



Improvements to the Objective Lightning Probability Forecast Tool in use at Cape Canaveral Air Force Station, Florida



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Outline

- Overview
- Background on Former and Current Tools
- Description of Current Tool
- Planned Modifications to Current Tool
- Summary





Overview



- 45 WS provides lightning probability for the day
 - Daily Weather Briefing at 7:00 am local time
 - Used for general daily Range operations planning
- Subjective analysis of model and observational data
- AMU-developed **Objective Lightning Forecast Tool**
 - Provide probability of lightning occurrence May–September
 - Accessed through GUI
- 45 WS requested an **update to the tool**:
 - Modify certain predictors and possibly improve performance
 - Create automated access to equations



Background

- Previous objective lightning forecasting tool:
Neumann-Pfeffer Thunderstorm Index (NPTI)
 - Developed over 30 years ago, tuned to KSC/CCAFS area
 - Official objective lightning forecasting tool
- NPTI performance **worse than 1-day persistence**
- Forecasters requested new lightning forecast tool
- New tool showed
 - **31-53% (month dependent) improvement over 1-day persistence**
 - Good reliability, accuracy measures, and skill scores
 - Ability to distinguish between lightning/non-lightning days
- Transitioned to operations before 2005 lightning season

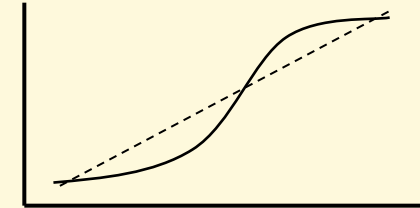


Current Lightning Probability Tool

- 5 equations output probability of CG occurrence

- One equation for each month

- Logistic regression:
$$y = \frac{e^{(b_0 + b_1x_1 + \dots + b_kx_k)}}{1 + e^{(b_0 + b_1x_1 + \dots + b_kx_k)}}$$



- Each equation has 5-6 predictors

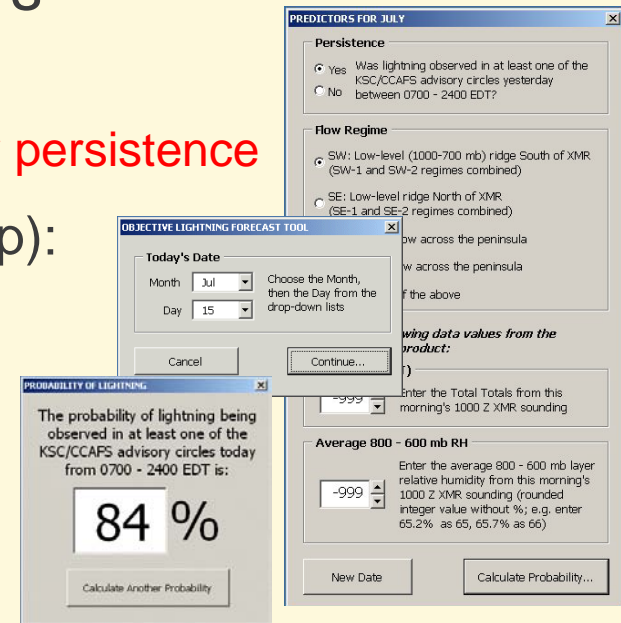
- Common to **all 5** equations:

Daily climatology, flow regime, 1-day persistence

- Common to **4** equations (Jun – Sep):

Mean RH in 800–600 mb layer

- Created GUI to interface with complex equations

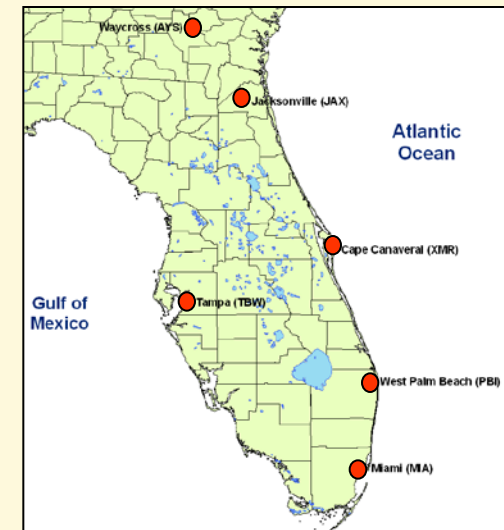
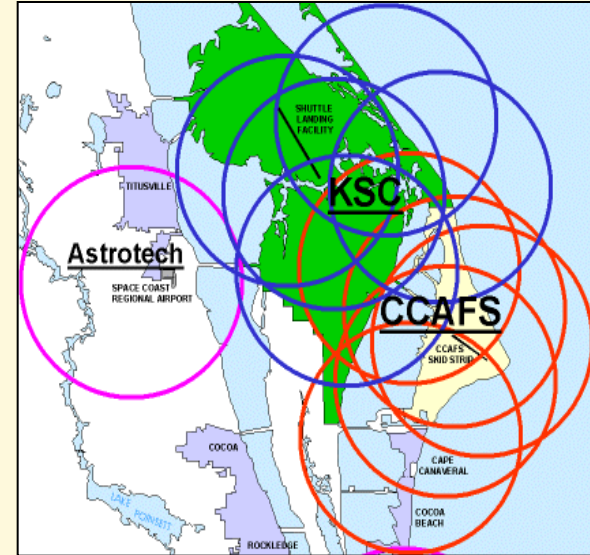




Data Sources

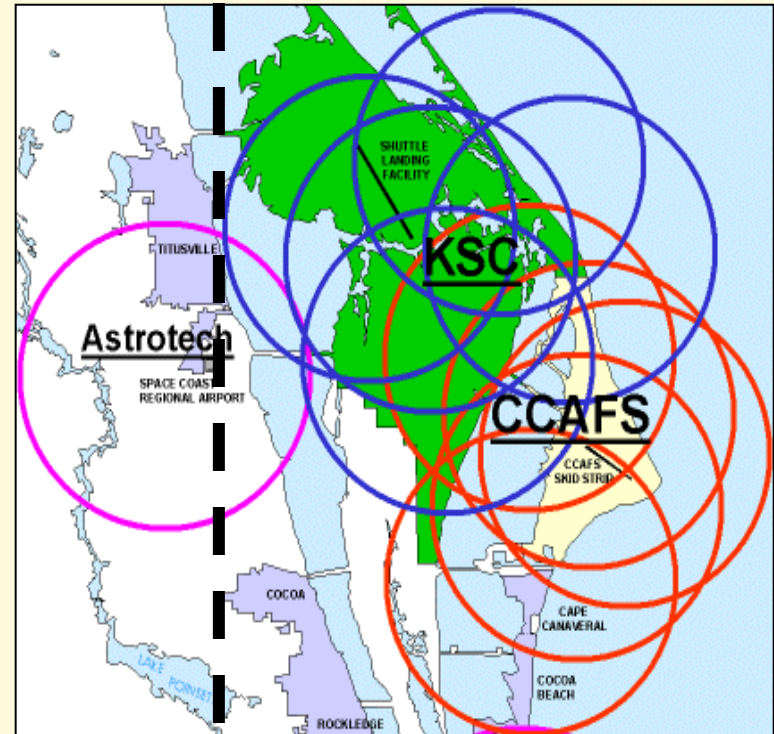


- POR May-September (warm season) 1989–2003
- Area: Rectangle surrounding all 5 nmi warning circles
- Cloud-to-Ground Lightning Surveillance System ▶
- CCAFS 1000 UTC sounding
 - Data used in 7:00 am briefing
 - 10 stability parameters (e.g. LI, KI, etc.)
- Florida 1200 UTC soundings
 - Flow regimes
 - Low-level wind dir at MIA – TBW – JAX



Modifications to Current Tool Valid Area

- Current valid area includes all users of CG forecast
- Overestimate probabilities
 - Large area outside of circles
 - CG density climatology increases inland
- More representative of CG in KSC/CCAFS area
- Re-calculate 3 predictors:
daily climo, **flow regime**, persistence

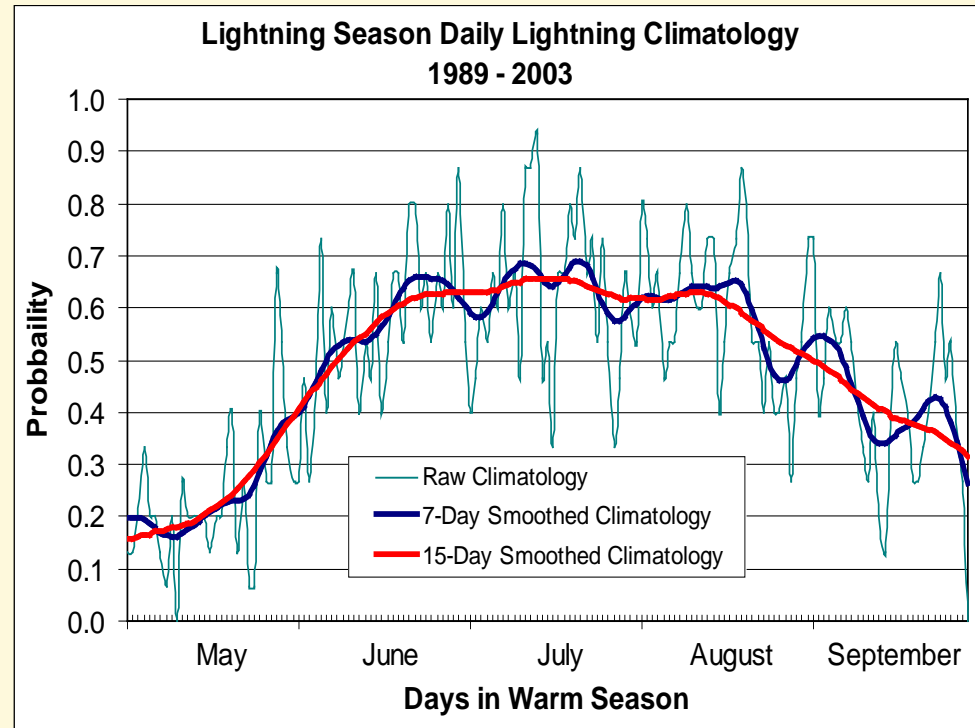




Modifications to Current Tool

Daily Climatology

- Number of days with CG for each day in period
- Re-calculated values using new area
- Also used a new smoothing technique
 - Center-weighted Gaussian
 - Current (dark blue curve):
±7 days, scale = 3 days
 - New (red curve):
±15 days, scale = 7 days

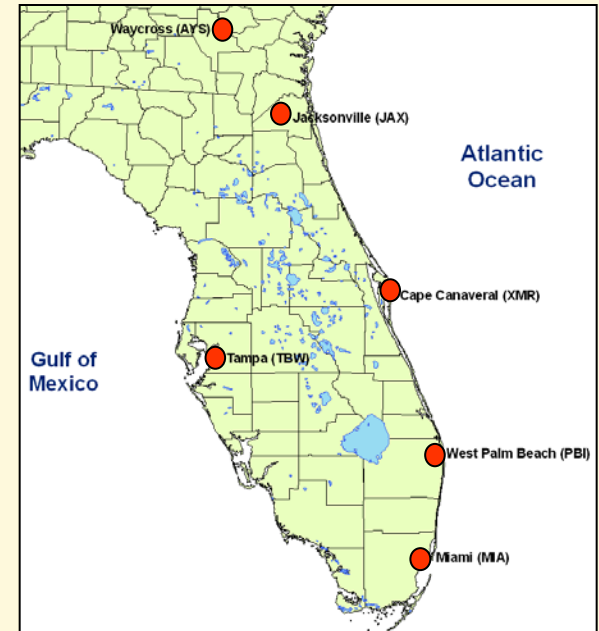




Modifications to Current Tool Flow Regime



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



- Recalculate values for new valid area
- Use 10Z CCAFS sounding as discriminator
 - Ridge north or south of CCAFS
 - Reduce the number of cases in 'Other' regime

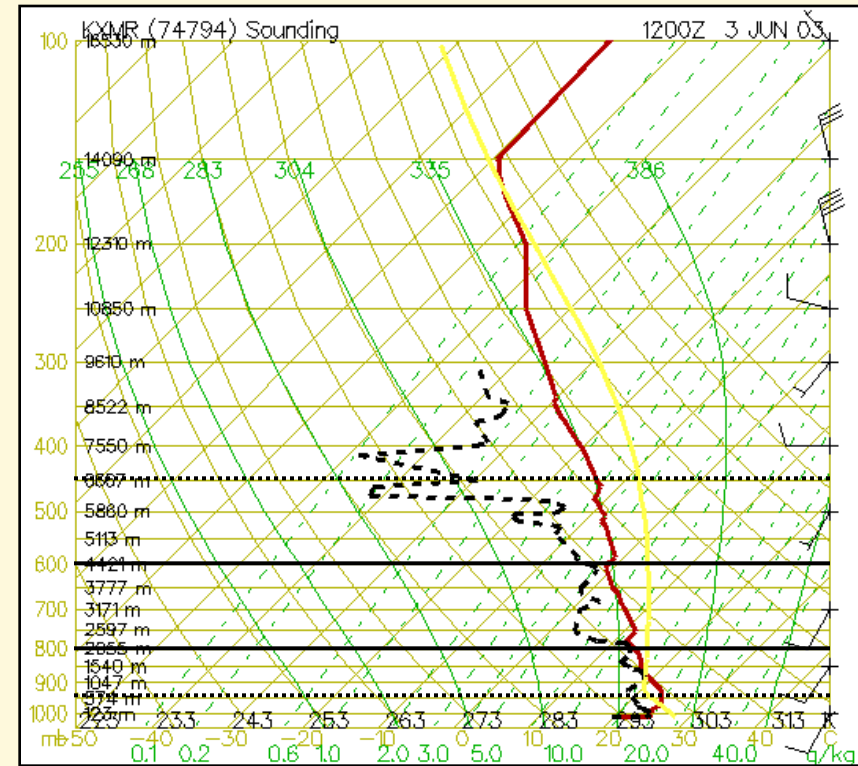




Modifications to Current Tool

Optimize Mid-Layer RH

- Used as a predictor in NPTI
- Perpetuated in following studies
- No rigorous attempts to test other layers
- Use an automatic iterative technique
 - Analyze +/- 50 mb layers from top and bottom of layer
 - Bottom: 950 mb; Top: 450 mb



1000 UTC 3 June 2003
CCAFS Sounding



Modifications to Current Tool Automated Access



24 Hour Planning Forecast

Monday, August 30, 2004

Cape Canaveral Spaceport

(Updated by 08L, 16L, & 00L)

| FORECAST | Monday 1st Period | | Monday 2nd Period | | Tuesday 3rd Period | |
|---|----------------------|---------------|----------------------|---------------|-----------------------|---------------|
| | 0800-1200L | 1200-1600L | 1600-2000L | 2000-2400L | 0000-0400L | 0400-0800L |
| Sky Condition | Partly Cloudy | Mostly Cloudy | Mostly Cloudy | Mostly Cloudy | Mostly Cloudy | Mostly Cloudy |
| Precipitation Probability | 20% | 90% | 90% | 60% | 30% | 10% |
| Lightning Probability | 10% | 80% | 80% | 40% | 20% | 10% |
| Prevailing Winds (Speed in knots) | SW 5-8 | SE 7-10 | SE 8-12 | SW 7-10 | NW 6-10 | NW 6-10 |
| Temperature Range (Fahrenheit) | 77-84 | 84-87 | 87-79 | 79-75 | 75-74 | 74-76 |
| Remarks | | | | | | |
| Severe Weather Potential | NONE | MODERATE | MODERATE | LOW | NONE | NONE |

(Severe Weather is defined as Tornadoes, wind GTE 50kts, and/or hail GTE 3/4")

| | |
|----------------------|-----------|
| Sunrise: | 30/0700 L |
| Sunset: | 30/1945 L |
| Moonrise: | 30/2029 L |
| Moonsset: | 31/0827 L |
| Illumination: | 98 % |

FOR PLANNING PURPOSES ONLY.

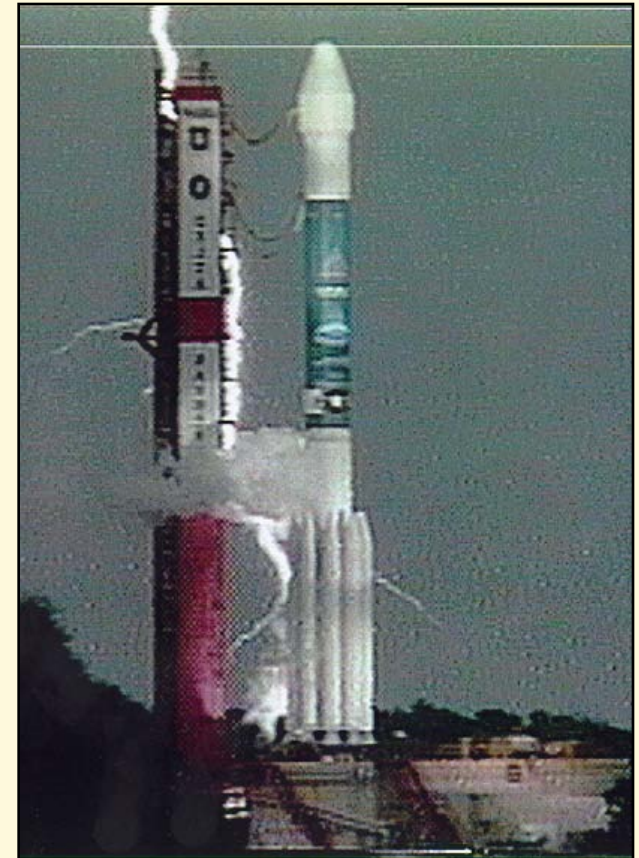
Prepared by 45WS
Range Weather Operations



Summary



- Current equations perform well
- Further Improvements:
 - Restrict area to KSC/CCAFS
 - Add data from 2004, 2005
 - Develop new daily climatology
 - Modify/test flow regime
 - Optimize mid-level RH predictors
- Automate data input
- Use probability with other data and forecaster experience



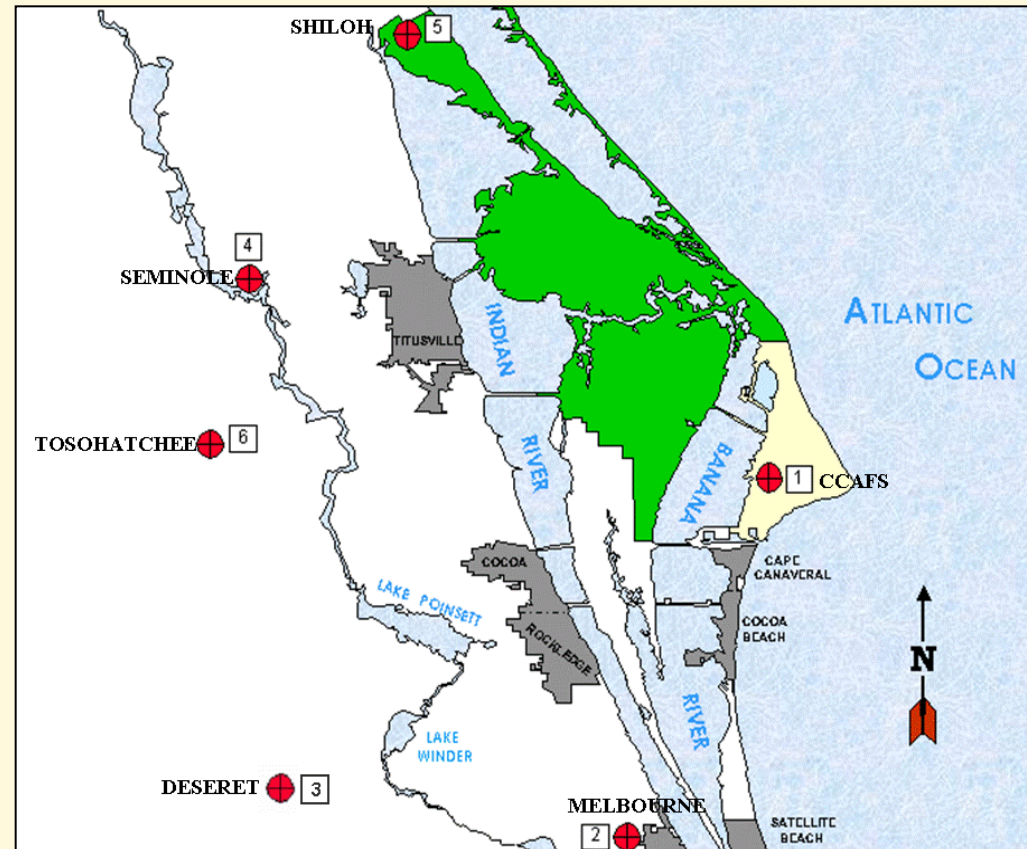
AMU Website: <http://science.ksc.nasa.gov/amu>



Cloud-to-Ground Lightning Surveillance System (CGLSS)



- Network of 6 sensors
 - IMPACT: MDF & TOA
- Provides date/time, lat/lon, strength, polarity of CG strikes
- Better detection efficiency and location accuracy than NLDN in KSC/CCAFS area



Flow Regimes

- Flow in lower atmosphere influences positions of sea breezes from Atlantic Ocean and Gulf of Mexico
- Thunderstorm activity varies across Florida peninsula according to sea breeze fronts

