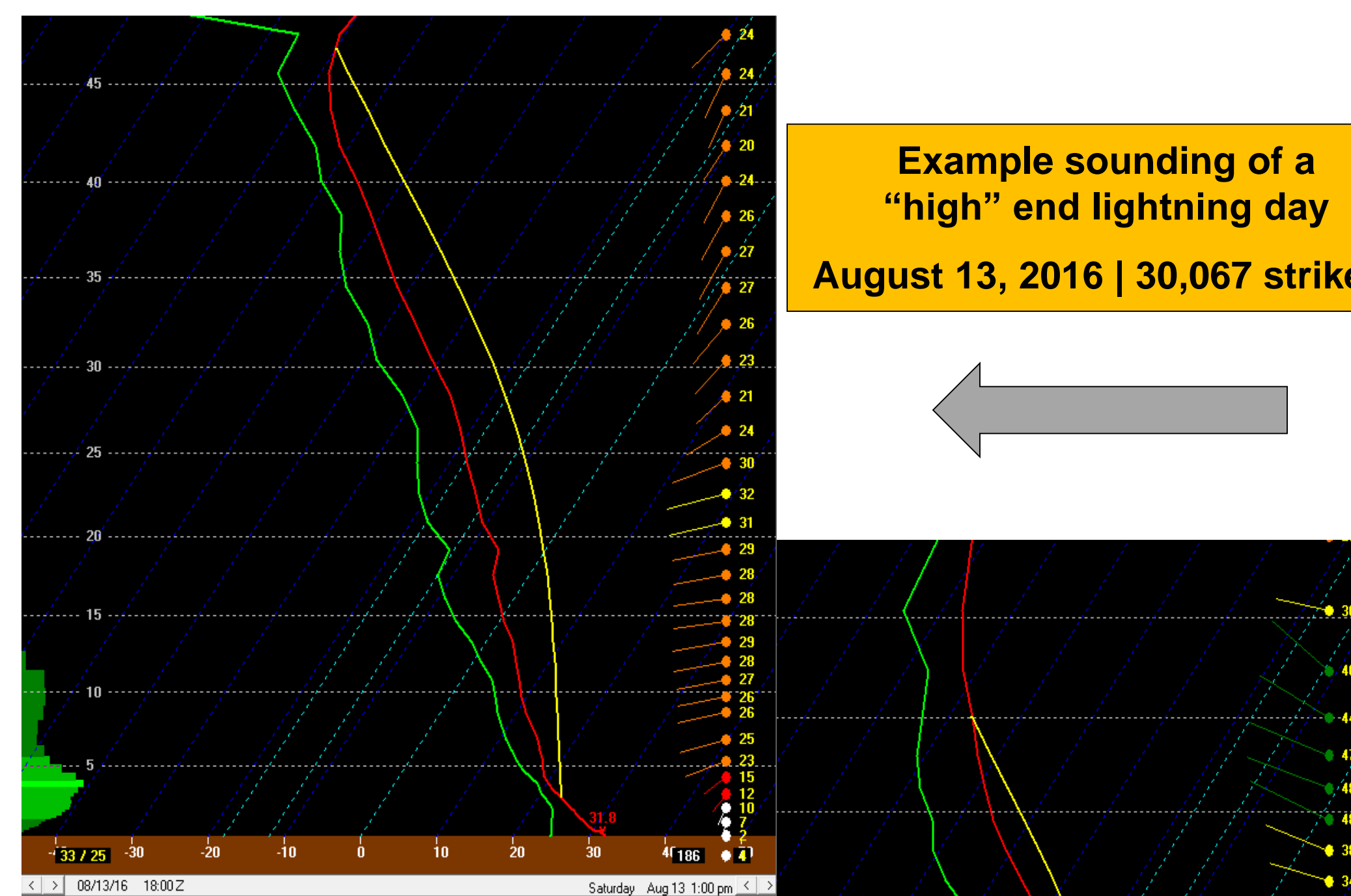
Example sounding of a "high" end lightning day
August 13, 2016 | 30,067 strikes
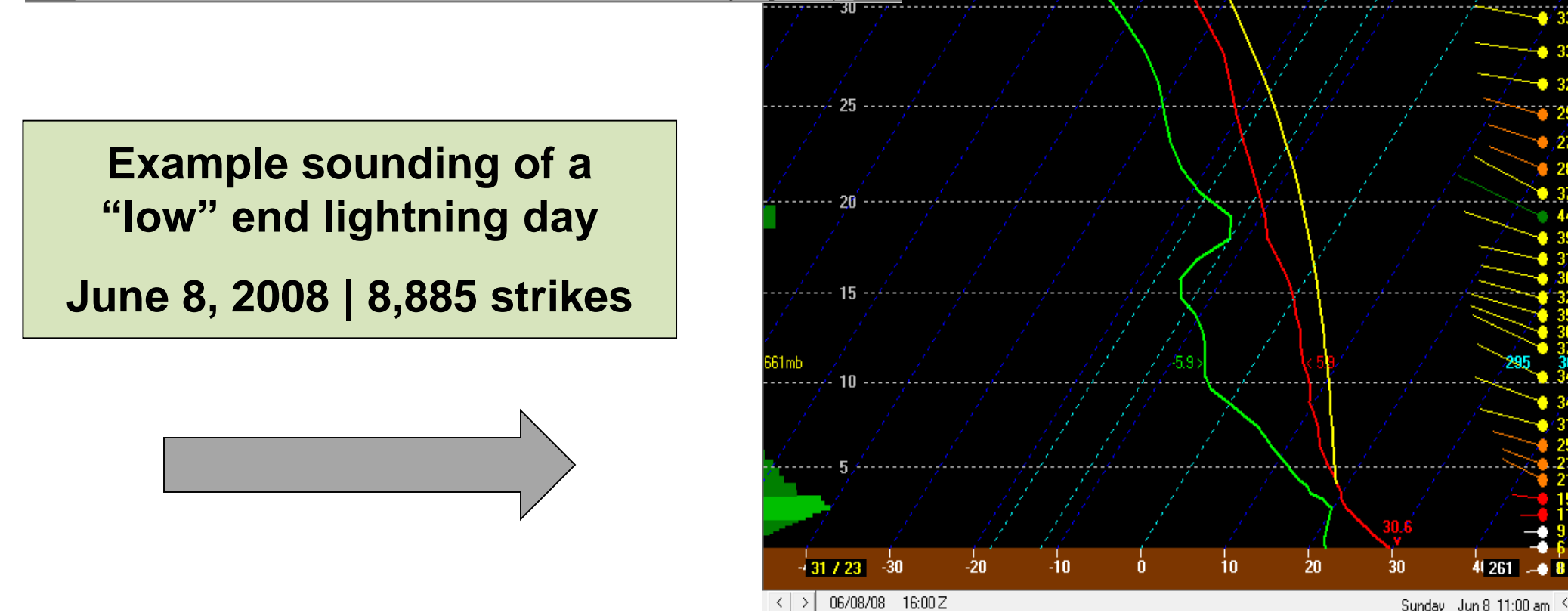
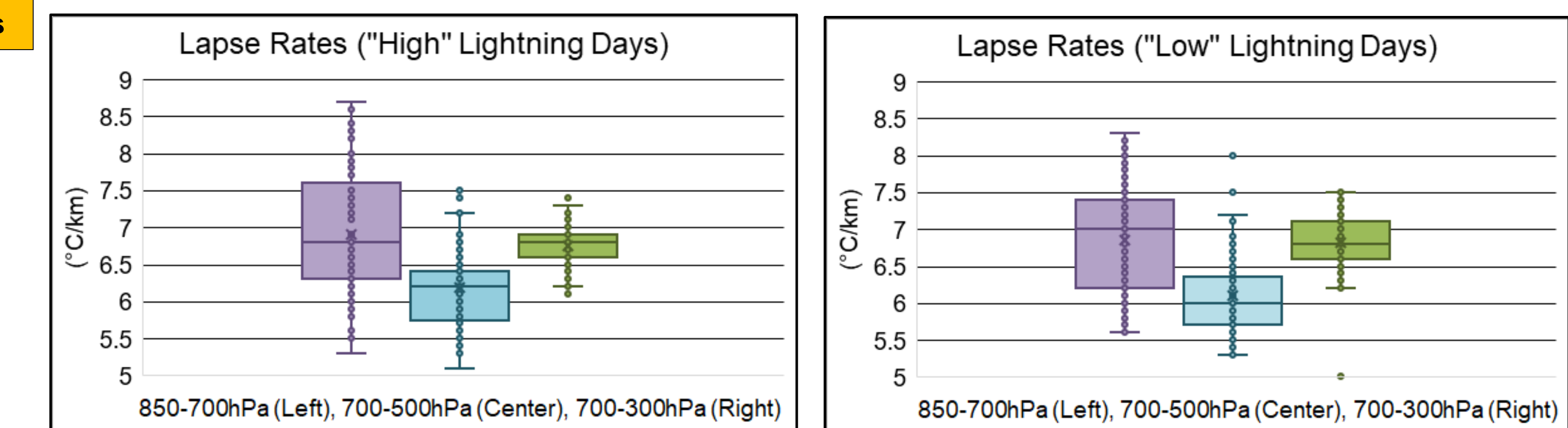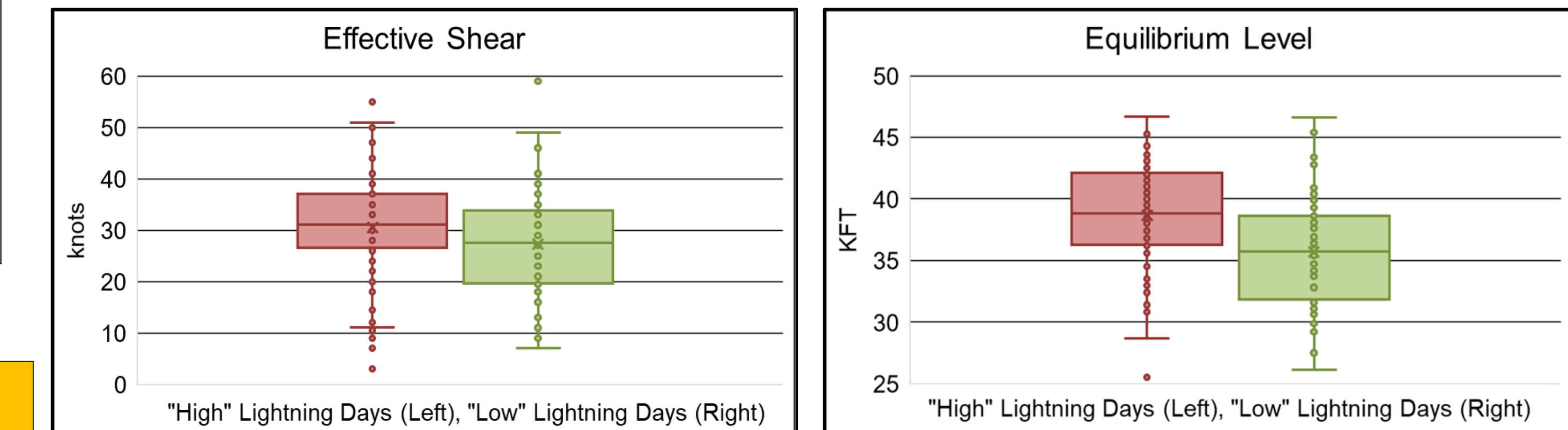Example sounding of a "low" end lightning day
June 8, 2008 | 8,885 strikes

Box and Whisker Plots

Parameters with the Best Predictability

Normalized CAPE (NCAPE)

Hail CAPE (Instability -10°C to -30°C)

"High" Lightning Days (Left), "Low" Lightning Days (Right)

Normalized Cape (NCAPE): The amount of CAPE within the buoyancy layer or the layer between the LFC and the Equilibrium level divided by the depth of that layer.[1]

Hail Cape: The -10°C and -30°C layer is the "mixed phase" region where supercooled water droplets, graupel and ice crystals coexist. Vigorous updrafts through this layer can lead to charge separation.[2]

Precipitable Water (PWAT)

Surface Based Instability

Effective Shear

Equilibrium Level

Lapse Rates ("High" Lightning Days)

850-700hPa (Left), 700-500hPa (Center), 700-300hPa (Right)

Lapse Rates ("Low" Lightning Days)

850-700hPa (Left), 700-500hPa (Center), 700-300hPa (Right)
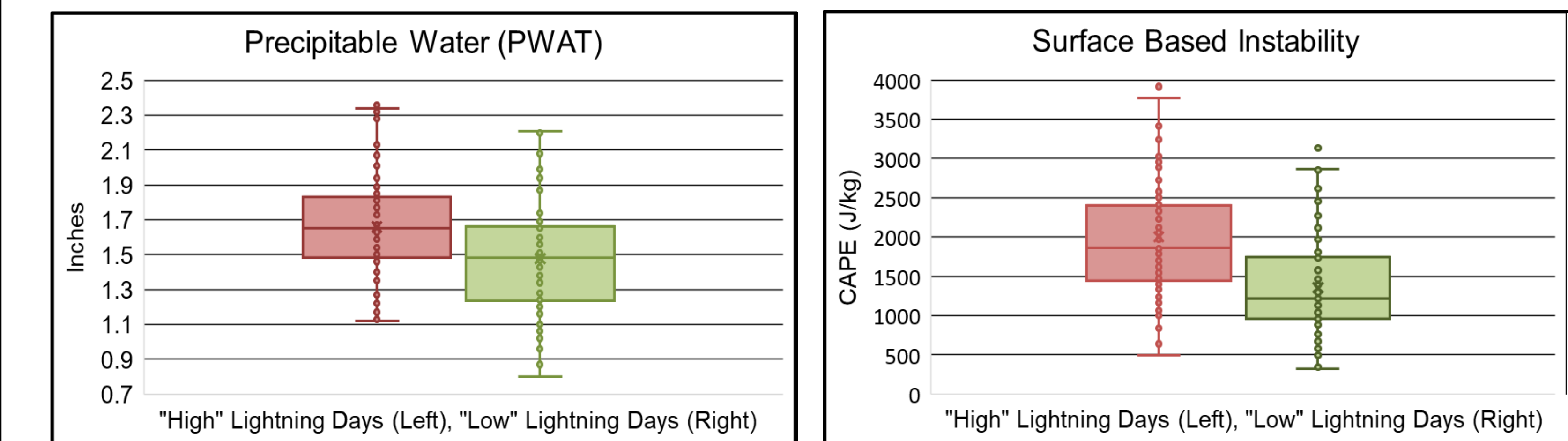
Future Work

- Create a lightning density output. This will give insight into days where storms produced frequent lightning strikes over a short distance compared to days where multiple storms produced occasional lightning strikes over a large area.
- Compare to null cases.
- Investigate lifting mechanisms at play in current list of lightning days.
- Present finding in an operationally useful format to forecasters.

Citations

1 - Blanchard, D. O., 1998: Assessing the Vertical Distribution of Convective Available Potential Energy. *Wea. Forecasting*, **13**, 870-877.

2 – *Investigation of Extreme Lightning Days in North Carolina.* Gail Hartfield and Jonathan Blaes, NWS Raleigh, NC and Gary Lackmann, Michael Graves, and Lindsey Anderson, North Carolina State University, Raleigh, NC. Prepared for the 38th NWA Annual Meeting, October 2013.