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Produced by the NASA Center for Aerospace Information (CASI)
UPDATE TO THE OBJECTIVE LIGHTNING PROBABILTY FORECAST TOOL IN USE AT CAPE CANAVERAL AIR FORCE STATION, FLORIDA

Winfried Lambert
ENSCO, Inc. / Applied Meteorology Unit
lambert.winifie@ensco.com

William Roeder
USAF 45th Weather Squadron
william.roeder@patrick.af.mil

BACKGROUND
The 45th Weather Squadron (45 WS) forecasters at Cape Canaveral Air Force Station (CCAFS) include the probability of lightning occurrence in their 24-Hour and Weekly Planning Forecasts, briefied daily at 0700 EDT (1100 UTC). This forecast is used to plan for daily operations at Kennedy Space Center (KSC) and CCAFS.

Prior to development of the Objective Lightning Probability tool, this forecast was based on a subjective analysis of model and observational data, and output from the Neumann-Pfeffer Thunderstorm Index (NPI); Neumann (1971), an algorithm developed specifically for KSC/CCAFS. However, several studies showed that one-day persistence outperformed the NPI by ~10%.

The 45 WS forecasters increased reliability and objectivity in the lightning probability forecast and requested that the Applied Meteorology Unit (AMU) build a tool that would meet those needs. Such a tool was developed by the AMU in Phase I of this work (Lambert and Wheeler, 2005). This poster describes results from Phase II in which the tool was updated to increase its skill, accuracy, and reliability (Lambert 2007).

PHASE I SUMMARY
The AMU developed five equations, one for each warm season month May-September, using data from the 15-year period 1985-2000. These equations optimize the probability of lightning occurrence for the day using data available to the forecasters prior to the 0700 EDT weather briefing. The Phase I equations showed:
- Ability to distinguish between lightning/non-lightning days,
- Good reliability, accuracy, and skill,
- 31-53% improvement over persistence, and
- 48% improvement over NPI.

Because of their good performance, they were transitioned to operations in the form of a user-friendly graphical user interface (GUI).

PHASE II GOALS:
The Phase II goals were two: The first was to modify the data set and determine if it would improve equation performance. These modifications were to:
- Increase the period of record (POR) from 15 to 17 years (1989-2005),
- Change the valid area for lightning occurrence, and
- Try new formulations for three important Phase I predictors:
  - Test new smoothening parameters for the daily climatological probability,
  - Use the CCAF’s 1000 UTC sounding to help determine the flow regime, and
  - Determine the mean RH layer most correlated to lightning occurrence.

The second goal was to create a GUI on the 45 WS operational weather display system. The Phase I GUI required forecasters to input data manually. This used critical time needed to forecast other parameters and increased the likelihood of entering an incorrect value.

DATA SOURCES (PHASE I and II)
Cloud-to-Ground Lightning Surveillance System (CGLSS)
CGLSS is a network of six sensors surrounding the KSC/CCAFS area that provide:
- Date and time,
- Latitude and longitude, and
- Strength and polarity of CG strikes.

These data were used to determine lightning occurrence for each day. Only one CG was required.

1200 UTC soundings at Miami, Tampa, and Jacksonville
Following Lerico et al. (2002), the mean wind directions in the 1000-700 mb layers at these stations were used to determine the flow regime for each day.

1000 UTC CCAF soundings
Eleven parameters from this sounding were used as candidate predictors. The mean wind in the 1000-700 mb layer was used to determine the flow regime in Phase II.

PHASE II: PREDICTOR MODIFICATIONS
New Valid Area for Lightning Occurrence
The forecasts are for areas within 5 mi radius circles on KSC/CCAFS (blue and red circles). In Phase II, the valid area for lightning occurrence was a rectangle around all circles.

The 45 WS requested the valid area include only the circles on KSC/CCAFS. If the distance between a CG strike and the center of any circle was 5 mi or less, that strike was considered to be in the valid area.

Change Gaussian Smoother Parameters for Daily Climatology

Flow Regime Discriminator
Lerico et al. (2002) defined six distinct flow regimes. In Phase I, a flow regime was defined on 44% of the days in the POR. The 1000 UTC CCAF sounding was used to determine the flow regime for these days, replacing the number of days in 'Other' and 'Missing' by 70%.

Optimal RH Layer in 1000 UTC CCAF Sounding
The mean 600-400 mb layer RH was a predictor in NPI and in following studies with no rigorous attempts to test other layers. An iterative technique was used to find the mean RH layer that most correlated with lightning by calculating:

- The mean RH for layers in 25-mb increments between 950-450 mb, then
- Their correlation to lightning occurrence.

The optimal layer was found to be 925-925 mb.

PHASE II: PERFORMANCE
Brier Skill Score
Measures equation performance against other forecast methods in terms of percent improvement or degradation.

The Phase II equations outperformed Phase I by 8% for the full warm season.

Reliability
Shows the degree of over- or under-forecasting at discrete forecast probability values.

Phase II and III equations tend to under-forecast lightning; e.g., when the forecast was 20%, lightning occurred 30% of the time. Overall: Phase II bias was -5.9%; Phase II bias was -0.4%. Phase II equations reduced the bias by over 5%.

Lightning / Non-Lightning Day Distributions
Distributions of forecast probabilities for lightning and non-lightning days show how the equations distinguish between them.

The two equation sets had similar performance for non-lightning days: The Phase II equations distinguished lightning days better than Phase I.

AUTOMATION
The Phase II equations were transitioned into 45 WS operations in May 2007.

They were made available through a GUI on the Meteorological Interactive Data Display System (MIDD) system.

The GUI automatically accesses the data and appropriate sounding parameters for each equation from the 1000 UTC CCAF sounding. Forecasters choose 'yes' or 'no' for persistence and a flow regime for the day. The MIDD GUI (right) is similar in form and function to the Phase I GUI, which made the transition easier for the forecasters.

FUTURE WORK: PHASE III
The work in Phase III is driven by the daily climatology curve and has three parts:
- Add October data to capture the spin-down in lightning days at the end of the season,
- Calculate a new 14-day smoothed daily climatology, and then
- Create equations for the progression of the daily climatology instead of each month.

REFERENCES


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

Winifred Lambert
William Roeder

ENSCO, Inc.
1980 N. Atlantic Ave Suite 230
Cocoa Beach, FL 32931

NASA
John F. Kennedy Space Center
Code KT-C-H
Kennedy Space Center, FL 32899

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This conference poster describes the improvement of a set of lightning probability forecast equations that are used by the 45th Weather Squadron forecasters for their daily 1100 UTC (0700 EDT) weather briefing during the warm season months of May-September. This information is used for general scheduling of operations at Cape Canaveral Air Force Station and Kennedy Space Center. Forecasters at the Spaceflight Meteorology Group also make thunderstorm forecasts during Shuttle flight operations. Five modifications were made by the Applied Meteorology Unit: increased the period of record from 15 to 17 years, changed the method of calculating the flow regime of the day, calculated a new optimal layer relative humidity, used a new smoothing technique for the daily climatology, and used a new valid area. The test results indicated that the modified equations showed an increase in skill over the current equations, good reliability, and an ability to distinguish between lightning and non-lightning days.

Lightning, Probability forecast, Weather