Emergency Manager Perspectives of Experimental Products Tested in the 2019 Spring and Fall HWT Experiments: A General Overview

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ABSTRACT

In May and October of 2019, five week-long experiments were conducted with emergency manager (EM) participants. A total of 19 EMs were chosen from across the United States and from various jurisdiction sizes including state, county, city/town, hospital, and utilities. During each experiment week, EM participants participated in surveys and focus groups to understand how they make decisions and use current weather forecasts and products and five experimental weather forecasts and tools developed by NOAA's National Severe Storms Laboratory (NSSL), the University of Oklahoma's Cooperative Institute for Severe and High-Impact Weather Research and Operations (CIWRO), and the NOAA/NWS Storm Prediction Center (SPC): Probabilistic Hazard Information (PHI), Threats-in-Motion (TIM), Warn-on-Forecast System (WoFS), SPC Timing tool, and Potential Severe Timing (PST). Survey and focus group results indicate that EM participants were able to easily understand and use the experimental products, that they all delivered pertinent information, and helped EM participants have more confidence in their decisions. The EM participants also noted that while the probabilistic information presented was helpful, there needs to be consistency across each product and they need more experience on how the probabilities would be used in their local jurisdictions.

1. Background

A total of five week-long experiments were conducted in the Spring and Fall of 2019 with two weeks taking place in May of 2019 and three weeks in October of 2019. During each week, emergency manager (EM) participants were shown several experimental products during a simulated severe weather scenario. EMs were recruited via NOAA's Hazardous Weather Testbed (HWT) recruitment process. Interested applicants filled out an application and wrote a small interest statement. HWT researchers read through the applications and then contacted and scheduled available participants for the experiment dates. 19 EM participants were chosen from various jurisdiction sizes, including state (n=5), county (n=6), city/town (n=6), hospital (n=1), and utilities (n=1). State, county, and city levels were prioritized because they are the most common jurisdiction levels across the United States.

At the beginning and end of each experiment week, participants responded to surveys so researchers could record participant perspectives before and after they were shown the experimental products. The "pre-test" surveys included questions about the EMs' current operations and use of severe weather products. The "post-test" surveys included questions about the EMs' thoughts and opinions of the experimental products shown throughout the week and how they envisioned using them. During the week, EMs participated in focus groups after each experimental product was shown, followed by a "debrief" discussion at the end of the day where they discussed their thoughts of the products more holistically.

Each day of the experiment consisted of a different archived severe weather event scenario with current and experimental National Weather Service (NWS) and Storm Prediction Center (SPC) products presented throughout the day (Table 1). The goal of this setup was to mimic a typical severe weather day so EMs could envision how the experimental products would fit alongside current products. Current products that were presented included SPC Convective Outlooks, SPC Mesoscale Discussions, and SPC Watches (tornado and severe thunderstorm).

The experimental products were developed by researchers in NOAA's National Severe Storms Laboratory (NSSL), the University of Oklahoma Cooperative Institute for Severe and High Impact Weather Research and Operations (CIWRO), and the NOAA/NWS SPC. The experimental products were shown either as a static graphic in slide show format or in an interactive format via an experimental version of the Enhanced Data Display (EDD). The EDD was an interactive interface that allowed users to layer and toggle various features, such as radar and warnings issued during the experiment. Five experimental products were shown to EMs during the 2019 HWT:

1. Probabilistic Hazard Information (PHI)
2. Threats-in-Motion (TIM; shown only to participants in the Fall)
3. Warn-on-Forecast System (WoFS)
4. SPC Timing tool
5. Potential Severe Timing tool (PST)

WoFS, SPC timing, and the PST were presented to EMs in a slide show format, and simulated as if they were accessing the graphics online. These products aimed to provide information at the pre-watch and pre-warning time frames. PHI and TIM were shown to EMs as a simulated real-time case in the EDD and provided information during the warning time scale.

Table 1 outlines the archived severe weather events that EMs worked through each day and what current and experimental products were shown. The EMs in the Spring and Fall experiment weeks saw different archived cases, but similar products each day. The only exception is that the Fall EM groups saw TIM while the Spring EMs did not since the TIM software was not completed until the Fall. The Spring experiment included a “Live Weather” PST, where a PST was created during the Spring Forecasting Experiment (SFE) at the beginning of the day for any severe weather that may have occurred on that particular day. The Live Weather PST was not done in the Fall, as the SFE was not occuring during that time.

	Spring 2019	**Fall 2019**
Day 1	Training case	Training case
Day 2	Columbia, SC 24 May 2017 ● Live Weather PST ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● PHI	Des Moines, IA 19 July 2018 ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● PST ● PHI
Day 3	Goodland, KS 25 May 2017 ● Live Weather PST ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● PST ● WoFS ● PHI	Jackson, MS 18 April 2019 ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● PST ● WoFS ● PHI ● TIM
Day 4	Topeka, KS 2 May 2018 ● Live Weather PST ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● SPC timing ● WoFS ● PHI	SW Ohio 27 May 2019 ● SPC Convective Outlooks ● SPC Mesoscale Discussion ● Watch ● SPC timing ● WoFS ● PHI ● TIM
Day 5	Live Weather PST End of week discussion	End of week discussion

Table 1: Archived cases and experimental products shown by day for both the Spring and Fall 2019 HWT.

2. Experimental Products

PHI is a tool where forecasters can create and provide probabilistic information for convective hazards, such as tornadoes, severe thunderstorms (wind and hail), and lightning (Karstens et al. 2015, 2018). The probabilistic information is depicted as an “object” (i.e., the storm itself) and a probability “plume”, with varying levels of probability to indicate the chance that a particular hazard will occur in that location. During the 2019 experiment, PHI was displayed for EMs on the EDD interface, and EMs were able to toggle different layers (i.e., adding/removing PHI, radar, base layer map features, etc.). Two color schemes were available for participants to view the PHI plumes: monochromatic and rainbow. The monochromatic color scheme depicted each hazard in a different gradation of color: tornado - red, severe - yellow, and lightning - orange. The rainbow color scheme depicted all hazards in the same rainbow gradation scale. Participants were able to choose between the two color schemes throughout the experiment. Participants were also able to choose between quantitative (as percentages) and qualitative (“low”, “medium”, “high”) labels indicating probability. Figure 1 is a screenshot of a PHI example case EMs were shown during the experiment.

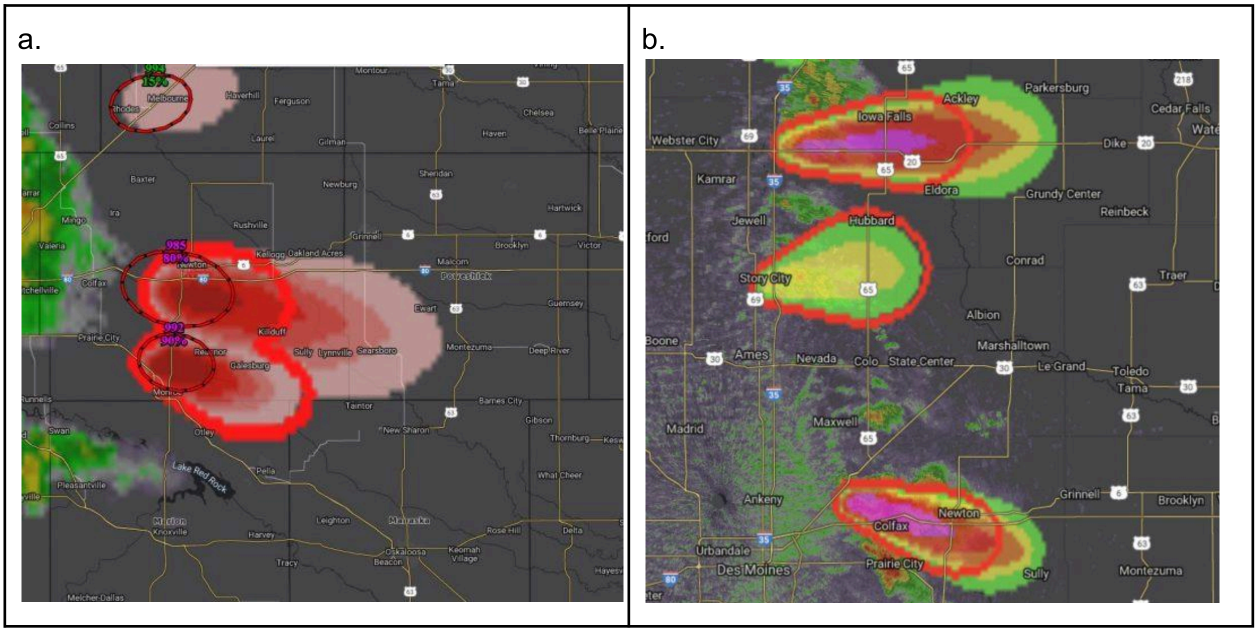


Figure 1: Experimental PHI plumes for archived severe weather cases. 1a shows the monochromatic PHI color scheme for tornadoes (red) and 1b shows the rainbow PHI color scheme. The red polygons indicate tornado warnings. Images were adapted from Shivers-Williams (2020): https://inside.nssl.noaa.gov/phi-em/2020/04/what-have-we-learned-a-quick-glance-at-emergency-managers-use-of-probabilistic-hazard-information-phi/

TIM is a rapidly-updating warning (Tornado and Severe Thunderstorm) that moves with the storm (Stumpf and Gerard 2021, Stumpf 2023). TIM was displayed as a polygon (similar to today’s warnings, with red indicating tornado warnings and yellow indicating severe thunderstorm warnings) on the EDD interface. One type of warning was issued per storm, and followed the storm throughout its cycle rather than new warnings being issued every 15-20 mins minutes (Harrison and Karstens 2017). Due to the software development process, TIM was only shown to participants in the Fall session of the 2019 experiment. Figure 2 is a screenshot of a TIM example case that EMs were shown.

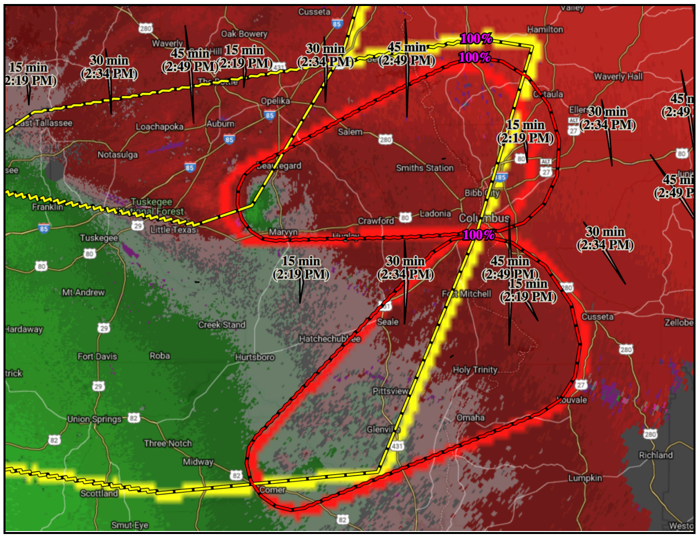


Figure 2: TIM tornado warning in the solid red line alongside a TIM severe thunderstorm warning outlined in yellow. TIM warnings “look” like current warnings in that they are polygons, except TIM warnings move with the storm.

WoFS is a rapidly-updating, high-resolution model system that aims to provide forecast output in the watch-warning time frame and increase lead time for warnings (i.e., tornado and severe thunderstorm) (Heinselman et al. 2024). During this experiment, simulated WoFS output was shown to EMs as static graphics and depicted a single probability of severe weather (i.e., one probability combining hail, wind, and tornado probabilities) within 25 miles of a point (Gallo et al. 2022). WoFS output graphics were shown to participants as 4-hour and 1-hour forecasts throughout the simulated event (Gallo et al. 2022). Figure 3 shows an example of WoFS output graphic that EMs saw during the experiment.

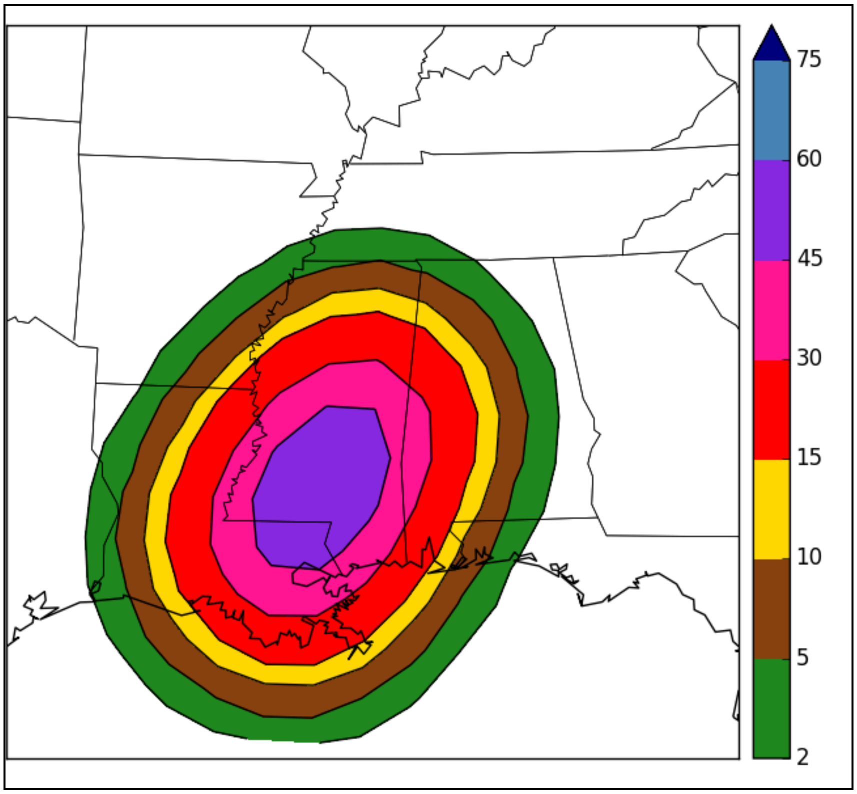


Figure 3: Experimental WoFS output for the probability of severe weather issued at 1730 UTC and valid at 1800-2200 UTC. This experimental output was issued for the 18 April 2019 Jackson, MS archived severe weather event.

The SPC timing tool depicts SPC's probability of a hail, wind, or tornado report within 25 miles of a specified point across time. The information in the static graphic is depicted via a line graph, where each colored line represents the hazard: red - tornado, blue - wind, green - hail, which matches the SPC's current color scheme. EMs were also shown a map-based version, which showed probability areas across the CONUS during a specified 4-hour period. These four hour periods rotated, showing a "moving convective outlook" when they were animated. Figure 4 shows a static image example of SPC timing tool output.

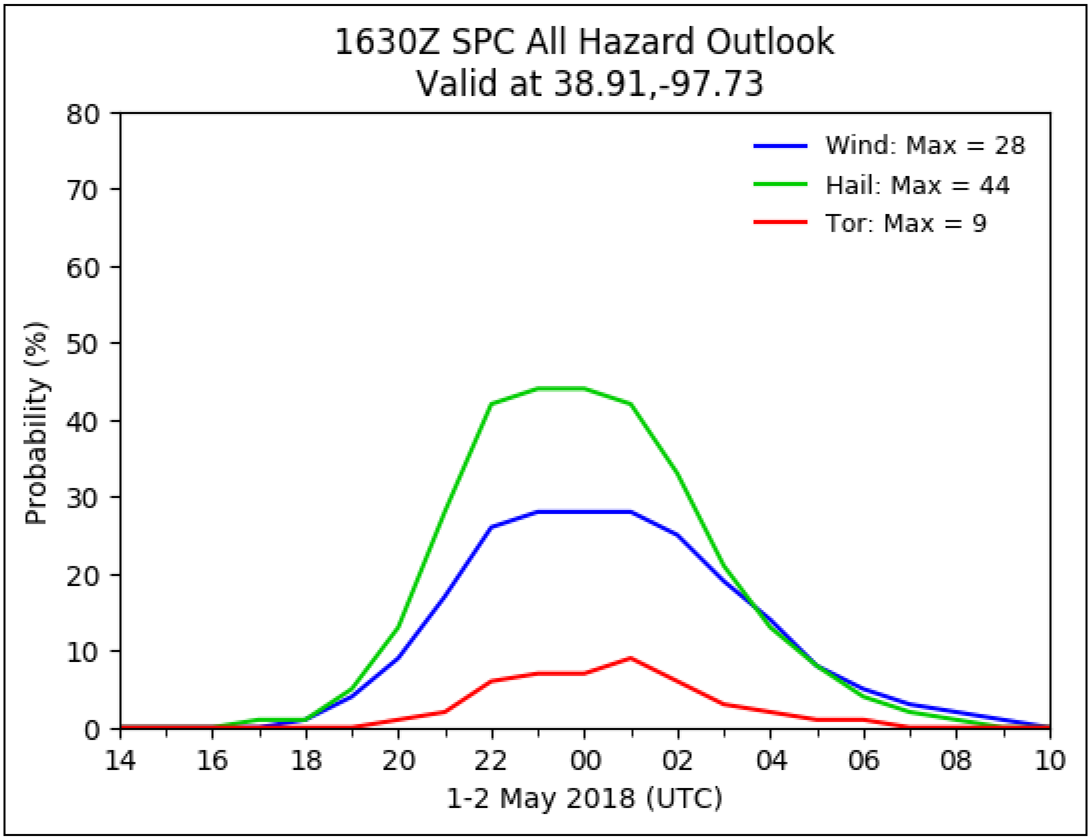


Figure 4: Experimental SPC graphic for the Day 1 Convective Outlook valid at 1630 UTC depicting estimated timing and probability of severe weather at a point (38.91, -97.73, approximately Salina, KS). Time is shown along the x-axis in UTC and the probability of occurrence is shown along the y-axis as percentages. Wind, hail, and tornado probabilities are depicted as the blue, green, and red lines, respectively. This experimental output was issued for the 1-2 May 2018 Topeka, KS archived severe weather event.

The PST is a graphic that depicts estimated timing of severe weather occurring within a forecast period. The EMs were shown static images of timing information, depicted as circles or “blobs” of time periods overlaid on a map of where severe weather was forecasted to occur (Figure 5). Examples of the PST were given in either UTC (for Live Weather cases) or CT (for displaced real time cases) times.

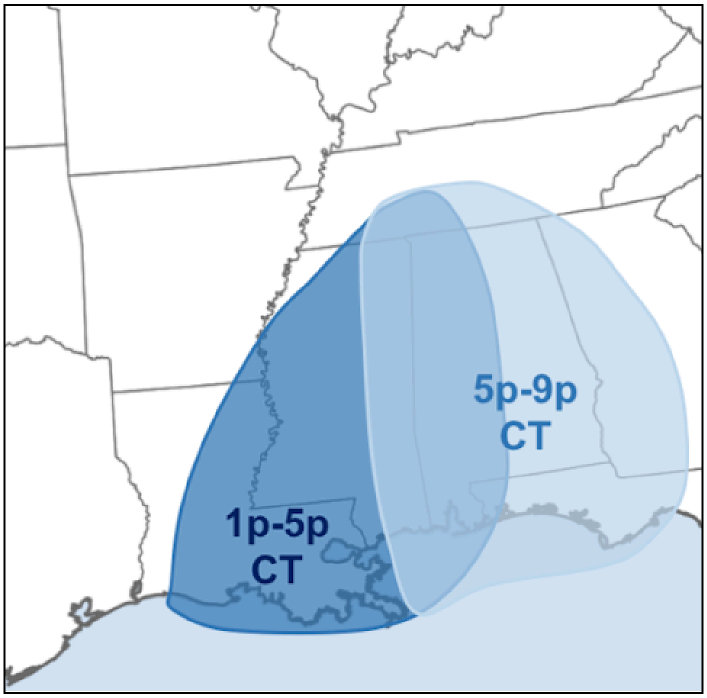


Figure 5: Experimental PST graphic for the estimated timing of severe weather issued with the SPC 1630 UTC Day 1 Convective Outlook. The darker blue circle indicates severe weather is expected in that area from 1-5 PM CT. The lighter blue circle indicates severe weather is expected in that area from 5-9 PM CT. This experimental output was issued for the 18 April 2019 Jackson, MS archived severe weather event.

3. Focus Group Results

Focus Groups were conducted each day of the experiment, several times per day. The focus groups occurred after EM participants were shown each experimental product (PHI, TIM, WoFS, SPC timing graphics, and the PST). They were semi-structured, so specific questions were asked each time, but conversation was allowed to take place and follow up questions were asked. Therefore, each week, though shown the same or similar experimental products, resulted in slightly different focus group discussions taking place.

The primary focus group questions that were asked include:

1) What were your initial thoughts or reactions to the [experimental product] you saw today?
2) Did the product change any of the ways you would perform your job duties? How so?
3) Did the product help you make any decisions earlier than you normally would?
4) Was the product easy to understand?
5) Would you share this product with your partners, stakeholders, or members of your communities?
6) [If probabilities were shown] How did you interpret the probabilities shown with this product?
    a) Were they easy to understand?

b) Did they help you make decisions in preparation for or during the experimental event?

Each focus group was recorded on audio devices and then transcribed using NVivo Transcription Software. The transcripts were then quality controlled, de-identified from any identifying participant information, and coded thematically. General themes were drawn from the transcripts and thematic codes and are described below.

a. Thoughts on Experimental Products Overall

Overall, EMs had a positive attitude towards the experimental products shown to them during the 2019 HWT. Sections 3b-f go into more specifics about each experimental product, but overall there were several general themes. First, the EMs felt that the experimental products provided “gap filling” information, or, more information between current, scheduled NWS and SPC product issuances. For example, the WoFS product provided information between SPC watches and NWS warnings, meaning EMs would get up to date information in a time frame that does not traditionally have official products issued in.

Second, the experimental products helped EMs feel more prepared and noted that their decision making felt more proactive rather than reactive. Today, the EMs explained, they receive a product and react to it quickly, often resulting in “scrambling” to get people or resources into place, or disseminate messages. For instance, in the aforementioned watch to warning gap, EMs would typically wait for a warning to get issued, receive the warning, and rush to sound sirens, send out mass notification system alerts, deploy first responders, deploy resources, contact partners, etc. The experimental products helped fill that gap meaning they could deploy resources or contact partners sooner.

Third, the EMs felt that they did not have to reach out to their local Weather Forecast Office (WFO) as often to ask questions. With a variety of products at different time frames that provided gap filling information, they did not feel like they had to ask questions as they could often answer it for themselves. This helped to save time, as the EMs did not have to take time to contact a NWS forecaster (via NWSChat, phone call, etc.), ask the question, and wait for a response before they had to make a decision.

In addition to these positive themes, the EMs had some overall concerns. Because the experimental products had more detailed and helpful information, the EMs felt like that then put them under more pressure, responsibility, or stress. They felt like they would be expected to make better decisions given the better information. This was a concern because many EMs’ jobs were appointed or elected positions, so if they did not do a “good job”, they would be fired. Second, some EMs mentioned that there was almost an “information overload” with the many new products. The EMs noted that lower resourced EMs and jurisdictions may not have the capacity to use all of the new products and do their jobs, as they may not have enough time or staff to add more information gathering into their day. They also mentioned that many of their partners would not have the time to read more information. Therefore, they would have to take the time to pick what information they should disseminate to partners, which can be time consuming.

Because of the potential for information overload and for being exposed to new products and new ways of visualizing forecast information, all of the EMs noted that they would like training and education on the new tools before they can be used effectively. Some of the probabilistic information was presented in a new format that they thought required explanation and training before it was expected for EMs to make decisions. Specifically, they noted the PHI tool would need more education surrounding it, as there was a lot of information contained in one tool: probabilities, timing information, storm tracks, etc. Several EMs also noted that they would need more experience with the tools in the real world to know what kinds of probability thresholds they would have and when to trigger operational decisions.

Finally, there were a couple specific points EMs made throughout their experiment weeks: 1) Consistency of messaging and forecaster confidence are important, 2) warnings are a baseline for action so probabilities without warnings are difficult to act on, 3) EMs would like these experimental products (and existing ones) to be accessible on mobile phones (either as an app or mobile friendly webpage) since many EMs operate in the field, and 4) EMs would like to see these tools expand beyond severe into other hazards, such as winter weather and flooding.

b. PHI

i. Overall Advantages

EMs liked the PHI tool because it combined multiple tools into one, since all information they needed was included and clearly shown in one place, such as source (storm reports), storm track, storm motion, storm direction, timing information, etc. One EM noted that PHI seemed like a “marriage of time and space in one graphic”. They could toggle on timing information and at the same time use the PHI plumes to infer storm motion and direction, which helped them to make decisions during the activity. Another EM noted that PHI felt like NWSChat, but in a visual format. Instead of asking NWS forecasters in the chat about the timing, direction, or intensity information about the storm, they were able to infer that from the PHI tool using the time tracks, PHI plumes, and watching the trends in probability. Additionally, the PHI tool included a “forecaster discussion box”, where forecasters were able to briefly describe some of their thinking and perspectives on the storm, if they thought it was strengthening or weakening, whether a warning would be issued, etc. EMs liked the discussion box because they liked seeing the forecasters’ thinking, giving them more confidence in their decisions and allowing them to refer back to the box to maintain situational awareness. One EM noted that the information contained in the PHI tool and discussion box gave them the “proof” to help back up or justify their decisions.

The creation of PHI plumes and objects also gave EMs confidence that the forecasters were paying attention to certain storms. The EMs watched the radar, but noted they may not have the knowledge of which storms were more concerning than others. Once a forecaster created a PHI object or plume, it signaled to EMs that it was time to start paying attention. EMs could then contact partners or ready resources if a warning was to be issued. Therefore, the creation of PHI objects and plumes also allowed EMs to anticipate warnings being issued. If they could see the trends in probability increasing, and follow along in the forecaster discussion box, then they could be better prepared and ready to act when a warning finally gets issued. It also helped them feel more comfortable making decisions ahead of time.

Additionally, the visual nature of the PHI plume helped the EMs narrow down the area of concern (i.e., the areas inside the plume) and isolate information and focus on certain areas. Often, EMs would use the higher end probabilities to focus their attention and messaging to partners and to the public.

Finally, the EMs liked the interactive format of PHI. It is unclear if the EMs were referring to PHI itself, or if they liked the interactive capabilities of the EDD, but it is clear that EMs liked having an interactive platform where they can personalize and prioritize information and therefore tailor it to their operational needs.

ii. Overall Disadvantages

There were three overall disadvantages EMs felt about the PHI tool. First, EMs thought that PHI could be overwhelming at first. The colors, plumes, probabilities, and other features were overwhelming to see at first glance all in one space (i.e., on one storm). It could be further complicated if there were multiple storms, with both severe and tornado PHIs. The screen became cluttered, and there were lots of different colors and objects on the screen, such as radar, severe PHI plumes, tornado PHI plumes, and warnings (severe and tornado). EMs were worried that other EMs might “walk away” if they were shown PHI without context, because of its visually cluttered nature. However, the EMs noted that by the end of the experiment week, they were more comfortable and did not find PHI as overwhelming as they did when they first saw it.

Second, EMs wondered how warning dissemination technology, such as weather radios and sirens, would be able to handle PHI. What types of information would they disseminate? Would they even disseminate probabilistic information to the public? Given the visual format of PHI, EMs thought that it would be best to keep online or on television where broadcast meteorologists could fully explain the information.

Finally, the EMs were mixed about whether they would like to share PHI information with their partners and the public. Overall, they thought that the probabilistic information would confuse their partners and the public and felt that it was best to keep that information internal for their own decision making purposes.

iii. Use of Color

Two primary color schemes were presented to EMs in the experiment: monochromatic, with yellow for severe plumes and red for tornado, and rainbow. A majority of the EMs preferred the monochromatic color scheme, as it was easier to separate out colors when it was overlaid with radar reflectivity. The rainbow color scheme of the plume and the rainbow color scheme of the radar reflectivity tended to wash each other out, and it was difficult to differentiate. However, those in favor of the rainbow PHI plume acknowledged that while it was not ideal, it showed gradation between the probabilities more readily than the monochromatic scheme. The rainbow color scheme, however, did not differentiate between severe and tornado (i.e., both were rainbow), so it was difficult to differentiate hazards. The monochromatic color scheme, therefore, allowed EMs to differentiate hazards more quickly.

The EMs had some concerns about the colors of the PHI plumes. Specifically, they felt that the screen got “busy” with all of the colors from the PHI plumes, warnings, and radar reflectivity. Because of this, they sometimes could not see the base map below the layers, and had trouble identifying towns, streets, or critical infrastructure. PHI also tended to “wash out” the radar data, preventing them from making some decisions. However, experience using the tool throughout the week lessened some of these concerns, as EMs gained more confidence layering and toggling information by the end of the week.

iv. Use of Probability

EM participants had mixed opinions about how the probabilities were presented in PHI via the plume. Specifically, there was no one probability threshold that prompted EMs to action. All of the EMs indicated that they would be preparing at “lower” probabilities and taking action at “higher” probabilities. There was no specific value to each probability threshold, but most EMs agreed that they might start taking action in the 60-70% probability range. Many of their decisions to action were based on other situational factors, such as storm reports, damage reports, forecaster discussion, NWSChat, and radar indicated/observed rotation. EMs indicated that they need more experience using the probabilities in real world settings to help them determine what the probabilities mean to them, what type of hazards and intensity are associated with each probability level, and how their local NWS forecasters use the probabilities.

One common theme among all EMs was that they wanted consistency across PHI probabilities and warnings. At one point during the experiment, a tornado warning was issued with a 20% PHI, yet another time a tornado warning was issued at 80%. In a different case, there was a 100% PHI and included wording for “radar indicated rotation”, but a warning was not yet issued. The EMs wondered why this was the case, and did not like that there was not a consistent use of probabilities and warning issuance. When asked at what probability a warning should be issued, the EMs did not have a consistent answer, as they indicated that they are not meteorologists and thus, do not know the science well enough to indicate a probability threshold. All EMs agreed that if the PHI is 100%, there should be a warning, but disagreed at lower probabilities. Some EMs indicated that they believed 50% was sufficient, others wanted it higher at 70% and greater. What they all agreed on was that if PHIs have “high enough” probabilities and spotter reports, then they wanted a warning issued.

Despite the discrepancies in probability threshold preferences, there was overall consensus that PHI helped them maintain situational awareness and gave them confidence regarding storm intensity trends. For example, once PHI was applied to a storm, EMs became aware that they needed to start paying attention to that storm. Rising probability trends alerted EMs that the storm is increasing in intensity and gave them confidence that a warning might be issued. In other words, PHI allowed them to anticipate warnings being issued. Conversely, decreasing probability trends indicated to the EMs that the storm was decreasing in intensity, and that they could potentially focus their attention elsewhere. This was especially true for the EMs who did not have as much exposure to severe weather and tornadoes, as they did not have the experience or the radar interrogation knowledge to know if a storm was increasing in intensity or not.

Finally, EMs had mixed feelings about the usage of quantitative versus qualitative PHI labels. During the experiment, EMs were able to toggle between quantitative labels (i.e., probability values) and qualitative labels (i.e., “low”, “medium”, “high”). When asked about which they preferred to share with their partners and the public, most indicated that they preferred the quantitative labels for themselves, but were more hesitant to share them with their partners and public. They were concerned that the public would not be able to understand the quantitative labels as well as the qualitative labels. However, some EMs indicated that “low, medium, high” is subjective. The quantitative labels were argued to be more objective and would therefore give partners and the public better information. In sum, EM thresholds for taking action varied greatly, but probability trends helped the EMs make decisions and maintain situational awareness.

v. Interplay of PHI and Warnings

One question asked during the experiment was how EMs felt about using PHI as a warning, as opposed to having an official warning “polygon”. The consensus among all EMs was that warnings are still needed, and very important to their operations. Many EMs noted that they need something official from the NWS or SPC or they do not have the authority to make certain decisions, like sounding outdoor warning sirens, issuing WEAs, opening Emergency Operation Centers (EOC), or deploying resources. EMs also mentioned that they make decisions based on the issuance of warnings, so not having a warning would be difficult to know when certain decisions need to be made. They mentioned that if a warning was issued, they were going to sound the sirens no matter what the probability was.

On the other hand, making decisions ahead of the warning based on the PHI plume helped them prepare and respond faster to the approaching threat. If they were allowed to make certain decisions without a warning using PHI, it would help them be more proactive rather than reactive during severe weather. If PHI is implemented for partner use, it would require a change in policy or how EMs currently operate.

vi. Tornado vs. Severe PHI

During the experiment, EMs were exposed to both tornado and severe thunderstorm PHIs. In most cases, both hazards were present in the same scenarios. EM participants noted that they found themselves turning off severe PHI to focus on tornado PHI. The primary reason behind this decision was to reduce screen clutter. However in doing so, EMs were sometimes caught off guard by storms that intensified. Participants felt that they missed opportunities to alert partners or their community to the increasing threat. EMs who experienced severe thunderstorms more often than tornadic storms noted that they preferred the severe PHI plumes to tornado PHI plumes because they anticipated using them more often.

The EMs also expressed a desire for differentiation between severe thunderstorm criteria (60-mph winds and 1-in hail) and significant severe criteria (75-mph winds and 2-in hail). Further, some geographies have lower thresholds for impactful winds. For example, an EM from a large city noted that because of the tall buildings, they need to take precautions when winds reach 40 mph. Therefore, they agreed that they would like to be able to set their own thresholds for severe winds.

vii. Timing Information and Lead Time

Participants generally liked the time marks in PHI as it helped them keep track of the storms and alert their partners and communities when the storm was likely to impact them. The EMs also mentioned that they would like the time marks on non-severe or non-tornadic storms, as it was still useful to know the timing in case they needed to shut down or shelter people in outdoor events.

EMs also felt that there were generally longer lead times for the storms with PHI. They liked having the extra lead time, as it helped give them more time to make decisions or alert partners and the public when needed. However, there was some concern over the longer lead times leading to people sheltering longer. They did not want people to sit in their shelters too long, or leave shelter too early as it could be dangerous. They were also worried that people might become complacent in the future because they do not want to sit in their shelters for long periods of time.

c. TIM (Fall only)

TIM was presented to EMs in the Fall portion of the experiment. Overall, EMs liked TIM, particularly that they do not have to wait as long for a warning update. They also liked how TIM worked in addition to PHI, because they liked having a “firm” warning boundary. They noted that when TIM was present, they were making decisions off of TIM rather than the PHI. They also liked that TIM followed storms more closely and gave them more lead time on storms, because they could see the storms coming and did not have to wait for a warning to be re-issued to include their area. This allowed them to be more proactive in making decisions and alerting partners and the public. The EMs also acknowledged that TIM felt like the next step in warning technology, much like the switch from county-based warnings to storm-based warnings.

However, the EMs did have some concerns with how TIM would be implemented and disseminated to the public. The biggest concern EMs had was with how locations could get pulled in and out of a TIM warning over relatively short periods of time. TIM followed the storm more closely, including adjusting the warning polygon anytime the storm shifted in direction or speed. This meant that locations could get dropped out of a warning, because the warning shifted, and then a few minutes later get added back into the warning again because the storm shifted in direction again. The EMs did not like this, as they believed it would cause confusion for their partners and the public as to why there was a “jog” in direction. They worried that confusion could cause a delay in protective action as people try to figure out if they are in the warning or not. They were also worried that the “jogs” in direction could cause over-warning or falsely warning locations. If a location goes in and out of a warning multiple times, that location could get over-warned and inundate the public with warning messages. This could be an issue with current warning dissemination methods like outdoor sirens, WEA messages, or weather radios. EMs wondered how often and when each should be sounded and how to make sure the public is not inundated with messages. For example, if a siren policy states that it should be sounded every time a tornado warning enters that jurisdiction, then a siren would have to be sounded multiple times for one storm.

Overall, participants agreed that they liked the moving warnings, but it caused them to think about how they currently operate and what changes would need to be made. The EMs noted that they would have to change their dissemination policies, such as sounding outdoor sirens, and adjust to how they disseminate warning information to their partners and the public.

d. WoFS

Participants generally had positive things to say about the WoFS products they were given. They liked how WoFS looked visually, such as its color and depicted “bullseye”, and that it was displayed on a map because they could easily pinpoint their location and associated risk. They thought it was relatively straightforward to use and understand, though they all agreed that a short, narrative explanation of what the product was showing would be helpful, especially for partners or other EMs who are not as knowledgeable about the weather.

WoFS also helped EMs monitor their risk throughout the day and maintain situational awareness. The hourly updates helped them monitor how the weather was changing throughout the day, such as if their location was still under threat, and if their risk was increasing. They liked having this information throughout the day, rather than just relying on morning forecasts or scheduled updates from the SPC. Thus, they felt that the WoFS product provided them with “gap filling” information. They did not have to wait for the next SPC Convective Outlook or if a mesoscale discussion or watch was to be issued. They were able to keep up with information and forecast updates throughout the day, helping them to be more prepared and proactive in their decision making as the day progressed.

EMs also liked that the WoFS products narrowed down time and space scales to one that was more useful for themselves and their operations. Additionally, the WoFS output gave them more manageable and specific timeframes that storms were expected to occur. EMs liked that it was more specific than just “afternoon” or “early evening”. The timeframes helped them to prepare and adjust staffing more proactively. They were even able to make decisions earlier than they do today, again, helping them to be more proactive rather than reactive when storms do occur. They noted that, specifically, a 2-4 hour window ahead of when storms occur was most beneficial for them and their decision making processes. Once storms started developing and showing up on radar, the EMs turned to monitor the storms using radar, spotter reports, and NWSChat rather than seeking out model guidance.

Overall, they felt that they would likely incorporate WoFS products into their severe weather routines. However, there were some mixed opinions on if they would share WoFS with partners or the public. The arguments against sharing WoFS with partners or the public centered around the perception that probabilities might be confusing or difficult to understand. They did not want their partners or the public to get too attached to numbers, or to misunderstand what the probabilities are telling them. They also did not want their partners or the public to pay too close attention to the outline boundaries. For instance, the EMs did not want someone thinking that they were not under risk of severe weather because they were not located in the center of the bullseye. However, the arguments in favor of sharing WoFS included the ability to share the narrowed down timing and location information, as the EMs thought it would be good information for their partners to know. They also argued that if WoFS information was publicly available anyway (i.e., on the SPC or NWS websites), then it would be best for themselves to also share it so they could provide context.

e. SPC Timing

EMs all agreed that timing information is one of the most important pieces of information, but there were some mixed feelings overall about the SPC timing graphics. All of the EMs agreed that the SPC timing graphics had good information, but they did not all think that the information presented was always clear. The lines and colors could be perceived as confusing, as it made the graphic appear busy. They did not all like the use of the colors, as reds to them indicated severity, rather than the SPC Convective Outlook colors as was intended. They also felt that the single hour time windows were too precise, and could be viewed as less reliable. Because of these concerns, the EMs agreed that they would not likely share this graphic with their partners or the public. The public, they believed, would not be able to understand the graphic or the associated probabilities.

There were also mixed feelings about the moving aspect of the SPC timing graphics. Of those that liked the moving piece, they liked that the graphic showed how storms were expected to evolve better than a static image, it helped them narrow down the timeframe, and they liked that the tool let you look at timing in different locations (i.e., by choosing different cities or latitude/longitude points). For those that did not like the moving graphic, the EMs noted that they just wanted general timing and that they did not need as much detail as the SPC graphic provided. They also noted that the moving timing graphic would be more difficult to disseminate to partners. Many EMs stated that they share information with their partners via briefing packets, typically PDF files, so static images would be easier to share.

The EMs were also worried about consistency in timing information from the SPC and their local NWS offices. They wanted to make sure that the information they were receiving and disseminating was consistent to avoid confusion. The EMs agreed that they tend to look at the SPC for general, big picture information and then turn to their local NWS offices for details as the event gets closer. Therefore, they were more likely to turn to their local offices for timing information, rather than the SPC. Many of the EMs gave examples of how their local NWS office creates timing graphics, and they rely heavily on those.

In sum, while they all indicated that timing information is one of the most important pieces of information, they felt that the SPC timing graphic was not altogether clear. The EMs indicated that they may still look at the SPC timing information if it was available, but they were more likely to turn to their local NWS office for specific timing information.

f. PST

Overall, EMs liked the PST and found it very helpful. Timing information is very important to them, and the PST was able to give them a simple picture of the overall timing for an event. They liked that it narrowed down the time frame from a subjective statement like “early evening” to something more approximate, like 5-7 p.m. This helped them to make more proactive operational decisions, such as adjusting staffing, when to open the EOC, etc. They also found that it was easy to interpret and share. Typically, they work in a fast-paced environment, so having something that gave general timing information quickly was helpful. They also felt that they could easily share the PST with their partners. Since it was a static image, they could send it in emails or even over text messages. Additionally, the ease of understanding with the PST gave them confidence that their partners could also quickly understand and obtain critical timing information. They were a little more hesitant on the thought of sharing the PST with the public, but they believed that it could be shared with them if there was a small discussion accompanying the PST.

Although the EMs agreed that they liked the PST and would use it, they had some concerns over how it was presented. They did not like when it was presented in UTC, as many EMs are not as familiar with it and they did not like that they had to take time to convert it to local time. They would prefer if it were presented in their local time, particularly in 24-hour or military time. However, they acknowledged that by converting it to local time, it would be difficult to depict time across time zones. They did not have a solution to this issue, but noted that if it was made clear somewhere on the graphic which time zone it was forecast for, it would be easy for EMs to adjust for the time zone difference.

While they all agreed that the PST was easy to interpret, there were two factors that caused, or could cause, confusion: overlaps in time and color. In terms of an overlap in time, or when the two time "blobs" intersected and had a small area of overlap, there were two main interpretations of the overlap: 1) taking the image literally as an overlap in time, or, 2) the overlap indicates the whole time period. In the first case, some EMs felt that if the time "blobs" overlapped, then time should too. Most EMs interpreted the overlap as the midpoint of the timeframe. For example, if one blob indicated 1-5 p.m. and the other blob indicated 5-9 p.m. (i.e., Figure 5) the overlap could be approximately 3-6 p.m. However, the EMs noted that even though they thought it was the midpoint in time, they would still likely prepare for the whole time frame (i.e., 1-9 p.m.). In the second case, the EMs interpreted that the area in the overlap is under risk for the whole time frame (i.e., 1-9 p.m.). One EM noted that they interpreted the PST as like a Venn Diagram, therefore, the intersection of the two times indicates that the area is under risk for the whole time. In addition to these interpretations, all of the EMs agreed that the overlapping areas, which were usually depicted as a darker shaded color, might unintentionally draw attention to that shaded area. This could give a misinterpretation that the overlapping area is at an "enhanced" risk of the threat or that there is more confidence that something will occur in that area. Because of these issues, some EMs would rather the overlap not be included in the timing graphic at all, but others stated that they still liked the PST whether it has the overlap or not. Again, they all agreed that a small discussion with the PST could be helpful in explaining the overlapping "blobs" (if present).

In terms of color, the EMs thought that the colors used in the PST could unintentionally infer confidence, type of hazard, or severity instead of simply timing itself. EMs perceived that darker (lighter) colors could infer more (less) confidence, probability of occurrence, or risk. For example, darker blue would indicate more confidence or probability of occurrence than lighter blue. In terms of inferring hazard, EMs noted that themselves, their partners, and the public often associated hazards with particular colors. For instance, blues typically indicate winter weather, yellows indicate severe, green indicate rain, etc. Therefore, depicting time as particular colors might lead to the impression that a particular hazard is going to occur in that colored timeframe. For example, blue time "blobs" would indicate timing for a winter weather event, not a severe weather event. Finally, the colors may also indicate levels of severity. Typically, yellows and reds indicate that something is more severe (i.e., "red means bad"). Therefore, if these colors, or gradations of these colors (i.e., yellow, orange, red) may unintentionally indicate that an area under that color is forecasted to receive more severe weather or stronger storms than the others. They worried that this could unintentionally cause panic. Thus, depicting time in colors could be tricky and may cause misinterpretations. It led to the question throughout the experiment: what color is time?

Finally, the EMs discussed whether the PST should come from the SPC or a local NWS office. They thought that the PST might be helpful coming from the SPC because they could provide a unified timing message across the United States. They noted that sometimes timing information varied across CWA boundaries, even though the offices try to coordinate and work together. Having one timing message for the larger scale would be helpful for them to get a general picture of timing. However, they all noted that they would still turn to their local office for specific or detailed timing information for their jurisdiction.

In sum, the EMs liked the PST and found it very useful, even with the discrepancies in overlapping time and color. They thought it was easy to use and helped give them a more specific timeframe to make operational decisions. They also indicated that between the SPC timing tool and the PST, they preferred the PST.

g. Focus group summary and discussion

There were several overall themes that emerged throughout the focus group discussions, namely: the importance of timing and geographic information.

Timing information was very important to the EMs, so much so that many of their favorite products centered around timing, specifically the PST. Having rough estimates of the timing of storms helped the EMs make proactive decisions such as determining when their community might be impacted, when to open the EOC, when to schedule additional staffing, when to open public tornado shelters, if they should preposition resources, etc. At the storm/warning time scale, timing information, such as those provided by TIM and PHI, gave them better indications of lead time. More lead time gave them opportunities to alert their community members and give them more time to shelter. This was especially beneficial for those who need more time to shelter such as those in mobile homes, hospitals, schools, nursing homes, etc.

However, they also acknowledged that too much lead time might stop being beneficial. If people were sheltered for long periods of time, the EMs were worried that they might come out of shelter too early, thinking the danger must have passed. They did not want people coming out of their shelters during or right before the storm hit, as it would negate the act of sheltering. The EMs were also concerned that encouraging people to shelter for too long could lead to complacency about sheltering in the future.

In addition to timing information, geographic information or experience with their local geographies was very important for EMs. Unsurprisingly, EMs wanted to know the areas or locations where storms were likely to occur so they could prepare. If their jurisdiction was not located in an area of risk, they did not worry about the storms and could move on to other tasks, such as potentially supporting or providing aid to neighboring jurisdictions or simply discounting the storm event altogether. However, EMs knew that forecasts could change, so they still paid attention throughout the event time period. They monitored forecasts by paying attention to forecast trends as the days evolved, like using SPC Outlooks and local NWS forecasts. On the day of a severe weather event and as it gets closer to the storms forming, they are monitoring the weather using radar, storm spotters, and NWSChat. Using the experimental products, like WoFS, PST, PHI, and TIM, helped them do that more effectively.

EMs also have an understanding of their local climatologies and hazards, which impacts many of their resulting decisions or interpretations of forecast information, including probabilities. For instance, knowing tornado occurrence in their area, types of severe storms they experience (squall lines vs. discrete cells), and overall intensities of severe weather all play into how they make decisions. If an EM is accustomed to tornadoes in their jurisdiction, they are more likely to have routines in place versus someone who is not accustomed to tornadoes. EMs are also aware of “non-severe” (i.e., not included in the NWS definition of severe weather) threats that impact their communities. For example, one EM from the Gulf of Mexico region noted that they have protocols in place to respond to any thunderstorm that has lightning, because they have had many deaths due to lightning in the past. EMs also use their local knowledge to anticipate other hazards, such as flooding. Rather than just relying on SPC convective forecasts, they mentioned they would also be looking at Weather Prediction Center products for rainfall and flooding information.

Finally, EMs’ local knowledge on their climatologies also impacted how they interpreted risk categories and probabilities, such as SPC Convective Outlooks, WoFS, and PHI. In terms of SPC Convective Outlooks, the EMs mentioned that they could interpret the risk categories (marginal, slight, etc.) and associated probabilities because they had experience in their geographies for what hazards each category posed. They knew, generally, what types of storms occurred when they were in a slight risk with a 2% tornado probability, for example, so they could prepare accordingly. Alternatively, an EM who did not have as much experience with severe weather interpreted the risk levels and probabilities differently, and had less experience and knowledge of how to deal with the impending threat. For example, the EMs mentioned that a 2% tornado risk means something different in the southern Plains than it does to someone in the Northeast. Thus, while probability values are objective, EMs use local knowledge to add context and anticipate what might happen.

When it came to using new probabilities, such as the WoFS and PHI tools, EMs noted that they did not have experience with what hazards were likely to be associated with each probability. They asked questions like, “what kind of hazards come from a storm with a x% PHI?”, “is x% bad?”, “does each forecaster issue probabilities the same way?”, “is x% probability in my state the same as x% probability in another state?”. In other words, they needed more experience “feeling” the probabilities before they could use them most effectively. This also meant that they were interpreting probabilities differently and had different thresholds for action. As noted above, EMs triggered different actions at different probabilities depending on what they deemed appropriate. There was not a “magic” probability value that triggered EMs to action, it depended on their experience and knowledge of their local communities. Thus, probabilities are still relative.

4. Survey Results

Two surveys were administered to EM participants for each experiment week. One pretest survey was given on the first day and one posttest survey was given on the final day.

The results from each survey are presented here. Note that one EM's data is missing from the pretest survey.

a. Pretest

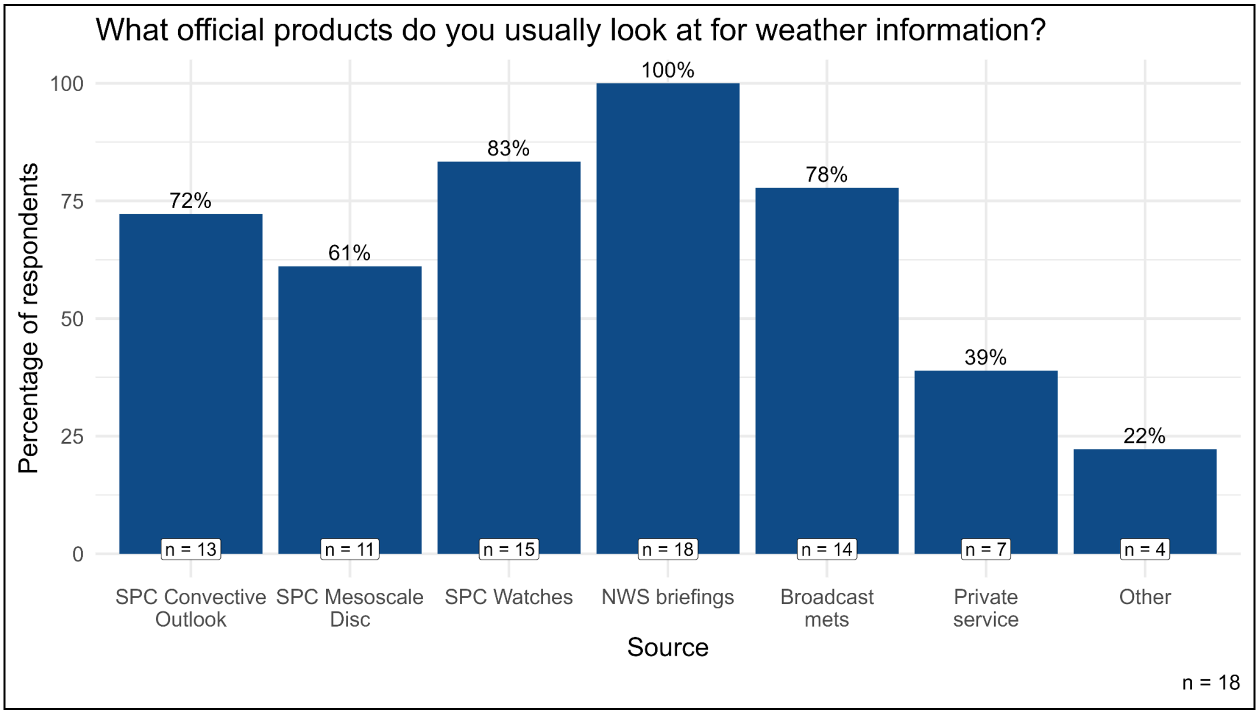
i. Weather Information and Operations

PHI_HWT_Expose: Have you had any previous exposure to the Probabilistic Hazard Information (PHI) tool and/or the Hazardous Weather Testbed (HWT)?
1- No, I have no previous exposure to the PHI tool or HWT. [77.8%, n=14]
2- Yes, I have done some online research on my own about the PHI tool and/or HWT. [16.7%, n=3]
3- Yes, I have previous exposure to the PHI tool or HWT because I was a participant during the previous year. [5.6%, n=1]
4- Yes, I have previous exposure to the PHI tool or HWT, but in another way. [0%, n=0]

seek_info_MC: In general, do you actively seek weather information as part of your job duties?
1- Yes [100%, n=18]
2- No [0%, n=0]

wx_info_SOP: Is weather information sent to you as part of your organization's standard operating procedures?
1- Yes [94.1%, n=16]
2- No [5.9%, n=1]

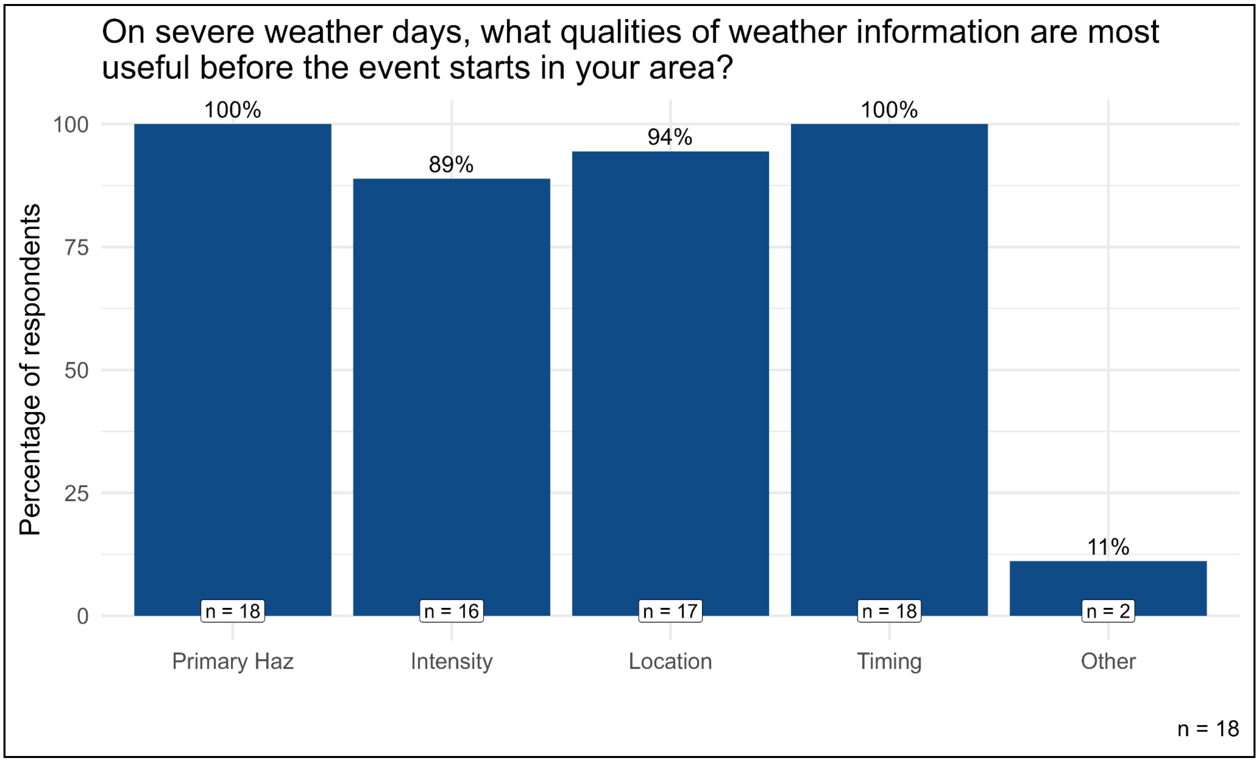
wx_product_used_general_all: What official products do you usually look at for weather information? (check all that apply)
1- Storm Prediction Center convective outlook [72%, n=13]
2- Storm Prediction Center mesoscale discussions [61%, n=11]
3- Storm Prediction Center watches [83%, n=15]
4- local NWS office briefings [100%, n=18]
5- broadcast meteorologist posts/forecasts [78%, n=14]
6- Private firm forecasts/apps [39%, n=7]
7- Other [VERBATIM] [22%, n=4]
Other responses: OK-FIRST/RadarFirst, College of DuPage weather page, spaghetti models, RadarScope, WxAlerts subscription, DTN, weather forecast models



radar_use_general: Do you generally use radar data on severe weather days? This includes looking at radar images on the National Weather Service webpage and/or radar-specific software such as RadarScope, GR, Radar First, etc.
1- Yes [100%, n=18]
2- No [0%, n=0]

radar_use_freq: On the day of potentially severe weather, how often do you look at weather radar data?
1- About every 10 mins or less [16.7%, n=3]
2- About 2-3 times per hour [61.1%, n=11]
3- About once per hour [16.7%, n=3]
4- 1-2 times throughout the entire severe weather event [0%, n=0]
5- I would not look at weather radar data at all in this situation [0%, n=0]
6- I look infrequently when storms are far away or do not exist yet, and very often when storms are near [5.6%, n=1]

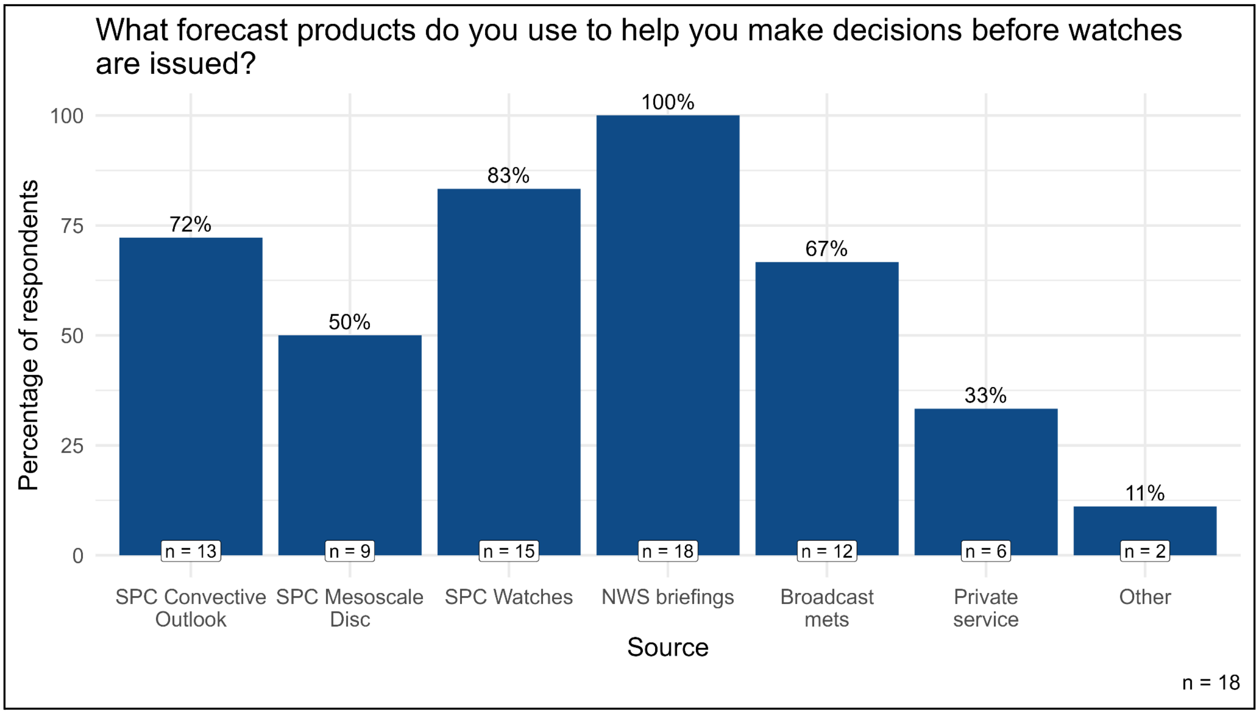
wx_qualities_useful_before_event_all: On severe weather days, what qualities of weather information are most useful to you before the event starts for your area? (select all that apply)
1- Primary hazard types [100%, n=18]
2- Intensity of possible hazards [89%, n=16]
3- Location of possible hazards [94%, n=17]
4- Timing of possible hazards [100%, n=18]
5- Other [VERBATIM] [11%, n=2]
Other responses: impact areas, “every piece of data I can get my hands on”



decision_before_watch: Think about your daily tasks on a severe weather day. What decisions need to be made or what tasks are you required to complete **before watches** are issued for your area? Please give examples of what the decisions/tasks are and when those decisions/tasks must be completed. [VERBATIM]

Decisions made before watch	**Count**
Contact partners/responders/staff	10
Assess staffing	7
Monitor/prep/deploy resources	6
Adjust community activities/closures	6
Monitor weather forecasts	6
Send out weather briefings	5
Activate EOC	3
Activate spotters	2
Alert public	2
Hold conference call/webinar	1

product_use_before_watch: What forecast products do you use to help you make those decisions or accomplish those tasks?
1- Storm Prediction Center convective outlook [72%, n=13]
2- Storm Prediction Center mesoscale discussion [50%, n=9]
3- Storm Prediction Center watches [83%, n=15]
4- local NWS office briefings [100%, n=18]
5- broadcast meteorologist posts/forecasts [67%, n=12]
6- private firm forecasts/apps [33%, n=6]
7- Other [VERBATIM] [11%, n=2]
Other responses: NWS Chat, weather models



watch_decision_MC: If a severe thunderstorm watch or tornado watch is issued for your area, are there additional decisions or tasks that must be completed prior to warnings being issued for your area?
1- Yes [61.1%, n=11]
2- No [38.9%, n=7]
3- If yes, please describe [VERBATIM]: **tor_watch_decisions:**

Decisions made during watch	Count
Call in/prep staff	5
Contact partners/responders	4
Activate EOC	3

Monitor weather	2
Resource prep	1
Assess mutual aid	1

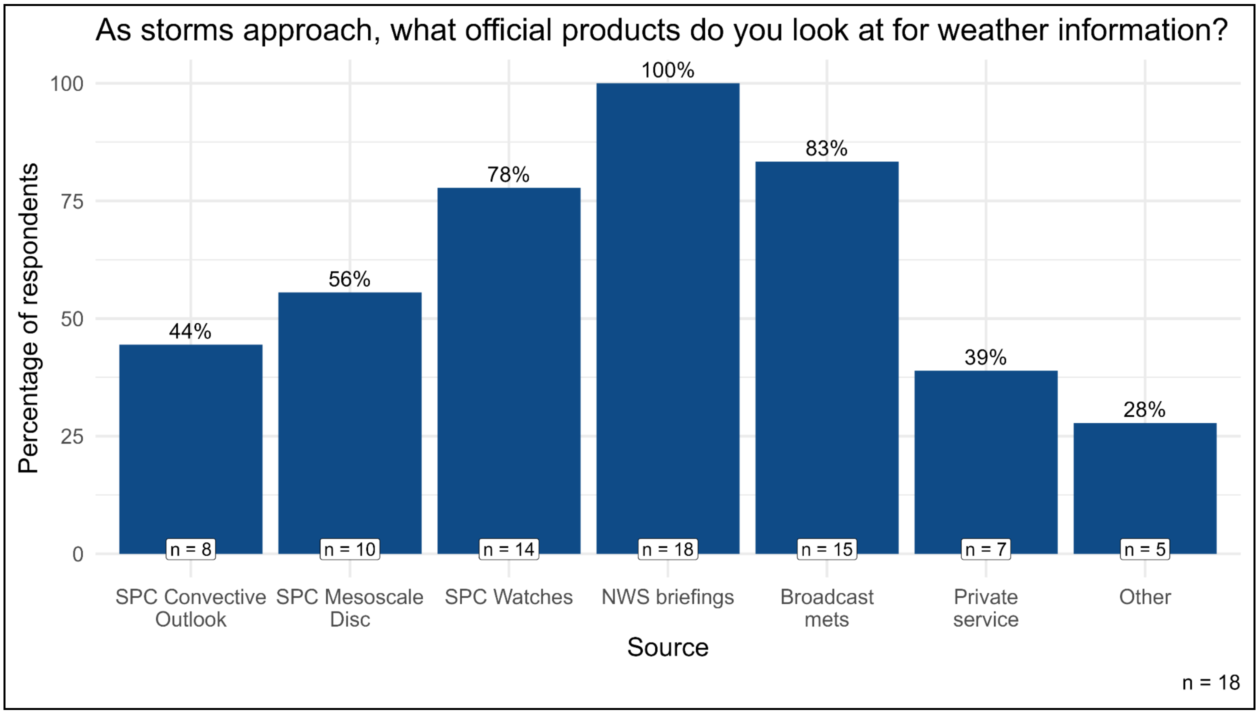
SOP_hazard_dependent: Does your procedure change depending on what the primary hazard for the day is (i.e., if tornadoes are the main threat vs. wind/hail as the main threat)?
1- Yes [50%, n=9]
2- No [50%, n=9]
3- If yes, please explain how your procedure changes [VERBATIM]

- Monitor
- Different threats impact different operational processes
- Greater push of information
- Hazard specific plans chosen based on primary hazard, departments notified of changes, resources/personnel on standby
- Primary concern is tornadoes
- Notify spotters for tornado threats, messaging changes for tornado, high-end damaging winds, or very large hail
- Notify spotters, notify schools and institutions
- Tornadoes and flash flood high concern, hail and wind monitored
- Tornado timeframe limited, so rapid response needed

seek_info_storm_approach: As storms approach, do you actively seek weather information?
1- Yes [100%, n=18]
2- No [0%, n=0]

wx_info_SOP_storm_approach: As storms approach, is weather information sent to you as part of your organization's standard operating procedures?
1- Yes [88.9%, n=16]
2- No [11.1%, n=2]

wx_product_use_storm_approach: As storms approach, what official products do you usually look at for weather information? (check all that apply)
1- Storm Prediction Center convective outlook [44%, n=8]
2- Storm Prediction Center mesoscale discussion [56%, n=10]
3- Storm Prediction Center watches [78%, n=14]
4- local NWS office briefings [100%, n=18]
5- Broadcast meteorologist posts/forecasts [83%, n=15]
6- Private firm forecasts/apps [39%, n=7]
7- Other [VERBATIM] [28%, n=5]
Other responses: NWS Chat, College of DuPage weather lab website, social media, phone calls, DTN, weather models



tor_warn_decisions: What decisions do you make based on the issuance of a tornado **warning**? [VERBATIM]

Decisions made on issuance of tornado warning	Count
Contact staff/partners/1st responders	12
Activate sirens	6
Alert social media/text/mass alert system	5
Monitor	5
Shelter	3
Prep/activate EOC	3
Contact spotters	1
Gather more info	1

tor_warn_required: What are you required to do given the issuance of a tornado **warning**? [VERBATIM]

Required actions given issuance of tornado warning	Count

Contact staff/partners/1st responders	8
Monitor	6
Activate sirens	5
Alert social media/text/mass alert system	5
Shelter	2
Prep emergency response	2
Prep/activate EOC	1
Contact spotters	1

time_more_info: In light of the typical severe weather timeline that you just described, are there specific timeframes at which you wish you had more forecast information?
1- Yes [66.7%, n=12]
2- No [33.3%, n=6]

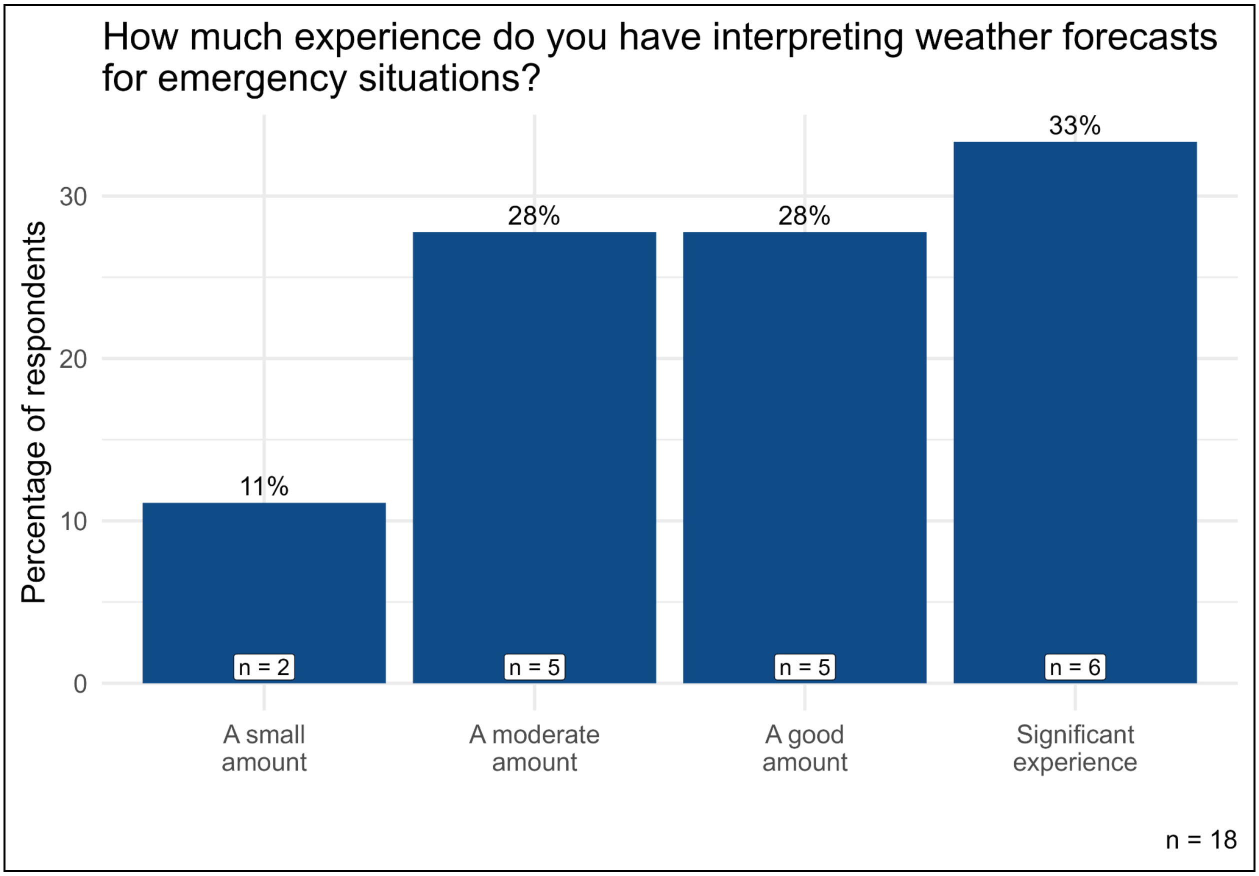
time_more_info_comment: When do you wish you had more information? [VERBATIM]

- More than 96 hours out
- Few hours leading up to event
- Detailed hazard info
- More frequent updates during rapidly evolving situations
- Estimated time of arrival
- About 2 hours prior to storm initiation
- More precise location
- Info on anticipated intensity
- More track and timing specificity
- More info on snow totals
- More info on why tornadoes seem to always dissipate before hitting jurisdiction

ii. Weather Experience

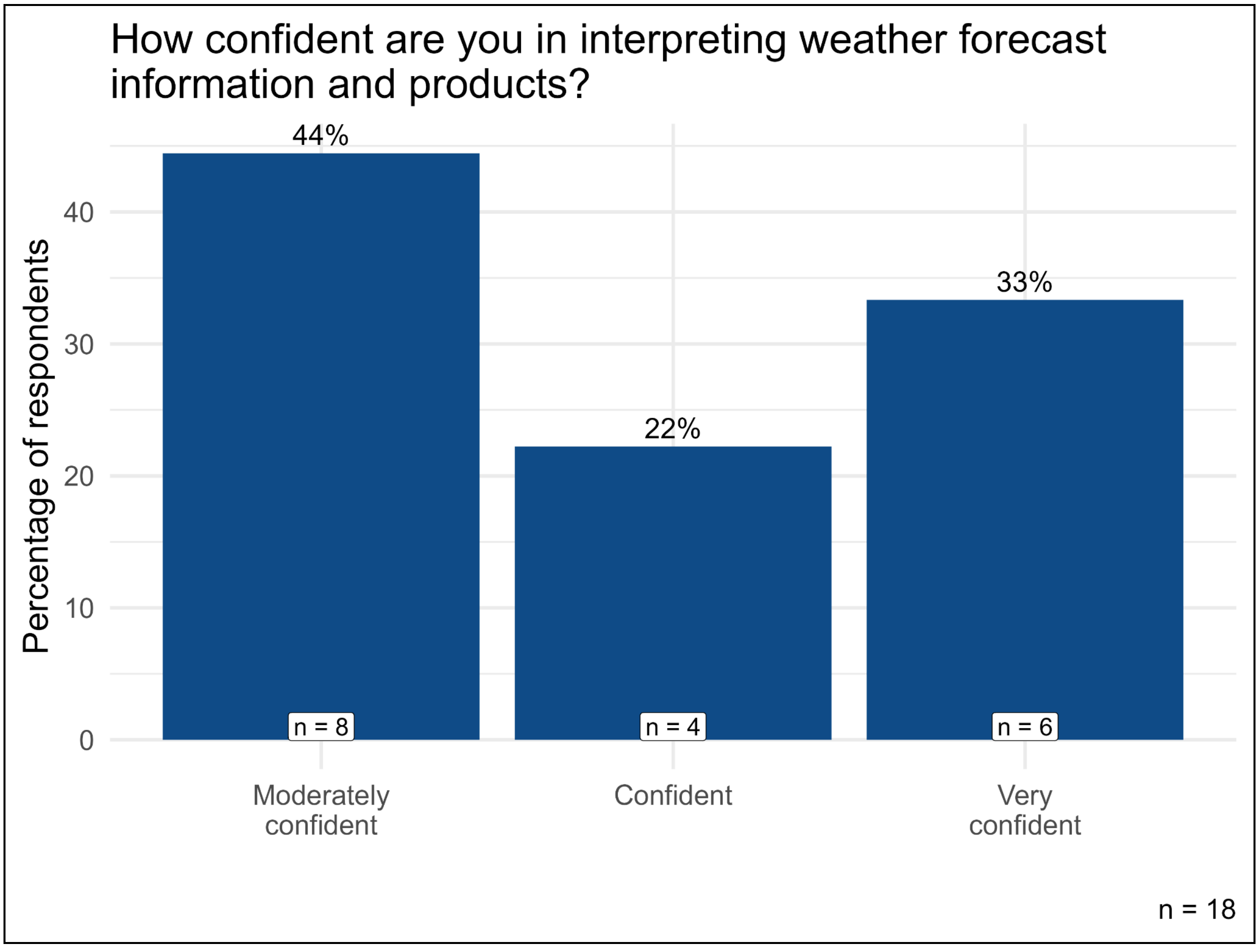
Please answer the following question about your experience interpreting weather forecasts during emergencies.

interpret_forecasts_emergencies: How much experience do you have interpreting weather forecasts for emergency situations?
1- Very little or none [0%, n=0]
2- A small amount [11%, n=2]
3- A moderate amount [28%, n=5]
4- A good amount [28%, n=5]
5- Significant experience [33%, n=6]

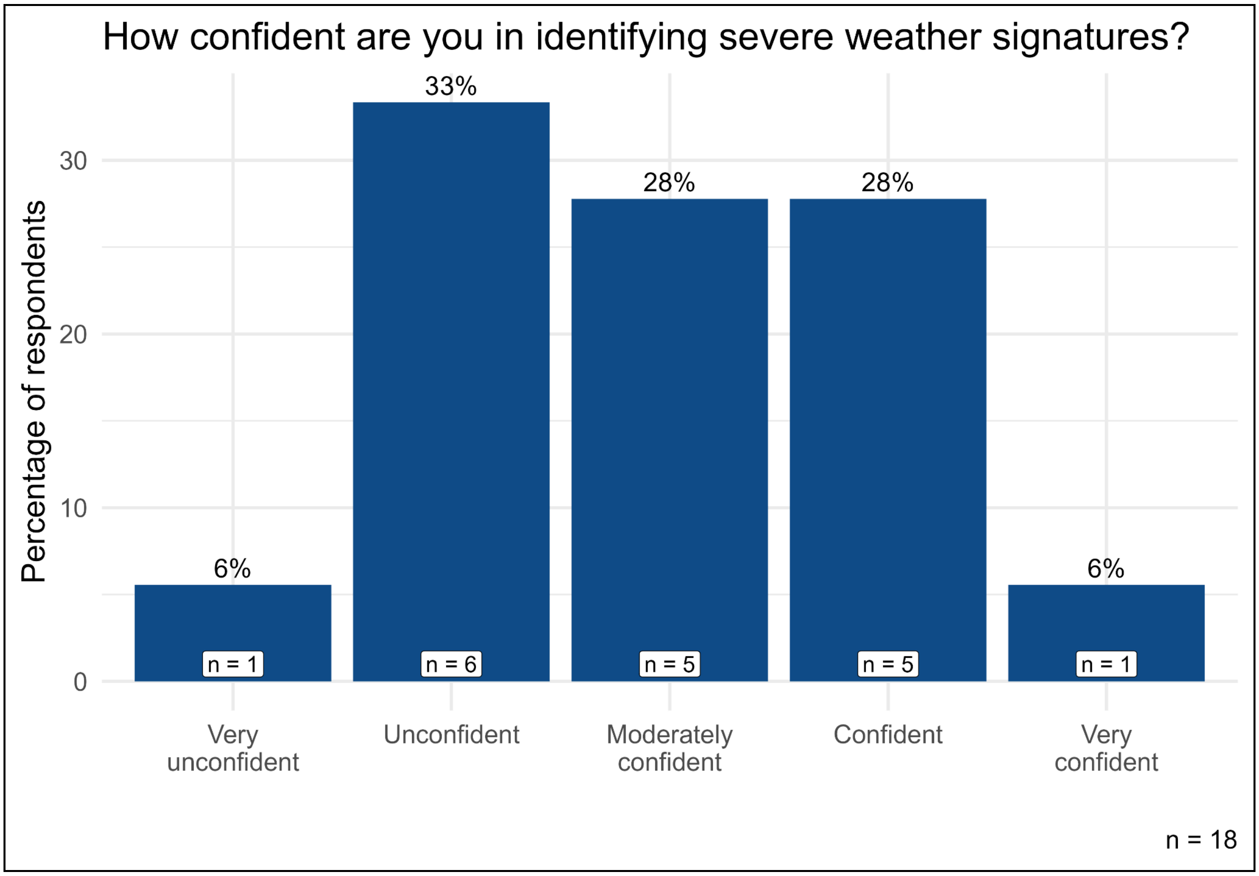


Please answer the following questions about your confidence in interpreting weather forecast information during emergencies.

confidence_interpret_forecasts: How confident are you in interpreting weather forecast information and products?
1- Very unconfident [0%, n=0]
2- Unconfident [0%, n=0]
3- Moderately confident [44%, n=8]
4- Confident [22%, n=4]
5- Very confident [33%, n=6]



confidence_identify_svr_wx_sigs: How confident are you in identifying severe weather signatures in reflectivity and velocity data (e.g., hail cores, velocity couplets, etc.)?
1- Very unconfident [6%, n=1]
2- Unconfident [6%, n=33]
3- Moderately confident [28%, n=5]
4- Confident [28%, n=5]
5- Very confident [6%, n=1]

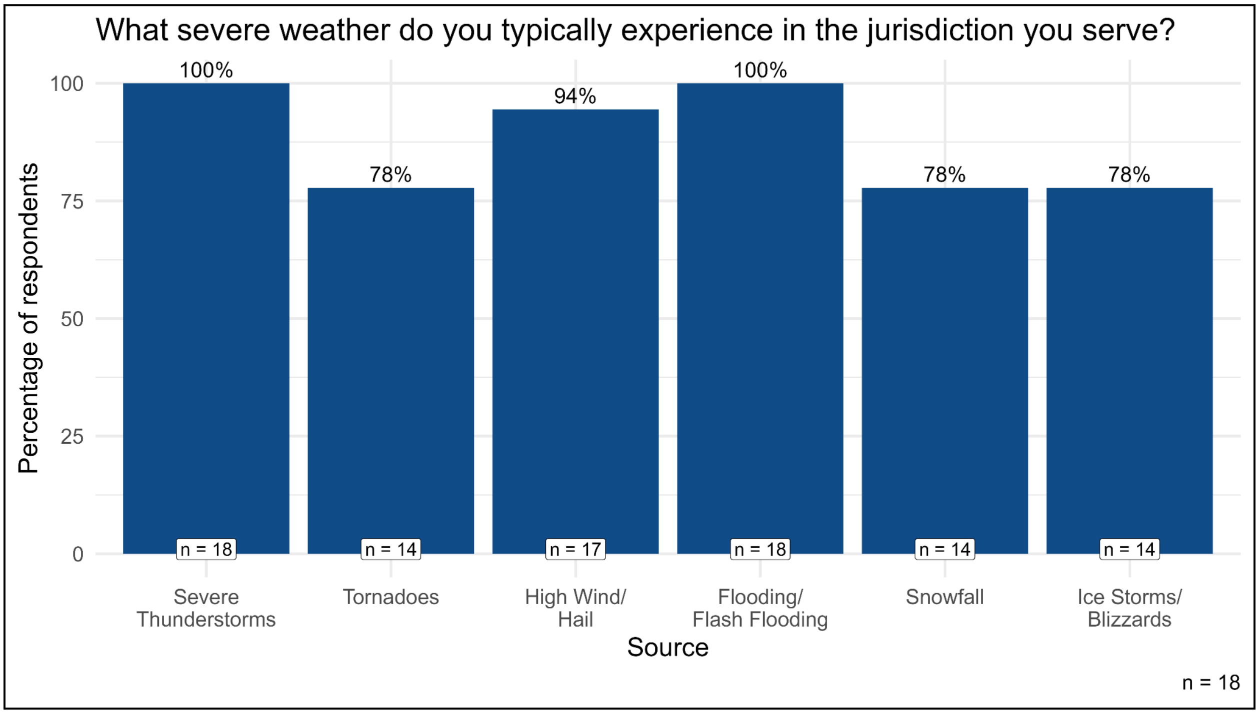


confidence_explain: Please describe why you chose the preceding confidence levels. For example, are you confident in your interpretations because of previous experience, a forecasting background, etc.? [VERBATIM]

Confidence Level	Reasoning
Very unconfident	• Understand forecast products, but less confident about understanding radar signatures
Unconfident	• More familiar with rain/snow, less with severe • Experience with area • Little experience with interpretation/forecasting of weather • Need more training in identifying tornado radar signatures
Moderately confident	• Have general knowledge, but do not use all the time • Degree in meteorology • Has experience and training
Confident	• Self-taught, but could use more training • Has experience and an in-house meteorologist • Has experience and training • Studies severe weather and radar interpretation as a hobby

Very confident	• Has a degree in meteorology

EXP: What severe weather do you typically experience in the jurisdiction you serve? Please select all that apply.
1- Severe Thunderstorms [100%, n=18]
2- Tornadoes [78%, n=14]
3- High Wind and Hail [94%, n=17]
4- Flooding/Flash Flooding [100%, n=18]
5- Snowfall [78%, n=14]
6- Ice Storms/Blizzards [78%, n=14]
7- None of the above [0%, n=0]



warn_convey_chance_occur: Please reflect on the last time a warning was issued while you were at work (e.g., a severe thunderstorm warning, tornado warning). How did weather forecasters convey how **likely** the event was to occur? Did they use percentages, odds, words, or some other language to convey that information? Please include the type of warning you are referencing, and be as descriptive as possible. [VERBATIM]

- Products received information from
  - NWS Chat
  - Convective Outlook
  - Warning text
  - NWS Graphic with rainfall amount, amount of days, which rivers were more of a threat
- “Uncertainty” verbage used
  - “Event likely to occur”

    - Possible, expected, likely
    - Graphic to represent risk, timing, and confidence
    - Mention of storms that may become “strong to briefly severe”
    - Express certainty, if it will be happening soon
- Confidence
    - Confidence wasn’t conveyed
    - Confidence charts of tornado threat
    - Convey confidence levels

To what degree do you feel forecasters issue weather warnings based on the following considerations:

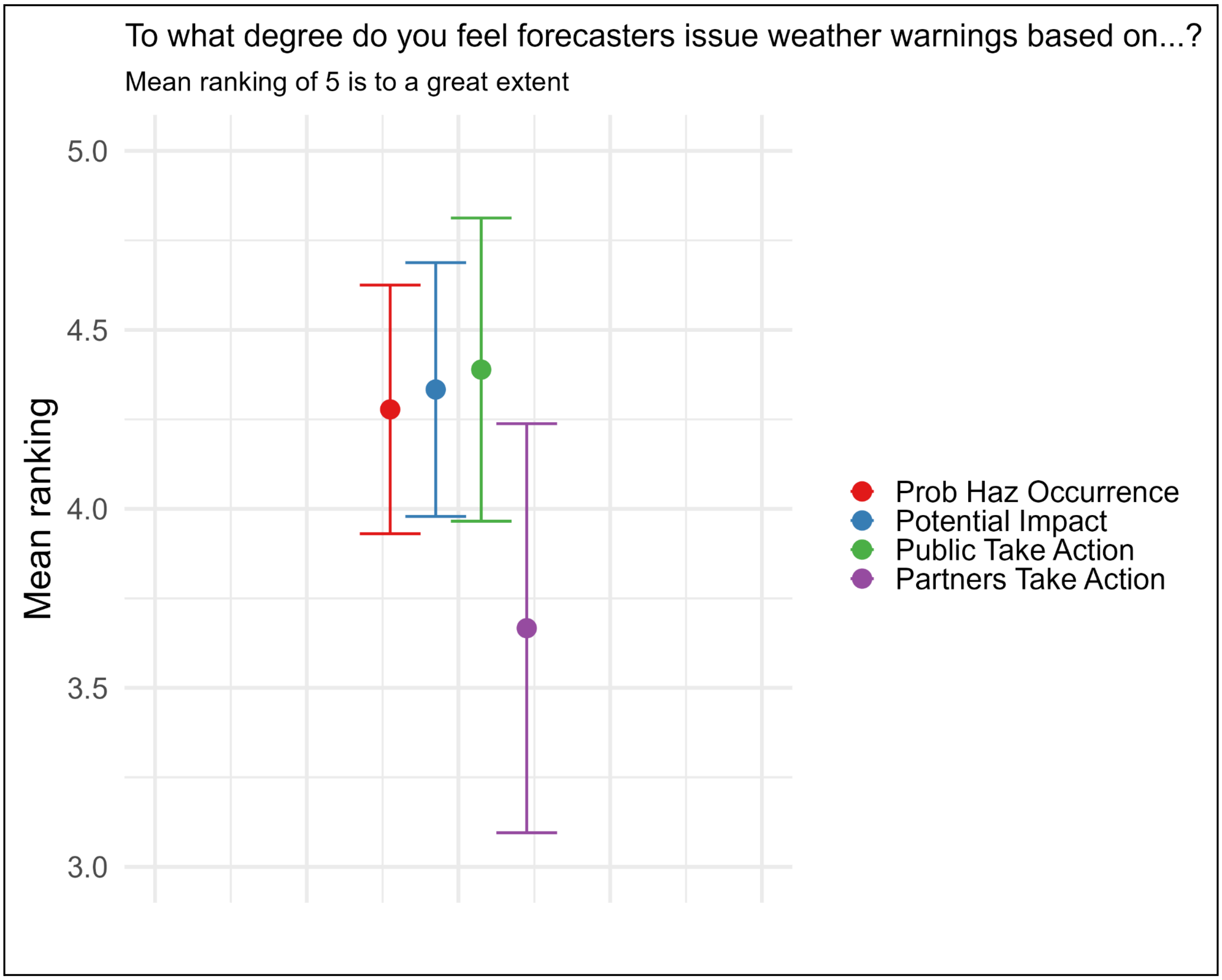
hazard_comm_prob_occur: The probability that a hazard will occur
1- Not at all [0%, n=0]
2- To a small extent [0%, n=0]
3- To some extent [16%, n=3]
4- To a moderate extent [37%, n=7]
5- To a great extent [42%, n=8]
Mean = 4.28

hazard_comm_impactful: The potential impact of the storm
1- Not at all [0%, n=0]
2- To a small extent [0%, n=0]
3- To some extent [16%, n=3]
4- To a moderate extent [32%, n=6]
5- To a great extent [47%, n=9]
Mean = 4.33

hazard_comm_public_take_action: Their desire for a population to start taking some kind of action
1- Not at all [0%, n=0]
2- To a small extent [5%, n=1]
3- To some extent [11%, n=2]
4- To a moderate extent [21%, n=4]
5- To a great extent [58%, n=11]
Mean = 4.39

hazard_comm_partners_take_action: As a heads up to their partners that they might need to take some kind of action
1- Not at all [0%, n=0]
2- To a small extent [26%, n=5]
3- To some extent [11%, n=2]
4- To a moderate extent [26%, n=5]
5- To a great extent [32%, n=6]

Mean = 3.67



relay_info_whom: When the time comes, who do you relay hazardous weather information to? [VERBATIM]

Who relay info to	Count
Partners	10
Staff/other EMs	8
Public	4
NWS	3

relay_info_feq: When you are relaying hazardous weather information, how often or at what frequency are you typically sending information out (e.g., every 15 minutes, every hour, etc.)? [VERBATIM]

Frequency relaying info	**Count**
As conditions change	6
Depends/as needed	5
When a watch/warning is issued	4
2-3 times/multiple times per day	2
About hourly	2
Minutes to hourly	2
About every 15-30 min	2
When get new info	1

iii. Demographics

MALE: Gender:
1- Male [72.2%, n=13]
2- Female [27.8%, n=5]
3- Transgender [0%, n=0]
4- Other [VERBATIM] [0%, n=0]

Age: What is your age [VERBATIM]

Age	**Count**
18-29	2
30-39	3
40-49	5
50-59	6
60+	2

Ethnicity: Are you of Hispanic, Latino, or Spanish origin?
1- No, not of Hispanic, Latino, or Spanish origin [94.1%, n=16]

2- Yes, of Hispanic, Latino, or Spanish origin (for example: Colombian, Cuban, Dominican, Mexican, Mexican American, Puerto Rican, and so on) [5.9%, n=1]

Race: What is your race? Please select all that apply.
1- Caucasian or White [94.4%, n=17]
2- African American or Black [0%, n=0]
3- Asian [0%, n=0]
4- Asian Indian [0%, n=0]
5- American Indian [0%, n=0]
6- Other [VERBATIM] [5.6%, n=1]
Other response: Vietnamese

Education: Highest education you have attained:
1- I completed some high school, but did not graduate [0%, n=0]
2- High school diploma or equivalent (e.g., GED) [0%, n=0]
3- I completed some college, but did not graduate [27.8%, n=5]
4- Associate's Degree [16.7%, n=3]
5- Bachelor's Degree [11.1%, n=2]
6- Master's Degree [38.9%, n=7]
7- Professional Degree (e.g., JD, MD) [5.6%, n=1]
8- Doctoral Degree (e.g., PhD) [0%, n=0]

AgencyType: What type of agency or organization do you work for:
1- For profit Agency [0%, n=0]
2- Non-Profit Agency [0%, n=0]
3- Government Agency [100%, n=17]
4- Other [VERBATIM] [0%, n=0]

CurrentJobTitle: Current Job Title (e.g., Director of Emergency Management) [VERBATIM]

Current Job Title	Count (EMs many have more than one title)
Director/Deputy Director/Assistant Director/Executive Director/Supervisor of Emergency Management	8
EM/Senior EM Specialist	3
Fire Chief/Captain	2
Emergency Manager	1
Emergency Management Coordinator	1
Deputy Commissioner of Public Safety	1

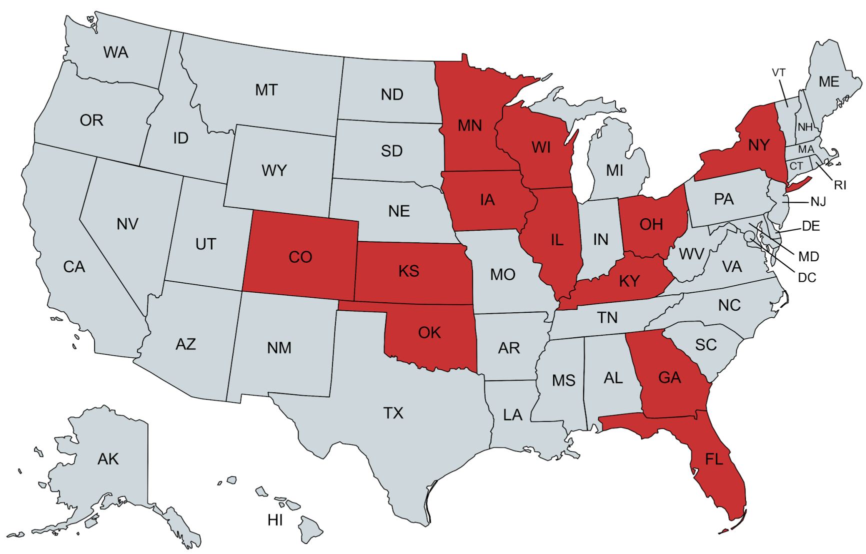
State EOC Manager	1
911 Dispatcher	1
Assistant State Meteorologist	1

Years_EM: Please indicate the number of years you have worked as an emergency manager (years, months) [VERBATIM]

Years worked as an EM	Count
Less than 10 years	7
10-19 years	4
20+ years	3

State: Please name the state or district where you primarily work [VERBATIM]

State	Count
Colorado	2
Florida	1
Georgia	1
Illinois	1
Iowa	1
Kansas	1
Kentucky	1
Minnesota	1
New York	2
Ohio	1
Oklahoma	5
Wisconsin	1



AreaType: The area where I work is considered:
1- Rural [11.1%, n=2]
2- Urban [50%, n=9]

3- Suburban [38.9%, n=7]

b. Posttest

i. General (Overall) Evaluation

In general, how useful were the following tools at informing your decisions this week?

useful_SPCoutlooks:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [5.3%, n=1]
6- Moderately useful [21.1%, n=4]
7- Extremely useful [73.7%, n=14]
Mean = 6.68

useful_SPCmeso_discussions:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [5.3%, n=1]
5- Slightly useful [10.5%, n=2]
6- Moderately useful [31.6%, n=6]
7- Extremely useful [52.6%, n=10]
Mean = 6.32

useful_SPCwatches:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [5.3%, n=1]
6- Moderately useful [26.3%, n=5]
7- Extremely useful [68.4%, n=13]
Mean = 6.63

useful_warnings:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [0%, n=0]

6- Moderately useful [5.3%, n=1]
7- Extremely useful [94.7%, n=18]
Mean = 6.95

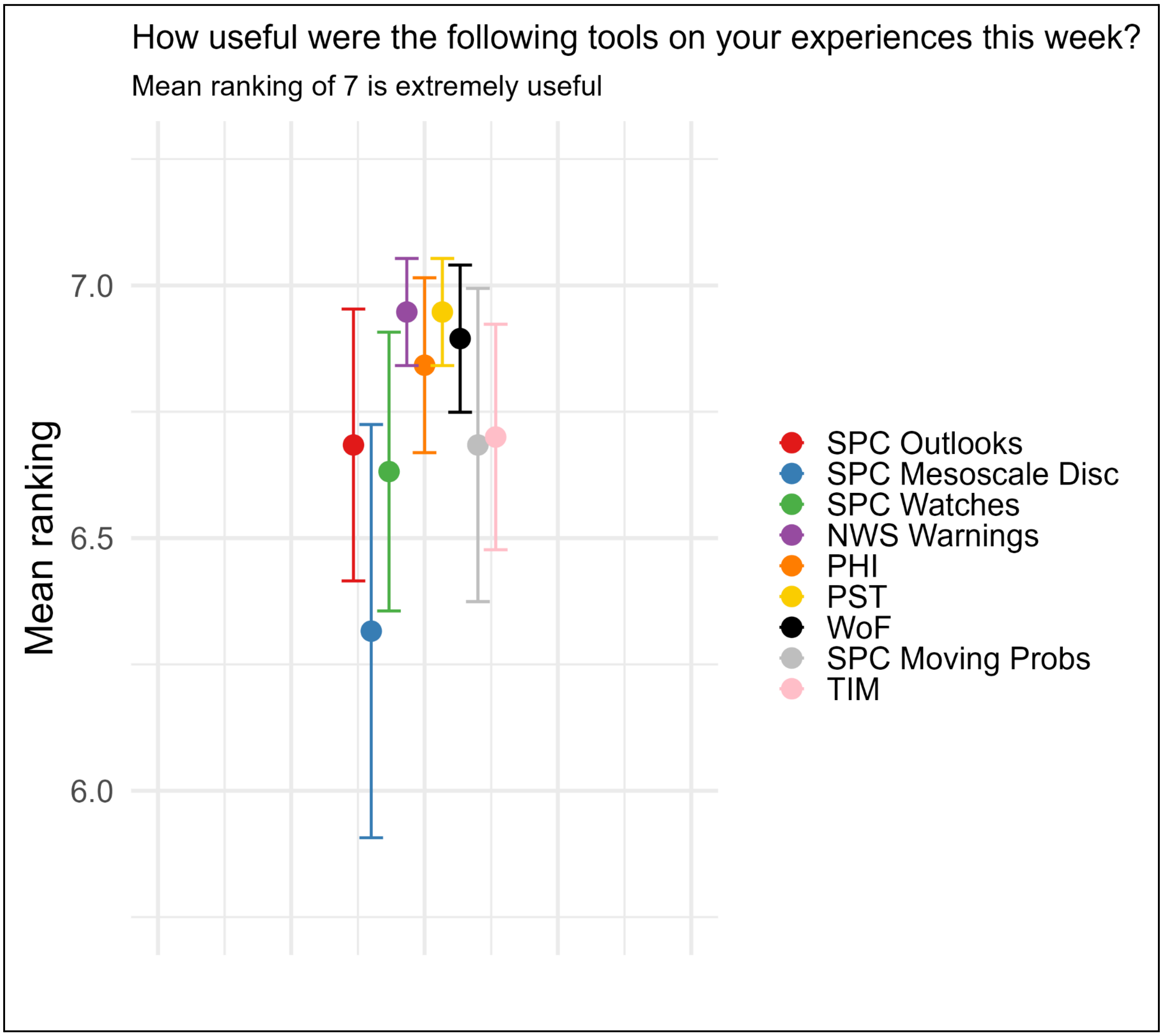
useful_PHI:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [0%, n=0]
6- Moderately useful [15.8%, n=3]
7- Extremely useful [84.2%, n=16]
Mean = 6.84

useful_PST:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [0%, n=0]
6- Moderately useful [5.3%, n=1]
7- Extremely useful [94.7%, n=18]
Mean = 6.95

useful_WoF:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [0%, n=0]
6- Moderately useful [11.1%, n=2]
7- Extremely useful [89.5%, n=17]
Mean = 6.89

useful_SPCmoving_probs:
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [10.5%, n=2]
6- Moderately useful [10.5%, n=2]
7- Extremely useful [78.9%, n=15]
Mean = 6.68

useful_TIM (Fall only, n=10):
1- Extremely useless [0%, n=0]
2- Moderately useless [0%, n=0]
3- Slightly useless [0%, n=0]
4- Neither useless nor useful [0%, n=0]
5- Slightly useful [0%, n=0]
6- Moderately useful [30.0%, n=3]
7- Extremely useful [70.0%, n=7]
Mean = 6.70



Please evaluate the degree to which PHI:

PHI_easy_to_use: Was easy to use
1- Strongly disagree [0%, n=0]

2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [16.7%, n=3]
6- Agree [38.9%, n=7]
7- Strongly agree [44.4%, n=8]
Mean = 6.28

PHI_deliver_important_info: Delivered pertinent information
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [10.0%, n=1]
6- Agree [20.0%, n=2]
7- Strongly agree [70.0%, n=7]
Mean = 6.60

PHI_deliver_info_quick: Delivered information quickly
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [22.2%, n=4]
7- Strongly agree [77.8%, n=14]
Mean = 6.78

PHI_confident_decisions: Made you more confident in your decisions
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [5.6%, n=1]
6- Agree [16.7%, n=3]
7- Strongly agree [77.8%, n=14]
Mean = 6.72

Please evaluate the degree to which the PST:

PST_easy_to_use: Was easy to use
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]

4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [5.3%, n=1]
6- Agree [26.3%, n=5]
7- Strongly agree [68.4%, n=13]
Mean = 6.63

PST_deliver_important_info: Delivered pertinent information
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [0%, n=0]
7- Strongly agree [100%, n=11]
Mean = 7.0

PST_deliver_info_quick: Delivered information quickly
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [10.5%, n=2]
7- Strongly agree [89.5%, n=17]
Mean = 6.89

PST_confident_decisions: Made you more confident in your decisions
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [26.3%, n=5]
7- Strongly agree [73.7%, n=14]
Mean = 6.74

Please evaluate the degree to which the Warn-on-Forecast (WoF):

WoF_easy_to_use: Was easy to use
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [15.8%, n=3]

6- Agree [21.1%, n=4]
7- Strongly agree [63.2%, n=12]
Mean = 6.47

WoF_deliver_important_info: Delivered pertinent information
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [36.4%, n=4]
7- Strongly agree [63.6%, n=7]
Mean = 6.64

WoF_deliver_info_quick: Delivered information quickly
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [5.3%, n=1]
6- Agree [31.6%, n=6]
7- Strongly agree [63.2%, n=12]
Mean = 6.58

WoF_confident_decisions: Made you more confident in your decisions
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [5.3%, n=1]
6- Agree [15.8%, n=3]
7- Strongly agree [78.9%, n=15]
Mean = 6.74

Please evaluate the degree to which the SPC experimental products:

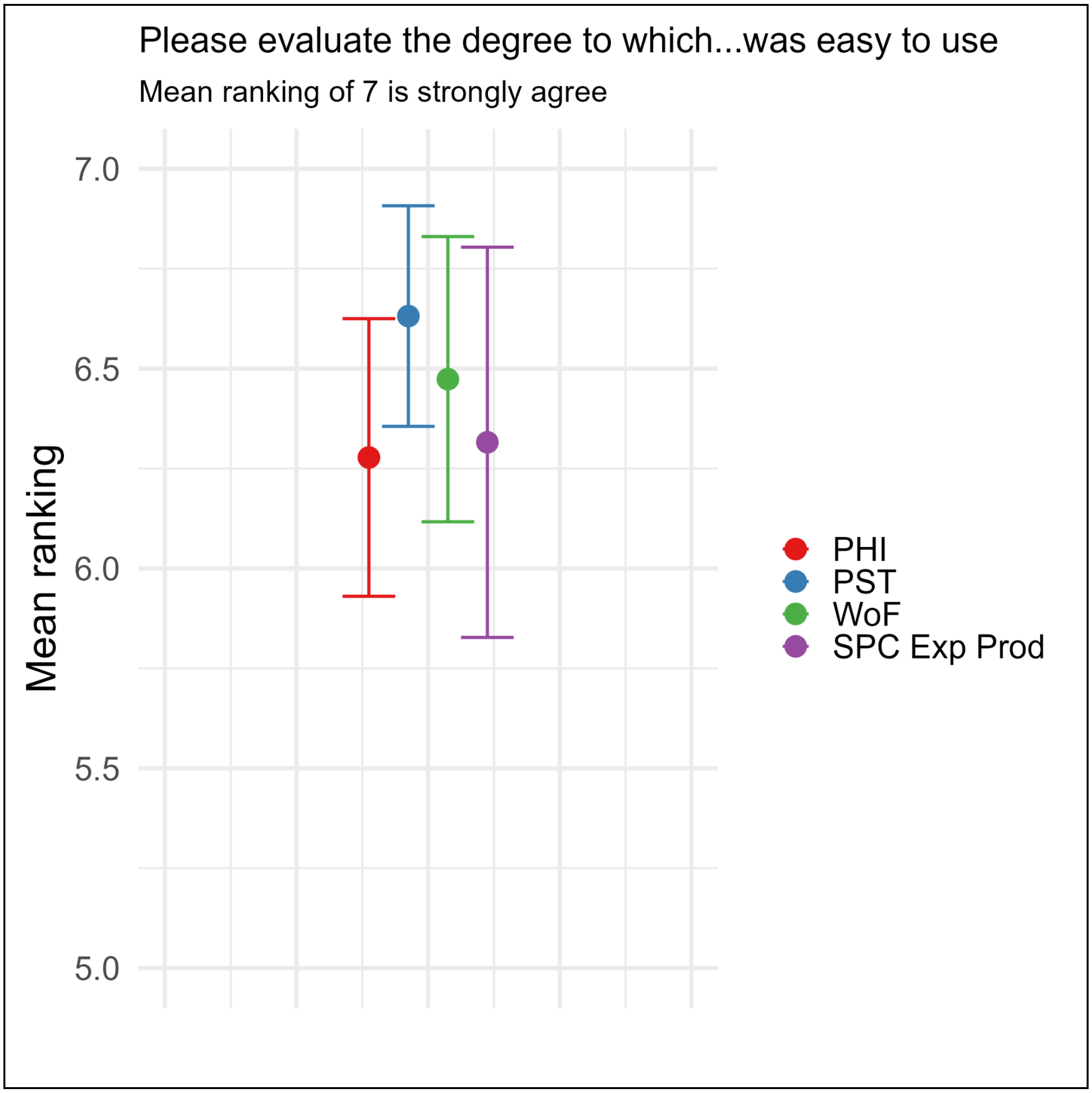
SPC_exp_prod_easy_to_use: Was easy to use
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [5.3%, n=1]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [10.5%, n=2]
6- Agree [26.3%, n=5]
7- Strongly agree [57.9%, n=11]

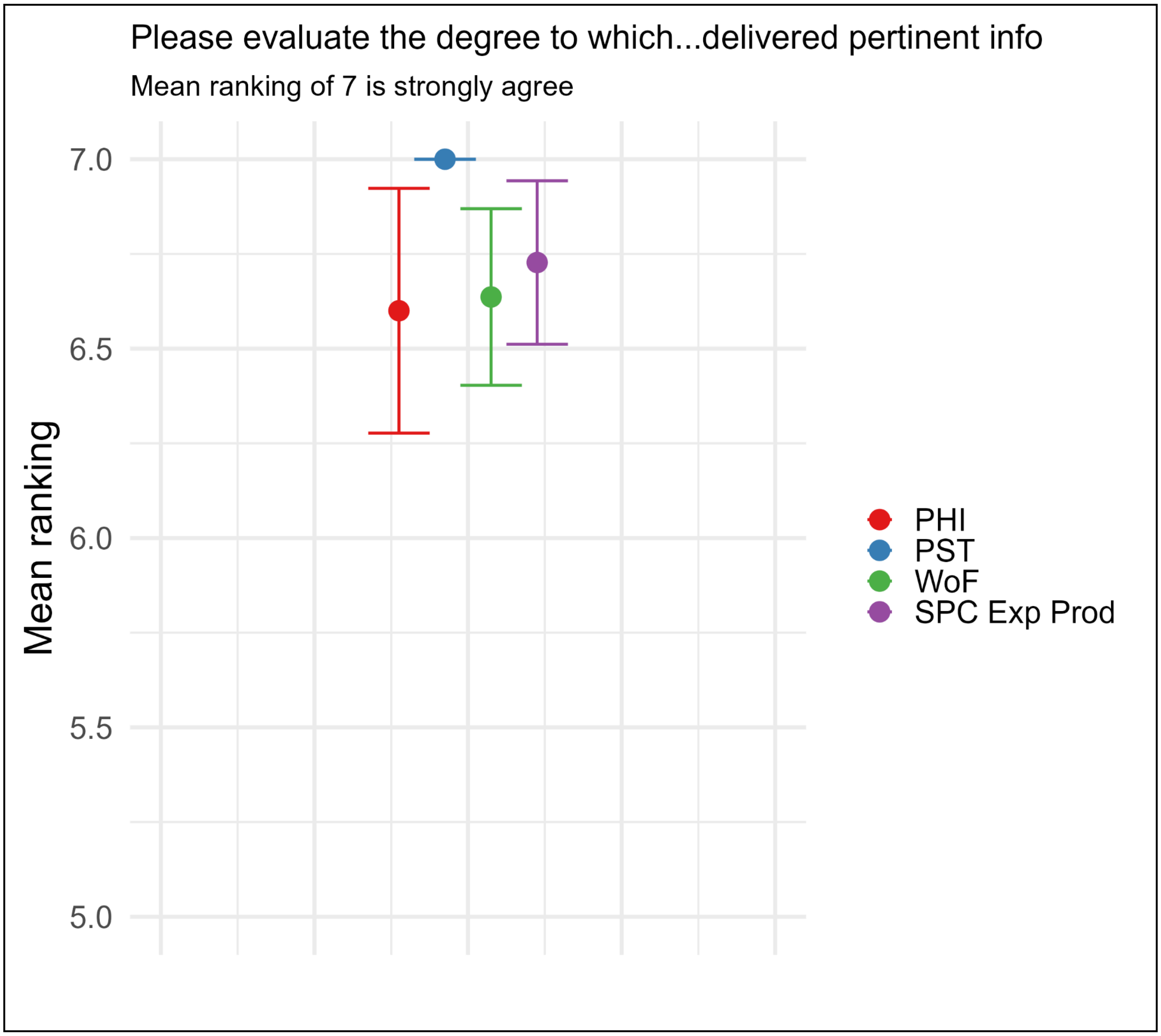
Mean = 6.32

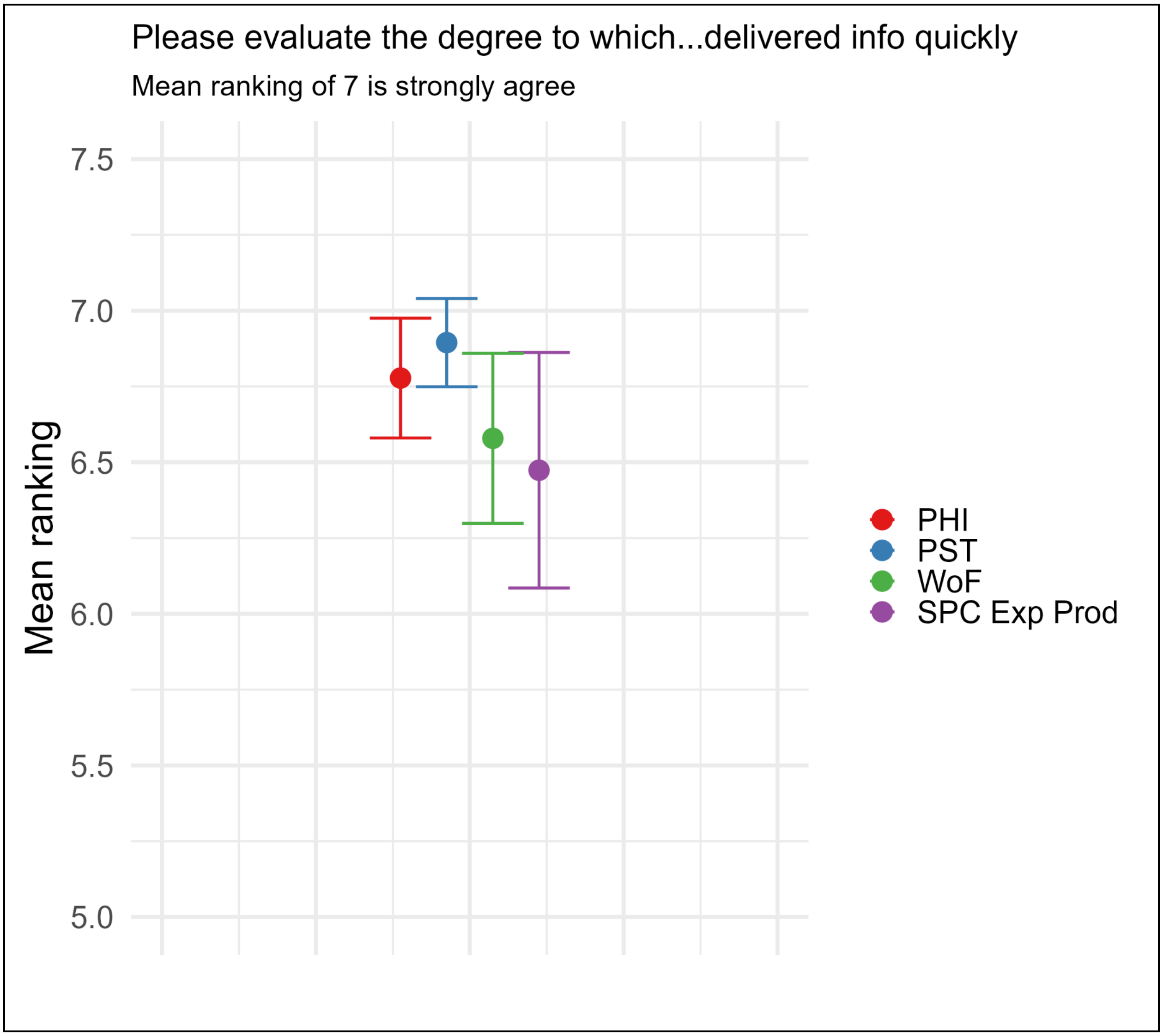
SPC_exp_prod_deliver_important_info: Delivered pertinent information
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [0%, n=0]
6- Agree [27.3%, n=3]
7- Strongly agree [72.7%, n=8]
Mean = 6.73

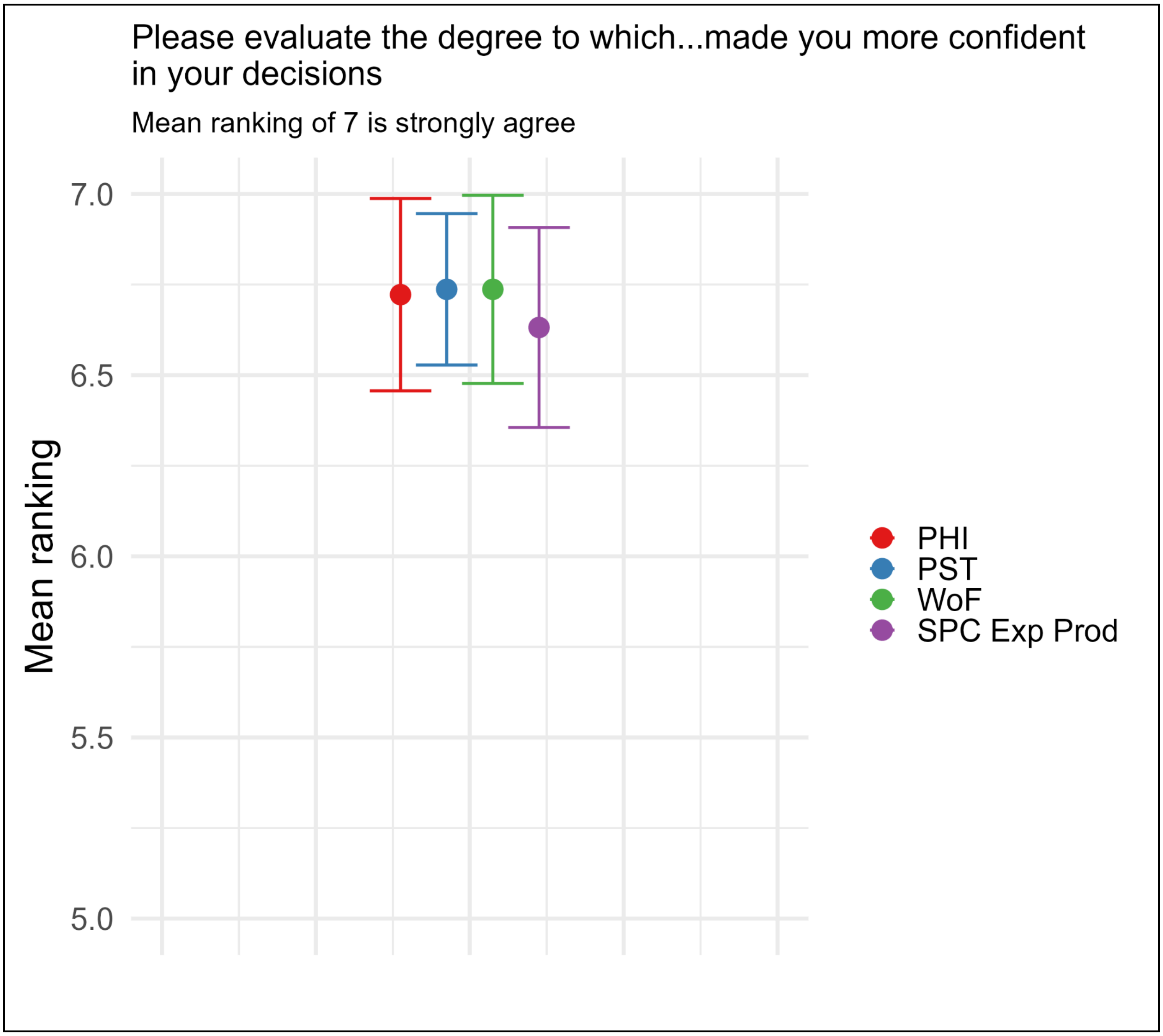
SPC_exp_prod_deliver_info_quick: Delivered information quickly
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [5.3%, n=1]
5- Somewhat agree [5.3%, n=1]
6- Agree [26.3%, n=5]
7- Strongly agree [63.2%, n=12]
Mean = 6.47

SPC_exp_prod_confident_decisions: Made you more confident in your decisions
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Somewhat disagree [0%, n=0]
4- Neither disagree nor agree [0%, n=0]
5- Somewhat agree [5.3%, n=1]
6- Agree [26.3%, n=5]
7- Strongly agree [68.4%, n=13]
Mean = 6.63


Please evaluate the degree to which...was easy to use
Mean ranking of 7 is strongly agree
Mean ranking
7.0
6.5
6.0
5.5
5.0
PHI
PST
WoF
SPC Exp Prod


Please evaluate the degree to which...delivered pertinent info
Mean ranking of 7 is strongly agree
Mean ranking
7.0
6.5
6.0
5.5
5.0
PHI
PST
WoF
SPC Exp Prod


Please evaluate the degree to which...delivered info quickly
Mean ranking of 7 is strongly agree
Mean ranking
7.5
7.0
6.5
6.0
5.5
5.0
PHI
PST
WoF
SPC Exp Prod



ii. PST Evaluation

PST_decisions_depend_threat: In the days leading up to a potential severe weather event, do your decisions change if the main threat is wind/hail instead of tornadoes? If so, please offer a brief (2-3 sentence) description of the different decisions you need to make. [VERBATIM]

Decision Change?	Count	What changes?
Yes	11	• Suggested protective actions change • May not increase staff • Widespread wind damage may require additional staffing • Wind/hail typical, tornadoes initiate… ○ Different/more actions

		○ More gathering of info ○ More staff and resource need ○ More frequent public dissemination ○ More preparation and deploying spotters ○ Shorter lead times which means less time to make decisions ○ Mobilization of assets and personnel
No	7	• Agency focuses on an all hazards perspective • Same levels of readiness regardless of hazard • Process of informing stays the same • Severe winds can cause similar damage as tornadoes so would treat similarly
Depends	1	• If wind/hail is strong/large enough, would make similar decisions as would a tornado

PST_time_window_change_decisions: In the PST product, we have shown you a 4-hour window of severe weather threat. Would your decisions change if you are given a 6- or 8-hour window of severe threat?

1- Yes, please explain how: [VERBATIM] [36.8%, n=7]

- 6-8 hours would allow more lead time to…
    - Make resources available for standby sooner
    - Help in preparation
    - Hold additional briefings
- Prefer 4-hour windows because…
    - Would like the most up to date information possible
    - 6-8 hours is vague, want more up to date information
    - 8 hours too far out in time
    - 6-8 hours would be too far out in time to make timely decisions

2- No [63.2%, n=12]

PST_change_order_tasks_decisions: Would a product like the PST or moving probabilities change the order of your tasks/decisions on a typical severe weather day?

1- Yes, please explain how [VERBATIM] [63.2%, n=12]

- Some decisions may become more priority
- May not change, but helps decisions based on time factors
- Operational environment changes
    - Staging vs. preparing
    - Adjust from daily operations to event operations
    - Would allow EM to stand down resources without having to wait longer time periods between SPC updates

    - Staffing and preparation decisions for EOC could be made earlier
    - More advanced notice for staff and better timing to open EOC
    - Allows EM to be proactive vs. waiting for info
- More detailed timing
    - Timing window gives them better idea for what decisions need to be made
    - Might be able to disseminate timing info to partners and stakeholders sooner
    - Better timing impacts their confidence

2- No [36.8%, n=7]

PST_allow_earlier_decisions: Would a product like the PST or moving probabilities allow for some decisions to be made earlier in the day?
1- Yes, please explain how: [VERBATIM] [100%, n=18]
2- No [0%, n=0]

PST_issue_time_preference: This week, we have shown you the PST product with the 11:30am CT (1630z) Day 1 SPC Convective Outlook. However, we are considering different times for when this product could be issued. If you had to choose, would you like this product: (Fall only)
1- With the 11:30am CT (1630z) Convective Outlook as it was presented this week [40%, n=4]
2- With the 8:00am CT (1300z) Convective Outlook [30%, n=3]
3- Other time frame (please explain) [VERBATIM] [30%, n=3]

- Same time frames as SPC
- Want consistency between local NWS office and SPC issuances of products
- Use 24-hour clock with Zulu in parenthesis

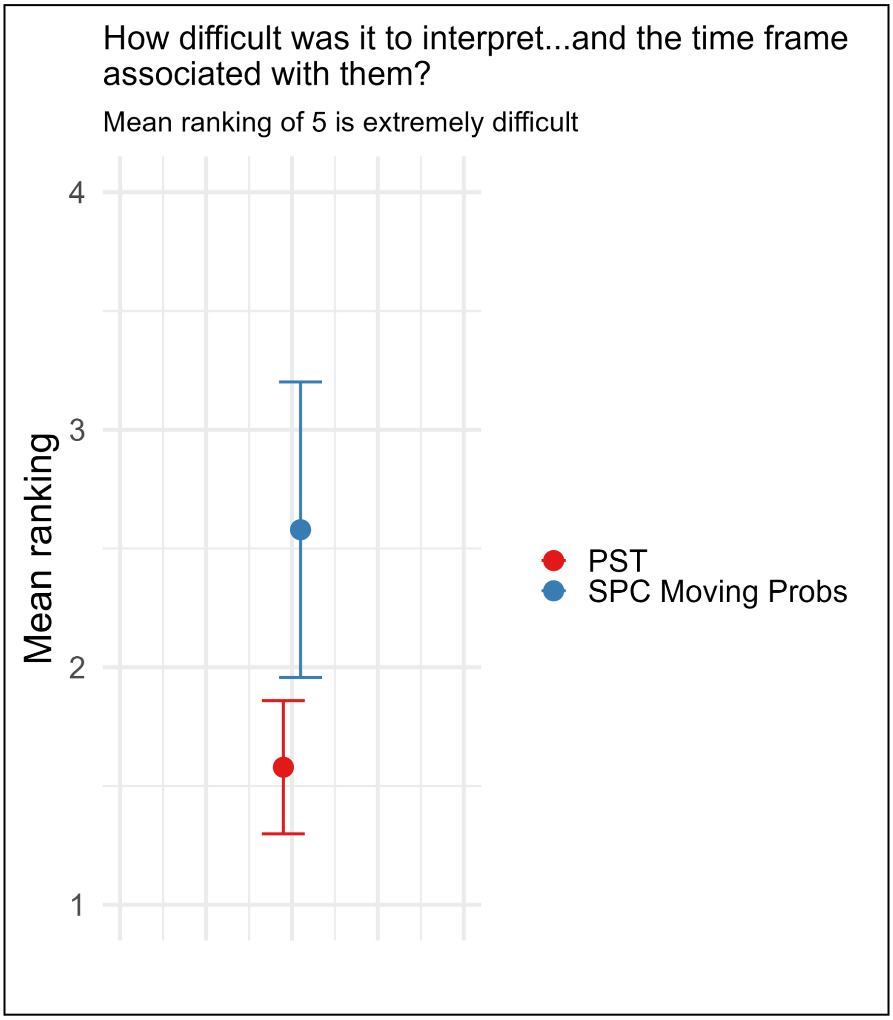
PST_issue_time_preference_explain: Why is this your preference? (Fall only)

- Allows earlier decisions like staffing, dissemination, and opening EOC
- Narrows down event time frame
- More time to prepare

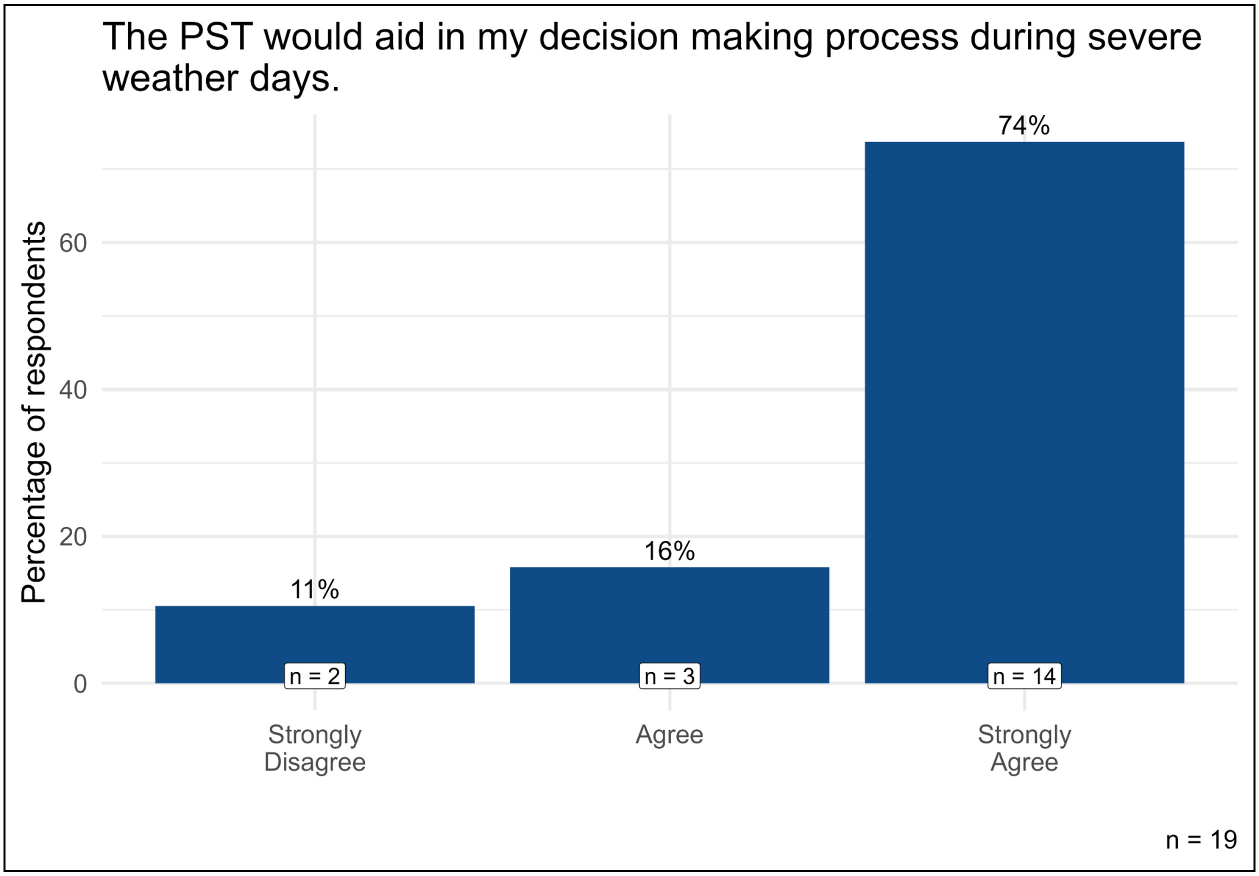
PST_interpret_difficulty: How difficult was it to interpret the PST areas and the time frame associated with them?
1- Extremely easy
2- Somewhat easy
3- Neither difficult nor easy
4- Somewhat difficult
5- Extremely difficult
Mean ranking: 1.58

moving_probs_interpret_difficulty: How difficult was it to interpret the moving probabilities and the time frame associated with them?
1- Extremely easy
2- Somewhat easy
3- Neither difficult nor easy

4- Somewhat difficult
5- Extremely difficult
Mean ranking: 2.58



PST_aid_decisions: How much do you agree or disagree with the following statement?
The PST product would help aid in my decision making process during severe weather days.
1- Strongly disagree [11%, n=2]
2- Disagree [0%, n=0]
3- Neither agree nor disagree [0%, n=0]
4- Agree [16%, n=3]
5- Strongly agree [74%, n=14]
Mean ranking: 4.42



PST_use_most_svr_days: How much do you agree or disagree with the following statement?
I believe I would use the PST on most severe weather days for my area.

1- Strongly disagree [5%, n=1]

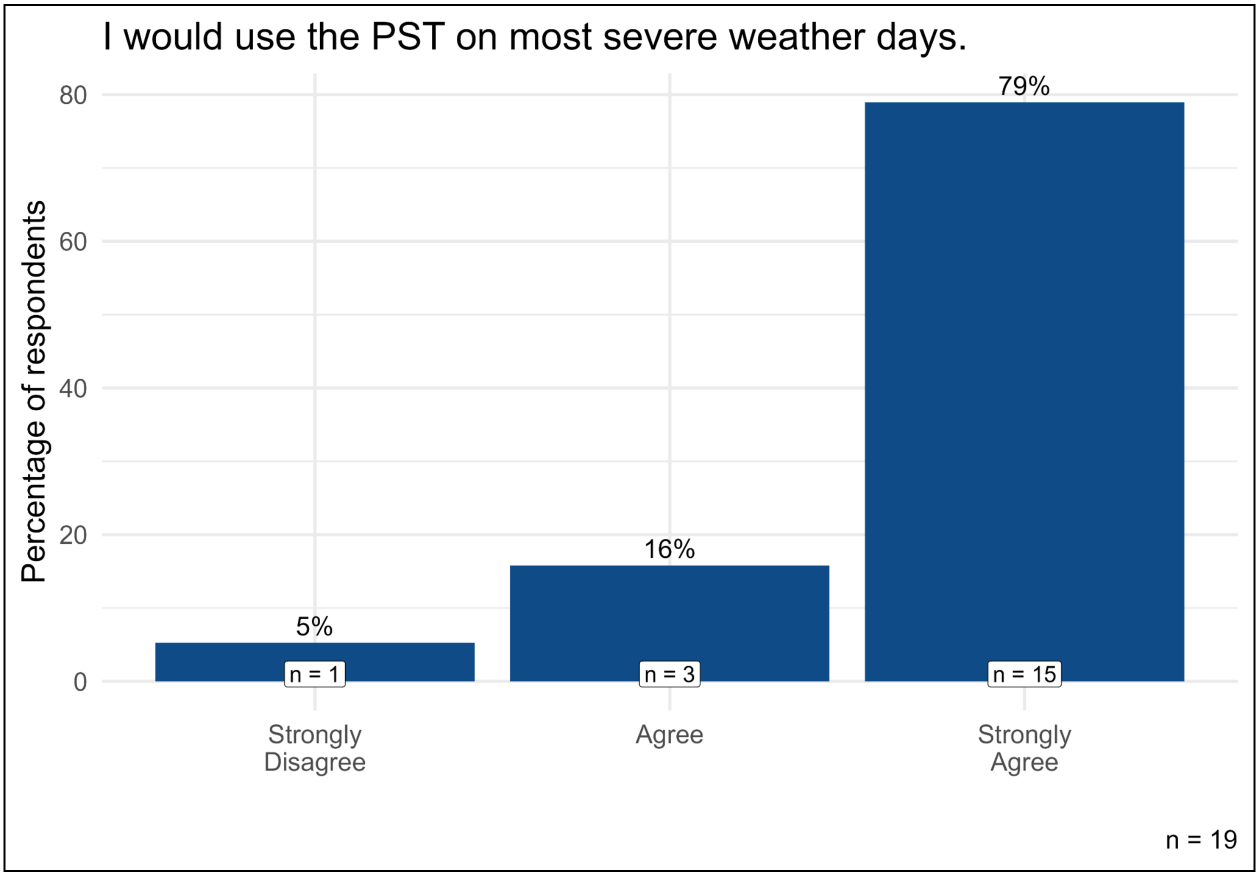
2- Disagree [0%, n=0]

3- Neither agree nor disagree [0%, n=0]

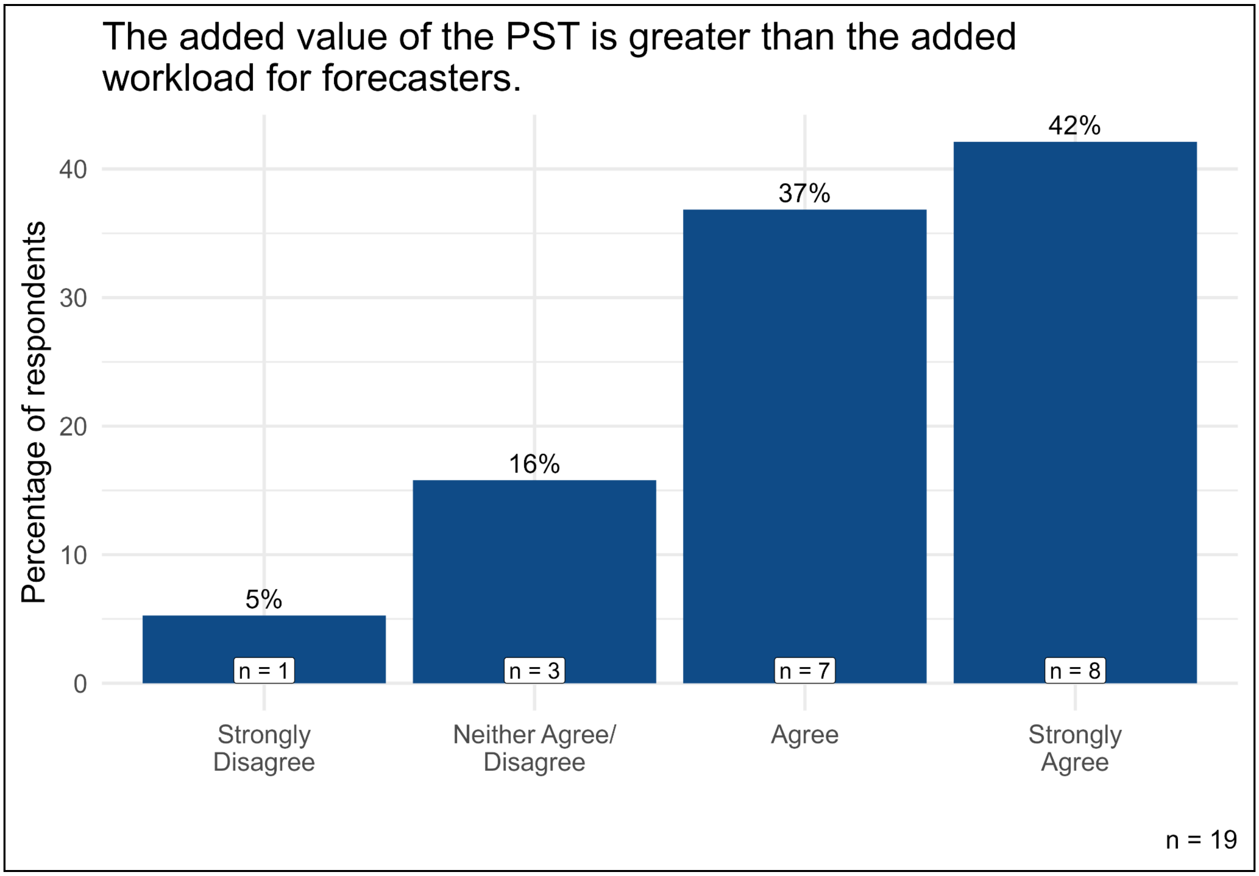
4- Agree [16%, n=3]

5- Strongly agree [79%, n=15]

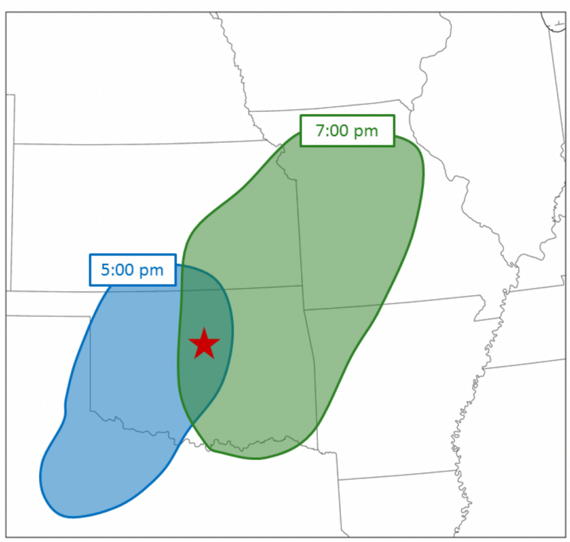
Mean ranking: 4.63



PST_costs_benefits: How much do you agree or disagree with the following statement?
The added value of the PST product is greater than the added workload for forecasters.
1- Strongly disagree [5%, n=1]
2- Disagree [0%, n=0]
3- Neither agree nor disagree [16%, n=3]
4- Agree [37%, n=7]
5- Strongly agree [42%, n=8]
Mean ranking: 4.11



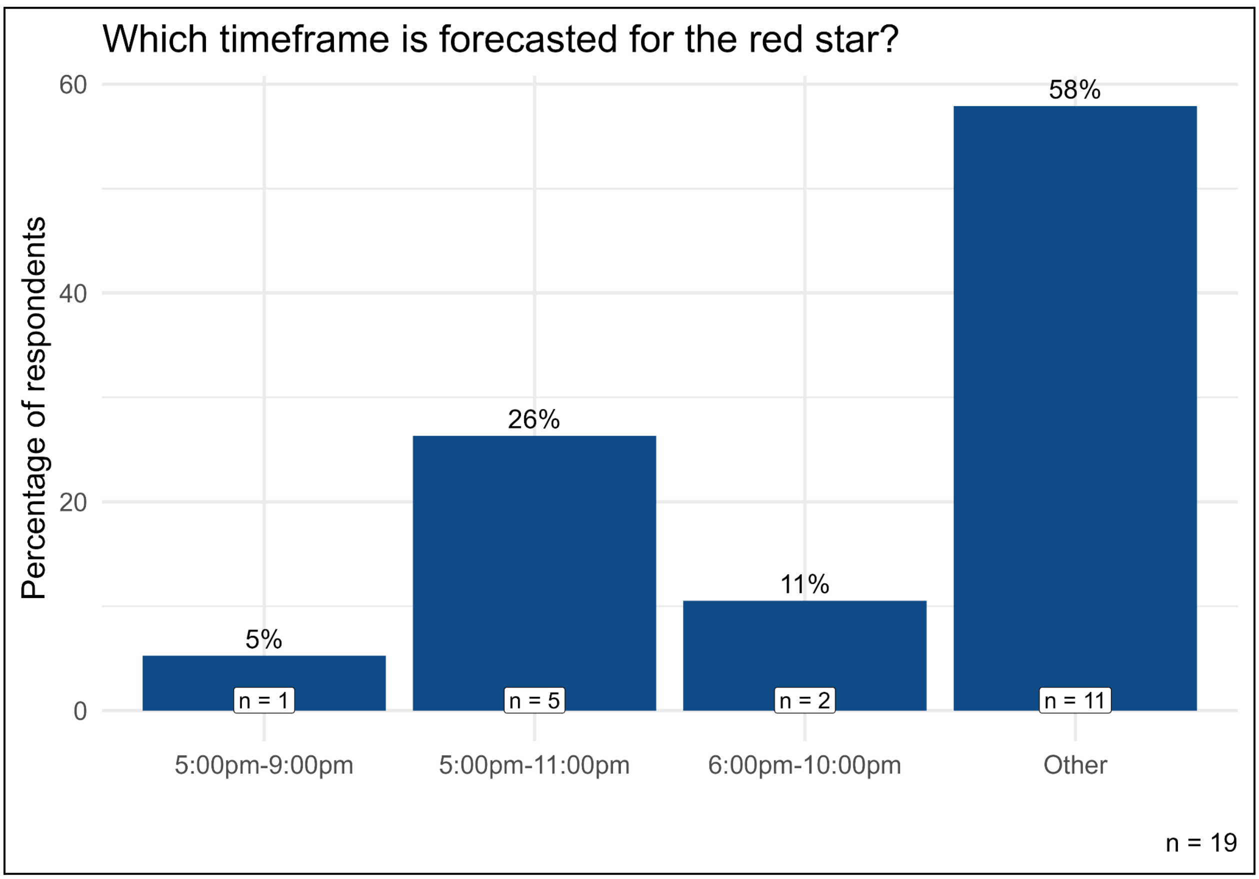
PST_timeframe_interpret: Below is an example of a forecasted PST area. Please indicate which timeframe is forecasted for the red star.



1- 5:00pm - 9:00pm [5%, n=1]
2- 7:00pm - 11:00pm [0%, n=0]
3- 5:00pm - 11:00pm [26%, n=5]

4- 6:00pm - 10:00pm [11%, n=2]
5- Other [VERBATIM] [58%, n=11]

Other responses	Count
5:00pm - 6:00pm	1
5:00pm - 7:00pm	5
5:45pm - 6:15pm	1
6:00pm	1
6:00pm - 7:00pm	1
6:00pm - 8:00pm	1



PST_overlaps_useful: Do you believe that overlapping PST areas are useful?
1- Yes, almost all of the time [5.3%, n=1]
2- Yes, in some situations (please give an example) [VERBATIM] [31.6%, n=6]

- If it has the potential to go longer than 4 hours
- If start and end times are included

- If there are more than one round of storms, though an explanation would be helpful
- If there is forecaster uncertainty or more than one round of storms
- If multiple lines or cells develop in a large geographic area
- If there is sufficient uncertainty

3- No, there should only be one period forecasted for each location [63.2%, n=12]

iii. WoF Evaluation (Fall only)

WoF_time_window_change_decisions: In the WoF products, we have shown you 4-hour probabilities of severe weather threat. Would your decisions change if you were shown a set (e.g., 4-panel image) of 1-hour probabilities that cover the same 4-hour window instead?
1- Yes, please explain how [VERBATIM] [45.5%, n=5]

- Decisions could shift
- Depends on when product is issued; 1-hour before event might not be as useful
- Depends on precision of timing
- Would take more time to study the panels during an event
- Emphasizes growing or reducing probabilities

2- No [54.5%, n=6]

WoF_allow_earlier_time_decisions: Would WoF products like those shown allow for some time-oriented decisions to be made earlier?
1- Yes, please give an example [VERBATIM] [81.8%, n=9]

- Planning for a time frame (1-4) is easier than planning for a vague time frame (afternoon)
- WoF Probabilities…
    - Provide certainty over time
    - Are linked to timing of decisions
    - Are basis of decisions
- WoF provides timely information for…
    - Helping make staffing decisions
    - Providing a clearer picture of what to expect as storms develop
    - Giving a quicker heads up to storms developing
    - More defined time of onset helps to refine decisions
    - More defined time predictions for storm development or arrival

2- No [18.2%, n=2]

WoF_allow_precise_location_decisions: Would WoF products like those shown allow for some location-oriented decisions to be made more precisely?
1- Yes, please give an example [VERBATIM] [81.8%, n=9]

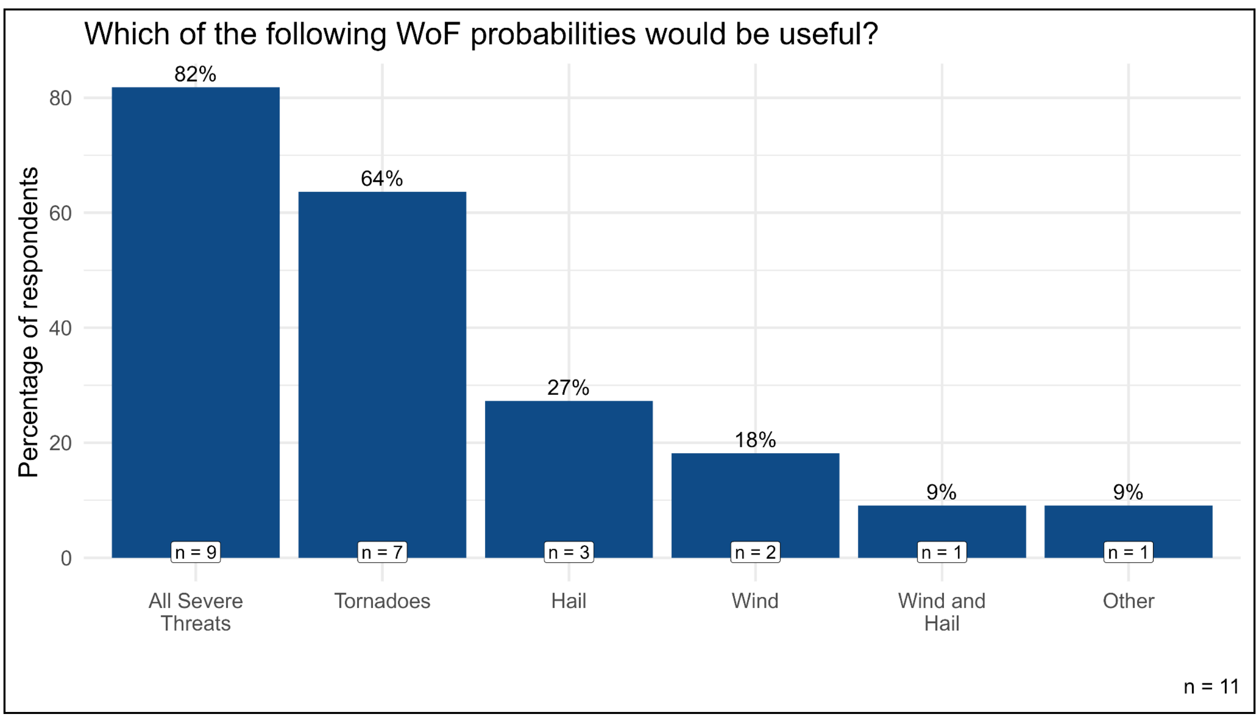
- Help focus field team information and focus
- Outdoor events or event planning
    - Helps aid in decision making
    - Able to focus on timing and location for events
    - Can help aid decision making for event organizers; whether or not to cancel outdoor events

- Helpful if they are updated
- More defined locations informs actions that need to be taken
- Allows EM to focus on more refined areas

2- No [18.2%, n=2]

WoF_interpret_difficulty: How difficult was it to interpret the WoF probabilities and the time frame associated with them?
1- Extremely easy [54.5%, n=6]
2- Somewhat easy [36.4%, n=4]
3- Neither difficult nor easy [9.1%, n=1]
4- Somewhat difficult [0%, n=0]
5- Extremely difficult [0%, n=0]

WoF_useful_prob: In this experiment, WoF products showed probabilities for all severe weather threats as a whole. It is possible for WoF-based probabilities to be produced for individual threats. Given your experience from this week, please select which of the following probability products would be useful (please select all that apply):
1- Probability of all severe threats [82%, n=9]
2- Probability of tornadoes [64%, n=7]
3- Probability of hail [27%, n=3]
4- Probability of wind [18%, n=2]
5- Probability of wind and hail [9%, n=1]
6- Other Probability product [VERBATIM] [9%, n=1]
"Other" responses: Excessive rainfall



WoF_useful_prob_explain: Please explain your choice(s). [VERBATIM]

- All threats useful:
    - All hazards useful for state EOC
    - Would like to see how storms change in intensity
    - Any severe weather event that may cause injuries or damage should be included, including flash flooding
    - All threats useful because jurisdiction receives all types of severe threats
    - Would like to see probabilities of all threats so they don't get too focused on only one threat
    - All threats would be useful for decision making
- Hazard specific useful:
    - Jurisdiction sees more wind events than tornado, so having a specific probability for wind is helpful
    - Specific probabilities for tornado and hail would be helpful for planning and preparedness
    - Probabilites should be reserved for tornado threats, all severe threats could become information overload
- Both useful:
    - All hazards worked fine and were useful during the experiment, but hazard specific probabilities would be useful to narrow down what a community might be specifically at risk for
    - All severe threats and tornado specific are useful, wouldn't need to have wind or hail separated as it is more or less included in the "all severe"

WoF_useful_timeframe: In this experiment, the WoF products were displayed from the Watch to Warning time frames. During what time frame(s) would WoF products similar to those that were shown be most useful to your decision processes? Why? [VERBATIM]

Useful Time Frames	**Count**
Watch-Warning time gap good	6
4-6 hours out from event, then again 1-2 hours out	1
During early morning hours	1
Updated as events change	1
Info provided 15-30 min before WoF issued	1
Unsure	1

WoF_aid_decisions: How much do you agree or disagree with the following statement?
The WoF product would help aid in my decision making process during severe weather days.
1- Strongly disagree [0%, n=0]

2- Disagree [0%, n=0]
3- Neither disagree nor agree [0%, n=0]
4- Agree [54.5%, n=6]
5- Strongly agree [45.5%, n=5]

WoF_use_most_svr_days: How much do you agree or disagree with the following statement? *I believe that I would use WoF products on most severe weather days for my area.*
1- Strongly disagree [0%, n=0]
2- Disagree [0%, n=0]
3- Neither disagree nor agree [9.1%, n=1]
4- Agree [45.5%, n=5]
5- Strongly agree [45.5%, n=5]

iv. Reference Class

The next set of questions relate to the PHI product.

advant_warnings_unrelated_PHIprobs: This week, you saw warnings that were not explicitly related to probabilities from PHI. In your experience this week, what were the advantages of this approach? [VERBATIM]

Advantages	Reasoning	Count
Provided more lead time	• Provides a better "heads up" • Warning across full area (out to 0%) provides more lead time • PHI probabilities outside the warning polygon/plume gave opportunity to pre-warn certain facilities that require more time to shelter (medical facilities, hospitals, schools, etc.) • Allowed for the opportunity to hold "pre-warning" discussions with stakeholders	8
Warnings important	• Warnings initiate/trigger action, regardless of PHI • Warnings indicate more forecaster/expert input • Warnings not easily missed • Warnings give defined region and timing of threat(s) • Warnings are easier to communicate • Warnings provide critical information to partners and the public • Want warnings to be the same as what we have today	5
Aided in decision making	• More diverse and multiple tools to make decisions • Able to isolate various pieces of information • Higher probabilities indicated more forecaster confidence which aided decision making	4

Helpful for situational awareness and tracking of storms	• Able to make own predictions based on storm track • Easier to see projected path of the storm • More defined track	4
No such thing as too much information	• The more info the better	3
Other	• Toggling tools was helpful • Addition of PHI provides a margin for error without having huge “swings” in warning areas	2

disadvant_warnings_unrelated_PHIprobs: In your experience, what were the disadvantages of this approach? [VERBATIM]

Disadvantages	Reasoning	Count

Lead time	• Too much
	    ○ Could lead to slower action and preparedness
	    ○ Could lead to public complacency and “train” residents that warnings are always issued far in advance
	    ○ Concerning to have too much lead time given uncertainty of storms
	    ○ Don’t want public believing they have more time to prepare than they actually would
	    ○ Don’t want to warn too early
	    ○ Could see early warning for facilities/events/schools/hospitals putting them into panic mode and then having the storm shift or dissipate before arrival
	• Too little
	    ○ Continuous warnings are more beneficial, but there are discontinuities near CWA boundaries
	    ○ Lead time could be reduced as warning criteria would need to be met
	• Need a balance to provide as much lead time for people to take action while still maintaining a sense of urgency
		7

Visually busy/confusing and can cause information overload	• Need ability to toggle layers • Confusing on screen • If not careful, could base decisions off of	6

	PHI rather than the warnings themselves • May be some confusion to the length of the warning • Colors could be confusing • Sometimes could be information overload	

None	• Except:
	  ○ Need education and training
	  ○ Don't think all of the information should be made available to the public
		4

Need for common language	• Want tornado warning language to match current usage, that a tornado is occurring or imminent, so as not to lead to mis-perceptions of the warning area and degree of risk	2

preference_keep_warnings_PHI_separate: An alternative to what you saw this week is warnings automatically issued at a particular probability level, for example, 50% for tornadoes. Do you prefer this approach or not? Please explain the reasoning behind your preference. [VERBATIM]

Automatic Warnings at 50%?	**Reasoning**	**Count**
Yes	• 50% seems reasonable • Just warn at 50%, don't want to take any chances • Left judgements to the forecaster • Only if the probability levels are consistent across the NWS	7
No	• Keep as is, but make more information available as additional layers • Want warnings and PHI kept separate • Want forecaster knowledge, experience, and input in creating a warning • Keep warnings the same as they are today • Probability thresholds/levels will mean something different to different EMs • If there is a need for a warning, it should be issued regardless of probability level	9
Unsure	• 50% seems reasonable, but still want the ability to turn warnings on and off • 50-60% threshold makes sense, but would still want forecaster input into issuing warnings	3

	• Want the ability to toggle PHI and warnings on and off	

interpret_warnings_diff_PHIprobs: How did you interpret warnings with different PHI probability values (e.g., if tornado warnings were issued with PHI of 30%, or sometimes not until 70%)? Why did you think that was happening? [VERBATIM]

How did you interpret different probabilities/why do you think that was happening?	Count
Forecaster dependent: experience, local knowledge, skills, training, etc.	12
Atmospheric conditions: local changes, delay in identifying hazard type, storms forming quickly/unexpectedly, weather always changing	4
Other: needs to be a standard, different probability levels makes things less clear, decisions/actions change at different probability levels	3

The next set of questions will refer to all of the new probabilistic products you saw this week. (Fall only)

By the end of the week, you had seen at least three kinds of probabilities in a single case: hazard probabilities issued at a country scale early in the morning (SPC probabilities), regional probabilities of severe weather 1-4 hours ahead of the storm (Warn-on-Forecast), and local probabilities that a given storm would produce severe weather within the next hour (PHI).

ALL_probs_interpret_difficulty: How difficult was it to interpret all of these probabilities together in a single case?
1- Extremely easy [63.6%, n=7]
2- Somewhat easy [36.4%, n=4]
3- Neither difficult nor easy [0%, n=0]
4- Somewhat difficult [0%, n=0]
5- Extremely difficult [0%, n=0]

ALL_probs_interpret_difficulty_explain: Please explain the degree of difficulty you selected above. [VERBATIM]

- Progression across time and space scales reasonable and intuitive
    - All products painted an overall picture of the event
    - Can use the products to get a holistic visual of the event
- Tools are user friendly
    - Graphics were easy to understand
    - Once gained some familiarity, the products were easy to use
- Need some time to adjust to the new products

    - Some were easy to understand, others were more challenging
- SPC good to get general timing information, PHI useful to make judgements on timing of a storm
- Able to turn PHI on and off to focus on tornado PHI

v. PHI/EDD Evaluation

layers_toggle_comment: As a whole, what layers were helpful in terms of being able to toggle them on and off? [VERBATIM]

Layer to Toggle	**Count**
PHI (plumes, objects, notifications, colors)	15
Radar (reflectivity, velocity, rotation tracks, etc.)	14
Warnings (NWS, TIM)	10
Mapping layer (counties, cities, streets, critical infrastructure, background color)	9
Timing information	4
Damage reports	1

layers_need_toggle_comment: Were there any layers that did not have a toggle feature that you would have liked to have an ability to toggle? [VERBATIM]

- None: 7
- Unsure
- Just radar
- Ability to dismiss alerts and sounds
- Ability to highlight selected PHI plumes and time projections
- Keep storm reports even after storm has passed
- Better color contrast
- Toggle severe and tornado separately

layers_depend_threat: Were there certain situations or threats that necessitated particular layers being on or off? [VERBATIM]

Situations to turn on/off layers	**Count**
Turning off Severe to focus on Tornado	7
Turn off layers to focus on Tornado/focus on tornado projections (leaving mapping layer)	4
None	3

Depends/various situations	2
Turn off PHI to look at radar	1
Turn off layers when got too cluttered	1
Turn off layers to differentiate probabilities	1

PHI_color_preference_MC: Which of the color scheme options did you prefer for the PHI plumes?
1- Rainbow [26.3%, n=5]
2- Monochromatic [73.7%, n=14]

PHI_color_preference_comment: Why is that the color scheme you prefer? [VERBATIM]

- Rainbow
    - Different colors helped differentiate
    - Didn't wash out radar
    - More familiar with rainbow color scheme
    - Rainbow colors helped focus more on the threat
- Monochromatic
    - Map features:
        - Easier to layer
        - Doesn't "blur" out radar or background images like streets, counties, etc.
        - Easier to discern on the map
        - Less distracting, but still added contrast
        - Less cluttered
    - PHI layered with radar:
        - Didn't clutter the screen and confuse with radar
        - Popped out more with reflectivity
        - Needed to be able to differentiate from the radar colors
    - Personal preferences:
        - People with color vision deficiency might find monochromatic easier to differentiate between colors
        - Less confusing than rainbow
        - Rainbow was too vivid for personal preference
        - Liked the varying shades of the monochromatic
    - Easier to differentiate between threats - red for tornado and yellow for severe

PHI_color_change_suggestions: Are there any aspects that you would change in the color scheme you preferred?
1- Yes, please explain [VERBATIM] [15.8%, n=3]

- Ability to select color based on preference or hazard
- Different color other than orange for lightning PHI (Spring only)
- Need a chart explaining the color scheme

2- No [84.2%, n=16]

public_see_PHI_comment: Would you want the public to see the type of data you were seeing (e.g., probability plumes, timing lines)? If not, what would you want the public to see? [VERBATIM]

Public see PHI?	Reasoning	Count
No	• Want to control the message/let professionals do the messaging • Everyone interprets probability differently • Might cause greater alarm or panic • There would be inconsistent probabilities of when to warn • Could ruin credibility • Would be too confusing; need to keep things simple • They wouldn't be able to understand the probabilities	9 (47.4%)
Yes	• It doesn't matter, they see all kinds of weather info anyway • As long as it's noted that it's for guidance only • Could help them make better decisions • Validates what is being said by professionals • If broadcast meteorologists explain it on air	5 (26.3%)
Maybe	• Don't think public should be making their own decisions on when to take shelter (because they usually wait as long as possible), but would share as long as it's known that experts are making the decisions • Concern that public could misinterpret the info, but transparency tends to be better option and [EMs] tend to give public less credit than they deserve for being able to interpret info as long as context is provided • If explained; and public would need constant updates • Would show timing lines, not the plume	4 (21.1%)
Unsure	• Worry they would try and "decipher" the info rather than seeking shelter	1 (5.3%)

Please indicate how important each of the following elements of PHI were to you for each hazard, listed below.

Tornado

torimportance_prob: Probability Value
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]

3- Moderately important [10.5%, n=2]
4- Very important [15.8%, n=3]
5- Extremely important [73.7%, n=14]
Mean = 4.63

torimportance_haz_graph: Hazard Graph
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [16.7%, n=3]
4- Very important [44.4%, n=8]
5- Extremely important [38.9%, n=7]
Mean = 4.22

torimportance_storm_history: Storm History
1- Not at all important [5.3%, n=1]
2- Slightly important [5.3%, n=1]
3- Moderately important [15.8%, n=3]
4- Very important [26.3%, n=5]
5- Extremely important [47.4%, n=9]
Mean = 4.05

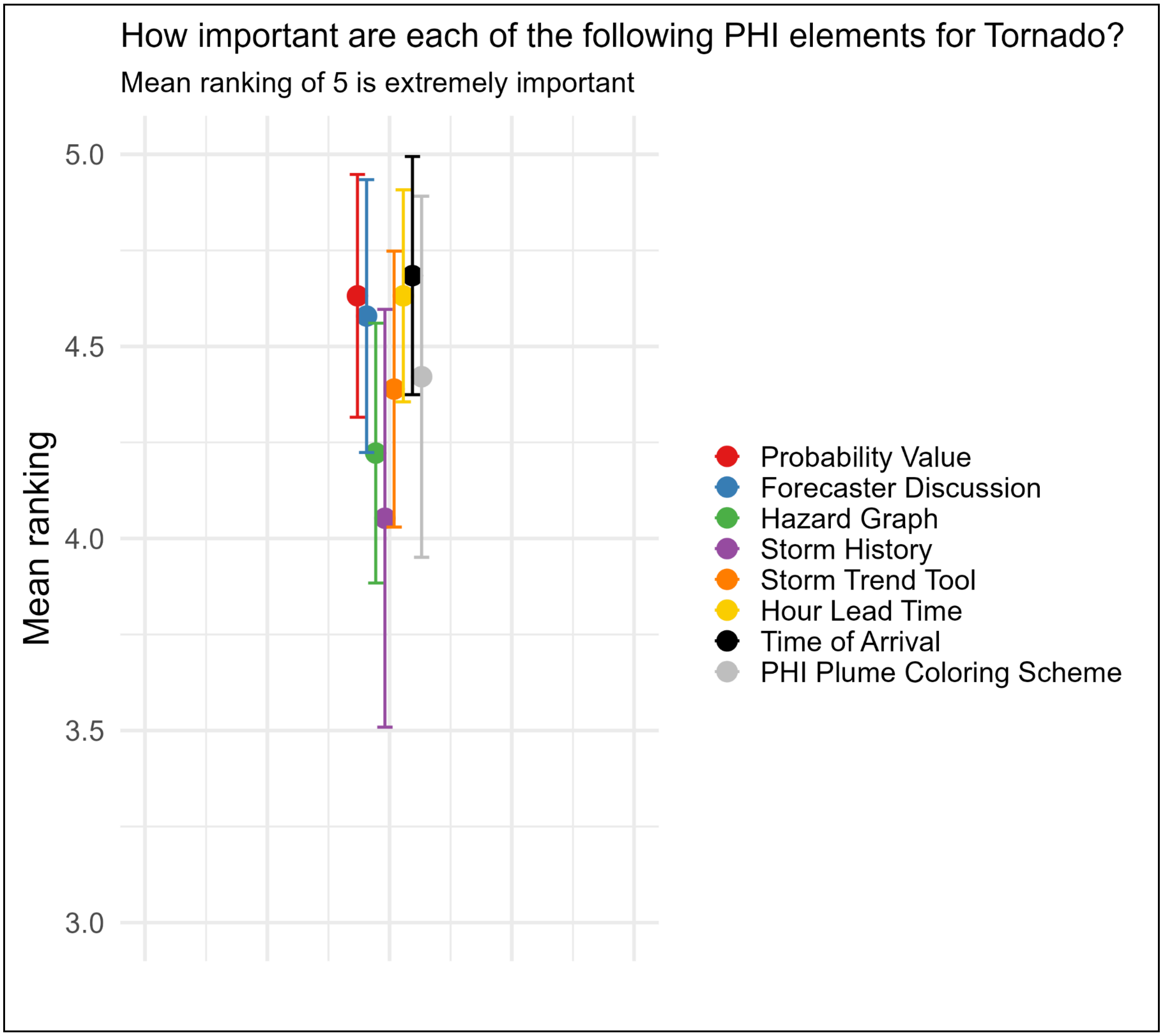
torimportance_STTT: Storm Trend Tool
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [16.7%, n=3]
4- Very important [27.8%, n=5]
5- Extremely important [55.6%, n=10]
Mean = 4.39

torimportance_hour_lead_time: Hour Lead Time
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [5.3%, n=1]
4- Very important [26.3%, n=5]
5- Extremely important [68.4%, n=13]
Mean = 4.63

torimportance_color: PHI Probability Plume Coloring Scheme
1- Not at all important [0%, n=0]
2- Slightly important [10.5%, n=2]
3- Moderately important [5.3%, n=1]
4- Very important [15.8%, n=3]
5- Extremely important [68.4%, n=13]
Mean = 4.42

torimportance_forecaster_discussion: Forecaster Discussion
1- Not at all important [0%, n=0]
2- Slightly important [5.3%, n=1]
3- Moderately important [0%, n=0]
4- Very important [26.3%, n=5]
5- Extremely important [68.4%, n=13]
Mean = 4.58

torimportance_time_of_arrival: Time of Arrival
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [10.5%, n=2]
4- Very important [10.5%, n=2]
5- Extremely important [79.9%, n=15]
Mean = 4.68



Severe (wind and hail)

svrtstormimportance_prob: Probability value
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [15.8%, n=3]
4- Very important [26.3%, n=5]
5- Extremely important [57.9%, n=11]
Mean = 4.42

svrtstormimportance_haz_graph: Hazard Graph
1- Not at all important [5.6%, n=1]
2- Slightly important [0%, n=0]
3- Moderately important [22.2%, n=4]

4- Very important [44.4%, n=8]
5- Extremely important [27.3%, n=5]
Mean = 3.89

svrtstormimportance_storm_history: Storm History
1- Not at all important [5.3%, n=1]
2- Slightly important [5.3%, n=1]
3- Moderately important [21.1%, n=4]
4- Very important [31.6%, n=6]
5- Extremely important [36.8%, n=7]
Mean = 3.89

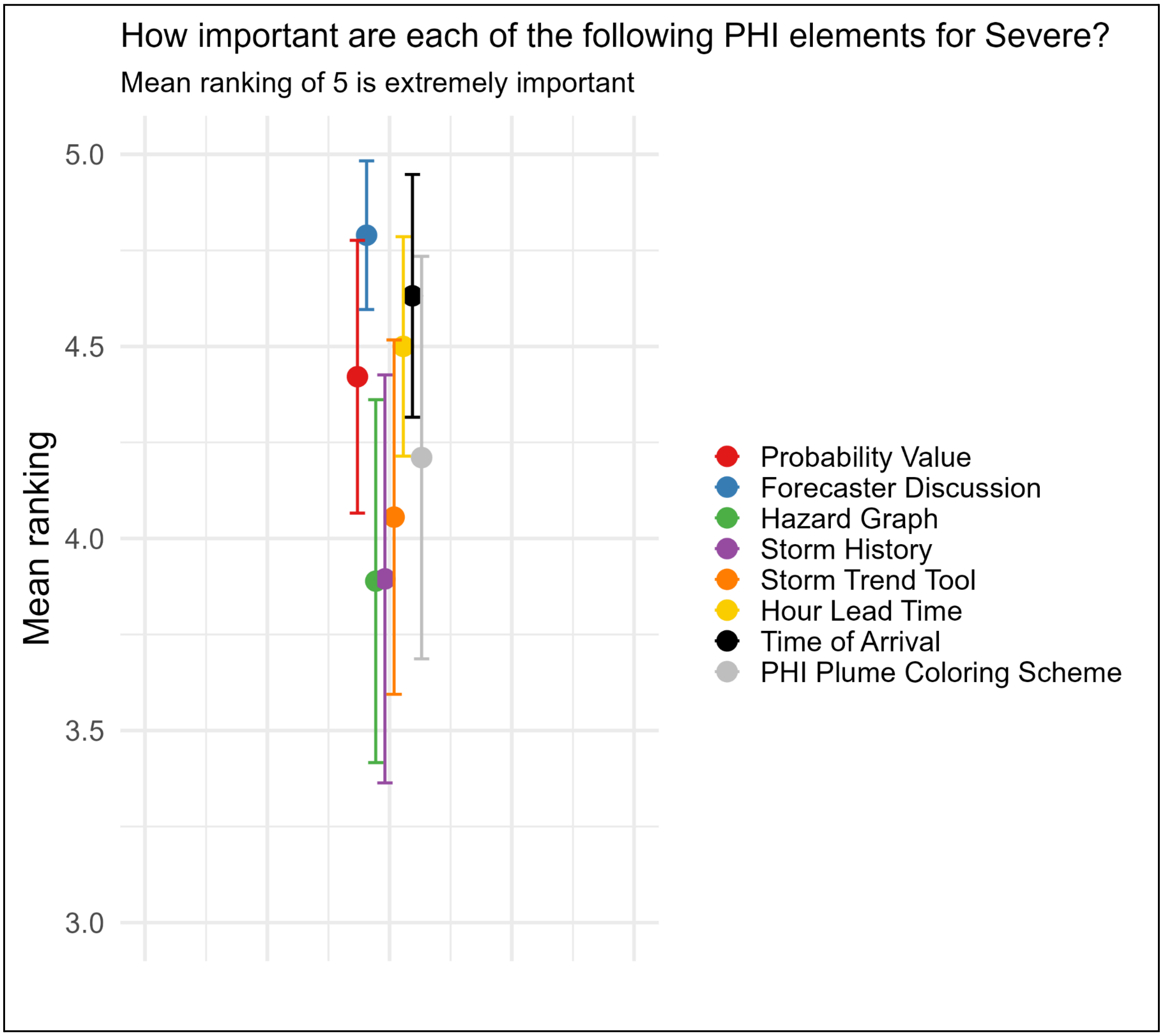
svrtstormimportance_STTT: Storm Trend Tool
1- Not at all important [5.6%, n=1]
2- Slightly important [0%, n=0]
3- Moderately important [11.1%, n=2]
4- Very important [50%, n=9]
5- Extremely important [33.3%, n=6]
Mean = 4.06

svrtstormimportance_hour_lead_time: Hour Lead Time
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [5.6%, n=1]
4- Very important [38.9%, n=7]
5- Extremely important [55.6%, n=10]
Mean = 4.50

svrtstormimportance_color: PHI Probability Coloring Scheme
1- Not at all important [5.3%, n=1]
2- Slightly important [5.3%, n=1]
3- Moderately important [5.3%, n=1]
4- Very important [31.6%, n=6]
5- Extremely important [52.6%, n=10]
Mean = 4.21

svrtstormimportance_forecaster_discussion: Forecaster Discussion
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [0%, n=0]
4- Very important [21.1%, n=4]
5- Extremely important [78.9%, n=15]
Mean = 4.79

svrtstormimportance_time_of_arrival: Time of Arrival
1- Not at all important [0%, n=0]
2- Slightly important [0%, n=0]
3- Moderately important [10.5%, n=2]
4- Very important [15.8%, n=3]
5- Extremely important [73.7%, n=14]
Mean = 4.63



vi. TIM Evaluation (Fall only)

To answer the following questions, please think back to the Monday afternoon scenario, when you were working a case with Threats-in-Motion (TIM), or the moving warnings.
advant_TIM: What are the advantages of TIM? [VERBATIM]

TIM Advantages	Count
Greater lead time	4
Seeing motion/movement; better for timing	3
More precise/refined/narrow warning area	2
Areas cleared out of warnings more quickly	1
Doesn't "jump" like current warning polygons	1
More realistic than current, static polygons	1

disadvant_TIM: What are the disadvantages of TIM? [VERBATIM]

TIM Disadvantages	Count
Issues with constant movement: location moves in and out of warned area, "jumping"/"wobble" of polygon, not smooth between updates	4
Difficult for decision making: less time between warning updates to relay warning info; how to relay moving warning information via current dissemination channels (weather radios, sirens, mass notification systems, social media, etc.)*	2
Requires training and education for public and EMs	2
None	2
Warning could project too far out ahead of the storm and unnecessarily warn people; could be confusing for public	1
Worry people might not pay attention to frequent updates	1

*Quote: *"The static polygons make decision-making regarding the relay of tornado warning information to other local systems (sirens, opt-in systems, social media, etc) relatively straightforward. Simple rules can be established and these relays can be automated. Even though the reality is that the storm is continuously changing and moving, continuous change in the warning area makes it a moving target and the rules for when to activate and reactivate these other systems becomes a real challenge. A whole new set of rules would need to be established"* (Survey respondent 14).

dissem_TIM_warning: Can you think of any innovative ways to disseminate TIM warnings? [VERBATIM]

- Automatic messaging:
    - GPS, road-side messaging boards; hotel messaging boards
    - Automatically connect to weather radios, WEA, IPAWS, social media
- Use forward edge as "enhanced watch" then issue warnings as likelihood increases

- Need to train EMs
- Apps with personal preference settings
- Dissemination of TIM needs to be given a lot of attention
- Needs constant updates to be effective

5. Summary

Survey results indicate that EM participants were able to easily understand and use the experimental products presented to them (PHI, TIM, WoFS, SPC Timing, and PST), with mean rankings greater than 6 (7 indicating extremely useful/easy to use) for all experimental products. EMs also indicated that the experimental products delivered pertinent information (means ranging from 6.60-7.0 with 7 as “strongly agree”), delivered information quickly (means 6.47-6.89, 7 “strongly agree”), and made them more confident in their decisions (means 6.63-6.74, 7 “strongly agree”) for all experimental products. Focus group results confirm the survey results, in that the EMs felt that they were able to effectively understand and use the experimental products. However, there was a little bit of a learning curve, as EMs indicated that exposure to the experimental products were a bit overwhelming at first, but by the end of the experimental week they were able to use them more confidently. Because of this, EMs noted that some training and education will be needed before any of the products become operational.

In addition to the EMs’ overall thoughts on the experimental products, there were some key conclusions from each of the products:

- **PHI**: the EMs liked PHI overall, especially that it felt like a visual form of NWSChat. They liked seeing the timing lines and the forecaster discussion box, as they were able to keep track of the storm’s evolution over time. However, there was more nuance in their utilization of the probabilities. EMs had different thresholds for action, and often did not have a “feel” for what the probabilities meant or what type(s) of weather was expected with each probability value. EMs have associated certain types/severity of weather with known probabilities, such as SPC Convective Outlooks. For instance, an EM “knows” what to expect with a 2% probability for tornadoes on a Day One Convective Outlook because they have experienced them before. They do not “know” what a 60% tornado PHI implies, therefore making it difficult to use the probabilities effectively. This came into play when asked if warnings should be automatically issued at a 50% PHI, 9 EMs indicated “no” (7 “yes”, 3 “unsure”), because they still wanted forecaster input as part of the warning process. This indicates that EMs value forecaster expertise and are willing to rely on it over probabilities alone.
- **TIM**: the EMs indicated that they liked the progression of TIM and how it made sense to have a warning move with a storm, but they had some concerns about the actual movement of the TIM polygons, especially in regards to tornado TIM. The EMs noted that a single TIM polygon could “wobble” and put locations in and out of the polygon multiple times in quick succession. The EMs thought that this was confusing to both themselves and, they believed, the public as it could cause dissemination challenges. They also pondered how they might disseminate TIM warnings with current technology, such as weather radios, mass alert systems,

outdoor warning sirens, etc., as they are currently set up for static polygons. Adding a moving component to the polygons would raise questions about how often and when to activate these systems.In 2021, a virtual severe weather activity was conducted with EMs regarding TIM “motion instabilities”, or TIM polygon movement resulting from uncertainties in storm speed, direction, or time (Maciag et al. 2024). The goal of the activity was to gain EMs’ operational perspectives and dissemination challenges due to these motion instabilities. The results of this activity concurred with the EM participants in the 2019 HWT: EMs were concerned about the possibility of locations being put in and out of warnings multiple times over short periods of time, which could cause public confusion, over warning, and challenges with dissemination (e.g., sounding outdoor warning sirens) (Maciag et al. 2024).

- **WoFs**: EMs liked that the WoFS products provided critical information during the time between a watch and warning. It helped them to make more proactive decisions, rather than waiting for and reacting to a warning.
- **PST vs. SPC Timing**: timing information is very important to EMs, which they mentioned over and over again during the focus groups. Thus, the PST and SPC timing tools were regarded as some of their top products, with the PST noted as their favorite. During focus groups, the EMs indicated that the PST was easier to interpret, use, and share with their partners. When asked which was more difficult to interpret, results showed that the SPC timing information was more difficult than the PST, with means of 2.58 and 1.58, respectively, where a mean ranking of 5 is “extremely difficult”. Although both of these mean rankings are still considered “easy” to use, they felt that the PST was even easier than the SPC timing graphic

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