Probabilistic forecasts of severe convection with a WRF-DART analysis and convection-permitting forecast system

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Introduction

- Explicit convection forecasts in WRF require Δx ≤ 4 km and no cumulus parameterization

Benefits
- Remove model errors due to cumulus parameterization
- Gain information about expected convective mode

Challenges
- Struggle to forecast timing and location of small-scale events
- Poor objective skill scores found during forecast verification

- **Purpose**: Evaluate the performance of probabilistic forecasts produced from the NCAR real-time WRF Data Assimilation Research Testbed (WRF-DART) ensemble data assimilation system

Methodology

- Case study: 19-20 May 2012 severe weather event
- Ensemble setup: 5 members randomly drawn from 1200 UTC real-time WRF-DART analysis
- Forecasts of simulated reflectivity and various severe storm proxies were subjectively compared to radar observations and storm reports
- Precipitation forecasts were objectively verified

Severe storm proxies:
- Updraft speed
- Updraft helicity
- Wind speed at 10 m
- Vertically integrated graupel

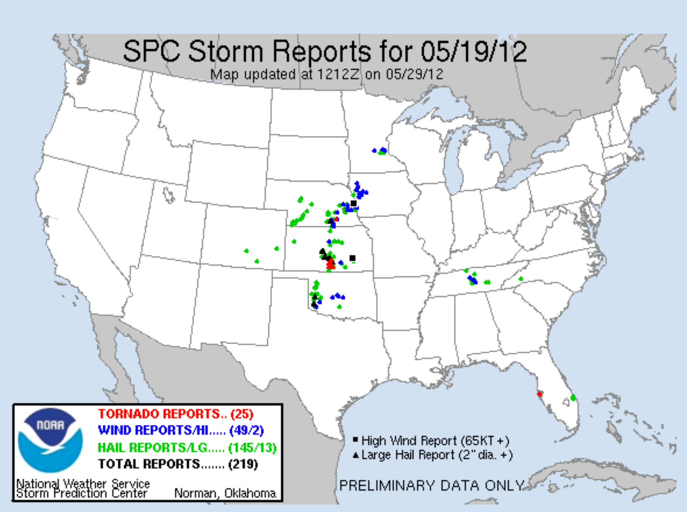

Figure 1: Storm reports for the 19-20 May 2012 severe weather event

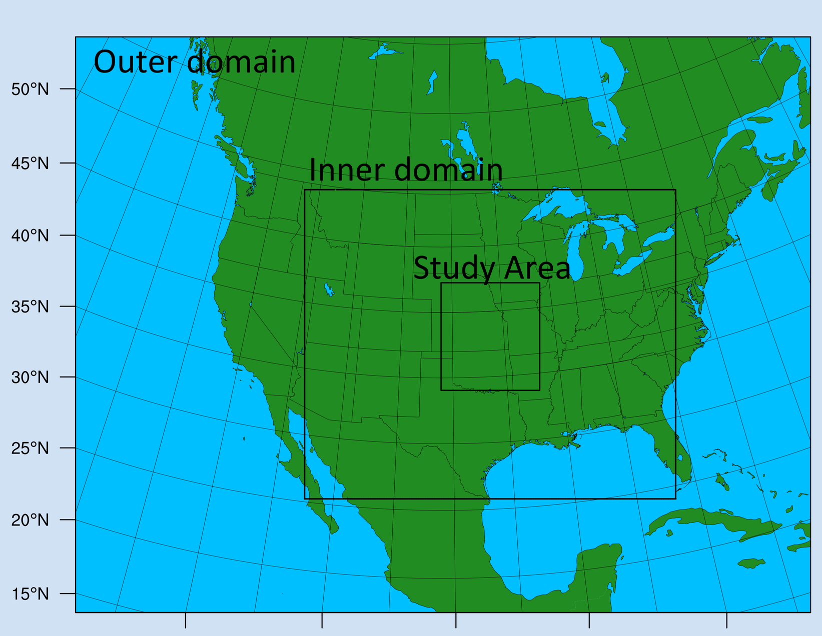

Figure 2: Model domain showing mesoscale outer domain and convection-permitting inner domain. The selected study area is also highlighted.

Table 1: Ensemble configuration

Model Parameter	Outer Domain	Inner Domain
Horizontal Grid	15 km	3 km
Vertical Levels	40	40
Microphysics	Morrison	Morrison
Cumulus	Tiedtke	none
PBL	MYJ	MYJ
Land Surface	Noah	Noah
LW & SW Radiation	RRTMG	RRTMG

Subjective Evaluation

Convective Initiation

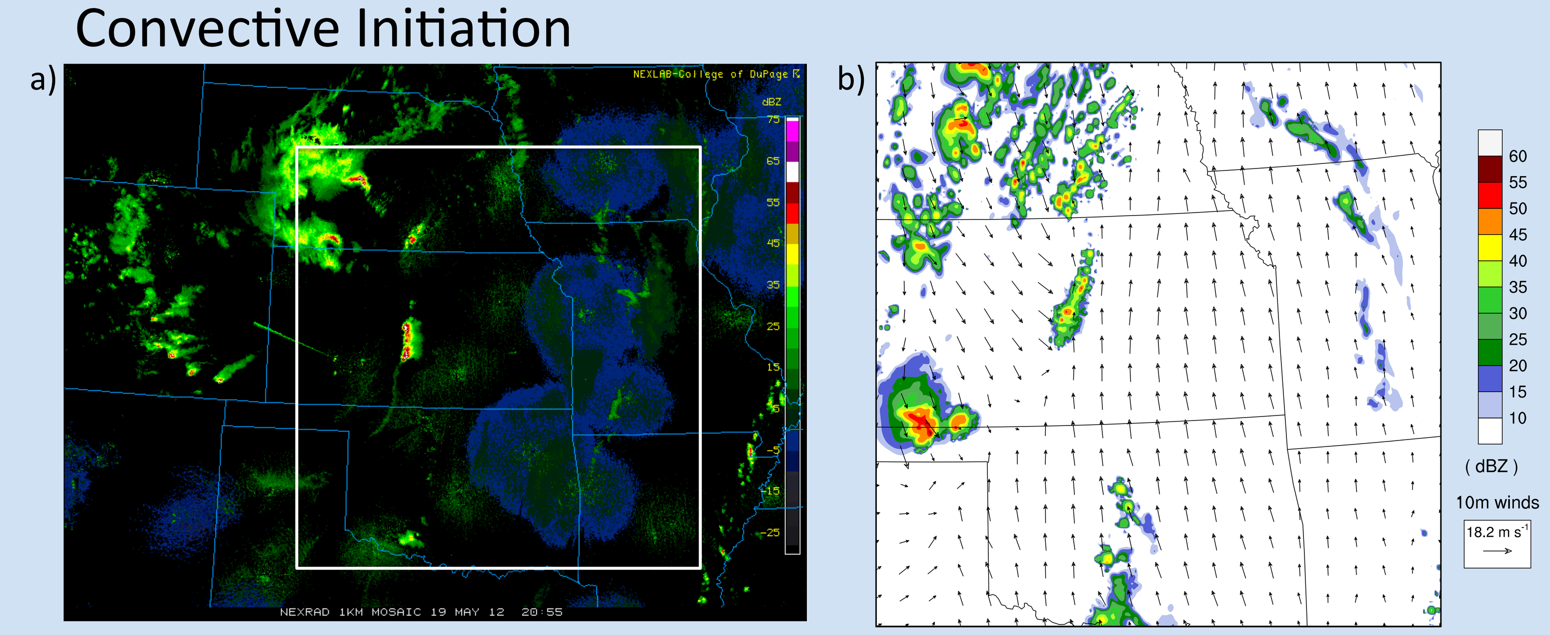

Figure 3: a) Observed composite reflectivity at 2055 UTC and b) simulated reflectivity forecast from Member 1 at 2200 UTC on May 19, 2012

Storm Evolution

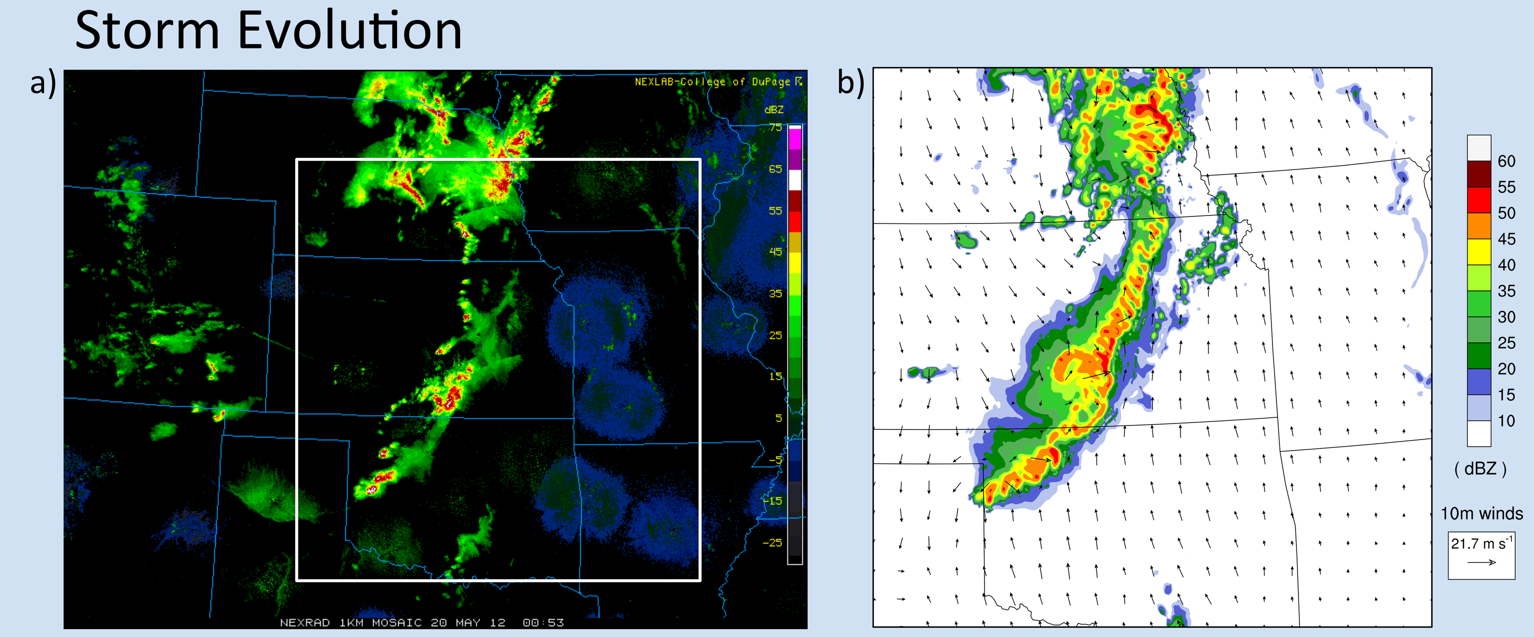

Figure 4: a) Observed composite reflectivity at 0053 UTC and b) simulated reflectivity forecast from Member 1 at 0100 UTC on May 20, 2012

Severe Storm Proxy Verification

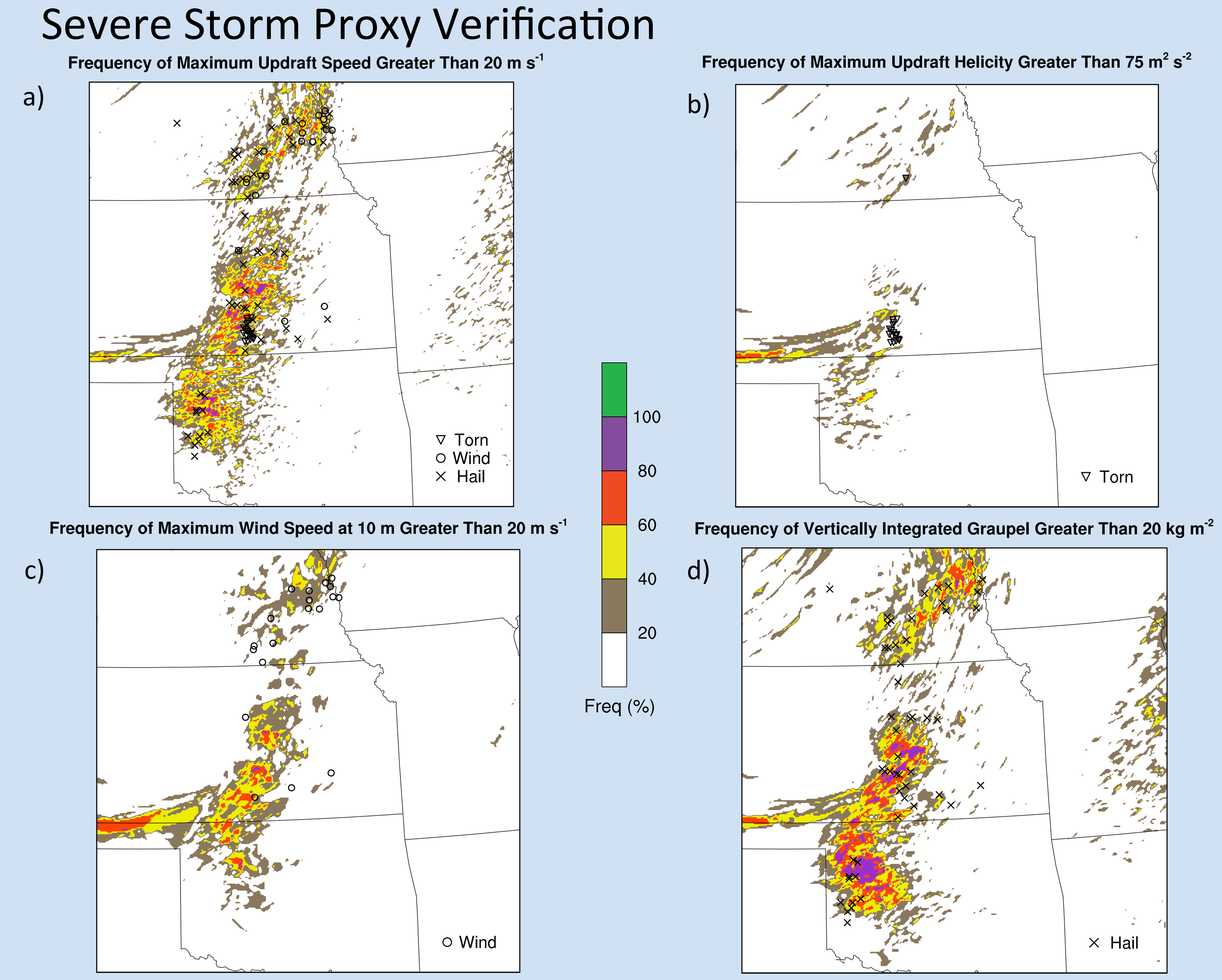

Figure 5: Frequency of maximum a) updraft speed, b) updraft helicity, c) wind speed at 10 m, and d) vertically integrated graupel greater than specified thresholds

Precipitation Verification

- Precipitation forecasts were verified against NCEP Stage IV hourly accumulated QPE analyses

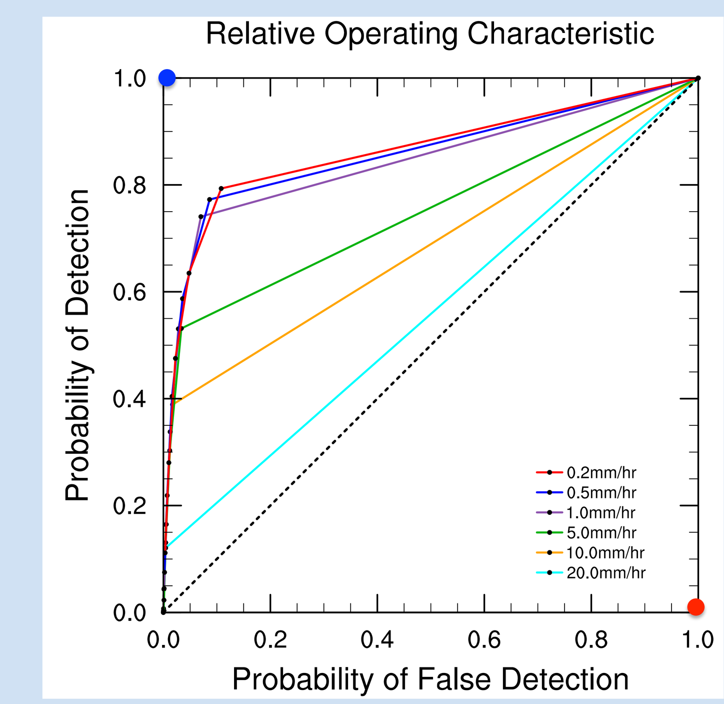

Figure 6: Relative operating characteristic (ROC) curves determined from grid scale verification

Table 2: Area under ROC curves

QPF Threshold (mm/hr)	Area Under Curve (AUC)
0.2	0.863
0.5	0.857
1.0	0.845
5.0	0.751
10.0	0.686
20.0	0.558

- Perfect forecast
- Worst forecast

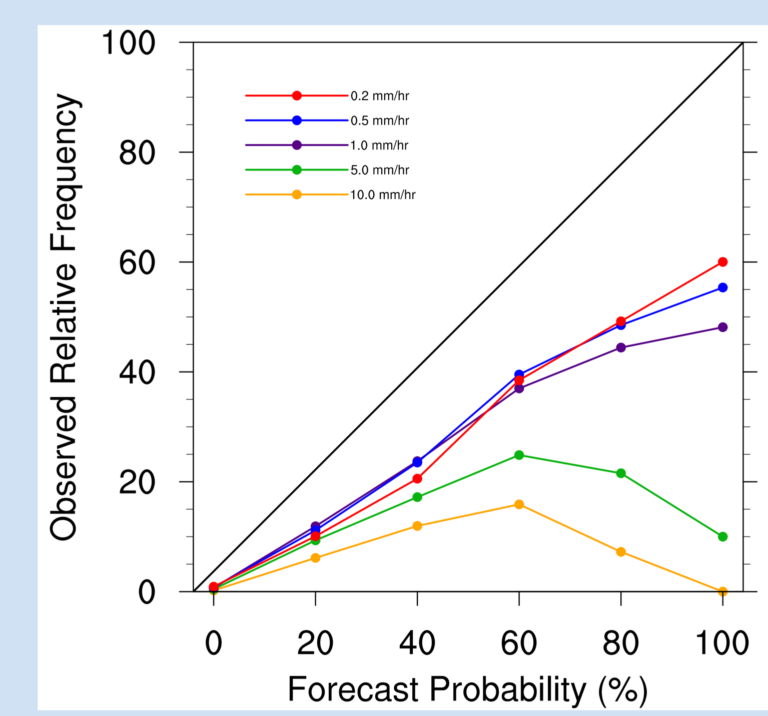

Figure 7: Reliability diagrams determined from grid scale verification

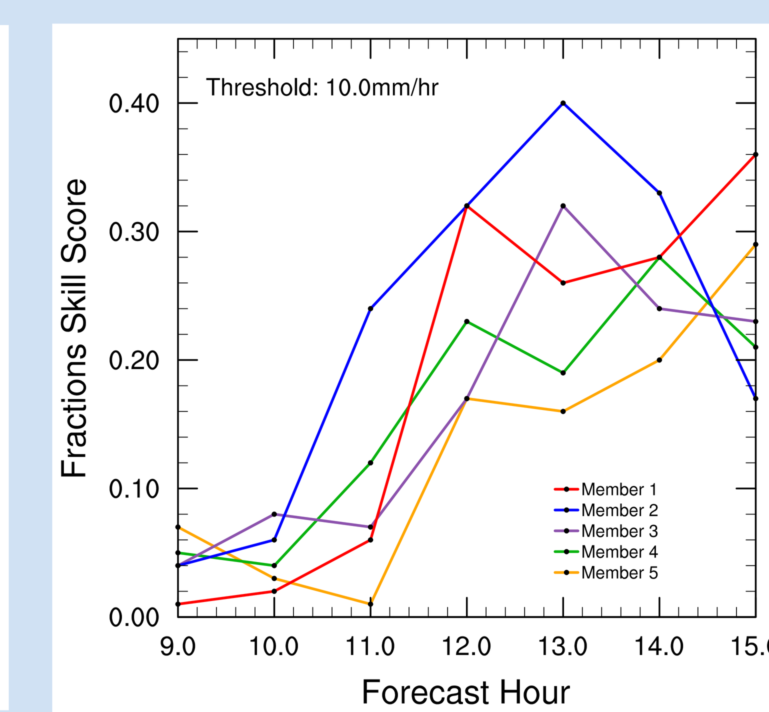

Figure 8: Fractions skill scores for a threshold of 10 mm/hr with a radius of influence of 25 km

Conclusions

- Ensemble system produced reliable convection forecasts
- Specific severe storm proxies were not always skillful in forecasting their associated hazards
- Probability of maximum updraft was most skillful in forecasting the location of severe weather
- Precipitation verification showed the ensemble forecast had skill in predicting the timing, location and intensity of rainfall

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