

Listening to Stakeholders II

Adapting Research Products on Subseasonal to Seasonal Heavy Precipitation Events by Exploring Options with Users

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ABSTRACT: Extreme precipitation events can cause significant impacts to life, property, and the economy. As forecasting capabilities increase, the subseasonal-to-seasonal (S2S) time scale provides an opportunity for advanced notice of impactful precipitation events. Building on a previous workshop, the Prediction of Rainfall Extremes at Subseasonal to Seasonal Periods (PRES²iP) project team conducted a second workshop virtually in the fall of 2021. The workshop engaged a variety of practitioners, including emergency managers, water managers, tribal environmental professionals, and National Weather Service meteorologists. While the team's first workshop examined the "big picture" in how practitioners define "extreme precipitation" and how precipitation events impact their jobs, this workshop focused on details of S2S precipitation products, both current and potential future decision tools. Discussions and activities in this workshop assessed how practitioners use existing forecast products to make decisions about extreme precipitation, how they interpret newly developed educational tools from the PRES²iP team, and how they manage uncertainty in forecasts. By collaborating with practitioners, the PRES²iP team plans to use knowledge gained going forward to create more educational and operational tools related to S2S extreme precipitation event prediction, helping practitioners to make more informed decisions.

KEYWORDS: Social Science; Communications/decision making; Societal impacts

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During the last two weeks of July 2022, parts of eastern Kentucky received more than a foot of rain, with much of it concentrated during a 5-day period when thunderstorm complexes progressed repeatedly over the same areas. This rainfall event resulted in catastrophic damage and 39 deaths (NWS 2022). Flooding in the North Fork of the Kentucky River at Whitesburg crested near 22 ft before the gauge broke, shattered the prior record of 14.70 ft from 1957, and caused major damages to downstream communities (NWS 2022; USGS 2022). This type of subseasonal-to-seasonal (S2S) precipitation event results in significant economic costs and losses (e.g., Wen et al. 2022); damages water, sanitation, and transportation infrastructure (e.g., Corringham et al. 2019); degrades water quality (e.g., Exum et al. 2018); and threatens human and animal health (e.g., Lowe et al. 2013; Anyamba et al. 2012).

Although all consequences cannot be avoided, sufficient notice of a potentially damaging event can provide time for public officials, businesses, nonprofits, and individuals to prepare and ultimately save lives and reduce damages. To move toward prediction of S2S heavy precipitation events, team members of the Prediction of Rainfall Extremes at Subseasonal to Seasonal Periods (PRES²iP) project, funded by the National Science Foundation (NSF), worked with decision-makers across the contiguous United States to learn what types of predictive tools may be helpful for increasing resilience and mitigating disaster. The primary way the team engaged with practitioners was through a 2-day, in-person workshop in July 2018 and a 3-day, virtual workshop in October 2021. This engagement has been critical to the PRES²iP research team members, who are all geophysical or social scientists, because common ways for the researchers to present data (e.g., using percentiles) were clearly difficult for many practitioners to apply to their operations. As a result, the project team changed the early design of their research to address the issues raised in the 2018 workshop (VanBuskirk et al. 2021). Then, a second workshop was held in 2021 to seek clarity on how PRES²iP research activities and results could best be translated into educational or operational products.

Studies indicate that co-development of research tends to result in products that are more useful and usable by decision-makers (Lemos et al. 2012). Different engagement methods are appropriate for different types of projects and depend on the time or policy constraints of decision-makers as well as the amount of available research funding (Bamzai-Dodson et al. 2021). Additionally, engaging with stakeholders allows for the development of mutually desired project outcomes that benefit both scientists and practitioners (Wall et al. 2017).

This manuscript overviews the purpose and design of the October 2021 PRES²iP workshop, discusses the elements of each workshop session and its results, and summarizes the main lessons learned from the workshop participants. While documenting our own work, this paper also is meant to serve as a source of ideas for other researchers, particularly

those who are developing products intended for use by nonresearchers. Importantly, the mentorship provided by senior team members and the leadership taken by graduate students in conducting the workshop likely will result in long-lasting contributions to society as the students shepherd similar engagement activities throughout their careers.

Methods

After hosting practitioners in Norman, Oklahoma, for our first workshop in 2018, it was important to the PRES²iP team to have as many participants as possible return for subsequent workshops so that we could continue building relationships with practitioners. Due to the COVID-19 pandemic, we had to delay an in-person workshop and ultimately chose to host the second workshop virtually, spread over three days in October 2021. The PRES²iP team planned the logistics of the workshop from January 2021 to October 2021.

Participants from across the contiguous United States included water managers (8), emergency managers (6), tribal environmental professionals (1), and decision-makers working with utilities (1). To recruit new participants, we used purposive and snowball sampling (Tongco 2007; Goodman 1961) contacting researchers who had previously worked with PRES²iP team members to obtain recommendations for new participants. We also asked participants who had attended the first workshop to recommend potentially interested colleagues. In addition, we invited two meteorologists from local forecast offices of the National Weather Service (NWS) and one climatologist from the NWS Climate Prediction Center. These weather and climate experts provided insight into product development from an operational perspective. We invited all 21 participants from the first workshop, nine of whom ultimately attended the second workshop. Ten participants joined for the first time.

On 4–6 October 2021, the PRES²iP team welcomed 19 participants to our virtual space for the Product Definition Workshop (Fig. 1). To create some feeling of a real workshop, the PRES²iP team sent a box of workshop materials and snacks to the participants during the prior week. These items were used during online activities and snack breaks. The workshop had four sessions, described in Table 1, and a panel discussion with three guest speakers. For sessions 1 and 4, the entire group participated in plenary discussions and interactive polls.



Fig. 1. Workshop participants and PRES²iP team members.

Table 1. Description of workshop activities and goals.

Workshop session	Activity	Session goal
Session 1: Workshop introduction Day 1	Presentation on PRES ² iP project and interactive polls	Provide an overview of PRES ² iP and learn how extreme precipitation influences practitioners
Session 2: Which forecast products do you currently use? Day 2	Small group discussions about how practitioners use existing forecast products to make decisions	Understand which products practitioners find most useful and how they are applied to make decisions
Session 3: Interpreting new PRES ² iP tools Day 2	Small group discussions over newly developed PRES ² iP fact sheets	Gather feedback from practitioners on fact sheets, how they could be improved, and potential uses for information
Session 4: Impacts and uncertainty associated with subseasonal forecasts Day 3	Large group discussion on probabilistic vs deterministic subseasonal forecasts and how they would be applied	Discuss the skill of subseasonal forecasts and provide practitioners with examples of probabilistic and deterministic forecasts to learn how they may apply forecasts

In sessions 2 and 3, participants were placed into small groups based on their work sector for more detailed discussions. In each session, notetakers from the PRES²iP team recorded discussion points. For the two sessions that used breakout groups, a facilitator summarized their group's main input at a later plenary session.

Session 1 served as an introduction to the PRES²iP project and team, and it included an ice-breaker activity for participants. Team members also gave updates on their research progress and how the results from the first workshop had influenced their work in the subsequent years. Participants answered poll questions from the PRES²iP team using an interactive platform. Questions included why participants had chosen to accept the invitation to attend the second workshop, what they remembered most from the first workshop, any new experiences with extreme precipitation events, and some trivia about extreme precipitation.

In session 2, the PRES²iP team wanted to understand which forecast products practitioners currently use to guide their decision-making. Before the workshop started, participants were asked to submit examples of one or two products they used in their jobs related to extreme precipitation. The PRES²iP team used these examples to shape the discussion questions. Then, during the workshop, participants were divided into small groups to answer questions such as “How does this product help you make a decision?,” “Which components of this product are most useful to you?,” and “What signifies to you that a forecaster is confident in the forecast the product shows?”

For the third session, the PRES²iP team provided the participants with fact sheets that applied output from the prior years' research. These fact sheets explained how PRES²iP researchers defined extreme precipitation events for the study and summarized the climatology of these events across the country. Other fact sheets showed impacts and seasonality of extreme precipitation events across the U.S. Great Plains and the West Coast. The fact sheets were developed iteratively by the PRES²iP team with adjustments made to graphics and wording during the months prior to the workshop. The PRES²iP team introduced the session prior to a lunch break, during which participants were asked to read through the fact sheets and complete a short survey to provide initial feedback and reactions to the information. After lunch, everyone returned to breakout groups and the participants provided more in-depth feedback on the fact sheets.

The fourth (and final) session of the workshop focused on uncertainty and skill associated with subseasonal-to-seasonal forecasts. In the first workshop, the PRES²iP team heard that practitioners were unsure of how much they could trust extended-range forecasts or how they might handle the uncertainty associated with them. This session was intended

to take a deeper dive into their thinking regarding the S2S time scale. PRES²iP graduate students gave a short presentation on S2S forecast skill and then facilitated a group discussion about how participants might use deterministic or probabilistic forecasts in their decision-making.

The discussion was designed as an interactive exercise using a forecast for a 14-day extreme precipitation event between 20 April and 3 May 2011, although these dates were withheld from session participants. Deterministic and probabilistic forecast maps were made using hindcasts from the S2S forecast system of the U.K. Met Office (MacLachlan et al. 2015). The maps displayed forecasts for the event period to meet or exceed the 95th percentile of total precipitation (Fig. 2a). We used hindcasts initialized on 9 March, 17 March, 25 March, 1 April, 9 April, and 17 April between 1993 and 2015 to calculate the 95th percentile of total precipitation for the 14-day period. Exercise participants received forecast maps from the 17 April 2011 initialization. Map data were smoothed using a Gaussian filter (sigma = 1.5) to reduce noise resulting from a relatively short climatology and from the model only having three ensemble members. Observed precipitation totals (Fig. 2c) were from the PRISM dataset (Daly et al. 1994).

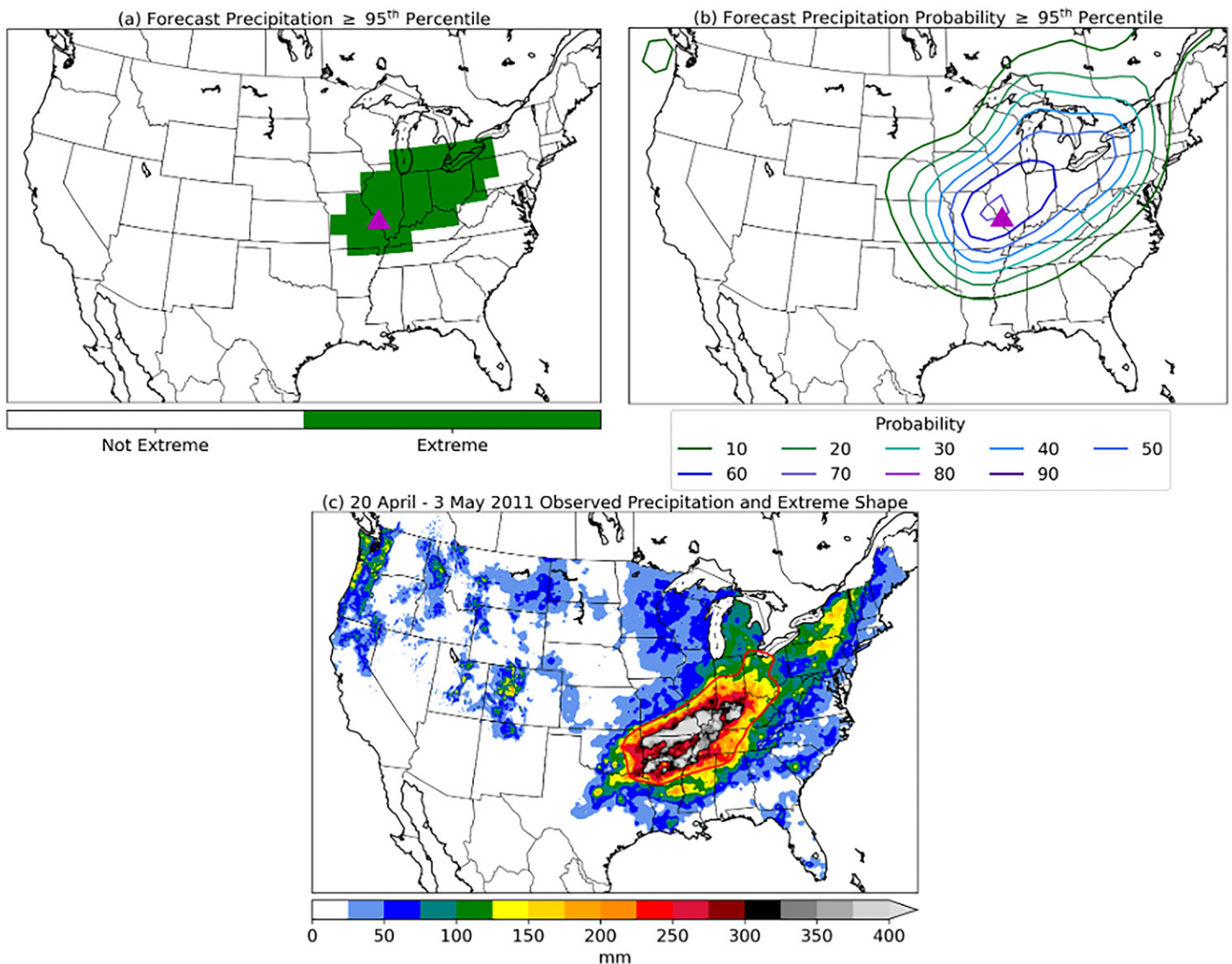


Fig. 2. Example of products in workshop activity focused on forecast skill and uncertainty. Participants were asked to role-play a decision-maker for St. Louis, MO, (purple triangle) and were provided (a) a simulated deterministic forecast of a 14-day extreme precipitation event, and (b) a simulated probabilistic forecast of the same event. After the activity was completed, the PRES²iP team showed the participants (c) a map of the actual event dates and observed precipitation.

Because subseasonal models are unable to skillfully simulate extreme precipitation (e.g., McAfee et al. 2023; Li et al. 2021), we chose a hindcast that initialized closer to the beginning of the extreme event so as to obtain a map with a wide range of spatial coverage and probabilities. During the exercise, we told participants the lead time was actually 7 days to gauge their thoughts and force them to think on longer time scales. Nevertheless, our forecast maps were still S2S products, as they encompassed total precipitation over a 2-week period.

Results

Although not an intended or measured outcome of the workshop, senior members of the project team noted that the graduate research assistants had developed substantial skills in working with practitioners during their time working on the PRES²iP project. These skills were demonstrated clearly during the workshop through interactions with the participants and were highlighted after the workshop by their descriptions of new knowledge they gained from the practitioners and how they might apply that knowledge. Senior team members consider this outcome to be important, as it signals an understanding by and willingness of the students to engage with decision-makers as partners in their research.

Outcomes from the workshop itself are discussed by session, in chronological order. It is important to note that the PRES²iP team was not conducting research *on* the workshop participants (i.e., no Institutional Review Board review) but conducting research *with* these practitioners. Hence, the discussion below simply summarizes notes taken by the team during the workshop.

Session 1: Workshop introduction. The majority of Session 1 focused on updating participants on PRES²iP research activities in the years following the first workshop and providing an overview of the entire 5-yr project. Additionally, participants answered questions about why they chose to accept the workshop invitation. Answers included wanting to learn more about ongoing research related to extreme precipitation, continuing to build connections from the first workshop, and learning more about forecast tools that could be used for precipitation events. These activities helped to ensure that researchers, prior workshop participants, and new participants had the same foundational understanding of the current state of the project.

Session 2: How do you use existing forecast products? Workshop participants submitted and discussed a variety of forecast products that they used to make decisions related to extreme precipitation. For short-term decisions (0–10 days), participants used forecasts from private companies, such as from the Windy app or The Weather Channel. They also relied on forecasts from their local National Weather Service Forecast Office, or quantitative precipitation forecasts (QPFs) and the excessive rainfall outlook from the NWS Weather Prediction Center. Others used flash flood guidance from the NWS River Forecast Center in their jurisdictions. In some cases, quantitative forecasts were used as input into statistical models developed by individual agencies to predict water supply and water quality, or to get an idea of what flooding impacts a given area may experience. At longer lead times (beyond 10 days), participants used the 2-week hazard outlook or seasonal outlook from the NWS Climate Prediction Center. Forecast usage also varied by sector; many of the participants who were more familiar with long-term forecasts were water managers, while most of the emergency managers were typically making decisions on shorter time scales.

All of these forecast products were applied in multiple ways. Emergency managers described using QPFs to get an idea of which areas in their jurisdictions could face the greatest impacts. Long-term forecasts and climate projections (not submitted as example products but discussed) also were used to plan for the impacts of climate change; for example, projections

were used to justify retrofitting stormwater infrastructure. For emergency managers, the key decision-making timeline was generally 1–3 days before an event started, and these practitioners were less likely to use subseasonal or seasonal forecasts. Communications with local NWS Forecast Offices were also important to emergency managers, and often NWS briefings were used to identify which areas might experience the largest impacts during a predicted event. Consistent with prior literature (e.g., Na-Yemeh et al. 2022; Hoss and Fischbeck 2016; Baumgart et al. 2008; Morss and Ralph 2007), trust with forecasters gained through these briefings was instrumental in participants' decision-making processes.

In addition to operational forecast products, some participants also discussed other tools that could combine multiple sources of data into one platform. For example, rain gauge observations could be layered with QPFs or radar and satellite data in geographic information systems (GIS). This combined information was usually assembled in-house in organizations that had access to GIS software. Many participants expressed how useful a system with those capabilities could be for their decision-making; however, some of the participants from small communities did not have access to GIS software at all, limiting their ability to efficiently visualize data sources together.

Finally, even though participants had certain products they relied on more than others, there were still challenges associated with applying a given piece of forecast information. Often, participants struggled with a lack of explanatory text for probability values and did not understand how to interpret some probabilistic information. Additionally, participants expressed they would like to see products that targeted potential loss, either in monetary loss or property damage, to help guide their preparation and response. Overall, the decision-makers at the workshop were significantly more familiar with forecast products for the weather time scale versus those at longer time scales, though some practitioners did use seasonal forecasts for planning purposes.

Session 3: Interpreting PRES²IP tools. Prior to the start of Session 3, workshop participants were given four fact sheets (FS) containing information on the creation of the event database (FSdata), the climatology of the events (FSclimo), and the impacts and seasonality of events within the West Coast (FSWC) and the Great Lakes (FSGL) regions. Initial feedback on the fact sheets was gathered through a pre-survey before small group discussions. Of the 10 participants who completed the pre-survey, eight found FSdata and FSclimo useful, whereas six participants found FSGL and FSWC useful. When asked what they liked the most within the fact sheets, the majority of participants stated they liked the organization and layout of each fact sheet. Multiple participants noted the usefulness of the CONUS-wide spatial trends of the extreme precipitation events within FSclimo, with one stakeholder sharing: “I like that it shows where changes are occurring and then the intensity of change.” However, when asked what they like the least, many participants stated that they were unsure how to apply this information or they found some of the technical details confusing.

Similar themes emerged during the small group discussion. When considering the details of FSdata and FSclimo, many participants shared concerns about how the database of extreme events was developed using an area threshold of extreme points. Instead, they desired databases focused on impact-based metrics, such as monetary loss, infrastructure damage, and presidential disaster declarations. For example, one stakeholder specifically stated, “You can have a great storm out in the middle of nowhere with historical rainfall, it hits the drainage, it does not have any value... it will literally go unnoticed.” Following this statement, the group had a discussion about how using impacts to define an extreme precipitation event could allow for easier comparisons of risk across regions.

Although most participants found FSWC and FSGL useful, with possible applications in planning and mitigation, many participants stated that they would benefit from more

contextualized impacts. For example, one practitioner noted that knowing what the antecedent conditions were within the region before a precipitation event occurred would help contextualize the impacts that might occur. Two different methods of representing the typical storm reports were used in FSWC and FSGL: 1) a box-and-whisker distribution of common storm reports for West Coast events (FSWC) and 2) a bar graph displaying the average number of reports during a Great Lakes event (FSGL). Although the box-and-whisker method showed more information about worst-case and best-case scenarios, all participants agreed that the bar graph was easier to understand and thus more useful. Nevertheless, some combination of typical impacts and how they may be amplified or muted by factors such as antecedent soil conditions would ultimately be optimal for all decision-makers.

FSWC and FSGL highlighted each region's seasonality (i.e., wet and dry seasons) of S2S events using a monthly distribution graphic for 1915–2018. Many participants noted this separation of seasons as useful, with one participant stating, “[An event] during the wet season, I think that that is very valuable, but also understanding that we can have significant storms outside of that timeframe.” Participants could apply their local knowledge and the seasonality of precipitation events to plan ahead for impacts that their communities could face. Participants remained aware, however, that events could happen outside of the wet season in their regions, and that, in many cases, events in the dry season could have a greater impact than those during the wet season.

Effective communication in the fact sheets was also a concern among the participants. Some noted that use of the sliding 14-day window would complicate communication to the public. Furthermore, other participants were confused how a 14-day event did not need to have precipitation on all 14 days. After the researchers further explained how events were defined, the PRES²iP team realized that the confusion centered on the use of the term “event,” which may be used both for heavy precipitation for the 14-day window and for precipitation on specific days within the 14-day window. This confusion also was compounded by regulations or policies that some practitioners must follow that already define what an event is. One participant suggested changing the terminology to a “14-day precipitation period” that could include multiple daily precipitation events.

Additionally, some participants asked for fewer technical details within the fact sheets, especially for FSdata and FSclimo, while other participants desired more detail. This feedback highlights the wide range of needs that may arise in differing stakeholder contexts. To take all suggestions into consideration, a revised version of all the fact sheets, with impact sheets for all regions within the CONUS, was made accessible through the PRES²iP website (<http://pres2ip.com/fact-sheetz/>). Creating web pages allowed the research team to go into more detail, in an accessible format. As such, FSdata and FSclimo were greatly expanded with varying amounts of technical detail. For example, the top of the web page for FSdata uses a graphical example to display the sliding 14-day window and walks through the process behind finding an extreme period in a simplistic manner. The top half of the page is dedicated to describing the process without any scientific jargon with the goal of being understandable by any person, regardless of background. The second half of the page then goes into much more detail at each step, providing interested readers the technical nuances of our database generation algorithm without the need to read the associated journal article (Dickinson et al. 2021).

Multiple participants also stated they would benefit from more contextualized impacts; therefore, storm reports have been split into wet and dry season reports within the revised fact sheets on the website. Additionally, when undertaking and communicating future research, the term “event” will be replaced by “period” to avoid confusion. Finally, while stakeholders desired the S2S precipitation events to be defined based on impacts, one challenge that remains is the lack of sufficient data on impacts available to build meaningful databases. It is difficult to obtain insurance data from companies, but practitioners expressed information

on damages and monetary loss from an event would be particularly useful to them. Storm reports from the National Centers for Environmental Information are not robust enough to build databases. More spatial information about the extent of damage related to flooding, wind, or other hazards could provide more specific assessments of impacts, but storm reports only provide the county where an event occurred (except for tornado reports). Determining ways to define events that may be more useful to practitioners is an issue the PRES²iP team and the broader scientific community has to grapple with moving forward.

Session 4: Forecast skill and uncertainty. During Session 4, we asked the practitioners to participate in a role-playing activity. After viewing the simulated deterministic forecast of a 14-day extreme precipitation event (Fig. 2a), participants were asked to role-play their current position but for the city of St. Louis, Missouri. They were then asked, “If you were giving this graphic with a lead time of 7 days, would this deterministic product cause you to take any action?” Eight (five) of the participants responded that they would (not) take action. Common actions practitioners described were notifying policymakers or stakeholders, starting initial messaging to partners, and monitoring the forecast more closely. Some of the participants who answered that they would not take action did state that they might monitor the forecast more carefully; they just did not consider this an “action taken.” Participants stated that they would also need to consider precursor conditions and the seasonal timing of the event because these and other factors could have a large effect on the regional impacts.

Next, after viewing the simulated probabilistic forecast (Fig. 2b) of the same event, participants were asked if this product would cause them to take any action 7 days in advance. Ten participants said yes; one said no. Although fewer participants answered this poll question during the session, more people stated they would take action with the probabilistic forecast product as opposed to the deterministic forecast. Participants stated the probabilistic product highlighted an area of higher risk; therefore, they were more likely to take action within that area. Our query about a second location with a lower event probability resulted in generally the same response—higher confidence where probabilities were higher.

The consensus among participants was that the probabilistic forecast would more likely be used in their decision-making processes. Practitioners told the team that the probabilistic forecasts gave more specificity to the location(s) of maximum potential impact. They indicated that if probabilities approached 50%, they would sharpen their focus on the potential event and its timing. As probabilities approached 70%, many would begin preparatory actions. Interestingly, water resource managers tended to be more conservative in decision-making, looking for higher probabilities before taking action. To see if their answers changed if the problem were framed differently, the researchers noted that a 40% probability constituted a heavy rainfall scenario that was 8 times higher than normal (i.e., long-term climatology was 5%). Several participants agreed that such information added confusion of probability versus risk. Because risk tolerance is variable among stakeholders, it appeared that for some, the lower probabilities framed in a historical context could spur actions under certain circumstances (e.g., moist soil conditions).

Participants also preferred the probabilistic forecasts because the maps displayed uncertainty. Although the locus of maximum probabilities could shift as lead times shortened, the decision-makers indicated that they could better focus on a potential impact zone in the probabilistic forecast as compared to the deterministic product. In fact, many participants expected a spatial shift in the forecast and continued to monitor movement trends as they considered the impact zone. They felt these trends were easier to interpret in a probabilistic product; hence, the probabilistic forecast communicated both spatial and temporal uncertainty to them. However, probabilistic forecasts are not without their limitations. Several participants commented that it was difficult for them to convey this model uncertainty to

other officials or the public. As most of the actions they oversaw were deterministic, they also found it challenging to make a deterministic decision from a probabilistic product. This challenge may explain why they tend not to take action until probabilities are much greater than 50%.

Overall, the probabilistic forecasts were the more comprehensive product and thus were more useful, although probabilities needed to trigger action tended to be relatively high. Most participants agreed that they would prefer a false alarm to a miss as the potential consequences from a miss vastly outweigh lost trust and wasted resources arising from a false alarm. One participant brought up the concept of a “near miss” where nearby areas had devastating impacts; another participant noted that relatively small shifts in the impact zone (e.g., 50 miles for utilities) are not detrimental. The insensitivity to perfectly precise forecasts suggests that an object-oriented verification framework (e.g., Davis et al. 2006) would outperform traditional gridbox-by-gridbox evaluation metrics in providing meaningful assessments of skill at all lead times, especially those on subseasonal scales.

A recurring theme in the discussion, though, was the need to place the forecast precipitation maps in a broader context. A suite of products that describe location, timing, intensity, and antecedent conditions would be ideal to make the most informed decision possible. The time scale in which the participants make decisions was also nonuniform and there is no “one size fits all” when working with subseasonal forecasts.

Summary

After this workshop, the PRES²iP team better understood how practitioners make decisions about extreme precipitation events, interpret tools the team had developed to communicate about these events, and how uncertainty associated with forecasts influences decisions. We confirmed that there are multiple existing forecast products related to extreme precipitation that practitioners use, though many of these are focused on shorter time scales instead of the subseasonal to seasonal. Additionally, the PRES²iP team learned when developing educational tools it is imperative to use clear language instead of scientific jargon. Furthermore, practitioners are likely to desire event definitions based on real-world thresholds such as damage costs or presidential disaster declarations. Finally, even though they desired high probabilities of an event occurring before taking action, practitioners were excited about using probabilistic forecasts for decision-making, especially at longer lead times. Overall, this workshop allowed the PRES²iP team to continue learning how practitioners make decisions, diving deeper into how uncertainty influences these decisions, and collaborate with stakeholders to develop educational tools from research outputs.

Going forward, the PRES²iP team plans to host a third and final workshop in spring 2023. We intend to include a testbed activity, where researchers and practitioners will work side-by-side with PRES²iP-developed and other forecast products during a simulated extreme precipitation event. This experience will allow the PRES²iP team to understand strengths and weaknesses of forecast products and gather feedback from practitioners.

After completing two workshops, the PRES²iP team greatly values how practitioner input has shaped our research implementation and helped us produce more meaningful products. Although transitioning these products to operations is beyond the scope of our 5-yr project, we anticipate that the road of transition will be less bumpy than had we not engaged our colleagues working in communities across the United States. Importantly, PRES²iP team members, including graduate students who will be the next generation of product developers and research leaders, find it difficult to imagine conducting any stakeholder-relevant research and development without practitioners at the table. We feel that it is incumbent on the weather and climate community to regularly and consistently collaborate with those experts who will become the users of our future products and research results.

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Data availability statement. The observed precipitation totals used in creating workshop graphics are openly available from the PRISM Climate Group at Oregon State University at <https://prism.oregonstate.edu>, as cited in Daly et al. (1994).

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