



# Forecasting Lightning at Kennedy Space Center and Cape Canaveral Air Force Station, Florida



**Winnie Lambert and Mark Wheeler**

AMU/ENSCO, Inc.

**William Roeder**

USAF 45th Weather Squadron

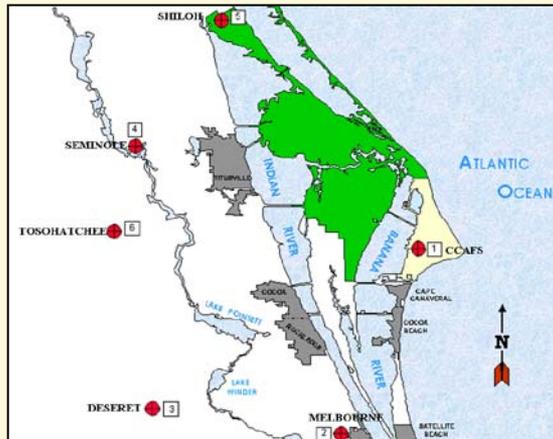
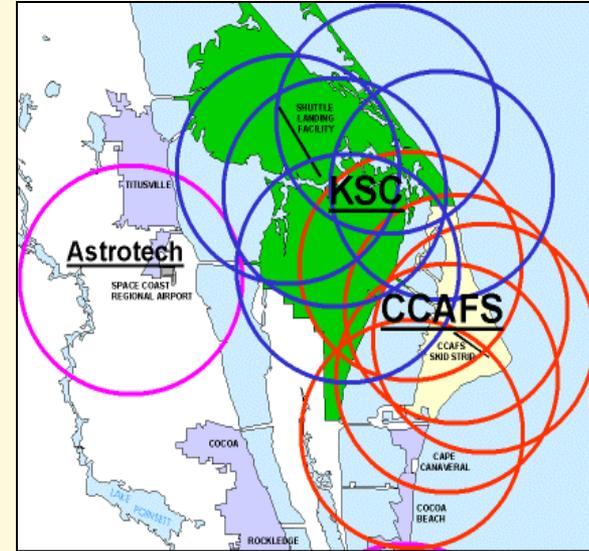


# Motivation

- 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
- Area: Rectangle surrounding all 5 nmi warning circles
- Cloud-to-Ground Lightning Surveillance System



- CCAFS 1000 UTC sounding
- Florida 1200 UTC soundings





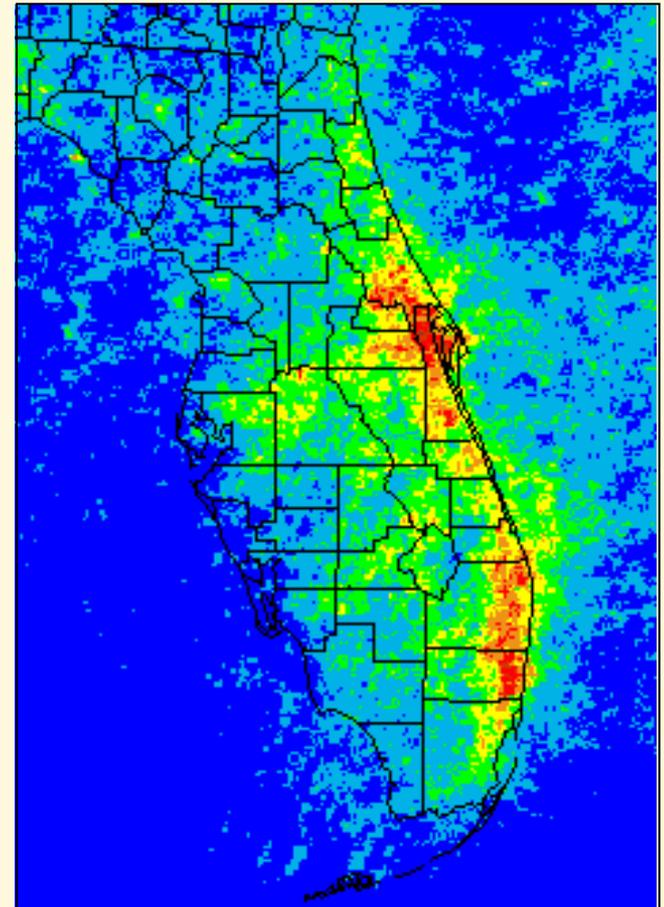
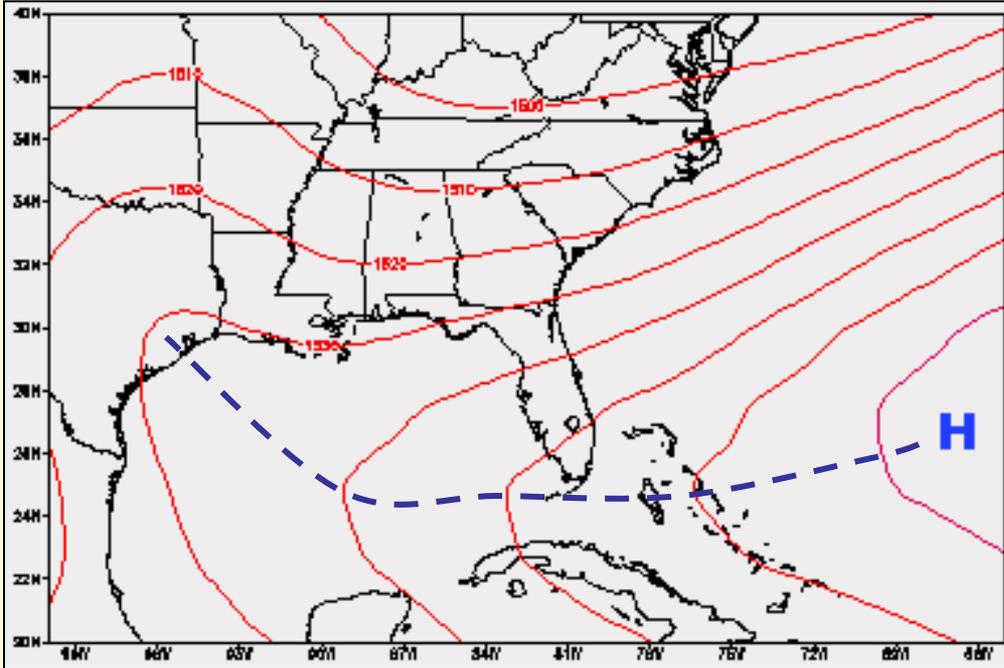
# Flow Regimes

- 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

Low-level ridge south of Miami



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





# Flow Regimes

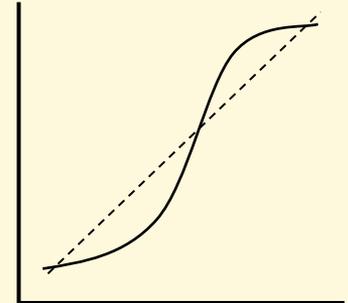
- 1200 UTC MIA/TBW/JAX
  - Average wind direction in 1000 – 700 mb layer defined flow regime
  - Lightning frequencies calculated for each flow regime
    - Each individual month
    - Entire warm season

<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>



# Equation Development

- Data stratified into development (13 years) and testing (2 years) data sets
- Logistic Regression: 
$$y = \frac{e^{(b_0+b_1x_1+\dots+b_kx_k)}}{1 + e^{(b_0+b_1x_1+\dots+b_kx_k)}}$$
- One equation for each month



Predictors for each month in rank order				
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

- Conducted 4 tests to determine equation performance
- Contingency Table statistics, optimal at 60% cutoff
  - Equations: POD - 75% FAR - 33% HR - 73%
  - Persistence: POD - 67% FAR - 37% HR - 68%
- Brier Skill Scores showed 31-53% improvement over 1-day persistence
- Possess good ability to distinguish between lightning and non-lightning days
- Good reliability, with a slight tendency to over-forecast lightning occurrence
- Good performance, transitioned to operations



# Graphical User Interface



- Forecasters need interface to complex equations
- Built using Visual Basic<sup>®</sup> in Microsoft<sup>®</sup> Excel<sup>©</sup>
- Workbook has 6 worksheets
  - Instructions
  - Data for each month
- GUI has 3 dialog boxes
  - Current month and day
  - Other predictors: persistence, flow regime, and stability index values
  - Lightning occurrence probability

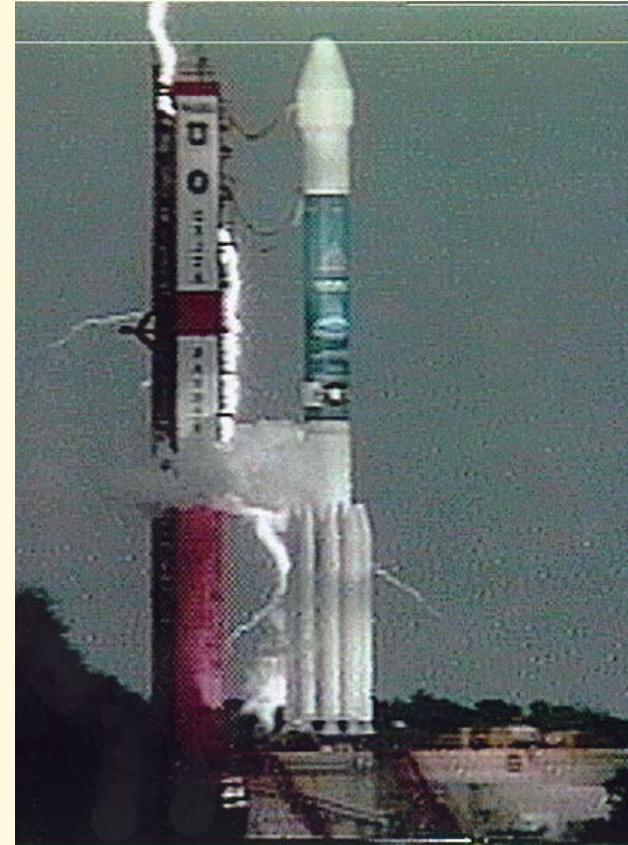
## Demo

The screenshot displays three overlapping dialog boxes from a graphical user interface. The background window is titled 'PREDICTORS FOR JULY' and contains several radio button options under 'Persistence' and 'Flow Regime'. The 'OBJECTIVE LIGHTNING FORECAST TOOL' dialog box is open, showing 'Today's Date' with 'Month' set to 'Jul' and 'Day' set to '15'. Below the date fields are 'Cancel' and 'Continue...' buttons. The 'PROBABILITY OF LIGHTNING' dialog box is also open, displaying the text: 'The probability of lightning being observed in at least one of the KSC/CCAFS advisory circles today from 0700 - 2400 EDT is: 84 %'. Below this text is a 'Calculate Another Probability' button. At the bottom of the main window, there are 'New Date' and 'Calculate Probability...' buttons.



# Conclusions

- New equations perform well, outperform Neumann-Pfeffer Index and 1-day persistence
- GUI has been transitioned to operations
- Tasked to update equations and automate data input
- Provides first guess to be used along with other data and forecaster experience



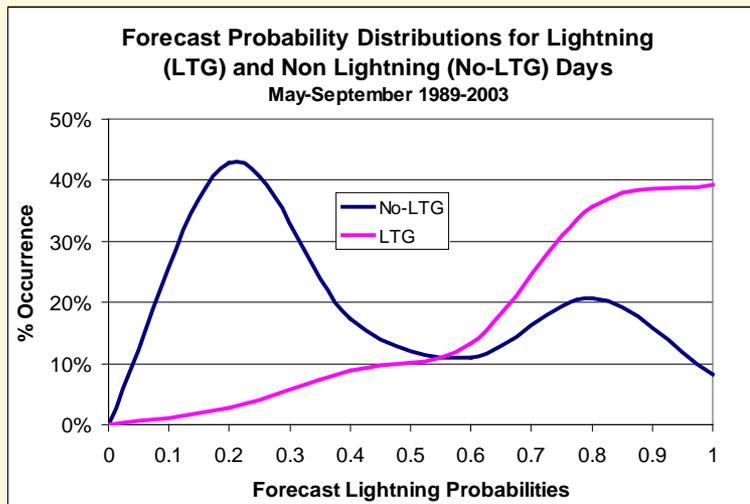
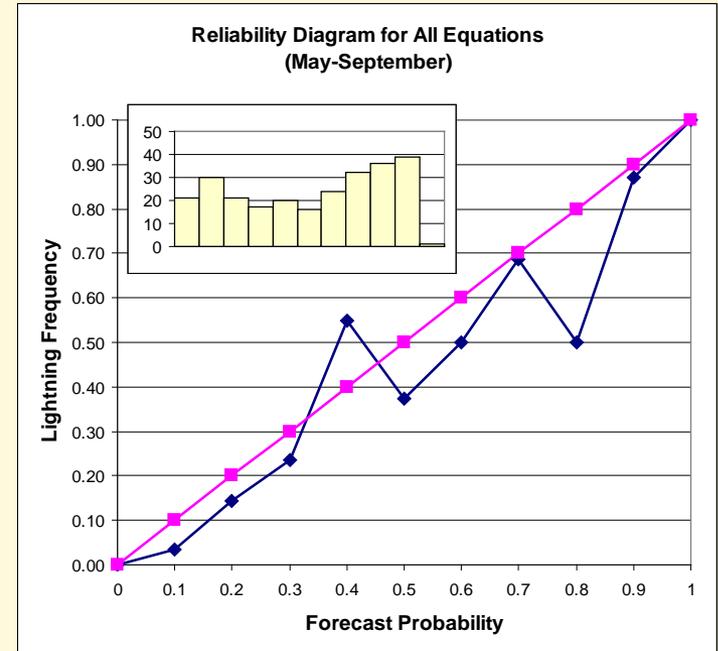
AMU Website: <http://science.ksc.nasa.gov/amu>



# Equation Testing

## % Improvement over Benchmark Methods

Forecast Method	May	Jun	Jul	Aug	Sep
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



### Equations:

POD = 75% FAR = 33% HR = 73%  
 CSI = 0.55 HSS = 0.45 KSS = 0.46

### Persistence:

POD = 67% FAR = 37% HR = 68%  
 CSI = 0.48 HSS = 0.36 KSS = 0.34