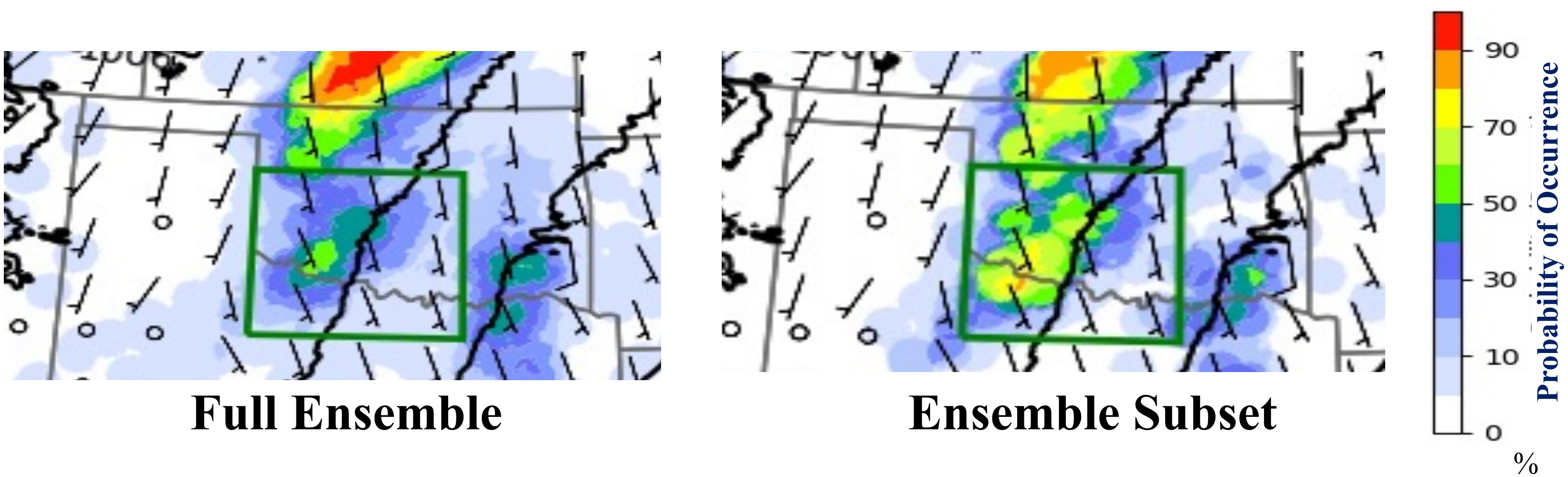
Improving High-Impact Weather Forecasts through Real-Time Ensemble Adjustment Techniques

Brian Ancell
Texas Tech University



Full Ensemble

Ensemble Subset

Ensemble Adjustment: The Big Picture

Ensemble Adjustment: Modification of an ensemble in some way to improve a forecast

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Focus: Forecast Skill of Specific High-Impact Forecasts

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Ensemble Adjustment: Modification of an ensemble in some way to improve a **specific aspect of a forecast**

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Redefine Ensemble Adjustment

Focus: Forecast Skill of Specific High-Impact Forecasts

Ensemble Adjustment: Modification of an ensemble in some way to improve a **specific aspect of a forecast**

→ **Can we use ensemble information specific to high-impact forecasts to improve their skill?**

Motivation: Simple Example

→ Consider an ensemble forecast distribution, one member as truth, involving some high-impact forecast

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1) Choose half the members with lowest IC errors against all state variables
(no knowledge of future)

→ Provides **slight** reduction in error of the event (and other forecast aspects)

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Experiment 2

1) Apply linear regression of forecast event onto ICs
2) Rank regression coefficients
3) Choose half the members with lowest IC errors against state variables with the highest regression coefficients
(applies knowledge of future)

→ Provides **substantial** reduction in error of the event (at the expense of other forecast aspects → "Dead-End Forecast")

Ancell (2016), MWR

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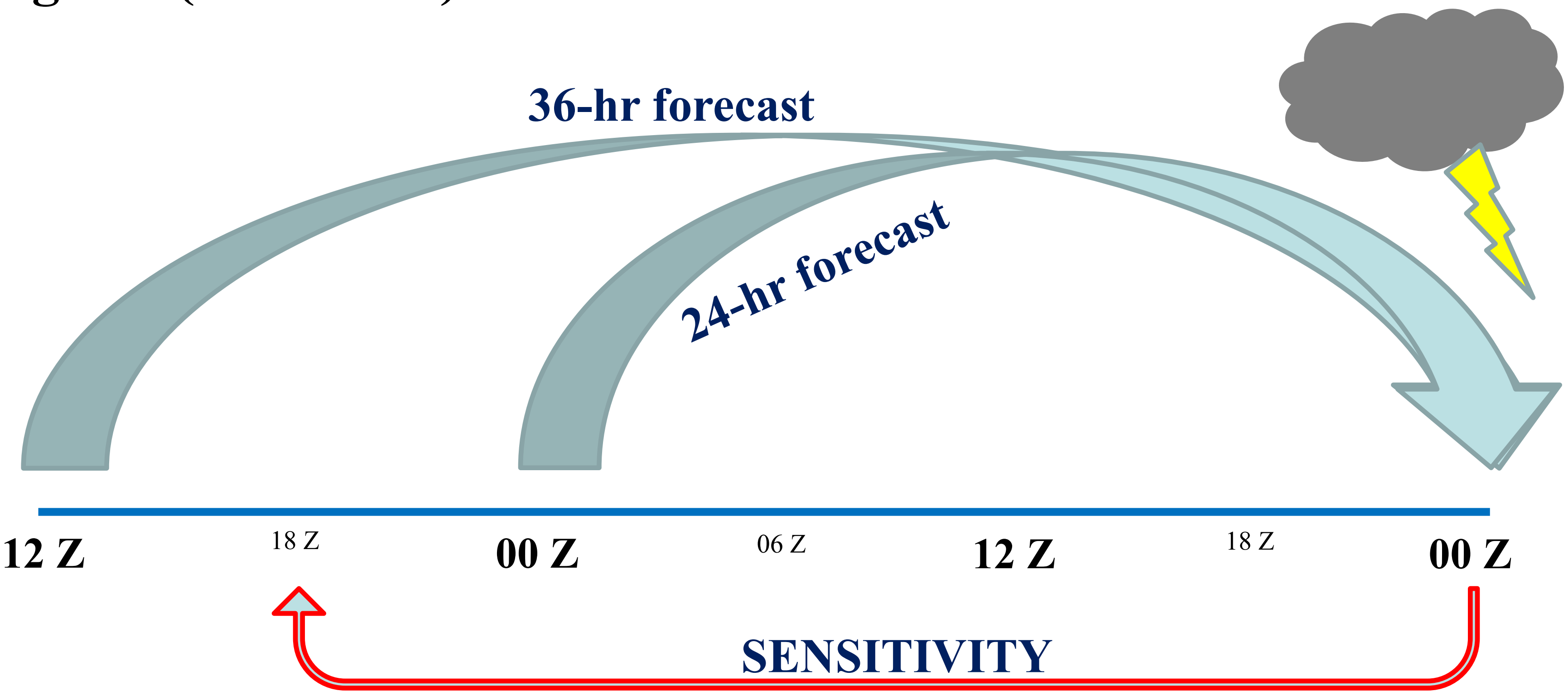
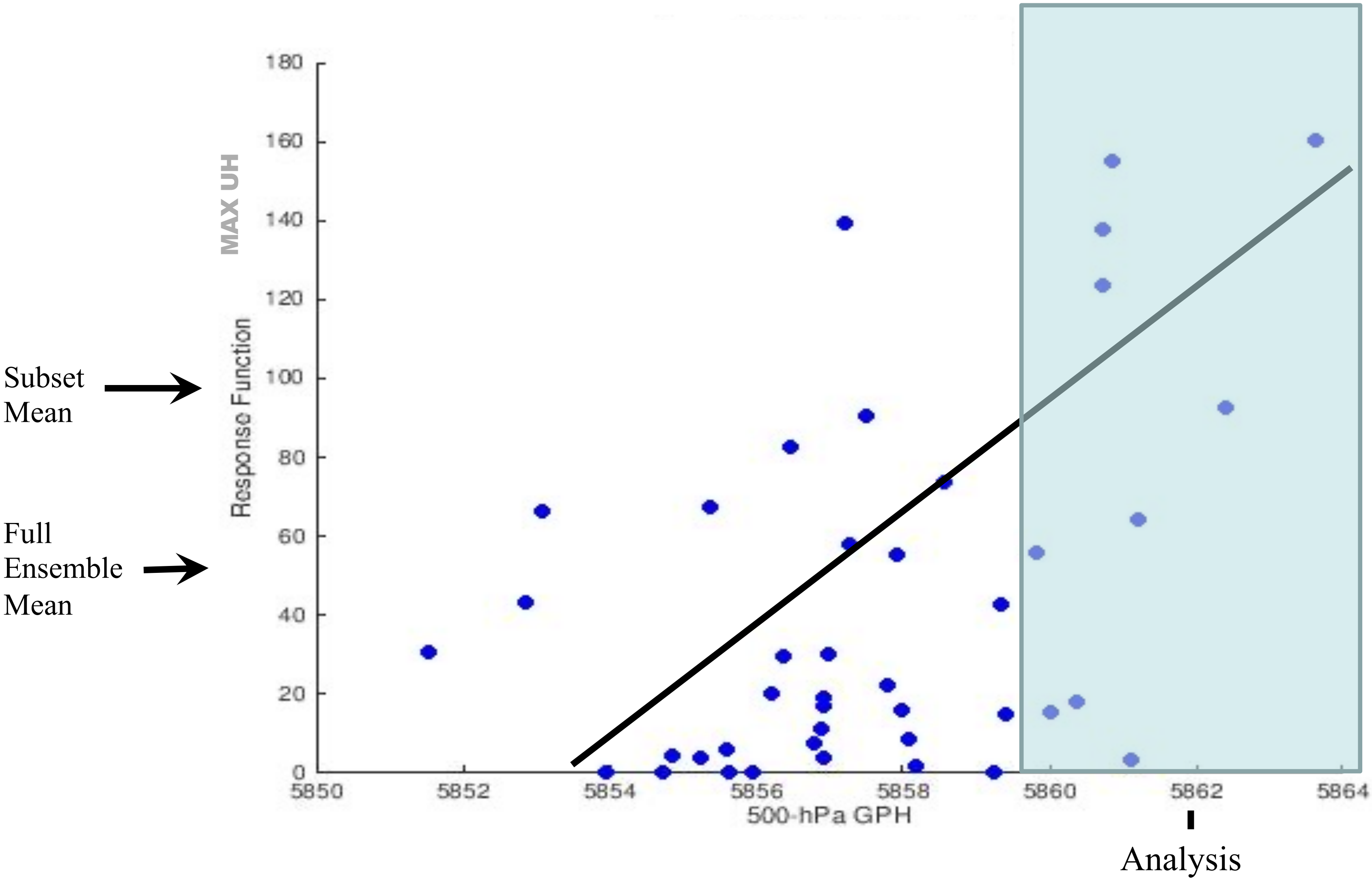
Ensemble Adjustment: The Big Picture

<u>One Ensemble Adjustment Technique: </u>Ensemble Sensitivity-Based Subsetting

→ Choose ensemble members with the smallest errors in sensitive regions (the subset)

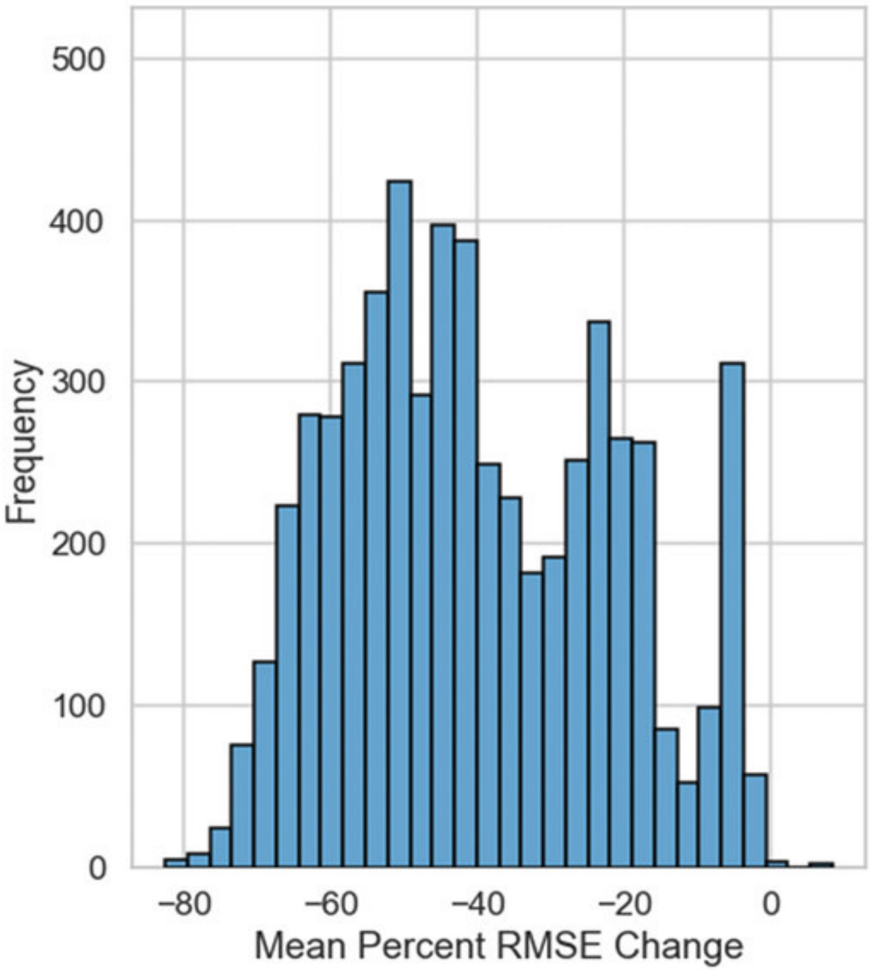


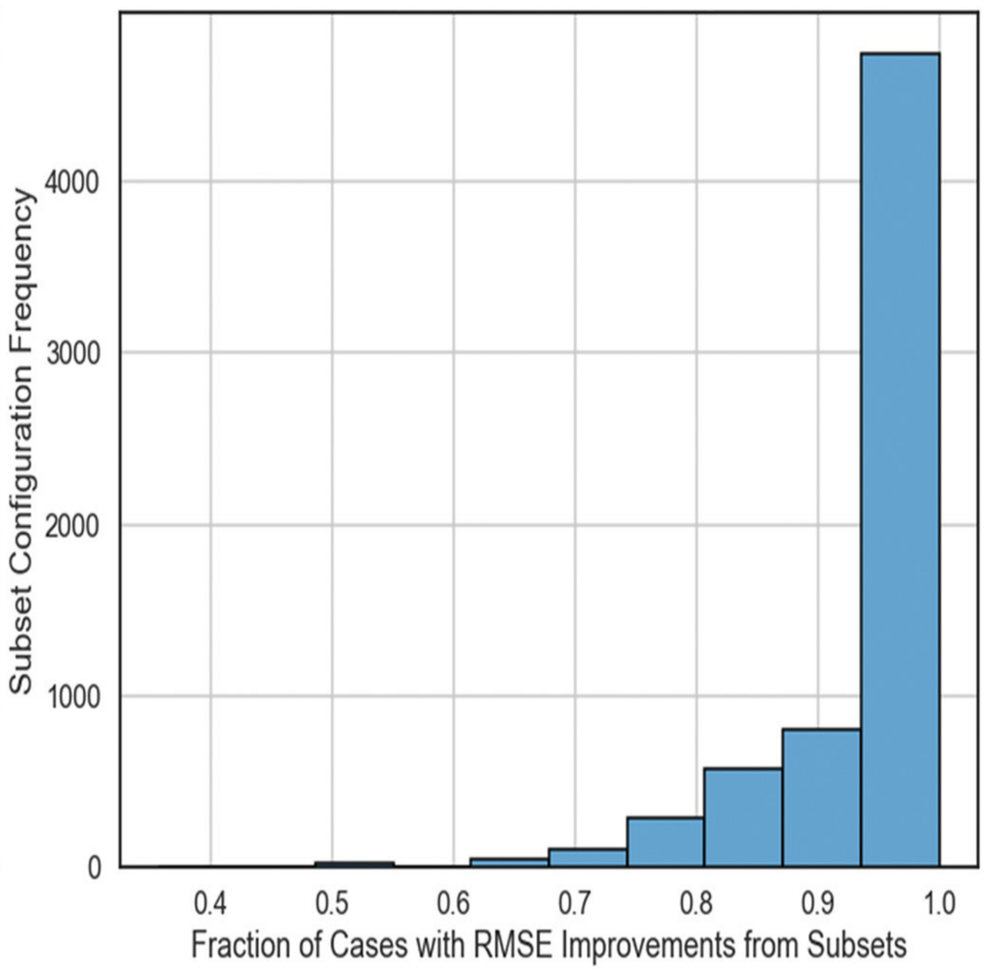
Ensemble Sensitivity-Based Subsetting



Ensemble Sensitivity-Based Subsetting

Idealized Experiments (Isolates the effects of nonlinearity)

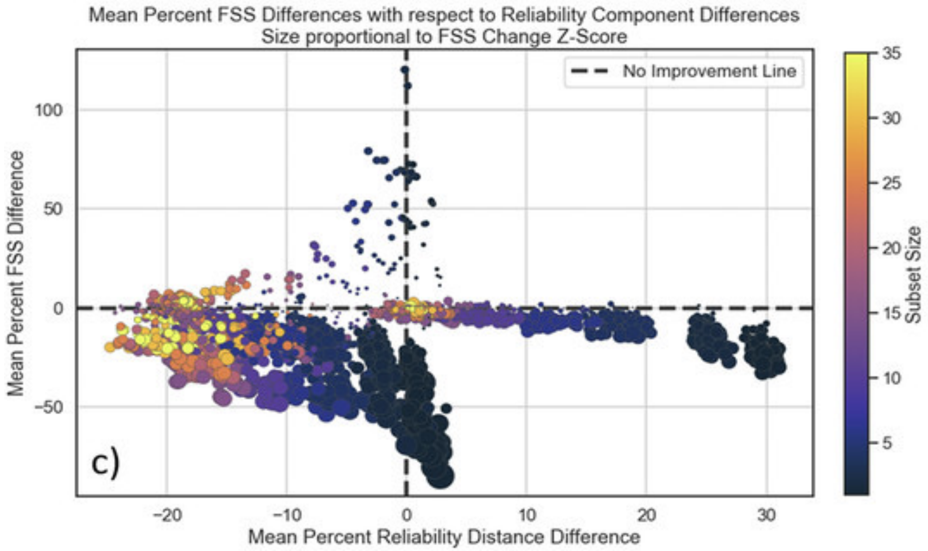




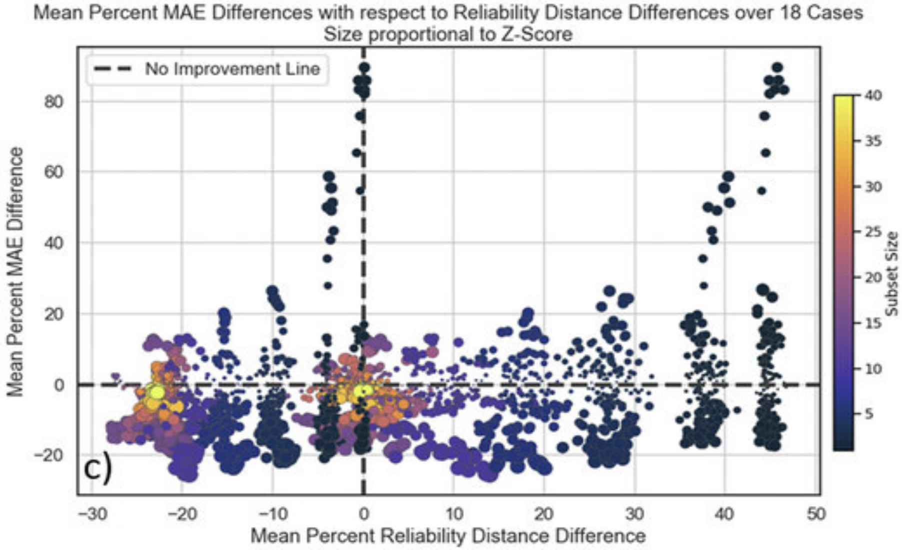
Ensemble Sensitivity-Based Subsetting

Practical (Real World) Experiments

- Model error
- Response not directly verified
- Analysis error
- Ensemble quality



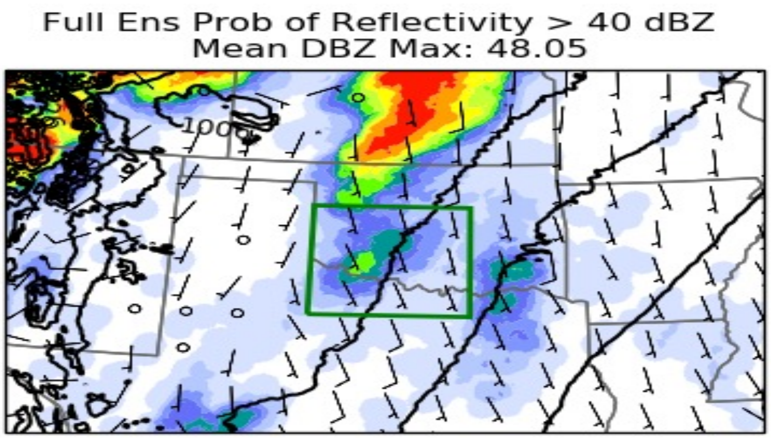
Response → UH



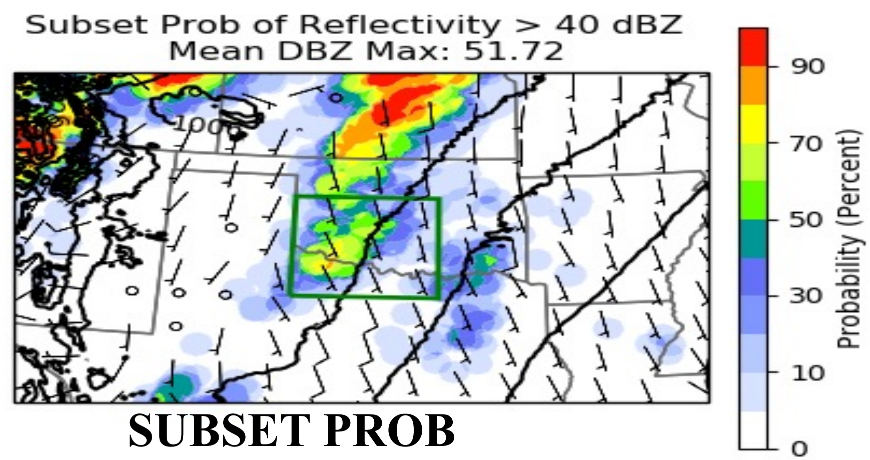
Response → dBZ

2018 NOAA HWT

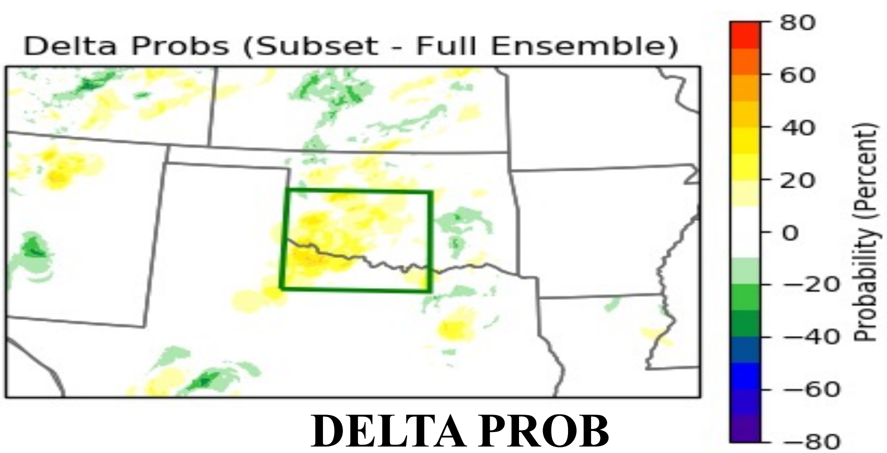
R = Simulated Reflectivity Coverage > 40dBZ (F21-F27)



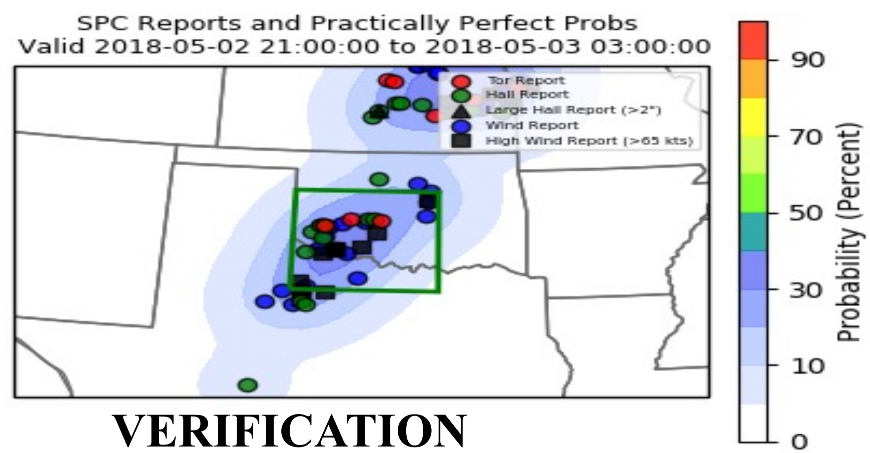
FULL ENSEMBLE PROB



SUBSET PROB



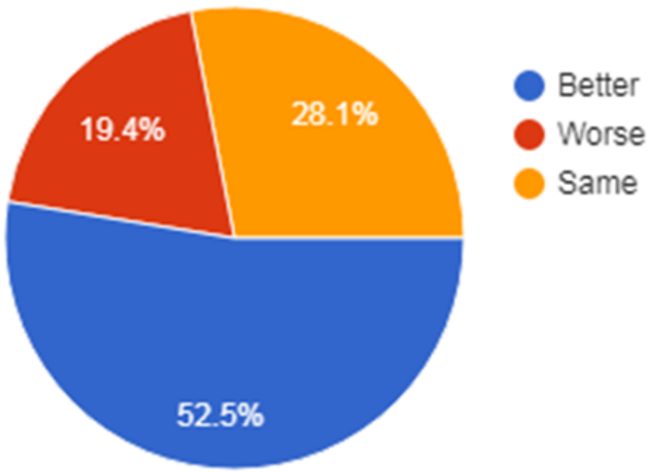
DELTA PROB



VERIFICATION

May 2

2018 NOAA HWT



Relative to the full ensemble, the forecast skill of the subset **inside** the response function box is...

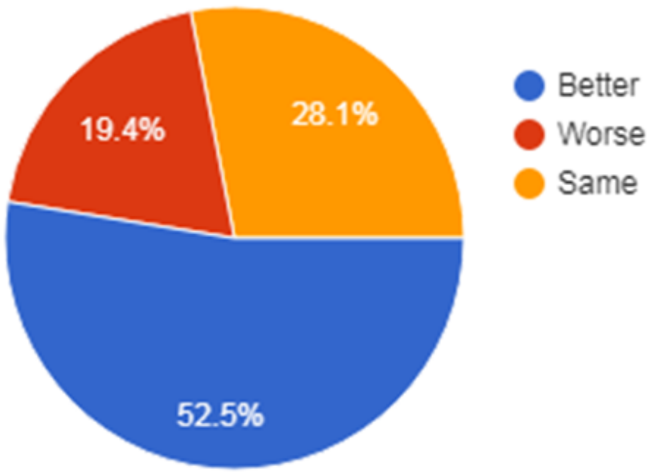
a) Better
b) Worse
c) Same

Overall Objective Success Rates

UH Coverage – 74%
dBZ Coverage – 74%
PCP Coverage – 86%

UH Maximum – 73%
dBZ Maximum – 54%
PCP Maximum – 72%

2018 NOAA HWT



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It works except when it doesn't…

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→ Can we retain successes and eliminate failures with the ensemble sensitivity-based subsetting technique?

- flow regime
- storm mode
- ensemble spread (at multiple times)
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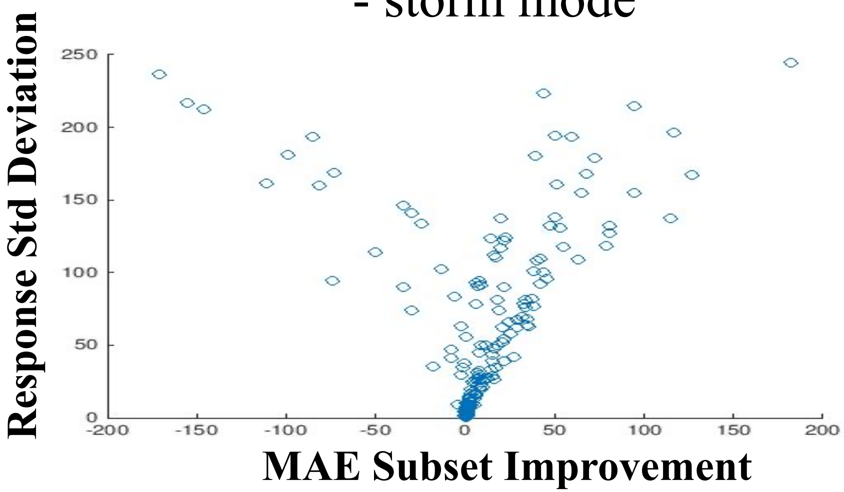

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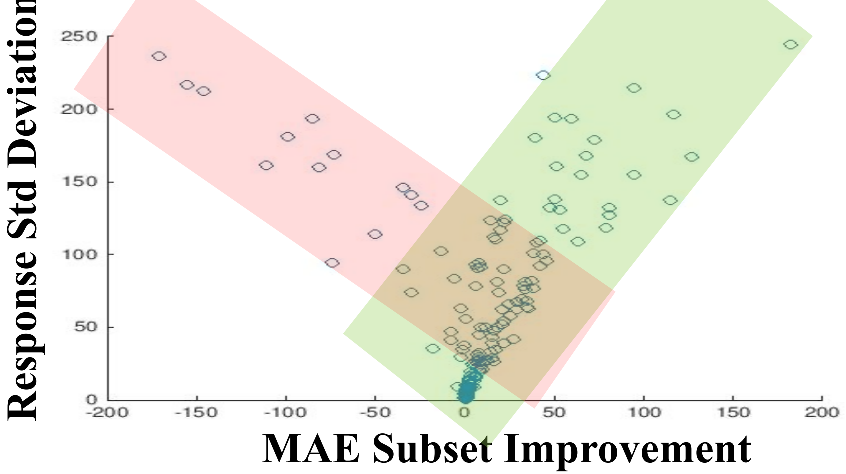

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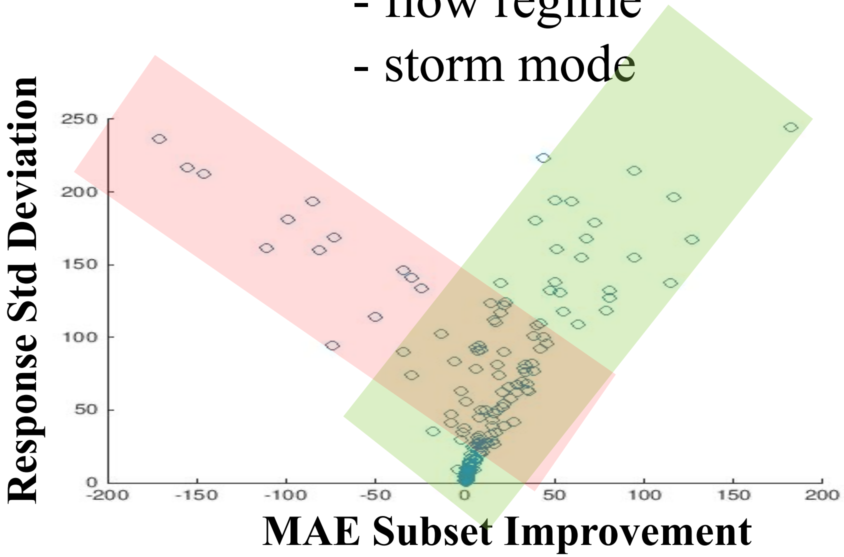

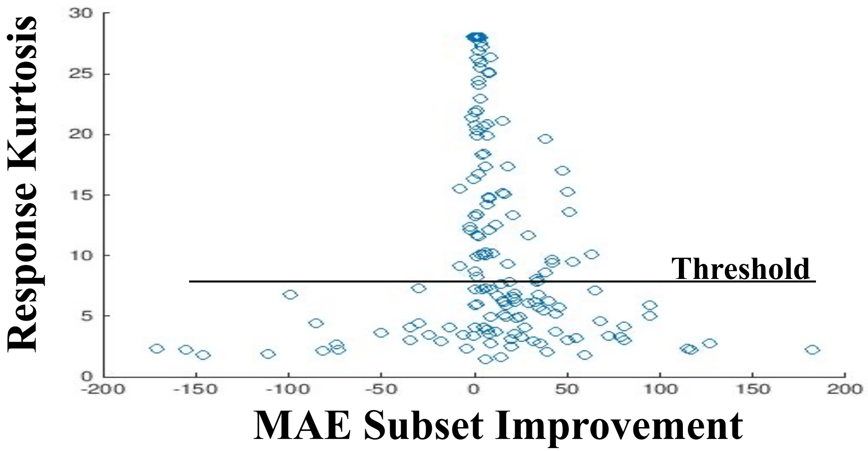

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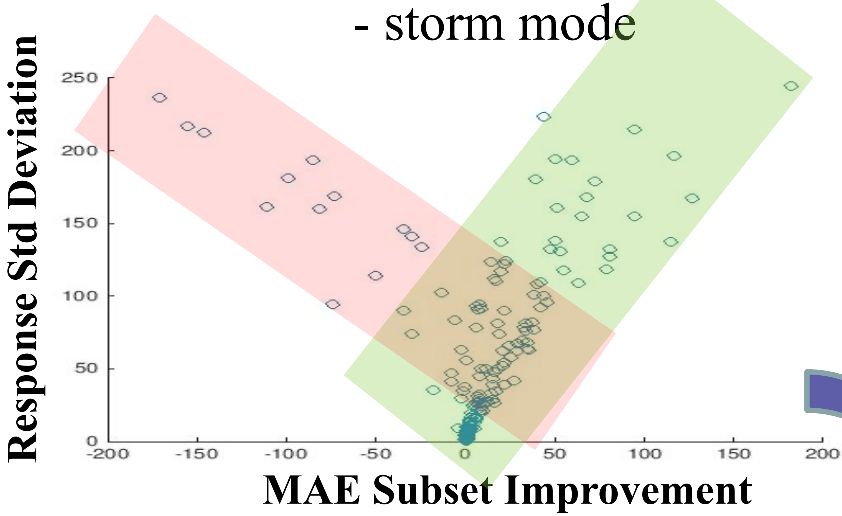

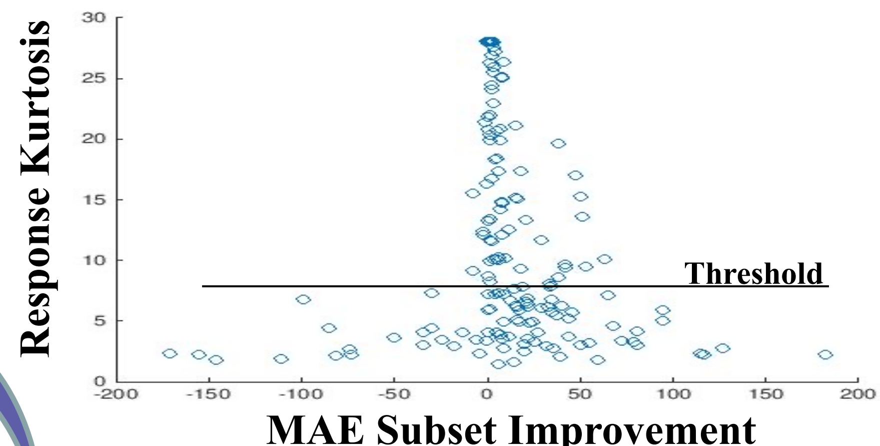

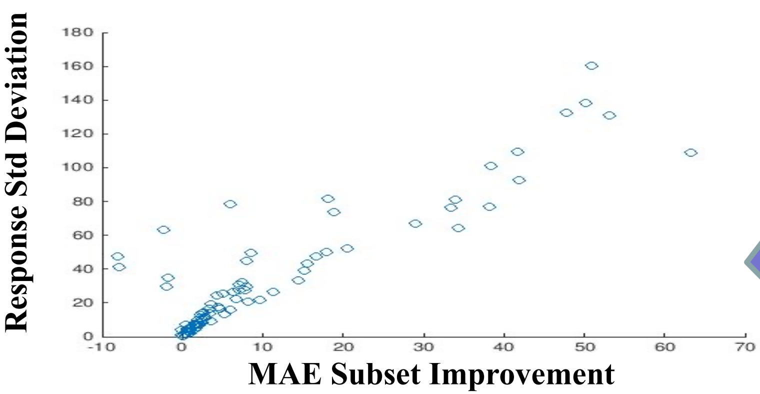

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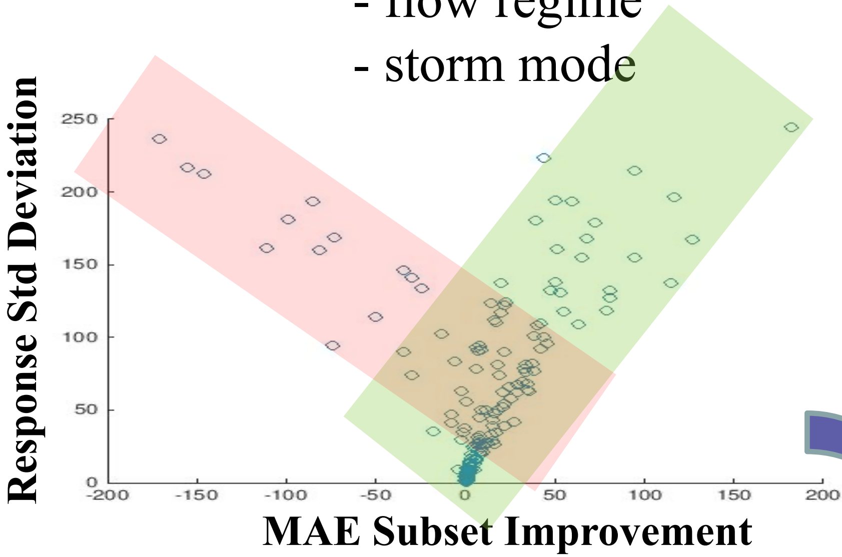

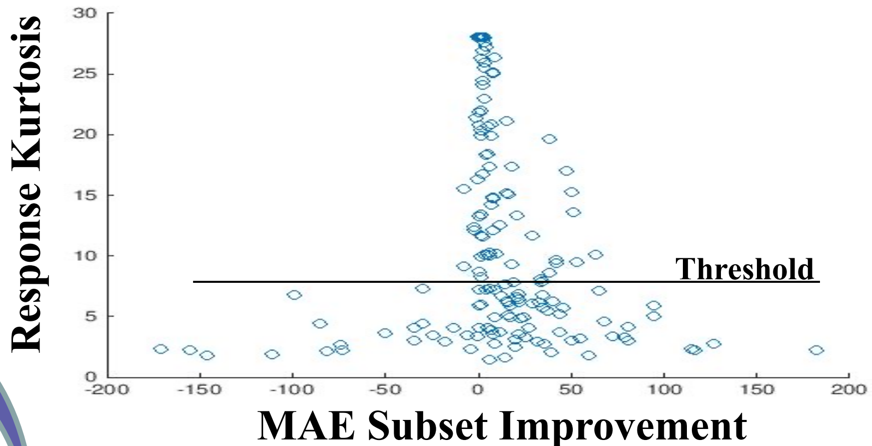

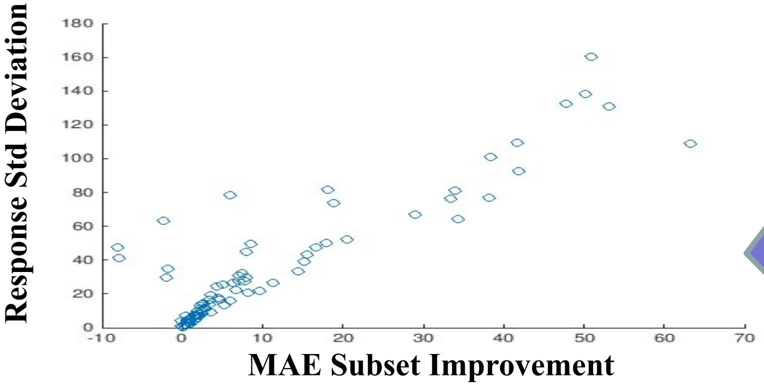

→ Near complete success

→ Failures that do exist are small

→ Large success associated with large response spread (with kurtosis threshold applied)

Summary

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1) **Ensemble adjustment techniques that use knowledge relevant to the predictability of an event may have great potential in improving high-impact forecasts**

2) **One ensemble adjustment technique, ensemble sensitivity-based subsetting, already shows promise but only scratches the surface**

3) **Substantial effort on advancing ensemble adjustment techniques (e.g., incorporating nonlinearity, or using AI/ML) could underpin important future CIWRO projects that lead to a new and valuable operational framework**