Communicating Winter Weather Using Uncertainty-Driven and Probabilistic Graphics

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NOAA Hollings Scholarship

Penn State Schreyer Honors College Thesis

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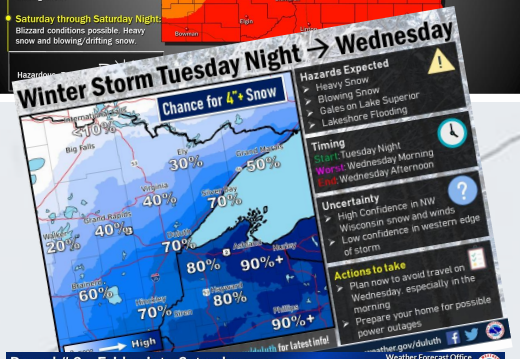
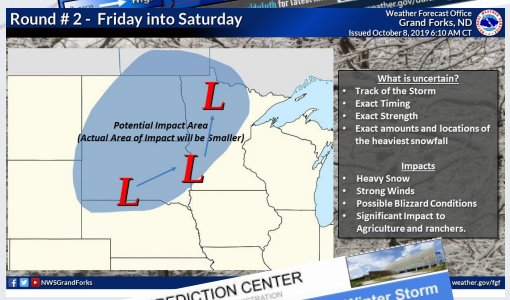
Penn State Meteorology Alumnus (‘21)

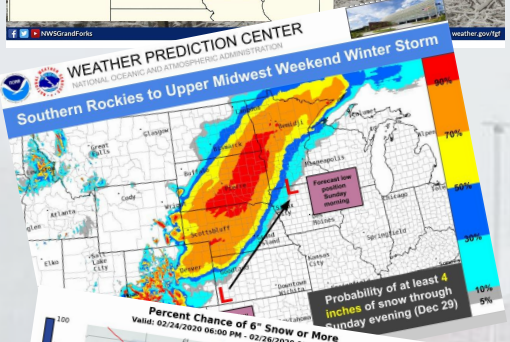
Research started at NWS Bismarck with Chauncy Schultz

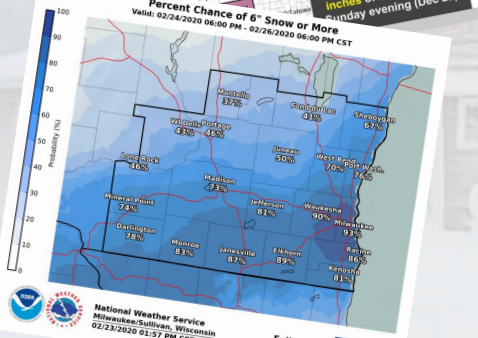
<u>See thesis for full details on this research project and its findings:</u>

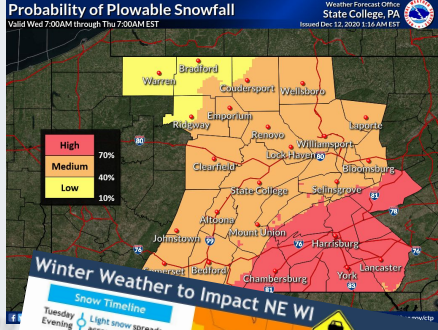
jacobmorsewx.weebly.com/research

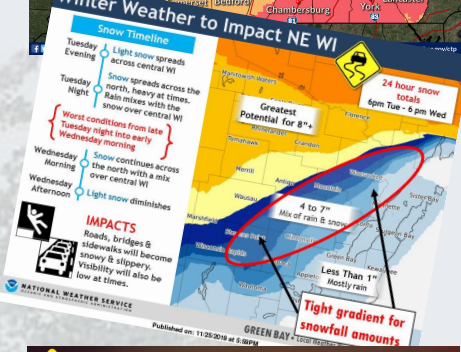


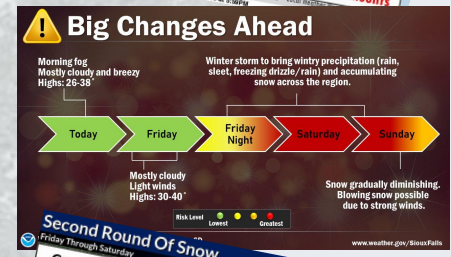


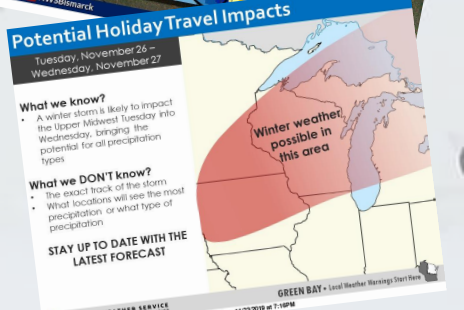












Probabilistic information can be helpful, even for the public *(past research)*

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. 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)
   - Categorical expressions are interpreted differently depending on the context.
   - Example: “Likely” can be interpreted as anywhere from 50% to 90%
   - **Threshold probabilities** are the **best** kind of uncertainty forecasts (ex.: 20% chance temp < 32°). Probability for **users threshold for action**.

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

Joe Ripberger
Andrew Bell
Carol Silva
Hank Jenkins-Smith

NATIONAL INSTITUTE for RISK and RESILIENCE
The UNIVERSITY of OKLAHOMA

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

A couple of their recommendations:

- Include **numeric translations** next to words/phrases that indicate probability information.
  - Example: Thunderstorms are possible *(30% chance)* this evening.

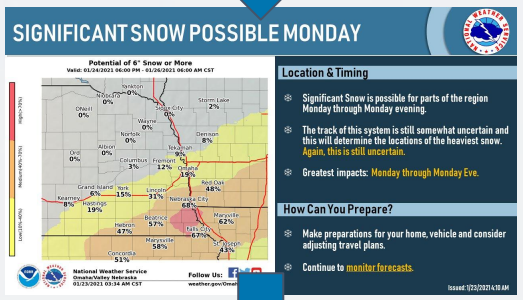
- Use **numeric point estimates** if available and appropriate. (Example: The forecast is rapidly evolving, but there is a *15% chance* that we will see *more than 10 inches of snow* in the metro area tomorrow morning.)
  - If they are not, use **numeric probability ranges or predictive intervals** to emphasize uncertainty. (Example: …there is a *50% chance* that we will see *6 to 14 inches of snow* in the metro area…)

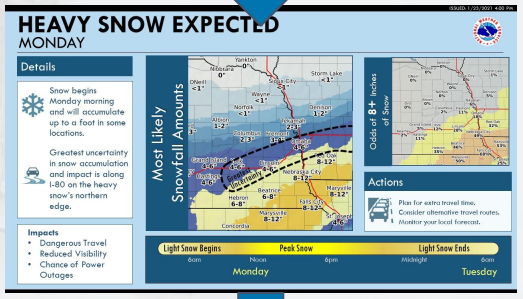
Lingering Qs: What about specifically for winter weather? What graphics are best for winter wx?

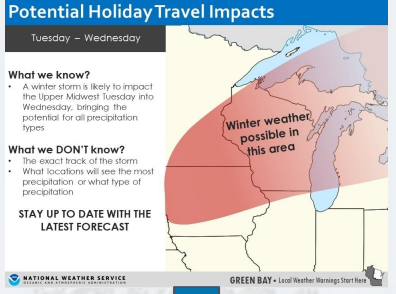
Received feedback through surveys and focus groups

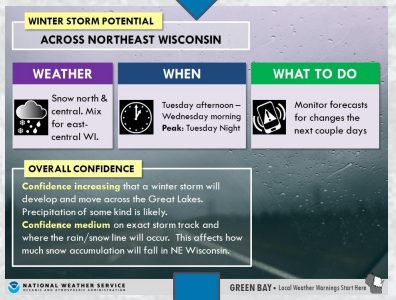
- Survey of U.S. public (N=833)
- Survey of meteorologists (N=40) and non-meteorologists (N=32) at NWS offices

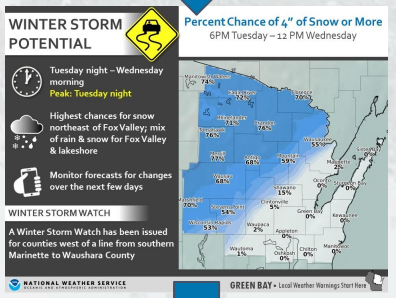
Put survey respondents in scenarios for upcoming winter storms with graphics that were used by various NWS offices

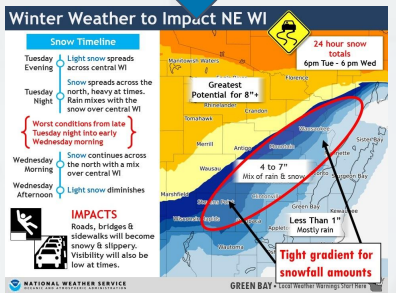










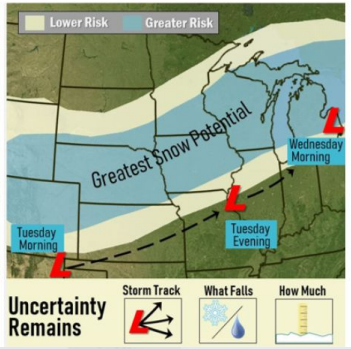


MAIN FINDING: IDEAL COMMUNICATION OF HIGH-IMPACT STORM

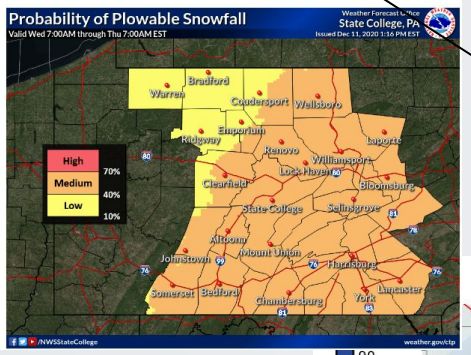
Days 3-7 before storm

EXAMPLE 1

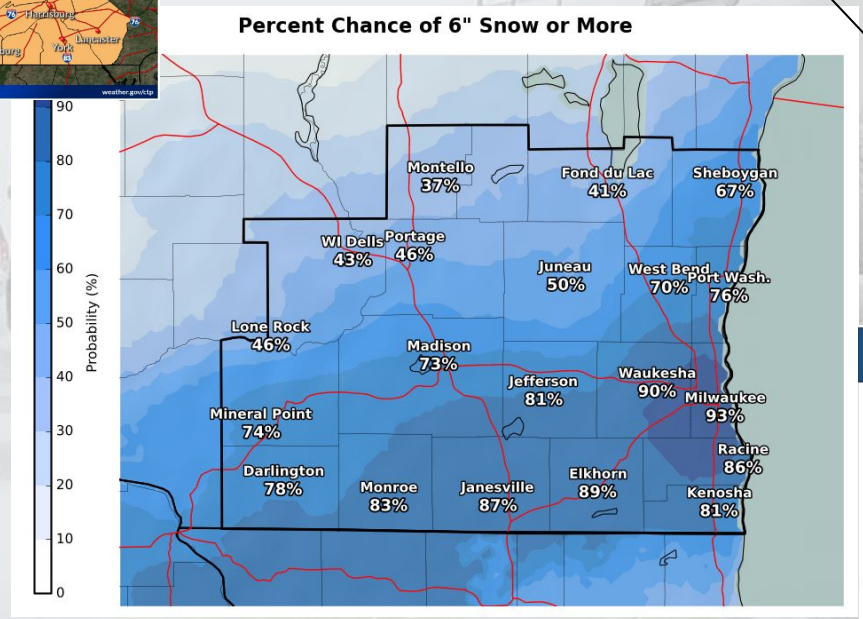
EXAMPLE 2



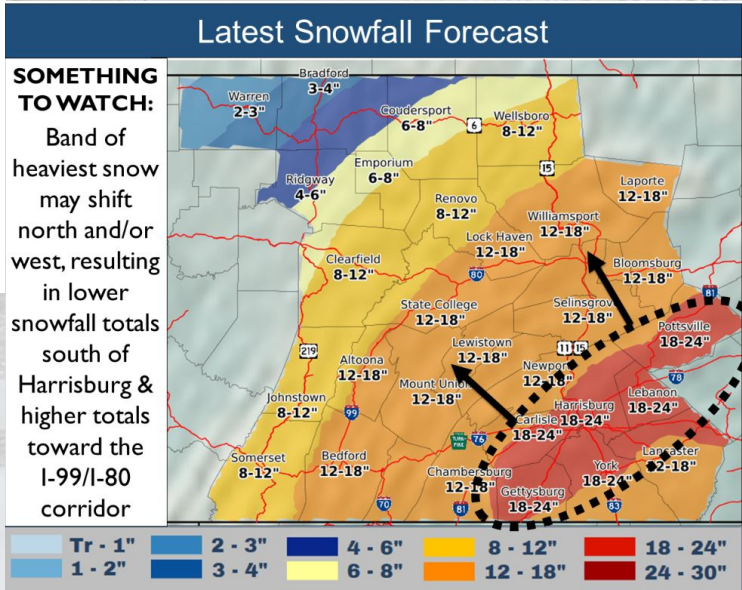
EXAMPLE 3



Days 2-3 before storm

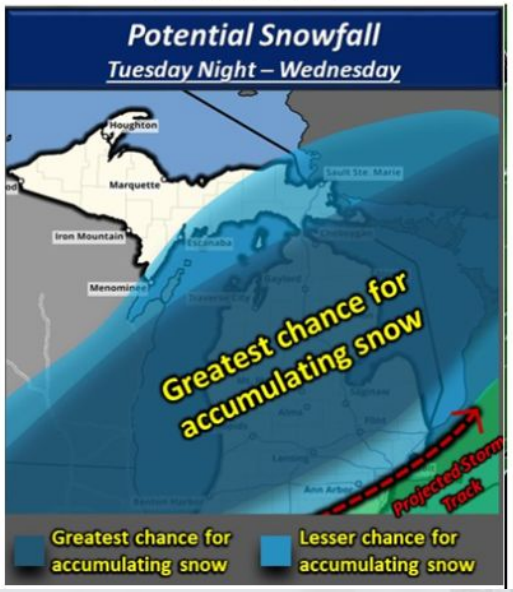


Days 1-2 before storm



LONGER RANGE: map-based graphics are preferred

EXAMPLE 1



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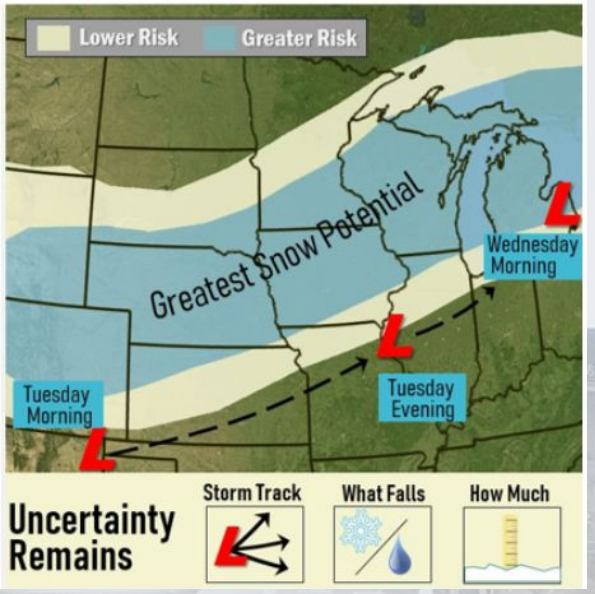

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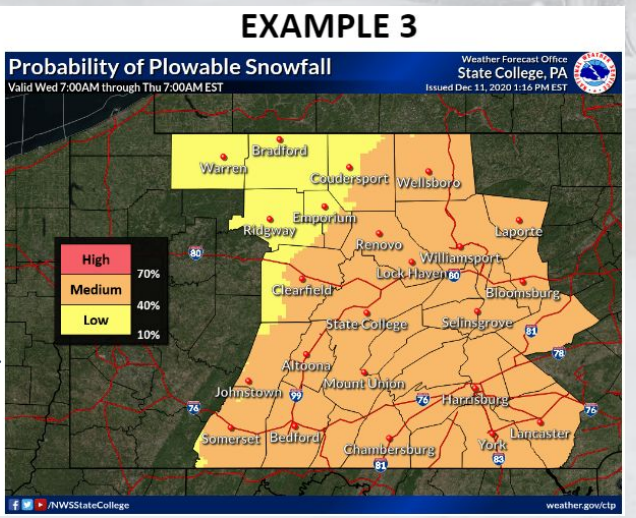
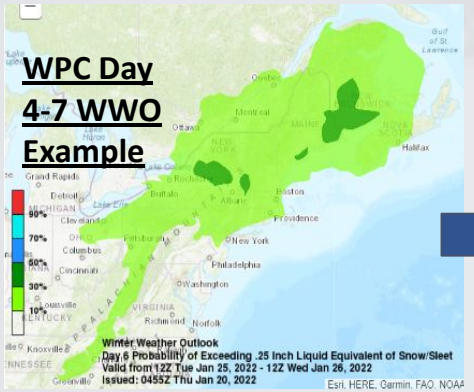
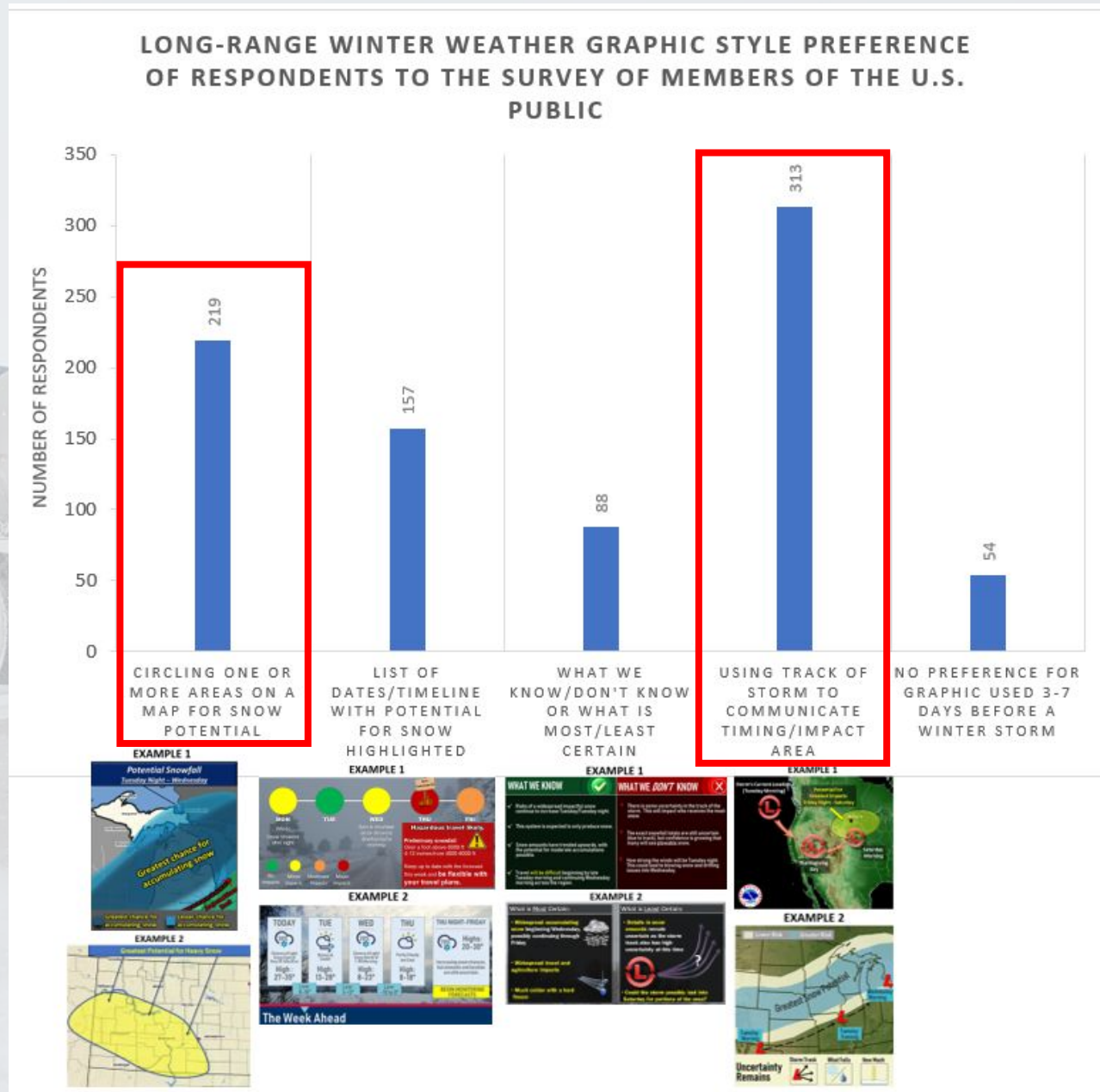
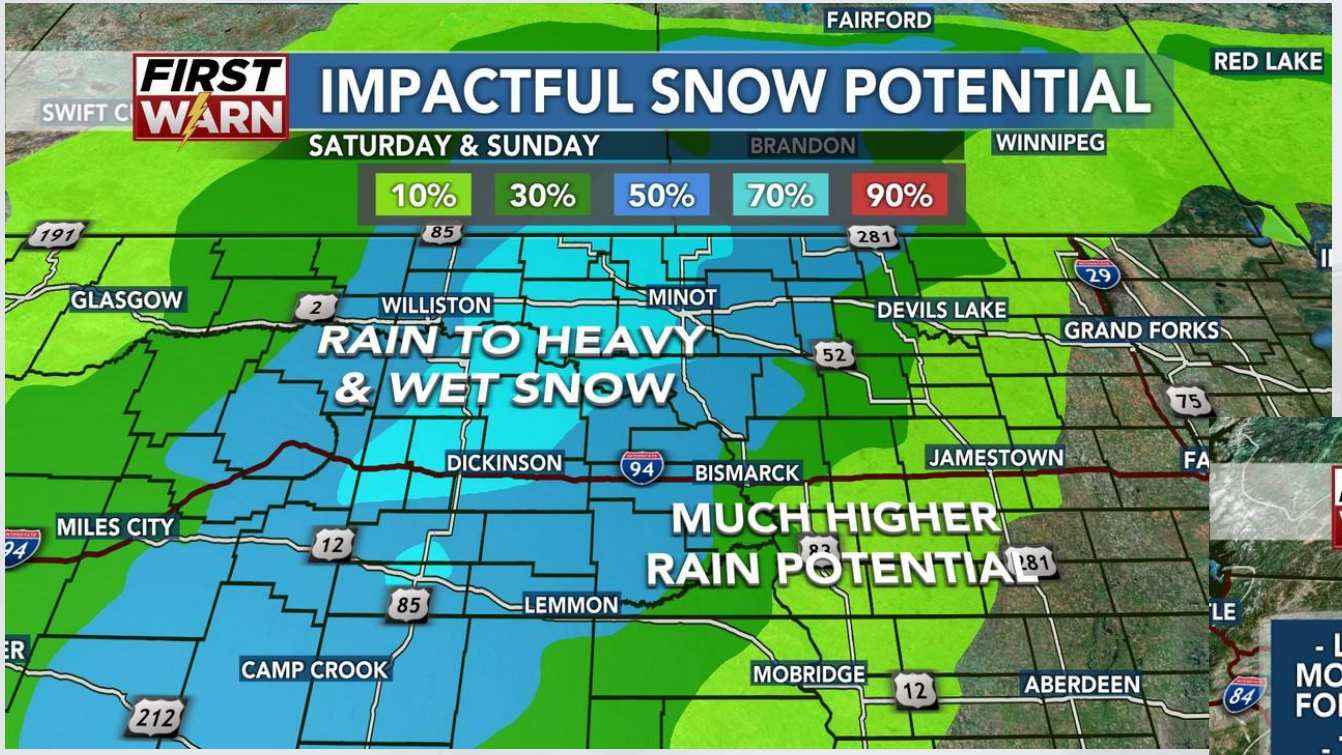






FOR BROADCAST METS: communicate some uncertainty with maps

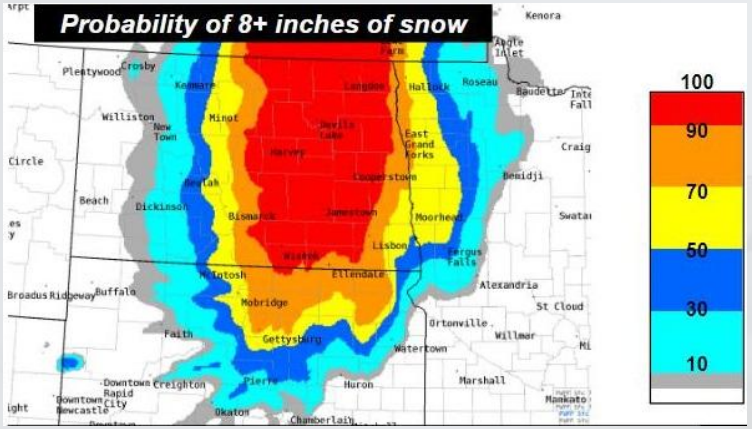
WPC Day 4-7 Winter Weather Outlook: KML download

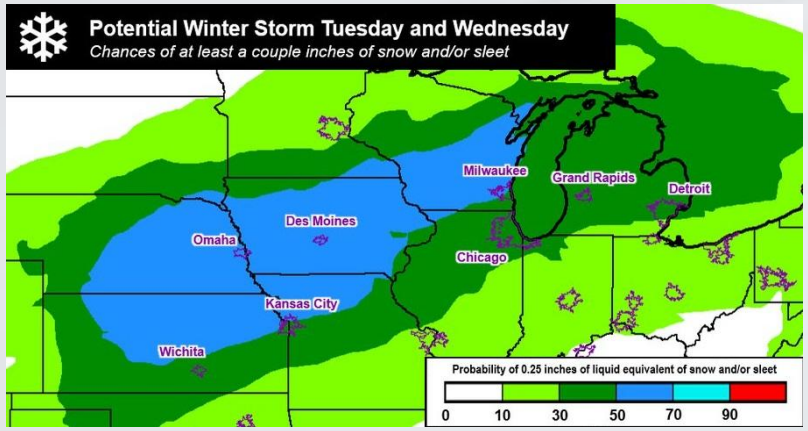


CLOSER TO STORM ONSET: probability of exceedance graphics

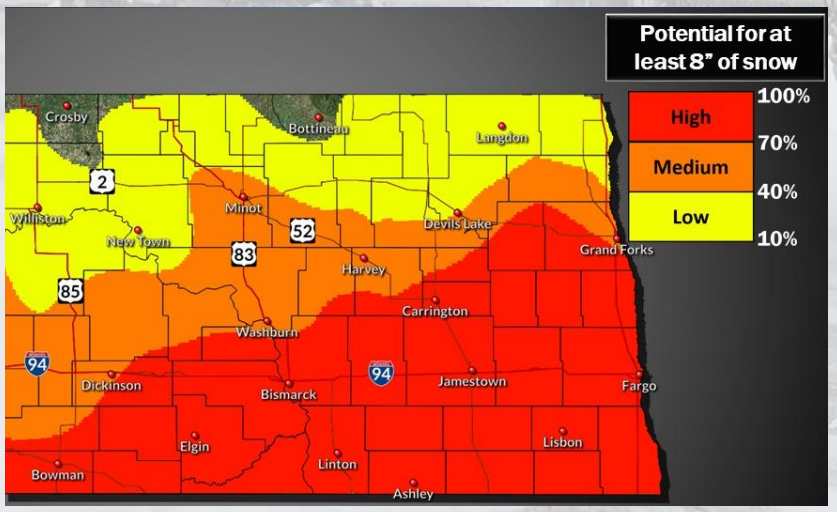
Probability of exceeding X inches of snowfall – ensemble based

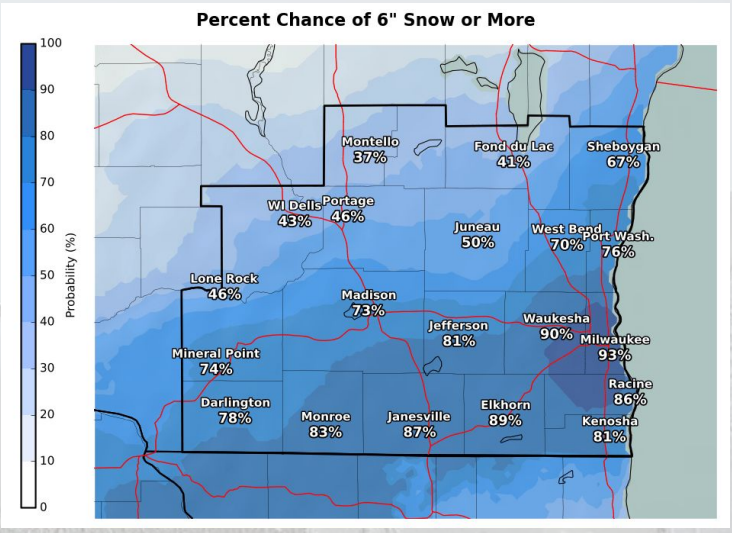
- Used when there's too much uncertainty for snow maps to be released
- Communicates the spatial coverage *and* likelihood of the threat
- Conveys the uncertainty in the forecast and encourages user to check back for updates

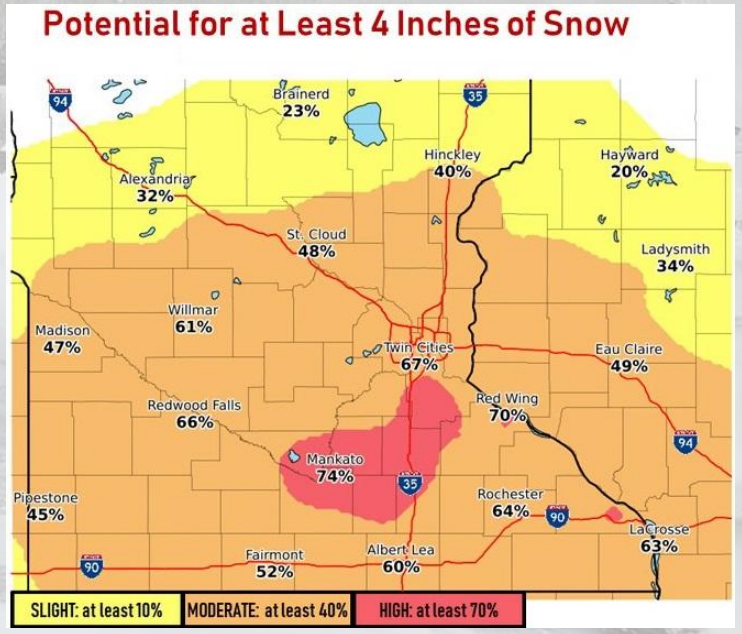




But there are many different color schemes used for these graphics:





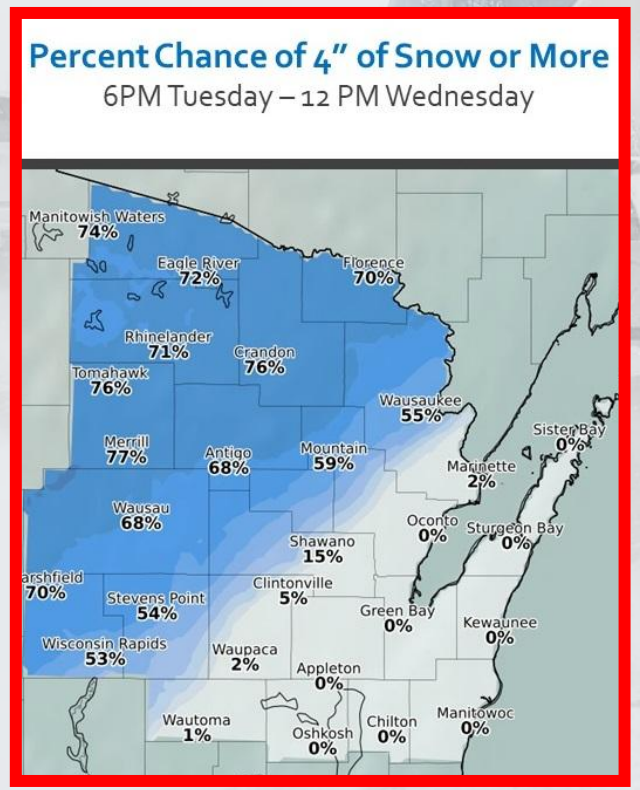


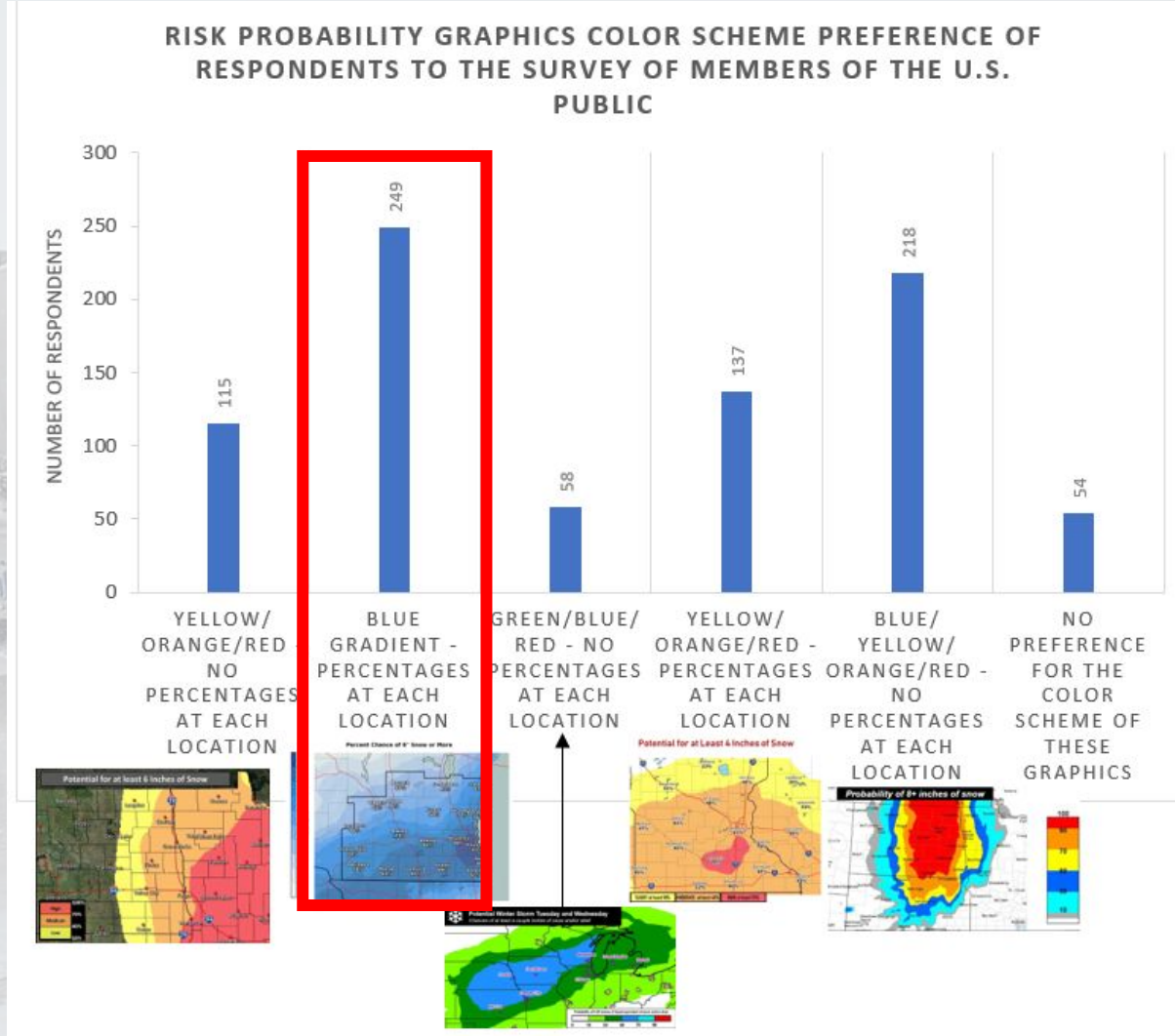
1–3 DAYS BEFORE STORM: probability of exceedance graphics

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

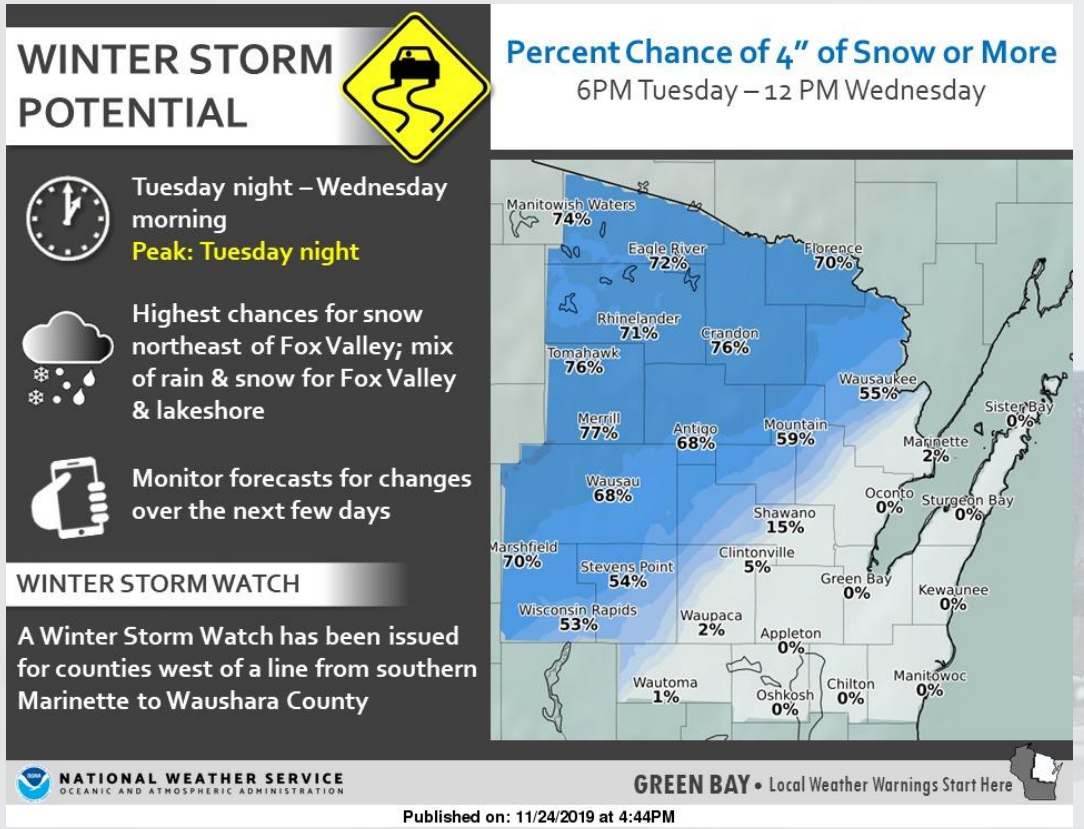
Easiest to interpret and the best communicator of the uncertainty present in the forecast based on the survey of the U.S. public.

Monochromatic color schemes can be helpful for those that are color blind

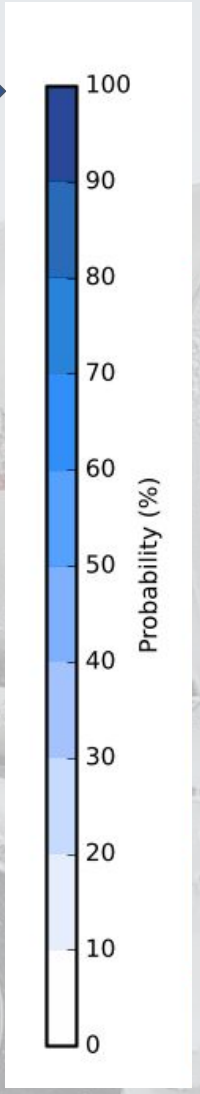




1–3 DAYS BEFORE STORM: probability of exceedance graphics



Probability percentages at locations were found to be helpful, but a **color scale** helps to fill in the gaps.



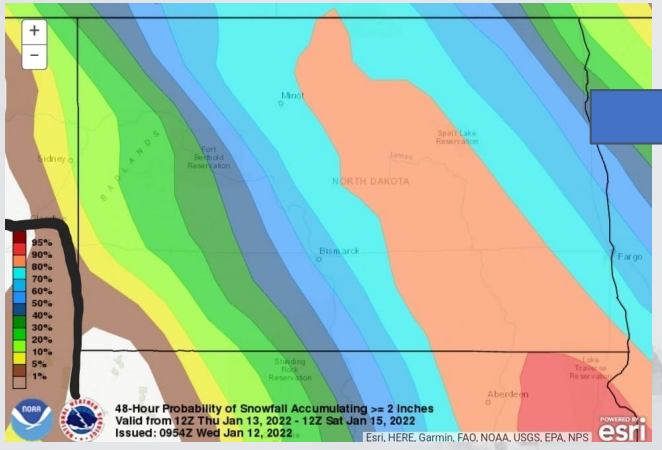
A possible suggestion would be to **round the percentages** at each location to the nearest 5% or 10%.

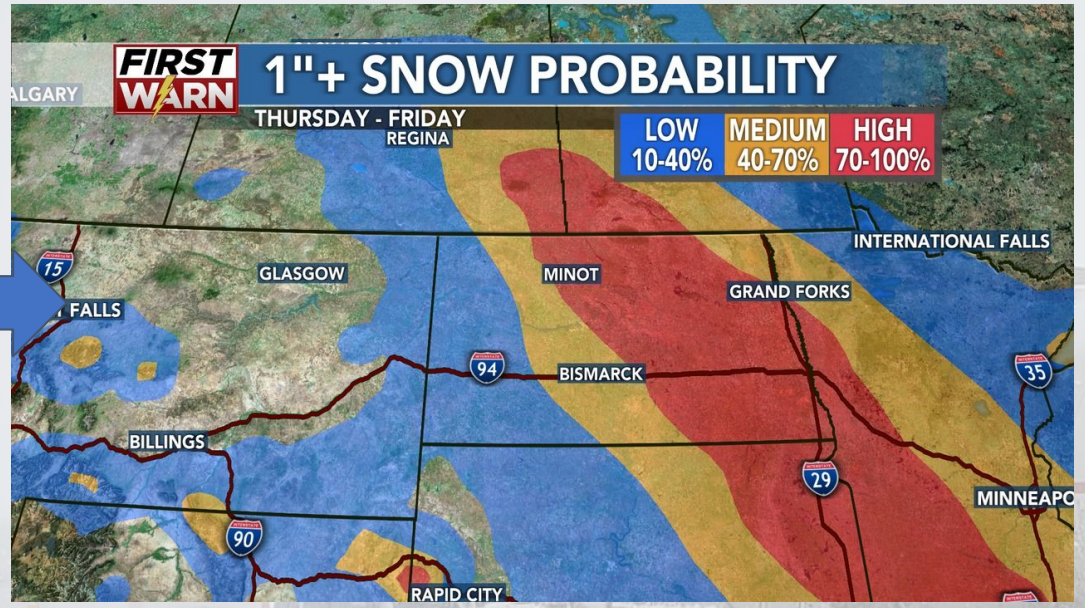
Based on heat maps: some brief, additional text was found to be helpful (especially **timing information**). However, "monitor forecast"/"check back for updates" was found to not be very helpful/important to public.

FOR BROADCAST METS: probability of exceedance graphics

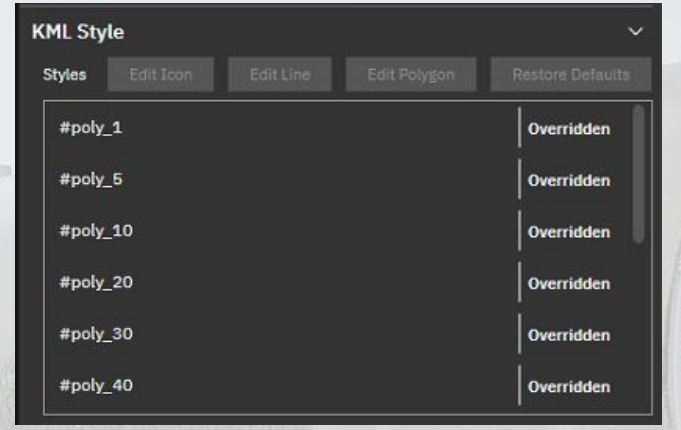
WPC 24, 48, or 72-hour probability of exceedance KML files

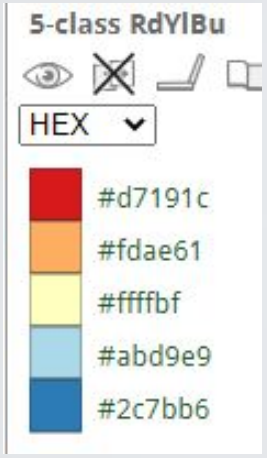
https://www.wpc.ncep.noaa.gov/kml/kmlproducts.php#winwx



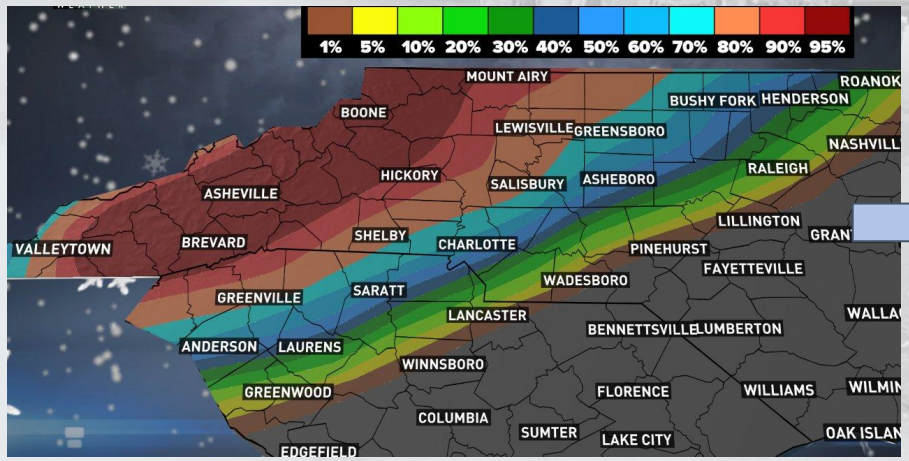


Override colors to combine 1-39%, 40-69%, 70-100%

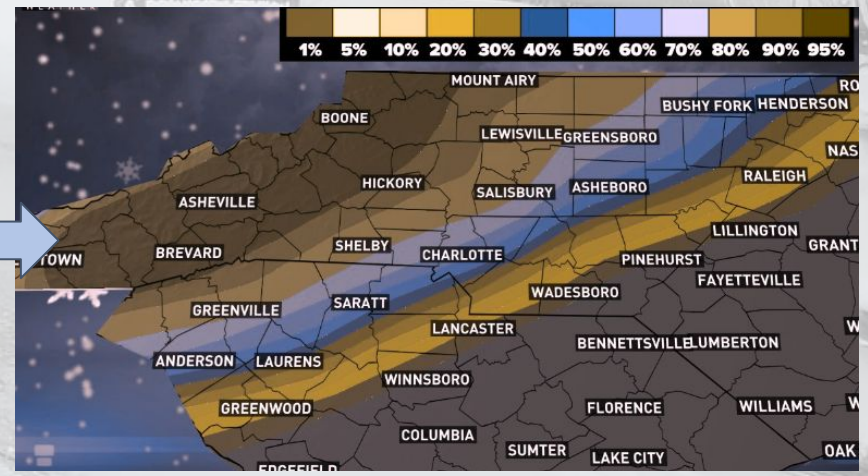


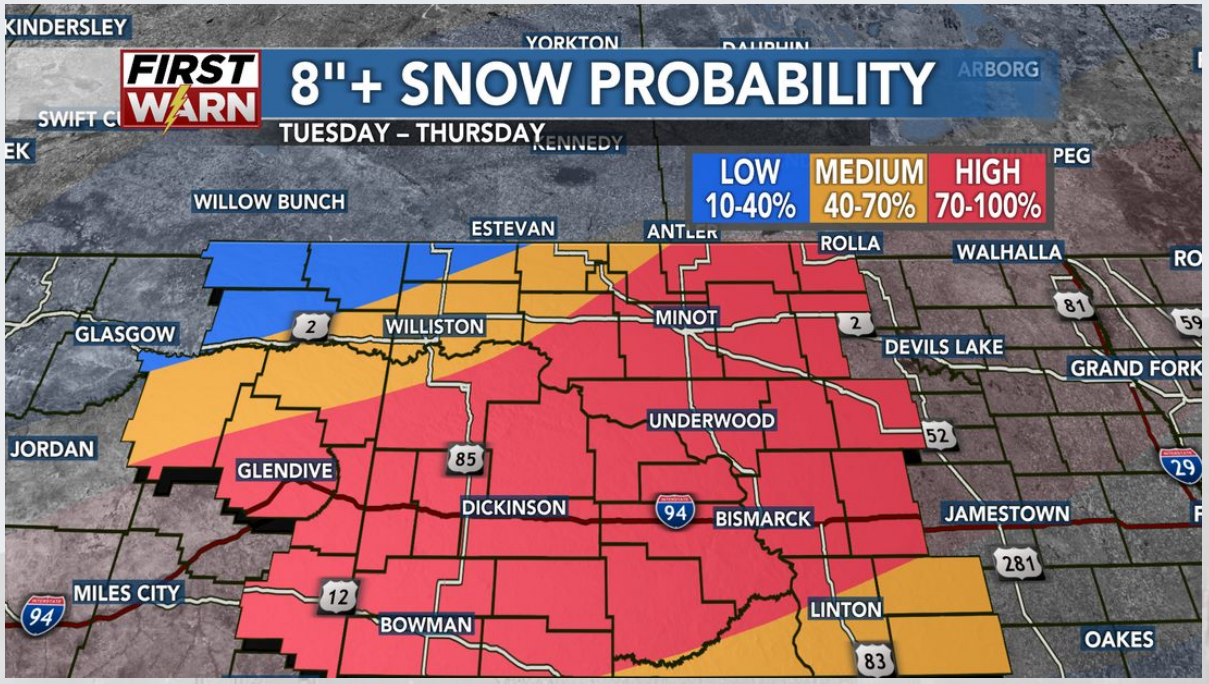


Three-tier is color blind friendly. Eliminates confusion with the standard rainbow color scheme.



Color blind simulator

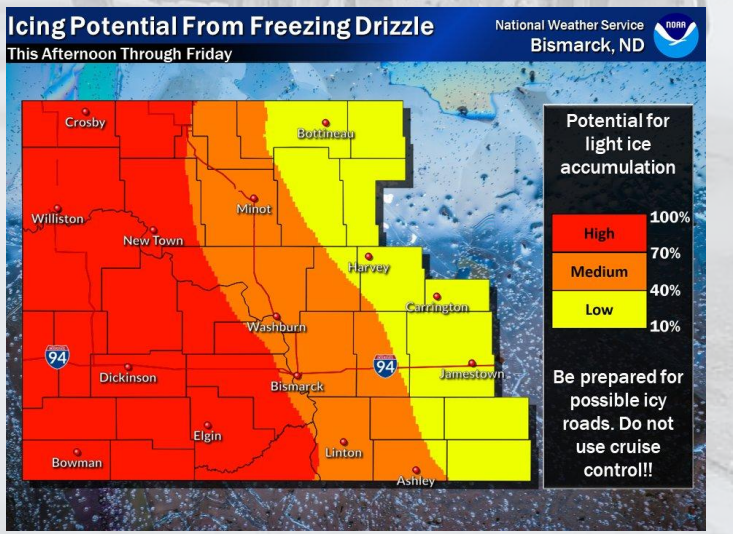


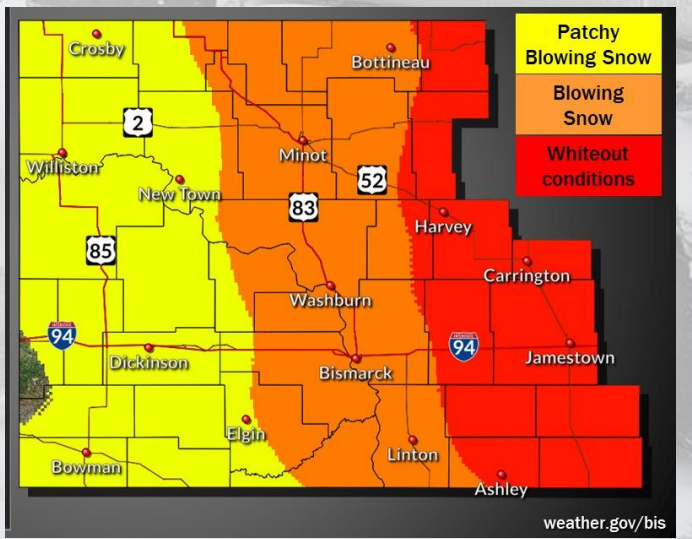


Examples from WFO Bismarck

Using probability of exceedance graphics to communicate other hazards, such as for icing/freezing rain potential, was shown to be valuable.

Possible monochromatic color scheme for freezing rain: pink or purple?



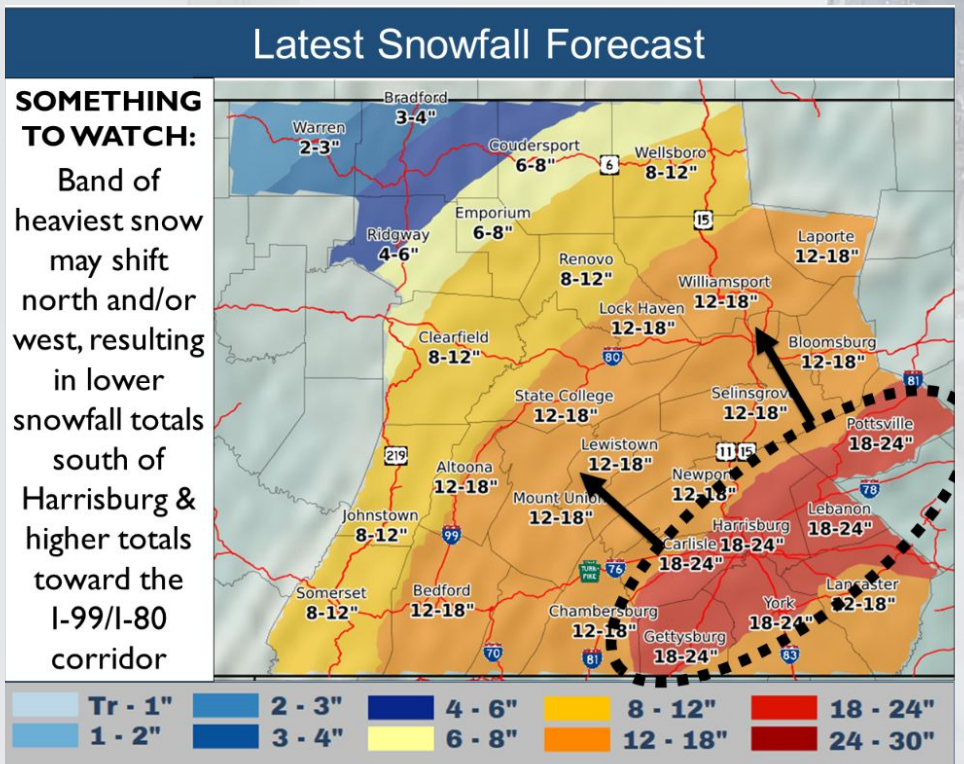


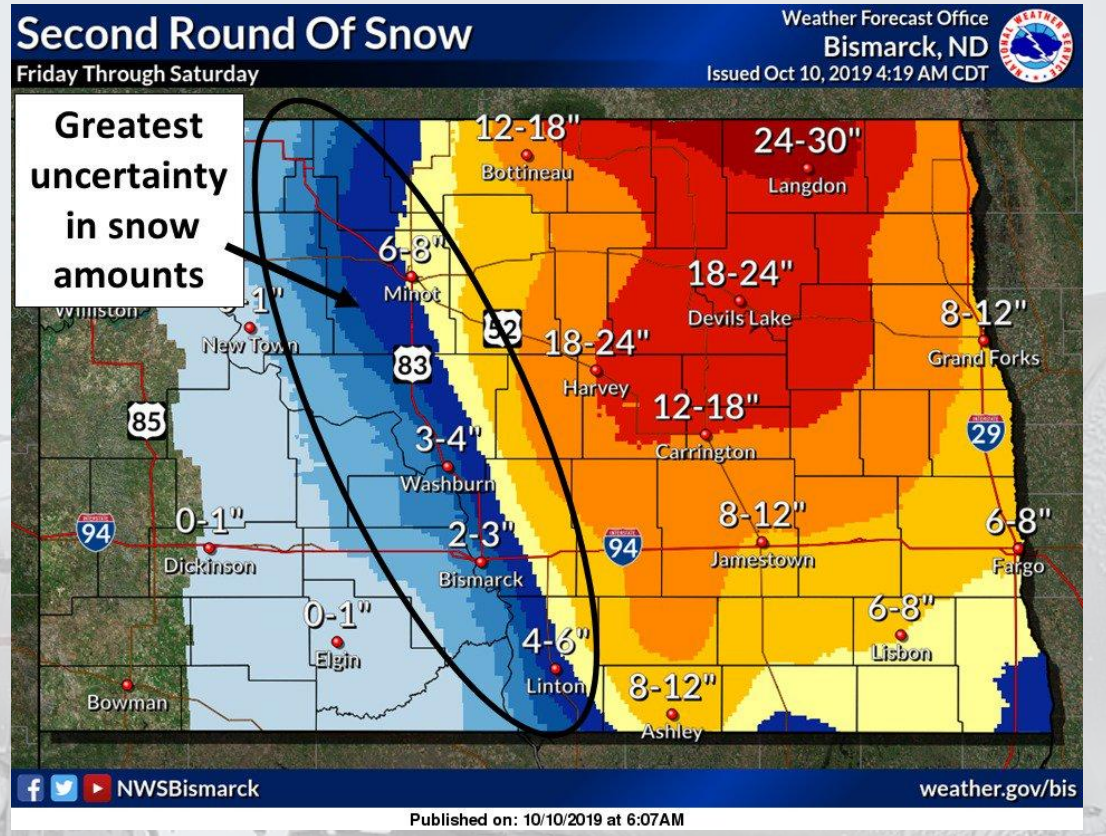
SNOW MAPS: Circling areas of uncertainty

<u>If survey respondents were in the circled area:</u>

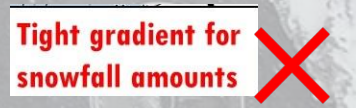
75% would **check back for forecast updates** to see if anything had changed.

46% would **prepare for higher snowfall amounts** in case the forecast changed.





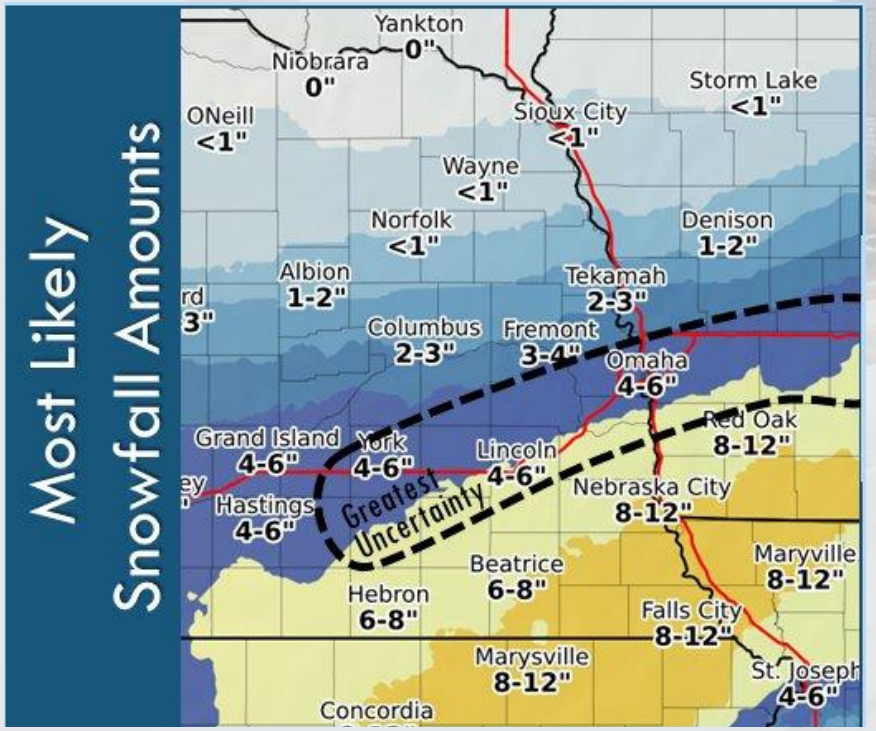
<u>The word "uncertainty" should be used</u> when describing this circled area and adding a ***<u>brief statement</u>*** on the graphic as to ***<u>why the uncertainty exists or where the band of heaviest snow might shift</u>*** was shown to be preferred.



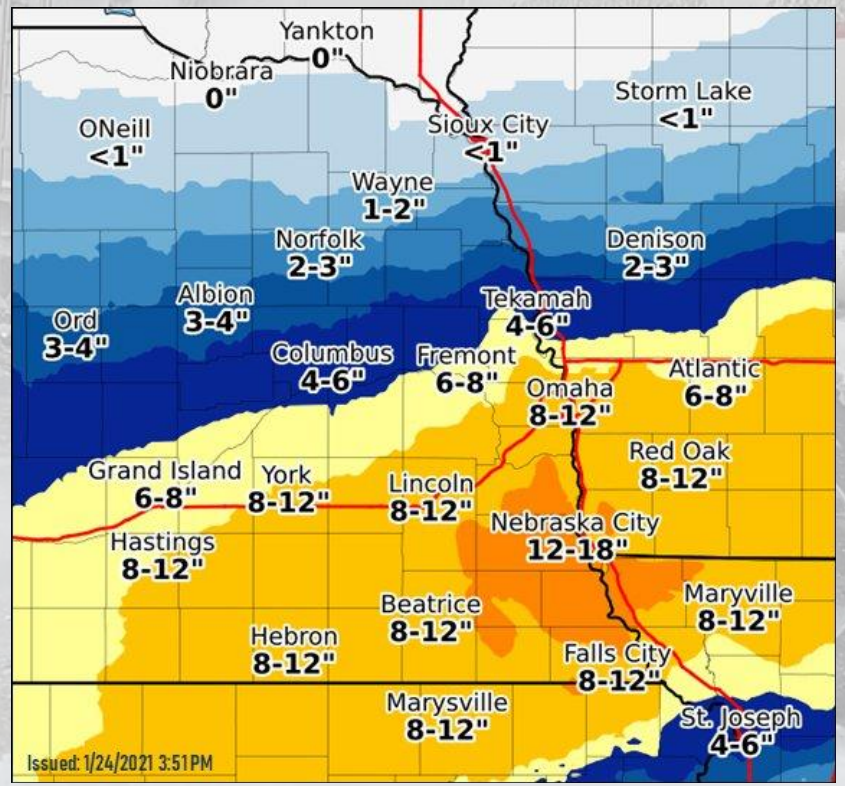
SNOW MAPS: Circling areas of uncertainty

60% of respondents said the circled area was **helpful for anticipating the increased** snow totals in the example below.

TWO DAYS BEFORE STORM



ONE DAY BEFORE STORM

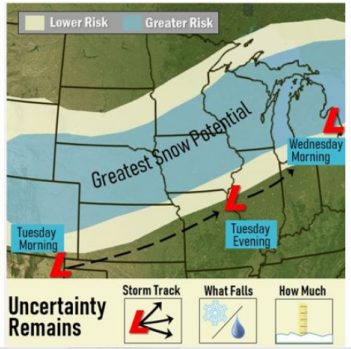


MAIN FINDING: IDEAL COMMUNICATION OF HIGH-IMPACT STORM

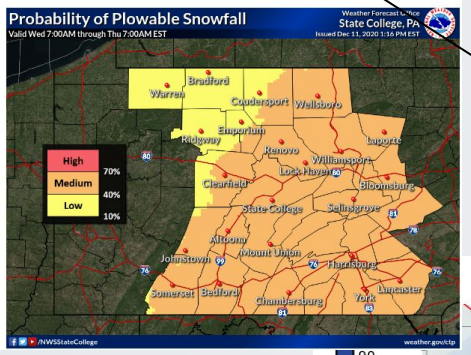
Days 3-7 before storm

EXAMPLE 1

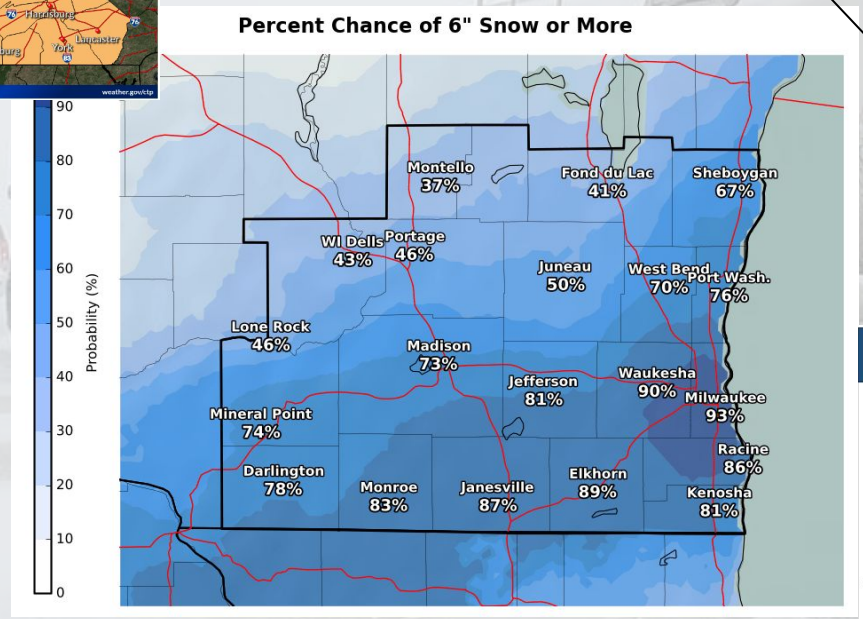
EXAMPLE 2



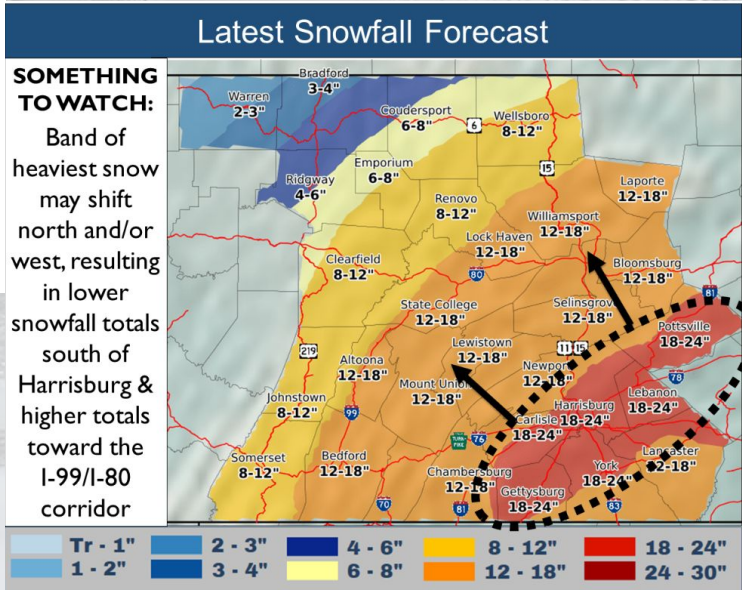
EXAMPLE 3



Days 2-3 before storm



Days 1-2 before storm



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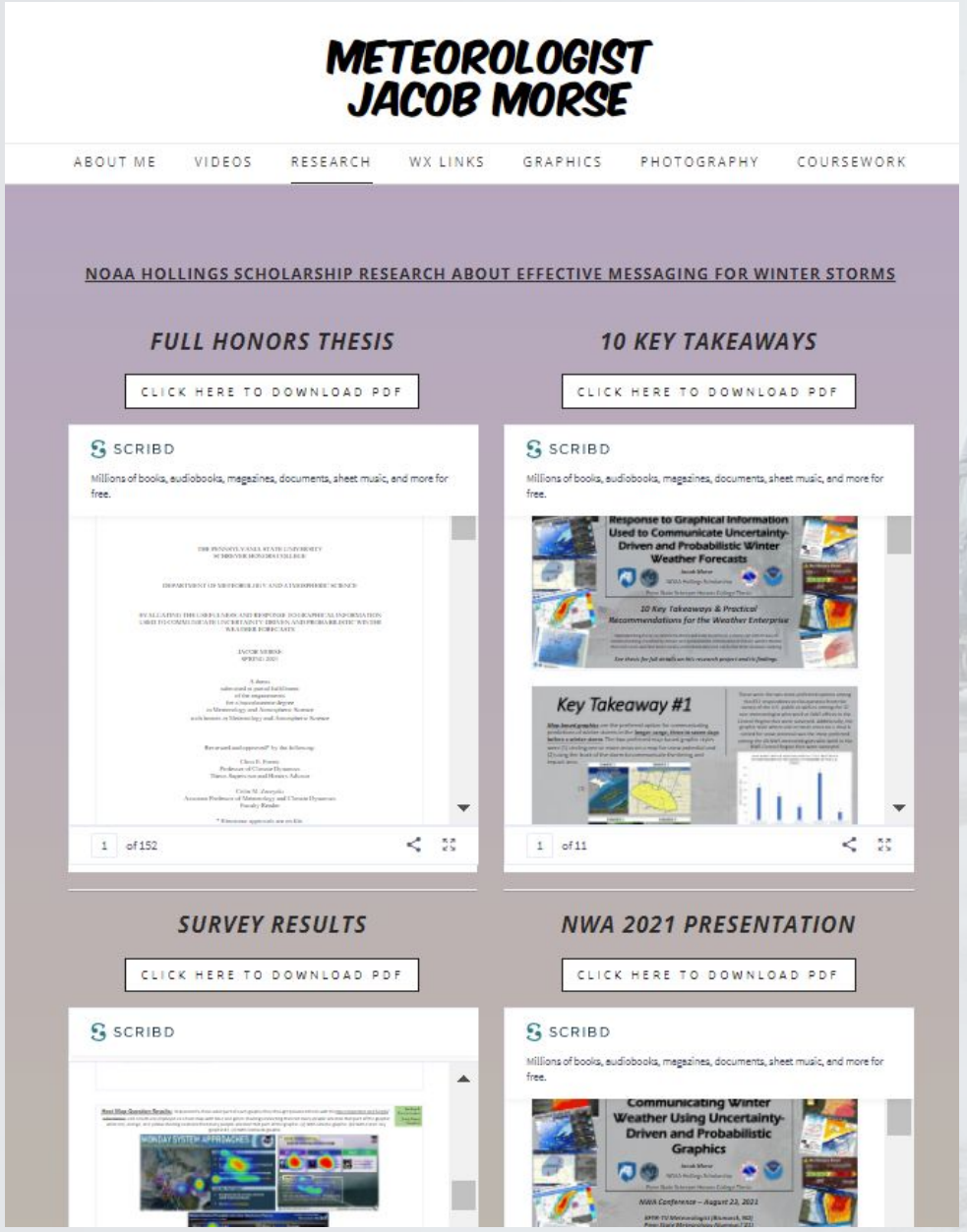

<u>TAKE-HOME MESSAGE:</u> People want to hear about uncertainty & probabilistic information and find it helpful for decision-making *<u>when presented correctly</u>*.
Greater *<u>consistency</u>* is needed across the weather enterprise with these forecast products.

THANK YOU!

<u>Reach out to me with questions:</u>

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