

Communicating Winter Weather Using Uncertainty-Driven and Probabilistic Graphics



Jacob Morse

NOAA Hollings Scholarship



Penn State Schreyer Honors College Thesis

NWS Presentation – January 20, 2022

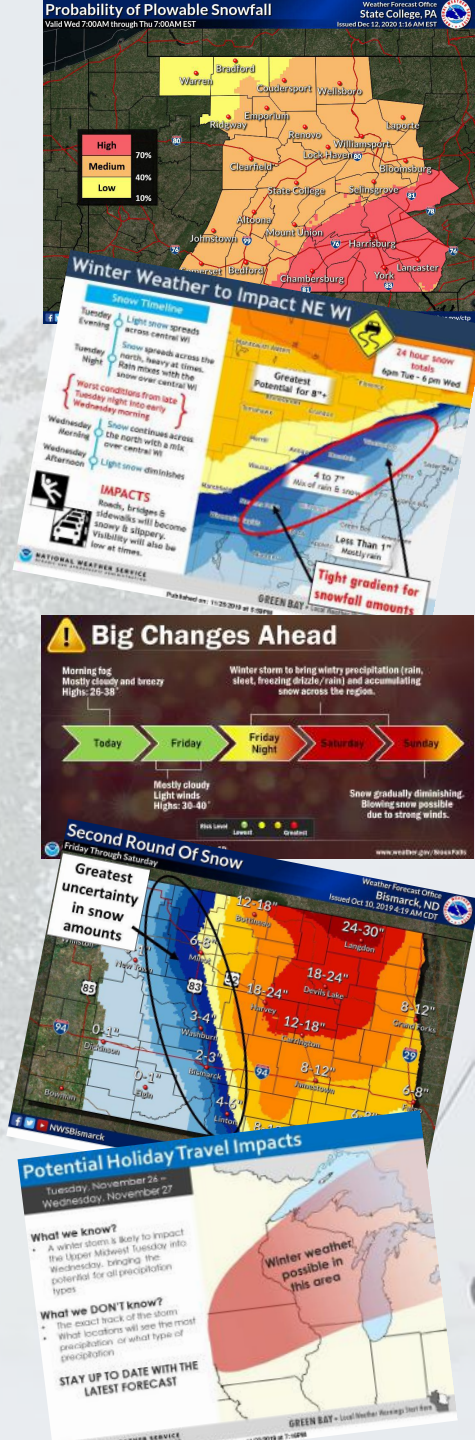
KFYR-TV Meteorologist (Bismarck, ND)

Penn State Meteorology Alumnus ('21)

Research started at NWS Bismarck with Chauncy Schultz

See thesis for full details on this research project and its findings:

jacobmorsewx.weebly.com/research



ROAD MAP FOR PRESENTATION

1. Past research
- 2. Discussion**
3. Intro to my research
4. Part 1: Long Range Forecast Graphics
- 5. Discussion**
6. Part 2: Risk Probability Graphics
- 7. Discussion**
8. Part 3: Uncertainty with Snow Maps
- 9. Discussion**
10. Bonus Results/Takeaways
- 11. Discussion & Final Questions**

How it all began...

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Science and Service Challenges of Providing Impact-Based Decision Support Services for a Mesoscale Heavy Snow Event
Patrick J. Ayd and Chauncy J. Schultz
NOAA/NWS Bismark, North Dakota

Predictability
Data Visualization → Recognizing The Trend
Simple, intuitive visualizations of rapidly updating hi-res and global guidance trends are essential to build confidence, understand the spectrum of possibilities, and shape messaging.

NWS Grand Forks "SnowPlus" page (Nicholas.Carletta@noaa.gov and Thomas.Grafenauer@noaa.gov)

- Hourly updates
- Same SnowRatio methodology as used in ForecastBuilder and the NBM
- Common-operating picture for collaboration
- Uses pre-existing image generation tools (SaclmageMaker). ***Efforts are underway to make images available through WAVE to improve efficiency and availability

Rapidly Updating Guidance

Global, Blends, Lower Cadence CAMs

Messaging
Someone Will Get A Ton, How Do We Say It?
Messaging impacts, magnitude and uncertainty associated with mesoscale heavy snow bands continues to be a significant science and service challenge. When a few miles matter so much, both probabilistic and more deterministic messaging strategies bring both benefits and risks to how the story will be interpreted.

2/15/2019 Afternoon Update: Given high uncertainty in amounts due to expected banding, a "Risk Probability" graphic was used to highlight the heavy snow potential. An effective way to "outlook" an area, but, the threat ceiling is unclear.

Potential For At Least 6 Inches of Snow
Saturday Through Sunday Evening
Weather Forecast Office Bismark, ND
Issued Feb 15, 2019 2:23 PM CST

Observed Storm Total Snowfall
NATIONAL WEATHER SERVICE

Snowfall Reports from the Last 24 Hours

Station	Location	Amount
11000	11000	1.0
11001	11001	1.0
11002	11002	1.0
11003	11003	1.0
11004	11004	1.0
11005	11005	1.0
11006	11006	1.0
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11098	11098	1.0
11099	11099	1.0
11100	11100	1.0

Webcam and Radar Snapshot (Partner Capability)

Bowman webcam (looking west)
Bowman webcam (looking north)
Bowman webcam (looking south)

Near-zero visibilities are being observed across southwest ND early this afternoon. Travel conditions will continue to deteriorate into tonight!

Marmarth webcam (looking west)
Marmarth webcam (looking east)

ND ARB Bowman Radar (1:35 PM CST)

Physical Processes Give Context to NWP Snowfall Trends
Coupling of frontogenetic and deeper forcing embedded in a zone of steep mid level lapse rates gives confidence to a narrow, intense snow band as depicted by the NWP snowfall outputs

2/16/19 18Z 850 mb Frontogenesis (purple contour) Heights, Isotherms, and Winds

700-400 mb DCVA (blue/red contours), 500 mb height and vorticity (fill)

700-500 mb Lapse Rate

Forecast Snow Totals Today Through Sunday
Bismark, ND
Issued Feb 16, 2019 2:00 PM CST

2/16/2019 Afternoon Update: The snowfall gradient is sharpened based on observations of narrow, intense banding confirming rapid updating NWP trends

Probabilistic information can be helpful, even for the public (*past research*)

Quarterly Journal of the
Royal Meteorological Society



SUPPLEMENT ARTICLE | Open Access |

Promoting the use of probabilistic weather forecasts through a dialogue between scientists, developers and end-users

APA PsycArticles: Journal Article

Communicating weather forecast uncertainty: Do individual differences matter?

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

Rebecca E. Morss¹, Julie L. Demuth¹, and Jeffrey K. Lazo¹

[View More +](#)

1. People make better decisions, have higher trust in information, and display a greater understanding of forecast information when they are shown a probabilistic forecast instead of a deterministic one (Ash et al. 2014; Bolton and Katok 2018; Joslyn and Demnitz 2019; Joslyn et al. 2007; LeClerc and Joslyn 2012; Marimo et al. 2015; Roulston and Kaplan 2009; Roulston et al. 2006; Joslyn and Grounds 2015)
2. It is very important to tailor probabilistic information to different audiences' needs. Forecasters should frame messages and forecasts that contain probabilistic information in a way that the end user can easily interpret (Connelly and Knuth 1998; Fundel et. al 2019).
3. Probabilistic information is most effective when displayed with numbers, as categorical expressions of uncertainty have been shown to be vague and open to interpretation among users (Windschitl and Wells 1996).
 - "Likely" can be interpreted as anywhere from 50% to 90%; "Possible" has a bi-modal distribution at 5% and 55%
 - Categorical expressions are interpreted differently depending on the context. "Slight chance" gastric disturbances vs. "slight chance" of skin cancer. Much less probability assumed for one versus the other.
4. Communicating probabilistic information in the form of visualizations is an effective way for groups of people who are less numerate or who may have difficulty with numeric probabilities (Johnson and Slovic 1995, Gerst et. al 2020, Okan et. al 2015).

Probabilistic information can be helpful, even for the public (*past research*)

Susan Joslyn's

Decision Making with Uncertainty Lab

Department of Psychology, University of Washington

Study 1: Does general public need uncertainty forecasts?

Survey: 1,340 residents of Pacific Northwest

At what probability would you take precautionary action for X? _____

Study 2: Can people understand uncertainty forecasts?

Threshold probability:

- Probability for users threshold for action
20% chance temp \leq 32°F
- Best kind of uncertainty forecast

Website: <https://depts.washington.edu/forecast/>

One of her presentations: <https://www.youtube.com/watch?v=SfXlt40StpA>

Two Groups

Deterministic forecast

Expected nighttime low temperature 35°F

Probability of freezing

Better decisions
Larger ending budget
Greater trust

Expected nighttime low temperature 35°F
20% chance temp \leq 32°F

Difference Increased

People with the deterministic forecast:

- Lost trust in forecast
- Salted significantly less often
- Distrust in the forecast led to reluctance to act

Expected nighttime low temperature 35°F

People with uncertainty forecasts:

- Maintained trust in the forecast
- Continued to salt more often
- Better performance overall

Expected nighttime low temperature 35°F
20% chance temp \leq 32°F

Risk and Uncertainty Communication Using Probabilistic Information: A Systematic Review and Assessment of Existing Research

Joe Ripberger
Andrew Bell
Carol Silva
Hank Jenkins-Smith



EXCELLENT summary of state of uncertainty communication:
<https://crcm.shinyapps.io/probcom/>



A couple of their recommendations:

- Replace: There is a chance of snow and ice this morning along I-75.
 - With: There is a low/medium/high chance of snow and ice this morning along I-75.
- Replace: These storms will cause heavy downpours and flooding.
 - With: There is an extremely high (90%) chance that these storms will cause heavy downpours and flooding.
- Replace: There is a low (15%) chance that we will see more than 10 inches of snow in the metro area tomorrow.
 - With: There is a low (10% to 20%) chance that we will see more than 10 inches of snow in the metro area tomorrow.
- Be aware of “directionality” when using probability information:
 - Replace: There is a high (90%) chance of sunny skies today.
 - With: There is a low (10%) chance of freezing drizzle today.
- When possible, include probability information in forecast visualizations.
 - Replace: Maps showing deterministic warning boxes/polygons.
 - With: Maps showing probabilistic information; for example: probability grids (NSSL’s FACETs)

Lingering Qs: What about specifically for winter weather? What graphics are best for winter wx?

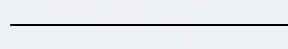
GOAL:

Identify best messaging strategies for winter storms and achieve more consistency

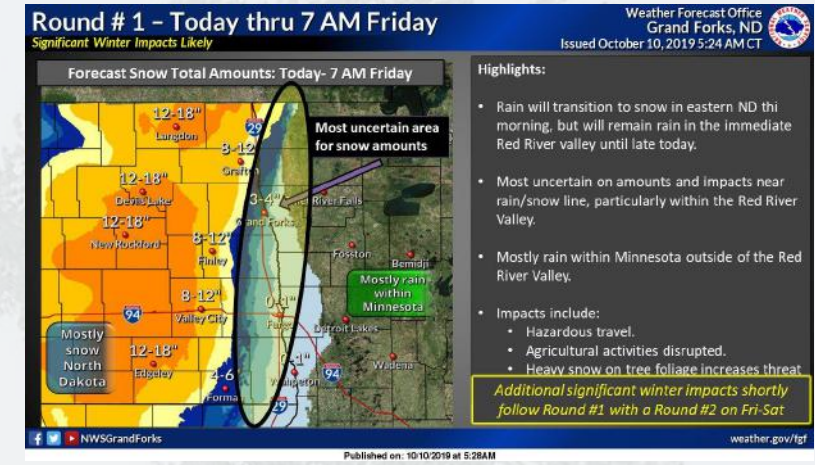
Days 3-7 before storm



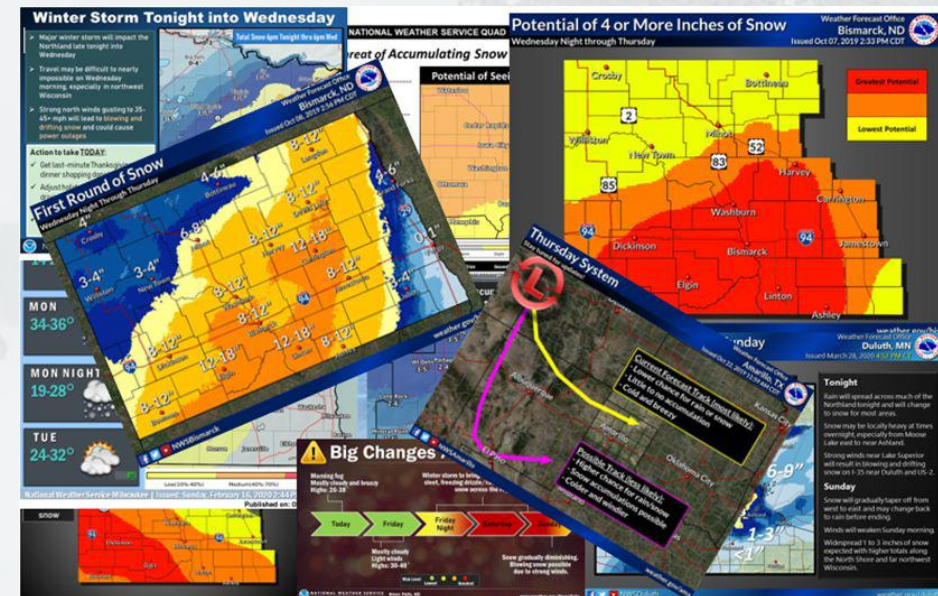
Days 2-3 before storm



Days 1-2 before storm



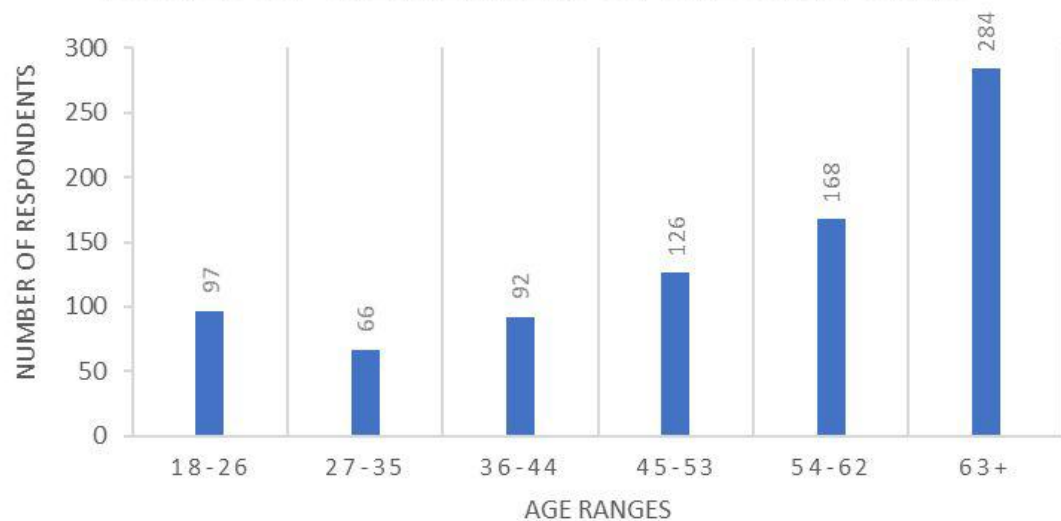
1. Gathered hundreds of NWS graphics
2. Organized and identified key differences among graphics
3. Used social media analytics to study specific storms
4. Received feedback through surveys and focus groups
 - a. Survey of U.S. public (N=833)
 - b. Survey of meteorologists (N=40) and non-meteorologists (N=32) at NWS offices



Focusing on survey of U.S. public

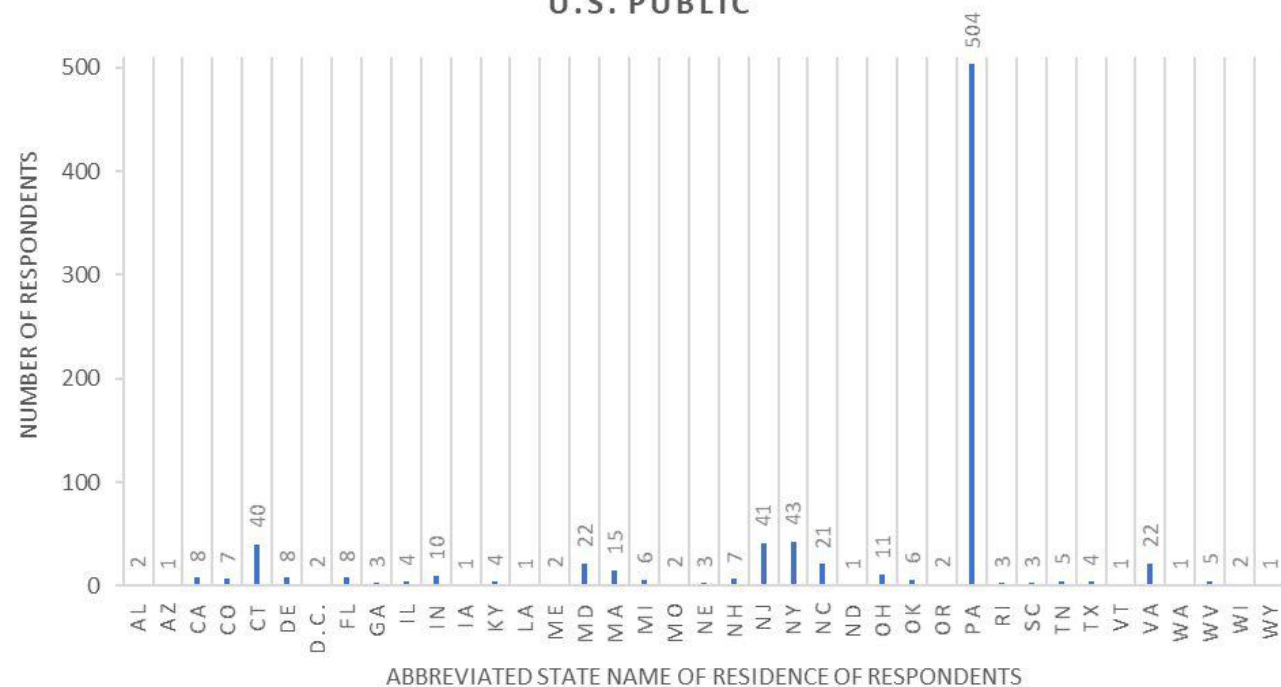
Please select your age group
(N=833)

AGE DISTRIBUTION OF RESPONDENTS TO THE SURVEY OF THE MEMBERS OF THE U.S. PUBLIC

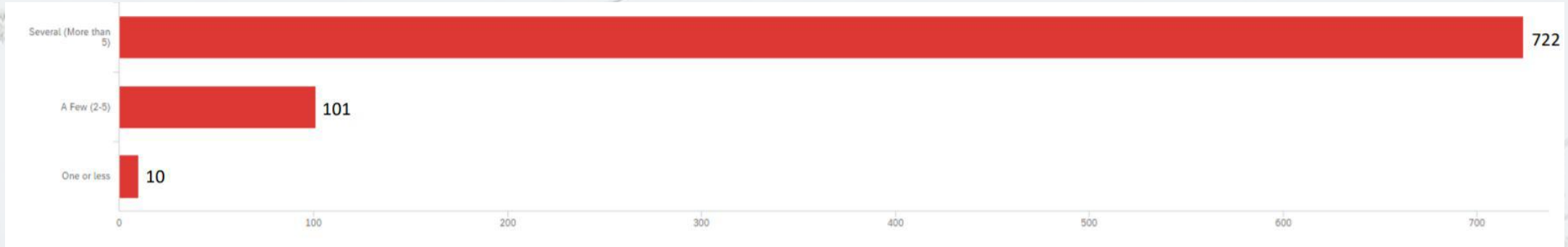


In which state do you currently reside?
(N=832)

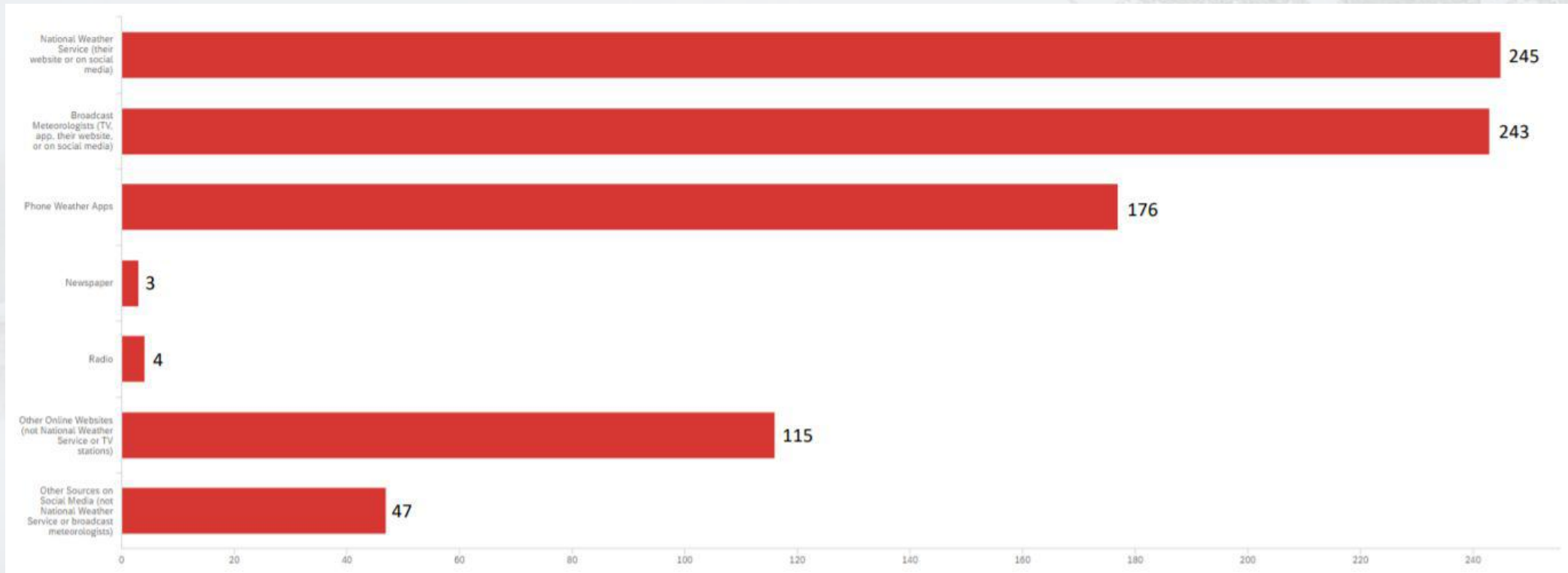
DISTRIBUTION OF THE STATE OF RESIDENCE OF RESPONDENTS TO THE SURVEY OF THE MEMBERS OF THE U.S. PUBLIC



How many winter storms have you experienced within the past 10 years? (N=833)

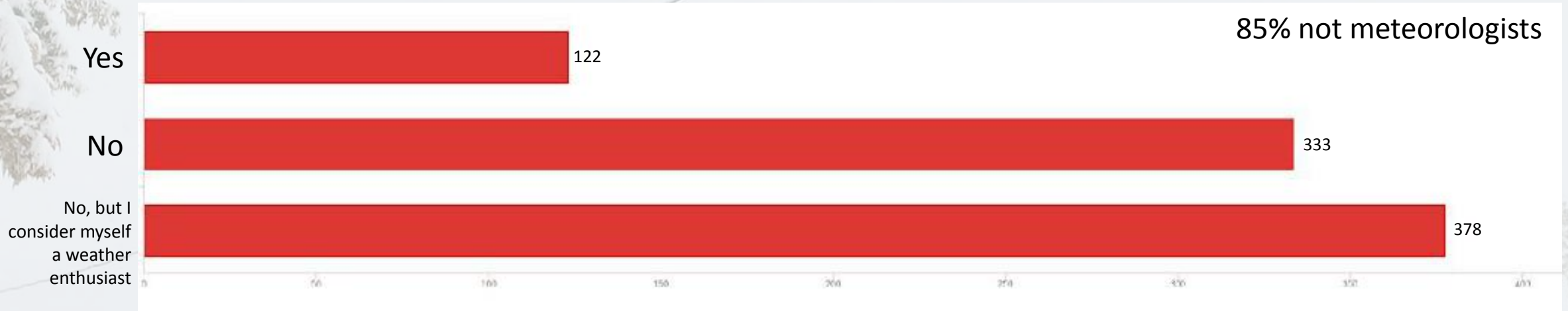


During the WINTER SEASON, what source of weather information do you look at most? (N=833)



Do you have a background in meteorology? (working towards a degree, have a degree, etc.)

(N=833)



I applied filters to the survey data to determine if any possible biases occurred.






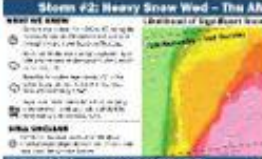
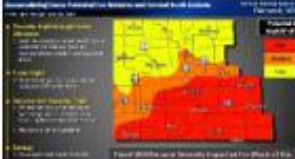


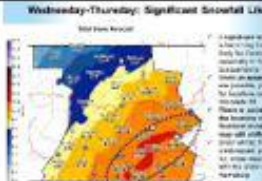
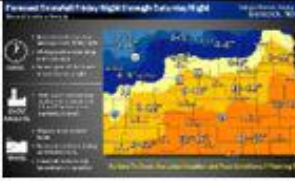


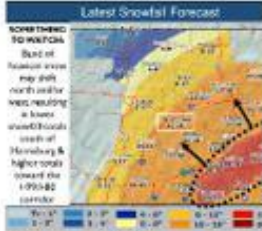

When meteorologists, PA residents, those who rely on NWS forecast info, and those not experienced with winter storms were filtered out, all the distributions of responses remained practically the same.

Format of survey of U.S. public

Four scenarios were created, and respondents were randomly placed in ONE of them by the survey software.

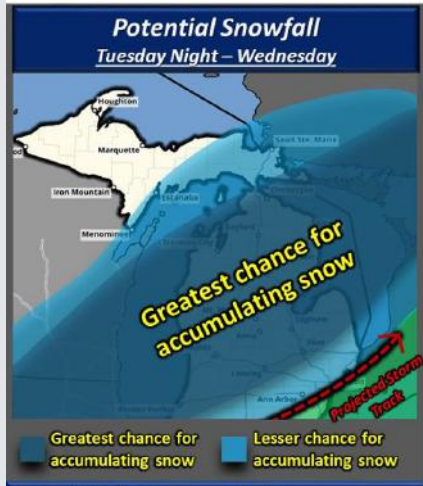
Within each scenario, a series of graphics that NWS offices used to message winter storms during the 2019-2020 or 2020-21 winter seasons were presented to respondents.

1. NWS Omaha from January 22-24, 2021 ($N=187$)
2. NWS State College from December 15-17, 2020 ($N=212$)
3. NWS Bismarck from November 24-28, 2019 ($N=221$)
4. NWS Green Bay from November 23-25, 2019 ($N=213$)

	Scenario #1 – NWS Omaha	Scenario #2 – NWS State College	Scenario #3 – NWS Bismarck	Scenario #4 – NWS Green Bay
First Graphic Presented	 <p>(Figure 67) Posted 1/22/21 – three days before storm</p>	 <p>(Figure 72) Posted 12/11/20 – five days before storm</p>	 <p>(Figure 77) Posted 11/24/19 – five days before storm</p>	 <p>(Figure 81) Posted 11/23/19 – three days before storm</p>
Second Graphic Presented	 <p>(Figure 68) Posted 1/23/21 – two days before storm</p>	 <p>(Figure 73) Posted 12/13/20 – three days before storm</p>	 <p>(Figure 78) Posted 11/27/19 – two days before storm</p>	 <p>(Figure 82) Posted 11/24/19 – two days before storm</p>
Third Graphic Presented	 <p>(Figure 70) Posted 1/23/21 – two days before storm</p>	 <p>(Figure 75) Posted 12/14/20 – two days before storm</p>	 <p>(Figure 80) Posted 11/28/19 – one day before storm</p>	 <p>(Figure 83) Posted 11/24/19 – two days before storm</p>
Fourth Graphic Presented	 <p>(Figure 71) Posted 1/24/21 – one day before storm</p>	 <p>(Figure 76) Posted 12/15/20 – one day before storm</p>		 <p>(Figure 85) Posted 11/25/19 – one day before storm</p>

LONG RANGE: Identified four common graphic types used at this lead time

EXAMPLE 1



EXAMPLE 2



EXAMPLE 1

UPDATE: WINTER STORM POTENTIAL FRIDAY-SATURDAY

WHAT WE KNOW

- The greatest potential for snowfall amounts of 6"-8" or more continues to be across the eastern half of Minnesota and western Wisconsin.
- The potential for heavier amounts of 8"-12" is increasing.
- Gusty winds are expected with this system, and could lead to additional impacts from blowing and drifting snow.

WHAT WE DON'T KNOW

- Exact snowfall amounts - or where exactly the heaviest snow will fall
- Exact timing of snowfall - although snow continues to look likely from Friday morning into Saturday afternoon

WHAT YOU CAN DO

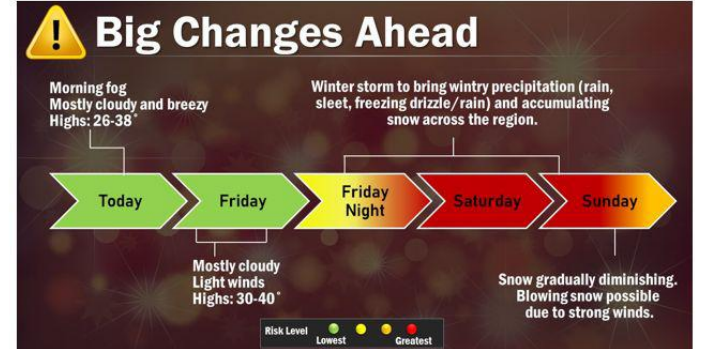
- Consider the need to alter travel plans this weekend
- Monitor forecast updates at weather.gov/mpx and weather.gov/mpx/winter



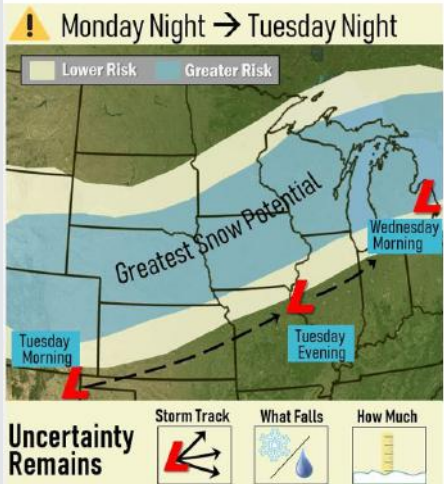
EXAMPLE 1

SUN	None	Potential for accumulating snow and travel impacts
MON	None	
TUE	Chance of PM Snow and Rain	
WED	Chance of AM Light Snow/Rain	
	Slight Chance of Snow or Mix	

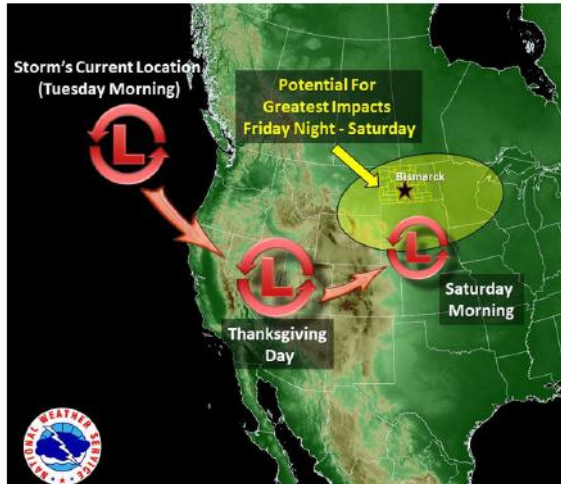
EXAMPLE 2



EXAMPLE 1



EXAMPLE 2



EXAMPLE 2

WHAT WE KNOW

- ✓ Risks of a widespread impactful snow continue to increase Tuesday/Tuesday night.
- ✓ This system is expected to only produce snow.
- ✓ Snow amounts have trended upwards, with the potential for moderate accumulations possible.
- ✓ Travel will be difficult beginning by late Tuesday morning and continuing Wednesday morning across the region.

WHAT WE DON'T KNOW

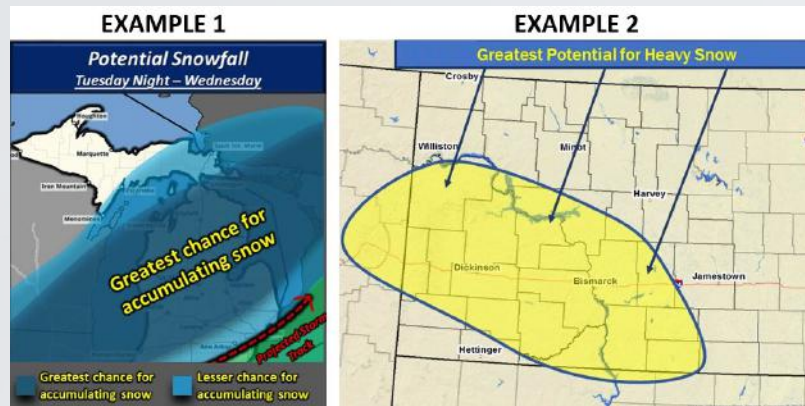
- ✗ There is some uncertainty in the track of the storm. This will impact who receives the most snow.
- ✗ The exact snowfall totals are still uncertain (due to track), but confidence is growing that many will see plowable snow.
- ✗ How strong the winds will be Tuesday night. This could lead to blowing snow and drifting issues into Wednesday.

Key Takeaway #1

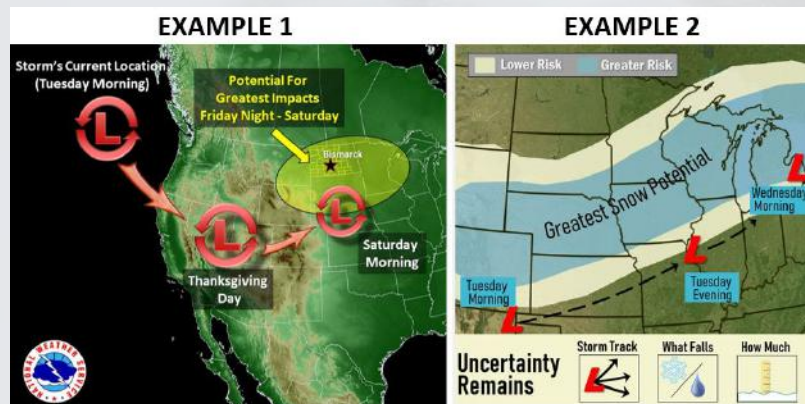
Map-based graphics for long-range messaging

1. Circling one or more areas on a map for snowfall potential
2. Using the track of the storm to communicate the timing and impact area

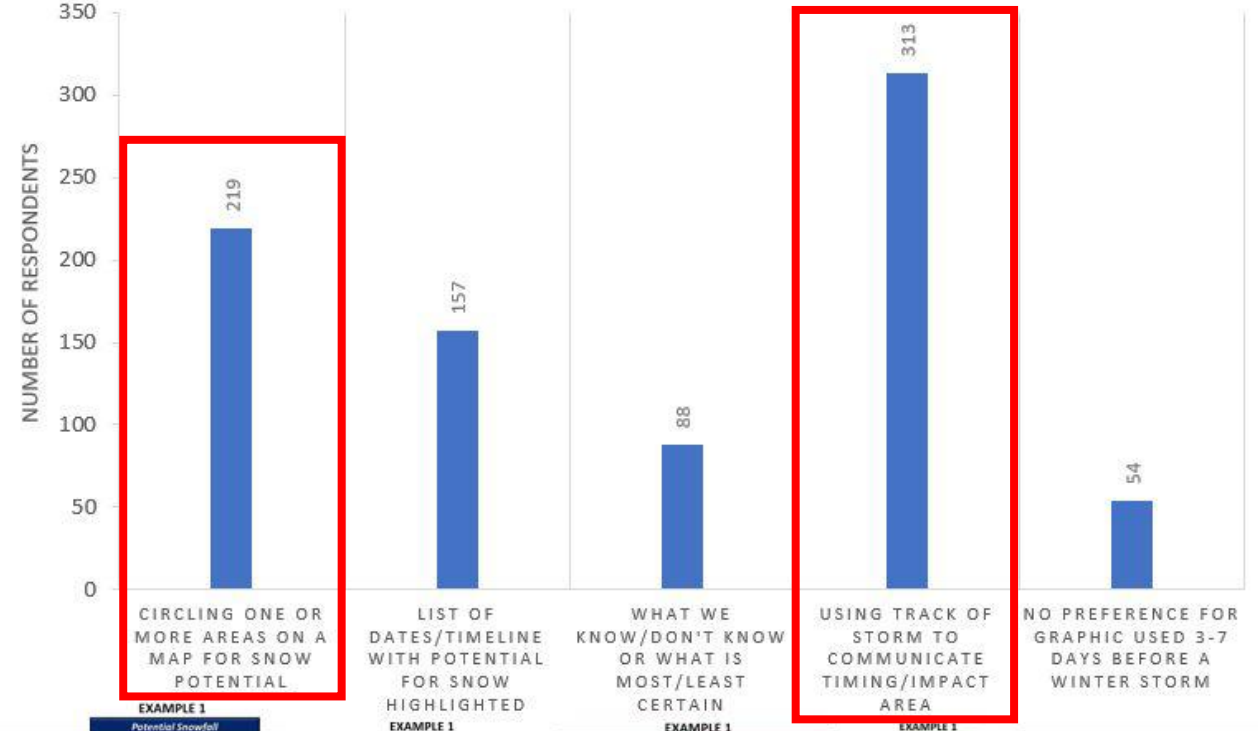
(1)



(2)



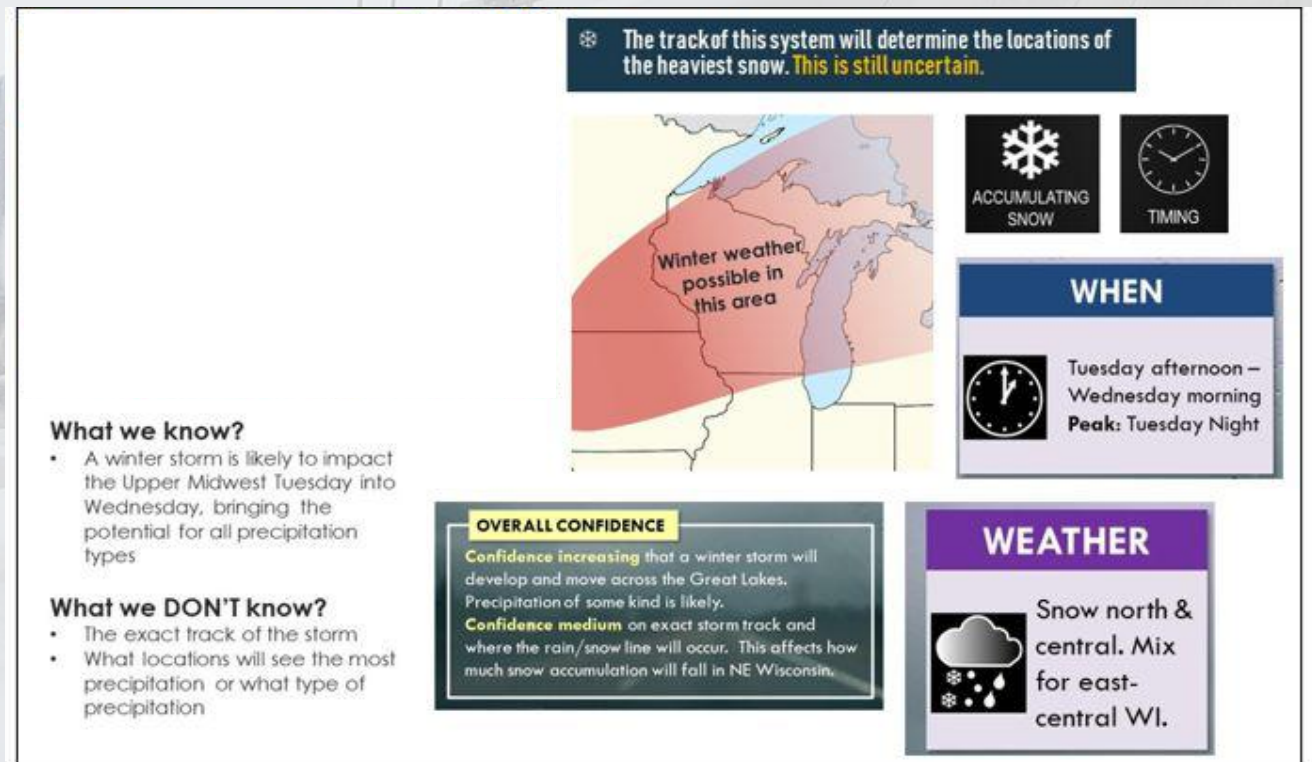
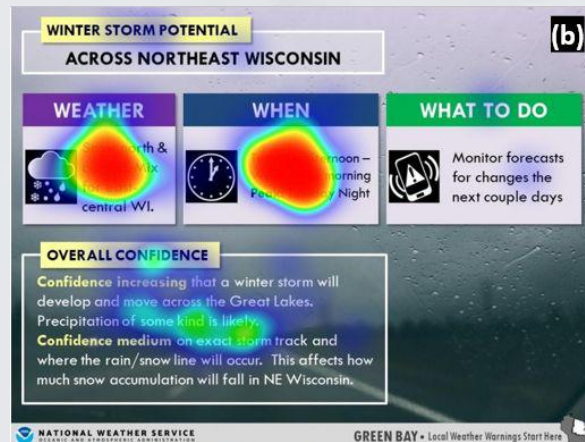
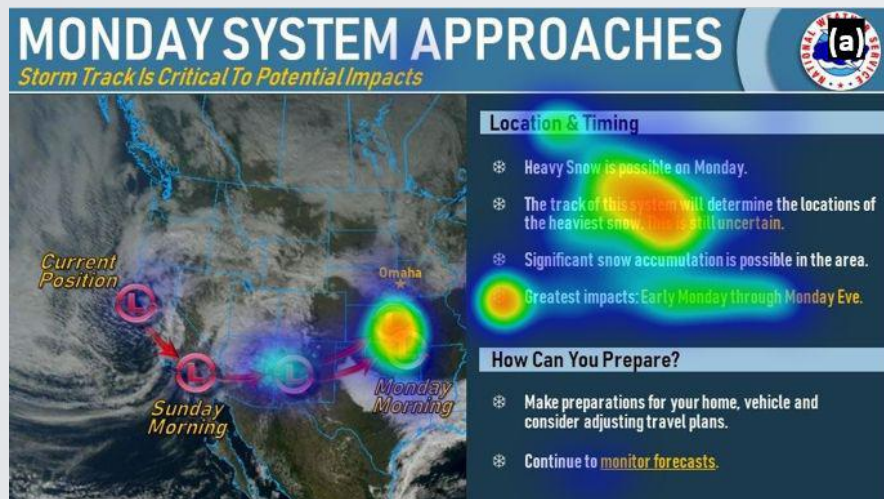
LONG-RANGE WINTER WEATHER GRAPHIC STYLE PREFERENCE OF RESPONDENTS TO THE SURVEY OF MEMBERS OF THE U.S. PUBLIC



Results were consistent with survey of NWS meteorologists and non-meteorologists, as well as emergency managers

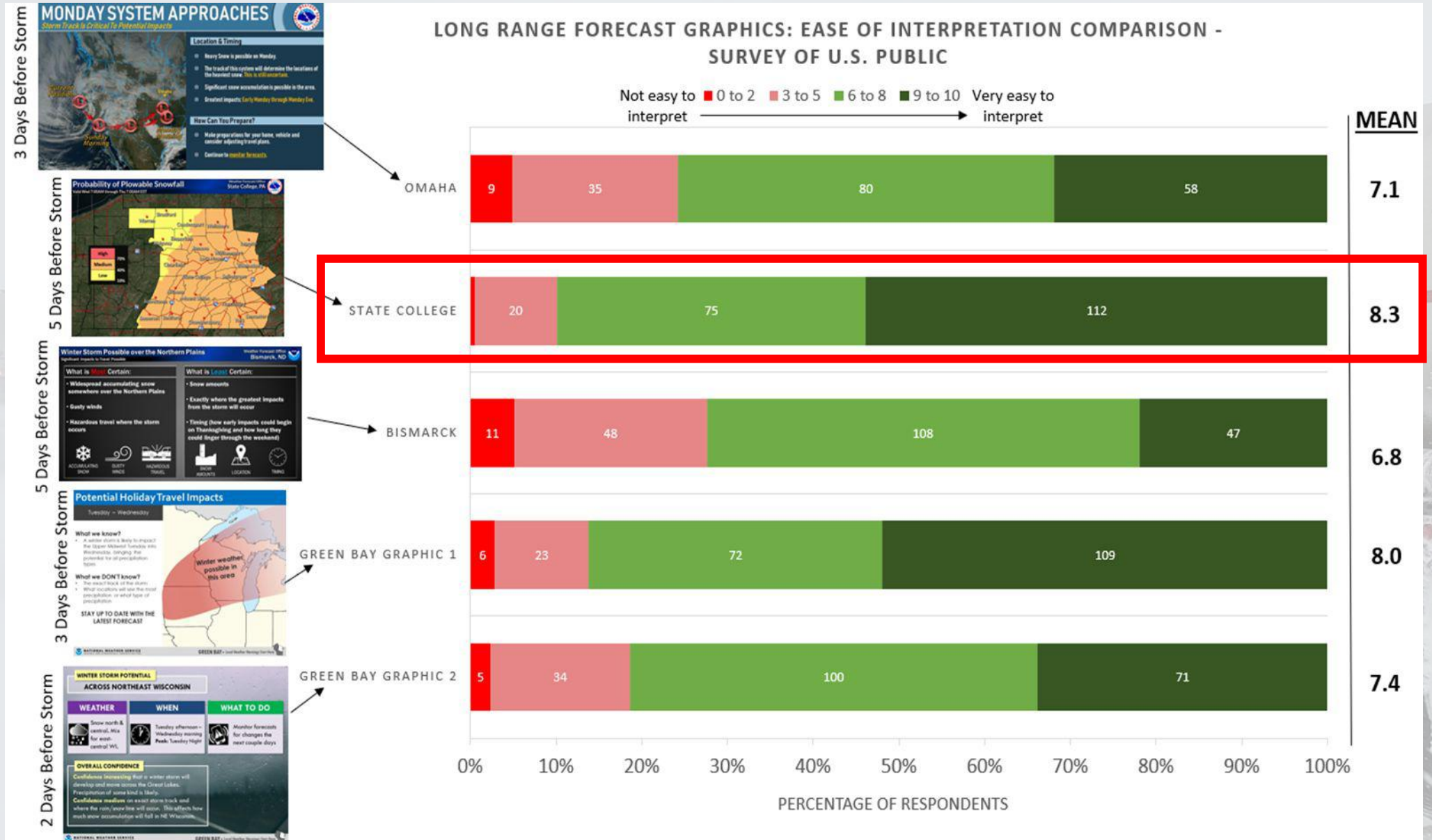
Key Takeaway #2

Simplistic graphics were also preferred at longer lead times, with not too much text on the graphics making them easier to interpret. Some text-based information communicating the uncertainty or confidence in the forecast was found to be useful to the public and should be added to these graphics alongside the maps.



Elements of long-range winter weather graphics found to be helpful and important to respondents of the survey of the U.S. public.

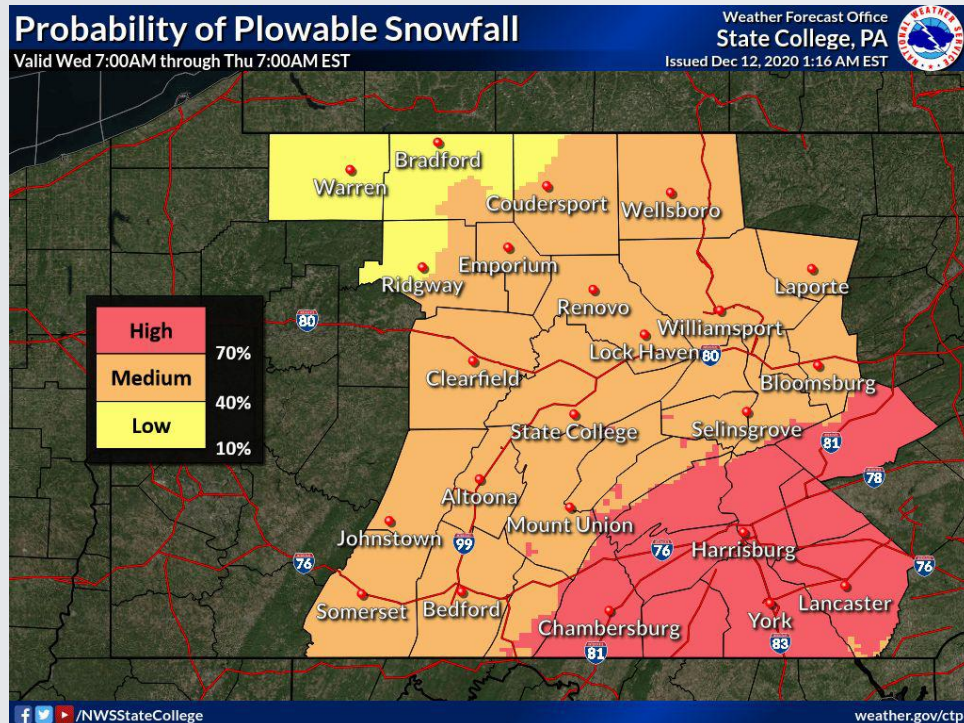
Key Takeaway #3



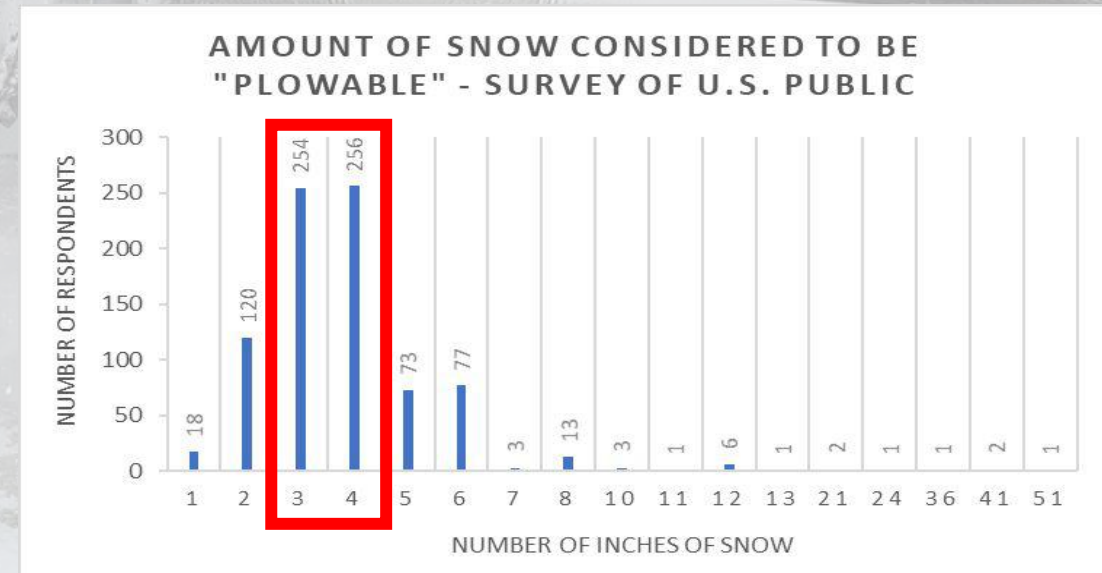
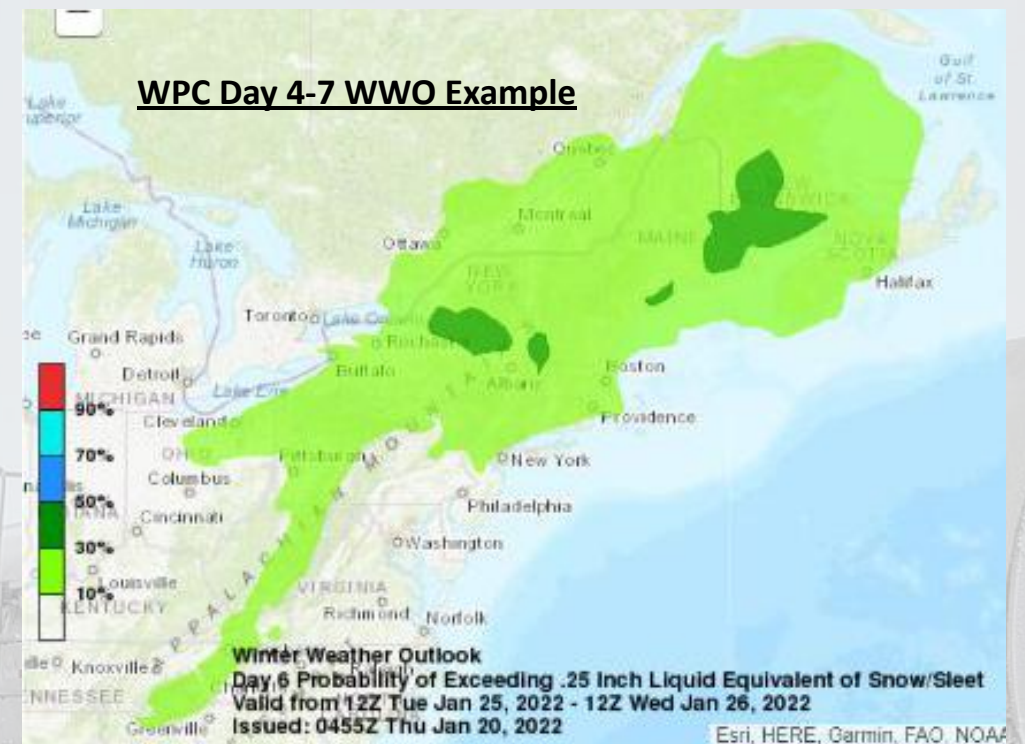
Key Takeaway #3 (cont.)

NWS State College's Probability of Plowable Snowfall Graphic

Allows WPC's probability of exceeding 0.25" of liquid equivalent of snow/sleet maps to be turned into helpful long-range weather information that is focused on the local area of the NWS office. <https://www.weather.gov/ctp/wwo>



Found to be easy to interpret and useful to the public 4-7 days before a storm.

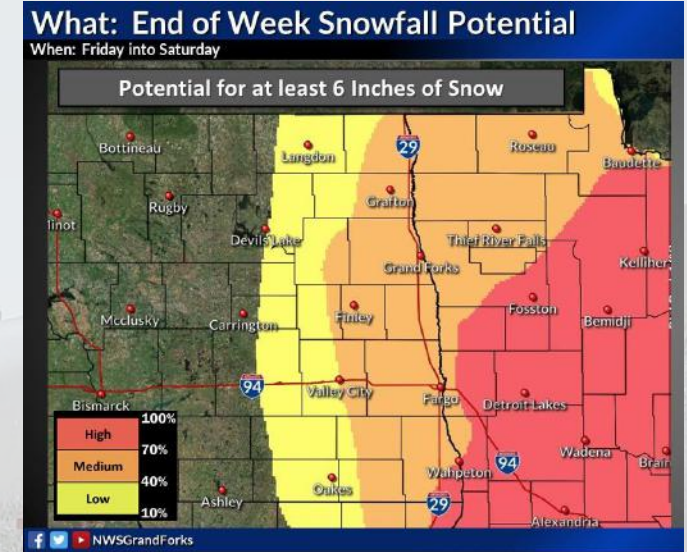
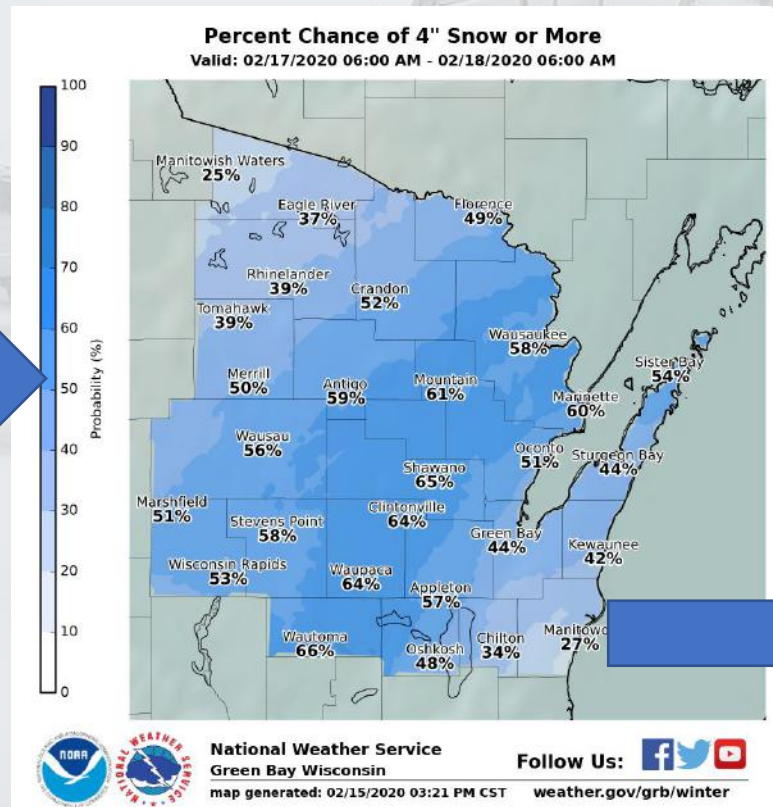
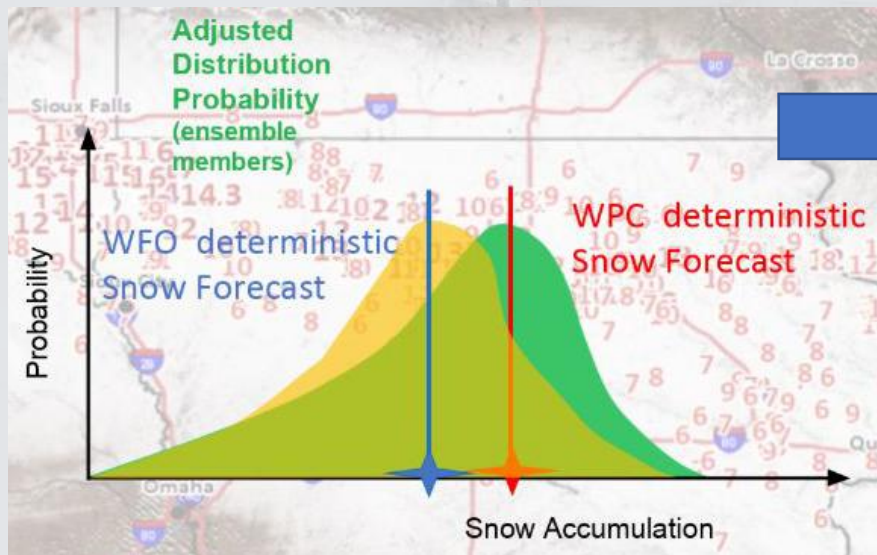


RISK PROBABILITY GRAPHICS: What's the purpose of these graphics?

Probability of exceeding X inches of snowfall – ensemble based

- Used when there's too much uncertainty for snow maps to be released
- Communicates the spatial coverage *and* likelihood of the threat
- Conveys the uncertainty in the forecast and encourages user to check back for updates

Ensemble distribution is shifted based on human forecasts to get probability percentages at a specific threshold



Discrete percentages can be placed in three categories



Key Takeaway #4

Risk probability graphics were found to be understandable & helpful with decision making.

Scenario 1

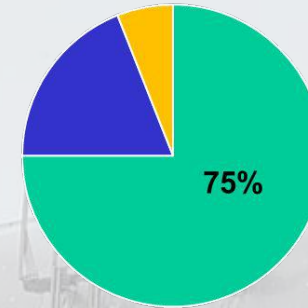


Scenario 2

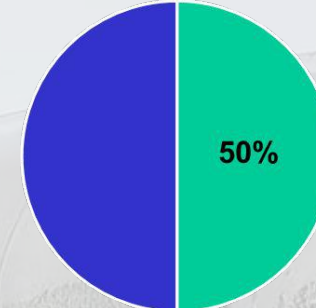


Three days before storm onset

NWS non-meteorologist survey when asked to decide about staffing for an upcoming storm based on different forecast graphics

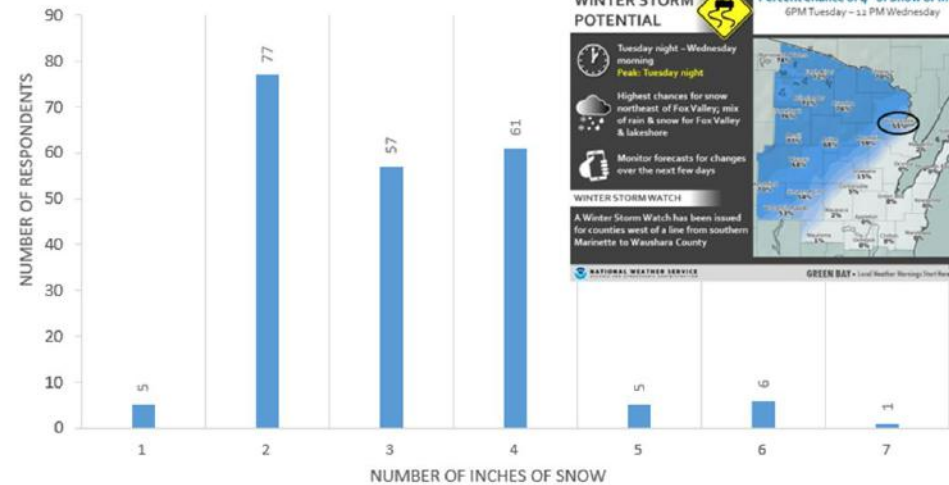


- Too early to make decision due to uncertainty
- Less than 10 people (not expecting > 4")
- More than 10 people (expecting > 4")

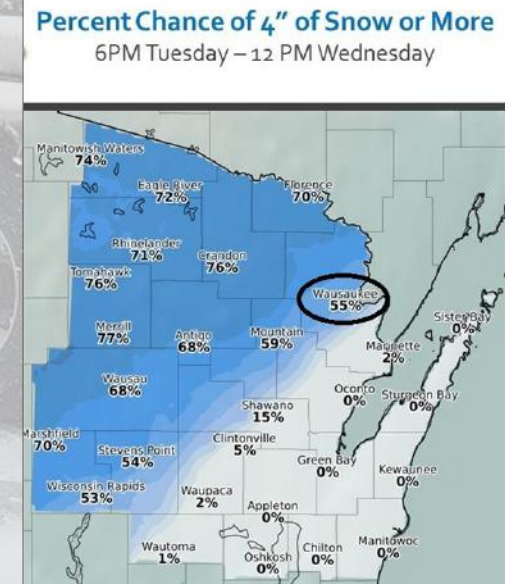


Public's Interpretation of Graphic:
For the most part, they thought the city on the map would get **the amount of snow listed in the title of the map or a range of values lower than that.**

BASED ON NWS GREEN BAY RISK PROBABILITY GRAPHIC:
AMOUNT OF SNOW FOR WAUSAUKEE - SURVEY OF U.S. PUBLIC



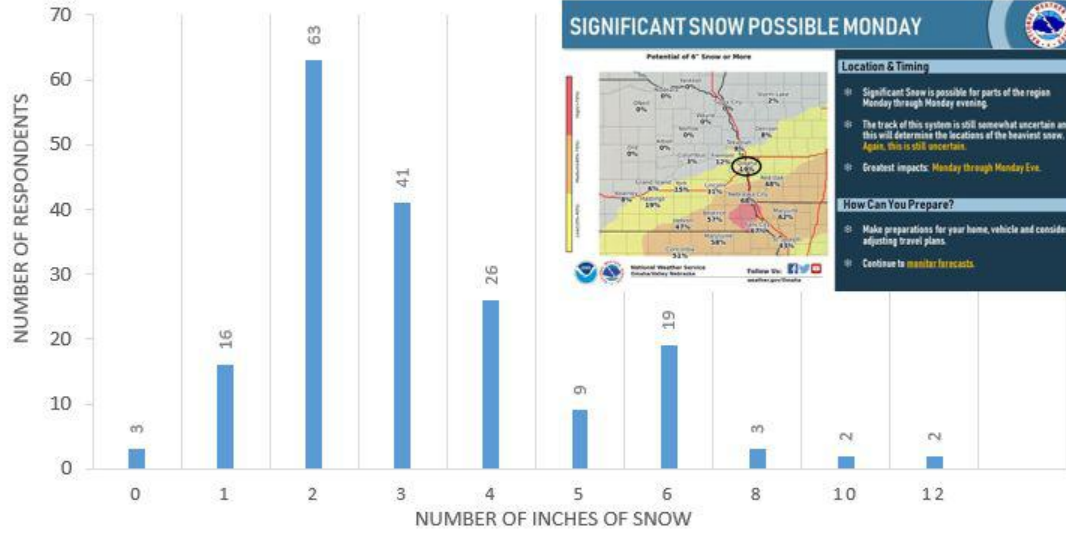
Zoomed in view of the risk probability map used in this question



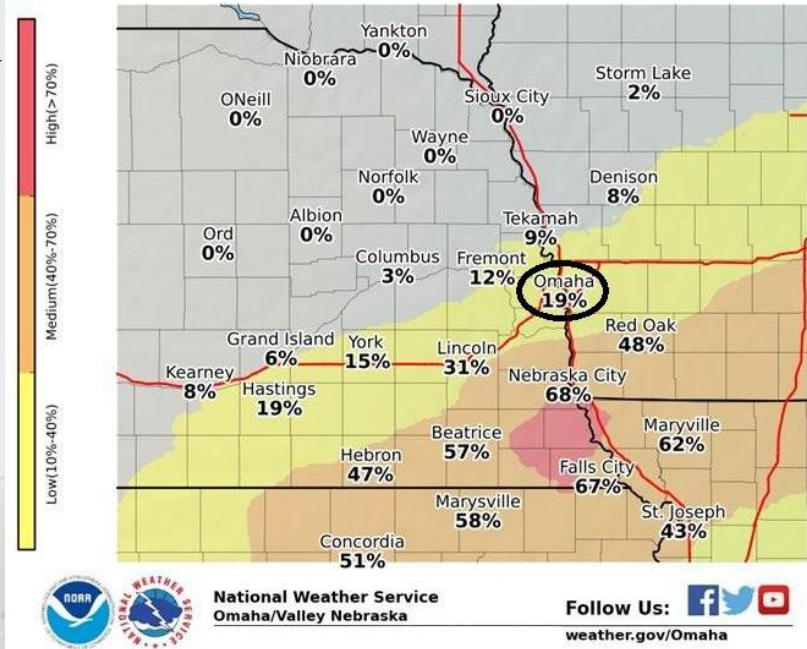
Remaining Question:

Is this the way we want people to interpret risk probability graphics?

**BASED ON NWS OMAHA RISK PROBABILITY GRAPHIC:
AMOUNT OF SNOW FOR OMAHA - SURVEY OF U.S. PUBLIC**

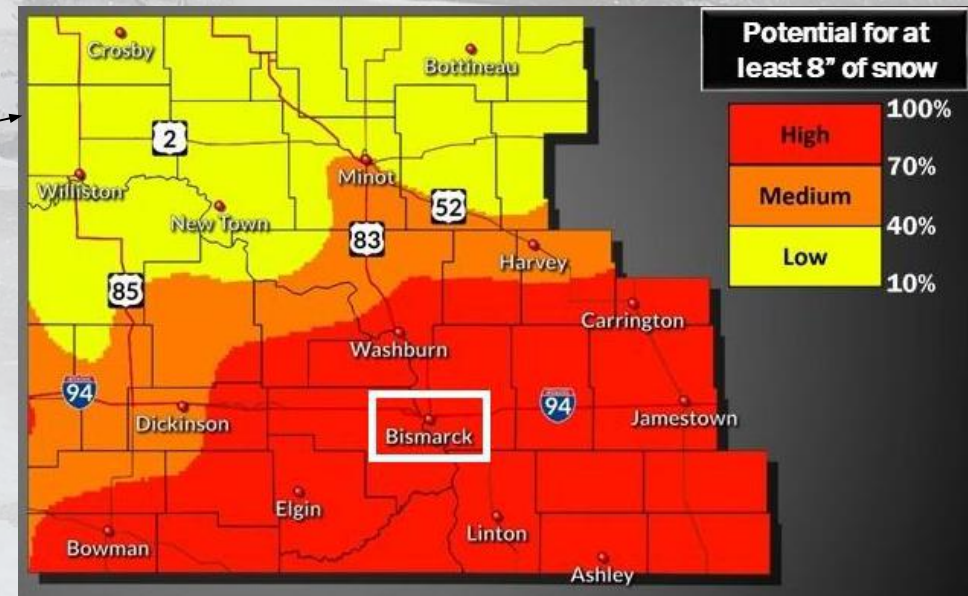
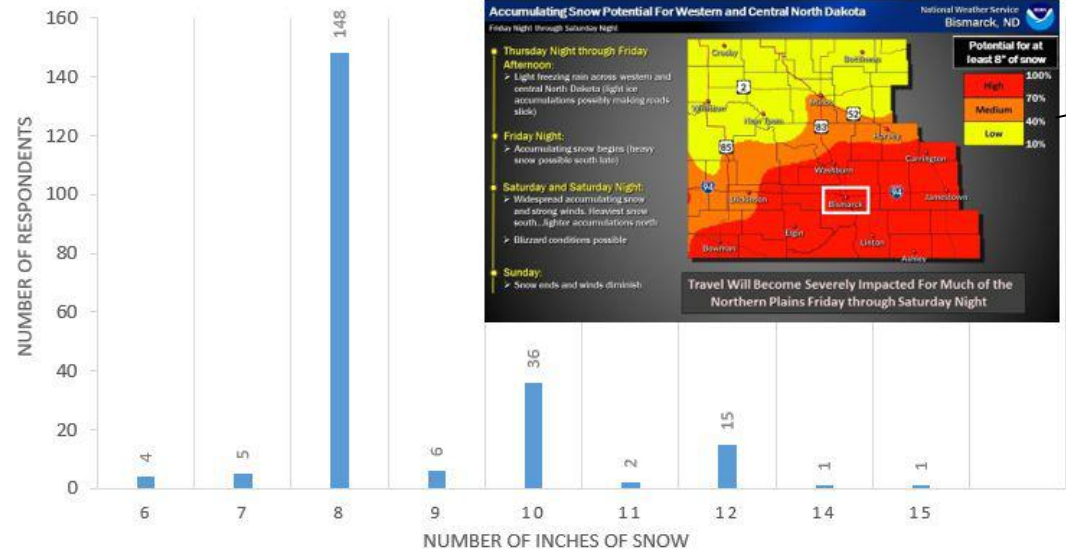


Potential of 6" Snow or More



Zoomed in view of the risk probability map used in this question

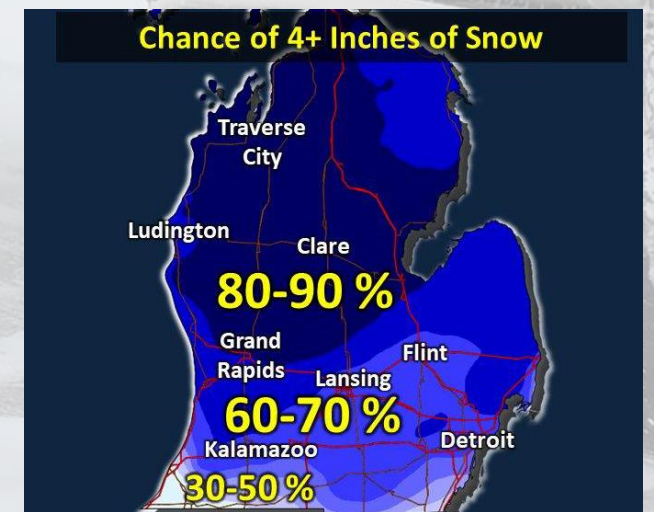
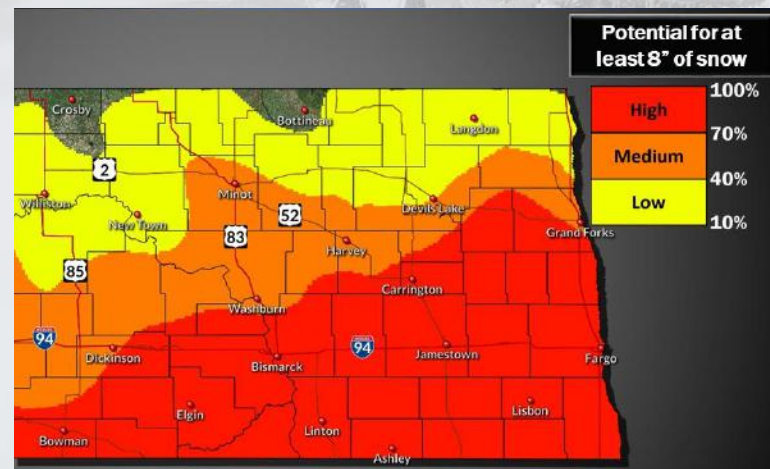
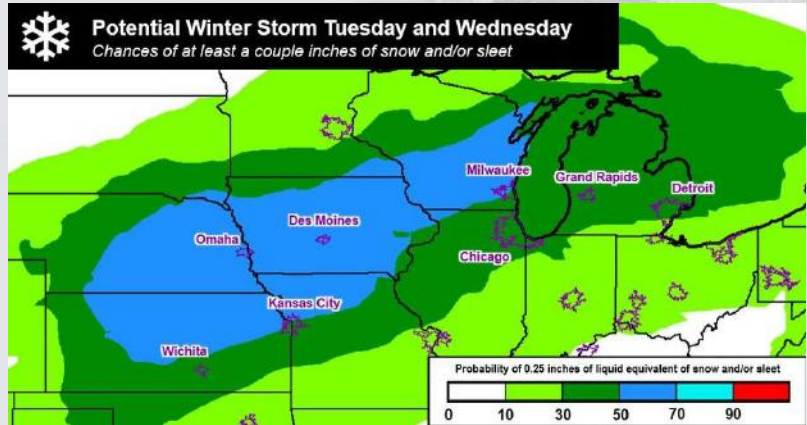
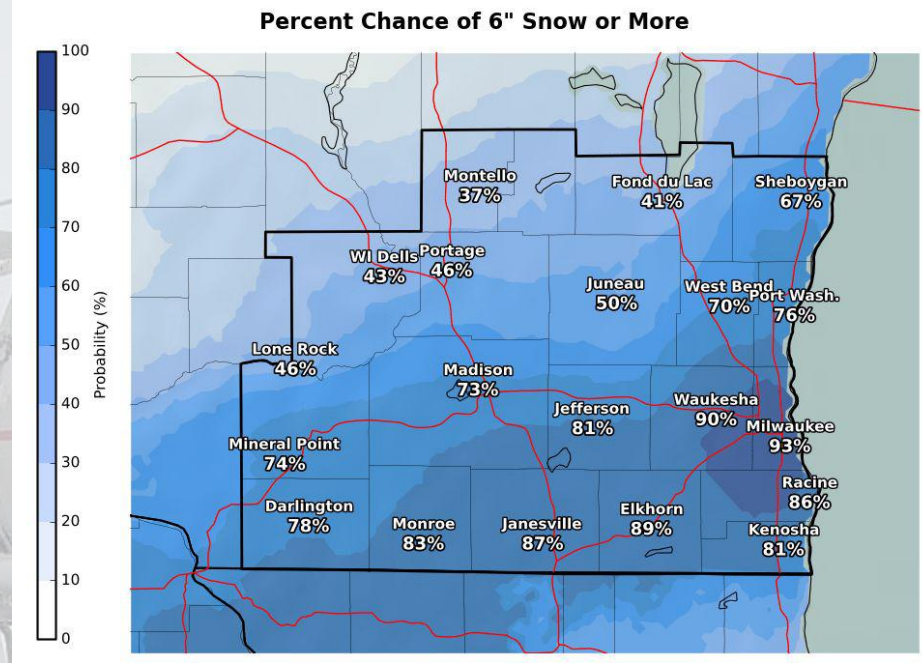
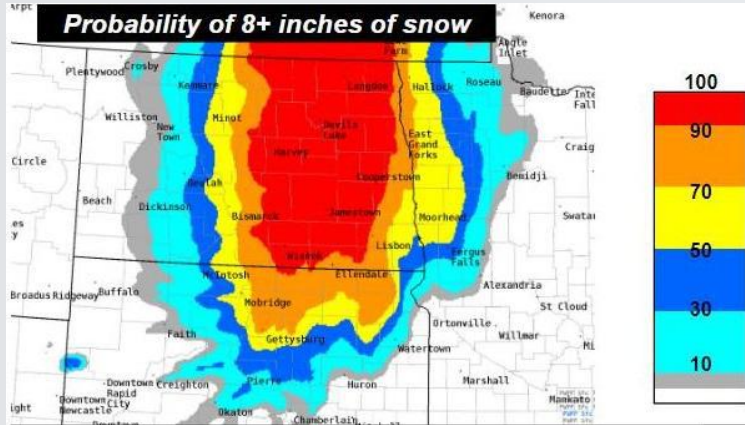
**BASED ON NWS BISMARCK RISK PROBABILITY GRAPHIC:
AMOUNT OF SNOW FOR BISMARCK - SURVEY OF U.S. PUBLIC**



Zoomed in view of the risk probability map used in this question

RISK PROBABILITY GRAPHICS

But there are many different color schemes used for these graphics:

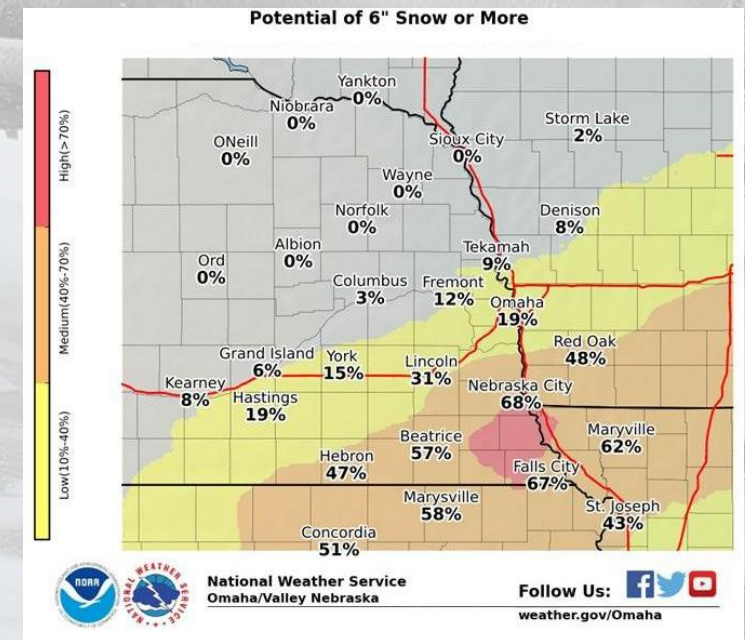
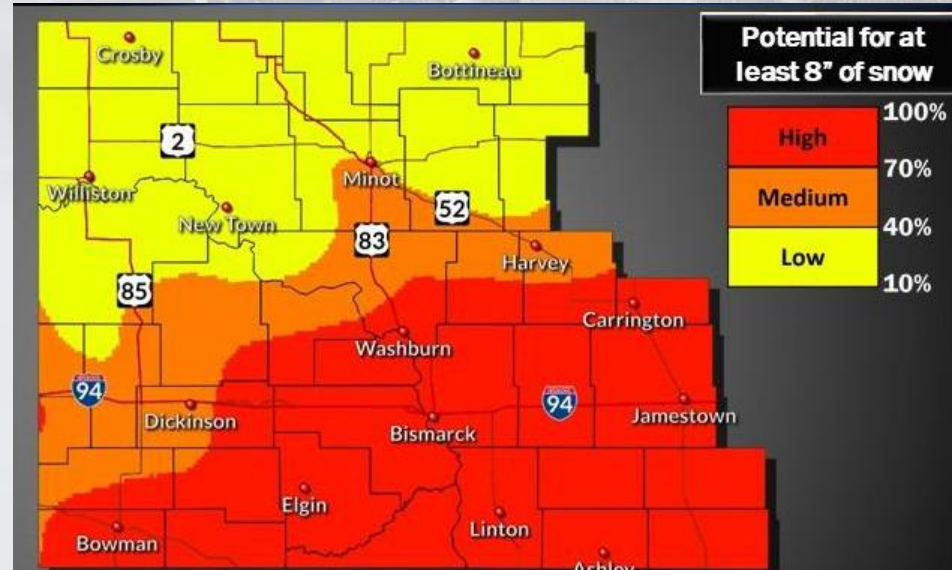
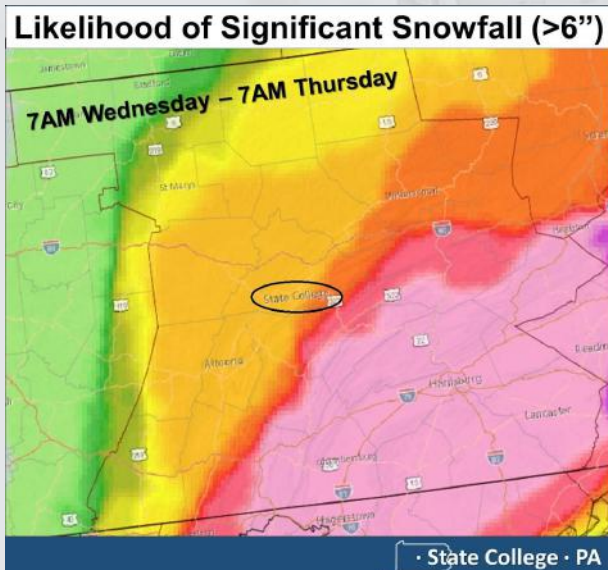
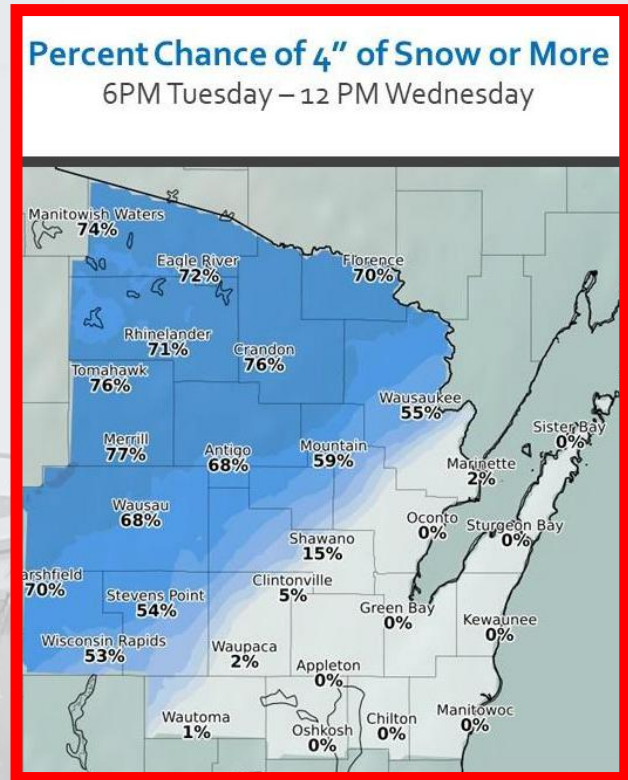


Key Takeaway #5

The **blue gradient** color scheme with probability percentages plotted at each location was the **most preferred**.

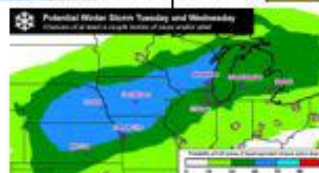
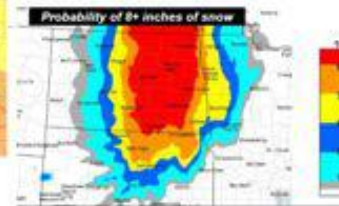
Easiest to interpret and the best communicator of the uncertainty present in the forecast based on the survey of the U.S. public.

Past research that suggests numerical expressions of uncertainty should be prioritized over purely categorical statements as numerical expressions of uncertainty are interpreted more consistently (Budescu et. al 1988, Jaffe-Katz et. al 1989).



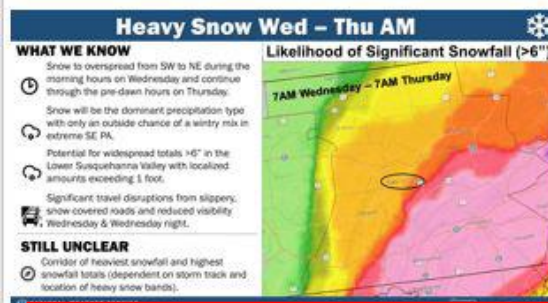
There are many different color schemes used in graphics to communicate the **probability of snowfall from a winter storm exceeding a specified amount.** Which color scheme do you think is the BEST?

RISK PROBABILITY GRAPHICS COLOR SCHEME PREFERENCE OF RESPONDENTS TO THE SURVEY OF MEMBERS OF THE U.S. PUBLIC





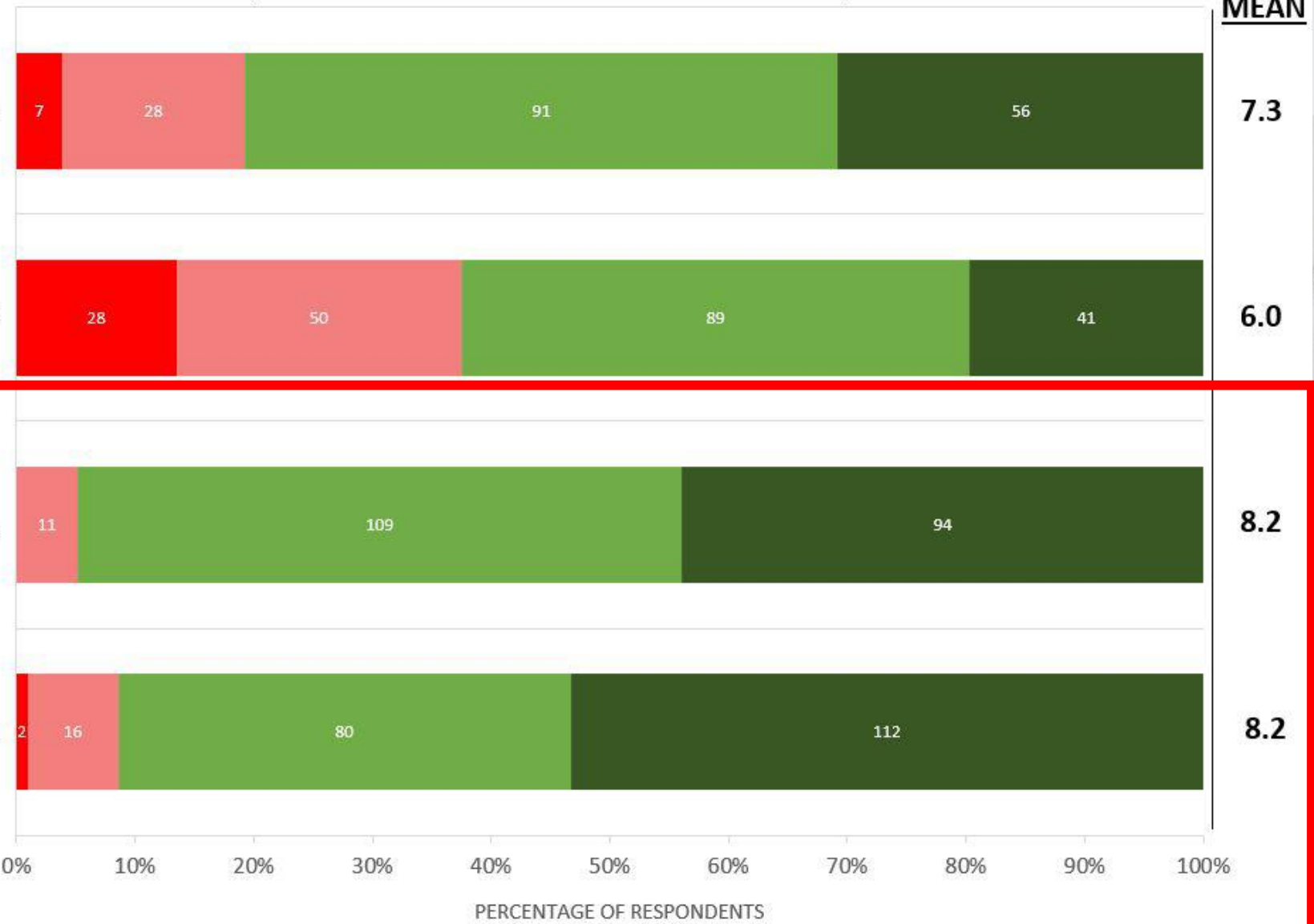
OMAHA



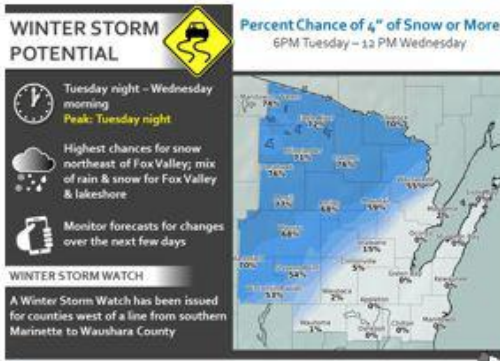
STATE COLLEGE

RISK PROBABILITY GRAPHICS: EASE OF INTERPRETATION COMPARISON

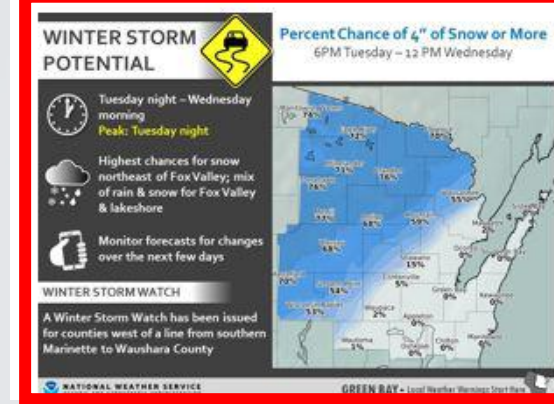
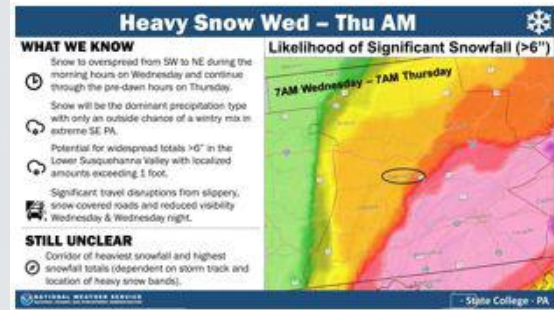
Not easy to interpret ← 0 to 2 (red) 3 to 5 (pink) 6 to 8 (green) 9 to 10 (dark green) → Very easy to interpret



BISMARCK



GREEN BAY



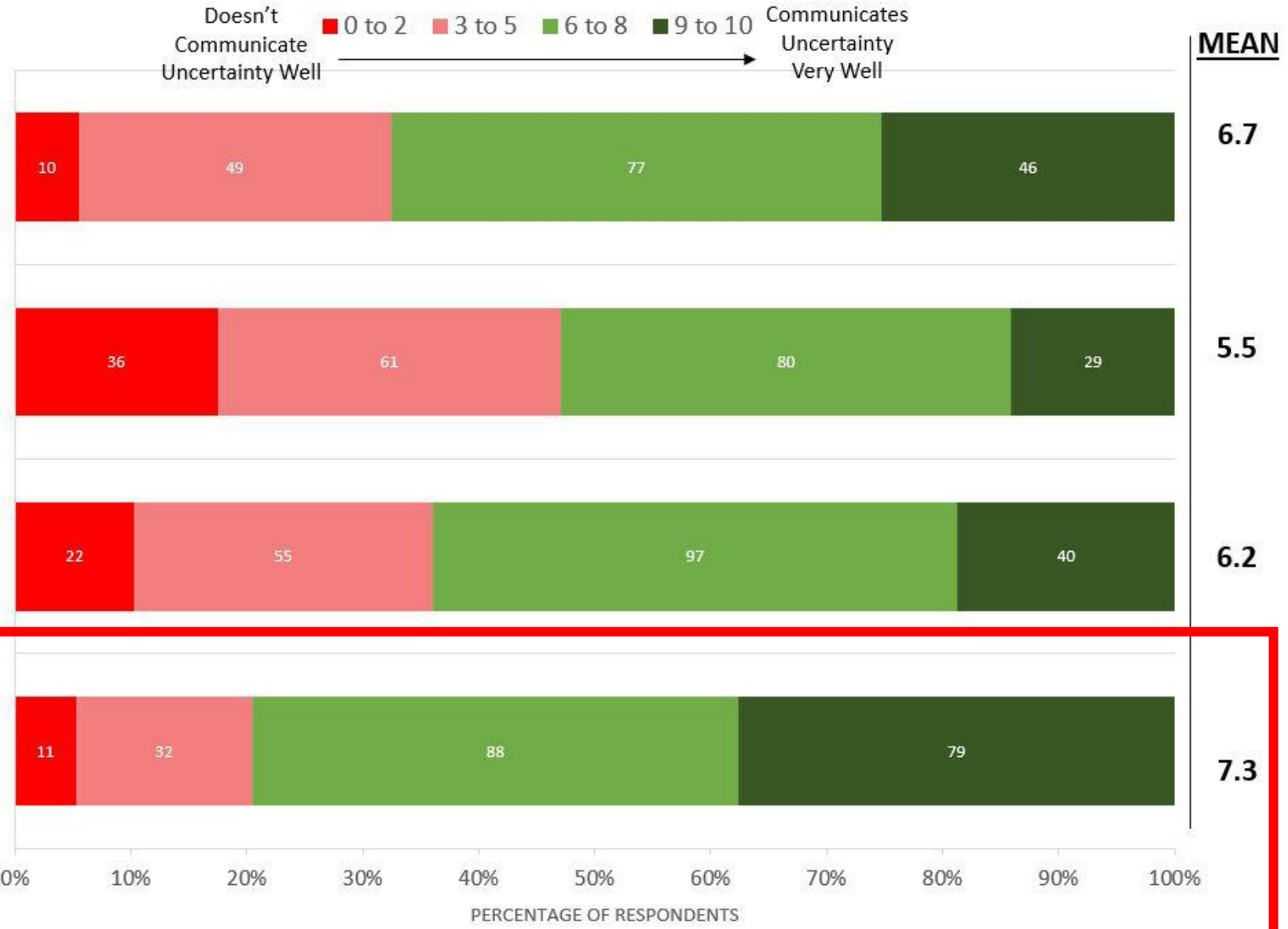
RISK PROBABILITY GRAPHICS: COMMUNICATION OF UNCERTAINTY COMPARISON - SURVEY OF U.S. PUBLIC

OMAHA

STATE COLLEGE

BISMARCK

GREEN BAY



WINTER STORM POTENTIAL



Percent Chance of 4" of Snow or More

6PM Tuesday – 12 PM Wednesday



Tuesday night – Wednesday morning

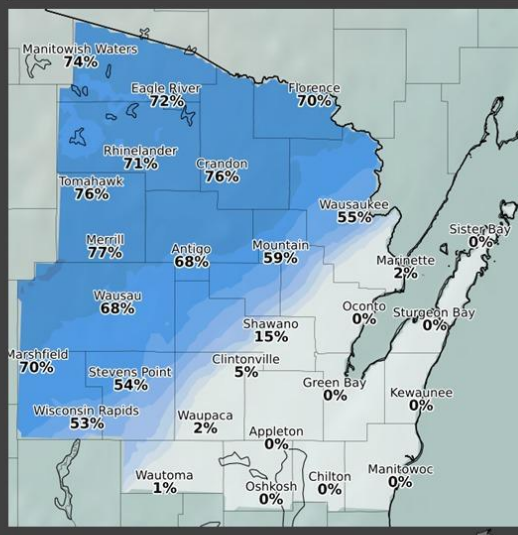
Peak: Tuesday night



Highest chances for snow northeast of Fox Valley; mix of rain & snow for Fox Valley & lakeshore



Monitor forecasts for changes over the next few days



WINTER STORM WATCH

A Winter Storm Watch has been issued for counties west of a line from southern Marinette to Waushara County

NATIONAL WEATHER SERVICE
OCEANIC AND ATMOSPHERIC ADMINISTRATION

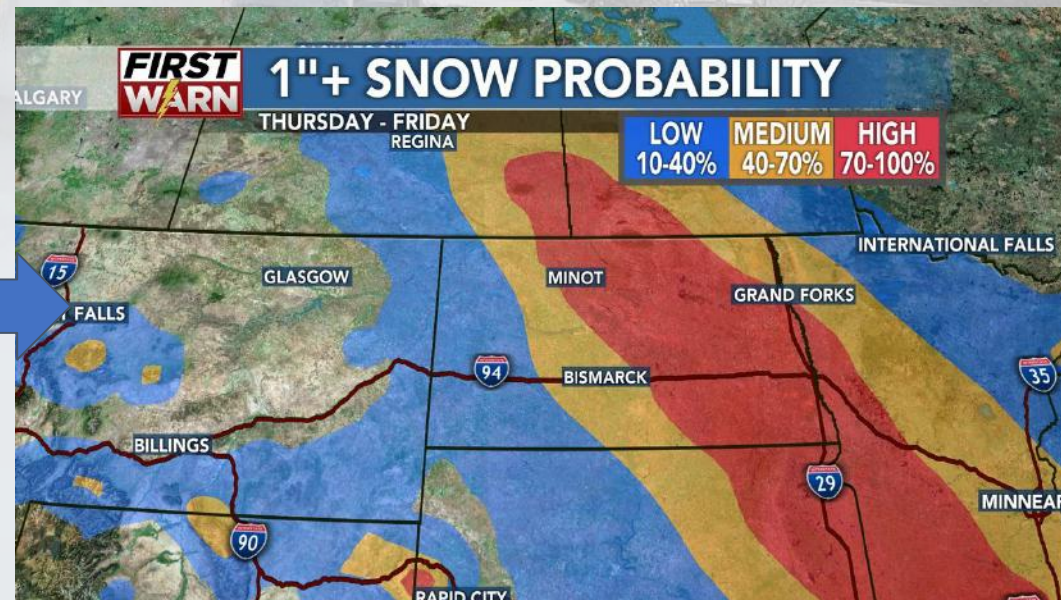
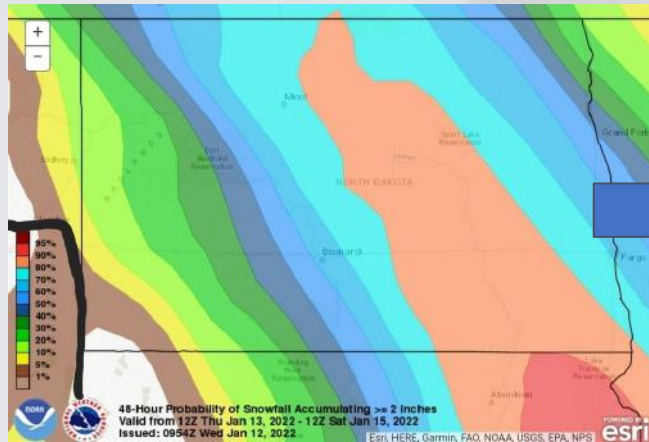
GREEN BAY • Local Weather Warnings Start Here

Published on: 11/24/2019 at 4:44PM

Some people found the probability percentages plotted at each location on this color scheme helpful for them to interpret the forecast.

A possible suggestion would be to round the percentages at each location to the nearest 5% or 10% so they're not so exact and down to the 1% – easier to interpret?

If probability percentages are not included as plotted locations on the risk probability map, **these percentages should at least be included on the legend of the graphic so that the risk probability graphic is not completely devoid of numerical expressions of uncertainty.**



Risk Prob graphics at KFYZ

Based on KML downloads from WPC

Went with blue as 10-40% contour for better contrast (yellow & orange were too similar with how the KML files work in MAX graphics - transparency issues)

Open to KML download of Risk Prob from individual NWS office

Key Takeaway #6

The red/orange/yellow color scheme for risk probability graphics was the preferred options for meteorologists that were surveyed in the Central Region, most likely due to their familiarity with it.

Q1 – Risk Probability Color Scheme Preference	Three-tiered (red, orange, yellow)	Blue shadings	Brown, Yellow, Green, Blue, Red	Grey, Blue, Yellow, Orange, Red (WPC Scale)	No preference for color scale
	21	6	7	6	2

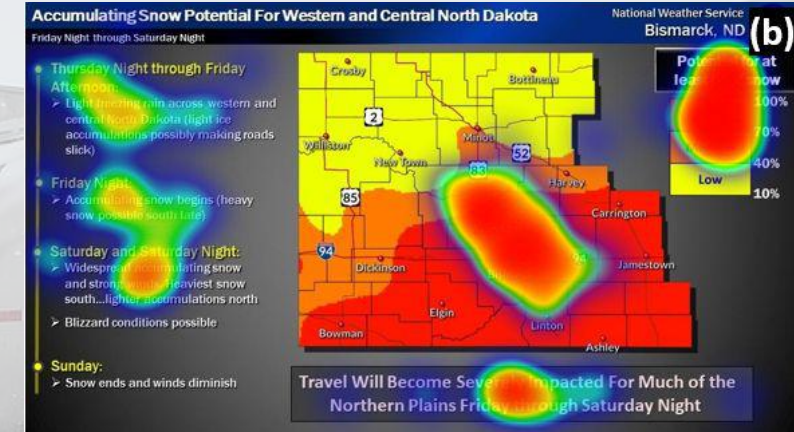
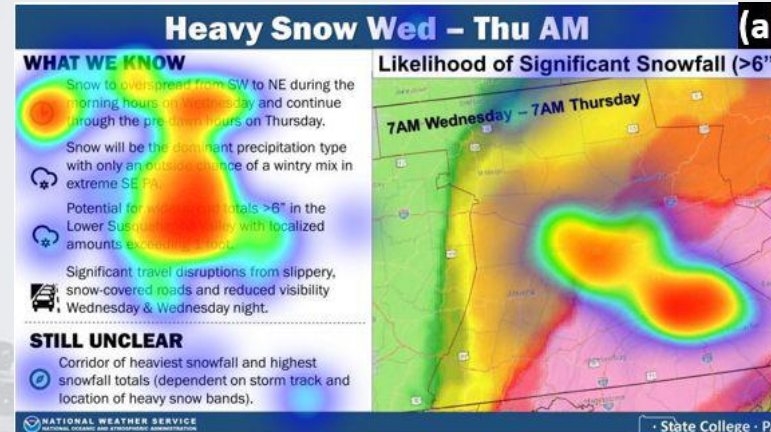


Key Takeaway #7

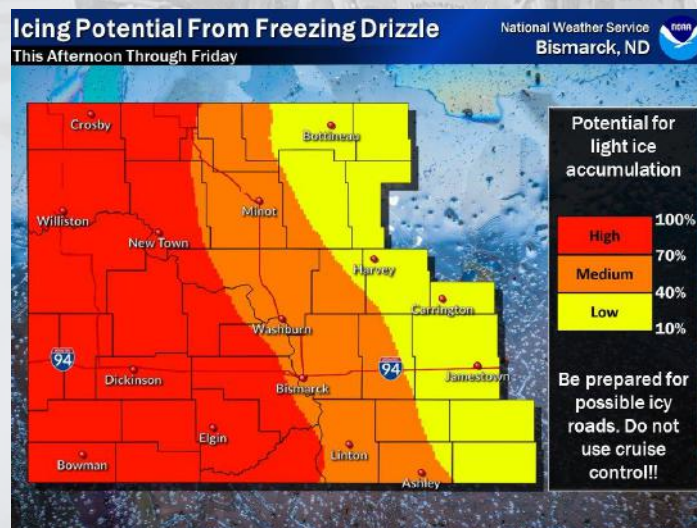
Risk probability graphics should overall be kept simple,
but some brief, additional text should be added



Heat map question results – shows that some people find the text on the graphic important and helpful (see full thesis for more analysis)



Using risk probability graphics to communicate other hazards, such as for icing/freezing rain potential, was also shown to be something that NWS meteorologists would want to do.

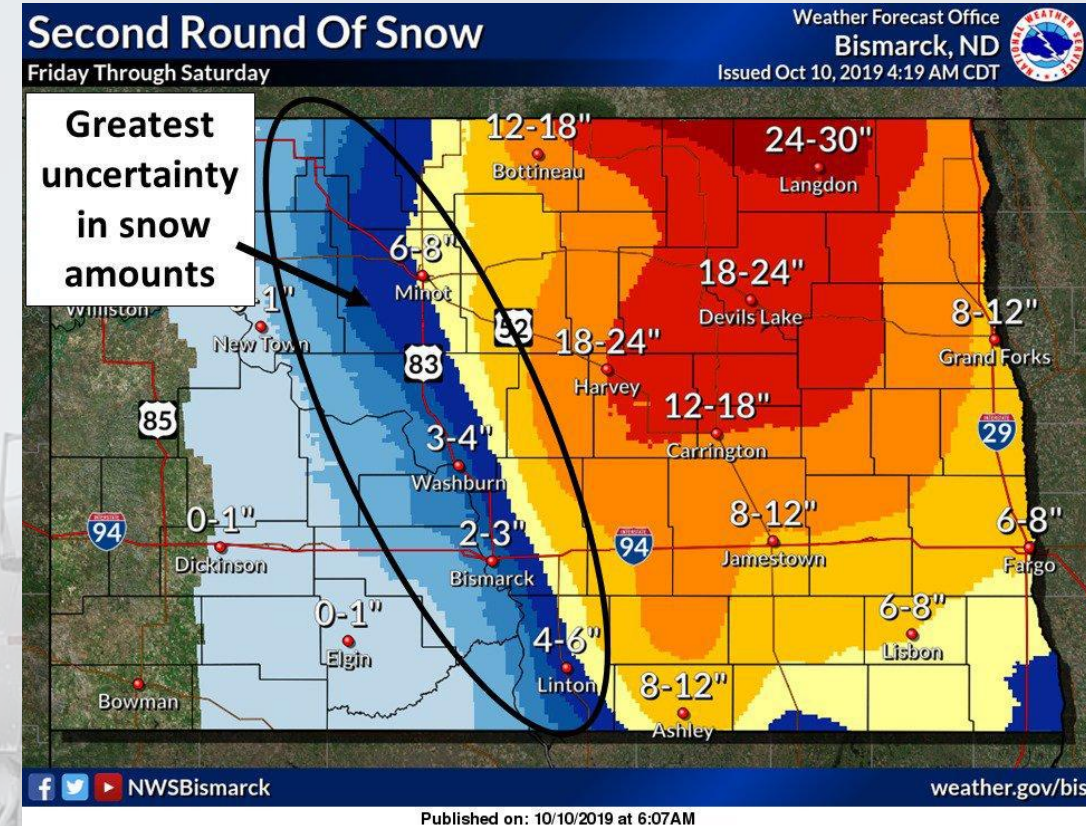


SNOW MAPS: Circling areas of uncertainty

Key Takeaway #8

Circling areas of uncertainty on snowfall forecast maps was liked by all and should be done by NWS offices and others in the weather enterprise when it is necessary.

Overall majority would check back for forecast updates if they lived in the circled area of uncertainty to see if anything had changed.



Since I live in the circled area, I need to check the forecast again before the storm starts to see if anything has changed



Since I live in the circled area, I need to prepare for higher snowfall amounts in case the forecast changes



Since I live in the circled area, my actions do not change



I do not understand what the circled area means



Other



SNOW MAPS: Circling areas of uncertainty

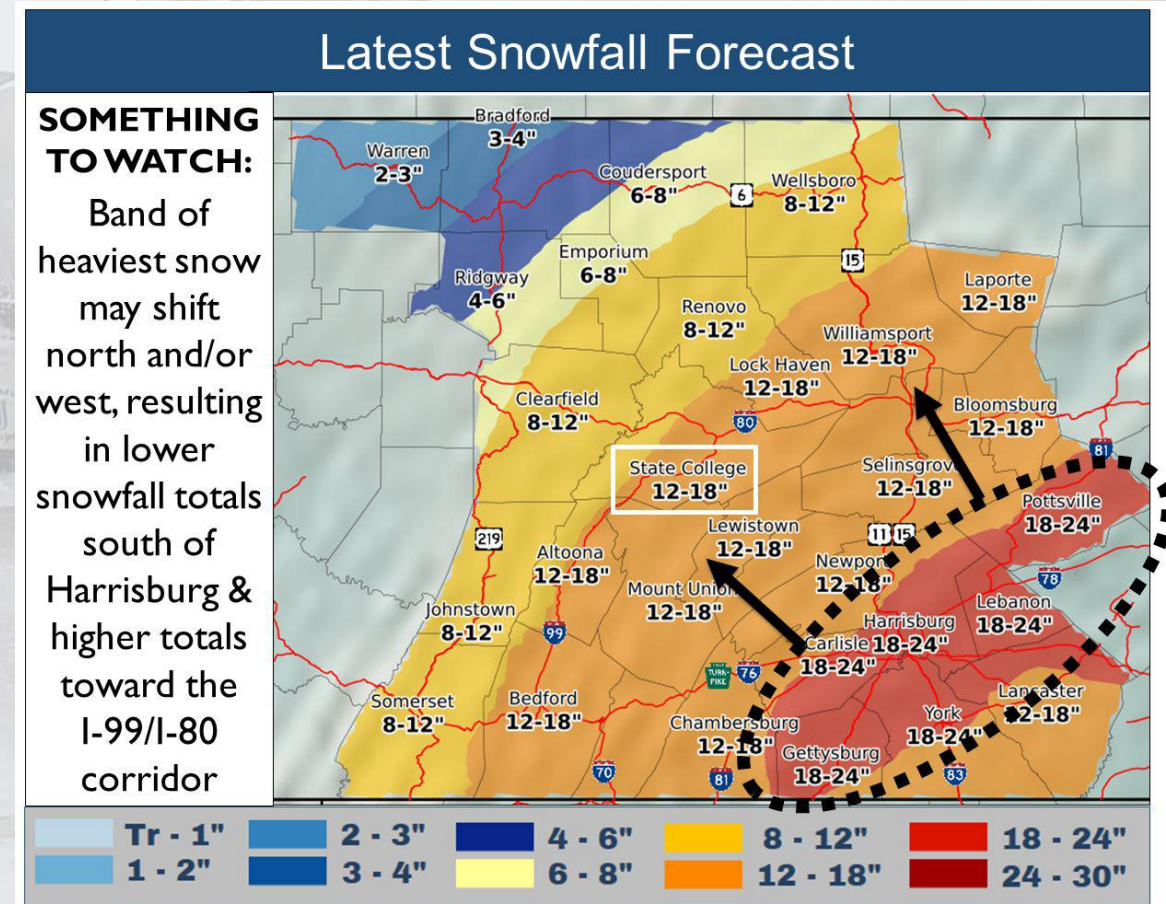
Results were consistent with NWS non-meteorologists that were surveyed ↓

Q27 – How Do You Interpret Circled Area of Uncertainty on Snow Maps If You Live Within It (select all that apply)	Check the forecast again before the storm starts to see if anything has changed	Prepare for higher snowfall amounts in case the forecast changes	Actions do not change compared to if I lived in an area that was not circled	I do not understand what the circled area means
	22	16	2	1

The word “uncertainty” should be used when describing this circled area and adding a brief statement on the graphic as to why the uncertainty exists or where the band of heaviest snow might shift was shown to be preferred.

Greatest uncertainty in snow amounts ✓

Tight gradient for snowfall amounts ✗

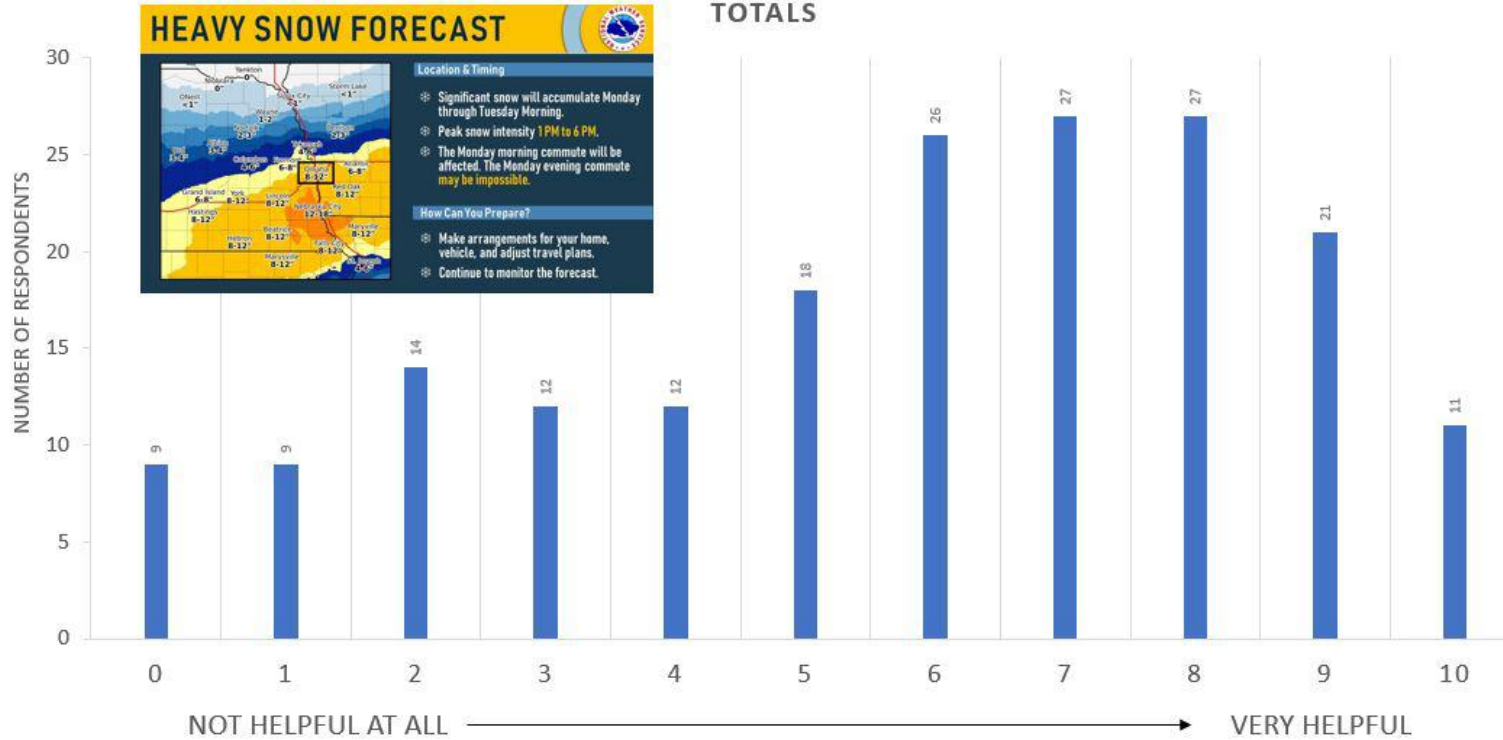


SNOW MAPS: Circling areas of uncertainty

Suppose you live in Omaha (in the black box on the graphic above). Did the circled area of uncertainty on the previous graphic help you anticipate the increased snow totals predicted for Omaha on this updated map?



NWS OMAHA SNOW MAP UPDATE: WAS CIRCLED AREA OF UNCERTAINTY ON PREVIOUS SNOW MAP HELPFUL FOR ANTICIPATING THE INCREASED SNOWFALL TOTALS



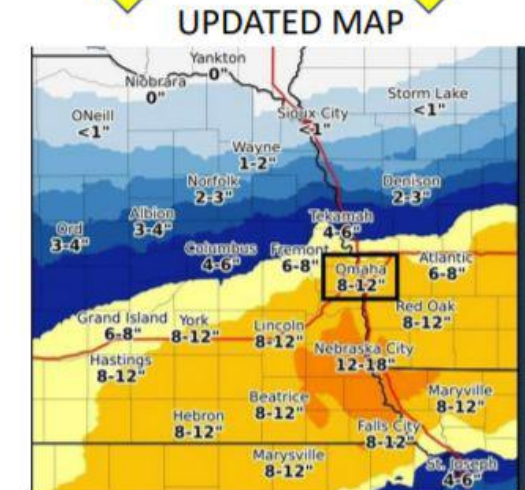
HEAVY SNOW FORECAST

Location & Timing

- Significant snow will accumulate Monday through Tuesday Morning.
- Peak snow intensity 1 PM to 6 PM.
- The Monday morning commute will be affected. The Monday evening commute may be impossible.

How Can You Prepare?

- Make arrangements for your home, vehicle, and adjust travel plans.
- Continue to monitor the forecast.

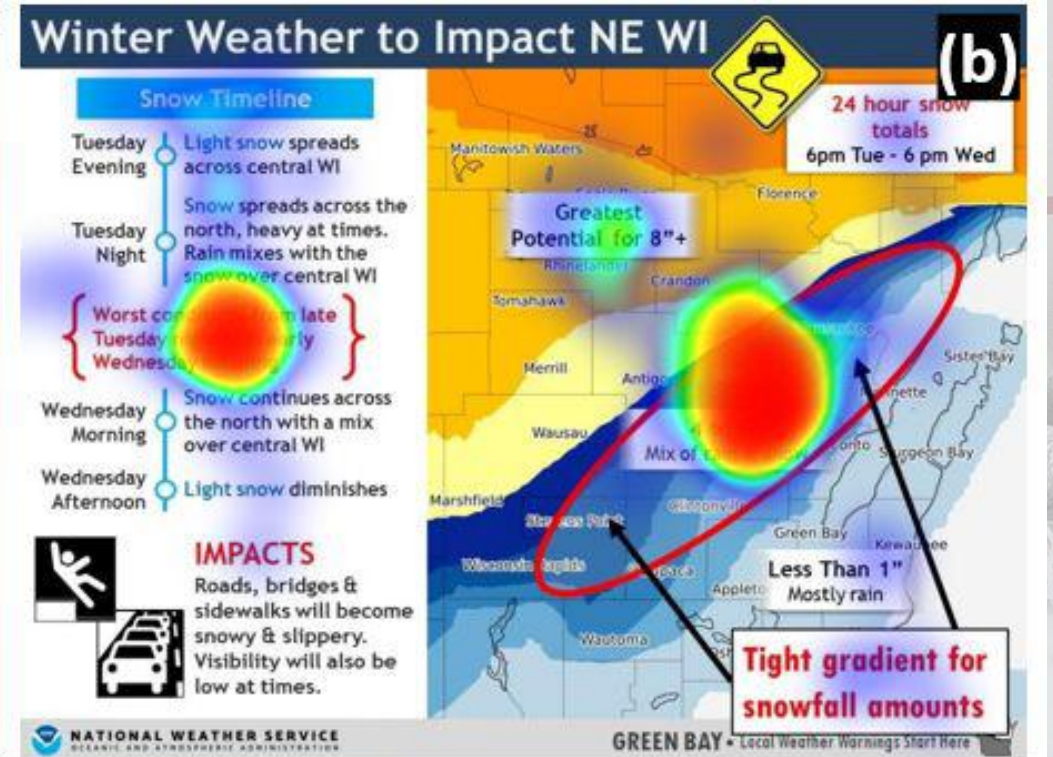
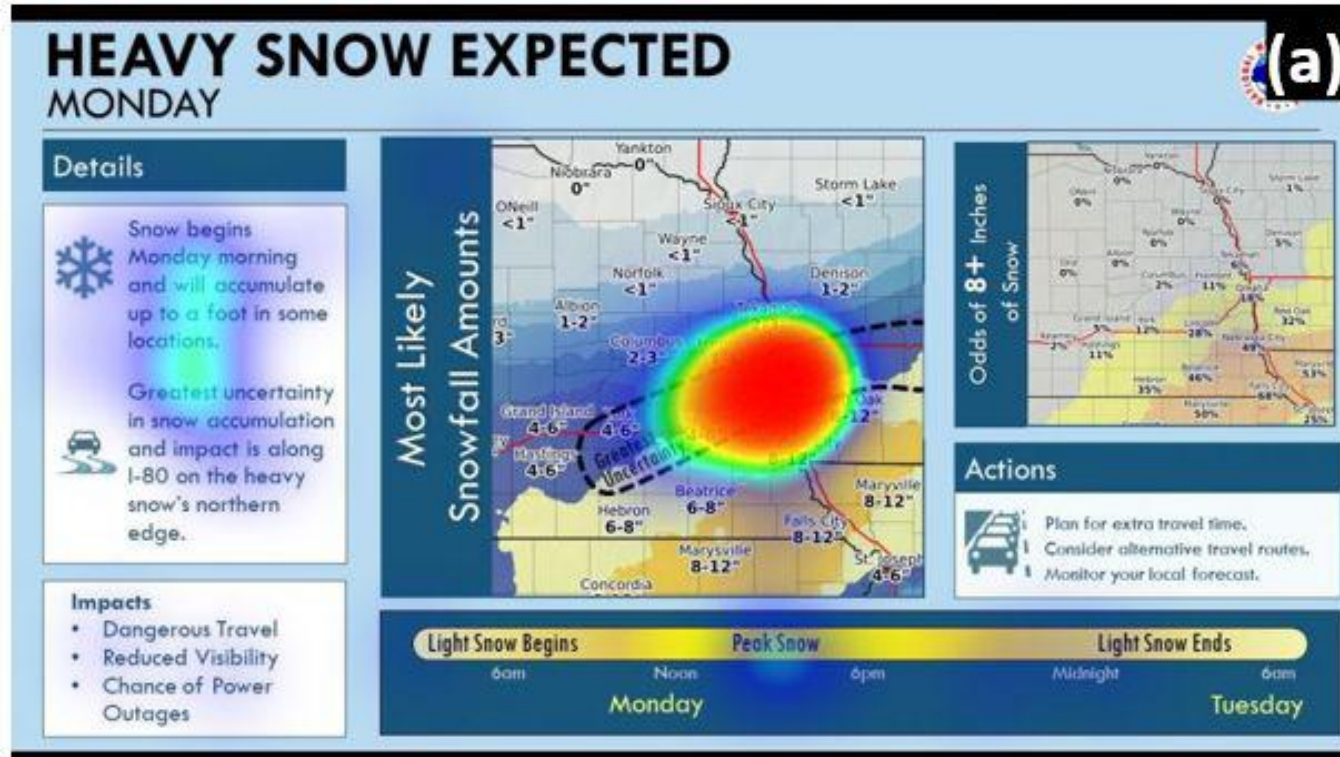


Two days before storm

One day before storm

SNOW MAPS: Circling areas of uncertainty

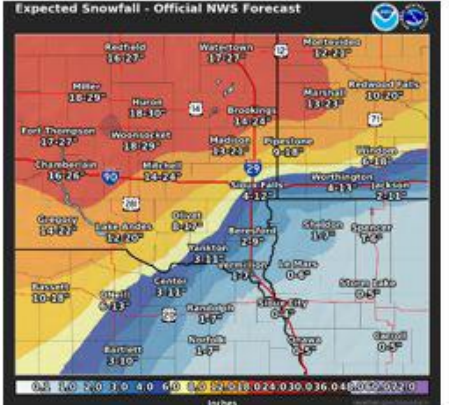
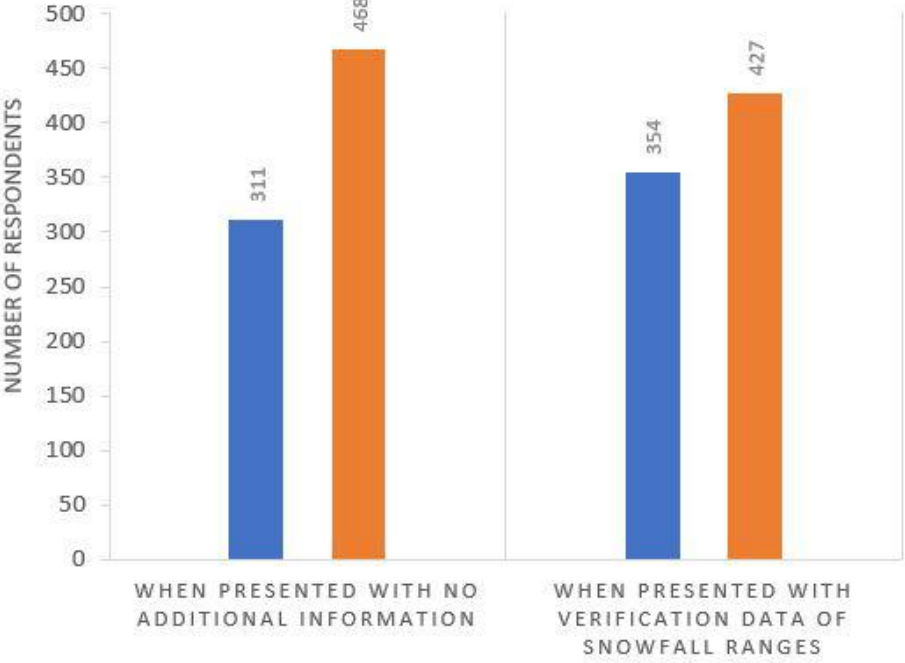
More heat map question results – because they're super cool :)



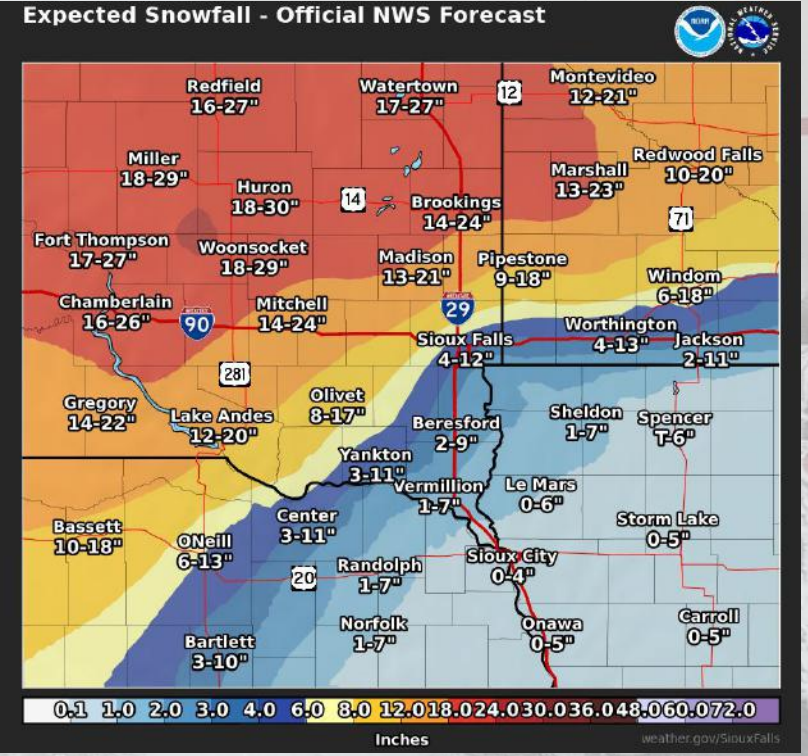
Probabilistic snowfall ranges are a viable alternative to the standard NWS color table snowfall ranges.

But very large ranges can be created, so **use caution** when choosing what snowfall range option to use.

SNOWFALL RANGE TYPE PREFERENCE FOR SNOW MAPS OF RESPONDENTS TO THE SURVEY OF MEMBERS OF THE U.S. PUBLIC



- 25th-75th percentile probabilistic snowfall ranges map (larger ranges) ▲
- NWS color table snowfall ranges map (smaller ranges) ▼



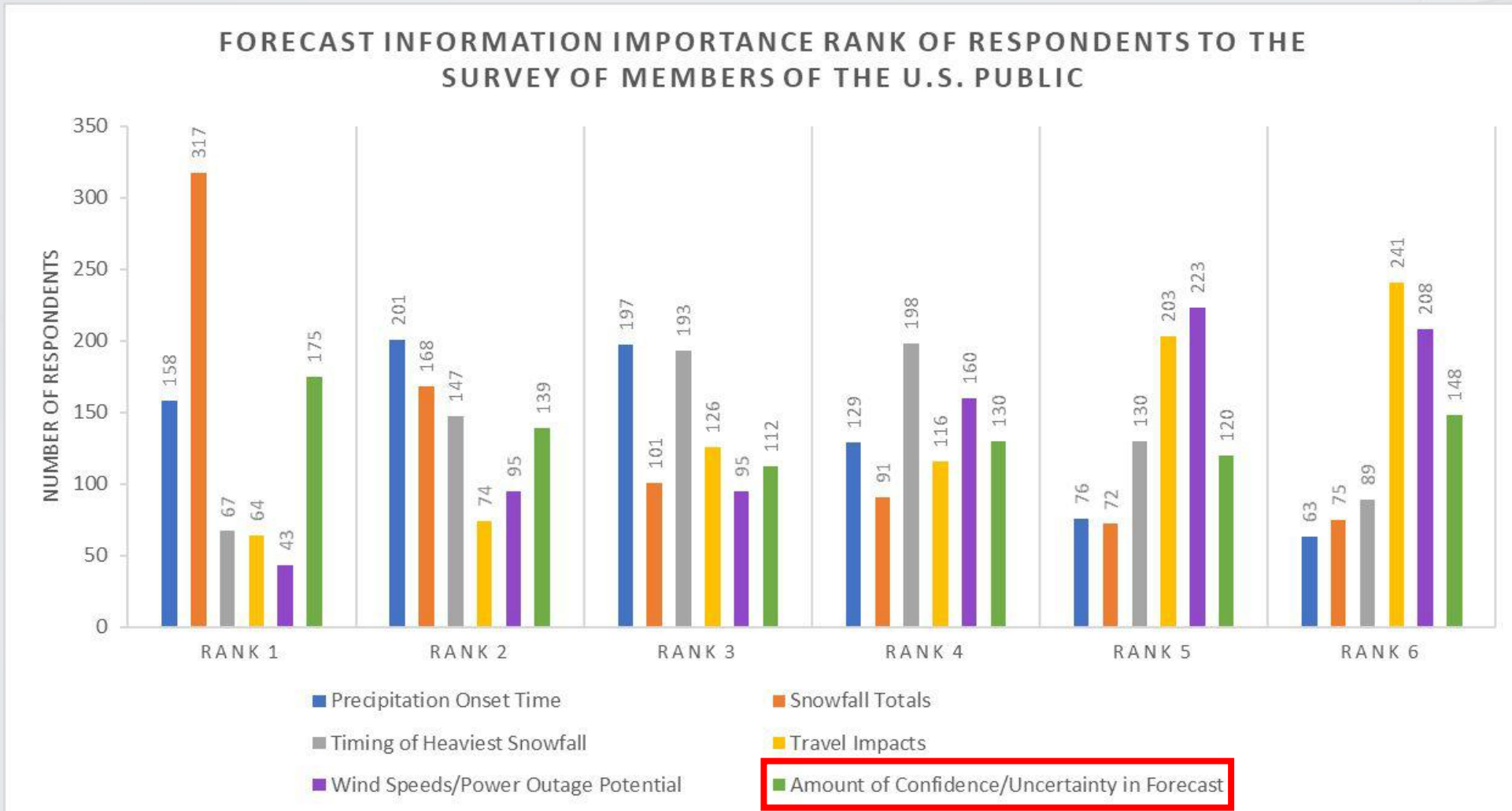
Verification stats from Phil Schumacher (SOO Sioux Falls):

Studies have shown that using the **larger snowfall ranges** results in the actual snowfall amount verifying within that range **50% of the time**. The **smaller snowfall ranges** result in the actual snowfall amount verifying within that range **30% of the time**.

NOTE: an extreme example of snowfall spreads was selected for the probabilistic snowfall map used in this question.

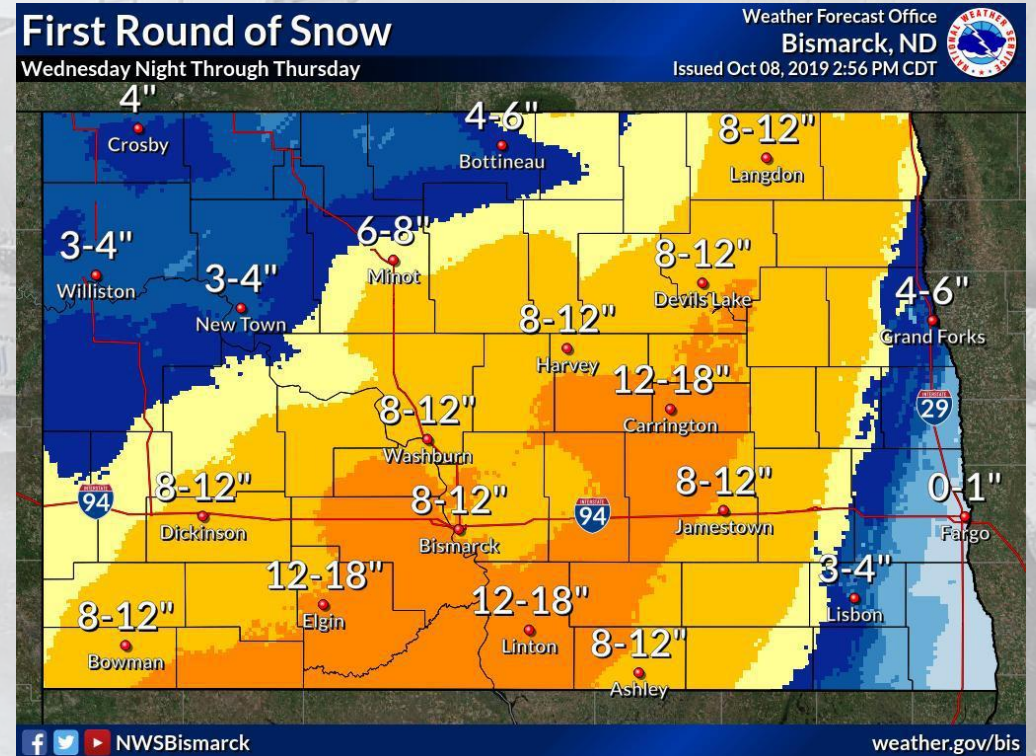
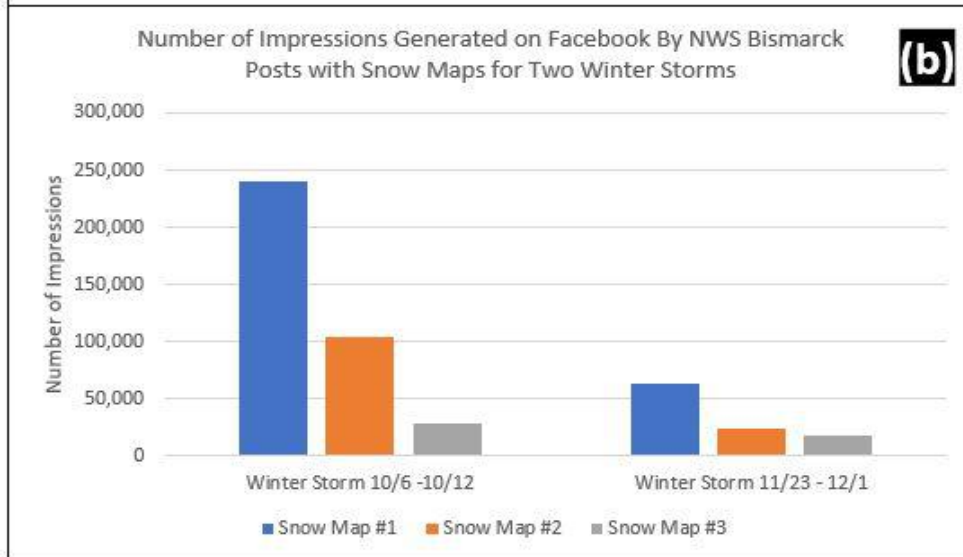
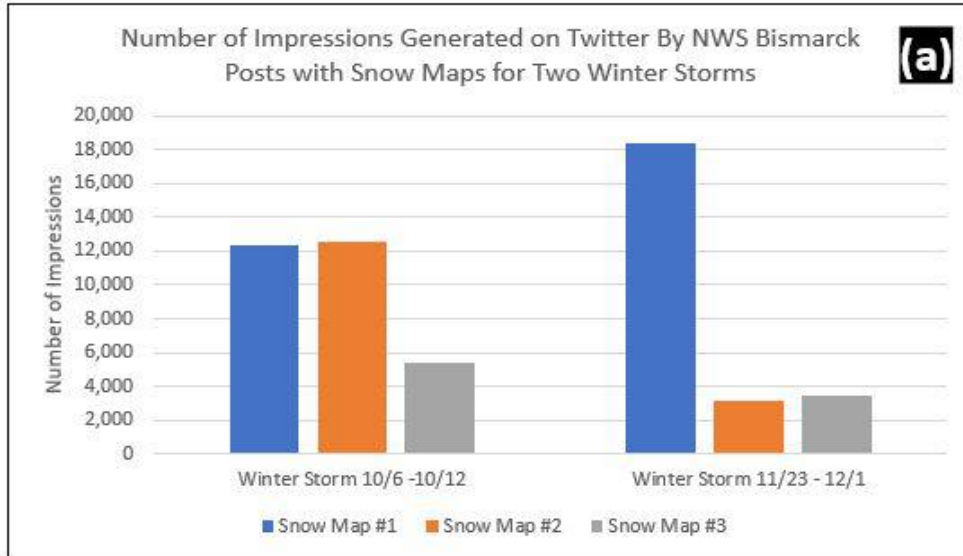
Key Takeaway #10

Members of the public want to see information about how confident or uncertain a forecast is.



Bonus Takeaway!

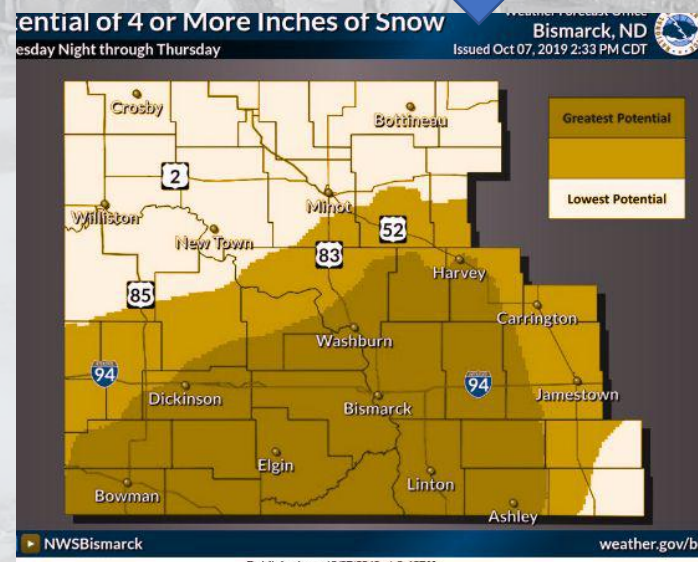
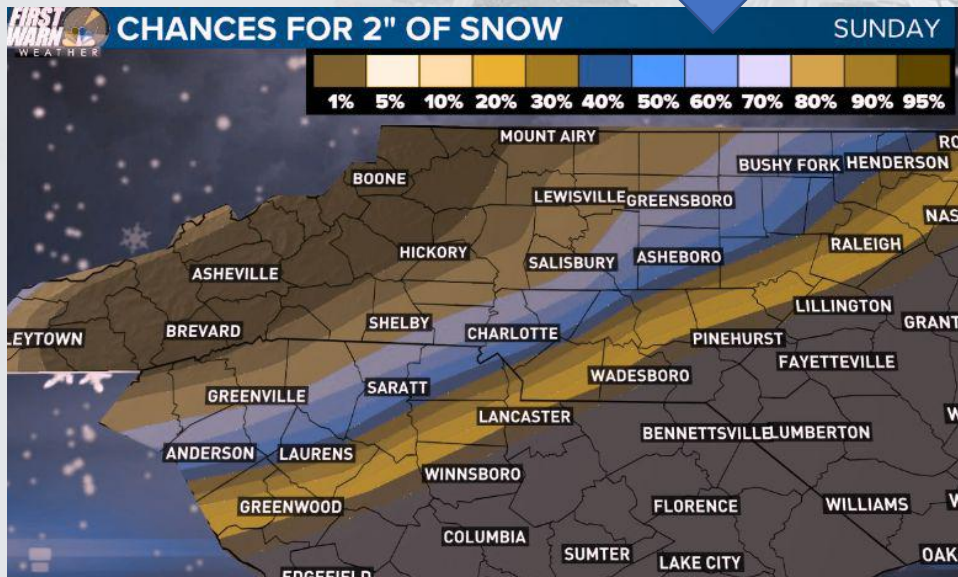
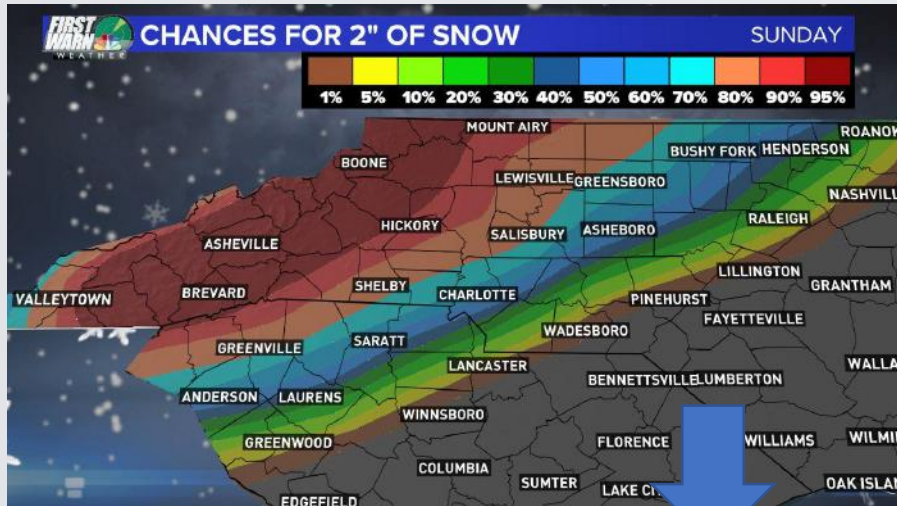
Very preliminary social media research:
 When looking just at snow maps, the first iteration that's posted gets more impressions than the subsequent ones



Another Bonus Takeaway!

What about those that are color blind?

<https://www.color-blindness.com/coblis-color-blindness-simulator/>
Green-Blind/Deuteranopia lens



jacobmorsewx.weebly.com/research

**METEOROLOGIST
JACOB MORSE**

ABOUT ME | VIDEOS | **RESEARCH** | WX LINKS | GRAPHICS | PHOTOGRAPHY | COURSEWORK

NOAA HOLLINGS SCHOLARSHIP RESEARCH ABOUT EFFECTIVE MESSAGING FOR WINTER STORMS

FULL HONORS THESIS
[CLICK HERE TO DOWNLOAD PDF](#)

10 KEY TAKEAWAYS
[CLICK HERE TO DOWNLOAD PDF](#)

SURVEY RESULTS
[CLICK HERE TO DOWNLOAD PDF](#)

NWA 2021 PRESENTATION
[CLICK HERE TO DOWNLOAD PDF](#)

TAKE-HOME MESSAGE: We need to be more comfortable talking about uncertainty and probabilistic information. People want to hear about this and find it helpful for decision-making.

Messaging for partners can/should be different than messaging for the public, but my research supports that **probabilistic information** is helpful for **the public when communicated correctly**

THANK YOU!

Reach out to me with questions:

Twitter: [@JacobMorseWX](https://twitter.com/JacobMorseWX)

Email: jmorse879@gmail.com