Improving Communication of Uncertainty and Risk of High-Impact Weather through Innovative Forecaster Workshops

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ABSTRACT: It is challenging to communicate uncertainty for high-impact weather events to the public and decision-makers. As a result, there is an increased emphasis and training within the National Weather Service (NWS) for "impact-based decision support." A Collaborative Science, Technology, And Research (CSTAR) project led by Stony Brook University (SBU) in collaboration with the Alan Alda Center for Communicating Science, several NWS forecast offices, and NWS operational centers held two workshops at SBU on effective forecast communication of probabilistic information for high-impact weather. Trainers in two 1.5-day workshops helped 15–20 forecasters learn to distill their messages, engage audiences, and more effectively communicate risk and uncertainty to decision-makers, media, and the general public. The novel aspect of the first workshop focused on using improvisational techniques to connect with audiences along with exercises to improve communication skills using short, clear, conversational statements. The same forecasters participated in the second workshop, which focused on matching messages to intended audiences and stakeholder interaction. Using a recent high-impact weather event, representatives in emergency management, TV media, departments of transportation, and emergency services provided feedback on the forecaster oral presentations (2–3 min) and a visual slide. This article describes our innovative workshop approach, illustrates some of the techniques used, and highlights participant feedback.

KEYWORDS: Decision support; Forecasting techniques; Operational forecasting; Communications/decision making; Probabilistic forecasts; Social Science; Societal Impacts; Uncertainty

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Weather forecasts have continuously improved over the last few decades (Alley et al. 2019), but as so eloquently stated by Murphy (1993), a forecast only has intrinsic value if the audience takes appropriate action. This is especially true for extreme weather events, which are challenging to predict and also have large human and economic consequences. Historically, the training of new meteorologists, both at universities and within agencies such as the National Weather Service (NWS), has focused on the meteorological part of the forecast problem (e.g., observations, utilizing weather models, and physical understanding). More recently, social science research has emphasized the importance of good communication in distilling the forecast message for the user. For example, the public does in fact want forecast uncertainty information (Morss et al. 2008; Zabini et al. 2015), but there are challenges on how best to communicate uncertainty such that users can accurately interpret risks and take appropriate action.

Uccellini and Hoeve (2019) summarize many of these issues within the NWS. In particular, there is now an increased emphasis and training within the NWS for "impact-based decision support" in order to build a Weather Ready Nation (Lazo et al. 2020; NWS 2019). For example, Uccellini and Hoeve (2019) highlight the tragic April 2011 tornado outbreak over the southeastern United States, in which the loss of life was as large as the April 1974 outbreak, despite all the new technology and relatively long lead time for warnings (~20 min). This emphasizes the need for improved connections to decision-makers, better message building and delivery, and ways to ensure the message is received. Much of this was also summarized in the National Research Council (2012), National Academy of Public Administration (2013), and NWS reports (NWS 2017).

Motivation. NWS offices provide briefings to emergency managers and other stakeholders during approaching storms, while additional information is often provided via social media (e.g., Twitter/Facebook). New probabilistic tools are available online, such as probabilistic storm surge inundation (Contento et al. 2020), river/streamflow levels (Roy et al. 2017), among others. Many of these provide the most likely range, high-end amount (top 10%) or worst-case scenario, and low-end amount (bottom 10%) or best-case scenario. However, forecasters still need to communicate the risk of an impact, thus training is needed to enable forecasters to gain skills necessary to communicate risk.

A Collaborative Science, Technology, And Research (CSTAR) project led by Stony Brook University (SBU) in collaboration with the Alan Alda Center for Communicating Science (www.aldacenter.org), several NWS forecast offices, and operational centers held two 1.5-day workshops on effective forecast communication at SBU. Using a unique improvisational approach described below, forecasters learned to distill their messages and effectively communicate risk and uncertainty to decision-makers, media, and the general public. This paper describes the approach and outcomes from these two workshops.

Communication workshops
Alan Alda Center and workshop approach. The Alan Alda Center for Communicating Science was established in 2009 at SBU. The center's goal is to help scientists and other professionals

learn how to communicate clearly with people outside their field using improvisational theater-based techniques and message design strategies. Improvisation techniques have been recognized as a tool for effective communication as they can help build empathy and connection with an audience (O'Connell et al. 2020). In addition, recognizing that facts do not speak for themselves, the Alda Center instruction focuses on message design strategies that communicate complex topics in "clear, vivid, and engaging ways." The workshops had a few general themes: 1) understand your end goal in order to be an effective communicator; 2) connect to your audience, since good communication is a two-way interaction; and 3) adjust your communication content and approach for the audience in order to convey effective messages.

Workshop goals and participants. Two workshops were conducted at SBU on 4–5 March and 14–15 November 2019, and the majority of participants attended both workshops. The first workshop included 14 forecasters from 13 forecast offices across NWS eastern and central regions (Fig. 1a), and four participants from operational and forecast centers (e.g., Weather Prediction Center, Northeast River Forecast Center). Participants were asked to bring some of their communication challenges from past storms to discuss. The Alda Center provided training in improvisation and message design (both oral and visual) through games, exercises, and role-playing scenarios. The second workshop focused on adapting the messages to intended audiences and included five different stakeholders from New York City and Long Island, New York.

Workshop 1: General principles and connecting to audience concisely. The workshop began with discussion of the challenges in communicating high-impact weather forecasts (Fig. 1b). Participants identified key issues, which included complicated terminology (jargon), building trust, numerous sources of information, different levels of understanding, and effective use of visuals. The subsequent activities focused on distilling messages and developing a connection with the audience. For example, to experience the importance of connection, partners faced each other and practiced following each other's motions (Alda 2017), an exercise adapted from Viola Spolin's "mirror" activity (Spolin 1999). In an exercise designed to practice storytelling and vivid, visual language, instructors asked participants to hold up a blank sheet of paper in a group circle and describe a personally meaningful photograph or image on that paper. Another exercise, based on the improvisational game "Half-Life" (Aurbach et al. 2018), focused on communicating a specific weather hazard in a 1-min statement. In subsequent rounds the time allowed was reduced to 30 s, and then

Fig. 1. Photos from workshop 1 showing (a) group photo that includes the forecaster participants and Alda Center staff and (b) some communication challenges from discussion and (c) forecaster briefing on a major weather event.

15 s. This forced participants to quickly get to the point and focus on the most important parts of their message.

During day 2, participants used the fundamentals taught in day 1 to give a 3-min weather briefing (Fig. 1c) and created one slide similar to that used for NWS social media. The Alda facilitators and peer forecasters provided constructive feedback. Two common issues were overly complicated slides with too much information, or the lack of an effective graphic to illustrate the main point (i.e., potential impacts, risk, or uncertainty). Overall, the presentations needed to convey a sense of urgency with take-home points that were clear, concise, and repeatable.

Workshop 2: Matching message to audience and stakeholder interaction. The second workshop focused on communicating an extreme weather event to actual stakeholders from New York City and the Long Island area (e.g., emergency managers, heads of departments of transportation, media). The forecasters prepared a briefing slide for the event. The workshop started with a review of what the participants learned from the first workshop and the techniques they have applied back in the office. Next, there were some activities to help focus on and connect with the audience (Fig. 2a). The afternoon work included tailoring messages to different types of audiences, message structure, and rehearsing the weather briefing presentations for stakeholders. The second day culminated with presentations to stakeholders from Nassau County Office of Emergency Management, New York City Emergency Management, Suffolk County Fire, Rescue and Emergency Services, New York Department of Transportation Long Island Region, and News 12 Long Island. We began with introductions, a brief warm-up exercise with the stakeholders, and then we did a "circuit exercise," where small groups of forecasters rotated between various rooms for 45-min sessions to give their presentations and slides to a different group of stakeholders. The stakeholders asked questions, similar to an actual event, and provided feedback to the forecaster. Stakeholders particularly appreciated presentations that communicated a level of confidence as well as worst-case or best-case scenarios, and offered a clear timeline of the event.

Workshop results

Participants embraced the unique, highly interactive exercises, games, peer, and stakeholder presentation sessions. Participant feedback revealed common take-home points (Table 1): "I thought this was a good workshop and the matching-the-message made sense as a follow-up. I always learn something from the improv sessions … and really demonstrated just how different audiences can be and how much adjustment that takes! In terms of the visit by the actual partners … that was a great step to take and again showed just how different even THAT
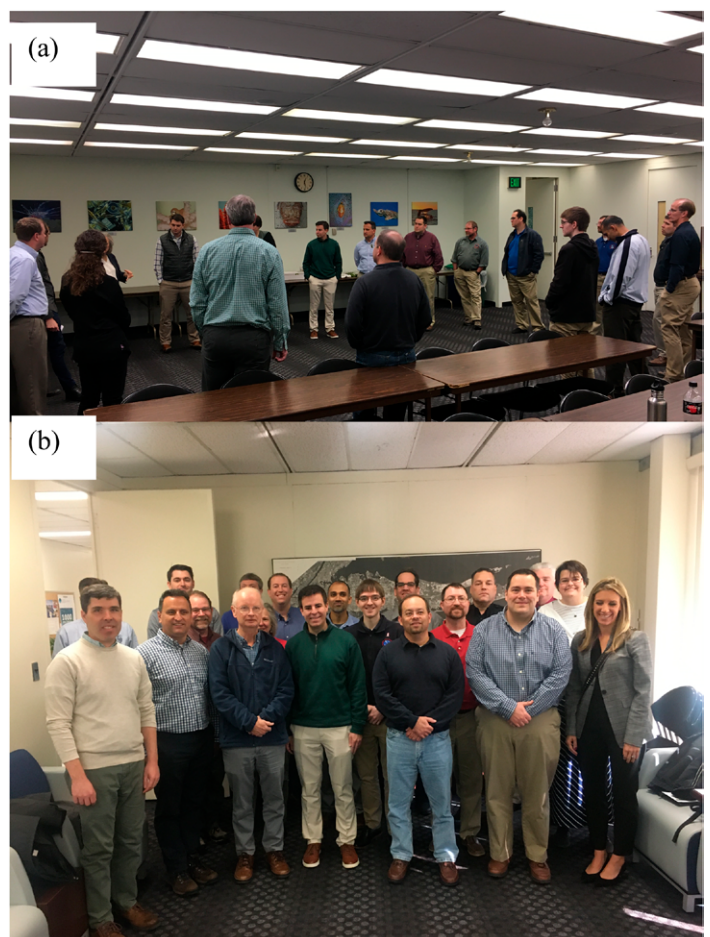
Fig. 2. Select photos from the 14–15 Nov workshop showing (a) forecaster group exercise and (b) group photo showing the forecaster participants with some of the stakeholders.

Table 1. Feedback themes from the forecasters about take-home points from the workshops.

Keep presentations to the point and limited to topics of interest to the audience. Use common and clear language, and try to anticipate audience questions/concerns based on their visual reactions.
Focus on connecting with, and matching your message with your audience.
Incorporate the feedback from our guest EM and DOT members.
Focus on knowing your audience, adjusting to their needs. It is important to do that of course but also have relationships with them so you actually know what they are looking for and what they care about.
Practice, practice, practice your material.
Engage with partners regularly to tailor and refine your message and briefings.
Deliver a message in multiple ways to hit multiple partner types and needs.
Understand that to effectively communicate we need to focus on what the other person is understanding.
Know your audience, set your goal: why they would care, know the obstacles, and know how you will achieve your goal. It is important to mention your goal several times and to have a strong finish.
Communicate in a concise way while still providing the needed information.
Each partner you work with has needs specific to their organization and it is important to know those ahead of a major event.
Adapt your message to suit the audience's needs and expectations is one key takeaway to always remember.
Distill your message … use vivid, concise presentation techniques.
Focus on the audience when giving a presentation.
Try to "home in" on a core customer needs. Brevity without losing substance as much as possible.
Know your audience, understand your partner's needs, and know the goal of your communication.

group can be!" Their enthusiastic feedback reflected their new insights in personal connection, empathy, and clear messaging central to their role as communicators. One participant's remarks were representative of many: "Continued focus on knowing your audience, adjusting to their needs. It's important to do that of course but also have relationships with them so you actually know what they are looking for and what they care about."

Several forecasters also viewed the improvisational teaching methods as an adaptive staff training opportunity: "We have two of our forecasters doing emergency operations (EOC) exercises to prepare them to be deployment ready. They both have to do stand-up briefings and I plan to incorporate a lot of what we were taught to prep them." Additional feedback comments are shown in the online supplemental material (https://doi.org/10.1175/BAMS-D-20-0108.2).

As O'Connell et al. (2020) pointed out, effective evaluation and assessment of the effectiveness of the workshops are challenging. In the case of these workshop outcomes, the strongest indicators were demonstrated over time: how the participants ultimately applied to operations the communication, engagement, and messaging principles they learned through these innovative teaching methods.

One meteorologist found his presentation to be particularly successful after quickly engaging a diverse audience: "I started the talk by engaging the audience with two quick 'raise your hands questions' keeping in mind the audience was a mix of meteorologists and nonmeteorologists. I was pleasantly surprised to see the whole audience raise a hand during one of the questions and I really felt they were more engaged after that. I also tried to incorporate the materials to keep the presentation focused on the core goals I set out to achieve beforehand. I definitely felt my presentation was more focused than similar talks I have given before incorporating the lessons learned from the workshop."

Another participant found a new way to connect with the general public in addition to the annual office hurricane forum: "Through the workshop I saw that you really only need 15 to 30 s to get out the main points beyond the traditional hurricane awareness week. This is the first time we have ever done it and we had 60 in person and 70 on Facebook Live watching a few weeks back. We were very excited."

Most significantly, employing new insights and effective communication techniques have made a very positive difference for many, both in collaboration with other weather forecast offices as well as with partners. For the hydrologist attending the workshops, ensuring concise and clear work with a core partner led to better tailored forecast information, improving service: "I've consciously tried to avoid making assumptions and to actually make time to communicate with our partners to ensure clarity. This includes collaboration with our Weather Forecasters, but also stakeholders such as the U.S. Army Corps of Engineers, which, as an example, has enabled us to better incorporate reservoir releases into our river forecasts."

The positive reception shown in early feedback indicated overwhelming openness to largely unfamiliar training methods. In turn, the operational examples above provided the greatest measure of participants' new insights, revealed in enhanced operations and stakeholder support in the months following the workshop.

Summary and future plans

The participants have demonstrated that clear, concise messaging and personal engagement have been key to enhancing their connection with NWS core partners. They have reported improved collaboration with their colleagues in surrounding forecast offices, and created new methods of serving the public and staff training. The improvisational approach and stakeholder interaction demonstrated in these workshops may also be beneficial to others in the broader weather and climate community.

The goals of the third and final workshop have been shaped by trend and circumstance. Due to the recent pandemic, meetings and presentations for stakeholders are held in person less frequently than in the past and remote communication is now established as a way of life. While platforms and venues change, the principles of effectively communicating actionable information have not. Thus, the focus of the third workshop will be to have participants learn to adapt and enhance their skills to these changes and continue to promote their core partners' readiness for threatening potentially high-impact weather in the future.

References

Alda, A., 2017: *If I Understood You, Would I Have This Look on My Face? My Adventures in the Art and Science of Relating and Communicating.* Random House, 213 pp.

Alley, R. B., K. Emanuel, and F. Zhang, 2019: Advances in weather prediction. *Science*, **363**, 342–344, https://doi.org/10.1126/science.aav7274.

Aurbach, E. L., K. E. Prater, B. Patterson, and B. J. Zikmund-Fisher, 2018: Half-life your message: A quick, flexible tool for message discovery. *Sci. Commun.*, **40**, 669–677, https://doi.org/10.1177/1075547018781917.

Contento, A., H. Xu, and P. Gardoni, 2020: Probabilistic formulation for storm surge predictions. *Struct. Infra. Eng.*, **16**, 547–566, https://doi.org/10.1080/15732479.2020.1721543.

Lazo, J. K., H. R. Hosterman, J. M. Sprague-Hilderbrand, and J. E. Adkins, 2020: Impact-based decision support services and the socioeconomic impacts of winter storms. *Bull. Amer. Meteor. Soc.*, **101**, E626–E639, https://doi.org/10.1175/BAMS-D-18-0153.1.

Morss, R. E., J. Demuth, and J. K. Lazo, 2008: Communicating uncertainty in weather forecasts: A survey of the U.S. public. *Wea. Forecasting*, **23**, 974–991, https://doi.org/10.1175/2008WAF2007088.1.

Murphy, A. H., 1993: What is a good forecast? An essay on the nature of goodness in weather forecasting. *Wea. Forecasting*, **8**, 281–293, https://doi.org/10.1175/1520-0434(1993)0082.0.CO;2.

National Academy of Public Administration, 2013: Forecast for the future: Assuring the capacity of the National Weather Service. NAPA Rep., 137 pp.

National Research Council, 2012: *The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment.* National Academies Press, 120 pp., https://doi.org/10.17226/13216.

NWS, 2017: National Weather Service enterprise analysis report. National Weather Service Rep., 24 pp., www.weather.gov/media/about/Final_NWS%20Enterprise%20Analysis%20Report_June%202017.pdf.

——, 2019: Building a Weather-Ready Nation: 2019-2022 strategic plan. NWS Rep., 28 pp., www.weather.gov/media/wrn/NWS_Weather-Ready-Nation_Strategic_Plan_2019-2022.pdf.

O'Connell, C., M. McKinnon, and J. LaBouff, 2020: One size does not fit all: Gender implications for the design of outcomes, evaluation and assessment of science communication programs. *J. Sci. Commun.*, **19**, A06, https://doi.org/10.22323/2.19010206.

Roy, T., A. Serrat-Capdevila, J. Valdes, M. Durcik, and H. Gupta, 2017: Design and implementation of an operational multimodel multiproduct real-time probabilistic streamflow forecasting platform. *J. Hydroinf.*, **19**, 911–919, https://doi.org/10.2166/hydro.2017.111.

Spolin, V., 1999: *Improvisation for the Theater*. 3rd ed. Northwestern University Press, 412 pp.

Uccellini, L. W., and J. E. Ten Hoeve, 2019: Evolving the National Weather Service to build a Weather-Ready Nation: Connecting observations, forecasts, and warnings to decision-makers through impact-based decision support services. *Bull. Amer. Meteor. Soc.*, **100**, 1923–1942, https://doi.org/10.1175/BAMS-D-18-0159.1.

Zabini, F., V. Grasso, R. Magno, F. Meneguzzo, and B. Gozzini, 2015: Communication and interpretation of regional weather forecasts: A survey of the Italian public. *Meteor. Appl.*, **22**, 495–504, https://doi.org/10.1002/met.1480.