Verification of Severe Weather Proxies from the NSSL-WRF for Hail Forecasting

Nathan A. Wendt*,#,†, I. L. Jirak†, and C. J. Melick#,†

#*University of Oklahoma Cooperative Institute for Mesoscale Meteorological Studies*; †*National Weather Service Storm Prediction Center*

Introduction

At the Storm Prediction Center (SPC), the NSSL WRF is a 4-km CAM that is routinely used for operational forecasting. To date, no work has specifically focused on quantifying the skill of the NSSL WRF with regard to forecasting severe hail (≥ 25.4 mm).

Objective : Provide a long-term (2012 – 2015), neighborhood forecast verification of the NSSL WRF for severe hail and determine the best existing CAM proxy for forecasting severe hail.

Methods

NSSL WRF

- WRF 3.4.1
- 4 km grid spacing
- Hourly output for each convective day (12Z –12Z) aggregated into daily max fields
- Neighborhood maximum field generated for multiple proxies/thresholds

MESH

Data obtained for 2012—2015 from NSSL archives. The MESH grid has ~1 km gird spacing.

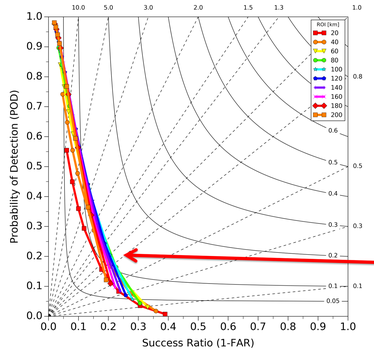
Quality control procedure (similar to Melick et al., 2014):

1. Apply Gaussian smoother with 3 grid cell sigma and mask raw MESH with the smoothed MESH, eliminating isolated pixels
2. Eliminate MESH pixels without a NLDN flash report within a 40 km radius
3. Remove MESH below severe limits (29 mm; Cinteneo et al., 2012)
4. Remove unrealistic MESH above 127 mm diameter (Blair et al., 2011; Cinteneo, 2016, personal communication)
5. MESH bilinearly interpolated to the NSSL WRF 4 km grid using the ESMPy (v 7.0.0) Python package.

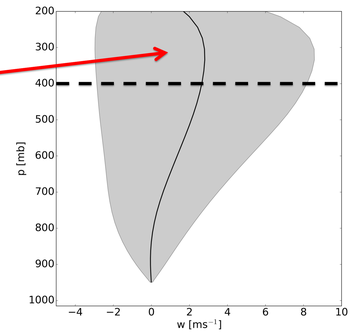
Verification Metrics

- Contingency Table/Performance Diagram (Roebber, 2009)
- Fractions Skill Score (Schwartz et al., 2010)

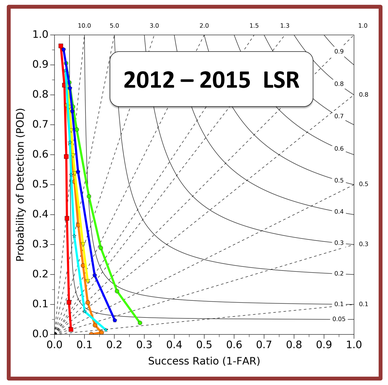
Verification Results



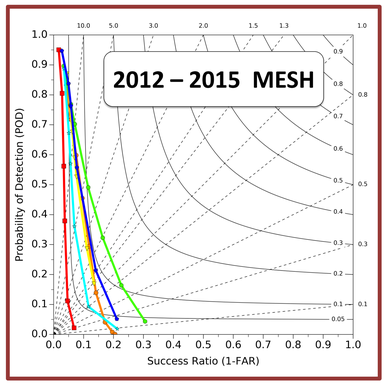
- NSSL WRF calculates Max W only below 400 mb
- Case from June 25, 2016 shows Max W often occurs above 400 mb
- Plot shows the vertical w profile (mean in **black**, ±1 SD in gray) for all CONUS points with Max UH ≥ 25 m^2s^{-2}



- Tested several neighborhood ROI for forecast fields
- 80 km ROI produces highest CSI
- Calculations based on Max UH

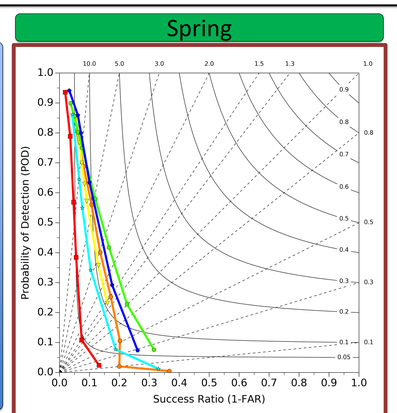


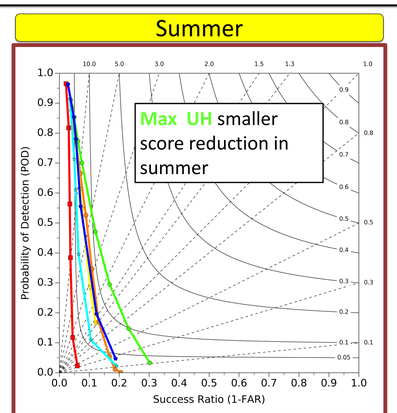
1 km Reflectivity
250mb W
HAILCAST
Max UH
Max VI Graupel
Max W

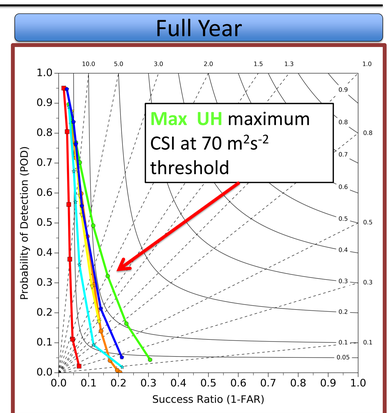


- Performance scores similar for both MESH and LSR baselines
- MESH performs better due to an increased spatial coverage relative to LSRs
- **250 mb W** is not hourly max field, but still performs comparable to the hourly **Max W field**

Performance



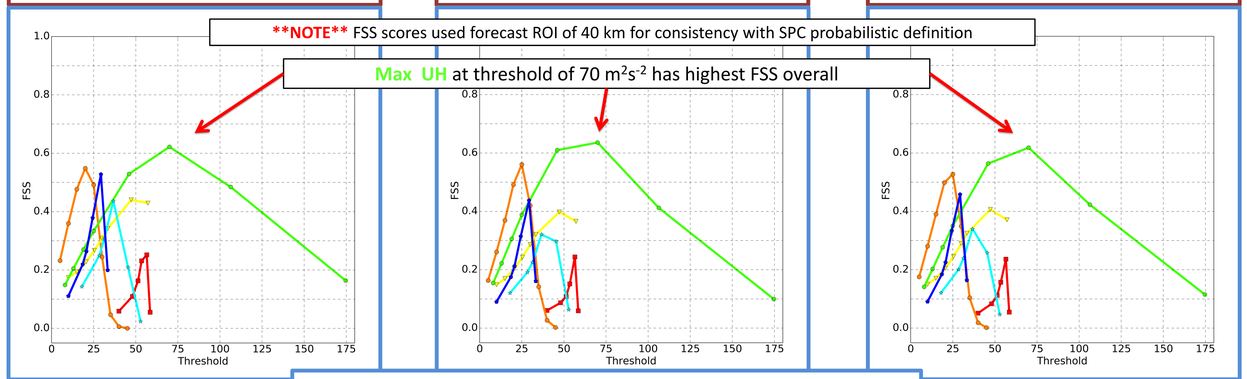




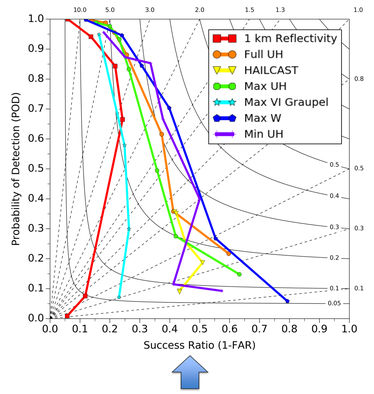
FSS

NOTE FSS scores used forecast ROI of 40 km for consistency with SPC probabilistic definition

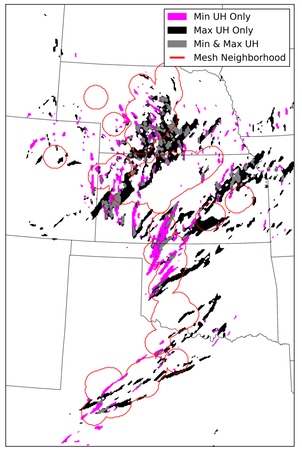
Max UH at threshold of 70 m^2s^{-2} has highest FSS overall



NSSL WRF Case Study: May 8th, 2016



- Can results be improved over existing proxies?
- Changed **Max W** to below 100 mb, added **Min UH** and **Full UH** to NSSL WRF
- **Full UH** defined as: $\max(abs(MinUH), MaxUH)$
- Max W highest CSI, Min UH beats Max UH and Full UH



- Spatially, we see how/where **Min UH** added value
- Plot shows **Min UH**, **Max UH**, and **Full UH** points along with **MESH 40 km neighborhood**

Key Findings & Further Questions

- Severe hail forecasts from the NSSL WRF are most skillful when using an 80 km neighborhood for verification calculations
- Using MESH as observational "truth" leads to higher CSI scores versus using LSRs
- Current NSSL WRF Max W (calculated below 400 mb) underestimates the true Max W in some cases
- Including vertical velocities above 400 mb can improve Max W forecast skill
- The Max UH hail proxy shows the most skill for predicting severe hail
- Max UH is the most consistent severe hail proxy in terms of forecast skill across seasons
- Of the thresholds used, 70 m^2s^{-2} Max UH showed the most skill and the best match to observed spatial probabilities
  - Is 70 m^2s^{-2} the optimal threshold for the NSSL-WRF?
- Including Min UH/Full UH can improve upon Max UH forecast skill
  - How often does adding Min UH help? In what environments?

Acknowledgements

Funding for this work was provided by NOAA grant #NA15OAR4590192.

Some of the computing for this project was performed at the OU Supercomputing Center for Education & Research (OSCER) at the University of Oklahoma (OU) as well as at NSSL.

The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the authors and do not necessarily reflect the views of NOAA or the Department of Commerce.

*nathan.wendt@noaa.gov