



# Objective Lightning Forecasting at KSC/CCAFS using Cloud-to-Ground Lightning Surveillance System Data



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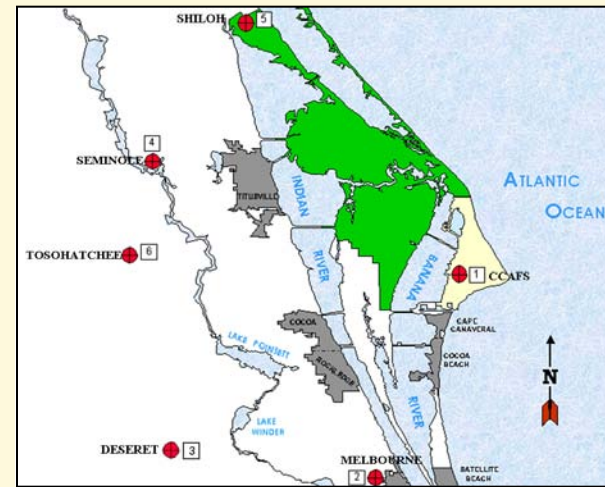
# Motivation

- 45 WS provides lightning probability for the day
- Subjective analysis of model and observational data
- Performance of current objective tool, Neumann-Pfeffer Index, **worse than 1-day persistence**
- Forecasters requested new objective tool
- Results from 2 research projects used in development
  - Everitt (1999) developed logistic regression equations that improved skill over Neumann-Pfeffer
  - Lericos et al (2002) identified major flow regimes over Florida and associated lightning distributions



# Data Sources

- POR May-September (warm season) 1989 - 2003
- Cloud-to-Ground Lightning Surveillance System (CGLSS)
- CCAFS 1000 UTC sounding
- Florida 1200 UTC soundings:
  - Jacksonville (1995 – 2003)
  - Tampa (1989 – 2003)
  - Miami (1995 – 2003)
  - *Waycross GA (1989 – 1994)*
  - *West Palm Beach (1989 – 1994)*

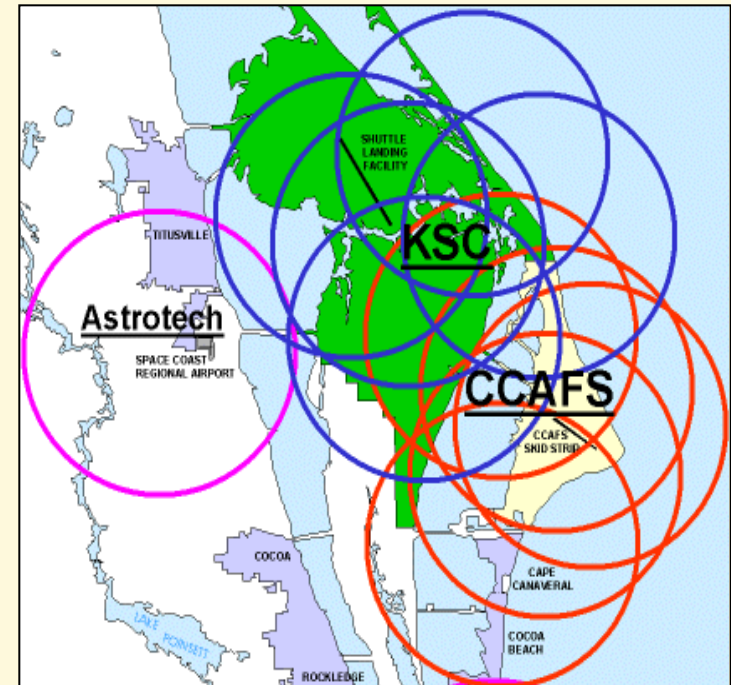




# CGLSS Data



- Filtered to only include:
  - 45 WS lightning advisory areas
  - Between 0700-Midnight EDT
- Determined lightning / non-lightning occurrence by day
- Used 3 ways:
  - Predictand for the equations
  - Daily climatological frequency of lightning occurrence
  - 1-day persistence



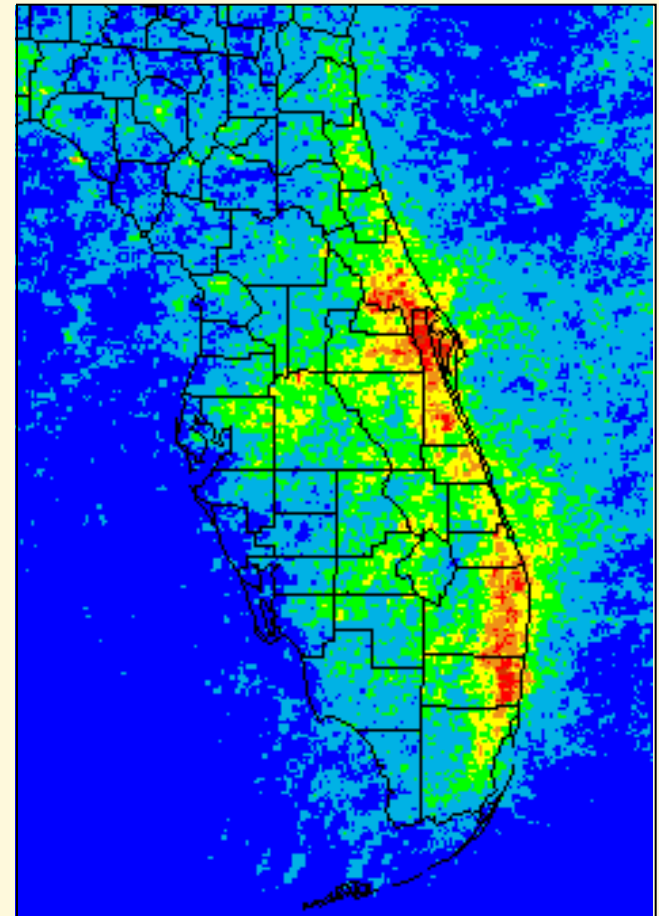
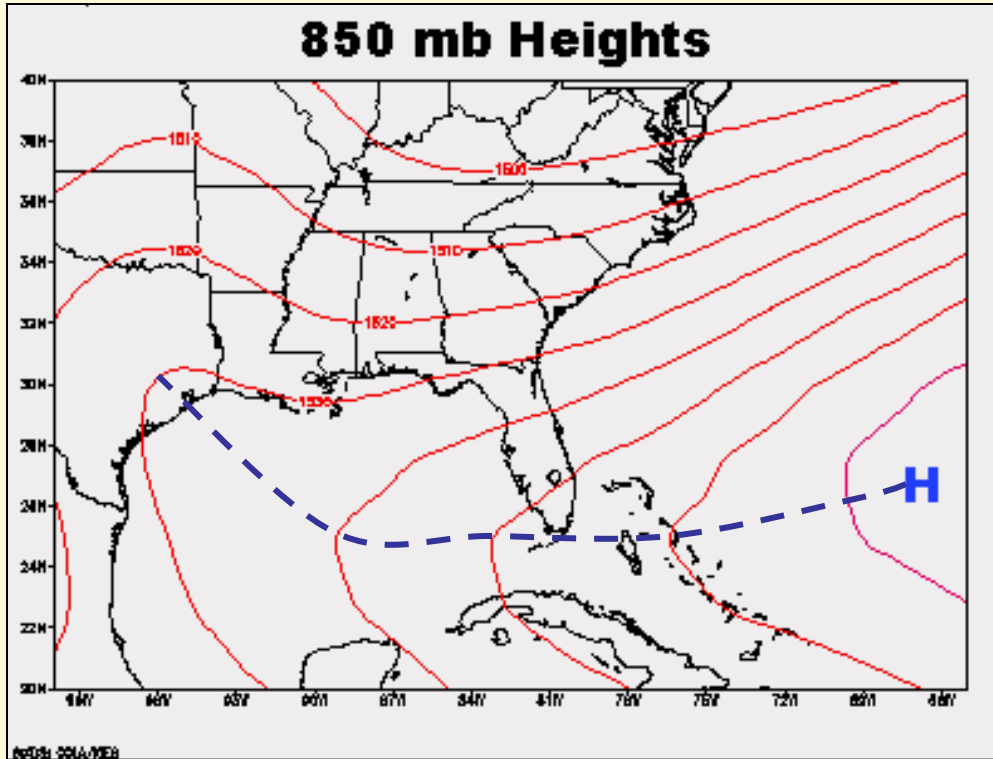


# Sounding Data

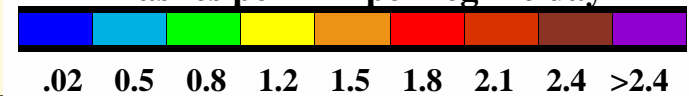
- CCAFS 1000 UTC
  - 3 soundings/day
    - 1000/1500/2300 UTC
  - 10 stability indices
- 1200 UTC MIA/TBW/JAX
  - Average wind direction in 1000 – 700 mb layer defined flow regime
  - Lightning frequencies calculated for each flow regime
    - Each individual month
    - Entire warm season

<i>Flow Regime</i>	<i>Total # Days</i>	<i># Ltg Days</i>	<i>Ltg Prob</i>
<b>SW-1 Ridge S of MIA</b>	271	179	<b>66 %</b>
<b>SW-2 Ridge between MIA/TBW</b>	218	158	<b>72 %</b>
<b>SE-1 Ridge between TBW/JAX</b>	283	143	<b>51 %</b>
<b>SE-2 Ridge N of JAX</b>	218	85	<b>39 %</b>
<b>NW</b>	93	40	<b>43 %</b>
<b>NE</b>	100	18	<b>18 %</b>
<b>Other (Regime Undefined)</b>	945	418	<b>44 %</b>
<b>TOTALS</b>	<b>2128</b>	<b>1041</b>	<b>49 %</b>

# SW-1 Flow Regime Example



Flashes per km<sup>2</sup> per regime day







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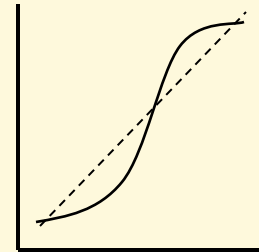
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# Equation Development

- Data stratified into development (13 years) and testing (2 years) data sets

- Logistic Regression: 
$$y = \frac{e^{(b_0 + b_1 x_1 + \dots + b_k x_k)}}{1 + e^{(b_0 + b_1 x_1 + \dots + b_k x_k)}}$$



- One equation for each month

Predictors for each month				
May	June	July	August	September
Thompson Index	800-600 mb RH	Total Totals	K-Index	Persistence
Flow Regime	Persistence	Persistence	Flow Regime	Flow Regime
Persistence	Lifted Index	800-600 mb RH	Total Totals	800-600 mb RH
Daily Climatology	Flow Regime	Daily Climatology	Daily Climatology	Daily Climatology
500 mb Temp	Daily Climatology	Flow Regime	800-600 mb RH	Lifted Index
			Persistence	





# Equation Testing

- Brier Skill Score: Percent improvement in skill over a forecast benchmark
- 4 forecast benchmarks
- New equations improved skill over all benchmark methods

<b>% Improvement over Benchmark Methods</b>					
<b>Forecast Method</b>	<b>May</b>	<b>Jun</b>	<b>Jul</b>	<b>Aug</b>	<b>Sep</b>
1-Day Persistence	31	53	38	42	43
Daily Climatology	27	18	27	12	21
Monthly Climatology	34	20	27	16	22
Flow Regime	34	13	20	8	21



# Equation Testing

## Reliability Diagram

Purple curve:

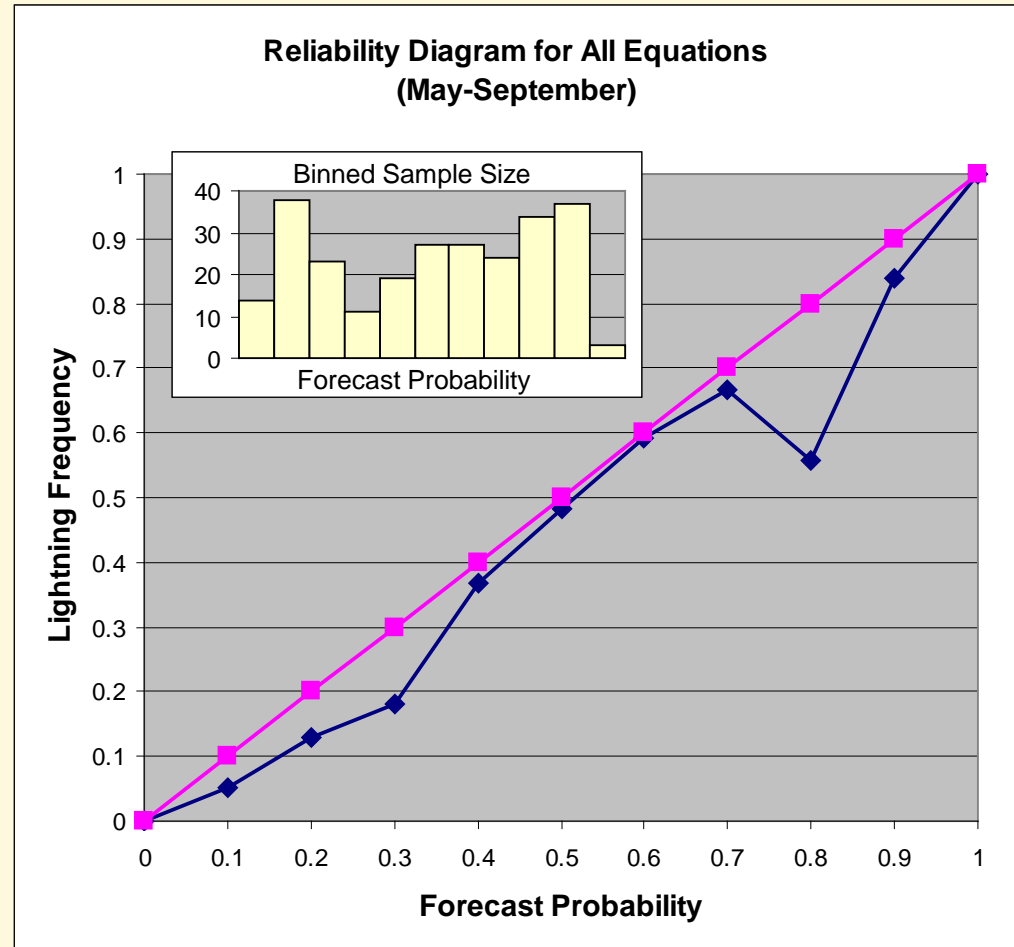
Perfect reliability

Blue curve:

Equation reliability

## Inset Histogram

Number of probability values in each bin





# Equation Testing

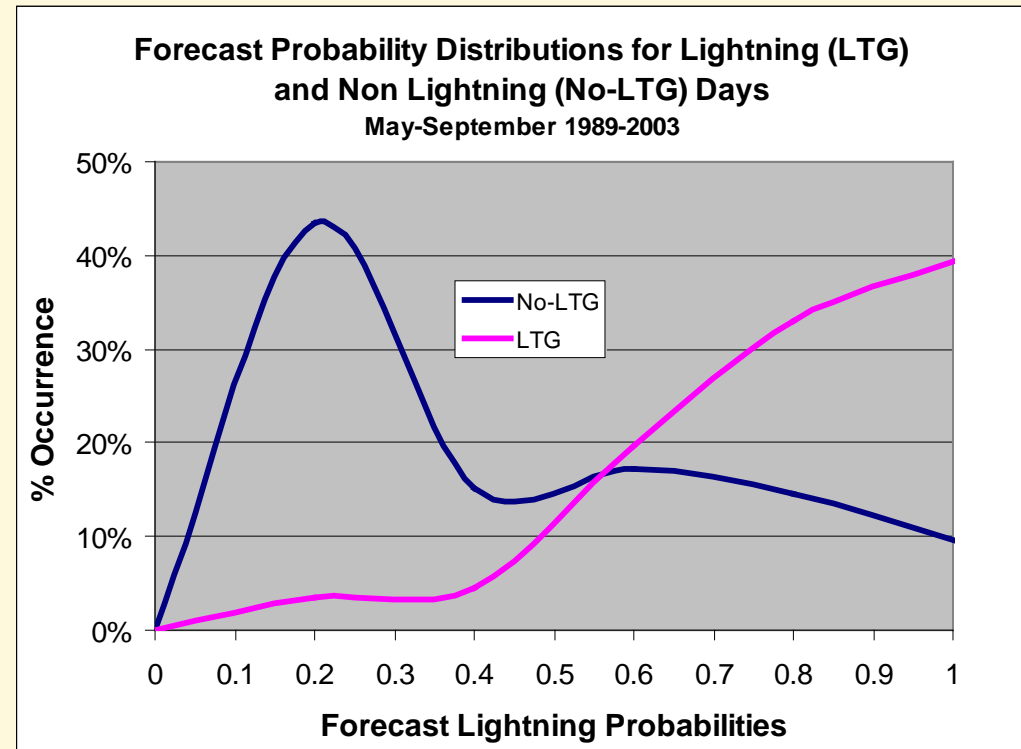
## Probability Distributions

Purple curve:

Lightning days

Blue curve:

Non-lightning days





# Conclusions



- New equations out-performed 4 forecast methods
- Good reliability, slight tendency to over-forecast
- Will be transitioned to operations
- Provides first guess to be used along with other data and forecaster experience



AMU Website: <http://science.ksc.nasa.gov/amu>