New Rapidly-updating Aviation Guidance for 15-minute Periods*

NATIONAL WEATHER SERVICE

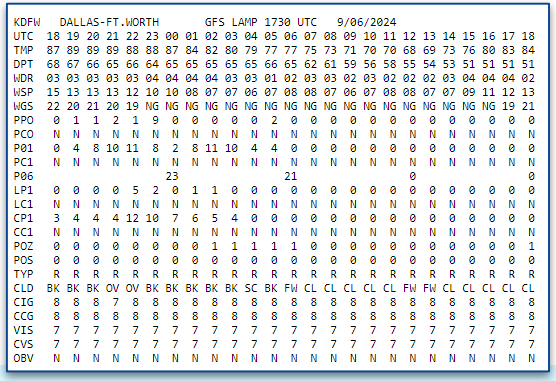
National Weather Association Annual Meeting
Irving, TX - September 18, 2024

Judy Ghirardelli (presenting), Dr. Phil Shafer
National Weather Service/Meteorological Development Laboratory

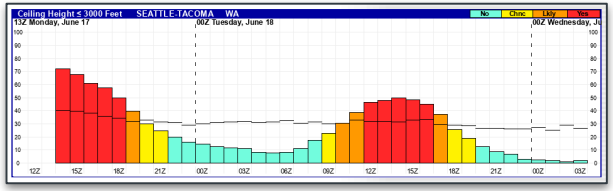
* Disclaimer: Portions of this research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.

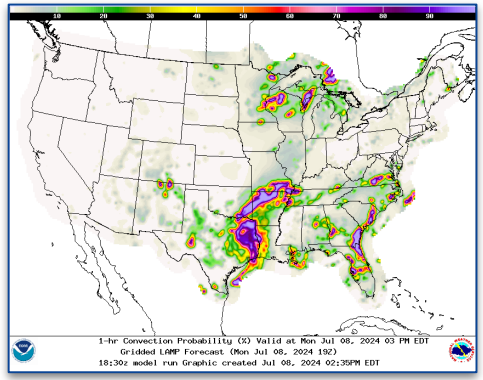
LAMP Background

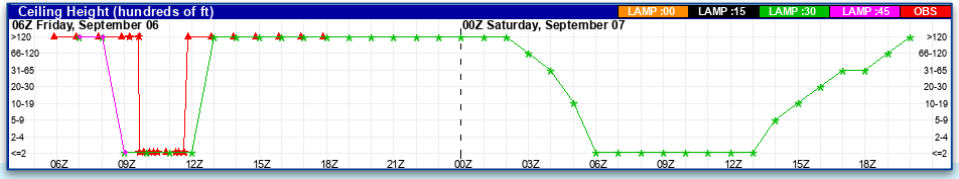
- The Localized Aviation MOS Program (LAMP) is a statistical system that uses observations (METARs, radar, lightning), MOS output, and model output (GFS, ECMWF, HRRR, NAM) to provide guidance for aviation forecasting.
- LAMP guidance covers the short-range period of 1-38 hours for most elements.
- Runs every hour in NWS operations (every 15 minutes out to 3 hours for ceiling and visibility).
- LAMP supports the National Blend of models (NBM).



```
KDFW   DALLAS-FT.WORTH       GFS LAMP 1730 UTC   9/06/2024
UTC  18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18
TMP  87 89 89 89 88 88 87 84 82 80 79 77 77 75 73 71 70 70 68 69 73 76 80 83 84
DPT  68 67 66 65 66 64 65 65 65 65 65 66 65 62 61 59 56 58 55 54 53 51 51 51 51
WDR  03 03 03 03 03 04 04 04 04 03 03 01 02 03 03 02 03 02 02 02 03 04 04 04 02
WSP  15 13 13 13 12 10 10 08 07 07 06 07 08 08 07 06 07 08 08 07 07 09 11 12 13
WGS  22 20 21 20 19 NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG 19 21
PPO   0  1  1  2  1  9  0  0  0  0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0
PCO   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
P01   0  4  8 10 11  8  2  8 11 10  4  4  0  0  0  0  0  0  0  0  0  0  0  0  0
PC1   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
P06                    23                    21                    0           0
LP1   0  0  0  0  5  2  0  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
LC1   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
CP1   3  4  4  4 12 10  7  6  5  4  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
CC1   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
POZ   0  0  0  0  0  0  0  0  0  1  1  1  1  1  0  0  0  0  0  0  0  0  0  0  1
POS   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
TYP   R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R
CLD  BK BK BK OV OV OV BK BK BK BK BK SC BK FW CL CL CL CL CL FW FW CL CL CL CL
CIG   8  8  8  7  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
CCG   8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
VIS   7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
CVS   7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
OBV   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N
```







Increasing Temporal Resolution of GLMP

- Current Gridded LAMP forecast projections are hourly, valid at the top of the hour.
- MDL was tasked by the Federal Aviation Administration Aviation Weather Research Program (FAA AWRP) to increase the temporal resolution of Gridded LAMP ceiling height and visibility guidance from 1 hour time steps to 15 minute time steps in the first six hours of the forecast period.
  - Aviation decision-making operators, including the Helicopter Air Ambulance operators, use the NWS Aviation Weather Center (AWC) Graphical Forecasts for Aviation - Low Altitude (GFA-LA) platform which currently uses GLMP data to update every 15 minutes with the latest observational and hourly forecast data.
  - GFA-LA users requested a higher temporal resolution Ceiling and Visibility (C&V) forecast to support decision making.
  - Providing updated GLMP guidance for C&V every 15 minutes for 15-minute periods (instead of valid at the top of the hour) will help fill the gap in the GFA-LA tool.

High Impact Weather C&V Development

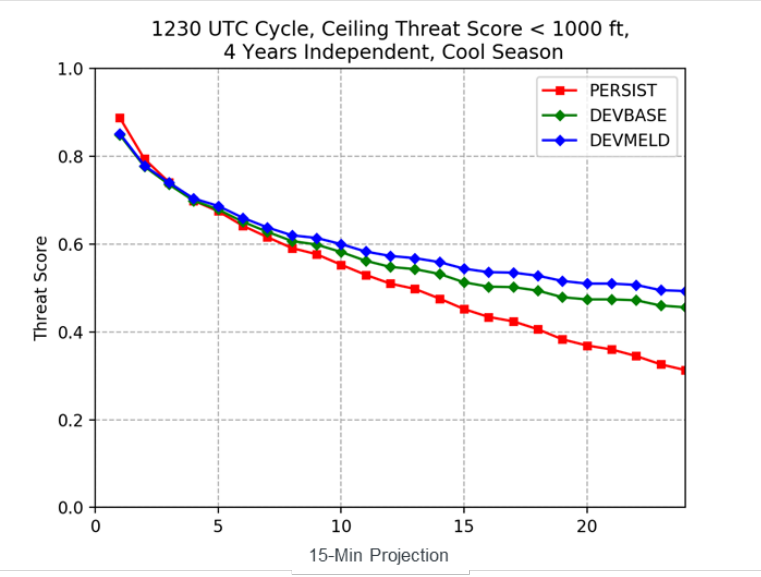
- Predictand: High Impact Weather (HIW) C&V predictand is defined as the **lowest C&V observed over a 15-minute period** ending at 14, 29, 44, and 59 minutes past the hour.
  - Most recent observation is persisted into the period unless a new observation indicates a worse condition.
  - Furthest lookback is 15-minute period prior to the previous hour.
- Technique: Multiple Linear Regression (similar to hourly C&V)
- Predictors include:
  - METAR observations; advection of observations including 15-min advected radar composite reflectivity (MRMS)
  - GFS MOS
  - HRRR model output including HRRR-based proxy C&V climatology
- Forecast period: 6 hours at 15-minute timesteps

15-Minute HIW C&V Development and Verification

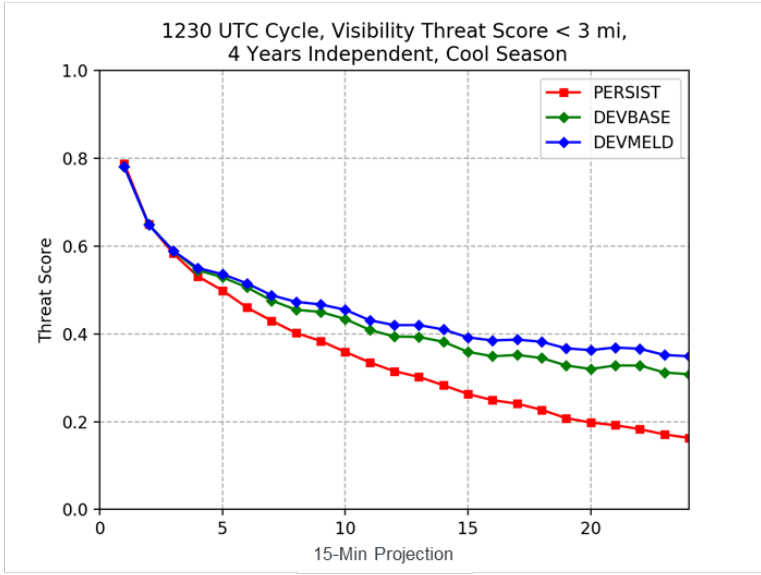
- Development period:
  - 4 years of warm season data (April-Sep 2017 – 2020)
  - 4 years of cool season data (Jan-Mar/Oct-Dec 2017 – 2020)
- Independent 4-fold cross validation:
  - Four developments were completed by withholding a different year from each of the development periods above
  - Much better than using single developmental and test samples
  - Results presented are for all 4 independent years combined
- ~1,850 CONUS stations verified

15-min HIW Independent Verification: Cool Season

Ceiling < 1,000 feet



Visibility < 3 miles



15-min Meld LAMP (blue) shows improvement over 15-min Base LAMP (green) at later projections due to the decreased predictive strength of the observation and the increasing predictive strength of the HRRR

15-Minute Text Bulletin

```
KBWI   BALTIMORE              GFS LAMP 1930 UTC   2/13/2024
UTC   19 20 20 20 20 21 21 21 21 22 22 22 22 23 23 23 23 00 00 00 00 01 01 01
MIN   45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30
CIG    6  6  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
VIS    7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
```

UTC: Ending hour of the 15-minute valid period

LAV Ceiling Height (CIG) Categories

1	< 200 feet
2	200 - 400 feet
3	500 - 900 feet
4	1000 - 1900 feet
5	2000 - 3000 feet
6	3100 - 6500 feet
7	6600 - 12,000 feet
8	> 12,000 feet or unlimited ceiling

LAV Visibility (VIS) Categories

1	< 1/2 miles
2	1/2 - < 1 miles
3	1 - < 2 miles
4	2 - < 3 miles
5	3 - 5 miles
6	6 miles
7	> 6 miles

15-Minute Text Bulletin

KBWI	BALTIMORE						GFS LAMP 1930 UTC						2/13/2024										
UTC	19	20	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	00	00	00	00	01	01	01
MIN	45	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30
CIG	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

UTC: Ending hour of the 15-minute valid period

MIN: Ending minute of the valid period

LAV Ceiling Height (CIG) Categories

1	< 200 feet
2	200 - 400 feet
3	500 - 900 feet
4	1000 - 1900 feet
5	2000 - 3000 feet
6	3100 - 6500 feet
7	6600 - 12,000 feet
8	> 12,000 feet or unlimited ceiling

LAV Visibility (VIS) Categories

1	< 1/2 miles
2	1/2 - < 1 miles
3	1 - < 2 miles
4	2 - < 3 miles
5	3 - 5 miles
6	6 miles
7	> 6 miles

15-Minute Text Bulletin

```
KBWI   BALTIMORE              GFS LAMP 1930 UTC   2/13/2024
UTC   19 20 20 20 20 21 21 21 21 22 22 22 22 23 23 23 23 00 00 00 00 01 01 01
MIN   45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30
CIG    6  6  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
VIS    7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
```

UTC: Ending hour of the 15-minute valid period

MIN: Ending minute of the valid period

CIG: Lowest forecasted LAMP categorical ceiling height during the 15-minute period

LAV Ceiling Height (CIG) Categories

1	< 200 feet
2	200 - 400 feet
3	500 - 900 feet
4	1000 - 1900 feet
5	2000 - 3000 feet
6	3100 - 6500 feet
7	6600 - 12,000 feet
8	> 12,000 feet or unlimited ceiling

LAV Visibility (VIS) Categories

1	< 1/2 miles
2	1/2 - < 1 miles
3	1 - < 2 miles
4	2 - < 3 miles
5	3 - 5 miles
6	6 miles
7	> 6 miles

15-Minute Text Bulletin

```
KBWI   BALTIMORE              GFS LAMP 1930 UTC   2/13/2024
UTC   19 20 20 20 20 21 21 21 21 22 22 22 22 23 23 23 23 00 00 00 00 01 01 01
MIN   45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30
CIG    6  6  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
VIS    7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
```

UTC: Ending hour of the 15-minute valid period

MIN: Ending minute of the valid period

CIG: Lowest forecasted LAMP categorical ceiling height during the 15-minute period

VIS: Lowest forecasted LAMP categorical visibility during the 15-minute period

LAV Ceiling Height (CIG) Categories

1	< 200 feet
2	200 - 400 feet
3	500 - 900 feet
4	1000 - 1900 feet
5	2000 - 3000 feet
6	3100 - 6500 feet
7	6600 - 12,000 feet
8	> 12,000 feet or unlimited ceiling

LAV Visibility (VIS) Categories

1	< 1/2 miles
2	1/2 - < 1 miles
3	1 - < 2 miles
4	2 - < 3 miles
5	3 - 5 miles
6	6 miles
7	> 6 miles

Gridded LAMP 15-min HIW C&V Process

- Process to make Gridded 15-min Meld C&V:

Gridded OBS:
C&V observations at stations are analyzed to a 2.5-km NBM CONUS grid

Gridded Base LAMP C&V Probs:
15-min Base LAMP C&V probabilities at stations are analyzed to 2.5-km NBM CONUS grid

Gridded HRRR MOS Probs:
15-min HRRR MOS equations are evaluated at each 2.5-km grid point

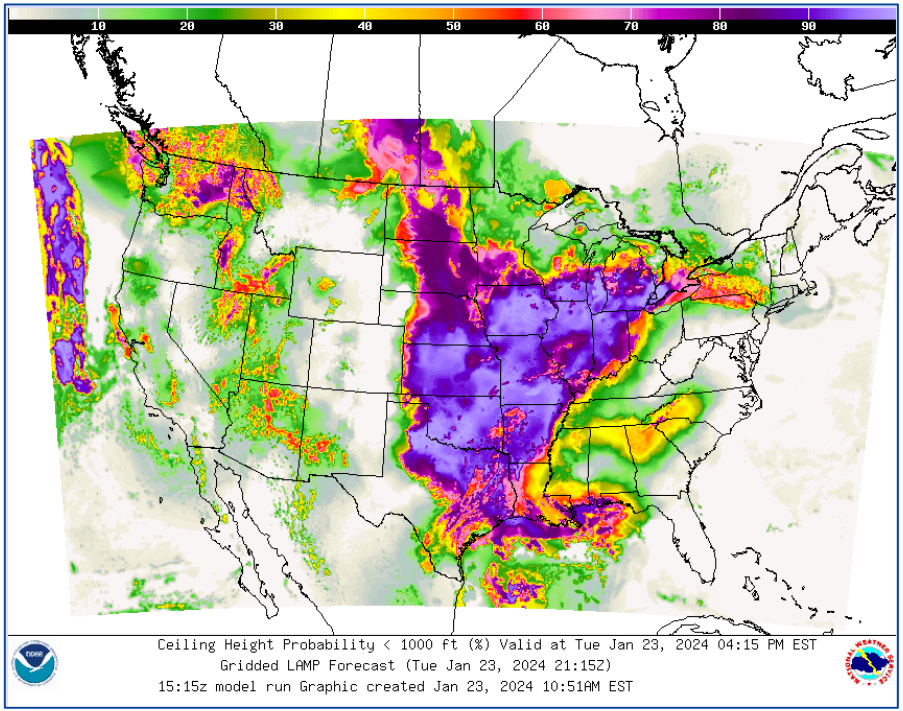
Gridded LAMP C&V Probabilities: 15-min Meld equations are evaluated at each 2.5-km grid point

Deterministic C&V guidance on the grid: Thresholds applied to gridded probabilities

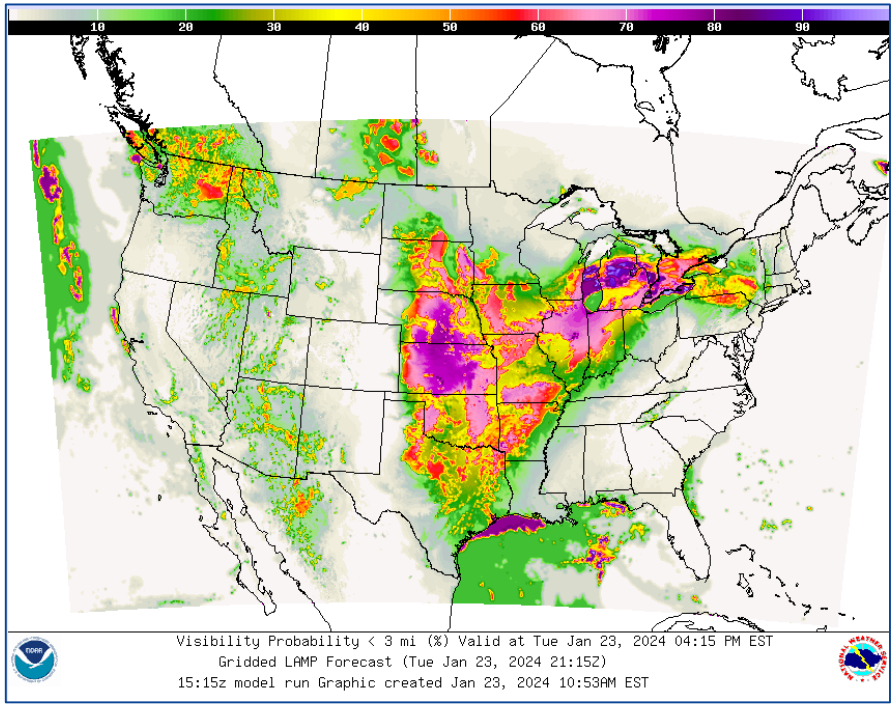
- National Blend of Models (NBM) CONUS grid - note that spatial extent of guidance will be limited to extent of sub-hourly HRRR.
- Will run for **96 cycles per day** - output out to six hours will be available every 15 minutes at nominal times of **HH:00, HH:15, HH:30, and HH:45**

Gridded LAMP 15-min HIW C&V - Probabilities

Probability of Cig < 1,000 ft

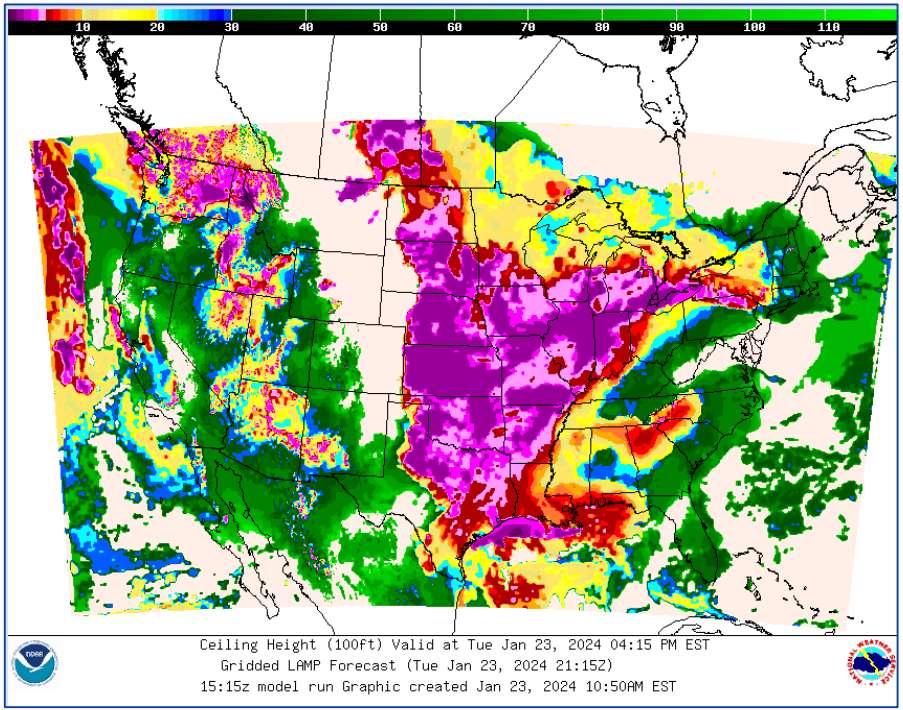


Probability of Vis < 3 miles

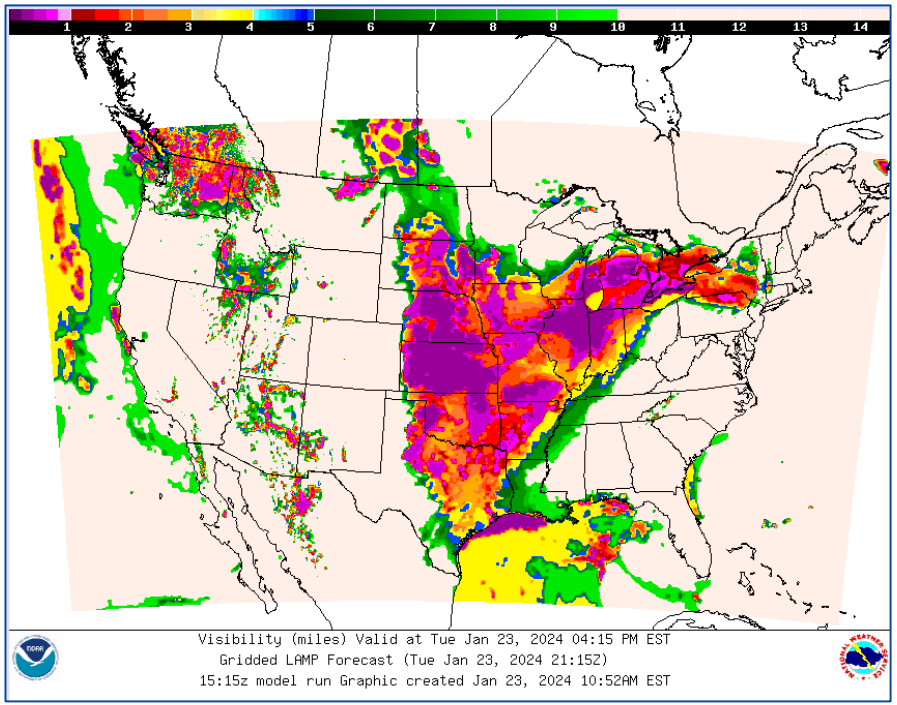


Gridded LAMP 15-min HIW C&V - Deterministic

Ceiling Height (100ft)



Visibility (mi)



Product Availability

- New 15-minute guidance will be included in LAMP/GLMP v2.6 upgrade scheduled for implementation on **September 26, 2024**.
- The 15-minute text bulletins containing categorical C&V guidance out to six hours will be available on NCEP Web Services / NOMADS
- The 15-minute Gridded LAMP C&V guidance in GRIB2 format will be available on NCEP Web Services / NOMADS:
  - Probability of ceiling height < 500 ft, < 1000 ft, and <= 3000 ft
  - Probability of visibility < 1 mi, < 3 mi, and <= 5 mi
  - Deterministic ceiling height and visibility
- AWC:
  - is evaluating using the 15-minute station guidance in an experimental onset/cessation Dashboard
  - plans to evaluate these products further for inclusion in the GFA-LA.

Sneak Peek into Future Work

Onset/Cessation of Flight Categories

- FAA-funded work to develop **guidance for onset/cessation of flight categories at Core 30 airports**:
  - Onset/cessation bulletins generated from new 15-minute C&V guidance through six hours
  - Includes C&V probabilistic guidance to support probabilistic Impact-based Decision Support Services (IDSS)
  - AWC is in the process of demonstrating new onset/cessation dashboard using this information

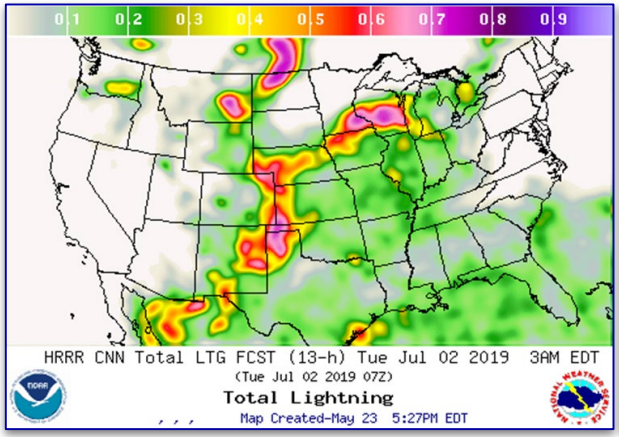
```
KBOS   BOSTON                GFS LAMP 1330 UTC   3/29/2024
UTC   13 14 14 14 14 15 15 15 15 16 16 16 16 17 17 17 17 18 18 18 18 19 19 19
MIN   45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30 45 00 15 30
FLT    M  M  M  M  M  M  M  M  M  V  V  V  V  V  V  V  V  V  V  V  V  V  V  V
VFR                                +-----------------------------------------
MVF   ----------------------------/
IFR
LIF
VLI
CIG    5  5  5  5  5  5  5  5  5  6  6  6  6  6  6  6  6  6  6  7  6  7  7
VIS    7  7  6  7  7  5  5  5  6  6  6  7  7  7  7  7  7  7  7  7  7  7  7
CPVL   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
CPL    0  1  0  0  1  2  3  4  3  4  4  5  2  3  2  3  0  0  0  0  0  0  0
CPI    5  6  4  7 14 18 19 17 15 18 17 16 11 13 12 13  7  6  6  8  5  5  6  6
CP2K  10 20 15 26 26 35 37 32 32 34 32 23 16 18 17 17 10 12 12 14  9 10  9  9
CPM   18 42 42 55 54 60 58 52 52 44 38 26 23 26 24 24 16 16 14 17 12 12 10 11
CPVFR 82 58 58 45 46 40 42 48 48 56 62 74 77 74 76 76 84 84 86 83 88 88 90 89
VPVL   0  0  1  1  1  0  0  1  2  2  3  2  2  2  2  2  2  2  3  3  3  3  2  3
VPL    0  2  2  3  3  0  0  1  2  4  4  5  4  5  5  5  4  6  6  6  5  6  5  6
VPI    3  9 11 13 12 16 19 17 15 19 18 18 14 16 16 16 13 16 15 16 12 14 12 14
VPM    4 21 31 29 26 37 42 39 34 34 33 30 23 28 25 26 22 26 24 25 19 24 20 22
VPVFR 96 79 69 71 74 63 58 61 66 66 67 70 77 72 75 74 78 74 76 75 81 76 80 78
```

Prototype LAMP onset/cessation text bulletin

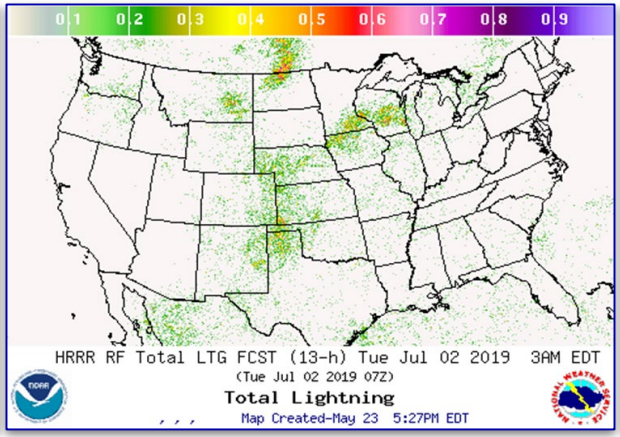
Artificial Intelligence/Machine Learning
Fire Weather

Image credit: NOAA Weather in Focus Photo Contest 2015 | Kevin Skow

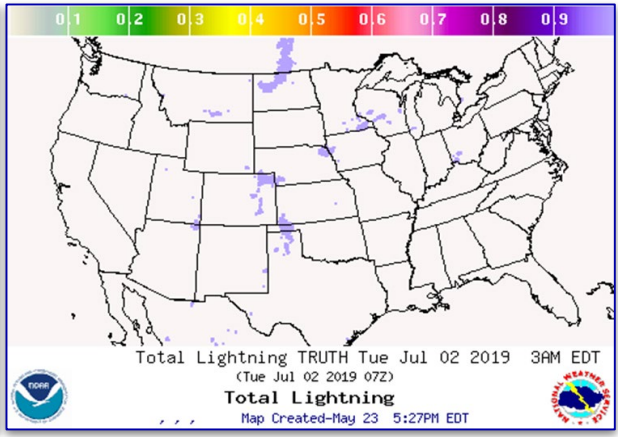
- Improving Fire Weather Guidance (lightning, convection, probability of precipitation) using:
  - Convolutional Neural Networks (CNN); Recurrent Neural Networks (RNN)
  - Random Forests; XGBoost
- **Successful techniques will be applied to improve C&V**



CNN



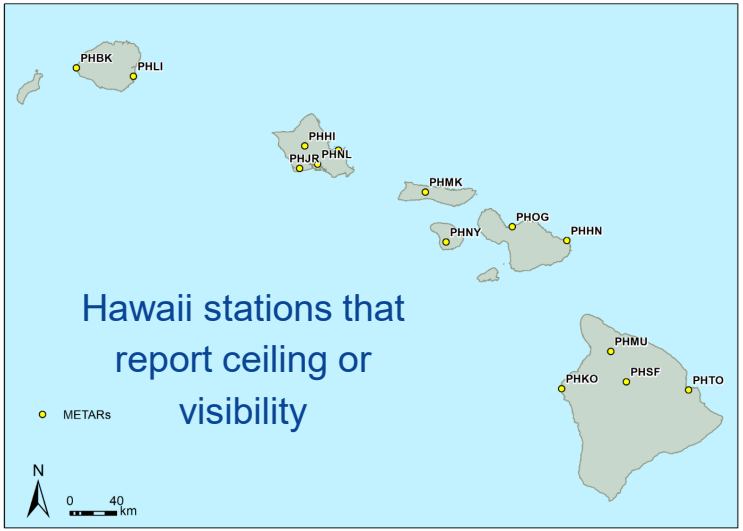
Random Forest



Verifying Truth (Lightning)

Gridded Guidance for Hawaii

- FAA-funded work to develop **hourly gridded ceiling height and visibility guidance for Hawaii domain**:
  - Challenging problem - not many C&V observations, no HRRR input
  - Development will include RAP input (and possibly other models)
  - Exploring AI/ML techniques (CNN, Random Forest, XGBoost)
  - Will support NBM over Hawaii



- Planned completion of initial prototype for one cycle - March 2025, implementation in 2026

Thank you!

Questions?

Contacts:

Judy.Ghirardelli@noaa.gov
Phil.Shafer@noaa.gov

LAMP Web Page:
https://vlab.noaa.gov/web/mdl/lamp

LAMP Contact:
nws.lamp@noaa.gov