INFORMATION EXTRACTION AND VERIFICATION OF NUMERICAL WEATHER PREDICTION FOR SEVERE WEATHER FORECASTING

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Project Overview

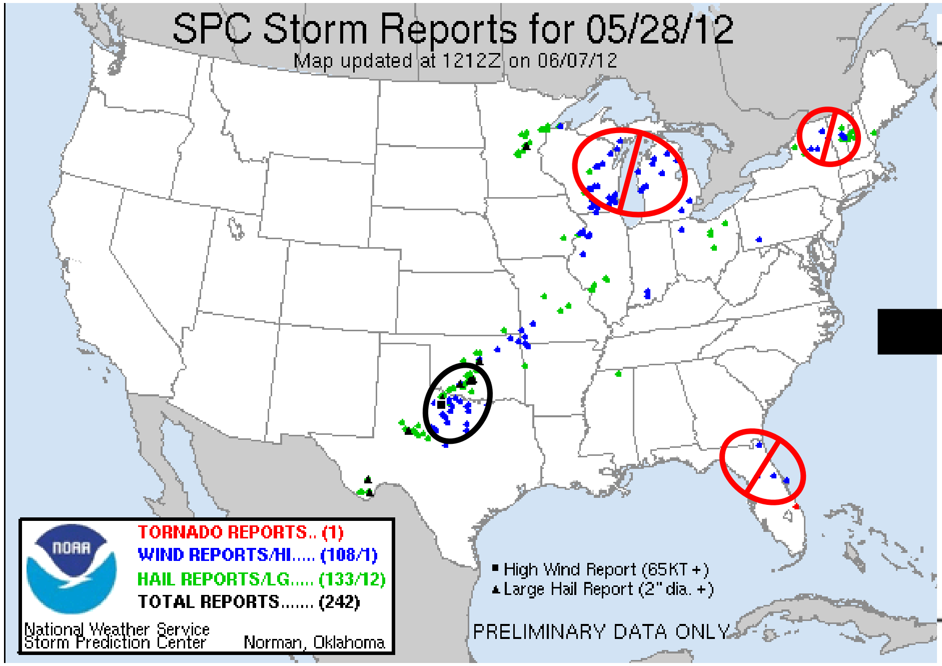
- Collaborative effort among SPC, NSSL, and EMC to improve severe weather forecasting
- Direct involvement with the Hazardous Weather Testbed (HWT) for testing and evaluation of products/techniques
- Two primary components:
  - Verification
    - Explore and refine scale-appropriate metrics for convection-allowing model and ensemble forecasts relevant to severe convective weather
  - Information Extraction
    - Develop techniques/diagnostics to mine useful information embedded within convection-allowing models for severe weather forecasting

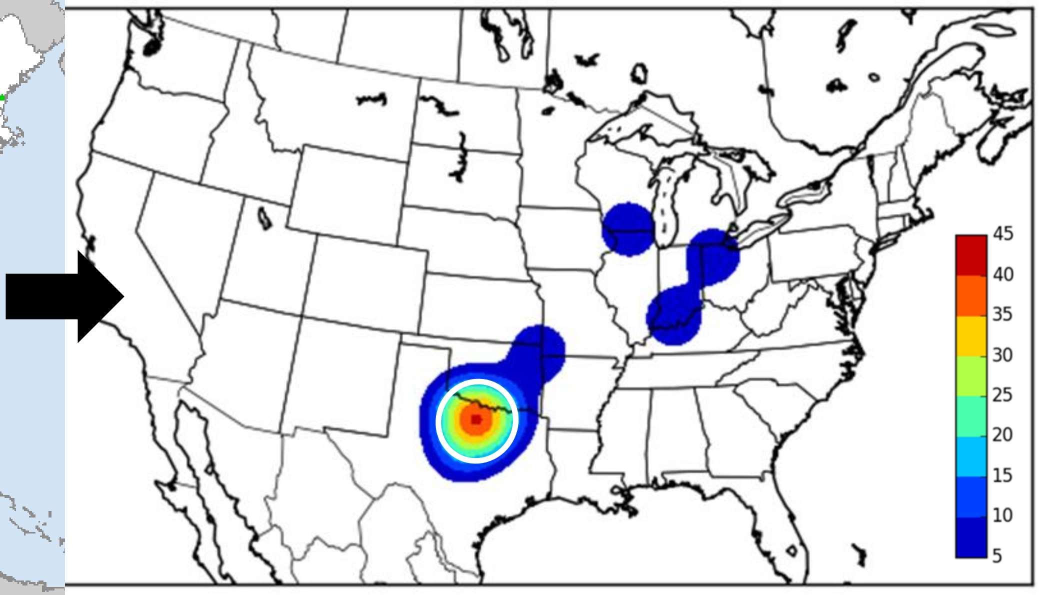
NGGPS Areas Addressed

- Advances in convective/severe weather prediction through innovative scale-appropriate information extraction and verification methods on convective scales
- Advances in ensemble development through evaluation of convection-allowing ensembles of opportunity to inform the design and configuration of future operational convection-allowing ensembles
- Advances in post-processing by extracting relevant simulated storm processes and characteristics from convection-allowing models to identify the likelihood of severe weather

Project Results: Severe Wind Event Definition

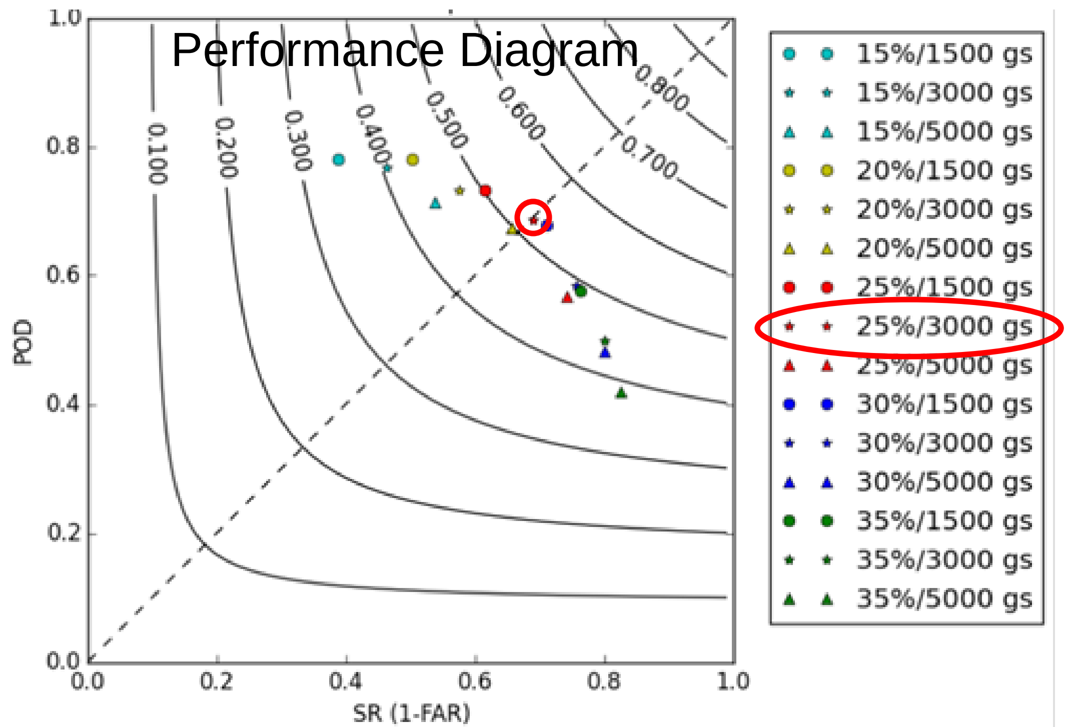
- For this study, we chose to focus on severe winds generated by mesoscale convective systems (MCSs), which are more organized/predictable than localized downbursts
- Starting from all wind reports, those not associated with a MCS were objectively filtered out, then a 2-D Gaussian smoother was applied to arrive at a severe wind "object"





Project Results: Severe Wind Event Definition

- Using this approach, probabilistic and size thresholds are needed to objectively define a severe wind event
- Severe wind objects at various thresholds were matched with 224 manually identified severe-wind-producing MCSs during 2012-14.

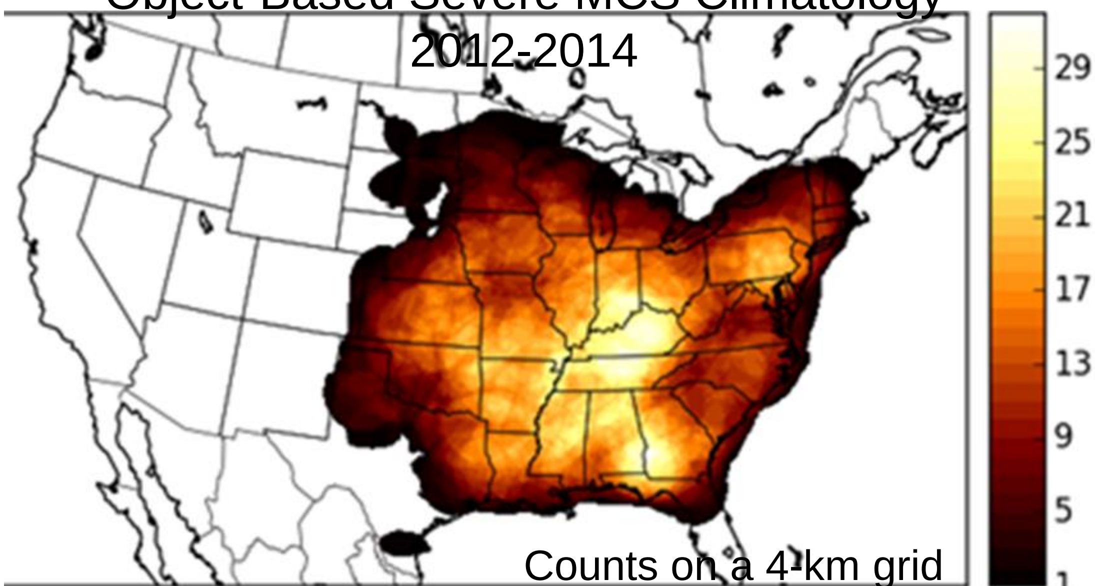


- Based on these results, a severe wind object was defined objectively as an object of 3000 grid squares (i.e. on a 4-km grid) at the 25% threshold (max CSI and bias ~1) using filtered wind reports.

Project Results: Severe MCS Climatology

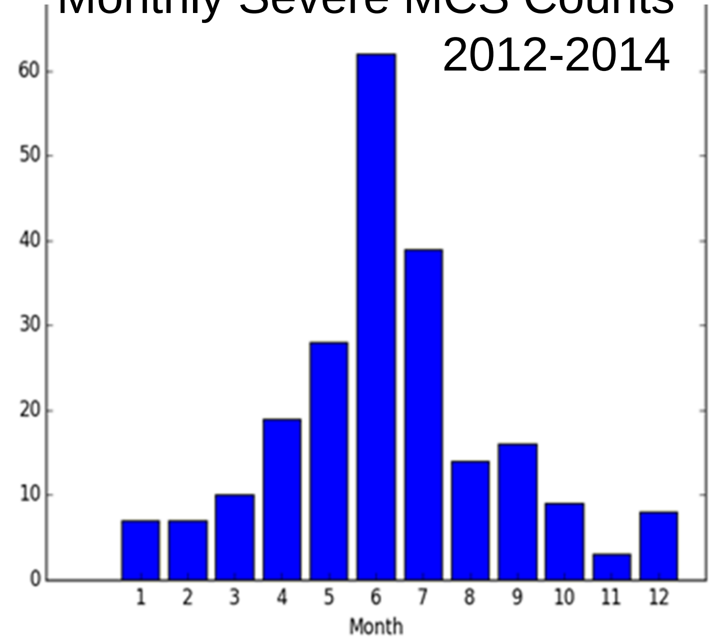
- Defining a severe wind object allowed for the development of a climatology of observed severe-wind-producing MCSs
- During 2012-14, the highest frequency of severe MCSs occurred near the Ohio and Tennessee River Valleys
- The month with the highest frequency of severe MCSs was June with less frequent occurrence of severe MCSs during the cold season (i.e., October through March)

Object-Based Severe MCS Climatology 2012-2014



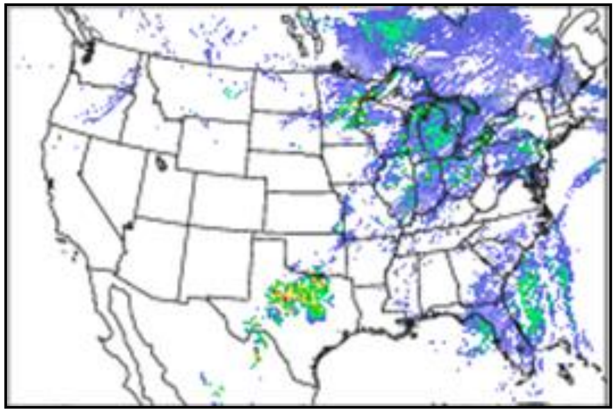
Counts on a 4-km grid

Monthly Severe MCS Counts 2012-2014

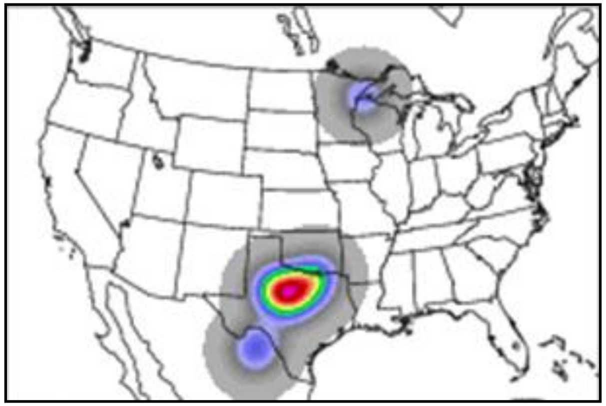


Project Results: Verification of NSSL-WRF

- To determine the skill of current convection-allowing models (CAMs) in predicting severe MCSs, the Developmental Testbed Center's Method for Object-Based Diagnostic Evaluation (MODE) Tool was used to verify 10-m wind forecasts from the deterministic NSSL-WRF (4-km grid spacing)
- The same 2-D Gaussian smoothing that was applied to wind reports was also applied to NSSL-WRF model forecasts of 24-hour maximum 10-m wind speeds to arrive at a forecast object



24-h Max 10-m Wind Forecast Valid 28 May 2012

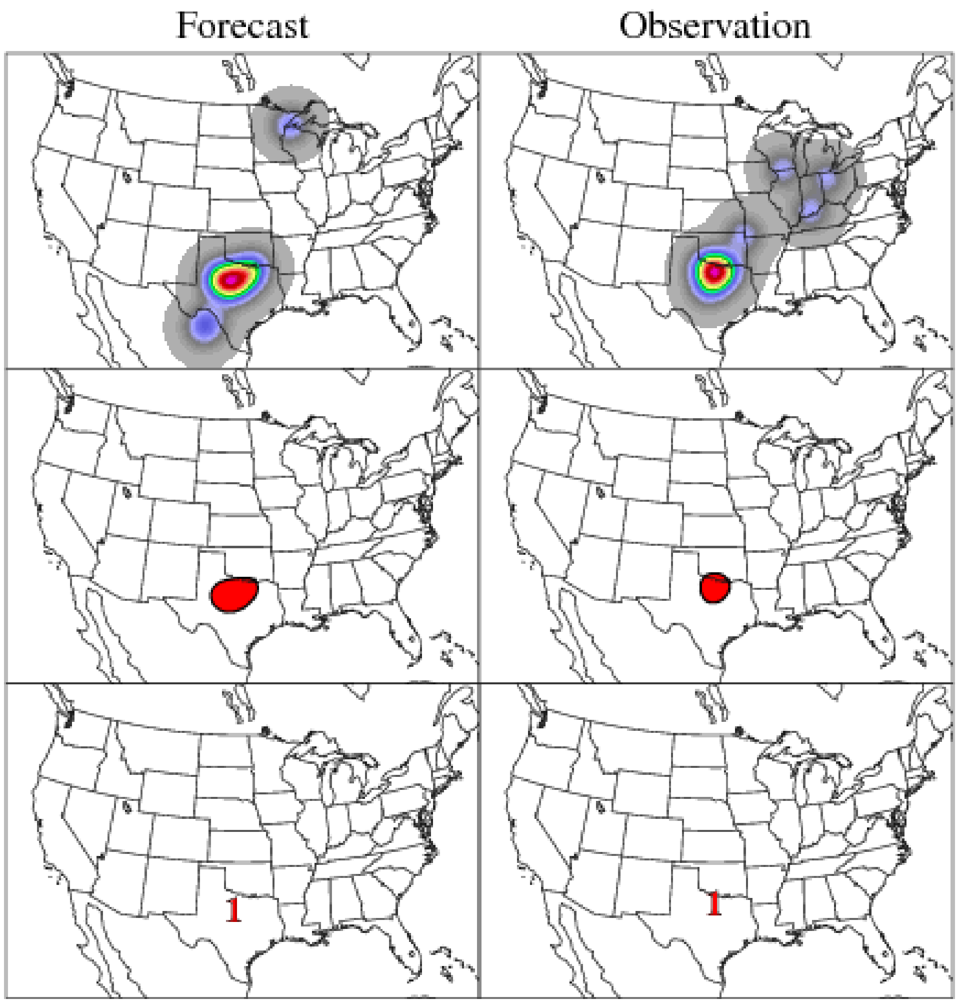


Smoothed 10-m Wind Forecast at 25 kts

Forecast 25 kt wind object (25%, 3000 gs)

Project Results: Verification of NSSL-WRF

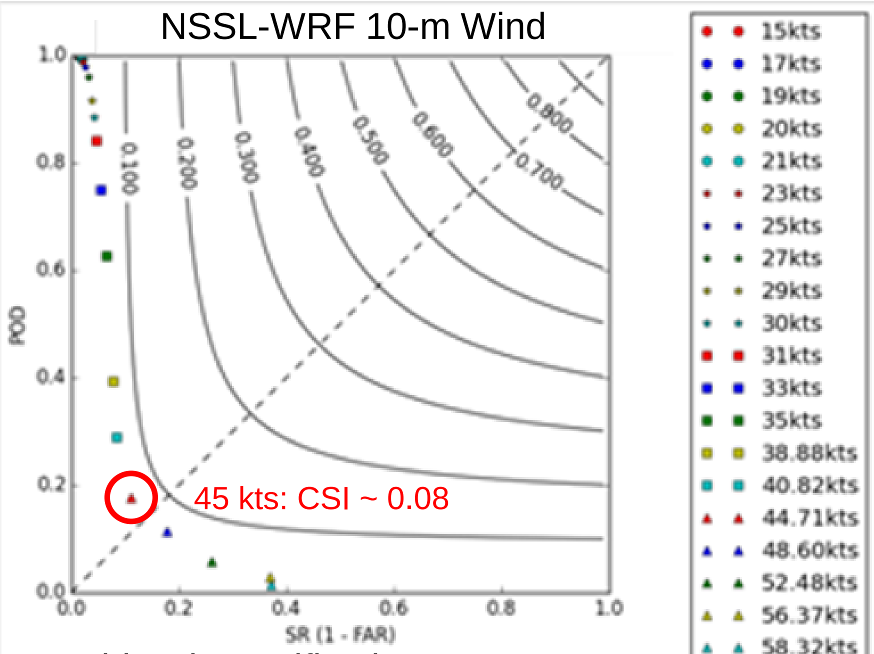
- MODE compares the forecast and observed objects, calculates an interest score for all objects based on their attributes (distance, orientation, area, etc.) and determines which objects “match”
- Traditional contingency table verification metrics (POD, FAR, CSI) were calculated for grid points within the objects and for the entire objects



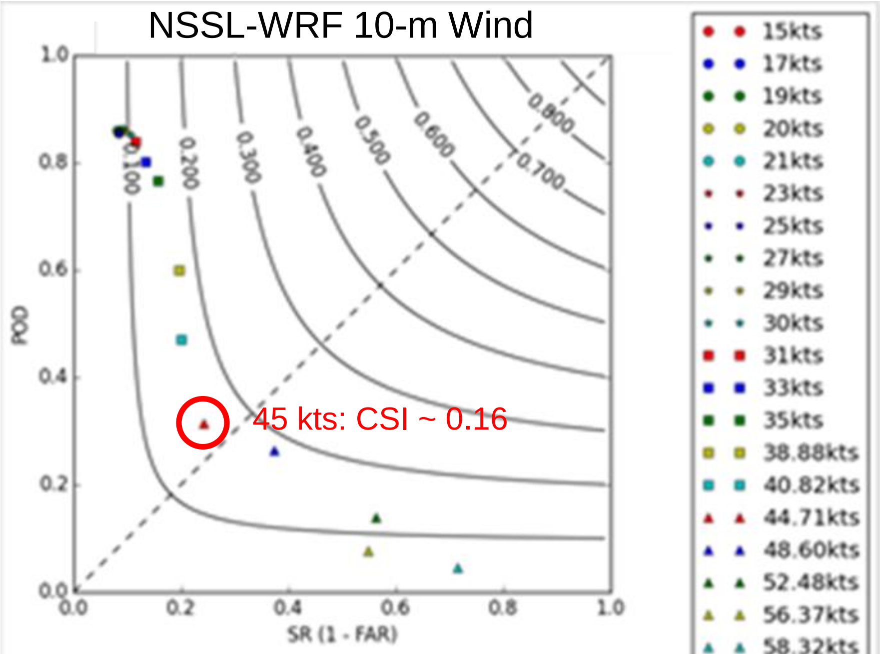
Valid 28 May 2012

Project Results: Verification of NSSL-WRF

- For grid-point verification, POD and, to a lesser extent, FAR decrease as the forecast wind speed increases, with CSI remaining relatively constant
- For object-based verification, the CSI values are generally higher than those for grid-point verification with a peak CSI for forecasts from the NSSL-WRF in the 40-50 knot range.



Grid-Point Verification 2012-2014



Object-Based Verification 2012-2014

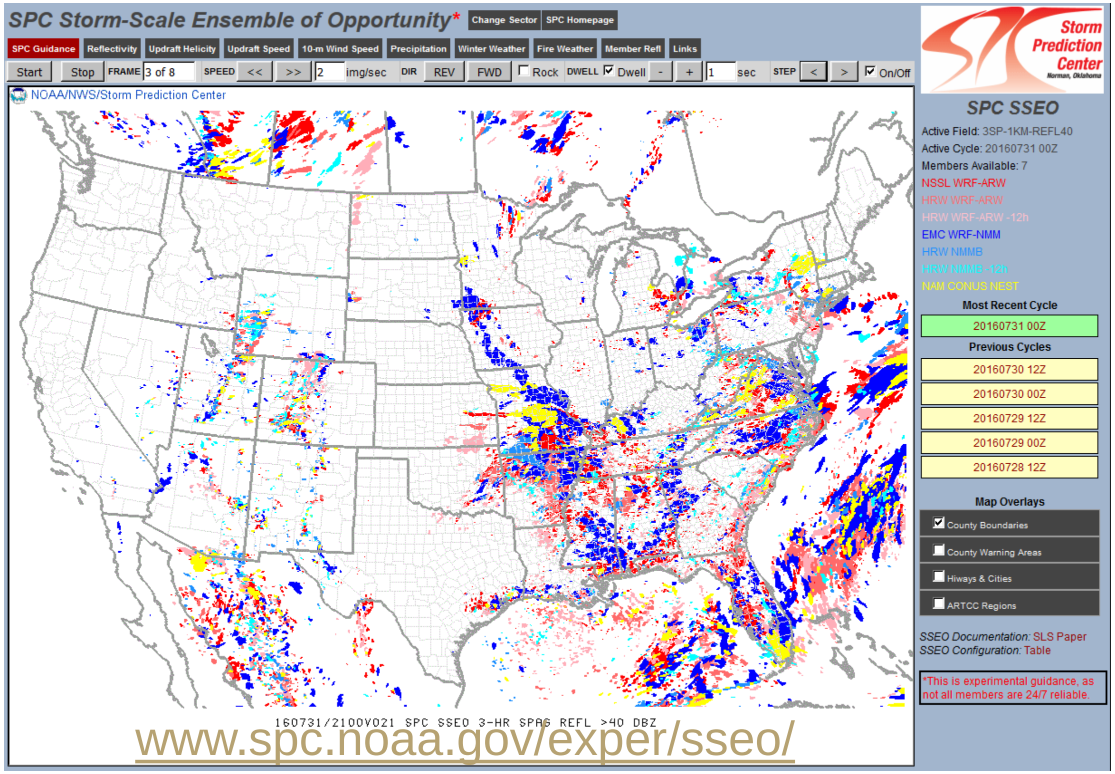
CAM Ensembles: SSEO Overview

- To better assess the forecast uncertainty of severe MCSs, an ensemble approach is useful
- The Storm-Scale Ensemble of Opportunity (SSEO) is a group of real-time deterministic CAMs processed by SPC as an ensemble
  - 7 members: multi-model, multi-physics, multi-initial conditions

Updated 12 Aug 2014	Grid Spacing	Vert Levels	Fcst Length	ICs/ LBCs	PBL	Micro
NSSL WRF-ARW	4 km	35	36 h	NAM/ NAM	MYJ	WSM6
EMC HRW WRF-ARW	4.2 km	40	48 h	RAP/ GFS	YSU	WSM6
EMC HRW WRF-ARW; 12-h time lag	4.2 km	40	48 h	RAP/ GFS	YSU	WSM6
EMC HRW NMMB	3.6 km	40	48 h	RAP/ GFS	MYJ	Ferrier updated
EMC HRW NMMB; 12-h time lag	3.6 km	40	48 h	RAP/ GFS	MYJ	Ferrier updated
EMC CONUS WRF-NMM	4 km	35	36 h	NAM/ NAM	MYJ	Ferrier
EMC CONUS NAM NEST	4 km	60	60 h	NAM/ NAM	MYJ	Ferrier-Aligo

CAM Ensembles: SSEO Overview

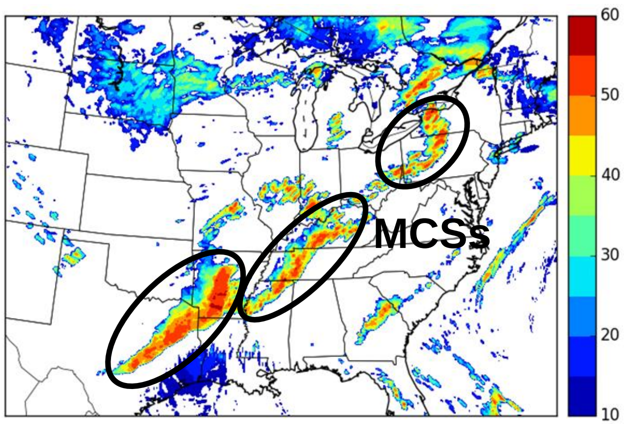
- SSEO has proven its utility in SPC operations (year-round) and has compared favorably to formally designed convection-allowing ensembles in the HWT (spring)
- As such, the SPC SSEO provides a baseline for the performance of a future operational convection-allowing ensemble (HREF)



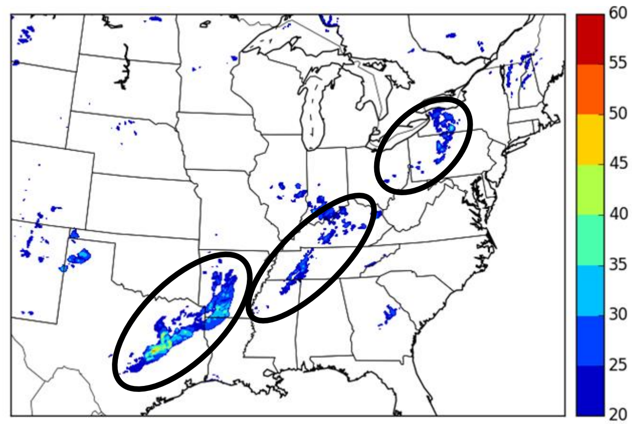
www.spc.noaa.gov/exper/sseo/

Project Results: Verification of SSEO Members

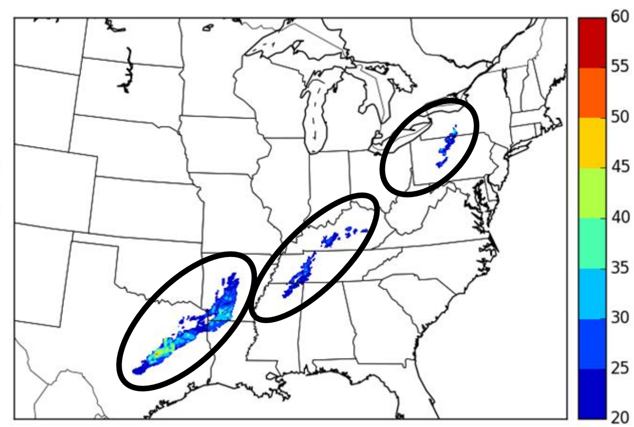
- To eliminate strong synoptic-scale winds and localized convective gusts in the model forecasts, the hourly max 10-m wind field was filtered by requiring association with a simulated radar object with >35 dBZ over at least a 500 grid space area (~8000 km^2)
- This filtering method was applied to all 10-m wind forecasts from members of the SSEO to assess their skill in forecasting severe MCSs



Hourly Max Reflectivity Forecast
Valid 02Z 22 May 2013



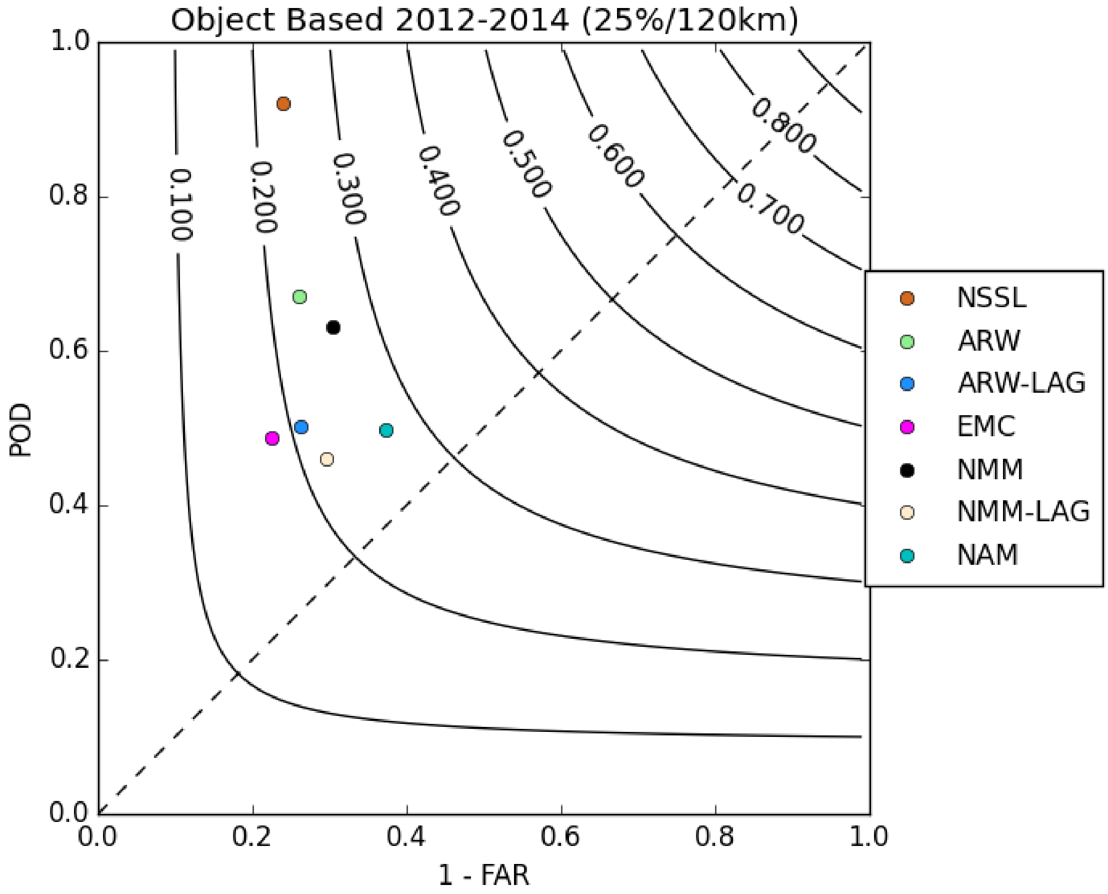
Hourly Max 10-m Wind Forecast
Valid 02Z 22 May 2013



Filtered Hourly Max 10-m Wind Fcst
Valid 02Z 22 May 2013

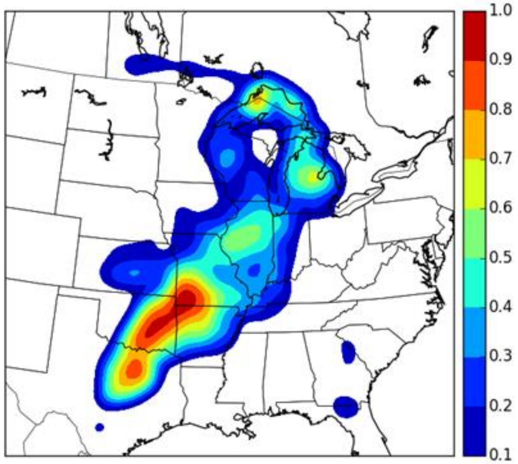
Project Results: Verification of SSEO Members

- Object-based verification of 10-m wind forecasts at 30 kts for SSEO members in forecasting severe MCSs during 2012-2014 reveal distinct characteristics among the members
- ARW members tend to have a higher POD for severe MCSs than NMMB or WRF-NMM members, but also have a higher frequency bias

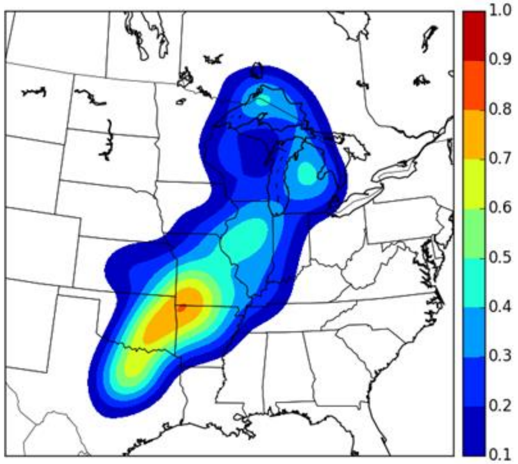


Project Results: Verification of SSEO

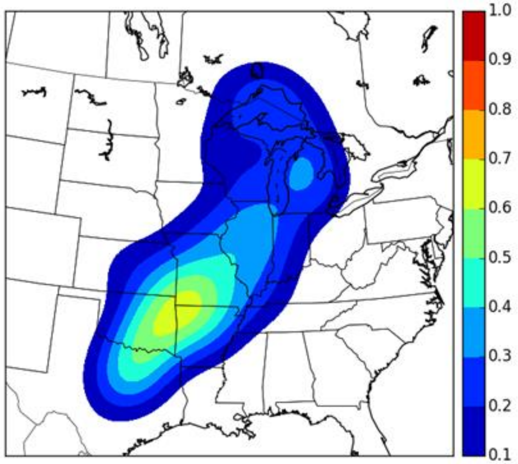
- The SSEO was also evaluated as an ensemble to assess its performance in predicting severe MCSs during 2012-2014
- To perform this verification, the 24-hour 40-km neighborhood probability of 10-m winds ≥30 kts (best correspondence with wind reports) were calculated for each convective day
- Gaussian smoothing parameters of 40, 80, and 120 km were applied to neighborhood probabilities of 10-m winds ≥30 kts to arrive at forecast objects (≥ 3000 grid spaces) for the SSEO



Neighborhood probability of 10-m winds ≥30 kts with **40-km** smoothing



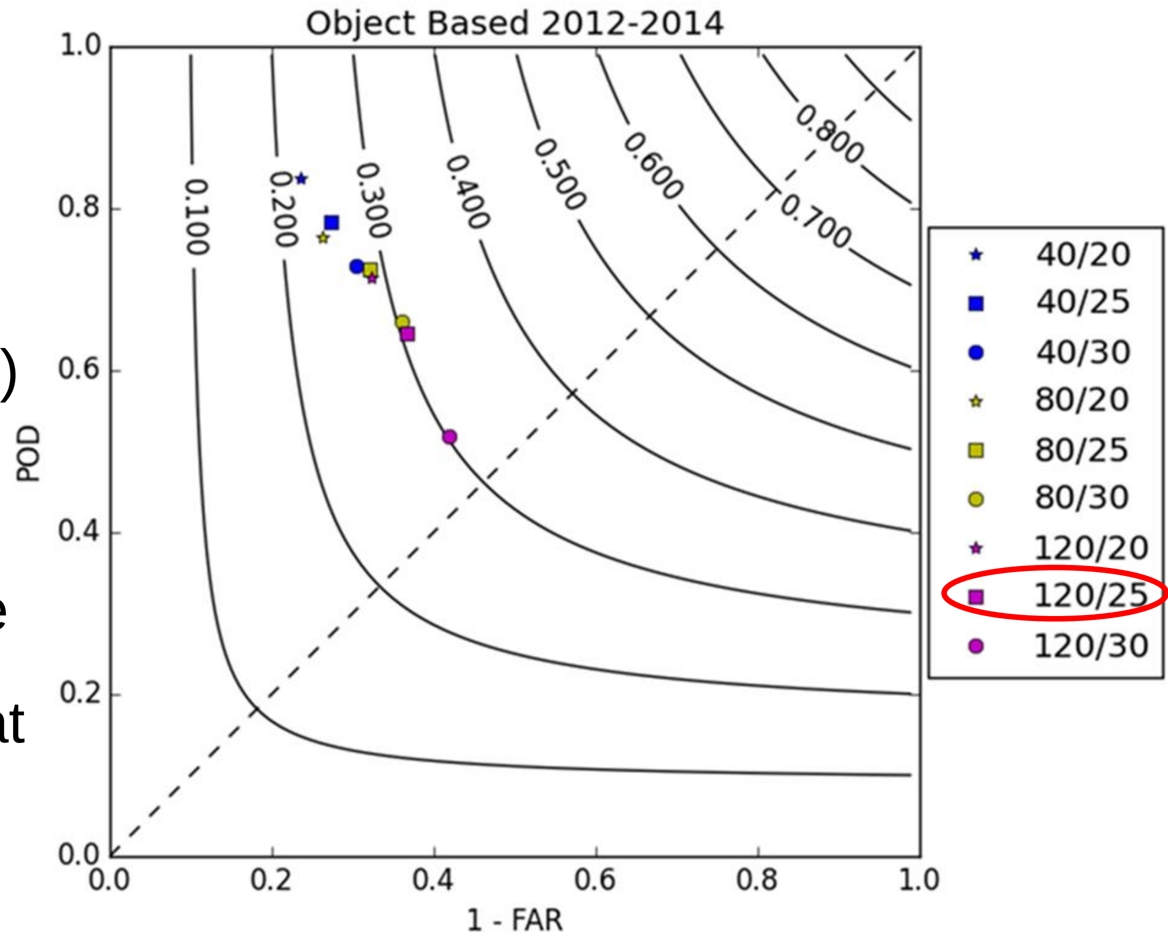
Neighborhood probability of 10-m winds ≥30 kts with **80-km** smoothing



Neighborhood probability of 10-m winds ≥30 kts with **120-km** smoothing

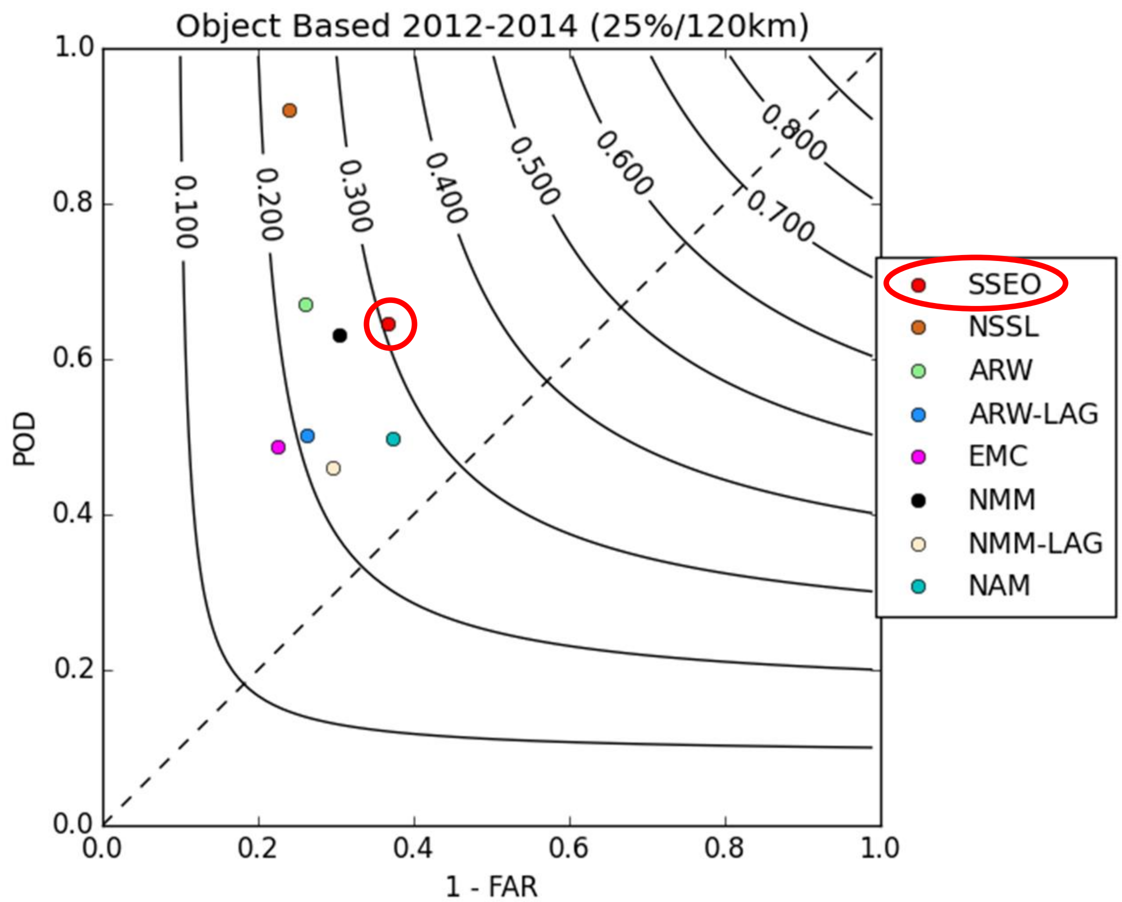
Project Results: Verification of SSEO

- The SSEO was verified at several different combinations of forecast probability thresholds (20%, 25%, 30%) and Gaussian smoothing parameters (40 km, 80 km, 120 km)
- The SSEO had an overall high bias in predicting severe convective winds at the 30 knot threshold with the highest CSI value at the 25% forecast probability threshold using a 120-km smoothing parameter



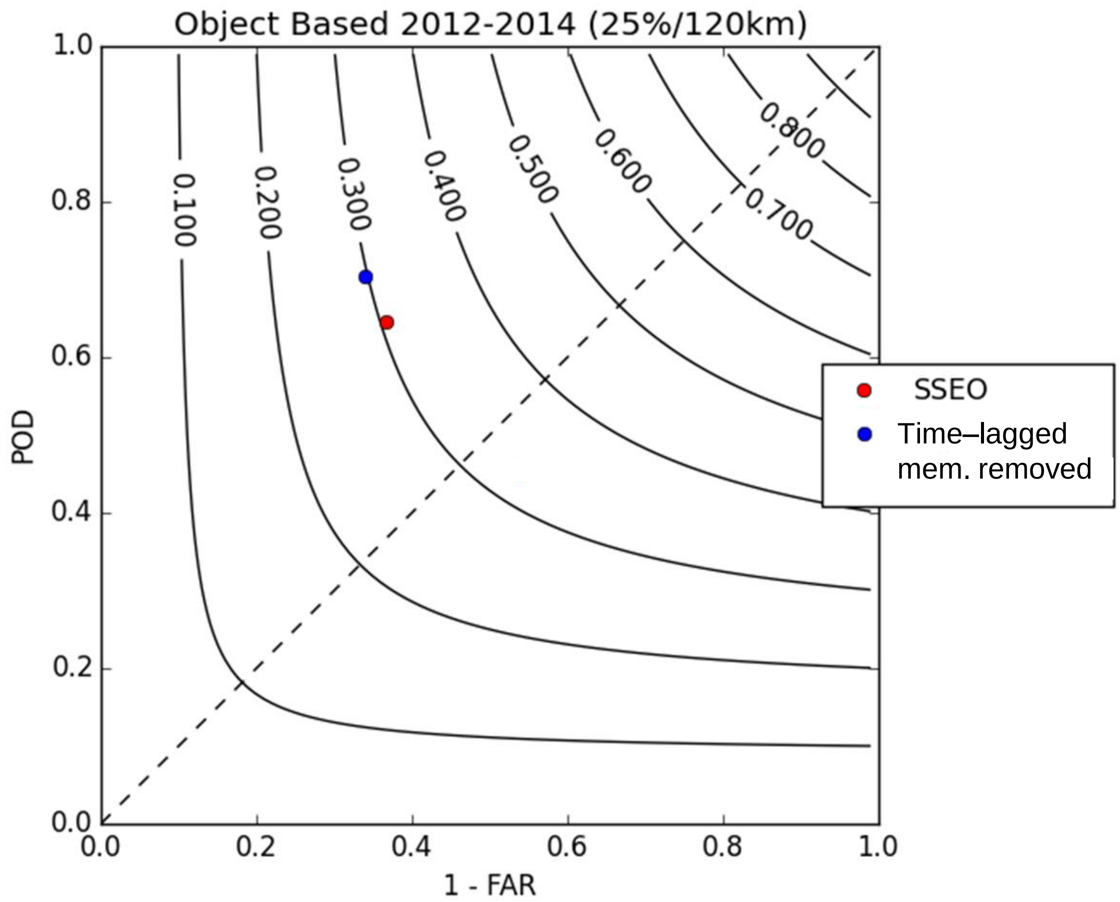
Project Results: Verification of SSEO

- The CSI values for the SSEO in forecasting severe wind objects are higher than any of the individual members that comprise the SSEO.
- This highlights the benefit of using a convection-allowing ensemble in forecasting severe-wind-producing MCSs.



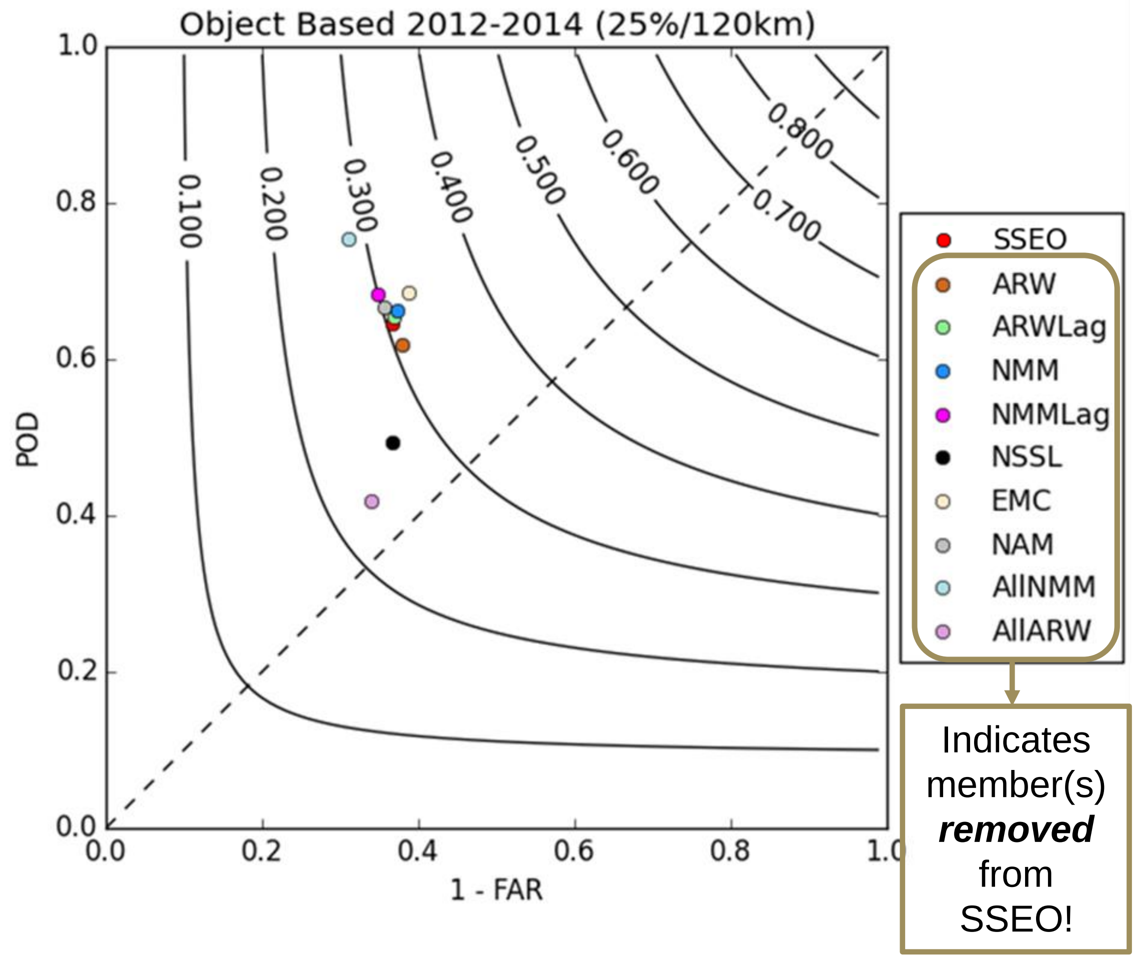
Project Results: Verification of SSEO Subsets

- The SSEO was formulated by including available deterministic convection-allowing model runs, but little work has been done to determine the optimal configuration
- Removing the 12-h time-lagged HiResW runs results in a slightly degraded forecast (in terms of CSI) for severe-wind-producing MCSs



Project Results: Verification of SSEO Subsets

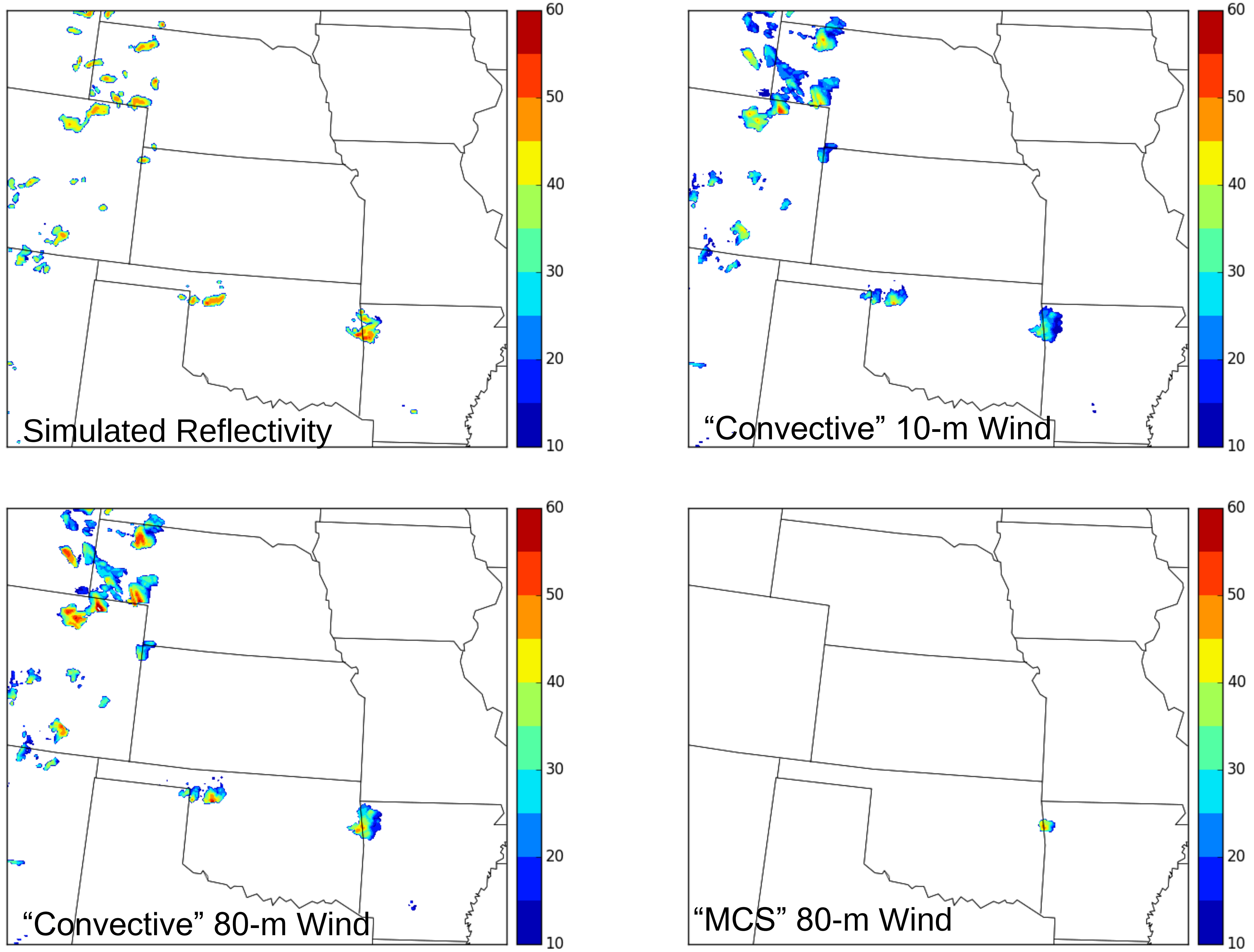
- Removing the NSSL-WRF from the SSEO has the largest impact on severe wind prediction
- Removal of any of the other individual members from the SSEO has a relatively minor impact on the results
- These findings highlight the importance of WRF-ARW members in a convection-allowing ensemble for forecasting severe-wind-producing MCSs



Project Direction

- Much of the baseline verification work for this project has been accomplished
- The focus will shift to developing/extracting model diagnostics/information that improve upon 10-m wind output from CAMs in forecasting severe-wind-producing MCSs
- Based on filtering approaches used here for verification, output of “convective” and “MCS” 10-m (and possibly 80-m) wind field(s) (i.e., using reflectivity field to mask the wind fields) may be useful to severe weather forecasters
- More advanced diagnostics (e.g., descending rear inflow jet, MCV, etc.) indicating the degree of organization and severe wind potential in a simulated MCSs will be considered as well
- Items for testing in the HWT and potential transition to EMC:
  - Object-based verification approach for severe-wind-producing MCSs in evaluating parallel CAMs
  - CAM output fields that improve upon the existing 10-m wind field in forecasting severe-wind-producing MCSs

BACKUP SLIDES


Simulated Reflectivity
"Convective" 10-m Wind
"Convective" 80-m Wind
"MCS" 80-m Wind
60
50
40
30
20
10