

# **Advances in Probabilistic IDSS for the Extreme Precipitation Challenge**

**Dr. David Novak and many others  
Weather Prediction Center**

# WEATHER PREDICTION CENTER

**Our Mission:** To synthesize the nation's daily weather story and champion the **operational prediction of rain storms, winter storms, and extreme temperature events** for the protection of life and property.

## The Nation's Big-Picture Weather Story

With a Focus On:

Rain Storms



Winter Storms



Temperature Extremes



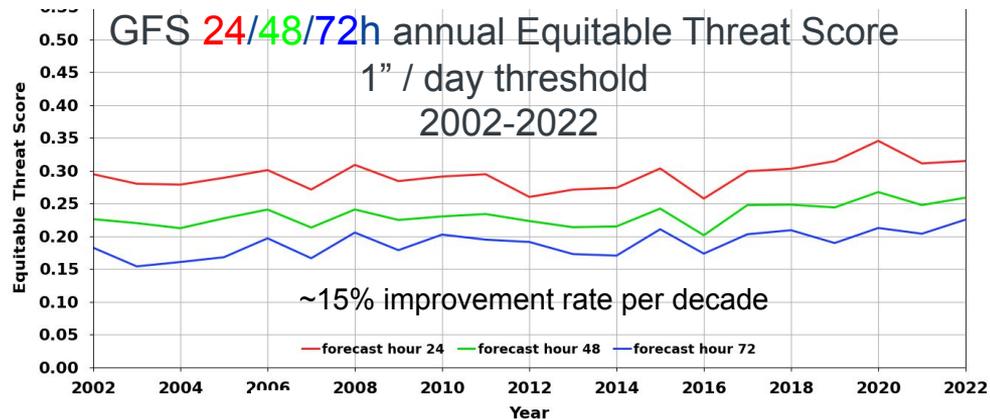


Imperative for accurate,  
understandable forecasts



# Precipitation Forecasts are Challenging!

Painfully slow improvement in past ....



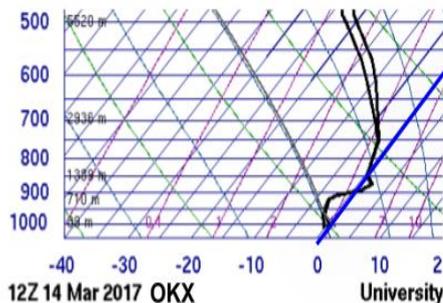
## Priorities for Weather Research Report

“Unfortunately, precipitation forecast skill has not improved substantially over decades and remains one of the major technical challenges in atmospheric sciences.

Poor prediction skill for flood and drought has an inordinate impact on disadvantaged communities”

# Precipitation Forecasts are Challenging!

March 14, 2017



Snow lovers from DC to NYC reporting their snow totals today.



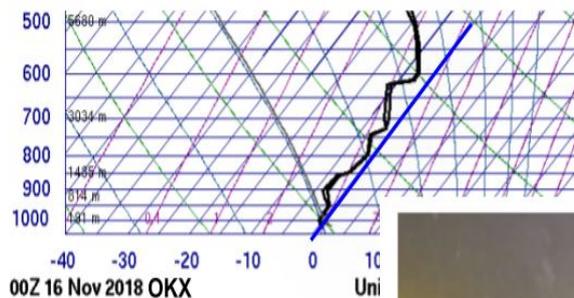
METRO

## NYC blizzard is a dud

By Danielle Furfaro and Yaron Steinbuch

It's not exactly the snowpocalypse.

November 15, 2018



## Outrage after a few inches of snow brings NYC to a halt

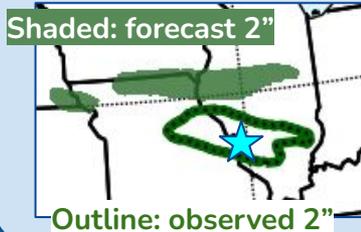
By Ben Feuerherd

November 15, 2018 | 11:09pm | Updated



# Ensemble Underdispersion

What do you do when the models agree on an extreme event, but not the location?



St. Louis hit with "catastrophic" rainfall, flash flooding prompts rescues



Axios



NWS St. Louis  
@NWSStLouis · Follow

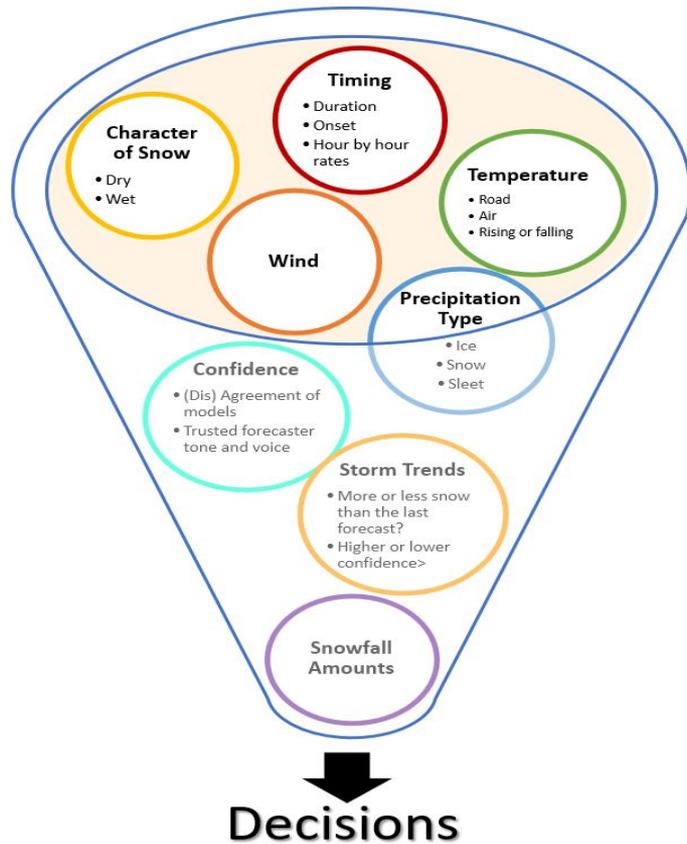
**\*\*All Time Daily Rainfall Record at St. Louis Shattered\*\***



*Bruce Veenhuis -  
Wednesday AM  
Session 5a*

*Jimmy Correia -  
Wednesday PM  
Session 7a*

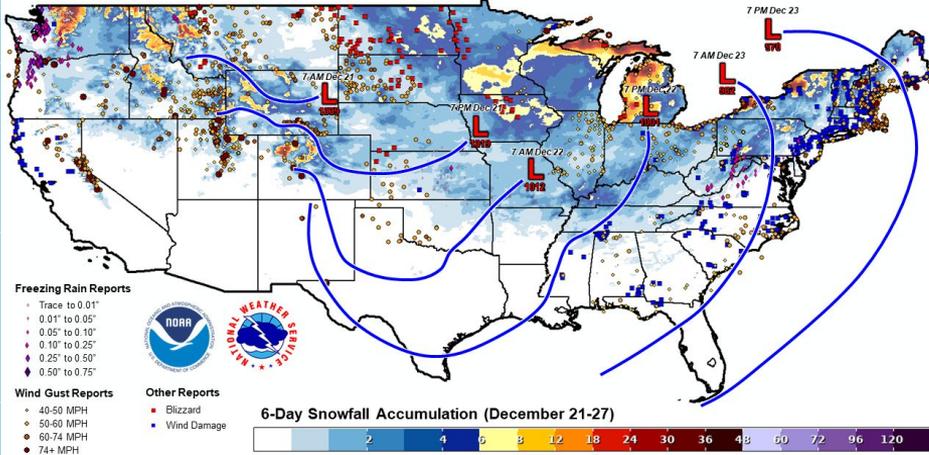
# Complex Decision Environments



# And the Stakes are HIGH

## Dec 21-27, 2022 Coast-to-Coast Winter Storm Summary

Underlay shading: Snowfall accumulation 12 UTC December 21 to 12 UTC December 27.  
Overlays: 12-hour low and front progression from WPC surface analysis and selected Local Storm Reports across the CONUS.



**“This was a very, very bad night  
in our community”**  
Mark Poloncarz, Erie County executive



News // Bay Area & State

## Pleas for help, daring rescues after snowstorm shocks California

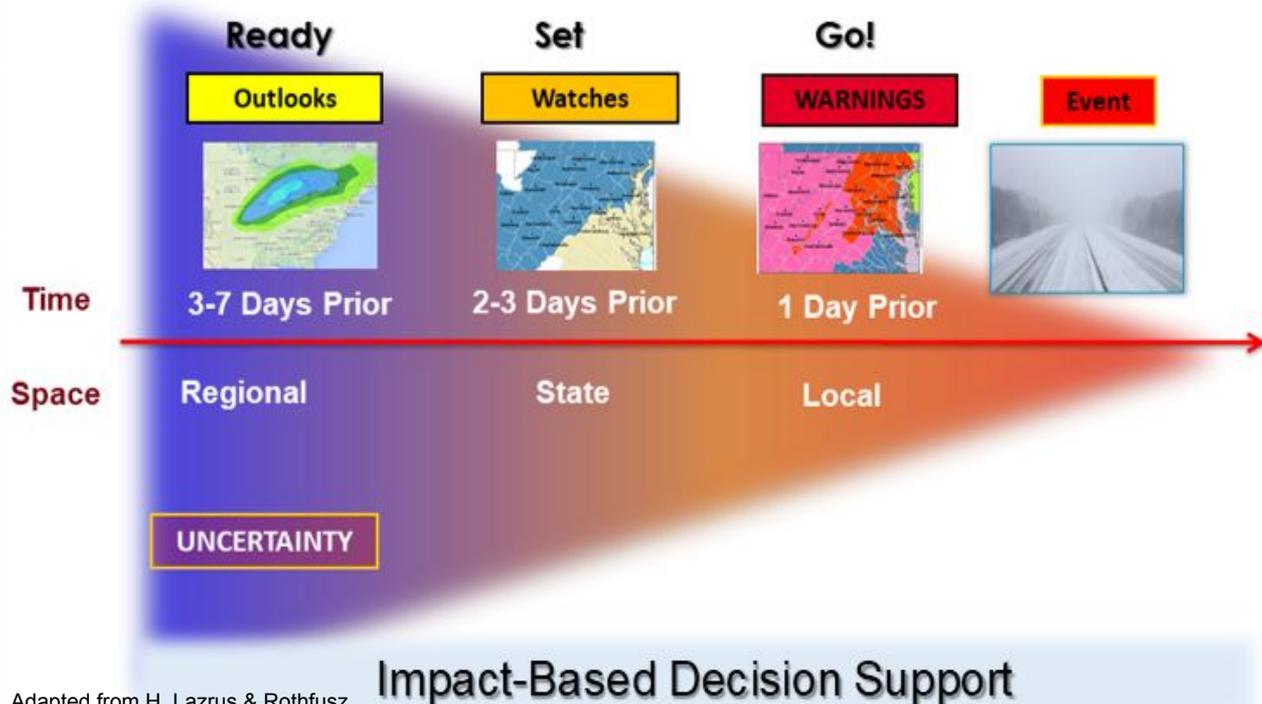
Katie Dowd, SFGATE

March 5, 2023 | Updated: March 5, 2023 9:57 a.m.



# Approach to the Challenge

## Use Probabilistic Impact Information to Drive Messaging



As the certainty of an event increases, the urgency & specificity of forecast information increases

*Gilbert, Waldstreicher, Jeglum - Tuesday PM Session 3*

Adapted from H. Lazrus & Rothfus et al. (2018)



# Empower Forecasters with Tools

Extract information from the full ensemble distribution - such as alternative scenarios

“These studies generally agree that ensemble/simulation representations (that highlight alternative possibilities) promote risk comprehension and awareness of unlikely (but possible) outcomes...”  
Ripberger et al. 2022

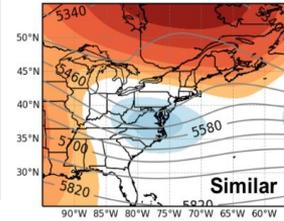
High End Amount - 1 in 10 Chance (10%) Of Higher Snowfall Twin Cities/Chanhassen, MN  
Valid 6 AM Fri Dec 10, 2021 through 6 AM Sat Dec 11, 2021 CST  
Weather Forecast Office  
Issued Dec 09, 2021 3:39 AM CST



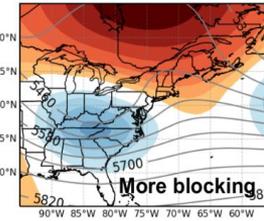
Low End Amount - 9 in 10 Chance (90%) Of Higher Snowfall Twin Cities/Chanhassen, MN  
Valid 6 AM Fri Dec 10, 2021 through 6 AM Sat Dec 11, 2021 CST  
Weather Forecast Office  
Issued Dec 09, 2021 3:39 AM CST



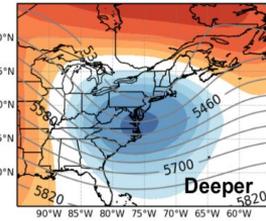
Cluster 1 C: 6=30% G: 11=37% E: 20=40% T: 37=37%



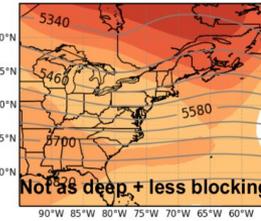
Cluster 2 C: 2=10% G: 0=0% E: 24=48% T: 26=26%



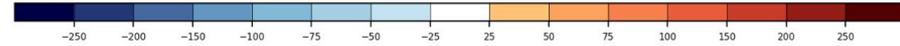
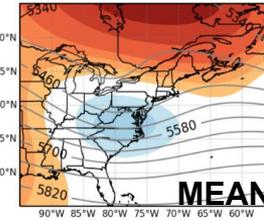
Cluster 3 C: 2=10% G: 14=47% E: 3=6% T: 19=19%



Cluster 4 C: 10=50% G: 9=17% E: 3=6% T: 18=18%



Multi-Model Ensemble C: 20=100% G: 30=100% E: 50=100% T: 100=100%

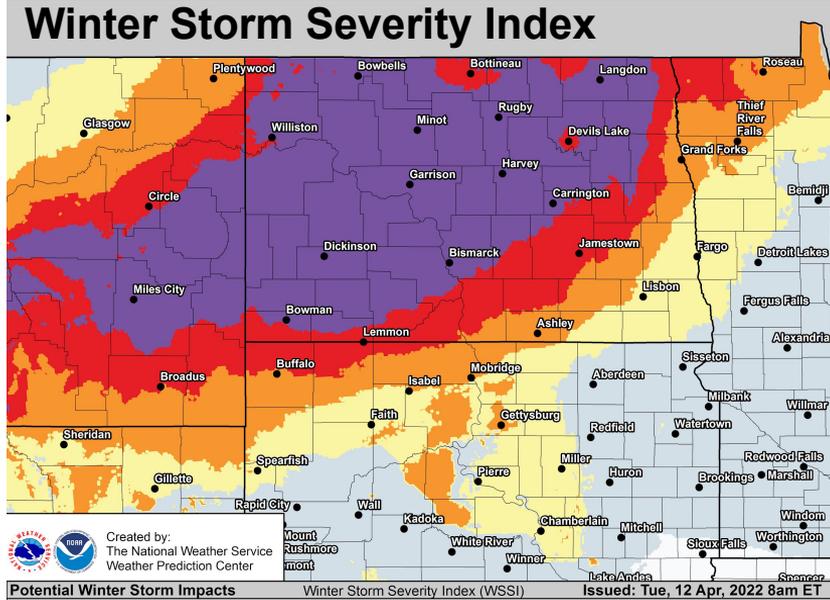


Cluster mean 500-hPa heights (contours) and anomalies (color fill)

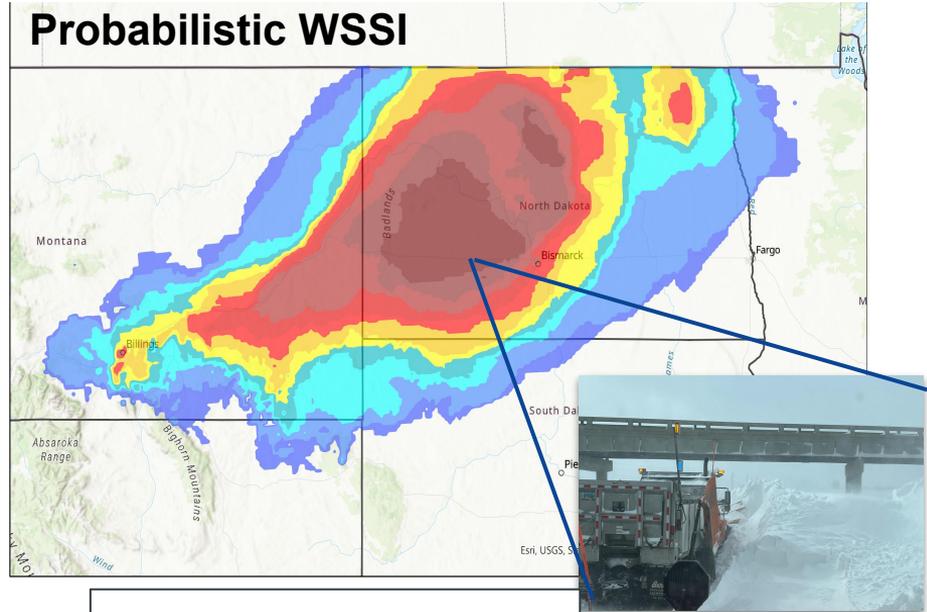
Austin Coleman - Wednesday AM Session 5a



# Translate to Impacts



Potential Winter Storm Impacts	Winter Storm Severity Index (WSSI)
Winter Weather Area	Winter weather possible
Minor Impacts	A few inconveniences to daily life
Moderate Impacts	Disruptions to daily life
Major Impacts	Considerable disruptions to daily life
Extreme Impacts	Substantial disruptions to daily life



### Likelihood of Major Impact

<5%	30%	70%
5%	40%	80%
10%	50%	90%
20%	60%	>95%



# And then Effectively Communicate

Continue to expand Federal, State, & Local partnerships to ensure public safety & mitigate damages.





## Key Messages for Dec 9-11 Winter Storm

Updated December 10, 2021  
2:30 PM CST

Significant snowfall and impacts from the Rockies through the Upper Midwest and Great Lakes

- **Significant winter storm will continue**  
A strong low pressure system will track across the Central Plains today to the Upper Midwest and Great Lakes tonight into Saturday.
- **Heavy snow will expand into the Upper Midwest and Great Lakes through Saturday morning**  
Total accumulations of 8-14 inches of snow with locally higher amounts are expected from southeastern SD through the Upper Midwest and into the U.P. of Michigan.
- **Widespread impacts to travel and infrastructure**  
All forms of travel will become dangerous as heavy snow rates reaching 2"/hr and strong winds create near whiteout conditions at times. The heavy and wet snow may produce scattered power outages.

### Winter Storm Severity Index



Potential Winter Storm Impacts

Light Impacts	Moderate Impacts
Limited Impacts	Major Impacts
Minor Impacts	Catastrophic Impacts

### Forecast Snowfall

Final Forecast Monday December 13th, 2021 at 6 AM CST



Additional Snowfall Forecast

 National Oceanic and Atmospheric Administration  
U.S. Department of Commerce

For more information go to:  
[www.wpc.ncep.noaa.gov](http://www.wpc.ncep.noaa.gov) and [www.weather.gov](http://www.weather.gov)

Weather Prediction Center  
College Park, MD





# The Precipitation Extremes Are Not Going To Stop

National damages exceeding **\$1T** a year are not out of the question.

**Are we ready?**

**A Typical Year in the 2030s?**

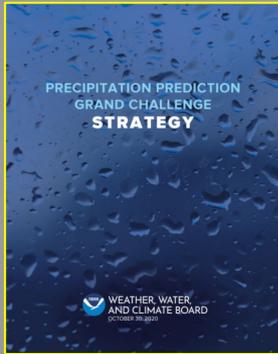


## Accurate Prediction is Essential to Resilience & Mitigation



# PPGC Strategic Goal:

Provide more accurate, reliable, and timely precipitation forecasts across timescales, from hours to decades, through the development and application of a seamless, fully coupled Earth System prediction model.



[NOAA Precipitation Prediction Grand Challenge Strategy](#)

# 6 Strategic Objectives:



# Summary

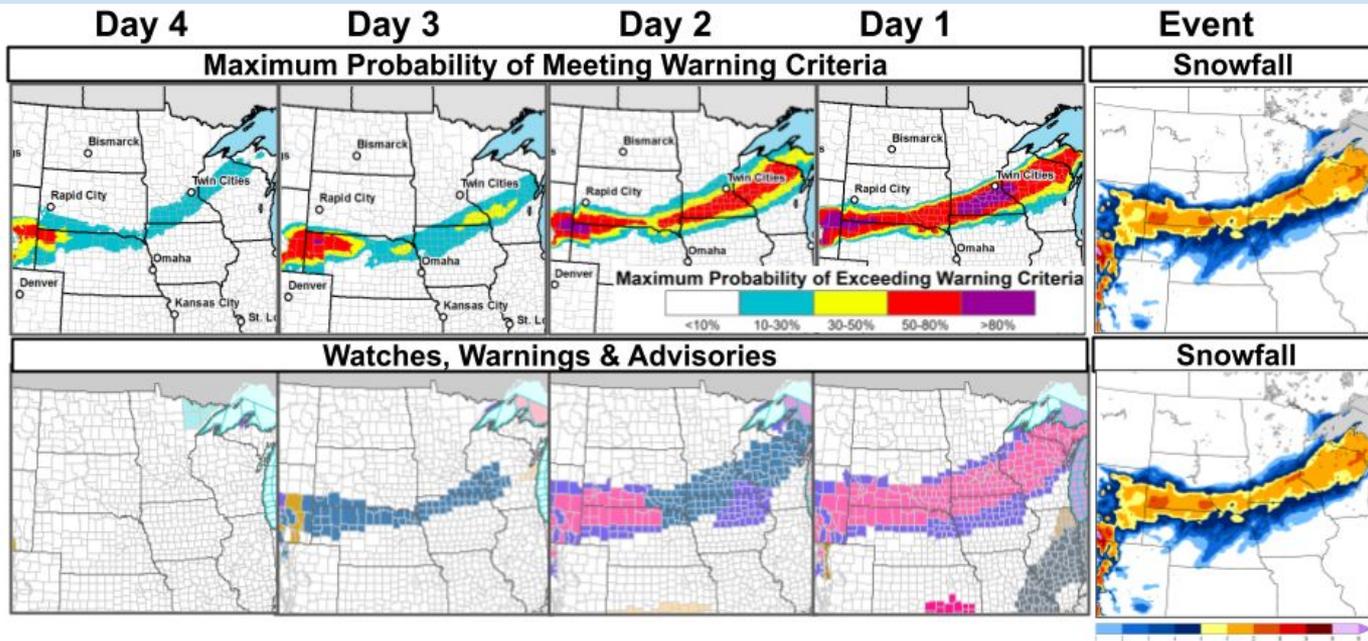
We are embracing a probabilistic framework with a vision of **providing community decision makers skillful and quantitative information on the likelihood of impacts from extreme precipitation**

## TO ACHIEVE THIS VISION:

- Fundamentally **improve model forecast precipitation** accuracy
- **Improve ensemble underdispersion**
- **Extend probabilistic services** further out in time
- Redouble efforts on **characterizing the mesoscale aspects** of storms
- Establish a rigorous and consistent **database of observed impacts** to support impact verification and the development of impact-based tools.
- Develop **probabilistic *impact* information** with decision maker thresholds.
- Expand support for **SBES research** with a range of users (forecasters, core partners, public)

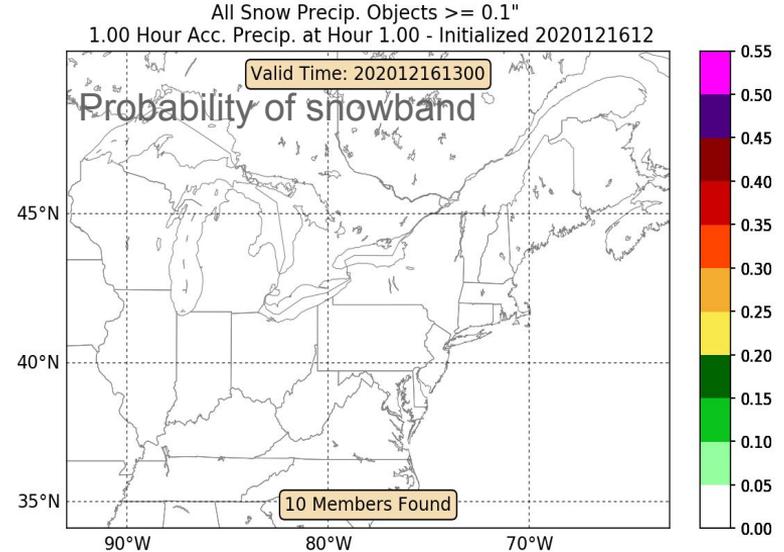
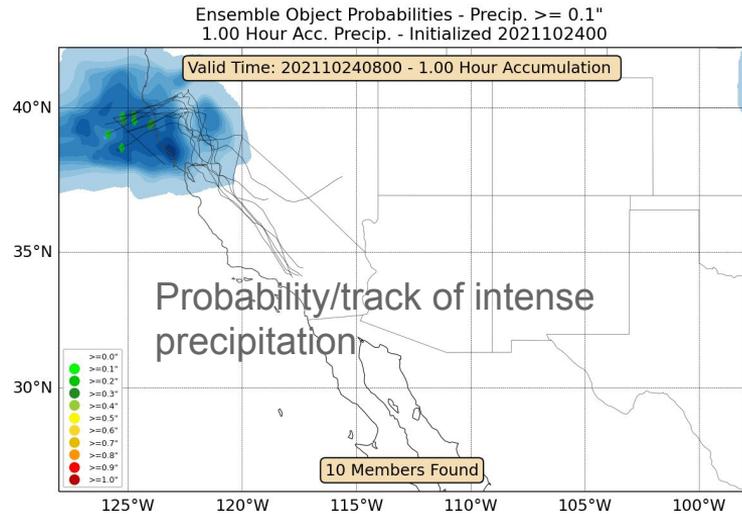
# Winter Probabilistic Hazard Information

The era of objective probabilistic winter hazard information has arrived.



Community debate as to *the degree* to which IDSS should be based on objective probabilistic information versus subjective impact information.

# Empower Forecasters with Tools



**Data mining and data visualization of ensemble data and extensive training to:**

- 1) Make a better forecast
- 2) Communicate risks and impacts (ultimately, probability of an impact)