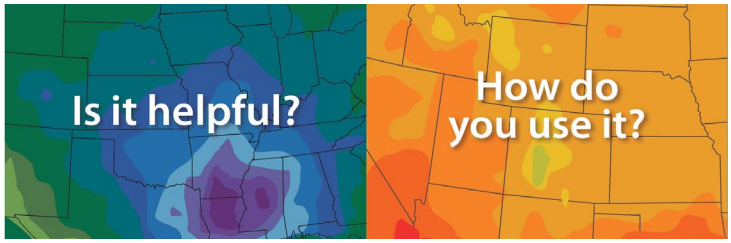
National Weather Service
Weather Prediction Center
Probabilistic Weather Information



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WPC 8-10 Day Probabilistic Products and Services Final Report

Prepared by Nurture Nature Center, Easton, PA and East Carolina University, Greenville, NC with ECS Federal

Introduction

The Weather Prediction Center (WPC) of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) provides weather forecast information on hydrometeorological conditions in the range from one to seven days. In response to an increase in user demand for longer-range forecasts, as well as increased capacity of model guidance, WPC has begun to explore prototype products to communicate forecasts for precipitation and temperature at the 8-10-day range. These 8-10-day forecasts are guided by ensemble prediction systems and result in probabilistic forecasts that can express a range of probabilities for temperature and precipitation outcomes.

Probabilistic forecast information in this range can be useful for decision-making for a wide range of users and also presents new challenges and questions surrounding the best ways to format and display information for multiple audiences. To better understand the potential users of these forecasts, as well as the decisions these forecasts may support, and to help inform the testing and creating of the prototypes, ECS, Inc., was contracted to undertake a social science collaboration with WPC forecasters. ECS engaged a research team comprised of staff from Nurture Nature Center, Inc., and East Carolina University, to work with forecasters and staff from WPC on a multi-phase study of 8-10-day probabilistic prototype forecasts. This study, conducted from May 2017 through February 2018, identified key users of WPC forecast products and the critical decisions they make that could be supported by these prototype forecasts, which then informed the design of the products to enhance the ability of users to understand and incorporate information into their decision-making. The study sought to answer the following:

- How do probabilistic forecasts improve decision-making by core partners in the 8-10-day timeframe?
- What is the appropriate manner to communicate potential hazards which enable risk assessments and preparedness in the 8-10-day timeframe through the use of probabilistic forecasts?
- What probabilistic forecasts improve core partners' ability to distinguish between low impact and high impact events?
- Is there an optimal mix of visualizations, stories, colors, etc. that best conveys information that improves decision support?

In addition to these questions, WPC partners throughout the project undertook a test of the prototype probabilistic model-based guidance from EMC's Global Forecast System and MDL's National Blend of Models to determine its effectiveness as an input to the WPC forecast process. An interim assessment of that guidance was undertaken by the research team at the outset of this project, and a report was submitted in November 2017; a copy of that report is appended here as Appendix A.

This study report shares findings about the needs of users, the key decisions these products can support, and concludes with recommendations and considerations for the presentation of probabilistic weather information in the 8-10-day range.

Methods

To identify needs for probabilistic weather information in the 8-10-day timeframe for a range of user groups, the project team completed a public online survey (Appendix B), two rounds of webinar-based focus groups encompassing five professional user groups, and iterative testing of several 8-10-day prototype products. The products tested in the first round of focus groups and in the public online survey included percent chance and probability of exceedance products for temperature and precipitation, as well as probability of exceedance for snow/sleet and a hazards outlook.

Specifically, the products shown were (Figure 1):

- Percent chance of maximum temperature > 90°F
- 10% chance of 24 hr maximum temperature non-exceedance
- 10% chance of 24 hr precipitation exceedance
- Percent chance of 24 hr precipitation greater > 0.25"
- Day Eight Probability of Exceeding 0.25 Inch Liquid Equivalent of Snow/Sleet
- Day 8-10 U.S. Hazards Outlook

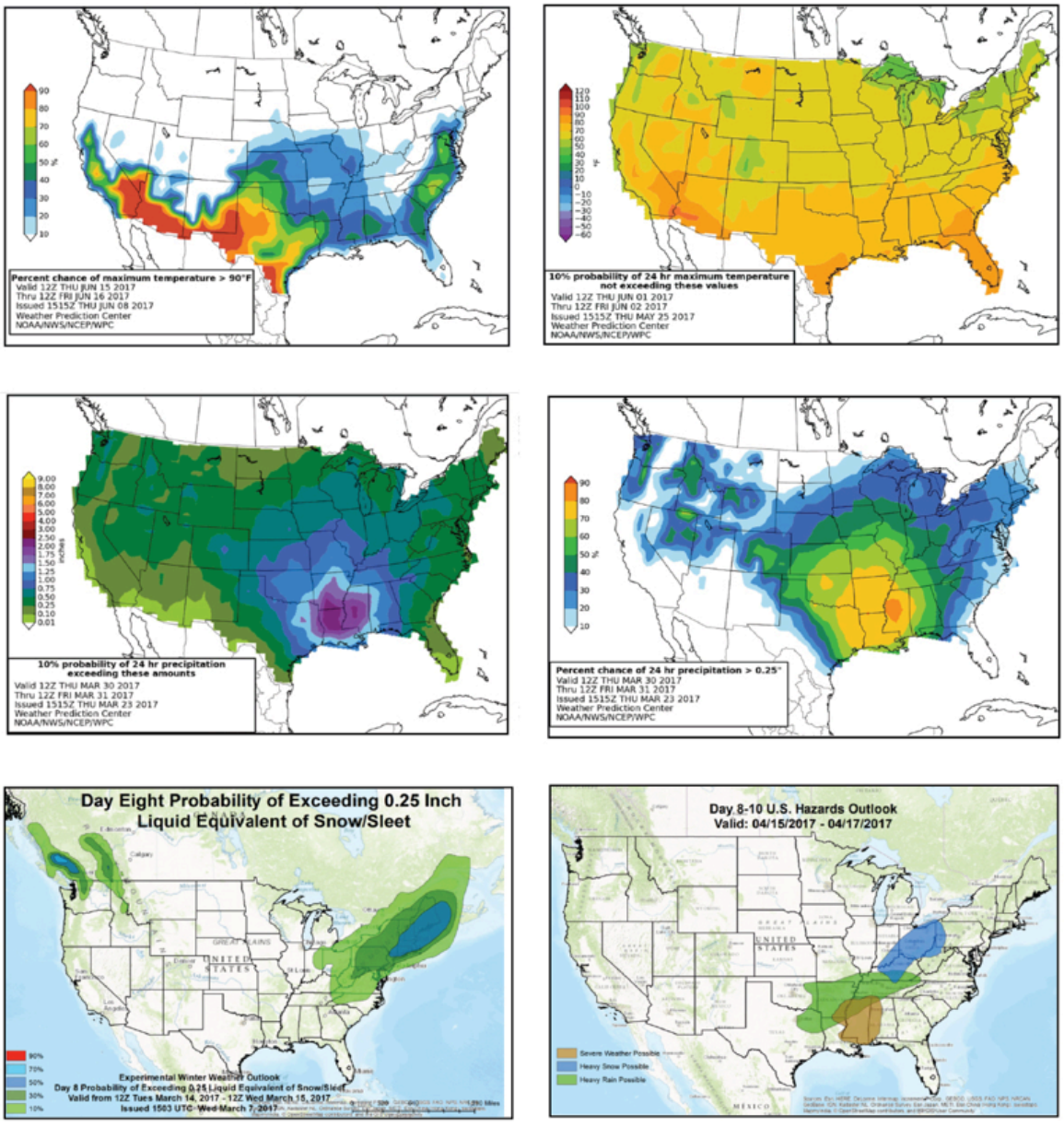


Figure 1. The six WPC 8-10-day probabilistic products tested in Round 1 focus groups and the online public survey.

The public online survey, launched in September 2017, asked questions about respondents' understandings of the graphics, utility/likelihood of use, and preference of information presentation. For specific questions and illustration of the graphics shown in Round 1 focus groups and the online survey, see Appendix B.

In Round 1, five focus groups were held November 14th – 17th 2017 with academic (3), federal (3), media (3), private (3), and state (4) partners. Each group was shown the products listed above and asked about product utility and what decisions would be made based on the information conveyed. Specific questions included:

- What is this product telling you?
- How would you use this product?
- What is most useful about this product?
- What decisions does the product support?
- Would you share this information with anyone?

Focus groups notes were summarized and analyzed along with responses from the public online survey, which were analyzed using SPSS. The findings informed recommendations for redesign of the products. These recommendations were developed by the project team and provided to the WPC team as shown in Appendix C.

WPC incorporated the suggested changes into revised and expanded versions of the products that were hosted on an interactive web interface (Figure 2). The platform allowed users to respond to additional aspects of the products, including thresholds and varied representations of information, as described below. In Round 2, four focus groups were held January 17th-19th 2018 with federal (5), media (3), private (7), and state/academic (5) partners (note that academic partners were included with the state partner group due to conflicts with scheduling). Each group was shown the revised products on the web interface and asked the same questions as Round 1. The revised products included: percent chance, percentile (or probability of exceeding a certain amount), and probability with respect to normal for maximum temperature, minimum temperature, and precipitation, with a range of thresholds specific to each product. Additionally, two winter weather products, probability of exceedance for snow/sleet and freezing rain, as well as a U.S. Hazards map, were tested. Notes from all focus groups and survey analyses were amalgamated to inform the Results section of this report.

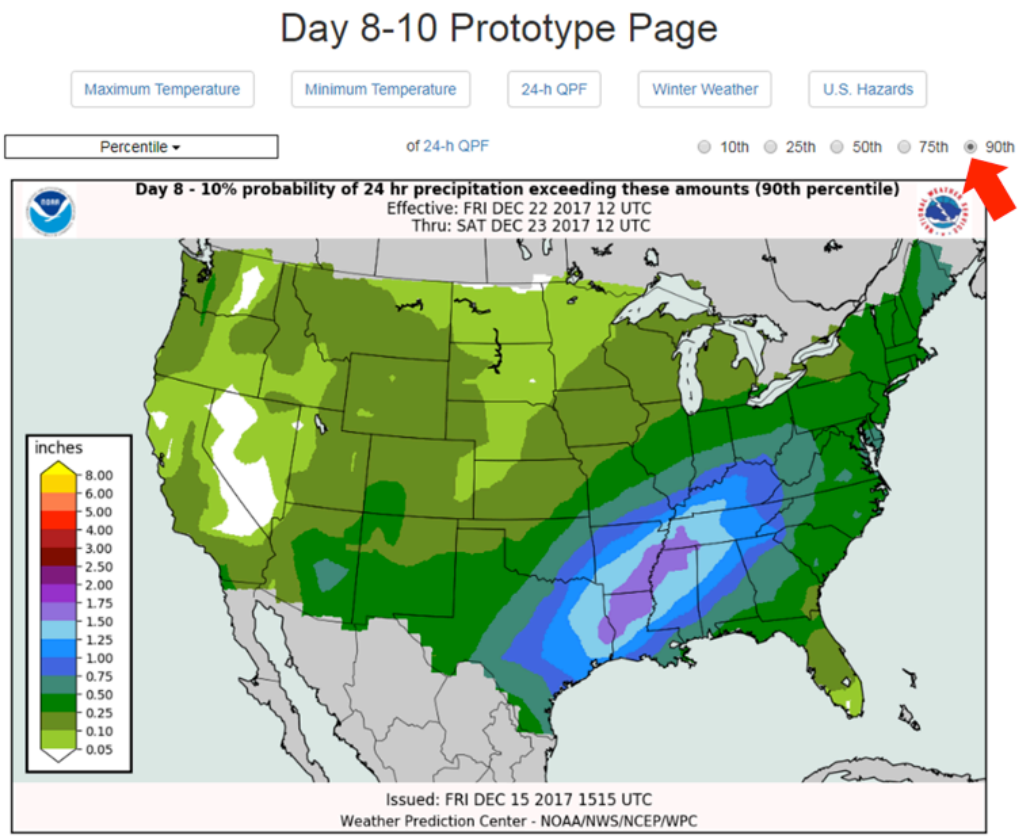


Figure 2. Example of the web interface showing the 8-10-day products.

Results

The results reported here stem from an online public survey that had 905 responses and notes summarizing responses from nine webinar-based focus group discussions.

Online Survey

The online survey was open from late September to late November 2017, collecting a total of 905 responses. Not all respondents answered all questions. Characteristics of the respondents are illustrated in Appendix D. The majority (76%) of respondents were members of the public and not associated with the National Weather Service and were from a wide range of locations across the country (Figure 3). Respondents were interested in the 8-10-day forecast primarily for preparedness actions, planning decisions, and general interest.

When asked about their preference for a probabilistic forecast, over 50% reported that a forecast with probabilities was very useful, and 40% felt it was somewhat useful.

However, when given a choice among two types of probabilistic forecasts (single probability or range of probabilities) and two types of deterministic forecasts (single deterministic forecast or a deterministic range), 45% of respondents preferred a forecast with a deterministic range and 19% preferred a single deterministic forecast, while 27% preferred a probabilistic forecast and only 9% preferred a probabilistic range.

For both the temperature and precipitation graphics, survey respondents overwhelmingly preferred the percent chance versions over the chance of non-exceedance, with 94% preferring the temperature percent chance over the non-exceedance, and 82% preferring the precipitation percent chance over the non-exceedance product. This finding was also strongly supported in the focus groups and is reflected in their reported likelihood of use shown in Figure 4. A majority (80%) of respondents was likely or somewhat likely to use the percent chance temperature and precipita-

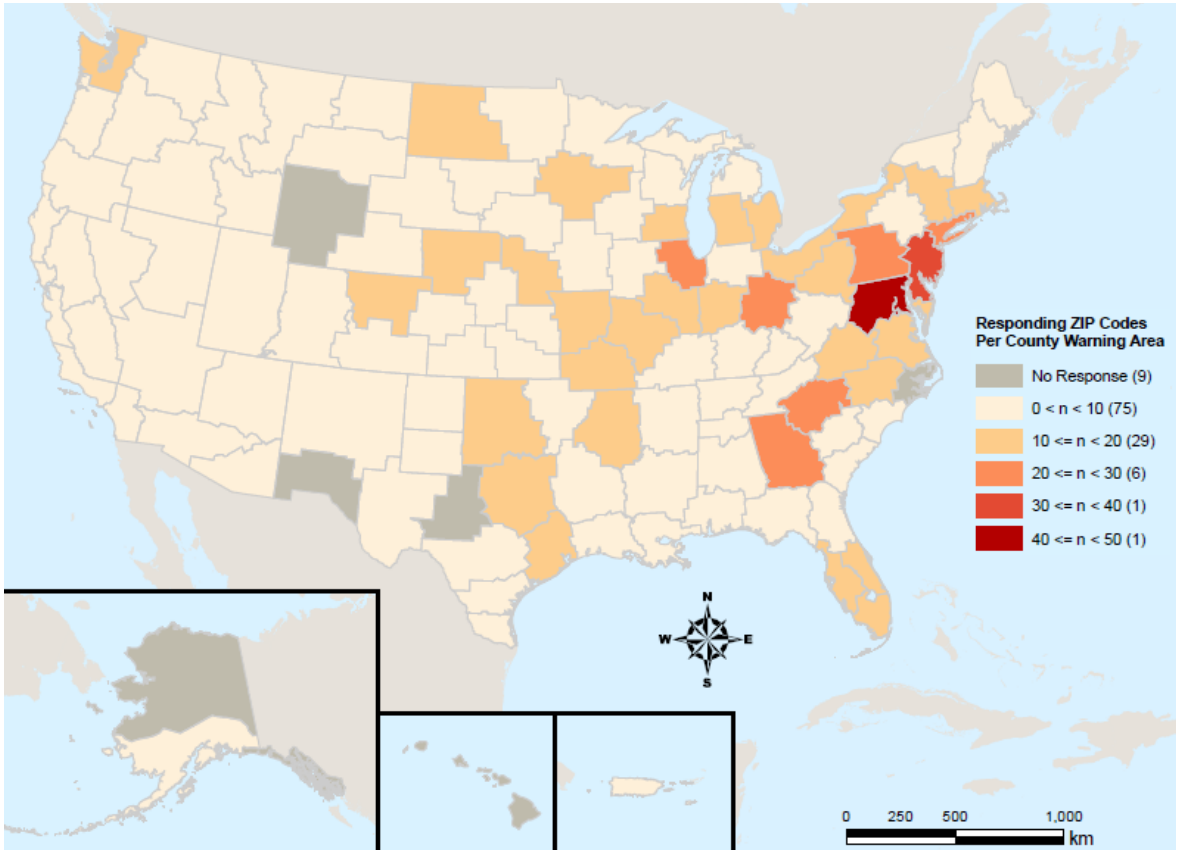


Figure 3. Density map of survey respondent locations

tion products while 53% were somewhat or very unlikely to use the temperature non-exceedance. The snow/sleet liquid equivalent product was likely to somewhat likely to be used by 69% of respondents. Over half (56%) felt that the U.S. Hazards Outlook was helpful for decision-making. When asked about additional products in the 8-10-day timeframe, the majority of respondents was very to somewhat interested in heat index (73%) and wind chill (79%) maps (Figure 5).

When looking at preferences for various graphics as well as likelihood of use, there were very few differences across different demographic categories (gender, age, education, employment) among those who completed the survey. The only difference that stood out was that males reported being more likely to use the precipitation graphics, including the liquid equivalent one, than females, but there was no significant difference with respect to the temperature products.

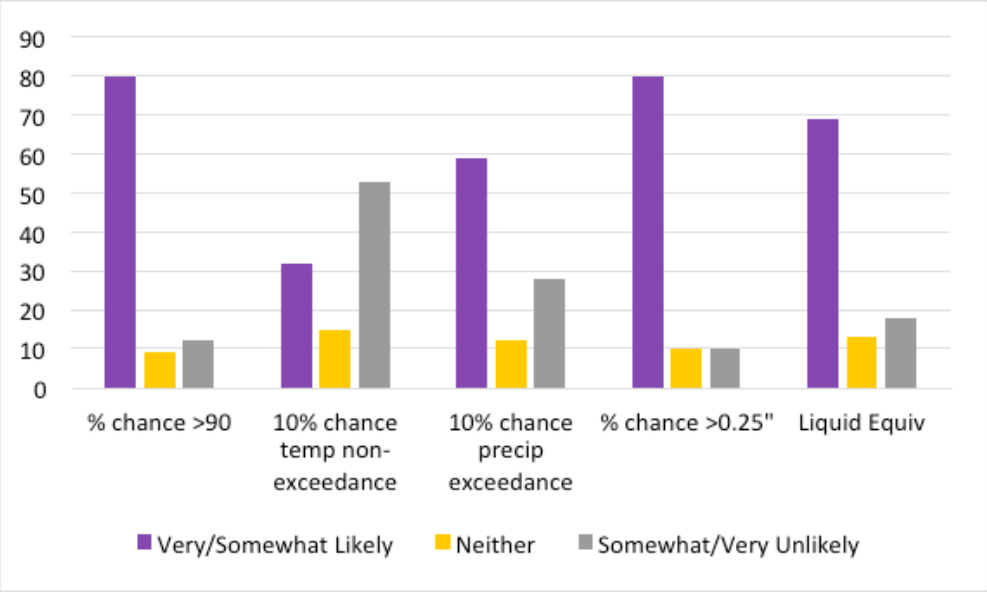


Figure 4. Likelihood of use for the temperature, precipitation and snow/sleet products.

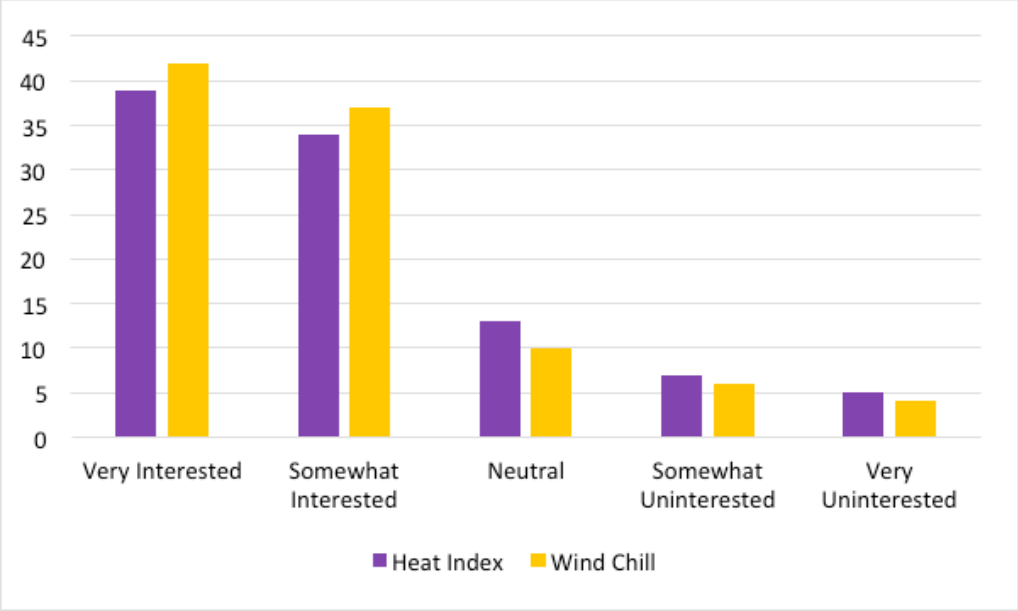


Figure 5. Interest in 8-10-day heat index and wind chill maps.

Focus Groups

To analyze focus group discussions, responses were organized into a few categories: usefulness of the product, actions that the products would inform, whether the products would be shared, the design elements and understandability of the graphic itself, and other considerations, including needed/preferred thresholds. A breakdown of these categories by product and user group is found in Appendix E.

There were minimal differences in responses across user groups in terms of preference and graphical design suggestions. Most differences were elucidated in the actions and operational decisions that the products would support, as well as end user considerations. For instance, in the federal group there were representatives from the Bureau of Land Management (BLM) who focused on wildfire management, from the Federal Aviation Administration (FAA) who focused on aviation concerns, and from the Weather Service who focused on forecaster needs. These users had varied applications for the same products, i.e., precipitation graphics could be used by one group for monitoring the end of wildfire season and by another for changes to flight patterns. The following chart (Figure 6) represents the range of decisions participants indicated might be supported by the 8-10-day forecast products. Many of the users' needs overlapped (i.e., needing to plan for pre-positioning of resources was a common response by several users), and as such, the decisions were categorized according to the nature of the decisions.

In Round 1, nearly all participants had a low preference for the probability of exceedance products, citing the confusion they generated and the time and mental processing necessary to understand the information. Users explained that the information would take too long to understand and therefore had little to no utility for decision-making or sharing with others. Many commented that having to go back and forth between the legend, map, and title significantly reduced the products' utility. The majority of participants felt the information conveyed in the percent chance products could be useful with user-defined thresholds, but they indicated that most actions and decisions related to product use would center on situational awareness. Significant actions were not anticipated with a forecast this far out, given the inherent uncertainty. With the exception of municipalities and transportation crews, most users would not have use for the snow/sleet product in the current form due to the use of liquid equivalent units. With a change of units, the product's value would increase for a wider range of users. The majority of users found the U.S. Hazards map to be useful for situational awareness but too vague to be of value to decision-making.

In Round 2, all participants appreciated the ability to select from a range of thresholds, but wanted this ability to be expanded to a slider scale so that there would be more flexibility to select their critical threshold, reflecting the diversity of their needs. The products (i.e. precipitation) with a higher number of available thresholds from which to choose were viewed more favorably than those with fewer (i.e. temperature). As elucidated in Round 1, participants still had concerns with the liquid equivalent units for the snow/sleet products. An option for users to switch between liquid equivalent and inches of accumulation for the snow/sleet and freezing rain products would enhance understandability and utility. Further, participants noted that legends did not provide an adequate range of options or information, especially in the case of the U.S. Hazards graphic, the legend of which showed only a subset of possible hazards.

Generally, participants indicated that having more details and even the underlying data about the elements that inform maps and prototypes, as well as how various map categories were defined, would add value and improve their ability to use the products in decision-making. For instance, in products that reference a relationship to normal, the need to determine "normal" quickly was cited as critical. For all products, there was concern expressed that the public would not understand the time element as denoted on the graphics. For professional users, UTC is understood, but having the option to choose a local time zone would improve the usability of the product among a wider range of audiences. There was also concern that users would interpret the maps as temperature or precipitation forecasts instead of percent chance and probabilities. Some participants suggested making this distinction as clear as possible, either through text or a different color scheme. A related confusion arose around the color schemes for temperature. Colors did not always match the weather being displayed. For example, a high probability of cold temperatures in the percent chance of maximum temperature map was indicated by red, causing cognitive confusion for users accustomed to understanding red as a warm temperature color.

Additionally, several participants wondered about how lack of skill in forecasting in the 8-10-day timeframe could be communicated to various audiences. They expressed concern that showing a probability forecast 8 or more days out could easily be misinterpreted by the less knowledgeable public as indicating more confidence than is warranted. Some cautioned against sharing such maps with external partners who may interpret the product as a definitive forecast and make operational decisions or potentially generate concern in the public of an impending storm. The majority of participants would only share the products internally, viewing probabilistic information in the 8-10-day timeframe as a difficult concept for the public to correctly understand. It was noted, however, that experience with

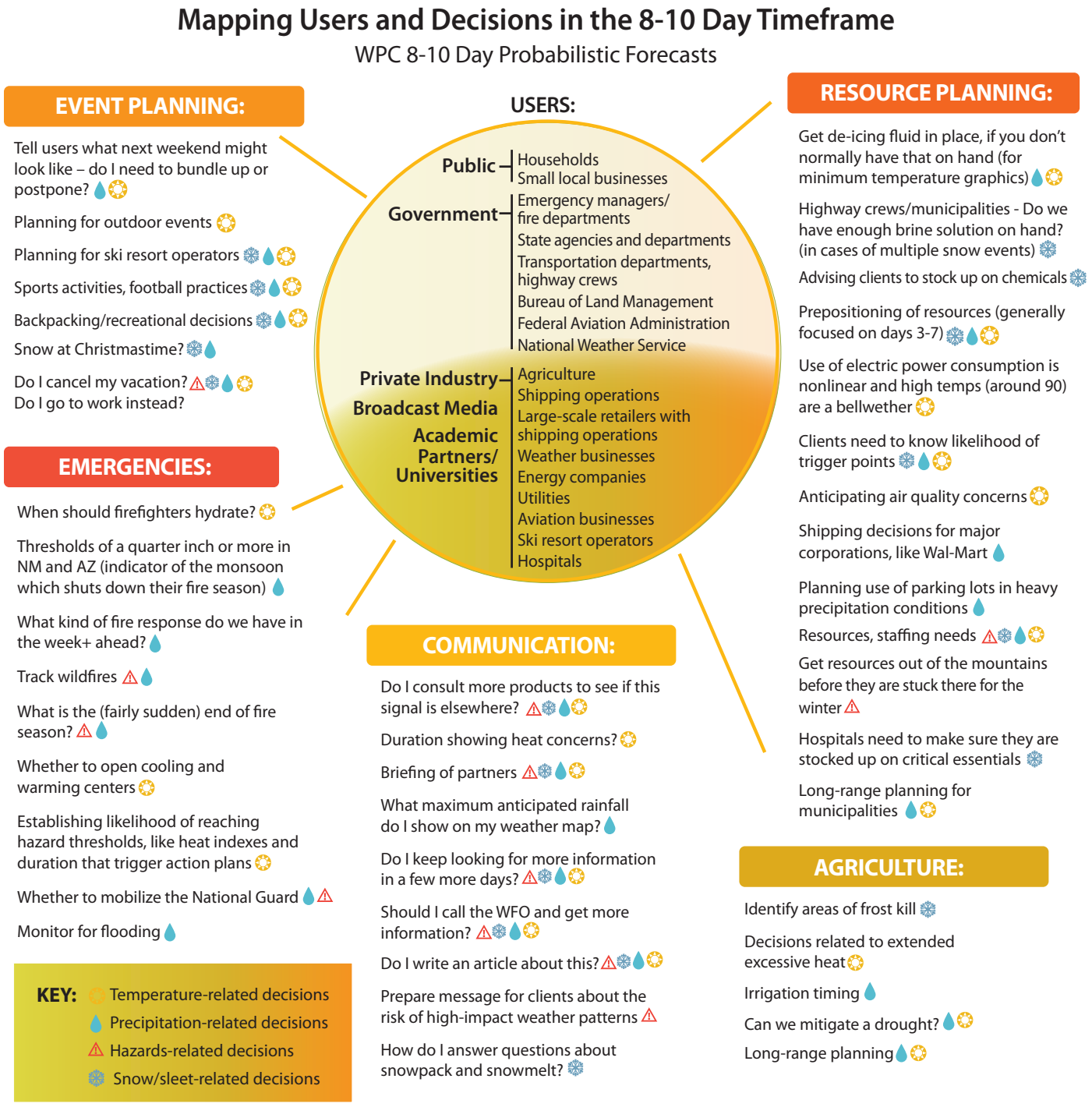


Figure 6. Decisions supported by WPC 8-10-Day Products

the products over time would help develop a level of understanding about the products that would, in turn, determine how useful the products could ultimately be for decision-making.

Overall, participants acknowledged the usefulness of much of the information shown in the 8-10-day prototypes. However, most products at this time range were seen as useful only for monitoring and situational awareness. In few cases were concrete, significant actions considered in response to these products, because of the timeframe. Across the user groups engaged, percent chance was the most preferred product type, with probability with respect to normal a close second. While probability with respect to normal had high utility for state/local partners for whom deviations from normal could trigger hazard plan implementation, other participants felt that most users would not know what normal represented (it is noted that a map of normal is available for viewing on the graphic web interface). Percentile/probability of exceeding a certain amount was not viewed favorably (Table 1).

While both temperature and precipitation products had utility for a number of decision points and users, participants felt that they needed to use the information in conjunction with other products. They noted that wind chill and heat index are important phenomena more critical for planning, human health, and day to day operations than just temperature or precipitation alone. Further, duration of a weather pattern was specifically cited as an important factor, especially in the 8-10-day timeframe. How long cold or hot spells, or other extreme events, would last was seen to be important for planning and management. Many participants asked how such information could be effectively displayed, and indicated that they would use these products in conjunction with 4-7-day deterministic forecasts to assess trends.

In general, the recommendations provided by participants centered around the need for increased user flexibility, including more thresholds, the ability to define time zone and product units, and having dynamic maps with zoom capability. Interactive maps with overlay functionality would be particularly useful for local and state partners who need to make decisions at those scales.

Table 1. Preference of type of temperature and precipitation product among the three choices presented in Round 2 – percent chance, percentile (probability of exceeding a certain level), and probability with respect to normal.

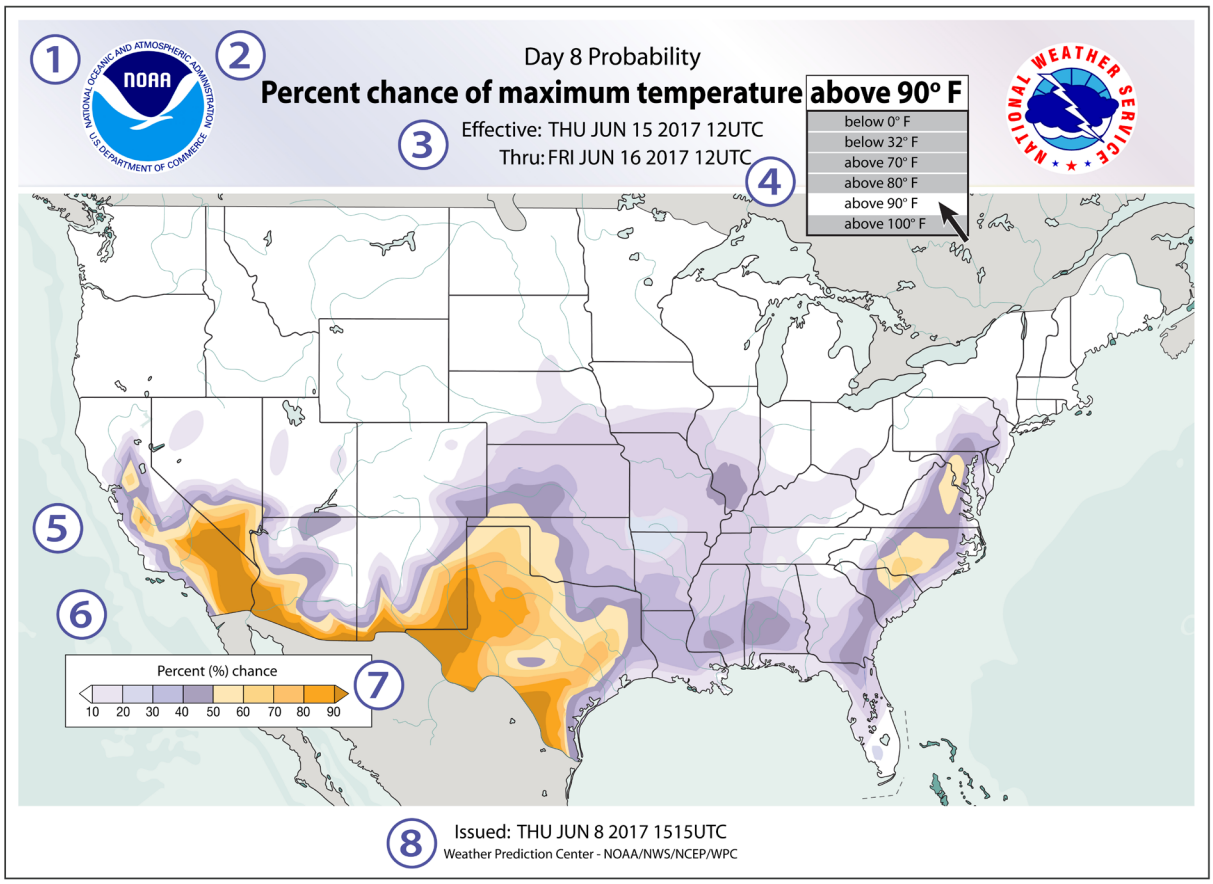
	Max temperature	Min Temperature	Precipitation
National Weather Service	Percent chance	Percent chance	Percent chance
Media	Percent chance/ Prob with respect to normal close second	Percent chance	Percent chance
Private	Percent chance for public/Prob with respect to normal or all 3 for meteorologists	Prob with respect to normal/Percent chance close second	Percent chance for public but meteorologists want all info
State	Prob with respect to normal	Prob with respect to normal	Percent chance

Final Recommendations

Feedback from both rounds of focus groups indicates that changes to the design and presentation of the products are needed to facilitate understanding and utility. A summary of product revisions completed between Rounds 1 and 2 is shared in Appendix B which details adjustments to elements including legend, overall formatting, use of color and other factors.

In response to Round 2 focus group feedback, the research team undertook a second redesign of select products to illustrate proposed ways to address user concerns about display (Figures 7 and 8). These revisions addressed use of language, labeling, ability to select thresholds, and visual presentation of data sets; they are designed to increase the ability of users to quickly assimilate information and distinguish high and low impact events.

Many of the same modifications were made to the precipitation and temperature graphics as indicated in Figures 7 and 8. For the precipitation graphic (Figure 8) the use of color has changed. The shaded blues and tans are selected to represent higher and lower percent chance of precipitation.



1. Logos of the source agencies were placed prominently and made consistent throughout all products.
2. The title of the product was moved to top center along with the valid dates. The title now begins with "Day 8", putting this critical information first in the hierarchy of information. The symbol "<" was replaced by the word "above" to simplify readability.
3. "Effective" replaced the word "valid;" valid was confusing to some participants. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.
4. The ability to determine different thresholds was identified as a key user need. A dropdown menu was added with predetermined thresholds at critical temperatures.
5. On the map: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary.
6. The legend was reoriented to read horizontally to indicate probability and to avoid confusion with a vertical temperature scale.
7. Colors were changed and muted in tone to avoid association with standard temperature colors. Colors result in improved ADA compliance (color blindness).
8. Secondary information was placed in the footer.

Figure 7. Mocked-up prototype of Percent Chance of Maximum Temperature product, with detailed explanation for revised changes

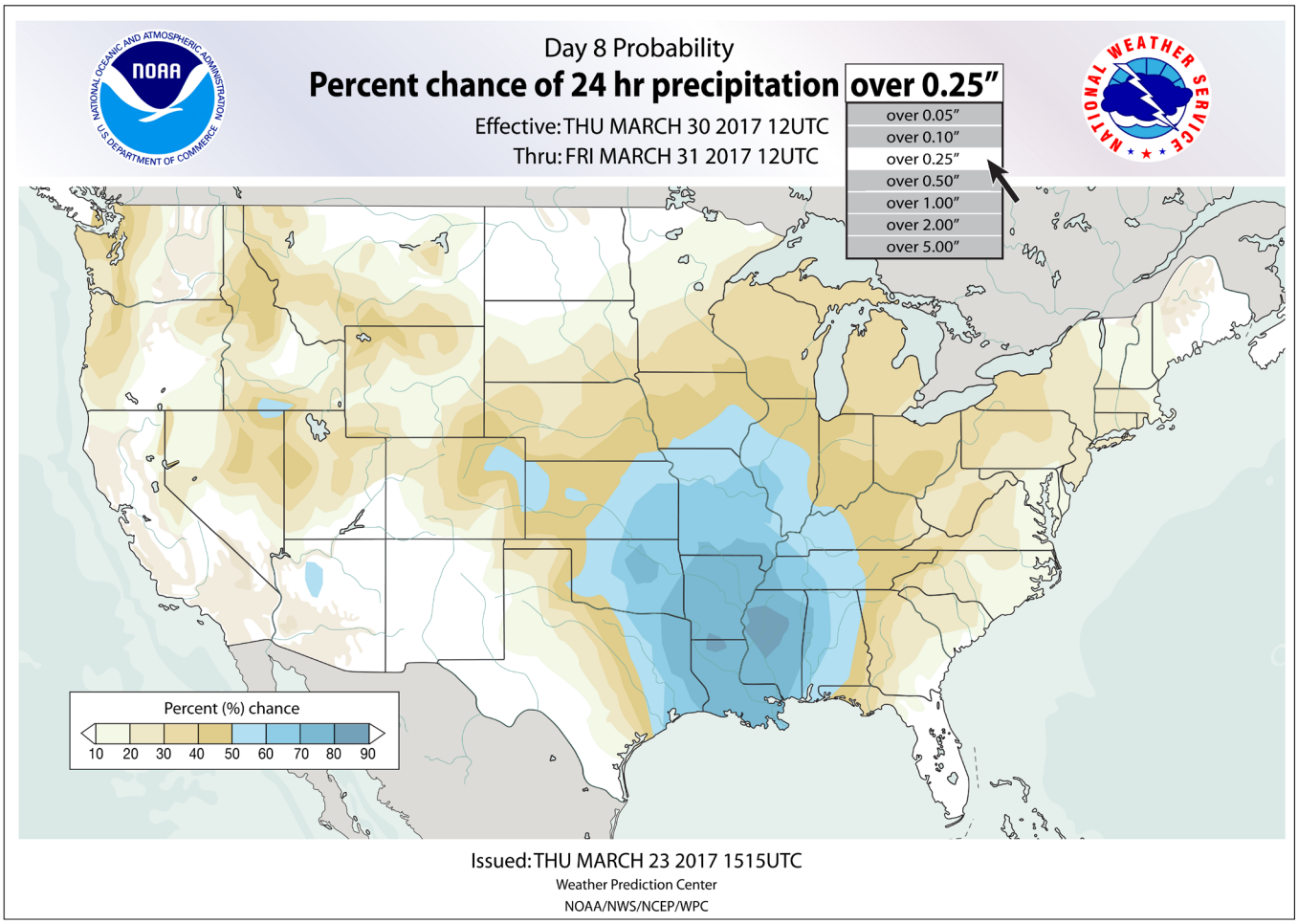


Figure 8. Mocked-up prototype of Percent Chance of 24 hr precipitation graphic

Summary

The results of the online survey and focus groups indicate that there is utility for temperature, precipitation, and snow/sleet probabilistic products in the 8-10-day timeframe for a variety of users, especially for monitoring and situational awareness, information that would most likely be shared internally among professional users. Incorporating modifications to graphic design and display as recommended here will enhance the utility and understandability of the information being conveyed. Both the professional users of the product engaged in focus groups and those completing the online public survey showed a preference for percent chance over non-exceedance graphics. Further, focus group participants strongly advocated for products that allow the user to define thresholds. Products with multiple factors – i.e., heat index and wind chill – were deemed important to users in both focus groups and surveys.

Given the longer timeframe of the products, focus group users' responses indicated that these products would be looked at quickly to determine the potential for upcoming high-impact events, and as a result, would be used in conjunction with other products and services as a guide for longer-term planning and to determine potential trends that might trigger thresholds for action plans. These products, therefore, are a part of a suite of tools users would deploy to tell stories to their internal (and in the case of broadcast media and emergency managers, potentially external) audiences about the potential for high-impact weather events.

Testing prototype products with potential users while still in development is a beneficial and time-saving practice that can provide critical information to guide the future development and rollout of the forecast services. In this study, findings on the need for more user flexibility with threshold choice, along with the potential decisions that the products would inform, provide valuable information for consideration as the products move beyond the prototype phase.

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Appendix A

Report on Engagement with Weather Prediction Service Forecasters
Meeting date: May 30, 2017

Introduction

In response to increased user demand for probabilistic forecasts, National Weather Service's Weather Prediction Center has developed a series of prototype products that provide probabilistic guidance for precipitation and temperature in the 8-10 day time frame. Because user needs for this information vary and because there is a range of possible presentation formats for this information, NWS has engaged with ECS, Inc. to develop user-tested and informed guidance for how to present 8 to 10-day probabilistic forecast guidance. This process will include iterative field-testing of core users and will result in recommendations for preferred delivery methods and the optimal mix of design and delivery considerations.

To initiate this process with the Weather Prediction Center (Project Title: Identify Partners/Users of WPC Products and Mapping Related User Decision-Making for the Day 8-to-10 Time Frame), ECS Inc.'s research team engaged with WPC forecasters and personnel at its headquarters in College Park, MD on May 30, 2017 for a daylong kick-off.

The identified goals for the day for the research team were to:

- Learn about the EMC and MDL systems, and to understand the roles and purposes of models and departments/staff
- Receive some basic training and introduction into the products and processes of the WPC for its 8-10 probabilistic products
- Identify WPC's perspective on the needs of various users
- Identify any technical, temporal or spatial gaps in capacity
- Identify any additional guidance needed in the 8-10 day time frame
- Develop list of priority products for study during the project

In attendance were: Dr. Burrell Montz, East Carolina University; Rachel Hogan Carr, Nurture Nature Center; Dr. Kathryn Semmens, Nurture Nature Center; and from WPC: Michael Bodner, Daniel Halperin, Joshua Kastman and James Nelson (project team members) and forecasters Anthony Fracasso, Michael Schictel and Marty Rausch.

I. Current Systems: Analysis + working list of priority products for study

The research team and WPC personnel discussed the various model and data sources being used by the Weather Prediction Center for the creation of its 8-10 probabilistic products. WPC relies on information from the Meteorological Development Laboratory (MDL) and the Environmental Modeling Center (EMC).

MDL provides statistical data post-processing. As part of its work relevant to the WPC 8-10 probabilistic products, MDL issues Model Output Statistics (MOS) and issues the new National Blend of Models with a global 8-10 day timeframe.

Environmental Modeling Center (EMC) does its own post-processing for different parameters. EMC models precipitation rates and types, and has teams focused on specific areas such as cloud physics and land surface. EMC has an evaluation group that verifies model performance through case studies and object-oriented verification. WPC forecasters reported during the meeting that verification is improving by "leaps and bounds." EMC is the primary model developer for global and regional modeling.

In addition, WPC also applies its own post-processing to EMC data and shares that data. As part of the process of developing probabilistic forecasts, WPC is creating its own model blend, while simultaneously running the national blend. Key questions identified for consideration include: how much of this processing can be automated, and

where is value added from human input? WPC's sample of human-generated forecasts was small at the time of the meeting in May, having begun in January 2017, and the staff anticipated that they would have a better analysis of how the human vs. automated (both WPC's automated blend and the national blend) compared in a few more months. As of the meeting, the human blend was generally performing similarly to the auto-blend in terms of accuracy, but with more months of data the team will refine its understanding of the relative performance of the national blend, the auto-blend and the human blend.

In addition to using EMC and MDL, WPC forecasters reported also using tools from the Climate Prediction Center (CPC). For instance, CPC is developing a new "drop-out" tool that will show where models contain errors; if a model with errors is then embedded within a blend, that error-laden model can have its weight reduced in the blend to de-amplify the impact of the error on the outputs. This function - identifying and reducing the weight of models with errors – is where human input becomes essential.

II. Technical/Temporal/Spatial Gaps

When discussing gaps in the technical, temporal and spatial ability to forecast 8-10 probabilistic hazards, the team identified that the EMC needs better precipitation output and improvements in precipitation post-processing. The team acknowledged that increased skill is needed also in the medium range (days 3-7) and that skill drops after day 4 when looking at joint probabilities which measure two parameters at one time (e.g., heat index, wind chill).

The team noted that work done out of SUNY Stonybrook was allowing for more ensemble sensitivity to account for differences in predictability in flows from the North and South, and encouraged more of this sort of grant-funded research work to continually refine capabilities. Generally, the WPC team did not report any significant challenges related to the performance of the MDL or EMC. The team did note recent improvements, such as progress in verification and the creation of the new national blend of models.

III. Key products

Emerging from the conversation was an acknowledgement that beyond the data, the core challenge the WPC team faces with the development of these products is communicating uncertainty in predictions to the public. The WPC team identified a core set of 8 to 10-day prototype products they want to test and analyze prior to distribution to the public. These include:

- 10% probability of 24-hr maximum temperature not exceeding set values
- Percent Chance of Maximum Temperature > 90 degree F
- Day Eight Probability of Exceeding 0.25 Inch Liquid Equivalent of Snow/Sleet
- Percent Chance of 24 hour precipitation > 0.25"
- 10% probability of 24 hour precipitation exceeding set amounts
- Day 8-10 U.S. Hazards Outlook (being taken from the CPC)

WPC also wanted to acquire feedback on heat index and wind chill, and the need for and usefulness of this information in the 8-10 day timeframe.

IV. User Needs

Generally, forecasters are the most important users of WPC products and are the primary customer. Specifically, WPC identified Weather Forecast Offices as their priority customer. Some core users, such as First Energy, use specific products (for instance, snow or sleet over 0.25 in). The WPC has access to data and tools that are not accessible to WFOs (including the entirety of the European model output) and therefore provides critical information to the WFOs.

When looking at 8-10 probabilistic products, considerations of external users are much larger than usual. End users are likely audiences for these new 8-10 day probabilistic products, and as such, there is a heightened need to ensure information is presented clearly. These products need to clearly convey uncertainty to an audience accustomed to thinking in a deterministic fashion.

V. Research questions:

The team reviewed the function of each of the products and focused conversation on the inherent communication challenges. A guiding, key research question emerged:

- Exceedance probability vs. percentile products: Which are more helpful? To whom? At what preset levels (i.e., what thresholds for precipitation, temperature?)

Additional research areas of interest also emerged:

- The team raised questions about how to identify the timing of hazards within the 8-10 day period. For instance, when issuing the probability of exceedance of 1" of precipitation in a 24-hour period, is it necessary that those 24-hour periods correspond to Days 8/9/10 or should instead the 24-hour periods be defined within increments that correspond to the weather patterns? In short, the team recognizes that weather events do not follow calendar days, and that patterns of intense precipitation in short periods of time may cross day-long borders.
- The WPC is also working on in-house post-mortem forecast verification presentations and asked if these would be helpful for any audiences.
- Would a mean temperature be helpful to specific audiences – perhaps energy or agriculture? Would a range of high temperatures be easier to understand than probabilities?
- How to present departures from normal was also a question: in warm temperatures, currently WPC is using +/- 10 degrees but should standard deviations or other representations be used? What do users need to understand the forecasts most easily and accurately?
- How valuable are joint probabilities – heat index, wind chills?
- For the hazards outlook: at this time frame, are audiences looking for probabilities, or simply outlines of general hazards?

Other questions about communication arose that could be considered during focus group conversation, such as how well people receive and translate terms including "Slight/high/marginal" when applied to risks.

The meeting provided critical context for survey and focus group protocol development and allowed the WPC team to effectively communicate their information questions and needs. A significant challenge is communicating uncertainty in methods that are understandable to priority and end users. The project will seek to assess the need for information at the 8-10 day timeframe, and what types and in what formats the data is most effective in meeting those needs.

APPENDIX B

Online Survey Questions and Graphics

WPC 8-10 Day Probabilistic Product Survey ECS, ECU, NNC

Dear Participant,

Thank you for logging into this survey. The survey is voluntary and any information you provide will be anonymous.

The purpose of this research is to understand the need for and interest in forecasts in the 8 to 10 day range and how best to show the probability of long range forecasts. By doing this research, we hope to learn how probabilistic forecasts can improve decision-making in the 8 to 10 day timeframe.

If you agree to take part in this survey, you will be asked questions that relate to how often you seek weather information and what decisions you make based on the weather forecast over one to two weeks. You will be asked your understanding and perceptions on ways to show forecasts of probabilities of temperature, precipitation, and winter weather. In addition, we will be collecting some demographic information. The amount of time it will take you to complete this survey is approximately 30 minutes.

This research is being conducted by an independent contractor, ECS Federal, LLC, on behalf of the National Weather Service. You do not have to take part in this research, and you can stop at any time. If you decide you are willing to take part in this study, please click here.

Thank you for taking the time to participate.

Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number.

If you have any questions, please contact Jennifer Sprague, National Weather Service, jennifer.sprague@noaa.gov.

1. What is your age?
- ❍ under 20
- ❍ 20-29
- ❍ 30-39
- ❍ 40-49
- ❍ 50-59
- ❍ 60-69
- ❍ 70+

2. What is your gender?
- ❍ Male
- ❍ Female
- ❍ Other

3. What is your highest level of education?
- ❍ High school (no diploma)
- ❍ High school diploma or GED
- ❍ Some college
- ❍ Associates degree
- ❍ Bachelor's degree
- ❍ Graduate/Professional degree
- ❍ Prefer not to answer

4. Please enter your zipcode_____

5. What best describes your employment?
- ❍ Self-employed
- ❍ Student
- ❍ Unemployed
- ❍ Government
- ❍ Private
- ❍ Non-profit
- ❍ Education
- ❍ Other

6. What is your relationship to the National Weather Service?
- ❍ Member of the public/do not work for NWS
- ❍ Employee at local WFO
- ❍ Employee at a NWS Regional Office
- ❍ Employee at a NWS National Center
- ❍ Employee at a RFC or ROC

- ❍ Collaborate with NWS
- ❍ Other

7. How often do you seek weather information (on average)?

	Several times a day	Once a day	Several times a week	Once a week	I rarely check the forecast
For tomorrow					
For 2 to 4 days from now					
For 5 to 7 days from now					
For 8-10 days from mow					

8. Where do you get information about the weather? (Please check all that apply)

- ❑ NOAA (National Weather Service) websites
- ❑ Other weather websites
- ❑ TV
- ❑ Radio
- ❑ Smartphone app(s)
- ❑ Twitter
- ❑ Facebook
- ❑ Other (please specify) _____

9. To what extent would the following 8 to 10 day forecasts assist your decision making?

	Very helpful	Somewhat helpful	Neither helpful nor unhelpful	Somewhat unhelpful	Very unhelpful
8-10 day temperature forecast					
8-10 day precipitation forecast					
8-10 day winter weather forecast					
8-10 day heat index forecast					

10. What reasons would you be interested in the forecast 8 to 10 days out (select all that apply)?

- □ General interest
- □ Decisions related to a planned event or activity
- □ Decisions related to travel plans

- □ Decisions related to work
- □ Decisions related to home maintenance
- □ Resource management/planning (decisions related to managing reservoirs, forests, etc.)
- □ Economic decision making/planning (decisions related to your business or purchasing decisions)
- □ Preparedness actions (preparing for weather events/natural hazards)
- □ I would not be interested in an 8 to 10 day forecast
- □ Other

11. What type of forecast do you prefer?

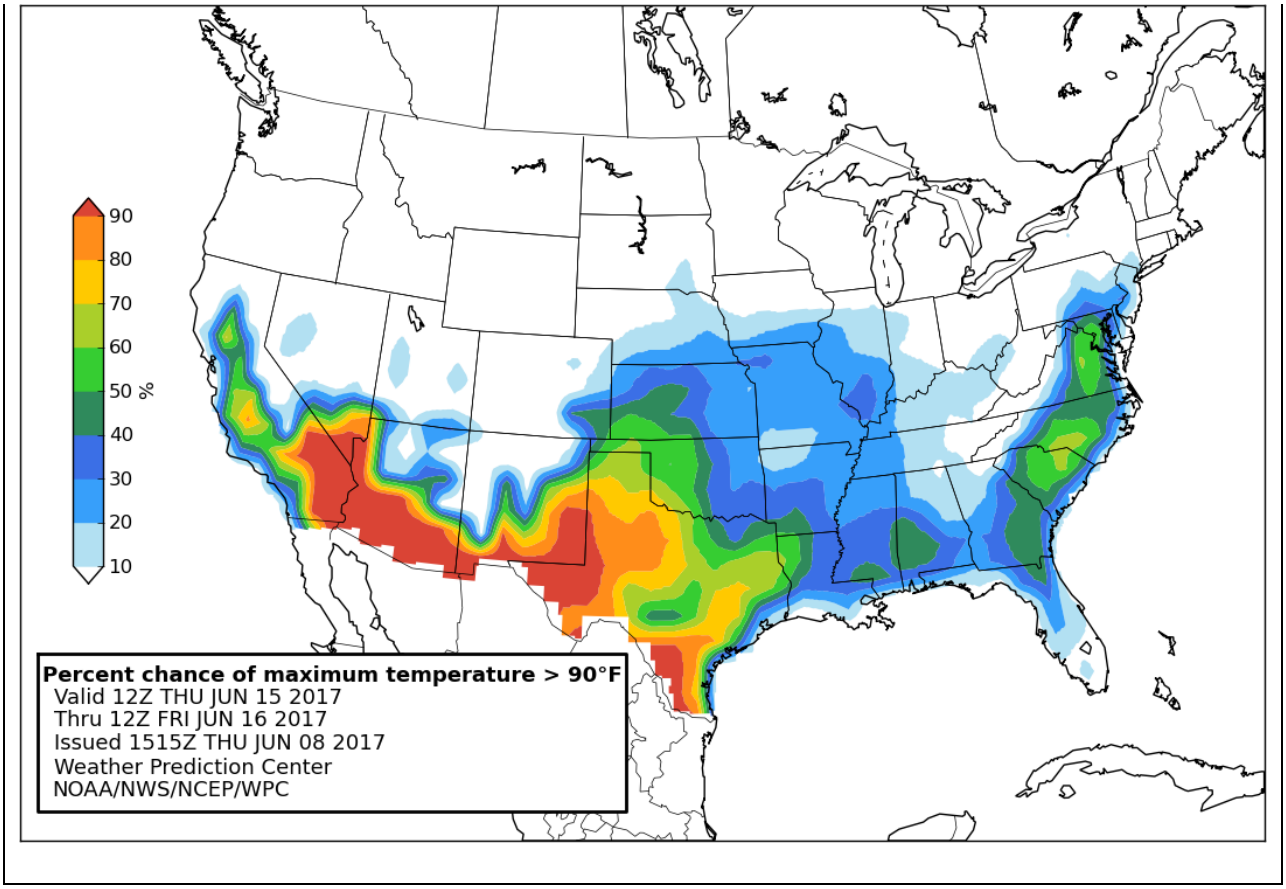
- ❍ A single, deterministic forecast. For example, "It will be 70°F on Tuesday."
- ❍ A range of possible forecasts. For example, "It could be between 60°F and 72°F on Tuesday."
- ❍ A probabilistic forecast such as "There is a 70% chance of reaching 65°F on Tuesday."
- ❍ A probabilistic forecast range such as, "There is a 60% chance of the temperature being 10°F above normal."

12. How useful to you is a forecast that provides probabilities?

- ❍ Very useful
- ❍ Somewhat useful
- ❍ Neither useful nor not useful
- ❍ Somewhat not useful
- ❍ Not useful at all

Specific product questions

Graphic 1:



13. What do you think this product is showing?

- ❍ The amount of confidence the forecasters have that it will be 90°F 8 days out
- ❍ The probability that the maximum temperature will exceed 90°F 8 days out
- ❍ The temperature will be 90°F 8 days out
- ❍ The percentage of the day that the temperature will be 90°F 8 days out
- ❍ I don't know

14. How likely would you be to use this product?

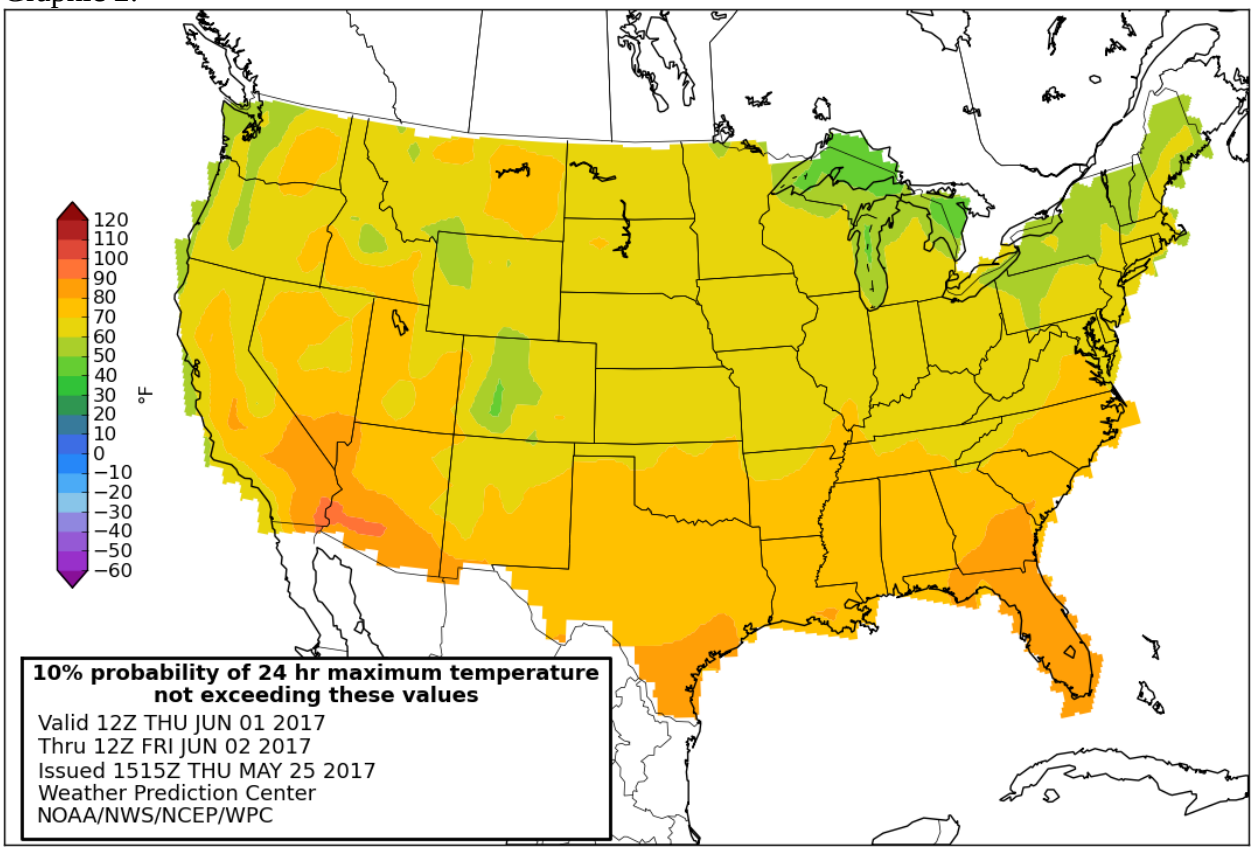
- ❍ Very likely
- ❍ Somewhat likely
- ❍ Neither likely nor unlikely
- ❍ Somewhat unlikely
- ❍ Very unlikely

15. Considering the product above, rate the following components:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive	Don't know
Information included						
Format						
Understandability						
Graphics						

Text						
Use of color						

Graphic 2:



16. What do you think this product is showing?

- ❍ The temperature values on the map are the forecast for 8 days out
- ❍ There is a 10% chance the temperature will not exceed the levels shown on the map 8 days out
- ❍ The forecasters are 90% certain it will exceed the temperatures shown on the map 8 days out
- ❍ There is a 90% chance the temperatures will be cooler than the amounts shown on the map 8 days out
- ❍ I don't know

17. How likely would you be to use this product?

- ❍ Very likely
- ❍ Somewhat likely
- ❍ Neither likely nor unlikely
- ❍ Somewhat unlikely
- ❍ Very unlikely

Considering the product above, rate the following components:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive	Don't know
Information included						
Format						
Understandability						
Graphics						
Text						
Use of color						

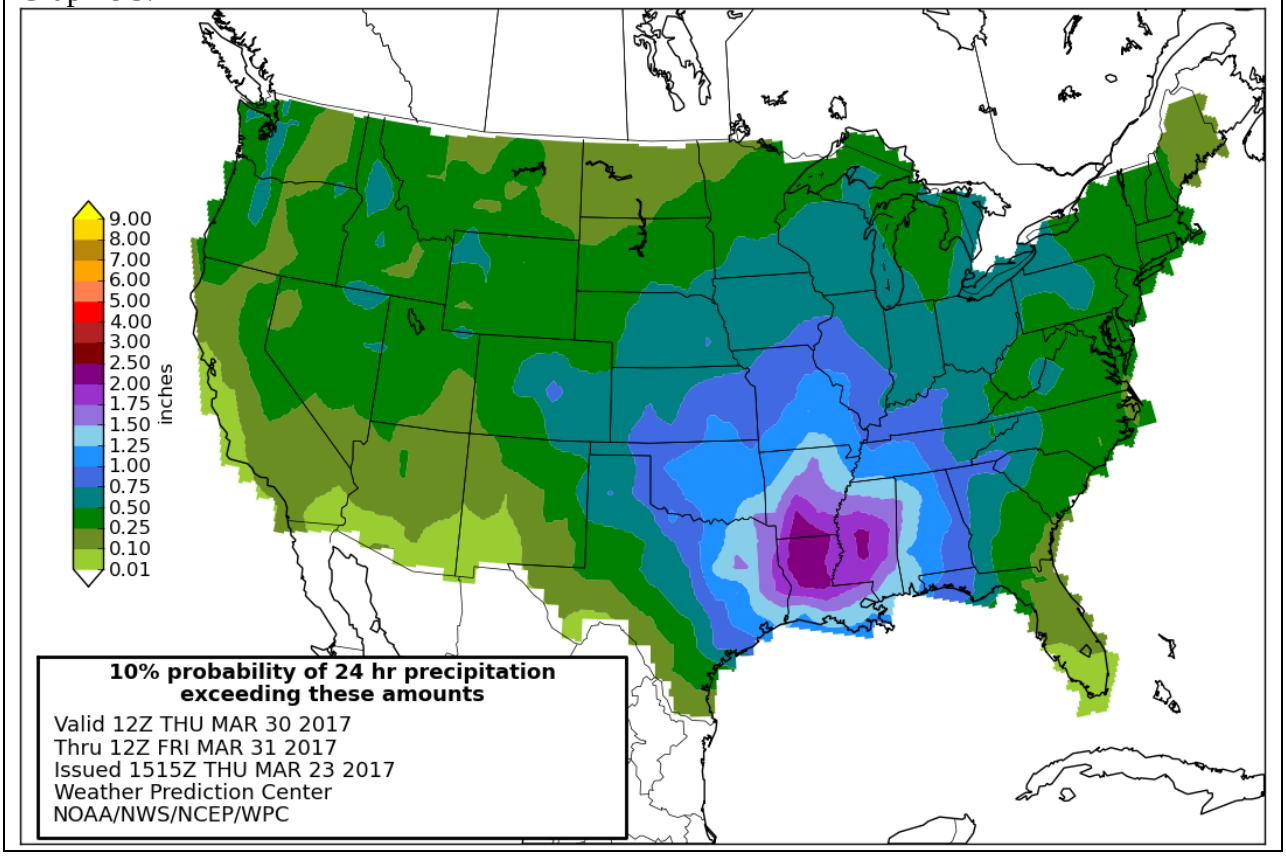
18. Of the two different types of products you just saw for temperature which do you prefer the most?

- o Percent chance (Graphic 1)
- o Chance of non-exceedance (Graphic 2)

19. Why?_____

- o It makes more sense to me
- o The information is more useful
- o The graphic is easier to read and understand
- o Other_____

Graphic 3:



20. What do you think this product is showing?

- ❍ There is a 10% chance that it will rain more than the amounts shown on the map 8 days out
- ❍ There is a 90% chance it will rain more than the amounts shown on the map 8 days out
- ❍ The precipitation values on the map are the forecasted total amounts 8 days out
- ❍ The forecasters are 90% certain it will rain the amounts shown on the map 8 days out
- ❍ I don't know

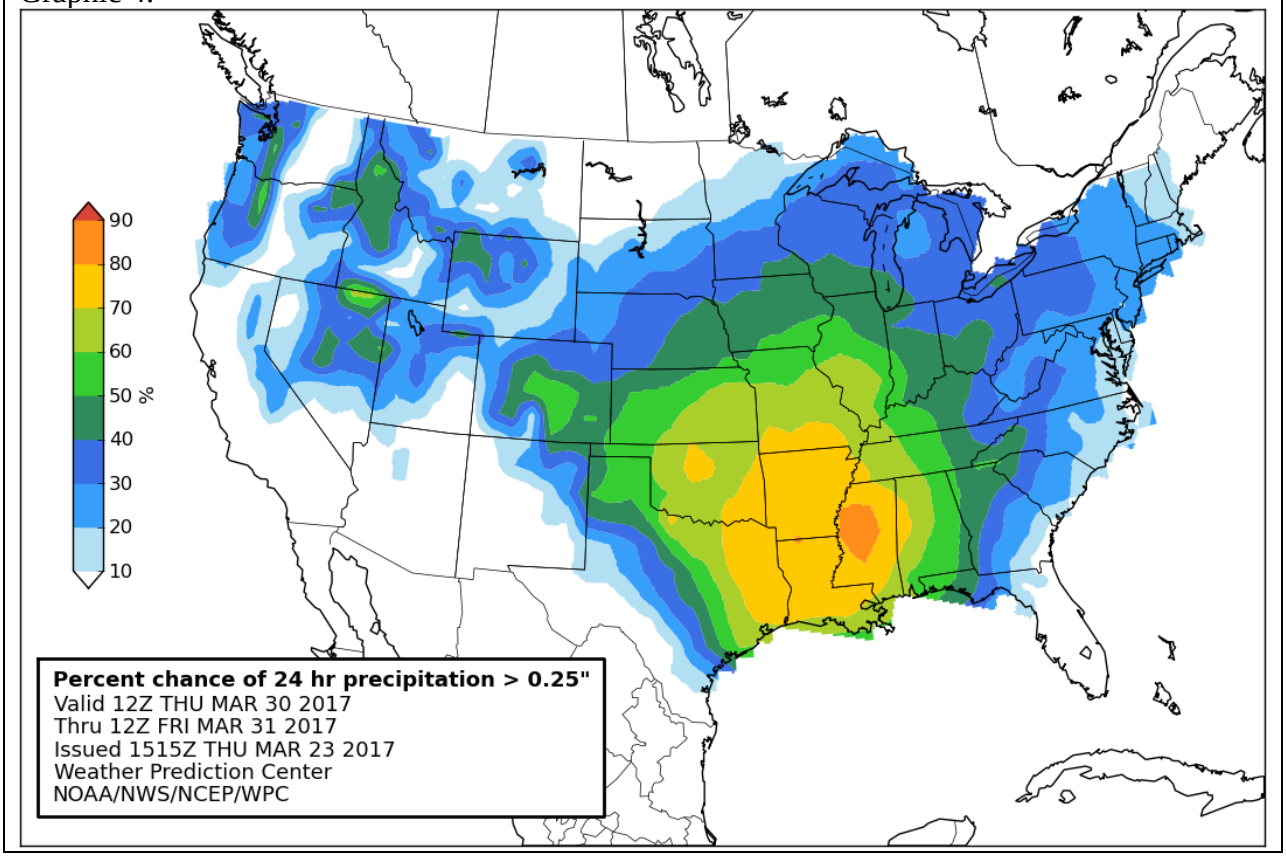
21. How likely would you be to use this product?

- ❍ Very likely
- ❍ Somewhat likely
- ❍ Neither likely nor unlikely
- ❍ Somewhat unlikely
- ❍ Very unlikely

22. Considering the product above, rate the following components:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive	Don't know
Information included						
Format						
Understandability						
Graphics						
Text						
Use of color						

Graphic 4:



23. What do you think this product is showing?

- ❍ The amount of confidence the forecasters have that there will be 0.25" of precipitation 8 days out
- ❍ The percentage of the day that it will be raining 8 days out
- ❍ The probability that the precipitation will exceed 0.25" 8 days out
- ❍ The precipitation will be 0.25" 8 days out
- ❍ I don't know

24. How likely would you be to use this product?

- ❍ Very likely
- ❍ Somewhat likely
- ❍ Neither likely nor unlikely
- ❍ Somewhat unlikely
- ❍ Very unlikely

25. Considering the product above, rate the following components:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive	Don't know
Information included						
Format						
Understandability						
Graphics						

Text						
Use of color						

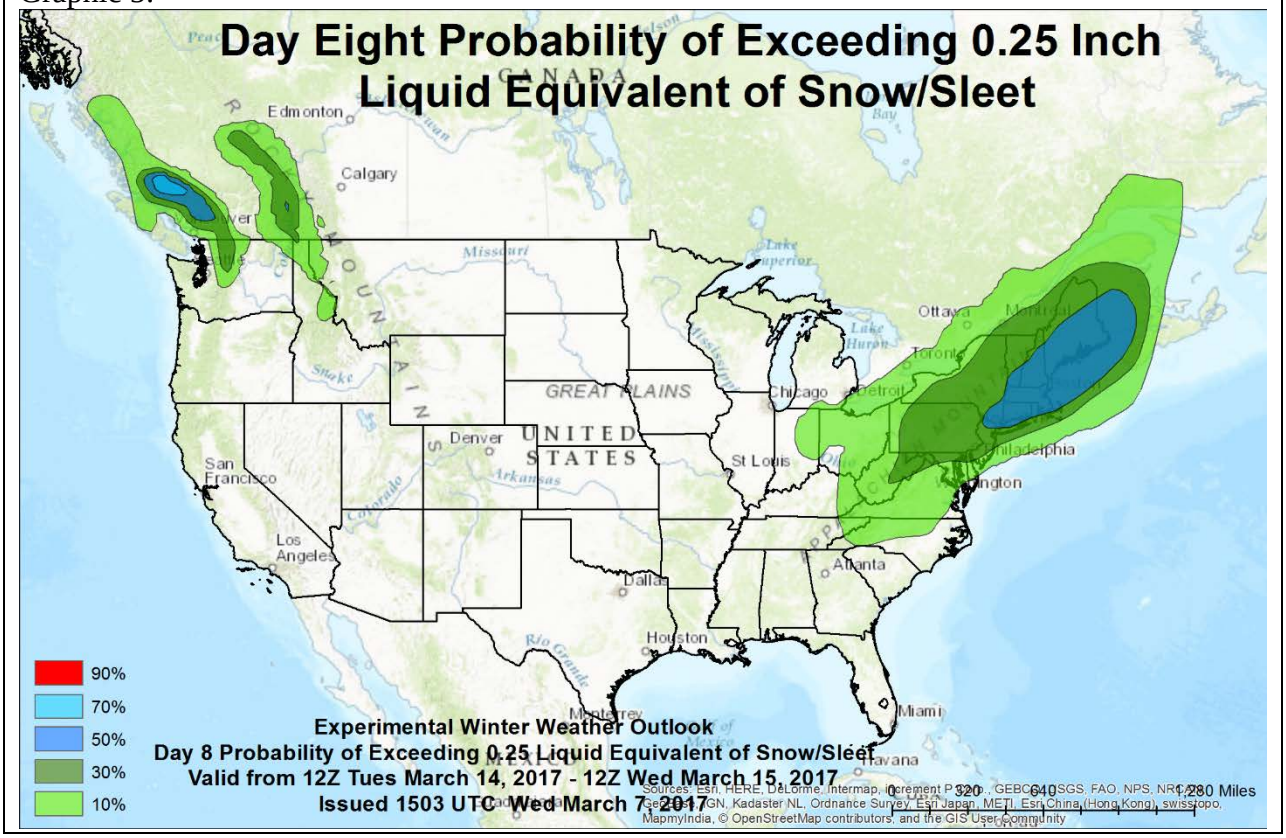
26. Of the two different types of products you just saw for precipitation which do you prefer the most?

- o Chance of exceedance (Graphic 3)
- o Percent chance (Graphic 4)

27. Why?_____

- o It makes more sense to me
- o The information is more useful
- o The graphic is easier to read and understand
- o Other_____

Graphic 5:



28. What do you think this product is showing?

- ❍ The probability that the amount of snow or sleet, when melted, will exceed 0.25" 8 days from today
- ❍ There will be 0.25" of liquid equivalent of snow 8 days from today
- ❍ The percentage of the day it will snow 8 days from today
- ❍ The amount of certainty the forecasters have that there will be 0.25" liquid equivalent of snow 8 days from today

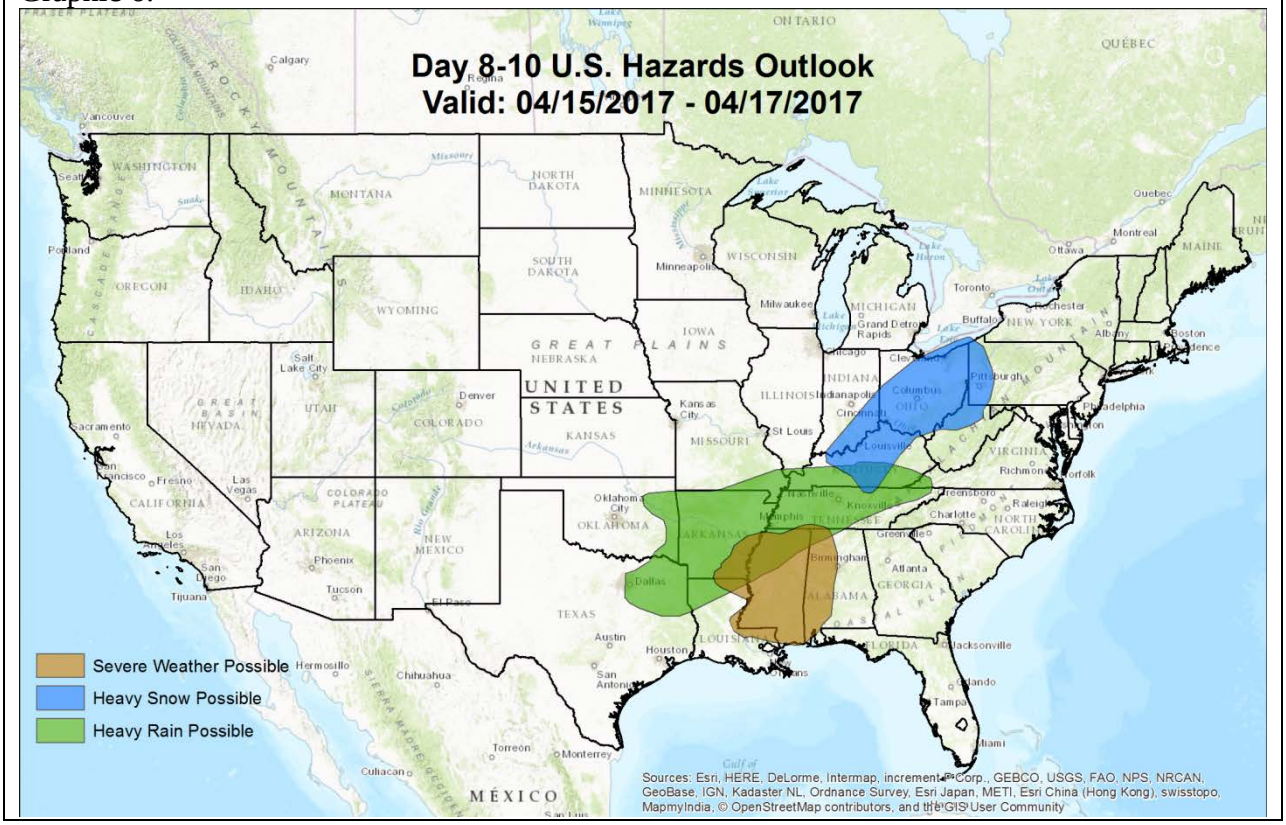
- I don't know

29. How likely would you be to use this product?
- Very likely
- Somewhat likely
- Neither likely nor unlikely
- Somewhat unlikely
- Very unlikely

30. Considering the product above, rate the following components:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive	Don't know
Information included						
Format						
Understandability						
Graphics						
Text						
Use of color						

Graphic 6:



31. This Hazards Outlook for 8 to 10 days out helps you make informed decisions.

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neutral
- ❍ Somewhat disagree
- ❍ Strongly disagree

32. The products you saw showed temperature, precipitation, hazards, and winter weather. How interested would you be in using a similar probability product for 8 to 10 days out that showed the following:

Heat index

- o Very interested
- o Somewhat interested
- o Neither interested nor uninterested
- o Somewhat uninterested
- o Very uninterested

Wind Chill

- o Very interested
- o Somewhat interested
- o Neither interested nor uninterested
- o Somewhat uninterested
- o Very uninterested

33. Is there any other type of weather information you would prefer in the 8 to 10 day forecast range?

_____

34. How would you prefer to receive an 8 to 10 day probability forecast?

- o Through social media
- o From local emergency manager
- o Emailed a link
- o Sign up for getting them based on a threshold I set
- o Seek them out on the Weather Prediction Center's website

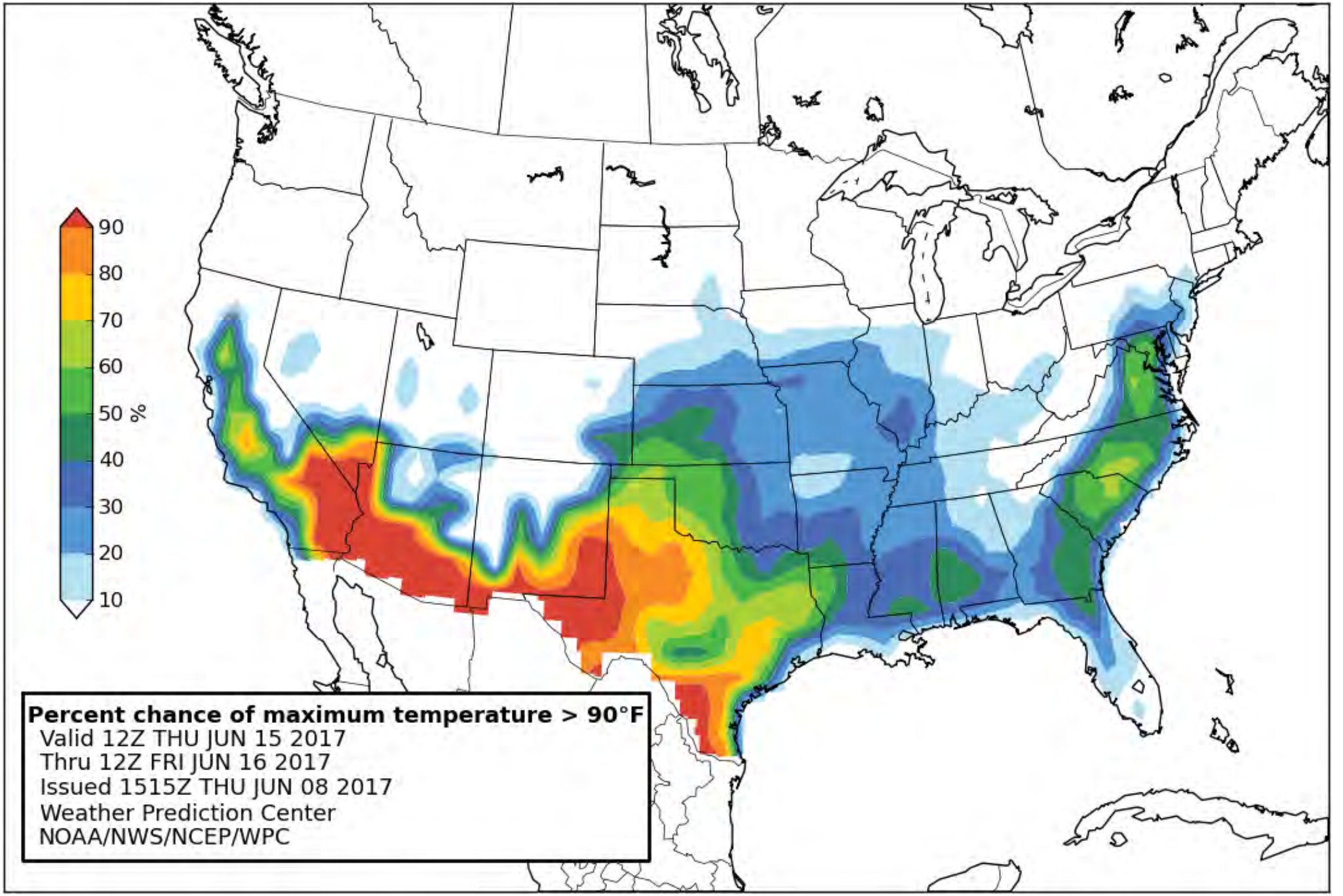
35. Do you have any additional comments about 8 to 10 day probabilistic Weather Prediction Center products?

_____

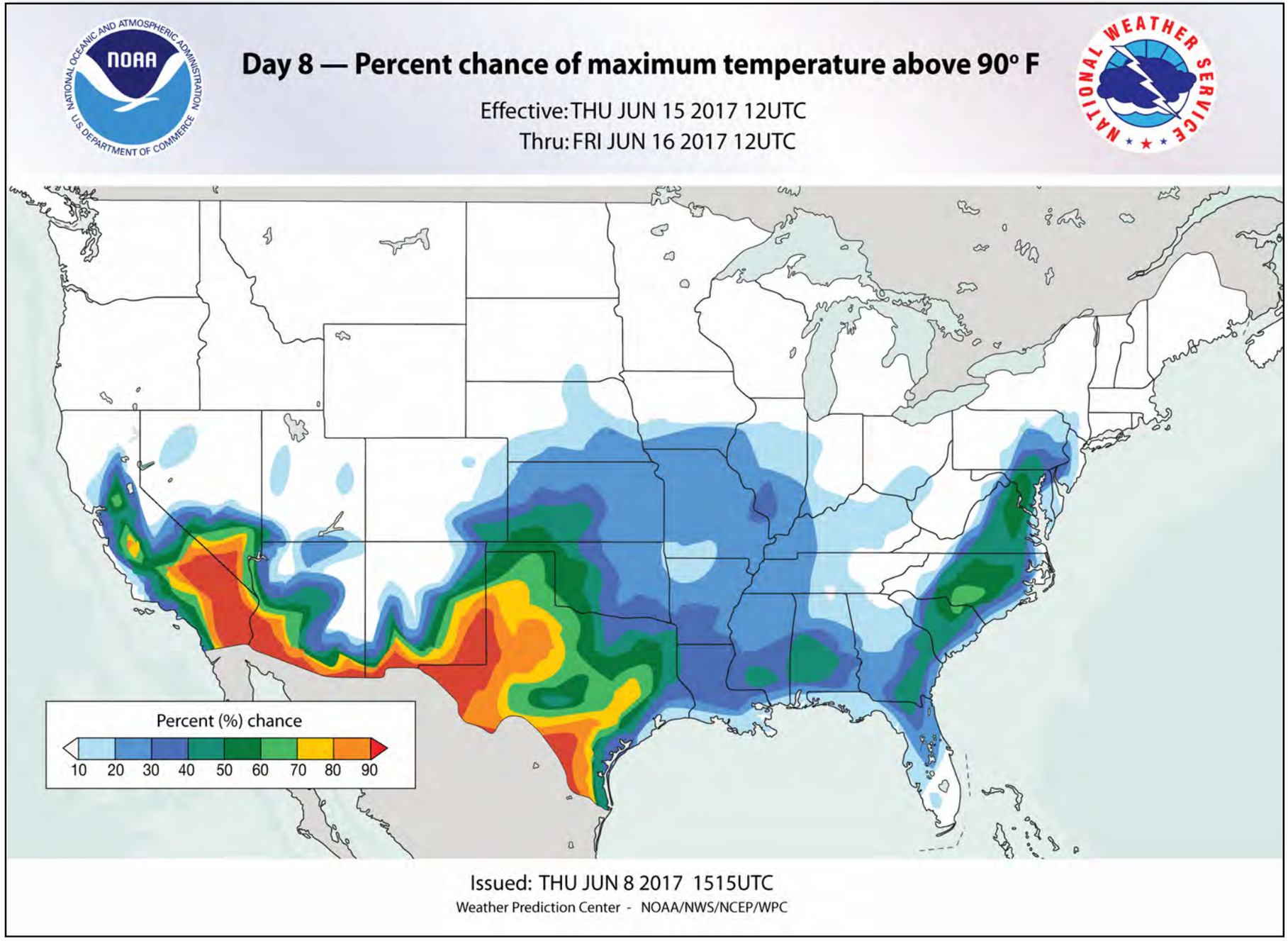
APPENDIX C

Illustrations and Summary of Product Revisions Completed Between Focus Groups Rounds 1 and 2

WPC 1 Original



WPC 1 Revised



WPC 1 Revisions:

- **Logos** of the source agencies were placed prominently and made consistent throughout all products

- **The title of the product** was moved to top center along with the valid dates. "Effective" replaced the word "valid;" valid was somewhat confusing to some participants. The title now begins with "Day 8", putting this critical info. first in the heirarchy of information. The symbol "<" was replaced by the word "above" to simplify readability. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.

- **On the map**: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary.

- **The legend** was reoriented to read horizontally to better indicate probability and not be confused with actual temperature. Colors were changed slightly (greens) for ADA compliance (color blindness). *See protanopia and deuteranopia type testing next page.*

- The **Footer** contains secondary information.

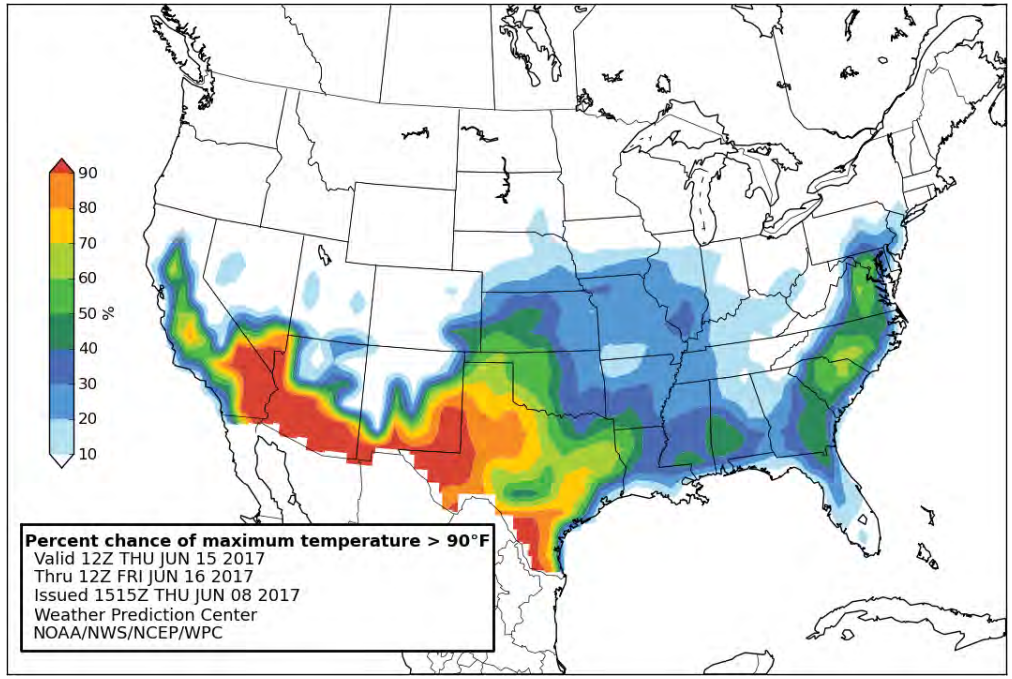
WPC 1 Questions:

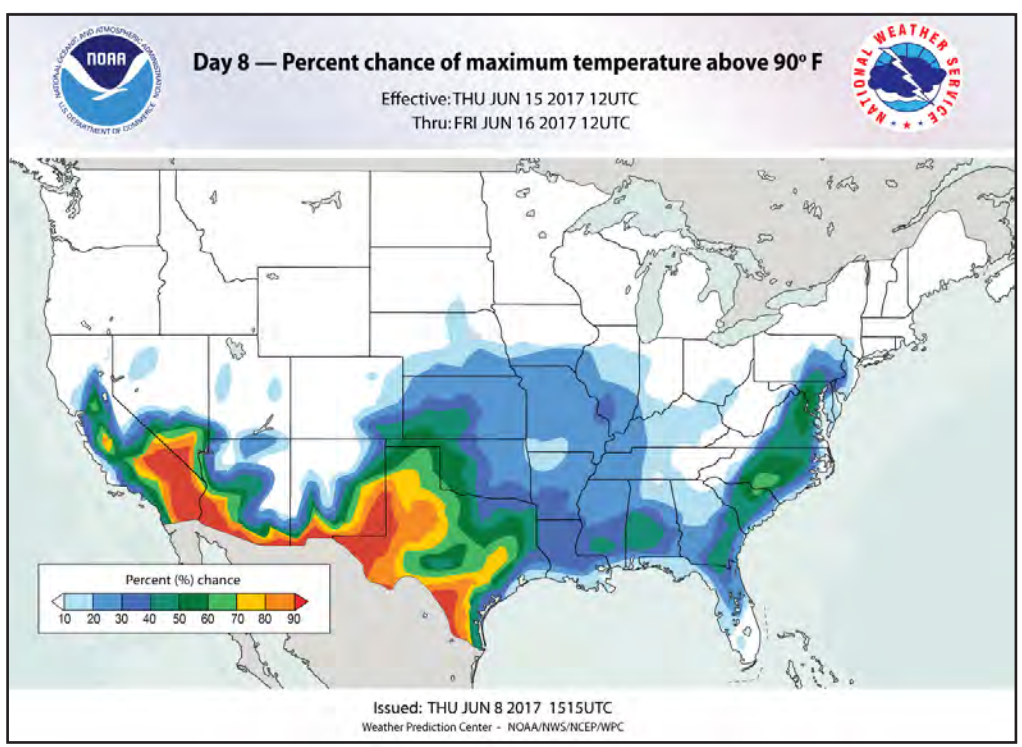
Should the WPC be represented on the top?

How much control do you have in altering colors for ADA compliance?

Do you need to be 508 compliant?

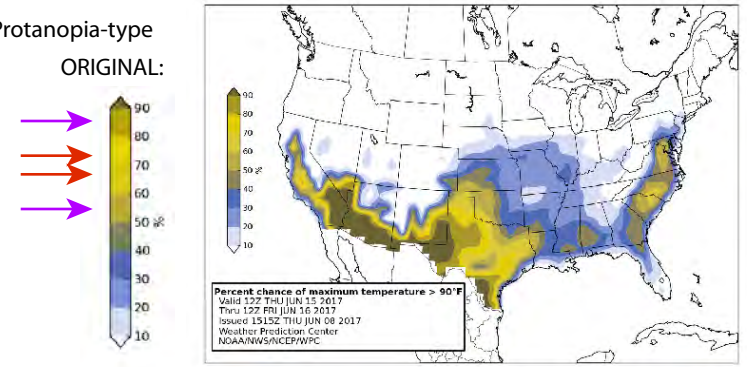
WPC 1



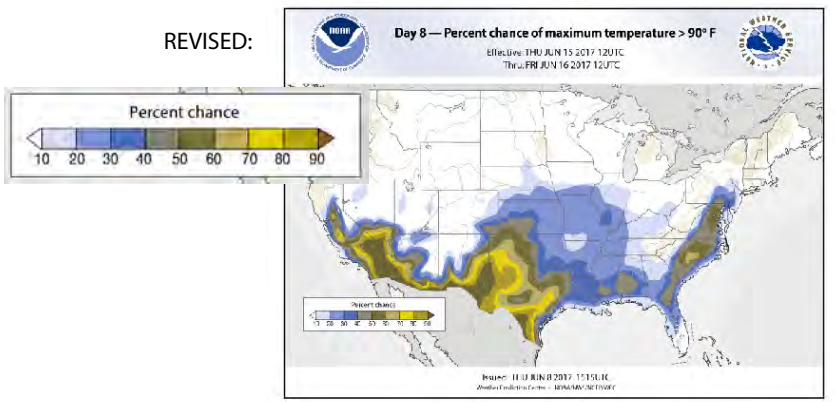


Protanopia-type

ORIGINAL:

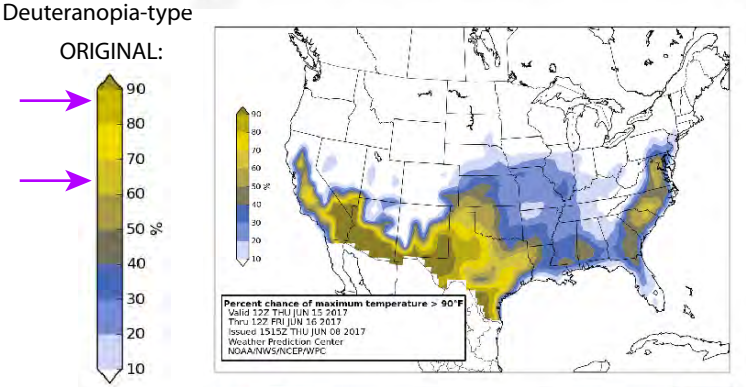


REVISED:

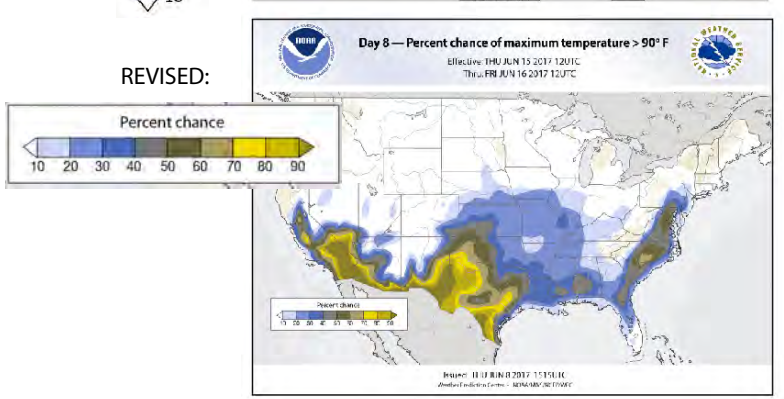


Deuteranopia-type

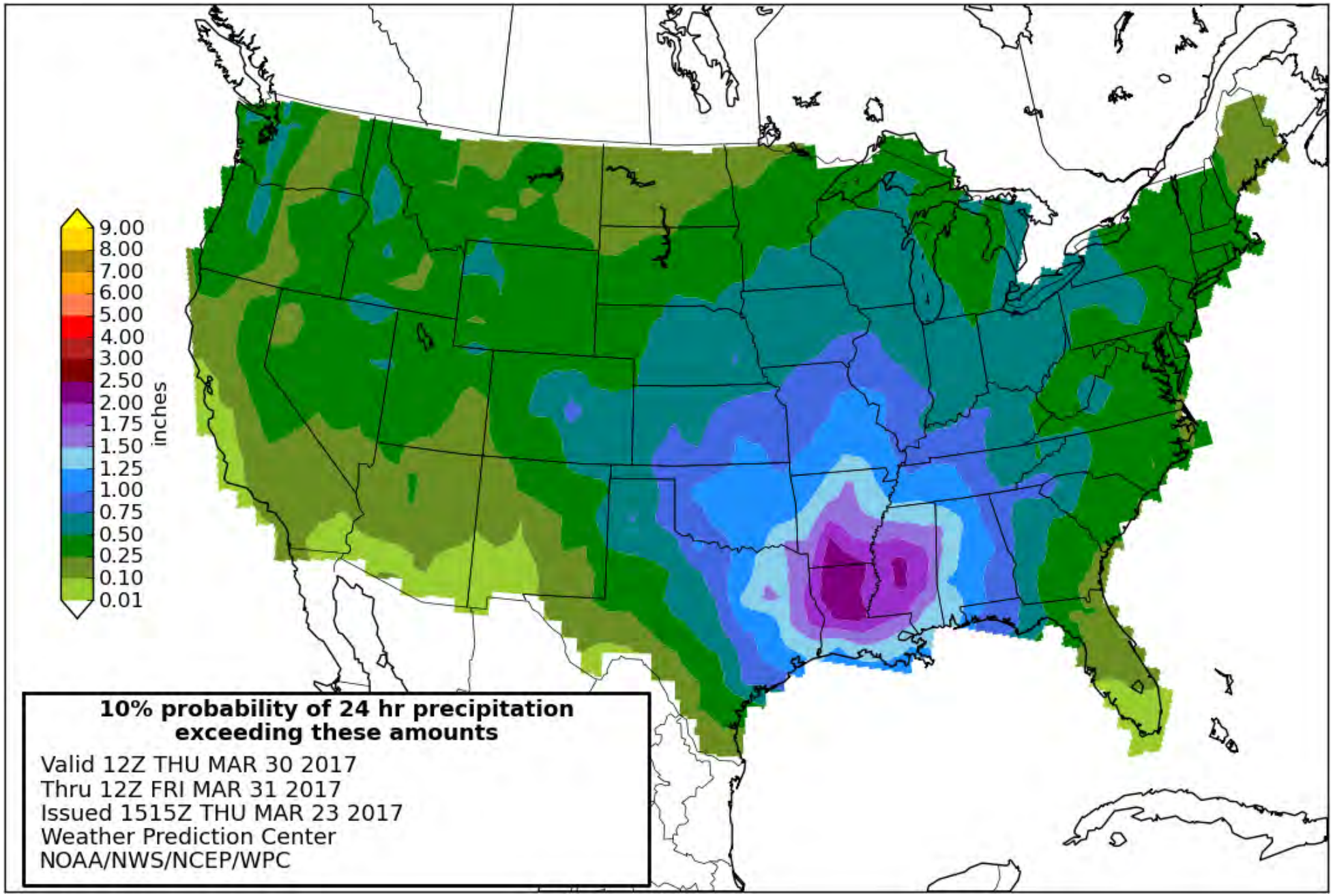
ORIGINAL:



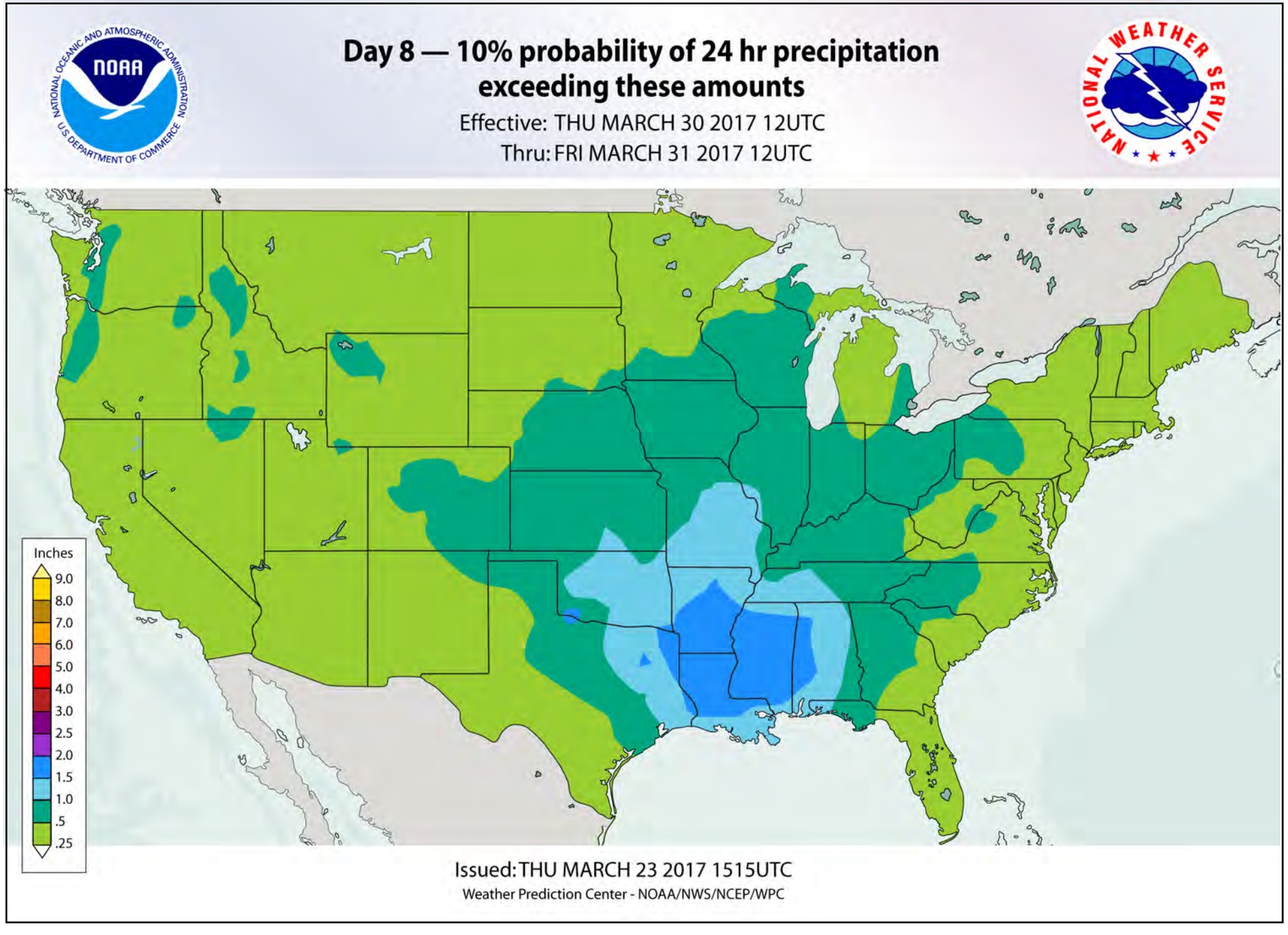
REVISED:



WPC 3 Original



WPC 3 Revised



WPC 3 Revisions:

- **Logos** of the source agencies were placed prominently and made consistent throughout all products

- **The title of the product** was moved to top center along with the valid dates. "Effective" replaced the word "valid;" valid was somewhat confusing to some participants. The title now begins with "Day 8", putting this critical info. first in the heirarchy of information. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.

- **On the map**: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary.

- **The legend** was kept in the vertical format to more intuitively represent depth. The increments on the scale were simplified, and as a result, the color range was also simplified. Less contrast was given to the colors representing under 2 inches so that they form less of a "bullseye" that might be confused with a significant rainfall event (*see original*). Colors were changed slightly (greens) for ADA compliance (color blindness). *See protanopia and deuteranopia type testing next page.*

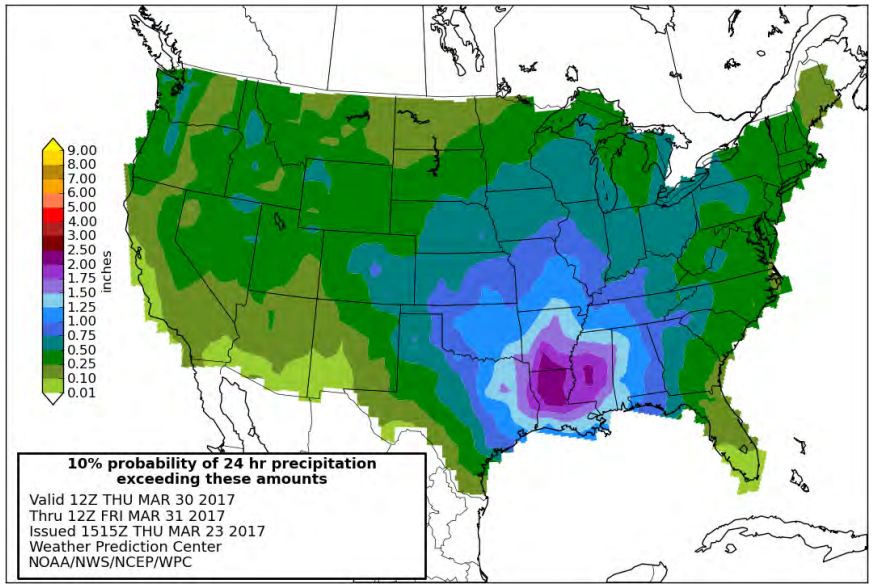
- The **Footer** contains secondary information.

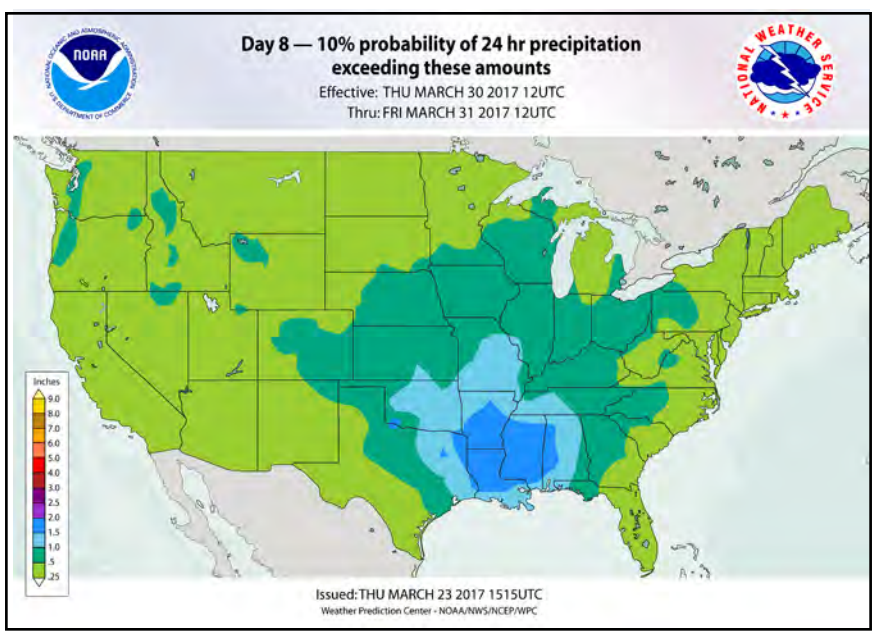
WPC 3 Questions:

Are there some instances where the smaller rainfall amounts we removed from the legend may be useful?

Should the color range be reordered as GBYORP to better reflect the order already associated with rain events?

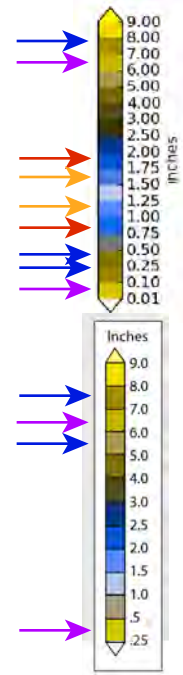
WPC 3

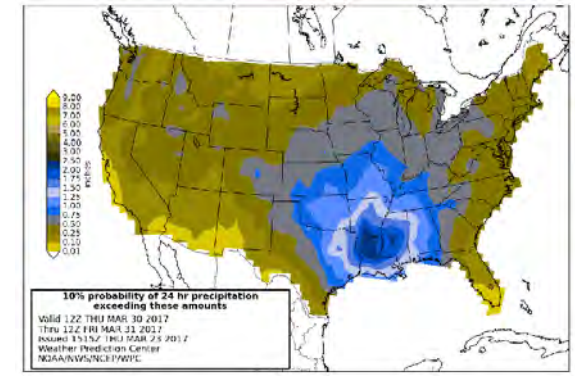




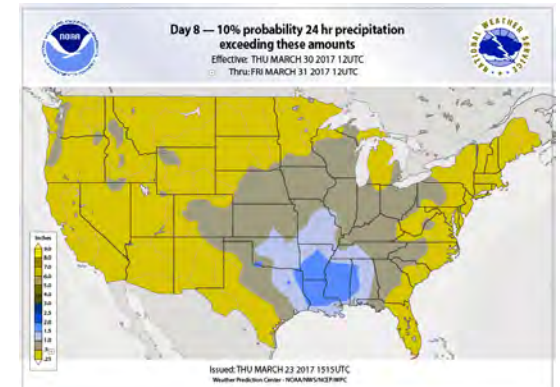
Protanopia-type

ORIGINAL:



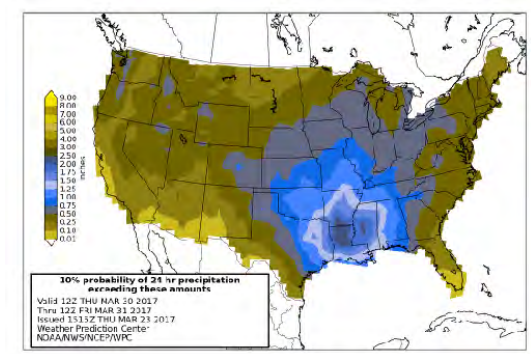


REVISED:

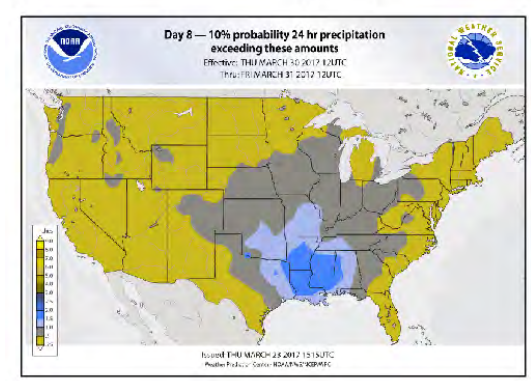


Deuteranopia-type

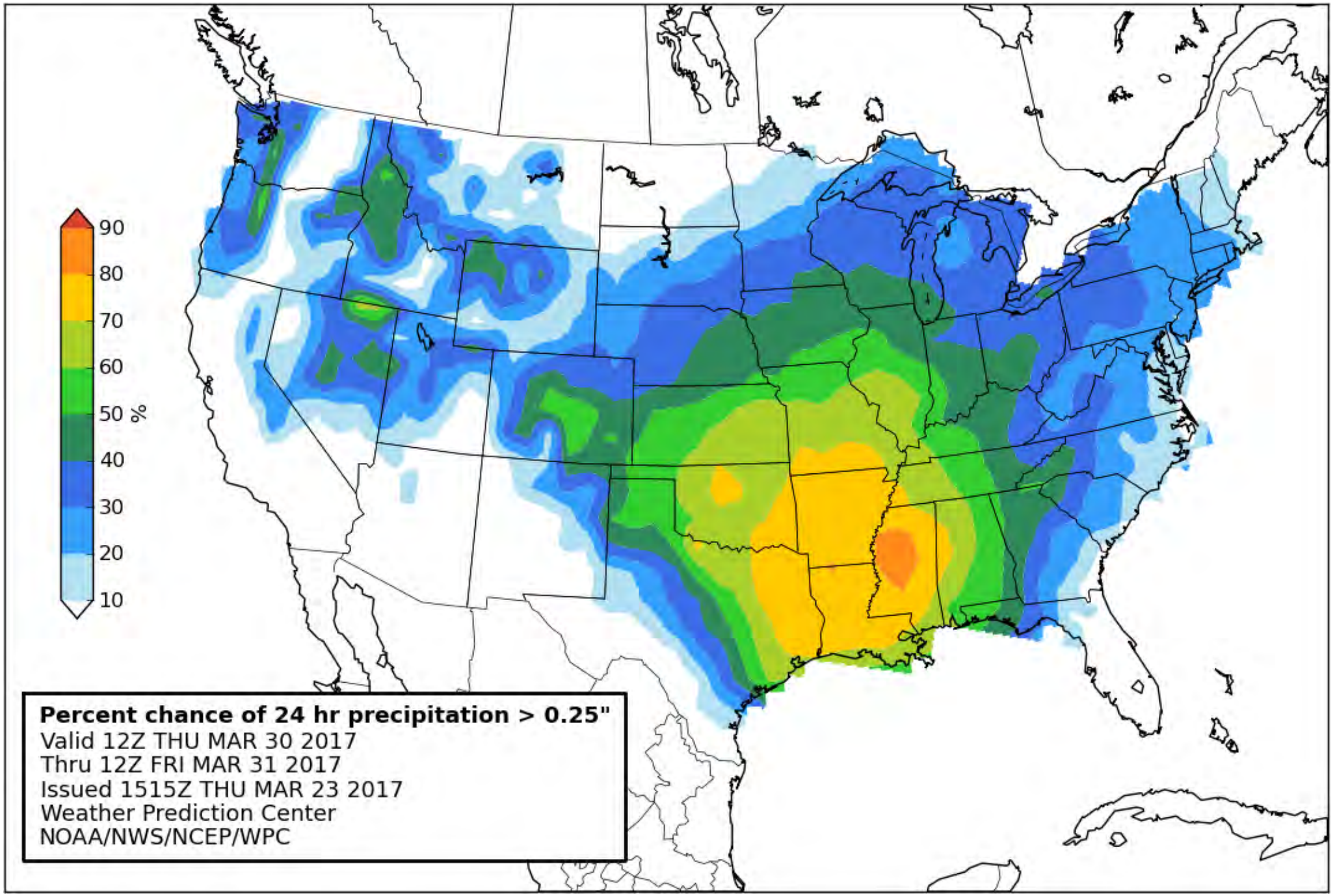
ORIGINAL:



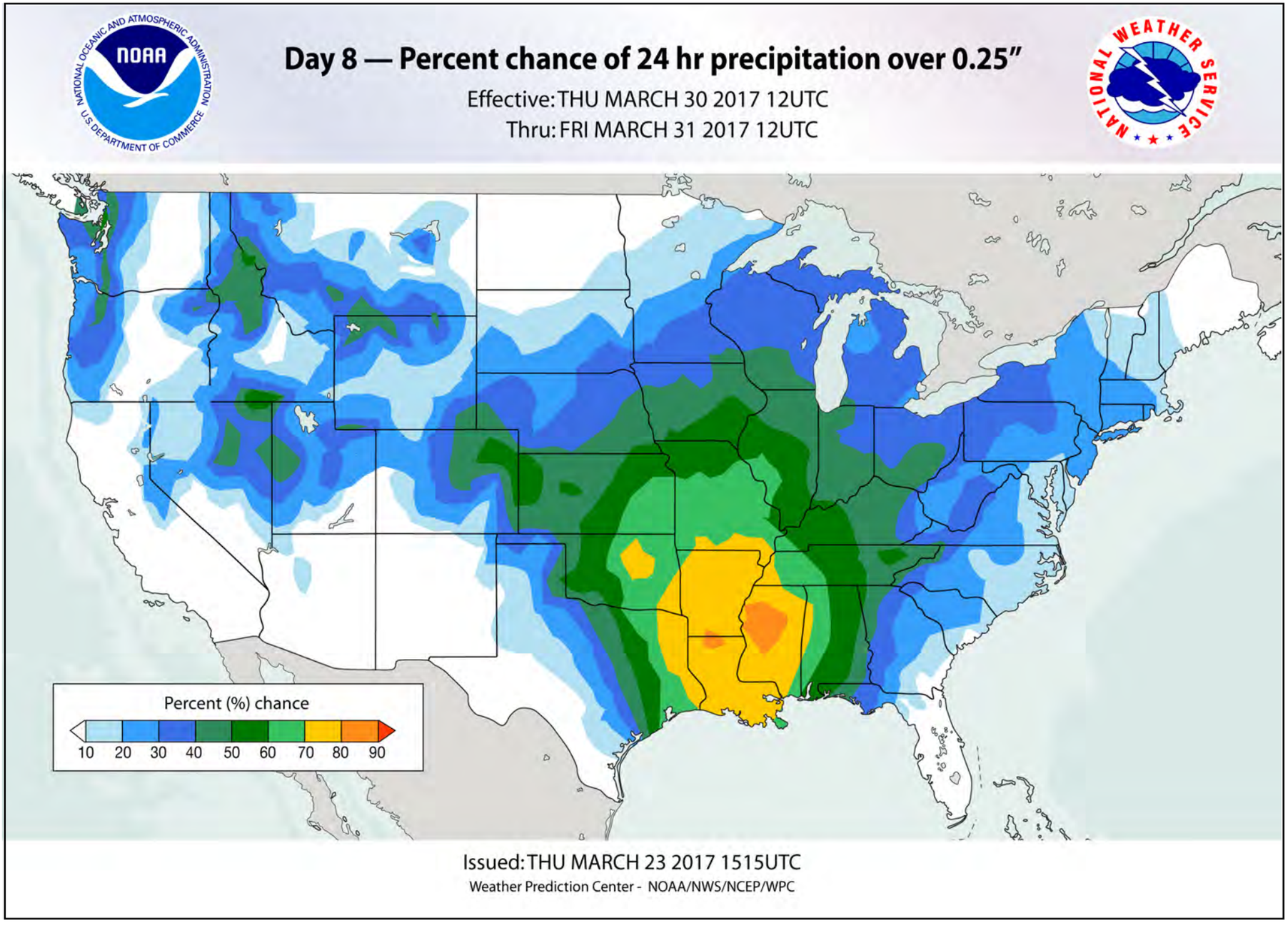
REVISED:



WPC 4 Original



WPC 4 Revised



WPC 4 Revisions:

- **Logos** of the source agencies were placed prominently and made consistent throughout all products

- **The title of the product** was moved to top center along with the valid dates. "Effective" replaced the word "valid;" valid was somewhat confusing to some participants. The title now begins with "Day 8", putting this critical info. first in the heirarchy of information. The symbol "<" was replaced by the word "over" to simplify readability. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.

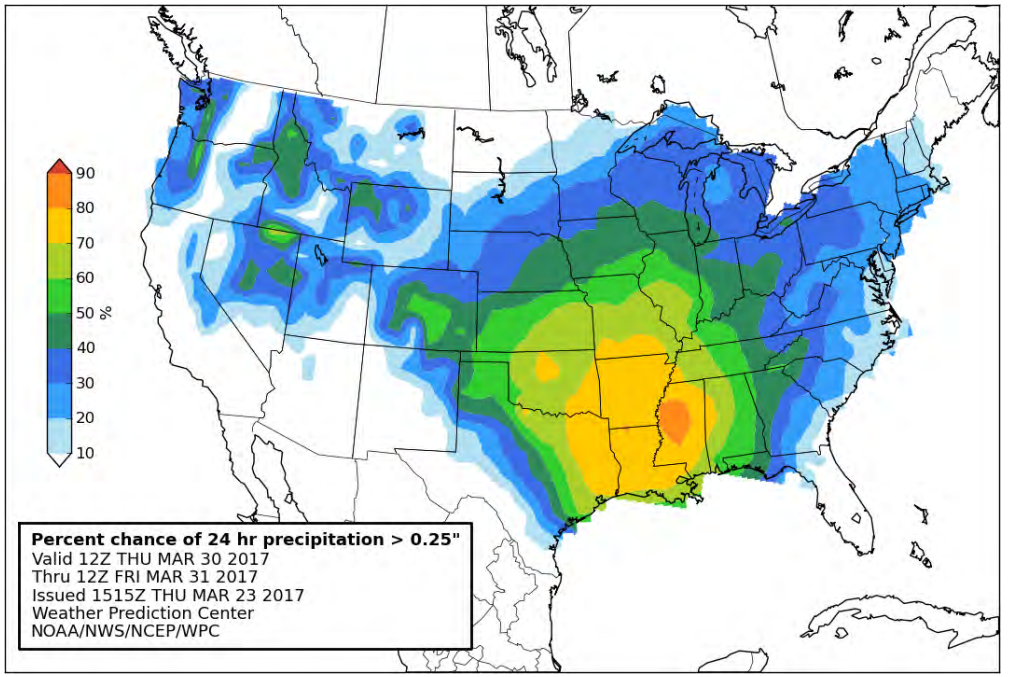
- **On the map**: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary.

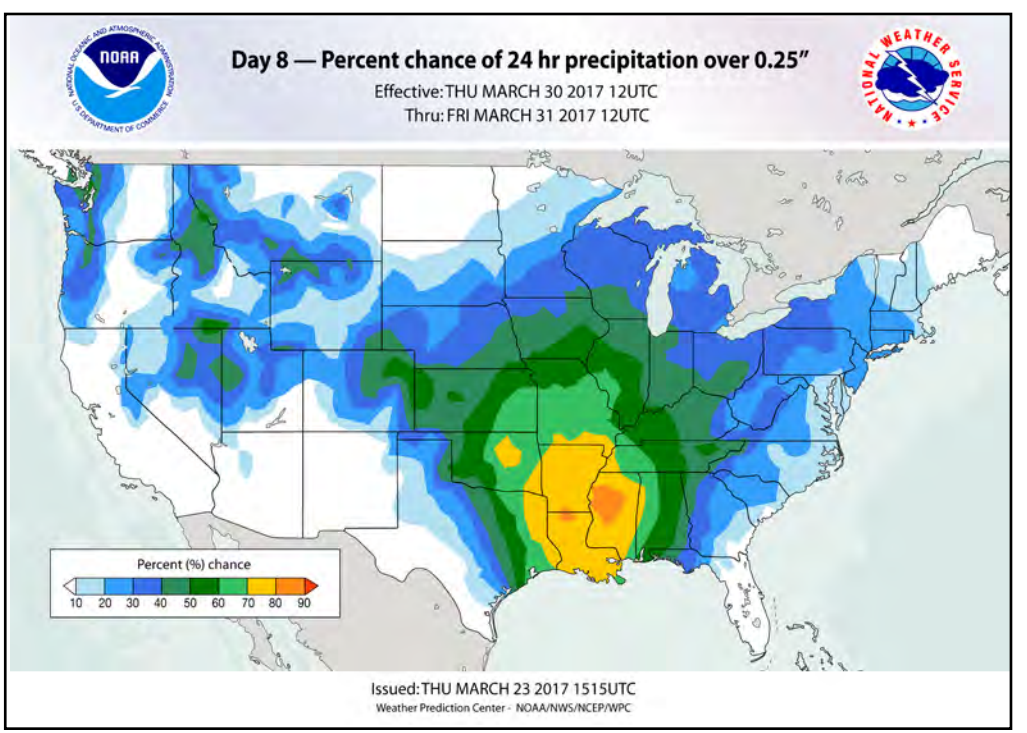
- **The legend** was reoriented to read horizontally to better indicate probability. Colors were changed slightly (greens) for ADA compliance (color blindness). *See protanopia and deuteranopia type testing next page.*

- The **Footer** contains secondary information.

WPC 4 Questions:

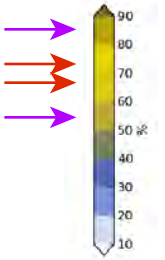
WPC 4

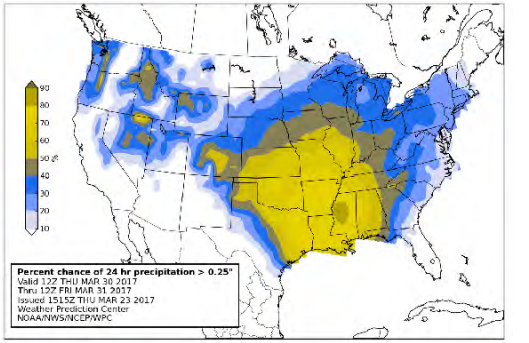




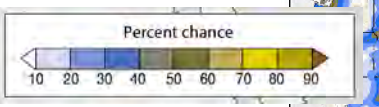
Protanopia-type

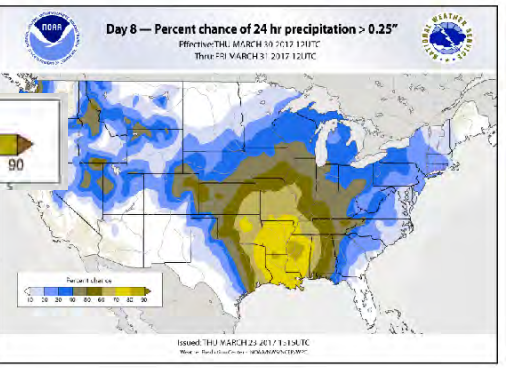
ORIGINAL:





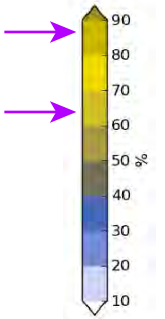
REVISED:

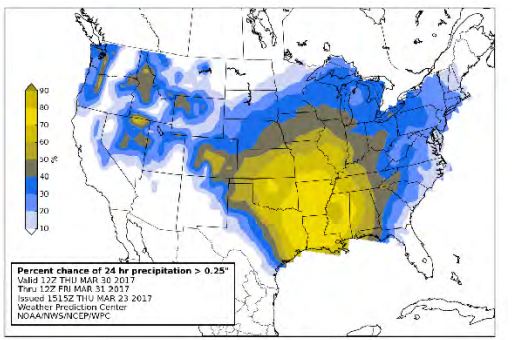




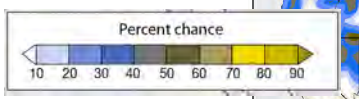
Deuteranopia-type

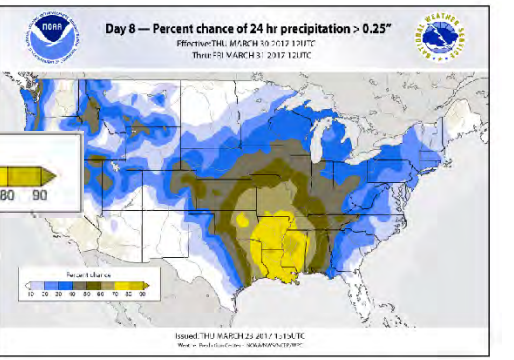
ORIGINAL:



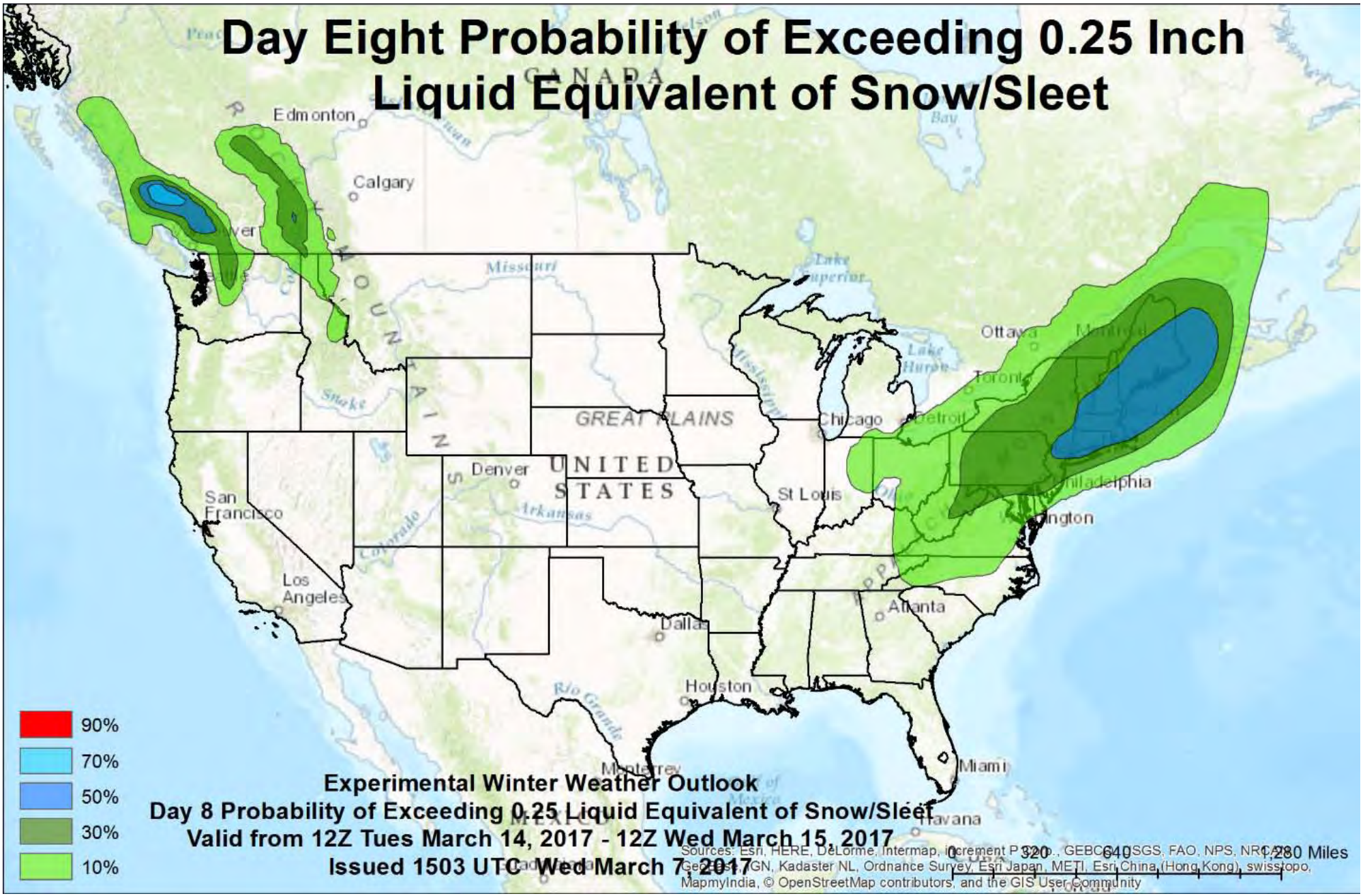


REVISED:

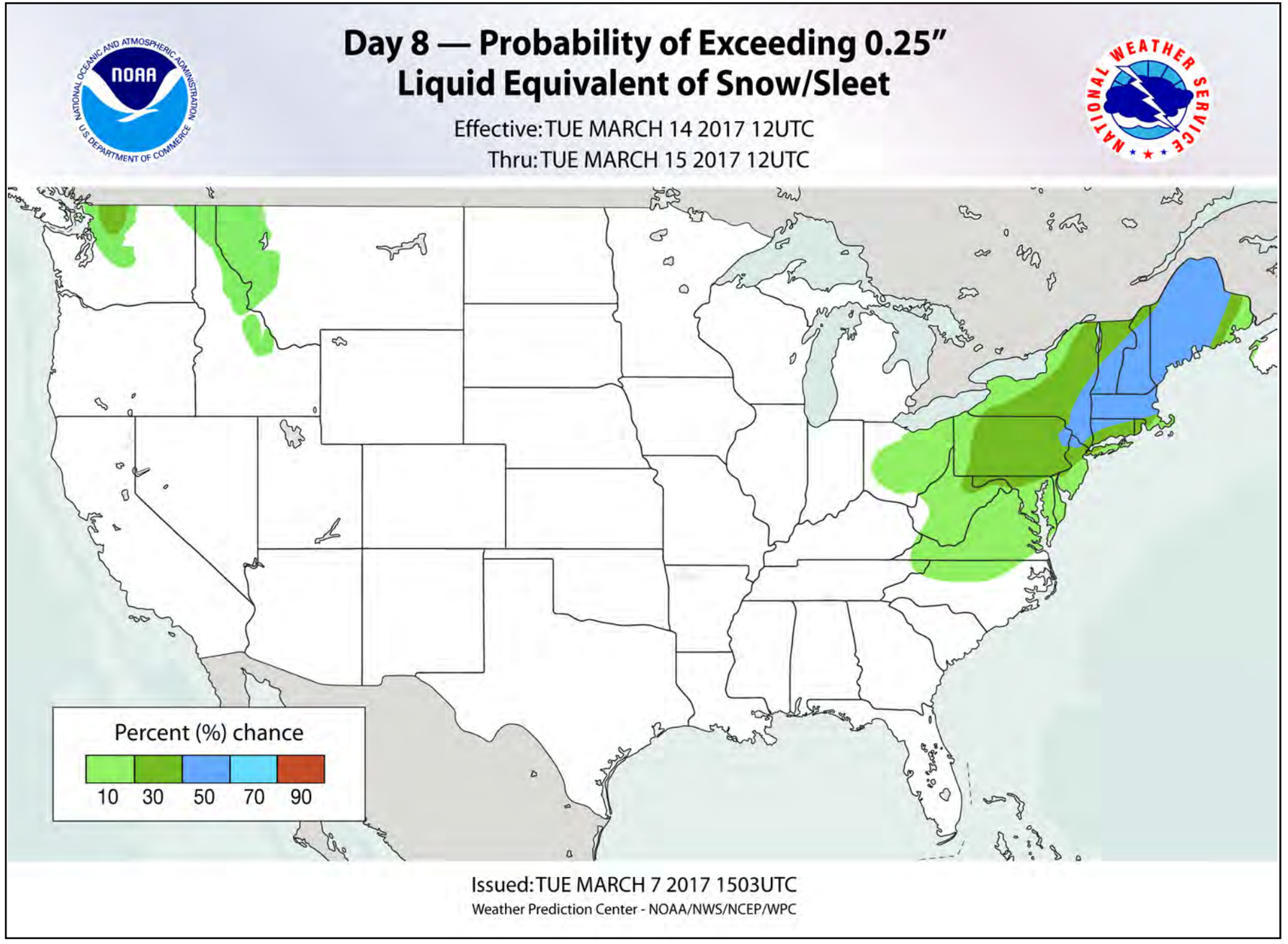




WPC 5 Original



WPC 5 Revised



WPC 5 Revisions:

- **Logos** of the source agencies were placed prominently and made consistent throughout all products

- **The title of the product** was moved to top center along with the valid dates. "Effective" replaced the word "valid;" valid was somewhat confusing to some participants. The title now begins with "Day 8", putting this critical info. first in the heirarchy of information. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.

- **On the map**: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary. Colors were changed to accurately match legend. In original, colors were overlapping so that the aggregate did not match the legend.

- **The legend** was reoriented to read horizontally to better indicate probability.

- The **Footer** contains secondary information.

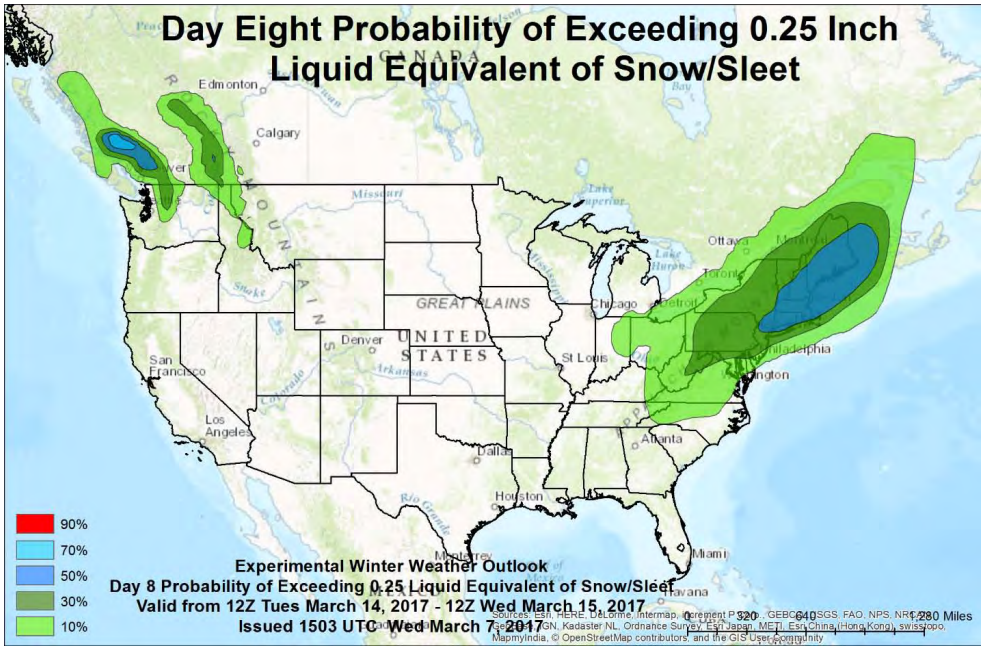
WPC 5 Questions:

Were colors here intended to represent a range (i.e., 10-30)?

A clarification should be made in the title and legend that indicates this does not include freezing rain. Is that correct?

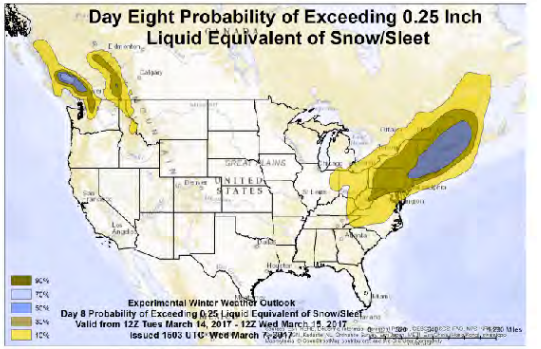
There was high interest in freezing rain. Should there be a separate product?

WPC 5

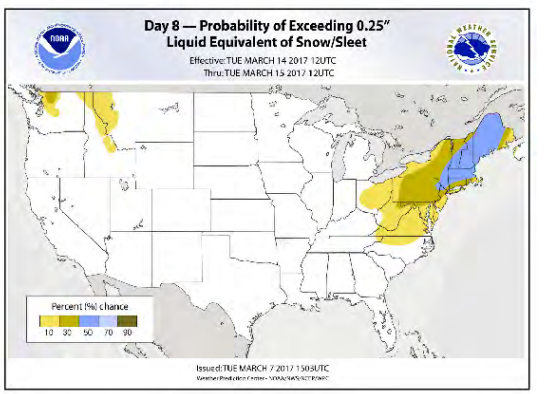


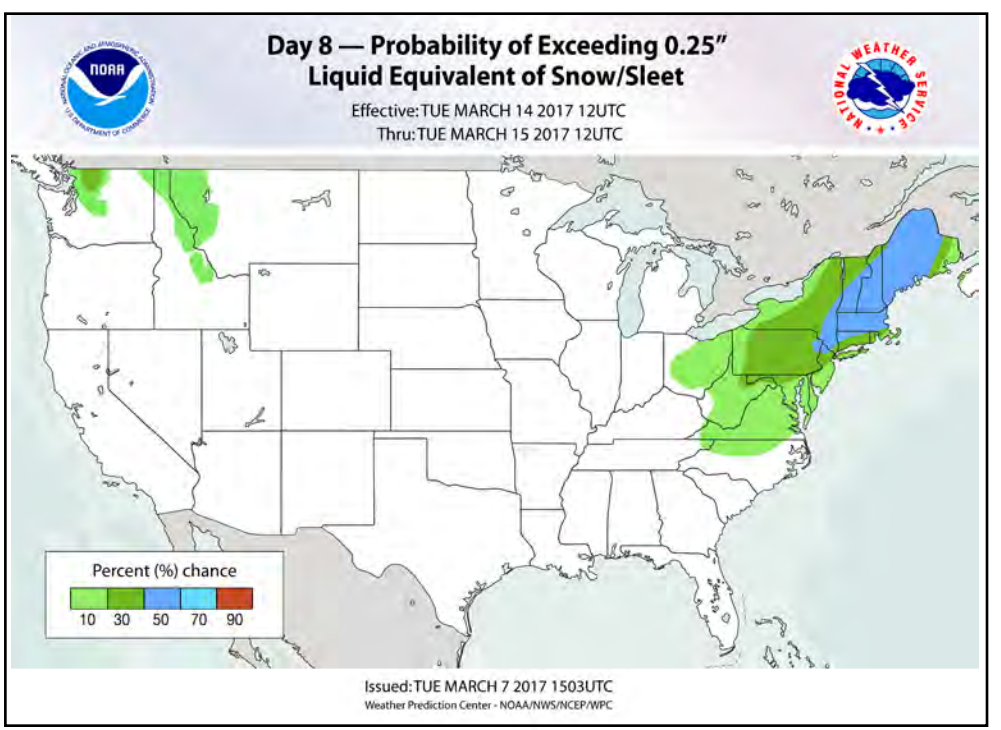
Protanopia-type

ORIGINAL:



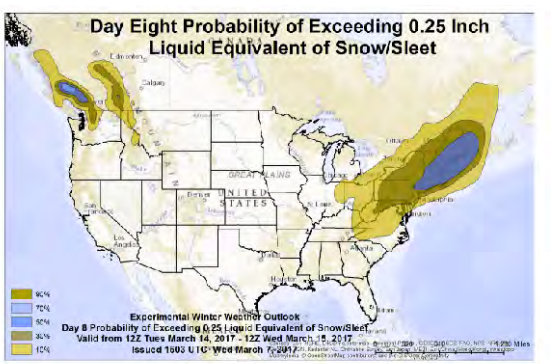
REVISED:



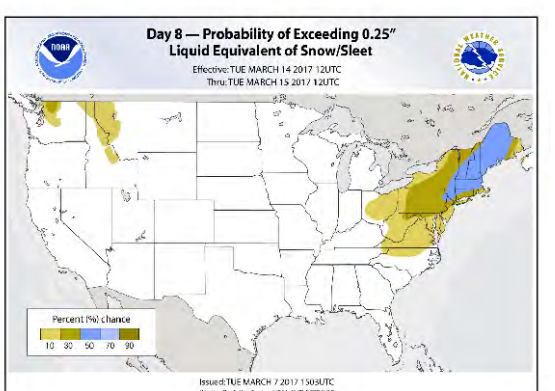


Deuteranopia-type

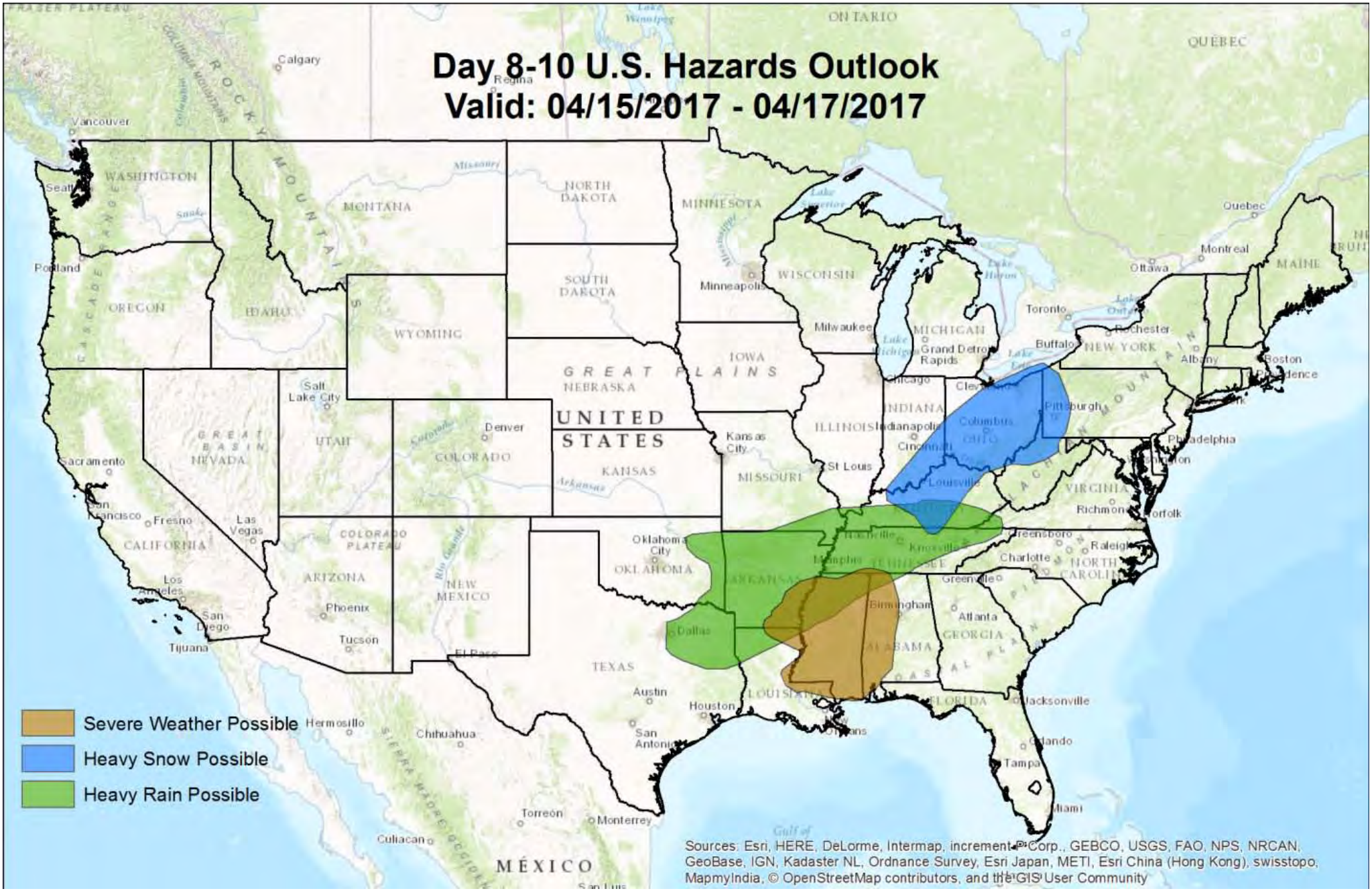
ORIGINAL:



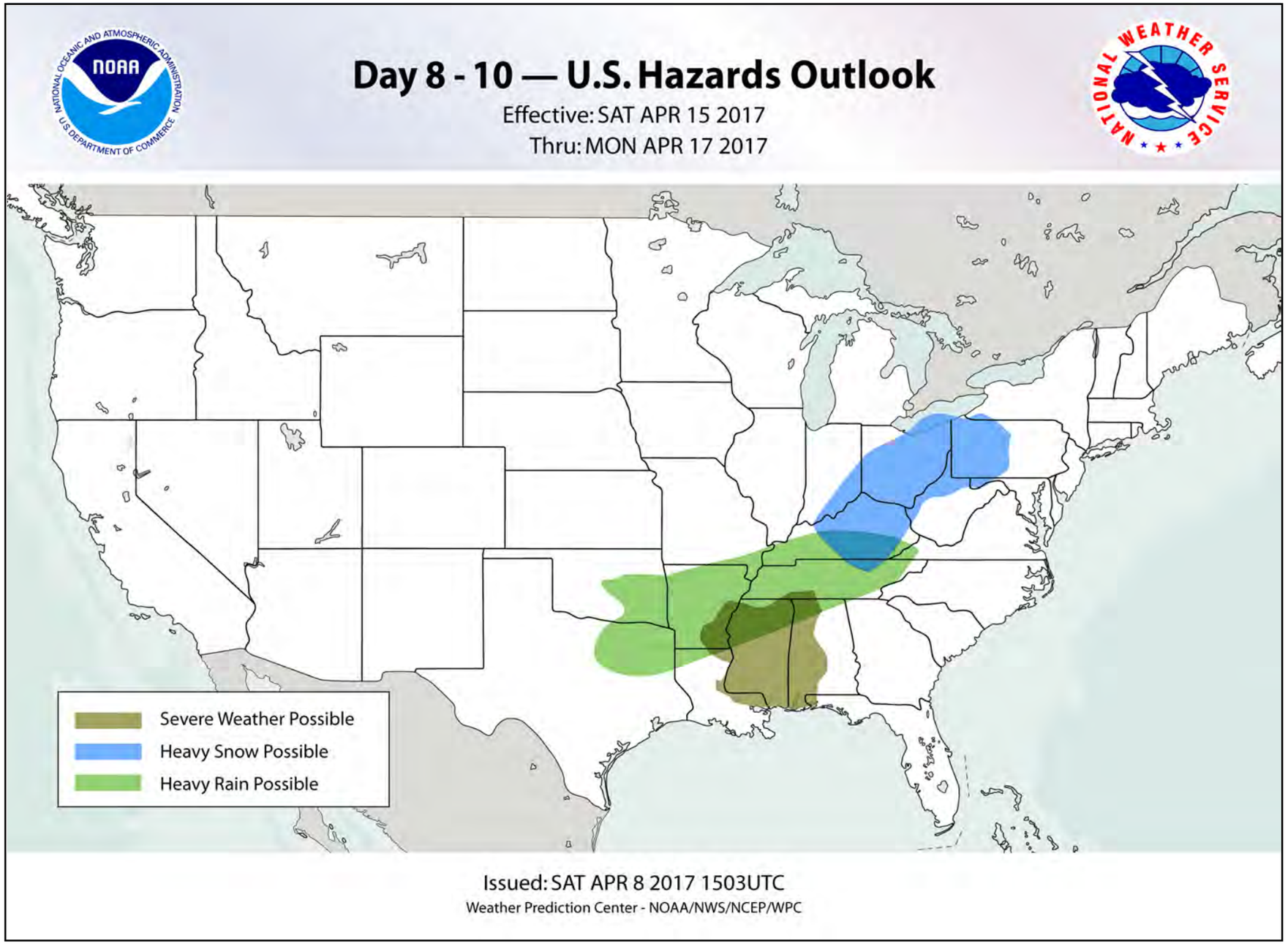
REVISED:



WPC 6 Original



WPC 6 Revised



WPC 6 Revisions:

- **Logos** of the source agencies were placed prominently and made consistent throughout all products

- **The title of the product** was moved to top center along with the valid dates. "Effective" replaced the word "valid;" valid was somewhat confusing to some participants. The title now begins with "Day 8", putting this critical info. first in the heirarchy of information. The more familiar "UTC" was consistently used to indicate time instead of "Z". The date was placed before the time.

- **On the map**: Canada and Mexico have been grayed out and the bodies of water have been colored in a gray blue to recede and become secondary.

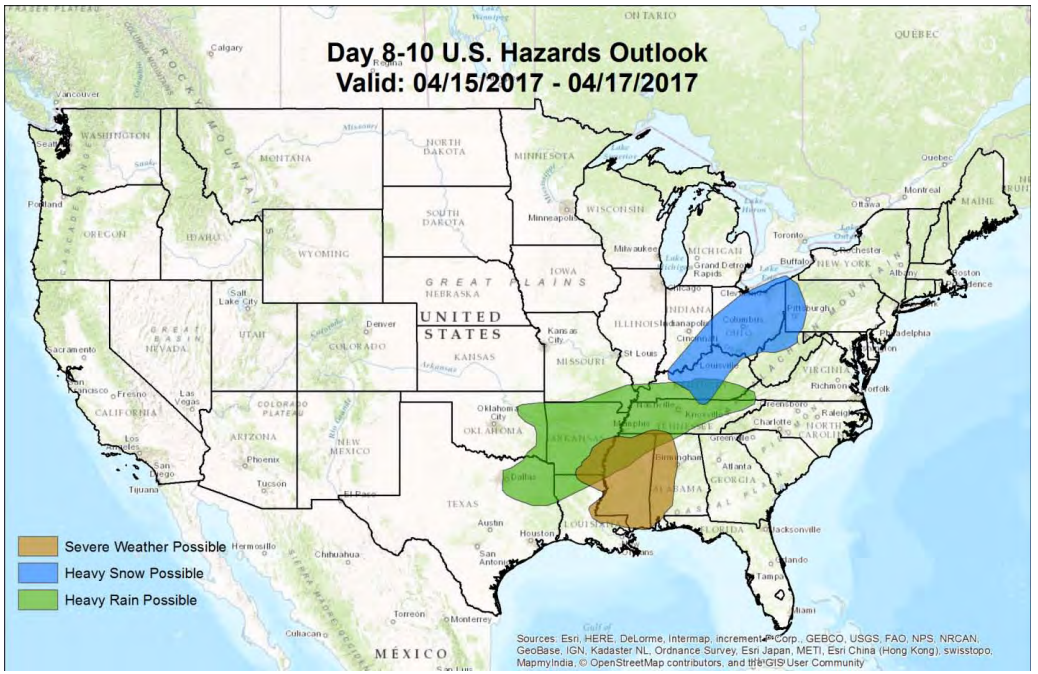
- **The legend** was placed in a box to be consistent with other graphics and to separate it from map. The brown color was adjusted for ADA compliance (color blindness). *See protanopia and deuteranopia type testing next page.*

- The **Footer** contains secondary information.

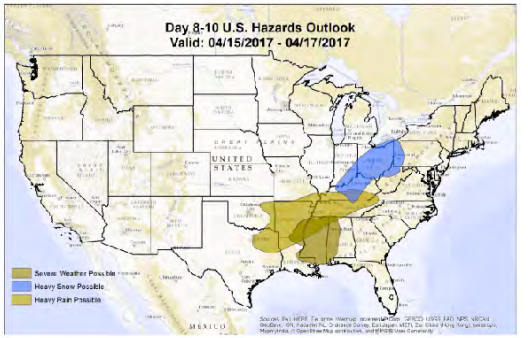
WPC 6 Questions:

What does possible mean? How do you quantify the threshold?

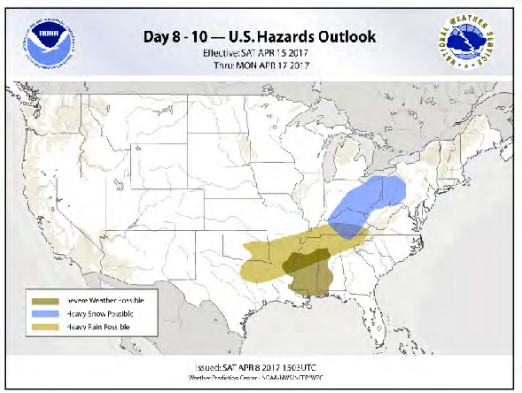
WPC 6

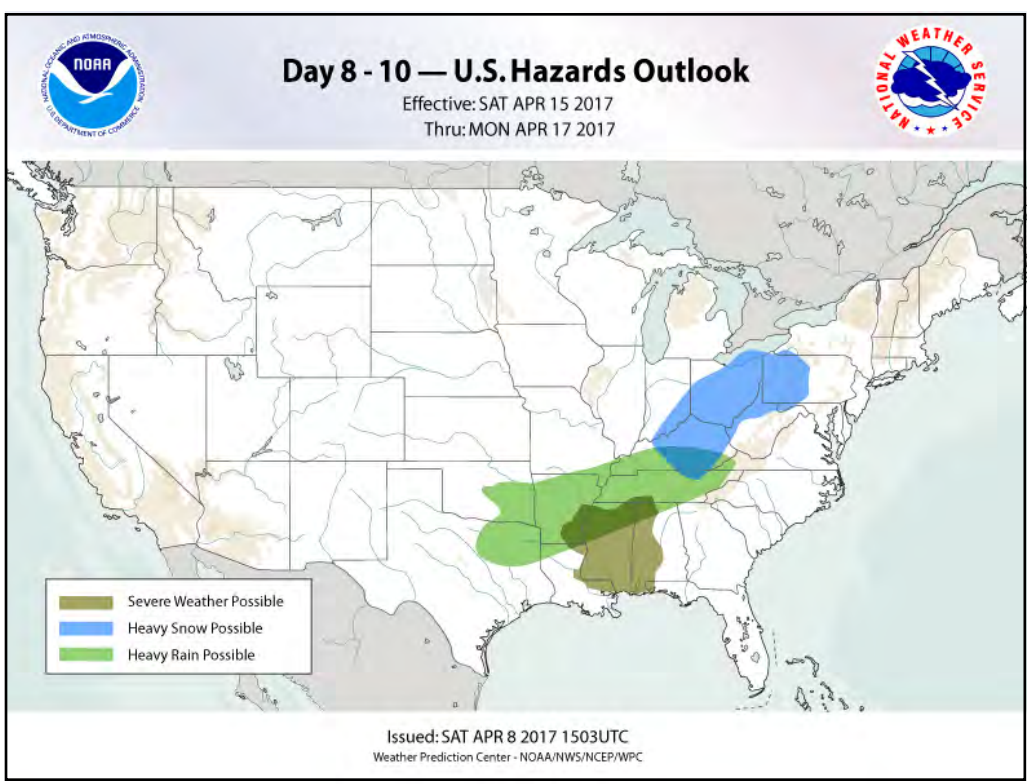


ORIGINAL:



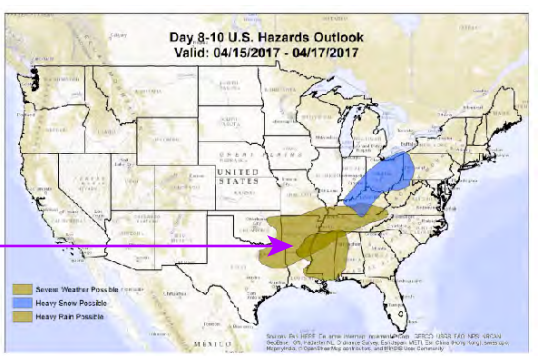
REVISED:



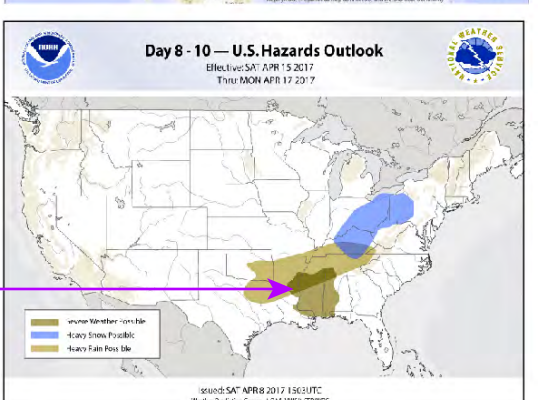


Deuteranopia-type

ORIGINAL:



REVISED:



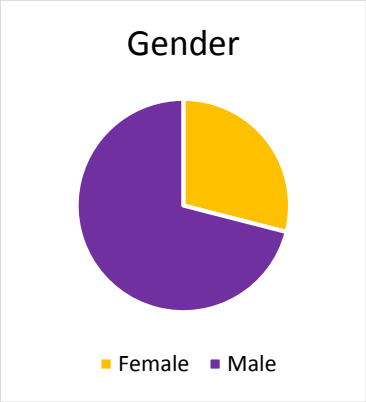
APPENDIX D

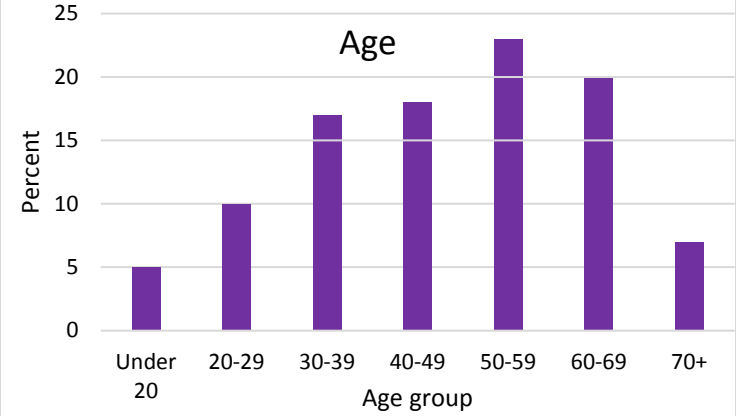
Survey Responses: Identifying Key Partners/Users of Weather Prediction Center Products and Mapping Related User Decision-Making for the Day 8 to 10 Time Frame

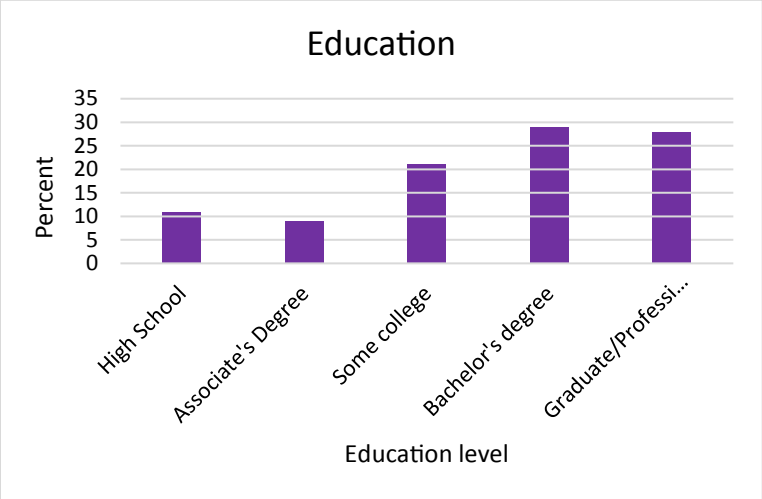
Survey completed November 2017

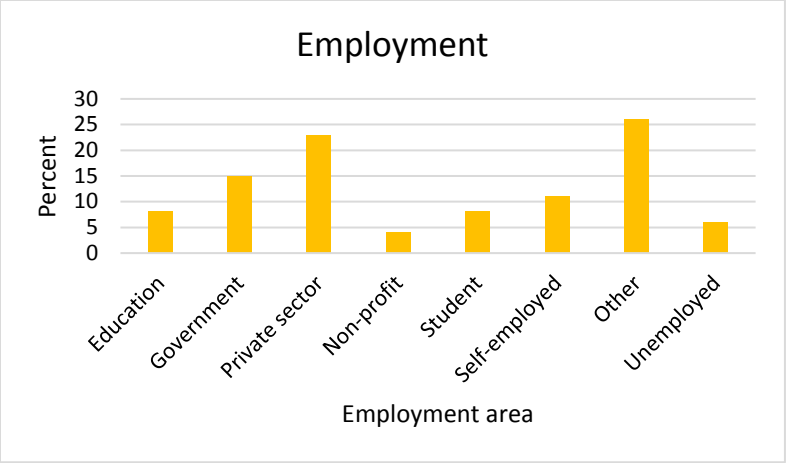
Participants = 905

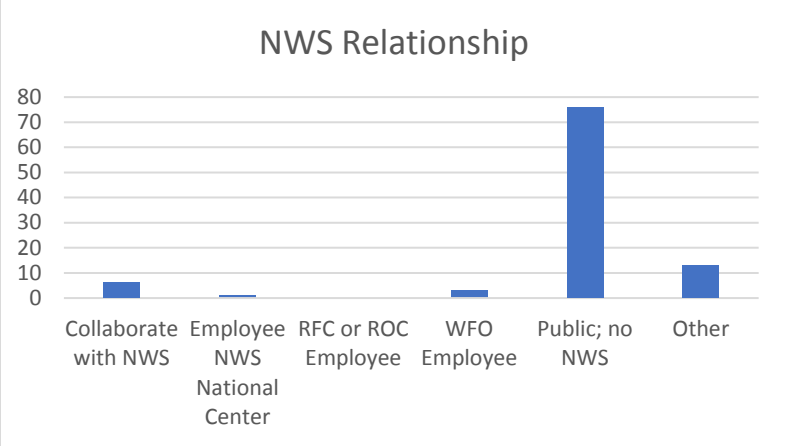
Characteristics of respondents

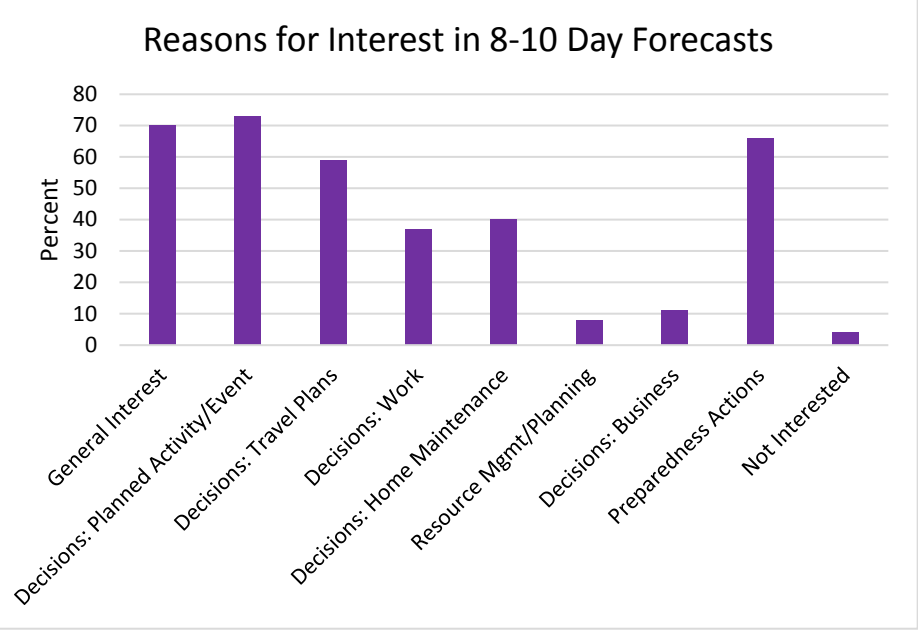


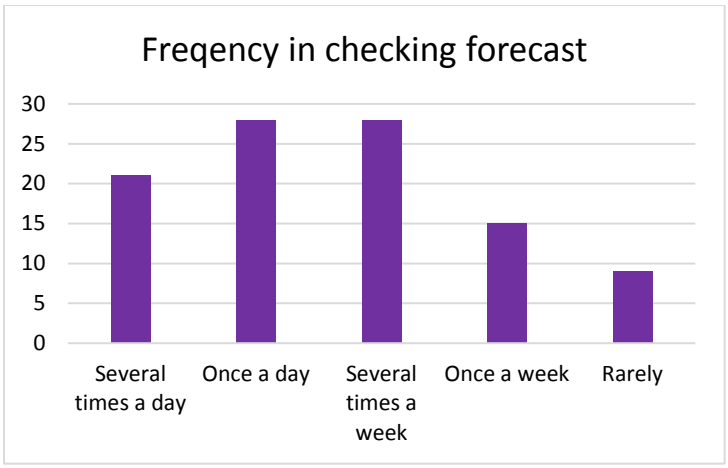




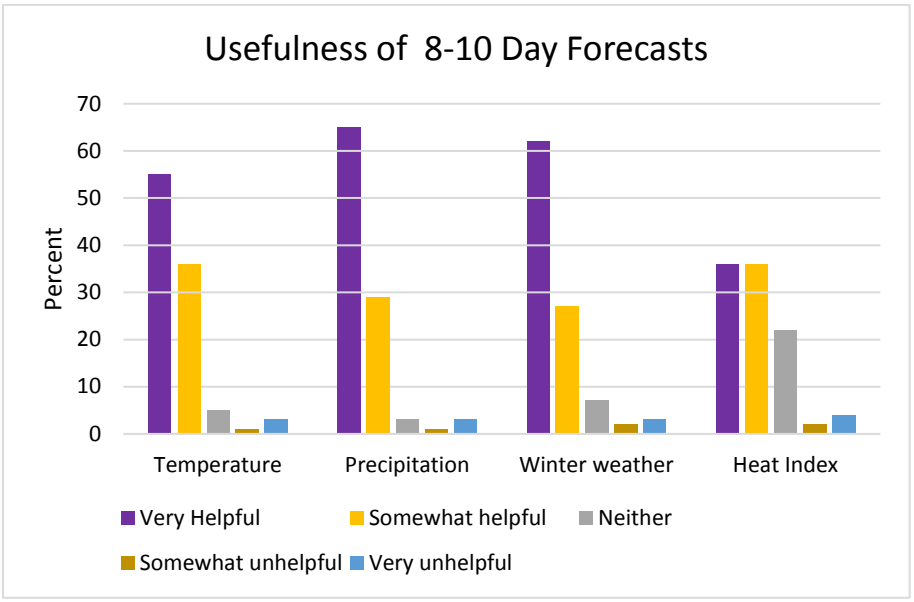

Employment
Percent
30
25
20
15
10
5
0
Education
Government
Private sector
Non-profit
Student
Self-employed
Other
Unemployed
Employment area

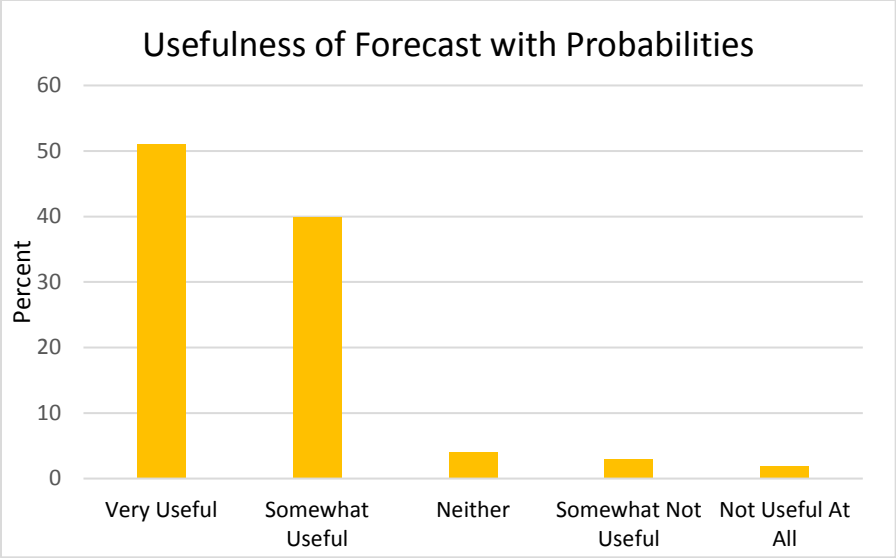

NWS Relationship
80
70
60
50
40
30
20
10
0
Collaborate with NWS
Employee NWS National Center
RFC or ROC Employee
WFO Employee
Public; no NWS
Other

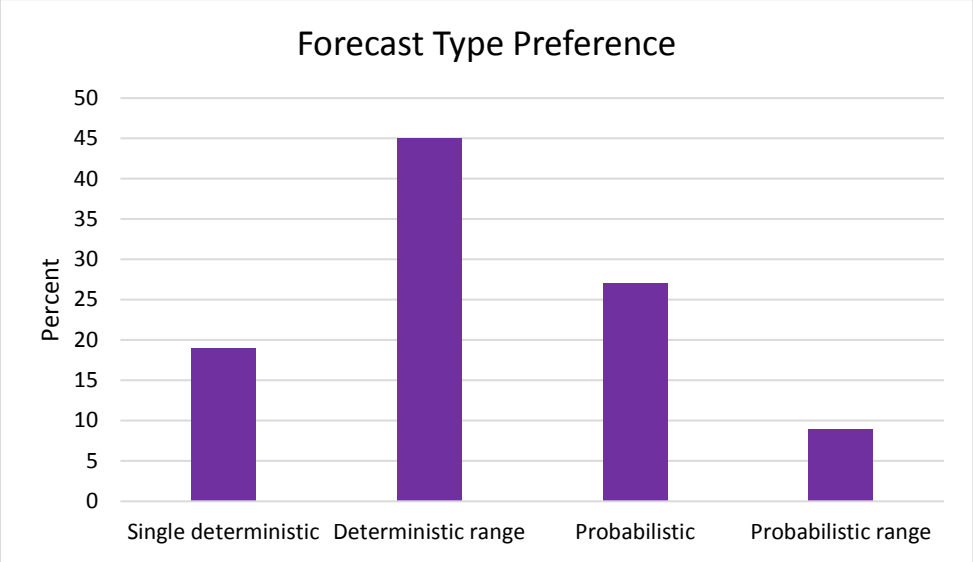

Reasons for Interest in 8-10 Day Forecasts
Percent
80
70
60
50
40
30
20
10
0
General Interest
Decisions: Planned Activity/Event
Decisions: Travel Plans
Decisions: Work
Decisions: Home Maintenance
Resource Mgmt/Planning
Decisions: Business
Preparedness Actions
Not Interested



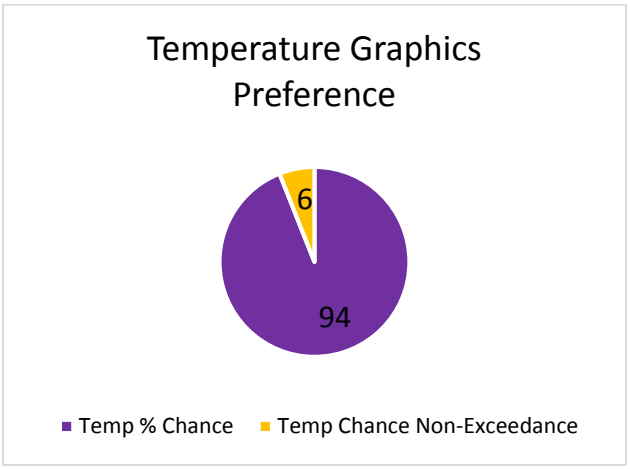
Overall views of usefulness

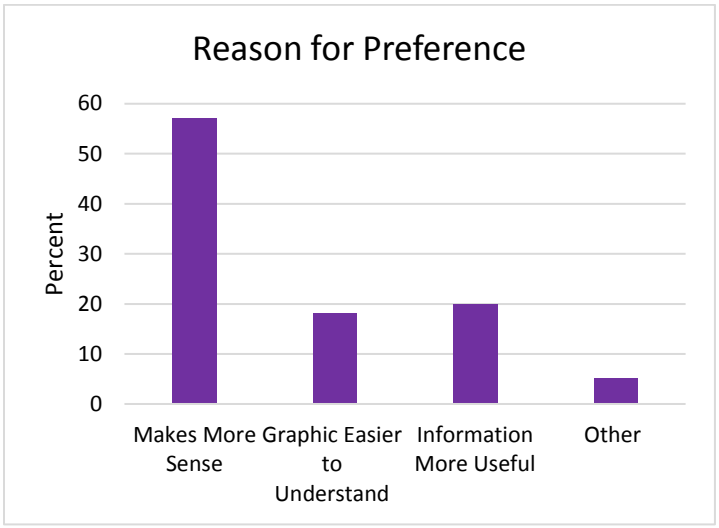



Usefulness of Forecast with Probabilities
Percent
60
50
40
30
20
10
0
Very Useful
Somewhat Useful
Neither
Somewhat Not Useful
Not Useful At All

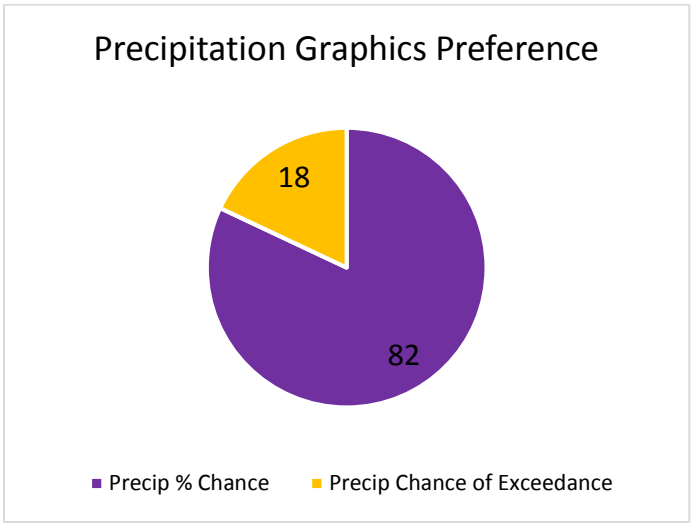

Forecast Type Preference
Percent
50
45
40
35
30
25
20
15
10
5
0
Single deterministic
Deterministic range
Probabilistic
Probabilistic range

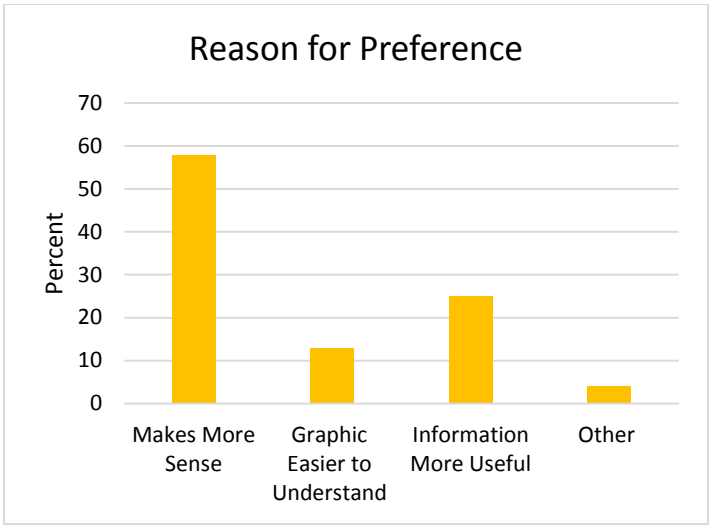
Temperature graphics



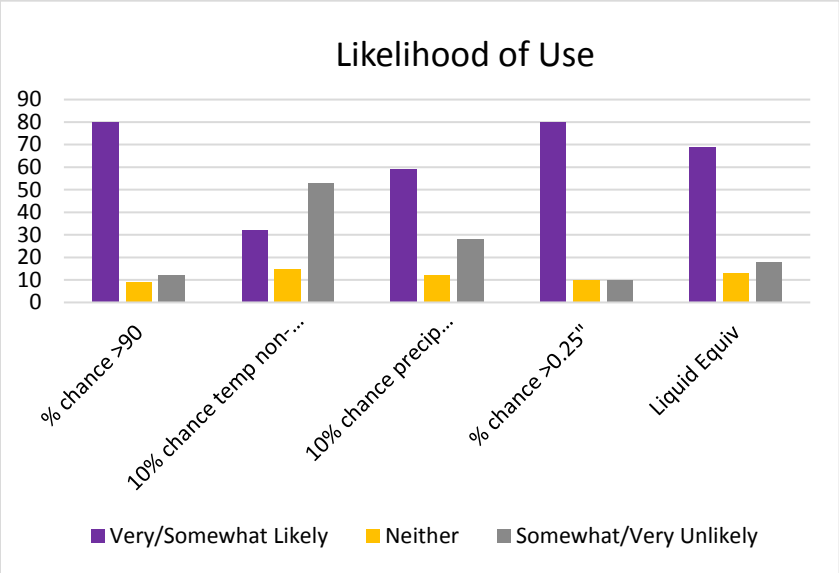


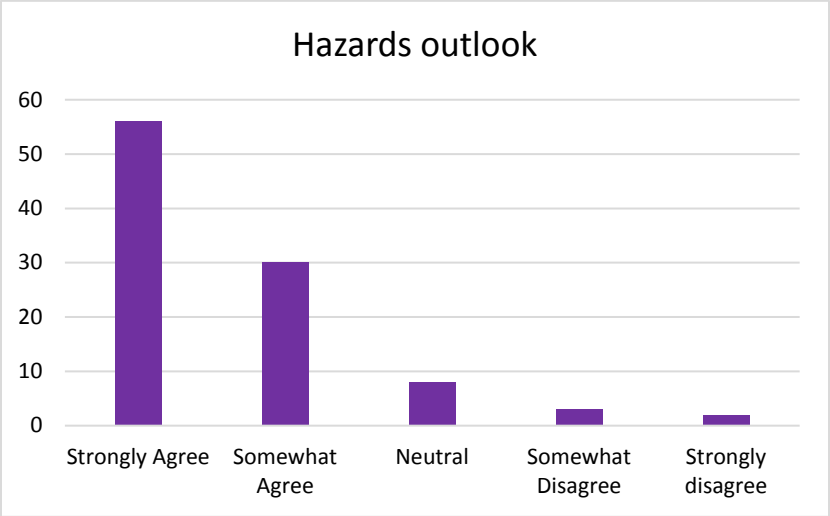
Precipitation Graphics



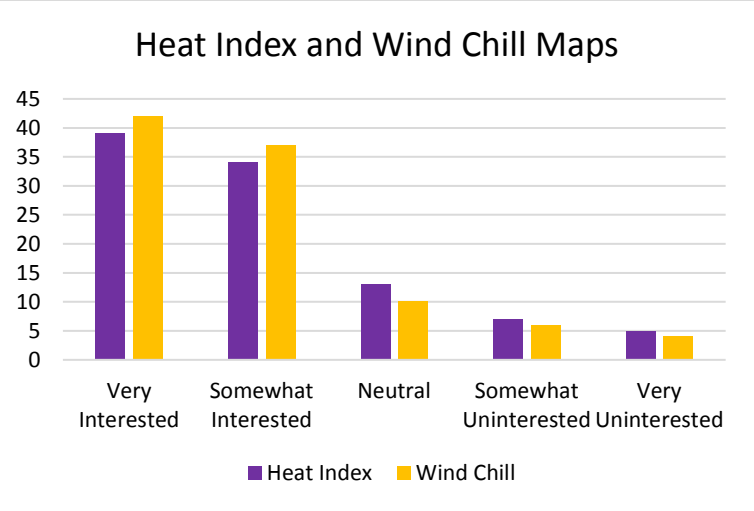

Reason for Preference
Percent
70
60
50
40
30
20
10
0
Makes More Sense
Graphic Easier to Understand
Information More Useful
Other

Overall





(Answering: Does this product help you make informed decisions?)



(Answering: How interested would you be in using a similar probability product in the 8-10 day range for heat index and wind chill maps)?

By group (Less than 100% reflects some non-responses)

Preference (%)

	Temp Percent Chance	Temp Chance Non-Exceedance	Precip Chance of Exceedance	Precip Percent chance
Gender:				
Female (n=262)	92	8	16	84
Male (n-640)	94	6	18	82
Employment:				
Education (n=71)	93	7	18	82
Government (n=133)	96	4	18	82
Non-profit (n=35)	89	11	11	89
Private (n=205)	95	5	13	87
Self-Employed (n=102)	93	8	19	81
Student (n=76)	93	7	18	82
Unemployed (n=50)	94	6	16	84
Other (n=233)	93	7	22	79
Age:				
Under 30 (n=142)	92	8	18	82
30-39 (n=149)	95	5	18	82
40-49 (n=159)	93	7	20	80
50-59 (n=210)	93	7	15	85
Over 60 (n=245)	94	6	18	82
Education:				
HS or less (n=97)	92	8	24	76
Some college/BS (n=534)	93	7	17	83
Graduate degree (n=253)	96	4	15	85
Relationship:				
NWS Employee (n=37)	100	0	11	89
Collaborate with NWS (n=54)	93	7	22	78
Public (n=689)	94	6	17	83
Other (n=121)	93	7	19	81

Liquid Equivalent: Likelihood of Use (%)

	Very/Somewhat Likely	Neutral	Somewhat/Very Unlikely
Gender:			
Female (n=262)	63	13	24
Male (n-640)	72	12	16
Employment:			
Education (n=71)	73	4	23
Government (n=133)	72	9	19
Non-profit (n=35)	63	11	23
Private (n=205)	65	16	19
Self-Employed (n=102)	66	18	17
Student (n=76)	82	12	7
Unemployed (n=50)	70	12	18
Other (n=233)	69	13	19
Age:			
Under 30 (n=142)	73	13	14
30-39 (n=149)	69	13	18
40-49 (n=159)	72	11	17
50-59 (n=210)	70	12	19
Over 60 (n=245)	66	14	20
Education:			
HS or less (n=97)	69	17	14
Some college/BS (n=534)	66	14	20
Graduate degree (n=253)	76	10	14
Relationship:			
NWS Employee (n=37)	78	5	16
Collaborate with NWS (n=54)	74	7	19
Public (n=689)	68	14	19
Other (n=121)	75	11	14

Hazards Outlook Usefulness (%)

	Strongly/Somewhat Agree	Neutral	Strongly/Somewhat Disagree
Gender:			
Female (n=262)	86	13	4
Male (n-640)	85	8	5
Employment:			
Education (n=71)	82	9	6
Government (n=133)	82	8	8
Non-profit (n=35)	91	3	3
Private (n=205)	89	5	5
Self-Employed (n=102)	82	13	3
Student (n=76)	91	4	4
Unemployed (n=50)	92	4	0
Other (n=233)	83	10	4
Age:			
Under 30 (n=142)	89	5	6
30-39 (n=149)	82	8	7
40-49 (n=159)	89	7	4
50-59 (n=210)	86	9	3
Over 60 (n=245)	83	9	5
Education:			
HS or less (n=97)	83	12	3
Some college/BS (n=534)	86	7	4
Graduate degree (n=253)	85	6	7
Relationship:			
NWS Employee (n=37)	76	11	14
Collaborate with NWS (n=54)	89	6	2
Public (n=689)	87	7	5
Other (n=121)	81	12	4

Interest in Wind Chill Graphic (%)

	Very/Somewhat Interested	Neutral	Somewhat/Very Uninterested
Gender:			
Female (n=255)	84	9	7
Male (n=629)	78	11	11
Employment:			
Education (n=68)	90	3	7
Government (n=131)	72	15	14
Non-profit (n=35)	63	11	23
Private (n=204)	74	14	12
Self-Employed (n=100)	84	10	6
Student (n=75)	84	12	4
Unemployed (n=48)	94	2	4
Other (n=227)	82	8	10
Age:			
Under 30 (n=142)	78	11	11
30-39 (n=145)	73	14	13
40-49 (n=159)	82	9	9
50-59 (n=206)	83	6	11
Over 60 (n=235)	81	12	7
Education:			
HS or less (n=95)	84	10	6
Some college/BS (n=522)	78	12	10
Graduate degree (n=249)	81	8	11
Relationship:			
NWS Employee (n=37)	76	8	16
Collaborate with NWS (n=52)	75	10	15
Public (n=676)	80	11	9
Other (n=118)	81	9	10

Interest in Heat Index (%)

	Very/Somewhat Interested	Neutral	Somewhat/Very Uninterested
Gender:			
Female (n=255)	78	12	8
Male (n=628)	71	14	14
Employment:			
Education (n=68)	73	13	10
Government (n=131)	70	12	16
Non-profit (n=35)	74	11	11
Private (n=204)	70	15	15
Self-Employed (n=100)	75	12	12
Student (n=75)	76	10	9
Unemployed (n=48)	80	8	8
Other (n=227)	74	13	10
Age:			
Under 30 (n=142)	73	14	13
30-39 (n=145)	69	10	18
40-49 (n=159)	77	11	11
50-59 (n=206)	77	12	9
Over 60 (n=235)	69	16	11
Education:			
HS or less (n=95)	72	16	10
Some college/BS (n=522)	71	14	13
Graduate degree (n=249)	78	10	10
Relationship:			
NWS Employee (n=37)	70	5	22
Collaborate with NWS (n=52)	69	13	15
Public (n=676)	72	14	12
Other (n=118)	79	10	9

APPENDIX E

Breakdown of Categories by Product and User Group

Breakdown of Categories by
Product and User Group

ROUND 1

ROUND 1	Graphic	Useful	Other	Actions	Share
Temperature - percent chance					
Academic	Colors are fine Meaning of 'valid' - be clear what day forecast is 10% intervals unnecessary	Camping/hiking Power companies in Southwest may use People who do outdoor work			
NWS	Check for color-blindness Graphic outdated, old GIMP background User defined scale preferred (100, 110)	Keep an eye on outlook product to trigger heat alert and coordination with emergency shelters Situational awareness Supplemental - cursory look to see how strong heat events in west will last If threshold was 100 useful for firefighters	Need to know the source Firefighters concerned about relative humidity	No decisions this far out	Share in briefing Situational awareness for aviation industry
Media	Legend seems like actual temp, not percent chance Confusing having blues show heat Think rain with percent chance Don't use all CAPS	Only do 7 day outlook so not useful Use with approaching holidays Use in drought situation Use in on-going or extreme events, not day to day Value in Chicago during heat waves	Need a signal from another product to go looking for this	No significant action	Not graphic but mention in a sentence the info it conveys
Private	Want info in digital form Point and click useful High, med, low confidence tied to percentages useful	Useful to certain markets - utilities and associated financial markets Ag industry - sustained heat leads to crop stress Electric power consumption - hockey stick behavior around 90 degrees Market sensitivity to temp in short and long term - med has lower value	Accuweather already producing similar maps internally that are more robust	Provide with statements of credibility - accuracy and calibration; what goes into creation Good awareness tool	Wouldn't share without knowing how it is created
State	Smooth colors so not blocky Deviation from expected high temp Add percent down left side (public may interpret as degrees) Other thresholds - 100 plus	Useful for outdoor events (sports, etc.) Tie to air quality monitoring Whether you have to open cooling centers due to heat index Useful in spring/May	Definition of heat wave differs	Heat index values would trigger plans (thresholds determined based on how long heat will last) Tool for quick glance Alert partners for activating cooling centers	Share with partners at state and county Including deviation from normal would make it more shareable
Temperature - exceedance probability					
Academic		Too much to reason through Might be useful in winter to make sure it is not below a certain temp Info for specifc use would need finer spatial scale			no
NWS		Takes awhile to understand Not useful		no actions or decisions	no
Media	Embed temperature text within contours	Long time to digest Tricky because title is a negative 10% probability of anything is a waste of time 10% chance I would use this product			
Private	Too complex	Useful for electric consumption decisions 10% is limiting its value		Would not use - too big of a range to make decisions	
State	Should be probability of exceeding	Would never use Like what trying to do but more confusing than value - wouldn't mind seeing another prototype but with context (next to max high)		10% of anything would not care to act	No, except with people I don't like
Precipitation - percent chance					
Academic	Threshold seems low, what is important? Does it exceed flash flood guidance? Match decision making needs Call it outlook, not forecast Give wider range (0 and half inch) because accuracy is poor that far out	Just a signal Can't imagine anyone using 8 days out Forces you to get another product			
NWS		Straightforward, easier to understand Useful for hydrologists Useful to fire managers for situational awareness		Not useful for FAA, thresholds too low unless frozen precip Too much info too far out for firefighters	Public may be able to absorb but more for water resources Weekly drought calls Water resources and stream flow (Army Corps)

Breakdown of Categories by
Product and User Group

ROUND 1

	Media	Good colors Gray out Canada/Mexico Each number should be followed by % symbol Extra work to go back and foth from map to legend	Would have to be over 3 or 5 inches to have value Helpful for mitigating drought situation		No extreme actions. Would look as part of daily routine if it were human input and not just computer generated	Little I share beyond 5 days May include in article
	Private	Add 50 percent line on scale State what day it is Different thresholds	Not helpful in current form Content has utility to some users Useful for picking up on threat of storm if option to click through different thersholds			Disseminate in a different form
	State	Percent down left side Rain or snow? Public wouldn't know zulu time	Value for low level events (Penn State game parking/don't park in grass) Wouldn't use unless range of probabilities Helpful for emergency managers but identify as 8 day		Higher threshold would be more valuable - next to flash flood guidance No action for quarter of an inch	Share with public if higher threshold
Precipitation - exceedance probability						
	Academic	Percentage in title is difficult Colors get greener with high rain/be consistent with radar Distinguish between hundredth and tenth at time frame is questionable Don't use 'worse case', use low probability Threshold is important and should quickly find on map Have pop up window with info instead of figuring out legend	Flooding situation Ag community Utility industry - substations flooding emergency managers Companies (eg. Walmart shipments)	Not useful in isolation - a signal that requires more information		
	NWS	More graduated green in lower end Different probability thresholds/precip levels	Useful in west in fire months (mid-late summer) - provide hope on horizon Useful in conjunction with mean, 10%, 90% envelope Situational awareness		Low prob not useful to FAA Too far out to be operational for fire	Would use in briefings to national directors and hydrologically savvy users Internal sharing only
	Media	Title at top Use in trio, least, likely, max Don't like greens and olives Don't like contours spilling into oceans	Useful for ongoing drought/flood situations 10% isn't useful or big deal		Check the trend in a few days No action	Top rain amounts would be helpful to communicate to users Don't use probabilities because of confusion it causes.
	Private	What is the chance of the event occuring in a specific time?	Looks like worst case scenario for potential flooding Irrigation or agriculture concerns Picking specific thresholds limits value.			
	State	More probabilities - see a range Map of flash flooding threat more valuable Have 'expect this much' and 'prepare for this possibility' - two graphics next to each other Fix blockiness Want the expected amount Darker colors should be more intense/high values	Use to prepare emergency managers for possibility of problems For showing potential for flash flooding concerns Higher utility if higher percentage (25% instead of 10%)		Use if there is a hazard facing us - along with WPC excessive rainfall graph Give to decision makers, move resources, bring personnel into EOC if higher probability	Share with EOC only if higher probability Not as a stand alone - with context Not for general public
Snow/sleet						
	Academic	Not sure about blue for higher probability Who cares about liquid equivalent? Title is off-putting - maybe 'accumulating sleet/snow' instead	Utility industry cares about freezing rain For planning/heads up Cancel employee vacations if there is a threat			
	NWS	Liquid equivalent might be difficult for some Straightforward graphically, easy to understand	Useful for briefings in off fire season Heads up but less useful because don't know snow/liquid ratio or precip type		Not actionable due to low precip amount Not useful for fire season	Share with DOT Keep internal, share with high levels
	Media	Geography is important - hate that state borders are obscured Legends are hidden and could be bigger Lack of consistency between products - different basemap (prefers this basemap) Great Plains/river basin labels don't need to be there Text at bottom is clutter	Useful where ther is an ongoing event or high impact Half inch more useful than quarter inch	Easier to digest, title at top, smoother contours		Share internally Use if doing long range discussion Lends itself to sharing more than other maps

Breakdown of Categories by
Product and User Group

ROUND 1

	Private	Looks similar to products we have Would not use equivalent wording Just say day 8, so you know what 24 hours you are looking at Pick standard base map - prefer simple maps	Seeing over 50% on day 8 is significant Agriculture clients would use Snow removal operations on aircraft and roadways/restocking salt reserves *Equivalent is better than accumulation because it determines the amount of melting material needed		Start to position resources	More likely to share with clients
	State	Text hard to read May confuse colors to quantitative values Will there be 20, 40, 60% probabilities? Just snow/sleet, not freezing rain or ice?	Stocking up on milk and bread Useful in shorter time period Public works use to stock up on brine Forecast tool - not for public Hospitals use to replenish resources		Just use for monitoring and see if trend continues Decision points at the earliest are 5 days out	Would not share with public - may overhype
Hazards						
	Academic	Darker orange/red to be consistent with severe weather Make product day 1 out to 10 Possible can be inferred differently - should define GIS products may be overlain - consider how it interacts Note impacts - flooding for heavy rain, accumulating snow for heavy snow	Useful for a heads up Planning/delay events Emergency managers outside typical extreme weather season			
	NWS	What is threshold? Define what is 'possible' Easy to understand and communicate to user groups Add high wind (50%) Add extreme temperatures Use winter weather instead of heavy snow - ice storms have impact	Useful for a heads up on staffing/resources Situational awareness	Thresholds would be different	Too early for action	Share as a broad overview in briefings
	Media	Like the simplicity, basic contours Use brighter color for severe weather Consider how the colors blend when overlapping Possible versus likely - likely more than 50? Text on map so don't have to go back and forth to legend	Useful as quick snapshot for what the largest threat in an area is Overlapping areas are biggest concern Include tropical threat, ice storm,drought, wildfire, extreme temp in terms of degrees above/below normal,wind		Whether to cancel vacation and go to work Everything in 8-10 day is just raising flag/ not precise enough to take action Review plan but don't take action that far out	would not share to avoid panic Use in digital publication Share internally for staffing decisions
	Private	Define 'possible' Assign percentage Define heavy snow and heavy rain Clarify time period - 3 days or 2? Show the hazards separately Interactive map you can turn layers on and off	Brings together into one dashboard - useful quick look		Too vague for decisions	Share content but not graphic
	State	Define percentage Topography jumps out - use standard background Dynamic map?	Use it leading up to event and watch trends Look at staffing around Christmas Too general to be helpful		Not specific enough for decisions	Keep close until more info

Other products

Academic	Intensity of drought	Useful for water resource managers and firefighters
NWS	Different ranges of time (14 day out to a month) Gradient wind helpful especially if recent icing event (knock down trees/lines)	
Media	Multiple maps - not just quarter inch snow/sleet Separate snow and sleet product 24 hour temperature product of not going below 80	Concerned there is a potential for misuse/abuse of 8-10 day if available to public Armchair meteorologists can misinterpret and cause false alarms
Private	Fire weather Wind speeds	Digital format of information available
State	Context specific thresholds	

Breakdown of Categories by
Product and User Group
ROUND 2

ROUND 2	Graphic	Useful	Thresholds	Actions	Share
Max Temperature - percent chance					
NWS	Simple and easy to interpret	For planning outdoor events Not for aviation unless combined with precip (de-icing) BLM not use as standalone - late season freezes that can lead to fire activity Heat index more a concern - work in apparent temp	Good for weather service User determined threshold more valuable for fire	For identification of areas of concern but not immediate	BLM - Heads-up FAA - only with other info (precipt)
Media	Have to jump around to understand Color is inverted - red is usually warmer, higher prob of cold should be deep blue Avoid all caps and effective date Legends upper left the way people read information Use Eastern time Percent chance of high temp below 32 degrees is better for general public	Not for normal winter in Gulf Useful when users ask what next weekend looks like	Color scale appropriate for 90 threshold 32 is critical, 100 is psychologically significant Maybe 85 - Europeans use for heat stress start	Discussion point for users Small value in day to day decisions bc already looking at models/upper air flow with that info	Not as broadcaster bc it is national If high heat or the 32 one near end of growing season
Private	Confusion with something being cold and a warm color Danger factor here - impact of weather or actual temp - color scheme should be different Emphasize it is percent chance and not temperature Transparency about how product is created	Useful for frost in agriculture Planning outdoor events, sporting events Useful if a significnat cold wave - but would adapt using own style Utility in the eye of the beholder - danger for ag but opposite for ski Gauge duration an area would be below freezing	Should be a slider and not pre-determined - limits the value As a starter those thresholds are the most popular but the more options the better	Having WPC product is better than just model data- value added in a product with human input	
State	Great from national perspective but not granular enough for local, esp mountainous areas out west Colors counter-intuitive, deep reds the coldest? ESRI based map more useful than static so you could zoom in and have county layers	Situationally useful - agriculture growing season treatment of roads Useful for frozen pipes/wind chill advisories First Energy would not use Wind chills for school closing For EM, looking at duration of temps and deviation from normal What about heat index - humidity and other factors more useful	Sound concept From utility perspective duration in heat or cold over a certain threshold User defined thresholds preferred	Not for utility operations More for general information - tie in with other infor for long term weather outlook From preparedness perspective not many actions that far out, just supportive info	Not in this format - not specific enough for operations
Max Temperature - percentile					
NWS		Too complicated - just turn into a temperature forecast 50th percentile could be detrimental if not matching forecast			Weather Service usually gives a best, average, and worst case scenario corresponding to percentiles
Media		People misintrepret as true point temperature Wouldn't use less than 90th percentile Don't know what it means			No.
Private	Need narrative to break it down	Not friendly to lay person Underlying data is most useful so it can be adapted for own systems			Would not share even internally
State	Poor man's attempt - hard way of visualizing the possibilities as opposed to click on a point and get a forecast and PDF. Flexibility where user could see the PDF to go with the map - the range and distributions and where probabilities are coming from	Can't figure out what you are trying to show Not intrinsic, leads to confusion		Don't know how warm you are going to get so hard to make a decision	
Max Temperature - with respect to normal					
NWS		People don't know what normal is Fire needs deterministic values			
Media	Color scheme above avg should be warm and below average should be cool - don't use same palette for both	People don't know what normal is Looks like CPC's maps Useful as general guidepost but that is what CPC does 8 days out should be low, med or high - this is too precise and implies accuracy that is not there	Nice round numbers but do not have universal meaning or outcome 20 F above and below	Get ready for potential communication needs in future	No Only if a serious outbreak (25 below)

Breakdown of Categories by
Product and User Group
ROUND 2

	Private		Useful to highlight the chance of big cold or warm snaps Most don't think about percent chance of having an anomaly - useful to tell a story once in a great while Percent chance stories unclear for general public - might lose confidence with you if they are confused			No
	State	Could be tailored to say level of confidence and not percentiles Put in Eastern or Central time or give the user the option to choose			For planning for an event or heat/cold waves planning for emergency managers	
		Being able to see day 8 for the last few cycles helpful	Useful - says when I need to kick in operations plan for warming centers Where bullseye areas might be where you need to take concern 30% chance of 25 below normal is significant! Correlate with hurricane striking - probability low but impact high		Use in conjunction with day 6 to 10 to see if the same pattern prevails and then dust off plan Briefing of external and internal partners so they are aware Monitor the trend - flipping back and forth?	Yes if there was experience with it and its performance was reliable Yes if the end users are partners of agency, not general public
Min Temperature - percent chance						
	NWS		Would not show on routine basis - only if extreme does it have utility	More user defined thresholds specific to location of fire manager Similar for aviation - different thresholds for different airports	Cold temperatures in southern states may act to get de-icing fluid in place/things not on hand Just as heads-up for aviation Situational for fire - in May-August if there are crews out and high temps you may swap crews or postpone operations	Yes if there are implications for what they are planning to do. For fire there is a prescription window where info has more weight if it has impact. Very specific about info they give and when.
	Media	Color scale inverted to what is intuitive Drop upper case	80 low temp is dangerouse so yes but with different colors Has value to average person	32 good for agriculture 70 instead of 75 bc 70 starts to get uncomfortable 80 is scientifically heat stress		No Only below 0 and above 80
	Private	Like color choices - it pops Would like digital format and user selected thresholds	More understandable because cold temps and not to exceed Useful for decisions for staffing people outside Useful for agriculture for livestock and transportation			
	State		Less useful bc no duration component - First Energy would use 75 threshold but need duration - load issue Useful if you know it will be cold/hot for a period of time - open cooling or warming centers Useful for getting word to elderly, gives us extra time if extended heat Useful for ice formation on rivers (Colorado) WInd chill more important than temperature	Not threshold of interest Seem artbitary - why 0 and not 10? Prefer user defined threshold or PDF		Not with public but within organization
Min Temperature - percentile						
	NWS	Simple In fire, red means bad so be clear about color scheme not characterizing information	Too complicated for end user			
	Media		Too complicated, don't understand			No
	Private	Scales with 10 degree range is too large - in summer it won't vary that much so just a few colors on map Cut off temperatures not shown, narrow range, and have 5 degree intervals	Least useful - more of a tool for meteorologists			No
	State		A duration based scale of temp below or above a certain degree more useful - for freezing/thaw on river			No
Min Temperature - with respect to normal						
	NWS					

Breakdown of Categories by
Product and User Group
ROUND 2

	Media		Useful to see spots that will be colder in 8-10 days	Arbitrary Only show extremes on either side above or below 25 degrees		No
	Private		Below normal not useful unless an extreme event Not useful for actions, maybe slightly for messaging			Share selectively depending on climate and concerns (transportation, agriculture, work outdoors)
	State	Contours of what normal is on map or displayed right next to it - not something you have to click	Help with opening cooling shelters - where do you go at night	Good - there are more in this one		Yes in concert with other information Yes with partners, not public
Precipitation - percent chance						
	NWS	Color scale odd - want to trend toward green for higher probabilities	More useful than temp since big driver of fire activity - value in making decisions about fire response to prepare for a week ahead Cold and precip in southern states would be useful	Not important threshold - user defined would be good.		
	Media	Colors look like temp contour map - stick with shades of green, blue implies frozen Easy to understand National Drought Monitor's colors used for the low numbers	Not helpful for day to day Consult if in a drought High value for agriculture and municipalities who have to do long range planning	Small amounts are not interesting Tough to know best thresholds		No as broadcaster On internet but only if stunning extreme event
	Private	Use different color table for precip and temp - precip just shades of blue so it is easier to separate out.	Useful as forecaster for communicating likelihood of precip - extended outlook Most useful if an extreme event needing long lead time to plan	Threshold slide is preferred More thresholds here is great but more flexibility is better		Just in house for monitoring - always telling public to ignore these maps past a certain date
	State	Fairly typical plot Discriminate between melted and frozen precip	Helpful for many First Energy not as helpful Corps in the Ohio Valley concerned with substantial rainfall - for flooding	Want any measurable precipitation - freezing drizzle events can cause problems too User defined - need to consider in light of context - 8 inches a few days prior, etc.		Yes
Precipitation - percentile						
	NWS		Too complicated	Threshold intervals that far out are fine - any closer and wouldn't trust	Depends on season - late June quarter of more precip in NM and AZ shuts down fire season, in Rockies looking in Aug/Sept for precip to shut down	Yes for fire Aviation - only if extreme Weather Service - share as package but only at higher thresholds
	Media		Only if coming out of extreme drought or flood Useful if 90% chance of 5-6 inches of rain	Would not use 50% -only 75% or higher 90% is where I would look first		Maybe if there was something in the 90%
	Private	Different color table might lose people	Same as temp - don't like this language, not understandable			No
	State		Mixing up amount with probability More understandable than temperature but not sure of usefulness		No, data overload	No
Snow/sleet						
	NWS	70-90% is pretty high and should be different color - yellow/orange	Not useful for fire - want prob snow forecast not 8-10 days out Aviation - highlighting extreme event Weather Service - useful for outlook/stay tuned Liquid equivalent means diff things in diff parts - half inch in Atlanta shuts down city but elsewhere is nothing	Ok for aviation - half inch =5-6in snow which is significant	Situational awareness	
	Media	No good answer for color scale Like that percent chance does not have hyper detail shows outlook down't have precision of near term forecast	Useful for city planners with melt runoff but not for general public Useful for heads-up/team planning Everyone thinks in inches not liq equ.	Thresholds seem low for many users	Help with planning proper shift coverage	No. Confidence is too low, don't want panic

Breakdown of Categories by
Product and User Group
ROUND 2

	Private	Format change you have to orient yourself to - possible to keep them the same? Title is bigger, different color palette, different colors per probability	Intent of product is useful but not in liquid equivalent 95% of people want to know how much snow fell	Thresholds ok for hydrology but not beyond that Option of converting to accumulation	Limits of predictability - snowfall 8-10 days out is shaky territory	More tempted if not liquid equivalent Good internal tool
	State	Understandable, colors, readability good Higher colors mean higher chance	Similar to the near term day 4 to 6. Liquid equivalent difficult for external users	Winter precip means different things for everyone Why not converted? Need the whole range of thresholds - sliding scale		With some emergency managers on a case by case basis Yes with internal partners
Freezing Rain						
	NWS	70-90% could be more eye catching	Users have issues with liquid equivalent Useful for in house outlook perspective		Combo of temp and this for an unusual event would have different decisions in southern states	No - it would freak people out
	Media	Color on freezing rain - yellows and oranges for ice accumulation Avoid all caps	Have to read it 3 times to understand liquid equivalent Non-intuitive way to think of freezing rain-thickness versus what it will melt down to be. Get team's attention 90% chance of an inch would be newsworthy	Thresholds even keeled - both equally get my attention		No
	Private	Not showing Canada/Mexico is limiting	Watch to see if confidence increases Concern we can do more harm than good - can't get snow right the day of		Utility may need to plan in advance - freezing rain cause outages and need crews	No, could be misused
	State					
Hazards						
	NWS	Clearly define hazards Understandable	Problematic when talking about below normal Too generic Useful to illustrate in a general way the potential threats Fire would not use bc already looking at models in detail so maybe just to back up what models are showing or for high level management who want a quick snapshot Useful in combination with probability products	Prefer different thresholds		
	Media	Intuitive colors	General idea of what is going on Background product since it is possibilities, not probabilities Low value for day to day operations Good planning graphic	Add two more thersholds for temperature anomalies	Potential for blizzards in Mid-Atlantic and power being knocked out - would get conversation going.	
	Private	Need to know the definition of possible (parenthesis of 30%) Break down by day 8, 9, 10	Good heads-up on how spatial/regional an event might be Would not use because we already create something like this ourselves for our clients.	Having threshold amount or some kind of probability is more useful than just possible		
	State	Legend should show the full range of hazards Want distinct color differences for different hazards - anything precip based filled in, temp based is outline, severe is hatched	How do you define heavy? Would let my boss know we are watching something down the line Awareness tool With some modifications, a pretty useful product			Yes

Preferred	**Max temperature**	**Min Temperature**	**Precipitation**
NWS	Percent chance	Percent chance	Percent chance
Media	Percent chance/ Prob with respect to normal close second	Percent chance	Percent chance
Private	Percent chance for public/Prob with respect to normal or all 3 for meteorologists	Prob with respect to normal/Percent chance close second	Percent chance for public but meteorologists want all info
State	Prob with respect to normal	Prob with respect to normal	Percent chance