

Utilizing Novel Object-based Methods in METplus to Assess Impactful Snow Events from the 2023-24 WWE

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WWE Seminar Series 3/12/2024

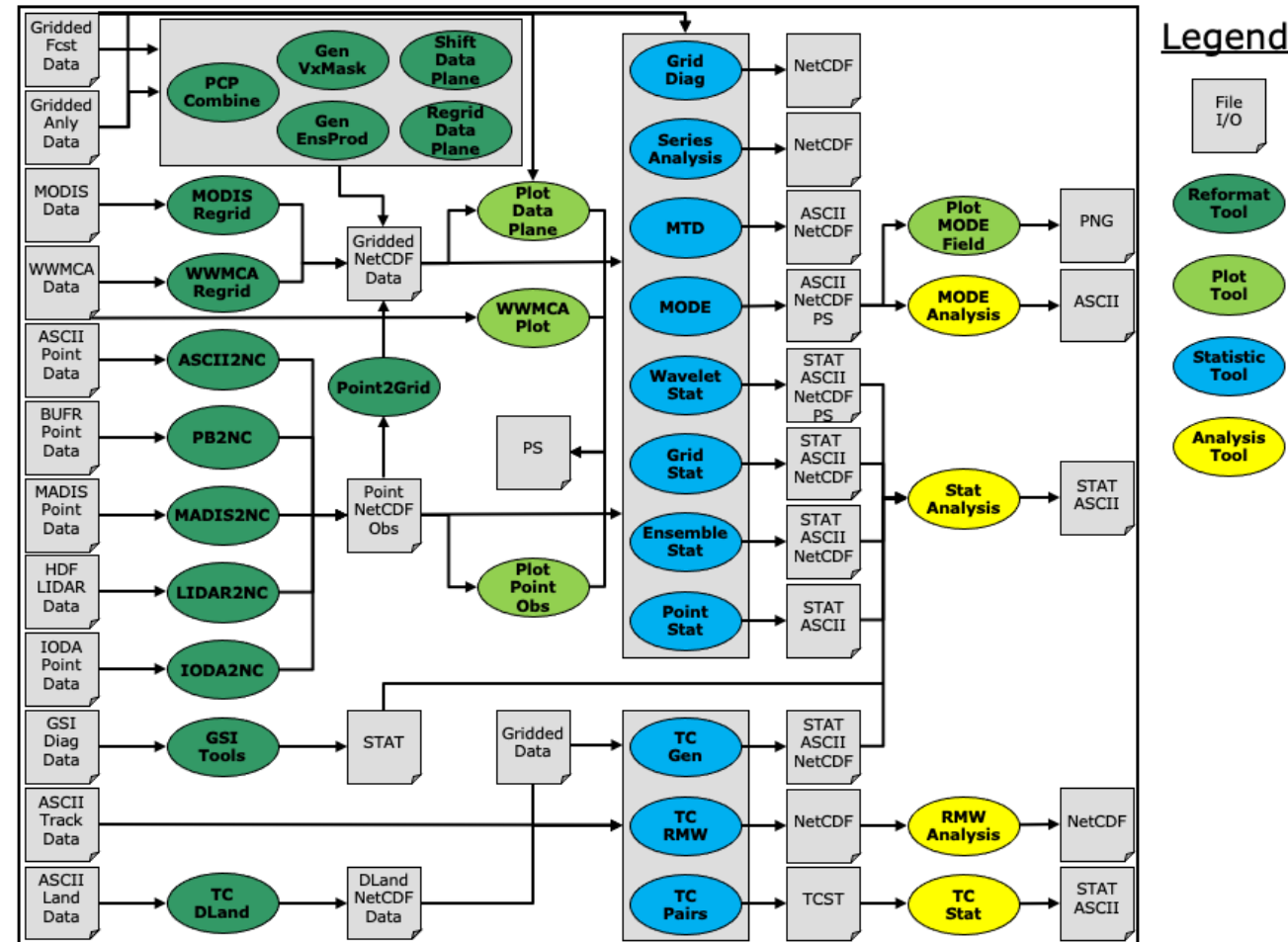
Project Background

The project is associated with the Joint Technology Transfer Initiative (JTII) collaborative effort between NCAR and WPC aimed to:

- Provide useful forecast tools for feature-driven evaluations of high-impact hydrometeorological events such as snowbands
- Explore, refine, and expand capabilities of several novel METplus use-cases
 - Forecast Consistency - Measure of stability of a forecast across forecast cycles
 - Difficulty Index - Provides guidance on the difficulty of a forecast based on ensemble mean/spread
 - Feature Relative - Provides statistics relative to a feature (e.g. snowband)
 - Multivariate MODE - Combines multiple variables to identify complex objects
- Integrate select use-cases into the WPC routine model evaluation

Enhanced Model Evaluation Tools (METplus)

- METplus is a suite of python wrappers aimed to enhance a user's ability to set up and run the MET verification software tools.
 - Ingests various types of data
 - Preprocessing utilities
 - Evaluation functions
 - Analysis tools
 - Plotting capabilities
- METplus has been adopted as the official verification software for various institutions
- Provides training tutorials/workshops



Object-based Methods

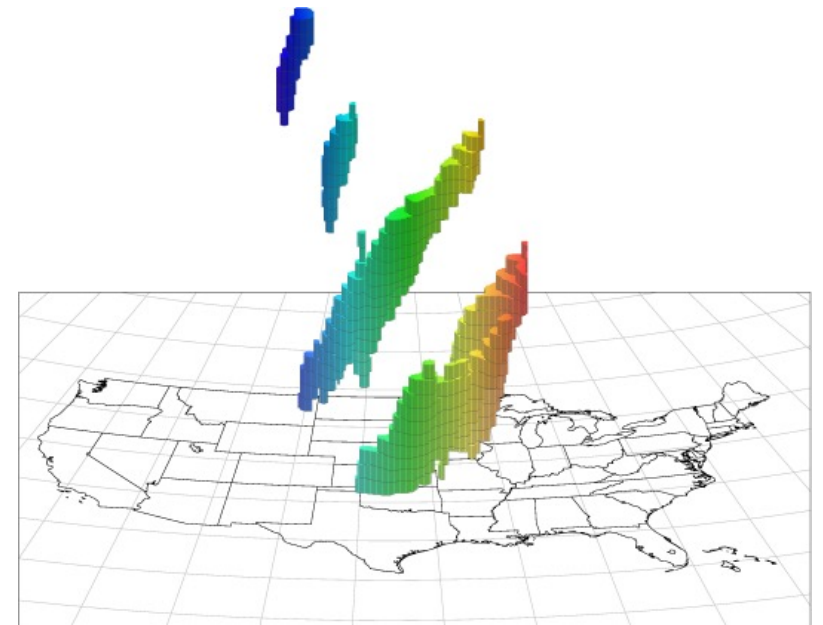
Spatial verification methods (MODE/MTD) are used for identifying and tracking coherent objects

MODE

- Identifies 2D objects from a single field, based on a user-defined threshold
- Matches forecast and observation objects
- Allows for merging objects
- Includes evaluation of size and displacement errors

MTD

- Identifies 3D objects, tracking it through time



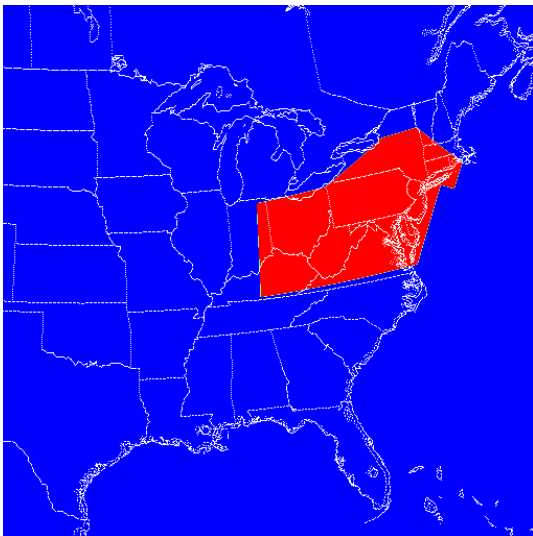
Forecast Consistency

Forecast Consistency Use-case

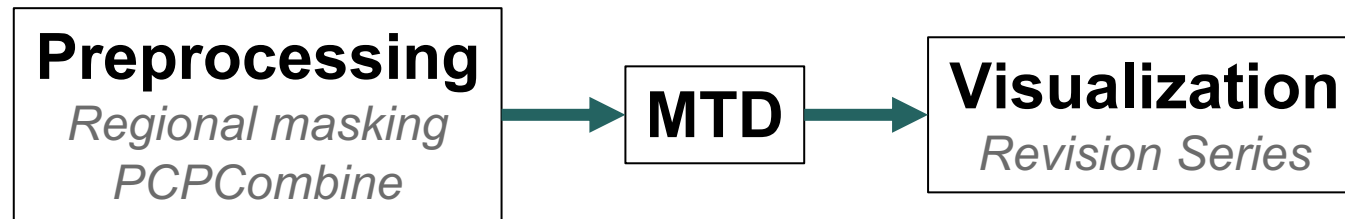
Provides a measure of stability of a forecast as the event nears

- MTD is run in reverse with valid hour kept constant
- Revisions are computed from the 2D MTD attributes (e.g. area or intensity)
- If the forecast remains consistent as the event nears, then there is more confidence in that forecast
 - Consistency \neq Accurate (independent of observations)

Red: Regional Mask



Workflow



MTD Configs

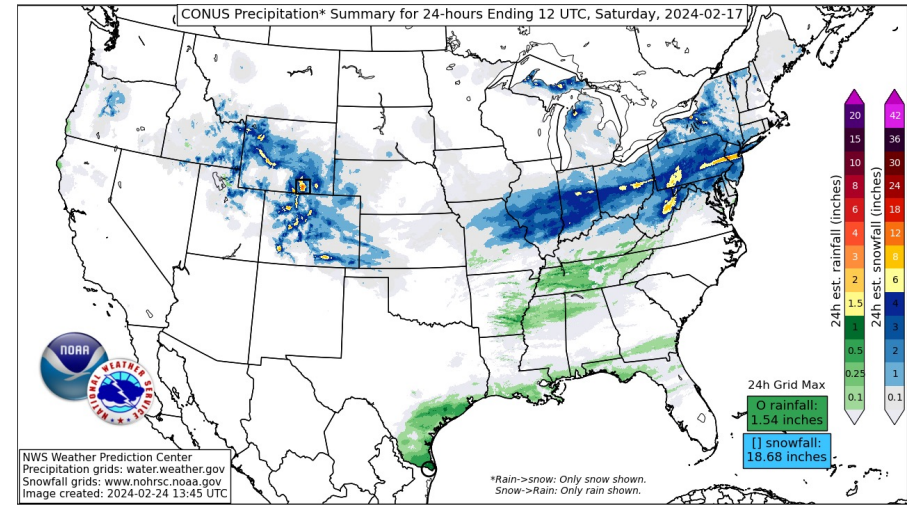
- Conv thresh: 24h ASNOW ≥ 1 in
- Conv rad: 5 grid points
- Min vol: 1000 grid points

Forecast Consistency

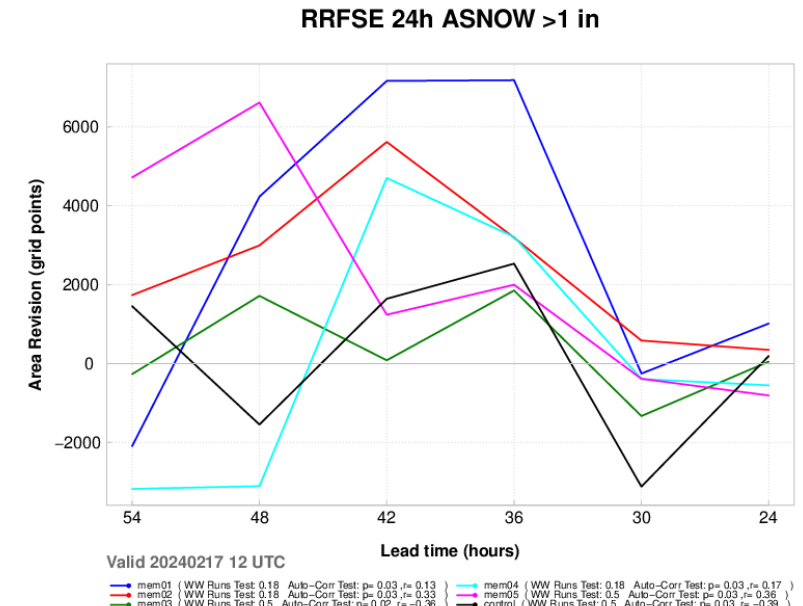
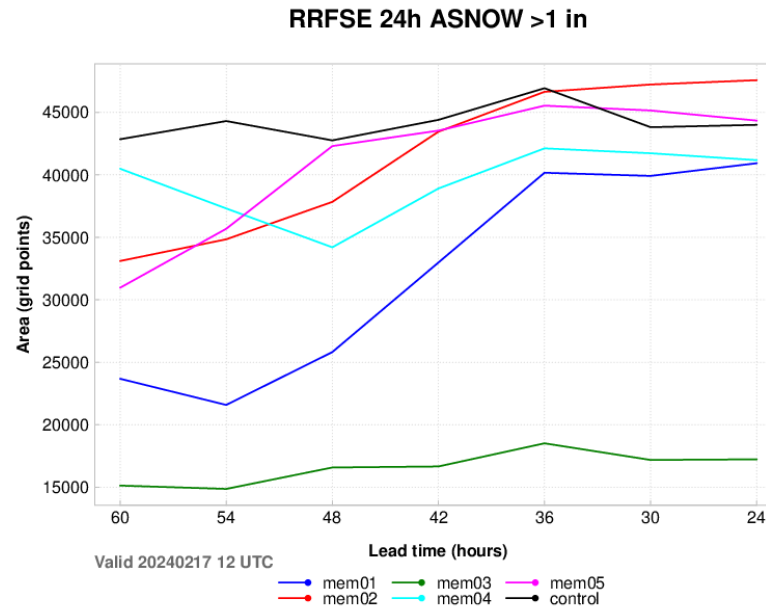
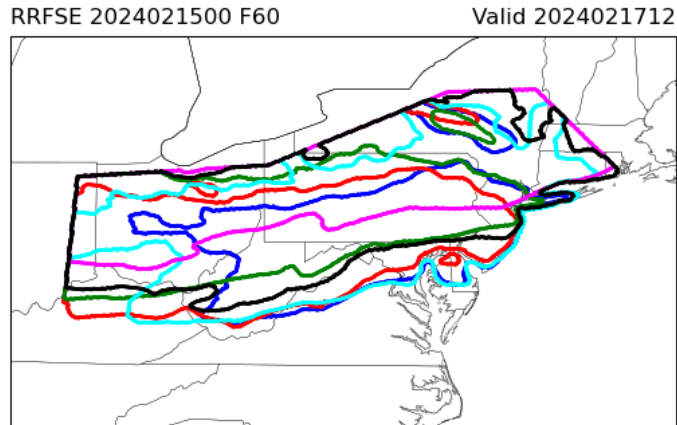
Valid: 20240217 1200 UTC

- Midwest/Northeast case producing a narrow band of enhanced snowfall
 - 6-12 inches snow
 - High SLR 25:1

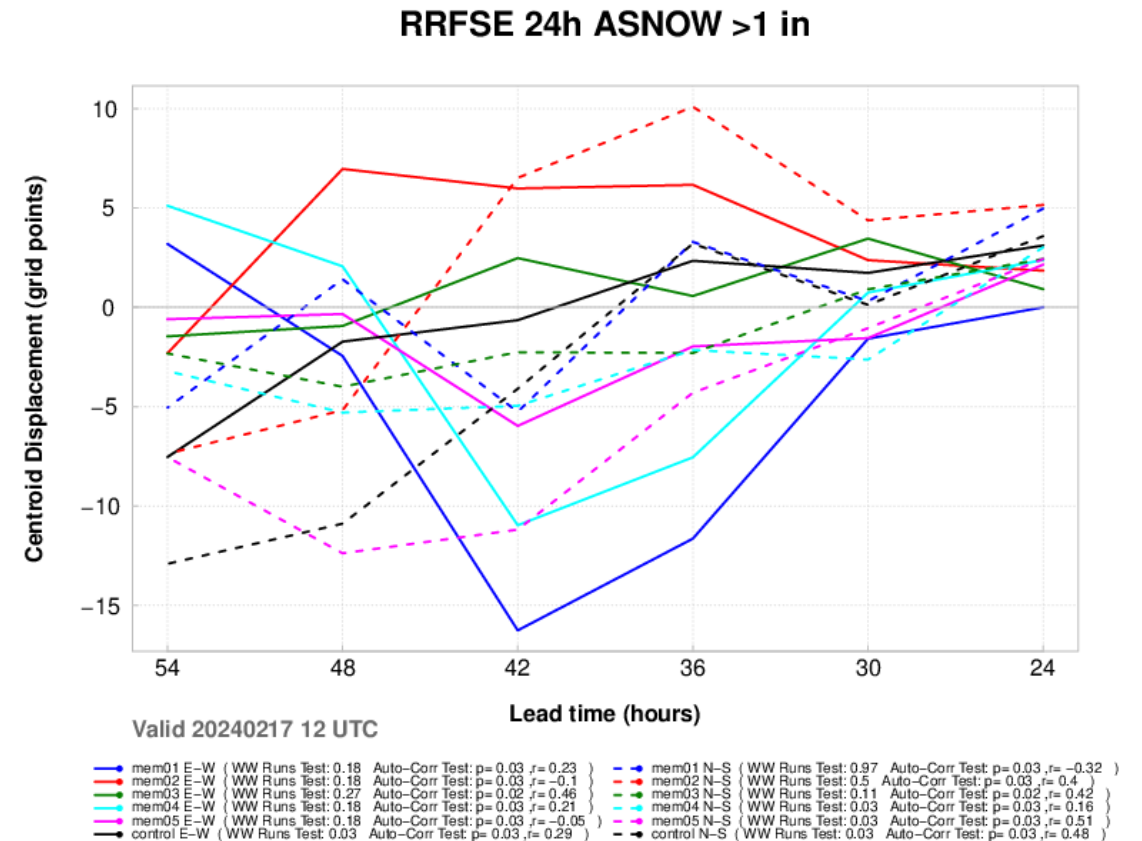
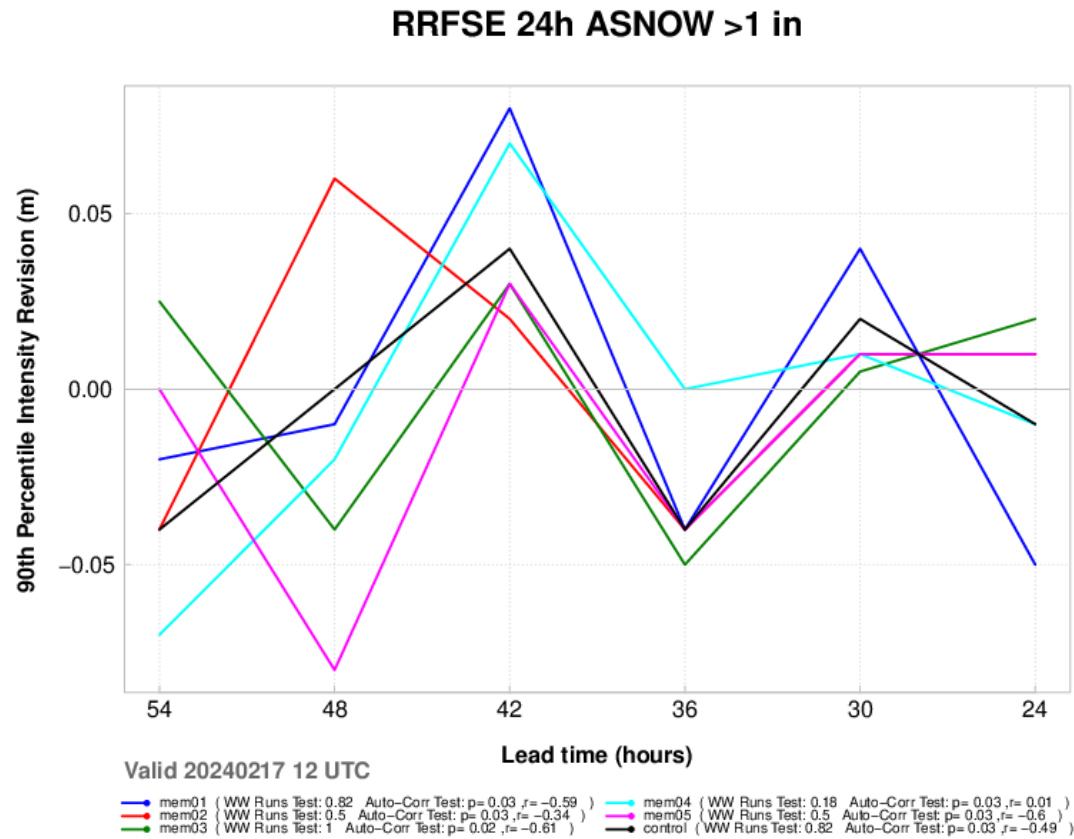
24h period ending February 17, 2024 12 UTC



Consistency of 24h accumulations updated every 6 hours



Forecast Consistency



- Two hypothesis tests can be used to test for randomness
 - Wald-Wolfowitz runs test
 - Autocorrelation statistic

Difficulty Index

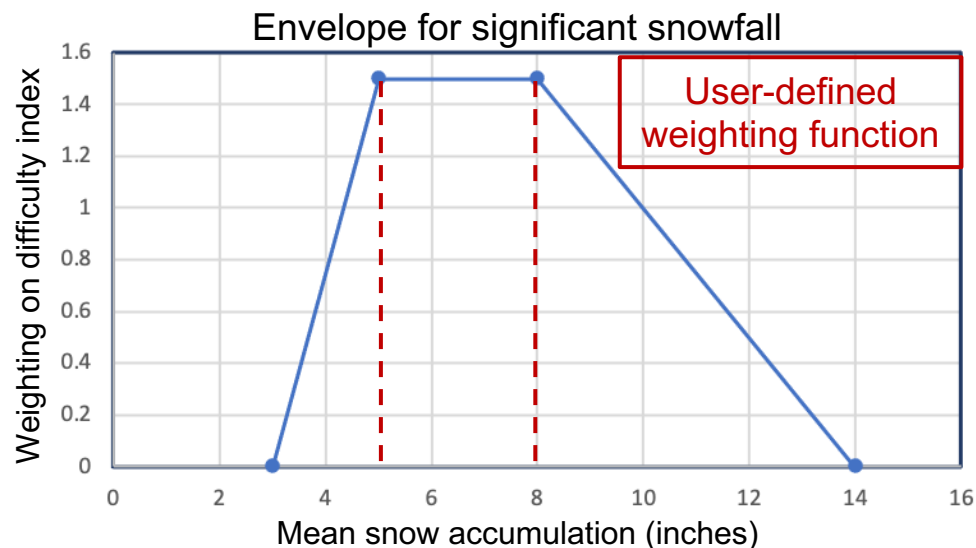
Difficulty Index Use-case

Provides guidance on the difficulty of a forecast decision based on ensemble mean/spread in a graphical manner

Two main factors make a decision difficult.

1. The proximity of the ensemble mean forecast to a user-specified decision threshold
2. The forecast precision or ensemble spread

Significant snowfall in a 24 hour period
(8 inches in 24 hours)

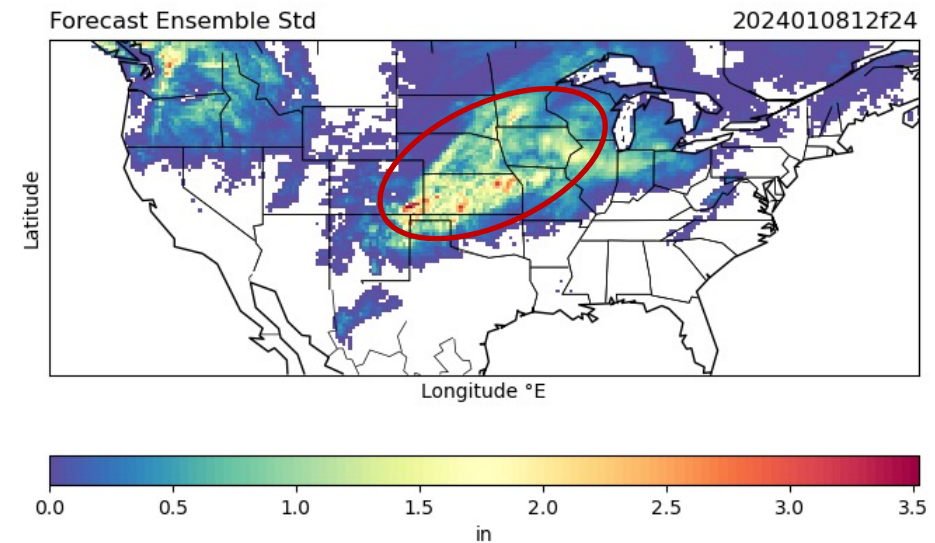
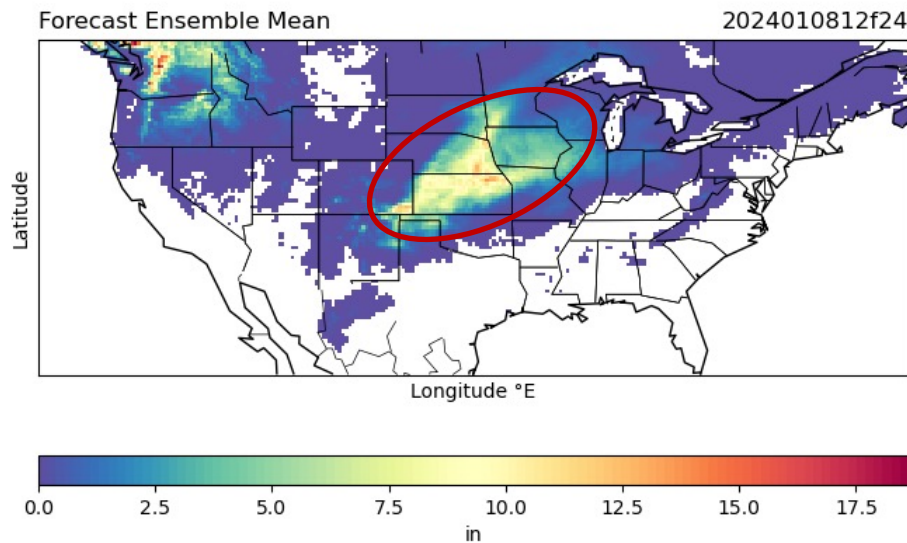
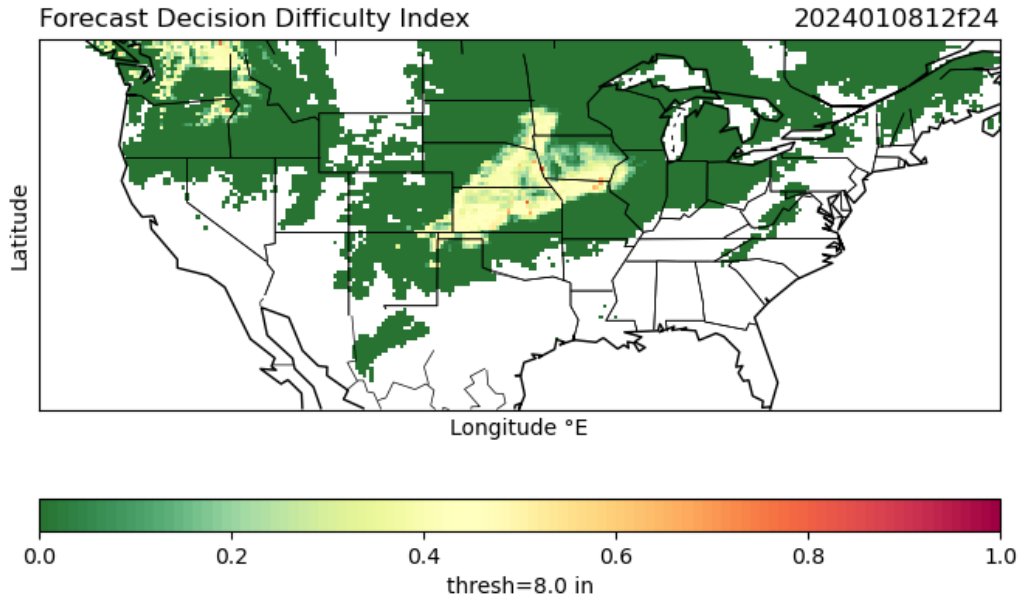


Workflow

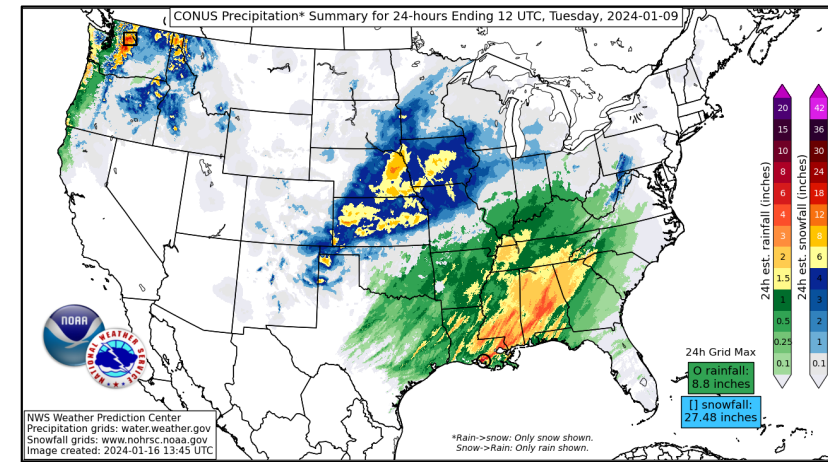


Difficulty of 8in in 24 hours

24h period ending 20240109 1200 UTC



Ending January 9, 2024 12 UTC



- Heavy snow (6-12") from mesoscale banding across plains
- Region with ensemble mean ~8 inches and highest spread produces moderate difficulty

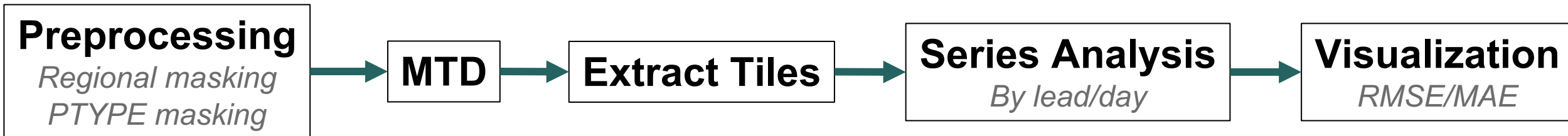
Feature Relative

Feature Relative Use-case

Provides statistics relative to a specific feature

- Useful for identifying systematic biases or studying known biases
- Intended to run on suite of relevant cases

Workflow



MET Configurations

MTD

- Conv thresh: 1h APCP \geq 2.54 mm
- Conv rad: 5 grid points
- Min vol: 1000 grid points

Extract Tiles

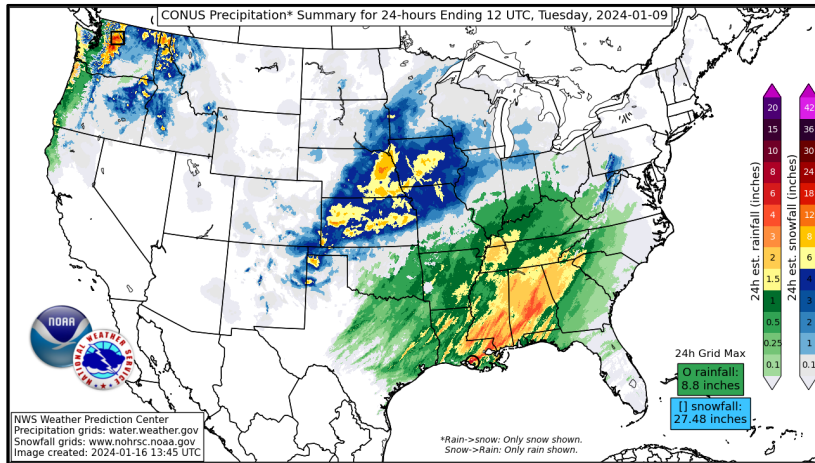
- 30° x 30° tile
- 0.25° grid spacing

Great Plains/Midwest Cases

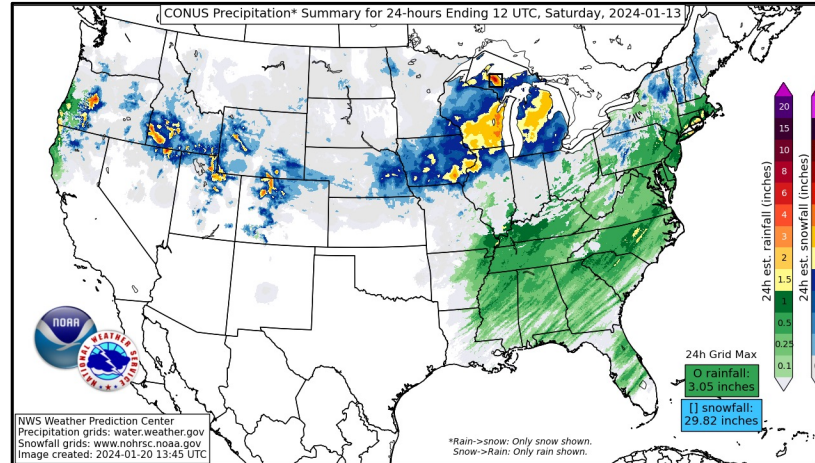
Mesoscale banding and blizzard conditions developing over the Great Plains region

- Cases: January 9-10, 2024 and January 12-14 2024
- Only use the RRFS control member

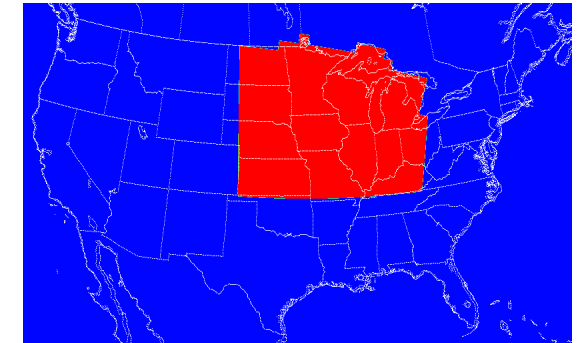
24h period ending 20240109 12 UTC



24h period ending 20240113 12 UTC



Red: Mask Region

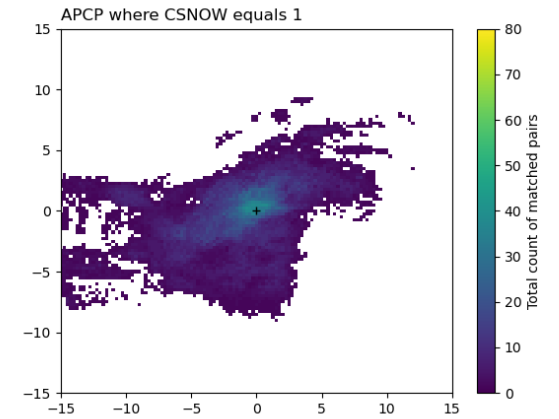


- Applied regional mask to eliminate any snow objects over the west

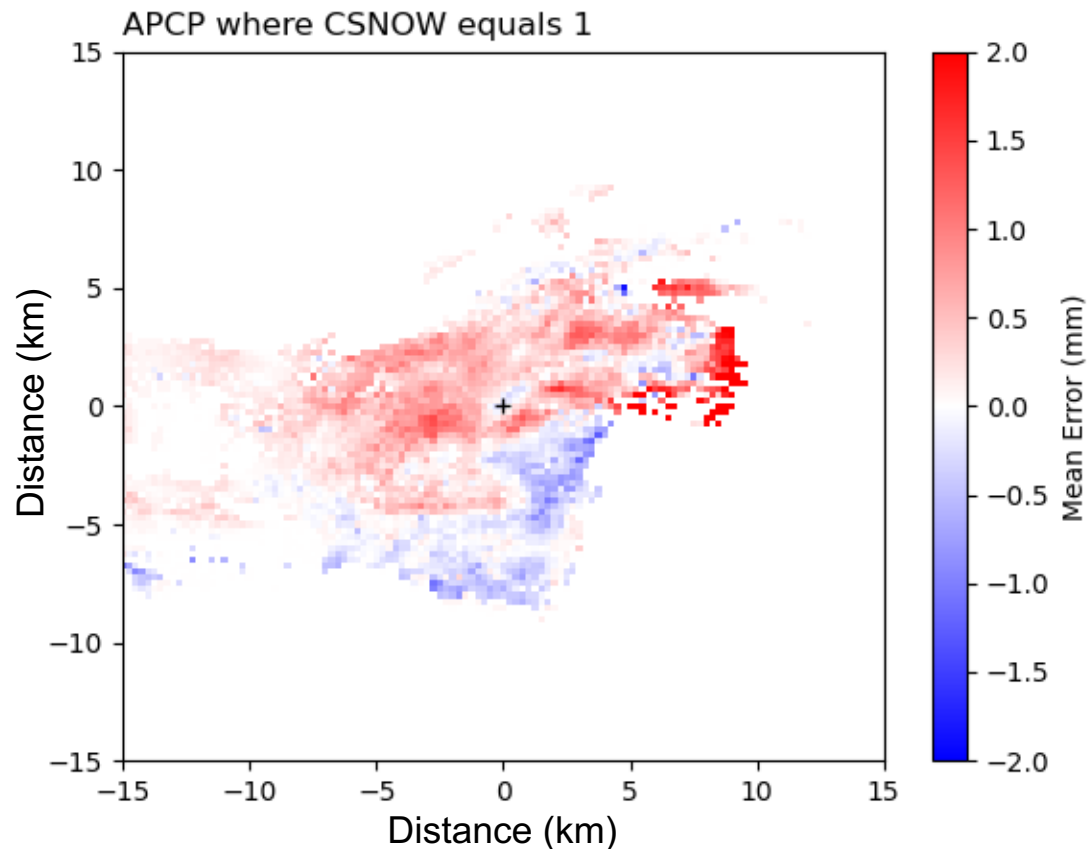
Feature Relative

- Accumulated precipitation ≥ 0.1 inches
 - Masked with categorical snow over the northeast
 - Compared to MRMS observation

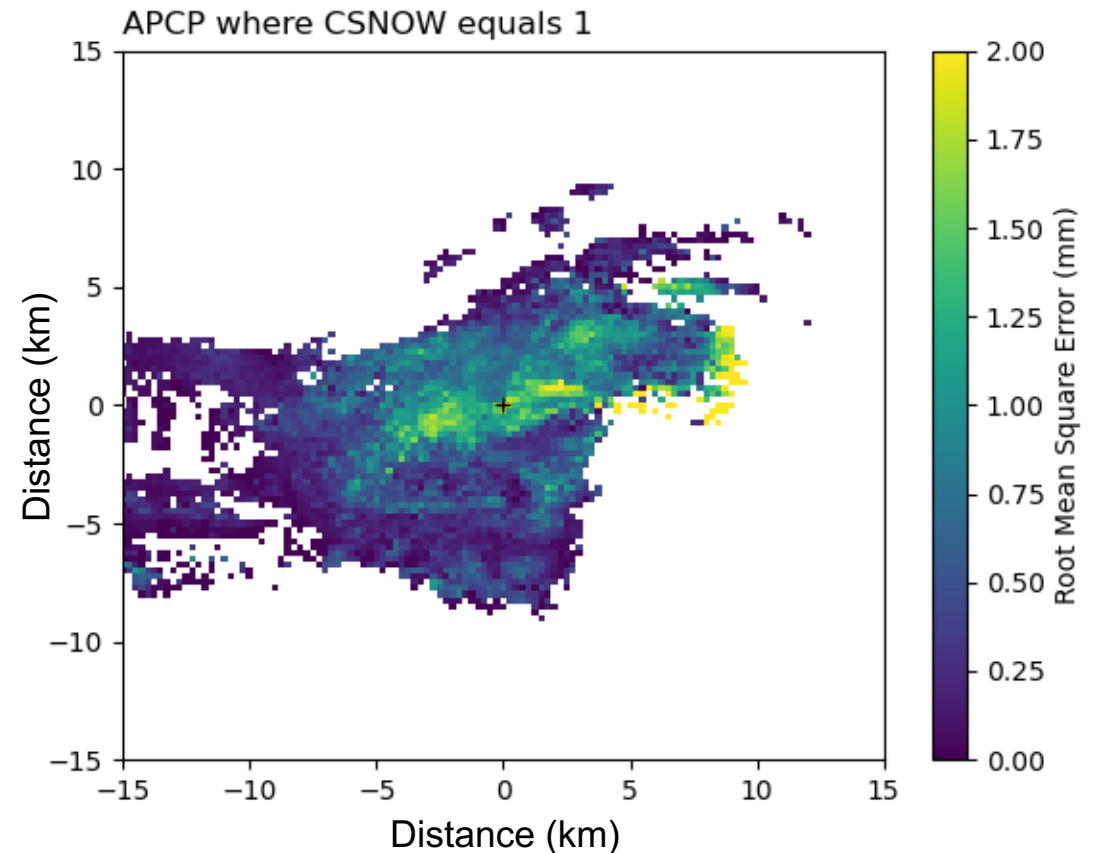
Total Counts



Mean Error (mm)

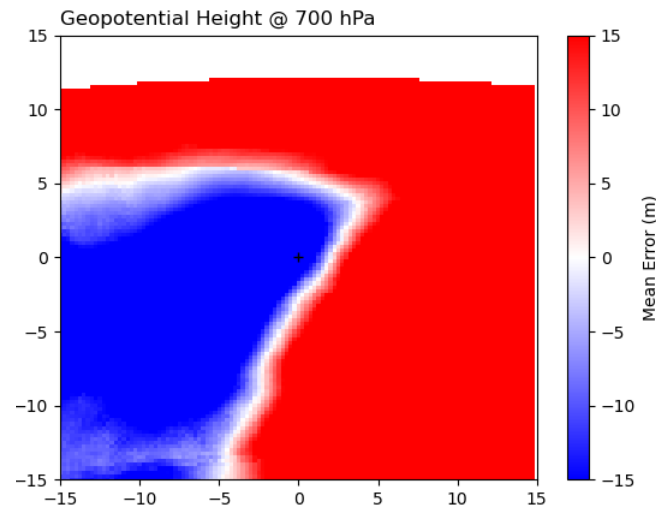
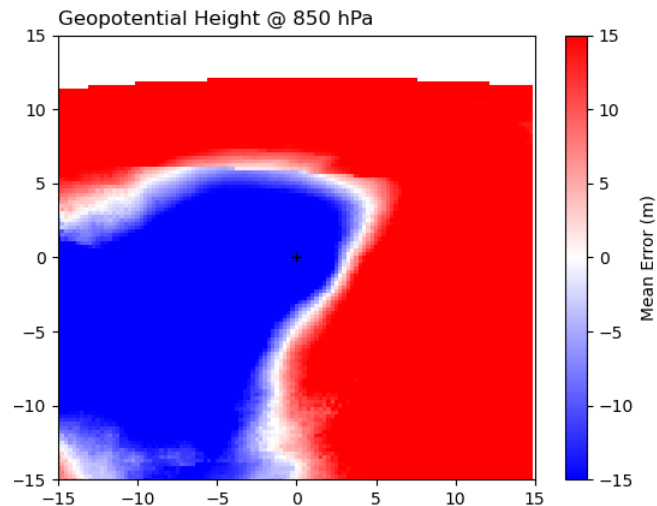
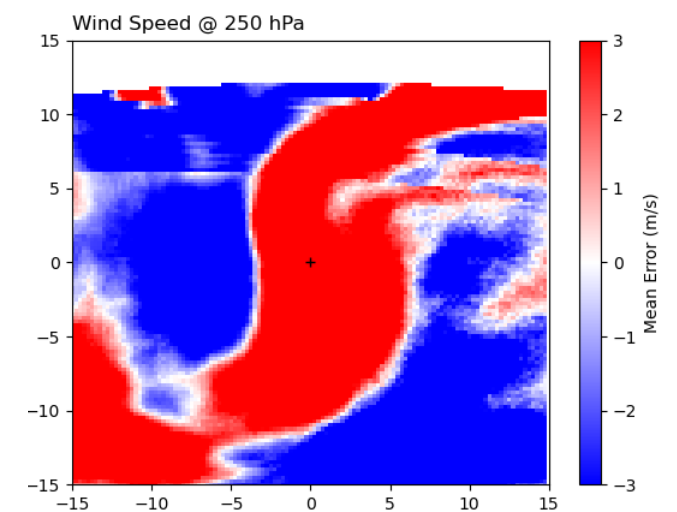
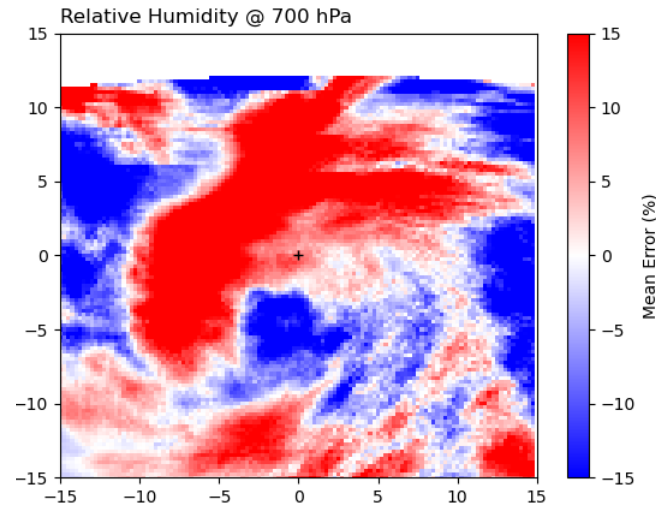
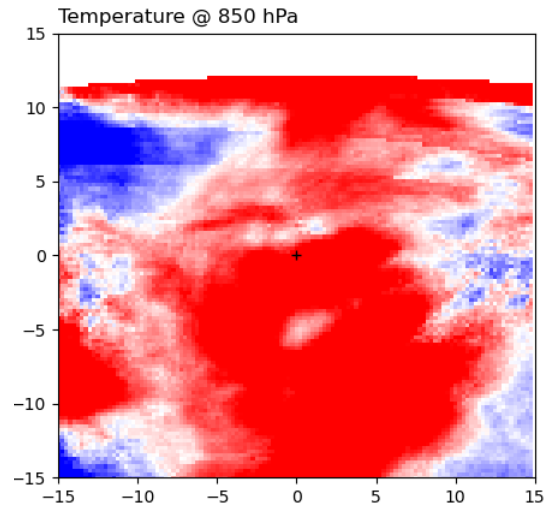


RMSE (mm)



Feature Relative

Comparisons to RRFS F00 control



Forecasted...

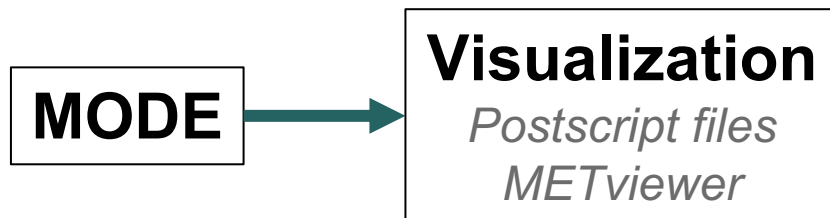
- Temps at 850 higher over the region
- RH at 700 higher in the area north/west
- Heights consistently too low in low to mid-layers over the center and southwest but too high to the east
- Winds at 250 high to the north and south

Multivariate MODE

Multivariate MODE Ues-case

- Combines multiple variables to identify complex objects
 - Objects are defined separately for each input field with separate configurations for each
- Runs MODE on 2+ variables to identify based on a user-defined logical expression
 - Logic for determining the super object can include 'intersection' or 'union'

Workflow



Example (Blizzard)

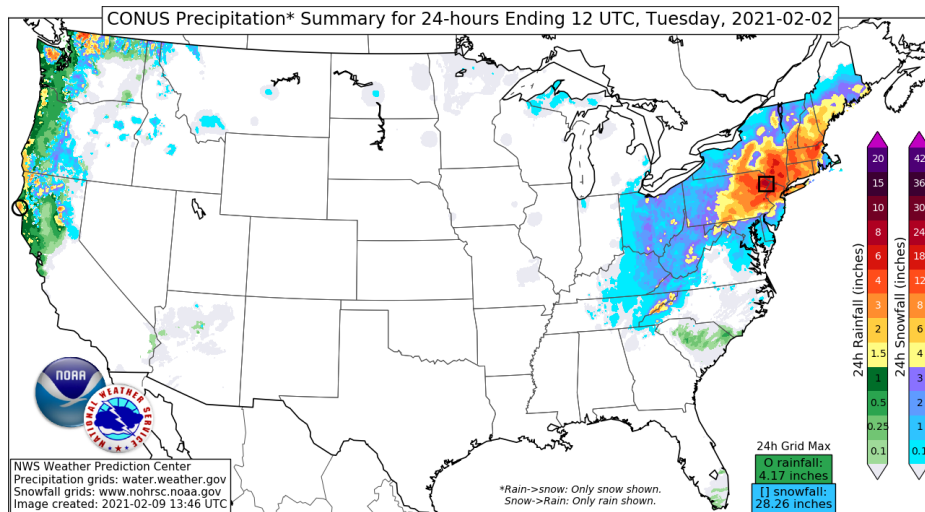
*MODE_MULTIVAR_LOGIC = #1 && #2 && #3

1. Precipitation type = snow
2. Wind speed \geq 35 mph
3. Visibility \leq $\frac{1}{4}$ mile

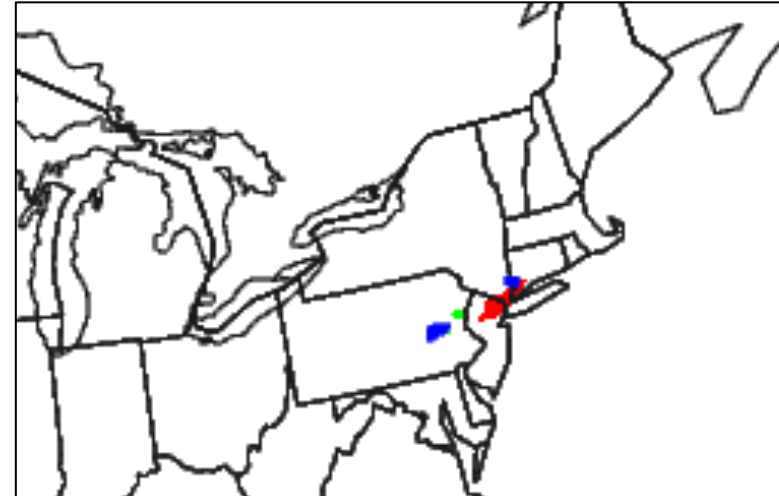
Multivariate MODE - Blizzard-like Features

Init: 20210201 0000 UTC

- Heavy banded snowfall events with blizzard conditions reported



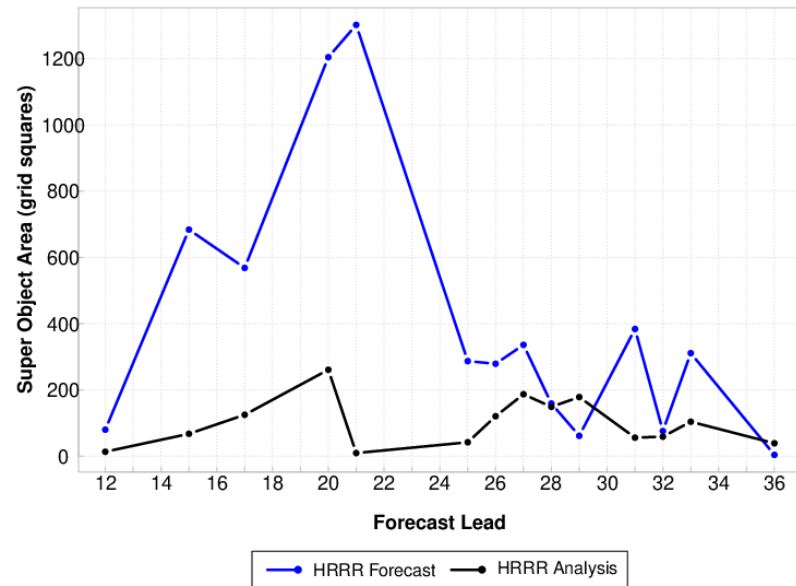
Forecast Objects with Observation Outlines



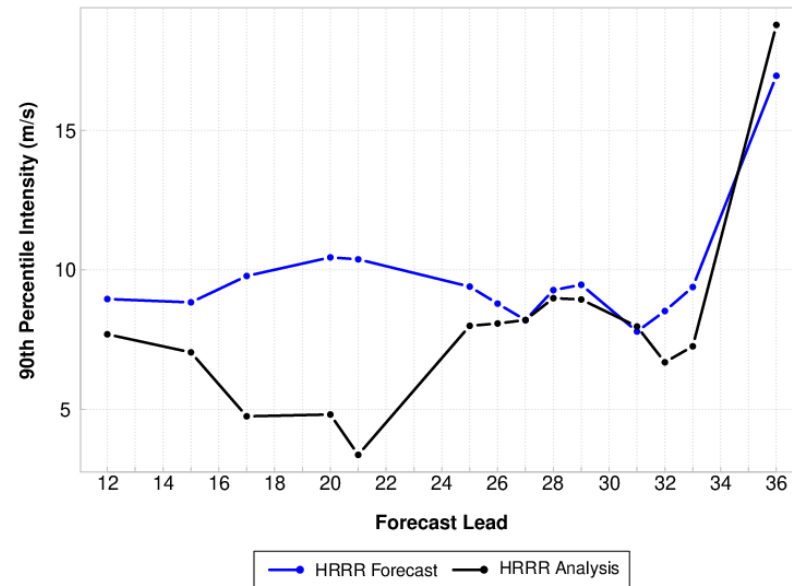
- Blizzard-like objects identified in forecast (solid) and observation (blue outlines) field using reduced thresholds
 - Winds ≥ 20 mph
 - Visibility $\leq \frac{1}{2}$ mile

Multivariate MODE

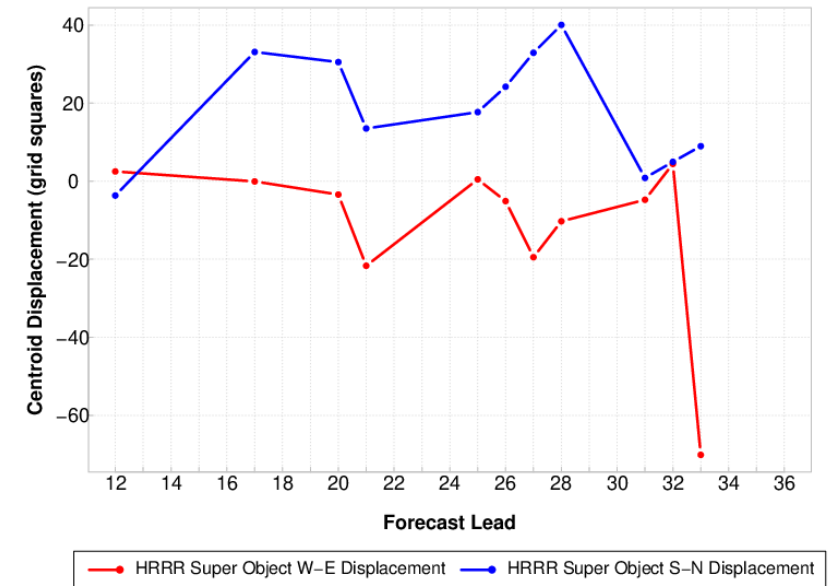
Object Area



90th Percentile Intensity Winds ≥ 20 mph



Centroid Displacement



- Forecast objects have a larger area and higher intensity in the first 12 hours
- Centroid displacement shows a northwestern displacement from the observations

Summary

- As part of the JTTI effort, numerous developments and enhancements have been contributed to existing METplus tools and methods for the purpose of evaluating high-impact winter features.
- The use-cases employ feature-based methods for evaluating hydrometeorological events such as heavy banded snow or blizzard events.
- A wide range of applications are presented
 - Evaluation of systematic biases
 - Providing confidence in a forecast through consistency
 - Informing of a difficult forecast decision
 - Identifying complex features from multiple fields
- Contributed numerous enhancements to METplus development
 - Added MvMODE use-case example
- Plan to contribute select METplus use-cases into the WPC routine model evaluation