

# Forecaster Decision Making with Automated Probabilistic Guidance in the 2015 Hazardous Weather

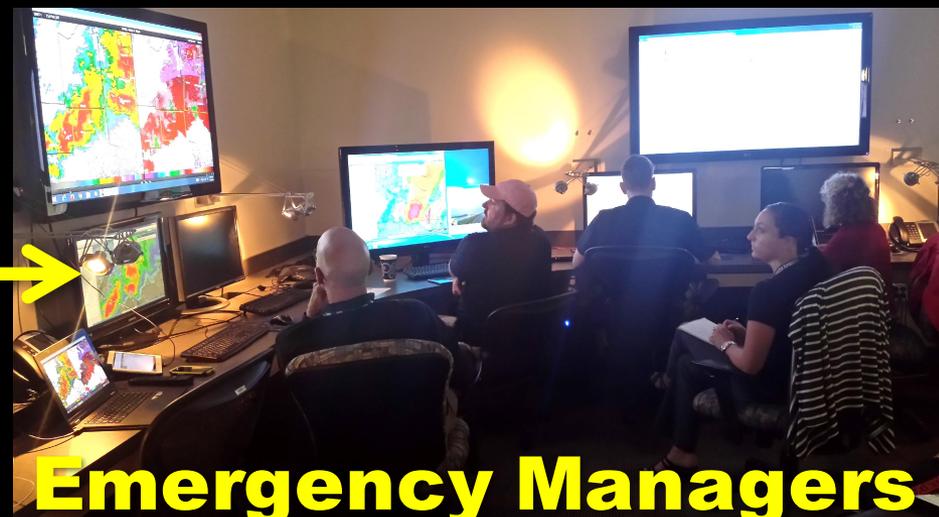
## Testbed Probabilistic Hazard Information Experiment



*cinms*



**NWS Forecasters**



**Emergency Managers**

Chris Karstens, Greg Stumpf, Chen Ling, Darrel Kingfield, Kristin Calhoun, James Correia, Jr., Daphne LaDue, Tiffany Meyer, Travis Smith, John Cintineo, Chris Melick, Lans Rothfusz

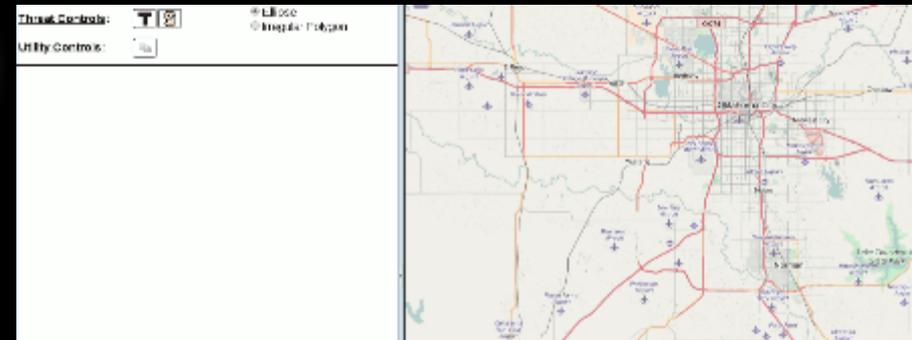
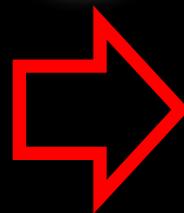
# HWT PHI Experiment Overview

- **3 Week Experiment**
  - May 4-8, May 19-23, June 1-5
- **6 NWS forecasters & 10 EMs**
  - Regional, experience, and gender diversity
- Issue and evaluate Probabilistic Forecasts of **Any Severe** and **Tornado**

Dr. Daphne LaDue et al.



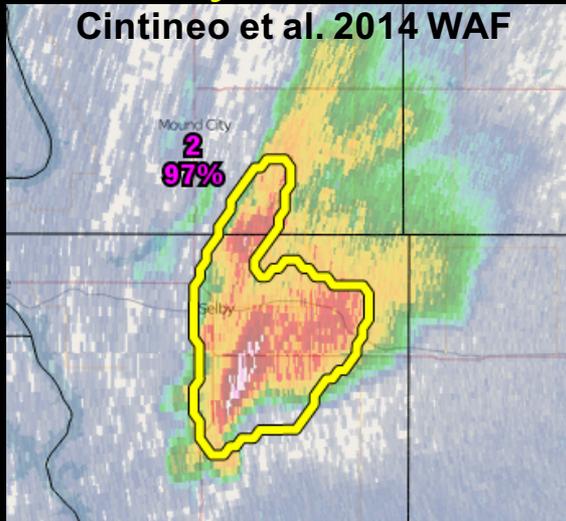
Deterministic Warnings



PHI Objects

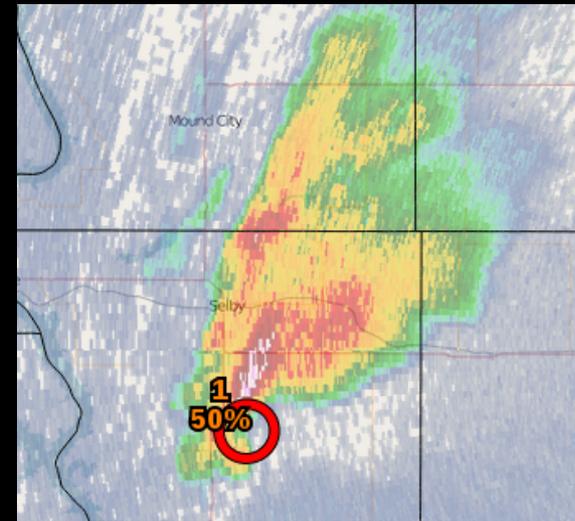
# Automated Object-Based Guidance

## Any Severe



- ProbSevere
- Naïve Bayesian Model
- MRMS Composite Reflectivity -> Objects
- 60 min. Probability of Any Severe

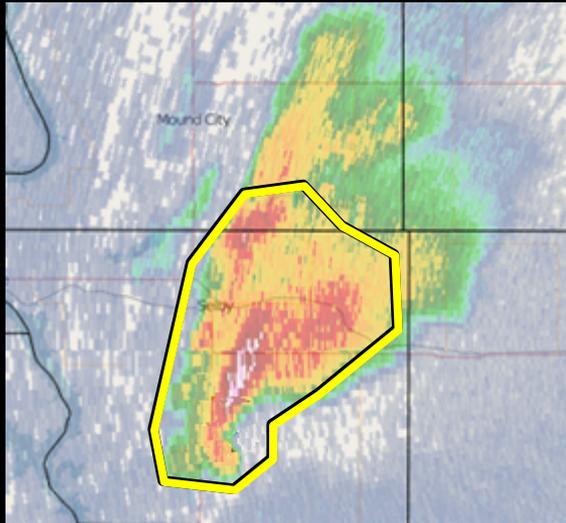
## Tornado



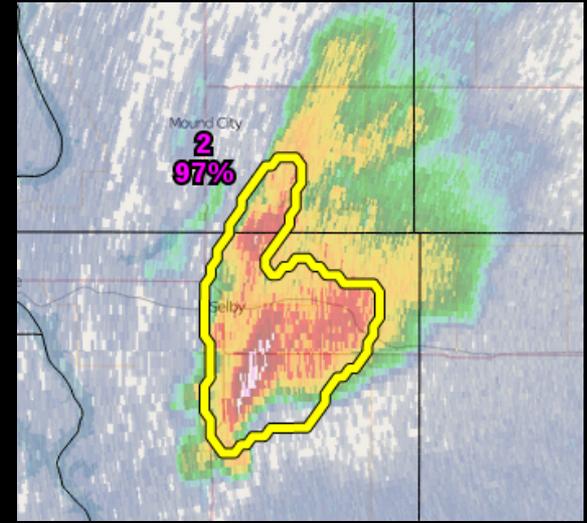
- Probability of Exceedance
  - MRMS 3-6 km AGL Azimuthal Shear
  - Tornado warning performance
- MRMS 3-6 km AGL Azimuthal Shear -> Objects
- 60 min. Probability of Tornado

# How to Utilize Emerging Guidance?

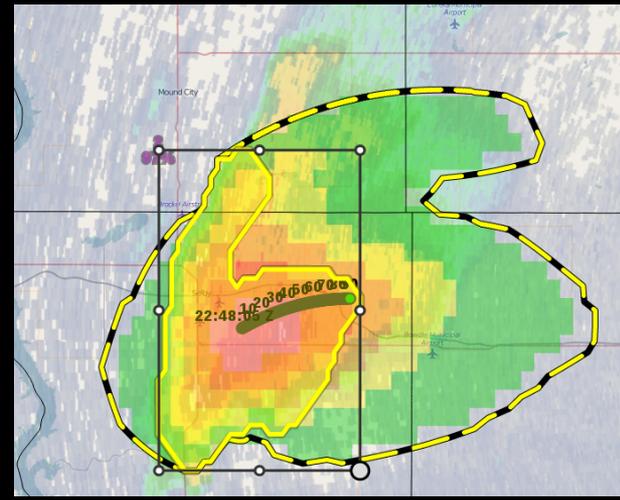
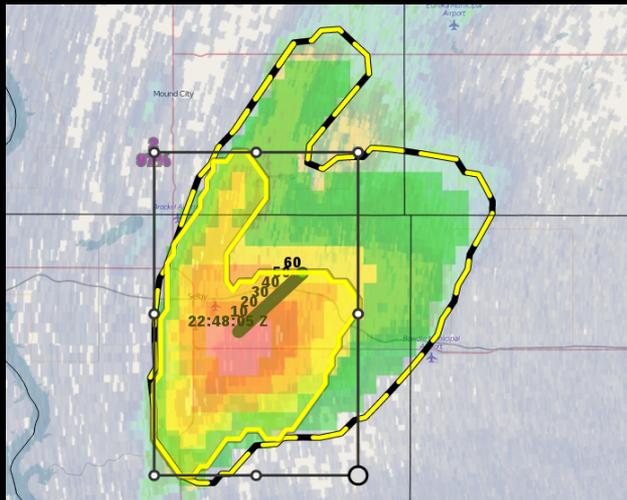
Manual?



Automated?



Forecaster-  
Machine Mix?

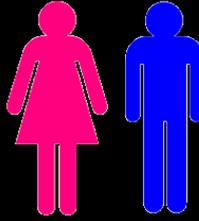


# HWT Experiment Design

Base Data /  
AWIPS 2



Forecasters



?

?

?

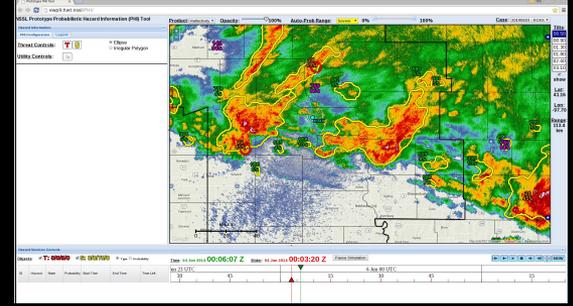
WC



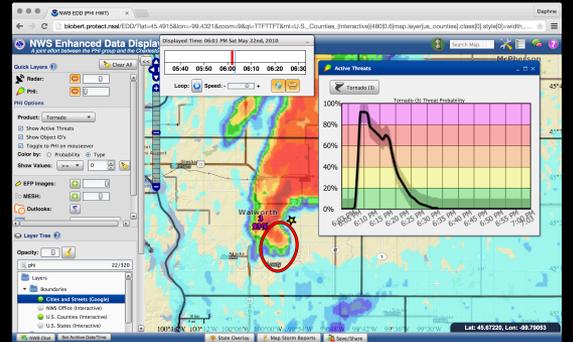
NWSChat



Prototype PHI Tool



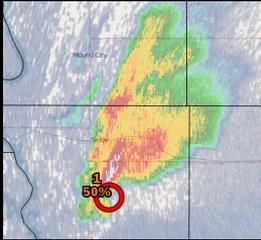
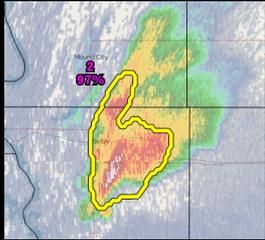
EDD



EMs



Automated Guidance



# Levels of Incorporating Automation

Level 1

Forecaster **generates** all probabilistic forecasts

No access to automated guidance

Level 2

Forecaster **optionally** uses automated guidance to generate probabilistic forecasts

Automated guidance is running, but can be overridden

Level 3

Forecaster **partially** overrides automation

Automated guidance is running, all attributes except mechanical aspects can be overridden

Level 4

Forecaster **observes** automatic probabilistic forecast generation

Automated guidance running and generating probabilistic forecasts

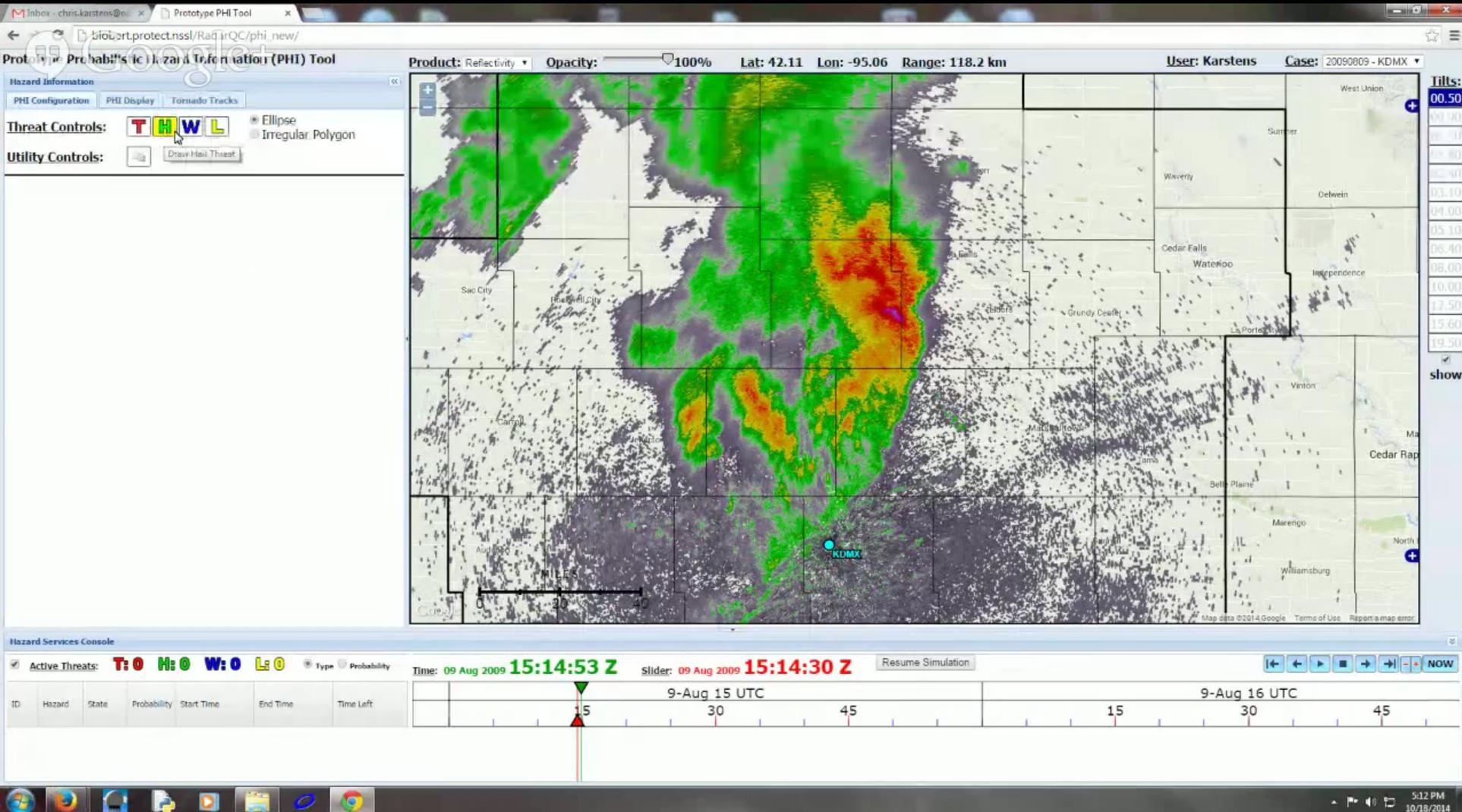
Manual



Automated

# Manual Probabilistic Forecast Generation Example

## Prototype PHI Tool (Karstens et al. WAF 2015 Early Online Release)



# HWT Results

## Level 1: Manual Forecast Generation

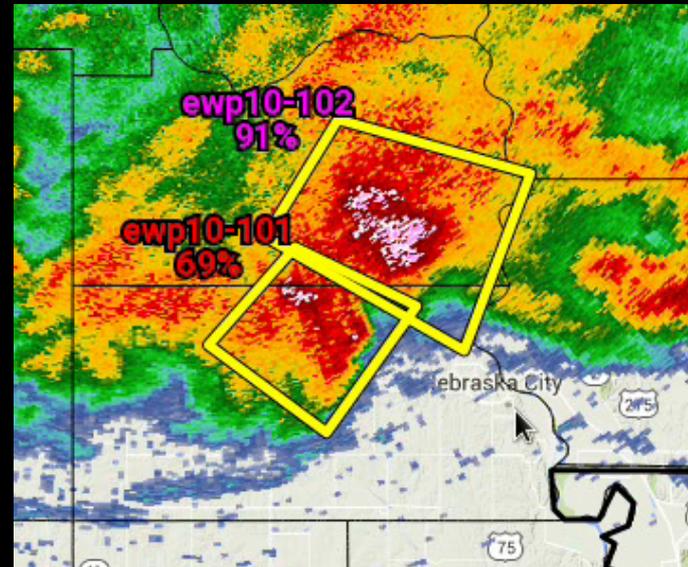
- **Replication of 2014 Results**

- Forecaster workload becomes too high with many (4-5+) hazard events to forecast simultaneously

- “Warning criteria”, “severe limits”

- **Fall-back to WarnGEN approach**

- Drawing/stacking parallelograms
  - Drawing boxes around things
  - Communication -> NWSChat



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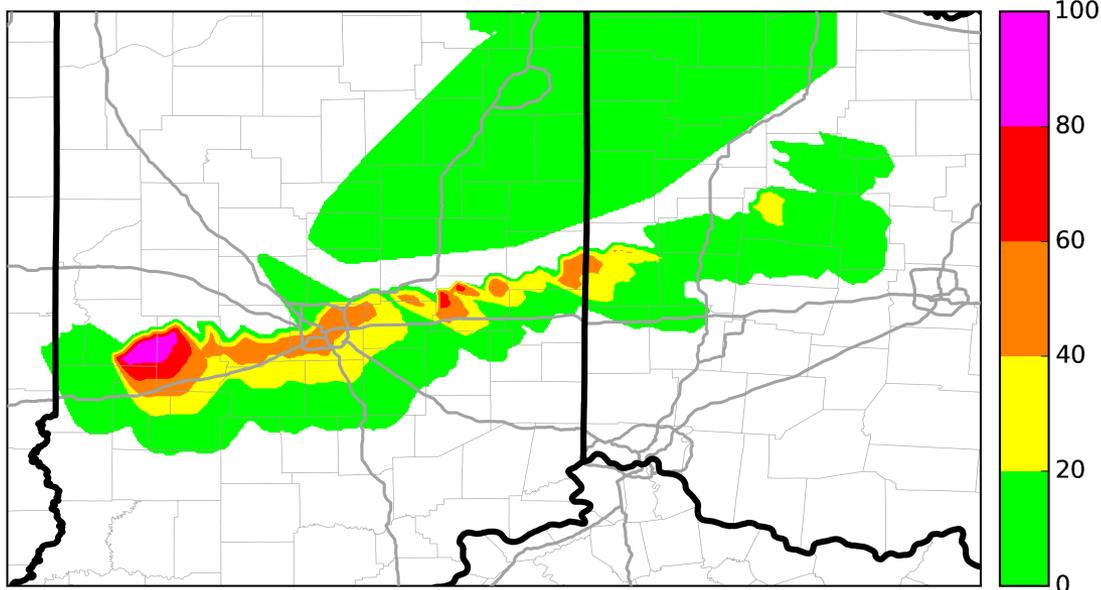
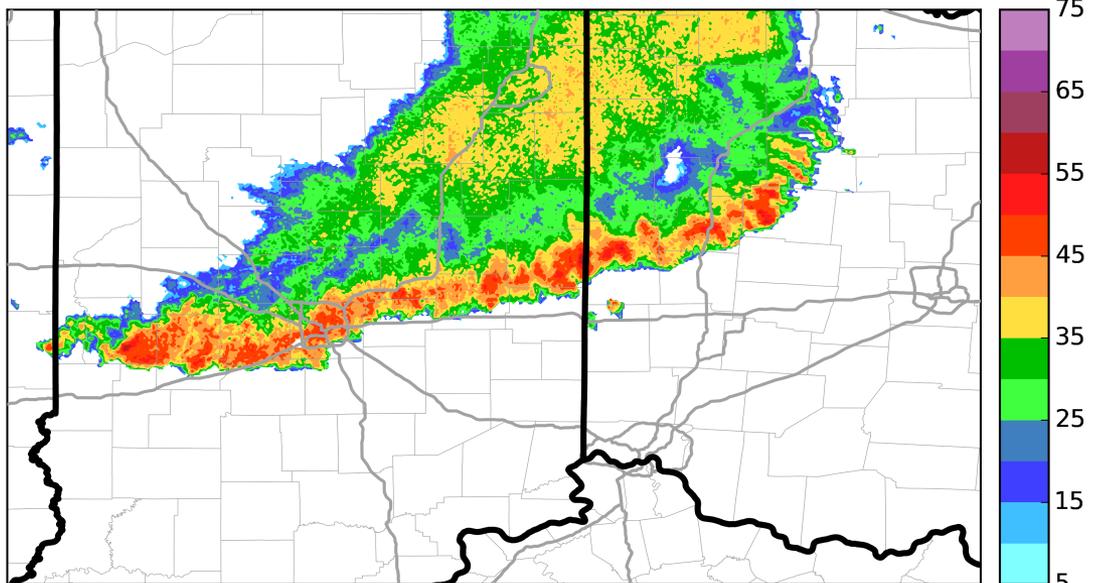


Automated

# Automated Probabilistic Forecast Example

**Any Severe**

13 July 2015  
1606z – 1658z



# HWT Results

## Level 4: Automated Forecast Generation

- **Forecasters were frustrated**
  - Wanted more control over the process, be involved.
  - Worried about verification (i.e., performance)
- **Emergency Managers were left guessing**
  - Interpreting radar signatures themselves
  - Relying on their own intuition
- **Communication bottlenecked through NWSChat**

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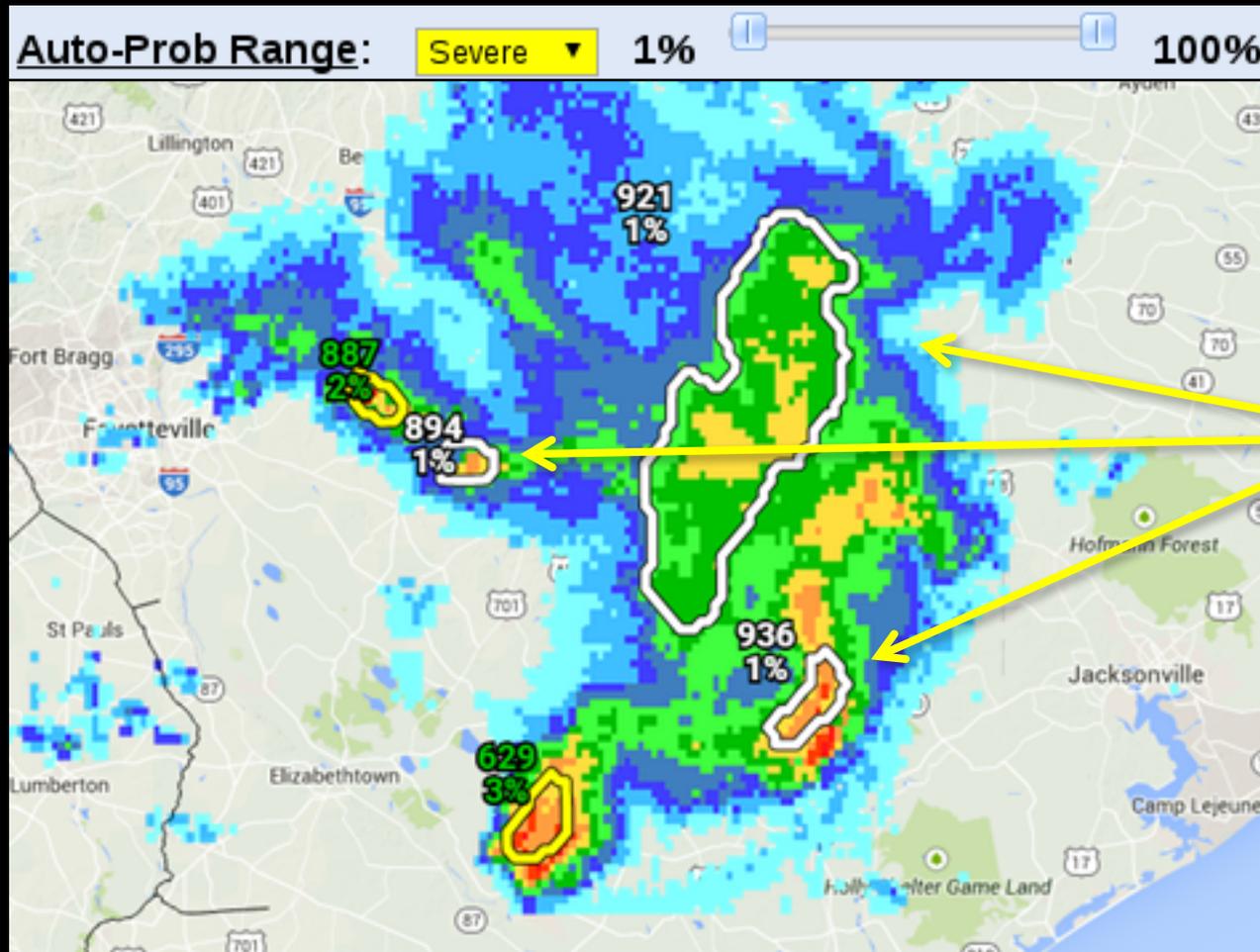
Automated guidance running and generating probabilistic forecasts

Manual



Automated

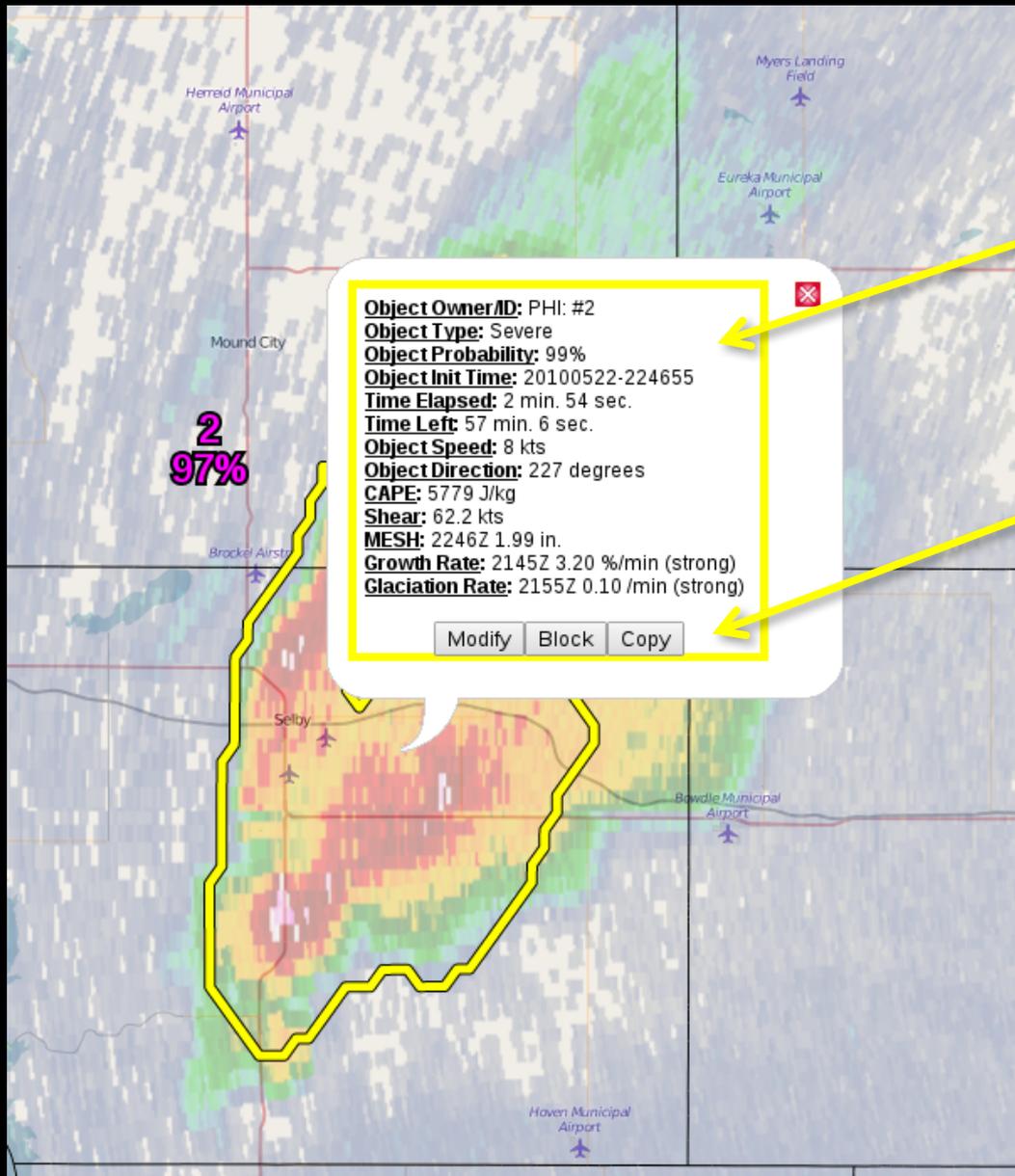
# Forecaster-Object Interactivity



Probability  
Threshold  
Slider Bar

Quickly Mask  
Automated  
Objects

# Forecaster-Object Interactivity



## Object Attributes

## Popup Options:

- Block
- Allow
- Modify
  - Adjust object attributes:
    - Object position & shape
    - Speed
    - Direction
    - Duration
    - Probability Trend
    - Discussion

# Forecaster-Object Interactivity

## Modification of "Recommender" Object Attributes

Threat ID: 2  
Valid Start Time: 22:48:05 UTC  
Motion Vector: 240 ° @ 8 kts  
Hazard: Total Severe  
Duration: 90 min.

Trend Interpolation: Draw Linear Exp1 Exp2 Bell +5 -5

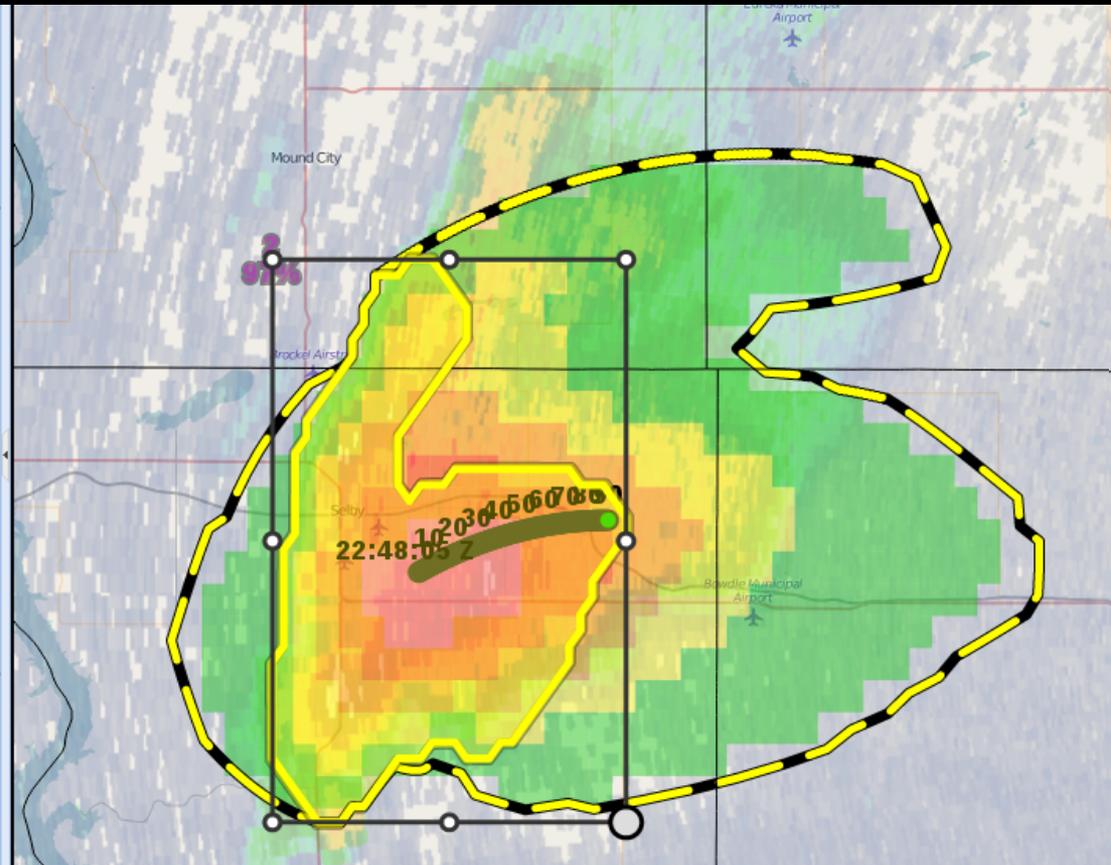
P(Severe)

UNDO REDO

Time (min)	P(Severe) (%)
0	95
10	92
20	88
30	82
40	75
50	65
60	52
70	38
80	22
90	0

Warning Decision Discussion:  
This storm is capable of producing large hail in excess of 2 inches in diameter.

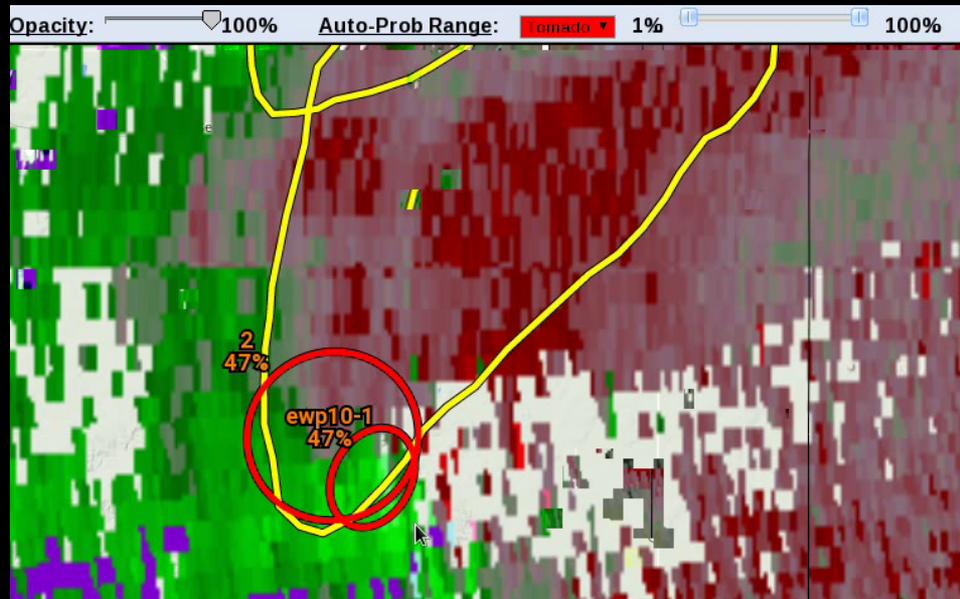
Activate Threat



# HWT Results

## Level 2: Optional Usage of Automated Guidance

- Forecasters trended toward turning off the guidance
  - “taught in DLOC to be leery of algorithms” – Trust Factor?
  - Dynamic complications – System Design Factor
    - Overlapping objects (manual vs. automated) -> “Whack-a-mole”
    - Forecasters and EMs were floundering



# HWT Results

## Level 2: Optional Usage of Automated Guidance

- Needed to rethink this process...
  - Find a way to combine the best human and machine abilities
  - Needed to make connections between our observations of forecasters' successes and failures in creating forecasts
    - Needed to develop an insight!
    - This is not easy!

But, why we have  
testbeds!



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Manual



Automated

# HWT Results

## Level 3: Partial Usage of Automated Guidance

- Any Severe:
  - Automation handles object shape/position over time.
    - ProbSevere object coverage and evolution is robust
  - Forecasters optionally override specific attributes
    - Speed, direction, duration, discussion, and probability
- Tornado:
  - Forecasters were 100% responsible for tornado forecasts (Level 1)
    - Too many false detections from automation
    - Circle/Ellipse shape easy to modify/update
    - Often few tornado objects to create/maintain

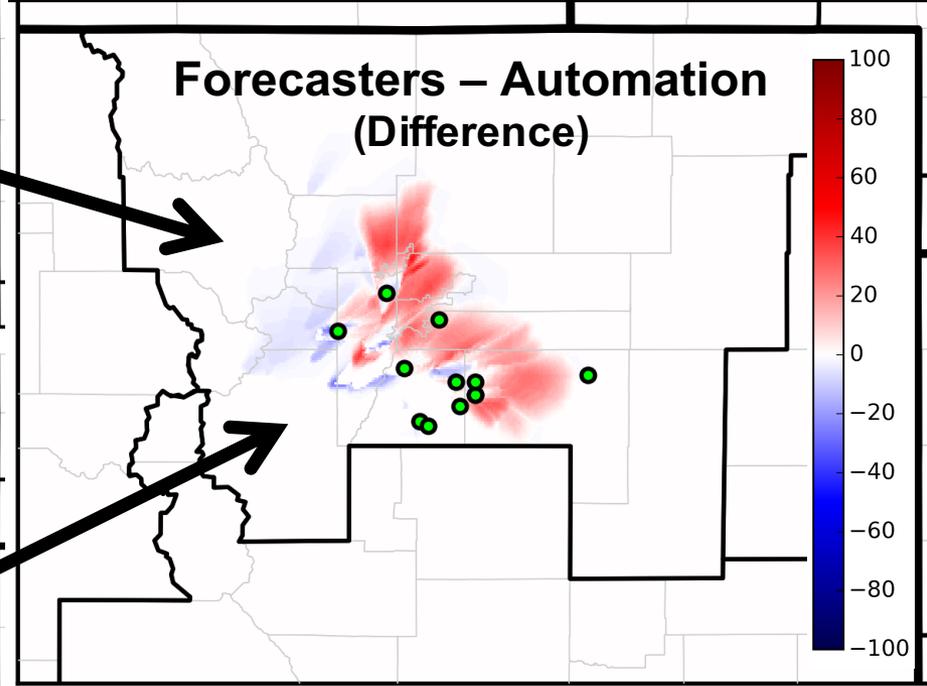
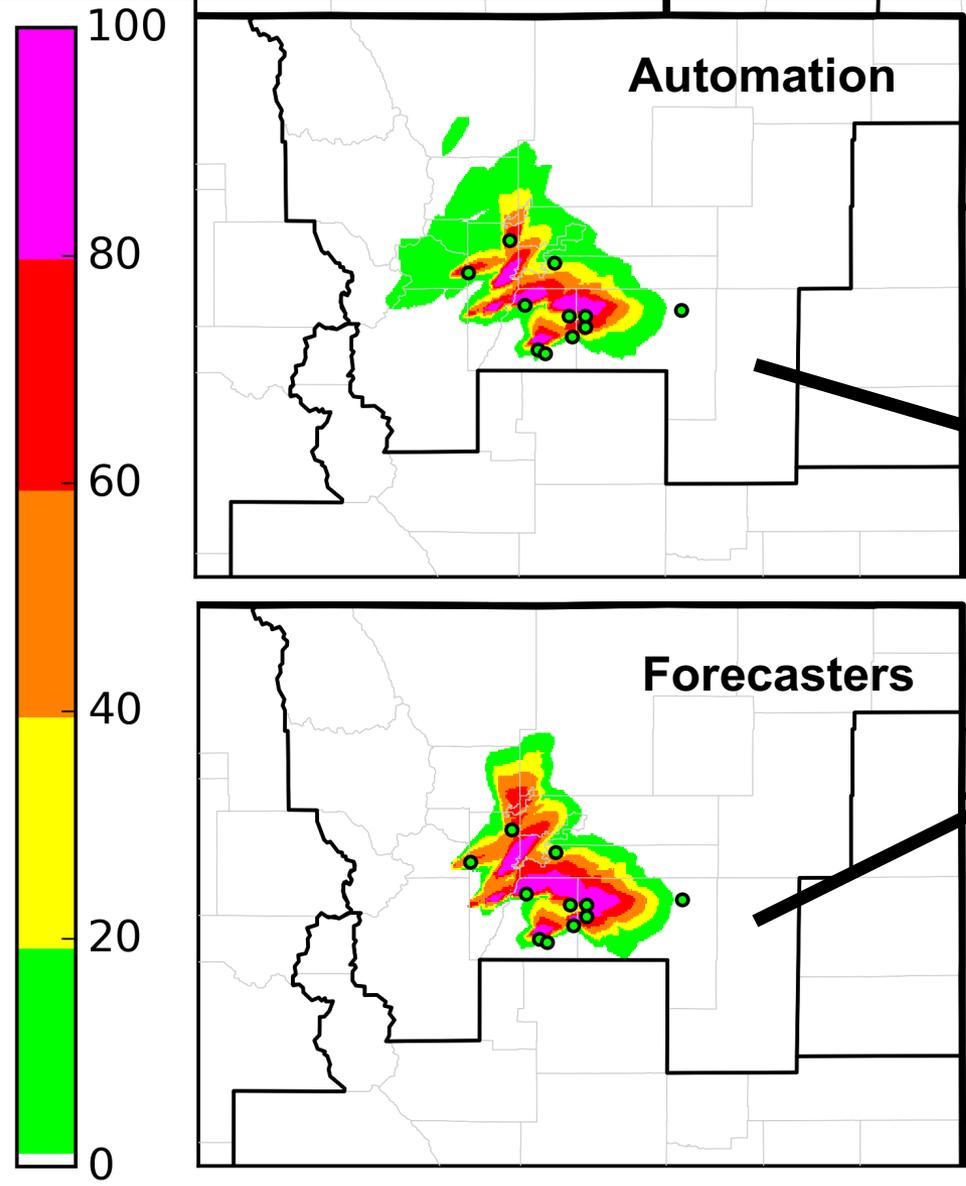
# Discussion

- Level 3 gave us new and interesting results
  - Saves time on forecast creation
    - Leveraging mechanical abilities (objects) from automation
  - More time for storm interrogation and communication
    - Understanding hazard potential and meeting EM needs
    - Situational Impasse - at least one instance of a hazard not being collocated with automated ProbSevere object (gust front)
      - Forecaster communicated the “discrepancy” (time as a tool)
      - EM found the information effective (DSS)
  - Adjustment of diagnostic probabilities...

# Usage of Automated Guidance

## Any Severe

3 June 2015 1830z –  
4 June 2015 0030z



# Usage of Automated Guidance

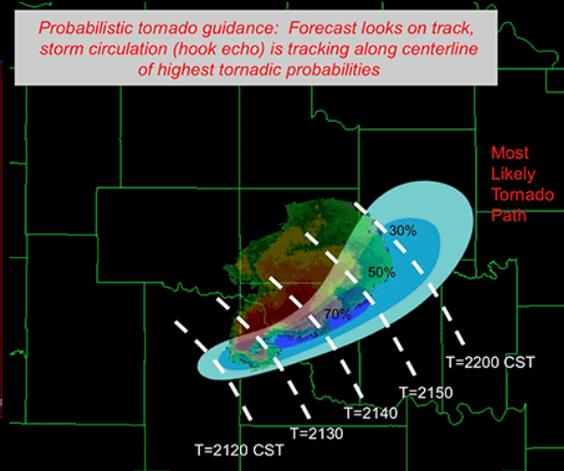
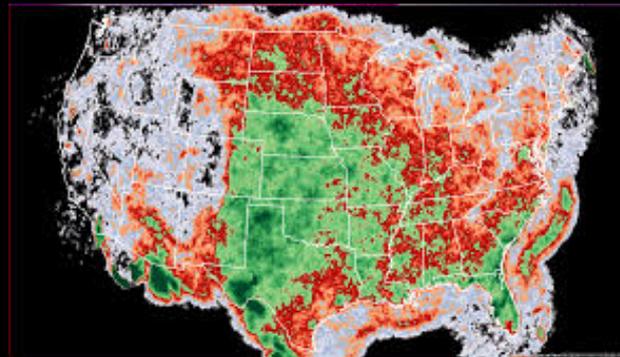
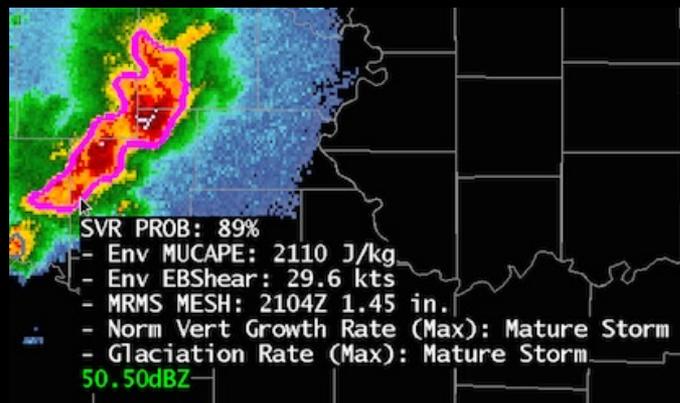
- Tendency to raise/lower diagnostic probabilities from automation
  - Informed by:
    - Real-time reports/non-reports
    - WarnGEN vs. New Warning System (FACETs)?
    - 2015 Forecaster vs. 2025 Forecaster
    - Forecaster/EM interaction (Adding “Value”)
  - A refined difference in perspective:
    - Forecaster perspective: Given a storm of x,y,z characteristics, what is the probability that it will produce severe weather?
    - User perspective: Given my location, will severe weather affect me or not?

# 2016 HWT PHI Experiment

- Incorporation & Fusion of Automated Guidance

- **ProbSevere** (K. Calhoun et al.) & **Lightning** (T. Meyer et al.)
  - Hazard identification, movement, and likelihood (**diagnostic**)
- **MYRORSS** (T. Smith et al.)
  - Hazard longevity & severe winds (**diagnostic**)
- **Warn-on-Forecast** (J. Correia, Jr. et al.)
  - Tornado prediction (**prognostic**)

Fusion of Information!



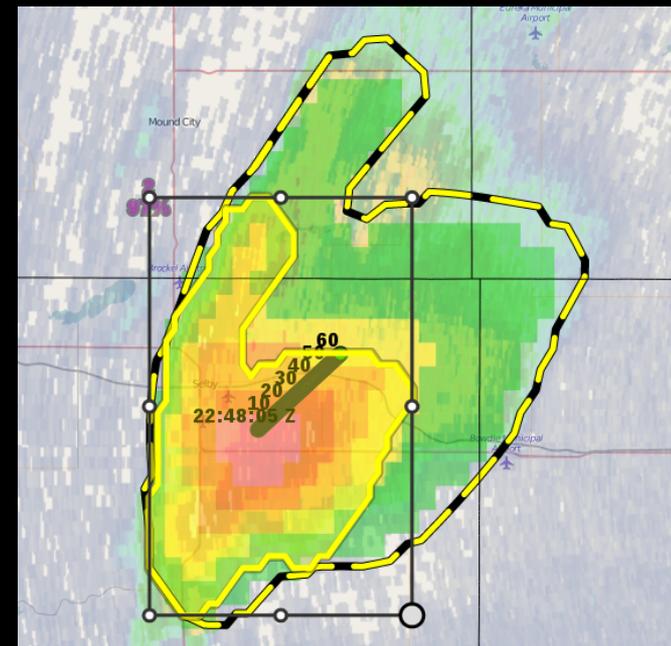
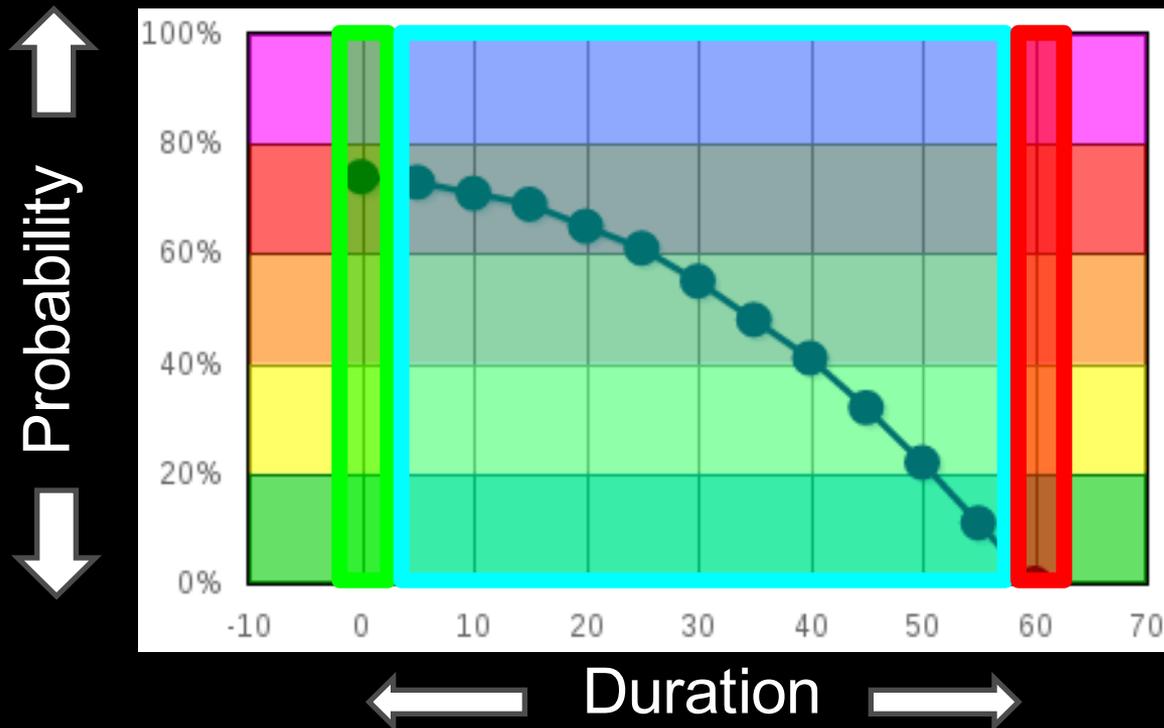
# Fusion of Guidance

“Forecasting involves **diagnosis** of the current state of the atmosphere and development of a trend (**prognosis**)” - Moller (1998)

Uncertainty  
Diagnosis

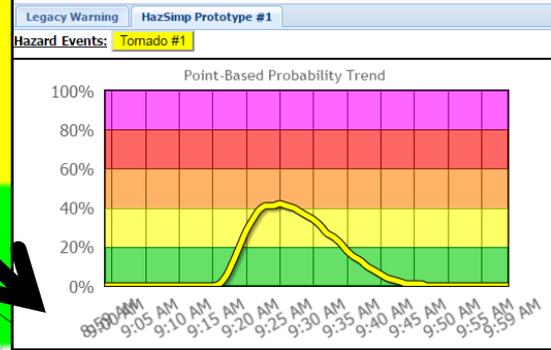
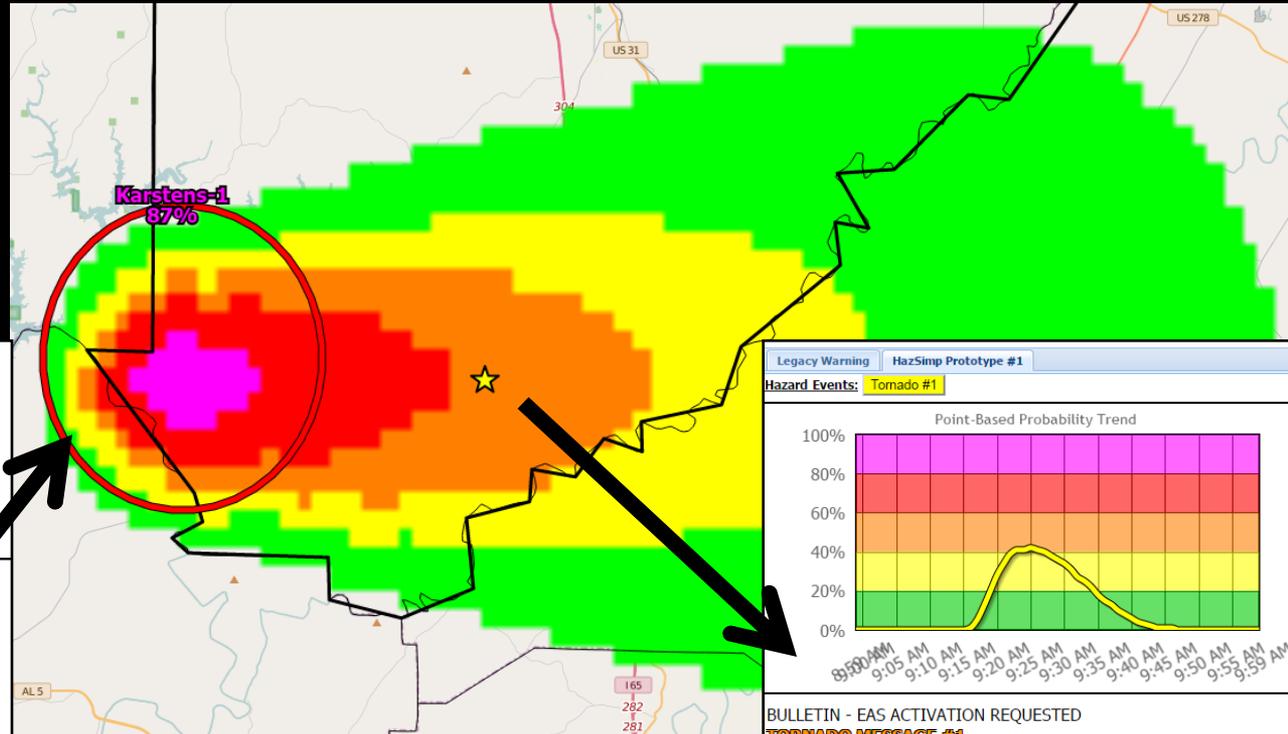
Linear or Nonlinear  
Prognosis

Predictability  
Limit



# 2016 HWT PHI Experiment

## Collaboration with NWS Hazard Simplification Project:



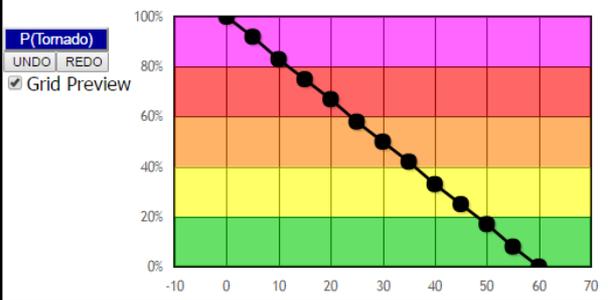
BULLETIN - EAS ACTIVATION REQUESTED  
**TORNADO MESSAGE #1**  
Audience: Public  
Source: Hazardous Weather Testbed  
Issued: 4/1/2016, 8:56 AM

**Alert Level: N/A**  
**What:** Tornado  
**Where:** 27 miles west-southwest of Hanceville, AL  
**When:** Between 9:16 AM and 9:46 AM (14 to 44 min. from now)  
**When (Likely):** Between 9:20 AM and 9:34 AM (18 to 32 min. from now)  
**Recommended Actions:** N/A

**Expected Impacts:** N/A  
**Forecast Severity:** N/A  
**Forecast Likelihood:** 42% (see chart for more details)  
**Observations:** N/A

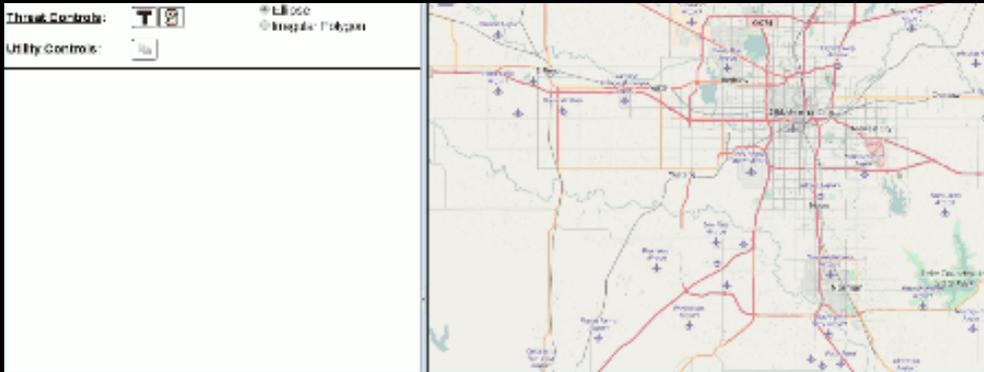
ID/Start Time: 1 13:52:34 UTC  
Hazard: Tomado  
Motion/Duration: 270 ° @ 32 kts for 60 minutes  
Prediction: Explicit  
Severity: Strong Tomado  
Alert Level: [Symbol]  
Warning Threshold: Probability = 50

Trend Interpolation: Draw Linear Exp1 Exp2 Bell +5 -5  
Peak Shear: [ ] kts

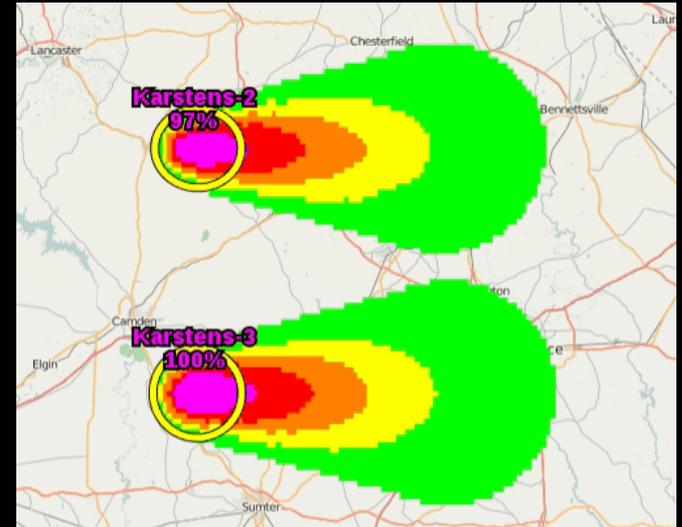


Warning Decision Discussion:  
Type discussion here.  
Issue

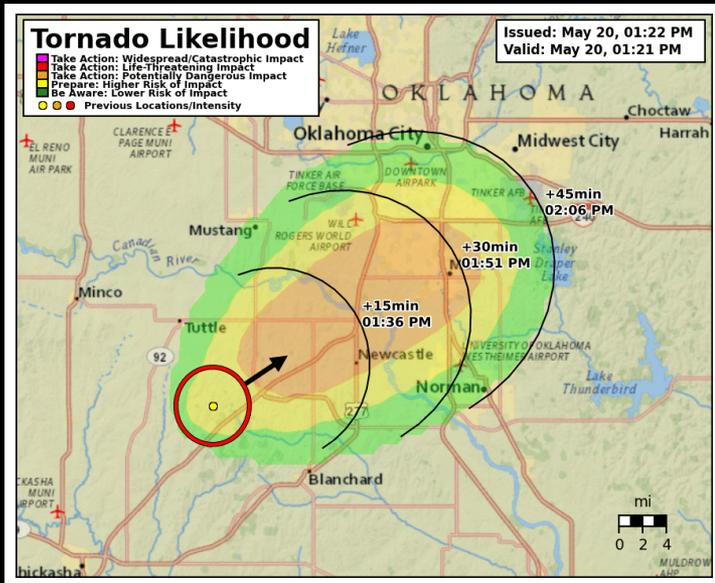
# 2016 HWT PHI Experiment



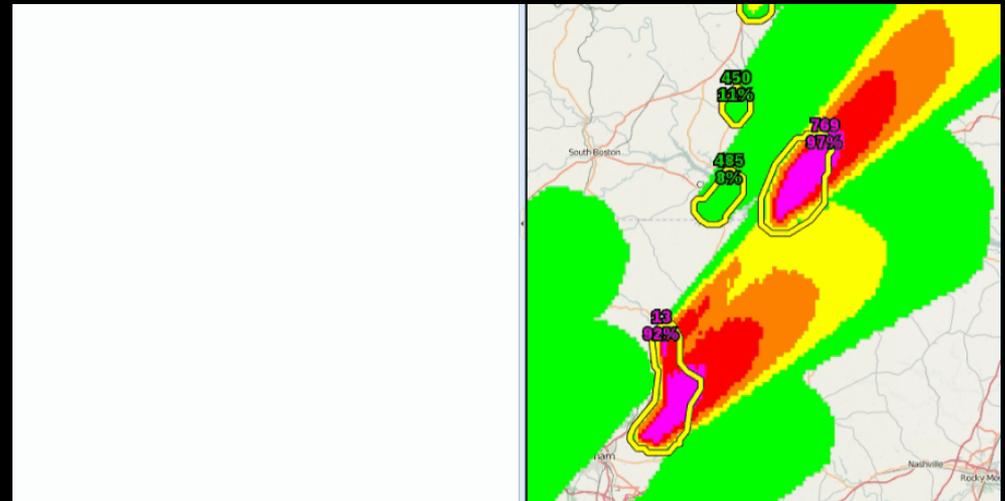
Enhanced Performance



Explicit/Persistence Forecasts



User Graphic Generation



Object Info/LSR History

# Parting Thoughts

“Clearly a man/machine mix is necessary to produce the best possible forecasts” - Moller (1998)

“A consistent collaboration between meteorologists, cognitive psychologists, and others involved in judgement and decision-making research will be necessary if the goal of improving human weather forecasting is to be achieved” - Doswell (2004)

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