NATIONAL WEATHER SERVICE

Updates on Improvements to Aviation Guidance in the Localized Aviation MOS Program (LAMP)*

Tenth Southwest Aviation Weather Safety Workshop (SAWS)
April 21, 2023

Presenters: Phil Shafer and Judy Ghirardelli, NWS/MDL

* 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.

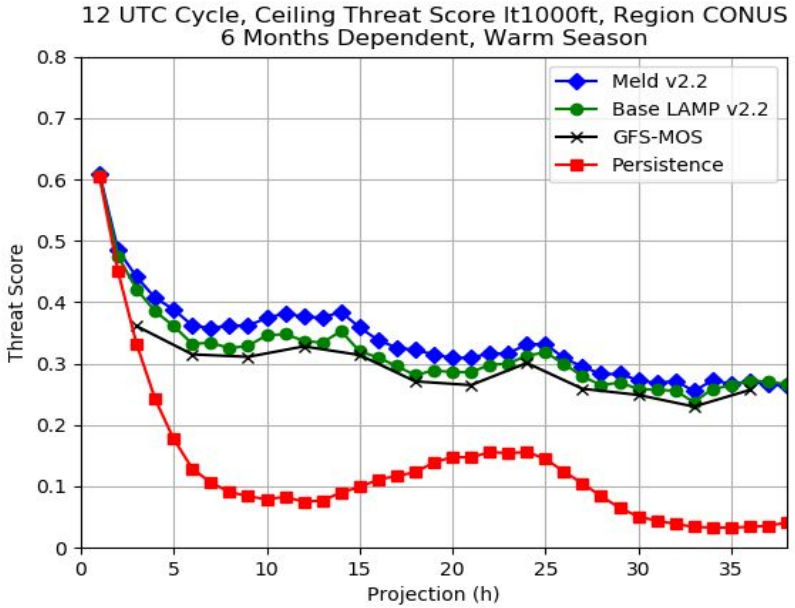
Outline

1. LAMP Background
2. Tour of Web Products
3. LAMP/GLMP v2.5 Upgrades
4. FAA Aviation Weather Research Program (AWRP)-funded work:
   a. 15-minute LAMP/GLMP
   b. Onset/cessation of flight categories
   c. Gridded ceiling height analysis at SFO
5. Summary/Future Work

1. LAMP Background

LAMP Background: What is LAMP?

- What is LAMP? LAMP is a statistical system that uses observations, MOS output, and model output to provide guidance for aviation forecasting.
- LAMP acts as an update to MOS - bridges the gap between the observations and the MOS forecast.
- LAMP guidance covers the short-range period of 1-25 hours (38 hours for some 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).



LAMP Background: Guidance Details

- LAMP provides station-oriented guidance for:
  - All LAMP forecast elements, ~2010 stations
  - CONUS, Alaska, Hawaii, Puerto Rico
- Gridded LAMP provides gridded guidance for:
  - Lightning & Convection
  - Temperature & Dewpoint
  - Wind Speed & Direction
  - Ceiling Height & Visibility
  - Sky Cover
  - Probability of Precipitation
- Available:
  - At NWS WFOs in AWIPS
  - Via NCEP NOMADS
  - Via website: https://vlab.noaa.gov/mdl/lamp

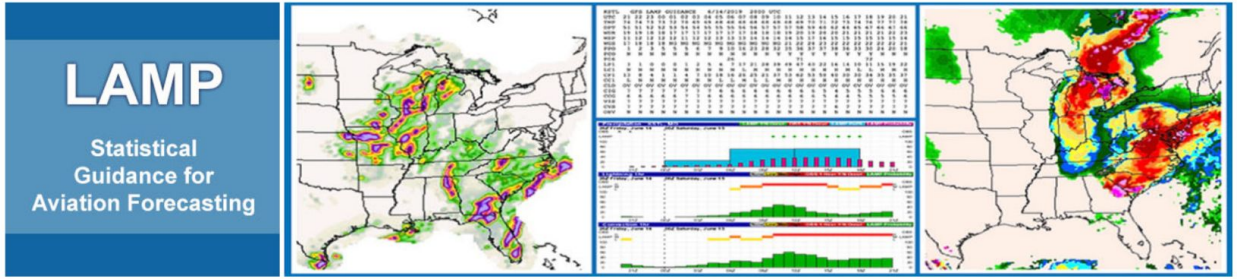
- Temperature and dewpoint
- Wind speed, direction, and gusts
- Probability of precipitation (on hr)
- Probability of measurable precipitation (1-, 6- and 12-h)
- Precipitation type
- Precipitation characteristics
- Lightning/Convection
- Ceiling height
- Conditional ceiling height
- Opaque sky cover
- Visibility
- Conditional visibility
- Obstruction to vision

2. Tour of LAMP Web Products

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

MDL The Meteorological Development Laboratory

HOME ABOUT MDL PROJECTS PEOPLE PUBLICATIONS



NWS OSTI / MDL / Projects / Localized Aviation MOS Program

As of February 2022, the LAMP pages hosted on the weather.gov server will be transitioning to the NOAA Virtual Lab (home page: https://vlab.noaa.gov/web/mdl/lamp). Please discontinue use of the LAMP weather.gov pages and instead use the LAMP VLab pages. All links to live data still go to the nws.noaa.gov server, so any bookmarks you have to live data should be unaffected by this change, which only impacts the static, informational LAMP webpages.

Please see here for more information about this transition.

Note: While we are transitioning our web pages, all of the products below link to product pages on the old system. Products on those pages are up-to-date, but links on those pages may go to old information or may be broken. Thank you for your patience!

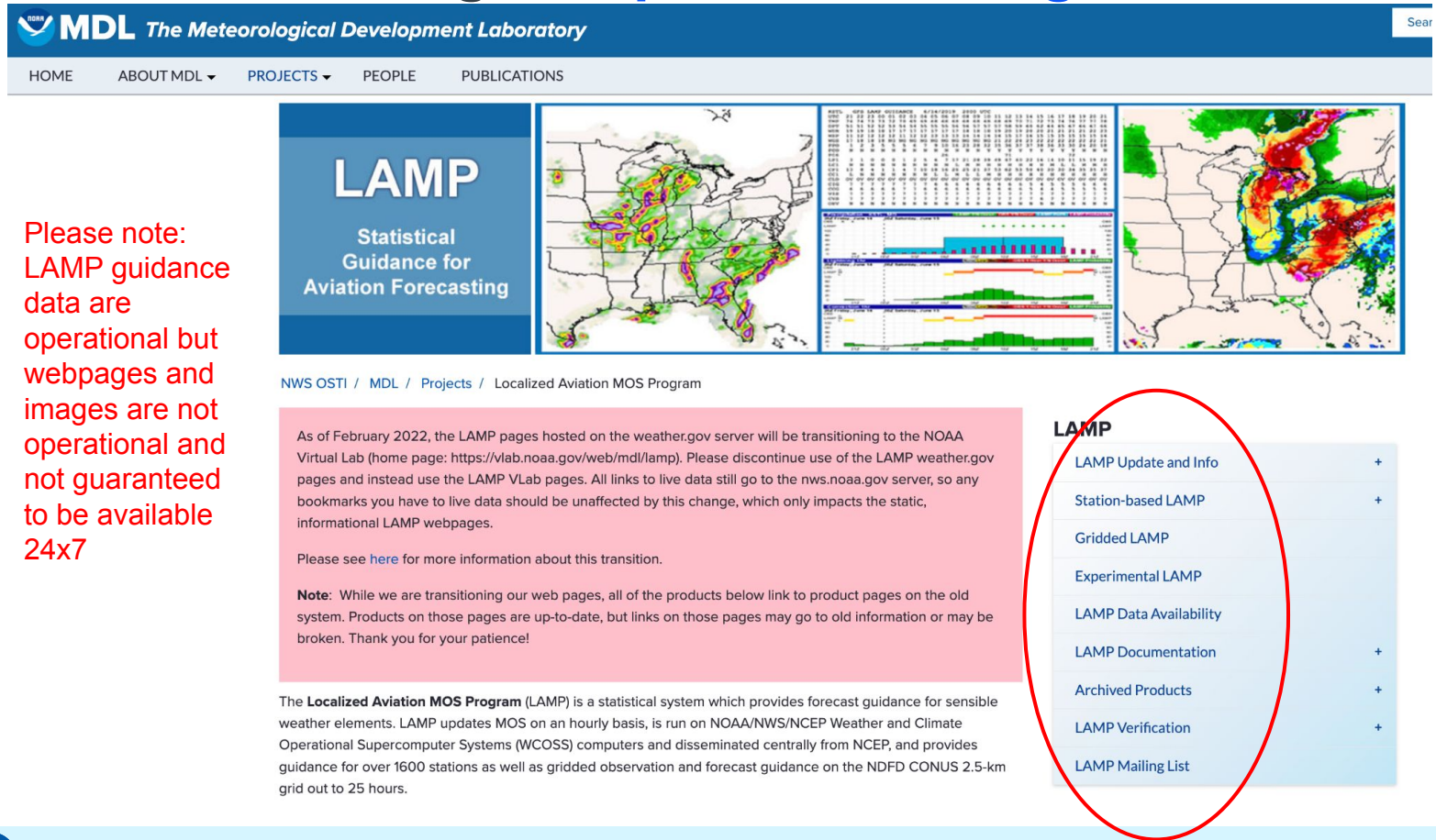
The **Localized Aviation MOS Program** (LAMP) is a statistical system which provides forecast guidance for sensible weather elements. LAMP updates MOS on an hourly basis, is run on NOAA/NWS/NCEP Weather and Climate Operational Supercomputer Systems (WCOSS) computers and disseminated centrally from NCEP, and provides guidance for over 1600 stations as well as gridded observation and forecast guidance on the NDFD CONUS 2.5-km grid out to 25 hours.

LAMP

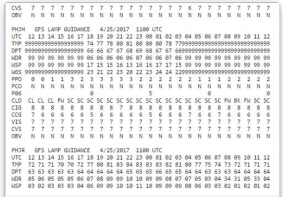
- LAMP Update and Info +
- Station-based LAMP +
- Gridded LAMP
- Experimental LAMP
- LAMP Data Availability
- LAMP Documentation +
- Archived Products +
- LAMP Verification +
- LAMP Mailing List

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

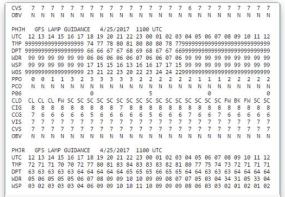
Please note: LAMP guidance data are operational but webpages and images are not operational and not guaranteed to be available 24x7



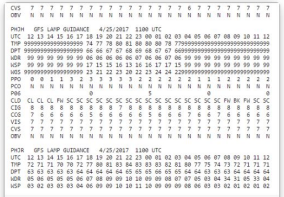
LAMP Web Page: https://vlab.noaa.gov/web/mdl/lamp



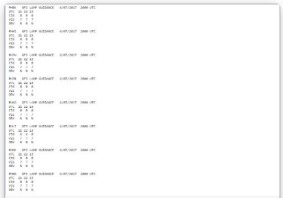
LAMP Full Text Bulletin



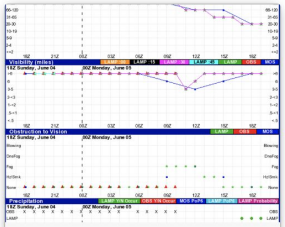
LAMP Text Bulletin by State



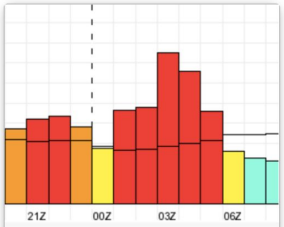
LAMP Text Bulletin by Station



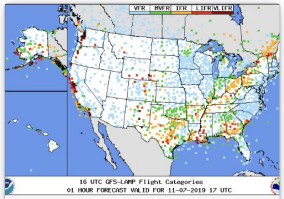
LAMP Bulletin Latest 15 Minute Update



LAMP Forecast Meteograms



LAMP Probability Plots



LAMP Station Forecasts

Click here to find real-time station-based forecast guidance

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```
KPHX   PHOENIX       ASOS     GFS LAMP GUIDANCE   6/05/2019  2100 UTC
UTC   22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22
TMP   99100100 99 99 97 95 93 91 89 87 86 84 82 81 79 81 84 87 90 93 95 97 99100
DPT   37 36 36 35 35 35 36 37 37 38 39 40 41 42 42 42 42 41 40 39 39 38 37 36 36
WDR   27 27 27 27 27 27 26 25 25 27 28 31 30 14 12 11 11 11 14 24 25 27 26 26 27
WSP   11 12 11 13 13 11 10 08 08 08 05 05 04 04 05 05 06 06 06 06 06 06 07 09 08
WGS   18 19 18 NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG 16
PPO    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
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
P06                                  0                 0                 0
LP1    1  0  0  0  0  0  0  0  0  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    0  0  0  0  0  0  1  0  0  0  0  0  1  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
CLD   FW FW FW FW FW FW CL CL CL CL CL CL CL CL FW FW FW FW FW FW FW FW FW FW FW
CIG    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
CCG    8  8  8  8  8  7  7  7  8  7  7  7  8  8  7  7  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
```

Click here to find LAMP text bulletins

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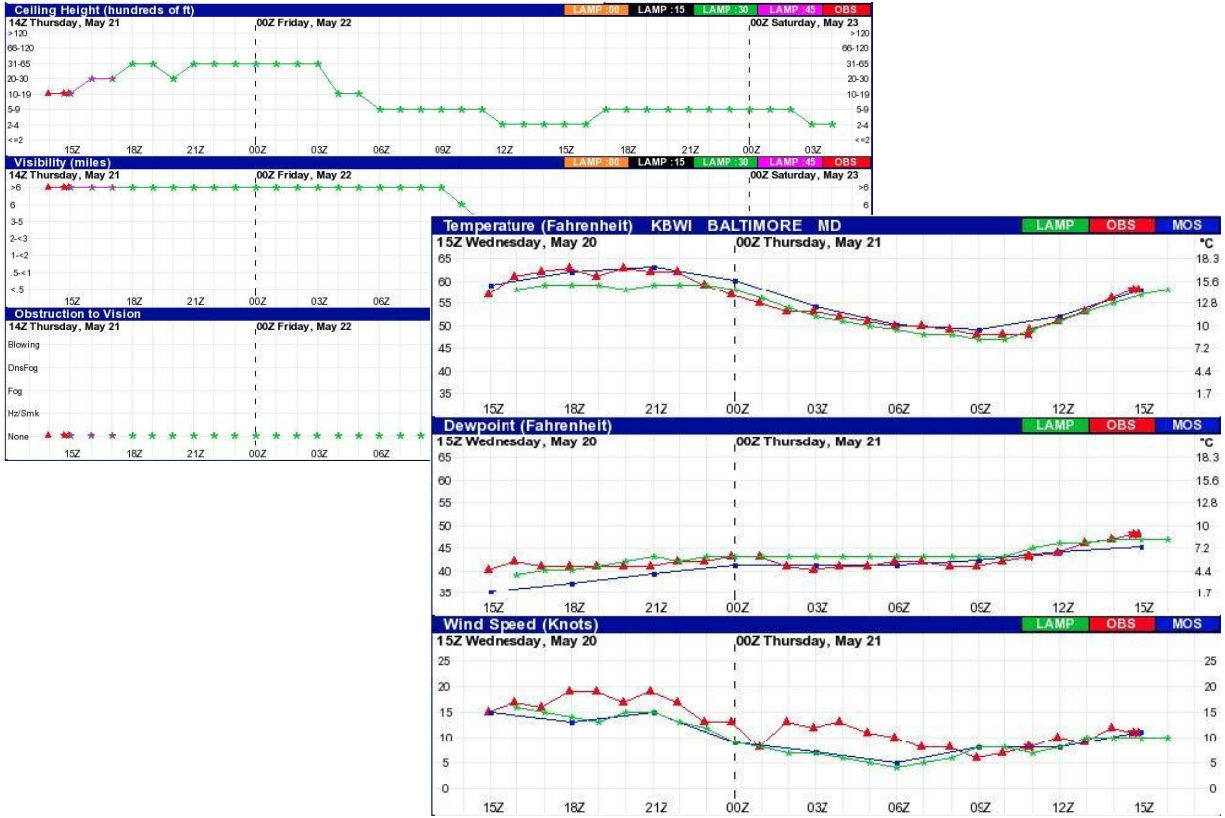

Click here for meteograms which display future guidance and past guidance with verifying observations

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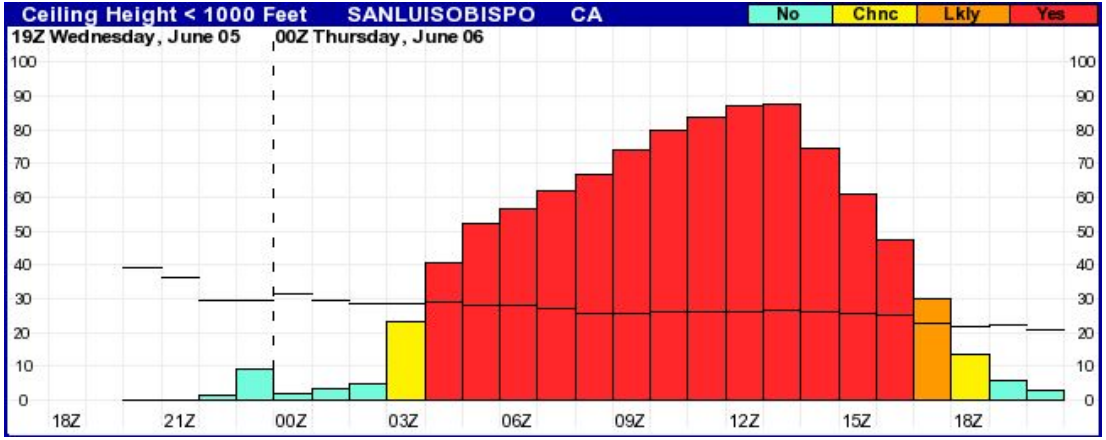

Probabilities (bars) and thresholds (lines) KSBP
Ceiling height < 1,000 feet

Click here for LAMP Probability and Threshold Plots

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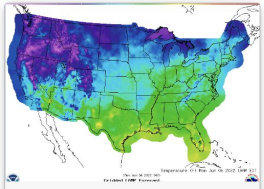
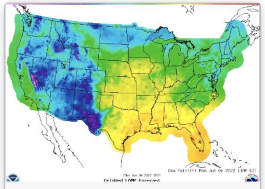
Download Gridded LAMP GRIB2 Data below (Information on Gridded LAMP GRIB2 Data)

This data applies to the CONUS Region and is of the GRIB format.


T Images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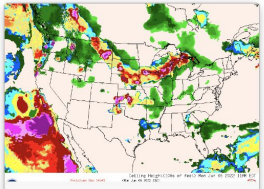
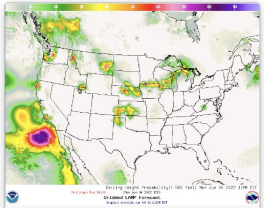
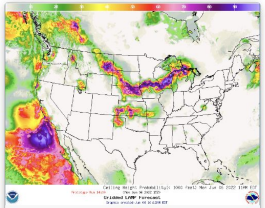
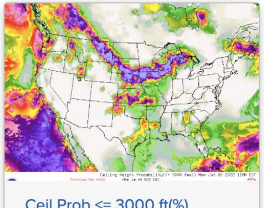
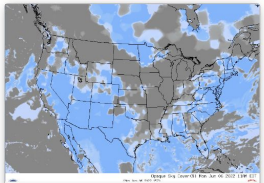
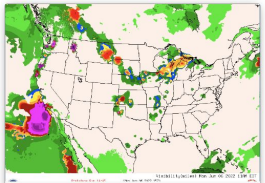

Ceil Images

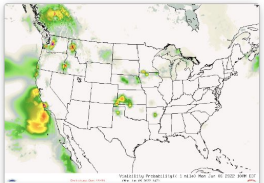

Ceil Prob < 500 ft(%) Images


Ceil Prob < 1000 ft(%) Images


Ceil Prob <= 3000 ft(%) Images


Sky Images


Vis Images


Vis Prob < 1 mi(%)

Click here to find real-time gridded forecast guidance

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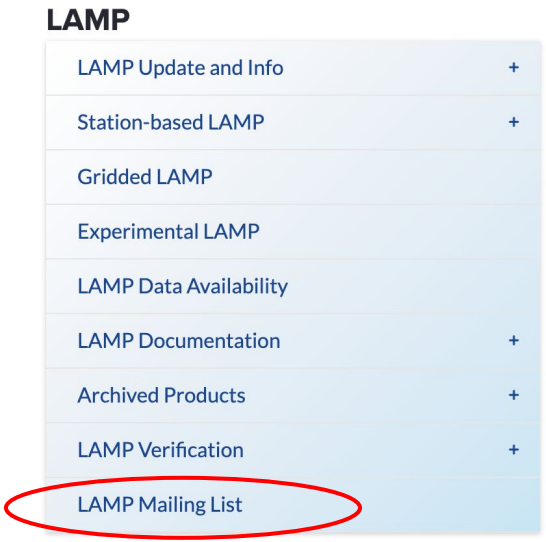
Instructions for joining LAMP Mail List

Please email nws.lamp@noaa.gov :

- If you have questions or to report a problem.
- To request to be added to our email list for notifications so that you will be aware of changes to LAMP webpages or other LAMP products.

Click here to join our mailing list



3. LAMP/GLMP V2.5 Upgrades

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

V2.5.0 highlights include:

1. Updated station-based temperature (T), dewpoint (Td), wind speed, wind direction, and wind gust guidance to incorporate the HRRR and updated GFS MOS and extend to 38 hours for input to NBM.

2. Re-tuned Gridded LAMP (GLMP) T, Td, and wind guidance to incorporate the updated station guidance.

3. Station additions/removals: 335 LAMP stations are being added and 33 stations are being removed in response to those stations being added or removed from GFS MOS.

SCHEDULED FOR IMPLEMENTATION IN SPRING 2023

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

- V2.5.0 highlights:

Operational LAMP v2.4
LAV 1-25 h bulletin

```
KEDW   GFS LAMP GUIDANCE  12/16/2022  1230 UTC
UTC  13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13
TMP 999999 26 30 35 39 42 46 49 51 53 52 48 44 42999999999999999999999999999999
DPT 999999 24 25 26 26 26 25 26 25 24 24 25 23 25999999999999999999999999999999
WDR  99 99 03 05 06 06 07 07 06 07 08 07 07 08 09 05 34 31 99 99 99 99 99 99 99
WSP  99 99 02 02 02 04 04 05 06 05 05 04 03 03 03 04 04 04 99 99 99 99 99 99 99
WGS 999999 NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG999999999999999999
PPO   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
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  0  0  0  0  0  0  0  0  0  0  0  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                  0                 0                 0                 0
LP1   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
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   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
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   4  5  5  5  4  3  2  2  1  1  1  1  1  1  2  1  1  1  2  2  3  2  3  3  3
POS  71 69 68 61 48 36 31 24 22 14  8  5  4  7 12 19 28 36 43 48 49 54 58 61 61
TYP   S  S  S  S  R  R  R  R  R  R  R  R  R  R  R  R  R  R  R  S  S  S  S  S  S
CLD  OV OV OV BK SC FW SC CL CL CL CL CL CL CL CL CL CL CL CL FW FW FW FW FW FW
CIG   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
CCG   8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  4  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
```

Experimental LAMP v2.5
LAV 1-25 h bulletin

```
KEDW   GFS LAMP GUIDANCE  12/16/2022  1230 UTC
UTC  13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12 13
TMP  28 28 27 29 33 39 45 47 48 50 51 50 46 42 37 36 34 34 32 31 30 27 26 25 25
DPT  25 24 23 25 25 26 24 24 22 21 21 21 22 19 20 19 19 19 18 18 17 16 15 14 15
WDR  36 35 35 03 03 03 05 06 07 07 07 07 07 08 07 03 01 36 02 36 36 33 33 34 32
WSP  02 03 02 02 01 02 04 06 06 06 06 05 06 04 03 04 04 06 04 04 04 03 02 02 03
WGS  NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG NG
PPO   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
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  0  0  0  0  0  0  0  0  0  0  0  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                  0                 0                 0                 0
LP1   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
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   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
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   4  5  5  6  4  3  2  2  1  1  1  1  1  1  2  1  1  1  2  2  3  2  3  3  4
POS  71 69 68 63 53 46 38 29 22 14  8  5  4  7 12 19 28 36 43 48 49 54 58 61 61
TYP   S  S  S  S  S  R  R  R  R  R  R  R  R  R  R  R  R  R  R  S  S  S  S  S  S
CLD  OV OV OV BK SC FW SC CL CL CL CL CL CL CL CL CL CL CL CL FW FW FW FW FW FW
CIG   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
CCG   8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  4  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
```

Many stations that had missing T/Td/Wind guidance for some or all projections in operational LAMP now have guidance in v2.5 LAMP.

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

- V2.5.0 highlights:

Operational LAMP v2.4
LEV 26-38 h bulletin

```
KBWI    GFS LAMP GUIDANCE   12/12/2022  1230 UTC
DT /DEC  13                          /DEC  14
HR    26 27 28 29 30 31 32 33 34 35 36 37 38
UTC   14 15 16 17 18 19 20 21 22 23 00 01 02
P01    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
P06                  0                   0
CLD   CL CL CL CL CL CL CL CL CL CL CL CL CL
CIG    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
VIS    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  6
OBV    N  N  N  N  N  N  N  N  N  N  N  N  N
```

Guidance for temperature, dewpoint, wind speed, wind direction, and wind gust now available in extended LEV bulletin

Experimental LAMP v2.5
LEV 26-38 h bulletin

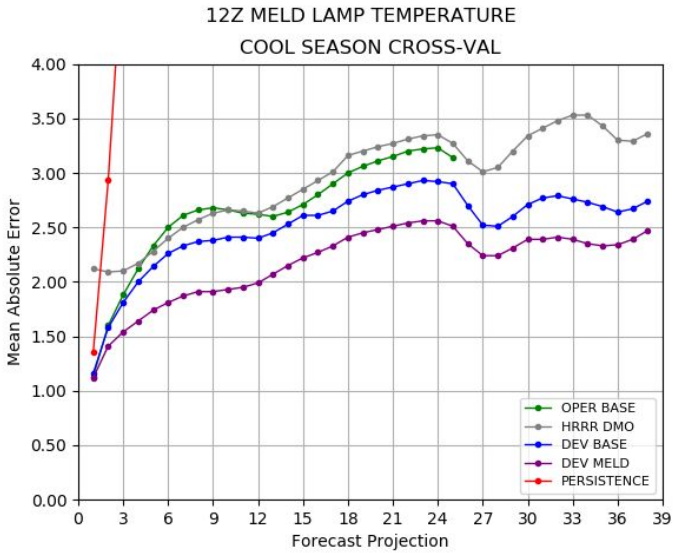
```
KBWI    GFS LAMP GUIDANCE   12/12/2022  1230 UTC
DT /DEC  13                          /DEC  14
HR    26 27 28 29 30 31 32 33 34 35 36 37 38
UTC   14 15 16 17 18 19 20 21 22 23 00 01 02
TMP   34 37 39 41 42 43 43 43 40 37 35 34 32
DPT   19 17 16 15 14 14 14 13 13 14 15 16 17
WDR   34 35 33 32 31 32 32 33 33 33 33 32 33
WSP   04 06 06 07 06 06 06 05 04 03 02 01 01
WGS   NG NG NG NG NG NG NG NG NG NG NG NG NG
P01    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
P06                  0                   0
CLD   CL CL CL CL CL CL CL CL CL CL CL CL CL
CIG    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
VIS    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
OBV    N  N  N  N  N  N  N  N  N  N  N  N  N
```

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

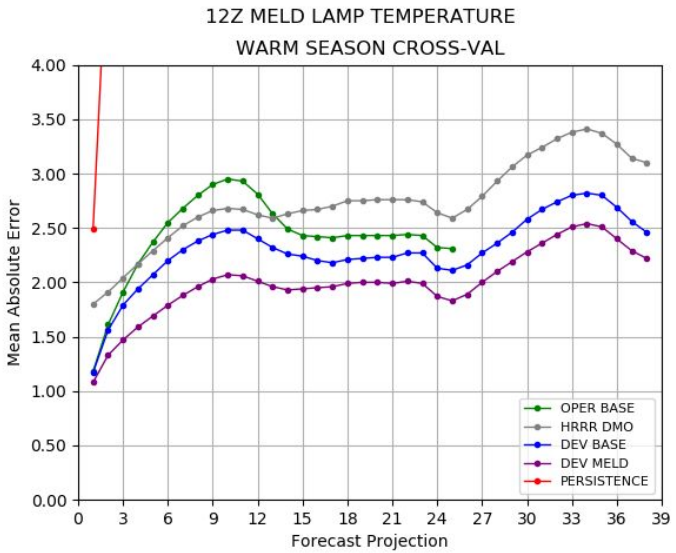
- Verification details
  - Development period:
    - T/Td: July 2018 - Dec 2021
    - Winds: July 2017 - June 2021
  - K-fold cross-validation sample:
    - T/Td: July 2018 - Dec 2021 (3.5 cool, 3.5 warm)
    - Winds: July 2018 - June 2021 (3 cool, 3 warm)
- ~2310 stations verified
- Results for 1200 UTC cycle are shown (other cycles similar)

LAMP Meld (V2.5) Independent Verification
1-38 h Temperature MAE 12 UTC cycle

Cool Season



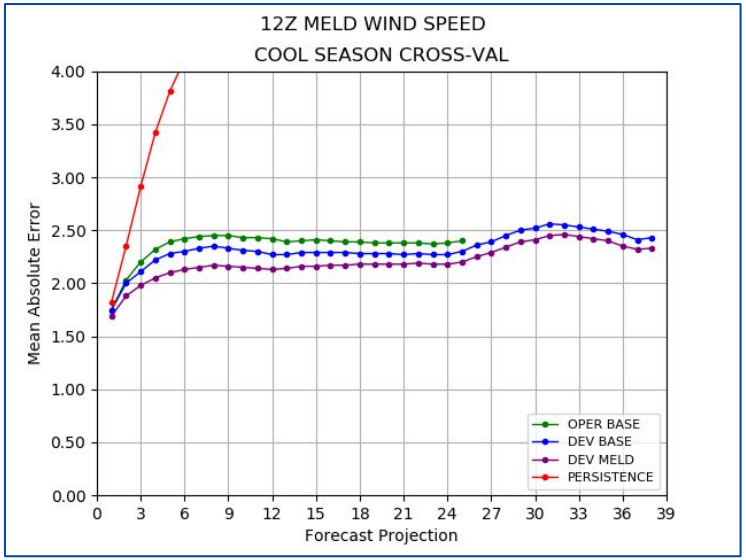
Warm Season



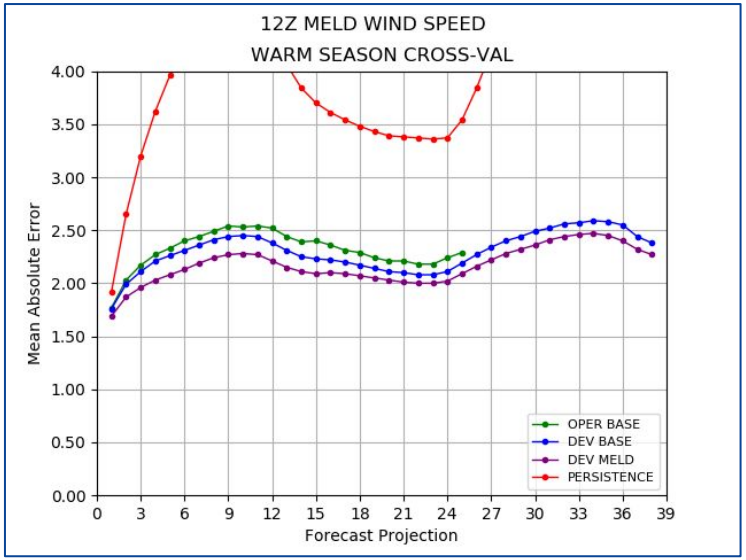
LAMP Meld (purple) shows improvement over Base LAMP (blue) and Oper LAMP (green) and HRRR (gray)

LAMP Meld (V2.5) Independent Verification
1-38 h Wind Speed MAE 12 UTC cycle

Cool Season

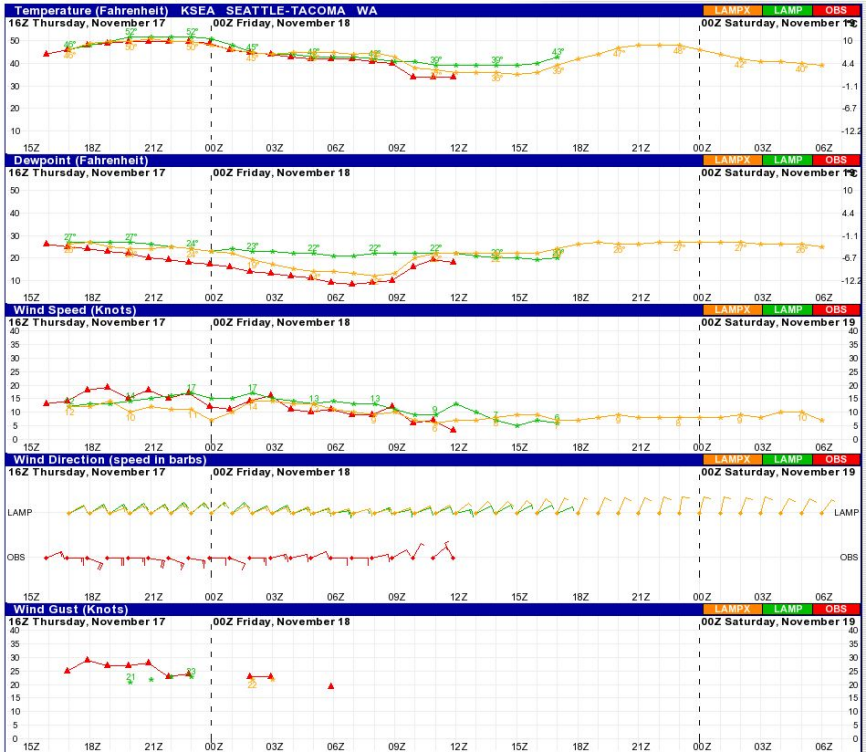


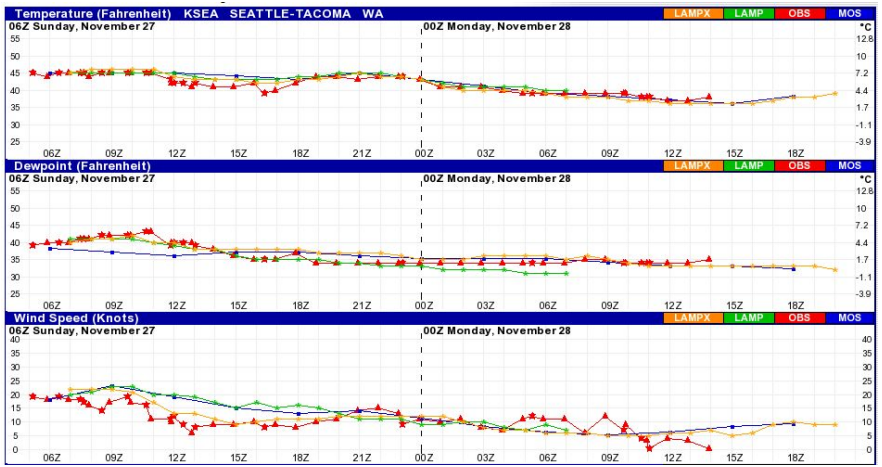
Warm Season



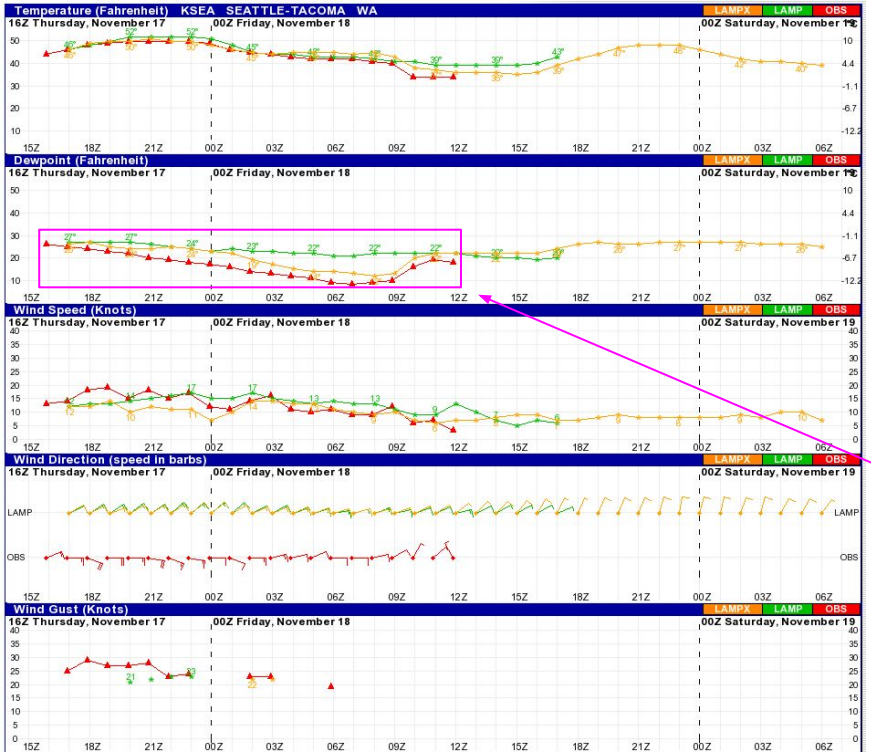
LAMP Meld (purple) shows improvement over Base LAMP (blue) and Oper LAMP (green)

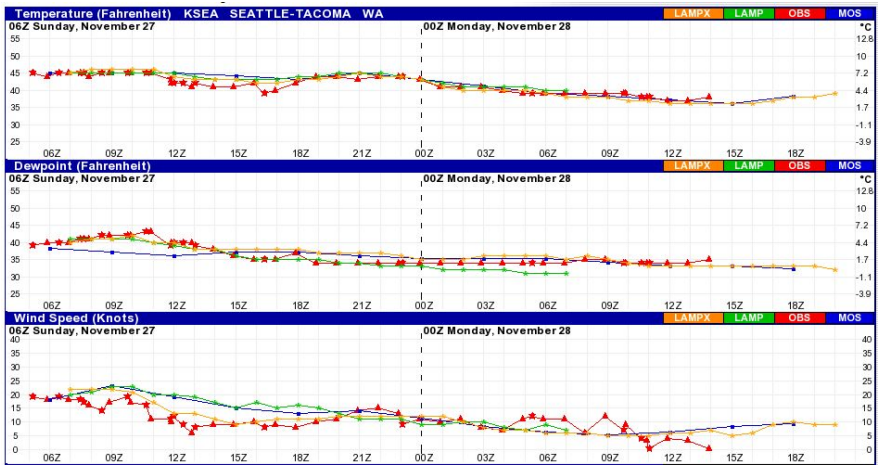
LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds





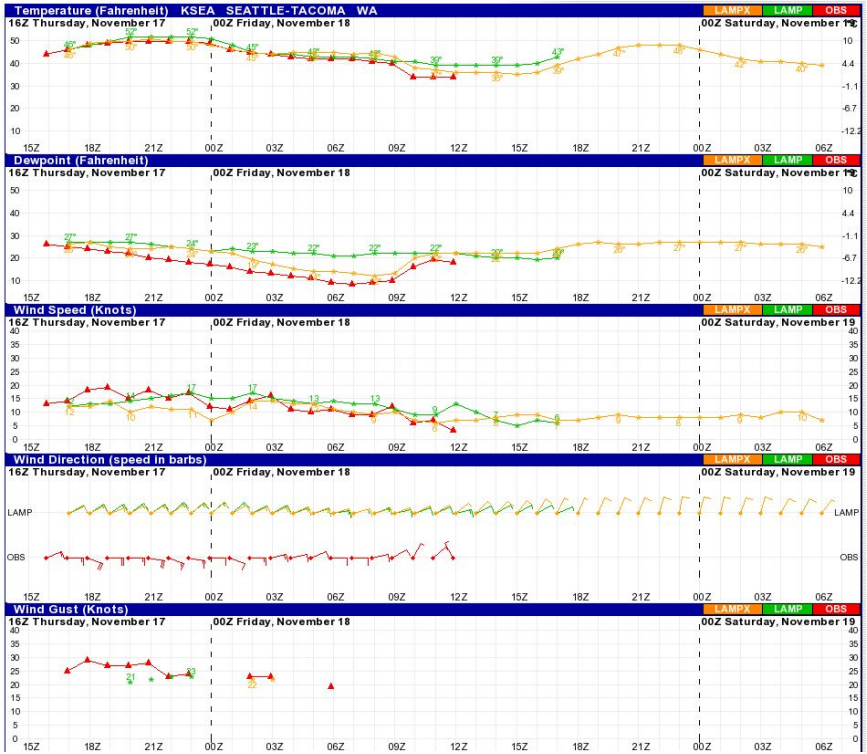
LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

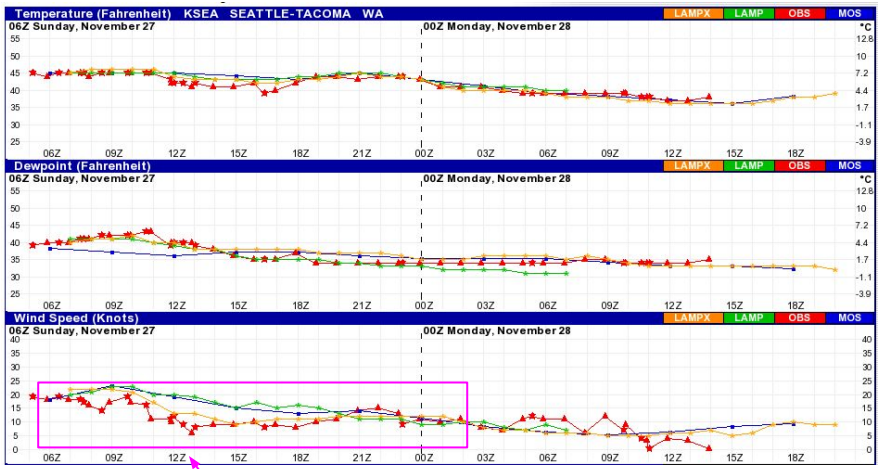




Example of improved dewpoint guidance
- likely due to influence from the HRRR

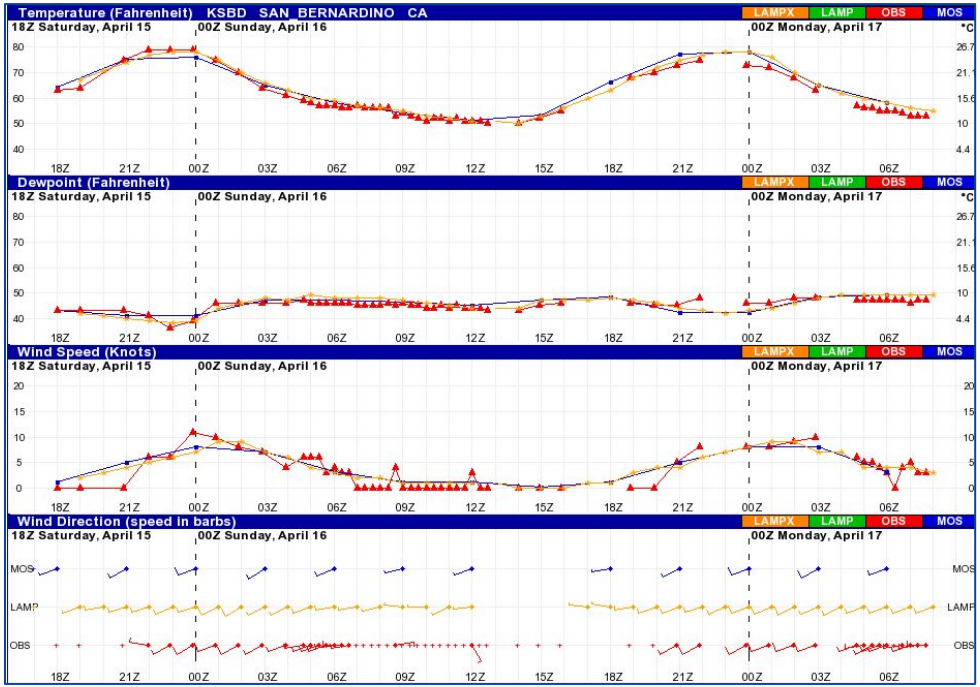
LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds





Example of improved wind speed guidance - likely due to influence from the HRRR

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds



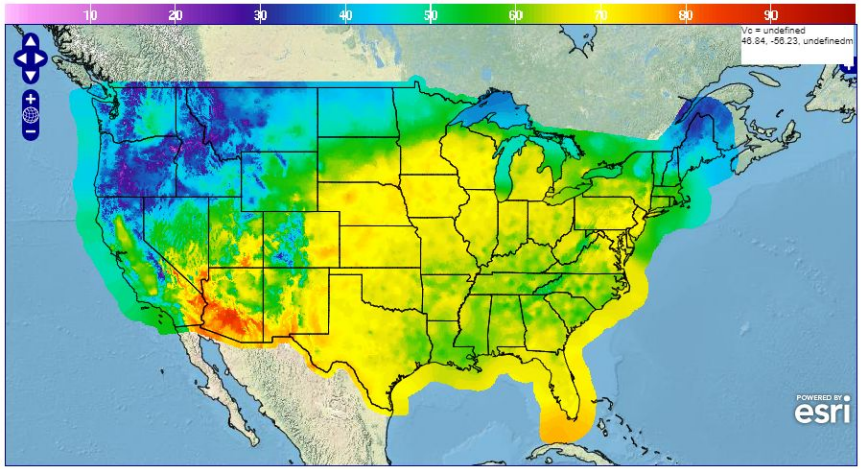
Example of new LAMP Temperature/Dewpoint/Wind guidance (shown as the orange line) at a station (KSBD - San Bernardino, CA) that did not have this guidance before this upgrade

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

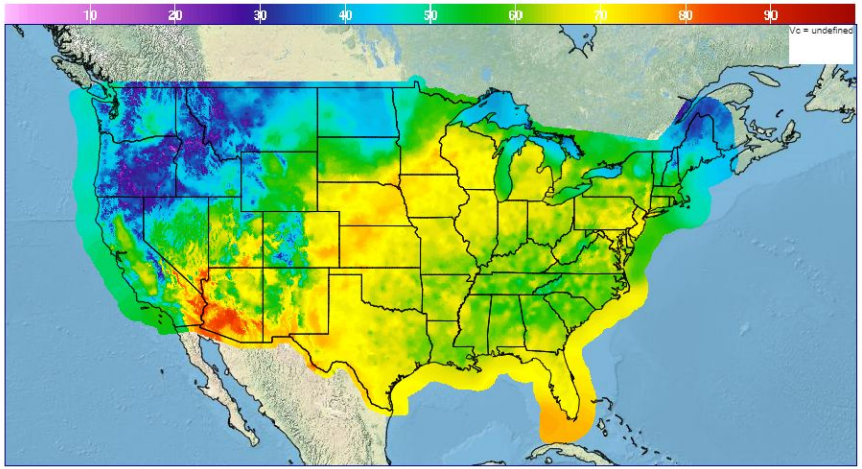
- V2.5.0 highlights:
  2. Gridded LAMP for CONUS has been re-tuned to incorporate the updated stn guidance.
     - Meld station guidance that incorporates the HRRR is analyzed
     - Addition of 335 new stations to GLMP analysis
     - Removal of 33 stations that no longer have MOS guidance

Temperature

v2.4



v2.5

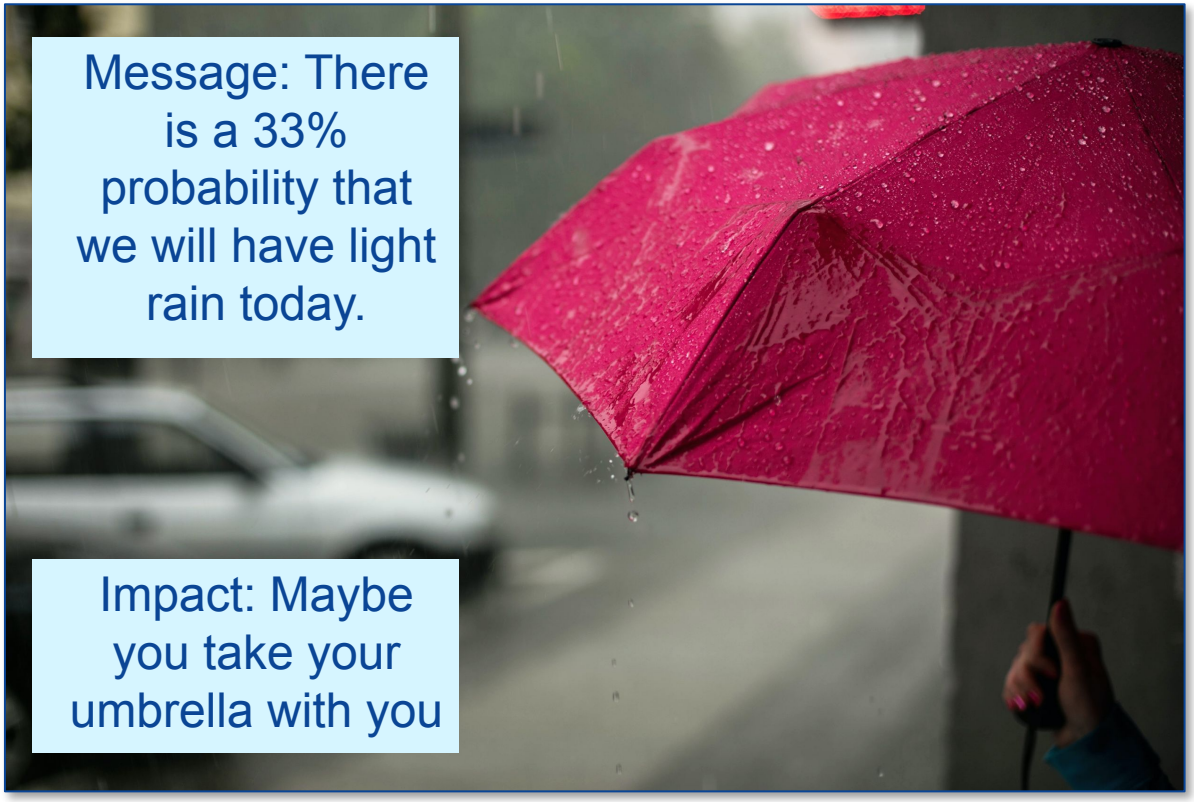


4. FAA AWRP Work

Why Probabilities Matter

- Probabilistic information can help provide Impact-based Decision Support Services (IDSS) for decision makers
  - "…forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts." - Murphy, A. H. (1993). What Is a Good Forecast? An Essay on the Nature of Goodness in Weather Forecasting, *Weather and Forecasting*, *8*(2), 281-293. Retrieved Dec 23, 2022, from https://journals.ametsoc.org/view/journals/wefo/8/2/1520-0434_1993_008_0281_wiagfa_2_0_co_2.xml

Why Probabilities Matter – Low Impact



Why Probabilities Matter – High Impact

There is a 33% probability that the ceiling of this room will fall in today.

Impact: No one would be here!!

Why Probabilities Matter – For C&V

- Per NTSB data from 2011-2020: “The proportion of Part 91 accidents that resulted in a fatality was 18%; while fatal IMC* accidents averaged 64%” – Don Eick, NTSB Senior Meteorologist**
  - Statistically calibrated probabilities of ceiling height and visibility below critical levels are important to indicate risk and to influence decisions
- NWS Director Ken Graham’s “Ken’s Ten” Priorities and Action Strategies for the Future include “Probabilistic IDSS/Hazard Services”

* IMC = Instrument Meteorological Conditions
** Source: July 13, 2022 presentation at the NCAR Aviation Weather Technical Exchange Meeting, Boulder, CA

4a. LAMP/Gridded LAMP 15-minute High Impact Weather for Ceiling & Visibility

15-minute LAMP/GLMP out to 6 hours

- Project funded by FAA Aviation Weather Research Program (AWRP) for Clouds & Visibility to increase the temporal resolution of Gridded LAMP ceiling height and visibility (C&V) guidance from 1 hour to 15 minutes in the first 6 hours of the forecast period.

- Helicopter Emergency Medical Services (HEMS) operators use the NWS Aviation Weather Center (AWC) HEMS Tool* which uses GLMP data to update every 15 mins with latest observational data and forecast data.
  - Providing updated GLMP guidance for C&V every 15 mins for 15-min periods (instead of valid at the top of the hour) will help fill gap in the HEMS tool.

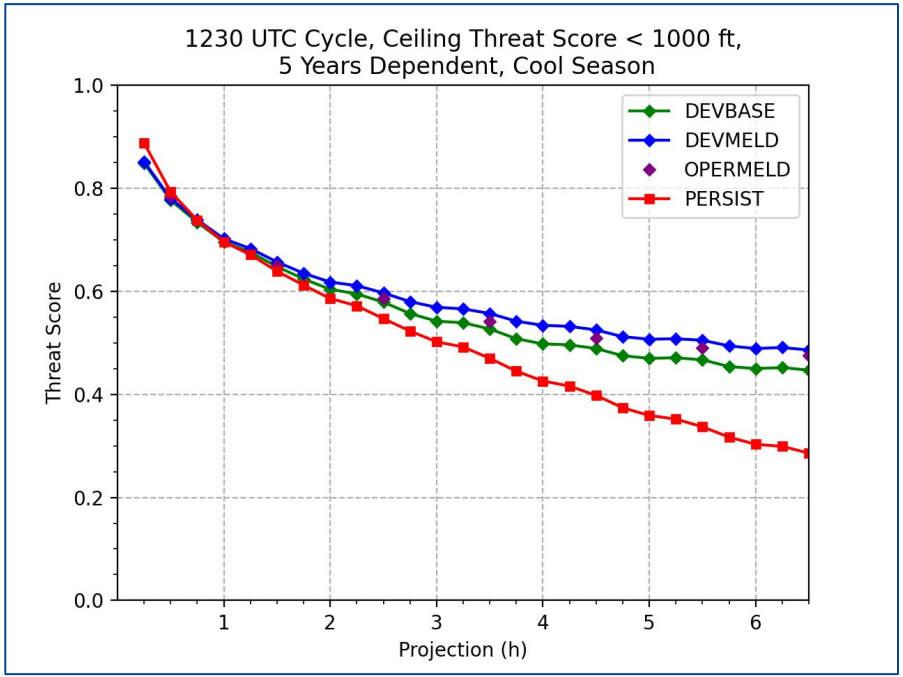
- Will be available at CONUS stations and on the CONUS grid

- High Impact Weather (HIW) C/V Predictand is defined as lowest C/V observed over a 15-minute period ending at HH:14, HH:29, HH:44, and HH:59.

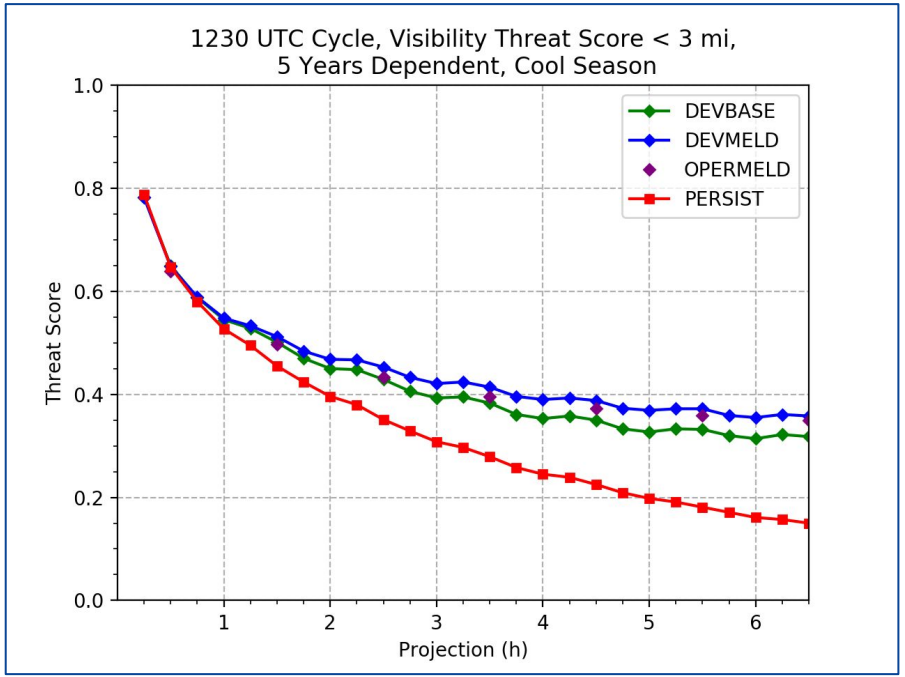
*The HEMS tool is planned to be renamed as the Graphical Forecast - Low Altitude (GFA-LA)

15-min Verification: Cool Season

Ceiling < 1,000 ft



Visibility < 3 miles



New 15-minute station-based LAMP Meld guidance (blue) shows improvement over the new LAMP Base guidance (green), operational hourly Meld (purple), and persistence (red)

4b. LAMP onset/cessation guidance for the Core 30 Airports

LAMP onset/cessation products

- Project funded by FAA AWRP for Clouds & Visibility to create onset/cessation guidance products for use by Traffic Flow Managers. Specific options developed include:
  - A **text product** similar to the operational LAMP text bulletin that displays:
    - Flight Categories (not currently shown in any LAMP text products)
    - Onset/Cessation of various Flight Categories
    - Probabilities of Ceiling Height and Visibility (currently only shown in LAMP BUFR messages and on LAMP website) corresponding to various Flight Categories
  - A **Webpage product** option

Summary of Options

- Numeric Flight Categories / Probabilities
- Letter Flight Categories / Probabilities

FLT	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	3	3	3	3	3	4	4	5	5
FLT	V	M	V	M	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	M	I	I	I	I	I	I	M	M	V	V
CP1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	4	4	3	2	1	0	0	0	1	1	1	1	1	1	0	1
CP2	3	5	1	0	0	1	0	0	0	2	4	4	4	5	6	7	8	9	10	13	14	16	16	11	5	10	6	4	8	14	17	15	14	14	13	9	5	6
CP3	5	10	1	3	6	5	0	0	1	2	5	6	6	7	9	10	12	11	11	14	17	19	16	11	5	13	15	18	26	35	44	39	35	30	25	17	10	10
CP4	18	43	35	44	37	34	32	33	32	30	16	15	15	14	13	12	13	11	12	14	17	19	18	14	9	16	22	29	43	58	72	67	65	62	50	38	26	21
VP1	0	0	0	1	1	1	0	1	1	0	0	0	0	1	1	2	2	2	3	4	5	6	8	6	2	1	1	1	1	1	2	2	2	2	1	1	1	1
VP2	1	1	1	2	1	1	0	2	1	1	2	1	2	3	3	3	5	5	5	8	9	11	12	11	5	3	3	3	2	3	4	5	5	4	4	3	3	3
VP3	1	1	1	2	2	1	0	2	2	3	4	4	4	5	5	5	6	7	8	11	13	16	18	17	9	9	11	12	12	15	19	19	15	12	9	6	5	5
VP4	1	1	1	2	2	1	0	2	3	5	6	7	6	7	7	8	9	11	12	16	19	24	27	23	15	16	19	20	22	26	31	30	23	19	15	12	9	8
CPVL	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	4	4	3	2	1	0	0	0	1	1	1	1	1	1	1	0	1
CPL	3	5	1	0	0	1	0	0	0	2	4	4	4	5	6	7	8	9	10	13	14	16	16	11	5	10	6	4	8	14	17	15	14	14	13	9	5	6
CPI	5	10	1	3	6	5	0	0	1	2	5	6	6	7	9	10	12	11	11	14	17	19	16	11	5	13	15	18	26	35	44	39	35	30	25	17	10	10
CPM	18	43	35	44	37	34	32	33	32	30	16	15	15	14	13	12	13	11	12	14	17	19	18	14	9	16	22	29	43	58	72	67	65	62	50	38	26	21
VPVL	0	0	0	1	1	1	0	1	1	0	0	0	0	1	1	2	2	2	3	4	5	6	8	6	2	1	1	1	1	1	2	2	2	2	1	1	1	1
VPL	1	1	1	2	1	1	0	2	1	1	2	1	2	3	3	3	5	5	5	8	9	11	12	11	5	3	3	3	2	3	4	5	5	4	4	3	3	3
VPI	1	1	1	2	2	1	0	2	2	3	4	4	4	5	5	5	6	7	8	11	13	16	18	17	9	9	11	12	12	15	19	19	15	12	9	6	5	5
VPM	1	1	1	2	2	1	0	2	3	5	6	7	6	7	7	8	9	11	12	16	19	24	27	23	15	16	19	20	22	26	31	30	23	19	15	12	9	8

Summary of Options (continued)

- One text bulletin out to 38 hours, OR
- Two text bulletins (01 - 25 hours & 26 - 38 hours)

- 3-space columns (consistent with operational LAMP text bulletins), OR
- 4-space columns (more readable, especially with 100% probabilities)

CP4 100 95 68 87 91 87 85100100 99100 88 77 86 77 75 58 53 46 48 48 48 47 44 41 46 53 58 63 66 66 63 57 52 47 41 35 39 (3-space)

CP4 100 95 68 87 91 87 85 100 100 99 100 88 77 86 77 75 58 53 46 48 48 48 47 44 41 46 53 58 63 66 66 63 57 52 47 41 35 39 (4-space)

- Display Flight Categories with dashes
- Display Flight Categories with 1s

```
VFR --/   +-/   +-----------------------------------------------------------------/
VFR   1     1     1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
```

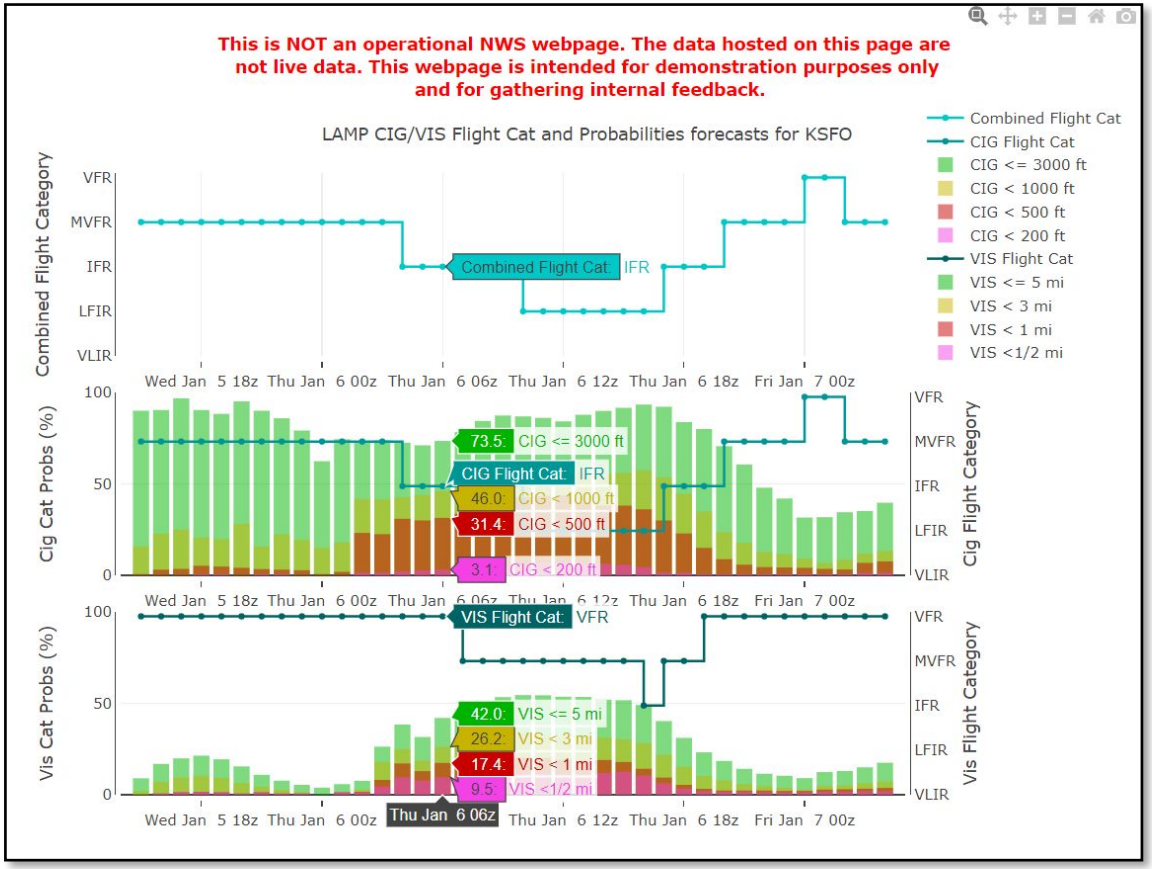
3 spaces, all projections (cumulative probs)

```
KATL   ATLANTA      ASOS     GFS LAMP 1430 UTC   1/05/2022
UTC  15 16 17 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 19 20 21 22 23 00 01 02 03 04
FLT   5  4  5  4  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  4  3  3  3  3  3  4  4  5  5
VFR --/   +-/   +-------------------------------------------------------------------/                    +-----
MVF    +-/   +-/                                                                 +-/                +----/
IFR                                                                                 +----------------/
LIF
VLI
CIG   8  5  8  5  6  6  6  6  6  8  8  8  8  8  8  8  8  8  8  8  8  8  7  6  6  6  6  5  3  3  3  3  3  3  4  5  6  7
VIS   7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  6  7  7  7  7  7  7  7  5  5  7  7  7  7  7  7
CP1   1  1  1  0  0  0  0  0  0  0  0  0  0  0  1  1  1  2  2  3  3  4  4  3  2  1  0  0  0  1  1  1  1  1  1  1  0  1
CP2   3  5  1  0  0  1  0  0  0  2  4  4  4  5  6  7  8  9 10 13 14 16 16 11  5 10  6  4  8 14 17 15 14 14 13  9  5  6
CP3   5 10  1  3  6  5  0  0  1  2  5  6  6  7  9 10 12 11 11 14 17 19 16 11  5 13 15 18 26 35 44 39 35 30 25 17 10 10
CP4  18 43 35 44 37 34 32 33 32 30 16 15 15 14 13 12 13 11 12 14 17 19 18 14  9 16 22 29 43 58 72 67 65 62 50 38 26 21
VP1   0  0  0  1  1  1  0  1  1  0  0  0  0  1  1  2  2  2  3  4  5  6  8  6  2  1  1  1  1  1  2  2  2  2  1  1  1  1
VP2   1  1  1  2  1  1  0  2  1  1  2  1  2  3  3  3  5  5  5  8  9 11 12 11  5  3  3  3  2  3  4  5  5  4  4  3  3  3
VP3   1  1  1  2  2  1  0  2  2  3  4  4  4  5  5  5  6  7  8 11 13 16 18 17  9  9 11 12 12 15 19 19 15 12  9  6  5  5
VP4   1  1  1  2  2  1  0  2  3  5  6  7  6  7  7  8  9 11 12 16 19 24 27 23 15 16 19 20 22 26 31 30 23 19 15 12  9  8
```

Bulletin on onset/cessation times

```
KSFO   SAN FRANCISCO          GFS LAMP 1430 UTC   1/05/2022
VFR  07/0000 - 07/0100
MVF  05/1500 - 06/0300   06/2000 - 06/2300   07/0200 -
IFR  06/0400 - 06/0900   06/1700 - 06/1900
LIF  06/1000 - 06/1600
```

Example Prototype Web Page

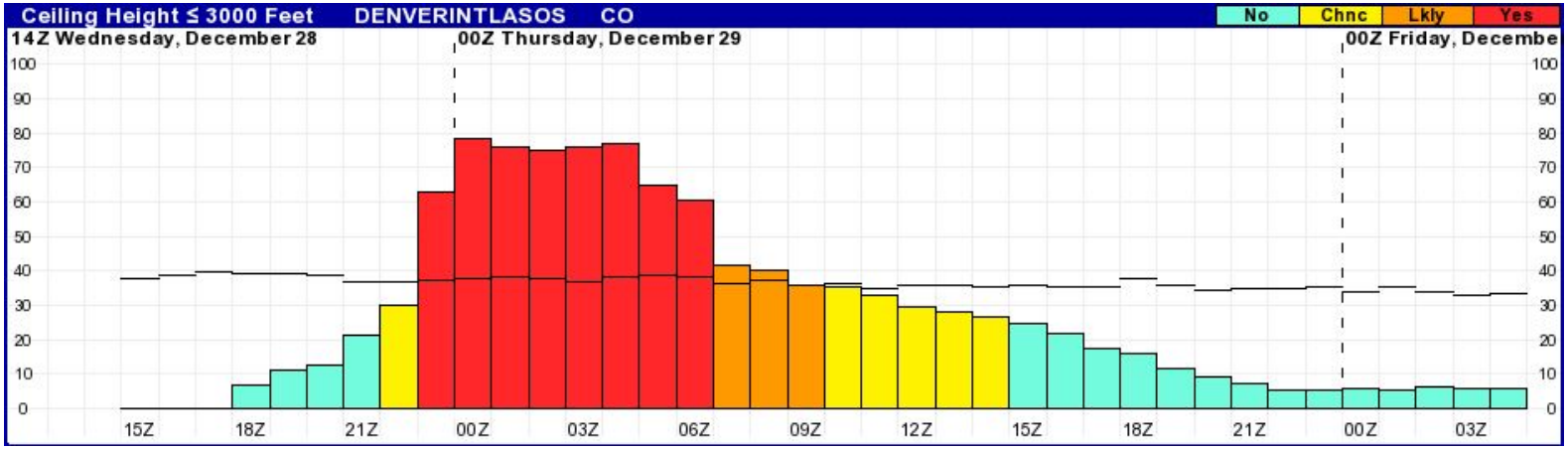


Time series plots of combined flight category (top), cumulative ceiling height probabilities (middle), and cumulative visibility probabilities (bottom)

Feedback Received

- Presented the text and web options to small group of FAA and requested feedback
- A common takeaway from the feedback received was the indicated need for airport-specific thresholds for C&V at Core 30 airports and not so much the traditional Flight Categories:
- It was also apparent that what meteorologists want may differ from what Traffic Flow Managers want:
  - “I won't use the text products.”
  - “I like the initial range of options, particularly with respect to the more simplistic text options.”
  - “Not much to dislike! As long as we consider that there are two distinct audiences here.”

Current Probability Images ≤ 3,000 ft



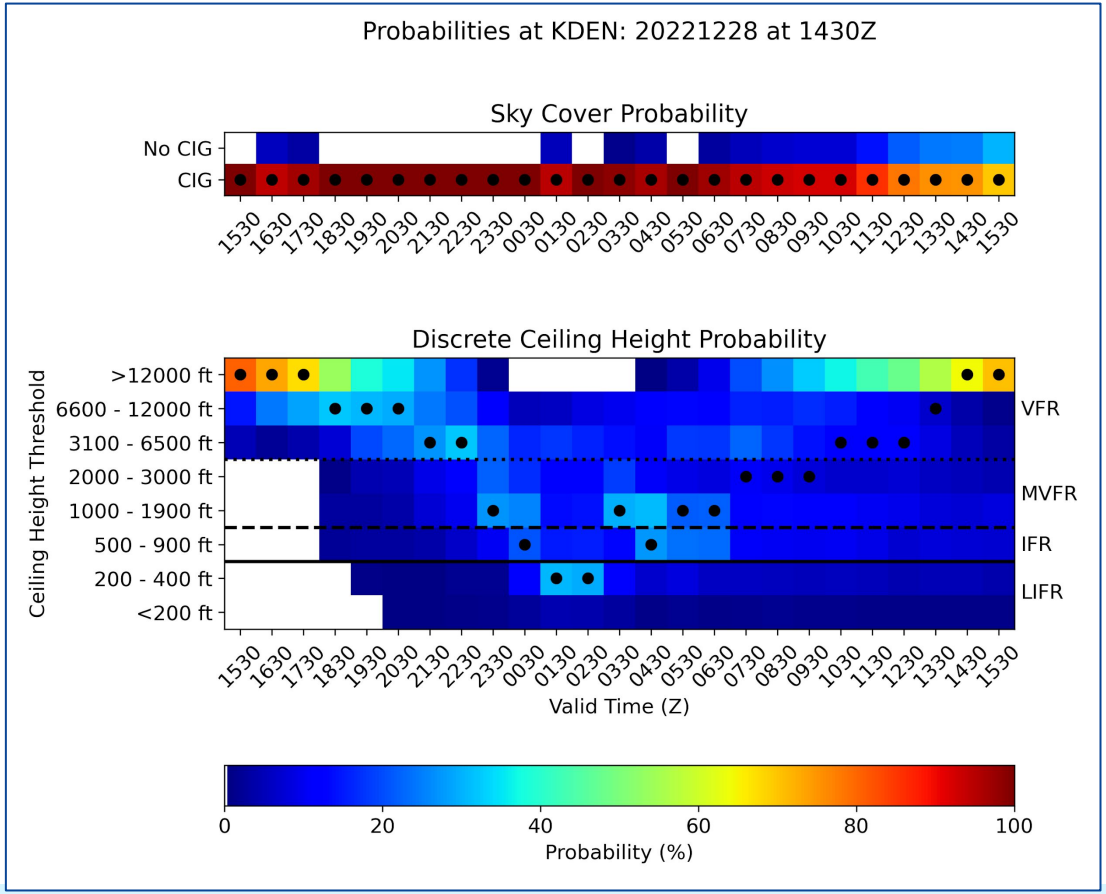
LAMP Probability of Ceiling **≤ 3,000** feet at Denver, CO, December 28, 2022, 14z cycle

But this does not indicate the probabilities/thresholds of the other ceiling height categories below this level

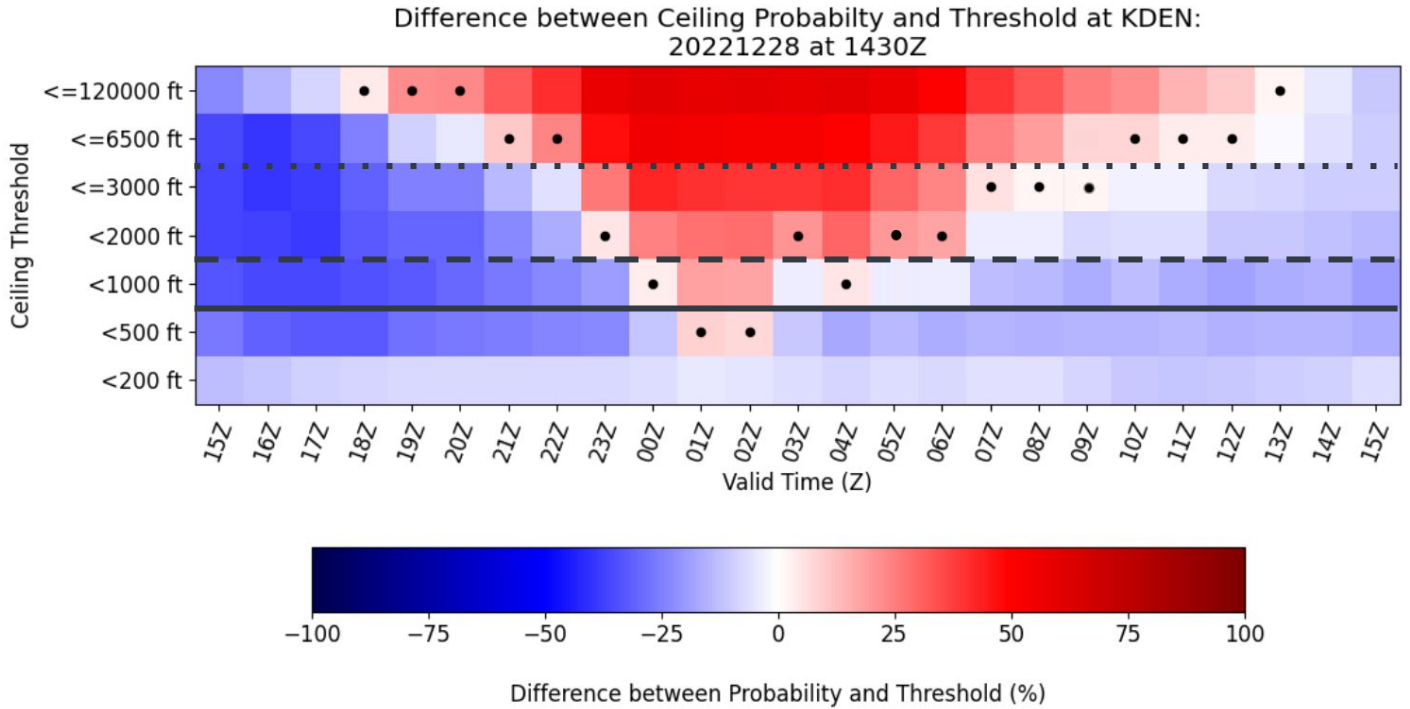
It would aid decision makers to put <u>all of this information together</u> on one display

Additional Graphical Options (Probabilities)

New Images being considered – Probabilities by category



Additional Graphical Options (Prob - Thresholds)



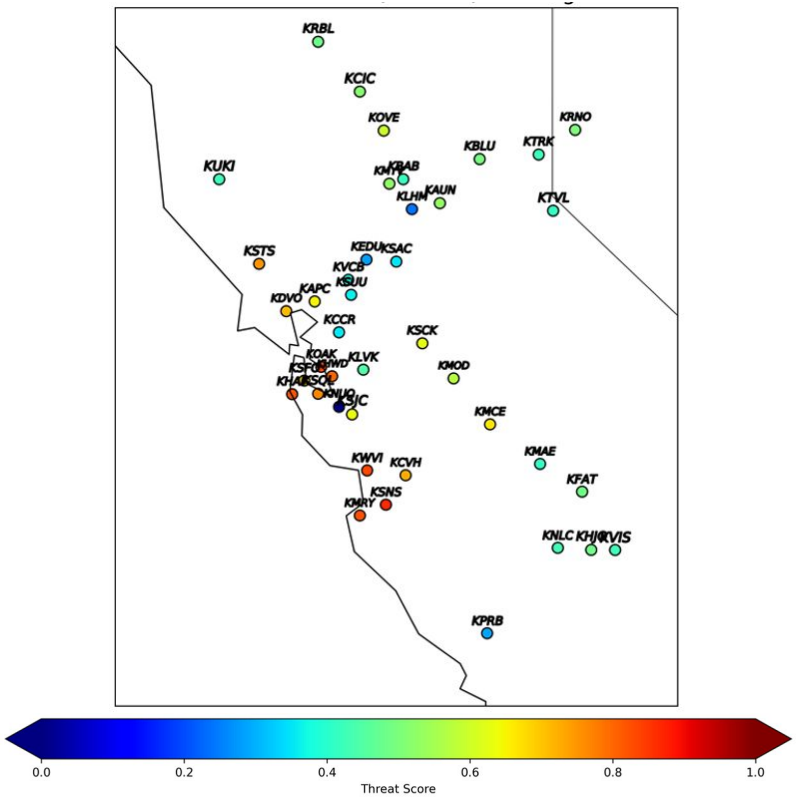
New Images being considered
(Probability – Threshold) differences by category

4c. Prototype of High Resolution Gridded Ceiling Height Observations at San Francisco

Gridded Ceiling Height Obs over SFO

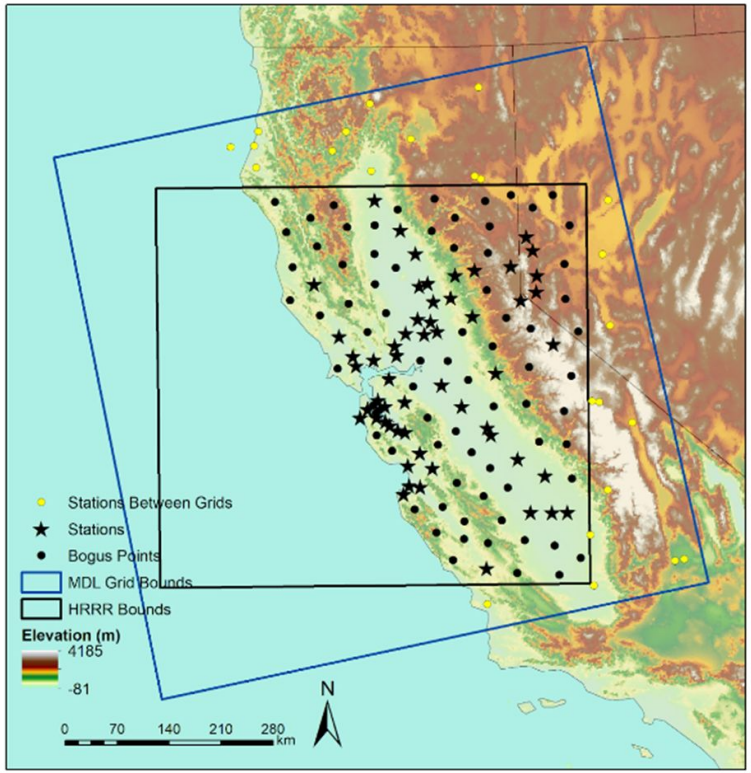
- Project funded by FAA AWRP for Clouds & Visibility to create a prototype of high resolution gridded observations of ceiling height over the San Francisco Airport region:
  - Station ceiling height observations are analyzed at 1.25-km resolution, with HRRR ceiling used over water (Ocean, Bay).
  - Analysis leverages “pseudo-observations” (pseudo-obs) of ceiling height to help inform what is happening in between the METAR stations:
    - “Smart predictor” informed by a Random Forest model.
    - Applied at strategically-placed “bogus” points where METAR coverage is sparse.

Random Forest “Smart” Predictor



- Random Forest model uses observations from closest three stations to predict the occurrence of a ceiling (defined by ≤ 12,000 ft).
- Provides probability (regressor) and binary yes/no (classifier) output as predictor in pseudo-ob equations.
- Threat scores generally highest where events occur most frequently (Bay area stations), and lower for inland stations.

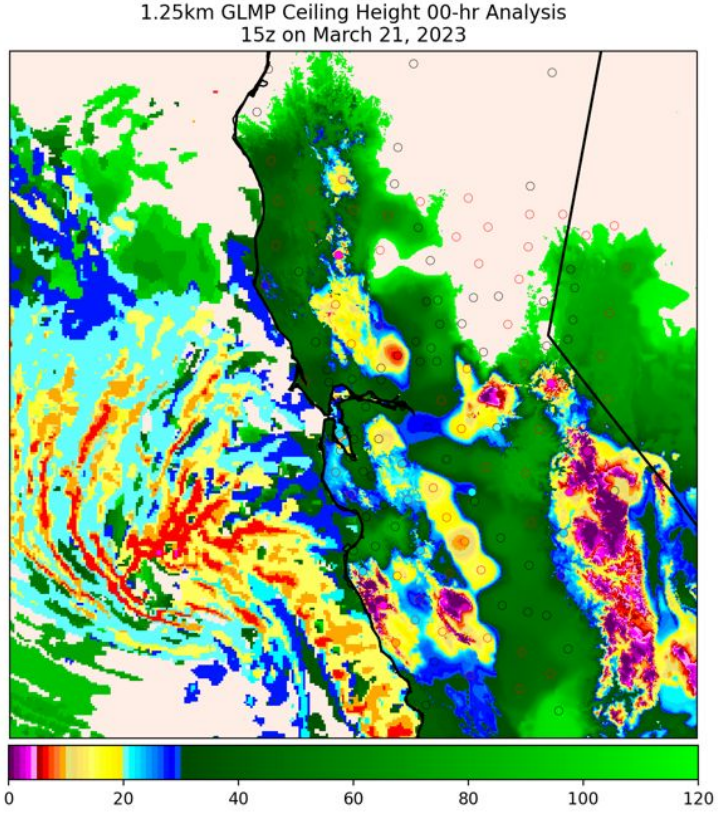
Pseudo-Obs Development: Forecasting the Observation

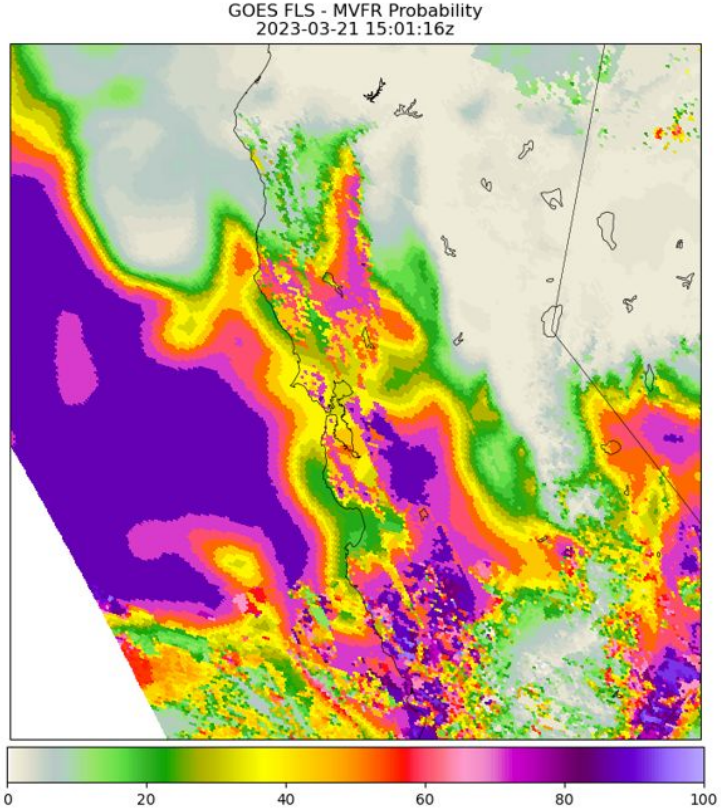


- Predictors include sub-hourly HRRR variables, HRRR-derived climatology, radar data, and Random Forest “smart” predictor.
- Equations for “stratus season” (May through September) and non-stratus season.
- Equations applied at bogus points to help inform what is going on between the METARs.
- Then analyzed METAR obs and Pseudo-ob → Gridded LAMP ceiling obs

Gridded Ceiling Observations

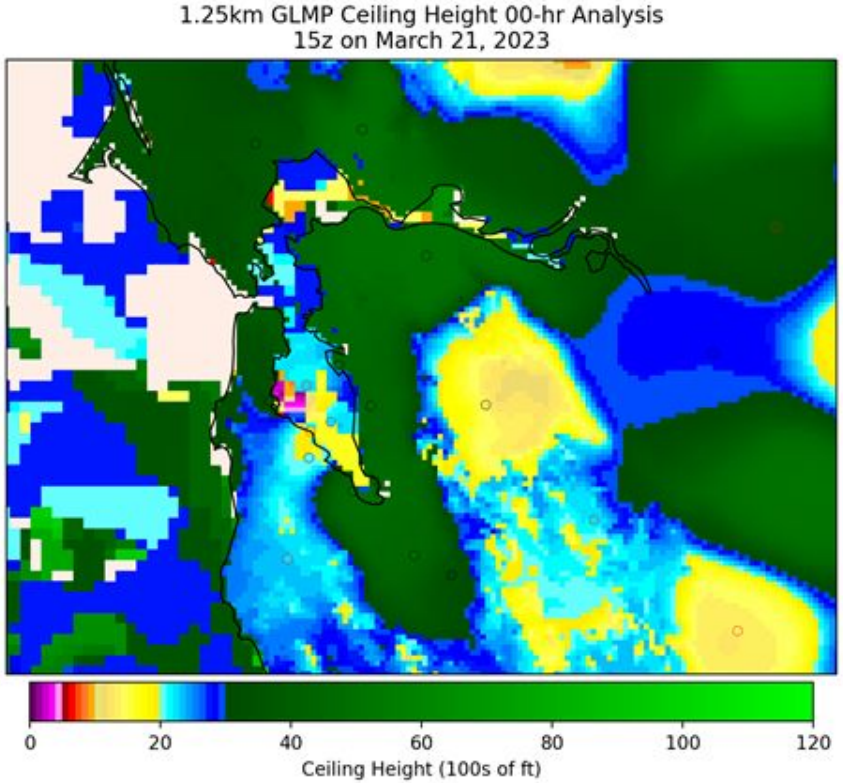
Full domain example



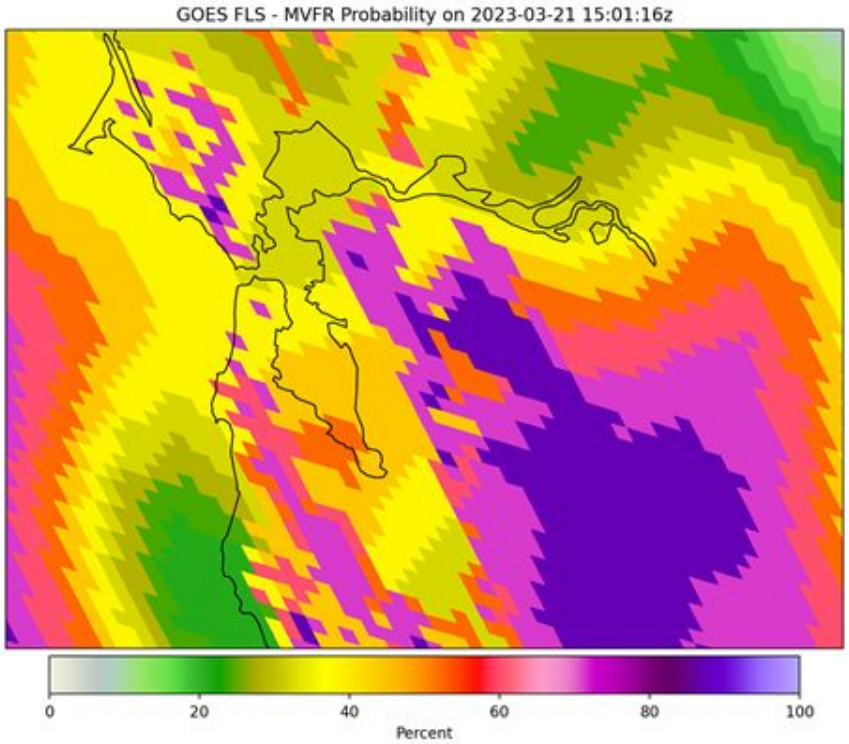


Gridded LAMP Ceiling Observations

Ceiling Height Analyses (1.25 km) for **1500 UTC**, March 21, 2023

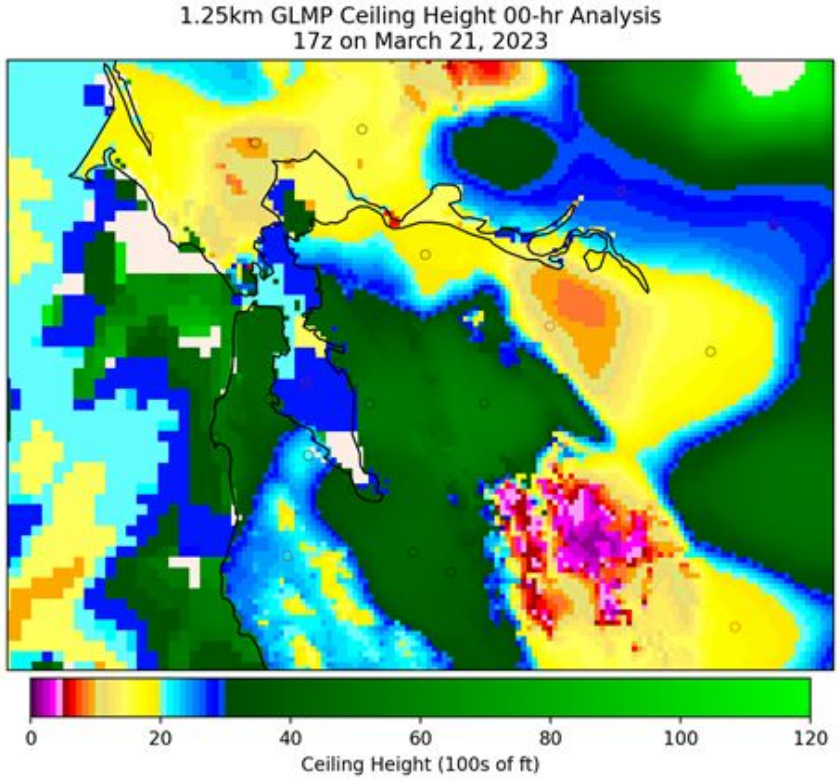


GOES Fog & Low Stratus Product

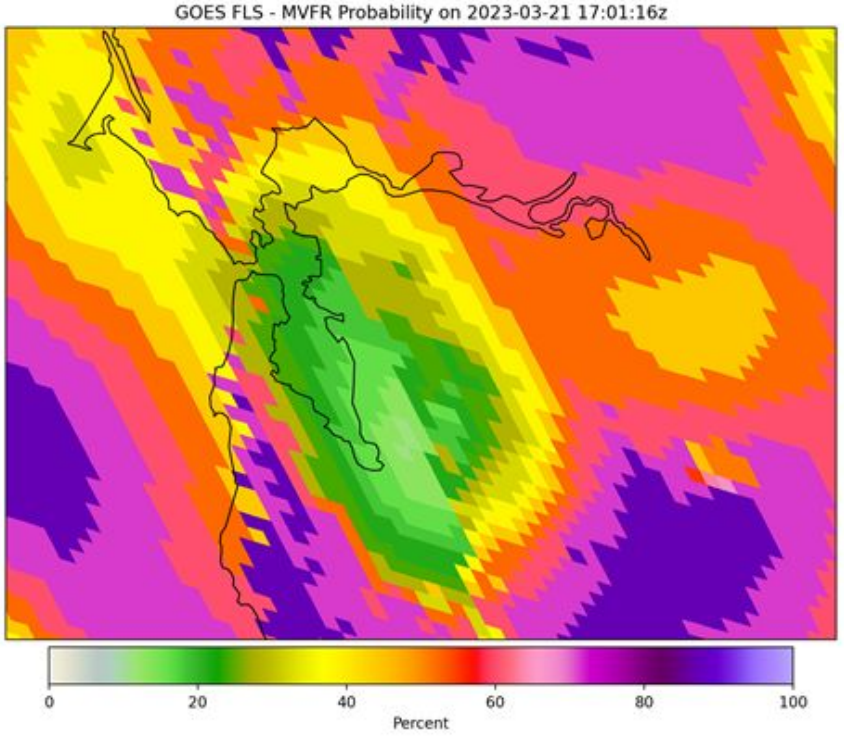


Gridded LAMP Ceiling Observations

Ceiling Height Analyses (1.25 km) for **1700 UTC**, March 21, 2023



GOES Fog & Low Stratus Product



Gridded Ceiling Obs Subjective Verification

Web camera images looking over Bay

1500 UTC

1700 UTC

Summary

- LAMP/GLMP v2.5 (T/Td/Winds): scheduled implementation May 2023
- 15-min LAMP/GLMP: LAMP C&V guidance valid at 15-min timesteps, to be produced every 15 minutes, out to 6 hours
  - Tentative code handoff in Spring 2024 with implementation in Summer 2024
- Onset/cessation: text bulletins and new web graphics showing probabilistic and flight category guidance
  - MDL/Aviation Weather Center (AWC)/FAA Aviation Weather Demonstration and Evaluation Team (AWDE) user demonstration from late Fall 2023 – early winter 2024.
- Gridded ceiling height analysis at SFO:
  - MDL/AWC/FAA AWDE user demonstration from May 2023 – Fall 2023.

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Thank you!

https://vlab.noaa.gov/web/mdl/lamp

Backup Slides

LAMP Background: Meld Technique

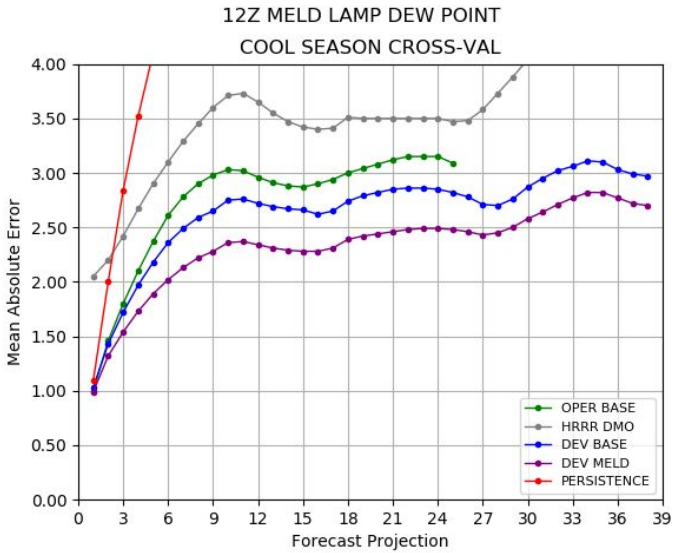
- Step 1: Base LAMP:
  - Station-based Base LAMP = Observations + locally-run models + GFS MOS
  - Technique = Linear Regression where predictors are statistically related to predictands via regression equations
  - Gridded Base LAMP = Station-based Base LAMP analyzed to a grid

- Step 2: Meld LAMP:
  - Station-based Meld LAMP = Obs + Base LAMP + HRRR MOS
  - Gridded Meld LAMP = Gridded Obs + Gridded forecasts Base LAMP + Gridded HRRR MOS
  - Combining HRRR information with Base LAMP results in increased skill

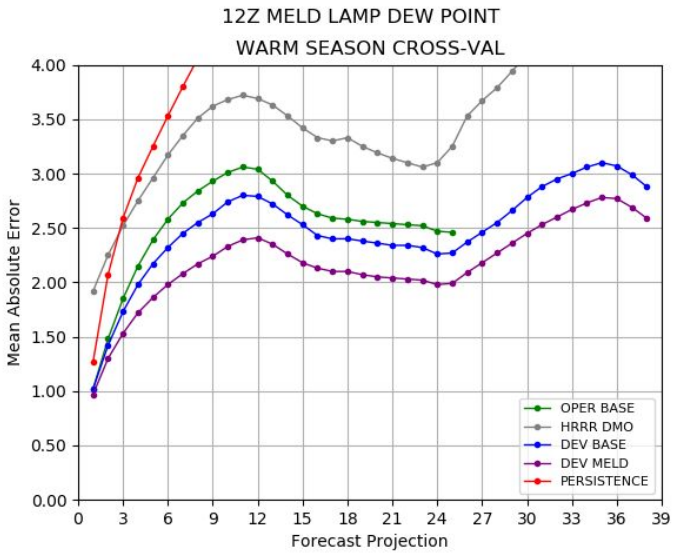
MOS = Model Output Statistics, GFS = Global Forecast System, HRRR = High Resolution Rapid Refresh

LAMP Meld (V2.5) Independent Verification
1-38 h Dewpoint MAE 12 UTC cycle

Cool Season



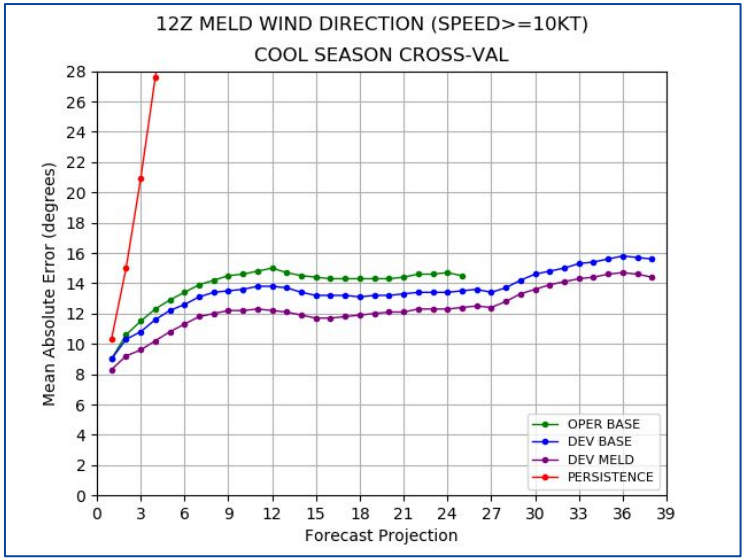
Warm Season



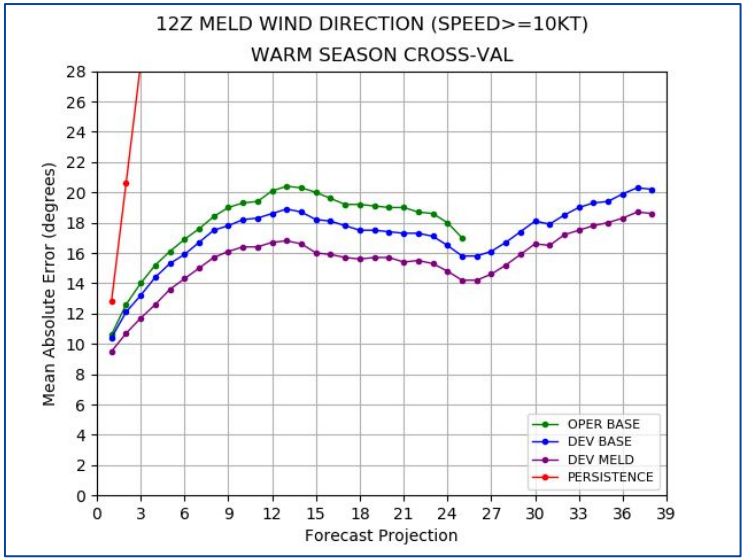
LAMP Meld (purple) shows improvement over Base LAMP (blue) and Oper LAMP (green) and HRRR (gray)

LAMP Meld (V2.5) Independent Verification
1-38 h Wind Direction MAE 12 UTC cycle

Cool Season



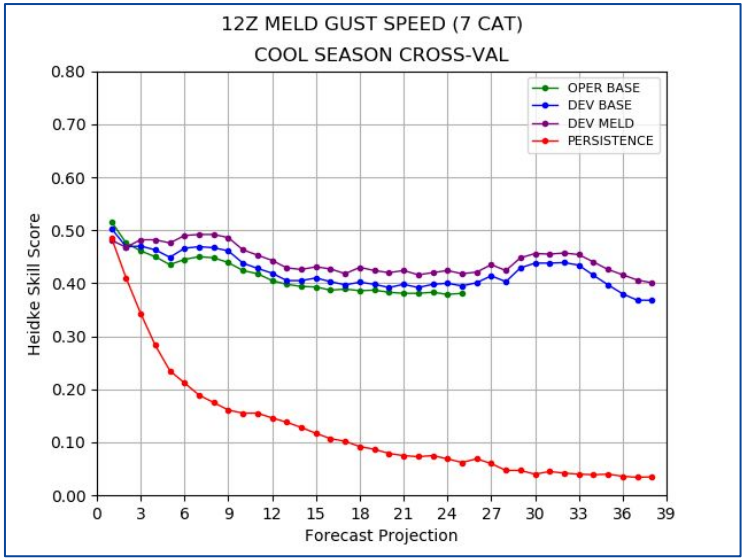
Warm Season



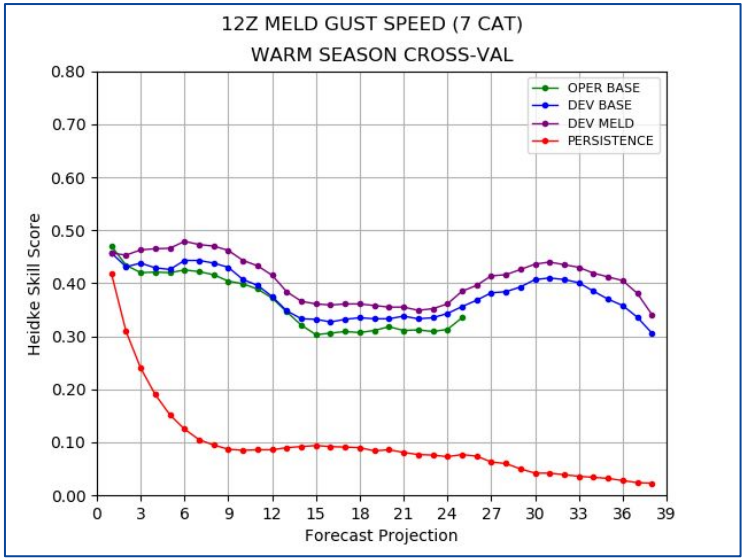
LAMP Meld (purple) shows improvement over Base LAMP (blue) and Oper LAMP (green)

LAMP Meld (V2.5) Independent Verification
1-38 h Wind Gust HSS 12 UTC cycle

Cool Season



Warm Season

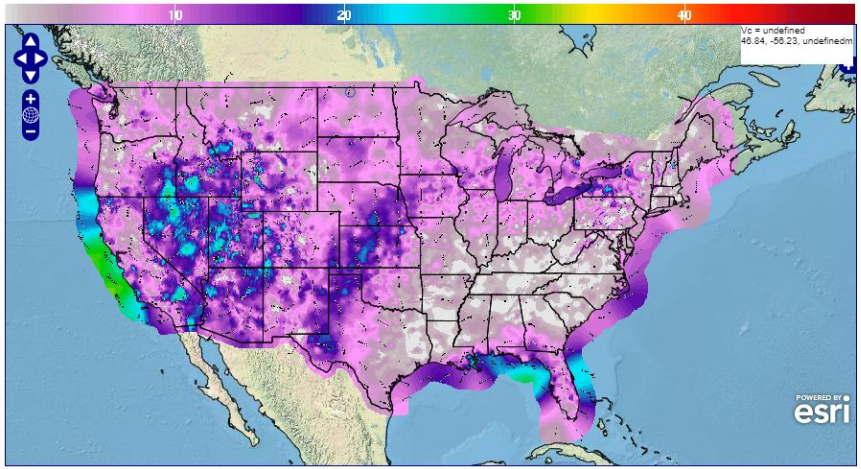


LAMP Meld (purple) shows improvement over Base LAMP (blue) and Oper LAMP (green)

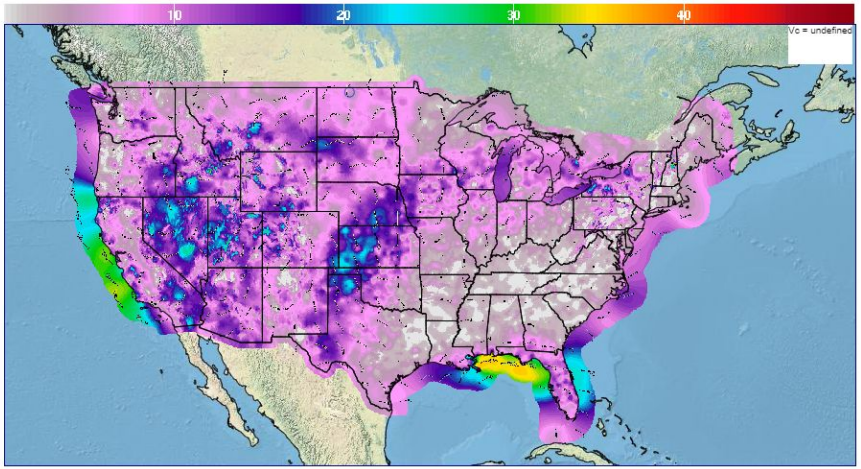
LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds Upgrade

Wind Speed

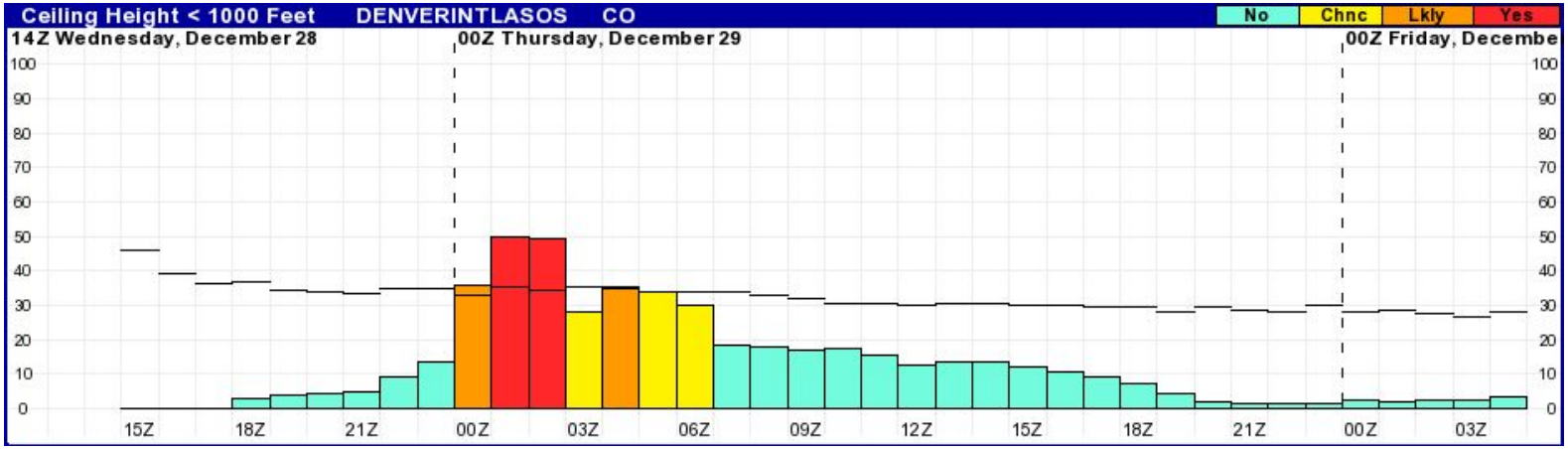
v2.4



v2.5



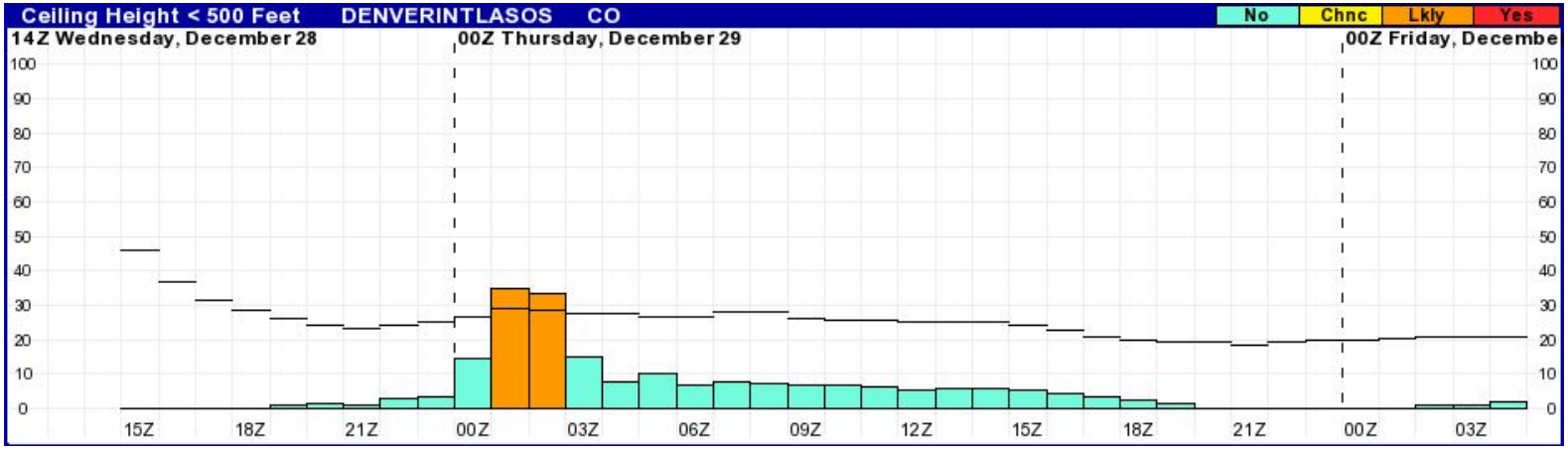
Current Probability Images < 1,000 ft



LAMP Probability of Ceiling **< 1,000** feet at Denver, CO, December 28, 2022, 14z cycle

But this does not indicate the probabilities of the other ceiling height categories below this level

Current Probability Images < 500 ft



LAMP Probability of Ceiling **< 500** feet at Denver, CO, December 28, 2022, 14z cycle

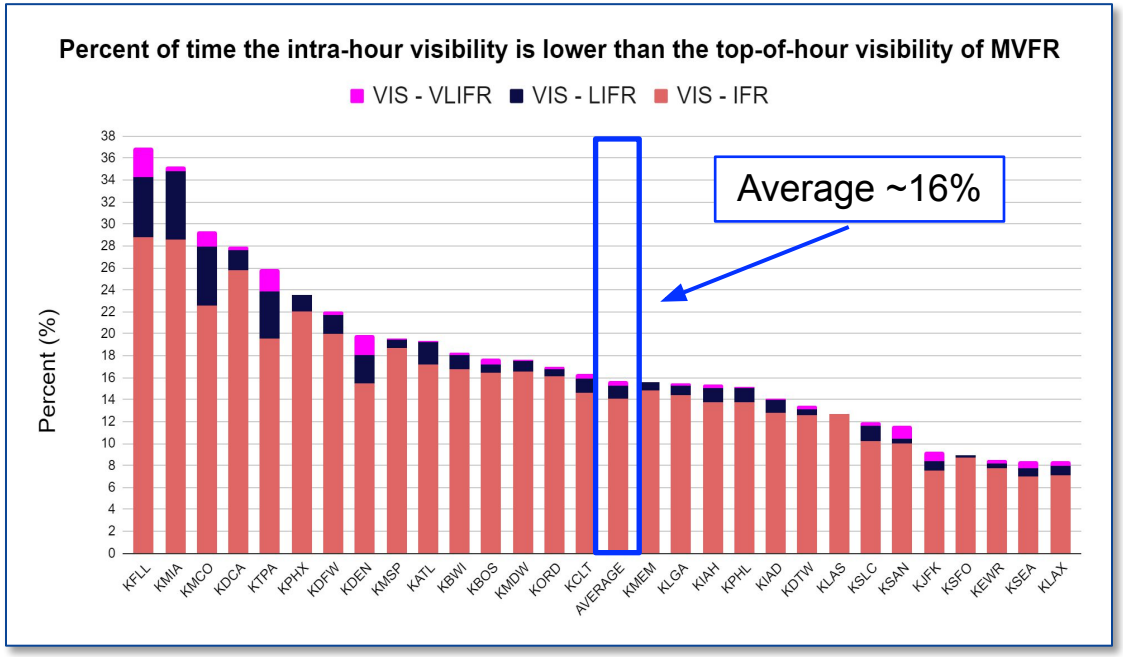
It would aid decision makers to put all of this information together on one display

Sub-hourly High Impact Weather

How often do top of hour observations miss impactful events during the hour?

- Intra-hour variability higher for visibility than for ceiling.
- Intra-hour visibility < top-of-the-hour visibility: Max ~37%, average, ~16%.

Visibility at the Core 30 airports*



* FAA Core Airports: https://aspm.faa.gov/aspmhelp/index/Core_30.html

LMP/GLMP V2.5 Upgrades: Temperature, Dewpoint, Winds

- Presently LAMP Temperature (T), Dewpoint (Td), and Winds (W) elements do not include HRRR inputs.
- T/Td/W have not been redeveloped in many years.
- MDL has received many user requests to add T/Td/W guidance to stations that did not report observations at all or for all 24 hours when LAMP was first developed, but which have since started reporting observations every hour. This upgrade will add LAMP T/Td/W guidance at existing LAMP stations if a sufficient number of observations are now available in the developmental sample.