Uncertain about Uncertainty: Part 2

"Meta-Uncertainty"

"I don't know what I don't know"

Dale Morris
University of Oklahoma/CIMMS
NOAA/NWS Warning Decision Training Branch

National Severe Weather Workshop
March 2010

Disclaimer

- Dabble in social science
- Not a social science expert
- Not a stats expert

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Changing from what *WAS* to what *IS*
the future of integrated weather studies

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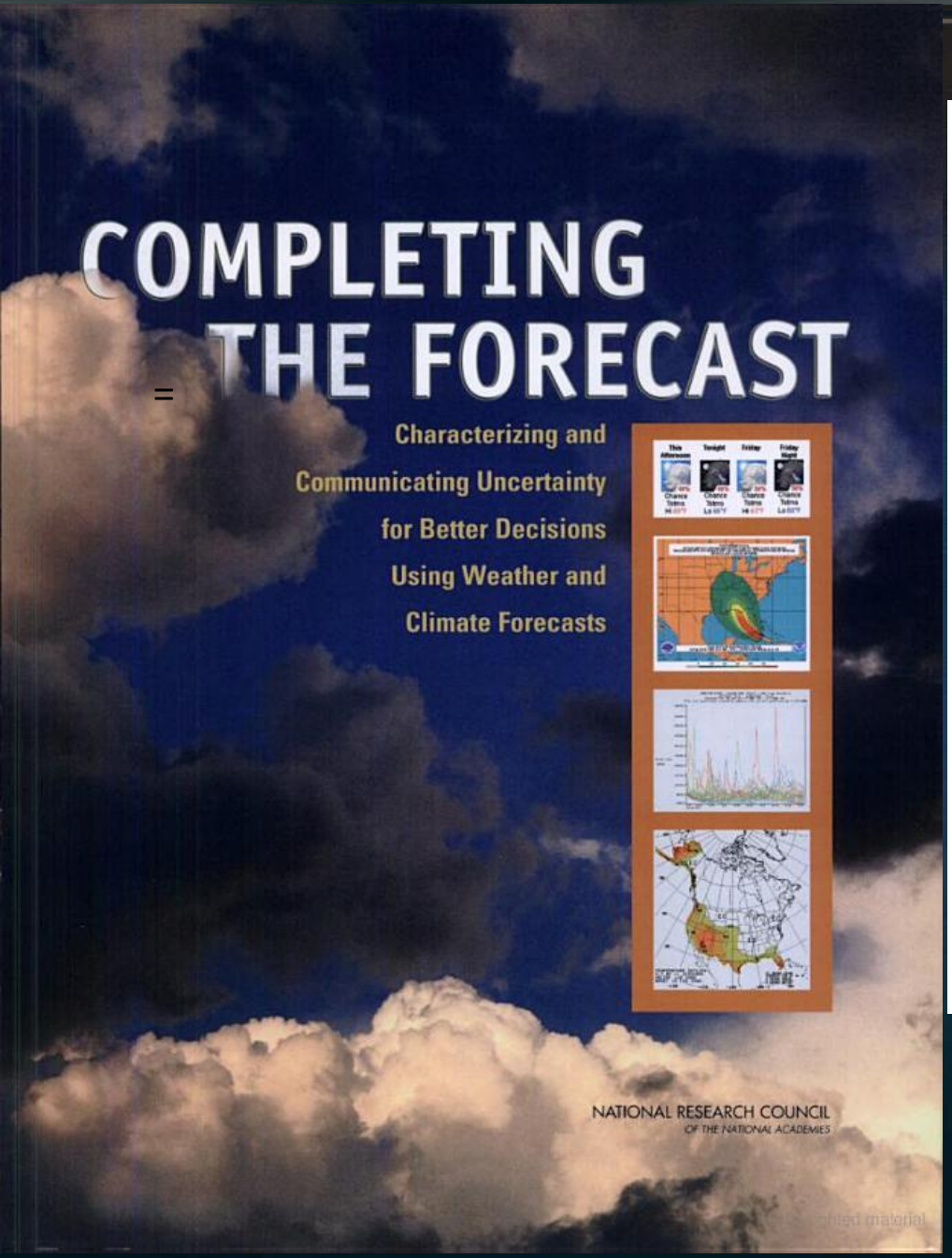
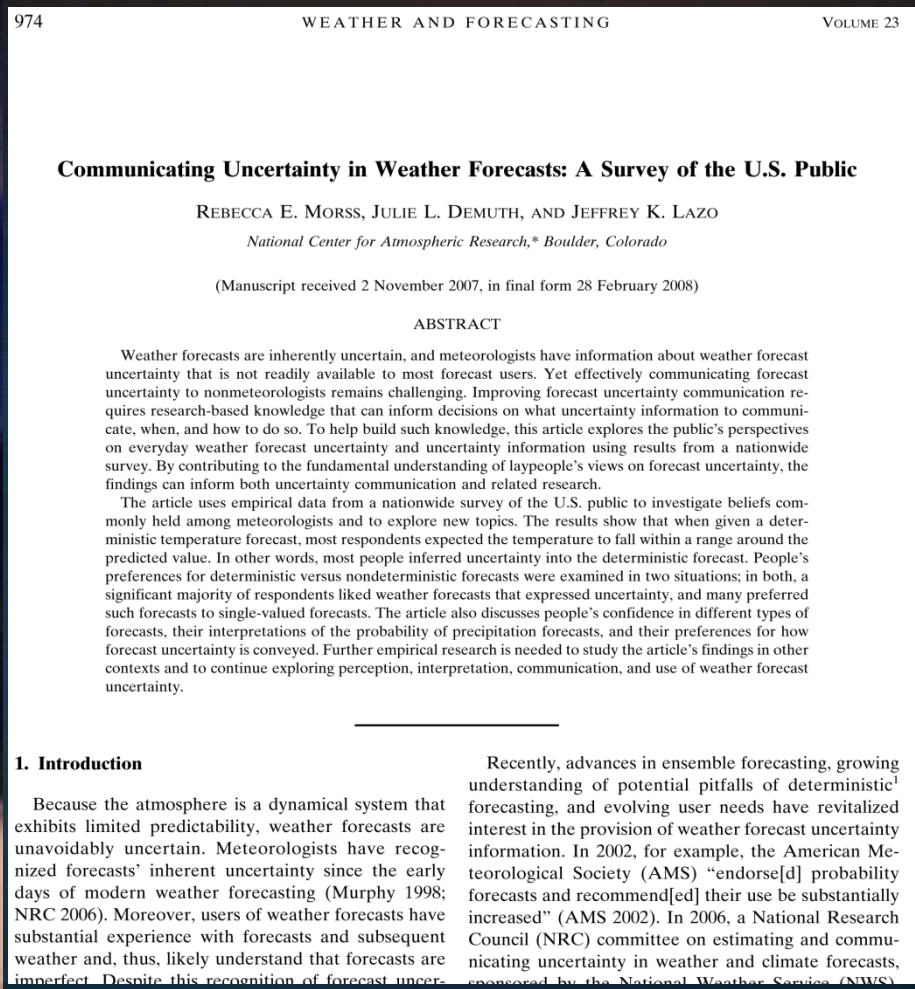


National Research Council, 2006



Communicating Uncertainty in Weather Forecasts: A Survey of the U.S. Public

REBECCA E. MORSS, JULIE L. DEMUTH, AND JEFFREY K. LAZO

National Center for Atmospheric Research, Boulder, Colorado*

(Manuscript received 2 November 2007, in final form 28 February 2008)

ABSTRACT

Weather forecasts are inherently uncertain, and meteorologists have information about weather forecast uncertainty that is not readily available to most forecast users. Yet effectively communicating forecast uncertainty to nonmeteorologists remains challenging. Improving forecast uncertainty communication requires research-based knowledge that can inform decisions on what uncertainty information to communicate, when, and how to do so. To help build such knowledge, this article explores the public's perspectives on everyday weather forecast uncertainty and uncertainty information using results from a nationwide survey. By contributing to the fundamental understanding of laypeople's views on forecast uncertainty, the findings can inform both uncertainty communication and related research.

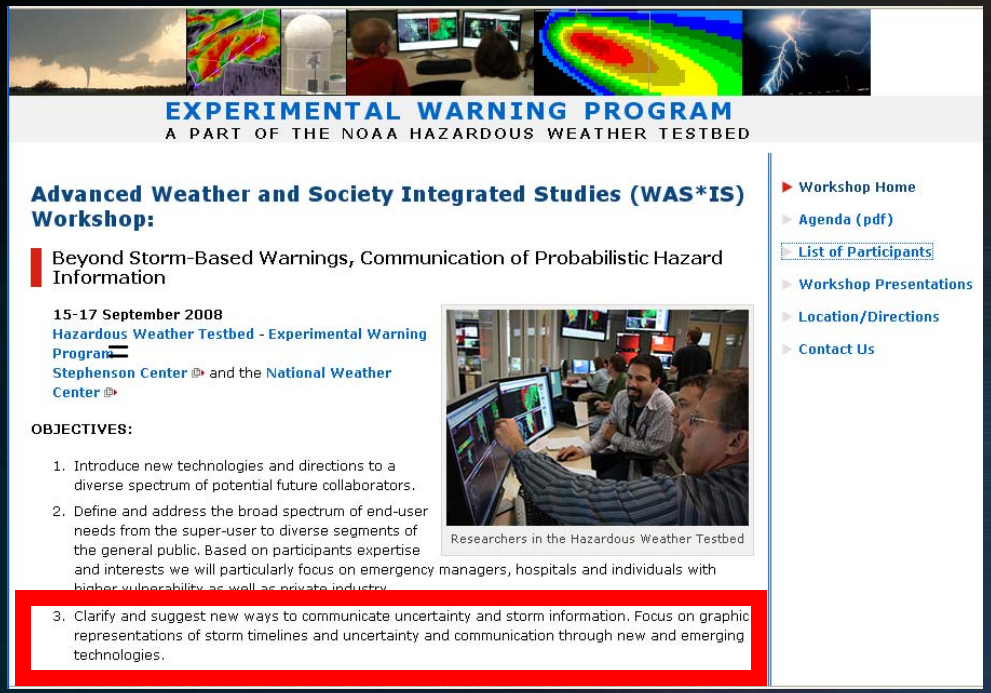
The article uses empirical data from a nationwide survey of the U.S. public to investigate beliefs commonly held among meteorologists and to explore new topics. The results show that when given a deterministic temperature forecast, most respondents expected the temperature to fall within a range around the predicted value. In other words, most people inferred uncertainty into the deterministic forecast. People's preferences for deterministic versus nondeterministic forecasts were examined in two situations; in both, a significant majority of respondents liked weather forecasts that expressed uncertainty, and many preferred such forecasts to single-valued forecasts. The article also discusses people's confidence in different types of forecasts, their interpretations of the probability of precipitation forecasts, and their preferences for how forecast uncertainty is conveyed. Further empirical research is needed to study the article's findings in other contexts and to continue exploring perception, interpretation, communication, and use of weather forecast uncertainty.

1. Introduction

Because the atmosphere is a dynamical system that exhibits limited predictability, weather forecasts are unavoidably uncertain. Meteorologists have recognized forecasts' inherent uncertainty since the early days of modern weather forecasting (Murphy 1998; NRC 2006). Moreover, users of weather forecasts have substantial experience with forecasts and subsequent weather and, thus, likely understand that forecasts are imperfect. Despite this recognition of forecast uncer-

Recently, advances in ensemble forecasting, growing understanding of potential pitfalls of deterministic[1] forecasting, and evolving user needs have revitalized interest in the provision of weather forecast uncertainty information. In 2002, for example, the American Meteorological Society (AMS) "endorse[d] probability forecasts and recommend[ed] their use be substantially increased" (AMS 2002). In 2006, a National Research Council (NRC) committee on estimating and communicating uncertainty in weather and climate forecasts, sponsored by the National Weather Service (NWS)

Morss, Demuth, and Lazo, 2008



Next Generation Warning Services Workshop

University of Oklahoma, Norman OK
December 2-4, 2008

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TORNADO WARNING
NATIONAL WEATHER SERVICE DODGE CITY KS
919 PM CDT FRI MAY 4 2007

THE NATIONAL WEATHER SERVICE IN DODGE CITY HAS ISSUED A

* TORNADO WARNING FOR...
  KIOWA COUNTY IN SOUTH CENTRAL KANSAS.

* UNTIL 1000 PM CDT

* AT 917 PM CDT...NATIONAL WEATHER SERVICE
METEOROLOGISTS WERE TRACKING A CONFIRMED LARGE AND
EXTREMELY DANGEROUS TORNADO 14 MILES SOUTH OF
GREENSBURG...OR 11 MILES NORTHWEST OF WILMORE...MOVING
NORTHEAST AT 25 MPH.
```

Current Tornado Warning

and interests we will particularly focus on emergency managers, hospitals and individuals with higher vulnerability as well as private industry.

3. Clarify and suggest new ways to communicate uncertainty and storm information. Focus on graphic representations of storm timelines and uncertainty and communication through new and emerging technologies.

4. Define new measures of success to properly assess service. Change concepts of storm verification

Future Tornado Threat Graphic?

nu·mer·a·cy: able to think and express oneself effectively in quantitative terms.

dictionary.com: The American Heritage Dictionary of the English Language, copyright 2009 by Houghton Mifflin Company

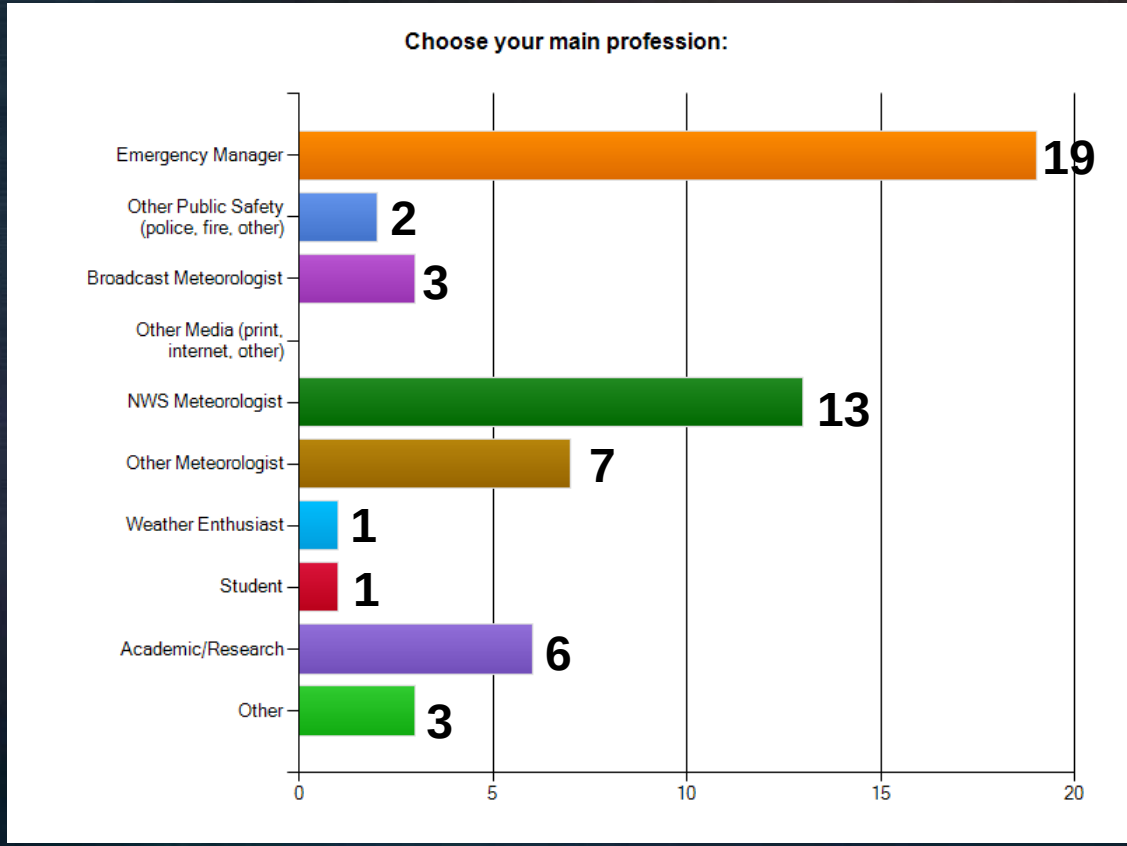
Morrs, Demuth, & Lazo Survey

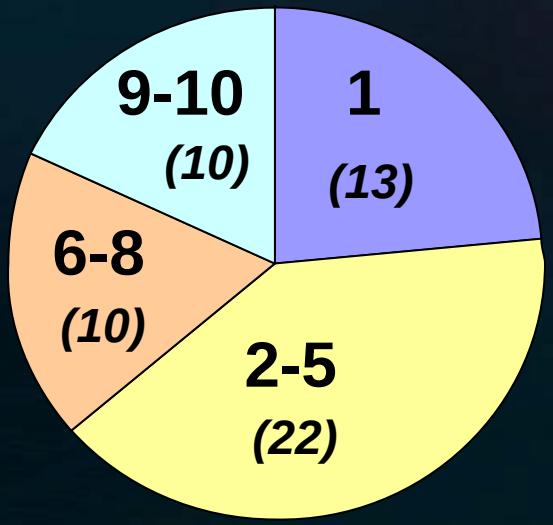
- National Web-based Survey
- General Public
- Every US State
- November 2006
- N=1520

Demographics of NSWW Study

What Do You Think?

- NSWW Attendees
  - Educated/Power Users (vs Public)
  - Diverse backgrounds/professions
- Do we agree?
- Short Electronic Survey
  - 8 questions + 2 demographic
  - 5 -10 minutes
  - Anonymous
  - Laptops in Expo Room
- Results Show: Saturday

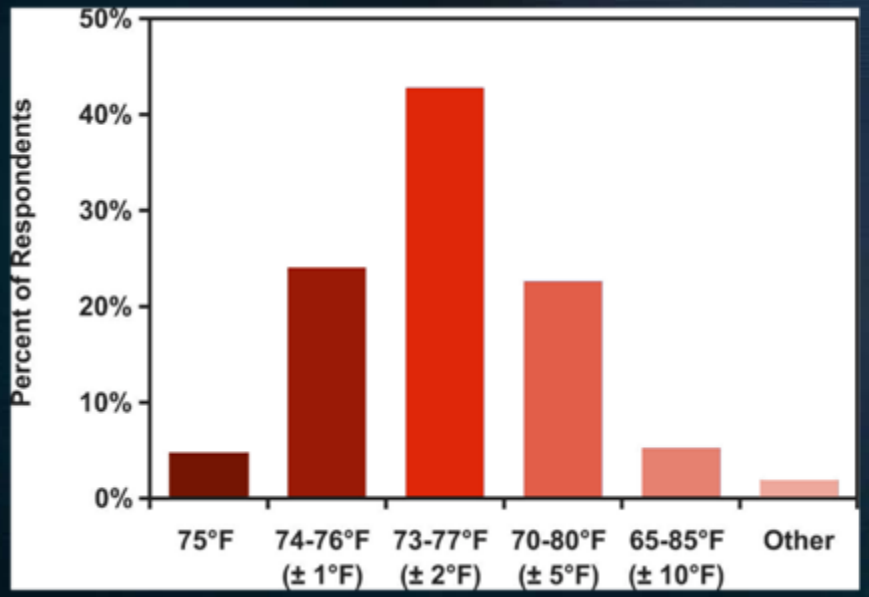




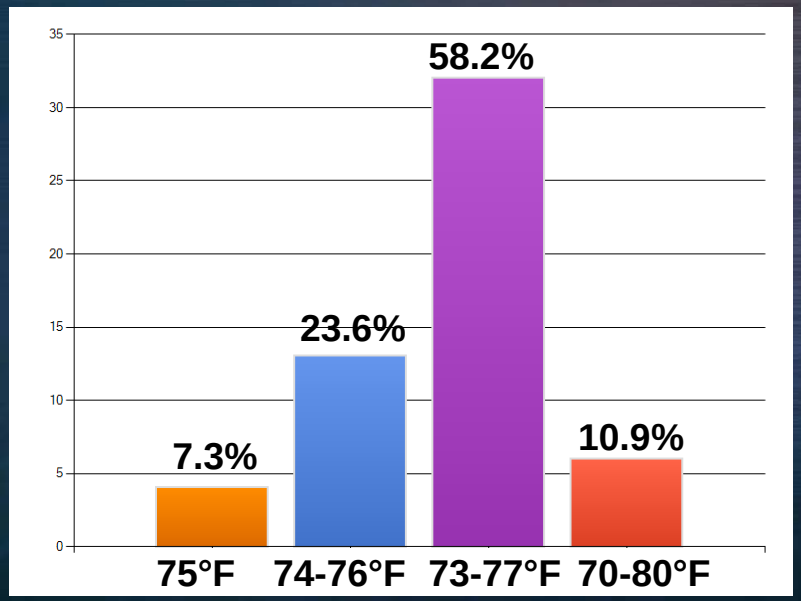
N = 55 (>10%)

Inferred Uncertainty: Deterministic Forecasts

Question: Suppose the forecast high temperature is 75°F. What do you think the high temperature will be?



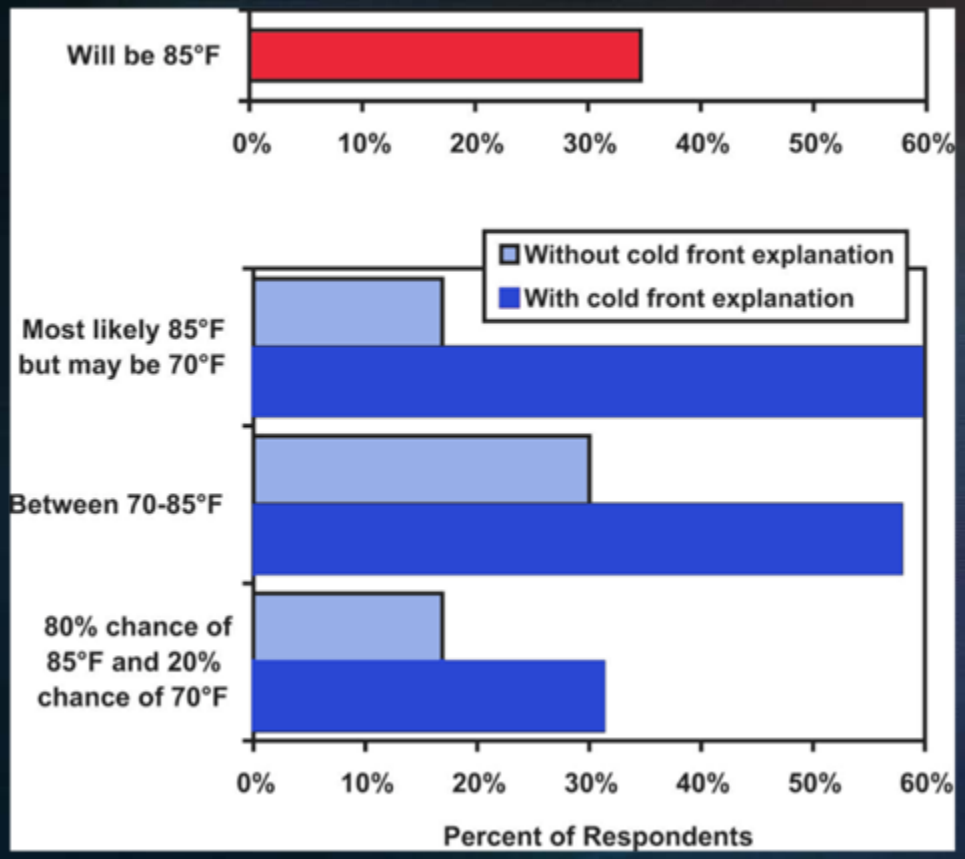
Morss, Demuth, Lazo



NSWW 2010

> People infer a range even with a single-value deterministic forecast (presumably based on prior experience)

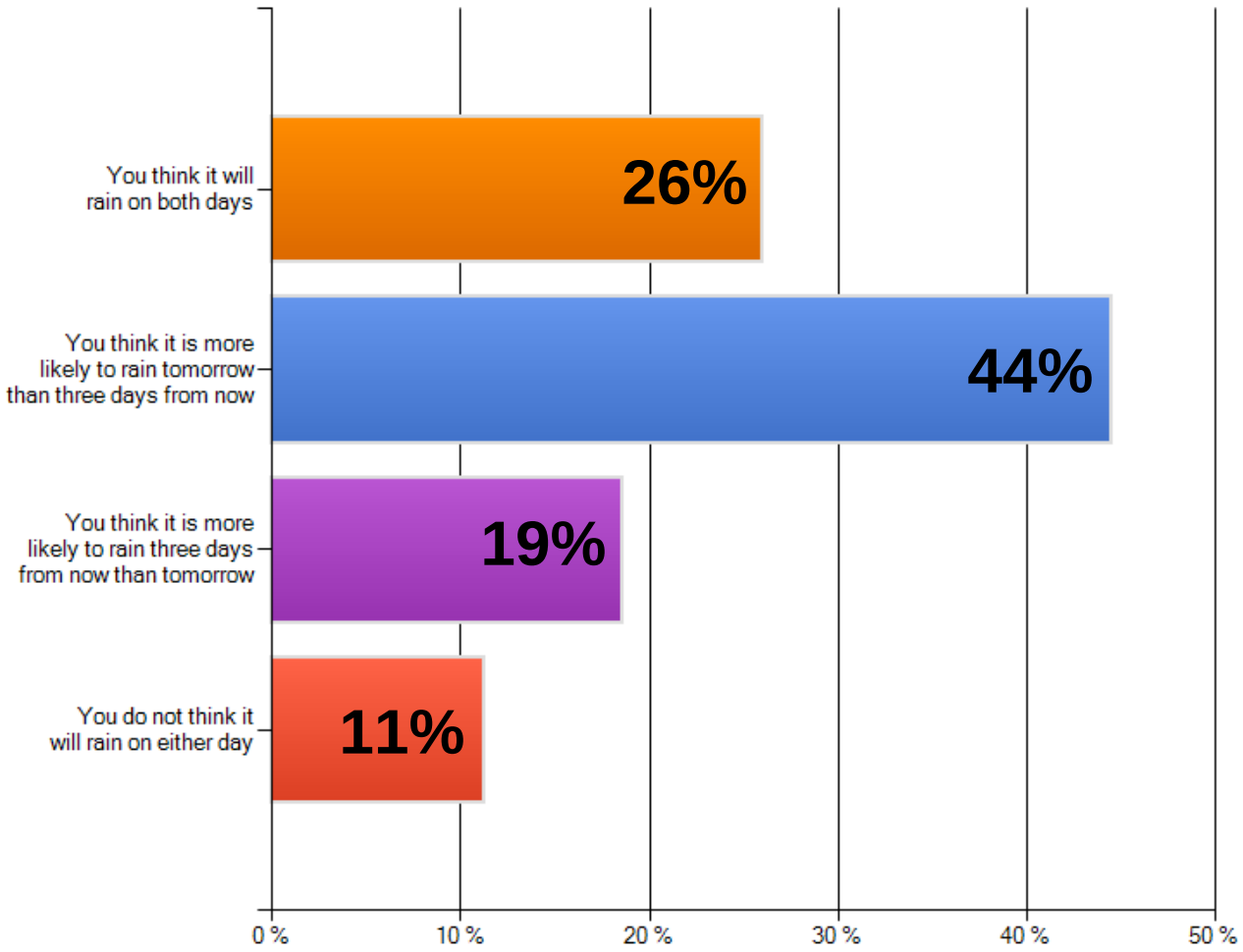
Deterministic vs Probabilistic vs Rationale



Morss, Demuth, Lazo

> Forecasters: Tell your customers what you know!

Inferred Uncertainty: Same POP tomorrow vs 3 days from now



Don't trust 3 day fcst

40% pop on 3 days: very high

Don't trust any fcst?

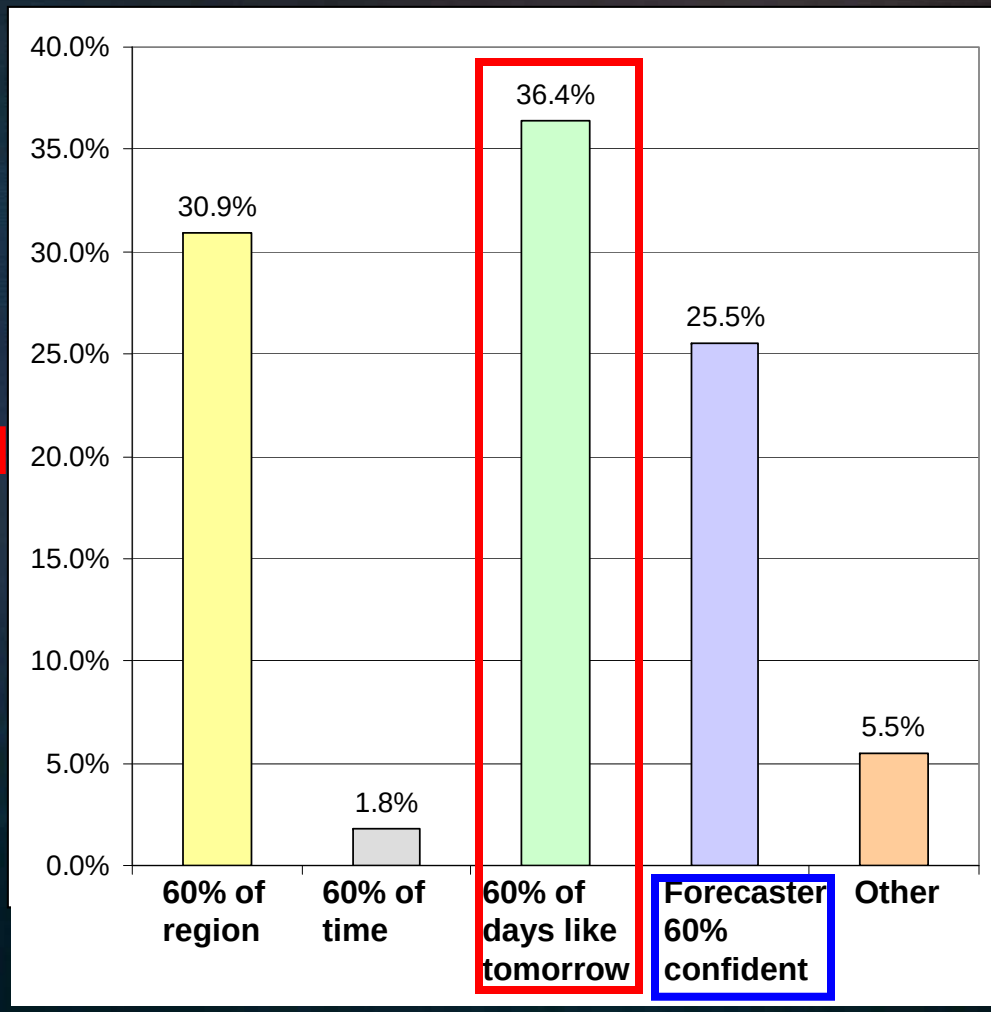
What does POP mean?

TABLE 2. Responses to Q14a, the meaning of the forecast "There is a 60% chance of rain for tomorrow" (N = 1330).

	Percent of respondents
It will rain tomorrow in 60% of the region.	16
It will rain tomorrow for 60% of the time.	10
It will rain on 60% of the days like tomorrow.*	19
60% of weather forecasters believe that it will rain tomorrow.	22
I don't know.	9
Other (please explain).	24

* Technically correct interpretation, according to how PoP forecasts are verified, as interpreted by Gigerenzer et al. (2005).

Morss, Demuth, Lazo



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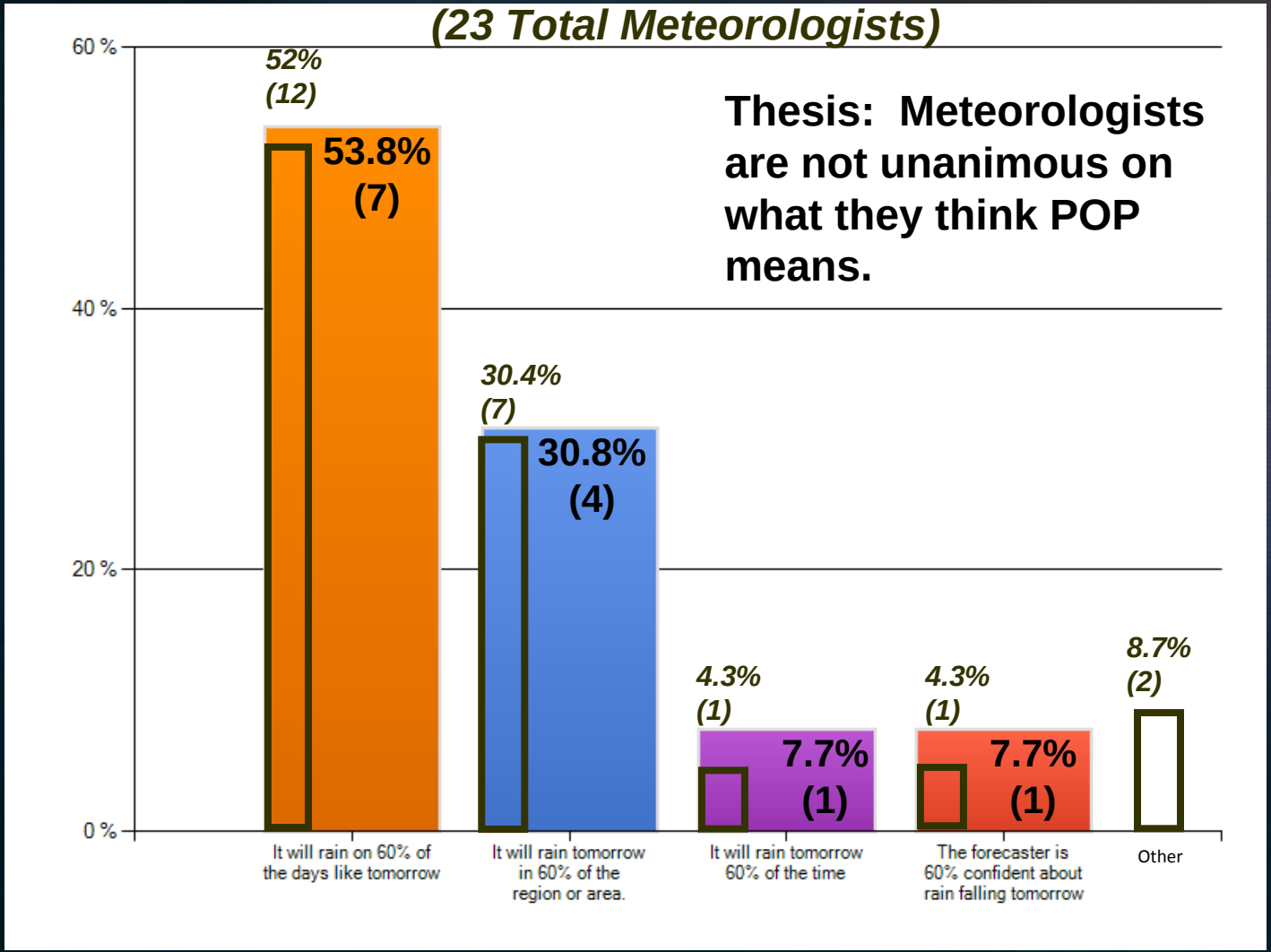
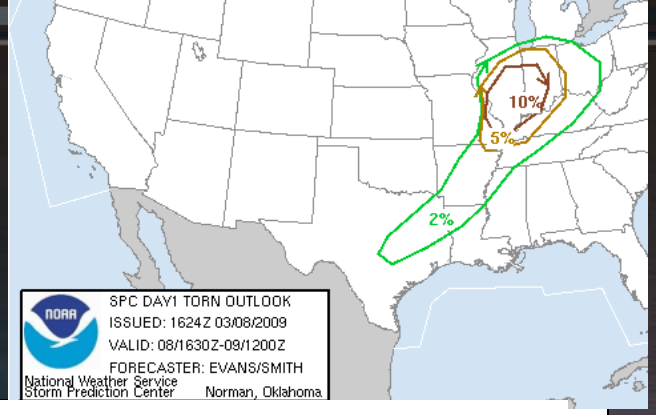
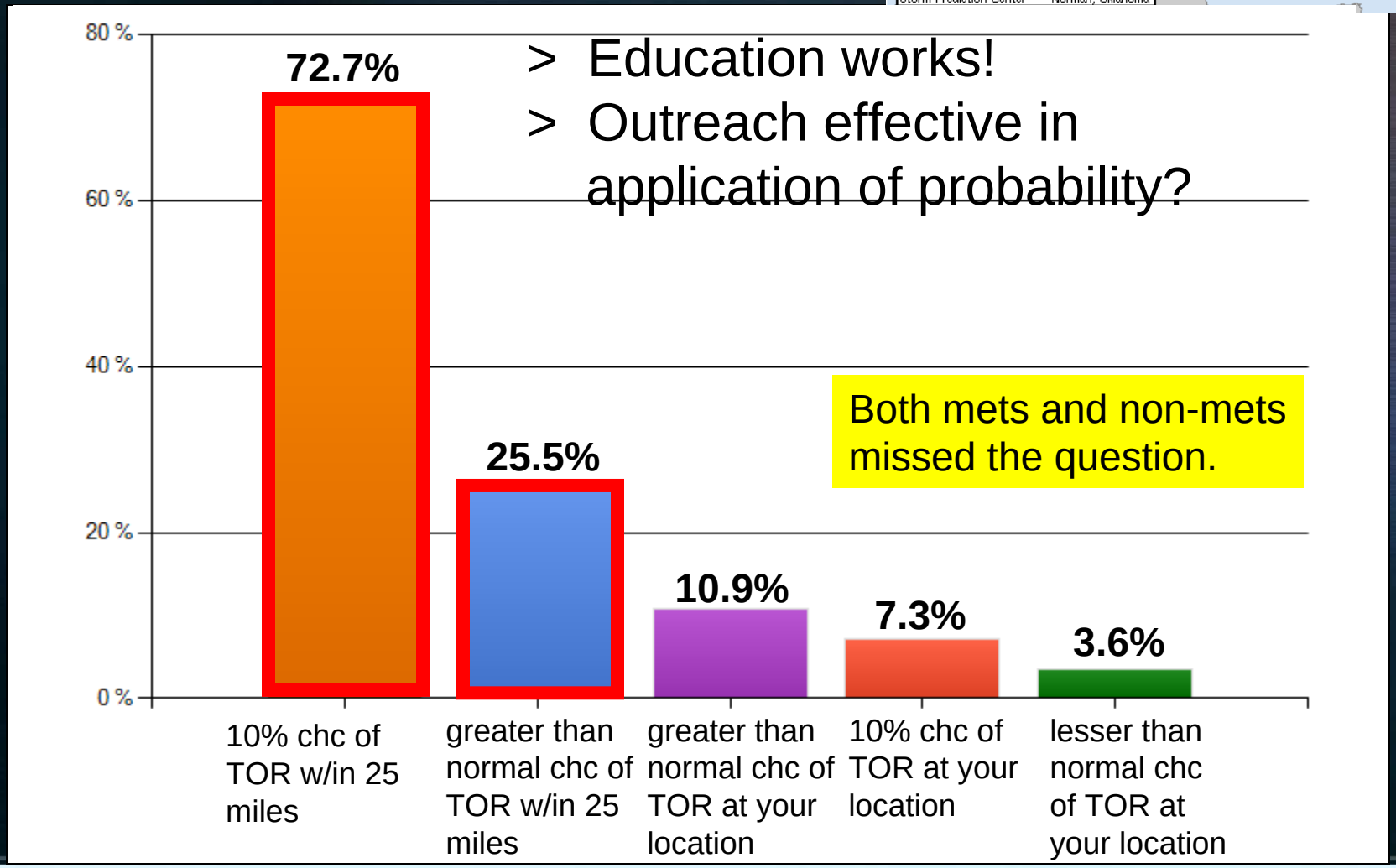
What does POP mean? (13 NWS Forecasters)



What does a 10% tornado contour mean in a SPC Convective Outlook?



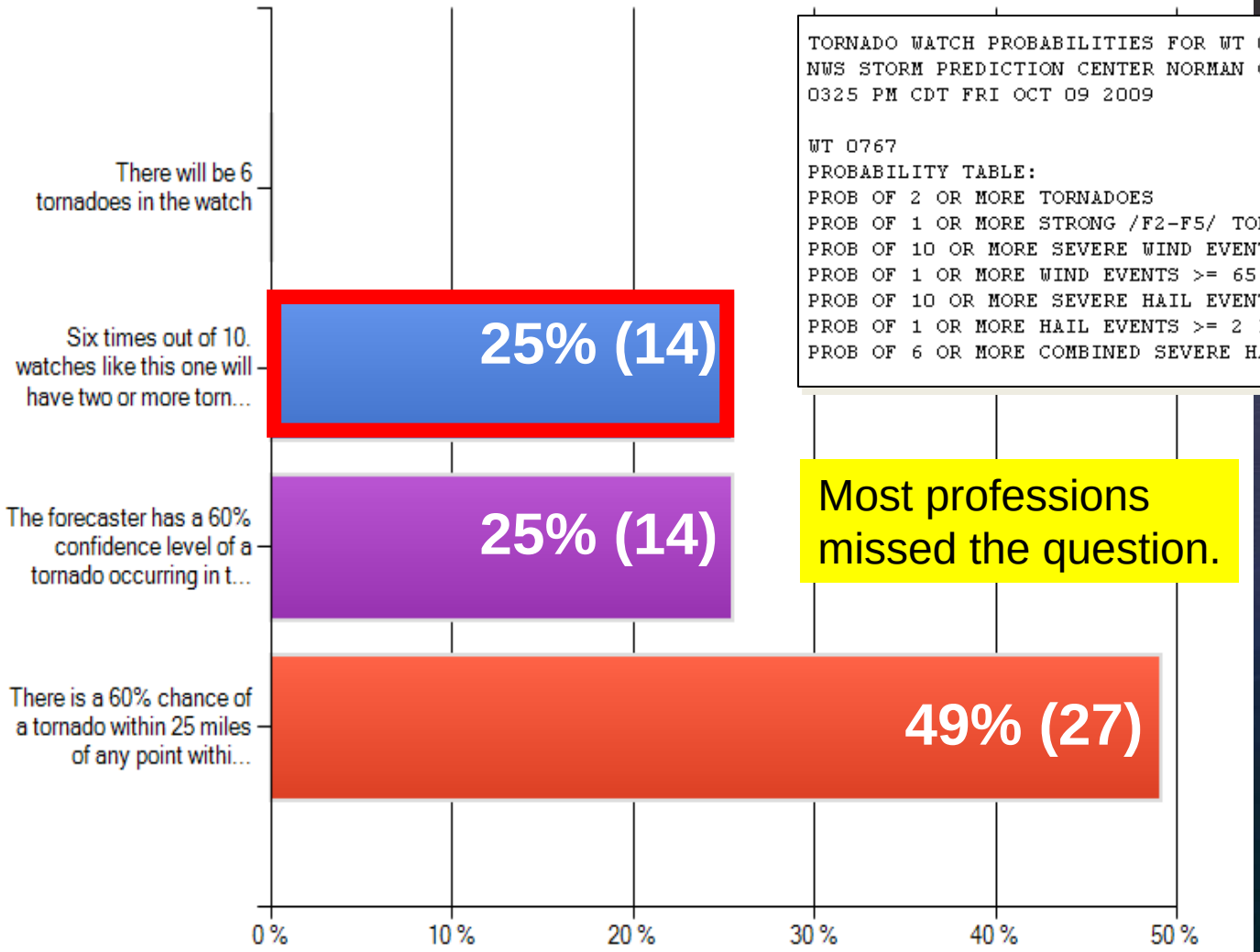


> Education works!

> Outreach effective in application of probability?

Both mets and non-mets missed the question.

What does 60 % probability in a TOR watch mean?

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TORNADO WATCH PROBABILITIES FOR WT 0767
NWS STORM PREDICTION CENTER NORMAN OK
0325 PM CDT FRI OCT 09 2009

WT 0767
PROBABILITY TABLE:
PROB OF 2 OR MORE TORNADOES                          :  30%
PROB OF 1 OR MORE STRONG /F2-F5/ TORNADOES           :  40%
PROB OF 10 OR MORE SEVERE WIND EVENTS                :  40%
PROB OF 1 OR MORE WIND EVENTS >= 65 KNOTS            :  30%
PROB OF 10 OR MORE SEVERE HAIL EVENTS                :  10%
PROB OF 1 OR MORE HAIL EVENTS >= 2 INCHES            : <05%
PROB OF 6 OR MORE COMBINED SEVERE HAIL/WIND EVENTS :  70%
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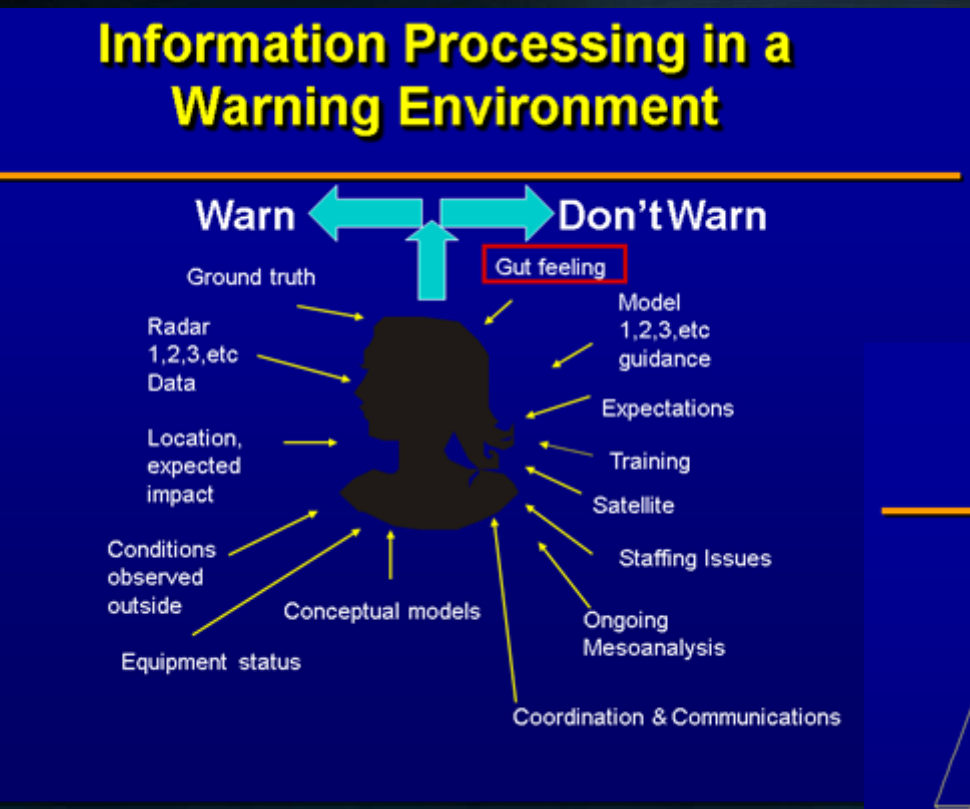
Most professions missed the question.

Question courtesy: Greg Carbin, SPC

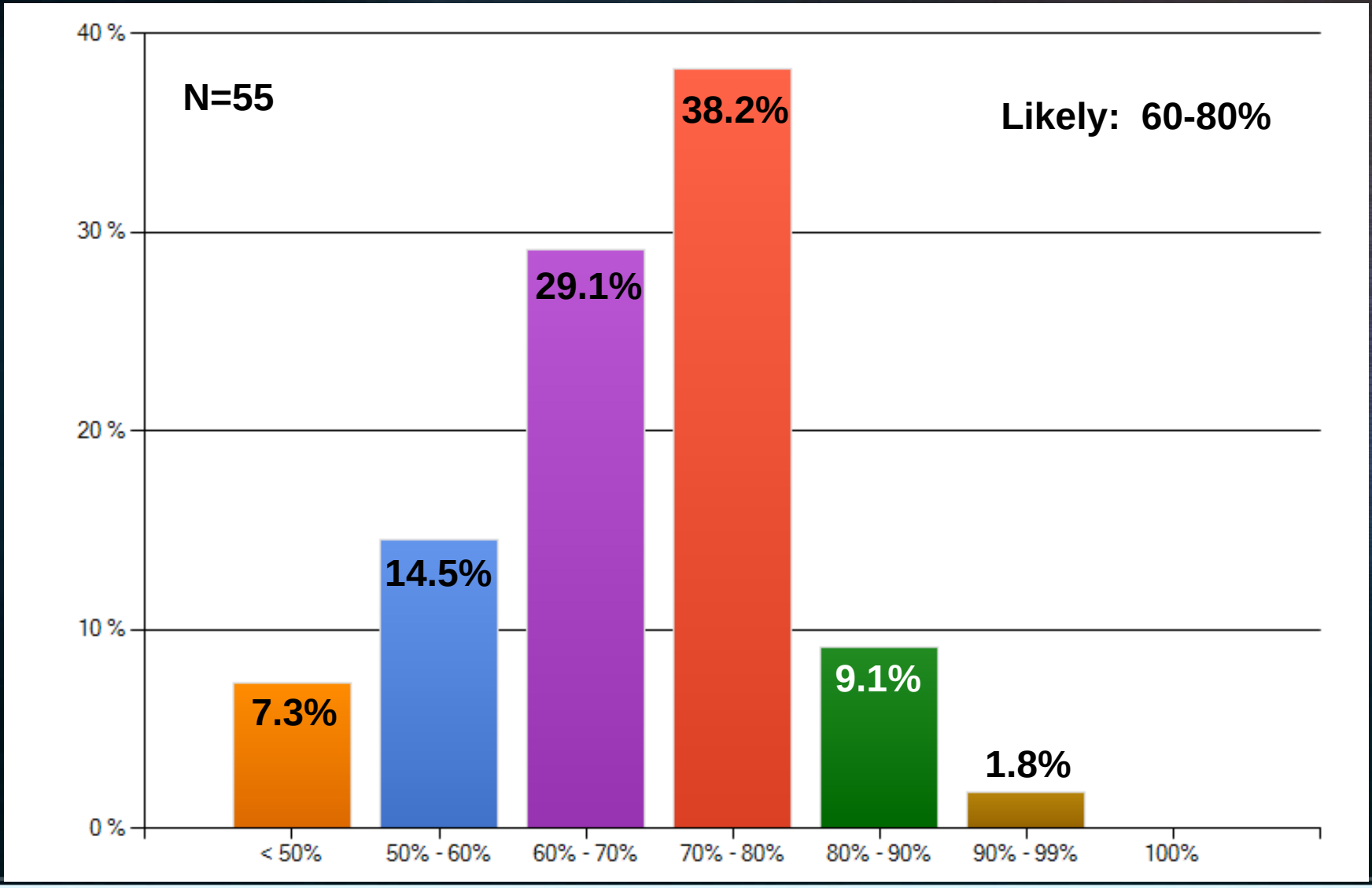
Forecaster Confidence



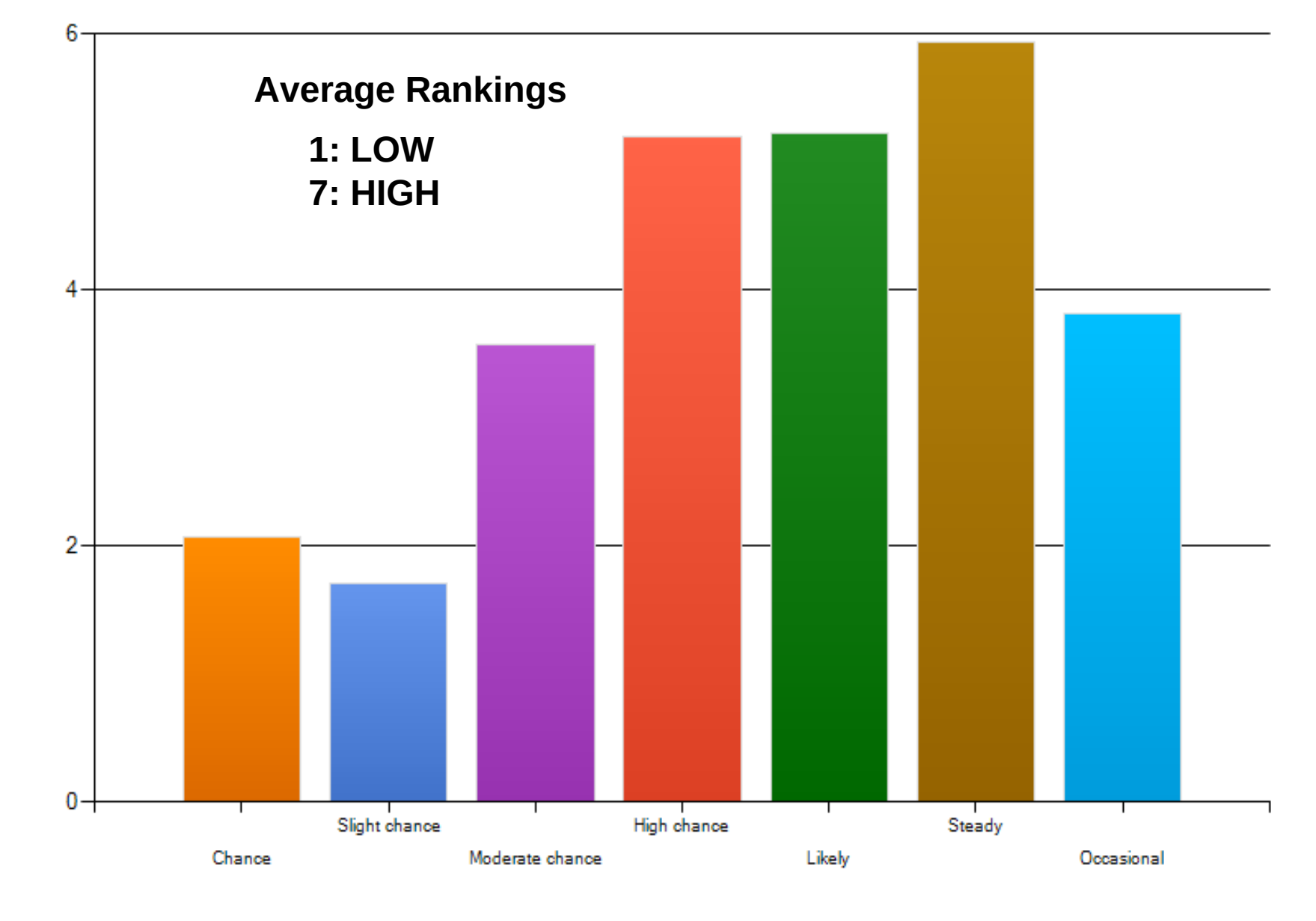
> Challenge: How do we get forecasters calibrated against one another?

Warning Decision Training Branch
Advanced Warning Operations Course

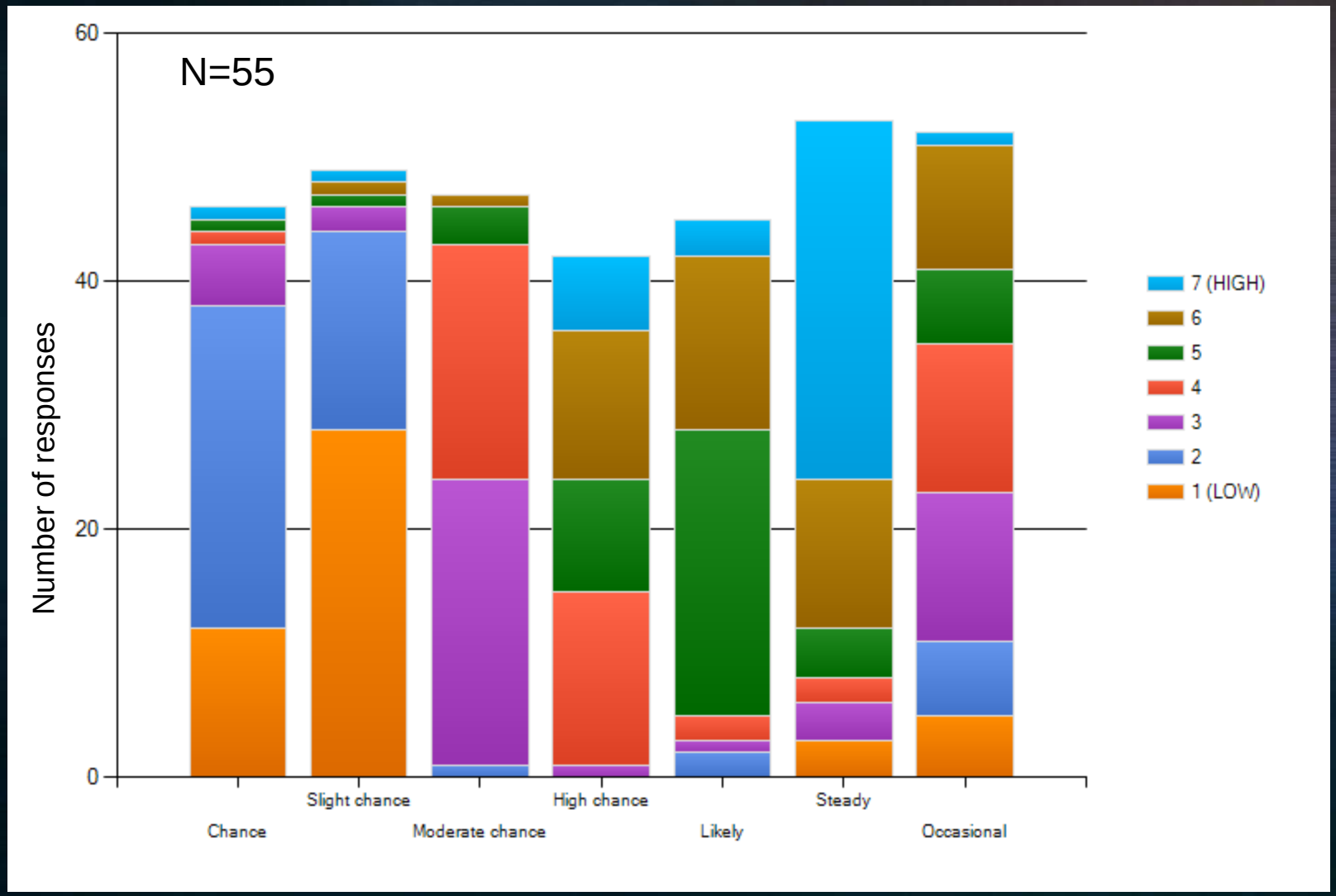
The forecast says “showers likely”. How confident are you that it will rain in your area?



Ranking Qualitative Probability Terms



Ranking Qualitative Probability Terms



Assigning Probabilities to Qualitative Terms (most common answers)

Highly Likely	80-90%	High Risk	80-100%
Uncommon	10%, <10%	Moderate Chance	50%, 40-60%
Unlikely	10%	Rare	5%, 1-5%
Likely	60%, 80%, 60-80%	Never	0% [nonzero responses]
Possible	50%	Common	50%, 70%
Slight Chance	20%	Slight Risk	20-30%
Once in 100 yrs	1% [90,96,99]	Normal	50%

IPCC Probability Terms

Climate Change Fitting the Pieces Together

produced by The COMET® Program in partnership with The National Environmental Education & Training Foundation

Introduction | What Changes Climate? | Is It Real? | How Do We Know? | Why Should We Care? | How Sure Are Scientists? | What Next? | FAQs

How Do We Know?

THE EXPERTS
- IPCC
- Other Experts

TOOLS: DATA
- Paleoclimate
- Observations

TOOLS: MODELS
- What They Are
- Uncertainties
- Climate and Weather Models

EXTRA PIECES
- FAQs
- Take Aways / References

Levels of Confidence

Terminology	Degree of confidence in being correct
Very high confidence	At least 9 of 10 chances of being correct
High confidence	About 8 of 10 chances
Medium confidence	About 5 of 10 chances
Low confidence	About 2 out of 10 chances
Very low confidence	Less than 1 out of 10 chance

Likelihood Scale

Terminology	Likelihood of occurrence/outcome
Virtually certain	>99% probability of occurrence
Very likely	>90% probability
Likely	>66% probability
About as likely as not	33-66% probability
Unlikely	<33% probability
Very unlikely	<10% probability
Exceptionally unlikely	<1% probability

"Changes in snow, ice and frozen ground have with *high confidence* increased the number and size of glacial lakes."

return home

IPCC

2:05 / 2:22

Ways to Define Probabilities

- Comparing similar conditions/events/watches
  - 60% prob in TOR watch
  - Probability of precipitation
- Forecaster confidence
- Model ensembles
  - 10 of 25 members with 2 m temp < 32 F: 40%
- Points vs areas
  - POP vs convective outlook probability

Summary

- Hypothesis: Lack of consensus among NSWW attendees (even meteorologists) about expressions of uncertainty (not 100% numerate)
  - Proved mostly true
  - Tend to agree with public in uncertainty inferred from deterministic forecasts
- Need consensus among meteorologists
  - "characterizing uncertainty"
  - definitions and calibrations
- Need education/outreach to power users before public outreach

For the Future?

- Need much more work in this area
- “Real” social scientists need to study forecasters in addition to user communities
- Are we ready to develop more probabilistic products?
- If so, are customers ready to use them?

NWS Point-n-Click Forecast
http://www.weather.gov

This Afternoon	Tonight	Wednesday	Wednesday Night	Thursday	Thursday Night	Friday	Friday Night	Saturday
30%	100%	100%	50%	30%	30%	30%		
Chance Snow	Snow	Snow	Chance Snow	Chance Snow	Chance Snow	Chance Snow	Mostly Cloudy	Partly Sunny
Hi 27 °F	Lo 23 °F	Hi 26 °F	Lo 18 °F	Hi 24 °F	Lo 17 °F	Hi 26 °F	Lo 14 °F	Hi 26 °F

Detailed 7-day Forecast

This Afternoon: A chance of snow, mainly after 5pm. Cloudy, with a high near 27. East wind between 5 and 9 mph. Chance of precipitation is 30%. Total daytime snow accumulation of less than a half inch possible.

Tonight: Snow. Low around 23. East wind between 11 and 13 mph. Chance of precipitation is 100%. New snow accumulation of 1 to 3 inches possible.

Wednesday: Snow. High near 26. Northeast wind between 11 and 15 mph. Chance of precipitation is 100%. New snow accumulation of 1 to 3 inches possible.

Wednesday Night: A chance of snow showers. Cloudy, with a low around 18. North wind between 10 and 15 mph. Chance of precipitation is 50%.

Thursday: Scattered snow showers. Mostly cloudy, with a high near 24. West wind between 10 and 14 mph. Chance of precipitation is 30%.

Thursday Night: A chance of snow showers. Mostly cloudy, with a low around 17. Chance of precipitation is 30%.

Friday: A chance of snow showers. Mostly cloudy, with a high near 26. Chance of precipitation is 30%.

Friday Night: Mostly cloudy, with a low around 14.

Saturday: Partly sunny, with a high near 26.

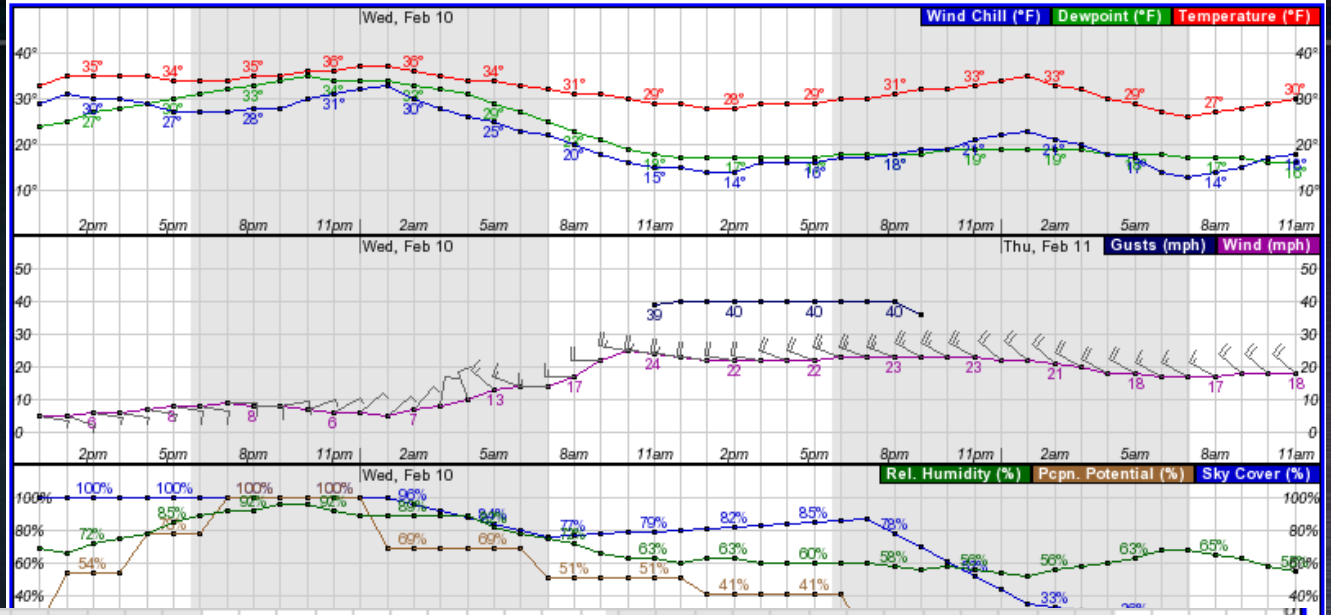
Saturday Night: Mostly cloudy, with a low around 16.

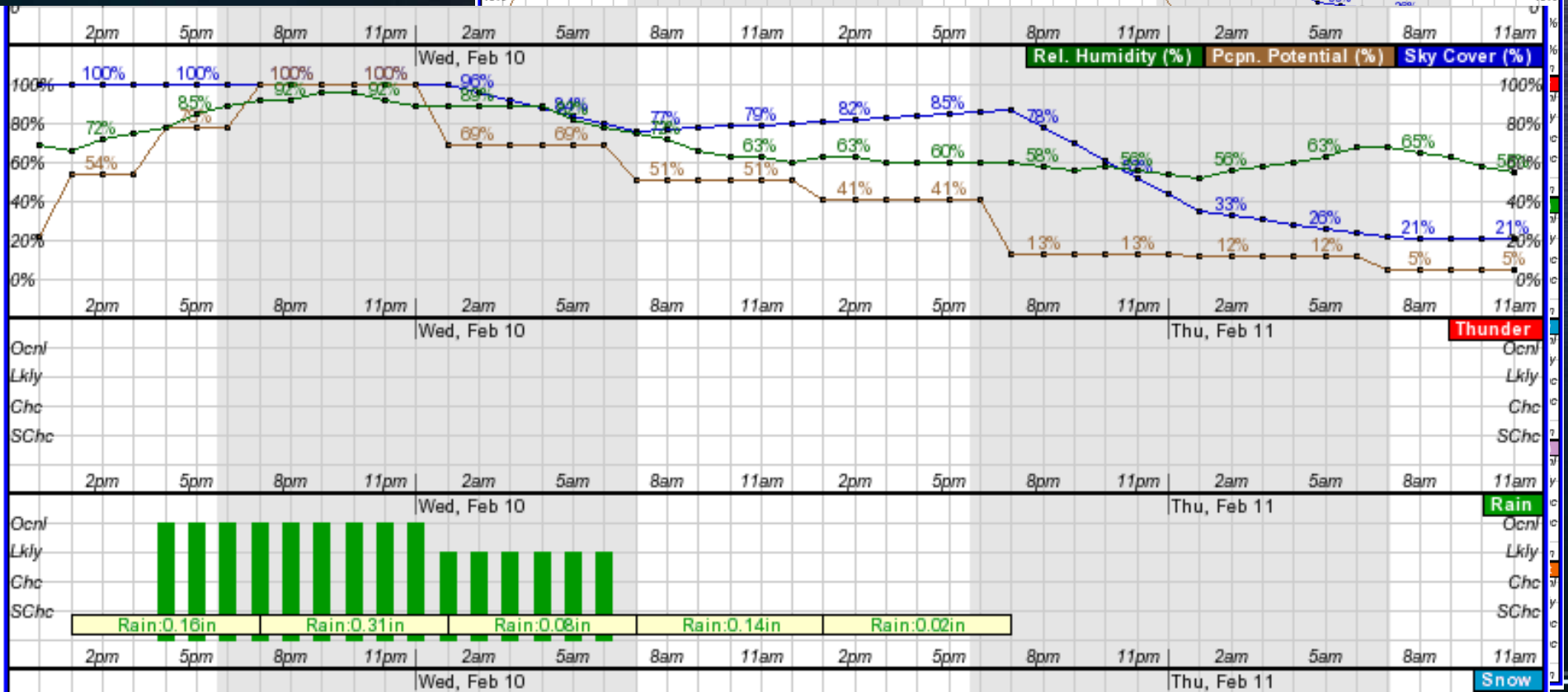
Sunday: Partly sunny, with a high near 26.

Sunday Night: A chance of snow showers. Mostly cloudy, with a low around 18. Chance of precipitation is 30%.

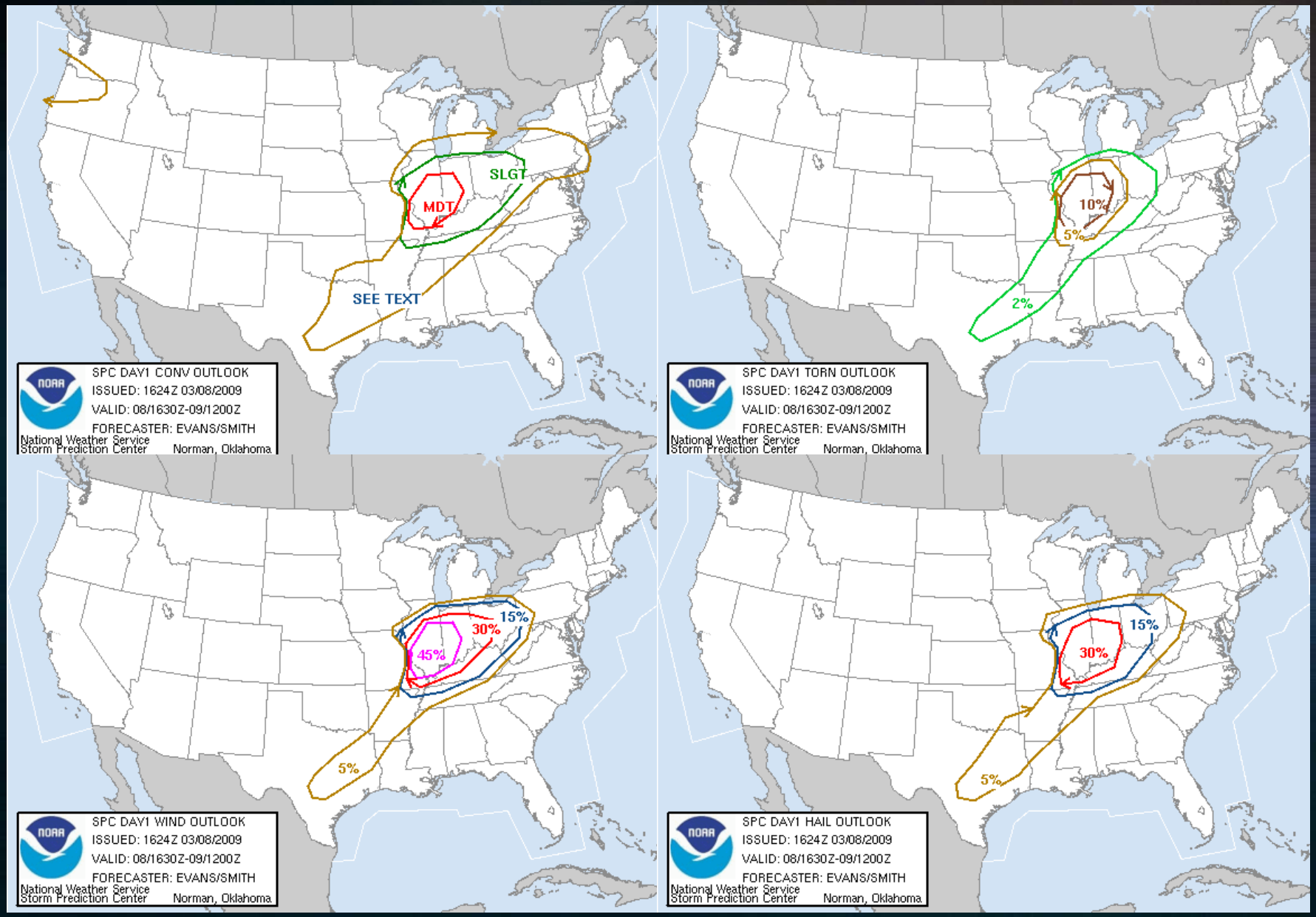
Presidents' Day: A chance of snow showers. Mostly cloudy, with a high near 29. Chance of precipitation is 30%.

NWS Hourly Weather Graph

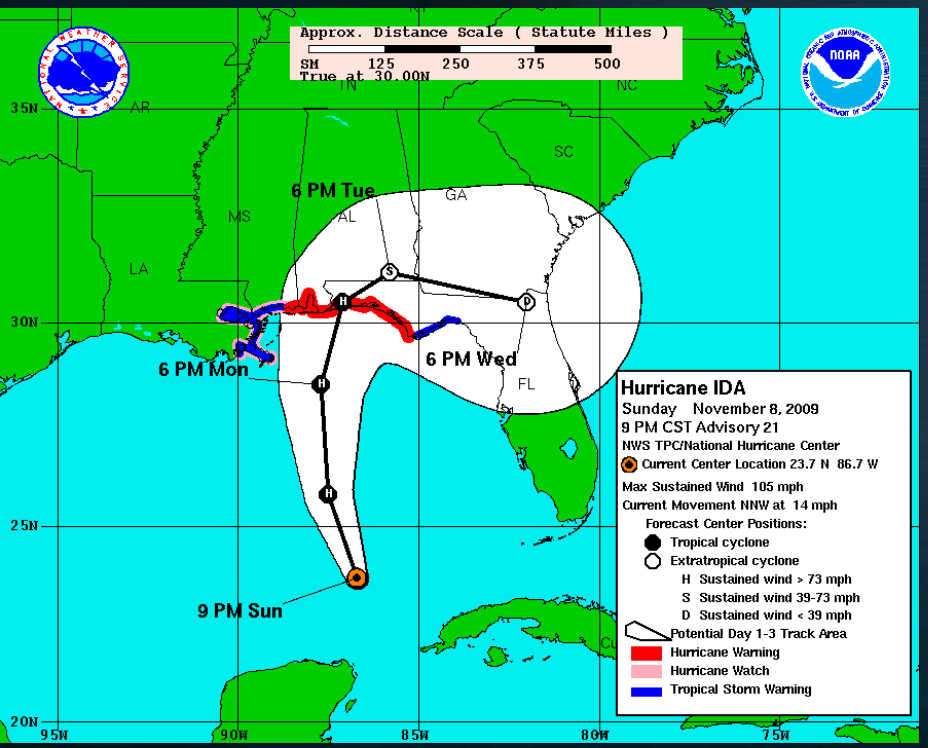


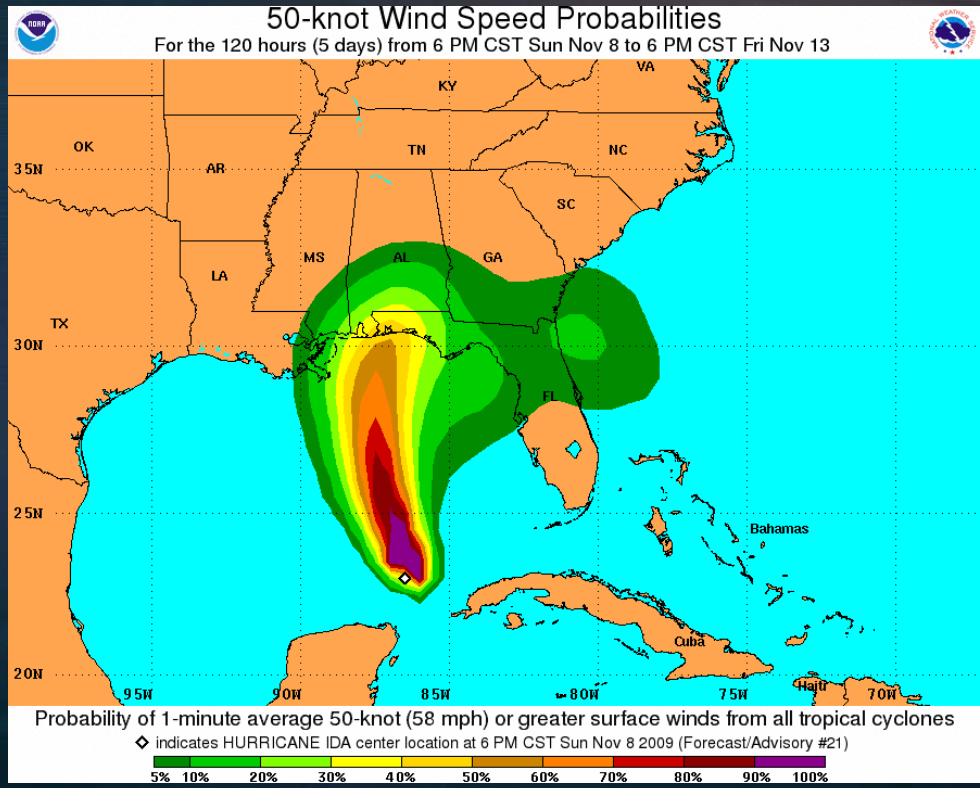


SPC Convective Outlooks



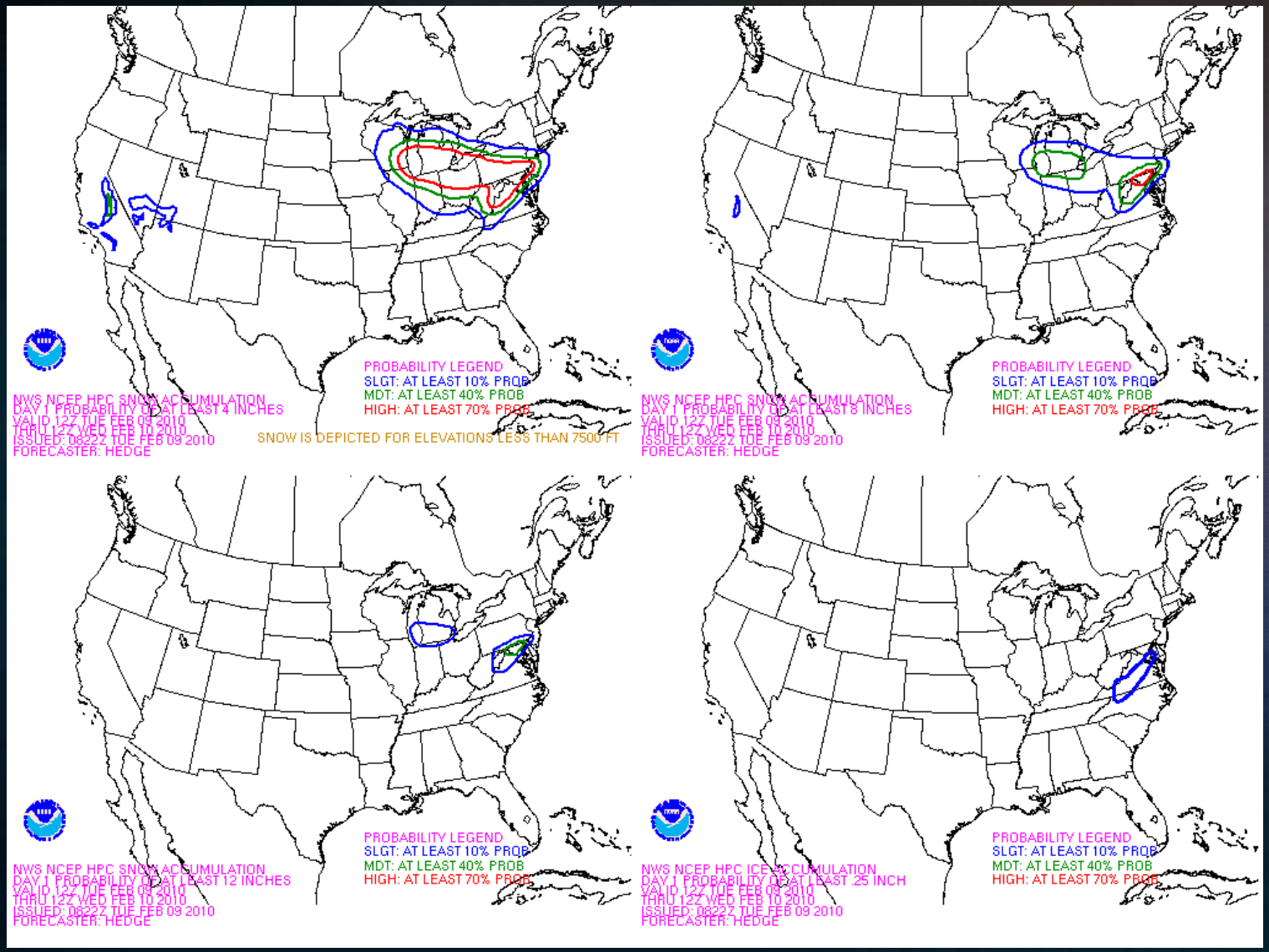
NHC Hurricane Track and Wind Forecast





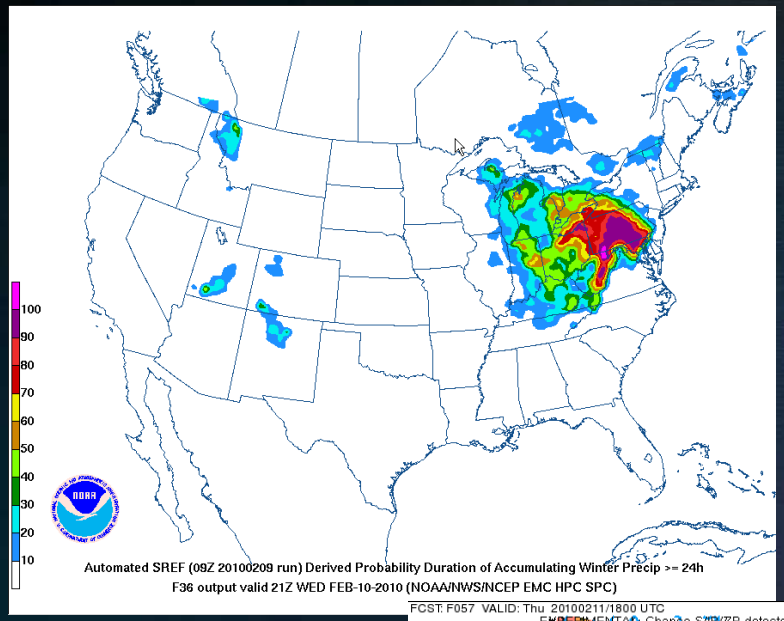
http://www.nhc.noaa.gov

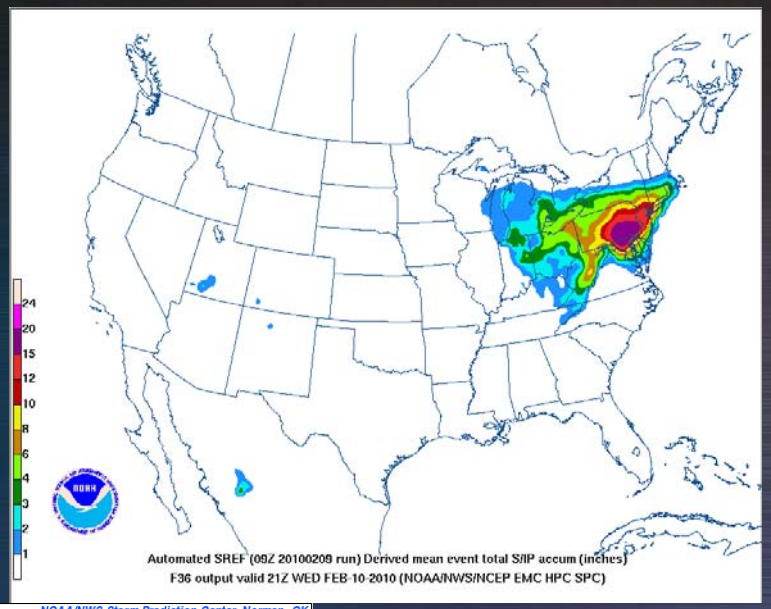
HPC Accumulation Composites

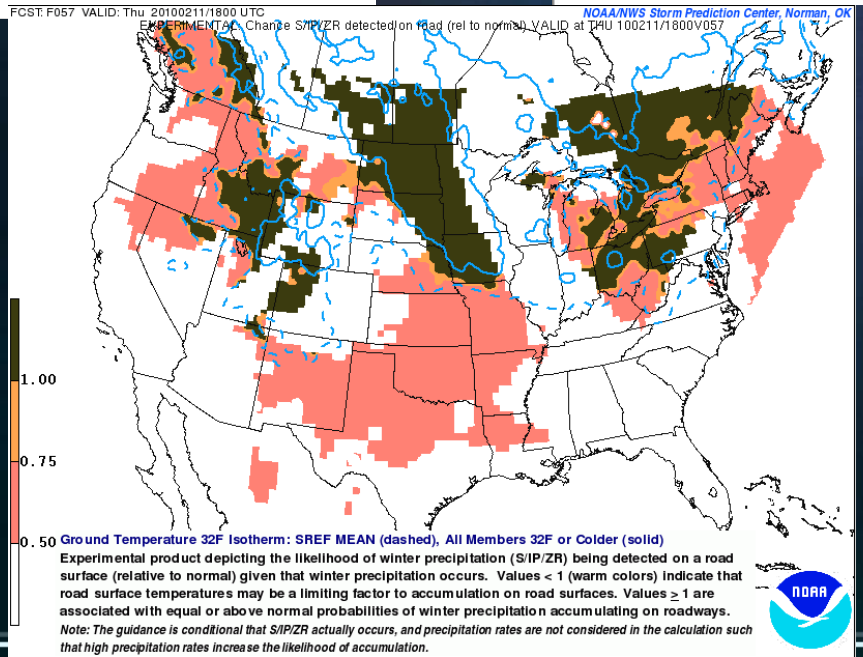


http://www.hpc.ncep.noaa.gov

HPC Winter Weather Impact Graphics







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