NATIONAL WEATHER SERVICE

Increasing the Temporal Resolution of LAMP Ceiling Height and Visibility Guidance*

Clouds, Cloud Ceiling, and Visibility (C&V) Technical Exchange Meeting, Boulder, CO
July 13, 2022

Presenter: Phil Shafer, NWS/MDL

* Disclaimer: 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.

Thanks to the LAMP team:

Michael Allard[1], Judy Ghirardelli[1], Bob Glahn[1],
Chenjie Huang[4], Andrew Kochenash[2], Allison Layne[2],
Gregory Leone[3], Frederick Samplatsky[1], Katelyn Zigner[1]

[1]NOAA/NWS/OSTI/MDL
[2]Cooperative Institute for Research in the Atmosphere/Colorado State University
[3]Ace Info Solutions Inc. (A Guidehouse Company)
[4]KBR, Inc.

Motivation

- FAA-funded project to increase the temporal resolution of Gridded LAMP ceiling height and visibility (C&V) guidance from 1 hour to 15 minutes.
- Helicopter Emergency Medical Services (HEMS) operators use the NWS Aviation Weather Center (AWC) HEMS Tool [planned to be renamed as the Graphical Forecast - Low Altitude (GFA-LA)] which updates every 15 minutes with latest observational data and forecast data.
- 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 gap in HEMS tool.
- Development of station-based 15-min guidance - complete
- Development of gridded 15-min guidance - in progress

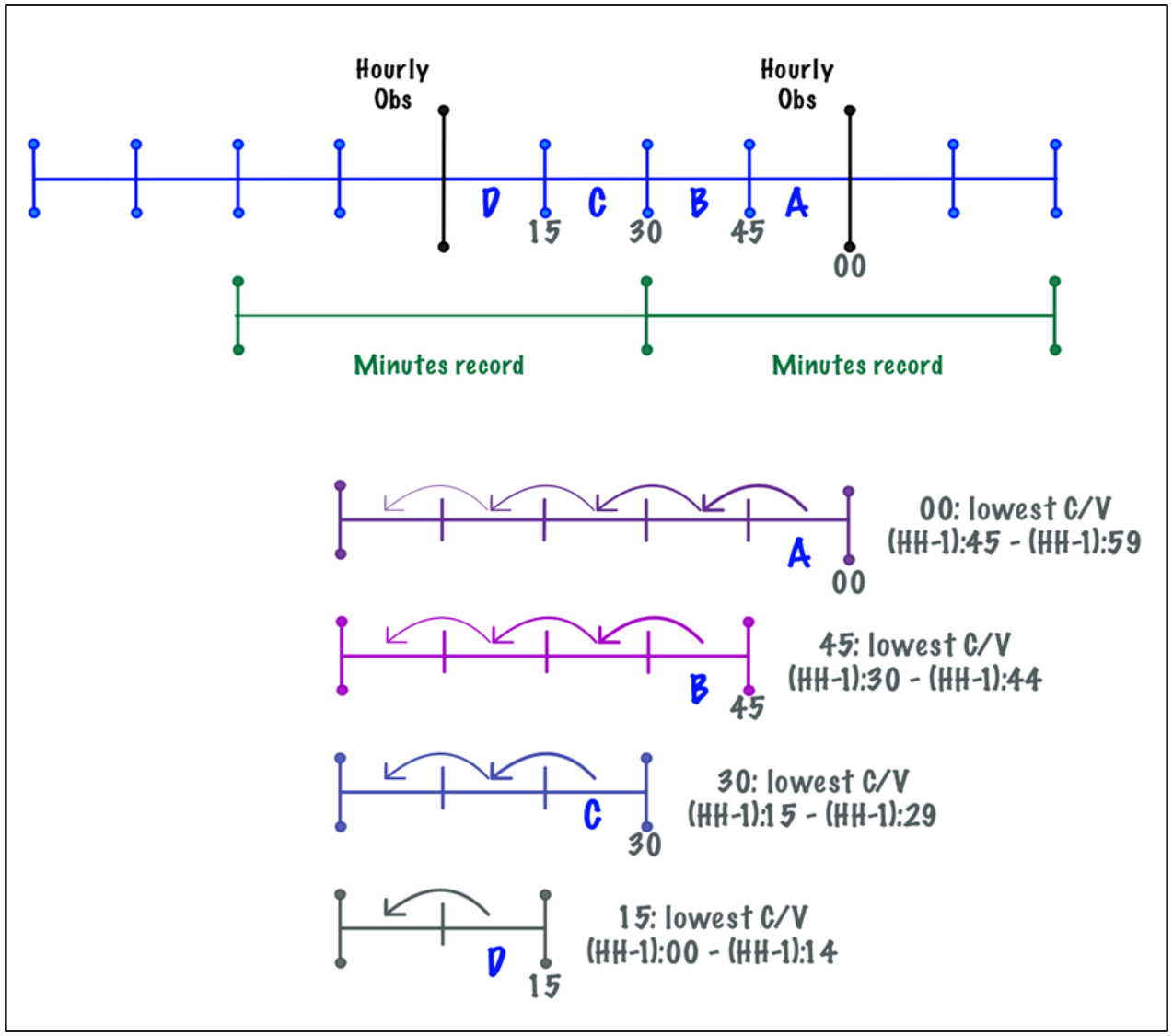
Station-based 15-min C&V

- Develop regression equations to produce LAMP station-based forecasts every 15 minutes and valid for 15-minute periods out to 6 hours for high impact ceiling height and visibility

$$Y = b + a_1x_1 + a_2x_2 + \ldots + a_nx_n$$

  - Create archive of sub-hourly observations
  - Create 15-minute advection predictors
  - Create 15-minute high impact weather predictand that captures the lowest (worst) observations over 15-minute periods instead of top of the hour observations
  - Experiment with adding new predictors to improve upon a baseline development
    - MRMS composite reflectivity, satellite data, etc.

15-minute C&V Predictand

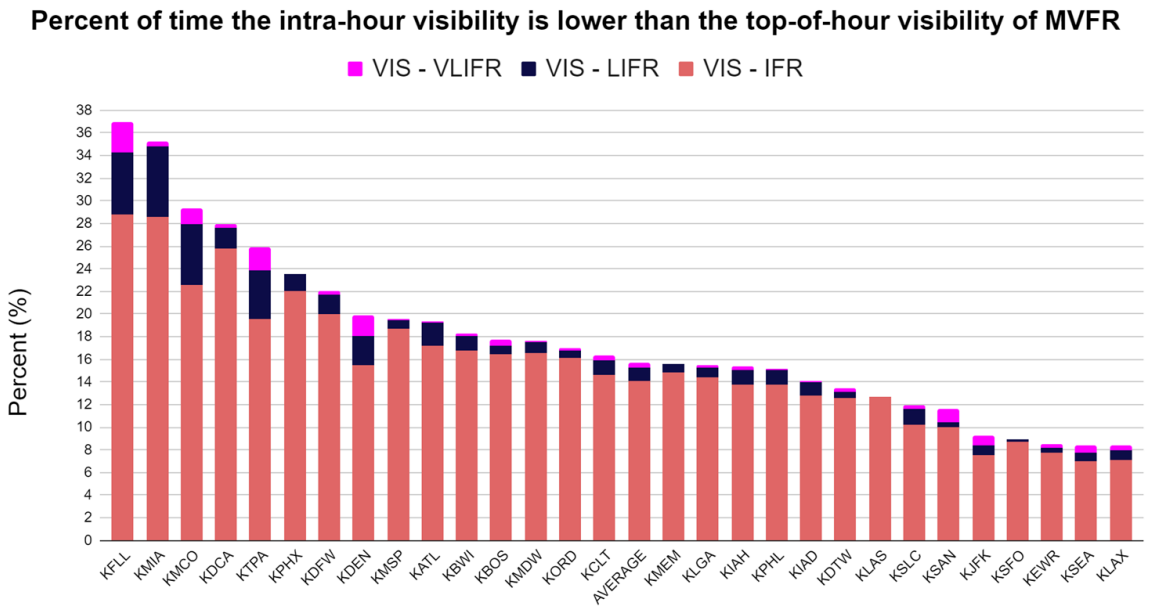


- Predictand is defined as lowest C/V observed over a 15-minute period ending at HH:14, HH:29, HH:44, and HH:59.
- Most recent observation is persisted into the period unless a new observation indicates a worse condition.
- Furthest lookback is 15-minute period prior to the previous hour.

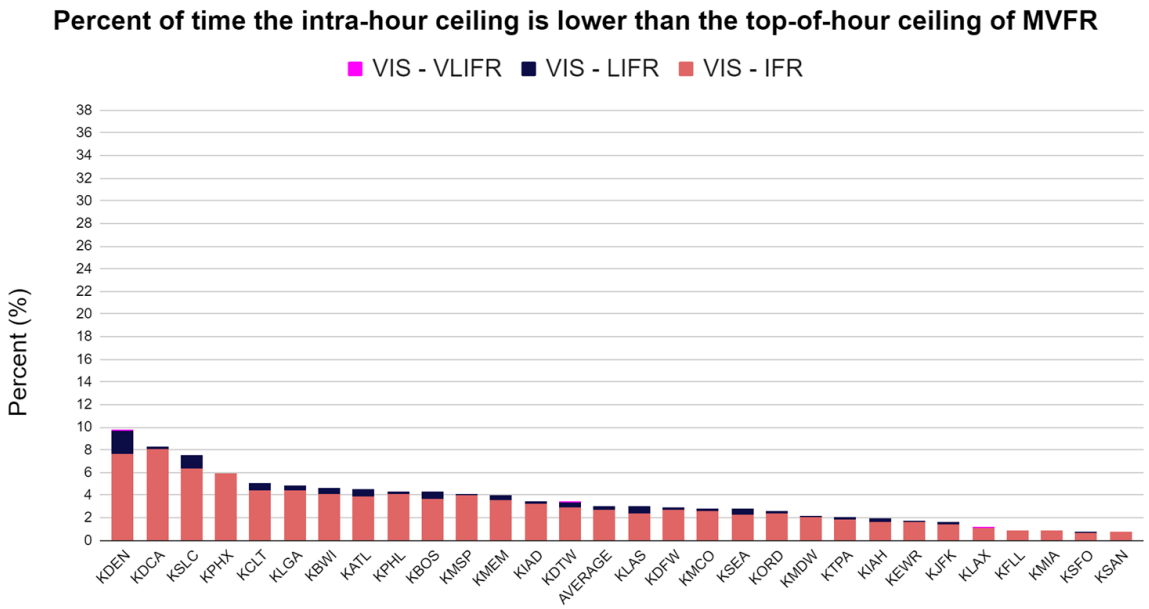
Subhourly High Impact Weather

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

Visibility



Ceiling



Intra-hour variability higher for visibility than for ceiling.

Subhourly High Impact Weather

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

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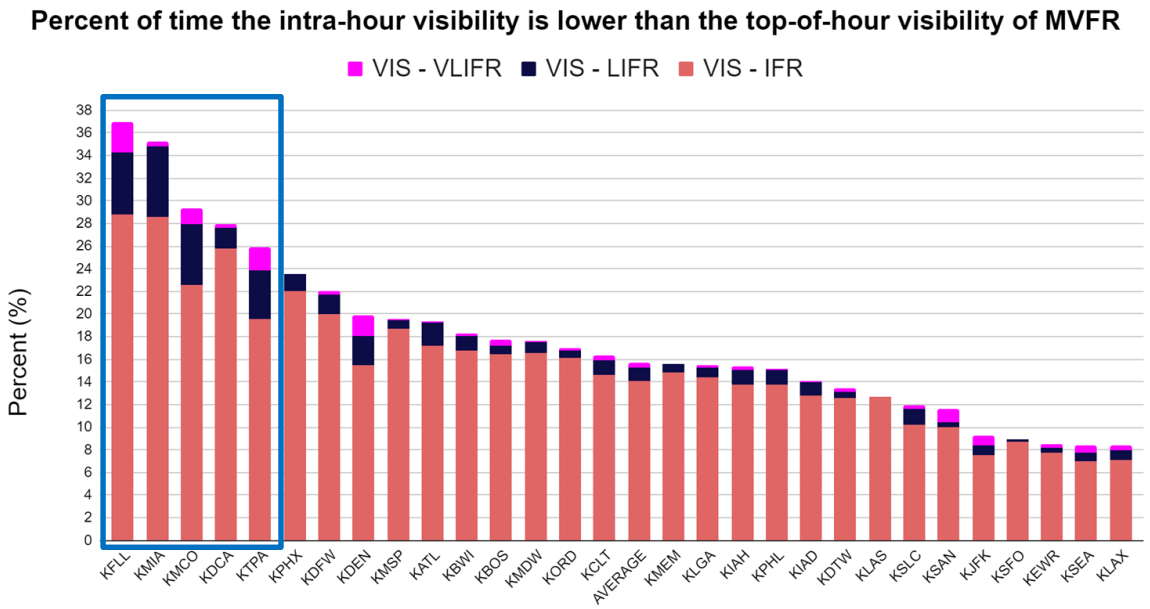
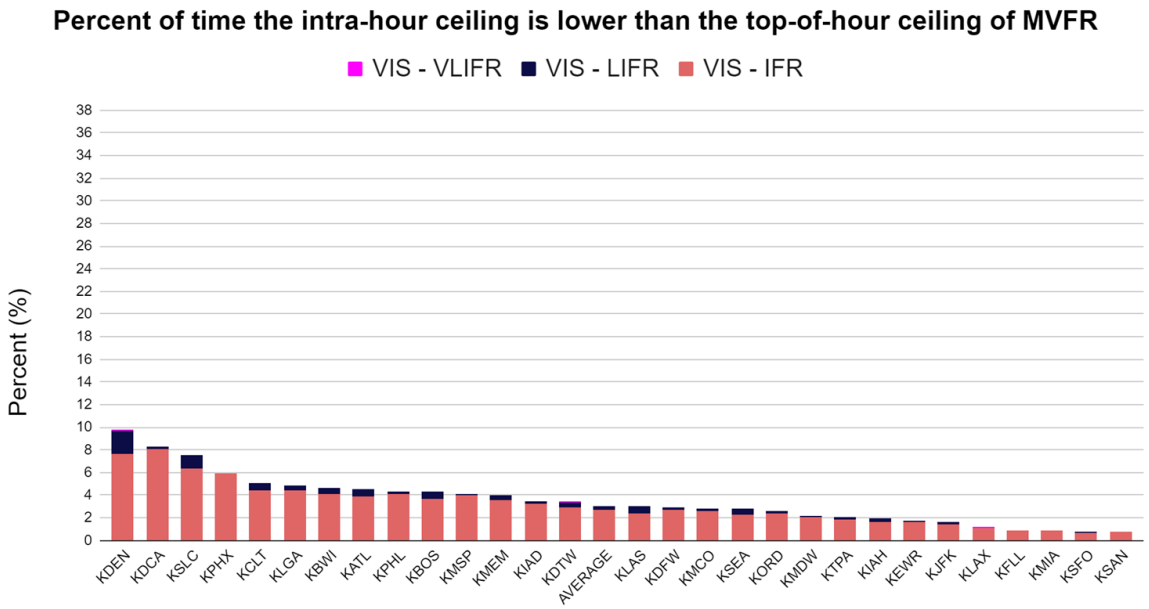


Ceiling



Intra-hour variability higher for visibility than for ceiling.

Four of top five for vis are Florida stations!

3-Step Regression Technique

1. 15-min Base LAMP = GFS MOS + 15-min Advection + Observations
2. 15-min HRRR MOS = Predictors from sub-hourly HRRR
3. 15-min Meld LAMP = 15-min Base LAMP + 15-min HRRR MOS

- Tests with different predictors:
  - Operational 1-hour Base LAMP
  - Operational 1-hour Meld LAMP
  - 15-minute advection
  - Most recent observation
  - Direct model output HRRR
  - Satellite data
  - 15-minute advected composite reflectivity

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Used 10 dbz threshold for ceiling height

Used 20 dbz and 25 dbz threshold for visibility

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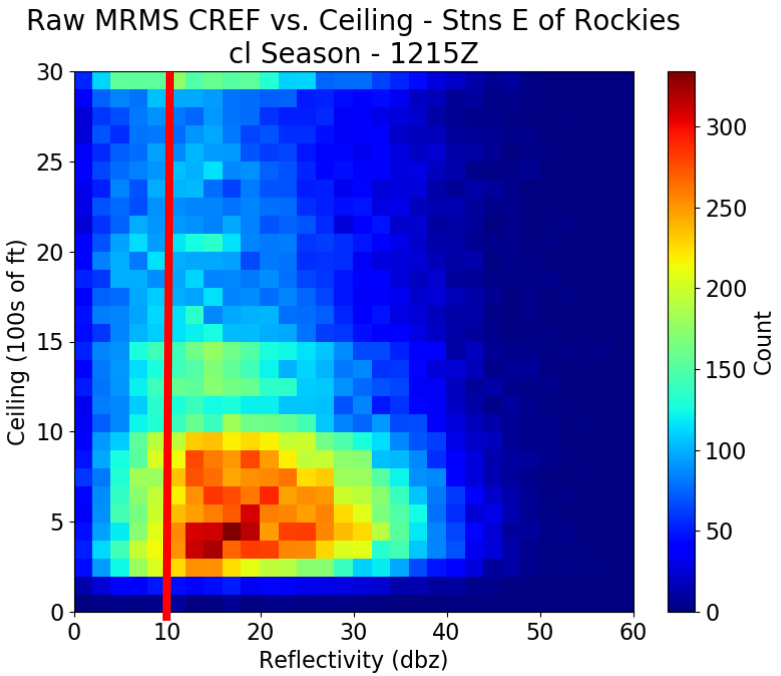
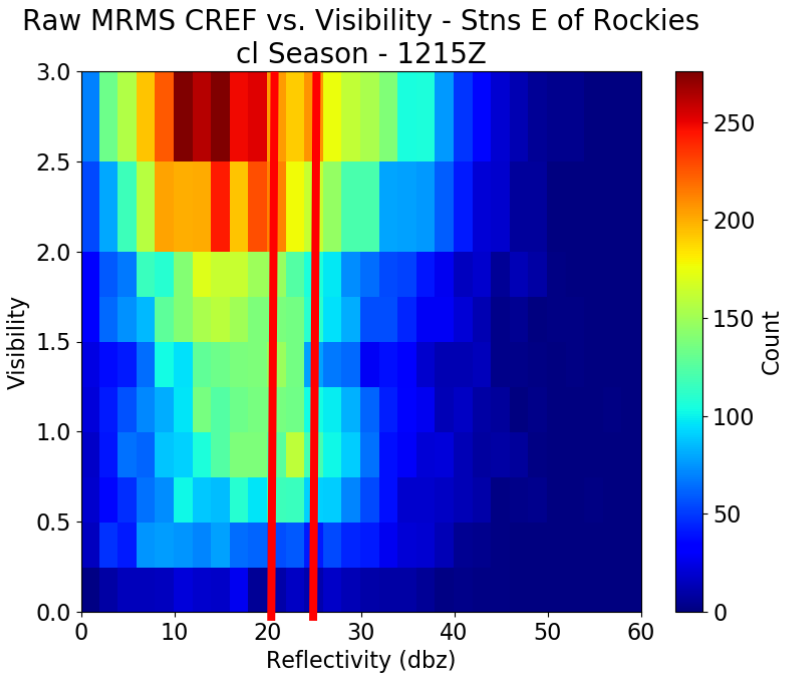
- Tests with different predictors:
  - Operational 1-hour Base LAMP
  - Operational 1-hour Meld LAMP
  - 15-minute advection
  - Most recent observation → Used in the first 3 periods only for ceiling height
  - Direct model output HRRR
  - Satellite data
  - 15-minute advected composite reflectivity → Used 10 dbz threshold for ceiling height; Used 20 dbz and 25 dbz threshold for visibility

MRMS Composite Reflectivity

- Looking at the relationship between MRMS composite reflectivity and ceiling height/visibility
  - Informs us of the thresholds to supply to the regression



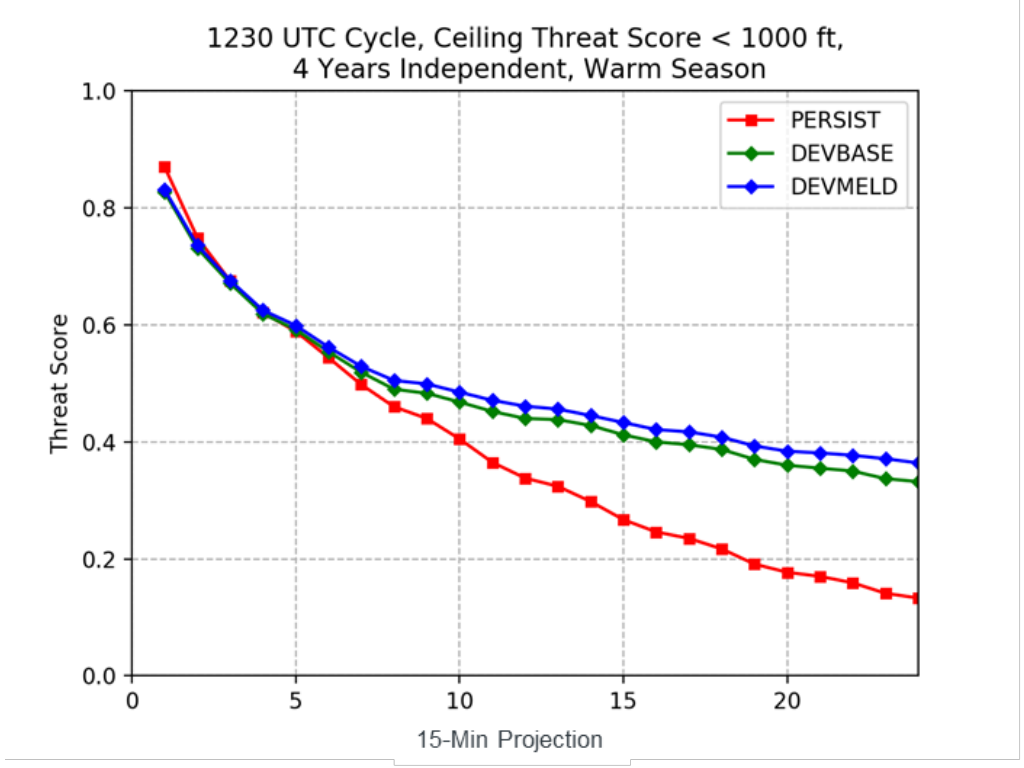


15-Min Base & Meld Verification

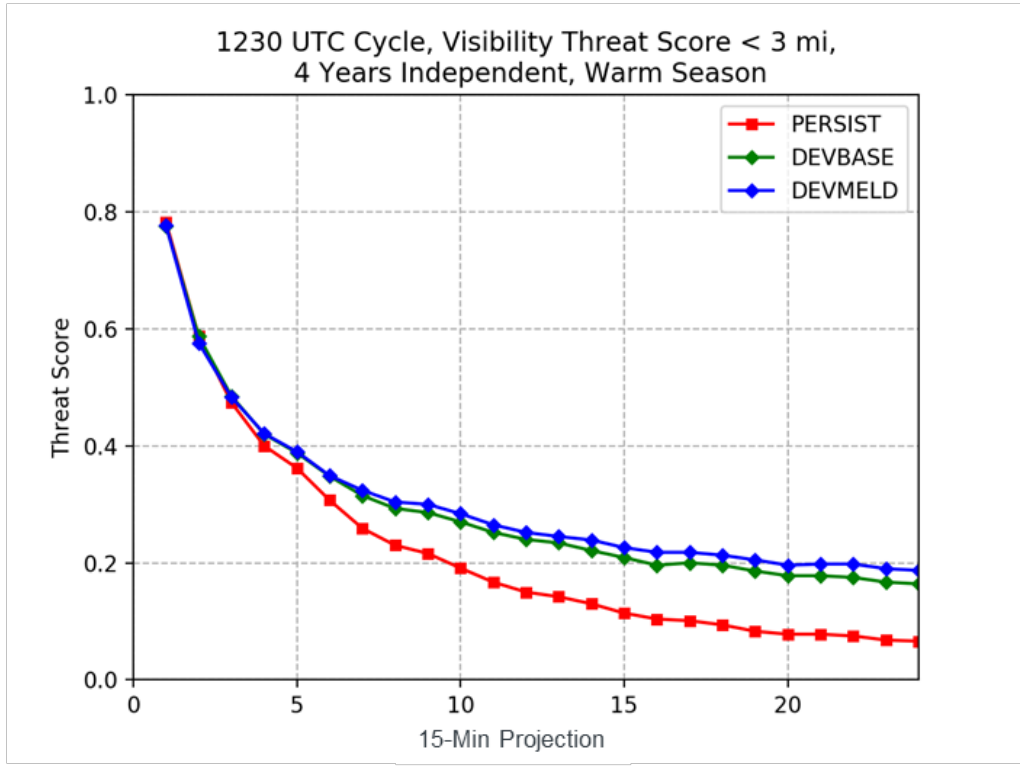
- Development period
  - 4 years of warm season data (Apr to Sep of 2017 – 2020)
  - 4 years of cool season data (Jan to Mar/Oct to Dec of 2017 – 2020)
- Independent 4-fold cross validation
  - Four developments were completed by withholding a different year from each of the development periods above
  - Much better than using single developmental and test samples
  - Results presented are for all 4 independent years combined
- 1,870 CONUS stations verified
- Only IFR thresholds shown in interest of time (results for other thresholds similar)

15-min Base & Meld Verification: Warm Season

Ceiling < 1,000 feet



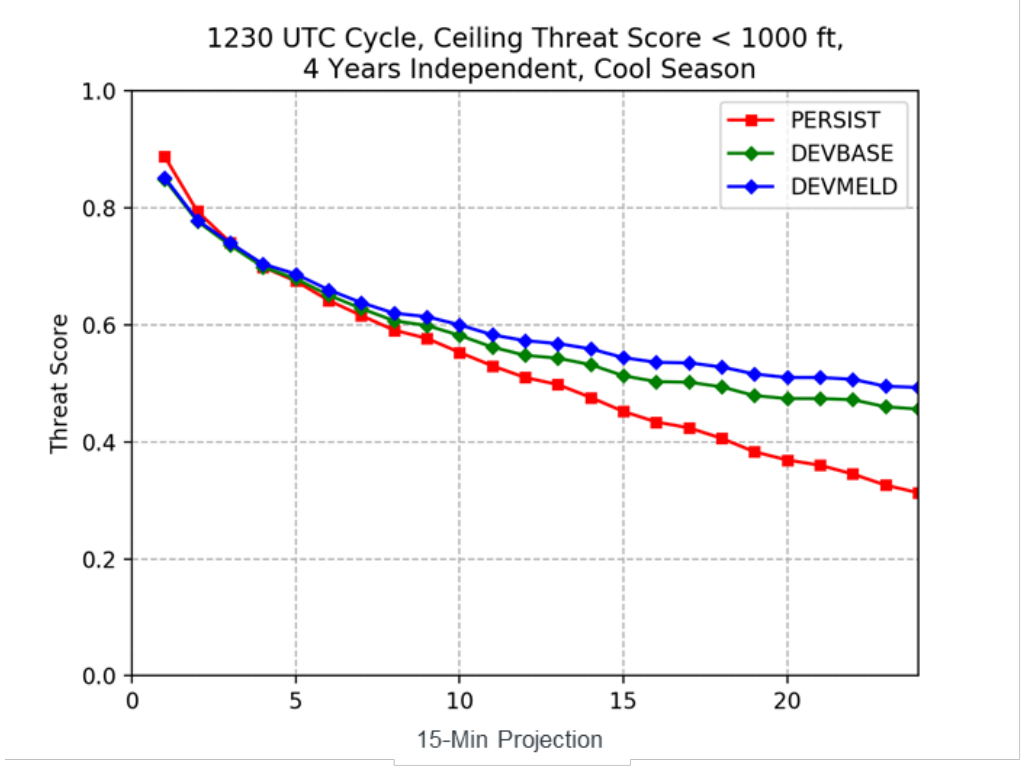
Visibility < 3 miles



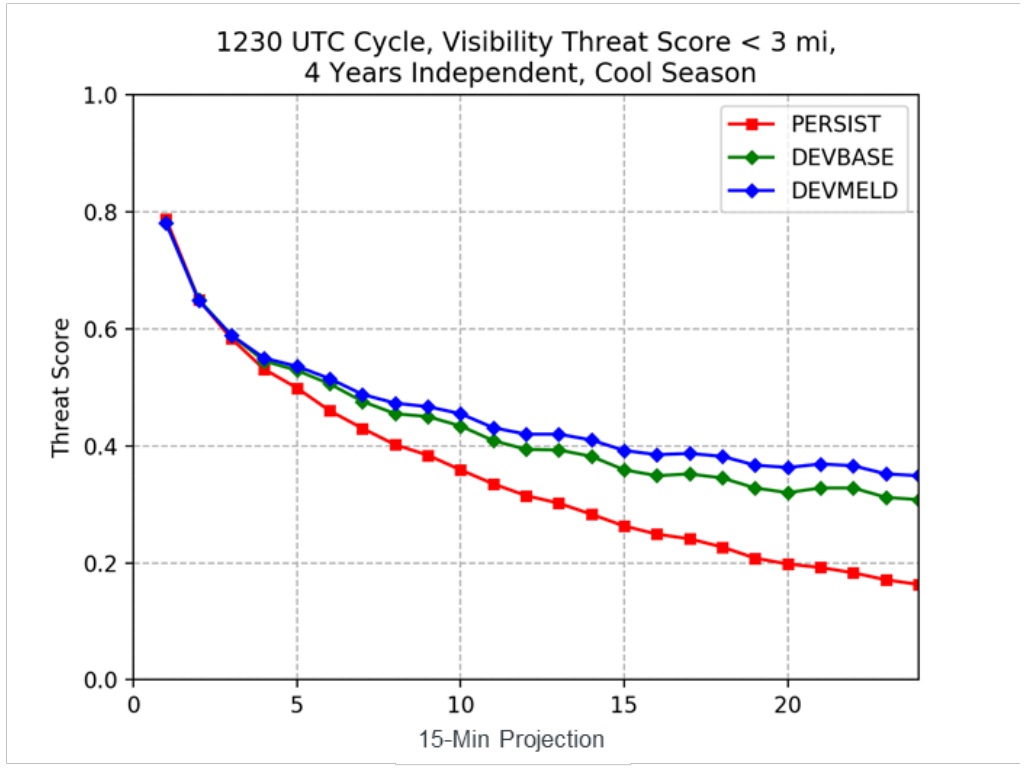
15-min Meld LAMP (blue) shows improvement over 15-min Base LAMP (green) at later projections due to the decreased predictive strength of the observation and the increasing predictive strength of the HRRR

15-min Base & Meld Verification: Cool Season

Ceiling < 1,000 feet



Visibility < 3 miles

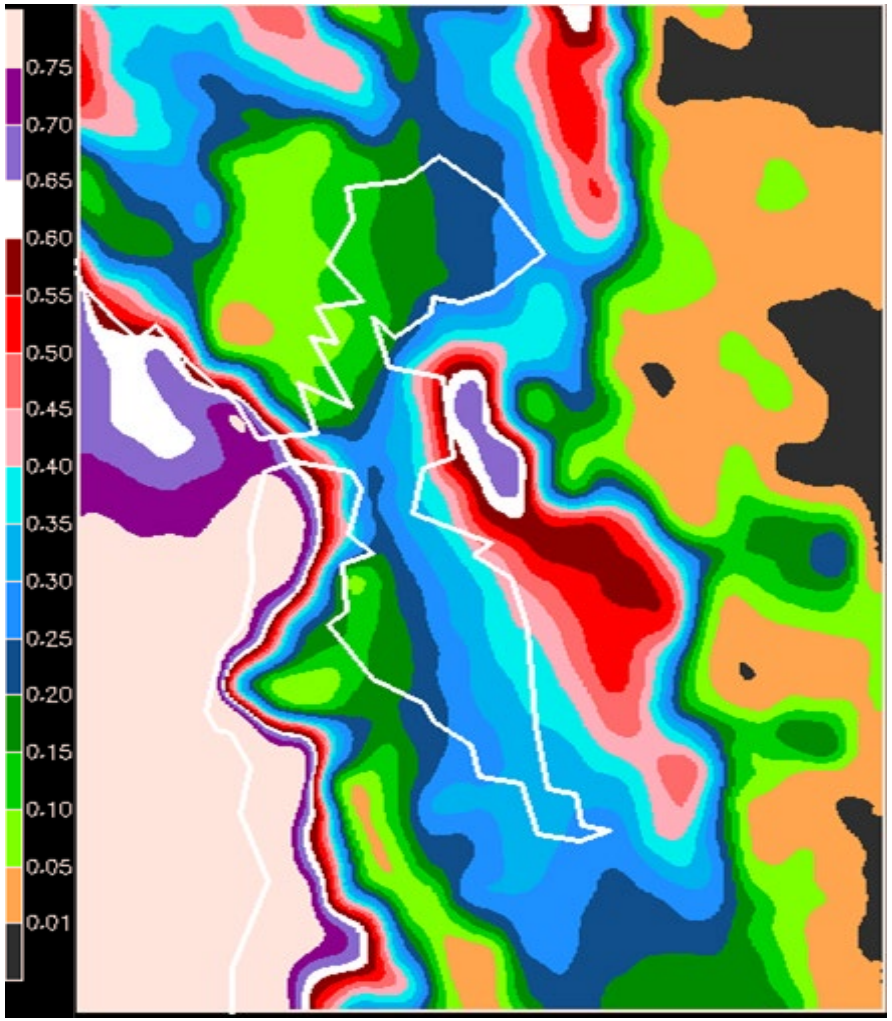


15-min Meld LAMP (blue) shows improvement over 15-min Base LAMP (green) at later projections due to the decreased predictive strength of the observation and the increasing predictive strength of the HRRR

Gridded LAMP 15-min C&V

- Work is underway to develop 15-min Gridded LAMP guidance for HIW C&V out to 6 hours.
- Station-based 15-min guidance for Base LAMP, HRRR MOS, and Meld LAMP developed previously is being updated:
  - To include more recent data
  - To include HRRR-based C&V relative frequencies as predictors (found to be useful for SFO pseudo obs work)
  - Clustering techniques are being explored for defining new regions for the station-based guidance.

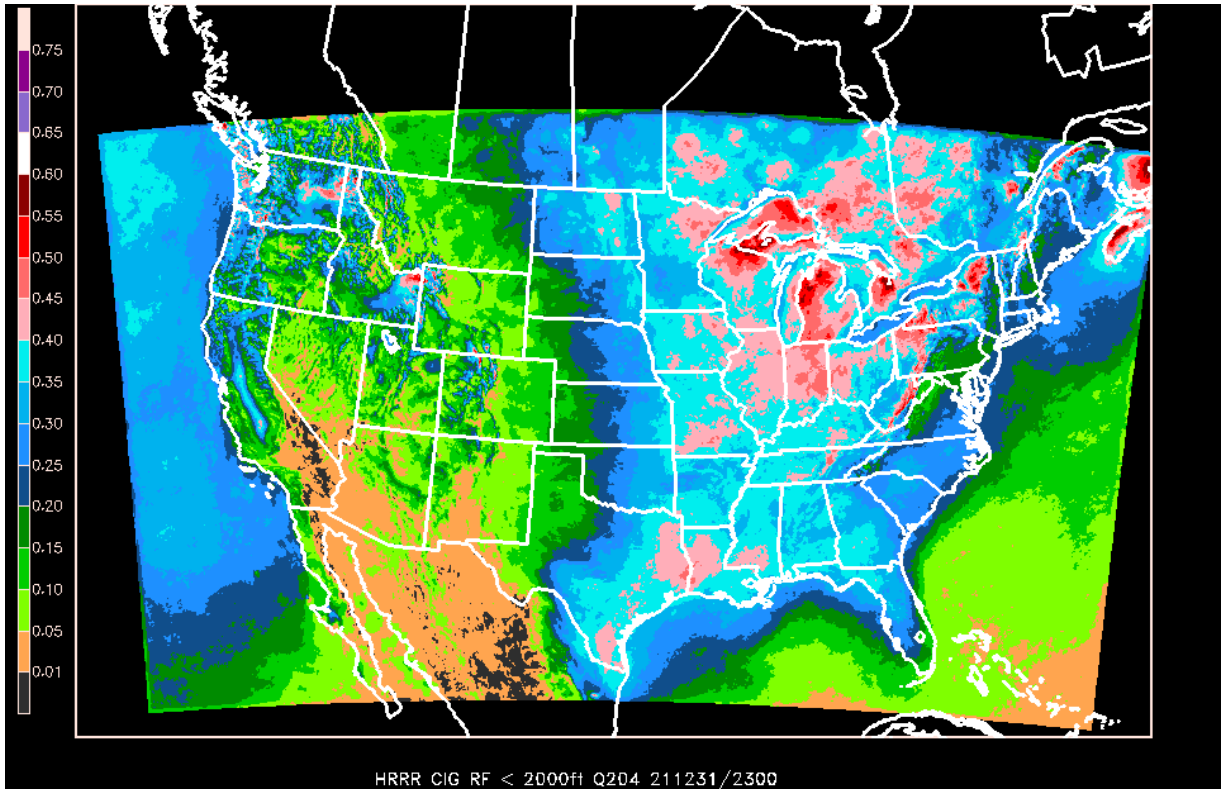
HRRR-Based Proxy Climatology



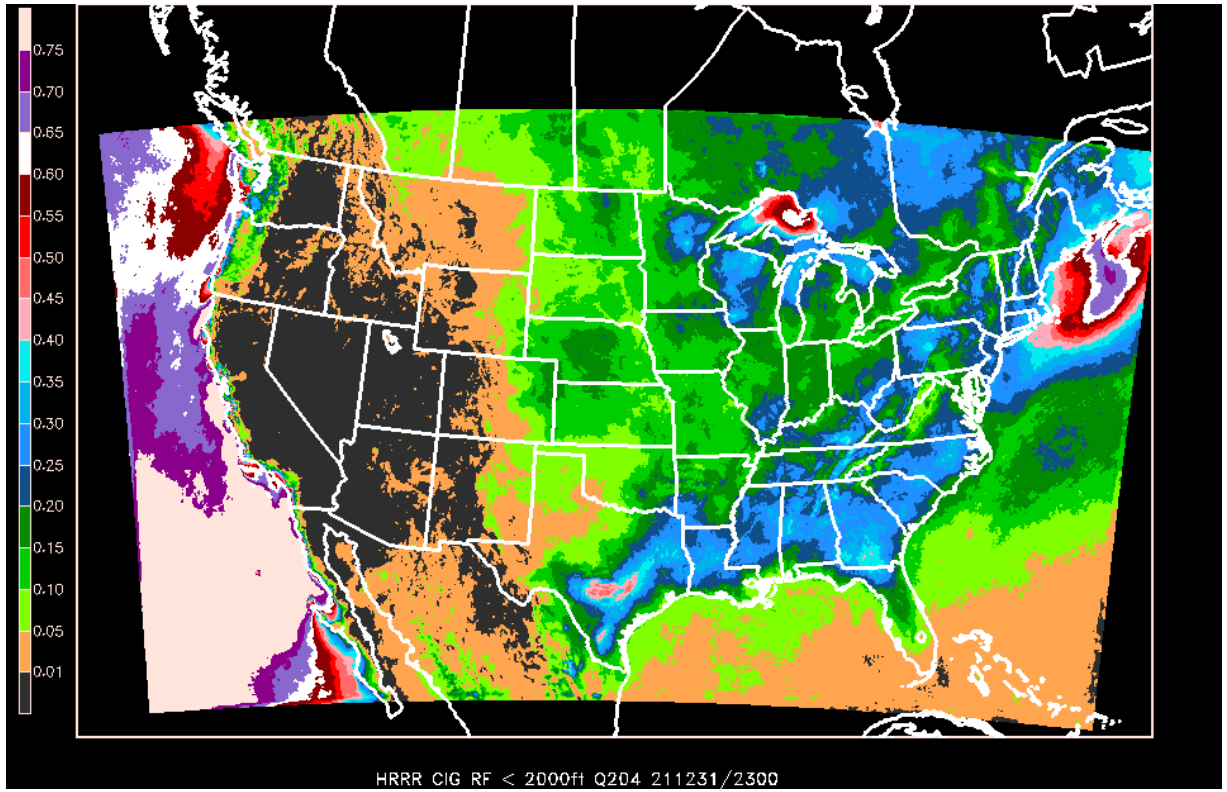
HRRR CIG RF < 1700 ft, July, 1200 UTC

- HRRR-based ceiling height relative frequencies (RFs) were calculated for all grid points over the HRRR CONUS domain for each month, time of day, and several C&V thresholds.
- Serves as proxy climatology predictor in 15-min C&V equations.
- RFs were found to be useful for SFO pseudo obs work.

HRRR-Based Proxy Climatology

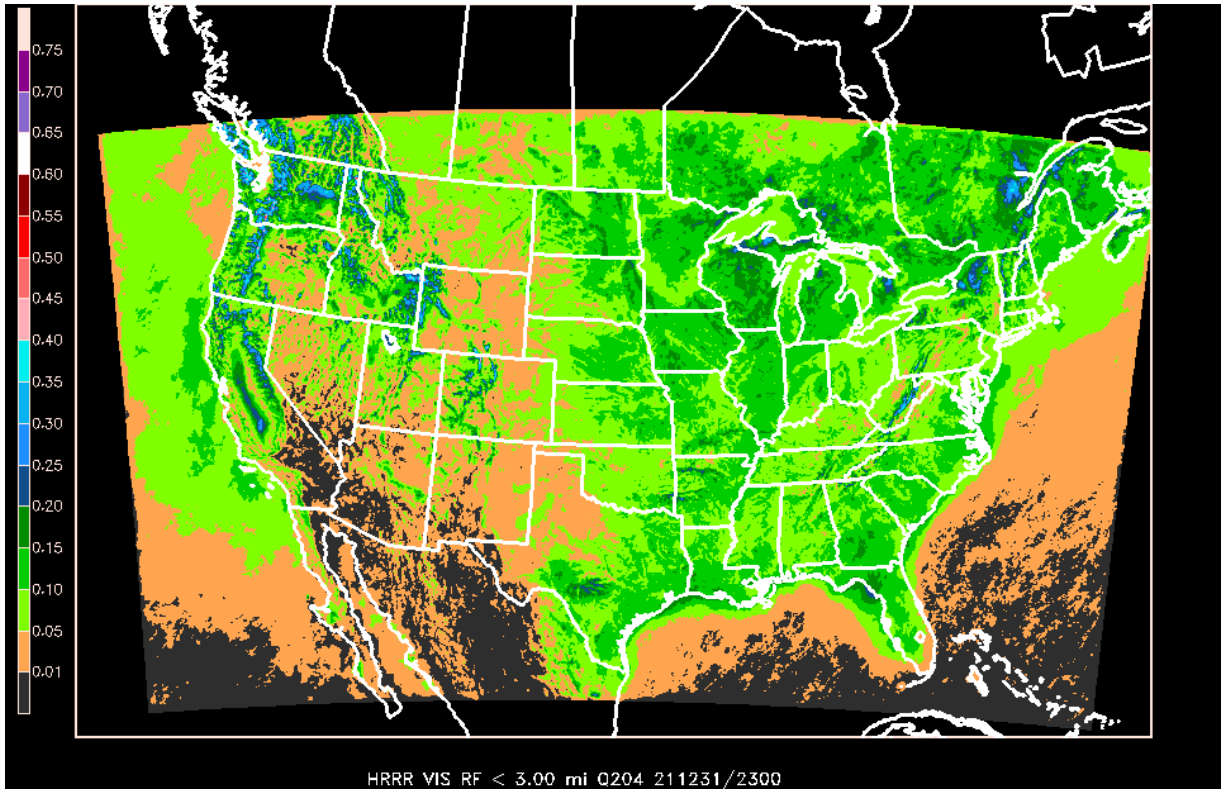


HRRR CIG RF < 2000 ft, Jan, 1200 UTC

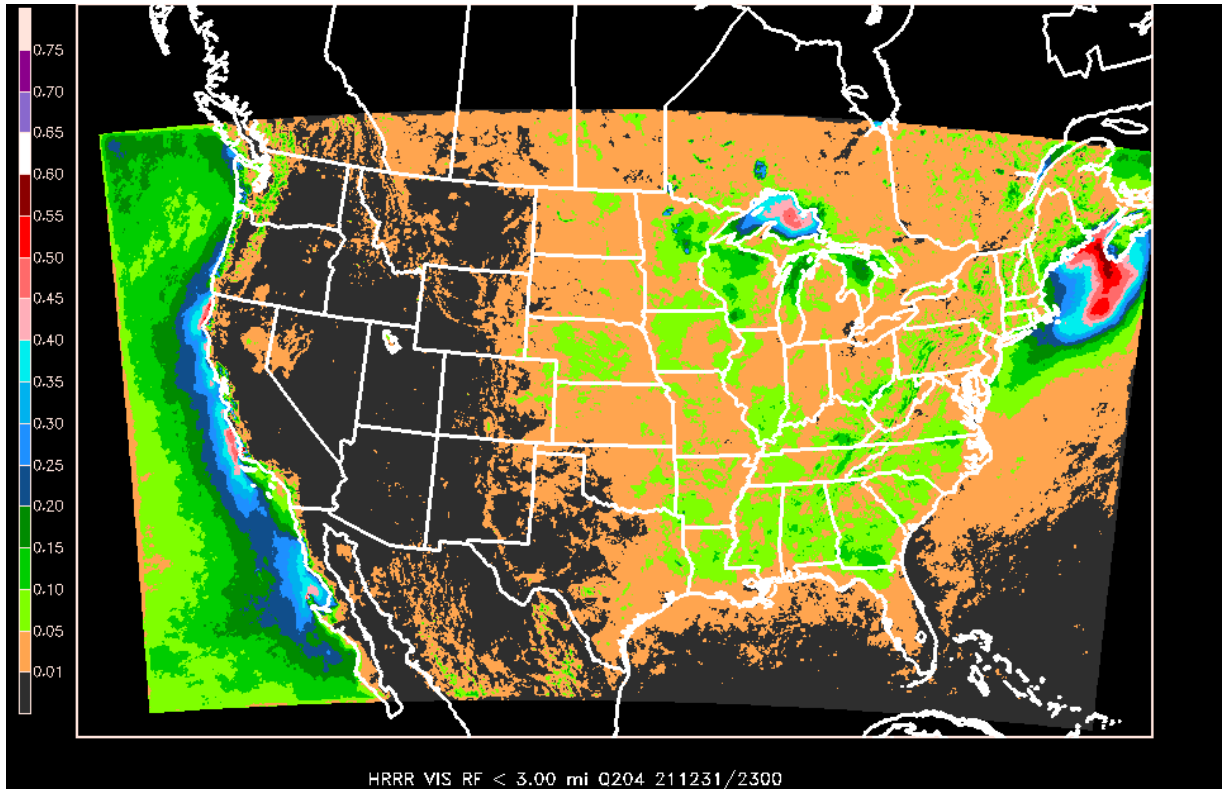


HRRR CIG RF < 2000 ft, July, 1200 UTC

HRRR-Based Proxy Climatology

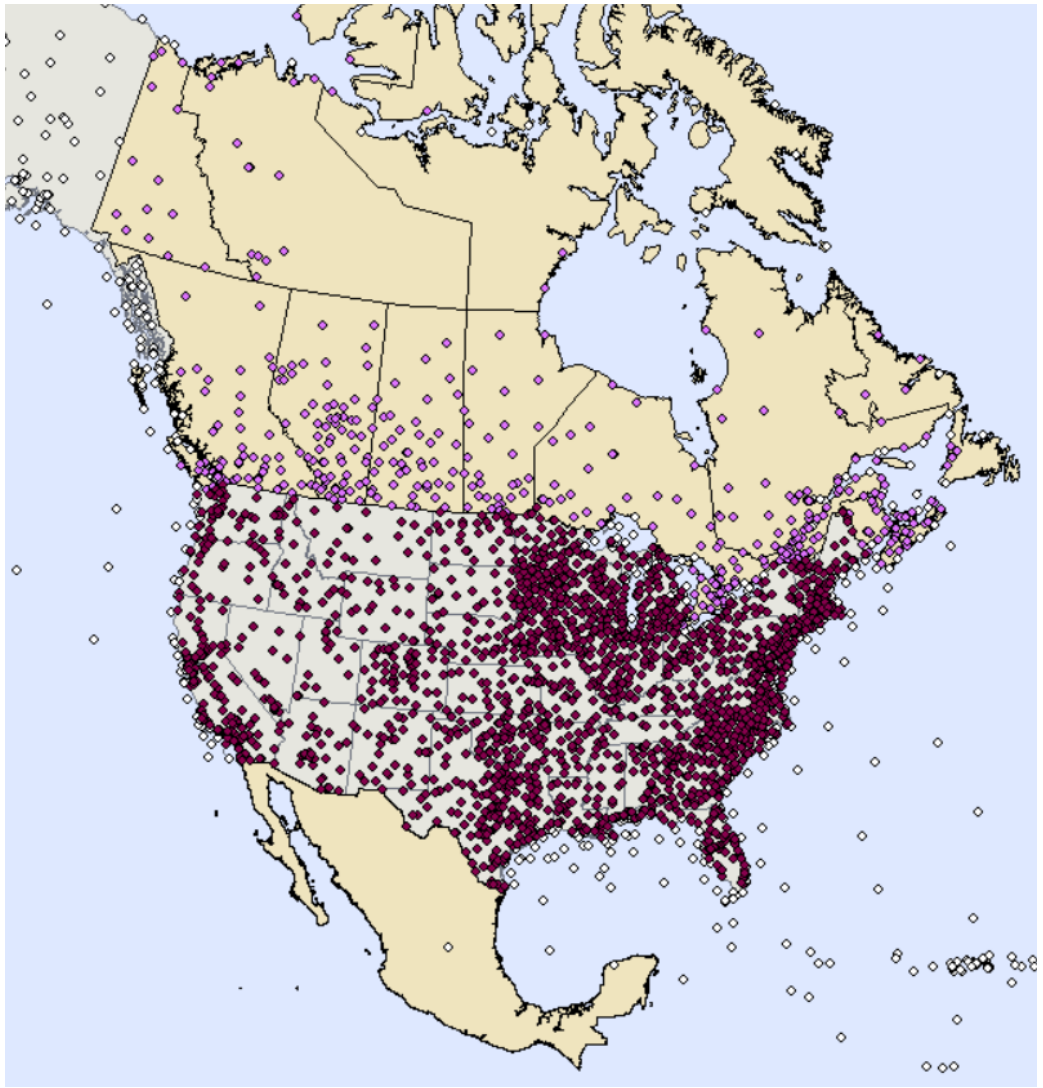


HRRR VIS RF < 3 mi, Jan, 1200 UTC



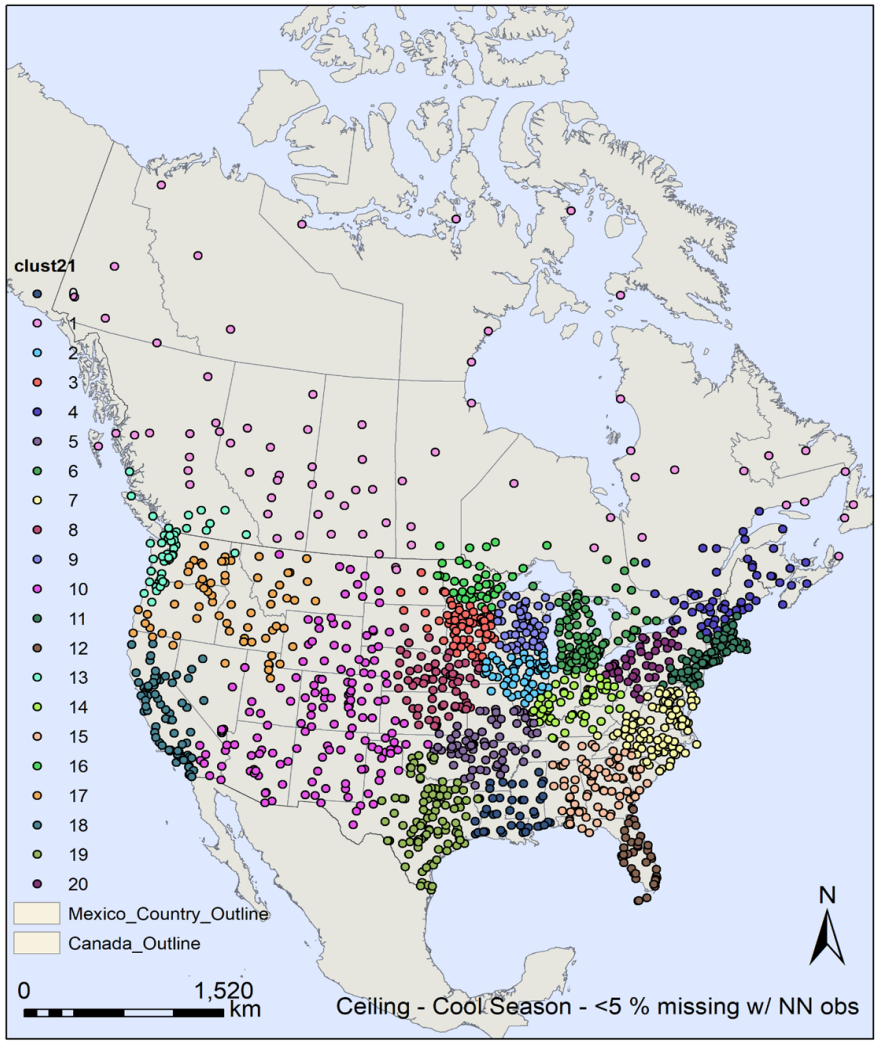
HRRR VIS RF < 3 mi, July, 1200 UTC

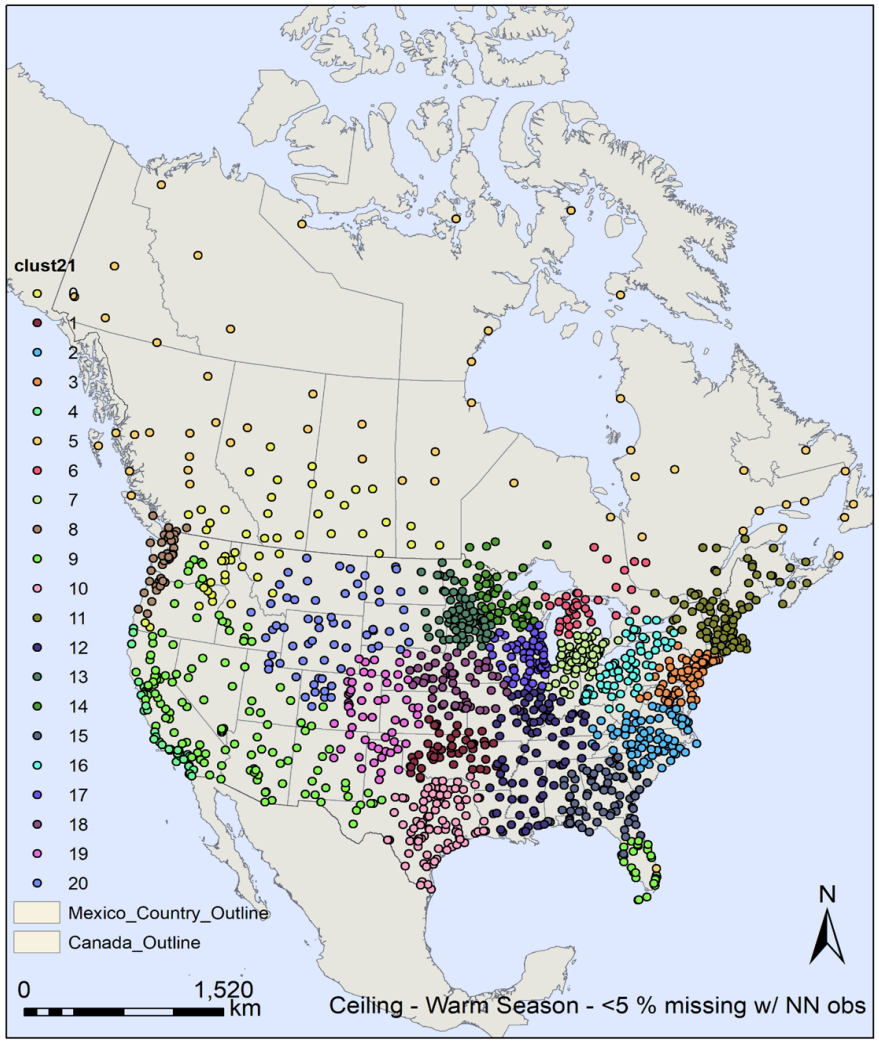
K-means Clustering



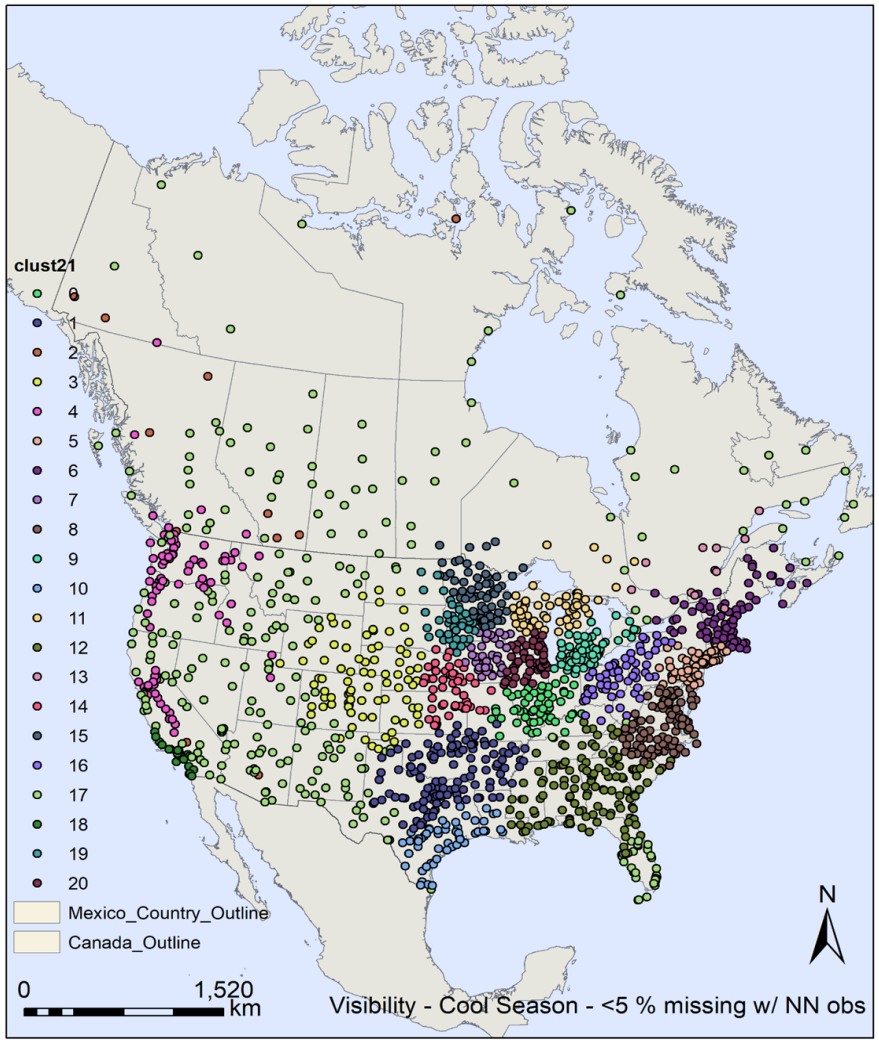
- K-means clustering is an unsupervised machine learning technique used to identify clusters of data based off certain similarities, e.g. ceiling or visibility observation characteristics.
- User must specify the number of clusters - we used 21 for testing purposes.
- K-means algorithm was applied to CONUS and Canada C&V observations (all stations in LAMP 15-min development list).

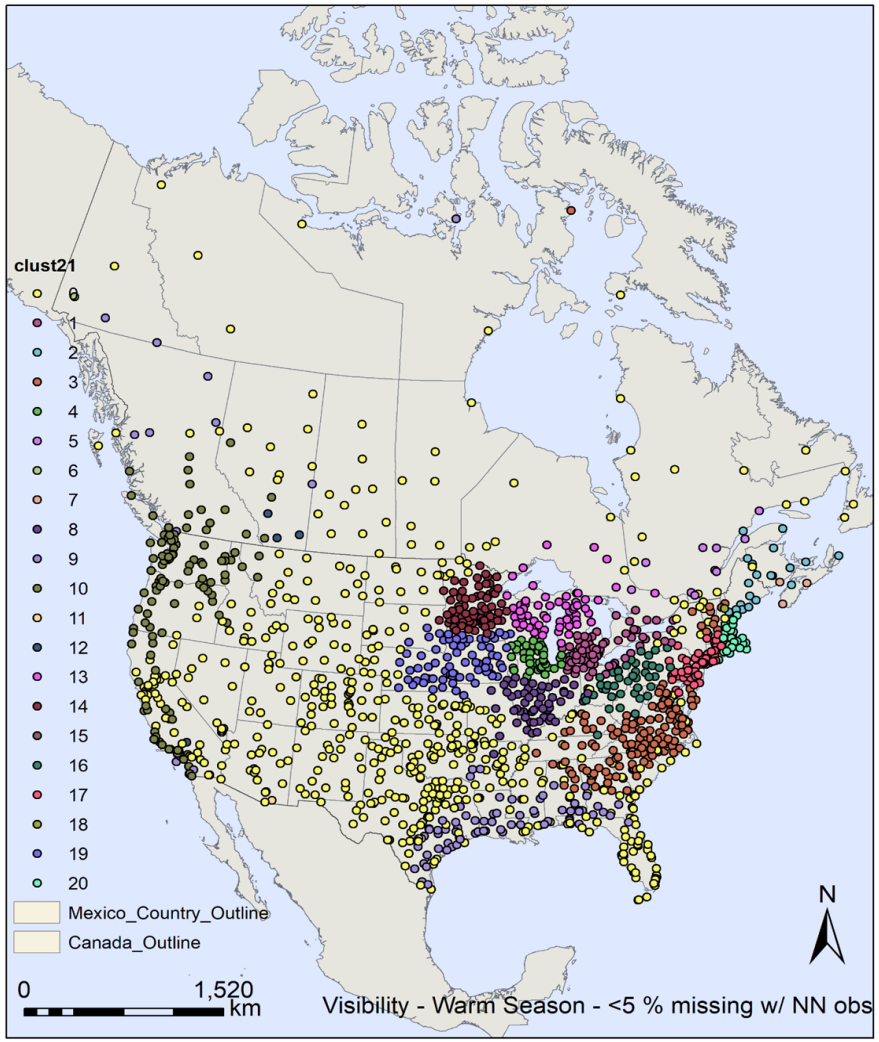
21 Clusters - Ceiling





21 Clusters - Visibility





Ongoing/Future Work

- Perform Base LAMP regionalization tests using 21 cluster-defined regions.
- Modify Gridded LAMP software settings to analyze 15-min station-based Meld LAMP guidance to the 2.5-km GLMP CONUS grid.
    - Explore adding more bogus points to improve the forecasts between the stations.
- Machine Learning / Artificial Intelligence (ML/AI) techniques will continue to be explored for improving LAMP guidance between stations.
- Station 15-min guidance will be run experimentally for onset/cessation product demonstration.

Thank you!

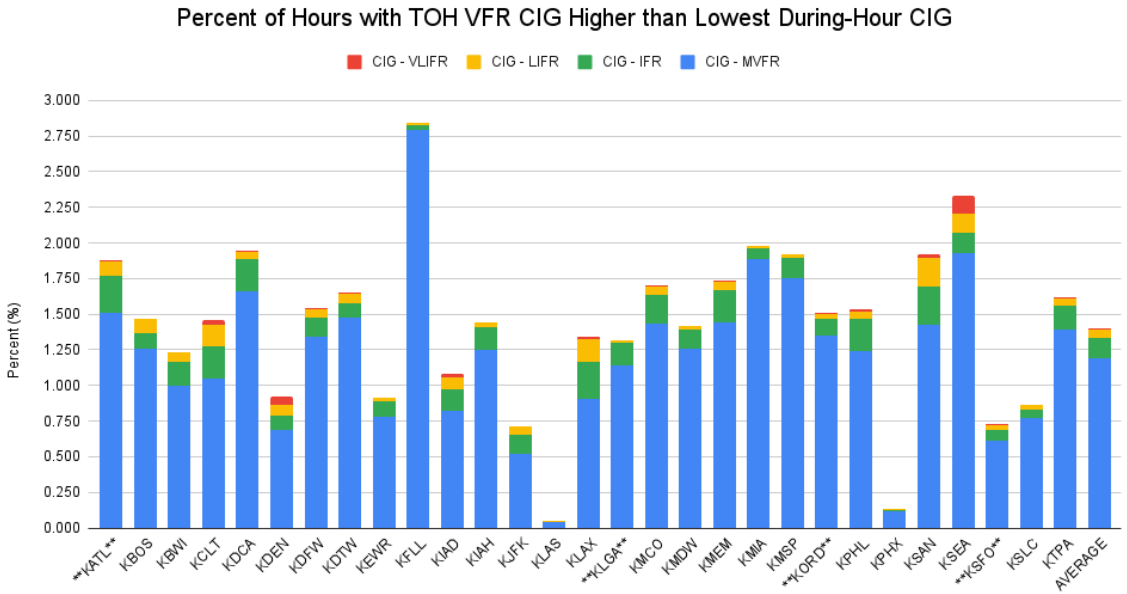
Contacts:
Phil.Shafer@noaa.gov
Judy.Ghirardelli@noaa.gov

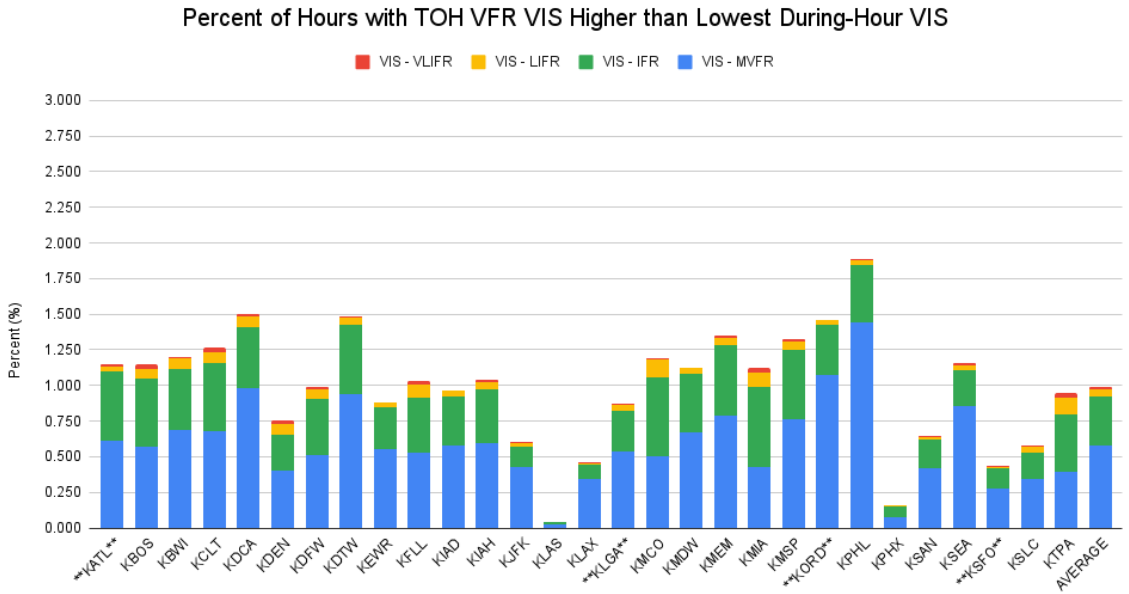
LAMP Web Page:
https://vlab.noaa.gov/web/mdl/lamp

Extra Slides

Subhourly High Impact Weather

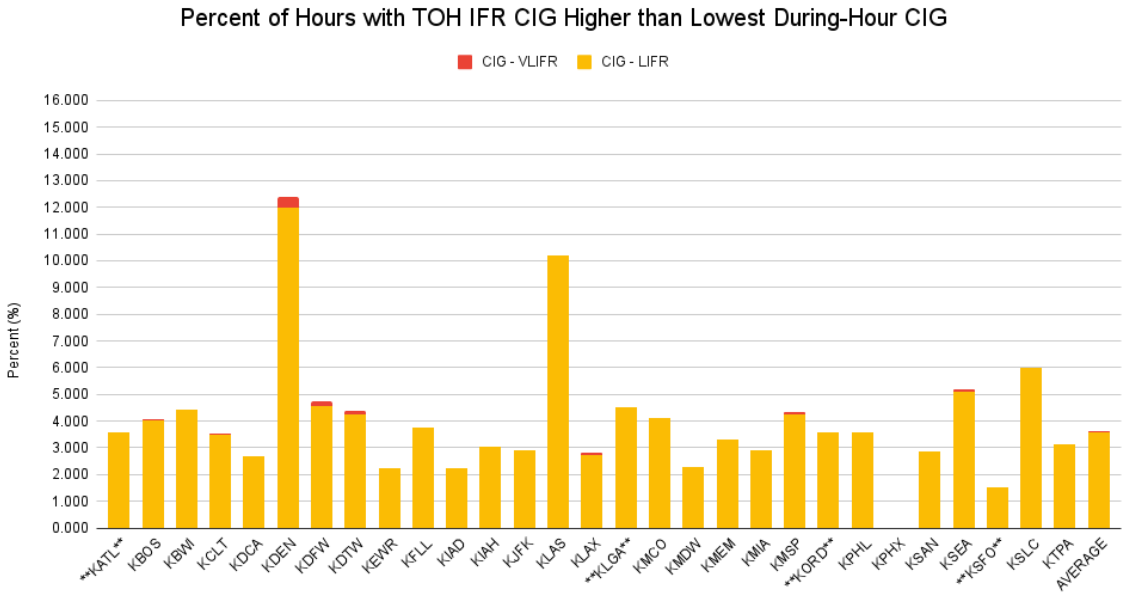
- From a 4-year observation dataset, Core 30 airports with VFR top of hour ceiling height observations missed:
  - MVFR conditions and lower on average 1.5% and up to almost 3% of the time

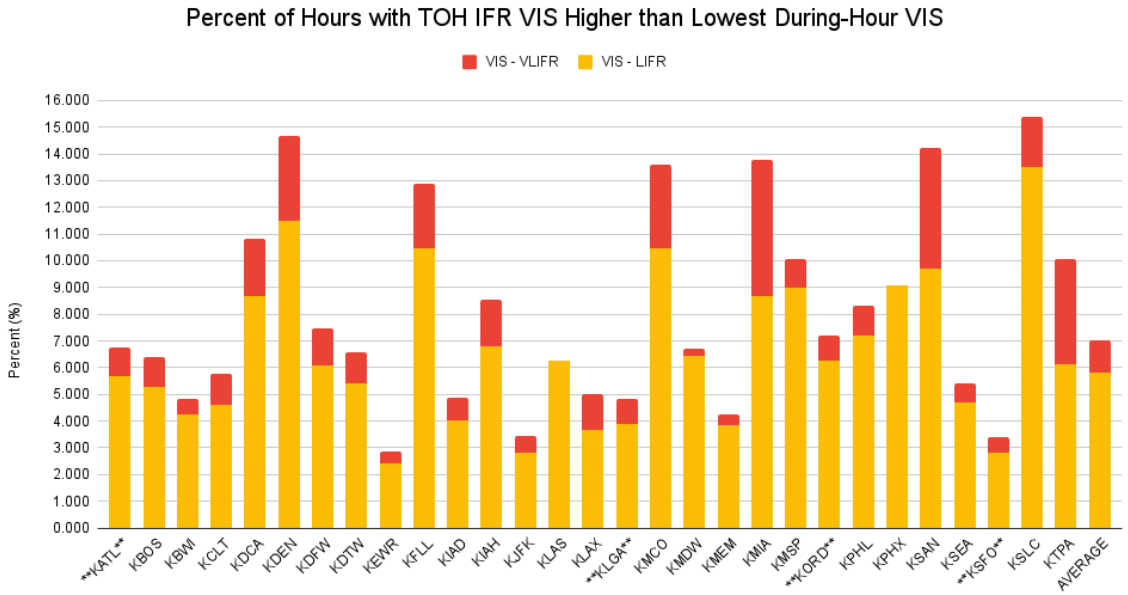




Subhourly High Impact Weather

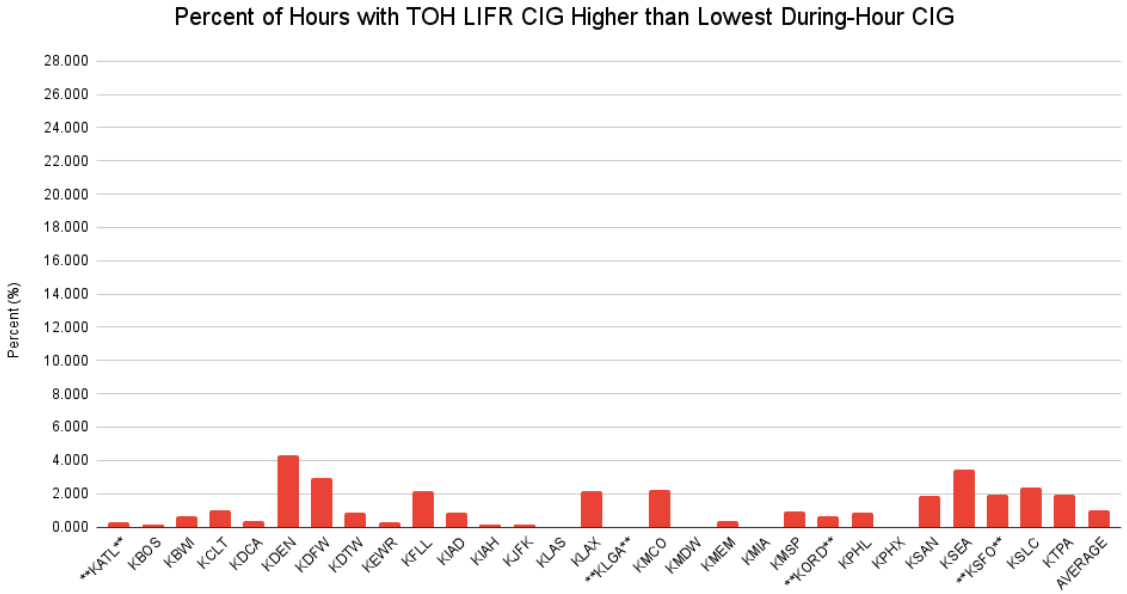
- From a 4-year observation dataset, Core 30 airports with IFR top of hour visibility observations missed:
  - LIFR conditions and lower on average 7% and up to 15% of the time

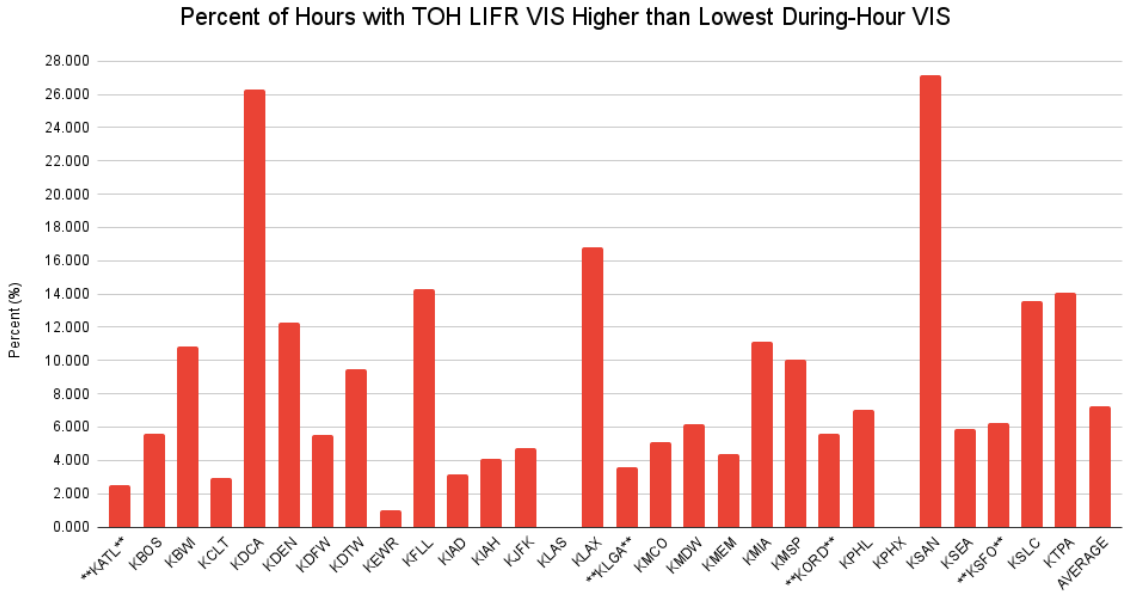




Subhourly High Impact Weather

- From a 4-year observation dataset, Core 30 airports with LIFR top of hour visibility observations missed:
  - VLIFR conditions and lower on average 7% and up to 27% of the time





Subhourly High Impact Weather

- Quantify how often the flight category of top of hour observation was higher than the lowest flight category observed during the hour
- From a 4-year observation dataset, Core 30 airports with MVFR top of hour visibility observations missed:
  - IFR conditions and lower on average 16% and up to 37% of the time