Evaluating The Usefulness and Response to Graphical Information Used to Communicate Uncertainty-Driven and Probabilistic Winter Weather Forecasts

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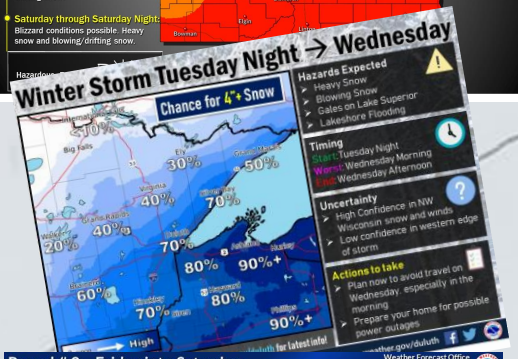
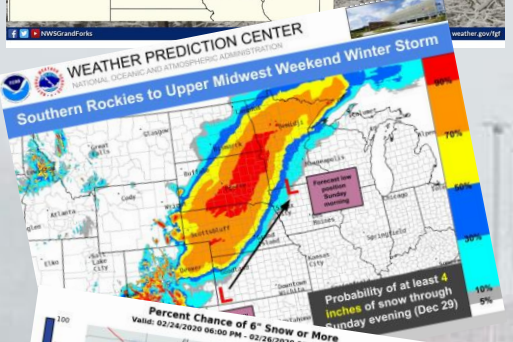
Penn State Schreyer Honors College Thesis

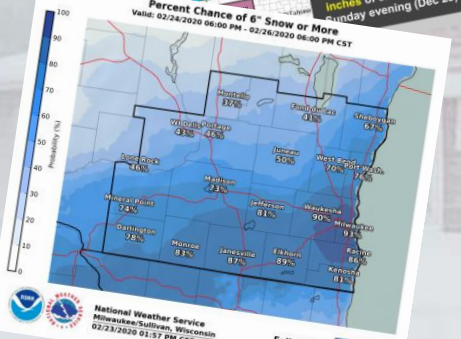
10 Key Takeaways & Practical Recommendations for the Weather Enterprise

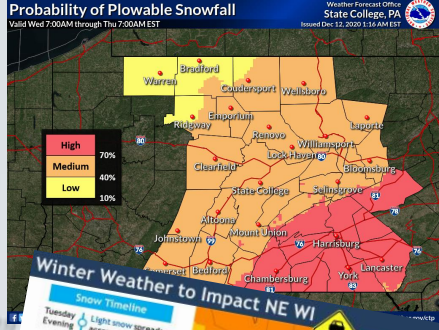
Implementing these recommendations will help to achieve a more consistent way of communicating uncertainty-driven and probabilistic information in future winter storms that end users will find to be easily understandable and useful for their decision-making

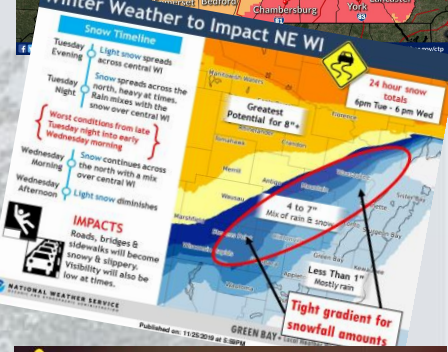
See thesis for full details on this research project and its findings

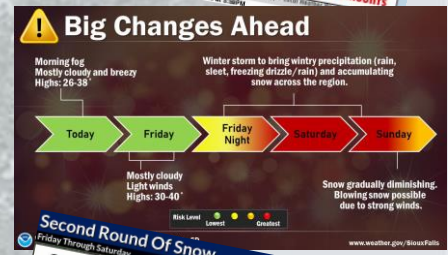








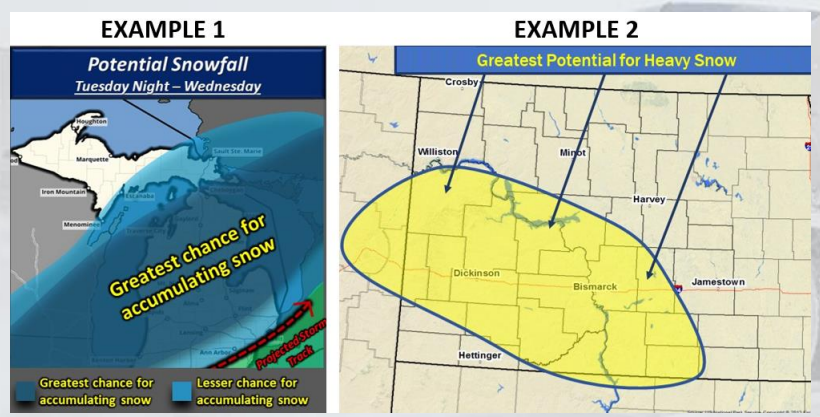




Key Takeaway #1

Map-based graphics are the preferred option for communicating predictions of winter storms in the **longer-range, three to seven days before a winter storm**. The two preferred map-based graphic styles were (1) circling one or more areas on a map for snow potential and (2) using the track of the storm to communicate the timing and impact area.

(1)



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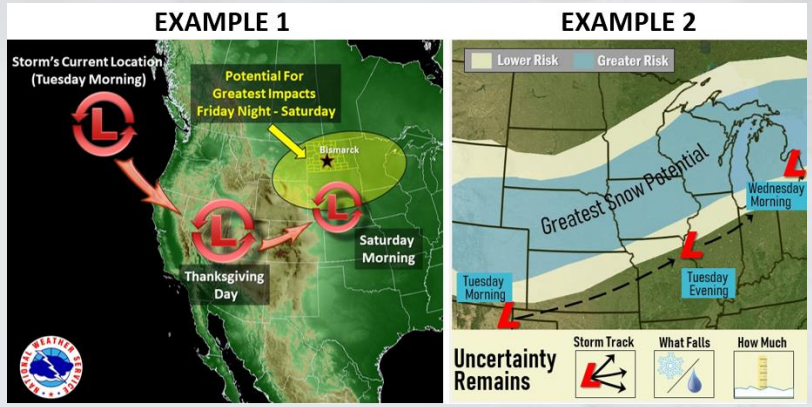
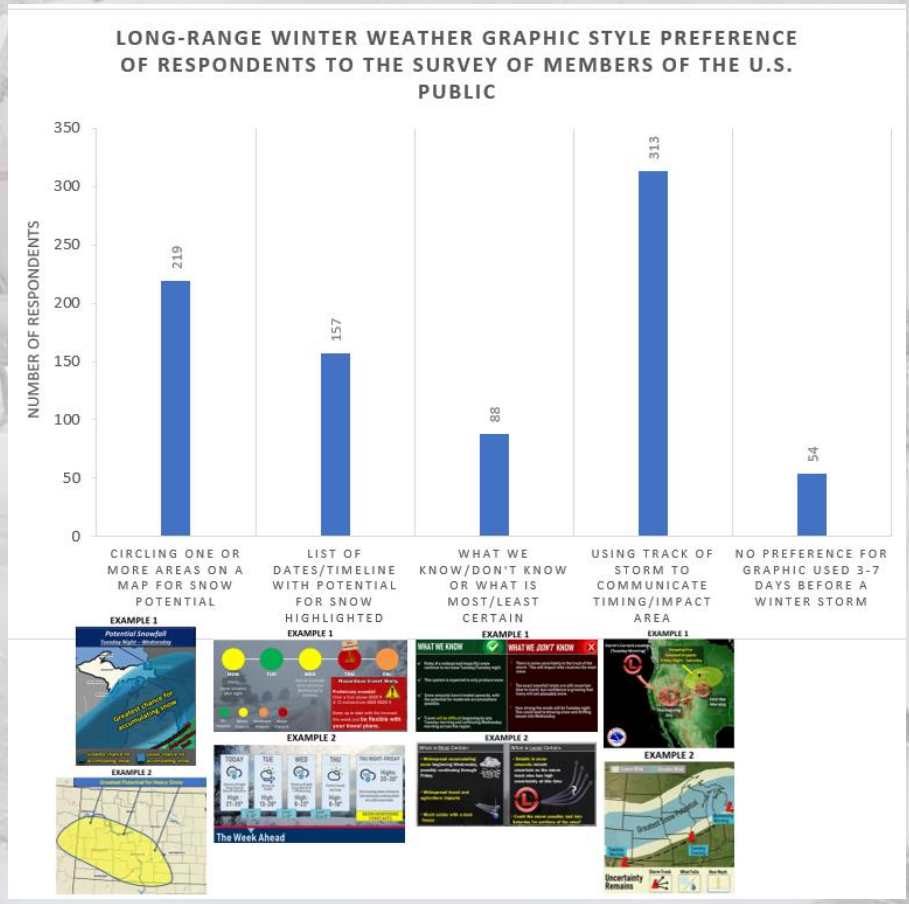
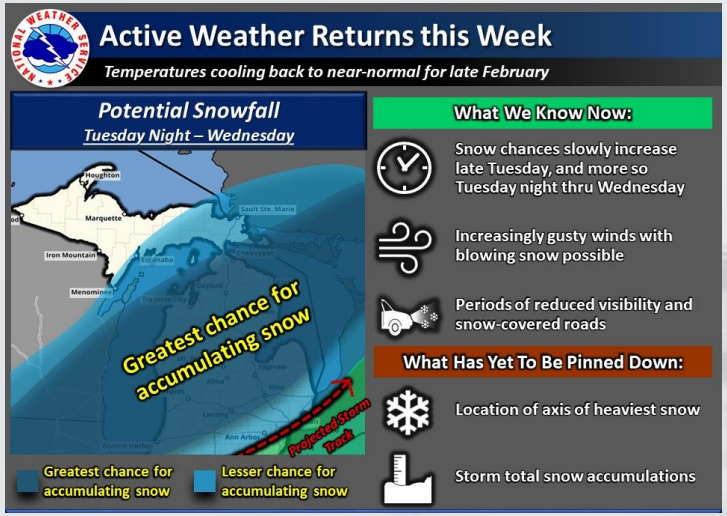


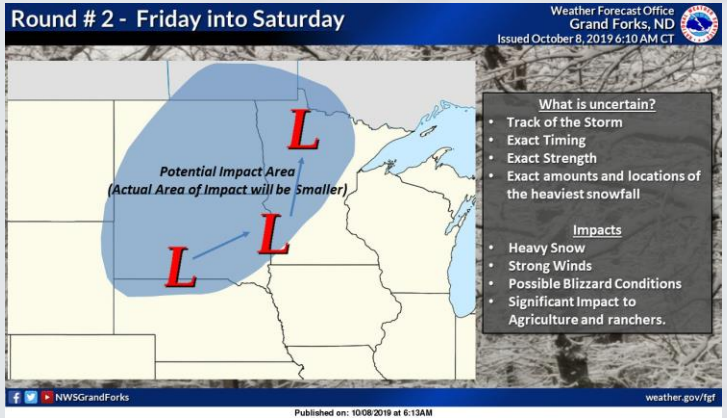
These were the two most preferred options among the 831 respondents to this question from the survey of the U.S. public as well as among the 32 non-meteorologist who work at NWS offices in the Central Region that were surveyed. Additionally, the graphic style where one or more areas on a map is circled for snow potential was the most preferred among the 40 NWS meteorologists who work in the NWS Central Region that were surveyed.



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.



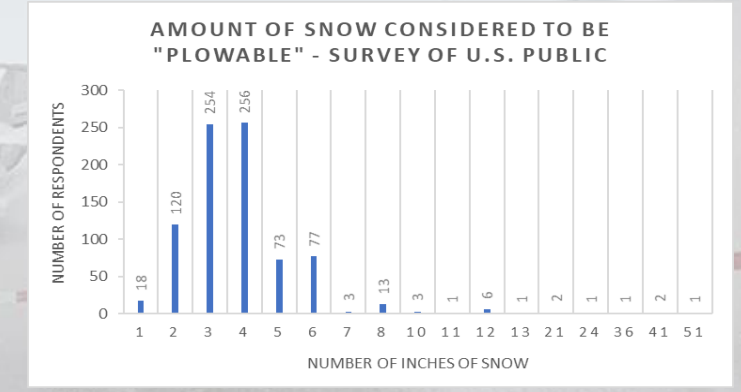


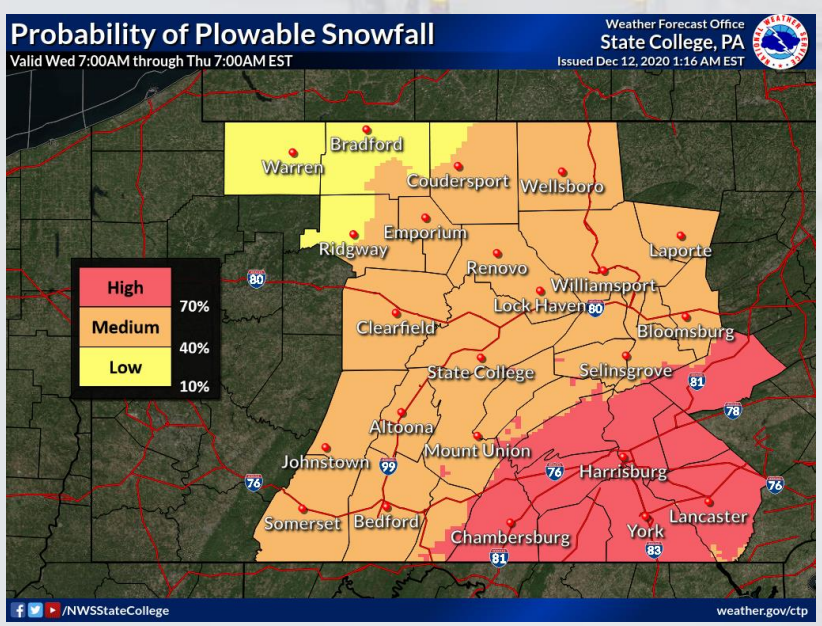
Elements of long-range winter weather graphics found to be helpful and important to respondents of the survey of the U.S. public.

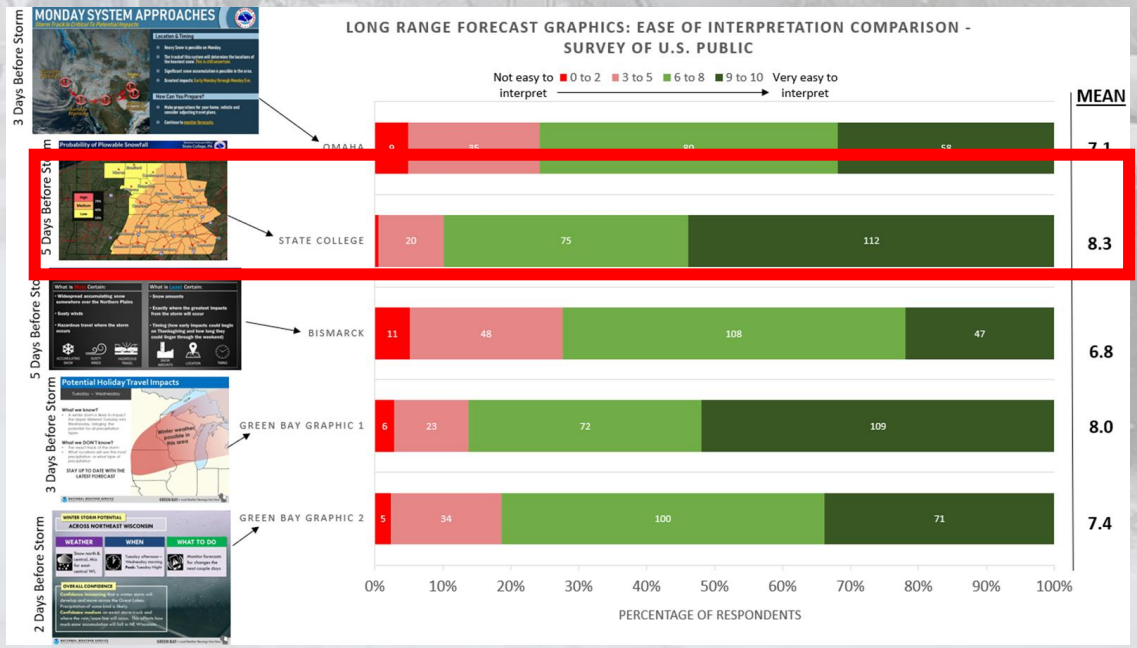
Key Takeaway #3

NWS State College's **probability of plowable snowfall graphic** was identified as ***easy to interpret and useful to the public at long lead times, such as five days before a winter storm.*** This graphic can be easily used by NWS offices across the country, creating a **more consistent message**, and would allow WPC's probability of exceeding 0.25 inches 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.

Past studies have also suggested that people understand basic probability information about forecasts when presented with a map, which agrees with the results from this part of the research project (Wu et. al 2014). ***Careful word choice must be used for the title of these graphics***, as the public infers "plowable" snowfall to mean three or four inches while "impactful" snowfall is usually interpreted as four to six inches of snowfall.



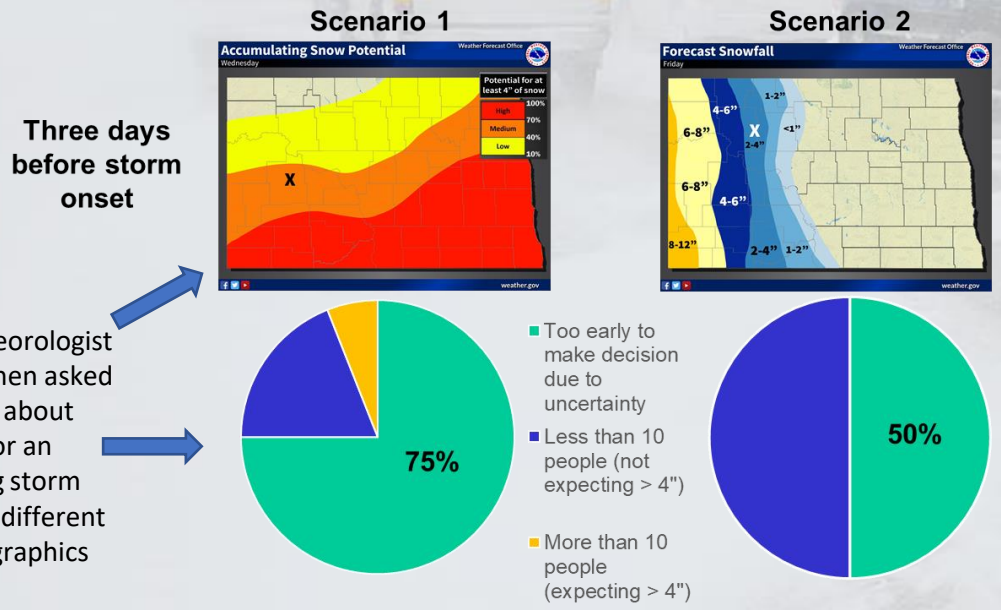


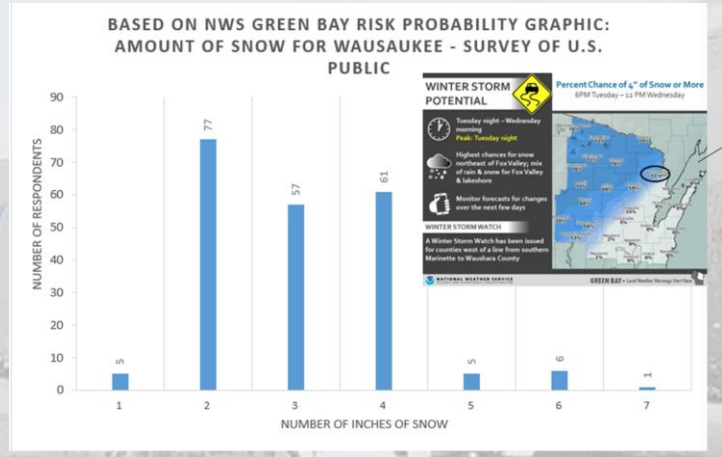


Key Takeaway #4

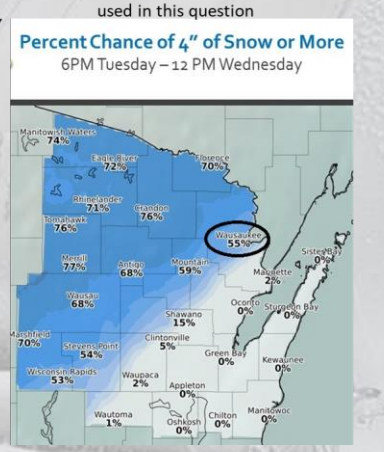
Risk probability graphics were understandable by non-meteorologists who work at NWS offices when using them to make decisions. However, the way the public interpreted the risk probability graphics when trying to determine how much snow a city on the risk probability map would receive ***might not have been the way these graphics are intended to be interpreted.*** People consistently thought that 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.**

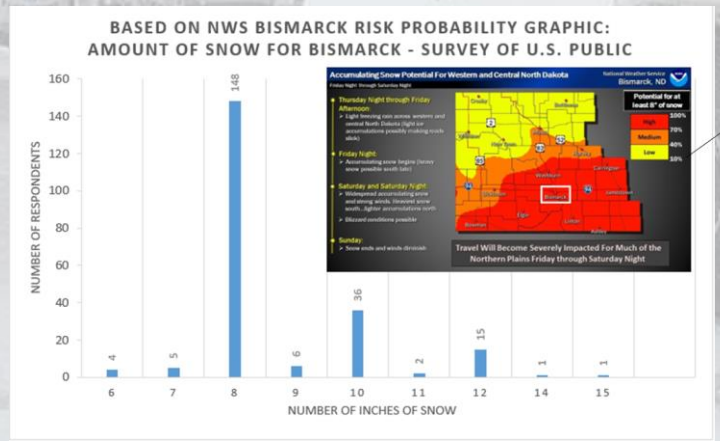
Future work should be done **investigating if the public can correctly interpret risk probability graphics** and if any of the color scheme options make proper interpretation easier for the public. Additionally, investigating if adding probability percentages at each location on the map helps or hurts people's interpretation of the graphics should be done.





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





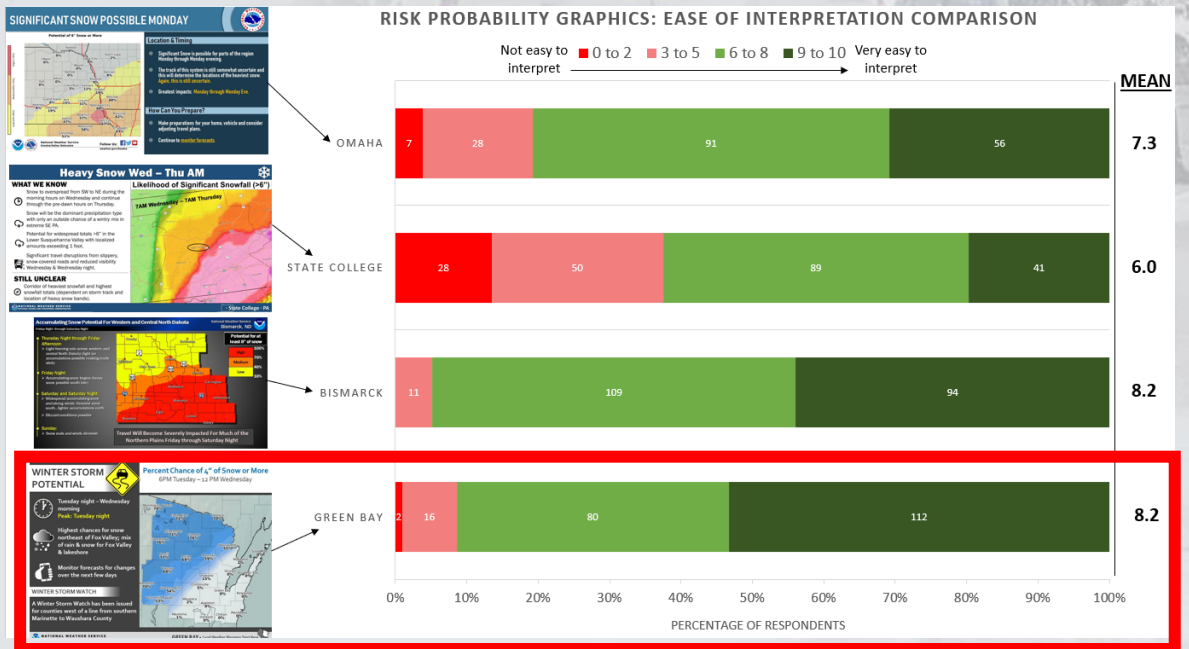
Zoomed in view of the risk probability map used in this question

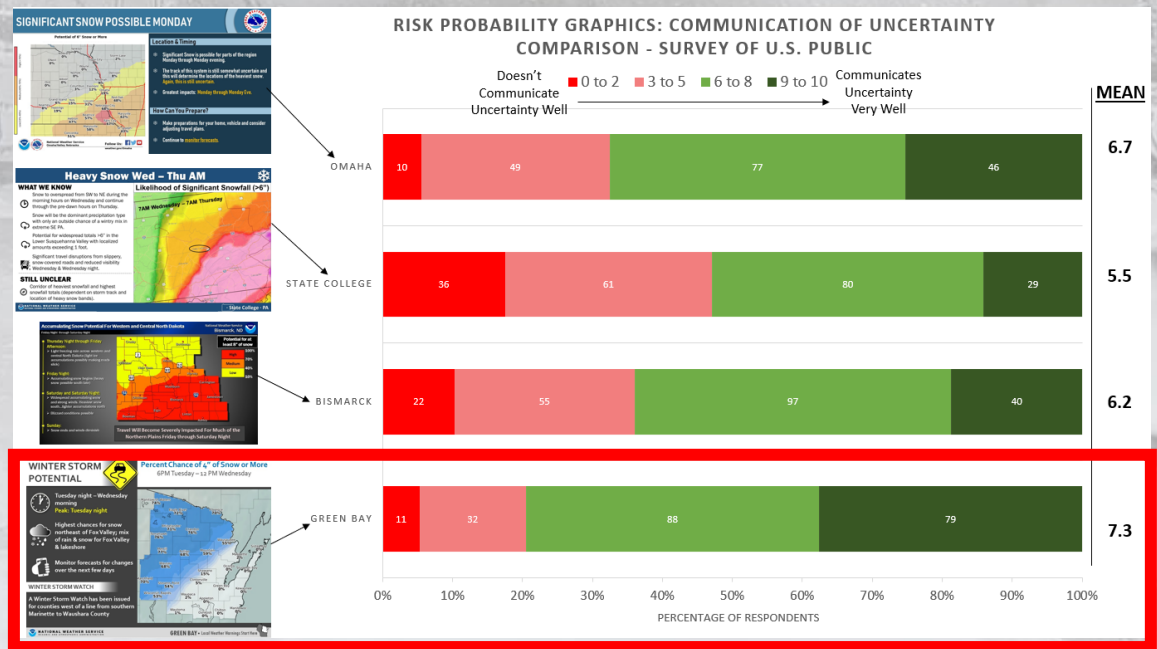
See more of these examples in the full thesis

Key Takeaway #5

The blue gradient color scheme with probability percentages plotted at each location was the most preferred risk probability color scheme based on the survey of the U.S. public. It was also the **easiest to interpret and the best communicator of the uncertainty present in the forecast** based on the survey of the U.S. public. This aligns with 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).

Some people found the probability percentages plotted at each location on this color scheme helpful for them to interpret the forecast. The second most preferred color scheme was blue/yellow/orange/red. 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.*** A legend should be included on all risk probability graphics, as without one, as shown by the NWS State College risk probability graphic used in the survey of the U.S. public, the graphic is harder to interpret and more open to interpretation.

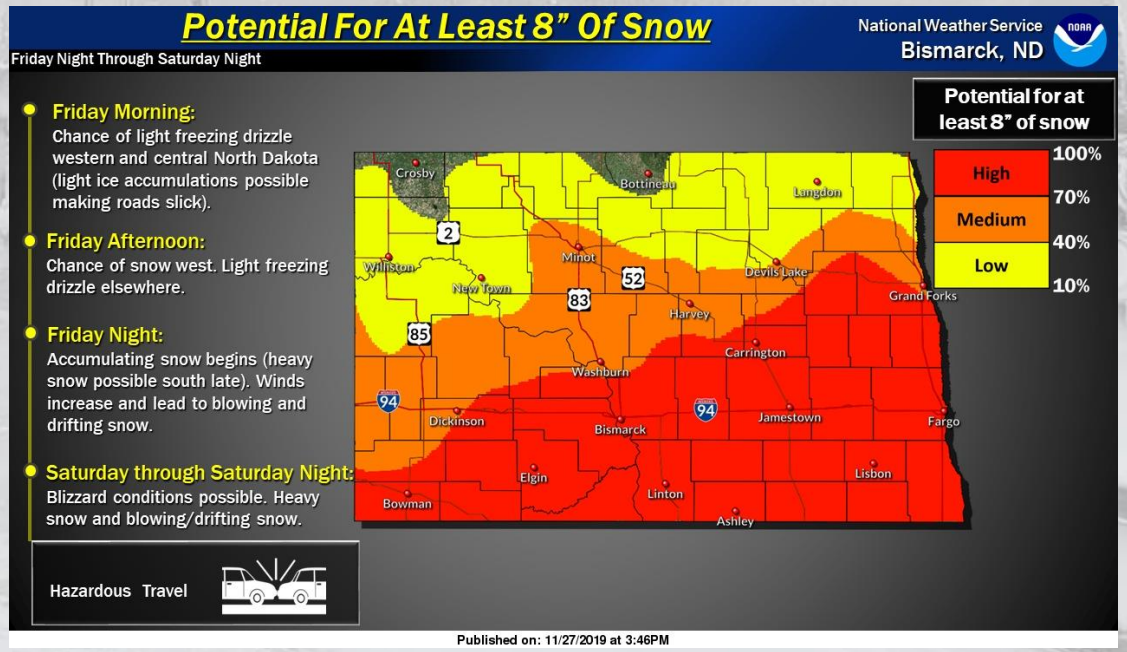




Key Takeaway #6

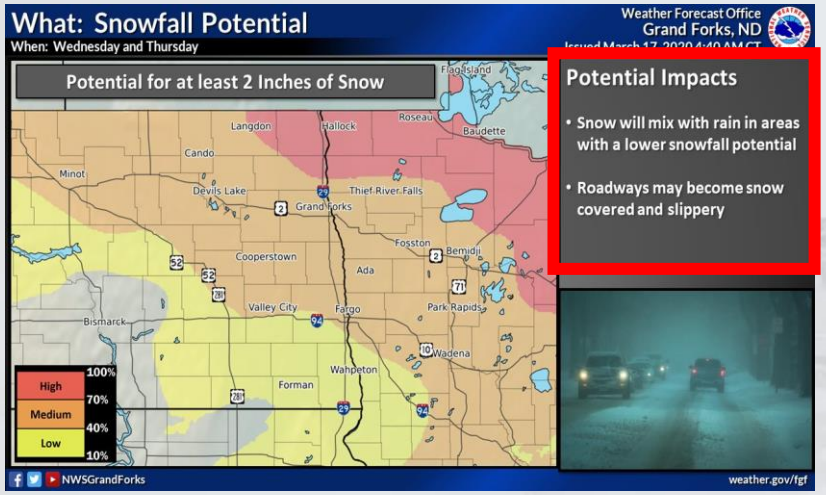
The ***red/orange/yellow color scheme for risk probability graphics*** was the preferred option for meteorologists that were surveyed in the **Central Region** along with broadcast meteorologists and emergency managers in **North Dakota**. This is most likely due to their ***familiarity with this color scheme*** for the risk probability graphics. It would be a transition for these people to prefer the blue gradient color scheme for risk probability graphics, if this color scheme were to be adopted more universally across the NWS.

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**

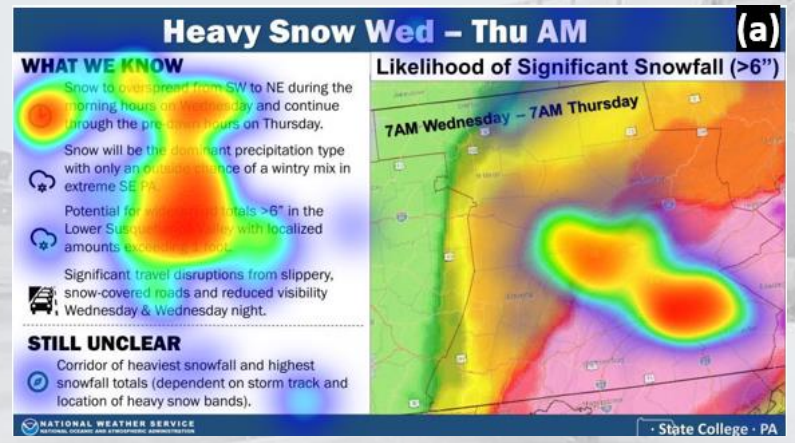


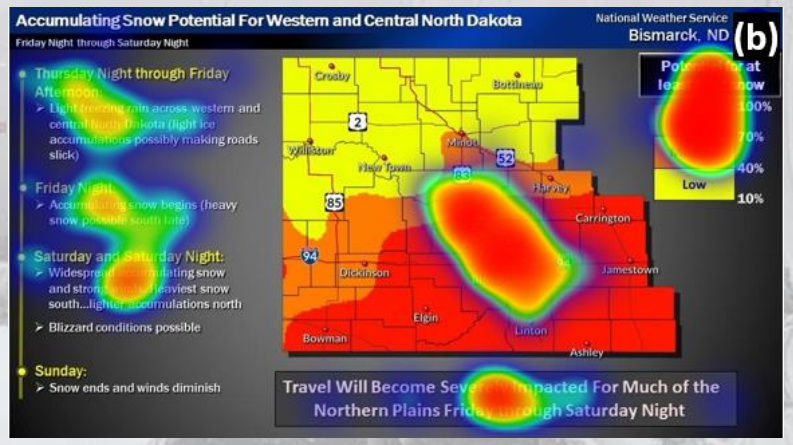
Key Takeaway #7

Risk probability graphics should overall be kept simple, but some **brief, additional text should be added** to the graphics such as timing information, potential impacts of the winter storm, or statements about "what is known" about the winter storm.



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





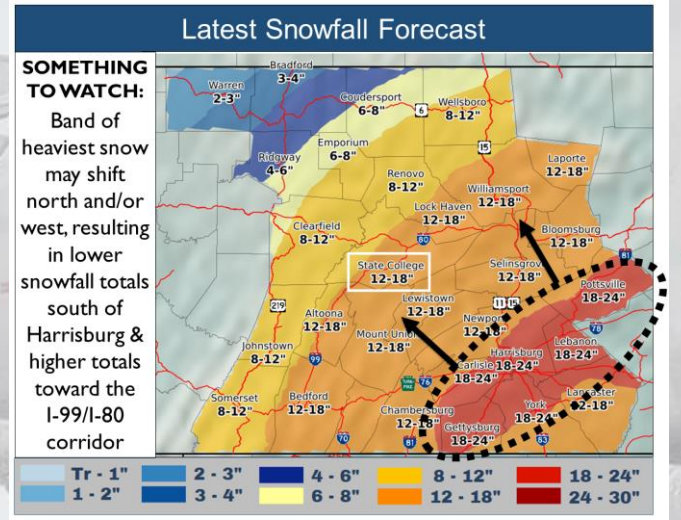
Using risk probability graphics to communicate other hazards, such as for icing/freezing rain potential, was also shown to be something that NWS meteorologists in the Central Region would want to do.

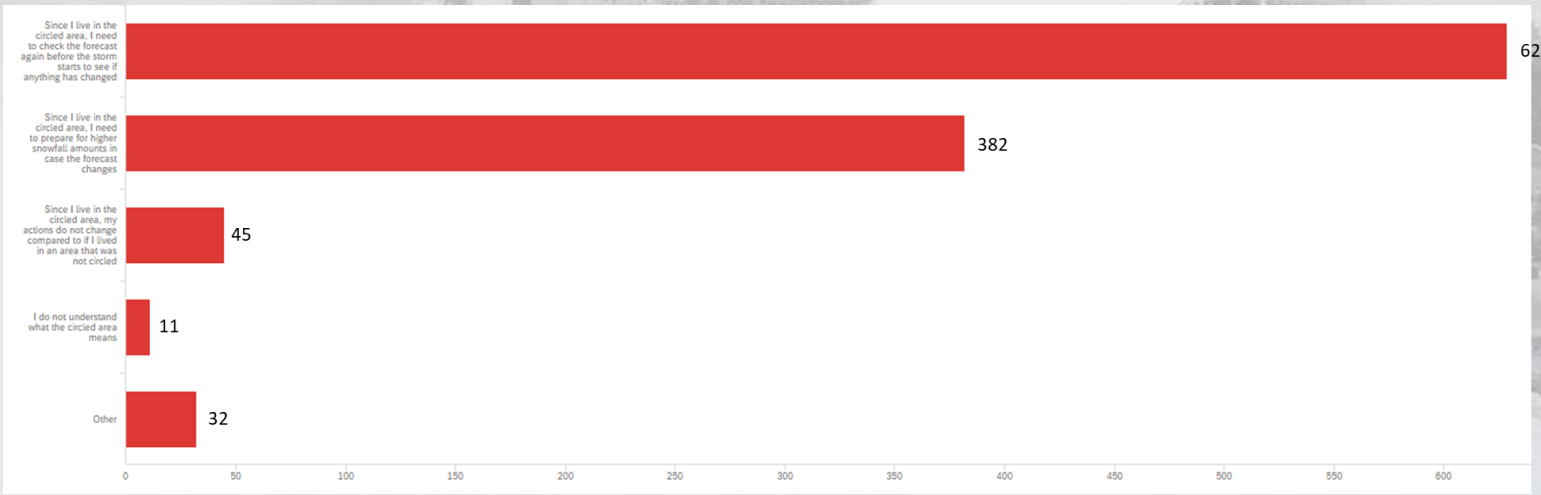
Q9 – Utilizing Risk Probability Graphics to Communicate Other Hazards (can select multiple)	Blowing/ Drifting Snow	Icing/ Freezing Rain Potential	Travel Impacts	Wind Gusts	Wind Chill
	24	**34**	**27**	**15**	**20**

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. 68% of non-meteorologists who work in the NWS Central Region and 75% of the members of the public who were surveyed across the U.S. said that they would check back for forecast updates if they lived in the circled area of uncertainty to see if anything had changed. Additionally, 50% of non-meteorologists who work in the NWS Central Region and 46% of the members of the public that were surveyed said they would also prepare for higher snowfall amounts in case the forecast changes. Broadcast meteorologists and emergency managers in North Dakota also like the circled area of uncertainty, and the majority of meteorologists who work at NWS offices in the Central Region thought that users understand this circled area.

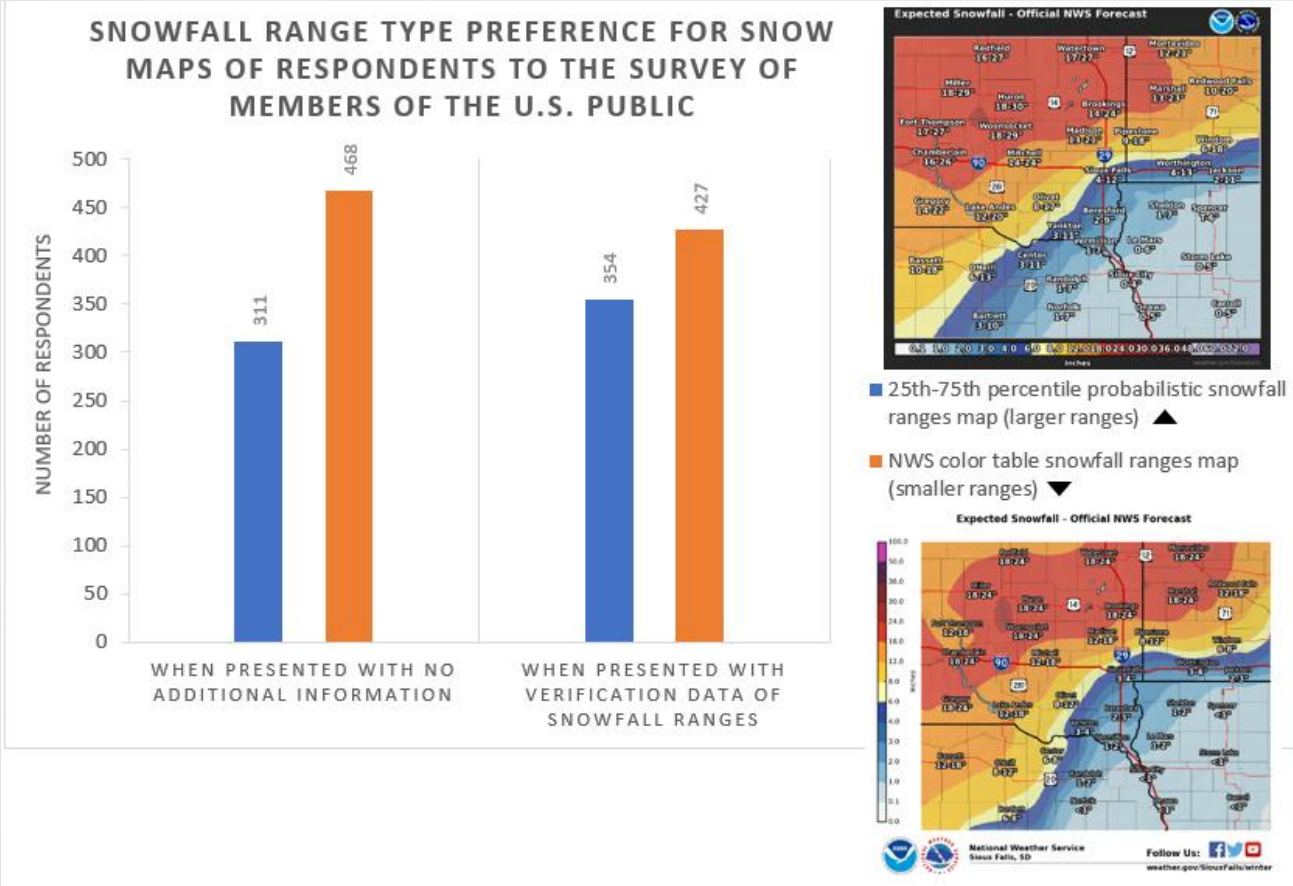
The word "uncertainty" should be used when describing this circled area and ***adding a brief statement on the graphic as to why the uncertainty exists or where the band of heaviest snow might shift was shown to be preferred.***





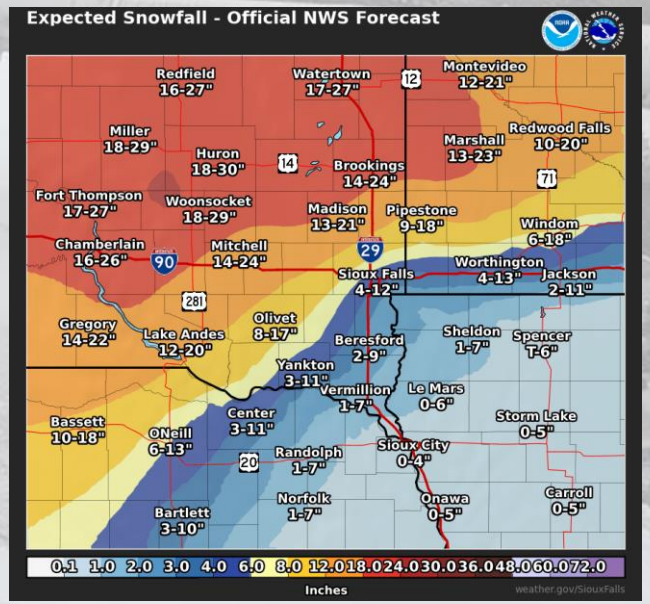
See full thesis for more charts and data that backs up this key takeaway

Key Takeaway #9



<u>Probabilistic snowfall ranges are a viable alternative</u> to the standard NWS color table snowfall ranges based on results from the survey of the U.S. public and the fact that they usually capture the spread of possible snowfall totals for a location better than the standard NWS color table snowfall ranges. However, **<u>snowfall ranges that are too large to be useable for the public and NWS core partners can be created by the 25th to 75th percentile probabilistic snowfall ranges</u>**, so NWS meteorologists ***<u>should be careful</u>*** when choosing what snowfall range option to use.

It should be noted that an extreme example of snowfall spreads was selected for the probabilistic snowfall map used in this question, with some snowfall ranges on the map spanning nine inches, such a 4-to-13-inch snowfall range for Worthington on the map



Key Takeaway #10

Members of the public ***want to see information about how confident or uncertain a forecast is during the winter***, as the second most respondents in the survey of the U.S. public selected the amount of confidence or uncertainty in the forecast as their most important piece of forecast information that they want to know about. Snowfall totals were clearly the primary choice, indicating that most people want to see these forecasted snow amounts when they are available, but at longer lead times, before snowfall totals can be formulated and released, ***relying on uncertainty-driven and probabilistic information is important.***