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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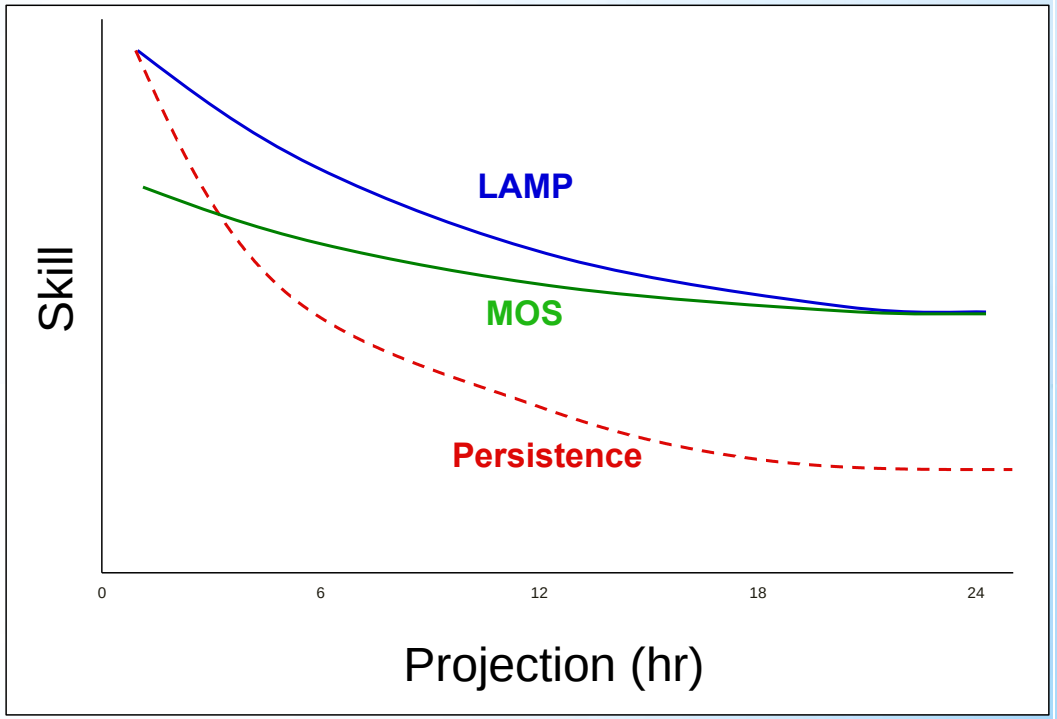
- Viewer
- Future Plans

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 per-sistence 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



LAMP Guidance Details

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

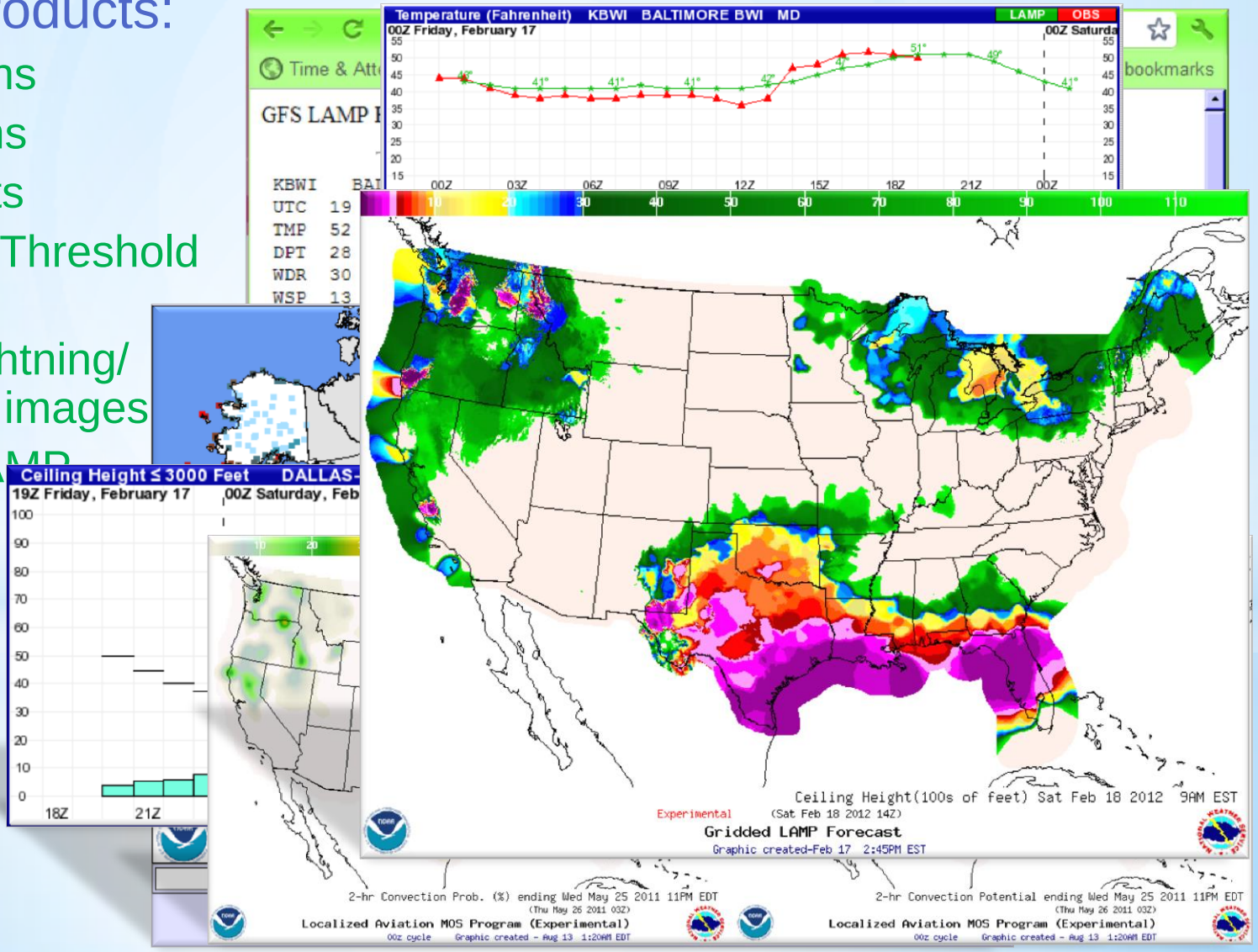
- Gridded LAMP provides grid-oriented guidance for:
  - Lightning (at least one CTG ltg strike)
  - Convection (at least one CTG ltg strike and/or Radar Reflectivity ≥ 40 dBZ)
  - Temperature
  - Dewpoint
  - Ceiling Height
  - Visibility

- 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

- 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

LAMP Current Status: Available Products

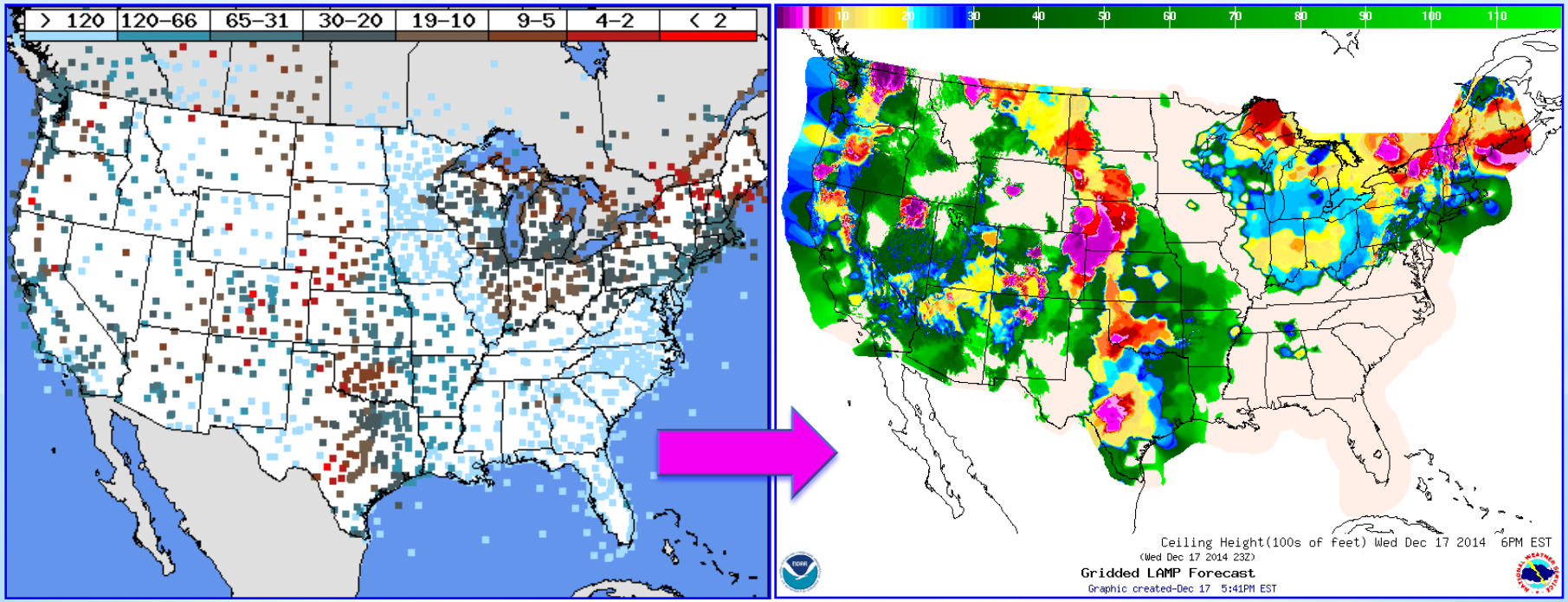
- Website products: http://weather.gov/mdl/lamp/index.shtml
- Website products:
  - Text bulletins
  - Meteograms
  - Station plots
  - Probability/Threshold images
  - Gridded lightning/ convection images
  - Gridded LAMP images



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

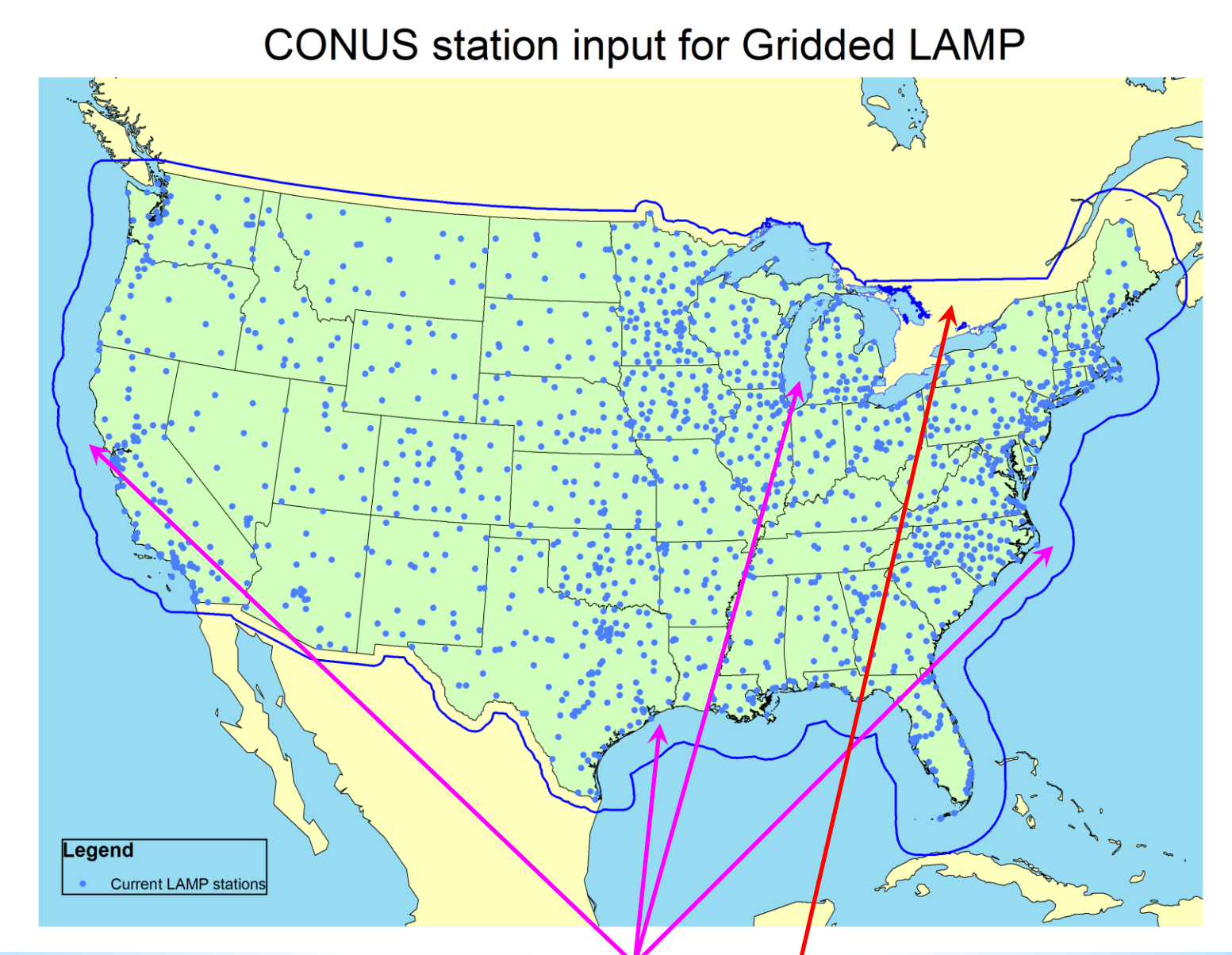
- LAMP Ceiling Height and Visibility:
  - Very few (< 3,000) METAR station observations to adequately cover the CONUS grid; no mesonet data
  - No observations of ceiling and visibility in the Atlantic or Pacific, some observations in the Gulf of Mexico → insufficient information in the water areas to 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

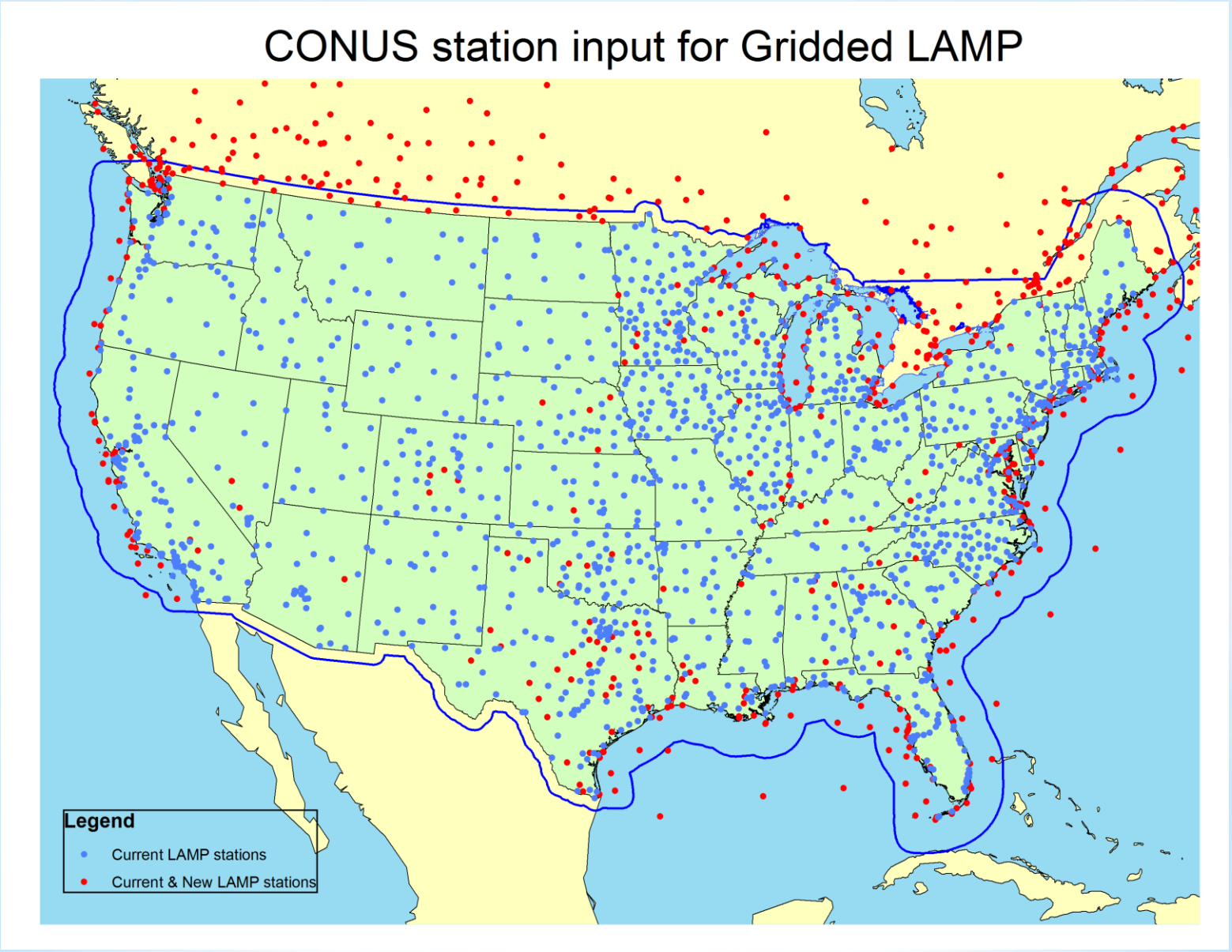
- GLMP Upgrade (v1.1.0):
  - Scheduled for 30-day parallel test in August 2015
  - Scheduled for implementation on September 15, 2015
  - Temperature and dewpoint:
    - Augmenting with additional MOS input points and observational data to provide improved, spatially detailed forecast grids. Will improve 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

Improving Gridded LAMP Ceiling and Visibility Forecasts



No input data (LAMP forecasts) in water or Canada

Improving Gridded LAMP Ceiling and Visibility Forecasts



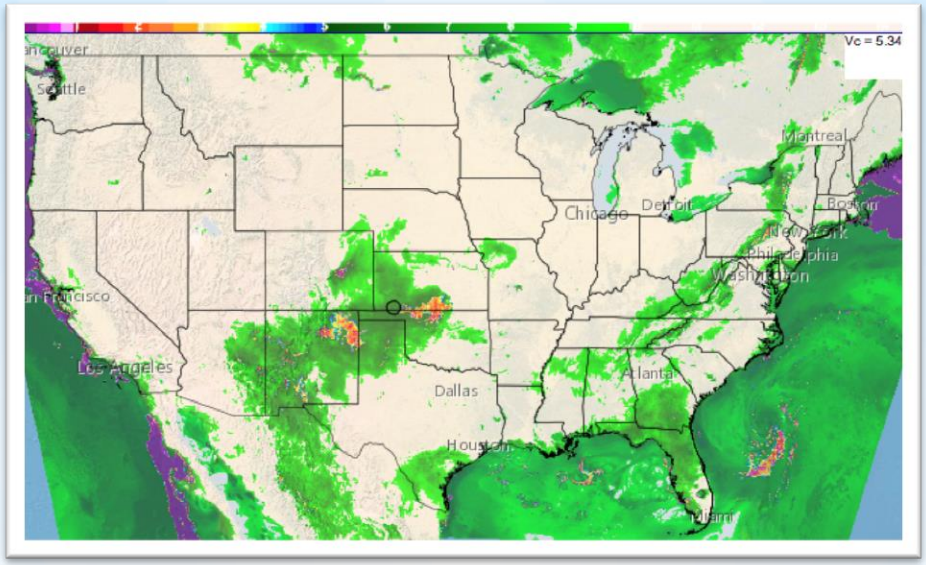
Additional input data (LAMP forecasts) in CONUS, marine areas, Canada (red dots)

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

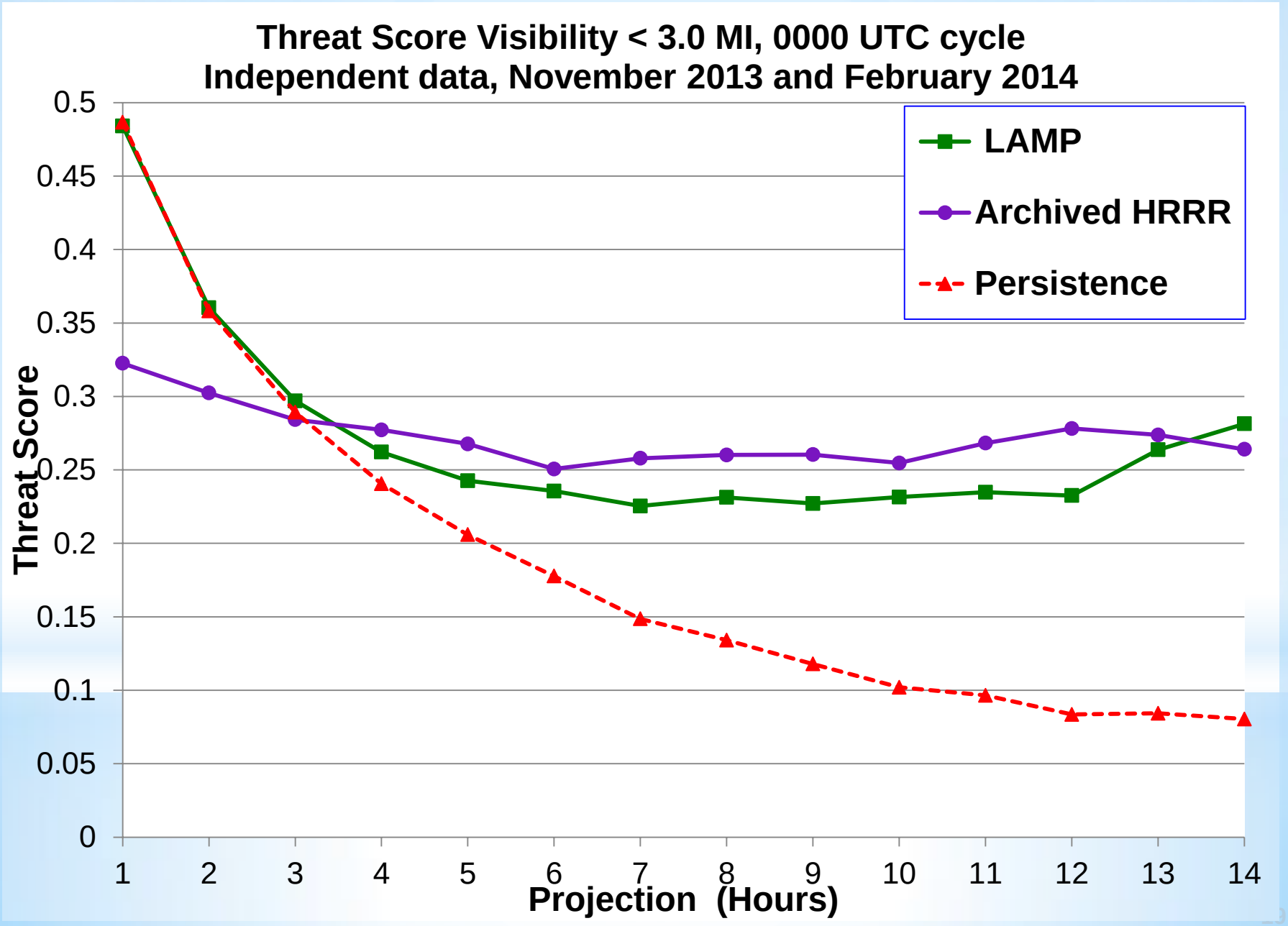
Improving LAMP CIG & VIS: HRRR Verification

- Initial Verification:
  - Verified at:
    - 1562 CONUS LAMP stations; 314 CONUS non-LAMP stations
    - Warm season (April – Sept. 2013) and cool season (Oct. 2013–Mar. 2014).
    - 0000 UTC LAMP vs 2300 UTC HRRR;
    - 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

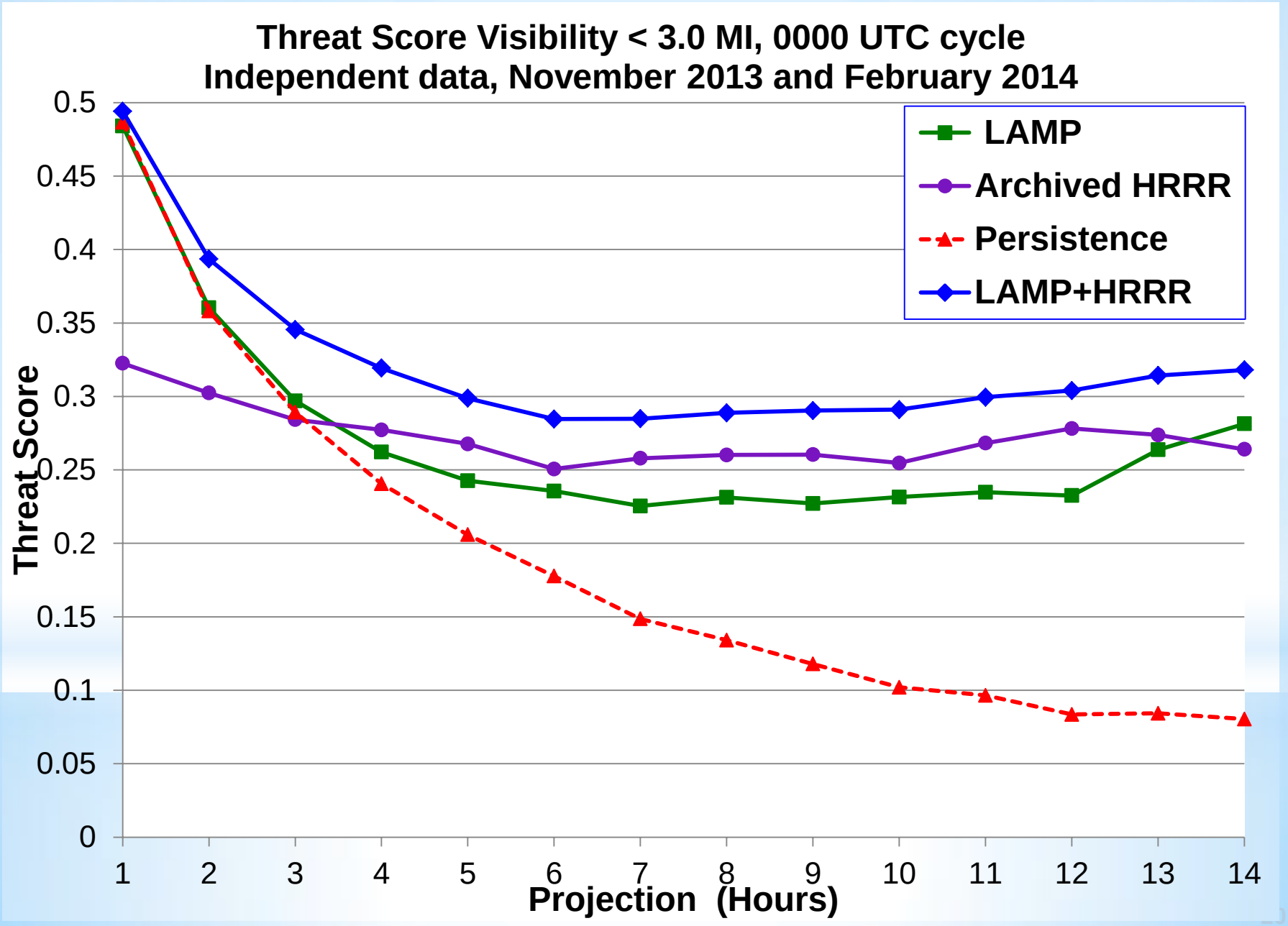
Improving LAMP CIG & VIS: Regression Equation Development – Cool Season

- 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
    - 4 months for dependent data
    - 2 months for independent data
  - Generalized Operator Approach → many cases
  - Equations developed for 0000 UTC:
    - LAMP+HRRR Regression:
      - Using 0000 UTC LAMP Cumulative Probabilities + 2300 UTC HRRR Cumulative Binaries only

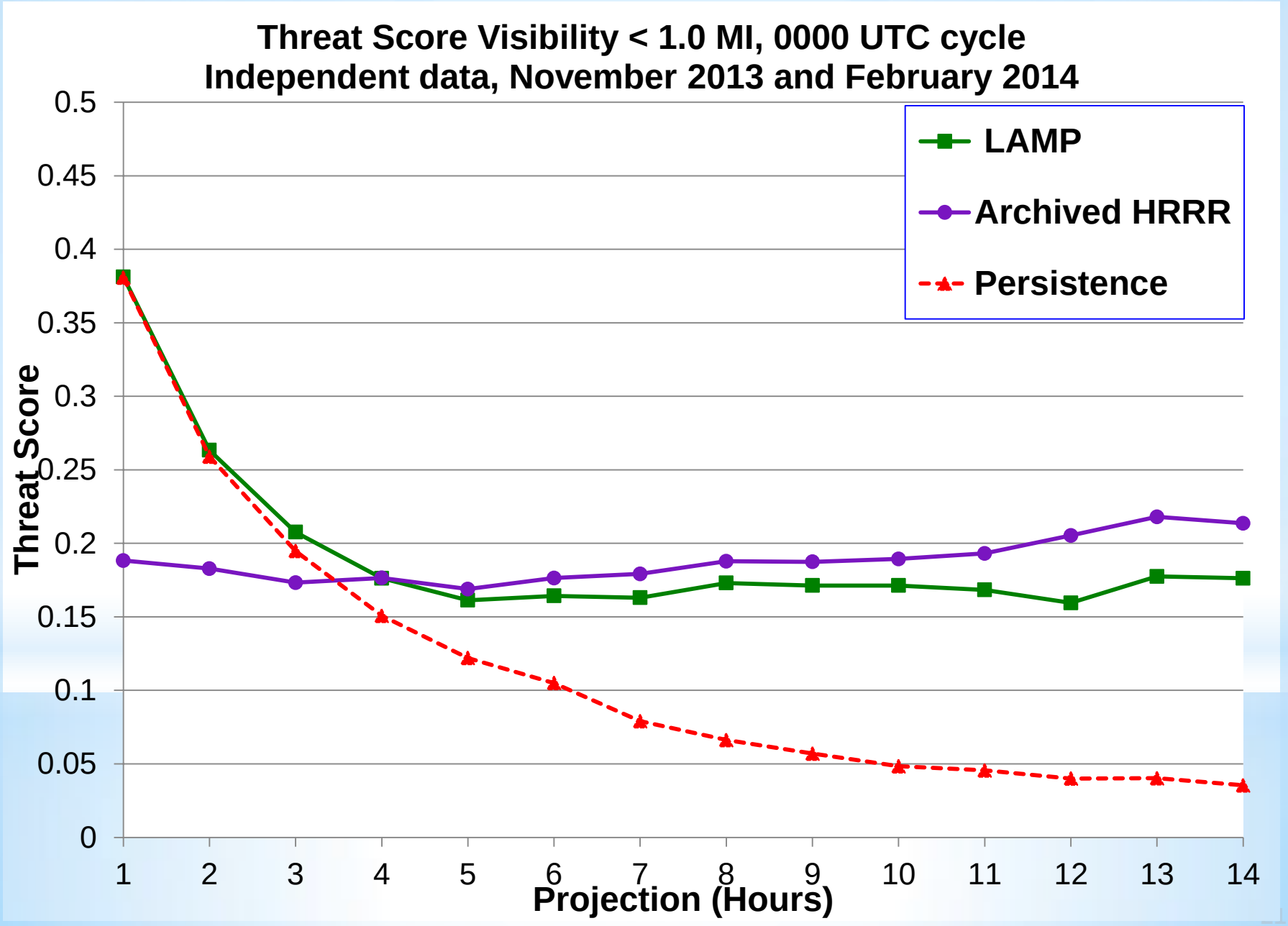
LAMP+HRRR Cool VIS: Preliminary Results



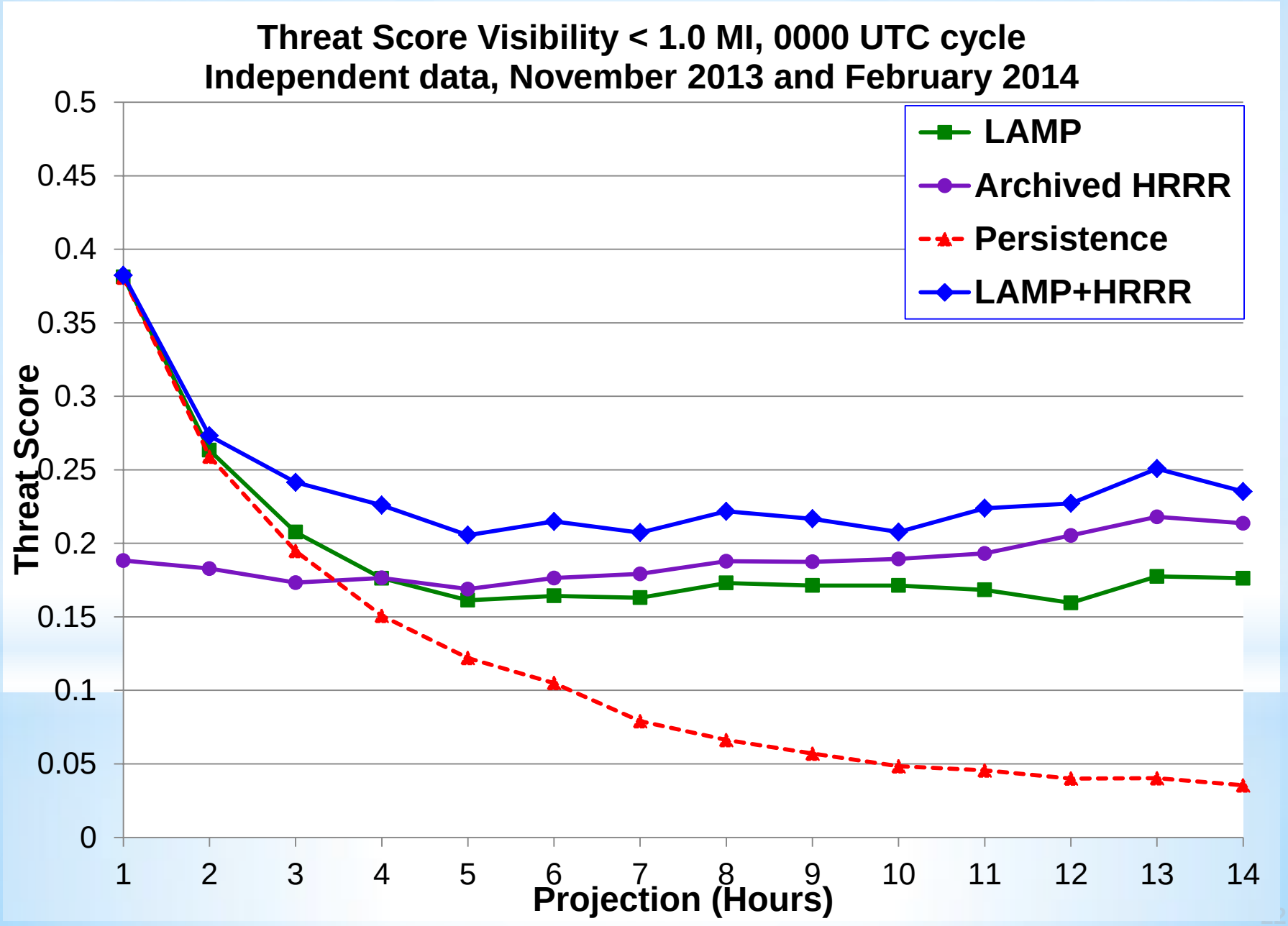
LAMP+HRRR Cool VIS: Preliminary Results



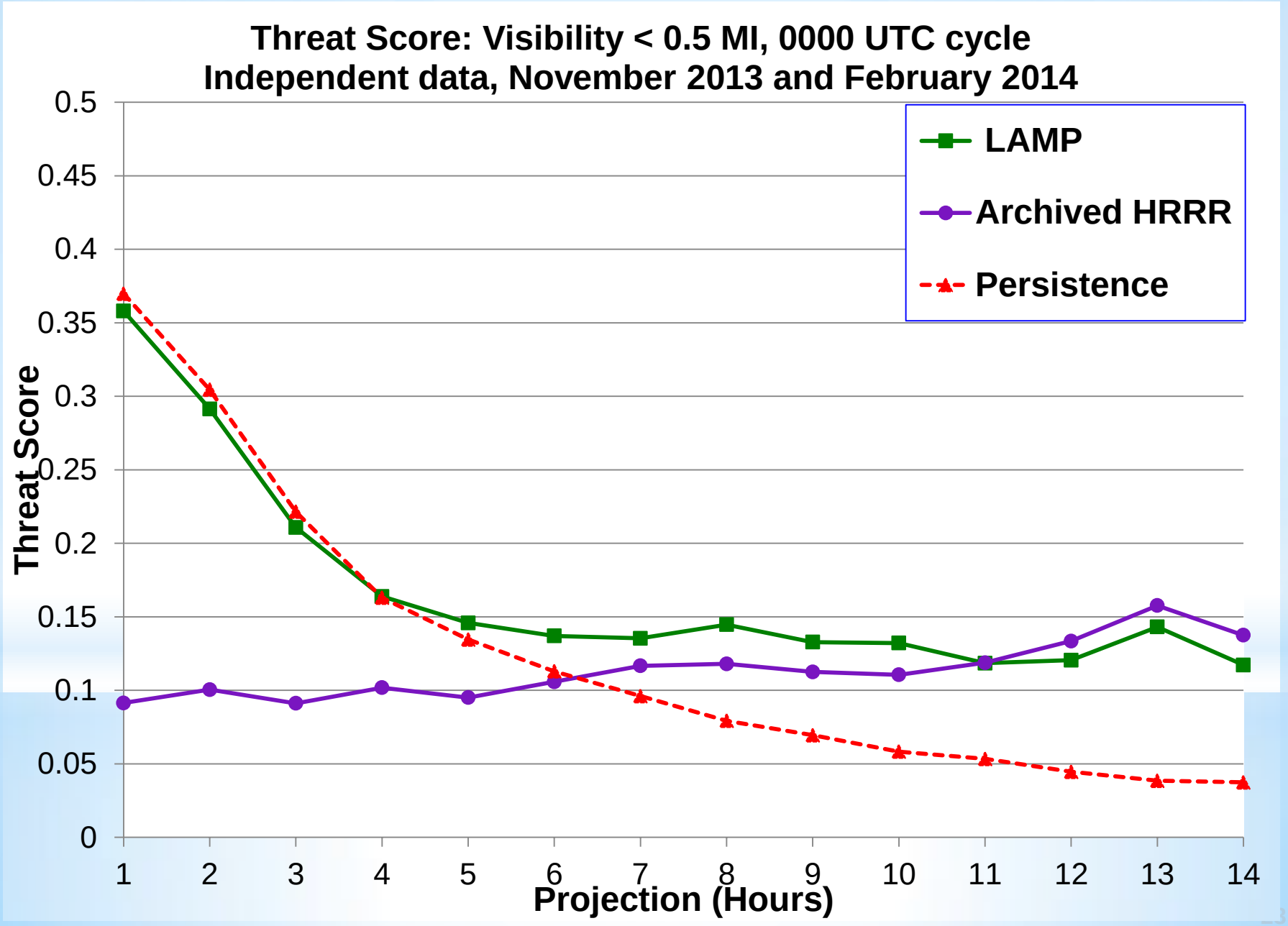
LAMP + HRRR Cool VIS: Preliminary Results



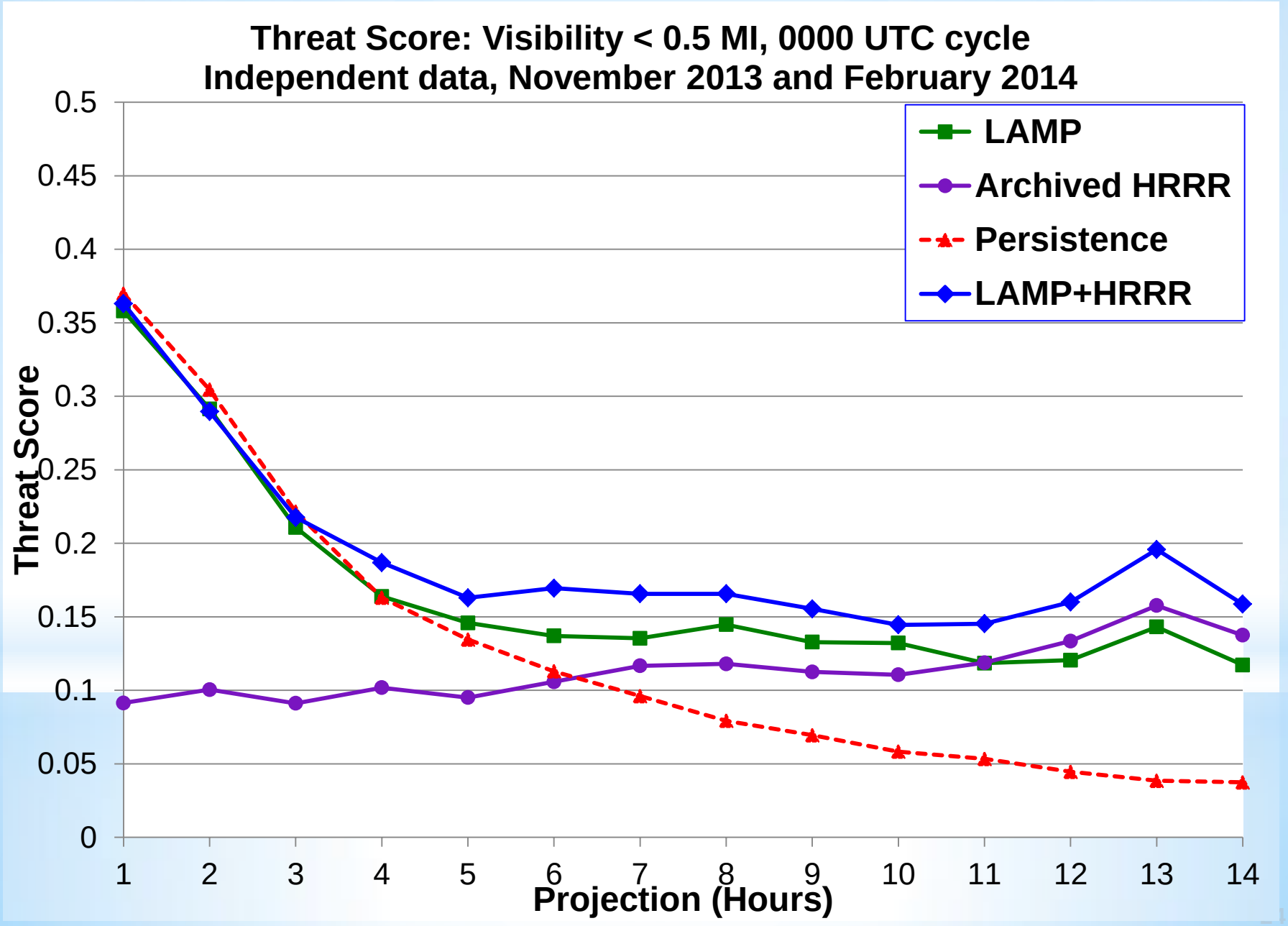
LAMP + HRRR Cool VIS: Preliminary Results



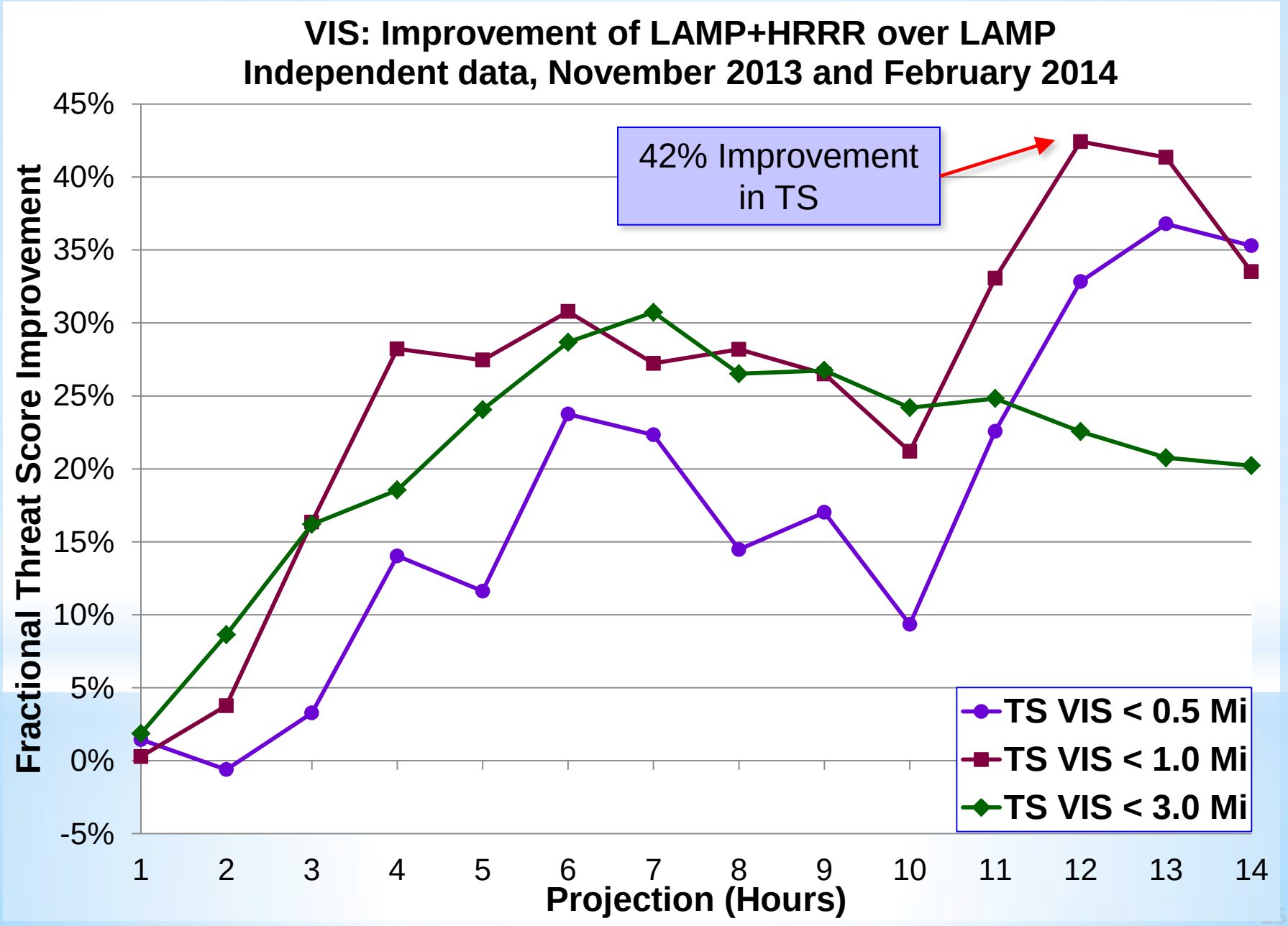
LAMP + HRRR Cool VIS: Preliminary Results



LAMP + HRRR Cool VIS: Preliminary Results



LAMP + HRRR Cool VIS: Preliminary Results



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:
    - 1200UTC 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

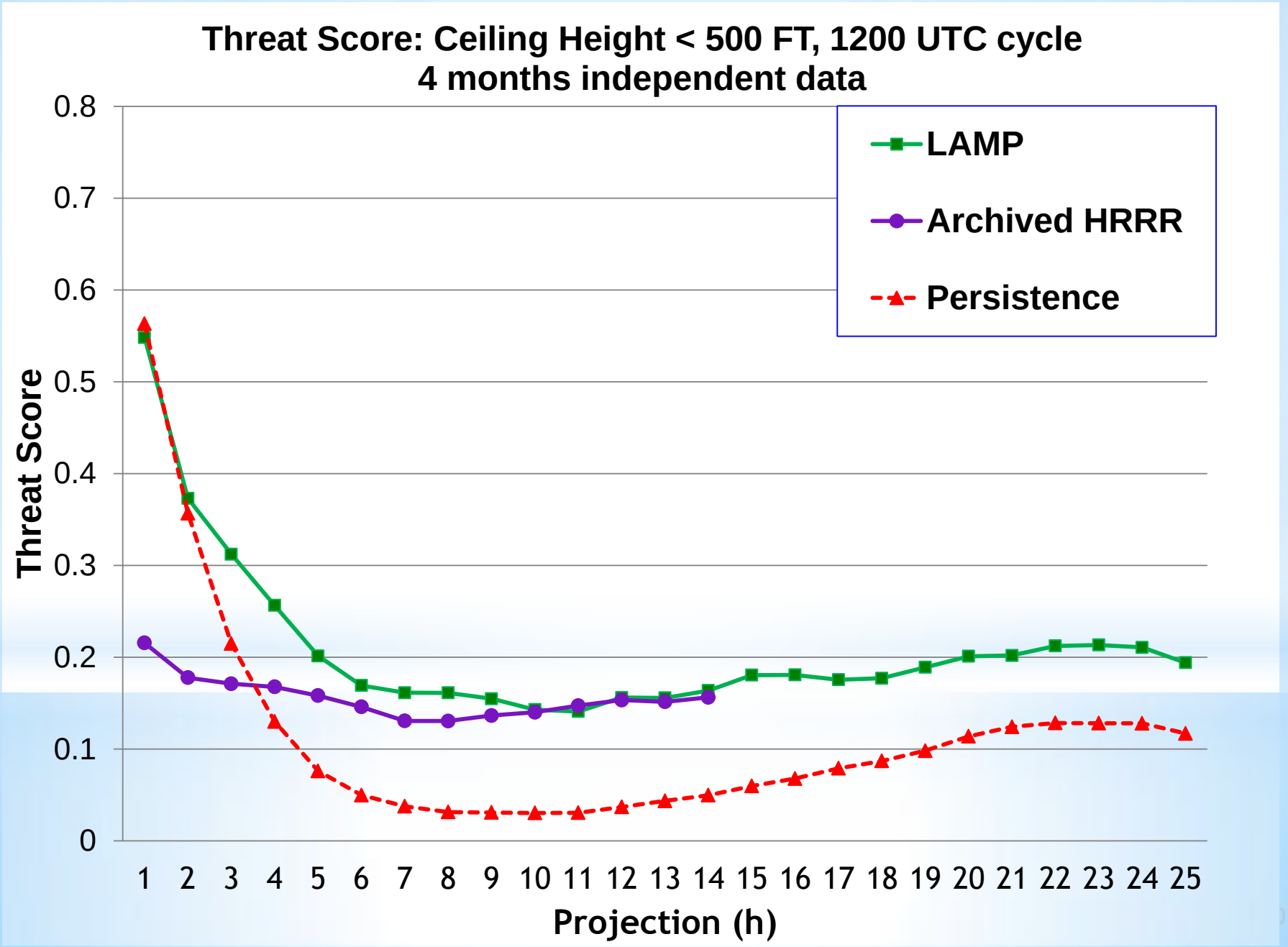
Improving LAMP CIG & VIS: Regression Equation Development – Warm Season

- 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

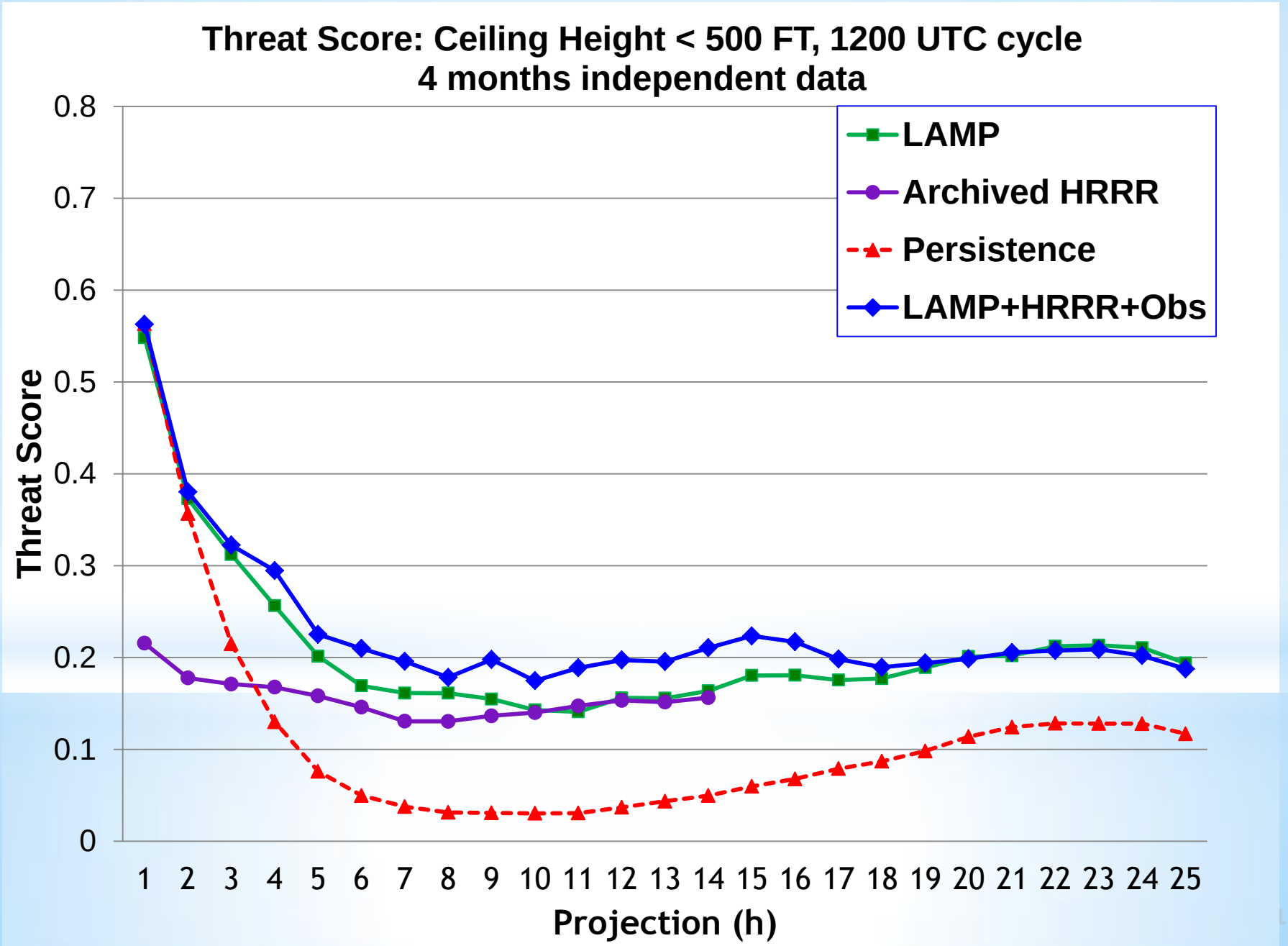
Improving LAMP CIG & VIS: Regression Equation Development – Warm Season

- 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

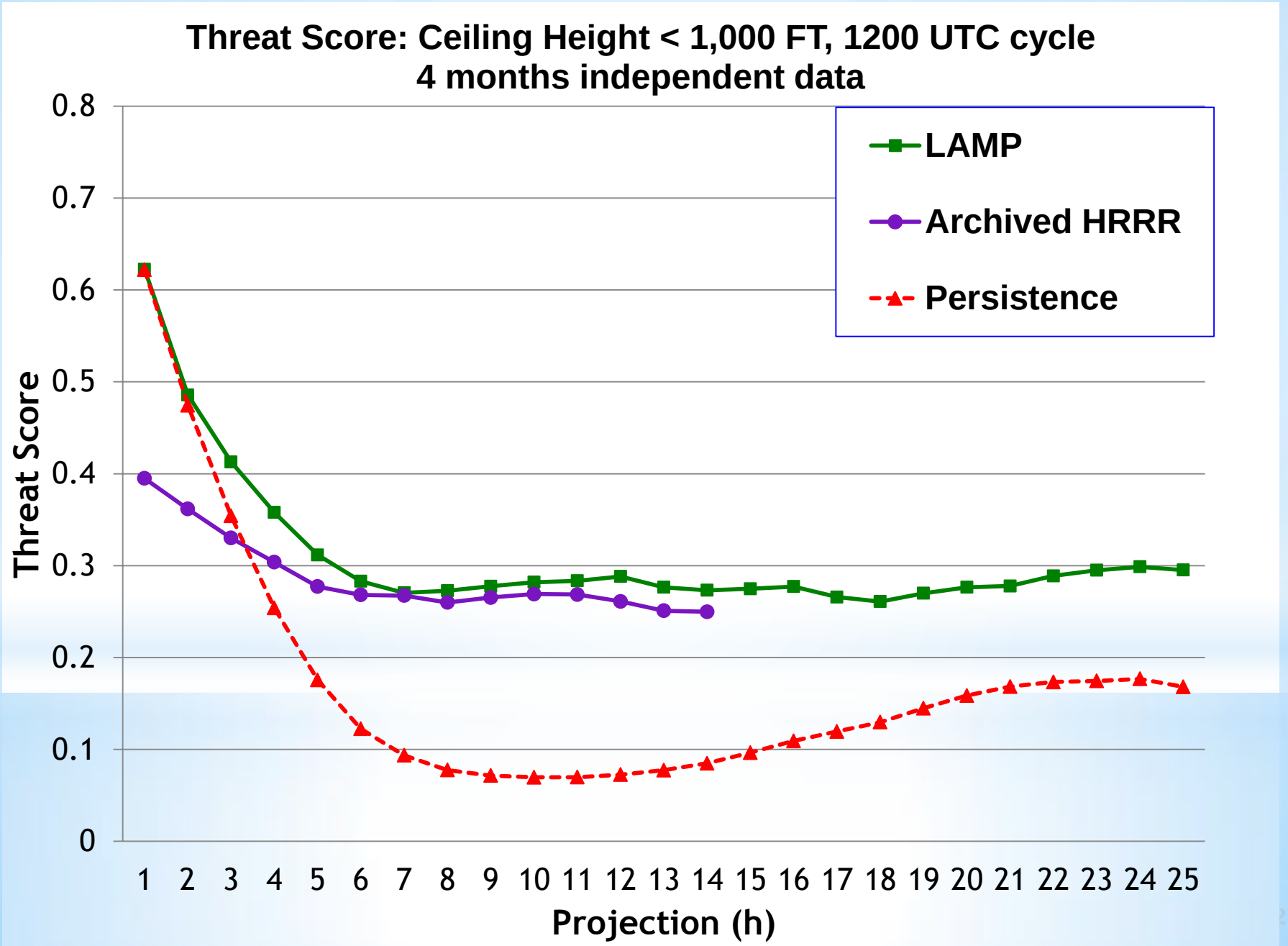
LAMP + HRRR Warm CIG



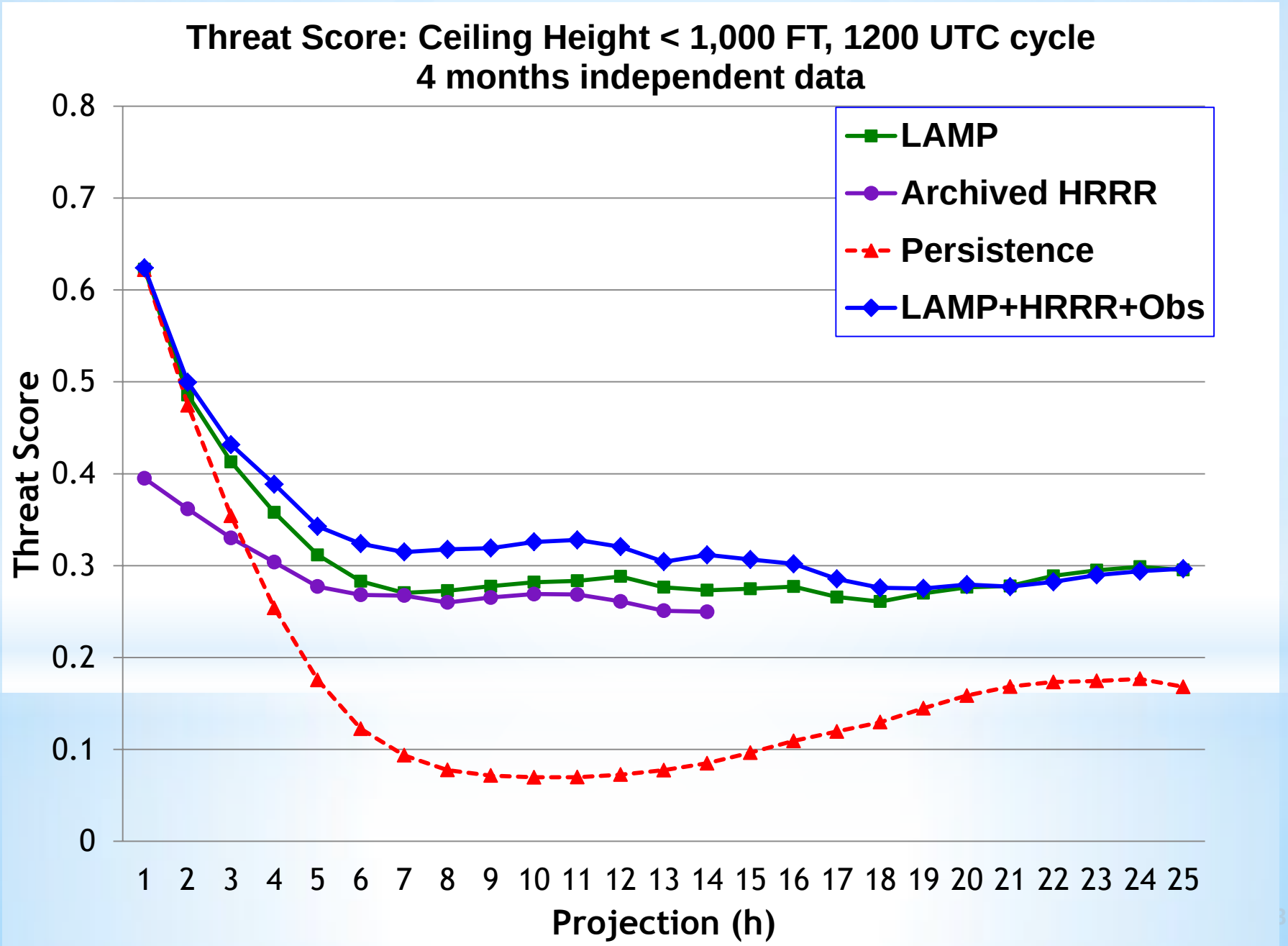
LAMP + HRRR Warm CIG



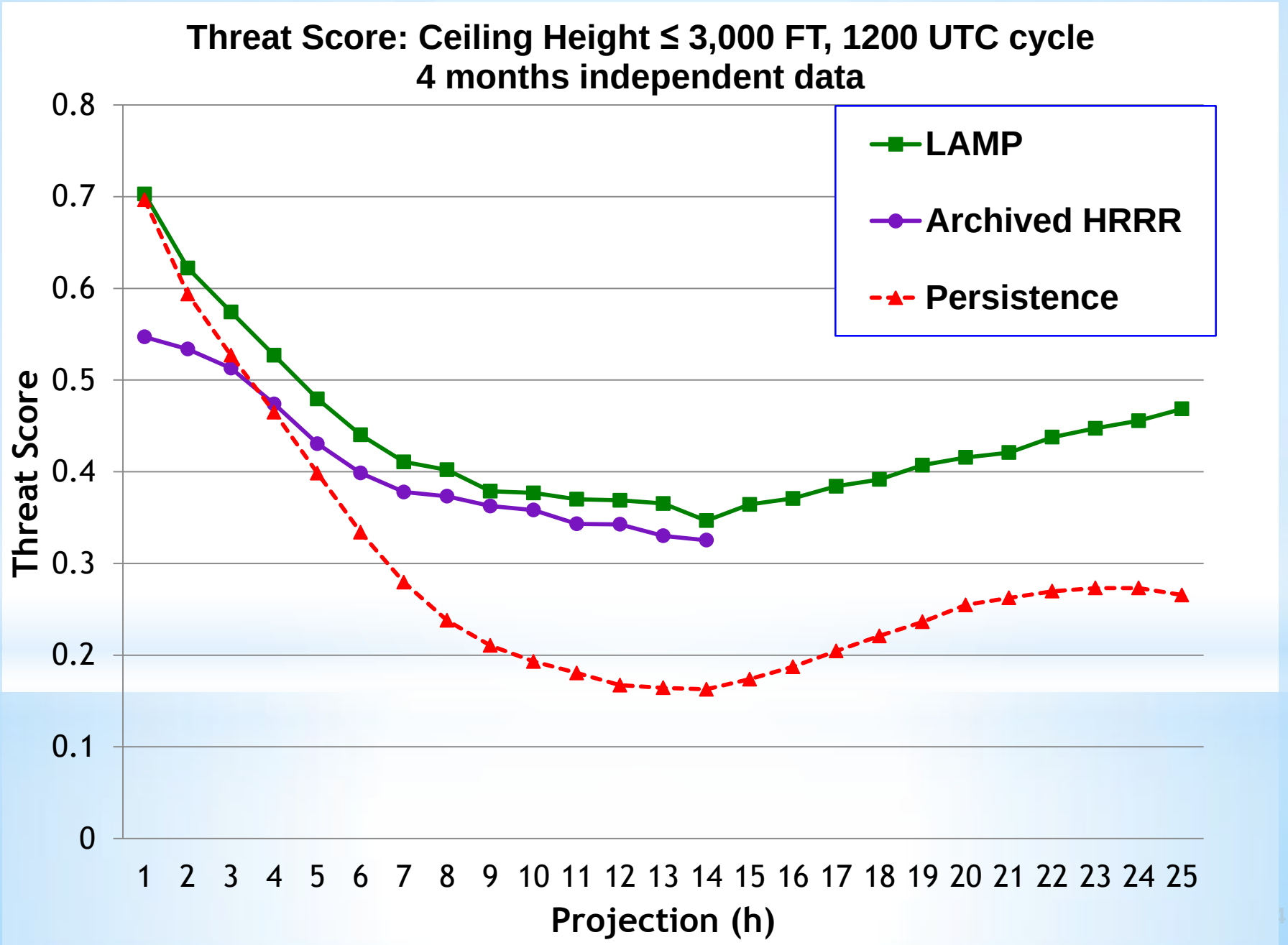
LAMP + HRRR Warm CIG



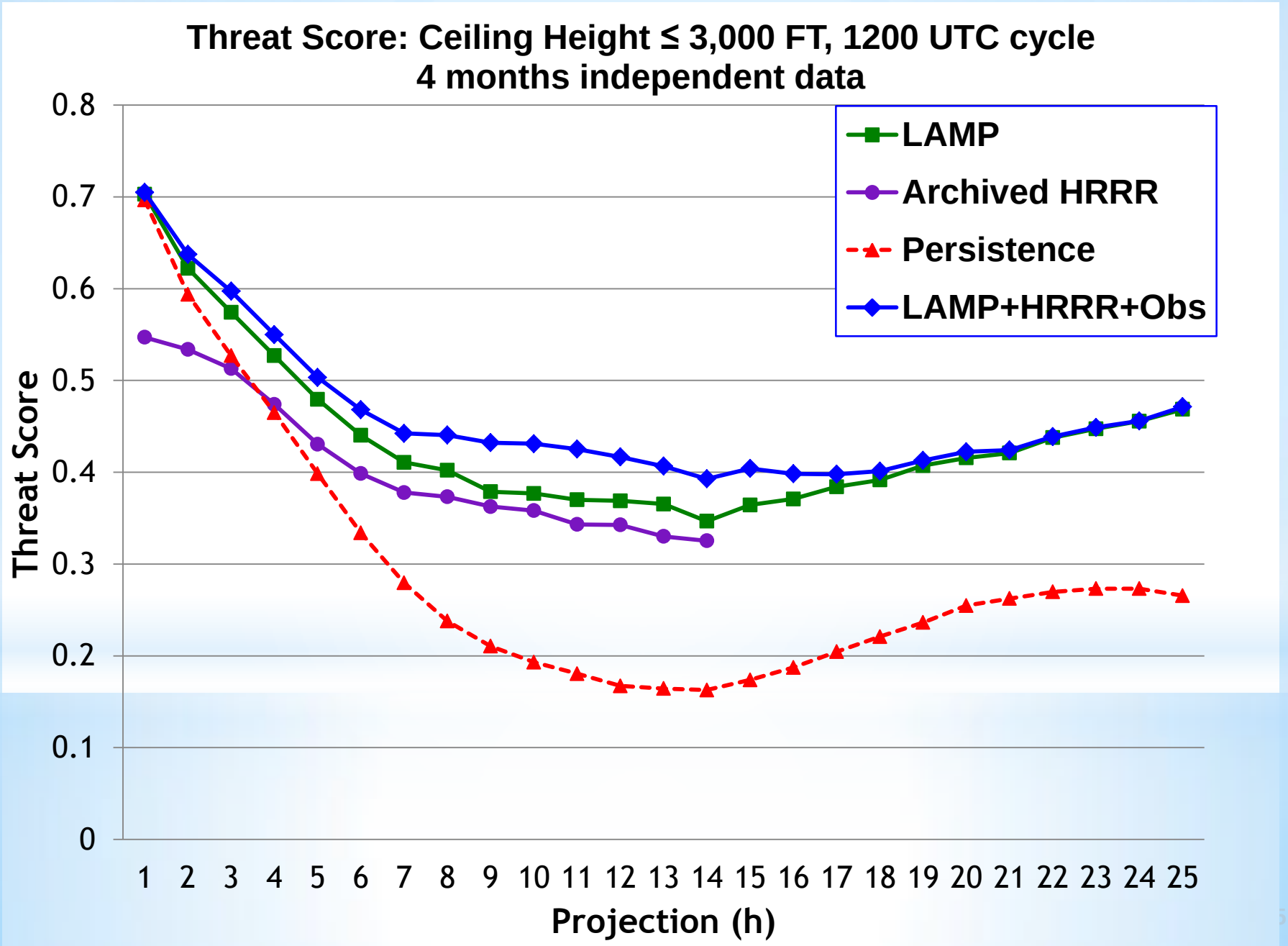
LAMP + HRRR Warm CIG



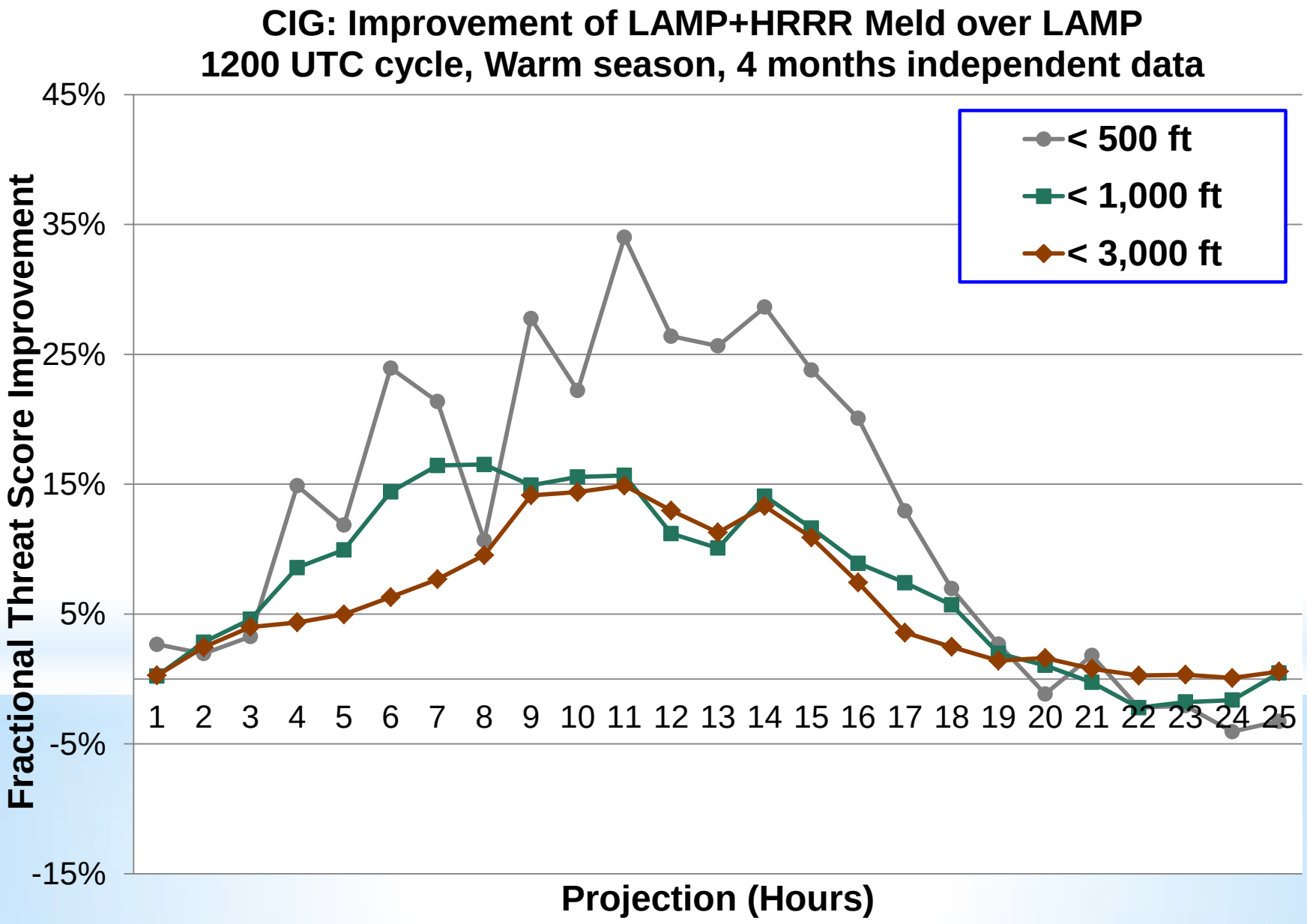
LAMP + HRRR Warm CIG



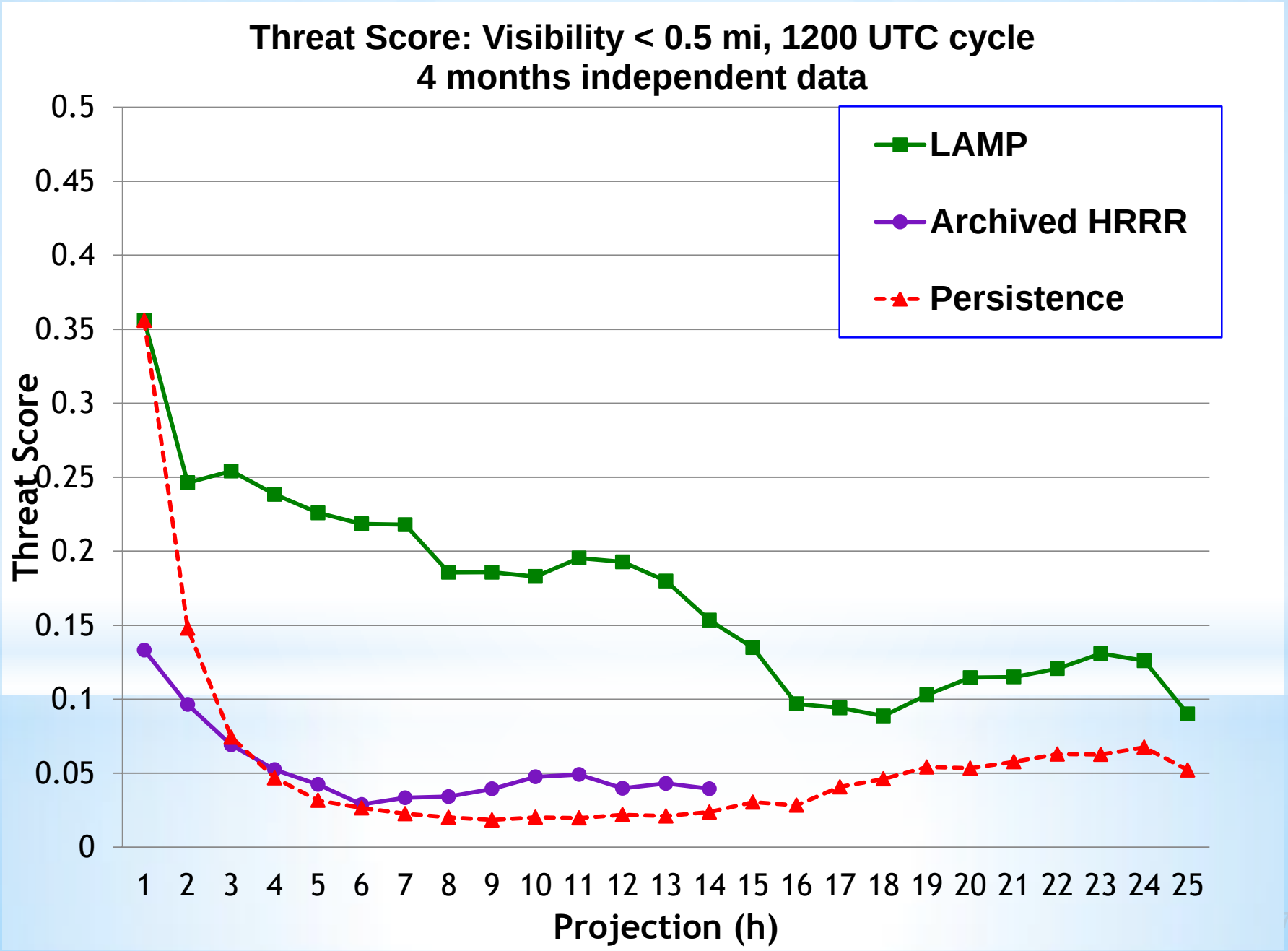
LAMP + HRRR Warm CIG



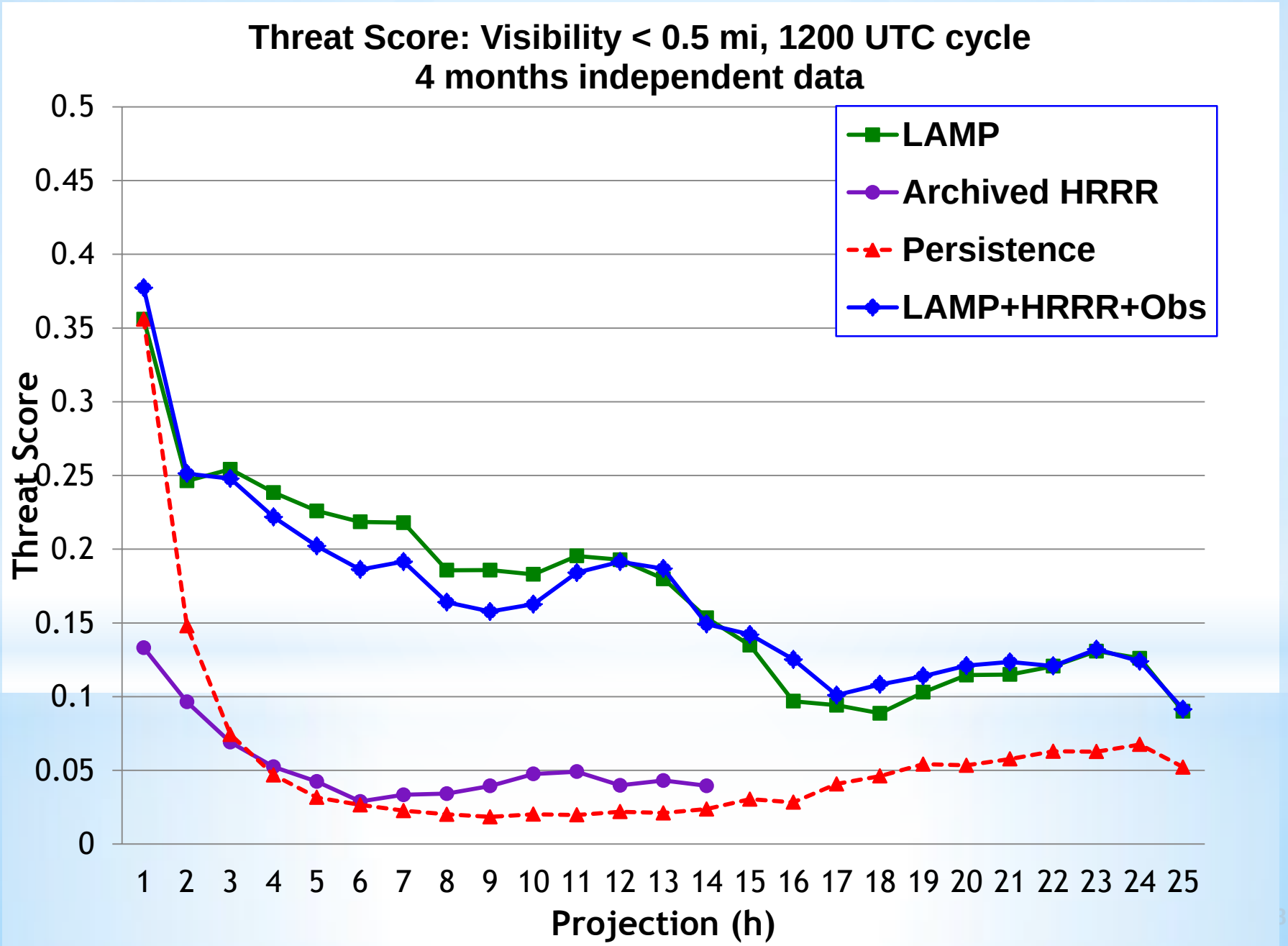
LAMP + HRRR Warm CIG



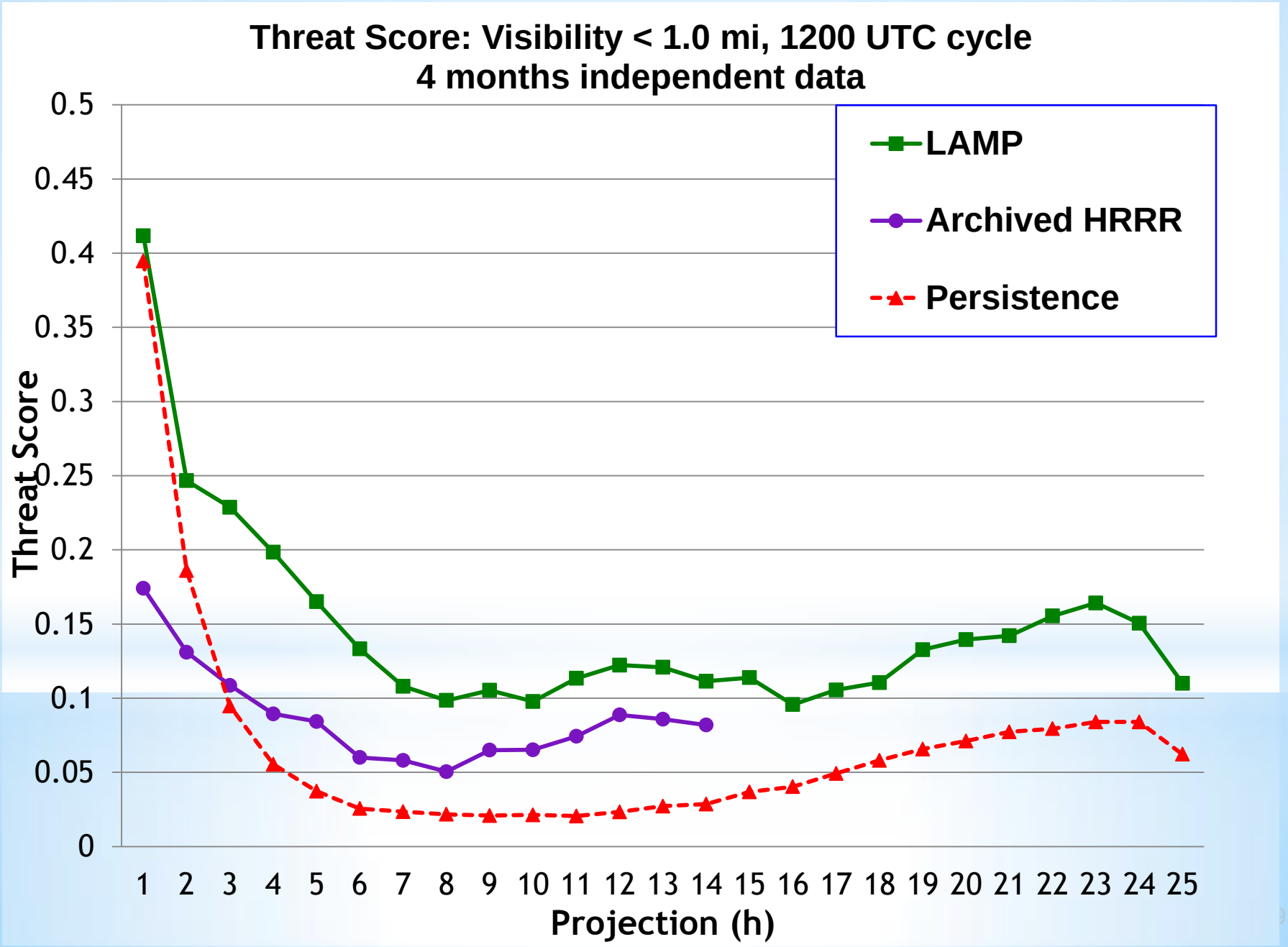
LAMP + HRRR Warm VIS



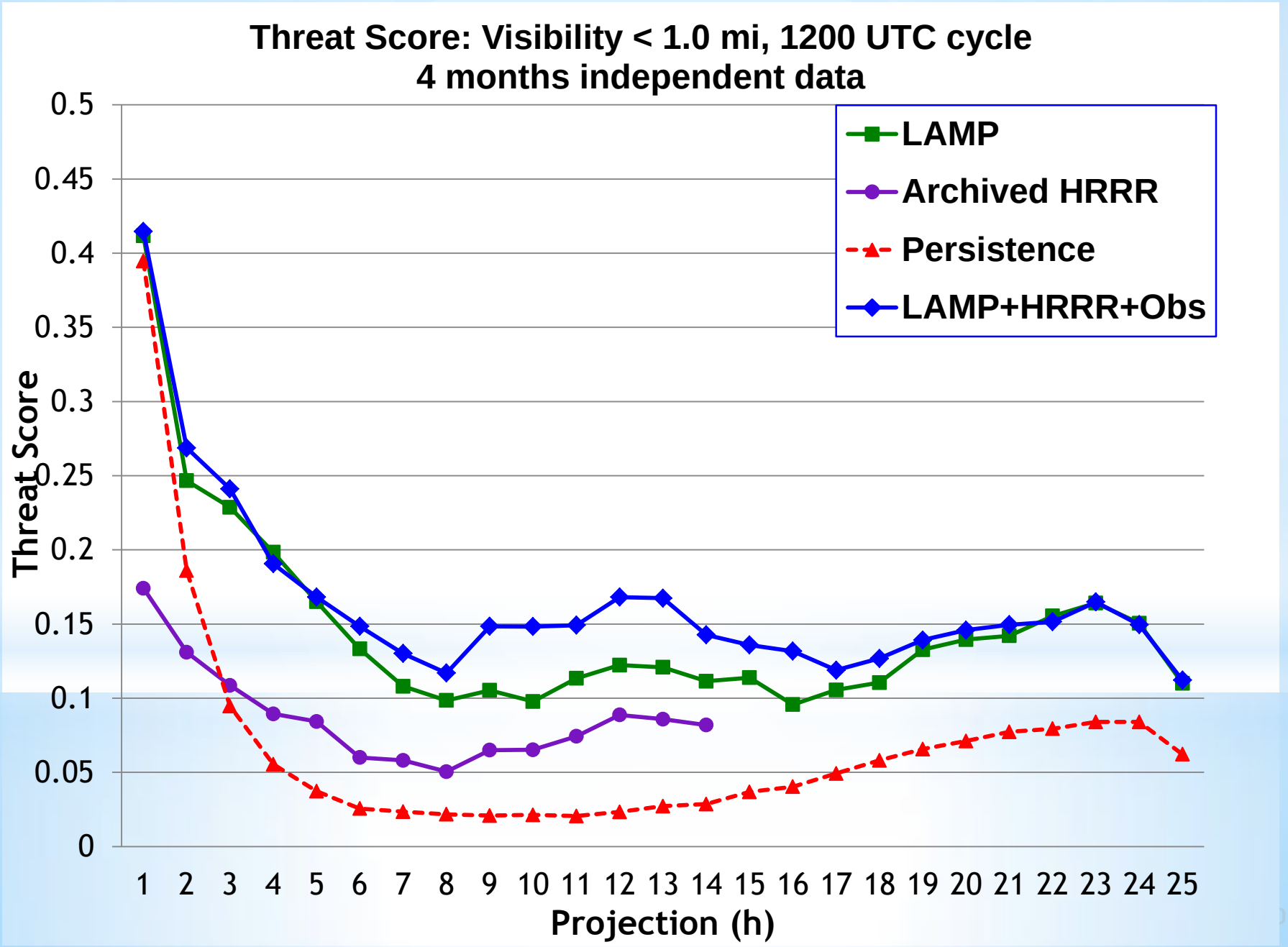
LAMP + HRRR Warm VIS



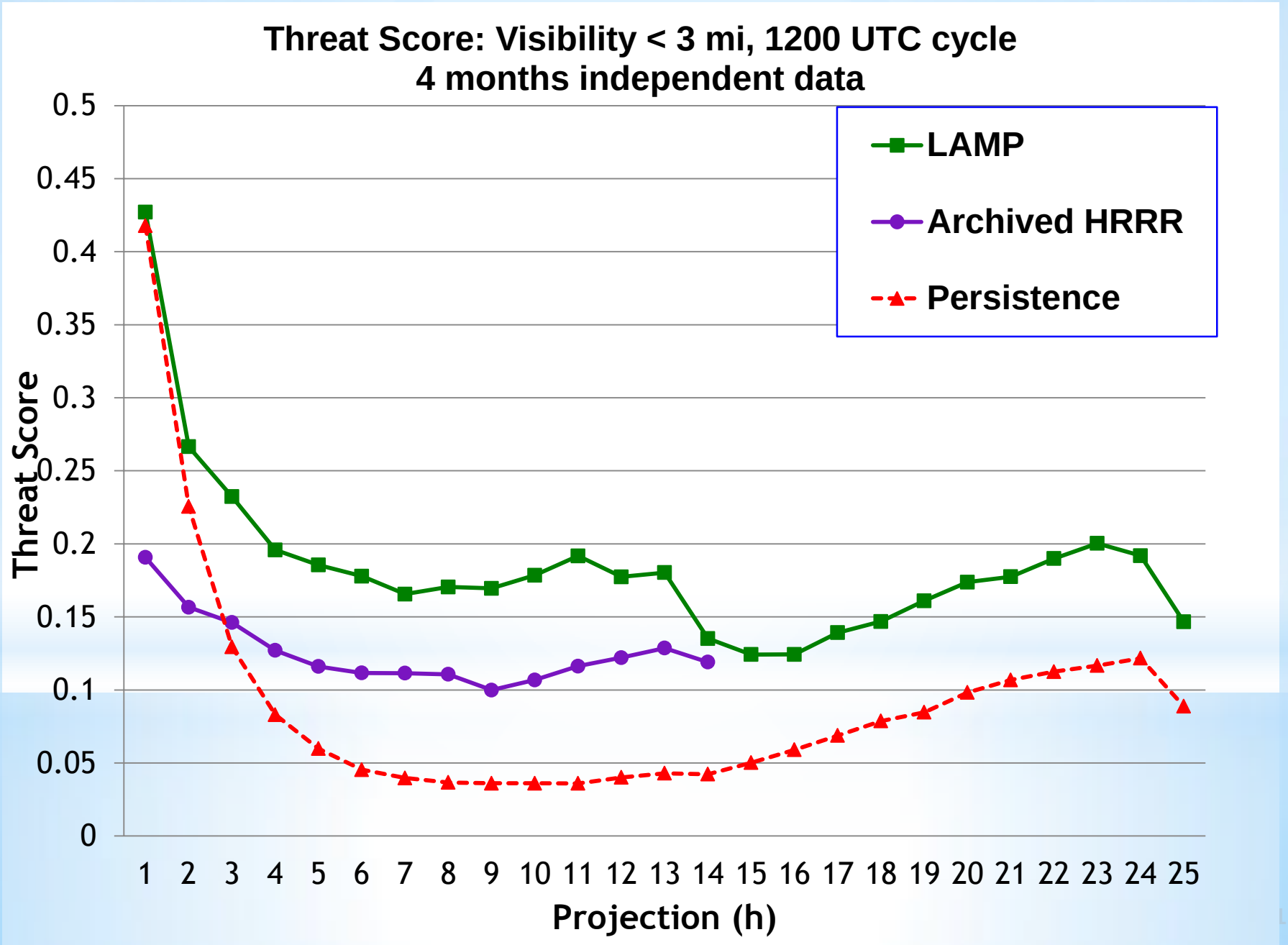
LAMP + HRRR Warm VIS



LAMP + HRRR Warm VIS



LAMP + HRRR Warm VIS



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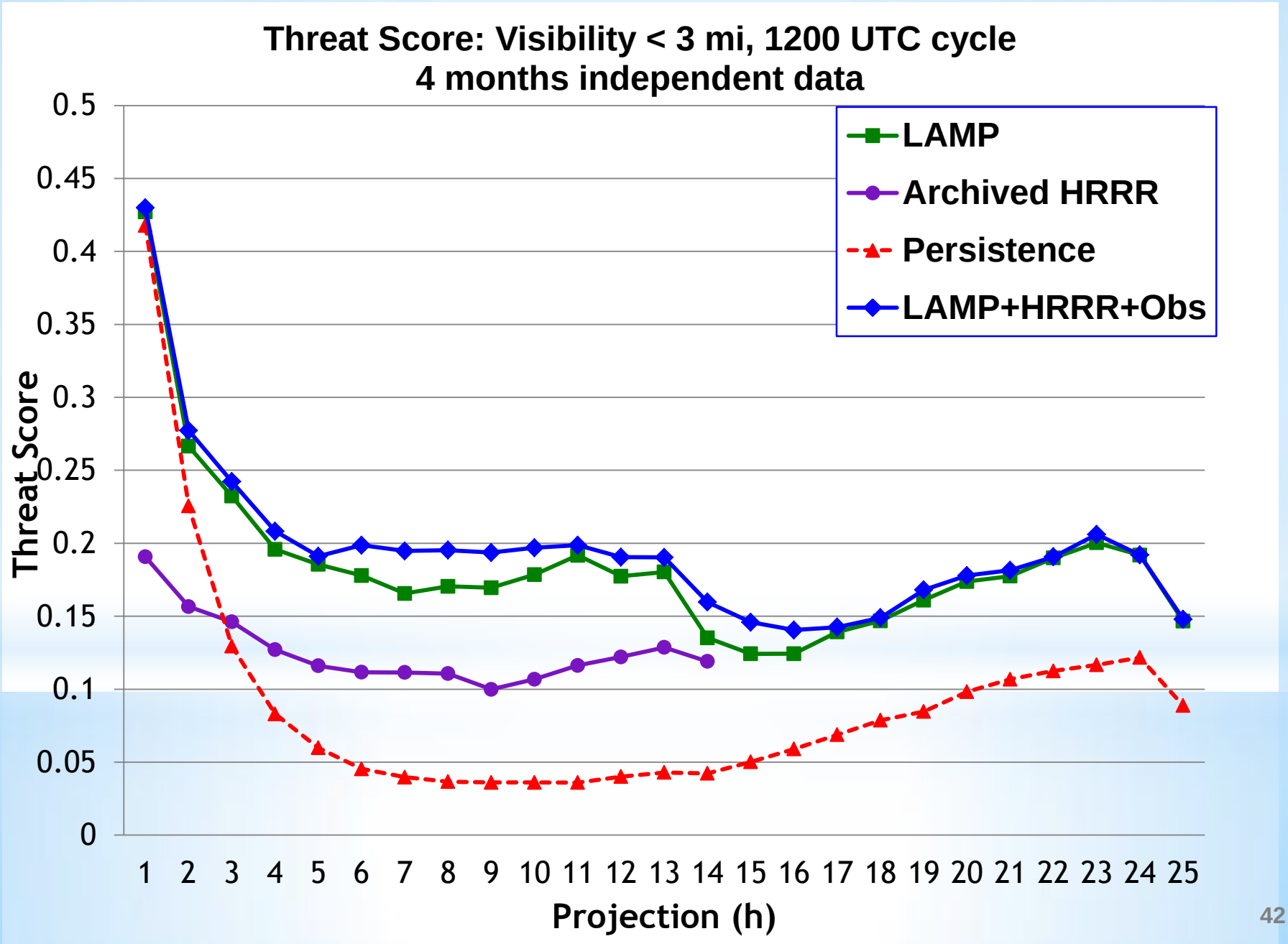
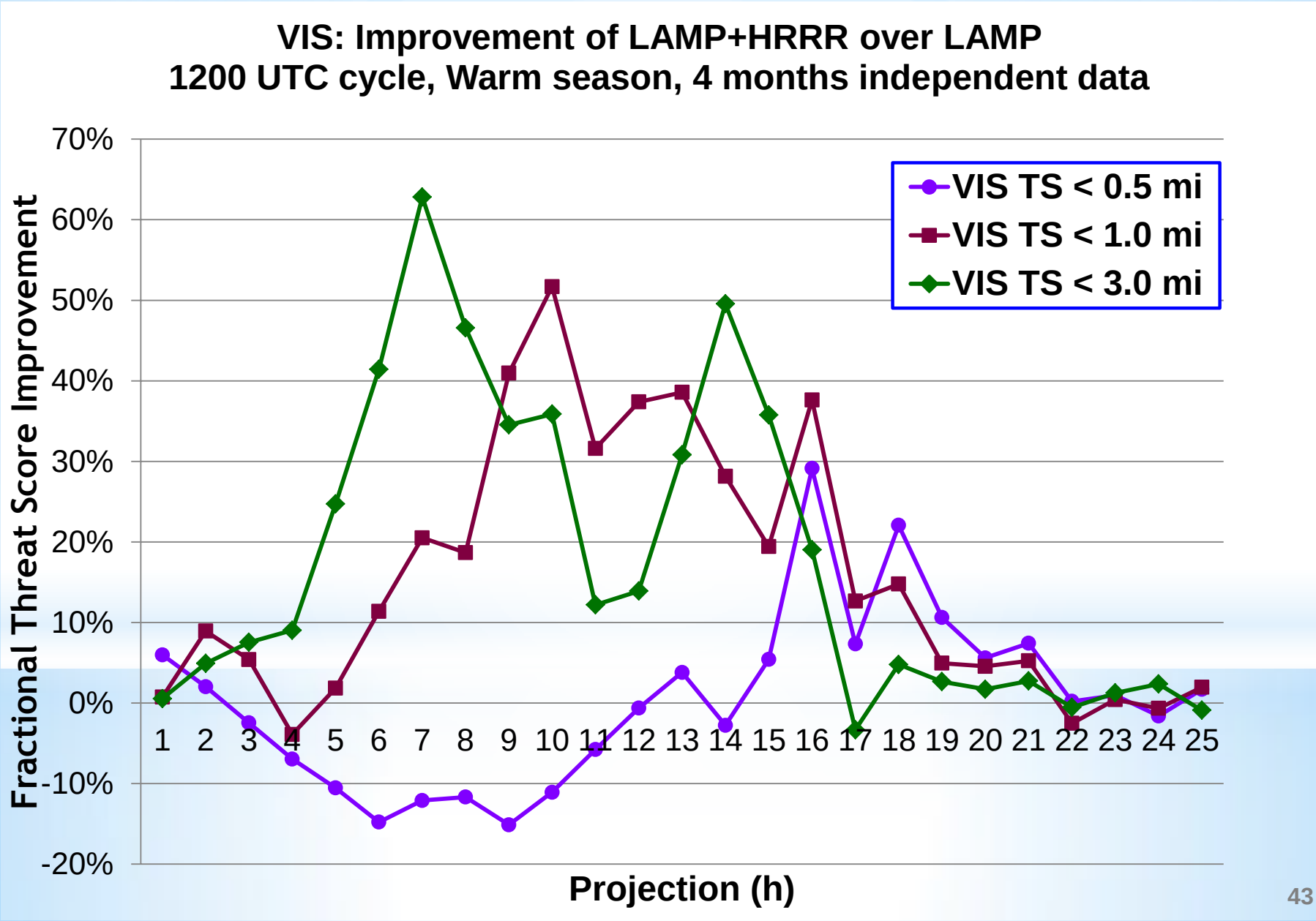


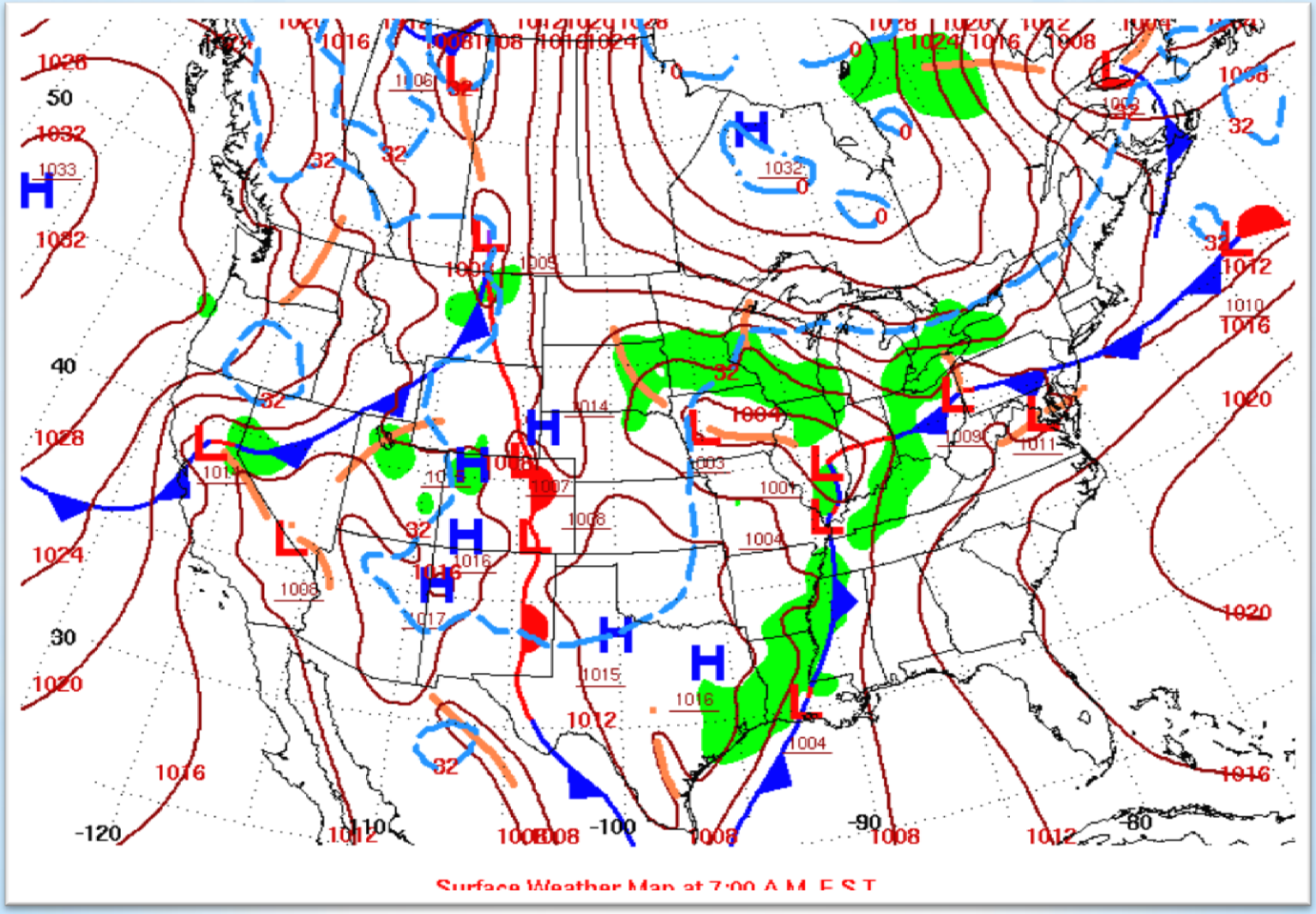
LAMP + HRRR Warm VIS



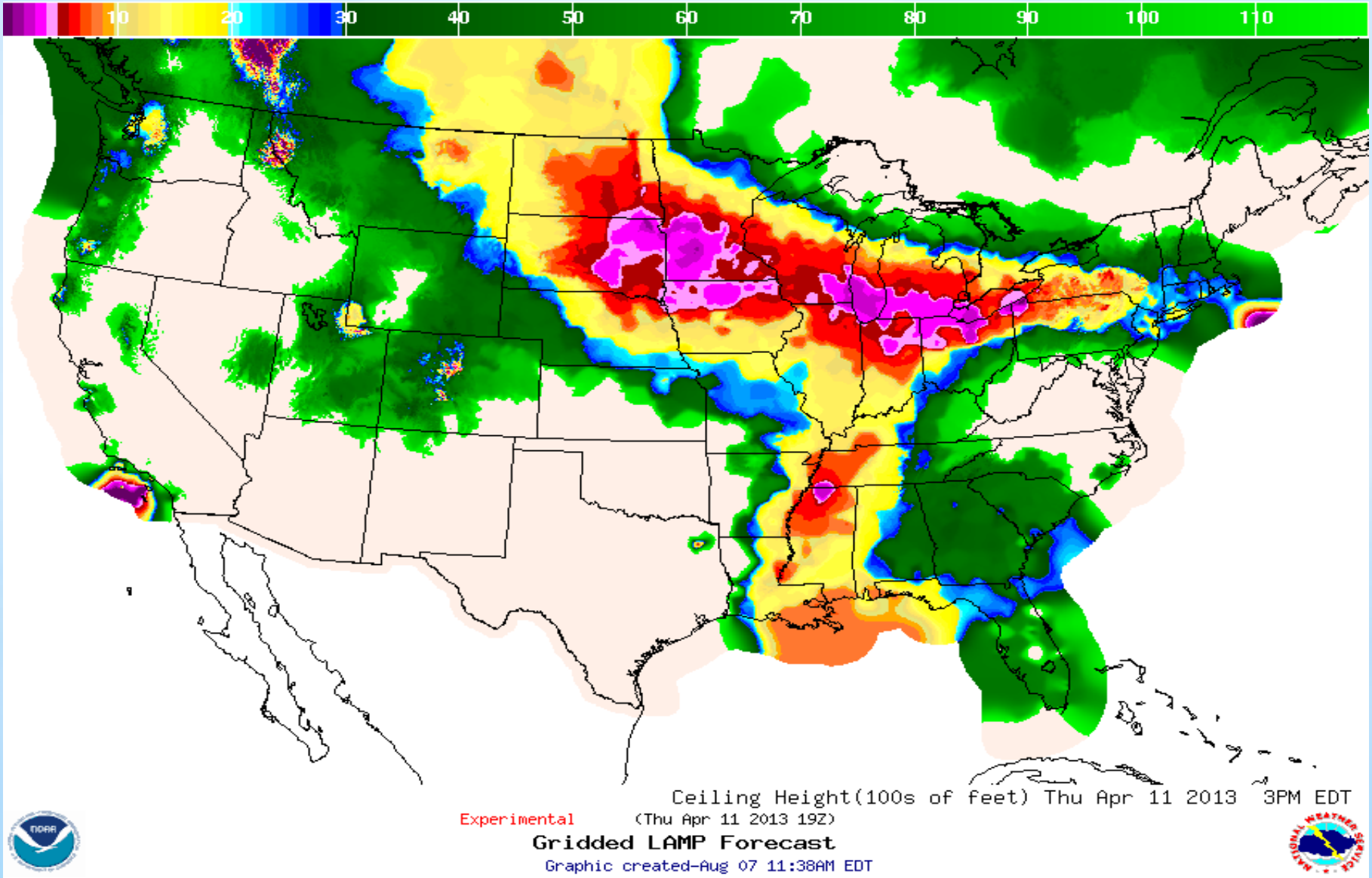
Case Examples

Example Case:

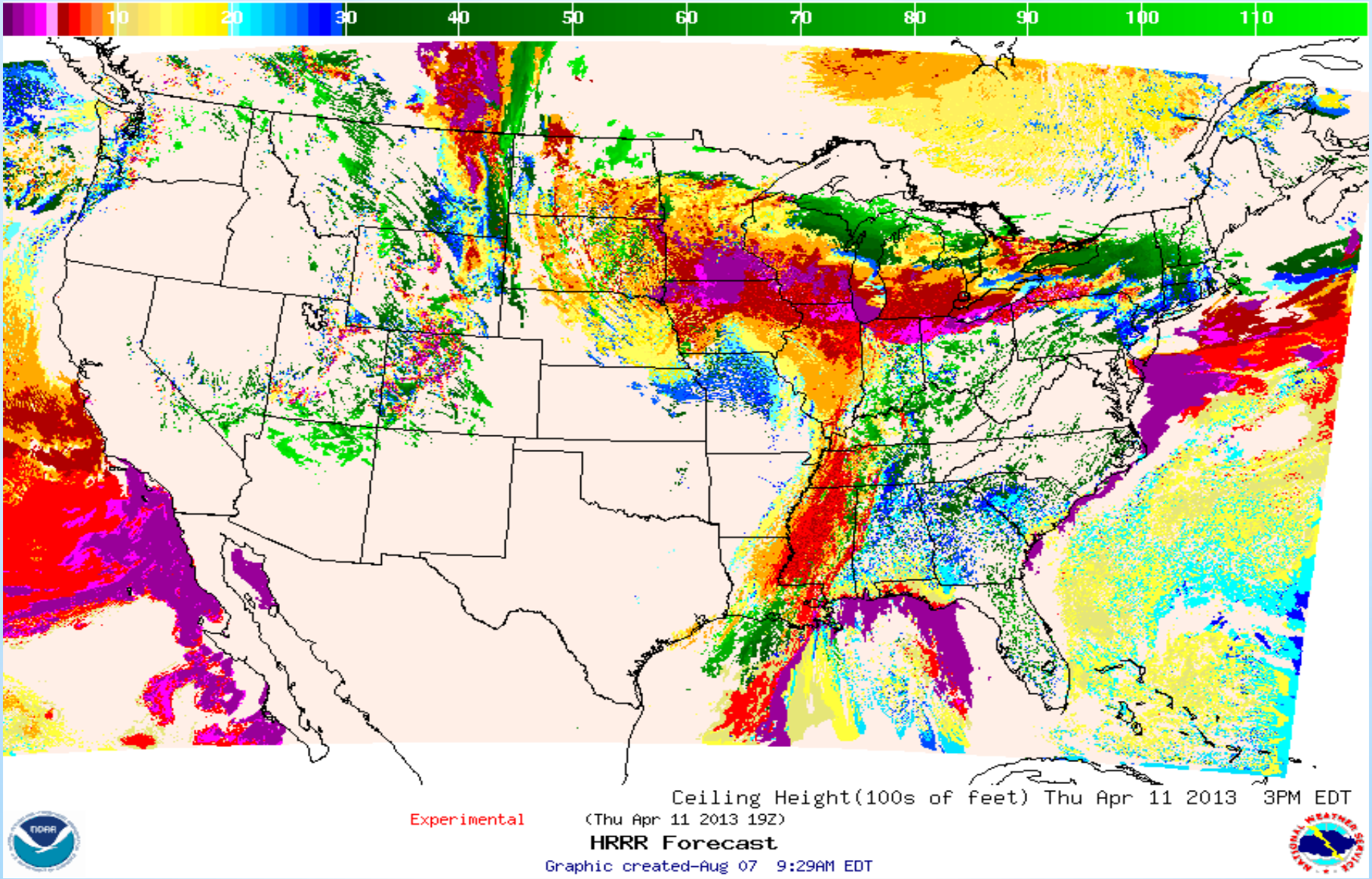
April 11, 2013, 1200 UTC, 7-h forecast valid at 1900 UTC



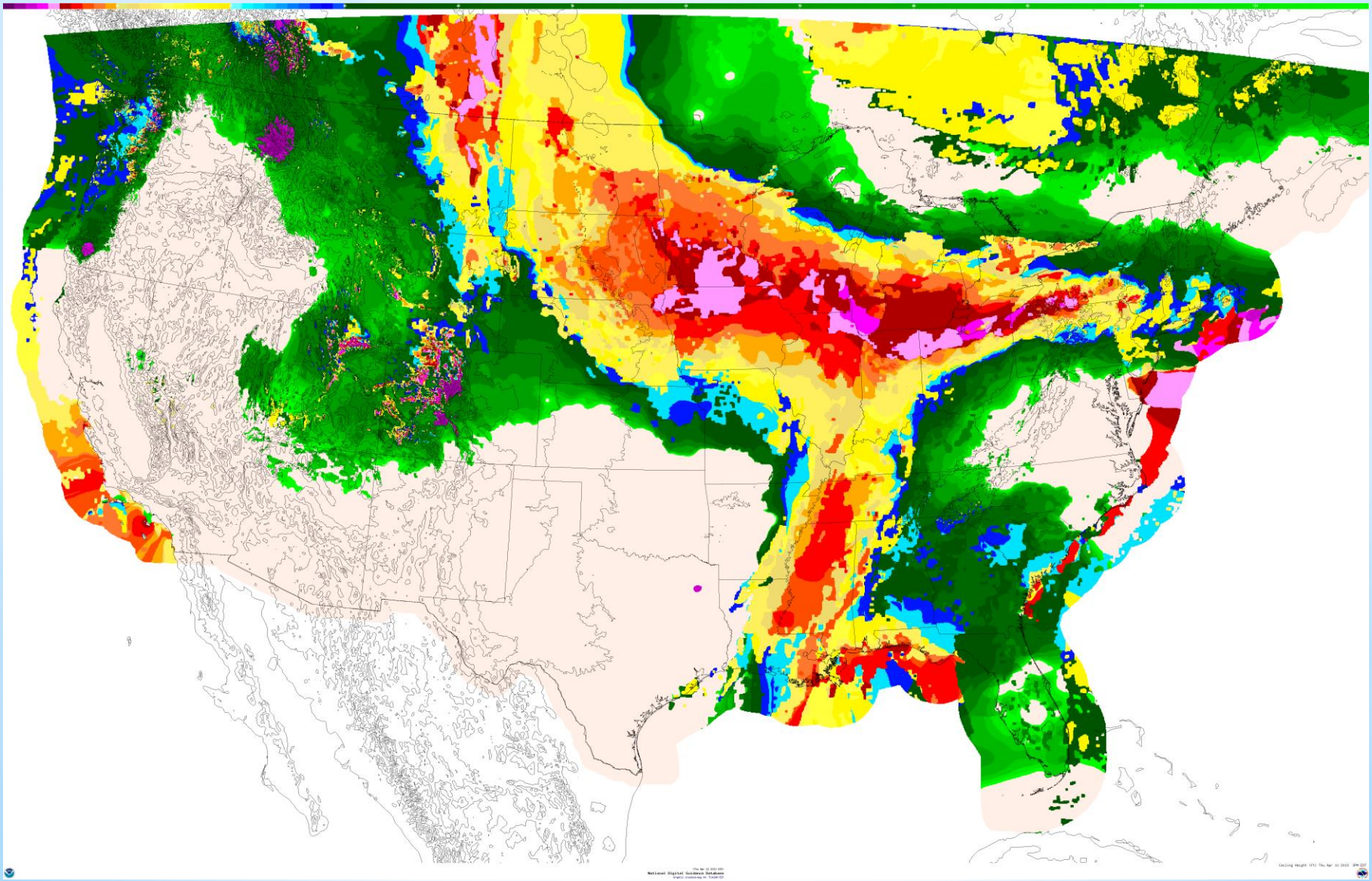
CIG: LAMP 7hr Forecast Valid 19z



CIG: HRRR 8hr Forecast Valid 19z

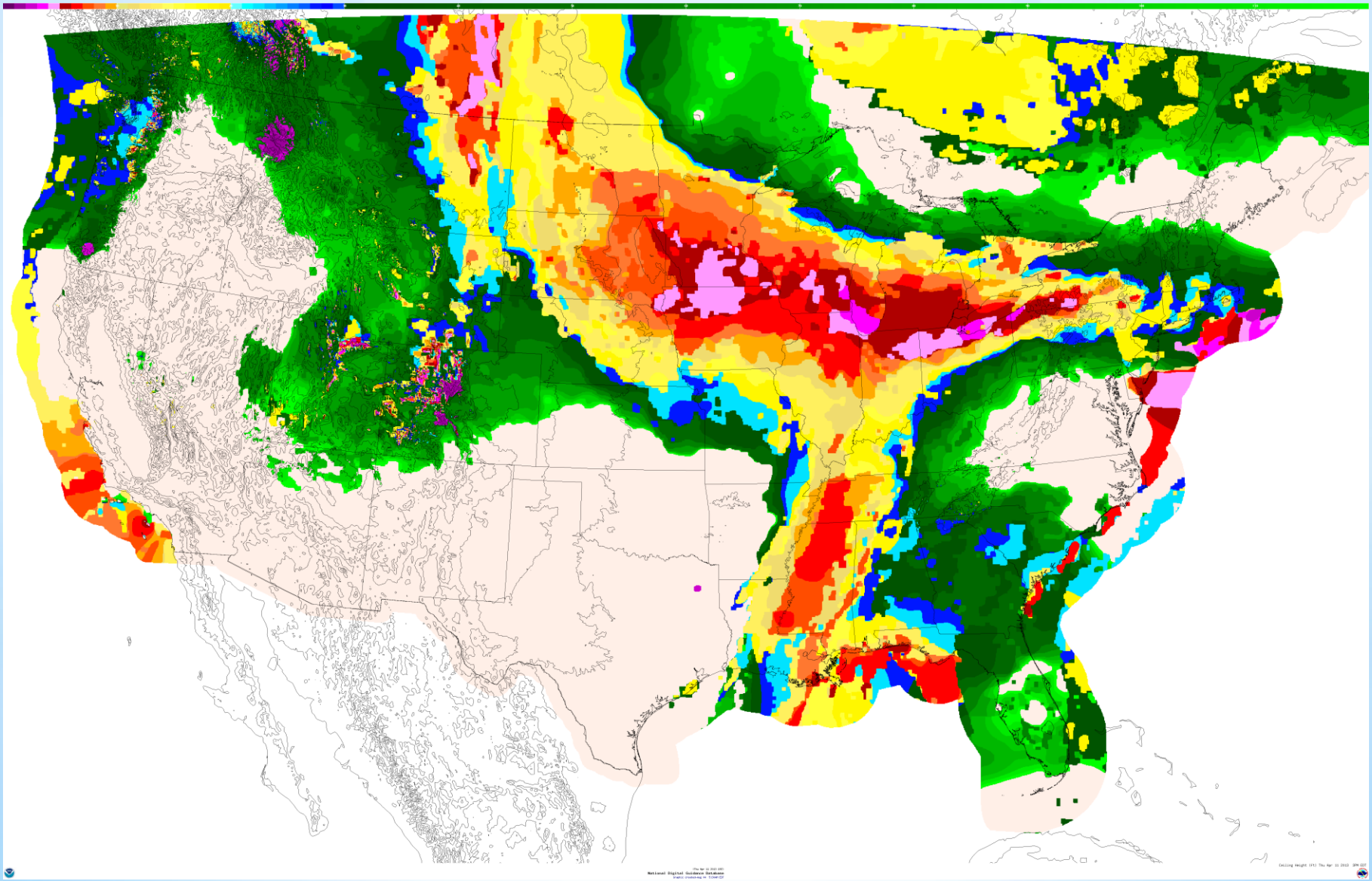


CIG: LAMP+HRRR Meld 7hr Forecast Valid 19z

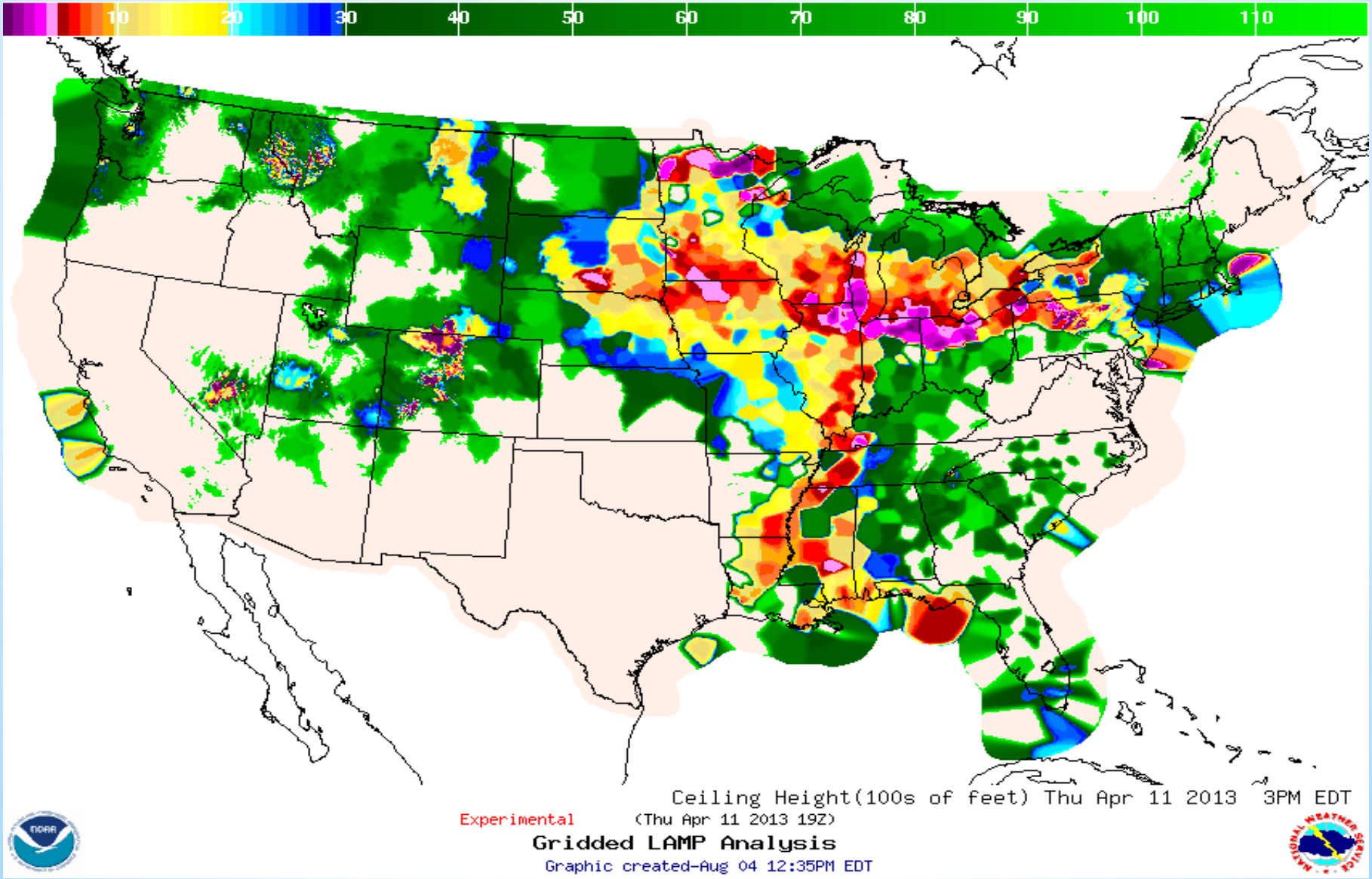


CIG: LAMP+HRRR Meld 7hr Forecast Valid 19z

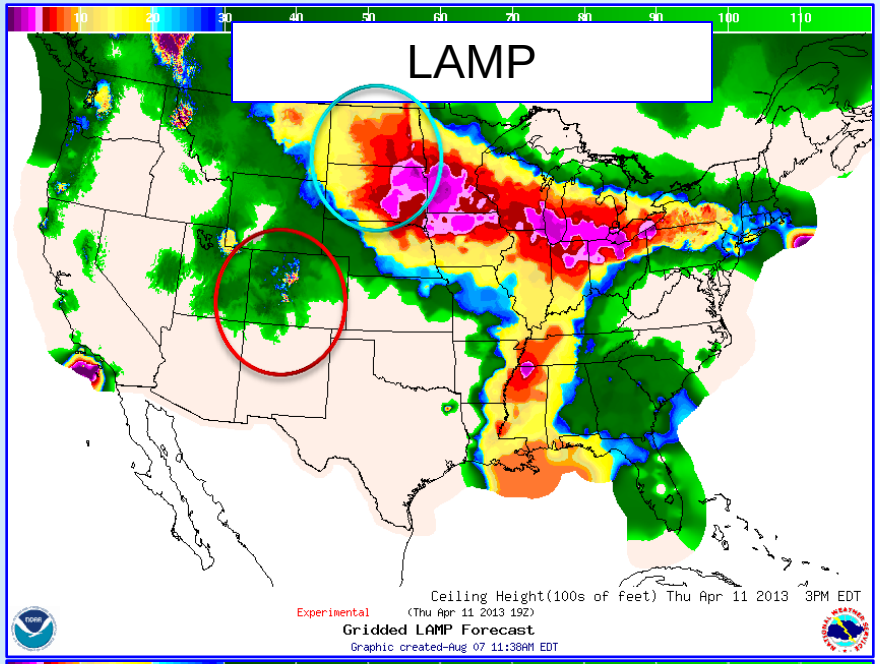
Spot Remover Applied

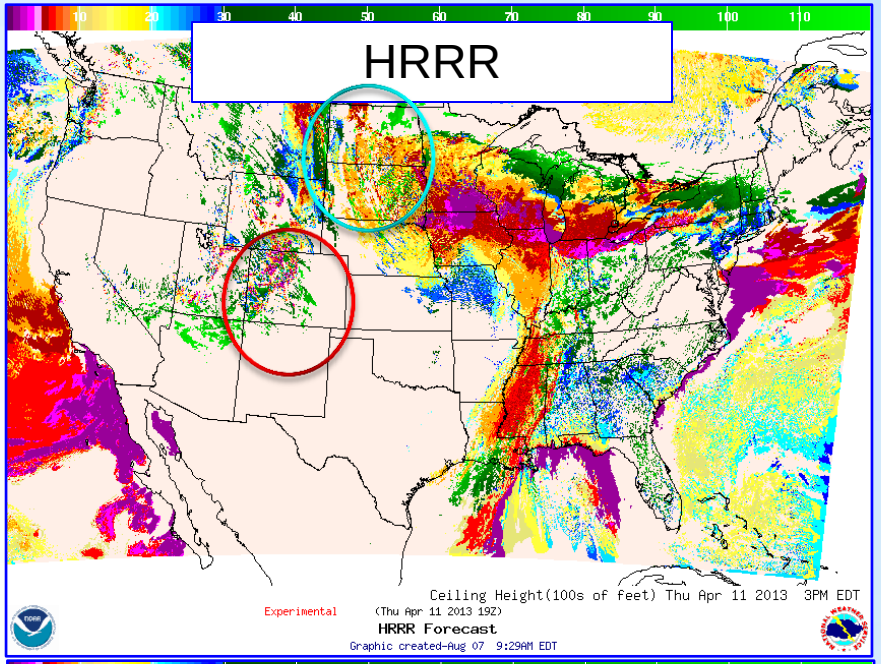


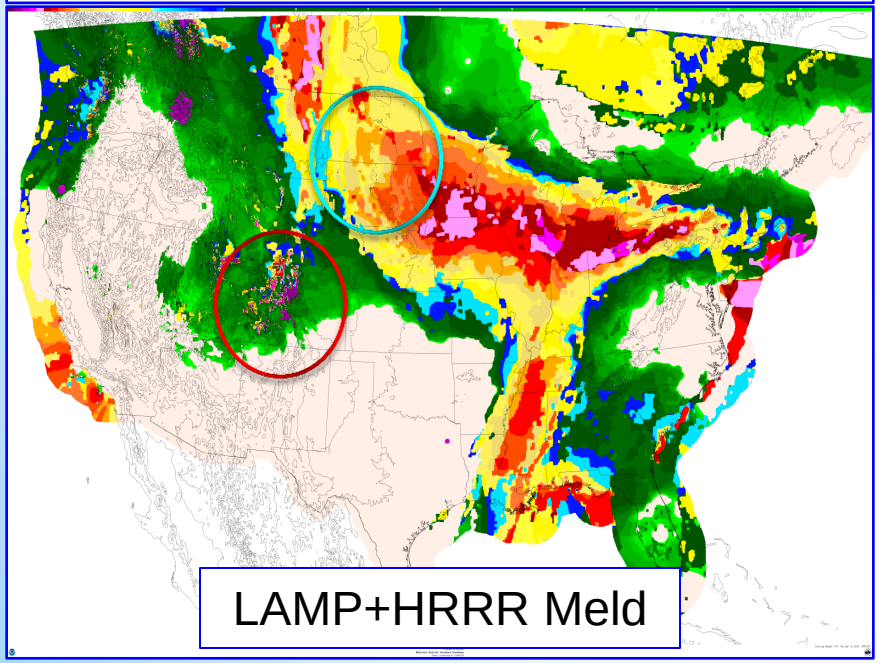
CIG: Verifying Observations at 19z

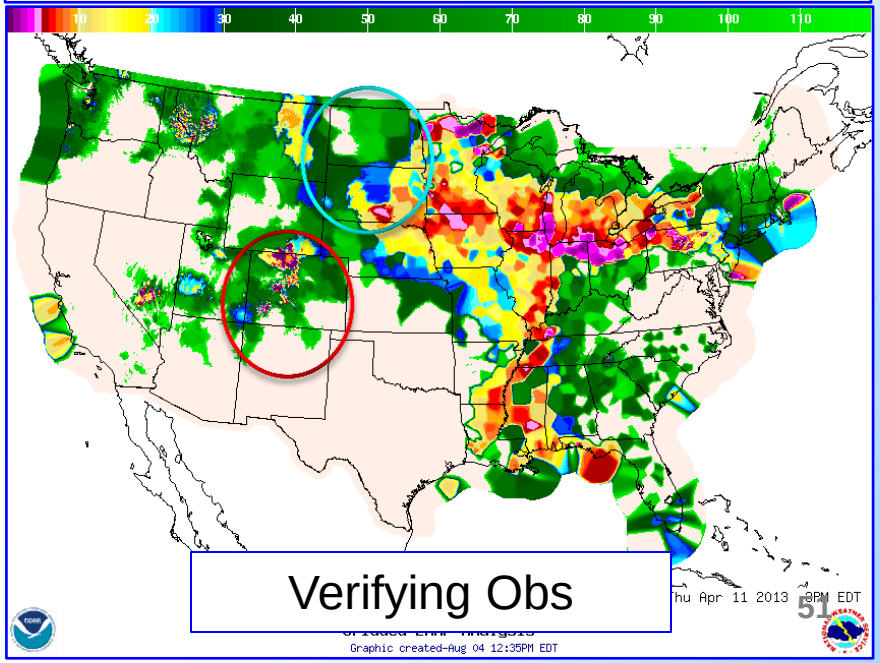


Ceiling Case 4/11/2013 1200 UTC 7-h forecast





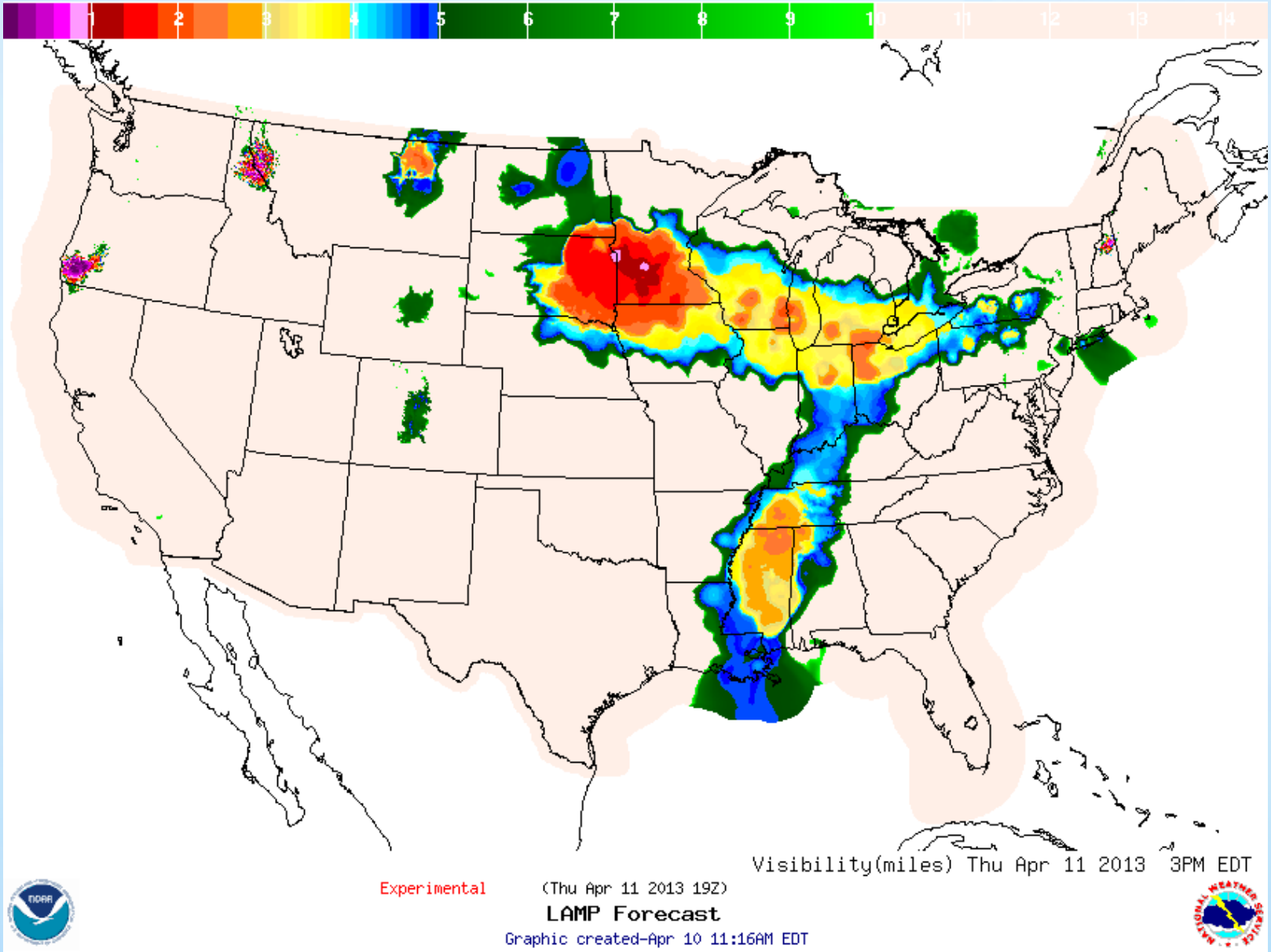




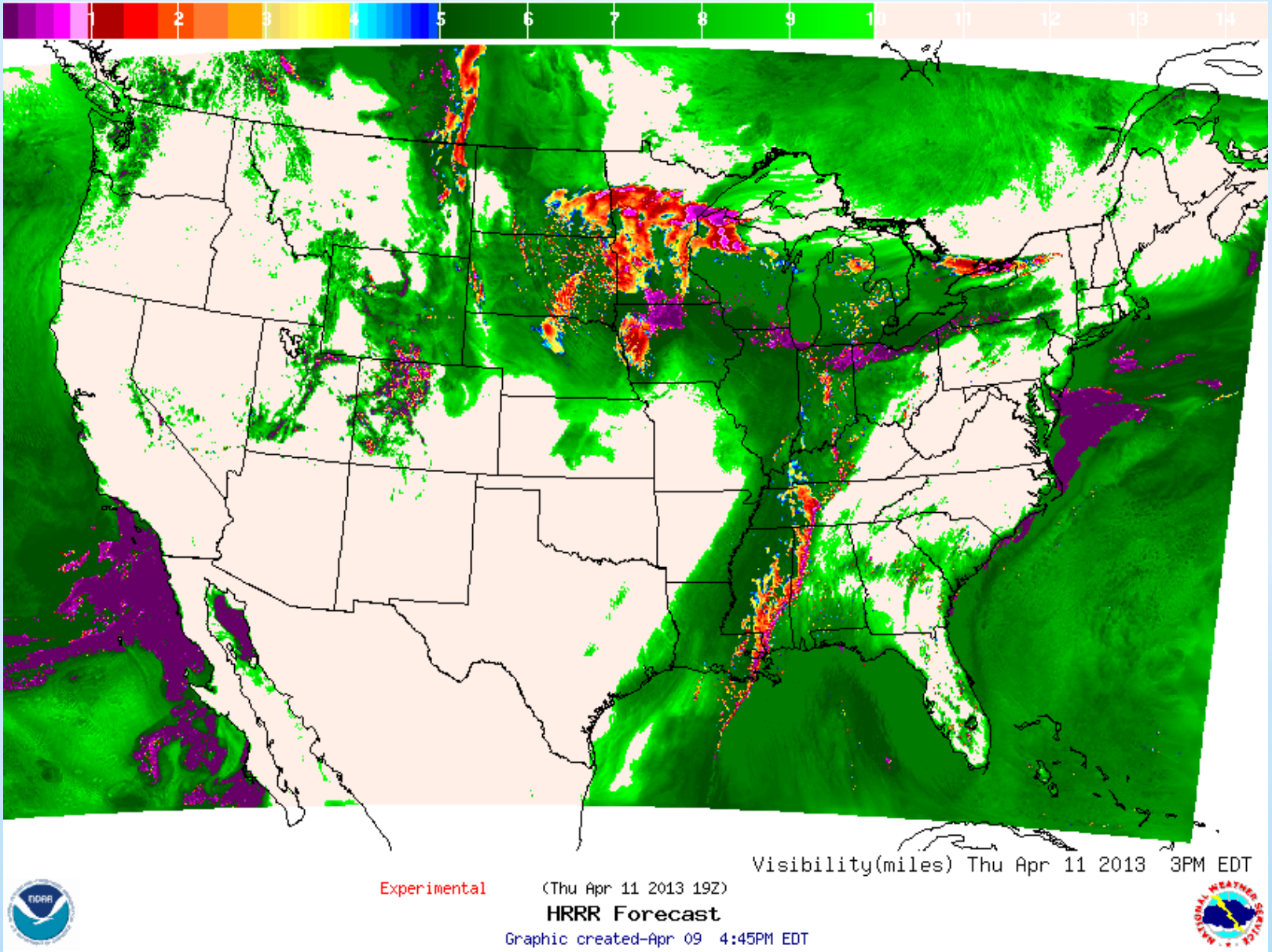
April 11th Ceiling Case

- 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.

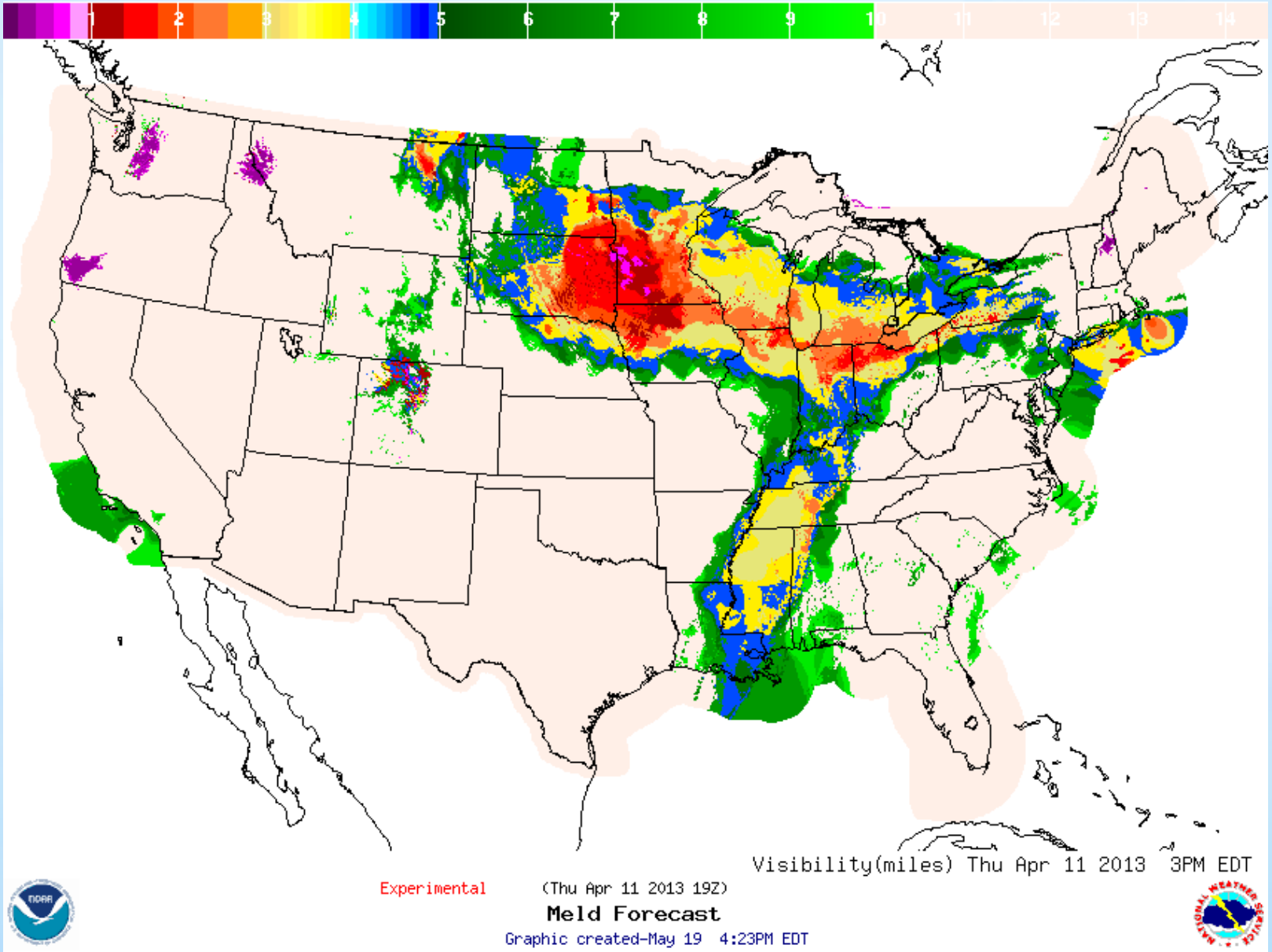
VIS: LAMP 7hr Forecast Valid 19z



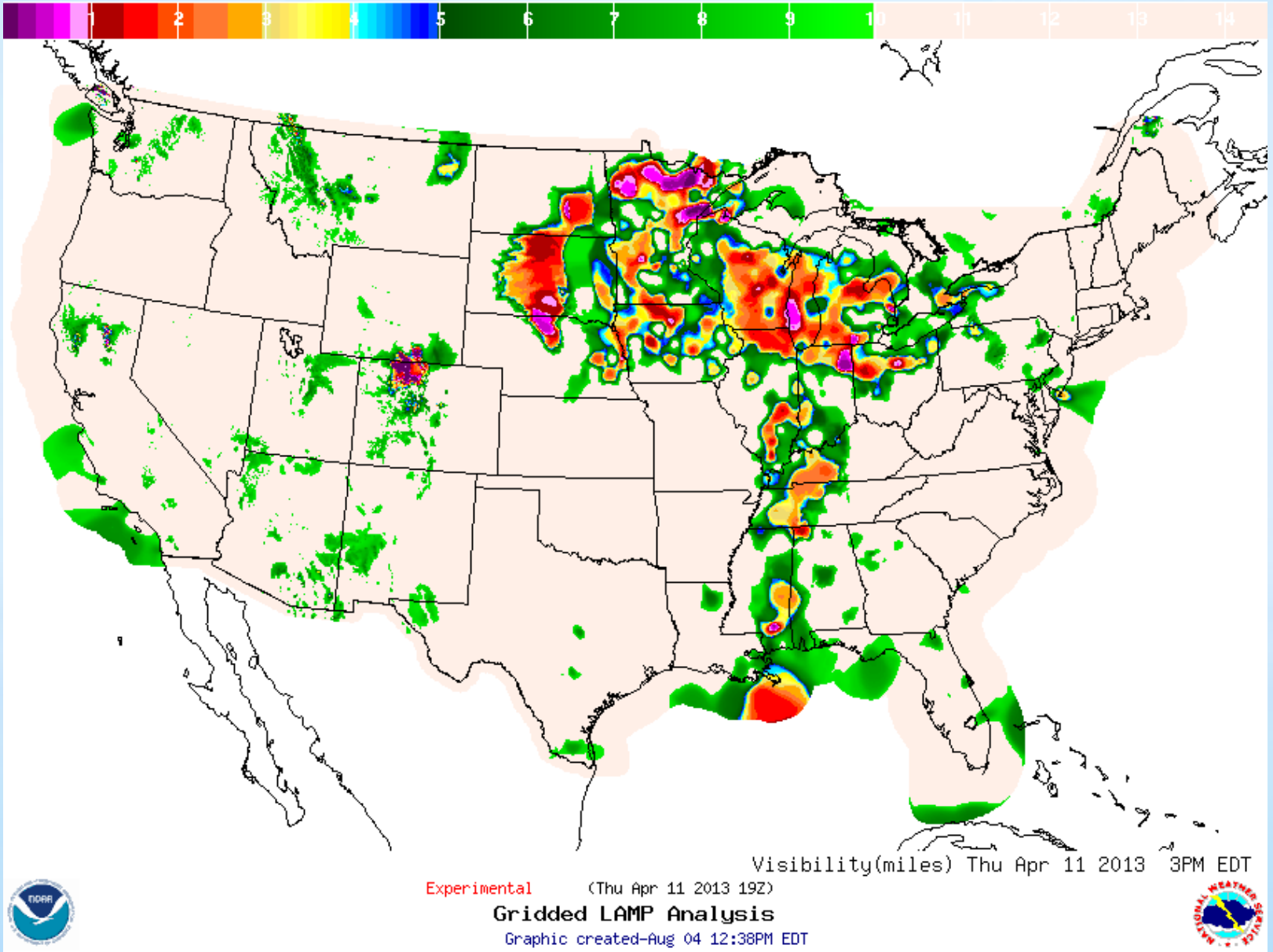
VIS: HRRR 8hr Forecast Valid 19z



VIS: LAMP+HRRR Meld 7hr Forecast Valid 19z

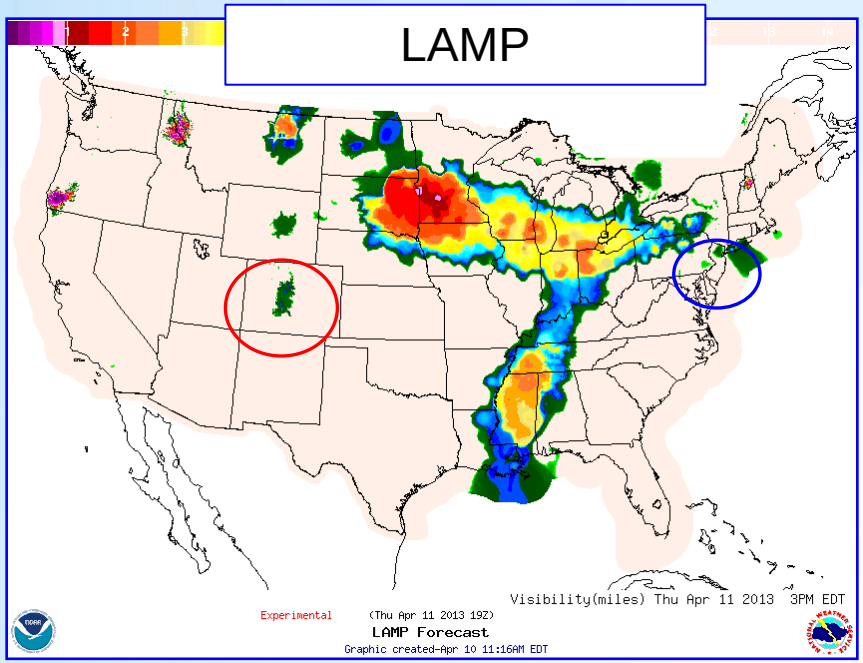


VIS: Verifying Observations at 19z

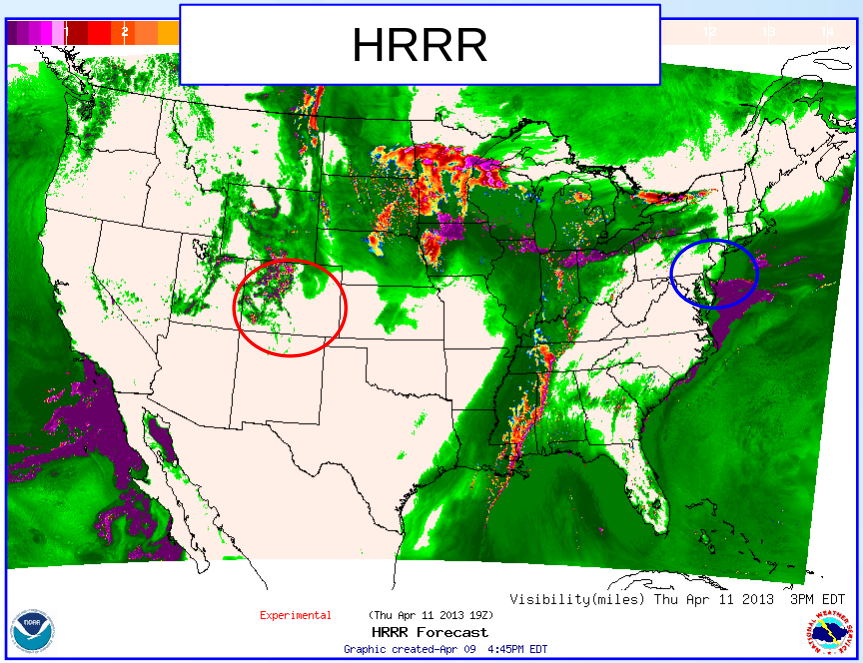


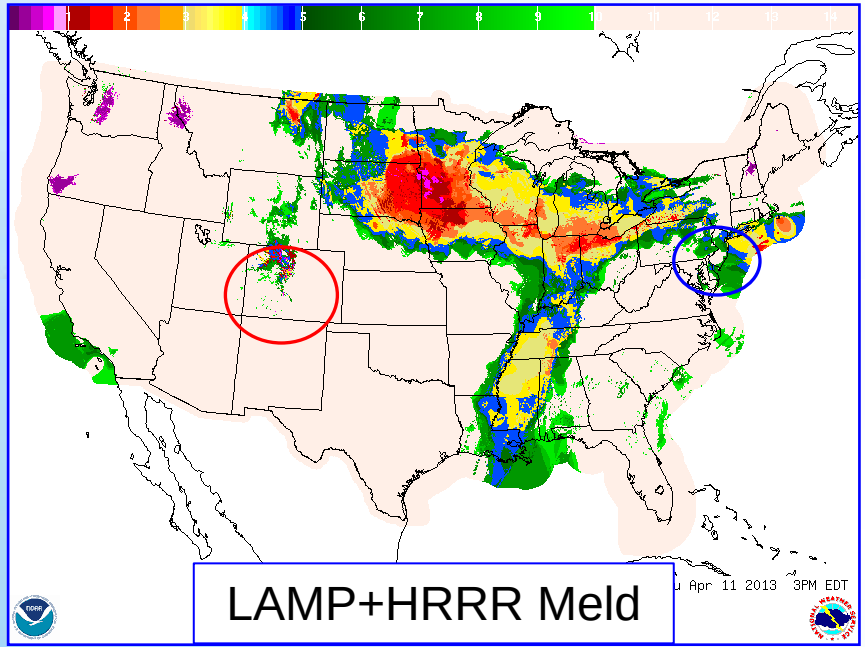
Visibility Case 4/11/2013 1200 UTC 7-h forecast

LAMP

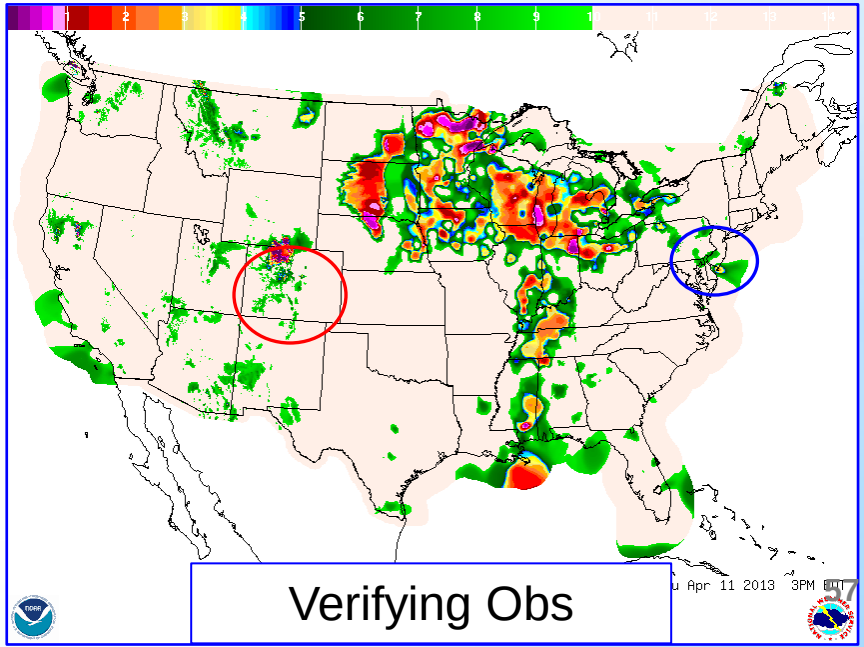


HRRR





LAMP+HRRR Meld



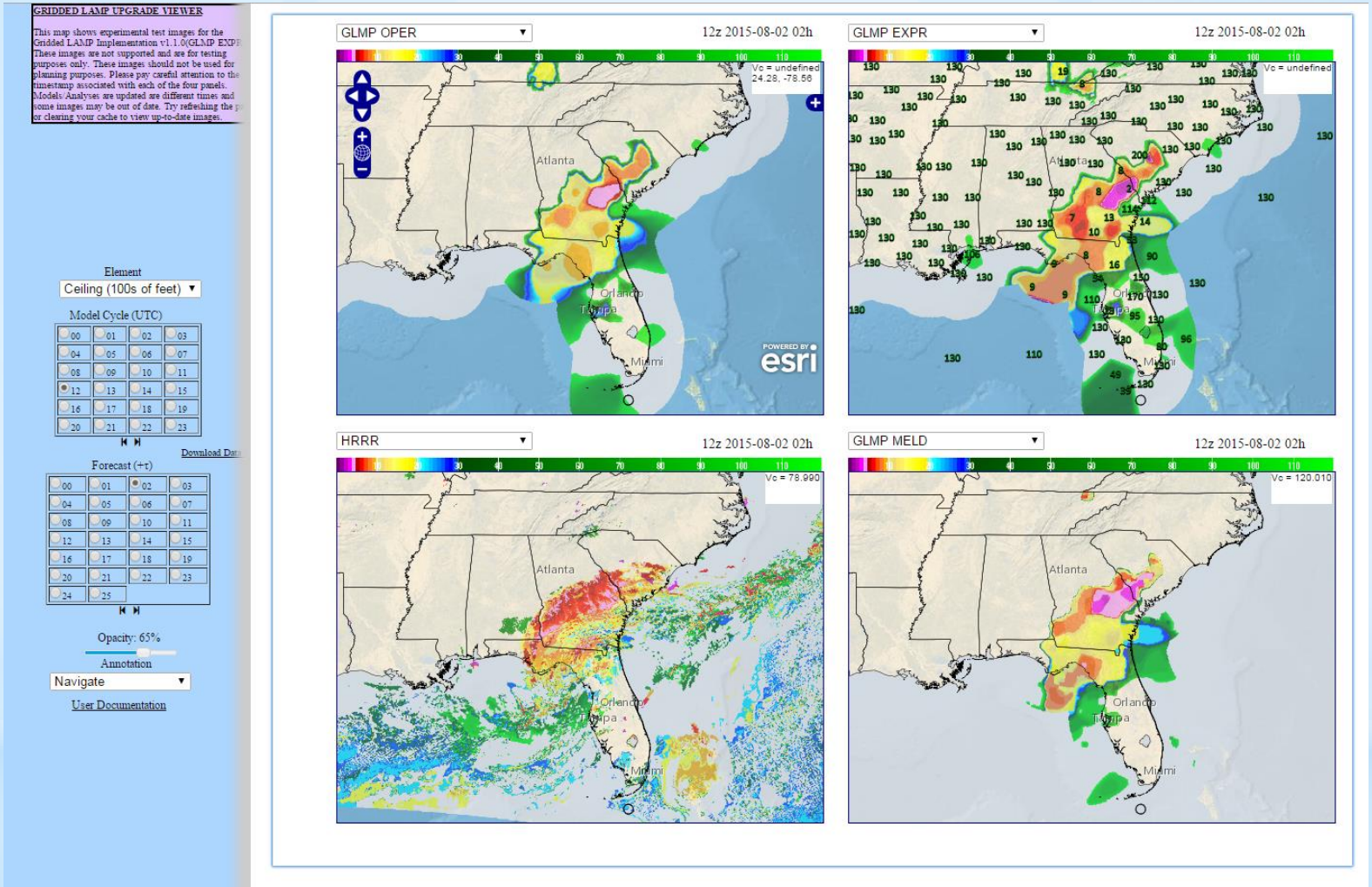
Verifying Obs

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: http://www.mdl.nws.noaa.gov/~rlamp/glmp_expr_viewer_meld.php



Website restricted to NWS only, accessible with LDAP credentials

Not supported 24x7; Cycles will be added as they become experimentally available

Summary

and

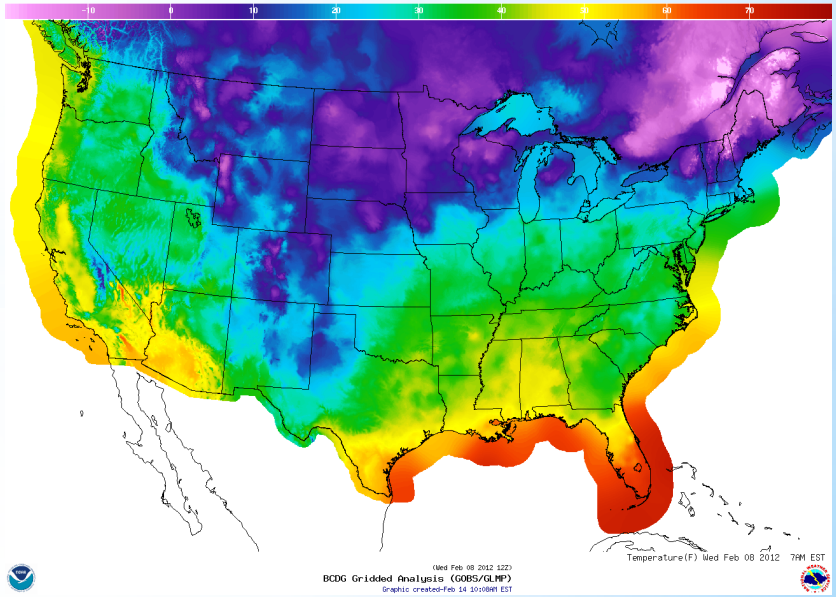
Future Plans

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:
    - Preliminary results show that post-processing HRRR and LAMP together yields very encouraging results.
    - 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:

  http://www.nws.noaa.gov/mdl/lamp/publications/lamp_hrrr_office_note_ON_15-1_7_31_15_final.pdf

- LAMP website: http://weather.gov/mdl/lamp

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Thank You!