Final Report

Communicating Probabilistic Information for Decision-Makers: A Case Study Using Experimental Snow Forecast Products

Summary of Decision-Maker Focus Groups, Simulations, and User Journey

February 28, 2018

Eastern Research Group, Inc.

Arlington, Virginia

Written under contract for the
NOAA's National Weather Service
www.weather.gov

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Summary and Conclusions

This study used social and behavioral science, risk communication, and market research techniques to better understand National Weather Service (NWS) partners' decision-making and information needs for winter weather—with a specific focus on a suite of NWS probabilistic, internet-based snowfall forecast graphics. During 2017/2018, a total of 80 Weather Forecast Offices (WFOs) in all four CONUS regions will participate in creating these graphics, and 64 offices will display the images on their websites and use them externally in partner briefings and social media.

The first phase of this study used one-on-one interviews, focus groups, and simulations to explore and gather input on the kinds of decisions that NWS partners make when a winter storm is threatening their area, along with the types of information (both weather and non-weather) they need to make these decisions. The study also collected a limited amount of qualitative data about the probabilistic graphics' visual design, labels, and messaging.

The second phase of research involved one-on-one, in-depth interviews with a few Colorado Department of Transportation (CDOT) personnel to learn about their decision-making processes before and during winter storm events. The information obtained during these interviews was used to construct a "user journey" (see text box at right) for CDOT.

The research involved both NWS forecasters and partners, such as state and local decision-makers, including department of transportation (DOT) officials, emergency managers (EMs), school superintendents, public works' officials, and others. These partners were located in both densely populated urban corridors as well as smaller, less densely populated cities in states across the nation that experience winter weather conditions. The partners in these locations have unique experiences with winter weather—with different storm types, varying levels of ability to treat/respond to snow, and thus different information needs.

User Journeys

A user journey visualizes the process that a person goes through to accomplish a goal. The goal of this user journey was to delineate the steps an NWS partner takes in the days/hours preceding a snowfall event, documenting:

- The series of tasks/decisions that an NWS partner goes through when a winter storm is approaching.
- If, when, and how they interact with NWS information and the probabilistic snowfall graphics.
- What other information a partner seeks at different times leading up to an event.
- Where a partner goes to get this information.
- Where partners' pain points are, or where they experience frustration.
- Opportunities for the NWS to provide additional value to better meet partners' needs.

Study Limitations

It should be noted that although the research provided extremely valuable *qualitative* insights into partners' decision-making processes and feelings about the graphics, the research was somewhat limited by the small sample size and restricted geographic scope. Also, while focus groups are useful in exploring issues and can help social scientists gain an initial understanding of an issue to guide further inquiry, the findings cannot be used to make generalizations about the population(s) of interest. Similarly, we constructed a single user journey based on interviews with three transportation officials in a single state DOT, so the results are in no way representative of the larger transportation sector. DOT officials in other localities could have very different user journey experiences and decision-making processes.

Key Findings

This research revealed important insights about the types of winter weather decisions that core NWS partners make and the information (both weather and non-weather) that they need to make informed decisions. The findings informed the key study questions as follows:

- **How do probabilistic snowfall forecasts improve decision-making by core partners?** Most partners stated that these products alone do not improve their decision-making because they need information on so many other critical weather variables, particularly timing, precipitation type, character of the snow, temperature, and wind. Political, societal, and economic factors also influence decision-making. The CDOT user journey corroborated that many different variables, both weather and non-weather-related, are used to make decisions leading up to and during a winter storm. Also, these users did not mention any use of probabilistic snowfall forecasts and only limited use of NWS weather information, primarily in the three to four days leading up to an event.

- **Do probabilistic snowfall forecasts communicate areas of increased risk, recommended actions, and precautions more precisely?** Partners in most regions perceive risk based on the potential impacts, which can only be determined in conjunction with other weather variables besides snowfall amount. Also, partners read probabilities subjectively, with some indicating they would only act if they saw very large probabilities (e.g., 75 percent), while others would act based on lower probabilities (e.g., 25 percent). Due to partners' subjective understanding of probabilities, the graphics could potentially create imprecision rather than precision.

- **Do probabilistic snowfall forecasts improve core partners' ability to distinguish between low impact and high impact events?** Probabilistic snowfall forecasts do improve the ability of some partners in the Northeast to distinguish between low and high impact events; however, the research did not support this finding in other geographies. Western states are well-equipped to handle very high snowfall amounts, while impacts in southern states could be devastating regardless of snowfall amount.

- **Is there an optimal mix of visualizations, colors, gradients, etc., that best convey information to improve IDSS?** There was no consensus on the optimal way to visualize the products. Suggestions included providing hourly snowfall amounts, providing smaller windows of time (such as a six-hour total snowfall total), animating the maps or making them interactive, providing the ability to click on a location on a map and get a popup image of the probability table, and using consistent language and numbers across the graphics.

Overarching Results and Recommendations

Based on the initial research findings, ERG recommended a couple of "quick fixes" to the products that the NWS implemented for the 2017–18 season, including using consistent labels across the graphics, making the headings in the probability table match the minimum/most likely/maximum maps, and changing the webpage layout so that the probability table appears together with the maps. While these changes may improve the interpretation and ease of use of the products for those who seek them out on WFO websites, it is also important to note that the research resulted in several more overarching conclusions, as discussed below. Where relevant, specific recommendations and possible next steps are also outlined along with these conclusions.

- **Conducting audience research before any kind of product development can help the NWS better understand--and serve—specific partners' and customers' information needs, including the appropriate format, level of detail, and dissemination mechanism for that information.** When it comes to winter weather information, one size does not fit all. The NWS has created winter weather products intended to meet the needs of a diverse set of audiences (with varying levels of sophistication in all kinds of geographies) before discerning whether all those audiences actually need the information. For example, our research with CDOT officials suggests that the probabilistic snowfall forecast graphics do not factor into their decision-making at all, with these officials relying heavily on a Maintenance Decision Support System (MDSS) for forecasts, storm data, and road treatment information.
    - **Recommendation:** Continue market research into the transportation sector to better understand if DOTs' winter weather needs are being met. A number of states are part of pooled fund study that is supporting the implementation of the MDSS. However, we don't know what systems, if any, are being used by states that are not part of this study. Consider market research with DOTs in these other states to better understand their decision-making processes and information needs.
    - **Recommendation:** Consider deeper explorations of winter weather needs with other affected sectors in targeted geographies. ERG's user journey focused on only a slice of the transportation sector in a very specific geography. In addition to the transportation sector, aviation, schools, and emergency management are other key sectors that use winter weather information in their decision-making. The CDOT research also indicated that third-party vendors use NWS winter weather information—and may be an important audience sector. Market research could help the NWS gain a better understanding of winter weather forecast needs of these other target audiences.
- **During winter weather events, uncertainty, confidence, and probability all play a role for partners; however, they often confuse these three factors, interpret them differently, and appear to depend more on forecast confidence than probabilities.** While some partners like probabilities to increase their situational awareness and knowledge of a storm, no partners base their winter weather decisions solely on probabilistic information. As a Georgia school official said, "It would be helpful to know the probabilities. … Anything we can get is helpful. There's no reason not to have it." Additionally, when it comes to confidence, the human element—the forecaster's body language and tone of voice, for example—is as important to NWS partners as the information itself. The findings from this research do not suggest that probabilities are not useful or that stakeholders never factor probabilities into their decision-making. Rather, that people experience challenges processing and understanding probabilities, and that they

interpret probabilities differently based on contextual and subjective influences. This finding highlights the importance of the NWS explicitly stating the probabilistic basis of its products and of providing more context around probabilities (i.e., through IDSS) to inform partner decision-making.

- **Recommendation:** Bring together a group of social scientists who have conducted research into the communication and interpretation of uncertainty, confidence, and probabilities to share their knowledge and ascertain research gaps and priorities.
- **Recommendation:** Conduct winter weather exercises with partners in a testbed environment. All partners make decisions in groups, not individually. Observing a small group of partners making a hypothetical winter weather decision in a testbed environment will allow the NWS to see what role the graphics play in decision-making, as well as understand how probabilities and uncertainty influence hypothetical outcomes. Such exercises can improve the NWS's ability to provide IDSS for winter weather events while testing the experimental products in an operational environment.

- **NWS partners want NWS data in formats that they can use and customize to meet their needs**. This is a recurring theme expressed in much of the social science research that ERG has conducted on behalf of the NWS. Partners do not necessarily use NWS graphics "off the shelf." Some partners depend more on private-sector vendors than the NWS, and these vendors want the underlying data in NWS graphics, so they can incorporate it into their own tools and systems, creating graphics and other products tailored to their area, customers, and needs.

  - **Recommendation:** Follow up with the third-party vendor, Iteris, that produces the MDSS for Colorado and other state DOTs to learn what NWS data the system uses and if there are opportunities for better integration to improve DOTs' operational decision-making. The NWS could also specifically talk to Iteris about the probabilistic snowfall forecast products (e.g., are they aware of the products, do they use them, do they have any suggestions for enhancements).

- **It takes time, use, and verification to build trust and use of NWS products by partners.** Partners have expressed that there is a learning curve to understanding new NWS products, particularly when these products are used only seasonally or periodically. It also takes time for both NWS forecasters and external NWS partners to gain trust in products; they often want to "test" them out in actual situations on their own before sharing them more broadly with partners or customers.

  - **Recommendation:** Conduct outreach and training in advance of the winter season to build familiarity with the products, as well as assessments during or after the season to learn whether and how the products were actually used.

- **Consider the feasibility of developing a forecast trend product.** In both the focus group and CDOT user journey research, some participants expressed a desire to better understand forecast trends (e.g., are snowfall amounts rising, are temperatures rising or falling?) to inform their decision-making. Looking at trends across different information sources is particularly important when forecasts conflict. For example, if forecasts are trending toward larger snowfall amounts, a DOT might base equipment decisions on a worst-case forecast (or vice versa if things are trending better). Being able to easily see trends in the forecast over time is of value to these users.

- **Recommendation:** Consider further exploration of this idea internally and externally to determine if a such a product is desirable/feasible and what format it could take (e.g., raw data, visualization). ERG cautions, however, against developing a "one size fits all" product and to pilot and refine any product with a cross-section of users in different geographies.

Finally, it is important to note that it may be most fruitful for the NWS to focus on better understanding its diverse partner base and providing a continuum of information through IDSS in the days leading up to/during a storm tailored to a specific event and partners, rather than developing somewhat generic graphics or products that may or may not meet the needs of partners in different sectors and geographies.

Also, leading up to an event, NWS partners need information about many winter weather variables to make decisions. No single product (e.g., probabilistic snowfall graphics) meets all their needs. Partners also need accurate, easy-to-understand, *early* information because they must make decisions before the NWS issues watches, advisories, and warnings. Increasingly, partners look to various sources to gather this information, and the NWS is often just one information source. As more and more systems are developed that assimilate information from various sources in "Big Data Mashups," it will be important for the NWS to ensure its data can be ingested into these systems and used effectively.

Communicating Probabilistic Information for Decision-Makers: Summary of Decision-Maker Focus Groups, Simulations, and User Journey

Full Report

Introduction

For decades, the NWS has provided forecast predictions based upon a single “deterministic” solution without any expressions of confidence. With improvements in computing and modeling, NWS forecasters can now bundle numerous solutions for a specific weather event. This capability, known as ensemble forecasting, can describe possible ranges in values for a predicted event, including a most likely forecast along with potential extremes, both high and low. As the NWS transitions from deterministic products to probabilistic, impact-based decision support services (IDSS), it has been experimenting with different methods and visualizations for showing probabilistic information.

This study used social and behavioral science and risk communication techniques to test and make recommendations for improving a suite of probabilistic, internet-based snowfall forecast graphics. During 2017/2018, a total of 80 WFOs in all four CONUS regions will participate in creating the graphics, and 64 offices will display the images on their websites and use them externally in partner briefings and social media.

The study was designed to address the following questions:

1. How do probabilistic snowfall forecasts improve decision-making by core partners?
2. Do probabilistic snowfall forecasts communicate areas of increased risk, recommended actions, and precautions more precisely?
3. Do probabilistic snowfall forecasts improve core partners’ ability to distinguish between low impact and high impact events?
4. Is there an optimal mix of visualizations, colors, gradients, etc., that best convey information to improve IDSS?

While this study focused on testing and recommending improvements to the experimental probabilistic snowfall products, the findings from this research are intended to feed into broader NWS efforts to communicate uncertainty and impacts across NWS service areas for the protection of life and property.

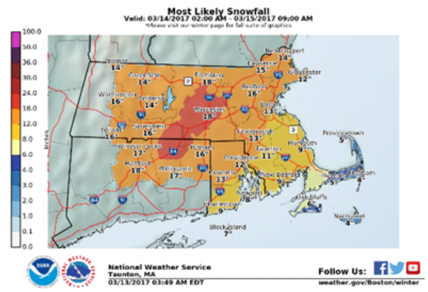
Overview of the Graphics

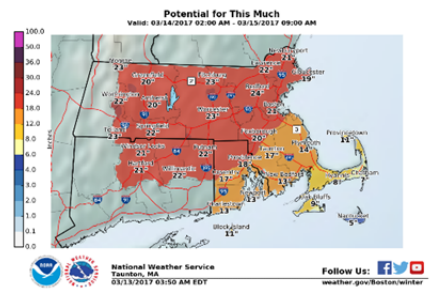
The NWS generates a suite of probabilistic snowfall graphics when snow is possible during the next 72 hours. The Weather Prediction Center (WPC) produces the initial data set, which WFOs may then edit, incorporating their local knowledge and experience. Once the data set is final, the WFOs generate the suite of graphics (see Table 1 on the next page). When the snow starts to fall, the graphics are discontinued so NWS forecasters can focus on the forecast snow amount.

Table 1. NWS Suite of Probabilistic Snowfall Accumulation Graphics

Minimum/Most Likely/Maximum Maps

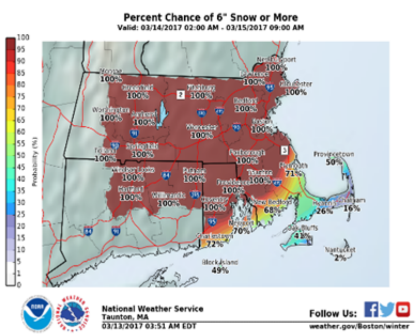
This set of three maps are titled "Expect at Least This Much," "Most Likely Snowfall," and "Potential for This Much." The "Most Likely Snowfall" graphic is the official forecast and is based on the amount of snow that appeared most often in the models combined with human forecaster expertise. The offices involved in producing the experimental probabilistic snowfall forecasts generate 10 percent and 90 percent exceedance graphics represented as "Minimum Case" and "Maximum Case" scenarios, along with a "Most Likely Amount" case.

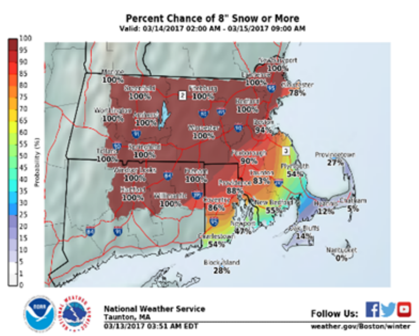


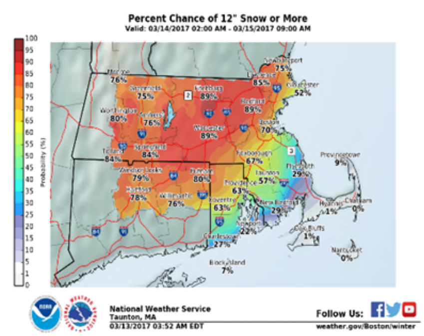


Percent Chance Snowfall Threshold Amount Maps

This set of maps shows snowfall threshold amounts in a range of values (0.1", 1", 2", 4", 6", 8", 12", 18") with color curve probabilities from 0 to 100 percent. On the NWS website, this graphic is interactive so that users can hover over a thumbnail of each threshold amount and the respective map will appear. This product is designed to indicate high or low confidence in the official snowfall forecast.







Chance of Snow Accumulation Table

The third product is a text-based range probability/exceedance probability table for specific locations that synthesizes information from the map products. The probability table can be sorted by county, rather than just seeing a list of points on the map. Also, a toggle feature allows users to switch the probabilistic representation from percent greater than to a range.

Chance of Snow Accumulation
Experimental - Leave feedback
11/19/2016 0700PM to 11/21/2016 0700PM
What's this?
County: All

Location	At least	Likely	Potential for	>=0.1"	>=1"	>=2"	>=4"	>=6"	>=8"	>=12"
Albany, NY	0	2	4	68%	55%	39%	13%	2%	0%	0%
Altamont, NY	0	3	5	78%	66%	50%	17%	2%	0%	0%
Amsterdam, NY	<1	4	5	87%	78%	64%	29%	5%	0%	0%
Atwell, NY	5	11	14	98%	97%	95%	88%	78%	62%	25%
Ballston Spa, NY	0	3	5	81%	70%	55%	21%	3%	0%	0%
Bennington, VT	1	4	9	94%	89%	81%	59%	36%	17%	2%
Brattleboro, VT	0	2	5	77%	65%	50%	22%	6%	1%	0%
Catskill, NY	0	<1	3	65%	46%	25%	4%	0%	0%	0%

Chance of Snow Accumulation
Experimental - Leave feedback
11/19/2016 0700PM to 11/21/2016 0700PM
What's this?
County: All

Location	At least	Likely	Potential for	0"	0.1-1"	1-2"	2-4"	4-6"	6-8"	8-12"	12-18"
Albany, NY	0	2	4	32%	13%	16%	26%	11%	2%	0%	0%
Altamont, NY	0	3	5	22%	12%	16%	33%	15%	2%	0%	0%
Amsterdam, NY	<1	4	5	13%	9%	14%	35%	24%	5%	0%	0%
Atwell, NY	5	11	14	2%	1%	2%	7%	10%	16%	37%	24%
Ballston Spa, NY	0	3	5	19%	11%	15%	34%	18%	3%	0%	0%
Bennington, VT	1	4	9	6%	5%	8%	22%	23%	19%	15%	2%
Brattleboro, VT	0	2	5	23%	12%	15%	28%	16%	5%	1%	0%
Catskill, NY	0	<1	3	35%	19%	21%	21%	4%	0%	0%	0%

Study Framework and Methods

This study encompassed four phases of research:

1. Interviews with select WFOs to gain a better understanding of how they use and disseminate the experimental probabilistic snowfall products, as well as how the products have influenced or changed how WFOs communicate uncertainty.
2. Focus groups with core NWS partners to gather information on the factors that affect their decision-making during winter storms, as well as feedback on the graphics' visual design, labels, and messaging.
3. Webinar simulation interviews with select NWS partners to test comprehension of the graphics and gather additional feedback on how the products might be improved.
4. User journey interviews with three CDOT partners to explore their decision-making process and needs before and during winter storm events.

This report summarizes the findings from the second–fourth phases of research. ERG submitted a separate memo summarizing the WFO interviews to the NWS in October 2016.

Focus Groups

ERG used the information gleaned from the WFO interviews to develop a script and accompanying slides (see Appendix A) for focus groups with state and local decision-makers, including DOT officials, EMs, school superintendents, public works' officials, and others. The focus groups were intended to gather information on the factors that affect partner decision-making during winter storms, as well as feedback on the visual design, labels, and messaging of the experimental probabilistic snowfall products.

As such, the first half of the focus groups focused on gaining an understanding of what decisions partners make that depend on winter weather forecasts, how they decide what actions to take, and where they get the information they need to make these decisions before a storm. During the second portion of the focus groups, participants were shown samples of each set of graphics in the product suite and asked to comment on the graphics' usefulness for decision-making. Participants also provided feedback on their understanding of the graphics; their preferences for colors, labels, and titles; and their suggestions for improving the graphical design and messaging.

ERG chose four locations for the focus groups (see Table 2 on the next page) based on their extensive experience with heavy snowfall events and the fact that officials in these areas must make critical decisions based on potential snowfall impacts. The WFOs in each location provided ERG with a list of decision-makers and their contact information, which ERG used to recruit participants for the focus groups, held in April–July 2017.

Table 2. Focus Group Sample

Location	Decision-maker Type	# Participants	Seen Graphics?
Taunton, MA	EMs, schools, DOT	9	Y
New York City, NY	EMs	15	Y
Casper, WY (group 1)	Broadcast meteorologists, state parks, schools/universities, airports, hospitals, local government	12	Y (media)/N
Casper, WY (group 2)	Trucking associations, schools, ski areas, EMs, fire departments, WYDOT	12	N (have seen “similar” products)
Denver, CO* (interview 1)	EM	1	Y
Denver, CO (interview 2)	Airports	2	Y
Denver, CO (interview 3)	CDOT	1	Y

* Due to time constraints, ERG had to conduct separate webinar interviews with the partners who were originally invited to participate in the Denver-area focus group.

Simulation Interviews

Following the focus groups, ERG conducted one-on-one simulation interviews with partners in eight locations (see Table 3). ERG chose these locations to represent a broader sample of states than the focus groups (which occurred in areas that are adept at handling winter weather conditions). ERG anticipated that these additional locations would have unique experiences with winter weather—with different storm types, varying levels of ability to treat/respond to snow, and thus different information needs.

Table 3. One-on-One Simulation Sample

Location	Affiliation
Wichita, KS	Wichita Public Schools
Independence, KS	Kansas DOT
Green Bay, WI	Brown County Emergency Management
DeForest, WI	Wisconsin State Patrol (under WI DOT)
Green Bay, WI	WI DOT
Raleigh, NC	NC DOT
Cary, NC	Wake County Public School System
Athens, GA	Clarke County School District

Because it became clear through the focus groups that partners need much more weather information than just snowfall amounts, ERG designed the simulations to complement the focus groups by similarly asking participants about their decision-making needs during winter weather events. However, ERG also used the simulations as an opportunity to obtain more meaningful feedback about the visuals by allowing partners to interact more deeply with the products in a one-on-one environment.

Because decision-making varies by storm type and by region, ERG worked with Eastern Region to choose a sampling of graphics for the simulation interviews that represented different storm-type scenarios that partners may encounter in real life. These scenarios included both large and small snow accumulation ranges, as well as 0-inch, low-end, and substantial minimum snowfall amounts.

Participants viewed a set of graphics that included the three maps in the minimum/most likely/maximum suite, a most likely map alone (because many partners *only* see this map in IDSS briefings), a threshold graphic (for the percent chance of greater than or equal to 4 inches of snowfall), and a probability table. The partners saw each type of graphic individually, and ERG rotated the graphics so no participant viewed the same product or location more than once. We asked participants a series of simple, close-ended questions to gauge if they understood how to use the graphics (e.g., showed participant a most likely map for Aberdeen, South Dakota, and asked "What do you think the most likely amount of snowfall is?").

ERG then asked for open-ended, qualitative feedback on whether the visuals were useful or not useful in helping them determine the answer. If not useful, ERG asked partners to explain how the visuals may be improved to better help their understanding. We also asked for information about how probabilistic information currently factors into partners' decision-making during winter weather events.

Research Limitations and Generalizability

It should be noted that although the focus groups and simulation interviews provided extremely valuable *qualitative* insights into partners' feelings about the graphics across a broad geographic representation, the research was somewhat limited by the small sample size. Also, while focus groups are useful in exploring issues and can help social scientists gain an initial understanding of an issue to guide further inquiry, the findings are not conclusive and cannot be used to make generalizations about the population(s) of interest. Similarly, we constructed a single user journey (based on the input of three CDOT staff), so the results are in no way representative of the larger state transportation sector.

Furthermore, there was no universal level of statistical expertise (i.e., the context necessary to understand and use probabilities) across the sample of participants, who ranged from novice to sophisticated users. Therefore, we cannot draw any conclusions about what percent of partners understand probabilities and generalize that to partners nationwide. Finally, participants viewed static PNG images of the graphics independent of the entire suite, losing the interactive interface and one-stop-shop nature of the live products.

Despite these limitations, the study did reveal several recurring themes across all of the research conducted, and these takeaways are reflected in the summary section of this report.

Report Overview

The findings in this report are presented in three sections, which synthesize the results of the complementary focus groups, simulation interviews, user journey, and overall project findings:

- **Part 1** focuses on core partners' perspectives on winter weather decision-making and forecast needs, drawn from the both focus groups and simulation interviews.
- **Part 2** presents focus group and simulation feedback on the products, with constructive suggestions from partners on how to improve the visuals and messaging.
- **Part 3** presents ERG's findings from the CDOT user journey.

Part 1. Core Partners' Winter Weather Decisions

To answer the question, "How do probabilistic snow total forecast improve decision-making by core partners," ERG set out to first understand what types of decisions core partners are making and what roles uncertainty generally, and probabilities specifically, play in their respective decision-making processes.

Information Sources

All partners mentioned the NWS as one of their primary sources for winter weather information. Specifically, partners highlighted the value of NWS webinars, briefing packets, and phone calls leading up to a winter weather event. In addition to the NWS, partners also utilize a variety of other sources of information summarized below:

- Local media
- Private sector vendors
- Road cameras
- Social media, such as Facebook feeds
- National media (e.g., Weather Underground, Weather Channel)
- Truck drivers (direct feedback)
- DOT website
- City website

Some partners, particularly those in the transportation sector, employ private sector vendors. Small changes in temperature and timing have a large economic impact on the transportation industry; therefore, these partners find added-value in using the services of a private sector vendor specializing in surface transportation.

As an event unfolds, partners tend to broaden their sources to include real-time information such as from truckers, road cameras, or DOT websites. Part of the dependence on real-time information stems from a perception (and a scientific reality) that winter weather forecasting is complicated and uncertain. Because partners understand and expect that a forecast will change, they depend on both the NWS leading up to an event and real-time sources during the event. A Wyoming school partner explained, "When you shut schools down, you shut a community [e.g., businesses] down. It's a delicate decision, depending on when you shut it—early release, late start, closure. We've had a few times where we closed down in the morning and by noon it's nice and [the] community is in an uproar."

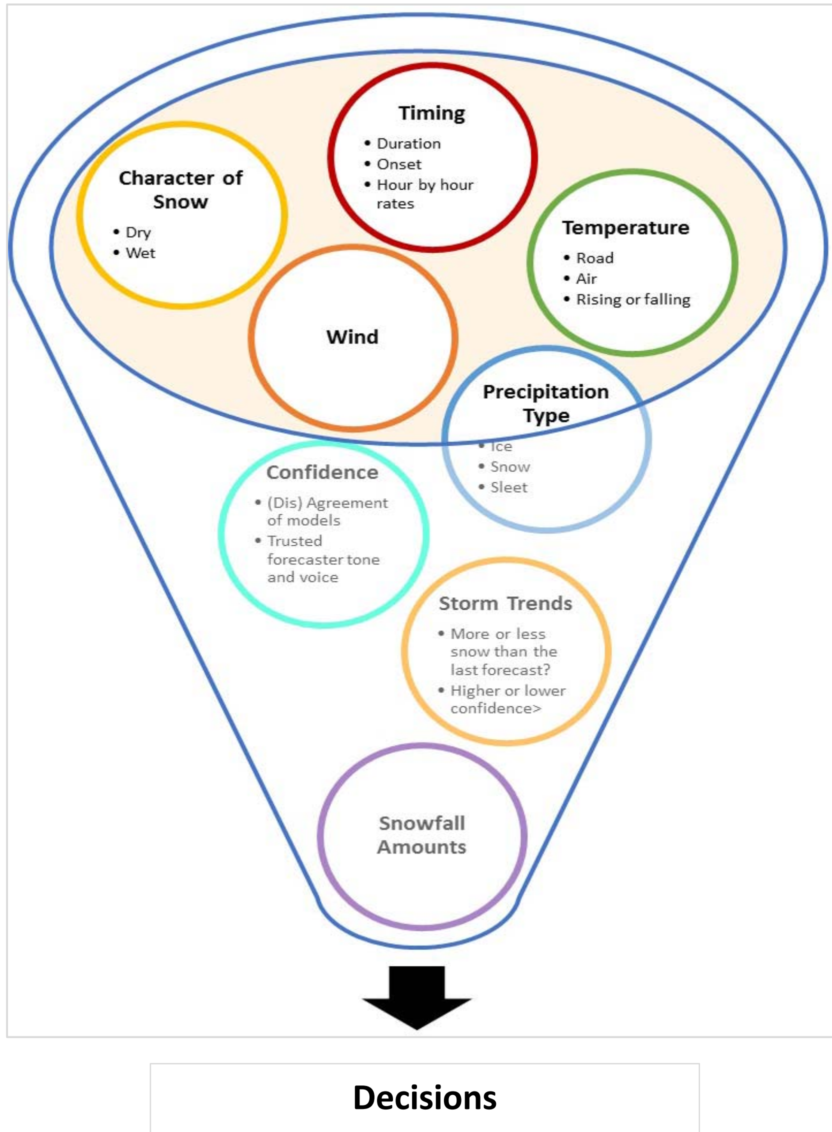
Winter Weather Forecast Needs

Partners feel that the NWS is largely meeting their winter weather forecast needs, especially with the new, bulleted information contained in Winter Storm Warnings that enables them to find information faster than in the old format. Partners also praised the change to mixed case font. Some partners felt that it was not intuitive to look for snow intensity information in the timing bullet, however. Others felt that trend information was missing altogether from the warning text and wanted to know how one forecast compares to the previous. Are snowfall amounts on the rise? Is the temperature decreasing or increasing? Are the models trending in agreement or disagreement? They remarked that decision support briefings sometimes include this information, even if the warnings do not.

Variables

Leading up to an event, partners seek all available information about different winter weather variables, from potential snowfall accumulation totals to model agreement to temperature trends. However, partners indicated they consider a *combination* of these variables in their decision-making, rather than a single variable, such as snowfall amounts (see Figure 1).

Figure 1. Summary of winter weather forecast variables used for decision-making



For example, snowfall amounts of 6–12 inches have different impacts during the day versus the night. The precipitation order, such as rain to ice to snow, combined with decreasing temperatures, impacts whether DOTs can use brine solutions before a storm and/or salt during the storm. The intensity of the snowfall per hour will impact if plows and buses can continue to stay out on the roads safely. Eight inches of heavy, wet snow combined with winds may impact powerlines or down branches. Although snowfall amounts play a factor in some of these examples, it is not necessarily the *key* influence. Rather, partners find value in combining winter weather forecast variables.

Timing

Partners indicated that the variable most critical for decision-making is *timing*. A New England DOT official said, "Timing, timing, timing. We want to know what to expect, when we will have plows on the road, when will we need to contact schools." Partners stressed that *all* decisions depend on the time of day. In fact, a North Carolina DOT representative said, "Whether it's 4, 7, or 10 inches, we deal with it the same way. It's about the timing." Their procedures remain the same regardless of the event, but *when* they initiate those procedures depends on the forecast timing.

Geographic Differences

While timing is the most critical forecast variable for decision-making in all states, partner needs also vary by geography:

- **Northeastern states**. These partners are the most dependent on snowfall amounts and the only core partners who stated that have formal snowfall thresholds for decision-making. They are also concerned with coastal flooding associated with winter storms. Given this area's vulnerability to nor'easters, uncertainty associated with the rain/snow line is also of great interest.

- **Central and Southern states.** These partners are highly concerned with precipitation type (e.g., rain, snow, or ice) and order. Ice storms pose a larger risk than snowstorms to power utilities in this region. As a result, the precipitation type has a significant influence on the actions the state EMs and DOTs may take. The precipitation order impacts how DOTs use brine, salt, and sand solutions for treating roads before and during events.

- **Western states.** These partners emphasized the role that wind plays during and after winter storms. Wyoming partners emphasized the dangers posed by "blue sky winds" that circulate already fallen, dry snow. Winds reduce visibility on roads, making it difficult for DOTs to respond and for buses to travel. Buses are not only used to transport K-12 students to and from schools, but also for long-distance travel to sporting and music events. Location and terrain also influence partners' response in these states. Mountain communities often know how to handle the snow better than urban areas. However, the terrain also makes trusting the forecast more difficult, as timing, intensity, and snowfall amounts vary widely from location to location.

Decision Types

Partners in different sectors make different kinds of decisions, but nearly all partners make decisions as a group rather than individually. Table 4 summarizes the major decisions types by sector.

Table 4. Decision Types by Sector

K-12 Schools	Colleges and Universities	DOTs	Aviation	Emergency Management	Other
Cancel school	Cancel classes	Partial shutdown of highways	Clear runways	Activate emergency operation center	Trucking: Dispatch trucks Public ski resort: Open or close, depending on safety on road conditions
Delay school opening*	Delay classes	Complete shutdown of highways	De-ice/anti-ice planes	Open shelter (for stranded motorists or for roof collapses)	Public trains: Reduce service to indoor tracks or shut down system Public buses: Open or close, depending on road conditions
Schedule early release*	Schedule early release	Travel bans	Cancel flights**	State EMs: Provide open, close, delay, or early release status for state government	Parking bans
Cancel extracurricular bus trips (i.e., sporting or music events)	Cancel evening events	Pretreatment	Close airport***		
		Plow deployment			
		Staffing			

*NYC only closes. There are no delays or early releases.
**Individual airlines make that decision.
*** Wyoming has *never* shut down its airport.

Schools

The timing of snow events, snowfall rate, and a combination of wind and temperature are the most critical factors for school closing decisions. The snow timing potentially impacts bus safety and the staff's ability to drive to work. Timing also influences when schools announce their closures. Snowfall rate or intensity matters because buses may not handle well in fast-falling snow. Extreme cold temperatures and wind chill are important considerations for schools with students who walk to school. In addition to weather information, other factors that influence school decision-making include:

- Costs
- Time/efficiency of contacting parents and staff
- Ability of parents to drop off late or pick up early
- Sidewalk/walkway status and safety for walkers (versus bus riders)
- Safety of roads and school bus routes
- Status of surrounding school decisions
- Parental pressure to close
- Media hype
- Snow removal equipment inventory

Political factors and social pressures can play a key role in schools' decisions to delay, cancel, or schedule an early release as these decisions impact people's livelihoods and the local economy. In addition, colleges and universities that cancel classes must still keep the campus open for residents and staff, as well as related services such as public healthcare facilities. School superintendents in all regions cited the social importance of providing lunches to children. A Georgia school official explained that closing decisions weigh heavily on their superintendent, as school lunches are some students' only meal of the day.

Additionally, every school in every state must satisfy *their* core partners: parents. Superintendents shared that parents will sometimes inquire days in advance about school closures. Television and social media hype about an impending storm often contribute to parental concern. Some partners admitted that if the parental pressure is too high, they will close school even when they know their community can handle the storm.

Local impacts are also important. While school officials are interested in knowing forecasted snow amounts, understanding *how* snow totals will impact roads is more useful. For this reason, schools maintain close relationships with their respective DOTS and public works and confer with officials in making closing decisions.

In some areas, the availability of snow removal equipment also plays a role in decision-making. Schools and universities that experience snow more often (Western, Central, and Northern states) have their own snow removal equipment for sidewalks and parking lots. The cost to purchase snow removal equipment in Southern schools, however, typically outweighs the benefit. This lack of equipment often means that that the threshold for closing school in the South is snow versus no snow. *Any* amount of snow (or ice) will thus close their school systems.

Transportation Sector

State DOTs and local public works depend heavily on winter weather information to make decisions, particularly related to staffing and snow removal. Key winter weather variables that inform their decision-making include timing (onset and duration), changing precipitation type, temperature (air and road), and snow intensity.

Storm timing and duration are critical factors for planning operational shifts. For example, for short duration storms with some geographic specificity, DOTs and public works can localize their efforts without needing to call in additional staff or contractors. For long duration storms, especially with widespread geographic impact, DOTs must place staff on call and perhaps bring in additional contractors, depending on equipment needs. Storm duration, in combination with other factors (snow intensity, temperatures, snowfall amount, etc.) can have a large economic impact. Despite a change in the forecast, once DOTs (and airports) call in contractors, payroll commences. Thus, timing influences their staffing decisions and their economic bottom line.

Another large consideration is plow operator schedules, which varied by geography. All regions had limits for the number of consecutive hours plow drivers could operate to ensure driver safety. While 12-hour shifts were most common, some states had complex rules such as 8 hours on, 4 hours off. Storm duration is the key weather factor affecting these decisions, followed by a combination of road and air temperatures, precipitation types, and snow intensity. For example, DOTs do not want to pre-treat roads with costly salt or brine if there is a chance that rain will wash it away. DOTs also choose road treatments based on temperature, as not all work at extremely cold temperatures. DOTs use hourly forecasts with precipitation type and potential temperature changes to help them improve their decision-making.

Storm timing information is critical for preparing the snow removal truck fleet. The North Carolina DOT explained that it needs to know when to swap out treatment materials on its trucks. Trucks often brine in advance of a storm, and then must return to their stations to switch to salt once a storm begins. Although snowfall amounts are helpful for estimating how much salt they may need, their operations do not change based on snowfall amounts. Whether it is 4, 7, or 10 inches of snow, they still operate at 100 percent capacity. However, snowfall amounts in combination with snow intensity *do* inform their decisions. Snow intensity rates of 2 inches per hour will stop plow operations.

Aviation Sector

There are some commonalities and differences between the transportation and aviation sectors. On the one hand, airports have runways that require snow removal, and thus timing and treatment types also play an influential role in their decisions. Unique to airports, however, is their coordination with the Federal Aviation Administration (FAA). For example, Denver International Airport (DIA) has peak air traffic windows during certain points of the day. If DIA knows that snow will start accumulating around 4 p.m., which is a peak time for in-bound traffic, it will start treating its paved surfaces around 3:00 p.m. The airport will also work closely with the FAA to efficiently route planes, thereby reducing holding patterns and the amount of fuel burned on the runway. In this case, the timing of *accumulating* snow is the important threshold for their decisions, not necessarily snowfall amounts alone.

Airport officials also mentioned a specific challenge for decision-making: predicting the location and timing of narrow snow bands, which can negatively impact air traffic flow. Distinct from a large snow system, snow bands are not as easy to predict. Therefore, the lead time is much shorter for these types of events as compared to large snow systems. Airport representatives suggested that more research in this area would help reduce impacts on the aviation industry.

Emergency Management

The formal role of EMs during winter weather events varies from region to region. Unlike tornadoes or hurricanes that pose a clear risk to public safety, winter weather impacts on public safety are more ambiguous. EMs in the Northeast commonly provide recommendations on closing decisions to local schools, mayors, and governors. In other areas of the country, however, EMs stated they have no formal role in these decisions. Some EMs also said that they forward NWS information to appropriate decision-makers. For example, a county EM in Wisconsin has an email distribution list for all schools.

EMs described their role as "in the background." They will help organize and coordinate state agencies, but state DOTs often take the lead in decision-making. If winter weather events reach a certain impact threshold, EMs may activate their emergency operations center (EOC). Large impact events (as measured by ongoing need and accidents) can even warrant a call to the National Guard for assistance. These decisions must have an associated high level of forecast confidence, however.

Considerations to activate an EOC include the following:

- Are drivers stranded on the highways?
- Are there any multi-car accidents?
- Will the weight of the snow impact power lines or potentially collapse roofs?
- Is sheltering necessary for stranded drivers and house occupants with collapsed roofs?

Reduced visibility due to snow intensity and/or winds are the primary indicators that EMs may need to activate their EOC because these weather factors often lead to increased accidents. They also consider the character of the snow (dry versus wet) and the precipitation type (snow versus ice) because these are measures of power outage potential. The location of the storm also influences EMs' decision to activate. For example, Colorado EMs explained that they might not activate as often in mountain communities that are well-versed in winter storms as they would in a high population corridor, such as Denver.

Much like closing schools, activating an EOC is a costly—and often political—decision. EMs explained that they consider all forecast information available, real-time DOT information, their team's input, and politics when making decisions.

Snowfall Thresholds

Given all the winter weather information needs, partners rarely make decisions based on snowfall amounts alone; instead, they rely upon a *combination* of forecast information. A Wisconsin DOT official summarized the predominant sentiment among partners: snowfall amounts are "nice to know," but he needs to consider that information in combination with snow character, wind, temperature, snow rate, timing, etc.

However, snowfall amount thresholds do exist in some areas and sectors (see Table 5), and in some cases, these thresholds do trigger particular actions.

Table 5. Snowfall Amount Thresholds by State and Sector

Colorado	
DOT	No thresholds based on snowfall amounts. No statewide plan; instead, all 240 of its patrols have a unique winter operation plan based on a combination of real-time information plus their experience with historical problem areas.
EM	No formal snowfall amount thresholds. Road conditions, impacts, and politics are primary considerations.
Connecticut	
DOT	No formal thresholds, but snow amounts do have impacts on the state (e.g., 12 inches of snow during a workday will shut down the state at a cost of $25 million/day). Officials plan for the worst-case scenario, even though they are "pretty confident it is not going to happen."
Georgia	
Schools	Snowfall amount threshold = any amount of snow due to the lack of snow removal equipment.
Massachusetts	
University	No formal thresholds, but do have thresholds for when to coordinate information and discuss cancellation decisions, including a forecast of 6 or more inches, a rate of 2 inches/hour, or a complex weather situation.
Schools	No formal snowfall amount thresholds. Normally stay open for up to 3 inches. Between 3–5 inches = factor in outside information. Over 6 inches, may close schools, but consider other factors such as road conditions.
Kansas	
DOT	No formal snowfall amount thresholds. Primarily use temperature and snow rates/hour.
Schools	No formal snowfall amount thresholds. Primarily concerned with character of the snow and winds.
North Carolina	
DOT	No formal snowfall amount thresholds. Primarily use precipitation type, timing, and intensity.

Schools	No formal snowfall amount thresholds, but consider the following: • 1 inch of snow or less: pay close attention, but remain open. • 1.5–2 inches: discuss cancelling tomorrow's plans (events, sports, etc.). • >2 inches = talk about closing. Note: any amount of snow may close schools, especially if it is at the wrong time (no snow removal equipment). • Any snow = pay attention and monitor. • Very large amount of snow = crystal clear shutdown.
New York	
EM, DOT, Schools	NYC has very specific thresholds due to its reliance on public transportation: • Outside subways: close at 8 or more inches. • Outside commuter rail: close at 12 inches or more. • Buses and paratransit: close at 10 inches or more. All thresholds are listed in an NYC Office of Emergency Management guidebook. A large percentage of the population depends on public transportation, so the snowfall thresholds that close public transportation also influence school closures and driving bans.
Wisconsin	
DOT	Contracts snow removal to counties and then subsequently compensates their drivers. Counties have criteria on amounts that equate to staffing needs.
EM, Schools	No formal snowfall amount thresholds. School closing thresholds depend on temperature and wind chill (which must be below -35 degrees ºF).
State Police	No formal snowfall amount thresholds. Staffing decisions depend on other weather factors, such as localized versus widespread impacts. Cities may have thresholds for side street parking and snow emergencies.
Wyoming	
Airport, EM, Schools	No clear snowfall amount thresholds. Snow intensity forecasts are uncertain due to radar distance, and snowfall amounts are often inaccurate due to terrain changes and microclimates. Threshold is whether snow is present or not. Plow regularly because the state receives consistent snow and the public expects clean roads.
DOT	No clear snowfall amount thresholds. Primarily make decisions based on air and road temperatures. Snow intensity also plays a role.

When Partners Make Decisions

In response to when partners make their decisions, the overwhelming response was "as early as possible." However, partners recognize that winter weather forecasts are uncertain, which makes it challenging to adhere to consistent timelines for decision-making.

School superintendents *prefer* to make decisions the night before a storm rather than the morning of an event. Making decisions the night before allows more time to inform parents and staff and provides more time to make childcare arrangements. If a winter weather event is highly uncertain, they may wait until morning, or make a decision based on the worst-case scenario.

State government closures are made by the respective governor of the states, who may have different preferences for making this determination. For example, the Colorado governor prefers to make decisions during the early morning of an event.

DOTs and airports start planning staff schedules days in advance of an event. They use hourly forecasts to make decisions on when to start brining or salting the roads or runways. Knowing when accumulating snow will start is key for both DOTs and airports. Thus, they have no specific decision point time. DOTs operate 24/7, while airports operate as long as they are open. Airlines make specific decisions about flight cancellations.

How Partners Perceive and Use Probabilistic, Uncertainty, and Confidence Information

During winter weather events, uncertainty, confidence, and probability all play a role for partners represented in the focus group and simulation samples. However, users across the samples repeatedly conflated these definitions. When ERG asked if partners incorporate probabilistic information, such as percentages or percent chance of snow, into their decision-making, many said yes. But, when they described *how* they incorporate probabilities, it became apparent that they were conflating the use of confidence as a probabilistic measure. For example, when asked to what extent probabilistic information played into his decisions, one partner said "It plays a huge role… If we have a high confidence level about some kind of accumulation or high probability, we may choose to move resources in advance to be more proactive in our response to the event." ERG further probed the participant by asking if probability and confidence meant the same thing to him, to which he replied, "Yes... decision-makers use the terms interchangeably. So, if the probability is high, we assume your confidence is high."

Use of Probabilistic Information

The partners did not reach consensus on whether they need and/or would use probabilistic information; however, *no* partners in our sample base their winter weather decisions solely on probabilistic information. Some partners like probabilities since they help increase their situational awareness and knowledge of the storm. One Georgia school official said, "It would be helpful to know the probabilities… Anything we can get is helpful. There's no reason not to have it." Other partners expressed reservations about probabilities. One said, "Personally, I don't like [probabilities]. Some people like it, but I don't. I would rather have a range of numbers. I prefer uncertainty communicated through ranges."

Additionally, all partners acknowledged that weather forecasts are inherently uncertain, especially those pertaining to winter weather. A North Carolina school official explained that "We don't rely on [probabilities] because we appreciate it's the weather. We can't say with 100 percent certainty what anything will be." While there was uniform understanding among all partners that uncertainty exists and forecasts *will* change, there was not a uniform understanding of probabilities.

For example, a North Carolina school official explained that his staff have a visceral response to the percentage assigned to winter weather. He said, "I won't get terribly worked up about 12 percent of dusting. If you tell me 100 percent for 6 inches, full operations started. On the other hand, we have had probabilities provided to us that were very high that did not pan out." However, he provided an anecdote that highlighted the danger in subjectively interpreting probabilities, recounting a winter event where there was a "22 percent chance of snow one night." He perceived this as a low probability and thus decided not to delay or cancel school. The next morning, the road impacts were significant enough that he had to chase a school bus down to stop it from leaving, and he noted, "I will never not prepare again based on less than 25 percent, because I was not ready."

Taken together, the feedback indicates that partners interpret probabilities subjectively based on their past experiences. This complicates decision-making, as most partners make decisions in a group environment. With no shared meaning amongst a group, the probabilities do not carry much weight. Additionally, the partners' emphasis on prior events when discussing probabilities suggests that they depend on past experiences for context to make sense of what these probabilities mean.

Furthermore, during the simulation interviews, ERG specifically asked participants to assign a percent chance to the corresponding minimum/most likely/maximum amounts for a specific location. Two major patterns emerged for how participants perceive the probabilities. Some participants assigned a 1 out of 10 chance (10 percent) to both the minimum and maximum maps, while others perceived the chances as 9 out of 10 (90 percent) for the minimum map and 1 out of 10 (10 percent) for the maximum map, indicating that there are at least two distinct ways the participants perceive the percent chance (i.e., bell curve versus downward slope). However, the graphics did not prompt consistency in how participants assigned probabilities, and no trend (10 percent versus 90 percent exceedance) was universally favored.

These results do not indicate that probabilities are not useful or that stakeholders never factor probabilities into their decision-making. Rather, the feedback suggests that there are recurring challenges processing and understanding probabilities, and that users interpret probabilities in different ways. This finding highlights the importance of the NWS explicitly stating the probabilistic basis of its products and of providing more context around probabilities (i.e., through IDSS) to inform partner decision-making,

Use of Confidence Information

All partners in all regions expressed that they factor forecast confidence into their decision-making process. Partners defined forecast confidence using the following attributes:

- *Model (dis)agreement.* Partners watch for changes from one model run to another. In decision support briefings, NWS forecasters often mention how the most recent model run compares to the previous runs. If the models are consistent, partners perceive this as high confidence. If models diverge from run to run, partners perceive this as low confidence.

- *Rain/snow lines.* Especially in the Northeast, partners want to know where the rain/snow line is and how much its placement has changed from one forecast to another. Partners also perceive large changes in the position of the rain/snow line as a sign of less confidence and small changes as more confidence.

- *Multiple sources*. Partners synthesize forecast information from multiple sources. When these sources have similar messages, partners feel more confident. Conversely, when these sources provide vastly differently forecasts, partners feel less confident in the forecast.

- *Forecaster interpretation and intonation.* Partners emphasized the importance of forming personal relationships with NWS forecasters and getting to know their personalities and tone of voice. When partners hear that trusted, credible individual, they have more or less confidence in the forecast based on how that forecaster describes the situation.

- *Explicitly stating confidence.* Partners look for words that explicitly convey high or low confidence in NWS text products, as well as listen for these keywords during NWS decision support briefings.

- *Use of ranges.* Partners perceive high or low confidence based on the range of snowfall amounts. Narrow ranges convey high confidence whereas wide ranges convey low confidence.

Partners indicated that they depend more on forecast confidence than probabilities. A Colorado EM explained, "I don't know that [probability] plays a role for me most of the time. Could be lack of info and understanding on my part. We will factor in confidence levels more so than probabilities." A North Carolina school official echoed this sentiment, stating that confidence "was something we saw from our local WFO [in briefings]. They would put a degree of confidence… and if there was high confidence, we were more apt to pull the trigger and do something."

The results show a recurring reliance on multiple forecasts, model alignment, and the human forecaster across participants in all geographies, suggesting that partners universally need more context (e.g., forecast confidence) than just probabilities before making decisions. One such piece of context may include forecast trends, as partners consistently asked how the forecast changed from one model run to another (e.g., are temperatures increasing or decreasing?). The results do not suggest that *no* NWS partners find probabilistic information to be useful. Rather, probabilistic information may *inform* what forecasters provide—along with a variety of other contextual information such as confidence—to partners through IDSS.

This repeated reliance on forecaster input results also echoes what concerns expressed during the WFO interviews.[1] During this phase of research, some offices expressed concern that disseminating model output without editing may underestimate or overestimate snowfall totals because of the way the models automatically bin the totals, leading partners to be underprepared or overprepared.

[1] See page 4 of ERG's October 31, 2016, memo "Summary of Findings from Interviews with Select Weather Forecast Offices on the Probabilistic Snow Products."

Part 2. Graphical and Messaging Feedback

During the focus groups and simulation interviews, ERG showed participants each type of graphic without any explanations. At the end of the sessions, ERG provided more context on the graphics and explained how they are produced by the NWS using a combination of model and human forecaster input. In both phases of research, participants provided suggestions for improving the visuals and messaging of the graphics. The feedback from both the focus groups and the simulations are presented below. Please note that the following information represents the viewpoints of a limited number of participating partners, and these suggestions are not representative of the larger partner populations.

Familiarity and Access

Core partner familiarity with the graphics was largely due to WFOs' IDSS. Many partners stated that they had seen the "Most Likely Snowfall" graphic or "something similar." These same partners were often unaware of the full product suite. Additionally, some partners mentioned seeing graphics "like these," implying that many NWS graphics have the same look and feel.

Website use and access varied by stakeholder type, especially as it related to their geographic needs. For example, local or town-based school superintendents access the NWS website by entering their zip code. In doing so, they bypass the WFO page and the initial access point to the snow information. Given that county superintendents need a broader geographic region, these partners access the local WFO page, though not all partners knew where to find the link to the winter page.

Additionally, not all partners found the NWS website intuitive. One partner knew exactly where the winter weather page was for his area but was unaware that there were many products on the page. Suggestions included having the winter weather page at the same location on each local WFO website, as well as providing an overview of links to the individual products at the top of the page.

Minimum/Most Likely/Maximum Maps

Overall, partners liked the minimum/most likely/maximum suite of maps better than any other product and provided the most feedback for these graphics. Major issues and partner suggestions included the following:

- **The map titles confused partners.** Several participants did not read and/or understand the titles of these graphics. Partners also suggested adding the word "Snowfall" to the minimum and maximum maps, which currently do not specify the precipitation type.

- **Partners want to know the probabilities.** While probabilistic snowfall forecasts are only one variable that partners may consider in decision-making, if the NWS continues to put out these maps, partners do want to know the probability basis used. Since the maximum/most likely/minimum maps do not indicate the probability basis, partners tended to interpret them as either a bell curve (e.g., 10 percent for minimum, 50 percent for most likely, 10 percent for maximum) or a downward slope (e.g., 100 percent for minimum, 50 percent for most likely, 10 percent for maximum). They suggested that adding the probabilities to the maps may help them consistently interpret the data, as well as equip them with better situational awareness about an impending event.

- **Some partners thought three separate graphics were unnecessary**, and that having to look at all three created more work to understand them. They suggested combining the graphics into a single official forecast map while adding a mouse-over to show the range of minimum to maximum snowfall amounts for each location.

- **Partners did not like the WFO-specific zoom levels.** Partners found the font size difficult to read when zoomed too far out (e.g., Alexandria, MN), and suggested maximizing all space provided for the WFO area to reduce any unnecessary geography.

- **Some partners do not need the minimum map** because they never make decisions based on the lowest amount of snow. They suggested eliminating the minimum graphic altogether.

- **Many partners prefer ranges.** They suggested using ranges as the default on all the maps as they feel people focus too much on specific numbers. They also remarked that the toggle feature to switch to ranges was too small and should be more visually prominent.

- **Partners thought that the graphics look too polished** and convey a level of precision that weather models do not have. They suggested adding an uncertainty swath to the locations with lower confidence, especially as it pertains to the rain/snow line placement.

- **Partners thought the graphics were too static.** They felt that the graphics convey a snapshot of the storm at one moment in time and wanted to see how the maps change from model to model as timing is critical to their decision-making. They suggested that the NWS archive the graphics so they can see how they've changed from the previous forecasts. Seeing a few snapshots over time will improve partner confidence in the forecast.

- **Partners did not uniformly understand the timeframe on the graphics.** Some individuals interpreted it as storm duration. Others stated that the snow would fall somewhere in that timeframe. All participants felt it is too large and suggested decreasing the time window. Partners ideally want to see hourly snowfall information, but they also mentioned 3-, 6- and 12-hour segments as more useful.

- **Partners believed there is a disconnect between the snowfall amounts and the ranges in the color bins.** Some participants overestimated the amounts in their area based on the map color bins. They asked if the NWS could unclip the range and reduce it to the range of the storm.

Threshold Map (Percent Chance of X or More)

Overall, partners viewed the threshold map as the least useful and most frustrating of the products, particularly if they were to use it during a severe weather event that requires timely response measures. Major issues ERG uncovered about the threshold map included the following:

- **Partners expressed mixed sentiments about using probabilities.** Many partners explicitly stated that percentages don't work for them because probabilities don't provide the full context, particularly about impacts. They also repeatedly said that probabilities are confusing and "do nothing" for them, emphasizing that they would need a trusted NWS forecaster to walk them through the meanings. Yet others liked seeing the spatial difference in the percent chance, as it gave them more confidence in areas more likely to see snow. Some partners suggested that training may increase the map's value to them, but others said that they may never want to use this type of probabilistic display.

- **Partners perceived color scales as snowfall amounts, not probability.** Even those who clearly read the Probability (%) label on the map's axis explained that they are trained to perceive color as snowfall amount, making it difficult to process color as probability. One partner stated that it is difficult to "un-train my brain." They suggested using a different color scale (e.g., shades of one color) for the percent chance maps than the snowfall accumulation maps to ensure that there is no confusion between the products.

Probability Table

Overall, the probability table was fairly intuitive for partners to read. Most participants said they preferred the minimum/most likely/maximum maps to the table, but upon seeing the full set of graphics, they valued having both and suggested linking the two products (e.g., give user the ability to mouse over a location on the map and a popup appears with the table information). Some issues ERG uncovered about the table included the following:

- **The table headers confused partners.** Despite conveying the same information as the minimum/most likely/maximum maps, the table headers ("At least," "Likely," and "Potential for") do not match the map titles ("Expect at Least This Much," Most Likely Snowfall," and "Potential for This Much"). The inconsistency confused some partners, who did not connect the two products. For example, one participant explained that he assigns a higher percent chance to the phrase "most likely" than to "likely."

- **A few partners read the >= sign incorrectly.** They instead read it as a <= sign. As these math signs are not commonly used in all partners' day jobs, the NWS may want to consider writing out "greater than or equal to" to reduce any potential confusion.

Part 3. Findings from User Journey Interviews with CDOT

Background

In January–February 2018, ERG interviewed three CDOT partners to explore their decision-making process before and during winter storm events. We used the information obtained during these interviews to construct a “user journey,” which visualizes the process a person goes through to accomplish a goal. In this case, our user journey helped us to better understand how and when (if at all) CDOT partners seek NWS information during winter storms and if their needs are being met.

ERG conducted these interviews as part of a larger NWS project, which used social and behavioral science and risk communication techniques to test and make recommendations for improving the NWS’s suite of probabilistic, internet-based snowfall forecast graphics. In the previous stage of this research, ERG conducted nationwide focus groups and interviews with state and local decision-makers from several sectors, including DOTs, aviation, emergency management, schools, public works, and others.

During this prior phase, partners provided a cursory overview of the kinds of decisions they make when a winter storm is threatening their area, along with the types of information (both weather and non-weather) they need to make those decisions. However, ERG mainly focused on gathering feedback about the probabilistic snowfall suite’s visual design, labels, and messaging.

Ultimately, we determined that while the probabilistic products are useful to have and work well in the Northeast, partners elsewhere need much more weather information than just snowfall amounts, and they often use other sources than the NWS to obtain that information. These findings pointed to a need for more in-depth research to determine:

- What decisions do core partners in other parts of the country make before and during winter storms?
- What information sources do they use to inform their decision-making process?
- What opportunities are available for the NWS to improve and/or offer partners new decision-making resources related to winter weather?

ERG selected the user journey approach because user journey maps help to visualize user-organization interactions. They capture the user’s experience, highlighting key interactions between the user and the organization. The maps also provide context for understanding the user’s experience and capture feelings and frustrations in a way that data-centric approaches often fail to achieve. Finally, they help organizations understand how users interact with information sources and specific products, what decisions they are making, and where and how products and decisions overlap.

Methodology

Sample

Because decision types and decision-maker needs vary widely based on sector and location, ERG decided to develop a user journey for one partner sector in one region of the country: department of transportation officials in the western United States. More specifically, we selected CDOT partners in the Denver/Boulder County area because they:

- **Provide insight into winter weather needs for partners in the West.** The first phase of our research indicated that partners in the Northeast use snowfall amounts to inform certain aspects of their decision-making and that probabilistic snowfall amount products largely meet their needs. However, we did not have in-depth information about what weather variables partners in the West need for their winter-weather decision-making, or what information sources and products they use to inform these decisions.
- **Have extensive experience with winter weather.** Because these partners respond to severe winter weather every year, they can provide meaningful information and feedback about their needs.
- **Serve a large population with urban concerns.** The area is densely populated and vulnerable to high impacts from severe winter weather, including road closures, traffic accidents, power outages, property damage, loss of life, etc.
- **Operate in an area with high forecast uncertainty.** The Rocky Mountains create a lot of uncertainty for winter weather forecasting in this area. Even small shifts in the storm track can result in significantly more or less snow than predicted.

ERG first interviewed the CDOT winter operations manager (who participated in the prior phase of research on the probabilistic product suite) to better understand the organizational structure of CDOT. The winter operations manager is the CDOT staff member who communicates most directly and frequently with the NWS for winter weather events. Other CDOT personnel usually receive NWS information through him.

To obtain a holistic CDOT perspective, the winter operations manager recommended interviewing the following partners, who represent three different organizational levels (manager, supervisor, and on-the-ground maintenance—see Figure 2 for how these individuals are represented with the context of the CDOT organizational structure[2]):

- **Deputy maintenance superintendent:** manages foremen (LTC OPS) in six areas in Region 4, Northeast Colorado (largest region in state).
- **LTC OPS (labor and trades craft operations):** manages/oversees 44 maintenance employees (TM 1–3) in eastern Colorado.
- **TM 2 (transportation maintenance 2):** supervises three maintenance employees (TM 1) in Livermore, Colorado (Highway 287).

[2] The organizational chart in Figure 2 only shows a portion of the larger CDOT structure and is meant to simply demonstrate how the interviewees for the user journey fit into the larger structure and interact.

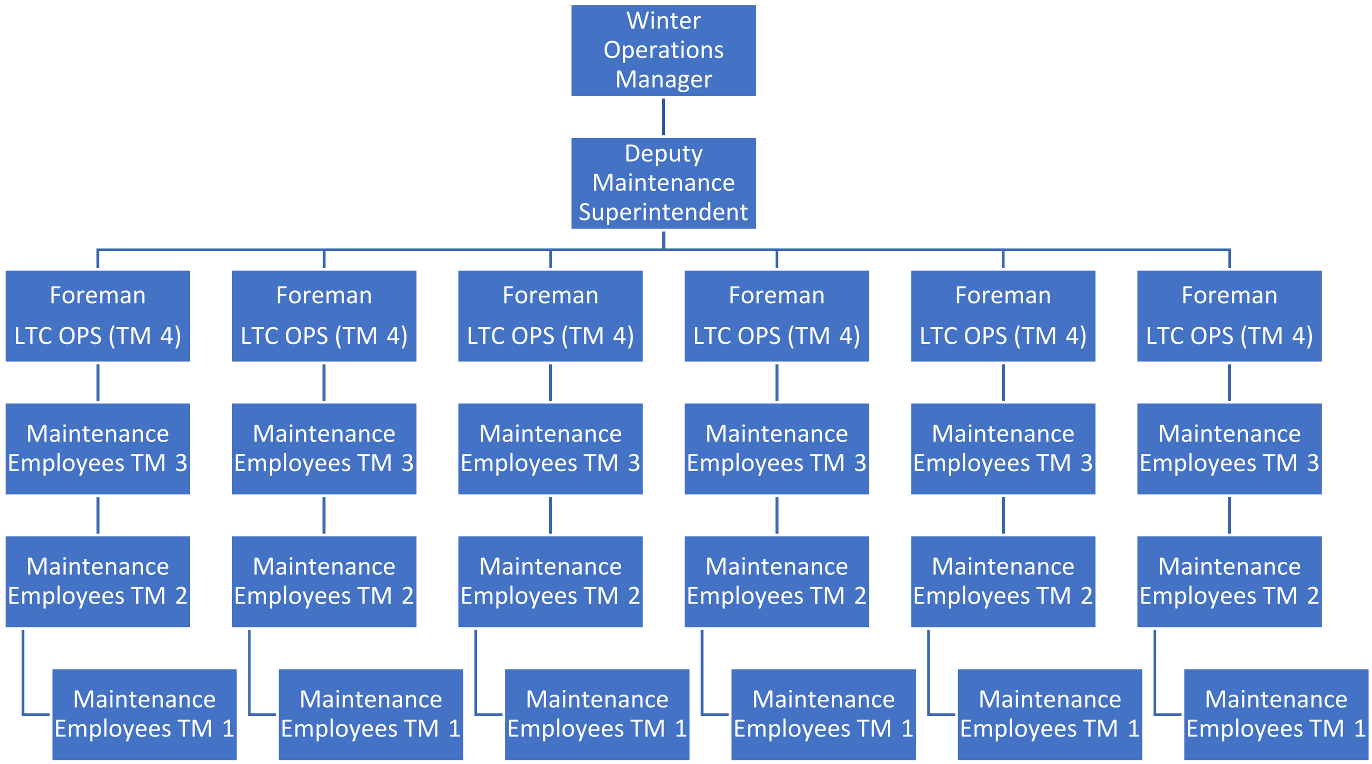


Figure 2. CDOT Interviewees Organizational Chart

Storm Scenarios

ERG worked with the Denver/Boulder WFO and the CDOT winter operations manager to develop a series of six scenarios that represent a realistic winter storm—12 to 18 inches of snow and high winds—with potentially high impacts for Colorado. The scenarios began three days out and culminated at the peak part of the storm.

1. It's Tuesday morning, and you learn that today's forecast calls for a mild day with temperatures in the 40s and thunderstorms possible. You also hear that there could be a chance of snow on Friday, but no other details.
2. Now, it's Wednesday morning. You learn that 8 to 12 inches of snow are possible on Friday. Temperatures have been steadily dropping and are expected to fall below freezing during the night.
3. It's now Thursday morning. You learn that snow is expected to start falling late tonight or early Friday morning, with anywhere from 12 to 18 inches of snow possible, along with high winds. Temperatures are below freezing.
4. It's Thursday afternoon around 4:00 p.m., and you learn that heavy snow and high winds are now more likely, with up to 18 inches of snow starting early Friday morning and accumulating by evening. Temperatures are expected to stay below freezing throughout the day on Friday.
5. It's Friday morning around 6 a.m., and snow has been falling and accumulating for the past couple of hours. Up to 18 inches of snow are expected by midnight, along with considerable winds. Temperatures are below freezing.

6. It's Friday afternoon around 2 p.m., and there are 12 inches of snow on the ground. Snow is still falling heavily, accumulating, and blowing. Temperatures have not gotten above freezing. The storm is now expected to taper off after 8 p.m.

Goals

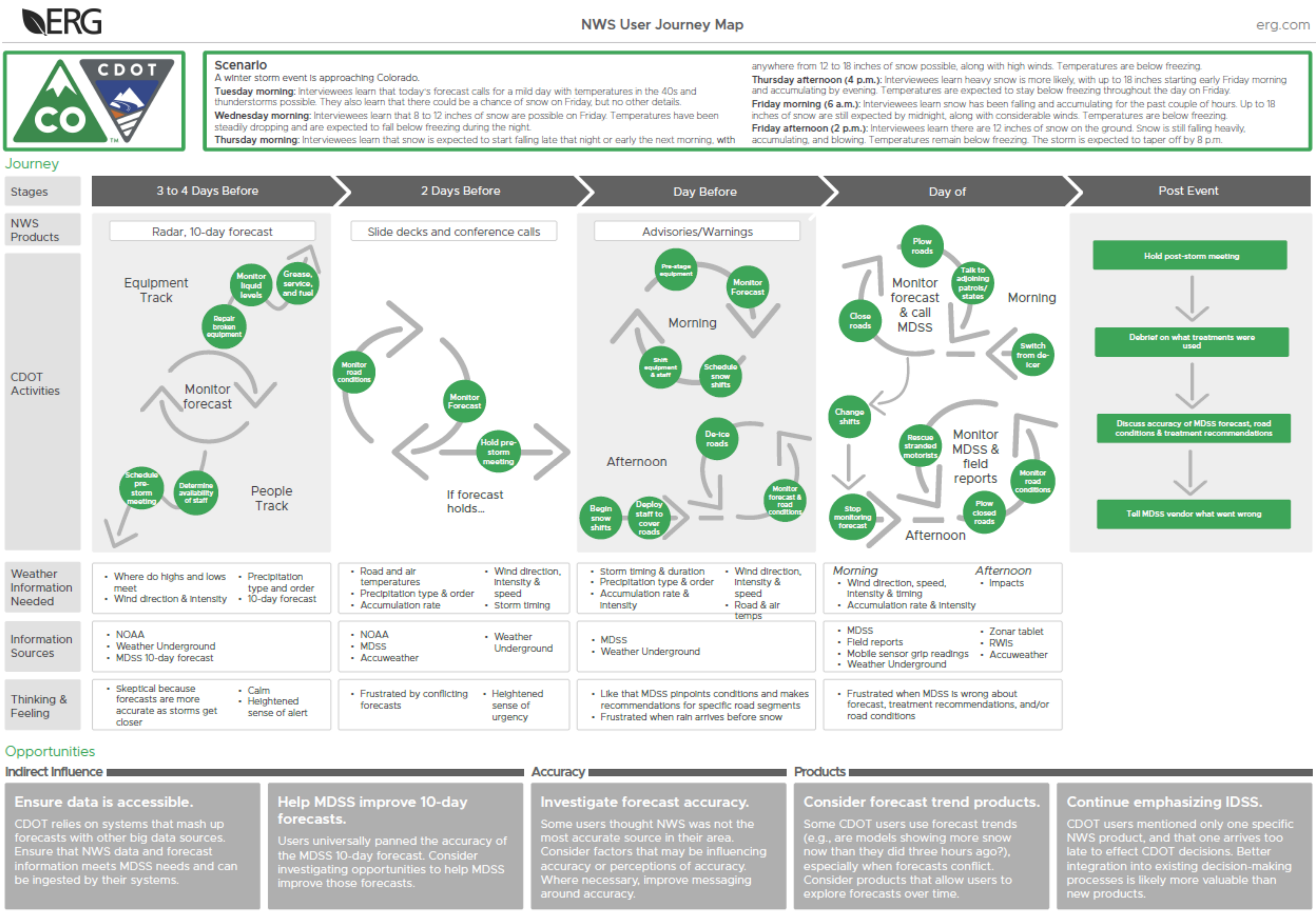
After presenting each scenario, we asked the interviewees to walk us through their day and describe what they would do after receiving that storm information. The goal of the scenarios was to uncover the following information:

- **NWS products:** If, when, and how partners interact with NWS information and products.
- **CDOT activities:** Activities/decisions CDOT partners go through at each stage of a storm.
- **Weather information needed:** All weather variables CDOT considers at each stage.
- **Information sources:** Whether and why CDOT seeks weather information from sources other than or in addition to the NWS.
- **Thinking and feeling:** How satisfied partners are with the information they get/seek from the NWS or other sources (satisfaction may be measured by the degree to which a partner finds the information complete, useful for decision-making, and easy to comprehend/use).

Findings and Analysis

After interviewing the three participants, ERG aggregated the results to create a CDOT user journey map (see next page), which visualizes touchpoints with NWS products, activities, weather information needed, information sources, and thoughts and feelings at each stage of a winter storm.[3]

[3] ERG provided a high-quality version of this map in a separate February 2018 memo on the user journeys.



User Journey Map

NWS Touchpoints

The CDOT interviewees said they rely heavily on the Maintenance Decision Support System (MDSS) for forecasts, storm data, and road treatment recommendations. They were not heavy users of NWS products before or during a winter weather event. While they did mention NOAA, they did not name specific NWS products. Instead, the interviewees spoke more generally about NWS radar, forecasts, conference calls, and slide decks. While some participants mentioned looking at NOAA or NWS sources three to four days before the storm, no participant mentioned NOAA or NWS as an information source the day before or day of the storm.

The interviewees typically combine early-stage NWS forecasts with forecasts from other sources—such as Weather Underground, Accuweather, and MDSS—to get an idea of potential storm severity and to start making preparation decisions. They noted the difficulty they experience in trying to "interpret the forecasts" when they receive conflicting information. One participant also volunteered that NWS forecasts "were not the most accurate" in his area, though he did note that the NWS had been the most reliable source in a geographic area he covered in a previous position.

Winter Storm Warnings and Advisories were the only NWS products mentioned specifically by name. However, one interviewee emphasized that by the time the NWS issues these products, CDOT has already made all decisions/preparations related to the event. The warnings and advisories therefore serve as confirmation that CDOT has prepared appropriately for a storm, but they do not factor into decision-making.

Furthermore, once a severe storm is fully underway, weather variables such as timing, temperature, and accumulation rate become irrelevant. At this point, the interviewees said that they stop monitoring weather forecasts and focus their attention on road impacts, hazards, conditions, and treatment (especially for closed roads and critical areas like bridges). They also rescue stranded drivers and help local law enforcement officials respond to major accidents. During the peak of the storm, they rely exclusively on MDSS and field reports for information about road and weather conditions.

These findings suggest that NWS information plays a limited role in CDOT decision-making in the few days leading up to the storm and has very little direct influence as the storm plays out.

MDSS

The CDOT interviewees mentioned MDSS more than any other information source during the storm scenarios. CDOT's version of MDSS (see Figure 3) was originally developed by the National Center for Atmospheric Research and is now produced by a private-sector vendor (Iteris). Many other state DOTs subscribe to Iteris' MDSS. As noted on the CDOT website, MDSS "combines advanced weather prediction, advanced road condition prediction and rules of practice for anti-icing and de-icing to generate road treatment recommendations on a route-by-route basis." Starting 48 hours out, interviewees rely almost exclusively on MDSS because of its ability to pinpoint conditions and recommendations for specific road segments.

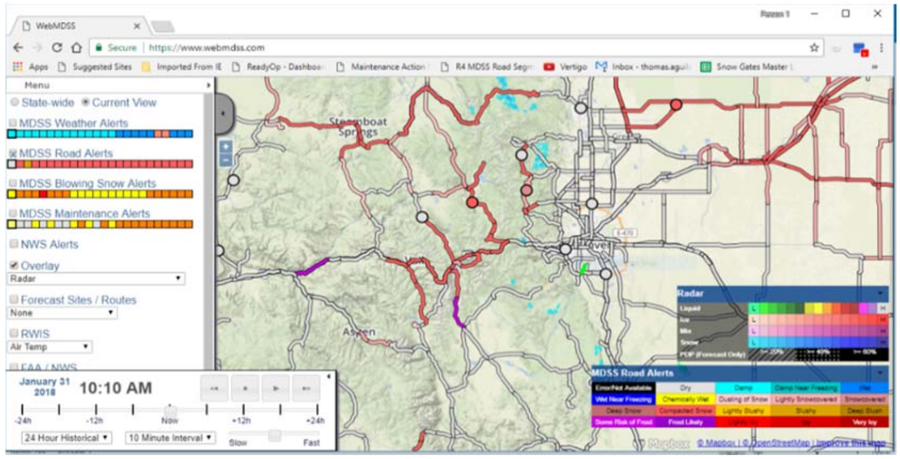


Figure 3. CDOT MDSS

Crucially, MDSS aggregates forecast information from multiple sources (including the NWS) along with detailed data about road conditions and road treatment products and techniques to make algorithmic treatment recommendations. It is that combination of different types of data (sometimes known as Big Data mashups) that makes MDSS so useful to CDOT. CDOT users have very little incentive to examine NWS data separately when MDSS already integrates that information into a more holistic (and uniquely tailored) picture. Where CDOT users do require a more detailed picture of weather information or forecasts, they will frequently call the on-staff meteorologists at Iteris. Notably, one interviewee volunteered that when NWS data conflicts with MDSS, his response is to call Iteris, not the Weather Service.

But CDOT's dependence on MDSS suggests an important—if indirect—line between NWS information and CDOT partners who make on-the-ground decisions. Specifically, NWS provides some of the raw data that MDSS uses in making treatment recommendations.

Partners did note, however, that MDSS is most useful only beginning 48 hours before a storm, when the system begins depicting road conditions and treatment recommendations based on weather information. Before this stage (three to four days out), users can access a 10-day forecast, though they stressed it is often inaccurate. Indeed, all CDOT interviewees specifically called out MDSS as inaccurate, and mentioned that they seek out other forecasts for predictions outside the two-day window. This suggests that MDSS's 10-day forecasts may have accuracy issues that extend beyond the general difficulty of longer-range forecasting.

Appendix A: Focus Group Script and PowerPoint

Focus Group Guide on Winter Weather Communication
Slide 1 – Welcome Slide

Introductions
Welcome and thank you for joining us! This focus group is entirely voluntary, and you may decide to leave at any time. We're excited to hear about your experiences. Before we get started, we will briefly introduce ourselves, explain the logistics of the focus group, and allow you all to introduce yourselves.

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Eastern Research Group will not release your name or information that could identify you as part of this focus group process or in our subsequent reports to NOAA NWS. Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number.

- Introductions
    - Go around the room and have everyone say their name and organization.
    - ERG gives background on project
- Logistics
    - Describe focus group format
    - Announcements (location of restroom, tornado shelter, etc.).

I. General Decision-Making Process (Slide 2)

1. What decisions do you make that depend on winter weather forecasts?
    a. Probe for Staffing policies, telecommuting options, closing schools, limiting access to highways, parking restrictions on roads/parking lots, etc.

2. How do you decide which action to choose? Please describe your process.
    a. Are these decisions made with input from others? Who are they?

3. Are there thresholds of snow amounts that generally lead to automatic action?
    a. What types of judgement calls must you make?

4. What information do you need to make those decisions?
    a. Where do you go to gather information about winter weather?

5. When do you begin planning for a winter storm response?
    a. Does your timeline/needs change between ice and snow events?
    b. Are reaction times different between ice and snow events?
6. When a winter storm is forecast, please explain your information needs starting 3 days before a

storm.

a. Now two days before ...,
b. Day before...,
c. Day of
d. <<If partners discuss general information>>, probe for utility of general information days before the storm
e. <<If partners don't bring up probabilities>>, With all the information sources you have brought up, how do probabilities play a role, if at all, in the messages you receive?

Facilitator Note: See if their needs are more specific as the event nears, and follow-up if clarity is needed.

7. What is your goal in making this decision (what outcomes make a better or worse decision)?

8. What kinds of information about winter storms do you need at this point?
    a. Probe for the following:
        1. Timing
        2. Intensity
        3. Confidence
        4. Precipitation type
        5. Road temp
        6. Accumulation on roads
        7. Character of Snow (wet vs powdery)
        8. Wind

9. Do you usually feel you have enough information to make a decision? Why or why not?

9. Experimental Probabilistic Graphics (Slide 3)

Now we'd like to show you a series of snowfall forecasts and gather your feedback.
(*Show Slide 4 – winter storm warning*)

10. Have you seen this before?

11. How useful is this product to you in guiding your decision-making process? Please explain.

    a. Probe for adequacy of information about timing, intensity, confidence, and uncertainty

12. Least/Expect/Most/Potential Questions – Show Slide 5

a. What does this set of graphics tell you? (Probe for the below questions if not mentioned already)

    i. How do you feel about the **title** of the graphics?

    ii. Do you feel you have enough information to understand what the graphics are communicating?

    iii. (IF they don't mention color) What do the colors represent in this picture?

iv. How do you feel about the **color** representation?

1. Would you change it?

b. Timing – Slide 6

i. What does the graphic tell you about the timing of the snow?

ii. What do you think is the relationship between the time on these graphics with the winter storm watch/warning/advisory products?

iii. Then tell them how the graphic is supposed to work with the timing. Ask if that meets their needs.

c. What do you see as the relationship among the 3 graphics?

i. How would you use these graphics to differentiate snow amounts by location?

d. **(Slide 7)** How useful are these maps in guiding your decision-making process? Please explain.

i. (If useful) Are all three of the graphics equally useful?

ii. Or, is one of the three more useful to you? Please explain.

e. Would you change anything to make it more useful to you?

13. Percent Chance That Snow Accumulation Will Be Greater Than...

a. **(Slide 8)** Show just one image. Explain that it comes in a larger suite of probability greater than 0.1”, 1”, 2”, 4”, 6”, 8”, 12”, 18”. Then show **Slide 9 and Slide 10**). Then show them together on **Slide 11**.

b. (*Stay on Slide 11*) What does this graphic tell you? (Probe for the below questions if not mentioned already)

i. What does it mean to you if an area has a 40% chance of >=4inches of snow, for example?

1. Do you all agree?

ii. How do you feel about the title of the graphic?

iii. Do you feel you have enough information to understand what the graphic is communicating?

iv. (IF they don’t mention color) What do the colors represent in this graphic?

v. How do you feel about the color representation?

1. Would you change it?

2. Do you need more or less levels within the color bar?

3. (at this time, make sure they know it’s probability and not inches)

c. (Show a few different graphics individually then show 3 or 4 on the screen at one time. Explain that on the web, they would be able to toggle over the images).

  i. What does this set of graphics communicate to you?

  ii. Do you feel you have enough information to understand what the graphics are communicating?

    1. (If no) What additional information do you need?

  iii. What do you see as the relationship among the graphics?

  iv. Specifically, what does the changing probability convey to you?

d. How useful are these maps in guiding your decision-making? Please explain.

14. Comparison of "expect/most/potential" to probability greater than – Show Slide 12

a. Please look at both graphics side by side.

  i. What do the colors represent to you in each graphic?

  ii. Should the color scheme remain the same or different?

b. How do these graphics complement one another? In other words, please explain to us what you see as the relationship between the graphics.

15. Chance of Snow Table Questions

a. <<show exceedance – **Slide 13**>> What does this table communicate to you?

  i. Probe for parts of the table, labeling, percentages, etc.

  ii. What does exceedance mean to you?

b. <<show range – **Slide 14**>> What does this table communicate to you?

  i. Do you notice anything different from the previous table?

    1. Probe for ranges

    2. How do you feel about the ranges? Do you need smaller or larger ranges of snow?

c. <<show both – **Slide 15**>> Do you have a preference for exceedance vs range? Please explain.

d. How useful is this table in guiding your decision-making? Please explain.

16. Show all three sets of graphics – Show Slide 16

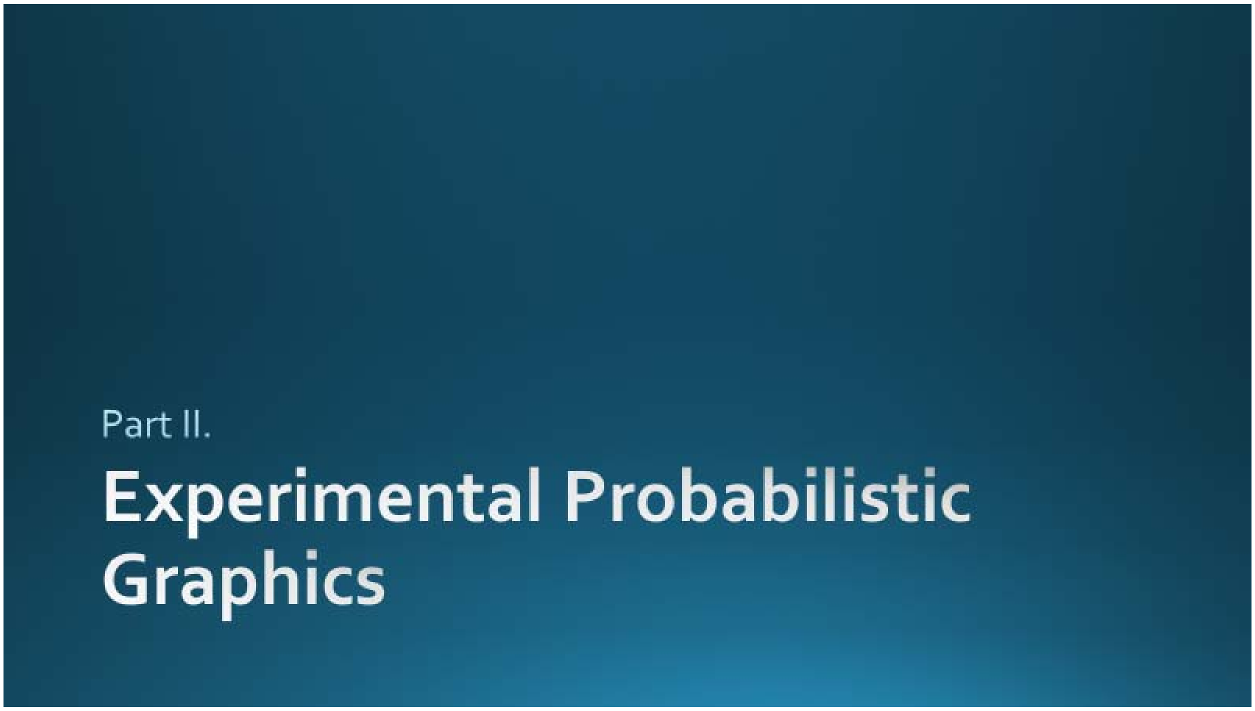
a. What do you see as the relationship among the 3 sets of graphics?

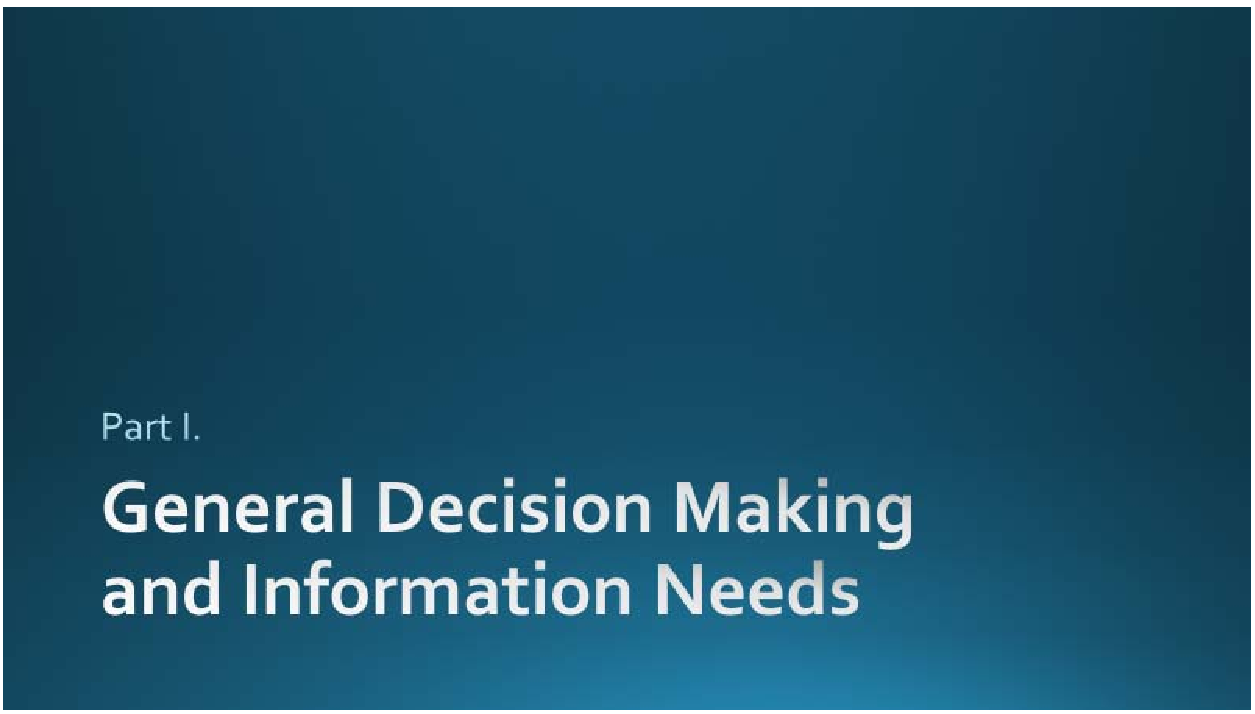
b. Relative to your decision-making needs, do you have a preference for one graphic over another? Why or why not?

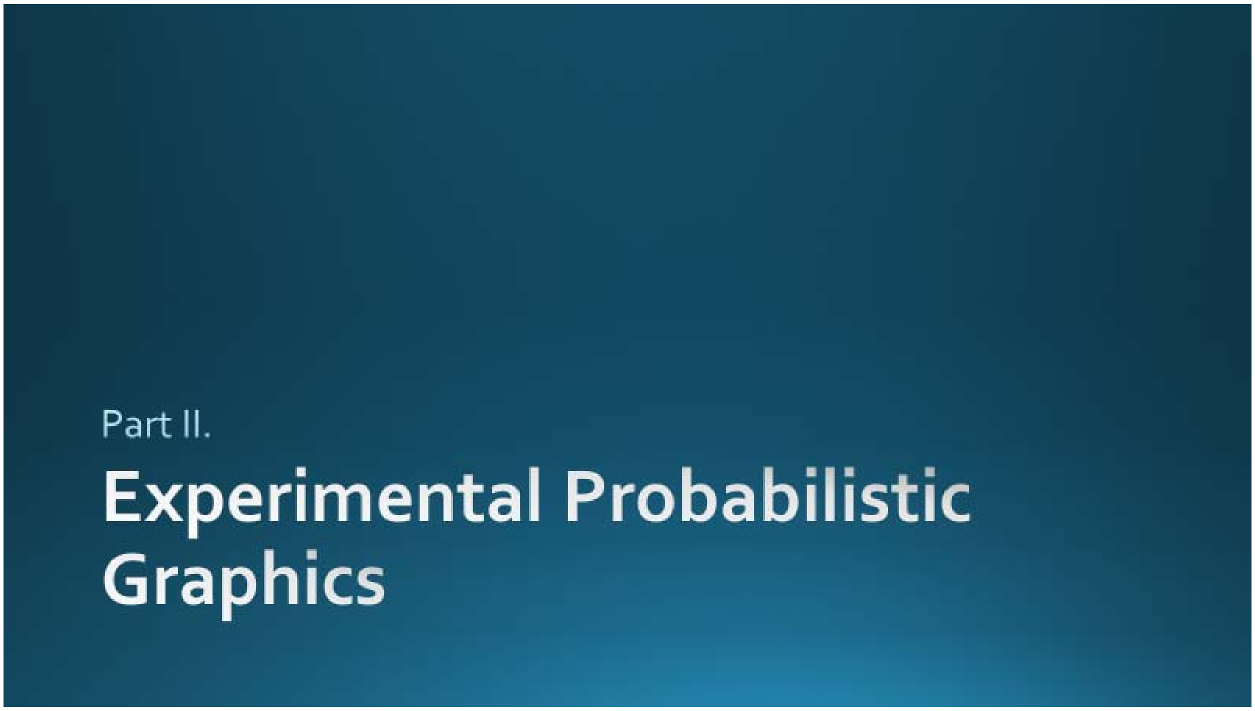
c. Are there any graphical changes you would make now that you can see all three together? If so, please explain.

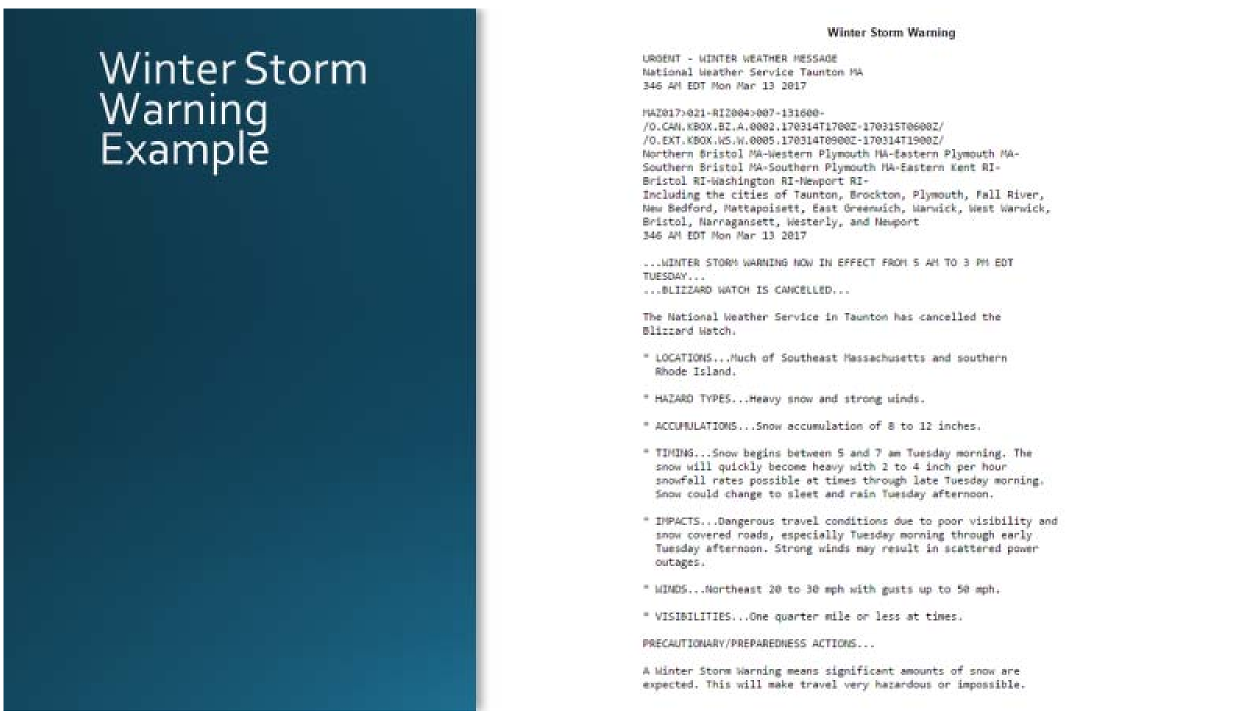
III. Final Graphical Details and Changes – Show Slide 17

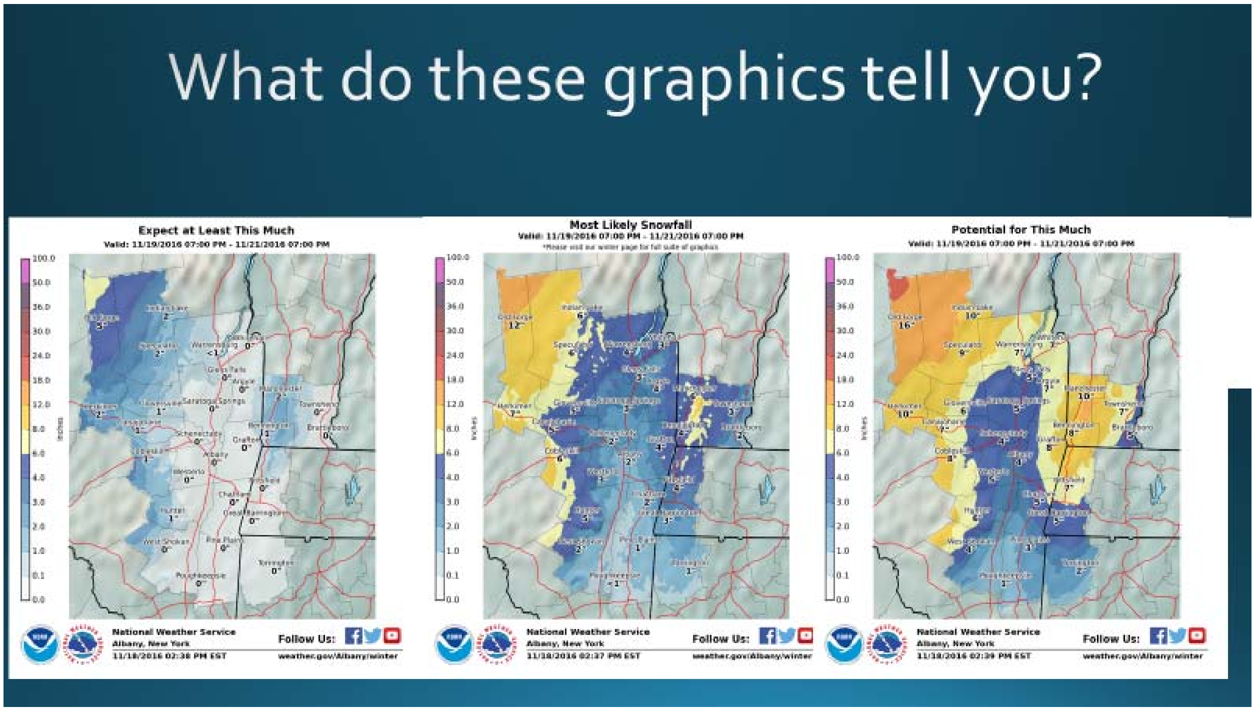
1. Format Needs
2. Accessibility
3. What additional snow information would help improve your decision process?
4. Is there anything we haven’t discuss that you would like to share with us today?

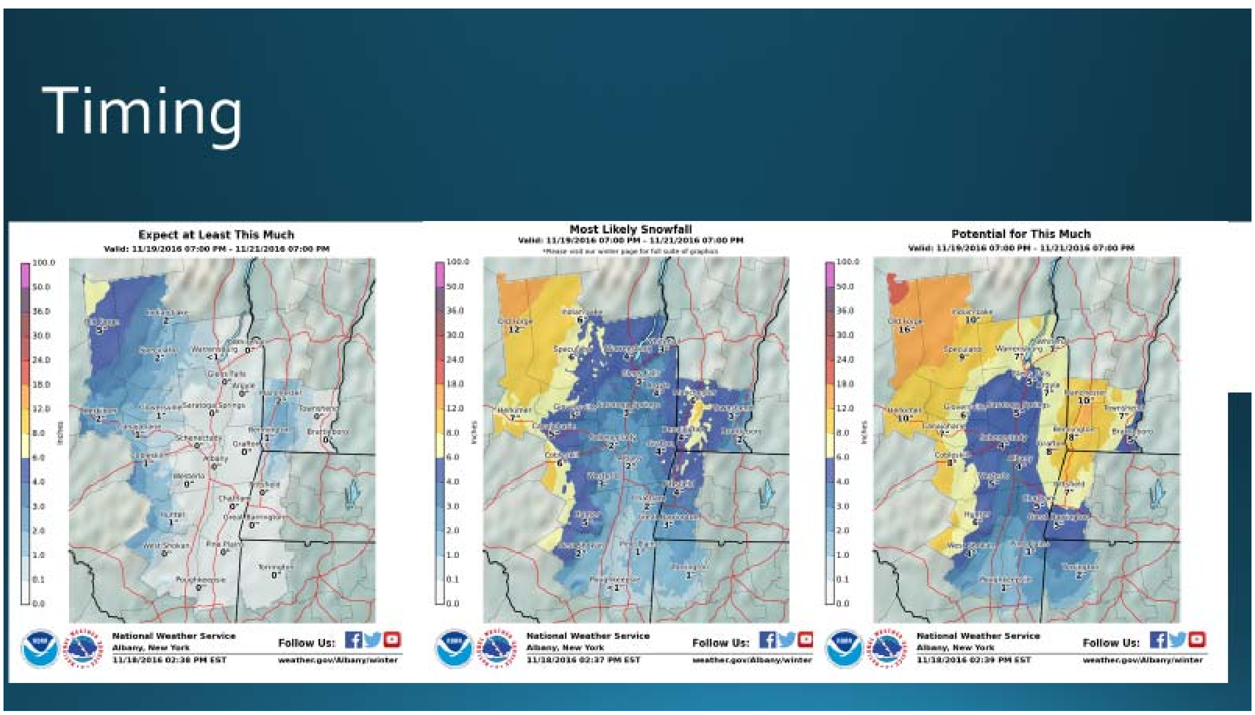

Part II.
Experimental Probabilistic Graphics


Part I.
General Decision Making and Information Needs

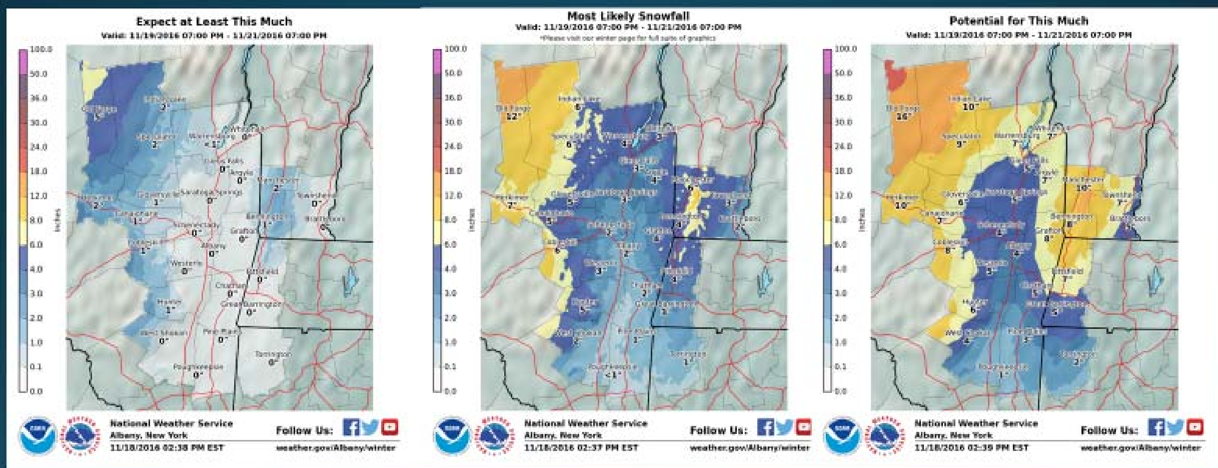

Part II.
Experimental Probabilistic Graphics


Winter Storm Warning Example
Winter Storm Warning
URGENT - WINTER WEATHER MESSAGE
National Weather Service Taunton MA
346 AM EDT Mon Mar 13 2017
MAZ017>021-RIZ004>007-131600-
/O.CAN.KBOX.BZ.A.0002.170314T1700Z-170315T0600Z/
/O.EXT.KBOX.WS.W.0005.170314T0900Z-170314T1900Z/
Northern Bristol MA-Western Plymouth MA-Eastern Plymouth MA-
Southern Bristol MA-Southern Plymouth MA-Eastern Kent RI-
Bristol RI-Washington RI-Newport RI-
Including the cities of Taunton, Brockton, Plymouth, Fall River,
New Bedford, Mattapoisett, East Greenwich, Warwick, West Warwick,
Bristol, Narragansett, Westerly, and Newport
346 AM EDT Mon Mar 13 2017
...WINTER STORM WARNING NOW IN EFFECT FROM 5 AM TO 3 PM EDT
TUESDAY...
...BLIZZARD WATCH IS CANCELLED...
The National Weather Service in Taunton has cancelled the
Blizzard Watch.
* LOCATIONS...Much of Southeast Massachusetts and southern
Rhode Island.
* HAZARD TYPES...Heavy snow and strong winds.
* ACCUMULATIONS...Snow accumulation of 8 to 12 inches.
* TIMING...Snow begins between 5 and 7 am Tuesday morning. The
snow will quickly become heavy with 2 to 4 inch per hour
snowfall rates possible at times through late Tuesday morning.
Snow could change to sleet and rain Tuesday afternoon.
* IMPACTS...Dangerous travel conditions due to poor visibility and
snow covered roads, especially Tuesday morning through early
Tuesday afternoon. Strong winds may result in scattered power
outages.
* WINDS...Northeast 20 to 30 mph with gusts up to 50 mph.
* VISIBILITIES...One quarter mile or less at times.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
A Winter Storm Warning means significant amounts of snow are
expected. This will make travel very hazardous or impossible.

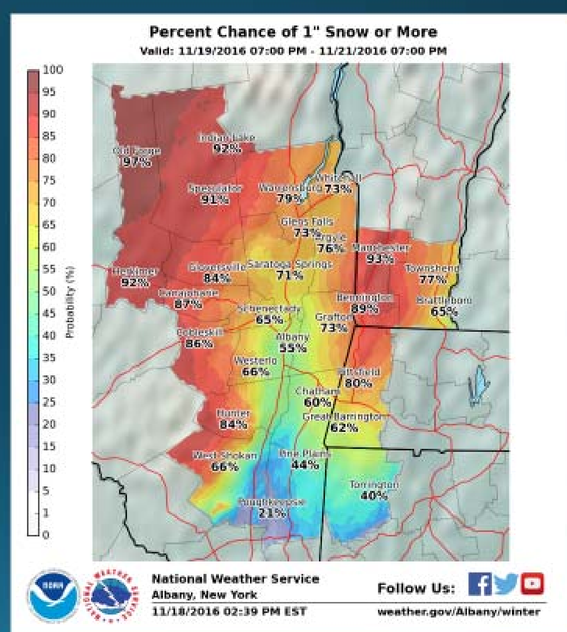

What do these graphics tell you?
Expect at Least This Much
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Most Likely Snowfall
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Potential for This Much
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
National Weather Service
Albany, New York
Follow Us:
weather.gov/Albany/winter


Timing
Expect at Least This Much
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Most Likely Snowfall
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Potential for This Much
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
National Weather Service
Albany, New York
Follow Us:
weather.gov/Albany/winter

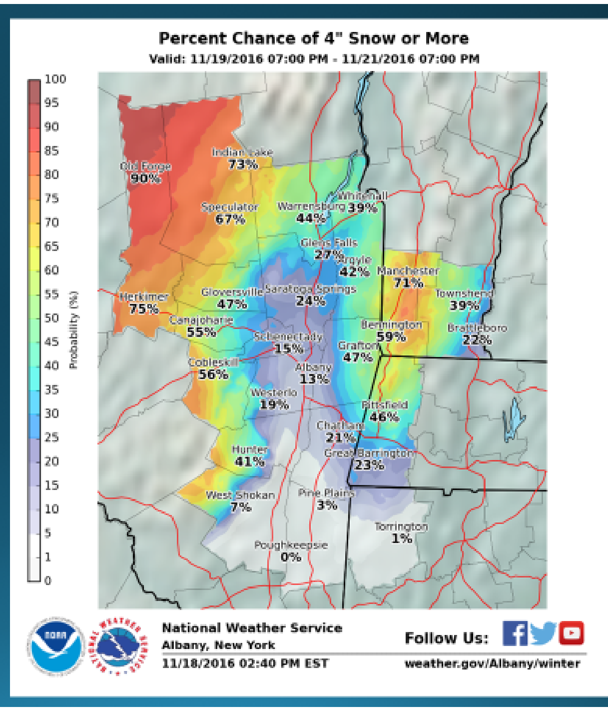
Usefulness



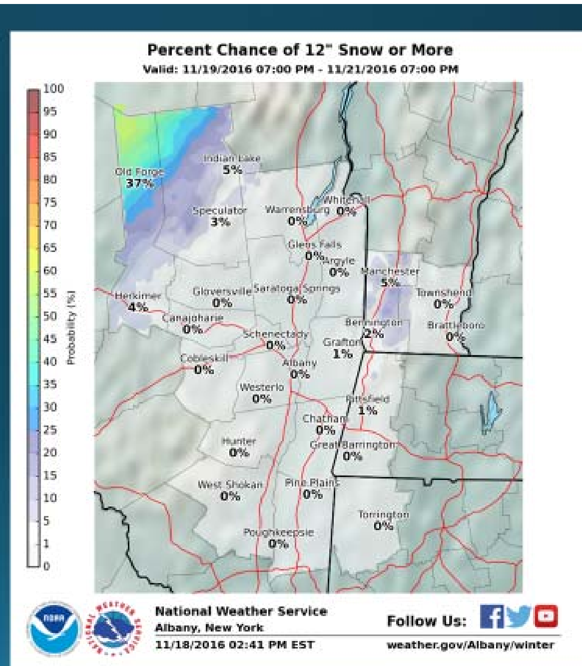
Percent chance >=1 inch snow

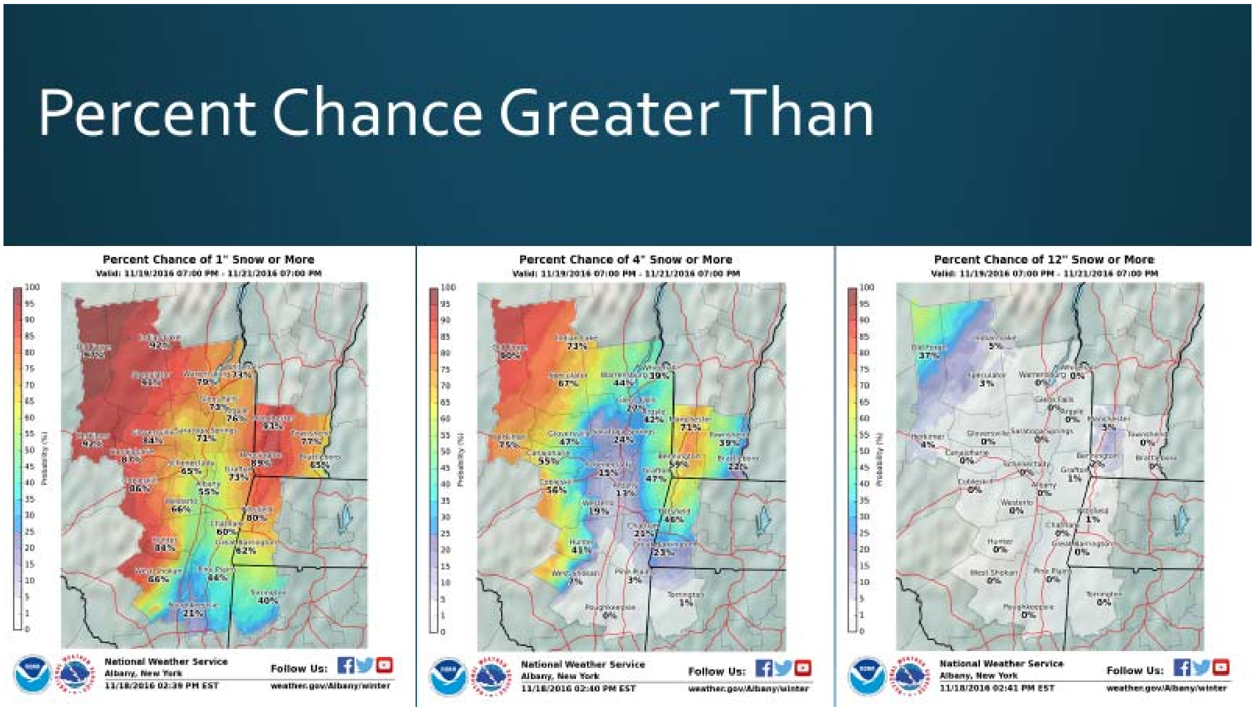


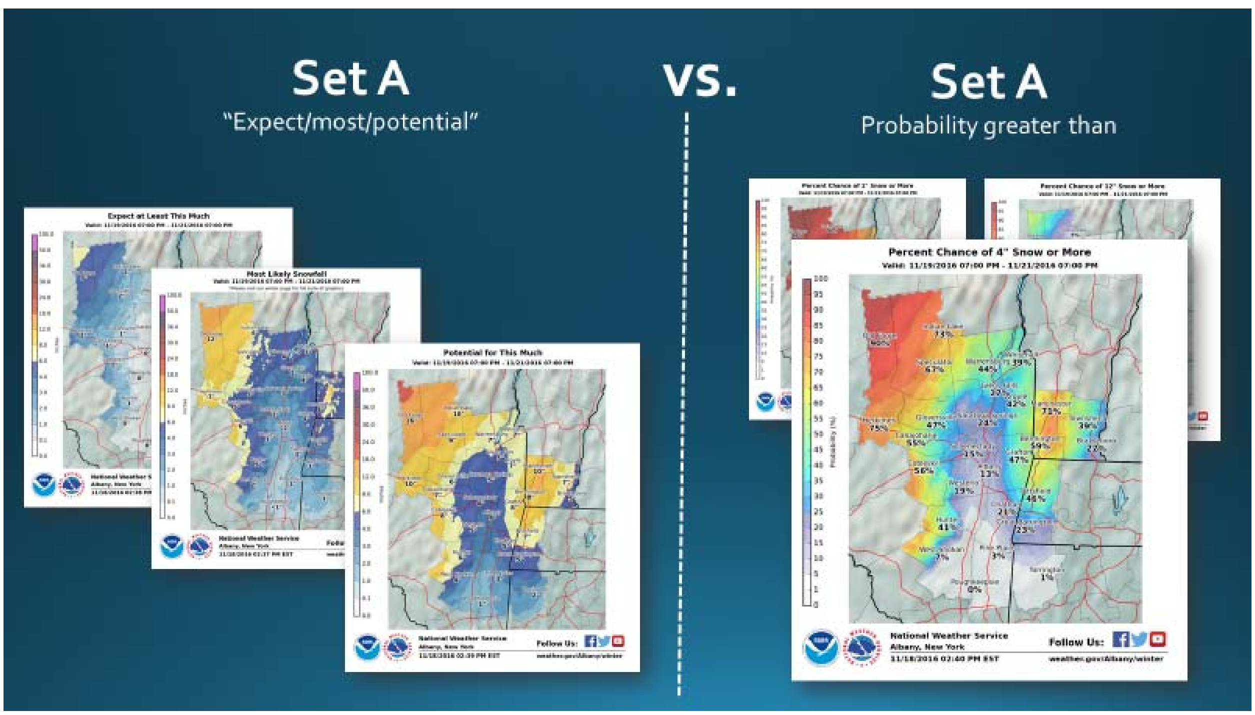
Percent chance >=4 inch snow



Percent chance >=12 inch snow




Percent Chance Greater Than
Percent Chance of 1" Snow or More
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Percent Chance of 4" Snow or More
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
Percent Chance of 12" Snow or More
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
National Weather Service
Albany, New York
Follow Us:
weather.gov/Albany/winter


Set A
"Expect/most/potential"
VS.
Set A
Probability greater than
Percent Chance of 4" Snow or More
Valid: 11/19/2016 07:00 PM - 11/21/2016 07:00 PM
National Weather Service
Albany, New York
11/18/2016 02:40 PM EST
Follow Us:
weather.gov/Albany/winter

What does this table communicate to you?

Chance of Snow Accumulation

Experimental - Leave feedback

11/19/2016 0700PM to 11/21/2016 0700PM

What's this?

County: All

Location	At least	Likely	Potential for	>=0.1"	>=1"	>=2"	>=4"	>=6"	>=8"	>=12"	>=18"
Albany, NY	0	2	4	68%	55%	39%	13%	2%	0%	0%	0%
Altamont, NY	0	3	5	78%	66%	50%	17%	2%	0%	0%	0%
Amsterdam, NY	<1	4	5	87%	78%	64%	29%	5%	0%	0%	0%
Atwell, NY	5	11	14	98%	97%	95%	88%	78%	62%	25%	1%
Ballston Spa, NY	0	3	5	81%	70%	55%	21%	3%	0%	0%	0%
Bennington, VT	1	4	9	94%	89%	81%	59%	36%	17%	2%	0%
Brattleboro, VT	0	2	5	77%	65%	50%	22%	6%	1%	0%	0%
Catskill, NY	0	<1	3	65%	46%	25%	4%	0%	0%	0%	0%
Chatham, NY	0	2	5	70%	58%	44%	17%	4%	0%	0%	0%
Cobleskill, NY	1	6	8	91%	86%	78%	56%	29%	9%	0%	0%
Delanson, NY	0	3	5	84%	74%	60%	27%	5%	0%	0%	0%
Glens Falls, NY	0	3	5	83%	73%	59%	27%	7%	1%	0%	0%
Gloversville, NY	1	5	6	91%	84%	75%	47%	15%	2%	0%	0%
Great Barrington, MA	0	3	5	72%	62%	49%	23%	6%	1%	0%	0%
Hoosick Falls, NY	<1	4	8	88%	82%	74%	52%	29%	12%	1%	0%
Hudson Falls, NY	0	3	6	82%	72%	58%	29%	9%	2%	0%	0%
Hudson, NY	0	<1	3	65%	47%	29%	7%	1%	0%	0%	0%
Hunter, NY	1	5	6	90%	84%	73%	44%	11%	0%	0%	0%
Ilion, NY	3	7	11	96%	93%	90%	77%	58%	36%	5%	0%