BAMS Article

Is a Consistent Message Achievable?

Defining "Message Consistency" for Weather Enterprise Researchers and Practitioners

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ABSTRACT: Although both research and practice contend that message consistency is a critical component of effective risk communication, neither provide systematic evidence demonstrating if, when, and where consistency matters. For this reason, meteorologists view message consistency as both a relevant research and operational concern. To address these concerns, members of the weather enterprise organized conference sessions, panels, webinars, and workshops to achieve message consistency, but were unable to make progress without a definition. Fortunately, research scholars in the fields of psychology and communication studies offer important theoretical insights for defining message consistency. As such, this paper takes an important first step by combining the needs of operational meteorologists with insights from social science research to offer a definition of message consistency for the weather enterprise. While it is logical to present both a definition *and* a recommendation on how to achieve message consistency, the systematic review revealed various research limitations and practical constraints that call into question the feasibility of achieving it. To further bridge research and practice, this paper recommends that researchers and practitioners collaboratively develop a message consistency evaluation process for the weather enterprise. A persistent community effort will shed light on when, where, and under which circumstances consistency is necessary, and more importantly, move us one step closer toward achieving a *more* consistent message within the weather enterprise.

KEYWORDS: Social Science; Operational forecasting; Broadcasting; Communications/decision making; Risk assessment; Societal impacts

https://doi.org/10.1175/BAMS-D-18-0250.1
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In final form 16 September 2020

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Message consistency, which emerged within the field of warning communication in the early 1990s (see Mileti and Sorensen 1990), remains a critical component of effective risk communication in both research (Sellnow et al. 2009, 28–29, 40; Seeger et al. 2018) and practice (AMS 2001; NAPA 2013; CDC 2014; NOAA 2016; WHO 2020). The challenge, however, is that the current literature does not explicitly define nor explain how practitioners can achieve a consistent message. Further, there are only a few empirical studies to date that have explored message consistency in a weather context (Burgeno and Joslyn 2020; Weyrich et al. 2019). Therefore, the current literature lacks empirical evidence demonstrating that message consistency does in fact affect an individual's risk perception and/or decision-making. Operational meteorologists, on the other hand, have provided anecdotal evidence that suggests their respective audiences perceive message inconsistencies. According to these practitioners, the increased availability of weather information from a variety of expert and amateur sources, social media platforms, and mobile-based devices is likely the cause. Therefore, research and practice both contend that message consistency is important, and yet, neither have systematic evidence pointing to if, when, and, where consistency matters. For this reason, meteorologists view message consistency as both a relevant research *and* operational concern.

With the research literature emphasizing the need for a consistent message, members of the weather enterprise (the public, private, and academic sectors of the weather community) focused their efforts on achieving it. This was accomplished by devoting time and resources to the planning and implementation of conference sessions, panels, webinars, and workshops to establish a dialogue within the weather community, and more broadly, between researchers and practitioners. In particular, these conversations highlighted that marketing and branding differences, both between and within sectors of the enterprise, pose challenges for achieving a consistent message. Broadcast meteorologists, for example, experience tremendous pressure to distinguish themselves from other weather sources (Eosco 2008). These distinctions, such as repurposing common weather products (e.g., the Day 1 Convective Outlook), creating new weather products (e.g., Tornado Index), and/or adhering to other strict station requirements (e.g., use of a specific color palette), may contribute to the nuances associated with achieving a consistent message. Thus, these organized efforts showed that achieving a consistent message is much more complex than initially anticipated. While the current body of literature describes the abstract need for consistency, it never provides concrete clarity for practitioners, and as a result, a definition of message consistency is needed *before* we can consider the feasibility of achieving it in the weather enterprise.

Fortunately, the path toward conceptual clarity lies beyond the weather community in the fields of political, health, and science communication––as their practitioners, like meteorologists, share a common concern for communicating a consistent message. Although an emerging area of research, these disciplines offer empirical evidence acknowledging the implications and effects of inconsistent messages. As such, these disciplines provide guidance on how to approach message consistency in a weather context. Therefore, this paper will 1) explore the recurrent themes and hypotheses that emerged from organized efforts in the weather enterprise, 2) synthesize and connect social science literature to evaluate the validity of the hypotheses put forward by the weather community, and 3) offer a working definition and recommended next steps for weather enterprise researchers and practitioners.

A closer look at the organized efforts in the weather enterprise

Throughout the last four years (2016–19), the weather enterprise has organized various efforts to explore message consistency (Fig. 1). The first documented effort, a panel session at the 2016 American Meteorological Society (AMS) Annual Meeting, sought to establish ground rules to

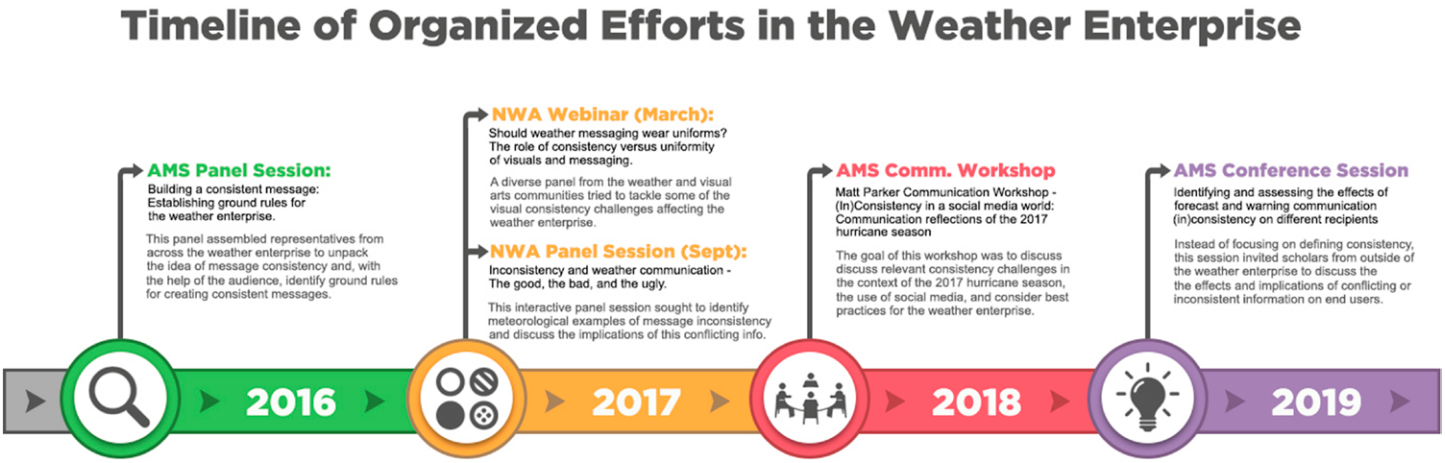

Fig. 1. A timeline of message consistency organized efforts in the weather enterprise.

achieve consistent messaging within the weather enterprise. This diverse group of panelists, which included members from all sectors of the weather enterprise, determined that providing ground rules is difficult without first defining message consistency (Klockow and Jasko 2016). A National Weather Association (NWA) webinar sought to continue the consistency conversation by instead asking, should weather risk messages wear a uniform? Like the previous panel session, the webinar panelists also struggled to conceptualize message consistency. However, using real-world examples, operational meteorologists, broadcast meteorologists, and social scientists agreed that inconsistencies frequently arise when meteorologists use different colors, numbers, and words to communicate severe weather risk information to the public (NWA 2017a).

A follow-up panel session at the 2017 NWA Conference had a different perspective. This panel of public and private sector meteorologists described the need for weather messaging to be unique and different. They emphasized that a one-size-fits-all approach does not work, and that "the same message must be conveyed in multiple ways to ensure that everyone walks away with the same general message" (NWA 2017b). However, the panelists did insist that protective actions provided in weather risk messaging should remain consistent, if not uniform, between sources. Participants at the Matt Parker Communication Workshop, which was held before the 2018 AMS Annual Meeting, also noted that a one-size-fits-all approach would not work. However, these participants essentially integrated the perspectives from the previous efforts by insisting that consistency could be implemented to certain degrees. Using the concept of "flexible consistency," they suggested that specific aspects of weather risk messages should remain consistent. For example, several individuals acknowledged the color discrepancies that exist in the weather enterprise and proposed the use of "a consistent set of colors" (AMS 2018b).

After recognizing commonalities across the organized efforts, each recorded conversation was qualitatively analyzed to illuminate the language and content used to describe message consistency in the weather enterprise. In doing so, this analysis revealed recurring words, phrases, and themes that were used to inform a social science literature review. This methodological approach began with the first author transcribing, analyzing, and examining each recorded conversation via an inductive content analysis (Hsieh and Shannon 2005). If the conference did not provide professional recording services, the author first obtained verbal consent from each participant and then used a personal recording device to document the discussion. The recordings ranged from 60 to 90 min; however, presentations and round table discussions at the Matt Parker Communication Workshop spanned over a 3-h period. Through this qualitative analysis, themes and categories emerged based on words, phrases, or

ideas that repeatedly appeared throughout the transcripts. These themes were then collected into a single document and further connections were made between the responses. A final set of themes was determined after several iterations of collapsing and combining thematic codes. The author then shared the final set of thematic categories with the second author to discuss, synthesize, and combine any redundant codes. These interactive discussions with the second author helped establish intercoder reliability, a measurement commonly used in qualitative research to determine the agreement between two or more independent coders (Lombard et al. 2002). Finally, it should be noted that this analysis does not include the most recent panel session at the 2019 AMS Annual Meeting. However, a separate section in this manuscript is devoted to some of the themes that arose in this panel session on consistency (see the section "Addressing the Effects of Inconsistent Information: Insights from the 2019 AMS Session on Conflicting Information"). For more information about the organized efforts discussed above, please see Table 1.

Five emerging themes from the organized efforts

Although not an exhaustive list, five prominent themes emerged from the content analysis. These data show that members of the weather enterprise frequently mentioned that

- a working definition of message consistency is needed;
- inconsistencies often arise in the individual parts of a message;
- specific message features likely play a role in maintaining consistency;
- protective action information should remain consistent, or even uniform, across messages; and
- a weather authority is needed to help facilitate message consistency within the weather enterprise.

Throughout each and every organized effort, panelists, presenters, and participants remained hyperfocused on defining message consistency (*theme 1*; Klockow and Jasko 2016; NWA 2017a,b; AMS 2018b). Without an established definition, individuals found it difficult to discuss operational best practices, ground rules, and recommendations for approaching consistency in the weather enterprise (Klockow and Jasko 2016). As a result, establishing a working definition emerged as the first compelling theme.

Table 1. The weather enterprise's organized efforts on message consistency.

Name of organized effort	Type of organized effort	No. of participants	Backgrounds represented
Building a consistent message: Establishing ground rules for the weather enterprise (Klockow and Jasko 2016)	Panel session	7	Public sector meteorologists, private sector meteorologists, broadcast meteorologists, social scientists, and emergency managers
Should weather messaging wear uniforms? The role of consistency vs uniformity of visuals and messaging within the weather community (NWA 2017a)	Webinar	5	Public sector meteorologists, broadcast meteorologists, graphic designer, social scientists
Inconsistency and Weather Communication—The Good, the Bad, and the Ugly (NWA 2017b)	Panel session	4	Public sector meteorologists, private sector meteorologists, broadcast meteorologists, and social scientists.
Matt Parker Communication Workshop—(In)Consistency in a Social Media World: Communication Reflections of the 2017 Hurricane Season (AMS 2018b)	Workshop presentations, panel session, and round table discussions	70	Public sector meteorologists, private sector meteorologists, broadcast meteorologists, and social scientists.
Identifying and Assessing the Effects of Forecast and Warning Communication (In)Consistency on Different Recipients (Williams et al. 2019)	Presentation and panel session	5	Health communication scholars, medical professionals, and psychologists.

Without agreement on a definition, panelists sought to redefine the problem by instead asking: what makes a weather message *inconsistent*? Using a severe weather threat as an example, participants explored weather messages and called attention to the parts that often differ across sources (NWA 2017a). While they identified differences in color, number, and word choice as "inconsistent," they felt that maintaining the overarching message (i.e., that a severe weather threat exists) was more important. This discussion exposed a need to strike a delicate balance between allowing differences in the individual parts of a weather message without interfering with the overarching goal of the message (*theme 2*). In other words, at what point do these differences in colors, numbers, or words, for example, promote or hinder the communication of a similar overall message that a weather threat exists?

Maintaining similar message goals across sources in the weather enterprise feels easier than discovering the exact point where differences in the individual parts of a weather message result in inconsistency. This balancing act, then, implies that certain variables or message features may affect the consistency of a message. The challenge, however, is identifying *which* message characteristics are important (*theme 3*). For example, conference panelists frequently emphasized the importance of consistency and, in some instances, argued for uniformity when considering the behavioral or protective action information associated with weather messages (*theme 4*). But, what about other message characteristics? Do other message-related variables result in inconsistencies that interfere with the weather community's mission to protect lives and property?

Beyond the need to establish a working definition and maintain a balance between weather messages, the final theme that emerged was the desire for a weather authority (*theme 5*). Throughout the organized efforts, participants repeatedly asked, *who* is going to help the weather enterprise achieve consistency? Does consistency need a form of enforcement, such as media monitoring? Finally, *who* should identify and recommend best practices to the weather enterprise?

Together, these five themes outline a problem statement relating to message consistency in the weather enterprise. Therefore, the following sections will explore each of these themes in more detail and connect relevant interdisciplinary literature to help contextualize the points that emerged during these organized efforts. By doing so, this manuscript takes an important first step by using insights from social science research and the needs of the operational meteorological community to question the feasibility of communicating a consistent message across the weather enterprise.

Defining message consistency

When members of the weather enterprise were asked to define "message consistency," they fell into two opposing camps: 1) those that equate consistency with uniformity (e.g., no variation in language or visual products; uniform terminology across all platforms) and 2) those that believe similarities between weather messages create consistency (e.g., similar meanings for colors and words; for example, the color red is always used to signify the same level of impact across hazards.). Although a tedious process, obtaining conceptual and definitional clarity of message consistency has numerous implications for the weather community (*theme 1*). Specifically, these dichotomous viewpoints, from members of the weather enterprise, embody different operational goals, challenges, and best practices for alleviating consistency concerns. Therefore, a definition is needed before moving forward. As a starting point, the weather enterprise should ignore the nuances of message consistency and instead consider what "being consistent" means at a fundamental level.

The Oxford English Dictionary (2019) offers two relevant definitions of the term "consistent" that help highlight its basic principles: 1) "Not containing any logical contradictions"

and 2) "Compatible or in agreement with something." The defining feature of the first definition is its use of the word "contradictions," as it implies that the absence of a contradictory statement or message is a key criterion for maintaining consistency. The fields of philosophy and logic share this argument in their abstract understanding of consistency. According to Wolfram (1989), a set of separate sentences is said to be consistent if and only if there is at least one possible situation in which they are all simultaneously true. For example, statements like "it is raining outside right now" and "it is cloudy outside right now" would be categorized as consistent because it could be both cloudy and raining at the same time. However, instead of emphasizing consistency, philosophers and logicians find more value in defining, identifying, and resolving inconsistencies (Dowden 2019).

Wolfram (1989) points out two types of inconsistent statements: contradictories and contraries. Contradictory statements represent a stronger type of inconsistency because the truth of one statement results in the falsity of the other. For example, consider these sentences: 1) Oklahoma City is at risk for severe weather tomorrow at 5:00 p.m. and 2) Oklahoma City is *not* at risk for severe weather tomorrow at 5:00 p.m. The example statements above are *contradictory*, because they cannot both be true and cannot both be false. *Contrary* statements, on the other hand, occur when two sentences cannot both be true but *can* both be false (Wolfram 1989). For example, consider numerical weather prediction and ensemble forecasting. Instead of a single forecast, ensemble forecasting produces a wide range of possible future states of the atmosphere. Because there can only be one future state, all of the ensemble forecasts cannot be true; however, they could also all be false, as the weather event may not adhere to any of the ensemble forecast's future states and could result in a completely different outcome. Like an ensemble forecast, then, contrary statements or messages cannot both be true but can both be false. Although informative, this basic interpretation of inconsistency—as deriving from contradictory or contrary statements—does not address all of the operational constraints and complexities that exist in the weather enterprise. However, it does offer a building block and key criterion for establishing a conceptual definition of message consistency: contradictions or conflicts often result in inconsistency.

The Oxford English Dictionary's (2019) second relevant definition describes "consistent" as "compatible or in agreement with something." Although sharing similar characteristics with the previous definition, as it describes the need for logical agreement, this definition uniquely identifies a secondary requirement: a subject, object, trait, behavior, feature, or attribute that must be evaluated for consistency. This ambiguous "something" ultimately prevents the weather community from establishing a definition of message consistency and agreeing on best practices. During the 2016 AMS Panel Session, for example, Dr. Gina Eosco grappled with the definition of consistency and attempted to pinpoint the "something" that the weather community needs to evaluate the consistency between two messages:

> If we don't mean identical, then what do we mean by [consistency]? Do we mean similar? Similar doesn't mean identical, but it means that part of the message is similar but not necessarily all of it. Therefore, what part of the message do we want to be similar? The science part? The design part? The words that we use? (Dr. Gina Eosco, Klockow and Jasko 2016)

This perspective closely mimics a definition put forward by the weather enterprise, and highlights that certain parts of a message may need to be similar to attain consistency.

However, in the same panel session, a broadcast meteorologist acknowledged the importance of key messages and described message consistency from a broader, more encompassing viewpoint. Dr. Josh Eachus stated:

> One [person] might watch my competitor, because he/she likes the way he looks better, likes the way he speaks better, or likes the way he delivers the weather [information] better. But, if we have the same message, maybe worded a bit differently, but still get the same points across, then that is consistency in the message. So, consistency or harmony in the key points, [even though] we might all word it differently. (Klockow and Jasko 2016)

Together, these competing perspectives highlight that the key to message consistency lies in the similarities between messages. Identifying and determining which similarities are the most important, however, is more challenging. Based on conversations in the community, the criteria (i.e., the "something") for evaluating a weather message's consistency is best described as a spectrum of possibilities ranging from messages that use different words but exhibit a similar goal (i.e., to inform the end user of a weather threat) to messages that must retain certain parts (e.g., words, colors, numbers). Therefore, a question and recurring theme emerges: What is more important, maintaining consistency in the key points or ensuring that parts of the message remain consistent across the weather enterprise (*theme 2*)? The next section will explore this notion further, utilizing both extant social science literature and previous conversations in the weather enterprise.

Inconsistencies often arise in the individual parts of a message

Risk communication is important to operational meteorologists; as such, understanding how changes in the different parts of a message (e.g., color, numbers, words) affect the communication of a similar overall message is at the core of their questions. Communication scholars share this interest in a message's discrete parts, as they frequently break down persuasive messages, manipulate a part of the message, and determine its effect on attitude and/or information processing (Shen and Bigsby 2013). As a result, the communication and persuasion literatures identify and describe the different parts of a message as "message elements," "message features," or "message characteristics." Although their conceptual definition often varies between studies, Shen and Bigsby (2013) offer three broad categories of message features: 1) the content (i.e., what the message is about), 2) the structure (e.g., number of arguments the message contains, presence of counterarguments), and 3) the style (e.g., word choices, visual design, music; Shen and Bigsby 2013). More importantly, this literature offers clear evidence that message features significantly affect persuasive outcomes (for review, see O'Keefe 2018). One could argue, then, that when a weather source alters the features of a message (e.g., color, numbers, words, etc.), it likely also impacts the consistency of the overall message.

Like the persuasive communication literature, psychologists are also interested in the relationship between the general and the specific. However, the psychological literature offers more insight into how people process conflicting or inconsistent information. For example, in medical settings, doctors who examine a patient's symptoms holistically accurately diagnose a patient more often than those who analyze the individual symptoms (Reyna 2008). Fuzzy-trace theory—a psychological theory of cognition that explores the relationship between memory encoding and reasoning processes—provides context as to why. At its core, this theory explains that individuals separately and simultaneously encode two types of representations when presented with any kind of information (Rahimi-Golkhandan et al. 2017). Like the weather community's distinction between the parts of a message and its key points, the two types of representations associated with fuzzy-trace theory vary in precision from detailed *verbatim* traces to vague *gist*. Although these conceptual definitions do not quite match those put forward by meteorologists, there are clear connections that warrant further exploration of fuzzy-trace theory.

According to previous studies, individuals exhibit a fuzzy processing preference (Reyna and Adam 2003), meaning they rely heavily on and prefer gist representations of risk

when performing judgement and decision-making tasks (Reyna 2012). However, gist representations may not always lead to the best risk interpretations. Women, for example, often underestimate their risk of cardiovascular disease because they presume older men are more at risk (Reyna and Adam 2003). Weather risk perception is also plagued by gist representations, as people often overestimate or underestimate their risk of experiencing various weather hazards (Hoekstra et al. 2011). Although individuals mostly benefit from gist representations when making decisions, the research in this area has yet to consider the role of conflicting or inconsistent messages. This presents more questions than answers. For example, while people prefer to process information holistically, would conflicting or inconsistent information prompt individuals to look more closely at the details? A related area of research, known as memory suggestibility and interference (Reyna and Brainerd 1995), provides some evidence that this may be true.

Memory suggestibility and interference research aims to understand whether misleading or contradictory information impacts an individual's recollection of a given event. Similar to the manipulation of certain message features in the communication and persuasion literatures, these studies often alter specific details about an event to determine its effect on memory recall (e.g., changing the color of the car involved in an accident; Reyna and Brainerd 1995). Although previous fuzzy-trace theory studies have acknowledged that individuals prefer and rely on gist representations when making decisions, by manipulating the details of an event and affecting an individual's ability to recall that event, these studies demonstrate that verbatim details matter. In fact, whether an individual relies on a gist or verbatim representation is a function of time. Individuals can recall and rely on verbatim details in the short term, but after a delayed period of time, only gist representations remain (Reyna and Kiernan 1994). As a result, differences in the details or features of a message likely have the most impact on message consistency in the short term. This becomes important as individuals search for more information after seeing a weather message (for review, see Wood et al. 2017). Consider, for example, that two local news stations use different color schemes to convey the same severe weather risk (Fig. 2). If an individual were to see TV Station A's graphic and then change the channel and see the graphic produced by TV Station B, according to the memory suggestibility literature outlined above, the individual would likely be able to remember the verbatim details

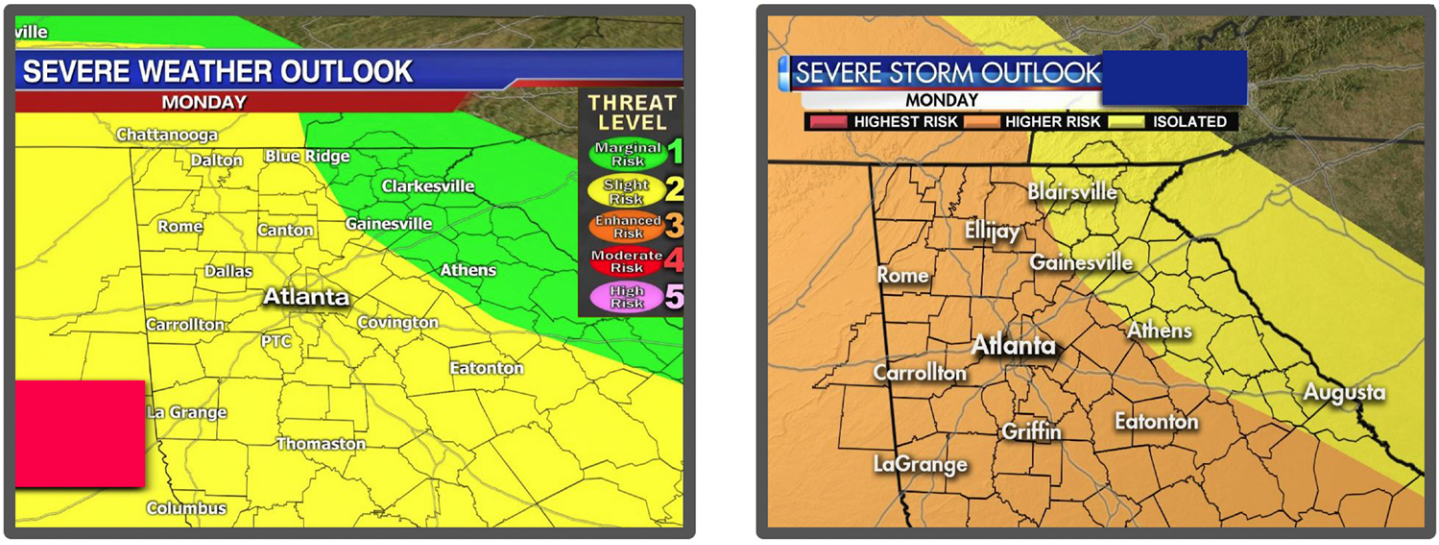

Fig. 2. An example of two local news stations using different colors schemes to convey the same severe weather risk. Local news station graphics were taken from the same 0800 UTC run of the Storm Prediction Center's Day 3 Convective Outlook on 17 May 2018.

of both severe weather graphics (i.e., the color scheme; Reyna and Brainerd 1995). As a result, the weather community's speculation that color and other message features may "get in the way" of communicating a consistent message becomes more noteworthy:

> The colors seem to be the first thing people notice and if we or some middle school blogger has a color that is different or a word that is different, it comes back to 'Well, who do I trust? Your opinions are different.' In this case, *sometimes the details get in the way* of saying: 'Hey, today is the day that you've got to watch out for either severe thunderstorms, fire weather, or [other extreme weather].' (emphasis added; Tim Brice, NWA 2017a)

Taken together, the communication and psychological literatures call attention to both the key points and the parts of a message. While these literatures do not explicitly reference message consistency, as their findings pertain to memory encoding, reasoning, and persuasion processes, they do offer some evidence that manipulating parts of a message may affect the overall takeaway message. Therefore, inconsistent message features or verbatim details may, in fact, stand in the way of communicating a consistent overall message. The psychological literature explains that this relationship may depend on time, such that individuals may evaluate the consistency between messages using message features or verbatim details (e.g., colors, words, and numbers) in the short term and the key points in the long term. As a result, both the key points *and* the parts of a message may be important when evaluating the consistency of weather messages. The challenge, however, is identifying the message features that may interfere with the consistency of two or more weather risk messages. For example, meteorologists, psychologists, and communication scholars alike share a common concern about color inconsistencies. Apart from the use of conflicting colors, what other message features might interfere with the weather enterprise's mission to protect lives and property? In search of answers, the next section will explore a specialized area of health communication known as conflicting information.

The role of specific message features in maintaining a consistent message

The weather enterprise is not isolated in its concern for communicating a consistent message. In fact, the fields of political, health, and science communication similarly struggle to conceptually define "message consistency" and identify the specific message features that affect it. However, these disciplines have slowly begun to untangle and explore these topics in a specialized area of health communication known as "conflicting information" (for review, see Nagler and LoRusso 2017). While often described as conflicting messages in the literature, they are variously termed competing, contradictory, inconsistent, mixed, or divergent messages. Within the last decade, however, health communication scholars have sought to refine the definition of conflicting information by offering two distinct conceptualizations. The weather enterprise can use these definitions to 1) better understand how to conceptually define message consistency and 2) discover message features that may be important for maintaining consistency.

The nascent literature identifies two broad conceptual definitions of conflicting health messages. First, conflicting information can be categorized as *decisional conflict,* or as Nagler (2010, p. 55) describes, "messages that provide information about two distinct behaviors and their effects on the same outcome." During the 2013 El Reno tornado, for example, members of the public reported receiving messages from different sources that recommended conflicting protective actions (NWS 2013). According to the NWS (2013), some individuals received a message suggesting they should shelter in place, while others reported receiving instructions that they should evacuate if they could not shelter underground. Although both messages consistently emphasized the dangers and the likelihood of the impending tornado

threat, they differed by providing two distinct behavioral actions. If an individual were exposed to both messages, they would be forced to decide whether to 1) take shelter now, 2) evacuate to another town, or more likely, 3) search for additional information to clarify the conflicting behavioral information (Lindell and Perry 2012).

The second conceptual definition of conflicting information is best described as *informational conflict*. Informational conflict, as Carpenter et al. (2015, p. 1175) outlines, "can be operationally defined as two or more health-related statements or assertions that are logically inconsistent with one another." For example, suppose an individual looks for the latest snow forecast and comes across a NWS visual graphic indicating that their area will likely receive 4–6 inches of snow tomorrow. That same individual then seeks additional information (e.g., watching their favorite local broadcast meteorologist) and is exposed to a different snow forecast graphic, this one suggesting that their area will receive 8–10 inches of snow tomorrow. Here, the forecast information is logically inconsistent and forces the individual to decide whether they should 1) trust the government source, 2) trust their local broadcast meteorologist, or more likely, 3) search for additional information to clarify the conflicting information (Lindell and Perry 2012).

These two conceptual definitions hint at several themes raised throughout previous consistency efforts. In particular, the weather enterprise has struggled to identify the message features that might lead to a message being perceived as inconsistent (*theme 3*). The 2016 AMS Panel Session (Klockow and Jasko 2016) offers a prime example of this dilemma. During an exchange, Dr. Kimberly Klockow-McClain pushed the panelists to describe their interpretation of "having the same message." Through this conversation, several key message features arose:

> You said something really interesting back there. We can all say different things, but still all have the same message. What do you think the 'message' means, then? If it's not about the words or the appearance, then what are you defining the 'message' to be? (Dr. Kimberly Klockow McClain, Klockow and Jasko 2016)

> The action that we're recommending you make in a situation… If we all inspire the same [action], that's consistency but not necessarily [using a] bland, boring, same exact message. (Dr. Josh Eachus, Klockow and Jasko 2016)

> Let me define it a little differently. As opposed to the same action, what about inspiring the same feeling of risk?" (Justin Accardo, Klockow and Jasko 2016)

Like the discussion above, some members of the weather enterprise argue that the communication of risk information can be inconsistent, while others focus on the behavioral components of a message. However, according to the conceptual definitions offered by the conflicting information literature, both the risk information and the recommended actions can be inconsistent.

Throughout previous consistency conversations in the meteorological community, the role of decisional conflict or the need for decisional consistency has remained a recurrent theme (*theme 4*; Klockow and Jasko 2016; NWA 2017b; AMS 2018b). During the NWA panel session (NWA 2017b), for example, participants explicitly acknowledged the need for consistency (if not uniformity) when sharing protective action statements during a weather event:

> Perhaps there are many parts of the message. So there's the risk aspect that maybe we can be a little bit different on, but at least in this case [we are] consistent that it is, indeed, a tornado. But, it sounds like what you're saying is the efficacy message, the protective action part of the message, may be the most critical [part of the message] where we should be in melody with one another versus perhaps harmony. (Dr. Gina Eosco, NWA 2017b)

Several of the organized efforts strongly echoed this sentiment, highlighting the importance of the recommended actions or behavioral dimensions of a message (also known as self-efficacy and response efficacy among communication scholars; Table 2; for review, see Meczkowski and Dillard 2017). Therefore, this message feature is likely essential when evaluating message consistency in the weather enterprise.

Table 2. Message-related variables in the risk communication and fear appeals literature. Definitions taken from Meczkowski and Dillard (2017).

Message-related variable	Definition
Susceptibility	Information that references the likelihood that the individual will experience these consequences.
Severity	Information that is relevant to the undesirable consequences of an external threat.
Response efficacy	The belief that the advocated recommendation will constitute an effective response to the external threat.
Self-efficacy	The belief concerning an individual's ability to execute the recommended response.

Although less tangible and more elusive to pinpoint, the risk information provided in a weather message is also an important message feature to consider. For example, meteorologists often vocalize their concerns of inconsistent risk messaging during severe weather events (i.e., severe thunderstorms and/or tornadoes) when visual graphics use "different colors, different words, different numbers, and different categories" to communicate a uniform threat (Rick Smith, NWA 2017a; Fig. 3). These visual inconsistencies are thought to be very confusing for members of the public and may, in fact, alter an individual's interpretation of their severe weather risk:

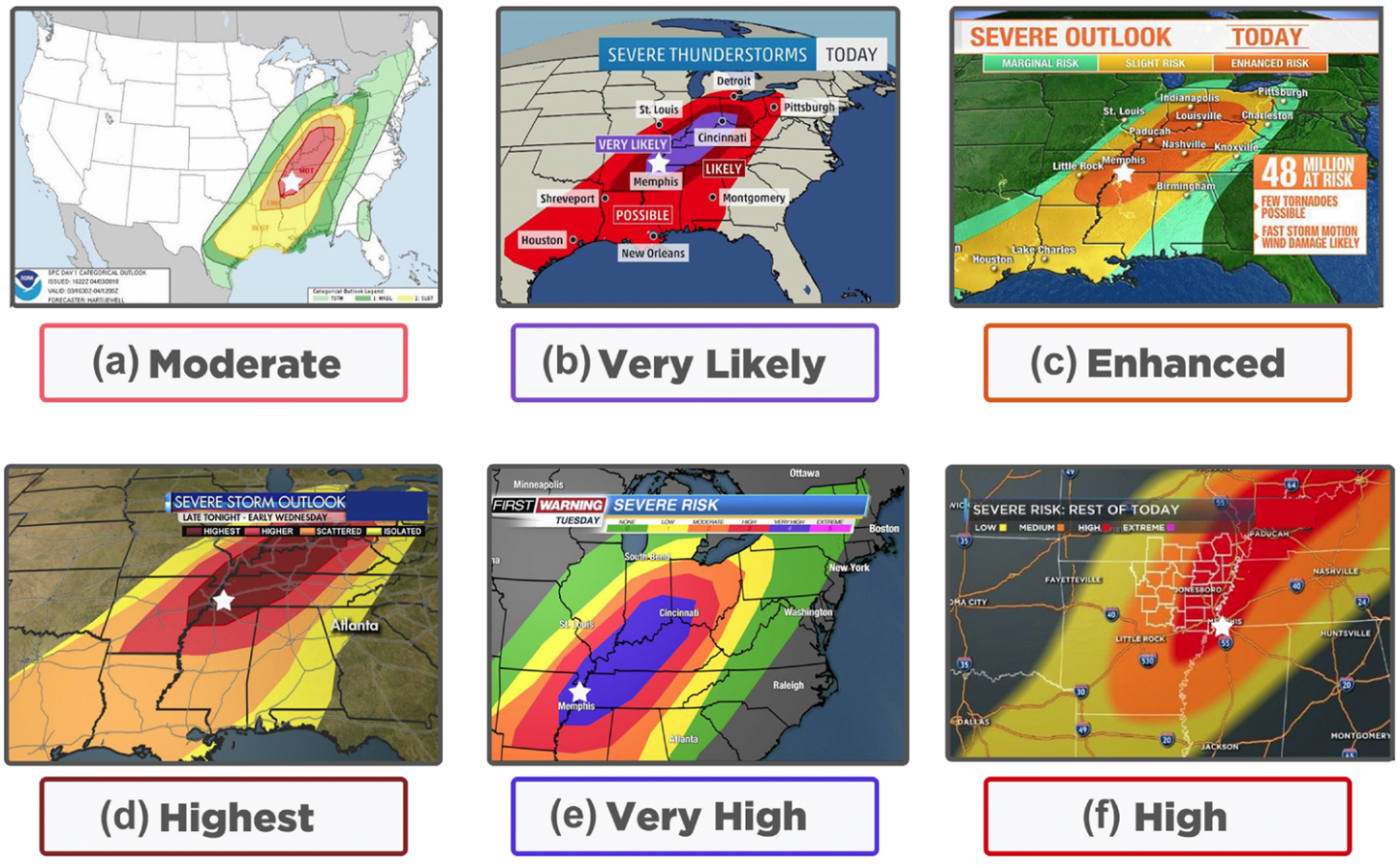

Fig. 3. A variety of Convective Outlook graphical designs that differ from the Storm Prediction Center's graphic by using different colors, risk language, and spatial risk contours. The star indicates Memphis, Tennessee, across all graphics for comparison purposes. All graphics were taken from the 2000 UTC run of the Storm Prediction Center's Day 1 Convective Outlook on 3 April 2018.

> There are a lot of ways that [severe weather] is being messaged out there. We occasionally hear from people that say, 'Well I don't know, I'm in the orange on this channel and purple on this channel, and you're telling me I'm in yellow. I don't think any of you know what's going to happen because none of you can agree on your wording or how you're conveying the information.' So that happens anytime we have severe weather, we'll hear comments about that. (Rick Smith, NWA 2017a)

Therefore, like the behavioral dimensions described above, some message features also correspond to the dimensions of risk information (also known as susceptibility and severity to communication scholars; Table 2; for review, see Meczkowski and Dillard 2017). As a result, the conflicting information literature acknowledges that both the efficacy and risk portions of a message are critical for evaluating whether two weather messages are consistent.

Beyond the basic understanding that these message features are likely important for maintaining consistency, the cognitive and behavioral significance of changing these message features deserves more attention. Previous meteorological research, for example, has shown that altering a message feature has implications on risk perception and behavioral intentions (Klockow 2013; Eosco 2014; Rickard et al. 2017). Rickard et al. (2017) varied the type of visual information participants received about a hurricane risk. This experimental study revealed that including a single, real-life photograph in a hurricane risk message produced higher risk perceptions and behavioral intentions to evacuate, in comparison to showing a map or no visual information at all. These results show that changing a message feature has cognitive and behavioral repercussions. However, two important questions remain: 1) Which message features are the most important when considering the consistency between two weather messages? 2) Is there a tipping point where differences in these message features affect an individual's risk perception and/or behavioral intentions? Although the conflicting health information literature has yet to address these important questions, it does offer some evidence regarding the implications of conflicting or inconsistent information. Therefore, the next section will explore both the positive and negative effects of conflicting messages.

Addressing the effects of inconsistent information: Insights from the 2019 AMS session on conflicting information

Until this point, conversations in the weather community have remained very abstract and fixated on defining consistency. As a result, the implications or effects of inconsistent messages have not received much discussion in the weather enterprise. However, after discovering the conflicting information literature and connecting with several scholars in this field, AMS held a presentation and panel session strictly devoted to the effects of inconsistent information on end users at its 2019 annual meeting (Williams et al. 2019). Here, presenters were able to provide insight on the prevalence, causes, and effects of inconsistent information from their respective fields.

The prevalence of conflicting information has been shown to vary by topic, with previous studies reporting that anywhere from 18% to 80% of people have received conflicting health information (Carpenter et al. 2010, 2014; Hämeen-Anttila et al. 2014; Nagler 2014; Niederdeppe and Levy 2007; Taplin et al. 1997). Despite the assumption that conflicting information confuses members of the public, few studies have been devoted to demonstrating the cognitive and behavioral effects of conflicting information—an area where health communication scholars have begun to thrive. Previous research in this area, for example, has revealed that conflicting information increases feelings of anxiety (Hämeen-Anttila et al. 2014; Pollock et al. 2004), alters risk perceptions (Han et al. 2006), affects a patient's ability to assess the reliability of sources (McIntosh and Shaw 2003), causes public confusion and decreased

trust in nutrition recommendations (Lee et al. 2017; Nagler 2014), and reduces the use of and adherence to medications (Carpenter et al. 2010, 2014; Hämeen-Anttila et al. 2014).

Evidence from the conflicting information literature has acknowledged the negative effects of exposure to inconsistent information, but does it provide any benefits? During the Matt Parker Communication Workshop (AMS 2018b), one participant asked this provocative question, suggesting that forecasters could use inconsistencies to communicate uncertainty:

> Instead of considering inconsistency as harmful, in actuality, could it be helpful? Does inconsistency among messages or graphics better convey inherent uncertainty associated with the forecast? (AMS 2018b)

The same question arose during the 2019 AMS Session, where conflicting information scholars agreed with this assessment—noting the informational value of inconsistency to convey scientific disagreement (Williams et al. 2019). However, they warned that in order for this implicit scientific uncertainty to be valuable, purposive inconsistencies must be eliminated:

> I think we need to reduce reducible uncertainty and reduce reducible conflict—especially if it is being created for commercial reasons. [For example,] weather stations competing with one another for eyeballs. That we need to get rid of, but some of this conflict is just scientific uncertainty. We are never going to make that go away. (Dr. Paul Han, Williams et al. 2019)

Given the discussion above, communicating scientific uncertainty may actually be a larger consistency problem. Dr. Paul Han hints at this point when he describes the two types of consistency affecting the weather community: 1) conflict and uncertainty that results from inconsistencies in the messaging and 2) conflict and uncertainty that results from scientific uncertainty. Although we cannot escape scientific uncertainty or the challenges associated with communicating uncertainty information, we *can* reduce any unnecessary conflicting information within our weather risk messaging. Therefore, the drawbacks and benefits of inconsistency, outlined above, will be critical as meteorologists create and refine strategies for crafting consistent messages in the weather enterprise.

A working definition of message consistency in the weather enterprise

The social science literature reviewed in this manuscript clearly articulates that message inconsistency matters in some contexts. What is missing, then, is an understanding of *when*, *where*, and *under which circumstances* consistency matters, and equally, where it does not. This lack of conceptual understanding is likely responsible for the tension the operational meteorology community feels between achieving message consistency and distinguishing their forecast from other sources (i.e., through their respective marketing and branding). In the absence of a working definition then, "message consistency" tends to adopt the qualities of uniformity, thereby instantly eliminating any differences found across weather messages. In theory, uniformity feels more concrete and easily attainable. Using identical messages in practice, however, calls into question the value of having a *diverse* weather enterprise. Although the previous section outlined literature that demonstrates the negative consequences of inconsistent information, message uniformity also creates impracticality.

Drawing on the social science literature outlined in this paper, and the need to strike a balance between research and practice, *we define message consistency as two or more weather messages that must attain an optimal amount of similarity without producing any negative or adverse effects. By definition, then, the messages must convey the same overall message, even though their individual features may differ.* Weather risk communication is complex; as such, this definition does not account for all of its intricacies. However, the simplicity of

this definition is purposeful, as it takes into consideration the evolution and uncertainty of weather forecast messages.

Although this definition offers a constructive way to conceptualize message consistency, it does not yet address how to achieve it. While it is logical to present both a definition *and* a recommendation on how to achieve message consistency, this systematic review revealed various research limitations and practical constraints that call into question the feasibility of achieving it. As stated above, current research does not yet have a full understanding of when, where, and under which circumstances message consistency matters, and equally, where it does not. Without this knowledge, the current body of literature is unequipped to offer advice on how practitioners and operational meteorologists can achieve a consistent message. Therefore, as a next step, it is recommended that researchers and practitioners work together to identify the bounds of message consistency and consider how to best integrate these research findings into practice.

In addition to these research gaps, there are also practical constraints that challenge the feasibility of achieving a consistent message at this time. For example, while it is ideal to assess end user perceptions prior to sharing a weather risk message, practitioners often do not have the time and/or resources to evaluate message consistency, especially in real-time as new messages become available. As such, we further pose that achieving message consistency requires a dynamic evaluation process to determine whether two or more weather messages are consistent with one another. At this time, however, this process is informal and ad hoc and needs more development. Therefore, after identifying when, where, and under which circumstances message consistency matters, it is strongly recommended that both the researcher and practitioner communities collaborate to design, iterate, and develop a message consistency evaluation process. It is only through this blended process that both the fast-paced nature of operational meteorology, and the findings from ongoing social science research, can be combined to accommodate these practical constraints and set the stage for achieving a more consistent message in the weather enterprise.

Moving forward: Recommendations for the weather enterprise

Moving forward, we invite and encourage the research and practitioner communities to critique and refine the definition offered in this manuscript, collaborate on research initiatives to further explore message consistency among both meteorologists and their respective end users, and work together to create research-guided best practices. As such, we offer the following recommendations to the weather enterprise:

Establish and support a new research agenda. Although previous studies (for review, Nagler and LoRusso 2017; Weyrich et al. 2019; Burgeno and Joslyn 2020) offer some initial insights on message consistency, the current literature concentrates more on theory as opposed to providing practical advice on how to deliver a consistent message. However, with a working definition of message consistency, there is an opportunity for the weather enterprise to establish a new research agenda that aims to identify the bounds of message consistency and addresses the practicality of a message consistency evaluation process. Therefore, the following research questions are offered for further inquiry: 1) How do meteorologists, members of the public, partners, and other end users describe message inconsistencies? How are these descriptions similar or different, and why? 2) Which message features are *the most important* for achieving consistency and subsequently minimizing any negative or adverse effects on individuals? 3) Do changes in the stylistic features of a message (e.g., color, word choice) affect an individual's interpretation of the overall message? If so, how and in what ways? 4) At what point do differences in these message features affect an individual's risk perception and/or behavioral intentions?

Form an ad hoc committee to develop enterprise-wide best practices. Even when the weather enterprise obtains research findings that point to when, where, and under which circumstances message consistency matters, there are still practical constraints that must first be considered before practitioners can evaluate the consistency of weather risk messages in real time. For example, a message consistency evaluation process would be useful when comparing and contrasting a limited number of messages; however, weather events are always evolving and constantly generating a stream of new information. Therefore, evaluating and implementing message consistency on a larger scale will require further guidance. Previous consistency conversations, for example, have highlighted the desire for a "weather authority," with many recommending that the National Weather Service should lead the charge and help facilitate message consistency across the weather enterprise (*theme 5*; Klockow and Jasko 2016). Given the different roles and responsibilities of each sector; however, it is unlikely that any one sector can (or should) create standards and force others to comply with those rules. Instead, we recommend that the weather enterprise come together as a community to consider relevant research and propose best practices.

Pulling from various committees (e.g., NWA Committee on Societal Impacts), boards (e.g., AMS Board on Enterprise Communication), organizations (e.g., Natural Hazards Center), and outside experts (e.g., risk communication experts, linguists, graphic designers), the weather enterprise could form a diverse and representative ad hoc committee to explore message consistency from an enterprise-wide perspective. This strategy is adapted from the field of warning communication, where warning safety signs, labels, and placards once lacked a consistent visual design. To overcome these consistency challenges, private sector companies collaborated and developed voluntary standards that helped establish a consistent warning graphical format (Wogalter et al. 1999). Drawing on their successes, an ad hoc committee could consider the strengths and weaknesses of developing voluntary graphical standards for weather-related graphics (e.g., uniform colors, risk language) and other enterprise-wide best practices that promote message consistency in the weather community.

Conclusions

Like the field of warning communication, the meteorological community values the importance of consistent weather risk messaging. As such, understanding how to "achieve" message consistency and what encompasses it are critical areas of interest within the weather enterprise. Research scholars in the fields of psychology and communication studies, for example, offer important theoretical insights that highlight the need for a consistent message in our community. What deserves more attention, however, is 1) whether end users perceive inconsistencies in our weather risk messaging and, if so, 2) when, where, and under which circumstances consistency matters, and equally, where it does not. Only then will operational meteorologists, weather enterprise practitioners, and other message designers have the knowledge they need to create and construct more consistent weather risk messages.

As a first step toward addressing this gap in both research and practice, this paper combines the needs of operational meteorologists with insights from social science research to offer a definition of message consistency to the weather enterprise. It is our hope that by providing a definition, weather enterprise researchers will be able to measure end user perceptions of message consistency and, in the process, more explicitly explore the bounds of this construct and consider how to best integrate these research findings into practice. Further, this paper also recommends that researchers and practitioners collaboratively develop a message consistency evaluation process. While this recommendation gives the impression that consistency is achievable, the constant influx of new weather messages calls into question the practicality of achieving consistency on a larger scale. For this reason, we emphasize that achieving consistency is a dynamic and evolving process that requires the full participation of the entire

weather enterprise. To work toward this common goal, we ask that the research and practitioner communities' critique and refine the definition offered in this manuscript, collaborate on research initiatives to further explore message consistency among both meteorologists and their respective end users, and work together to develop research-guided best practices. A persistent community effort will shed light on when, where, and under which circumstances consistency is necessary, and more importantly, move us one step closer toward achieving a *more* consistent message within the weather enterprise.

Acknowledgments. The authors thank Margaret Orr, Alison Banks, Kathleen Edwards, Dr. Andrew Grundstein, Dr. Jiyeon So, Jennifer Sharp, and three anonymous reviewers for their constructive feedback on the manuscript. The first author (CAW) would like to acknowledge the support of the National Science Foundation Graduate Research Fellowship (Grant DGE-1443117) and the National Oceanic and Atmospheric Administration's Office of Atmospheric Research and the Office of Weather and Air Quality in the completion of this work (Grant NA18OAR4590366). Any opinions, findings, conclusions, or recommendations expressed in this manuscript are those of the authors and do not necessarily reflect the views of the National Science Foundation or the National Oceanic and Atmospheric Administration. Disclosure Statement: At the time of writing this manuscript, Author Eosco would like to acknowledge that she was employed at an office that funded author Williams; however, she removed herself from reviewing grant proposals involving him to avoid a conflict of interest.

References

AMS, 2001: Expectations concerning media performance during severe weather emergencies. *Bull. Amer. Meteor. Soc.*, **82**, 705–707, https://doi.org/10.1175/1520-0477(2001)082<0701:ASSTIC>2.3.CO;2.

——, 2018b: (In)consistency in a social media world: Communication reflections of the 2017 hurricane season. *Matt Parker Communication Workshop*, Austin, TX, Amer. Meteor. Soc., https://annual.ametsoc.org/2018/index.cfm/programs/short-courses-workshops/workshop-the-matt-parker-communication-workshop-on-consistent-weather-messaging/.

Burgeno, J. N., and S. L. Joslyn, 2020: The impact of weather forecast inconsistency on user trust. Wea. Climate Soc., 12, 679–694, https://doi.org/10.1175/WCAS-D-19-0074.1.

Carpenter, D. M., R. F. DeVellis, E. B. Fisher, D. M. DeVellis, S. L. Hogan, and J. M. Jordan, 2010: The effect of conflicting medication information and physician support on medication adherence for chronically ill patients. *Patient Educ. Couns.*, **81**, 169–176, https://doi.org/10.1016/j.pec.2009.11.006.

——, E. A. Elstad, S. J. Blalock, and R. F. DeVellis, 2014: Conflicting medication information: Prevalence, sources, and relationship to medication adherence. *J. Health Commun.*, **19**, 67–81, https://doi.org/10.1080/10810730.2013.798380.

——, L. L. Geryk, A. T. Chen, R. H. Nagler, N. F. Dieckmann, and P. K. Han, 2015: Conflicting health information: A critical research need. *Health Expect.*, **19**, 1173–1182, https://doi.org/10.1111/hex.12438.

CDC, 2014: Crisis and emergency risk communication. Centers for Disease Control and Prevention, 462 pp., https://emergency.cdc.gov/cerc/resources/pdf/cerc_2014edition.pdf.

Dowden, B. H., 2019: Logical Reasoning. 585 pp., www.csus.edu/indiv/d/dowdenb/4/logical-reasoning-archives/Logical-Reasoning-2020-05-15.pdf.

Eosco, G. M., 2008: A study of visual communication: Cyclones, cones, and confusion. M.S. thesis, Dept. of Communication, Cornell University, 153 pp., https://hdl.handle.net/1813/11170.

——, 2014: Exploring risk and uncertainty perceptions in weather broadcasts using real-time response to measure visual effects. Ph.D. dissertation, Cornell University, 169 pp., https://hdl.handle.net/1813/39337.

Hämeen-Anttila, K., H. Nordeng, E. Kokki, J. Jyrkkä, A. Lupattelli, K. Vainio, and H. Enlund, 2014: Multiple information sources and consequences of conflicting information about medicine use during pregnancy: A multinational internet-based survey. *J. Med. Internet Res.*, **16**, e60, https://doi.org/10.2196/jmir.2939.

Han, P. K., R. P. Moser, and W. M. Klein, 2006: Perceiving ambiguity about cancer prevention recommendations: Relationship to perceptions of cancer preventability, risk, and worry. *J. Health Commun.*, **11**, 51–69, https://doi.org/10.1080/10810730600637541.

Hoekstra, S., K. Klockow, R. Riley, J. Brotzge, H. Brooks, and S. Erickson, 2011: A preliminary look at the social perspective of warn-on-forecast:

Preferred tornado warning lead time and the general public's perceptions of weather risks. *Wea. Climate Soc.*, **3**, 128–140, https://doi.org/10.1175/2011WCAS1076.1.

Hsieh, H. F., and S. E. Shannon, 2005: Three approaches to qualitative content analysis. *Qual. Health Res.*, **15**, 1277–1288, https://doi.org/10.1177/1049732305276687.

Klockow, K. E., 2013: Spatializing tornado warning lead-time: Risk perception and response in a spatio-temporal framework. Ph.D. dissertation, University of Oklahoma, 155 pp.

——, and S. A. Jasko, 2016: Building a consistent message: Establishing ground rules for the weather enterprise. *11th Symp. on Societal Applications,* New Orleans, LA, Amer. Meteor. Soc., PD2.1, https://ams.confex.com/ams/96Annual/webprogram/Paper290526.html.

Lee, C. J., R. H. Nagle, and N. Wang, 2017: Source-specific exposure to contradictory nutrition information: Documenting prevalence and effects on adverse cognitive and behavioral outcomes. *Health Commun.*, **33**, 453–461, https://doi.org/10.1080/10410236.2016.1278495.

Lindell, M. K., and R. W. Perry, 2012: The protective action decision model: Theoretical modifications and additional evidence. *Risk Anal.*, **32**, 616–632, https://doi.org/10.1111/j.1539-6924.2011.01647.x.

Lombard, M., J. Snyder-Duch, and C. C. Bracken, 2002: Content analysis in mass communication: Assessment and reporting of intercoder reliability. *Hum. Commun. Res.*, **28**, 587–604, https://doi.org/10.1111/j.1468-2958.2002.tb00826.x.

McIntosh, A., and C. F. Shaw, 2003: Barriers to patient information provision in primary care: Patients' and general practitioners' experiences and expectations of information for low back pain. *Health Expect.*, **6**, 19–29, https://doi.org/10.1046/j.1369-6513.2003.00197.x.

Meczkowski, E. J., and J. P. Dillard, 2017: Fear appeals in strategic communication. *The International Encyclopedia of Media Effects*, Wiley, 9 pp., https://doi.org/10.1002/9781118783764.wbieme0160.

Mileti, D. S., and J. H. Sorensen, 1990: Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. Tech. Rep. ORNL-6609, Oak Ridge National Laboratory, 159 pp., https://doi.org/10.2172/6137387.

Nagler, R. H., 2010: Steady diet of confusion: Contradictory nutrition messages in the public information environment. Ph.D. dissertation, University of Pennsylvania, 300 pp.

——, 2014: Adverse outcomes associated with media exposure to contradictory nutrition messages. *J. Health Commun.*, **19**, 24–40, https://doi.org/10.1080/10810730.2013.798384.

——, and S. M. LoRusso, 2017: Conflicting information and message competition in health and risk messaging. *Encyclopedia of Health and Risk Message Design and Processing*, https://doi.org/10.1093/acrefore/9780190228613.013.292.

NAPA, 2013: Forecast for the future: Assuring the capacity of the National Weather Service. National Academy of Public Administration Rep., 137 pp., www.napawash.org/studies/academy-studies/forecast-for-the-future-assuring-the-capacity-of-the-national-weather-servi.

Niederdeppe, J., and A. G. Levy, 2007: Fatalistic beliefs about cancer prevention and three prevention behaviors. *Cancer Epidemiol. Biomarkers Prev.*, **16**, 998–1003, https://doi.org/10.1158/1055-9965.EPI-06-0608.

NOAA, 2016: Seven best practices for risk communication. National Oceanic and Atmospheric Administration, https://coast.noaa.gov/digitalcoast/training/risk-communication-best-pratices.html.

NWA, 2017a: Should weather messaging wear uniforms? The role of consistency versus uniformity of visuals and messaging within the weather community. Wednesday Webinar Series, National Weather Association, www.youtube.com/watch?v=IcnXfL92orE.

——, 2017b: Inconsistency and weather communication—The good, the bad, and the ugly. *Broadcasters Workshop*, Garden Grove, CA, National Weather Association, https://nwas.org/annual-meeting-events/past-meetings/2017-annual-meeting-agenda/.

——, 2013: Service assessment: May 2013 Oklahoma tornadoes and flash flooding. National Weather Service, 63 pp., www.weather.gov/media/publications/assessments/13oklahoma_tornadoes.pdf.

O'Keefe, D., 2018: Message characteristics and persuasion. Oxford Bibliographies, https://doi.org/10.1093/obo/9780199756841-0206.

Oxford English Dictionary, 2019: "Consistent." *Oxford Living Dictionaries*, https://en.oxforddictionaries.com/definition/consistent.

Pollock, K., J. Grime, E. Baker, and K. Mantala, 2004: Meeting the information needs of psychiatric inpatients: Staff and patient perspectives. *J. Ment. Health*, **13**, 389–401, https://doi.org/10.1080/09638230410001729834.

Rahimi-Golkhandan, S., D. M. Garavito, B. B. Reyna-Brainerd, and V. F. Reyna, 2017: A fuzzy-trace theory of risk and time preferences in decision making: Integrating cognition and motivation. *Impulsivity*, J. R. Stevens, Ed., Springer, 115–144

Reyna, V. F., 2008: A theory of medical decision making and health: Fuzzy-trace theory. *Med. Decis. Making*, **28**, 850–865, https://doi.org/10.1177/0272989X08327066.

——, 2012: Risk perception and communication in vaccination decisions: A fuzzy-trace theory approach. *Vaccine*, **30**, 3790–3797, https://doi.org/10.1016/j.vaccine.2011.11.070.

——, and B. Kiernan, 1994: Development of gist versus verbatim memory in sentence recognition: Effects of lexical familiarity, semantic content, encoding instructions, and retention interval. *Dev. Psychol.*, **30**, 178–191, https://doi.org/10.1037/0012-1649.30.2.178.

——, and C. J. Brainerd, 1995: Fuzzy-trace theory: An interim synthesis. *Learn. Individ. Differ.*, **7**, 1–75, https://doi.org/10.1016/1041-6080(95)90031-4.

——, and M. B. Adam, 2003: Fuzzy-trace theory, risk communication, and product labeling in sexually transmitted diseases. *Risk Anal.*, **23**, 325–342, https://doi.org/10.1111/1539-6924.00332.

Rickard, L. N., J. P. Schuldt, G. M. Eosco, C. W. Scherer, and R. A. Daziano, 2017: The proof is in the picture: The influence of imagery and experience in perceptions of hurricane messaging. *Wea. Climate Soc.*, **9**, 471–485, https://doi.org/10.1175/WCAS-D-16-0048.1.

Seeger, M. W., L. E. Pechta, S. M. Price, K. M. Lubell, D. A. Rose, S. Sapru, M. C. Chansky, and B. J. Smith, 2018: A conceptual model for evaluating emergency risk communication in public health. *Health Secur.*, **16**, 193–203, https://doi.org/10.1089/hs.2018.0020.

Sellnow, T. L., R. R. Ulmer, M. W. Seeger, and R. Littlefield, 2009: *Effective Risk Communication: A message-Centered Approach*. Springer Science and Business Media, 185 pp.

Shen, L., and E. Bigsby, 2013: The effects of message features. *The SAGE Handbook of Persuasion: Developments in Theory and Practice*, SAGE Publishing, 20–35.

Taplin, S. H., M. T. Mandelson, C. Anderman, E. White, R. S. Thompson, D. Timlin, and E. H. Wagner, 1997: Mammography diffusion and trends in late-stage breast cancer: Evaluating outcomes in a population. *Cancer Epidemiol. Biomarkers Prev.*, **6**, 625–631, https://pubmed.ncbi.nlm.nih.gov/9264276/.

Weyrich, P., A. Scolobig, and A. Patt, 2019: Dealing with inconsistent weather warnings: Effects on warning quality and intended actions. *Meteor. Appl.*, **26**, 569–583, https://doi.org/10.1002/met.1785.

WHO, 2020: Risk communication and community engagement readiness and response to coronavirus disease (COVID-19): Interim guidance. World Health Organization, 5 pp., https://apps.who.int/iris/handle/10665/331513.

Williams, C. A., D. M. Carpenter, P. K. J. Han, and S. Joslyn, 2019: Identifying and assessing the effects of forecast and warning communication (In)consistency on different recipients. *14th Symp. on Societal Applications: Policy, Research, and Practice,* Phoneix, AZ, Amer. Meteor. Soc., PD3.1, https://ams.confex.com/ams/2019Annual/webprogram/Paper350959.html.

Wogalter, M. S., D. M. DeJoy, and K. R. Laughery, 1999: *Warnings and Risk Communication*. Taylor and Francis, 365 pp.

Wolfram, S., 1989: *Philosophical Logic: An Introduction*. Psychology Press, 308 pp.

Wood, M. M., D. S. Mileti, H. Bean, B. F. Liu, J. Sutton, and S. Madden, 2017: Milling and public warnings. *Environ. Behav.*, **50**, 535–566, https://doi.org/10.1177/0013916517709561.