Improved Gridded Localized Aviation MOS Program (LAMP) Ceiling and Visibility Guidance using HRRR model output

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Outline

- LAMP Background
  - General
  - Ceiling height and Visibility
- Current Operational System
- Planned Improvements
- Development and Verification
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- 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.
• LAMP bridges the gap between the observations and the MOS forecast.
• LAMP outperforms persistence in the early period and trends towards MOS at the end of the period.
• LAMP guidance covers the short-range period of 1-25 hours.
• Runs every hour in NWS operations.

![Graph showing skill projections for LAMP, MOS, and persistence over time.](image-url)
LAMP Guidance Details

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

- Gridded LAMP provides grid-oriented guidance for:
  - Lightning (at least one CTG ltg strike)
  - Convection (at least one CTG ltg strike and/or Radar Reflectivity \( \geq 40 \) dBZ)
  - Temperature
  - Dewpoint
  - Ceiling Height
  - Visibility

- Available:
  - At NWS WFOs:
    - Currently operational guidance viewable at WFOs
    - Gridded LAMP grids available on SBN, can be brought into WFO AWIPS
  - Via FTP, in the National Digital Guidance Database

- Temperature and dewpoint
- Wind speed, direction, and gusts
- Probability of precipitation (on hr)
- Probability of measurable precipitation (6- and 12-h)
- Precipitation type
- Precipitation characteristics
- Lightning/Convection
- Ceiling height
- Conditional ceiling height
- Opaque sky cover
- Visibility
- Conditional visibility
- Obstruction to vision
LAMP Current Status: Available Products

- Website products:
  - Text bulletins
  - Meteograms
  - Station plots
  - Probability/Threshold images
  - Gridded lightning/convection images
  - Gridded LAMP images
Current Operational System
LAMP: Ceiling Height and Visibility Guidance

• The LAMP Ceiling and Visibility predictands are METAR observations, valid at stations
• The equations are developed at stations
• The guidance is **produced at stations** and analyzed to a grid

Developed and produced at stations  Analyzed to a 2.5km grid
Current Challenges

- **LAMP Ceiling Height and Visibility:**
  - Very few (< 3,000) METAR station observations to adequately cover the CONUS grid; no mesonet data
  - No observations of ceiling and visibility in the Atlantic or Pacific, some observations in the Gulf of Mexico → insufficient information in the water areas to provide spatially detailed guidance over the water or in marine areas
  - Ceiling height and visibility are very discontinuous fields
Planned Improvements
Planned Improvements to LAMP C&V

• GLMP Upgrade (v1.1.0):
  ▪ Scheduled for 30-day parallel test in August 2015
  ▪ Scheduled for implementation on September 15, 2015

• Temperature and dewpoint:
  ▪ Augmenting with additional MOS input points and observational data to provide improved, spatially detailed forecast grids. Will improve grids in WR and over marine areas.

• Additional elements:
  ▪ Winds
  ▪ Sky cover

• Improvements to GLMP C&V:
  ▪ Improvements to consistency of 0-hr and early projections of ceiling and visibility forecasts based on observational data
  ▪ Minimizing C&V temporal inconsistencies
  ▪ New LAMP stations to improve C&V in marine areas and Canada
CONUS station input for Gridded LAMP

No input data (LAMP forecasts) in water or Canada
Improving Gridded LAMP Ceiling and Visibility Forecasts

CONUS station input for Gridded LAMP

Legend
- Current LAMP stations
- Current & New LAMP stations

Additional input data (LAMP forecasts) in CONUS, marine areas, Canada (red dots)
Planned Improvements to LAMP C&V

• GLMP Upgrade (v1.1.0):
  ▪ scheduled for 30-day parallel test in August 2015
  ▪ Scheduled for implementation on September 15, 2015

• GLMP Upgrade (v1.2.0):
  ▪ Add wind gusts to Gridded LAMP
  ▪ Add probabilistic gridded output for ceiling and visibility (no new science)
  ▪ Scheduled for implementation early 2016

• GLMP LAMP+HRRR Meld (v2.0.0):
  ▪ 1200 UTC running in real-time experimentally
  ▪ Output to be evaluated at the Aviation Weather Testbed Summer Experiment in August 2015
  ▪ Includes benefits of v1.1.0
  ▪ Additional cycles available in 2016
  ▪ Operational Implementation in 2016
Planned Improvements to Gridded LAMP – C&V

• Statistically Blending LAMP data with HRRR data → LAMP+HRRR Meld

- High Resolution Rapid Refresh (HRRR) model data:
  - Available on a 3 km grid, produced hourly in 1-hr time steps to 15 hours
  - Data provided by NOAA/ESRL/Global Systems Division
  - Operational on the NOAA/NWS Weather and Climate Operational Supercomputing System (WCOSS) - September 2014
Development and Verification:
Cool Season
Improving LAMP CIG & VIS: HRRR Verification

• Initial Verification:
  ▪ Verified at:
    o 1562 CONUS LAMP stations; 314 CONUS non-LAMP stations
    o 0000 UTC LAMP vs 2300 UTC HRRR;
    o 1200 UTC LAMP vs 1100 UTC HRRR
  ▪ Results:
    ➢ HRRR had better Threat Scores (TS) than LAMP for VIS after the beginning period at LAMP stations at 0000 UTC, and in general, much better scores at non-LAMP stations
    ➢ HRRR had higher biases than LAMP at the lower visibility categories
    ➢ HRRR showed less improvement over LAMP for CIG and in the 1200 UTC comparison, even at non-LAMP stations
    ➢ HRRR showed less improvement over LAMP for CIG and VIS in the warm season compared to the cool season
Improving LAMP CIG & VIS: Regression Equation Development – Cool Season

• Regression Analysis:
  ▪ First focused on visibility
  ▪ Predictand Data: METAR Observations
  ▪ Predictor Data: LAMP and HRRR VIS forecasts
  ▪ Data Sample: Cool season development October 2013 – March 2014
    o 4 months for dependent data
    o 2 months for independent data
  ▪ Generalized Operator Approach \(\rightarrow\) many cases
  ▪ Equations developed for 0000 UTC:
    o LAMP+HRRR Regression:
      ➢ Using 0000 UTC LAMP Cumulative Probabilities + 2300 UTC HRRR Cumulative Binaries only
LAMP+HRRR Cool VIS: Preliminary Results

Threat Score Visibility < 3.0 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

Threat Score vs. Projection (Hours)
- **LAMP**
- **Archived HRRR**
- **Persistence**
LAMP+HRRR Cool VIS: Preliminary Results

Threat Score Visibility < 3.0 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

- **LAMP**
- **Archived HRRR**
- **Persistence**
- **LAMP+HRRR**
LAMP + HRRR Cool VIS: Preliminary Results

Threat Score Visibility < 1.0 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

- **LAMP**
- **Archived HRRR**
- **Persistence**
LAMP + HRRR Cool VIS: Preliminary Results

Threat Score Visibility < 1.0 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

Threat Score

Projection (Hours)

LAMP
Archived HRRR
Persistence
LAMP+HRRR
LAMP + HRRR Cool VIS: Preliminary Results

Threat Score: Visibility < 0.5 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

- LAMP
- Archived HRRR
- Persistence

Projection (Hours)

Threat Score

1 2 3 4 5 6 7 8 9 10 11 12 13 14

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5
LAMP + HRRR Cool VIS: Preliminary Results

Threat Score: Visibility < 0.5 MI, 0000 UTC cycle
Independent data, November 2013 and February 2014

- LAMP
- Archived HRRR
- Persistence
- LAMP+HRRR
LAMP + HRRR Cool VIS: Preliminary Results

VIS: Improvement of LAMP+HRRR over LAMP
Independent data, November 2013 and February 2014

42% Improvement in TS

Fractional Threat Score Improvement

Projection (Hours)

- TS VIS < 0.5 Mi
- TS VIS < 1.0 Mi
- TS VIS < 3.0 Mi
Development and Verification:
Warm Season
Improving LAMP CIG & VIS: Regression Equation Development – Warm Season

• Regression Analysis for developing 1200 UTC C&V equations:

  - **Predictand Data:**
    - 1200 UTC METAR Observations

  - **Predictor Data:**
    - 1200 UTC Observations
    - 1200 UTC LAMP Cumulative Probability forecasts
    - 1100 UTC HRRR cumulative binary forecasts:
      - HRRR data interpolated to LAMP stations
      - HRRR CIG forecasts adjusted from above sea level to above ground level using the HRRR terrain
    - Spots of ≤ 7.5 km in size were eliminated → coalesced the spots into larger ones that were still reasonable but which might have higher predictability.

  - **Data Sample:** Warm season development April to September 2013 and 2014.
    - 8 months for dependent data
    - 4 months for independent data
Improving LAMP CIG & VIS: Regression Equation Development – Warm Season

• Regression Analysis:
  - Generalized Operator Approach → many cases
  - Equations developed at the stations
  - Equations developed for 17 VIS categories and 25 CIG categories (compared with 8 and 9 categories for operational station-based LAMP)
  - To minimize any inconsistency between the Meld projections 14 (HRRR projection 15) and 15 (no HRRR valid forecast), the 14-h HRRR forecast was used in the regression for Meld 15- through 25-h projections.
  - Thresholds developed to convert from probabilities → single value forecast
Improving LAMP CIG & VIS: Regression Equation Development – Warm Season

• Development:
  - LAMP (at stations) + HRRR (interpolated to stations) + obs (at stations)

• Implementation:
  - LAMP probabilities (analyzed to grid) + HRRR (interpolated to LAMP grid) + obs (analyzed to grid) → equations evaluated AT gridpoints

• Verification:
  - Equations evaluated at stations, thresholds applied to get single value forecasts, resulting forecasts verified at stations
LAMP + HRRR Warm CIG

Threat Score: Ceiling Height < 500 FT, 1200 UTC cycle
4 months independent data

- **LAMP**
- **Archived HRRR**
- **Persistence**

Graph showing threat score projections over time (h):

- **Threat Score**
- **Projection (h)**

Values range from 0 to 0.8 on the y-axis and 1 to 25 on the x-axis.
LAMP + HRRR Warm CIG

Threat Score: Ceiling Height < 500 FT, 1200 UTC cycle
4 months independent data

Threat Score (h)

Projection (h)

LAMP
Archived HRRR
Persistence
LAMP+HRRR+Obs
LAMP + HRRR Warm CIG

Threat Score: Ceiling Height < 1,000 FT, 1200 UTC cycle
4 months independent data

Threat Score

Projection (h)

LAMP
Archived HRRR
Persistence
Threat Score: Ceiling Height < 1,000 FT, 1200 UTC cycle
4 months independent data

- **LAMP**
- **Archived HRRR**
- **Persistence**
- **LAMP+HRRR+Obs**
LAMP + HRRR Warm CIG

Threat Score: Ceiling Height ≤ 3,000 FT, 1200 UTC cycle
4 months independent data

- LAMP
- Archived HRRR
- Persistence

Threat Score vs. Projection (h)

Projection (h)
LAMP + HRRR Warm CIG

Threat Score: Ceiling Height ≤ 3,000 FT, 1200 UTC cycle
4 months independent data

- LAMP
- Archived HRRR
- Persistence
- LAMP+HRRR+Obs

Threat Score vs. Projection (h)
CIG: Improvement of LAMP+HRRR Meld over LAMP
1200 UTC cycle, Warm season, 4 months independent data
LAMP + HRRR Warm VIS

Threat Score: Visibility < 0.5 mi, 1200 UTC cycle
4 months independent data

- **LAMP**
- **Archived HRRR**
- **Persistence**

Threat Score

Projection (h)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
LAMP + HRRR Warm VIS

Threat Score: Visibility < 0.5 mi, 1200 UTC cycle
4 months independent data

Projection (h) vs. Threat Score

- LAMP
- Archived HRRR
- Persistence
- LAMP+HRRR+Obs
LAMP + HRRR Warm VIS

Threat Score: Visibility < 1.0 mi, 1200 UTC cycle
4 months independent data

- **LAMP**
- **Archived HRRR**
- **Persistence**

Projection (h)
LAMP + HRRR Warm VIS

Threat Score: Visibility < 1.0 mi, 1200 UTC cycle
4 months independent data

- LAMP
- Archived HRRR
- Persistence
- LAMP+HRRR+Obs
LAMP + HRRR Warm VIS

Threat Score: Visibility < 3 mi, 1200 UTC cycle
4 months independent data

- LAMP
- Archived HRRR
- Persistence

Projection (h)
LAMP + HRRR Warm VIS

Threat Score: Visibility < 3 mi, 1200 UTC cycle
4 months independent data

- LAMP
- Archived HRRR
- Persistence
- LAMP+HRRR+Obs

Threat Score vs. Projection (h)
LAMP + HRRR Warm VIS

VIS: Improvement of LAMP+HRRR over LAMP
1200 UTC cycle, Warm season, 4 months independent data

Fractional Threat Score Improvement

Projection (h)

-20%
-10%
0%
10%
20%
30%
40%
50%
60%
70%

VIS TS < 0.5 mi
VIS TS < 1.0 mi
VIS TS < 3.0 mi
Case Examples
Example Case:
April 11, 2013, 1200 UTC, 7-h forecast valid at 1900 UTC
CIG: LAMP+HRRR Meld 7hr Forecast Valid 19z
CIG: LAMP+HRRR Meld 7hr Forecast Valid 19z
Spot Remover Applied
April 11\textsuperscript{th} Ceiling Case

- LAMP+HRRR Improved awareness of low ceilings over the Colorado Rockies.

- LAMP+HRRR was less aggressive with low ceilings over the Dakotas. While the forecasted ceilings were still too low, it was a change in the right direction.

- LAMP+HRRR appears to depict the extent of the low ceilings more realistically over the water areas.

- Detail from the HRRR does show up in the LAMP+HRRR Meld.
VIS: LAMP 7hr Forecast Valid 19z

Visibility (miles) Thu Apr 11 2013 3PM EDT
VIS: HRRR 8hr Forecast Valid 19z

Visibility (miles) Thu Apr 11 2013 3PM EDT

Experimental
VIS: Verifying Observations at 19z
April 11th Visibility Case

• LAMP+HRRR Improved awareness of low visibility over the Colorado Rockies.

• LAMP+HRRR does not appear to do well over water, however it is surprising how well it forecast the low visibility at Cape May, NJ.

• LAMP+HRRR appears to depict the extent of the widespread area of low visibility better than LAMP.

• Detail from the HRRR does show up in the LAMP+HRRR Meld.
LAMP+HRRR Meld Viewer


Website restricted to NWS only, accessible with LDAP credentials
Not supported 24x7; Cycles will be added as they become experimentally available
Summary and Future Plans
Improving LAMP Guidance: Summary

• Challenges still to overcome:
  ▪ Only two cycles tested; short sample
  ▪ Need to continue to evaluate and improve where needed
  ▪ Need to better understand if users want more or less detail in the merged grids

• Plans:
  ▪ Ceiling and Visibility:
    o Preliminary results show that post-processing HRRR and LAMP together yields very encouraging results.
    o Improvement expected at stations and on the grid from developing second order LAMP+HRRR Blend equations
Future work beyond 2015

• Redeveloping LAMP convection and lightning using upgraded inputs: MRMS, Total Lightning, and HRRR data
• Additional forecast elements for Gridded LAMP:
  • Wind Gust
  • Obstruction to vision
  • POPs
  • Ptype
  • Flight categories?
  • Additional probabilities
• Redeveloping temperature, dewpoint, and wind LAMP guidance at stations to include additional stations
  • Including new TAF stations for which we have received numerous WFO requests.
  • This work will provide guidance at new TAF stations as well as improve Gridded LAMP for these elements.
• Additional areas (Alaska, Hawaii, PR)
• Eventual Extension to 36 hrs
• Extended grid into Canada
Additional Resources

- MDL Office Note describing this work:

- LAMP website: [http://weather.govmdl/lamp](http://weather.govmdl/lamp)

- Contacts:
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Thank You!