GFS-based Localized Aviation MOS Product (LAMP)

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Outline

• Background
  – What is LAMP?
  – How is it developed?
• Thunderstorms
• Verification
• Products
• Current Status
• Future Plans
LAMP Background
Localized Aviation MOS Program (LAMP) Background

- LAMP is a system of objective analyses, simple models, regression equations, and related thresholds which together provide guidance for sensible weather forecasts.
- LAMP acts as an update to MOS guidance.
- Guidance is both probabilistic and non-probabilistic.
- LAMP provides guidance for aviation elements.
- LAMP bridges the gap between the observations and the MOS forecast.
  - Good quality recent surface observations help to decrease the uncertainty in the short term. As the observations become less predictive later in the forecast period, the uncertainty increases.
  - Verification shows improvement on MOS in the first hours, then skill comparable to MOS.
GFS LAMP Guidance Details

- LAMP guidance is in the range of 1-25 hours in 1 hour projections

- LAMP provides station-oriented guidance for:
  - all LAMP forecast elements
  - ~1600 stations
  - CONUS, Alaska, Hawaii, Puerto Rico

- LAMP provides grid-oriented guidance for:
  - Thunderstorms:
    - Probability of thunderstorm occurrence in a 2 hour period in a 20-km grid box
    - Best Category Yes/No of thunderstorm occurrence in a 2 hour period in a 20-km grid box
  - CONUS only

- Eventually will run 24 times a day (every hour)
Points/Grid for which LAMP generates forecasts

LAMP stations

LAMP thunderstorm grid points
Theoretical Model Forecast Performance of LAMP, MOS, and Persistence

LAMP outperforms persistence for all projections and outperforms MOS in the 1-12 hour projections.

The skill level of LAMP forecasts begin to converge to the MOS skill level after the 12 hour projection and become almost indistinguishable by the 20 hour projection.

The decreased predictive value of the observations at the later projections causes the LAMP skill level to diminish and converge to the skill level of MOS forecasts.

0 6 12 18 24
Projection (hr)
The Development Process of Generating LAMP Forecasts

1) Collate the data from a variety of sources for the regression analysis

2) Generate a regression equation for each element at each projection using a specific training period of data

3) Post-process the forecasts to ensure consistency (e.g., ensure that the temperature is always equal to or greater than the dewpoint) and create thresholds for categorical elements

4) Verify the weather element at each projection hour
LAMP Predictor Data Sources

- Predictors are data (e.g., temperature) that explain a portion of the behavior exhibited by the predictand.

- Possible predictor sources used in LAMP developments include:
  - Hourly METAR Data
  - GFS MOS forecasts
  - Simple models (such as advection of moisture)
  - Radar mosaic data
  - Lightning strike data* from the National Lightning Detection Network
  - GFS model output

- Only those predictors that make physical sense are chosen from these data sources as predictors.

* Archives obtained from Global Hydrology Resource Center (GHRC)
LAMP Equation Development
Sample Linear Regression for KATL, June 2005

Y = -16.568 + 1.2498*X

The sum of squares of the vertical distances between the line and the data points is minimized.

0000 UTC Forecast of 2-m Temperature (°F) (Predictor)

Observed Temperature (°F) (Predictand)
LAMP Threshold Development for Categorical Forecasts

- Probabilities can be used to develop “thresholds” for selecting a best category from the probabilistic information.

- Thresholds are developed by one of two techniques, either:
  - Targeting unit bias (forecast the event as often as it occurs), or
  - Maximizing the threat score.
LAMP Categorical Forecast Selection Process

The probability of “few” exceeds the threshold value for “few” – LAMP categorical forecast is “few”.

- Does the forecast probability of few equal or exceed the threshold for few?
- Does the forecast probability of scattered equal or exceed the threshold for scattered?
- Does the forecast probability of broken equal or exceed the threshold for broken?
- Does the forecast probability of overcast equal or exceed the threshold for overcast?

The forecast probability threshold values for each category are as follows:

- Category 1: Clear
- Category 2: Few
- Category 3: Scattered
- Category 4: Broken
- Category 5: Overcast
LAMP Thunderstorms
1-3 hr LAMP Thunderstorm forecast

Predictor: lightning strike data

Predictor: MOS Thunderstorm Prob

LAMP Thunderstorm Probability
11-13 hr LAMP Thunderstorm forecast

LAMP
Thunderstorm Probability

Predictor: MOS
Thunderstorm Probability
June 8, 2007

GMOS 03h forecast
Available ~16:45 UTC
Valid 18-21 UTC
June 8, 2007 1500 UTC LAMP forecast

LAMP 02h forecast
Available ~15:45 UTC
Valid 17-19 UTC
June 8, 2007 1800 UTC LAMP forecast

LAMP 02h forecast
Available ~18:45 UTC
Valid 19-21 UTC

Verifying Lightning Strikes
LAMP Thunderstorm: Probabilities and Best Category (Y/N) All Projections

[Maps showing thunderstorm probabilities and best category for different regions of the USA]
LAMP Verification
0900 UTC LAMP compared to MOS
Categorical Ceiling Height < 1000 feet

0900 UTC threat for ceiling height < 1000 feet
Cool season (October 2003 - March 2004); 1523 stations

0900 UTC LAMP verified against 0000 UTC GFS MOS
0900 UTC threat for visibility < 3 miles

Cool season (October 2003 - March 2004); 1523 stations

0900 UTC LAMP compared to MOS
Categorical Visibility < 3 miles

0900 UTC LAMP verified against 0000 UTC GFS MOS
LAMP compared to WRF-NMM and RUC20
Categorical Ceiling Height < 1000 feet

0000 UTC threat for ceiling height < 1000 feet
Cool season (October 2006 - March 2007); 1462 stations
LAMP compared to WRF-NMM and RUC20
Categorical Visibility < 3 miles

0000 UTC threat for visibility < 3 miles
Cool season (October 2006 - March 2007); 1462 stations

Threat score vs Projection (hour)
Probabilistic Verification

- Basic measure of accuracy is Brier score (lower is better).

- Measure of skill is the improvement in Brier score over a benchmark standard, such as climatology.

- The reliability of probability forecasts describes the degree to which the observed relative frequency of the weather event has an overforecasting or underforecasting bias.
LAMP vs. CMOS* Thunderstorm Brier Score Improvement on Climatology

1800 UTC Brier Score Improvement on Climatology for thunderstorms
Spring season (April 1997 - June 2005); 27,373 grid points

* CMOS stands for calibrated MOS, wherein the 1200 UTC GFS MOS is calibrated from a 3-h valid period to a 2-h valid period.
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Ceiling Height ≤ 3000 Ft

![Graph showing the comparison of observed relative frequency against 3-h forecast probability for LAMP and SREF. The graph includes a line for perfect reliability and two lines for LAMP and SREF, respectively.](image-url)
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Ceiling Height \leq 3000 \text{ Ft}
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Ceiling Height < 1000 Ft
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Ceiling Height < 1000 Ft

The diagram shows the observed relative frequency compared to the 6-h forecast probability for LAMP and SREF. The perfect reliability line represents the ideal scenario where the observed frequency matches the forecast probability. The graph indicates that both LAMP and SREF have some deviation from perfect reliability, with SREF showing a slightly better performance compared to LAMP.
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Visibility < 3 Miles
0900 UTC LAMP and SREF Reliability
October 2006 – March 2007
Probabilistic Visibility < 3 Miles

The diagram shows the reliability of 12-hour forecast probabilities against observed relative frequencies for LAMP and SREF. The gray line represents perfect reliability. The LAMP forecasts are indicated by red triangles, and the SREF forecasts are indicated by blue circles.
LAMP Products
Overview of Available Products

- Sent out on SBN/NOAAPort and NWS FTP Server
  - ASCII text bulletin
  - BUFR data
  - GRIB2 thunderstorm data
- AWIPS
  - Displayable in D2D
    - Local menu
    - Volume Browser
  - Guidance available for display and Terminal Aerodrome Forecast (TAF) preparation via the Aviation Forecast Preparation System (AvnFPS)
- GFS LAMP Website
  http://www.nws.noaa.gov/mdl/gfslamp/gfslamp.shtml
<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
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<tr>
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<td>BUFFALO GFS LAMP GUIDANCE 2/19/2008 1200 UTC</td>
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<td>UTC</td>
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<tr>
<td>WDR</td>
<td>Wind Direction</td>
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<td>WSP</td>
<td>Wind Speed</td>
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<tr>
<td>WGS</td>
<td>Wind Gust</td>
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<tr>
<td>PPO</td>
<td>Probability of Precipitation Occurrence on the hour</td>
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<tr>
<td>PCO</td>
<td>Yes/No Precipitation Occurrence on the hour</td>
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<td>P06</td>
<td>Probability of 6-Hour Measurable Precipitation</td>
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<td>TP2</td>
<td>Probability of Thunderstorms during 2-Hour period</td>
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<tr>
<td>TC2</td>
<td>Yes/No Thunderstorm Occurrence during 2-Hour period</td>
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<tr>
<td>POZ</td>
<td>Probability of Snow</td>
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<tr>
<td>POS</td>
<td>Probability of Freezing</td>
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<td>TYP</td>
<td>Precipitation Type</td>
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<td>CLD</td>
<td>Total Sky Cover</td>
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<tr>
<td>CIG</td>
<td>Ceiling Height</td>
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<td>CCG</td>
<td>Conditional Ceiling Height</td>
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<td>CVS</td>
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<tr>
<td>OBV</td>
<td>Obstruction to Vision</td>
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</table>
GFS LAMP Station Plots

Click an element name on this slide to see its plot

Elements
- Flight Category
- Ceiling Height
- Visibility
- Obstruction to Vision
- Total Sky Cover
- Precipitation Type
- Probability of Precipitation
- Wind Speed
- Wind Gust
- Wind Direction
- Temperature
- Dewpoint
GFS LAMP Station Meteograms

**Features**

- Up to 12 displayable GFS LAMP forecast elements
- Real-time verification of current and past cycles
- Verification of completed past cycles including the corresponding GFS MOS forecast
Timing of Precipitation start/stop

The meteograms can be helpful in determining the timing of a particular weather event. In the example above, LAMP correctly forecasted that precipitation would begin at 08Z Monday, which was eight hours before the event, but missed the onset of the thunderstorms by one hour.
Timing of gusts

In another example, these meteograms show LAMP handling the timing of a high wind event by correctly forecasting 40 knot gusts and diminishing the high winds in the overnight hours.
LAMP was able to catch this dense fog event on Monday morning, when the 06Z MOS had no reduced visibilities. The influence of the observed dense fog allowed the LAMP to “update” the MOS forecast and correctly depict this event.
The Influence of the Observation (Degradation)

The above image shows the 00Z LAMP temperature and dewpoint meteograms with the corresponding GFS MOS forecast and the verifying observation. You’ll notice that the observation becomes bad after 15Z. On the next slide, we will see how this impacts the temperature and dewpoint forecasts at the 18Z cycle.
With bad observations still being reported at 18Z, we see a negative influence on the temperature and dewpoint forecasts. The influence of this observation causes the LAMP forecasts to be unreasonably lower than MOS at many of the forecast projections.
Current Status and Future Plans
Operational Implementation:

- 04/03/2008: 12 cycles running operationally at NCEP
- 04/08/2008: four additional cycles running
- 06/24/2008: four additional cycles running
- Final four cycles running in early 2009
- LAMP runs every hour!
Depicting Probabilistic Information

Purpose: indicate to user the uncertainty associated with the Best Category forecasts given the probabilistic information.

Threshold = dashed black line
Probability < thres = green line
Probability ≥ thres = red line

San Francisco – very small chance of precip
St. Louis – slight chance of precip
Chicago – slight chance yes and slight chance no precip
St. Cloud – high chance of precip
San Francisco – very small chance of precip
Deicting Probabilistic Information

Options:

1) Don’t show probabilistic information

2) Show probability and related threshold by element, by category (one category at a time) (similar to WFO RLX)

3) Show probability and related thresholds by element, multiple categories (selected by user) at one time

4) Show probability and likelihood (relationship between probability and threshold, indicating relationship between threshold and probability)

What do users want?
What’s next?
Gridded LAMP

Total sky cover - Station guidance

Total sky cover - Gridded guidance

Gridded Sky Cover Guidance
February 12, 2007 18h
LAMP Aviation Grids

LAMP Probability of ceiling height $\leq 3000$ feet
LAMP Aviation Grids

LAMP Best Category of Ceiling Height
LAMP Aviation Grids

LAMP Best Category of Visibility
LAMP Training

• Two LAMP training modules developed by MDL
  ▪ An Introduction to The Localized Aviation MOS Program (LAMP)
  ▪ Accessing and Using GFS LAMP Products

• Delivered to Aviation Services Branch in March 2008
Questions?

• GFS LAMP Website:

• Contact:
  – Judy.Ghirardelli@noaa.gov