Modernizing the NWS Tropical Cyclone Product Suite by Evaluating NWS Partner Decisions and Information Needs,

Part 2: Surveys with Broadcast Meteorologists and Emergency Managers

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EXECUTIVE SUMMARY

Introduction

This report presents methods and results from surveys with broadcast meteorologists and emergency managers that were conducted as part of a multi-method evaluation of the NWS tropical cyclone (TC) product suite. The overarching goals of the evaluation are to investigate the utility of the current collection of NWS TC products, information, and services for these key NWS partners' decisions, analyze important unmet needs and gaps, and prioritize potential improvements to TC research and operations. Building on in-depth knowledge developed from interviews conducted with members of both NWS partner groups, survey data were collected and analyzed to address four research questions:

- RQ1: What types of TC information do broadcast meteorologists and emergency managers need to support their decisions and communications during TC threats?
- RQ2: How well is NWS currently supporting broadcast meteorologists' and emergency managers' decisions and communications during TC threats?
- RQ3: How useful and usable are current NWS TC information and services for broadcast meteorologists and emergency managers, and what difficulties do they experience using NWS TC information and services?
- RQ4: What are broadcast meteorologists' and emergency managers' views about potential changes to NWS TC information and services?

This Executive Summary synthesizes the report, and it includes embedded links to sections, figures, and tables in the report where readers can find additional details on topics of interest.

Research Methods (details in section 2)

The surveys were implemented online in spring 2021. Responses were received from 87 broadcast meteorologists and 265 emergency managers located throughout regions of the conterminous United States potentially affected by Atlantic TCs. Respondents were recruited by email, using researcher-developed sampling frames of each NWS partner group in the study area.

The survey instruments used for the two NWS partner groups asked questions on similar topics, with adjustments to reflect their different job roles and activities during TC threats. However, the survey instrument used for emergency managers was significantly shorter, to decrease response burden given their increased workload during the COVID-19 pandemic. Where available, parallel results are reported for the two NWS partner groups. To investigate how NWS partners' responses varied geographically, analyses were also conducted with broadcast meteorologists and emergency managers partitioned based on proximity to the coast.[1]

[1] Broadcast meteorologists were partitioned into two subgroups: coastal (≤120 km from coast, a proxy for their media market including coastal locations) and inland (>120 km from coast). Emergency managers were partitioned into three subgroups: coastal (jurisdiction includes coastal locations), non-coastal (jurisdiction is 1–120 km from coast), and inland (jurisdiction is >120 km from coast).

Broadcast Meteorologist and Emergency Manager Job Roles (sections 3.1 and 4.1)

The most common job roles reported by broadcast meteorologists during TC threats were interpreting or developing forecasts, developing forecast graphics, and communicating about the threat on television, social media, and websites. The most common TC job roles for emergency managers were making or coordinating emergency management decisions, interacting with elected government officials, gathering and interpreting forecast information, and raising situational awareness in their office. These results underscore the importance to broadcast meteorologists of multimedia, rapidly updatable visual communication of TC risks with a broad public audience, and the emphasis of emergency managers on using TC forecast information to protect public safety.

Broadcast Meteorologist and Emergency Manager Information Priorities and Needs (in-depth results in sections 3.2 and 4.2; summarized results in sections 3.9.1 and 4.8.1)

Regarding NWS partners' TC information priorities and needs (RQ1), broadcast meteorologists and emergency managers both indicated that **a variety of types of TC information are important for their communication and decision making**. Some types of information are important across coastal and inland areas and phases of a TC threat, whereas other types of information vary in importance based on proximity to the coast and/or lead time.

- **For broadcast meteorologists**:
    - *More than five days before storm impacts*, forecast uncertainty and the importance of paying attention to the threat were rated the most important types of information to communicate (Figure 3.4).
    - *As a storm approaches*, their ratings of the importance of communicating forecast uncertainty decreased, and their ratings of the importance of communicating forecasts of storm track, timing of storm arrival, intensity, and TC hazards and impacts increased (Figures 3.7 and 3.8).
    - *Less than five days before impacts*, they rated forecasts of storm track, timing of storm arrival, intensity, potential storm impacts, and TC hazards—including wind speeds in different areas, flooding from rainfall, and storm surge or coastal flooding — very to extremely important to communicate. They also rated communicating the importance of paying attention to the threat, how to protect oneself, and how to prepare as very to extremely important (Figures 3.5 and 3.6).
    - *Several types of TC information were rated more important to communicate by coastal than inland broadcast meteorologists*. These include forecasts of storm track and timing more than five days before impacts, and forecasts of storm surge or coastal flooding less than five days before impacts. However, both of these types of information were still rated important to communicate by many inland broadcast meteorologists (Figures 3.4 and 3.5).
- **For emergency managers**:
    - *Across all phases of a TC threat*, forecasts of storm track, timing of storm arrival,

and potential storm impacts were rated most important for decisions in their organization. Forecasts of storm intensity, flooding from rainfall, storm wind speeds in different areas, tornadoes, and different storm scenarios were also rated very to extremely important (Figure 4.3).

- *Forecasts of storm surge or coastal flooding were rated very to extremely important by coastal emergency managers*, but only slightly important for near-coastal and inland emergency managers (Figure 4.3).
- Regarding *when different types of information are important for their decisions*, emergency managers indicated that forecasts of timing of storm arrival are most important during all time periods more than 48 hours before impacts. Forecasts of different storm scenarios and flooding from rainfall were rated most important 120−48 hours before impacts, and storm wind speeds in different areas were rated most important 72−48 hours before impacts. For each of these types of information, almost all emergency managers said that they are important during at least one phase of a TC threat (Figure 4.4).
- *Forecasts of storm surge or coastal flooding were rated most important 120−48 hours before impacts by coastal emergency managers*. More than two-thirds of inland emergency managers and half of near-coastal emergency managers reported that this information is not important for their decisions during any phase of a TC threat (Table 4.1).

NWS Support of TC Decisions and Communications (in-depth results in sections 3.3, 3.4, 4.3, 3.5, and 4.4; summarized results in sections 3.9.2 and 4.8.2**)**

Regarding how well NWS is currently supporting NWS partners' TC decisions and communications (RQ2), overall, **broadcast meteorologists and emergency managers find the current collection of NWS information and services very beneficial in their jobs**. For example:

- More than 5 days before TC impacts, over 75% of broadcast meteorologist respondents said that ***NWS information and services are very or extremely helpful*** to them. Five days or less before impacts, this increases to more than 95% of broadcast meteorologists (Figure 3.9).
- **Interactions with local WFOs during TC threats were rated excellent or good** by more than 85% of broadcast meteorologists and more than 90% of emergency managers (Figures 3.11 and 4.5).
- Broadcast meteorologists and emergency managers both find ***a wide variety of types of NWS TC forecast information and services very or extremely useful*** (Figures 3.12 and 4.6). This includes:
  - *a variety of NWS graphical and text TC products* produced by NHC, WFOs, WPC, SPC, and RFCs (Figures 3.13, 3.14, 4.7, and 4.8),
  - *weather prediction models and TC observations* (Figure 3.16 and 4.10), and
  - *multiple ways of obtaining information from and interacting with NWS forecasters* (Figures 3.15 and 4.9).

Usability of Current NWS TC Information and Services and Usability Gaps (in-depth results in sections 3.6, 4.5, 3.5, and 4.4; summarized results in sections 3.9.3 and 4.8.3)

Although the results of the evaluation were positive overall, broadcast meteorologists and emergency managers also experience some difficulties using NWS TC information and services (RQ3). These usability gaps include:

- **Alignment of NWS information with partners' decision making timelines**: More than 25% of broadcast meteorologists and 20% of emergency managers reported that NWS forecast information could be better timed to align with their decision making timeline (Figures 3.17 and 4.11). In their open-ended responses, broadcast meteorologists indicated that this misalignment was due at least in part to NHC and/or WFO products (graphical products and associated data layers, as well as forecast discussions and other text products) not being released far enough in advance of their on-air newscast times (section 3.6.1). Emergency managers' related responses suggest that this misalignment is associated at least in part with needs for certain types of information at longer lead times (section 4.5.1).
- **Usability of NWS graphics**: When asked whether NWS graphics meet their needs, more than 90% of broadcast meteorologists reported that they modify NWS graphics when communicating with their audiences, some of the time or more frequently (Figure 3.18). More than 50% of emergency managers reported that they sometimes modify NWS graphics when communicating about TC threats and coordinating decisions (Figure 4.12).
- **Broadcast meteorologists reported difficulties using some NWS products**, including river stage forecasts (hydrographs), Potential Storm Surge Flooding Maps, Hurricane Local Statements, and Arrival of Tropical-Storm-Force Winds maps (Figure 3.20).
    - The most common reasons that broadcast meteorologists reported having difficulties using NWS products are that *the product is hard to edit on the devices they use or the data layer is not available.* In addition, some said that *the product provides too much information or is difficult to understand* (Figure 3.21).
- **Emergency managers also reported difficulties using some NWS products**, including SPC Convective Outlooks, Track Forecast Cones, Graphical Tropical Weather Outlooks, river stage forecasts (hydrographs), and Arrival of Tropical-Storm-Force Winds maps (Figure 4.13).
    - The most common reasons that emergency managers reported difficulties using NWS products are that *the product does not provide information specific enough to their area or takes too much time to understand.* In addition, some said that *the product is often misunderstood or difficult to explain to the public* (Figure 4.14).
- Regarding **mechanisms for obtaining information and interpretations from NWS forecasters**, broadcast meteorologists rated NWS briefings and conference calls less useful (Figure 3.15), and emergency managers rated NWSChat less useful (Figure 4.9) than other mechanisms.

Two NWS summary products were rated less useful by inland than coastal NWS partners: NHC Key Messages for broadcast meteorologists in inland media markets (versus coastal media

markets; Table 3.2), and Hurricane Local Statements for emergency managers in inland jurisdictions (versus coastal and near-coastal jurisdictions; Table 4.2).

Views about Potential Changes to NWS TC Information and Services (in-depth results in sections 3.8 and 4.7; summarized results in sections 3.9.3 and 4.8.3)

To enable comparison of the usefulness of different improvements to NWS information and services while also gathering diverse perspectives, broadcast meteorologists' and emergency managers' views on potential changes to NWS TC information and services (RQ4) were assessed using multiple types of questions. This included closed-ended questions that asked respondents to rate the usefulness of a small set of potential changes developed from the interview results and conversations with NOAA, as well as open-ended questions that allowed respondents to suggest any types of additional information or improvements.

- **Regarding the usefulness for their work of eight potential changes to NWS TC information and services** (sections 3.8.3 and 4.7.2):
    - *Two changes — a summary product compiling key information for a storm, and compiling NWS products and information about a storm in one place — were rated most useful by both broadcast meteorologists and emergency managers*, on average (Figures 3.25 and 4.16). Both changes were rated very to extremely useful by coastal and inland broadcast meteorologists, and by coastal, near-coastal, and inland emergency managers (Figures 3.26 and 4.17).
    - *Forecasts of duration of sustained tropical-storm-force winds and forecasts of when hazardous conditions will end were also rated very to extremely useful by both broadcast meteorologists and emergency managers* (Figures 3.25 and 4.16).
    - *Forecasts of storm track more than 5 days out and forecasts of storm intensity more than 5 days out were rated very useful by emergency managers, but only moderately useful by broadcast meteorologists* (Figures 3.25 and 4.16).
    - *Forecasts of storm surge more than 5 days out and forecasts of timing of onset of storm surge were rated very to extremely useful by coastal emergency managers and broadcast meteorologists* — as useful as the two highest-rated changes, a summary product and compiling information in one place. These additional types of storm surge forecast information were rated less useful by non-coastal emergency managers and broadcast meteorologists (Figures 3.26 and 4.17).
- **Several areas for improvement across a TC threat emerged from respondents' open-ended comments** (sections 3.8.2, 3.8.4, and 4.7.2):
    - *Both broadcast meteorologists and emergency managers requested additional, more specific or detailed, or earlier information about TC hazards and impacts*. As a storm approaches, this included requests for *forecasts of hazards and impacts in different regions and local areas*, as well as improved *information about the anticipated timing of hazards* (beginning, end, duration).
    - *Broadcast meteorologists requested improved graphical NWS products and associated data layers*, including graphics that are easier to edit, are more user-friendly for communicating on television and other platforms, and integrate better

with their vendor-provided data analysis and display systems. Some broadcast meteorologists also requested *NWS text products that are better organized and more consolidated* (e.g., with the newest and most important information at the top and less redundancy); *simpler, less technical textual information* in NWS products; and *improved timing of NWS product releases*.

  - *Emergency managers requested improved accuracy / decreased uncertainty in TC forecasts*. Some emergency managers also requested *communication or dissemination of TC information in ways that are more relevant to emergency managers' needs or public safety decisions*.
  - In addition, some broadcast meteorologists and emergency managers requested *more frequent forecast updates*, *more rapid release of newly updated information*, or *more interpretations from or interactions with NWS forecasters*.

- **Several areas for improvement also emerged for different phases of a TC threat** (sections 3.8.2, 3.8.4, and 4.7.2):
  - *More than five days before impacts*, broadcast meteorologists requested additional graphics, information from forecast models, and information about TC scenarios and forecast confidence / uncertainty. Emergency managers requested additional track and intensity forecast information, either by extending the Track Forecast Cone or through depictions of weather prediction model output, and additional information about TC scenarios.
  - *From 5 days to 48 hours before impacts*, broadcast meteorologists requested improved information from forecast models, information about scenarios, and storm-specific forecast confidence / uncertainty information. Emergency managers requested additional or earlier information about potential TC hazards and impacts, especially storm surge, heavy rainfall, and associated flooding; several specifically noted that improved information during this time period would help with planning evacuation and sheltering.

Priorities for Modernizing the NWS TC Product Suite (sections 3.9.3, 4.8.3, and 5.2)

Together with prior related research, these survey results suggest several priorities for modernizing the NWS TC product suite:

- **For both broadcast meteorologists and emergency managers**:
  - *improved ways to access and quickly understand the most updated TC information available from different NOAA entities*, e.g., through new or improved summary products or an interactive web site or other easy-to-navigate central location to access a wide variety of relevant TC forecast, warning, and observational information
  - *more regionally or locally relevant information about forecasted TC hazards and impacts, especially storm surge and inland flooding, with an emphasis on several days to 48 hours before impacts* (when such information is often needed for decisions but not currently available)

    - *more information about the anticipated timing of TC hazards and impacts*, including onset, cessation, and duration
    - *graphical NWS products that are easier to quickly understand, by both NWS partners and their audiences* (e.g., simpler products that are accessible to a broad audience accompanied by more detailed versions with additional information)
    - *improved concision, organization, and non-technical language* in NWS text products to enable rapid understanding of key highlights and updates
- **For broadcast meteorologists**:
    - *improved alignment of NWS TC information releases with the timing of newscasts*
    - *improved editability of graphical TC products and availability of data layers*
    - *support in communicating TC forecast uncertainty and scenarios more than 5 days before impacts*
- **For emergency managers**:
    - *graphical TC product formats that better support emergency managers in interpreting locally relevant information*
    - *improved information about storm track, timing, and scenarios more than 5 days before impacts*
    - *for those whose areas may be affected by storm surge, information about the timing of surge onset and improved storm-specific information about coastal flood risks more than 48 hours before impacts*

Principles for Modernizing NWS TC Information and Services (section 5.2)

The results also suggest several principles for NOAA to consider when designing and implementing modernizations to NWS TC information and services:

- **NWS partners use and find useful a mix of TC information types, which provide complementary value.**
    - *This includes graphical, text, and hybrid products; data layers; numerical model output; and observations. Human forecasters are also a core component of the TC product suite, providing forecast information, interpretations, and decision support through both asynchronous and synchronous interactions with NWS partners.*
- **Graphical TC forecast and warning products are used in different ways by NWS partners at different times, providing different ways to leverage their roles in the TC forecast and warning system.**
    - *For broadcast meteorologists, NWS graphics and associated data layers provide a critical foundation for revising to communicate forecast information with a broad audience across multiple media platforms.*
    - *For emergency managers, graphical products are often used as provided by the NWS, although they are sometimes revised to improve communication among emergency management partners and coordination of decisions to protect public safety.*

- **Different types of NWS partners in different regions have overlapping but not always the same TC information needs.**
    - *NWS partners' information needs also vary as a TC threat and their associated communications and decisions evolve.*
- **Accelerating improvements to NWS weather forecasts and warnings and their communication and use requires understanding forecast users' decision timelines, the interactions of information with those timelines, and their unmet information needs, alongside advancing forecast science and technology.**

1. INTRODUCTION

Improvements in weather forecasting and communication technologies have led to a proliferation of information conveyed by the meteorological community when a tropical cyclone (TC) threatens the United States (Bostrom et al. 2016, Morss et al. 2017, Bica et al. 2019). However, despite this growing accuracy and volume of forecast and warning information, National Weather Service (NWS) partners still experience major challenges in effectively communicating about TC risks with diverse populations and in coordinating protective decisions. Such challenges have been clearly demonstrated by recent TCs affecting the United States. For example, in 2021, Hurricane Ida made U.S. landfall as a Category 4 storm in Louisiana, causing more than 35 deaths and $25 billion in damage in the Gulf Coast region, followed by more than 55 additional deaths and billions of dollars in damage as the storm traveled northeast through the United States.

Although people can obtain weather information from a variety of sources, most TC forecast information in the United States originates with the NWS. The NWS includes multiple entities[2] that provide a variety of TC products and other information, tools, and services that are collectively referred to as the *TC product suite* (NOAA 2019, Morss et al. 2022b). To help future investments in TC research, forecasting, and warning provide maximum benefit to the nation, a systematic evaluation is needed of the NWS TC product suite with respect to how it meets key decision-makers' needs. This document reports on surveys conducted as part of a multi-method evaluation of the TC product suite that pursued three intersecting objectives:

1. Evaluate key NWS partners' TC information needs and the utility of the current TC product suite in supporting decision making;
2. Analyze key unmet decision-makers' needs and associated gaps in the TC product suite; and
3. Develop research-guided recommendations to NOAA on modernizing the TC product suite in ways that improve TC risk communication and better support decisions.

At the request of NOAA, the project focused on two types of NWS partners: *broadcast meteorologists* (*BRs*), in their roles communicating about TC risks with the public, and *emergency managers* (*EMs*), in their roles protecting public safety during TC threats.

Prior to conducting the surveys reported on here, our research team conducted and analyzed data from interviews with a targeted set of BRs and EMs in TC-affected areas of the United States (see Morss et al. 2022b). Building upon in-depth knowledge developed from the interviews, we then conducted online surveys with BRs and EMs throughout regions of the conterminous United States (CONUS) potentially affected by Atlantic TCs. The goal of the surveys was to gather a broader range of perspectives for evaluating the TC product suite and prioritizing improvements, from larger, more systematic samples of BRs and EMs in both coastal and inland areas. The surveys addressed four research questions:

[2] These include the National Hurricane Center (NHC), which focuses TCs and other hazardous tropical weather; two other national NWS entities, the Weather Prediction Center (WPC) and Storm Prediction Center (SPC); and local NWS Weather Forecast Offices (WFOs), which focus on a multi-county area of responsibility. NWS is an office within the National Oceanic and Atmospheric Administration (NOAA).

RQ1: What types of TC information do BRs and EMs need to support their decisions and communications during TC threats?

RQ2: How well is NWS currently supporting BRs' and EMs' decisions and communications during TC threats?

RQ3: How useful and usable are current NWS TC information and services for BRs and EMs, and what difficulties do they experience using NWS TC information and services?

RQ4: What are BRs' and EMs' views about potential changes to NWS TC information and services?

We then synthesized the survey findings across these research questions to recommend several priorities for modernizing the TC product suite, over the shorter and longer term.

This project builds on prior work by the research team and others on weather risk communication and forecast and warning systems (e.g., Mileti and Sorensen 1990; Parker and Fordham 1996; Sorensen 2000; Gladwin et al. 2007; Lindell et al. 2007; Demuth et al. 2012; Morss et al. 2015; Bostrom et al. 2016, 2018). It also draws on principles from risk communication and assessment, human-centered design, and evaluation research (e.g., Patton 1997, 2012; Morgan et al. 2002; Norman 2005, 2013; Bruine de Bruin and Bostrom 2013; Fischhoff 2013). Bringing these approaches together and applying them to questions of direct interest to NOAA provides the foundation for developing important new understanding about NWS partners' TC information needs and helping NOAA prioritize future TC research, product development, and risk communication efforts (NASEM 2018). The project design is grounded in a utilization-focused evaluation approach, which emphasizes communication and collaboration with the intended users of the data as a critical component of the evaluation process (Patton 1997, 2012). Consistent with this principle of utilization-focused evaluation, we examined the applicability and usefulness of the TC product suite for key users and identified potential gap areas, which we consider as opportunities for improving information and services and enhancing communication.

Mismatches observed to date between TC forecast information provided and key TC users' information needs suggest that the design of TC forecast and warning products could be improved by better incorporating such principles and approaches. The above literature motivated our choice to conduct a multi-method evaluation of the current TC product suite and potential improvements, using a user- and decision-centered approach. In addition, we used recent relevant research to inform the research design as well as our findings and recommendations (e.g., Losego et al. 2012; Morrow and Lazo 2013a,b,c; Hoekstra and Montz 2017a,b; Maibach et al. 2017; Munroe et al. 2018; see also the literature review in Morss et al. 2022b).

The project is a collaboration among researchers at the National Center for Atmospheric Research (NCAR) Weather Risks and Decisions in Society (WRaDS) group and the University of Washington (UW). In addition, throughout the project, our research team interacted regularly with a set of NOAA Research and NWS personnel, referred to as the core NOAA team, to incorporate perspectives from a range of relevant NOAA entities. These interactions were designed to ensure that the project met NOAA's goals, with an emphasis on helping accelerate NOAA's efforts to effectively create and communicate weather forecast and warning

information. They also provided venues for our research team to iterate with the core NOAA team on connecting this project with recent and ongoing developments within NOAA.

Section 2 describes the survey methods, followed by results from the surveys with broadcast meteorologists (section 3) and emergency managers (section 4). The report closes with a cross-survey summary and associated recommendations (section 5). A synthesis of key findings and recommendations across the interview and survey components of the project is provided in a companion report (Morss et al. 2022a), and preparation of journal publications on the surveys is in progress. As in the Executive Summary, references to sections, figures, and tables throughout the report include embedded links, to help readers navigate through the report to find additional information on topics of interest.

2. METHODS

The sampling frame for the surveys consisted of broadcast meteorologists and emergency managers who operate in TC-affected regions of the CONUS in the North Atlantic TC basin, which we refer to as the *study area*. As recommended by the core NOAA team, we defined the study area as the County Warning Areas (CWAs) for all CONUS NWS WFOs with tropical cyclone wind watch/warning responsibility, according to the NWS Directives for Weather Forecast Office Tropical Cyclone Products (NWSI 10-601). This includes coastal and inland WFOs, as shown in Table 2.1.

Table 2.1. WFOs in study area.

Coastal WFOs (Eastern Region)	
Caribou, ME	Baltimore, MD / Washington, DC
Portland, ME	Wakefield, VA
Boston / Norton, MA	Newport / Morehead City, NC
New York City, NY	Wilmington, NC
Philadelphia, PA	Charleston, SC
Coastal WFOs (Southern Region)	
Brownsville, TX	Tallahassee, FL
Corpus Christi, TX	Tampa Bay, FL
Houston / Galveston, TX	Miami, FL
Lake Charles, LA	Key West, FL
New Orleans, LA	Melbourne, FL
Mobile, AL	Jacksonville, FL
Inland WFOs (Eastern Region)	
Albany, NY	Greenville / Spartanburg, SC
Blacksburg, VA	Raleigh / Durham, NC
Columbia, SC	
Inland WFOs (Southern Region)	
Atlanta, GA	Little Rock, AR
Austin / San Antonio, TX	Memphis, TN
Birmingham, AL	Morristown, TN
Fort Worth, TX	Nashville, TN
Huntsville, AL	Shreveport, LA
Jackson, MS	

The broadcast meteorologist and emergency manager surveys were implemented using Qualtrics, an online survey platform that allowed us to program the survey, contact potential survey respondents individually, send reminders to those who had not completed the survey (see Appendices A and B), and integrate information from the sampling frame with survey responses. The sampling and implementation of both surveys were led by the UW team, and the survey design, data analysis, and interpretation of results was co-led by UW and WRaDS. This research

was reviewed by the UW Human Subjects Division, which deemed the study exempt for the duration of the research.

In both the BR and EM surveys, survey response scales for closed-ended questions were presented with verbal labels for all response options, many on 5-point Likert scales. Numerical labels were applied to some of the data for analyzing and reporting results, with

- **1 representing the highest (most positive) rating** (e.g., *Extremely important*, *Extremely easy*) and
- **5 representing the lowest (least positive or most negative) rating** (e.g., *Not at all important*, *Extremely difficult*).

Many of the figures presented show the mean of the response scale (for 5-point response scales), along with an estimated 95% confidence interval to indicate uncertainty on the mean. Small differences, or those with overlapping confidence intervals, should be interpreted with caution; when discussing results, we focus on those differences that are likely to be meaningful. Responses to open-ended questions are presented verbatim, except for correction of typographical errors or punctuation.

2.1. Broadcast Meteorologist (BR) Survey Methods

2.1.1. BR survey sampling

The planned sampling frame for the broadcast meteorologist survey was all BRs (local, regional, or national) in the study area, as defined above. The UW research team developed the BR sample, starting from a national sample of U.S. BRs developed at the George Mason University (GMU) Center for Climate Change Communication (Maibach et al. 2017). The GMU sample included 2,087 BRs, with first and last name, city and state, station, contact title, and email address for each. For this study, we extracted the subsample of the GMU sample corresponding to our study area, using the geospatial analysis methodology described in Appendix C. The resulting list of 985 BRs was then quality controlled using manual checks, including removing duplicates and correcting invalid emails. This yielded a final sampling frame of 964 BRs for this project.

2.1.2. BR survey instrument

The broadcast meteorologist survey instrument was designed to address the research questions above, building on the interviews. Some survey questions were adapted from prior related questionnaires;[3] others were developed to follow up on aspects of the BR interview findings or address additional topics of interest to NOAA. After review and discussion among the research

[3] Survey questions adapted from prior related work include: BRs' job roles, credentials, education, experience (Timm et al. 2020, Morrow and Lazo 2013c); communication methods (Timm et al. 2020); perceived importance of communicating TC information (J. Demuth, personal communication; Morrow and Lazo 2013a); relationship with NWS WFOs (Morrow and Lazo 2013b, 2013c); and perceived usefulness of TC information/products (Morrow and Lazo 2013a, 2013b).

team, the draft BR survey instrument was shared with the core NOAA team and revised based on their feedback.

The programmed survey in Qualtrics was then pretested with two BRs in the study area via online conferencing. Each BR pretest consisted of a "think aloud" session lasting approximately one hour, with two members of the research team and one pretester. In each session, the pretester proceeded through the survey at their own pace, reading the survey questions and response categories aloud and providing responses online while sharing their thoughts. This setup was used to assess the survey functionality and timing as well as to test the design of the survey questions and responses. At the conclusion of each think aloud session, pretesters were asked to respond to several questions about the survey design, to comment on their experience going through the survey, and to share any additional thoughts about its content and flow. Lastly, they were asked to provide feedback on a draft of the invitation email to be sent to potential survey participants. Pretest sessions were recorded and transcribed with consent. After the pretests, the research team made minor revisions based on the feedback received and then conducted quality checks to finalize the BR survey instrument and invitation email.

The final BR survey instrument included six blocks: job characteristics and roles (1), perspectives on TC information and services (2–5), and demographics (6); see Figure 2.1. Blocks 2–4 of the survey asked a similar set of questions about three temporal phases of a TC threat:

- **Phase I**: more than five days before a storm impacts your area,
- **Phase II**: from 5 days to 48 hours before a storm impacts your area, and
- **Phase III**: 48 hours before a storm impacts your area through impacts.

This formulation was utilized because the interview analysis found that NWS partners' TC-related decisions and information uses and needs vary as a TC threat evolves, and that these three phases provide a first-order summary of the major phases in BRs' and EMs' TC decision timelines (Morss et al. 2022b). Block 5 of the survey asked questions about TC information and services across all three phases of a TC threat. The BR survey consisted primarily of closed-ended questions, with several open-ended questions distributed throughout. The order of items within a survey question were randomized whenever possible. The BR survey questions are presented in Appendix D, along with summaries of the quantitative survey data.

2.1.3. BR survey implementation

The broadcast meteorologist survey was fielded online via Qualtrics, from March 16 to April 20, 2021, during the second year of disruption from the COVID-19 pandemic. Respondents were recruited by email using the BR sampling frame described in section 2.1.1. Email invitations to participate in the survey were personalized and included individualized codes for accessing the survey. Six reminder emails were sent, with slight variations in timing (day of week and time of day), subject lines, and email content and wording to encourage responses and decrease the likelihood of emails being bounced or filtered into spam. (See Appendix A for details.)

QUESTION BLOCK	CONTENT
Block 1	**Introduction to survey and informed consent**
	Background questions on job in broadcast meteorology and roles during TC threats
Block 2	**Helpfulness of current and additional NWS TC information, TC information priorities and needs (more than five days before a storm impacts your area)**
Sample questions	*How helpful to you are the information and tools that NWS provides during this phase?*
	How important do you think it is to communicate the following about tropical cyclone threats to your audiences during this phase?
Block 3	**Helpfulness of current and additional NWS TC information, TC information priorities and needs (five days to 48 hours before a storm impacts your area)**
	Parallel questions to Block 2
Block 4	**Helpfulness of current and additional NWS TC information, TC information priorities and needs (from 48 hours before a storm impacts your area, through impacts)**
	Parallel questions to Block 2
Block 5	**All phases of a TC threat, from the time a potential threat is identified through impacts:**
	- Use of different communication channels during different phases of a TC threat
	- Usefulness of different types of TC information and services
	- Perceived audience understanding of different types of TC forecast information
	- Difficulties using NWS TC products, alignment of NWS TC forecast information with decision-making timeline, usability and modification of NWS TC graphics
	- Most important change to improve NWS information and services
	- Usefulness of potential changes to NWS TC information and services
	- Monitoring social media, interactions with local NWS offices, COVID-19 impacts
Sample questions	*How useful to you are each of these types of information, products, or tools during tropical cyclone threats?*
	How well do you think your audiences understand each of the following types of information?
	Which of these NWS products, if any, do you have difficulty using because of their formatting or editability?
	How useful would it be for you to have the following information, tools, or services for your work, if the NWS could provide them accurately and effectively?
	How would you rate your interactions with your local NWS Forecast Office(s) during tropical cyclone threats?
Block 6	**Demographics**

Figure 2.1. Structure and flow of broadcast meteorologist survey.

As summarized in Table 2.2, nearly one third of the contact email addresses bounced or failed. This reduced the effective sample to 668, of whom 112 started and 87 completed the survey. The completion rate of 13.0% was lower than a previous survey of coastal TC-affected BRs conducted by Morrow and Lazo (2013c), which achieved a 42% response rate in 2012. However, survey researchers have noted declining response rates in the last several decades for surveys of professionals (Nix et al. 2019) as well as households, especially in the absence of personal contact. Our completion rates are similar to those reported by Perkins et al. (2020) for their national survey of BRs, which obtained completion rates of 17.8% in 2015 and 18.2% in 2017. The median time to complete the BR survey was 21.7 minutes.

Table 2.2. Summary of broadcast meteorologist survey sample and response rate.

Initial contact list (N)	% of email contacts bounced or failed	Effective survey sample (N)	% of effective sample who started survey	% of those starting survey who completed it	Completes (N)	Completion rate*
964	31%	668	17%	78%	87	13.0%

* Completion rate is calculated as the % of the effective survey sample that completed the survey.

2.1.4. BR survey data quality control and analysis

Of the 87 broadcast meteorologists who submitted the survey, all responded to 90% or more of the questions and were thus included in the final BR data set. During the data cleaning process, identifying information was removed, and missing values were identified and coded as missing. The number of respondents for each question or question item varies based on randomization (where applied) and missing responses and is indicated by N in the relevant figure or table. Frequencies and descriptive statistics were calculated and aggregated, and consolidated tables and figures were created to synthesize and compare results across related questions.

BR survey respondents were asked what station they work for and for their station's ZIP code, both in an open-ended response format. Their responses to these two questions were compared with their station name and city / state in the sample list (using their unique response ID). For those with a match across these data, reported ZIP code was used as their location. For those with missing or unmatched locational data, Google searches and responses to other open-ended survey questions were used to resolve discrepancies (e.g., correct typographical errors in ZIP code responses, confirm that a BR had moved locations) and assign their location. Each respondent's ZIP code was then mapped to a county-level FIPS code,[4] using Esri ArcGIS, for visualization and additional geospatial analysis.

We then used respondents' locations and ArcGIS to partition the sample in several ways. Each respondent's county-level FIPS code was used to determine their NWS WFO/CWA (Table 2.1), NWS region (Eastern or Southern Region), and time zone (Central or Eastern). We also calculated the distance from the centroid of each respondent's ZIP code to the coastline and used this distance to partition BRs into 2 subgroups:

- **coastal** (≤120 km from coast) or
- **inland** (>120 km).

This coastal/inland designation was developed to indicate whether or not a BR's primary media market includes locations at risk from storm surge; the 120-km distance was chosen based on the typical size of coastal television media markets in the study area. The sample included 60 coastal and 27 inland BRs. Although we explored variations across the BR sample using these different variables, there were insufficient data to analyze reliably by most of these characteristics. Thus, in our analysis of variation among BRs, we focus on proximity to the coast.

[4] FIPS (Federal Information Processing Standards) codes are numbers which uniquely identify geographic areas in the U.S.

2.2. Emergency Manager (EM) Survey Methods

The emergency manager survey was implemented with two samples: 1) a planned, targeted sample, and 2) a convenience sample. The targeted sample is described further below. For the convenience sample, the same EM survey instrument was distributed via email with an anonymous link for accessing the survey on Qualtrics. The second sample enabled EMs to advertise the survey directly to relevant emergency management partners, including those who may be interested in responding but did not see the recruitment email or were not included in the targeted EM sampling frame.

This report focuses on results from the targeted EM sample, because of its relatively well-known (and controlled) characteristics. Summaries of quantitative survey data from both EM samples are provided in Appendix E. A high-level comparison of characteristics of the two EM samples is provided in Appendix F, as a potential starting point for further analysis of the convenience sample and for consideration in designing sampling strategies for future related surveys.

2.2.1. EM survey sampling

The planned sampling frame for the emergency manager survey was local, regional, national, and tribal EMs in the study area, with an emphasis on local EMs. The EM sample for this study was created by the UW research team with assistance from other project team members, the core NOAA team, and the National Emergency Management Association (NEMA) Hurricane Subcommittee.

EM sample development started with using geospatial analysis to create a list of states and counties in the study area, as described in Appendix C. Official emergency management websites for states in the study area were then used to gather contact information for EMs within those states, where such information was available. In searching for information for the EM sample, county EMs were prioritized, but we also gathered contact information for city, tribal, or state EMs that we came across, as well as deputy or office contacts in cases where full EM names, positions, and email contact information were not available. For states that did not have such information available, google searches were performed for EM contact information in individual counties within the study area, occasionally supplemented by searches for emergency management departments on social media.

Tribal EM contact information was typically not available on state websites. Therefore, a list of federal and state recognized tribes within the study area was created using the U.S. Department of Interior Bureau of Indian Affairs Tribal Leaders Directory mapping tool and used to gather EM contact information by tribe, where available.[5]

[5] The Tribal Leaders Directory is available at https://www.bia.gov/bia/ois/tribal-leaders-directory/. Out of respect for privacy and consistent with best practices for data gathering and research partnerships, we only collected contact information for tribal EMs that was clearly listed on official tribal emergency management sites.

This process produced a list of 1,833 EMs, with first and last name, city and state, contact title, and email address for each. This list was then manually quality controlled, including removing duplicates and correcting invalid emails, yielding a final sampling frame of 1,752 EMs to contact.

2.2.2. EM survey instrument

The emergency manager survey instrument was adapted from the BR survey instrument described in section 2.1.2. Some changes were made based on differences between BRs' and EMs' job roles and activities during TC threats[6] and to follow up on aspects of the EM interview findings. We also made changes to shorten the EM survey, informed by the BR survey response rate and recognizing the challenges experienced by EMs during the COVID-19 pandemic. This included compacting blocks 2–4 in the BR survey instrument (Figure 2.1) to ask most questions across all phases of a TC threat, compacting some of the multi-item questions, and removing most of the open-ended questions.[7] Balancing these changes, we also kept some questions consistent to enable direct comparison across the BR and EM data sets. After review and discussion among the research team, the draft EM survey instrument was shared with the core NOAA team and revised based on their feedback.

The programmed survey in Qualtrics was then pretested with five state-level EMs in the study area, in three sessions. Two of the EM pretest sessions were conducted via online conferencing, with two members of the research team and two pretesters. Each of these sessions was similar to the BR pretests, consisting of a "think aloud" session as a primary pretester proceeded through the survey, followed by several questions about the survey design, an opportunity to share any additional thoughts about the survey, and a request to provide feedback on the draft invitation email. The second (assisting) pretester in each of these sessions was not active in the think aloud process, but occasionally weighed in during this process and shared feedback at the end of the session. For the third EM pretest session, the pretester reviewed a copy of the survey remotely and then provided feedback on a telephone call with members of the research team. After the pretests, the research team made minor revisions based on the feedback received and conducted quality checks to finalize the EM survey instrument invitation email.

The final EM survey instrument included eight blocks: job characteristics and roles (1), perspectives on TC information and services (2–7) and demographics (8); see Figure 2.2. Block 2 in the EM survey contained questions on similar topics to Blocks 2–4 on the BR survey, but with most questions asked across all phases of a TC threat rather than for different phases. Blocks 3–6 in the EM survey contained questions on similar topics to Block 5 on the BR survey, across all phases of a TC threat. Block 7 asked the EM survey's only open-ended question. Block 8 in the EM survey asked demographic questions similar to Block 6 in the BR survey. The order

[6] Survey questions on EM's job roles, credentials, education, and experience were adapted from Morrow and Lazo (2013a, 2013b) and Weaver et al. (2014).

[7] As discussed in section 4.7.2, only about one quarter of EM respondents responded to the open-ended questions that were included on the EM survey, a much lower percentage than on the BR survey. This suggests that it would not have been advantageous to include more open-ended questions on the EM survey, given the likely reduction in EM response rate from a longer survey instrument.

of items within a survey question were randomized whenever possible. The EM survey questions are presented in Appendix E, along with summaries of the quantitative survey data.

QUESTION BLOCK	CONTENT
Block 1	**Introduction to survey and informed consent**
	Background questions on job in emergency management and roles during TC threats
Block 2	**TC information priorities and needs, when different information is important for EM decisions**
Sample question	*How important are each of the following types of forecast information about tropical cyclone threats for emergency management decisions in your organization?*
Block 3	**Usefulness of different types of TC information and services**
Sample question	*How useful to you and your emergency management team are each of these during tropical cyclone threats?*
Block 4	**Perceived audience understanding of different types of TC forecast information**
Sample question	*How well do you think the people who you interact with in your job understand each of the following types of forecast information?*
Block 5	**Difficulties using NWS TC products, alignment of NWS TC forecast information with decision making timeline, modification of NWS TC graphics**
Sample question	*Which of these NWS products, if any, do you or your emergency management team find difficult to use when communicating with others during tropical cyclone events?*
Block 6	**Usefulness of potential changes to NWS TC information and services**
Sample question	*How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively?*
Block 7	**- Most important change to improve NWS information and services, in different phases of a TC threat**
	- Interactions with local NWS offices, COVID-19 impacts
Sample question	*How would you rate your interactions with your local NWS Forecast Office(s) during tropical cyclone threats?*
Block 8	**Demographics**

Figure 2.2. Structure and flow of emergency manager survey.

2.2.3. EM survey implementation

The emergency manager survey was fielded online via Qualtrics, from May 6 to June 7, 2021, several weeks after the BR survey (and again during the second year of disruption due to the COVID-19 pandemic). Respondents were recruited by email using the sampling of 1,752 EMs described in section 2.2.1. As with the BR survey, email invitations were personalized and included individualized codes for accessing the survey; five reminder emails were sent. (See Appendix B for additional details.)

As summarized in Table 2.3, 14% of the contact emails bounced or failed, reducing the effective sample to 1,506. Of those, 341 started the survey, and 265 submitted the survey and answered at least 90% of the questions, yielding a completion rate of 17.6%. As discussed in section 2.1.3, this completion rate is lower than some past related surveys, such as the national EM survey in Weaver et al. (2014), which obtained a 30% response rate. However, this lower response rate is

not unexpected given the recent trends discussed in section 2.1.3 and the additional burden on EMs' workload during the COVID-19 pandemic. The median time to complete the EM survey was 10.5 minutes.

Table 2.3. Summary of emergency manager survey sample and response rate.

Initial contact list (N)	% of email contacts bounced or failed	Effective survey sample (N)	% of effective sample who started survey	% of those starting survey who completed it	Completes (N)	Completion rate*
1,752	14%	1,506	23%	78%	265	17.6%

* Completion rate is calculated as the % of the effective survey sample that completed the survey.

2.2.4. EM survey data quality control and analysis

Of those sampled, 275 emergency managers submitted the survey; 10 of those did not respond to more than 10% of the questions and were removed from the data set, leaving 265 completed EM surveys. The remainder of the data cleaning and analysis (with the exception of locational analysis, discussed below) was conducted as described in section 2.1.4 for the BR survey data.

EM survey respondents were asked what jurisdiction, state, or organization they work for and for the ZIP code of their Emergency Operations Center (if applicable), both in an open-ended response format. Their responses to these two questions were compared with their contact title and city / state in the sample list, discrepancies were resolved, and a location and county-level FIPS code were assigned for each respondent, as discussed in section 2.1.4 for the BR survey data.

We then used respondents' locations and ArcGIS to partition the EM sample in several ways. Each respondent's county-level FIPS code was used to determine their NWS WFO / CWA, NWS region (Eastern or Southern Region), and time zone (Central or Eastern), as with BR respondents. We also calculated the closest distance from the boundary of each EM's jurisdiction (county for city or county EMs, state for state EMs, tribe for tribal EMs) to the coastline, to represent the proximity of their jurisdiction to the coast. Given the larger sample of EMs compared to BRs, this distance was used to partition EMs into 3 subgroups:

- **coastal** (=0 km from the coast, i.e., county or jurisdiction includes locations along the coast),
- **near-coastal** (1–120 km), and
- **inland** (>120 km).

This coastal / near-coastal / inland designation was developed to indicate whether an EM's jurisdiction includes locations directly at risk from storm surge, is inland but near the coast, or further inland. The sample included 95 coastal, 54 near-coastal, and 116 inland EMs. As with the BR data, analysis of the EM data by WFO, NWS Region, or time zone did not provide meaningful results. Thus, in our analyses of variation among EMs with different characteristics, we focus on proximity to the coast.

2.3. Limitations

Overall, this study achieved its goal of gathering perspectives on the TC product suite from systematically recruited samples of broadcast meteorologists and emergency managers working in a variety of TC-affected regions of the CONUS, especially considering the constraints of available funding and the COVID-19 pandemic. However, the study has several limitations. Ideally, the surveys would have been sent to the complete populations of BRs and EMs working in the geographical area of interest, or to random samples of those populations. For EMs, in particular, our ability to develop a complete sample was limited by the irregular, imperfect, and potentially out-of-date publicly available contact information for EMs. The fact that 14% of the emails to EM contacts bounced or failed (Table 2.3) suggests that the EM contact list contained some out-of-date contact information. The BR sampling frame was developed based on a pre-existing U.S. BR contact list, as described in section 2.1.1; however, 31% of the emails to BR contacts bounced or failed (Table 2.2). This indicates that developing and maintaining updated contact lists for these NWS partner groups can be challenging as people change positions or retire. As discussed in Appendix F, however, a convenience sampling approach can have even larger biases. Partnering with a certifying or membership organization, such as the American Meteorological Society, to share the survey with their list of certified broadcast meteorologists might be a viable strategy but would likely have other limitations.

A related potential limitation is the survey completion rates, which were 13% for the BR survey and 18% for the EM survey. Lower response rates do not necessarily mean that nonresponse bias is an issue (e.g., Cull et al. 2005, Phillips et al. 2016, Hendra and Hill 2019). However, the geographic distribution of our EM sample, in particular, indicates some imbalances in the EM survey sample, potentially associated with the sample development or lower response rates in certain regions (Appendix F). These completion rates could be due to the pandemic or to the length of the surveys. Only 17% of BRs and 23% of EMs whose emails did not bounce or fail started the survey, which suggests that the biggest obstacle was motivating recipients to read the survey emails and click on the link to enter the survey. Some emails may also have been filtered out as spam and thus not seen by recipients, which is a limitation of the sampling approach. Future surveys could attempt to address this issue by offering incentives, leveraging personal contact from individuals or organizations known to the recipients, using another survey transmission strategy such as U.S. mail or social media, or employing another approach.

Another potential limitation concerns changes in the populations of broadcast meteorologists and emergency managers in the targeted geographical area over time. Such changes would raise challenges for drawing inferences from these results for purposes of informing current and future practice, if the populations have changed significantly since the data were collected. Together, these types of issues affecting the resulting samples may limit the validity and generalizability of the survey results. We adopted best practices to mitigate these potential sources of error, including detailed reporting of all procedures and sample characteristics. In addition, the convergence of results from the multiple open- and closed-ended questions in the surveys, together with the interview results in Morss et al. (2022b) and prior related research, suggest that the findings are fairly robust to potential weaknesses in our sampling strategies.

A further consideration is that this study was designed to understand and address the needs of BRs and EMs throughout TC-affected areas of the United States, integrated across the heterogeneous audiences and constituencies they serve. Examining the intersectional nature of the vulnerabilities and risks faced by respondents' audiences and constituencies was not a focus of these surveys, and this would likely reveal additional TC information needs related to specific vulnerabilities. Moreover, the survey collected data across the different types of TC situations respondents have experienced, whereas their information needs likely vary across situations. Future work can build on the broad understanding developed here with more explicit efforts to incorporate diverse situations and perspectives, including those of NWS partners who engage with harder-to-reach populations or may have less capacity to utilize NWS products and services. Doing so can help NOAA understand the needs of and improve its reach to those who are most vulnerable to TC threats, thereby reducing inequities in access to and use of forecast information and the disproportionate impacts on underserved populations.

3. BROADCAST METEOROLOGIST (BR) SURVEY RESULTS

We start by reporting results on the characteristics of the broadcast meteorologist survey sample and the BR respondents' job roles and communication context, in section 3.1. Section 3.2 addresses RQ1 by examining BRs' priorities and needs for TC information for their jobs. Next, we address RQ2 by examining BRs' evaluations of the helpfulness of current NWS information and tools (section 3.3), their interactions with NWS WFOs (section 3.4), and the usefulness of different types of TC information and services (section 3.5). The results in section 3.5 transition to addressing RQ3, which continues with an examination of the usability of NWS TC information and services for BRs (section 3.6), along with BRs' perceptions of audience understanding of TC information (section 3.7). Section 3.8 addresses RQ4 by examining BRs' views of potential changes to NWS TC information and services. The section then closes with a summary of key findings from the BR survey and opportunities for improvement, in section 3.9. Descriptive statistics for the BR survey data are provided in Appendix D.

3.1. BR Survey Sample and Communications Context

3.1.1. Characteristics of BR survey sample

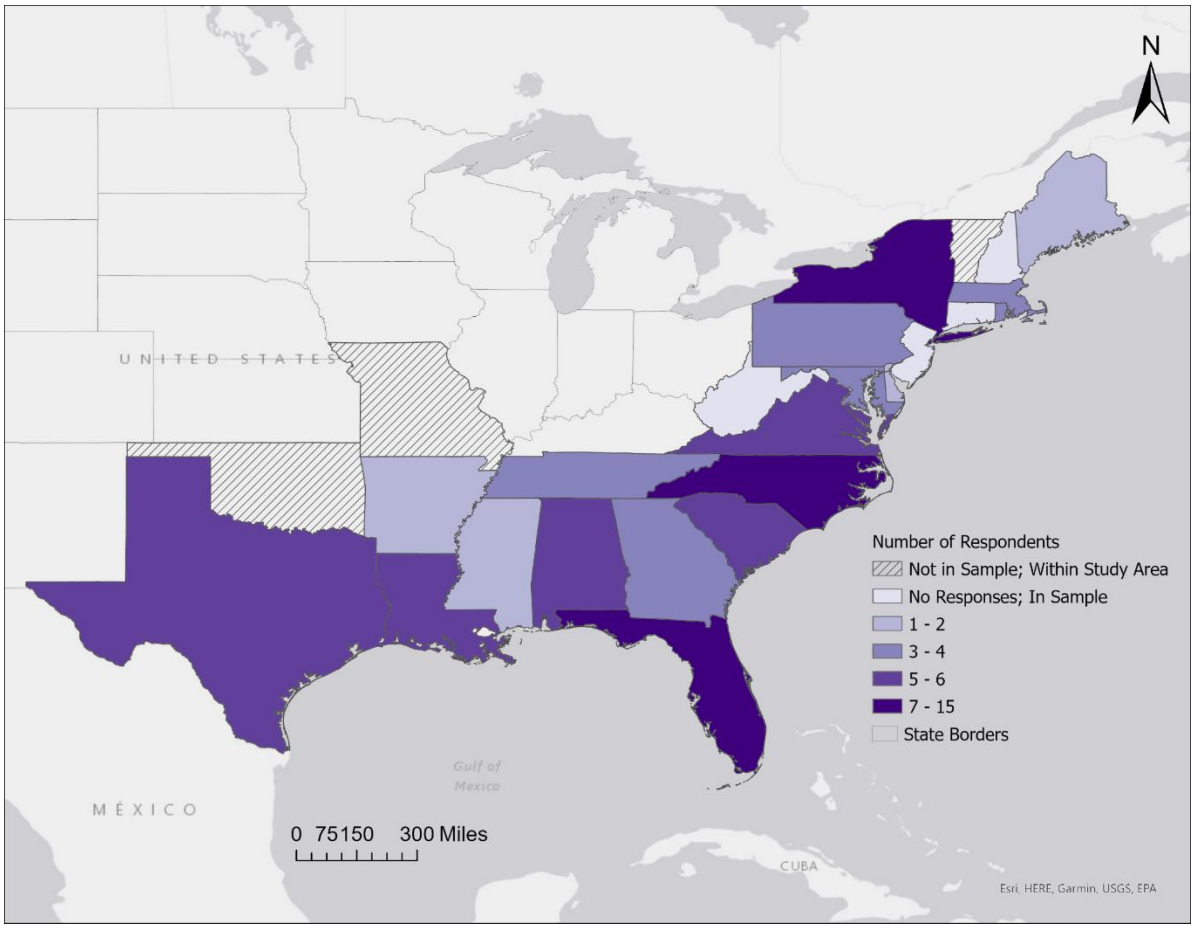

Figure 3.1. Broadcast meteorology survey respondents mapped by state. N=87.

As shown in Figures 3.1 and 3.2, the 87 broadcast meteorologist survey respondents were located in a variety of TC-affected regions of the CONUS, including most of the WFO CWAs in the study area. They reported having between 1–48 years of experience as a BR (mean=20.6 years) and 1–48 years of experience as a BR in regions affected by TCs (mean=17.7 years).

The majority of respondents (69%) reported holding at least one formal certification or seal of approval from the American Meteorological Society (AMS) or National Weather Association (NWA), and nearly one-quarter (21%) held two or more certifications. Among respondents, 41% were AMS Certified Broadcast Meteorologists, 28% held an NWA Seal of Approval, 23% held an AMS Seal of Approval, and 3% were AMS Certified Consulting Broadcast Meteorologists. Nearly all (95%) reported having a bachelor's degree or higher, and 20% a masters' degree and/or PhD.

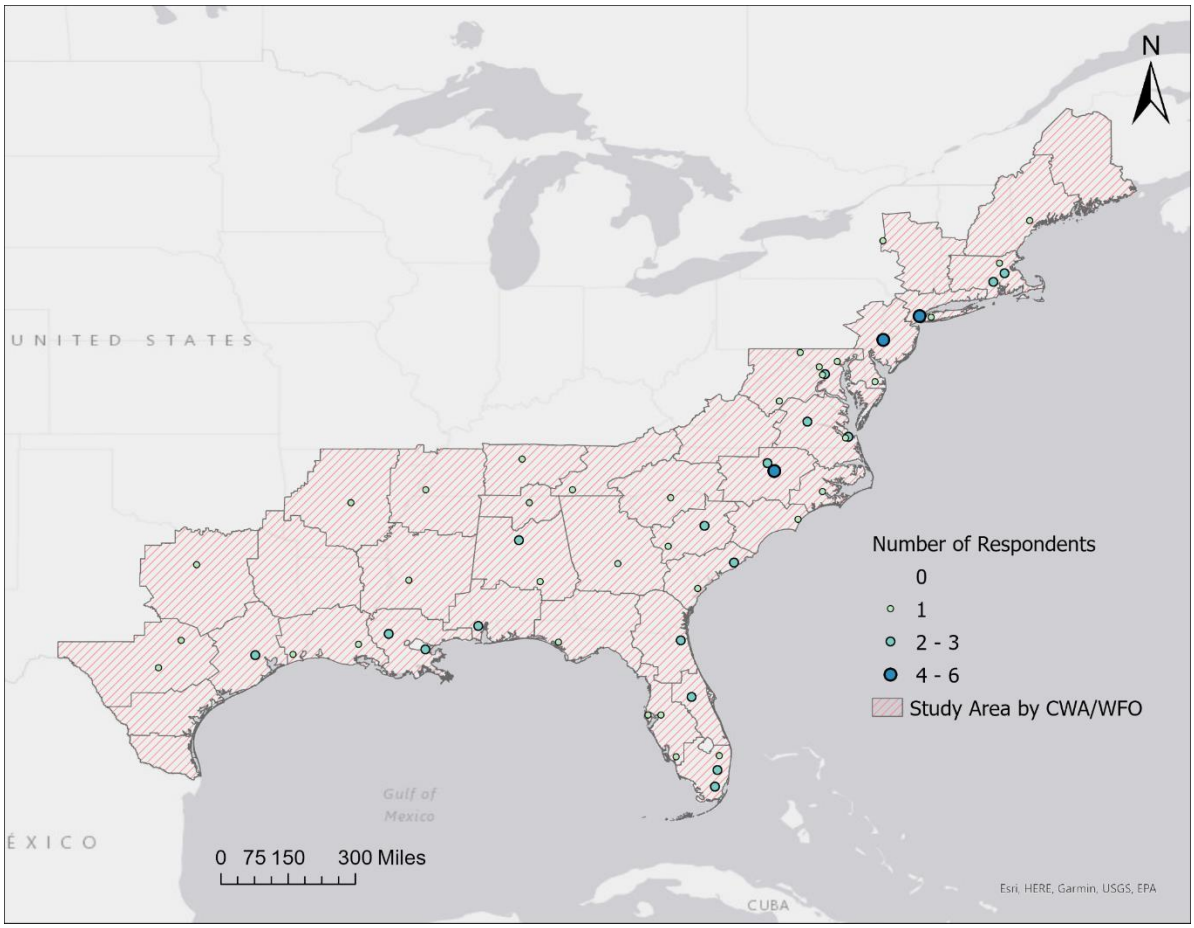

Figure 3.2. Broadcast meteorology survey respondents mapped by county centroid, overlaid with WFO CWAs in the study area. N=87.

When asked what job title best describes their current position, over half (56%) of respondents reported that they were a Weather anchor or Meteorologist, one-third (33%) reported that they were Chief meteorologist, and 12% reported that they were a Primary weather anchor. The remainder said Reporter or Environmental reporter (6%), Weather producer (5%), Digital

meteorologist (1%), or Senior meteorologist (1%). Nearly all respondents (97%) reported having full-time jobs in broadcast meteorology; the remainder had part-time jobs.

A minority of the BR sample was female (22% female; 71% male); 7% did not report gender. Of those who reported race, 4% reported being Black or African American and the remainder White; 7% reported being Hispanic.

3.1.2. BR job roles, communications channels, and COVID-19 impacts

When asked about their major job roles when a TC threatens, the vast majority of broadcast meteorologist respondents said that their responsibilities include communicating on air (99%), communicating on social media (95%), developing forecast graphics (94%), and interpreting or developing forecasts (91%). Most also said that they develop content for or push content to apps or websites (85%). Almost half said that their roles include communicating with NWS and other external partners (47%), and about one-third (31%) reported that they supervise or manage staff. These responses indicate that our BR sample was well suited to provide perspectives on the types of questions asked on the survey.

Complementing the survey question about major job roles during TC threats, we asked respondents when (if ever) during a TC threat they use different types of communication channels, according to the three phases of a threat noted above. This question was included to provide context for our evaluation, and to enable analyzing BRs' other responses by communications channels used, if there was significant variability across the sample. As shown in Figure 3.3, most respondents said that they communicate about TC threats on-air (television), on social media, and on their station website during each of the three phases of a threat. Approximately two-thirds said that they communicate on radio during at least one phase, with the proportion communicating on radio increasing as a storm approaches (from 24% in Phase I to 66% in Phase III). Fewer respondents reported communicating about TC threats via newspaper or community events, with approximately three-quarters reporting that they do not use these channels at all. Together, these results indicate that the BR respondents focus primarily on conveying TC risks through mechanisms that include visual communication and allow for rapid updates as new information emerges, which is consistent with the BR interview results (Morss et al. 2022b).

The BR survey was conducted during the COVID-19 pandemic, which is another risk that affects how people can and do respond to TC threats (NASEM 2021). Toward the end of the survey, BRs were asked "How much has COVID-19 affected the ways that you advise your audiences about how to prepare or respond to tropical cyclone threats? (e.g., making preparation, evacuation or sheltering decisions given public health guidance)" (Response options: *A great deal, A lot, A moderate amount, A little, Not at all*). More than half of respondents (51%) reported that COVID-19 had affected how they advise their audiences during TC threats at least a moderate amount, and only 19% reported that COVID-19 had not affected their communications at all. This illustrates the influence of the co-occurring COVID-19 pandemic on many BRs' TC risk communications.

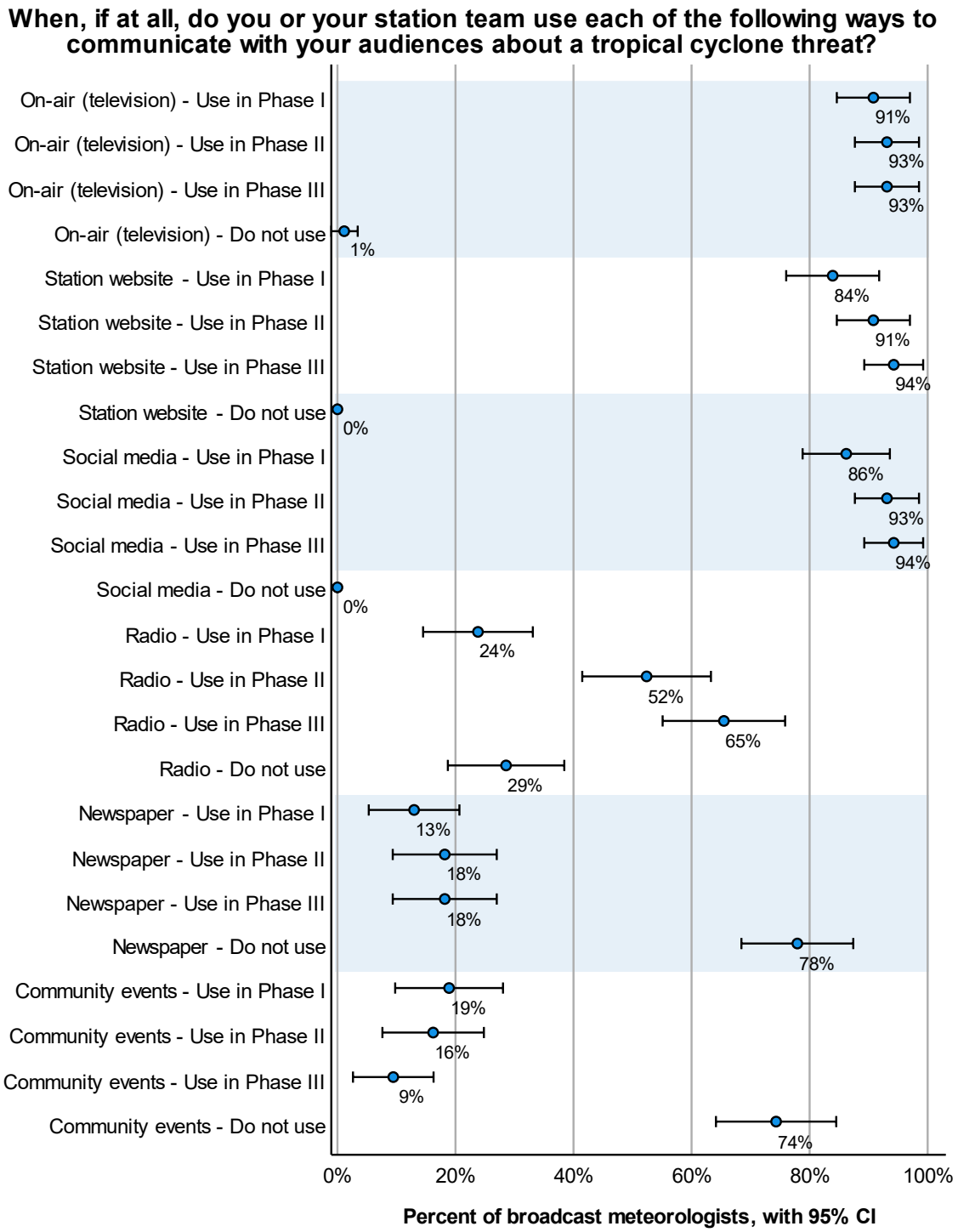

Figure 3.3. Broadcast meteorologists' reported use of different communications channels during different phases of a TC threat. Dots indicate the percentage who selected each option, with 95% confidence intervals. Respondents were asked to select all that apply, with four response options for each communication channel: *Use in Phase I (more than five days before a storm impacts your area)*, *Use in Phase II (five days to 48 hours before a storm impacts your area)*, *Use in Phase III (48 hours through impacts)*, and *Do not use*. Percentages were calculated relative to the number of BRs who selected any option for that communication channel: N=87 (on-air, station website, social media), 84 (radio), 77 (newspaper), 74 (community events).

3.2. BR Tropical Cyclone (TC) Information Priorities and Needs

To investigate broadcast meteorologists' priority needs for TC information (RQ1), the survey included a set of questions for each of the three phases of a TC threat asking respondents to rate the importance of communicating different types of TC information during that phase. Seven types of information were rated in Phase I, and 17 types of information were rated in Phases II and III. The questions were designed so that most types of information were rated in more than one phase, to allow comparison across different forecast lead times. In Phase I, the question focused on general types of TC forecast information and different types of forecast uncertainty information. In Phases II and III, the question added a number of more specific types of forecast and protective action information that typically become available and are more frequently communicated as a TC threat approaches.[8]

In this section, we first examine results on the importance of different types of information during each phase of a TC threat separately, for the full BR sample and compared between coastal and inland BRs (sections 3.2.1, 3.2.2, and 3.2.3). Then we compare results across phases of a TC threat (section 3.2.4). Finally, we show results for two survey questions related to monitoring social media (section 3.2.5), an activity that was discussed by several BR interviewees (Morss et al. 2022b).

3.2.1. Importance of different types of TC information for BRs: Phase I (more than 5 days before impacts)

Broadcast meteorologists' ratings of the importance of communicating different types of TC information in Phase I (more than five days before impacts) are depicted in Figure 3.4. During this time period, BRs rate communicating *forecast uncertainty* and the *importance of paying attention to the threat* as most important (means=1.43–1.48, both between Very and Extremely important, on the 5-point response scale). The other five types of information were rated less important (means=2.08–2.51), but still Moderately to Very important to communicate. These ratings reflect BRs' understanding of the uncertainty in forecasts of a TC's track, intensity, and other characteristics more than five days out, and thus the importance of their audiences paying attention to updates that will be provided as a storm gets closer and forecast skill increases.

Statistical tests suggest that in Phase I, communicating *forecasts of storm track and timing* was rated more important by coastal BRs (mean=1.97) than inland BRs (mean=2.48; one-way ANOVA: $F_{(1,85)}=5.62$, $p=0.02$). This may indicate that BRs think it is more important to communicate storm track and timing to coastal than inland populations at these longer lead times, potentially due to the greater likelihood of major TC impacts on coastal populations and

[8] Note that not all of the types of TC information rated in each phase are currently part of the NWS TC product suite during that phase. For example, even though TC-specific forecasts of storm surge are currently only provided in Phase III (less than 48 hours before anticipated impacts), BRs were asked to rate the importance of communicating forecasts of storm surge or storm surge or coastal flooding in Phase II as well as Phase III. We structured the questions in this way to help assess whether BRs thought it was important to communicate such information earlier, if it could be reliably provided. We included storm track, timing, and intensity in Phase I for similar reasons.

the longer lead times needed for preparatory decisions such as evacuations from coastal regions. Note, however, that inland BRs still rated communicating forecasts of storm track and timing as, on average, Moderately to Very important to communicate more than five days before impacts. For the other six types of information, ratings in Phase I are similar for coastal and inland BRs.

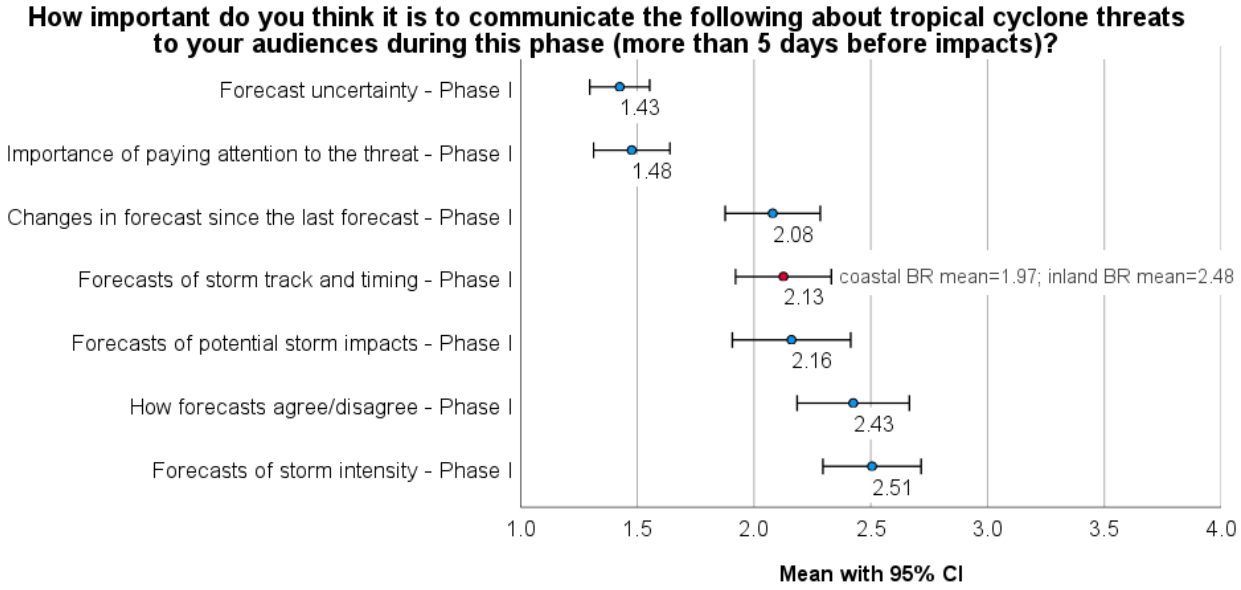

Figure 3.4. Broadcast meteorologists' ratings of the importance of communicating different types of TC information during Phase I of a TC threat (more than 5 days before impacts). Dots indicate mean ratings, with 95% confidence intervals; red dots with annotation indicate types of information for which ratings differed by BR proximity to the coast. Types of information are ordered from highest (1) to lowest (5) mean importance for the full BR sample. Response scale: *1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important.* N=86–87, depending on the question item.

3.2.2. Importance of different types of TC information for BRs: Phase II (5 days to 48 hours before impacts)

Broadcast meteorologists' ratings of the importance of communicating different types of TC information for Phase II (5 days to 48 hours before impacts) are depicted in Figure 3.5 for the full sample. Statistical tests indicate that BRs' ratings differed with proximity to the coast for only one of these variables in Phase II: *forecasts of storm surge or coastal flooding* (one-way ANOVA: $F_{(1,85)}$=8.83, p=0.004), which coastal BRs rated more important to communicate (mean=1.60) than inland BRs (mean=2.33). This difference is consistent with the fact that coastal areas are typically at greater risk from storm surge than inland areas. However, inland BRs still rated forecasts of storm surge Moderately to Very important to communicate. This reflects BRs' role in providing news coverage of aspects of TCs that do not directly affect their viewing area, as several indicated in their open-ended responses on the survey.

Figure 3.5 shows that in Phase II, BRs rated four types of information as most important to communicate: *forecasts of storm track, forecasts of timing of storm arrival, forecasts of potential storm impacts,* and the *importance of paying attention to the threat*. All were rated between Very

and Extremely important. The type of information that BRs rated least important to communicate in Phase II is *how forecasts agree or disagree*. However, as in Phase I, even this lowest-rated type of information was rated by BRs as, on average, Moderately to Very important to communicate.

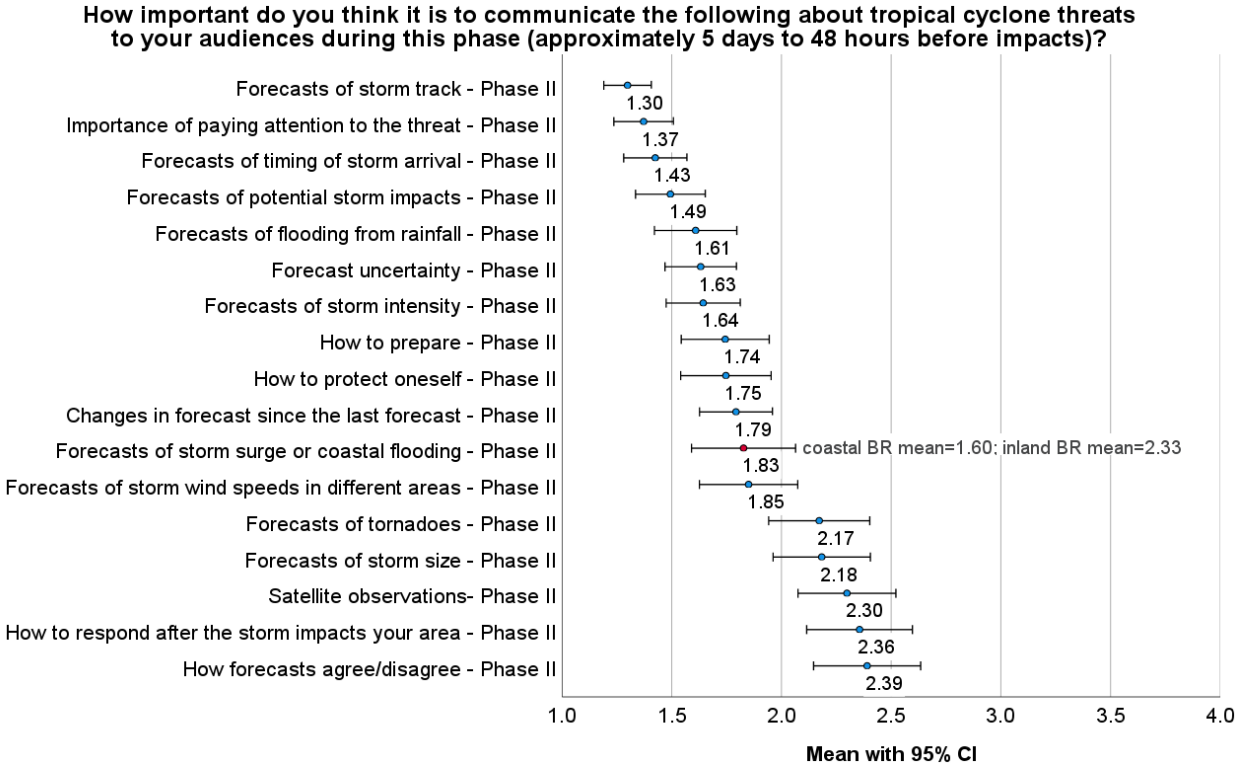

Figure 3.5. Broadcast meteorologists' ratings of the importance of communicating different types of TC information during Phase II of a TC threat (5 days to 48 hours before impacts). Dots indicate mean ratings, with 95% confidence intervals; red dots with annotation indicate types of information for which ratings differed by BR proximity to the coast. Types of information are ordered from highest (1) to lowest (5) mean importance for the full BR sample. Response scale: *1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important.* Two types of information (*how to protect oneself* and *how to prepare*) are abbreviated in the figure; the full versions provided in the survey are *how to protect oneself (where to evacuate to, how to evacuate, etc.)* and *how to prepare (get emergency supplies, prepare your home, etc.)*. N=86–87, depending on the question item.

3.2.3. Importance of different types of TC information for BRs: Phase III (48 hours through impacts)

Results for Phase III (48 hours through impacts) are depicted in Figure 3.6 for the full broadcast meteorologist sample. In Phase III, as in Phase II, *forecasts of storm surge or coastal flooding* was rated more important to communicate by coastal BRs (mean=1.08) than inland BRs (mean=1.89) (one-way ANOVA: $F_{(1,85)}=16.24$, $p<0.001$). Statistical tests also suggest differences between coastal and inland BRs in Phase III ratings of the importance of communicating *forecasts of potential storm impacts* ($F_{(1,85)}=5.24$, $p=0.025$), *how to protect oneself* ($F_{(1,85)}=7.82$, $p=0.006$), and *how to prepare* ($F_{(1,85)}=6.50$, $p=0.013$), with all rated more important by coastal

BRs (see annotation in Figure 3.6). For the other types of information, ratings in Phase III are similar between coastal and inland BRs.

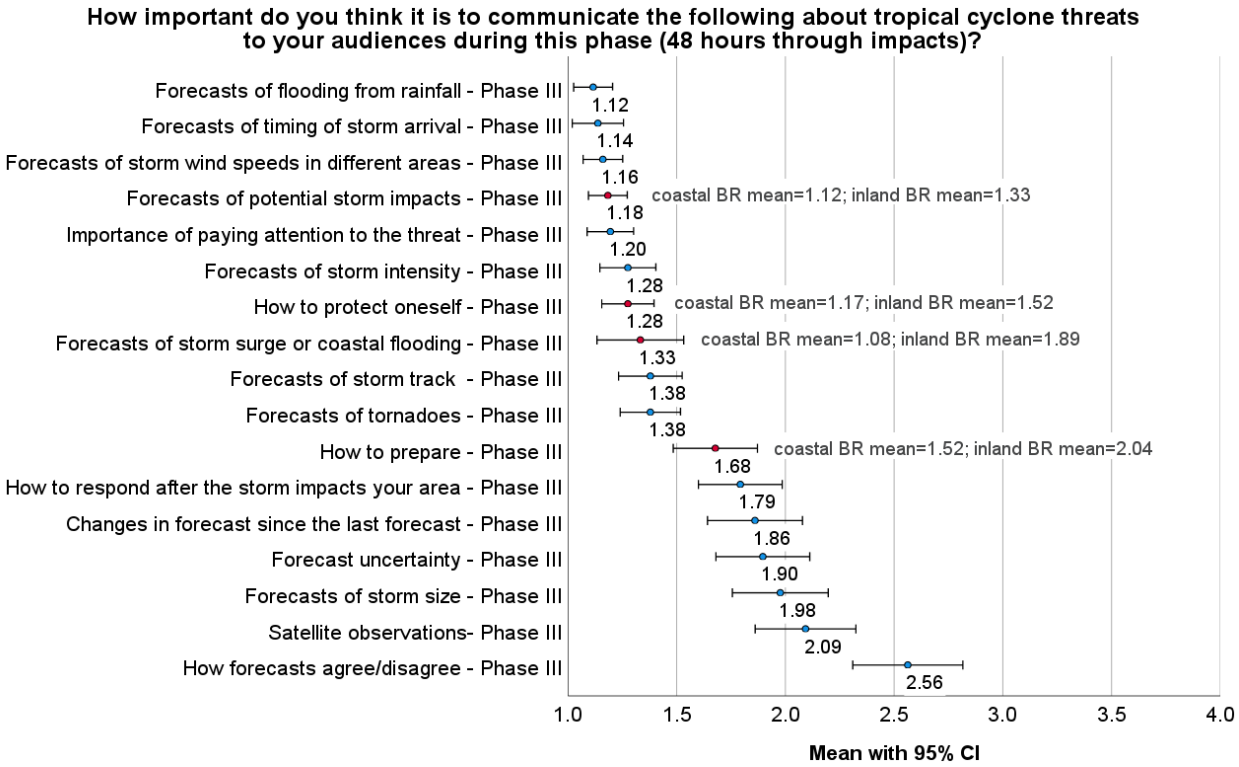

Figure 3.6. Broadcast meteorologists' ratings of the importance of communicating different types of TC information during Phase III of a TC threat (48 hours through impacts). Dots indicate mean ratings, with a 95% confidence interval; red dots with annotation indicate types of information for which ratings differed by BR proximity to the coast. Types of information are ordered from highest (1) to lowest (5) mean importance for the full BR sample. *Response scale: 1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important.* Two types of information (*how to protect oneself* and *how to prepare*) are abbreviated in the figure; the full versions provided in the survey are *how to protect oneself (where to evacuate to, how to evacuate, etc.)* and *how to prepare (get emergency supplies, prepare your home, etc.)*. N=86–87.

As shown in Figure 3.6, the types of information that coastal and inland BRs rated most important to communicate in Phase III included those rated most important in Phase II — *forecasts of storm track, timing of storm arrival*, and *potential storm impacts*, along with the *importance of paying attention to the threat* — as well as *forecasts of flooding from rainfall, storm wind speeds, tornadoes*, and *storm intensity* and *how to protect oneself*. Coastal BRs also rated *forecasts of storm surge or coastal flooding* in this set of most important information to communicate. As in Phase II, the type of information that BRs rated least important in Phase III is *how forecasts agree or disagree*, although still Moderately to Very important to communicate.

Several types of information (the top five in Figure 3.6 and *forecasts of storm surge or coastal flooding*) were rated Extremely important to communicate by 85% or more of coastal BRs. Interestingly, one type of information, *forecasts of flooding from rainfall*, was rated Extremely important by all inland BRs. This likely reflects the fact that rainfall-induced flooding is the TC

hazard that is most likely to have widespread, significant impacts in inland areas, where storm-surge-induced flooding typically does not reach and winds typically attenuate after landfall.

3.2.4. Importance of different types of TC information for BRs: Comparison across phases of a TC threat

Figures 3.7 and 3.8 depict the same data on importance of information to broadcast meteorologists as Figures 3.4, 3.5, and 3.6, but with different phases of a TC threat combined. Data in these figures are grouped into four categories of related types of information:

- **storm characteristics**,
- **forecast uncertainty**,
- **hazards and impacts**, and
- **actions**.

Figure 3.7 compares ratings across Phases I, II, and III for all of the types of information that were rated in all three phases. Figure 3.8 compares ratings across Phases II and III for all of the types of storm characteristic, hazard and impact, and action information. Note that some types of information are included in both figures for ease of comparison.

As discussed previously, in Phase I, BRs rated *forecast uncertainty* one of the most important types of information to communicate. Figure 3.7 indicates that as a TC approaches, BRs rate *forecast uncertainty* less important to communicate — although still, on average, Very important. In contrast, the importance of communicating *forecasts of storm track* increases between Phase I and Phases II–III, and the importance of communicating *forecasts of storm intensity*, *timing of storm arrival*, and *potential storm impacts* all increase from Phase I to Phase II to Phase III. These results likely reflect the increasing skill in these types of forecasts (and decreasing forecast uncertainty) as a storm approaches.

Figure 3.8 indicates that BRs rated communicating all five types of information in the "Hazard and impacts" group — *forecasts of potential storm impacts*, *flooding from rainfall*, *storm surge or coastal flooding*, *wind speeds in different areas*, and *tornadoes* — more important in Phase III than Phase II. Again, these ratings likely reflect the increasing skill in TC forecasts, especially forecasts of more specific TC-related hazards, as a storm approaches.

Figure 3.8 also shows that in Phase II, within the "Actions" category, BRs rated both *how to prepare* and *how to protect oneself* Very important to communicate (means=1.74–1.75), more important than *how to respond after the storm impacts your area* (mean=2.36; paired-sample t-test with *how to prepare*: $t_{85}=5.99$, $p<0.001$, with *how to protect oneself*: $t_{86}=6.55$, $p<0.001$). This is likely because Phase II (5 days to 48 hours before impacts) is a critical time period for members of the public, businesses, and others to make decisions about evacuations and pre-storm preparations. In Phase III (less than 48 hours before impacts), BRs' ratings of the importance of *how to protect oneself* and *how to respond after the storm impacts your area* increase compared to Phase II, suggesting that they think these types of information becomes more urgent for people as a storm approaches. BRs rated *how to prepare*, on the other hand, similarly important to communicate in Phase II and Phase III.

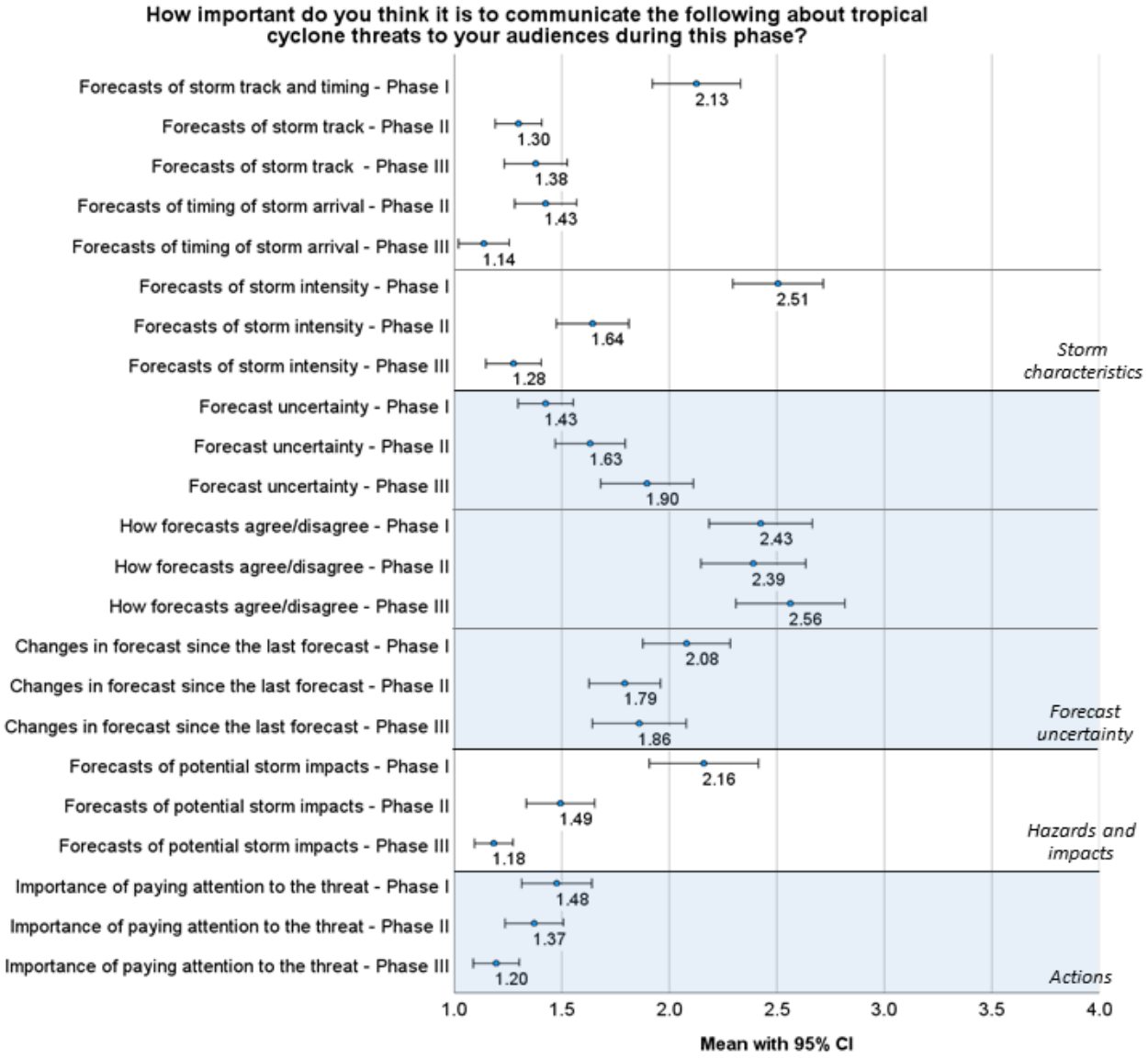

Figure 3.7. Broadcast meteorologists' ratings of the importance of communicating different types of TC information during Phase I (more than 5 days before impacts, Phase II (5 days to 48 hours before impacts), and Phase III (48 hours through impacts) of a TC threat. Dots indicate mean ratings, with a 95% confidence interval. The graphic is organized into four categories of information types, indicated by the blue and white shading, with the categories labeled in italic text on the right of the graphic. Response scale: *1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important*.

The final type of information in the "Actions" group, the *importance of paying attention to the threat* was rated Extremely important to communicate in all three phases (Figure 3.7) — of similar or greater importance than *how to protect oneself* in each phase where both were rated (Figure 3.8). In other words, throughout a TC's lifetime, BRs believe that it is important to convey to their audiences the importance of paying attention to updated information.

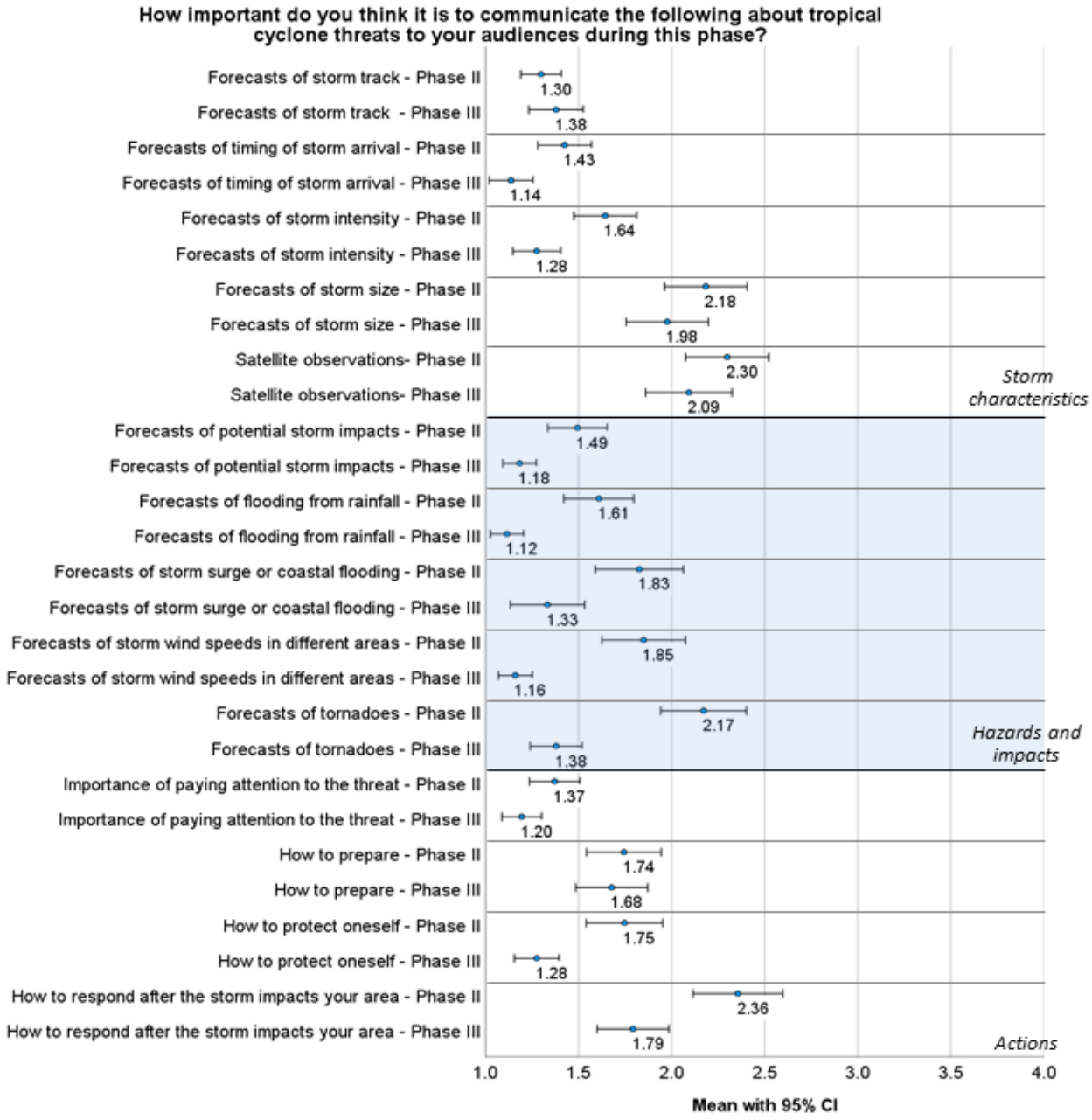

Figure 3.8. Broadcast meteorologists' ratings of the importance of communicating different types of TC information during Phase II (5 days to 48 hours before impacts) and Phase III (48 hours through impacts) of a TC threat. Dots indicate mean ratings, with a 95% confidence interval. The graphic is organized into three categories of information types, indicated by the blue and white shading, with the categories labeled in italic text on the right of the graphic. Response scale: *1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important*.

Although BRs commonly use *satellite observations* when communicating about TC risks, they rated this information less important to communicate in Phases II-III than forecasts of most other storm characteristics, hazards and impacts, and action information (Figure 3.8). Similarly, although *forecasts of storm size* are related to forecasts of TC hazards and impacts, BRs also rated this less important to communicate in Phases II-III. *Forecasts of tornadoes*, on the other

hand, were rated less important to communicate than many other aspects of a TC in Phase II, but by Phase III they were rated similarly important. This likely reflects the difficulty of predicting tornado threats at longer lead times, as well as the more localized nature of tornadoes and thus the shorter lead time needed to take protective action compared to other TC hazards.

Across these data, we can see that BRs rated all of the types of information included in these questions as important to communicate. Even the type of information with the lowest importance rating (*how forecasts agree/disagree* in Phase III) was rated approximately 2.5 (between Moderately and Very important) on the 1 to 5 scale. Several types of information (the top eight in Figure 3.6) were rated Extremely important to communicate by 75% or more of BRs.

3.2.5. BRs monitoring social media

Given the importance of social media for communicating with their audiences (Morss et al. 2022b, section 3.1.2), the survey asked broadcast meteorologists about the importance of monitoring social media to understand what people are thinking or doing about TCs. This was followed by a question about how helpful it would be for them to have a tool or service that collects and analyzes local social media posts about TCs. These data are presented together in Table 3.1.

Table 3.1. Crosstabulation of broadcast meteorologists' responses to "How important is it for you to monitor social media during tropical cyclone threats to understand what people are thinking or doing about them?" and "To what extent would it be helpful in your job to have a tool or service that collects and analyzes local social media posts about tropical cyclones?" Response scales: *Extremely important* to *Not at all important* and *Extremely helpful* to *Not at all helpful*. N=86.

		Importance of monitoring social media					
		Extremely important	Very important	Moderately important	Slightly important	Not at all important	*Total*
Helpfulness of a social media tool or service	Extremely helpful	25.6%	4.7%	0.0%	0.0%	0.0%	*30.2%*
	Very helpful	14.0%	18.6%	4.7%	1.2%	0.0%	*38.4%*
	Moderately helpful	3.5%	2.3%	10.5%	2.3%	0.0%	*18.6%*
	Slightly helpful	0.0%	1.2%	2.3%	3.5%	1.2%	*8.1%*
	Not at all helpful	0.0%	1.2%	0.0%	1.2%	2.3%	*4.7%*
	Total	*43.0%*	*27.9%*	*17.4%*	*8.1%*	*3.5%*	*100.0%*

As shown in Table 3.1, a large majority (71%) of BRs reported that it is Very or Extremely important for them to monitor social media to understand what people are doing or thinking about tropical cyclones (mean=2.01, Very important). Of these, 89% (62% of all respondents) reported that it would be Very or Extremely helpful in their job to have a tool or service that collects and analyzes social media posts about tropical cyclones. However, such a tool

(mean=2.19, Very helpful) was, on average, rated less useful than several other potential new types of information or services asked about on the survey, discussed in section 3.8.3. BR respondents also did not raise the topic of monitoring social media in their open-ended responses on the survey.

3.3. Helpfulness of Current NWS Information and Services for BRs

Next we transition to assessing how well NWS is currently supporting broadcast meteorologists' decisions (RQ2). As part of addressing this question, the survey asked BRs to rate the helpfulness of NWS information and tools during each of the three phases of a TC threat (section 3.3.1). For each phase, this closed-ended question was followed by an open-ended question: "In responding to the previous question, which information or tool(s) came to mind first?" (section 3.3.2).

3.3.1. Helpfulness of current NWS information and services: BR ratings in different phases of a TC threat

Overall, as shown in Figure 3.9, most broadcast meteorologist respondents said that NWS information and tools are Very or Extremely helpful throughout a TC threat: more than 75% of respondents in Phase I, and more than 95% in Phases II and III. On average, BRs rated NWS TC information and tools Very helpful (mean=1.95) more than 5 days before impacts (Phase I) and Extremely helpful when a TC is within 5 days of impacts (Phase II: mean=1.28; Phase III: mean=1.22).

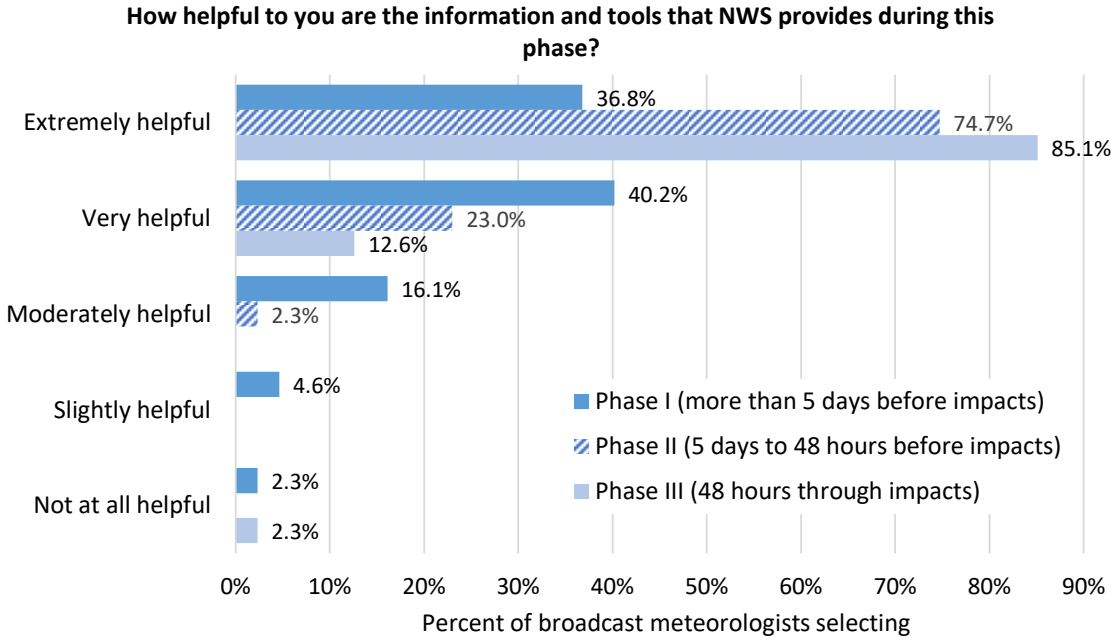

Figure 3.9. Broadcast meteorologists' ratings of the helpfulness of NWS information and tools during different phases of a TC threat. Response scale: *1=Extremely helpful, 2=Very helpful, 3=Moderately helpful, 4=Slightly helpful, 5=Not at all helpful.* N=87.

Figure 3.10 shows results for the BR sample partitioned into coastal and inland respondents; one-way ANOVAs indicate no differences by proximity to the coast (Phase I: $F_{(1,85)}=0.61$, $p=0.44$; Phase II: $F_{(1,85)}=0.065$, $p=0.80$; Phase III: $F_{(1,85)}=0.14$, $p=0.71$). In other words, both coastal and inland BRs find NWS TC information and tools Very to Extremely helpful throughout a TC threat.

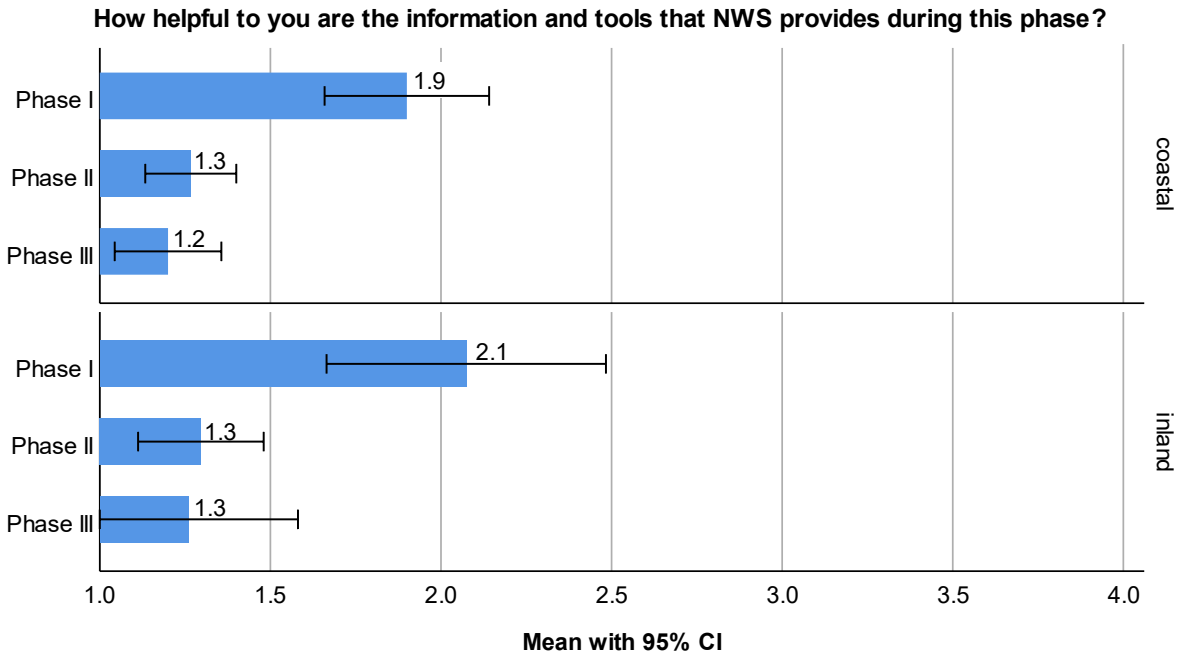

Figure 3.10. Broadcast meteorologists' ratings of the helpfulness of NWS information and tools during different phases of a TC threat, partitioned into coastal (upper) and inland (lower) respondents. Bars indicate mean ratings, with 95% confidence intervals. Response scale: *1=Extremely helpful, 2=Very helpful, 3=Moderately helpful, 4=Slightly helpful, 5=Not at all helpful.* N=60 (coastal), N=27 (inland).

3.3.2. Most helpful NWS information and services: BR open-ended responses

In response to the open-ended question asking what information or tools came to mind first as being particularly helpful in Phase I, broadcast meteorologists most commonly reported the NHC Tropical Weather Outlook product, TC track forecasts or the NHC Track Forecast Cone product, forecast model output (including ensemble forecasts and spaghetti plots), and NWS Forecast Discussion products. WFO briefings, other information from local WFOs, and time of arrival estimates were also mentioned by several BRs during Phase I. Illustrative quotes include:

- "The outlook making us aware that something might affect our area."
- "The outlooks themselves are great tools to give the audience an idea of where a tropical wave is headed and what the probability for development is."
- "Honestly, at five days out I will take anything they give me. We are all watching the models and anything I can put into a graphic or map is gold. The tropical outlook graphic is what comes to mind first."
- "The cone of uncertainty and predicted storm track come to mind first."
- "Tropical weather outlooks, NHC forecast products, local NWS briefings."

- "Cyclone path graphics. Spaghetti plots. Wind arrivals."
- "Forecast track and forecast models along with the interpretations"
- "The storm "technical" discussions that unveil more than the "cone" which stops at 5 days"
- "Forecast discussion from NHC help to give us an understanding of forecast track."
- "Forecast track, but just as important, the forecast discussion that explains why the track is where it is"
- "Discussions about confidence in the models and what features will impact the future of the storm"

In Phase II, commonly reported helpful information and tools included TC track forecasts, the Track Forecast Cone, forecast models, and Forecast Discussions, similar to Phase I; Tropical Weather Outlooks were also mentioned, but only by a few BRs. Also commonly mentioned in Phase II were forecasts of TC timing and intensity, forecasts for different areas, and forecasts of TC hazards and impacts including winds, rainfall, and storm surge inundation. Some BRs mentioned information from local WFOs, especially graphical products and webinars / conference calls, and watches or warnings. Illustrative quotes include:

- "Forecast cone, potential impacts, timing graphics"
- "The track updates and intensity and impacts"
- "Days 3, 4, 5 it's still mostly the cone. Inside of 2–3 days the watches and warnings begin to take precedence."
- "Track, timing, impacts, model consensus or disagreement"
- "Forecast track, forecast discussions on reasoning of the track/intensity forecast"
- "Breakdown of specific areas targeted by the impending storm and the impacts they will face"
- "The probable path of the storm with locations that could see various impacts. Rainfall becomes more important during this period, as well as wind and surge projections, as they are likely much more spot on and I can talk about them with more confidence."
- "The one pagers and webinar graphics. I like the content of these …"
- "The expanded graphics that local NWS offices provide. It helps to know their thinking in addition to ours as meteorologists."

In Phase III, BRs reported similar types of helpful information and tools as in Phase II, with increased emphasis on TC hazard and impact forecasts, more spatially and temporally specific forecasts, and information from local WFOs. Some BRs noted that their answers would be the same as in previous phases, and some explicitly said things like "everything" or "too many to list." A few mentioned specific types of observations, nowcasts, high-resolution models, or evacuation or other protective action recommendations. Illustrative quotes include:

- "The forecast discussion, cone/track, potential rainfall, wind radii, local impacts."
- "Storm surge maps, wind maps, track maps, discussion"
- "Expected rainfall, wind gusts, tornado potential, surge, duration of impacts, types of impacts, flooding potential."
- "Local impacts, the more specific, the better"

- "Graphic elements that help tell the story"
- "The Local Hurricane Statement is very important as a storm nears or is set to make landfall. It is extremely useful to alert our viewing area."
- "Any mesoscale forecasts from SPC, NHC, and our local WFOs is important to have. Hurricane local statements are so important during the event. It becomes a nowcast, so anytime we can get nowcast information from our local and national NOAA partners, we will take it and use it."
- "One pagers are helpful because they specify timing and more precise impacts"
- "The local NWS offices really tend to take the handles here and ours does a spectacular job in [WFO location] and I really think their PDF briefings are the most useful tool during this time frame. The text info in watch/warnings that breaks down each threat - wind, rainfall, surge, etc. is always updated and so helpful."
- "Local forecast office becomes more and more important as time shortens and threat increases."
- "Conference calls... frequently."
- "Basically almost everything you provide is monitored and used by our staff."

Although these types of responses dominated, and BRs generally indicated that NWS information is quite helpful, not all responses to these open-ended questions were fully positive. These issues are discussed further in later sections of the BR results.

Overall, these open-ended responses indicate the variety of types of NWS TC information and services that BRs find helpful, including graphical and text products from NHC, WFOs, and other NWS national centers, as well as information from and interactions with forecasters. These results also indicate that more than five days before TC impacts, BRs find the NHC TC Outlook and NWS Forecast Discussions most useful, along with TC track forecasts (and associated uncertainties) when available. Less than five days before landfall, TC track, timing, and intensity forecasts become more important to BRs, again along with Forecast Discussions. As a TC approaches, TC hazard and impact forecasts increase in importance, along with more specific timing and location information and information from local WFOs. These findings are consistent with the types of TC information that are typically available during these different time frames, given current forecast skill, as well as with the BR interview results (Morss et al. 2022b).

3.4. BR Interactions with NWS Weather Forecast Offices

The interview analysis found that information from and interactions with NWS forecasters are a valuable component of NWS products and services for some broadcast meteorologists (Morss et al. 2022b). Thus, as part of assessing how well NWS is currently supporting BRs' decisions (RQ2), the survey asked BRs to rate their interactions with their local NWS Forecast Office(s) during TC threats. As shown in Figure 3.11, overall, their ratings were quite positive (mean=1.71, between Good and Excellent). Coastal and inland BR respondents provided similar average ratings (one-way ANOVA: $F_{(1,84)}=1.43$, $p=0.24$). This indicates that most BR respondents throughout the study area have positive experiences interacting with WFOs (although as we discuss in section 3.9, in some cases there is room for improvement).

Only two broadcast meteorologists indicated that interactions with their WFO were Poor or Terrible. In responding to other survey questions, the BR who responded Terrible to this question indicated that they rely primarily on information from NHC rather than WFOs and experience some challenges using WFO information. For example, in response to one of the open-ended questions, they wrote: "The biggest problem with my LOCAL NWS - is that they release information - well after we have already developed the forecast and gone on air. Their deadlines are not in conjunction with our deadlines." This BR also rated *NWS briefings or conference calls* Moderately useful and *NWSChat* Not at all useful (see section 3.5). For the BR who responded Poor to this question, the reasons are less clear from the other survey data; however, this BR also indicated difficulty using some WFO information and rated *NWS briefings or conference calls* Moderately useful. These different ways of interacting with NWS forecasters are discussed further in later sections.

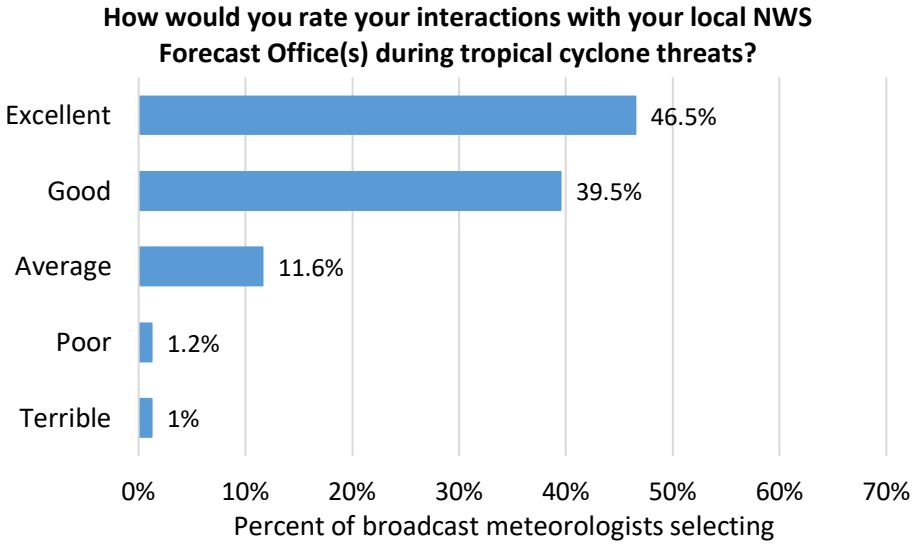

Figure 3.11. Broadcast meteorologists' ratings of interactions with their local NWS Forecast Office(s) during TC threats. Response scale: *1=Excellent, 2=Good, 3=Average, 4=Poor, 5=Terrible*. N=86.

3.5. Usefulness of Different Types of TC Information and Services for BRs

As another way of addressing how well NWS is currently supporting broadcast meteorologists (RQ2) and as part of addressing how useful and usable BRs find current NWS TC information and services (RQ3), the survey asked respondents to rate the usefulness of 26 different types of TC information and services, including a variety of TC products provided by different NWS entities. To reduce survey length, this set of questions was asked across all phases of a TC threat, and some items were received by only a subset of respondents (randomly assigned).

Figure 3.12 depicts ratings for the full set of TC information and services rated in the survey. Consistent with the results in section 3.3.1, on average, respondents rated all of the types of information and services asked about Very or Extremely useful. This provides further evidence that overall, NWS is currently supporting most BRs' TC decisions and communications quite well. These results also indicate that, as discussed in section 3.3.2, BRs find it useful to have the many different types of TC information and services currently available from the NOAA.

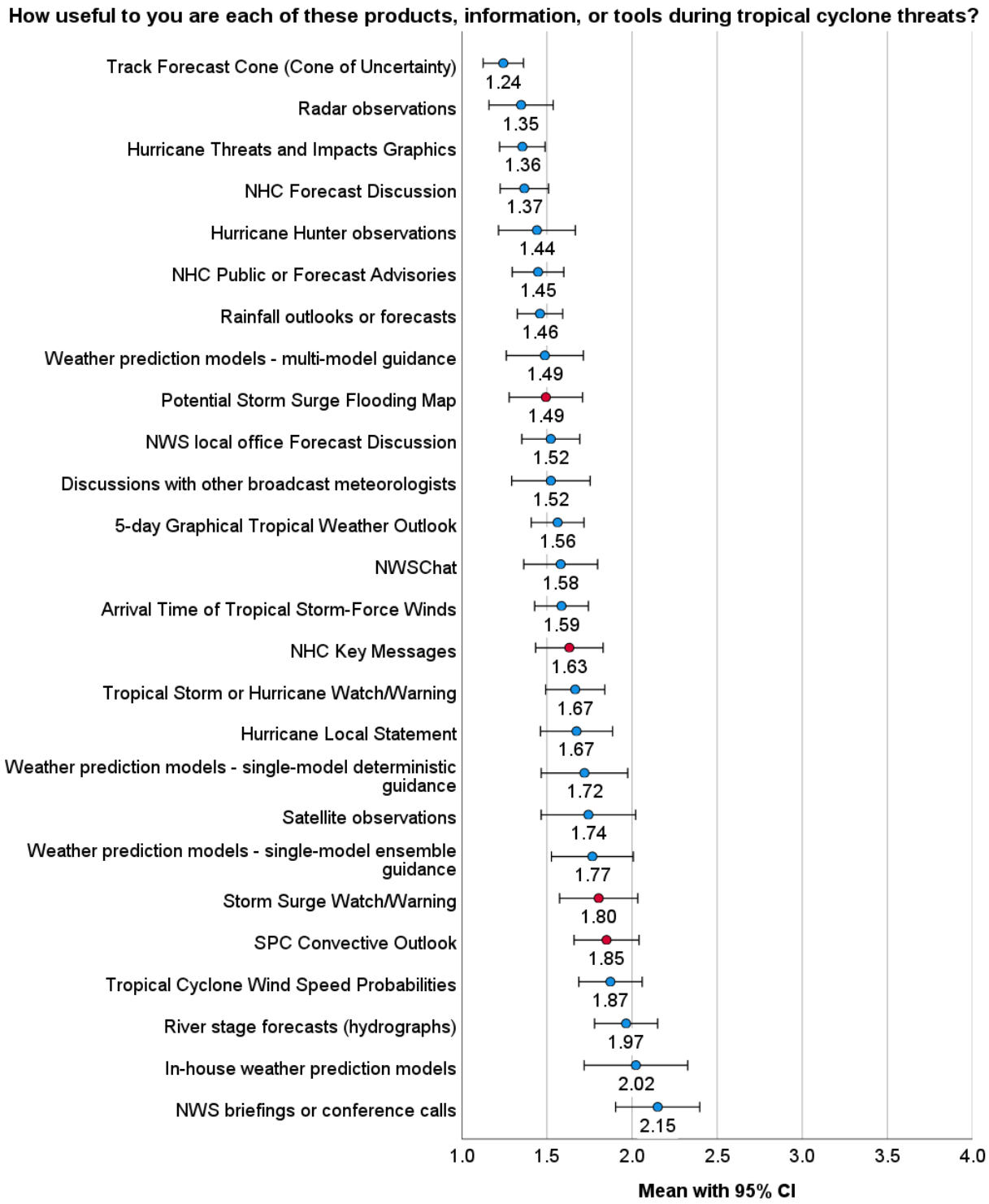

Figure 3.12. Broadcast meteorologists' ratings of the usefulness of different types of TC information and services. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by BR proximity to the coast (see Tables 3.2 and 3.5). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full BR sample. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful.* Several types of information and services are abbreviated in the figure; the full versions provided in the survey are shown in Tables 3.2 and 3.5. N=42–87, depending on the question item.

Although Figure 3.12 orders the types of TC information and services by their mean rating, many of the confidence intervals overlap. In addition, some ratings may differ across coastal and inland BRs. Thus, to examine these results in more depth, next we examine the same data segmented into four groups of TC information and services:

- **Group 1:** TC overview products provided by NHC and WFOs,
- **Group 2:** TC hazard and impact products (provided by NHC, WFOs, WPC, SPC, RFCs),
- **Group 3:** Forecaster interpretations (from NHC and WFOs), and
- **Group 4:** Numerical model output and observations,

for the full sample and comparing coastal to inland BRs. These groups were developed in collaboration with the core NOAA team, to represent different categories of information and services of interest.

Results for the first group of TC information and services — TC overview products — are shown in Figure 3.13 for the full sample, and in Table 3.2 partitioned into coastal and inland BRs. The mean ratings of Very to Extremely useful for each of these five products underscore their value to BRs. Each was rated Extremely useful by more than half of BR respondents, with the highest-rated product, *Track Forecast Cone*, rated Extremely useful by 80% of respondents.

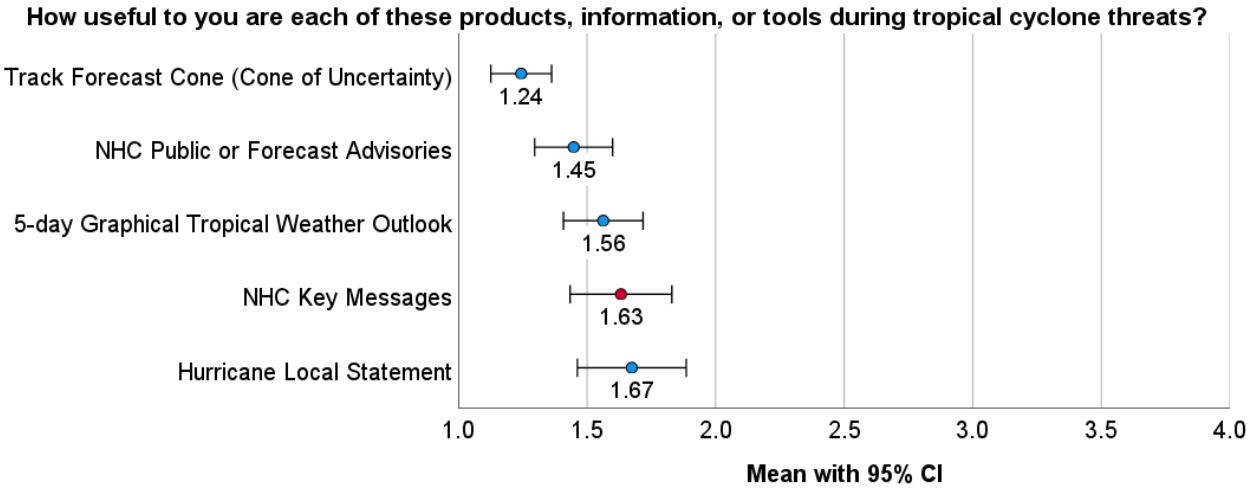

Figure 3.13. Broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 1: NWS TC overview products. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by BR proximity to the coast (see Table 3.2). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full BR sample. Response scale is the same as in Figure 3.12. N=86–87.

Statistical tests suggest that BRs' ratings differed with proximity to the coast for one product in this group, *NHC Key Messages*, with coastal BRs rating this information more useful to them than inland BRs (Table 3.2). This is consistent with the interview results that NHC Key Messages typically focus on the largest and most urgent anticipated impacts, which are often coastal rather than inland (Morss et al. 2022b). However, on average inland BRs still rated *NHC Key Messages* Very useful.

Table 3.2. Comparison of coastal and inland broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 1: TC overview products. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed between coastal and inland BRs ($p<0.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal BRs: mean (SD)	inland BRs: mean (SD)	one-way ANOVA F	one-way ANOVA p
Track Forecast Cone	86	1.25 (0.58)	1.22 (0.51)	0.062	0.80
NHC Public or Forecast Advisories	87	1.42 (0.67)	1.52 (0.80)	0.38	0.54
NHC Key Messages	**87**	**1.50 (0.88)**	**1.93 (1.00)**	**4.05**	**0.047**
5-day Graphical Tropical Weather Outlook	87	1.53 (0.70)	1.63 (0.79)	0.17	0.32
Hurricane Local Statement	86	1.58 (0.93)	1.88 (1.11)	1.70	0.20

Results for the second group — TC hazard and impact products — are shown in Figure 3.14 for the full sample, and in Table 3.3 partitioned into coastal and inland BRs. Statistical tests suggest that *Potential Storm Surge Flooding Map* and *Storm Surge Watch/Warning* were rated more useful by coastal than inland BRs. However, consistent with the results in section 3.2, on average, inland BRs still rated storm surge forecast and warning products Very useful.

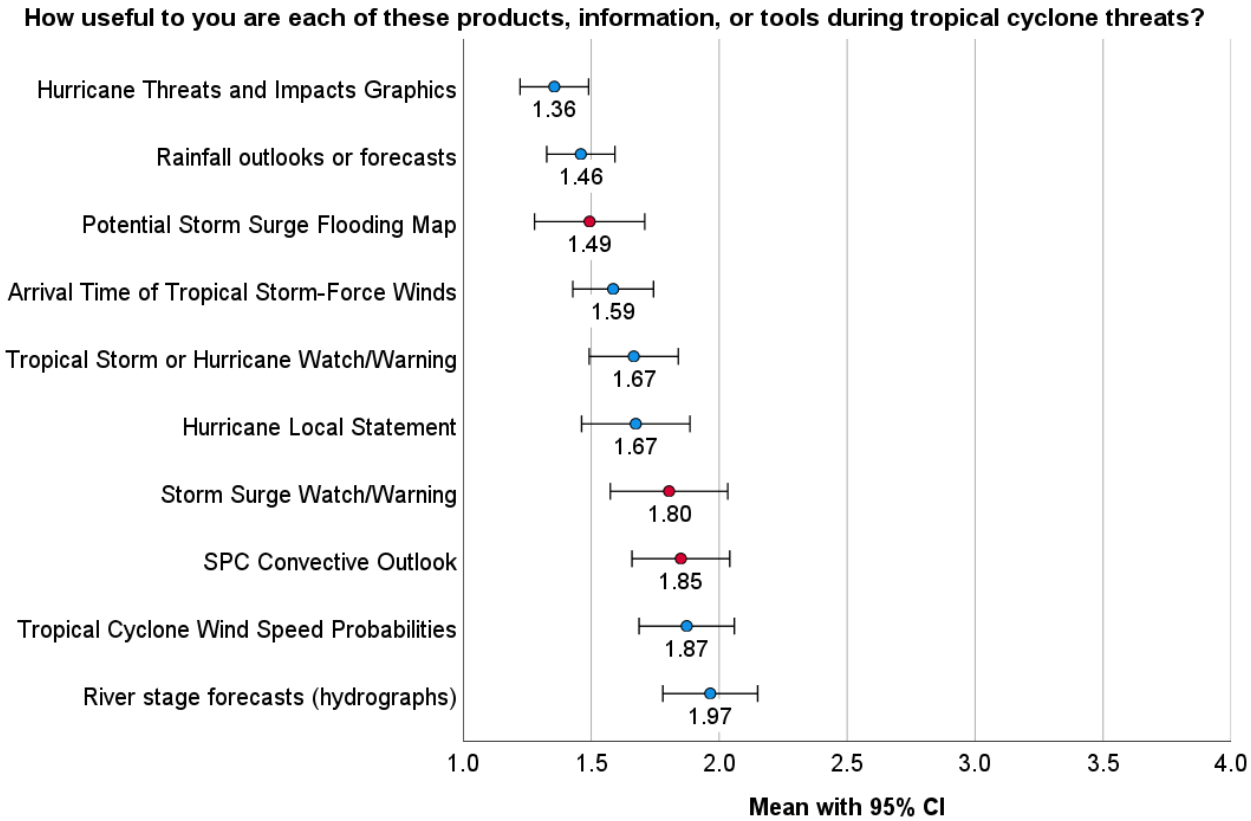

Figure 3.14. Broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 2: TC hazard and impact products. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by BR proximity to the coast (see Table 3.3). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full BR sample. Response scale is the same as in Figure 3.12. N=87.

Table 3.3. Comparison of coastal and inland broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 2: TC hazard and impact products. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by BR proximity to the coast ($p<0.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal BRs: mean (SD)	inland BRs: mean (SD)	one-way ANOVA F	one-way ANOVA p
Potential Storm Surge Flooding Map	**87**	**1.28 (0.61)**	**1.96 (1.48)**	**9.24**	**0.003**
Hurricane Threats and Impacts Graphics	87	1.33 (0.60)	1.41 (0.69)	0.26	0.61
Rainfall outlooks or forecasts	87	1.53 (0.65)	1.30 (0.54)	2.73	0.10
Arrival Time of Tropical Storm-Force Winds	87	1.55 (0.65)	1.67 (0.92)	0.46	0.50
Storm Surge Watch/Warning	**87**	**1.58 (0.77)**	**2.30 (1.46)**	**8.92**	**0.004**
Tropical Storm or Hurricane Watch/Warning	87	1.68 (0.73)	1.63 (1.01)	0.080	0.78
Tropical Cyclone Wind Speed Probabilities	87	1.95 (0.93)	1.70 (0.72)	1.49	0.23
River stage forecasts (hydrographs)	87	1.95 (0.87)	2.00 (0.88)	0.061	0.80
SPC Convective Outlook	**87**	**2.02 (0.93)**	**1.48 (0.70)**	**7.11**	**0.009**

Table 3.3 also suggests that *SPC Convective Outlook* was rated more useful by inland than coastal BRs. One possible explanation is that storm surge and hurricane-force winds typically do not reach far inland, leaving tornadoes as one of the most life-threatening TC hazards. Another possibility is that inland BRs are more familiar with convective outlooks from non-TC weather situations, which translated into more positive ratings of their usefulness during TC threats.

Results for the third group — forecaster interpretations — are shown in Figure 3.15. Comparison of coastal and inland BRs (Table 3.4) indicates no statistically significant differences, although inland BRs may rate the NWS Local Office Forecast Discussion more useful than coastal BRs.

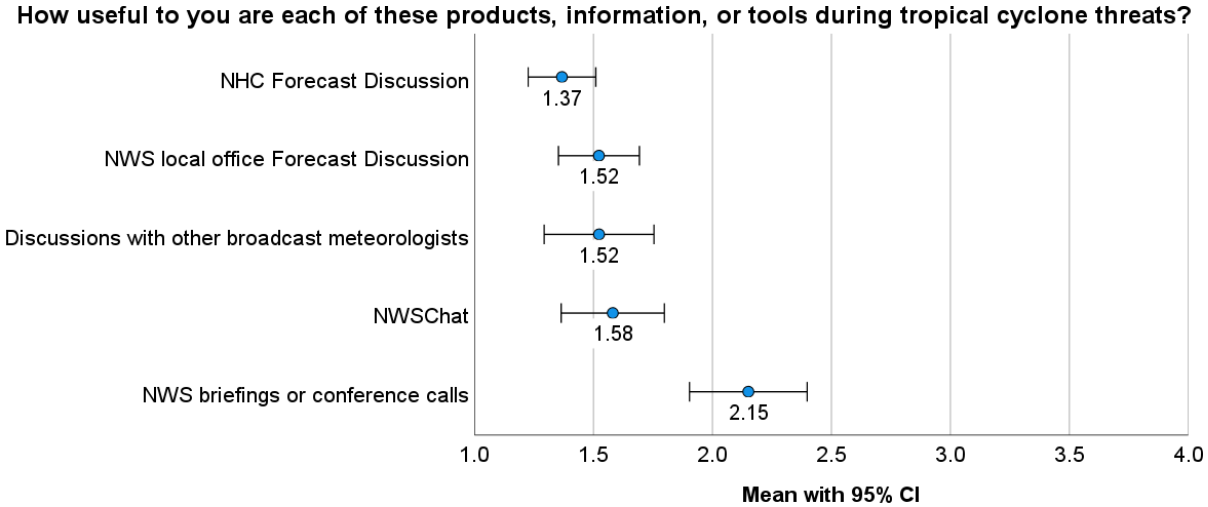

Figure 3.15. Broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 3: Forecaster interpretations. Types of information are ordered from highest (1) to lowest (5) mean usefulness. Dots indicate mean ratings, with 95% confidence intervals. Response scale is the same as in Figure 3.12. The full version of each survey question item is shown in Table 3.4. N=42 for Discussions with other broadcast meteorologists; N=86–87 for others.

Table 3.4. Comparison of coastal and inland broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 3: Forecaster interpretations. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by BR proximity to the coast ($p<0.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal BRs: mean (SD)	inland BRs: mean (SD)	one-way ANOVA	
				F	p
NHC Forecast Discussion	87	1.30 (0.50)	1.52 (0.79)	2.02	0.16
Discussions with other broadcast meteorologists in your workplace	42	1.48 (0.74)	1.62 (0.77)	0.28	0.60
NWS local office Forecast Discussion	86	1.63 (0.86)	1.27 (0.53)	3.96	0.050
NWSChat	86	1.67 (1.05)	1.38 (0.90)	1.42	0.24
NWS briefings or conference calls	86	2.19 (1.14)	2.07 (1.21)	0.17	0.68

The high ratings for the *NHC and WFO Forecast Discussion* products and for *NWSChat*, all between Very and Extremely useful, on average, indicate that, BRs find NWS forecasters' interpretations highly useful, accessed both asynchronously (in written products) as well as through real-time interactions. This extends one of the results from our interviews (Morss et al. 2022b) to a larger, more geographically diverse BR sample. Each of these NWS products and services was rated Extremely useful by 60% or more of respondents, as were *discussions with other broadcast meteorologists in your workplace*. *NWS briefings and conference calls* were rated Very useful, on average, with a wider distribution of ratings: 40% Extremely useful, 23% Very useful, and 22% Moderately useful. This variation may be associated with variation in WFOs' use of briefings and conference calls overall, or for communicating with EMs and other partners compared to BRs.

Results for the fourth group — numerical models and observations — are shown in Figure 3.16. Statistical tests suggest no significant differences between coastal and inland BRs (Table 3.5), which is not unexpected given the smaller sample sizes (due to randomization of some items within this question). *Radar observations*, *Hurricane Hunter observations*, and *multi-model guidance (e.g., spaghetti plots)* were rated Extremely useful by more than 60% of BRs; this is consistent with the BRs' discussions of spaghetti plots in the interviews (Morss et al. 2022b). *Satellite observations* and the other two types of model output were rated Extremely useful by 40–55% of BRs. Although *in-house weather prediction models* (non-government models, e.g., accessed through private sector vendors) were not among most useful information and tools, they were still rated, on average, Very useful.

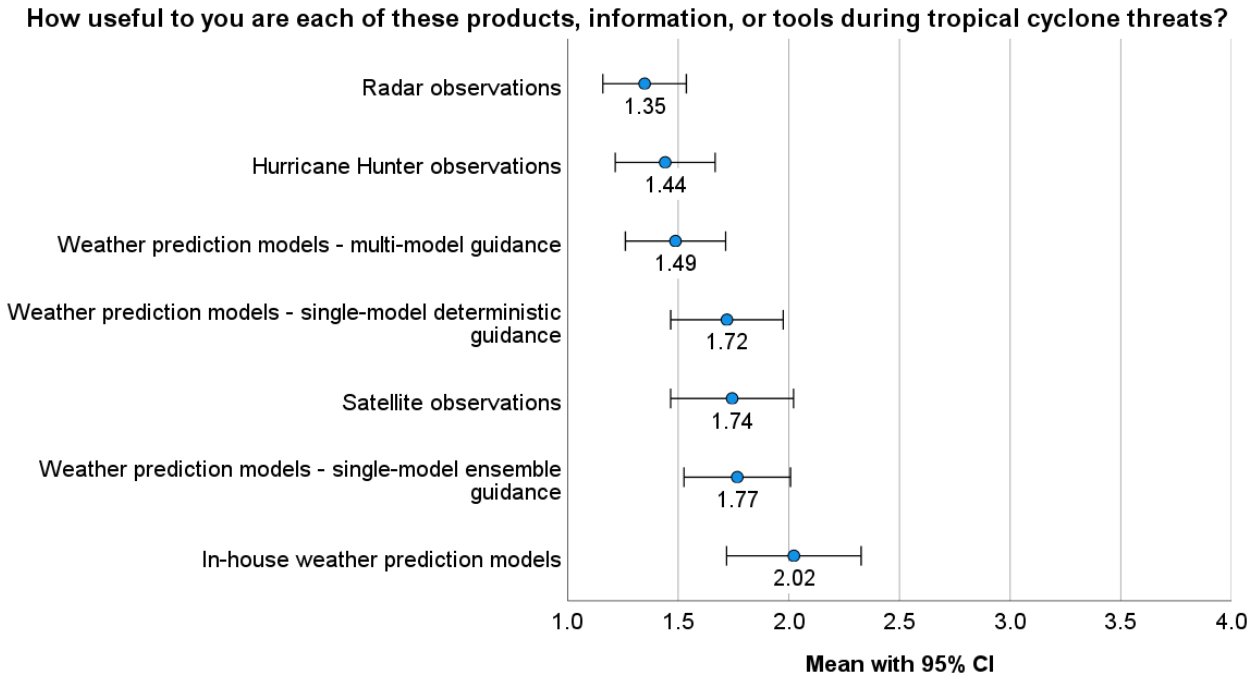

Figure 3.16. Broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 4: Numerical models and observations. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from highest (1) to lowest (5) mean usefulness. The full version of each survey question item is shown in Table 3.5. Response scale is the same as in Figure 3.12. N=43.

Table 3.5. Comparison of coastal and inland broadcast meteorologists' ratings of the usefulness of different types of TC information and services, for Group 4: Numerical models and observations. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by BR proximity to the coast ($p<0.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal BRs: mean (SD)	inland BRs: mean (SD)	one-way ANOVA F	one-way ANOVA P
Radar observations	43	1.38 (0.62)	1.29 (0.61)	0.22	0.64
Hurricane Hunter observations	43	1.41 (0.78)	1.50 (0.65)	0.13	0.72
Operational weather prediction models - multi-model guidance (e.g., multi-model spaghetti plots)	43	1.47 (0.68)	1.54 (0.88)	0.08	0.77
Operational weather prediction models - single-model deterministic guidance (e.g., GFS, HWRF, Canadian, or European)	43	1.67 (0.88)	1.85 (0.69)	0.42	0.52
Satellite observations	43	1.79 (0.86)	1.64 (1.01)	0.26	0.62
Operational weather prediction models - single-model ensemble guidance (e.g., GEFS)	43	1.80 (0.81)	1.69 (0.75)	0.17	0.68
In-house weather prediction models	43	2.03 (1.10)	2.00 (0.71)	0.01	0.92

3.6. Usability of NWS TC Information and Services for BRs and Usability Gaps

Next we focus in more depth on RQ3, examining the usability of NWS TC information and services from several perspectives. This includes investigating in further depth, with a larger sample of broadcast meteorologists, several potential gaps in usability that arose in the interviews (Morss et al. 2022b): the timing of NWS information releases relative to BRs' timelines for preparing for news broadcasts (section 3.6.1) and difficulties that some BRs experience using NWS graphics and other products (sections 3.6.2, 3.6.3, and 3.6.4).

3.6.1. Alignment of NWS TC information and services with BR decision-making timeline

As part of assessing overall usability, the survey included a question asking how well NWS information and services match with broadcast meteorologists' job timelines. As shown in Figure 3.17, approximately three-quarters of BR respondents said that NWS information currently aligns well with their timeline, whereas one-quarter said there was room for improvement. Few respondents said that NWS information was not at all aligned with their timeline.

Conversation with one of the BR survey pretesters suggested that the timing of NWS TC product releases may be a greater issue for BRs in the Eastern than in the Central U.S. time zone, associated with differences in timing of some television news broadcasts. However, the distributions of responses to this question were similar between the 64 BRs in Eastern Time and the 23 BRs in Central Time (Independent samples Mann-Whitney U test: p=0.24).

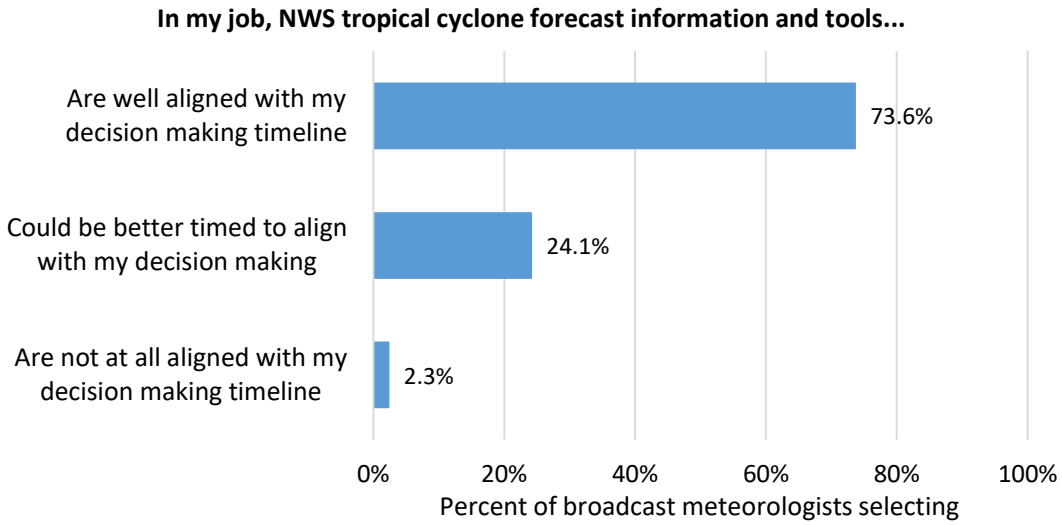

Figure 3.17. Broadcast meteorologists' ratings of the alignment of NWS TC forecast information and tools with their decision-making timelines. Respondents were asked to select which of the three response options shown best fits their judgment. N=87.

In their open-ended responses to other survey questions, some BRs indicated why they said that NWS TC information and tools could be better aligned with their decision timeline or are not at

all aligned. In particular, BRs requested that NWS TC products be consistently released with sufficient time before they go on air during regularly scheduled television newscasts that they can understand the new information and build graphics for their weathercast. Illustrative quotes include:

- "Time release from NHC of discussions, forecasts and upgrades. We need more time to read, digest and prepare graphics of the information BEFORE going on air."
- "Outlook timing coming prior to 5pm/11pm newscasts"
- "Don't be late with the NHC forecast updates every 6 hours. It would be very helpful if the forecasts always came in around 10-15 minutes before the top of the hour."
- "Make sure latest discussions and forecast are out at least 10-15 minutes before standard newstime."
- "Back up the advisories so that they are on a 4/10 cycle not 5/11; that makes it very hard for all but the noon newscasts on the East Coast"
- "We need the advisories at least 15 minutes before the top of the hour. We almost always lead the newscast for tropical systems (even ones that don't impact our state) and we need a few minutes to adjust the time stamps on the cone so they're not jumbled on top of each other and also to process the info for a minute before we're on air. This also allows us to put out a quick social post and tease to the TV in 10 minutes with a closer look at why we have these changes, new info, etc."

As the last quote illustrates, BRs value timely release of NWS products not only for regularly scheduled television weathercasts, but also as part of their multi-platform strategies for communicating weather information with a broad audience.

Some BRs were not specific about the amount of time needed prior to newscasts or requested more time; however, they most commonly requested that NWS TC products be released about 15 minutes before regularly scheduled newscasts begin (see quotes above). This is important in part because, as the last quote above illustrates, TC threats will often lead the newscast rather than being covered towards the end of a newscast as is often the case for weather. BRs noted the importance of timely provision of the graphical products and data layers needed for the visuals they will show on air, as well as text products that will help them understand and communicate key updated forecast information. Although the majority of BRs who mentioned this topic on the survey referred to NHC products, several specifically noted the importance of timely WFO products. Illustrative quotes include:

- "Timely AFD"
- "… and get HLS out asap from NHC forecast packages at 5a/11a/5p/11p"
- "… The local NWS office's hurricane impacts could be delivered at the same time as the NHC advisories.

Discussion with NWS project collaborators indicated that NHC TC product packages are typically released on schedule or early — unless NHC forecasters are waiting for a key new piece of information to come in, such as data from a Hurricane Hunter reconnaissance flight in progress. Unfortunately, some of these times when NWS forecasters are waiting for important new information are likely the same times when the risk posed by a TC is evolving, and thus when it is most important for BRs to communicate the most updated TC information to the

public. This suggests that NOAA may need to adopt a multi-faceted strategy for addressing mismatches of NWS TC product releases with BRs' timelines, combining a standard release time of at least 15 minutes before the hour with additional approaches when the release is delayed while waiting for key information. In the latter situation, possible approaches include notifying BRs of the reason for the delay and the expected timing of the product release (so they can most effectively plan how to prepare for their weathercast) and phased release of key NHC products when ready if that will be faster than a full package release.

Also related to product timing, several BRs requested that NWS update TC information more frequently or release new information more rapidly. Illustrative quotes include:

- "More frequent updates"
- "Faster turnaround of potential impact graphics as generated by local WFO"
- "When in the "intermediate advisory" phase, to see more latitude in the ability to make short-term changes in the track and intensity forecasts based on recent conditions/changes...incorporating more "now-casting" information and not waiting until the main update to shift a track."

Providing more frequent updates when the TC forecast situation is changing, as described in the last quote, may also help alleviate issues with the release of NWS information relative to newscast times, discussed above. These and other topics in the BRs' open-ended responses to the survey questions are discussed further in sections 3.8.2 and 3.8.4.

3.6.2. Usability of NWS TC graphics for BRs

To assess another aspect of the usability of NWS information, the survey included a question asking broadcast meteorologists the extent to which NWS graphics meet their needs for communicating about TC threats, versus needing to modify them. As shown in Figure 3.18, only 8% of BR respondents said that they use NWS graphics "as is" to communicate with their audiences. About two-thirds said that they sometimes modify NWS graphics to communicate better, and almost one-quarter said that they are able to communicate more effectively if they modify NWS graphics. A few who said that they had to modify NWS graphics to communicate; however, none said that the graphics are not useful to them. Overall, this indicates that the vast majority of BRs find at least some aspects of NWS graphics useful and usable, but most modify existing NWS graphical products when communicating.

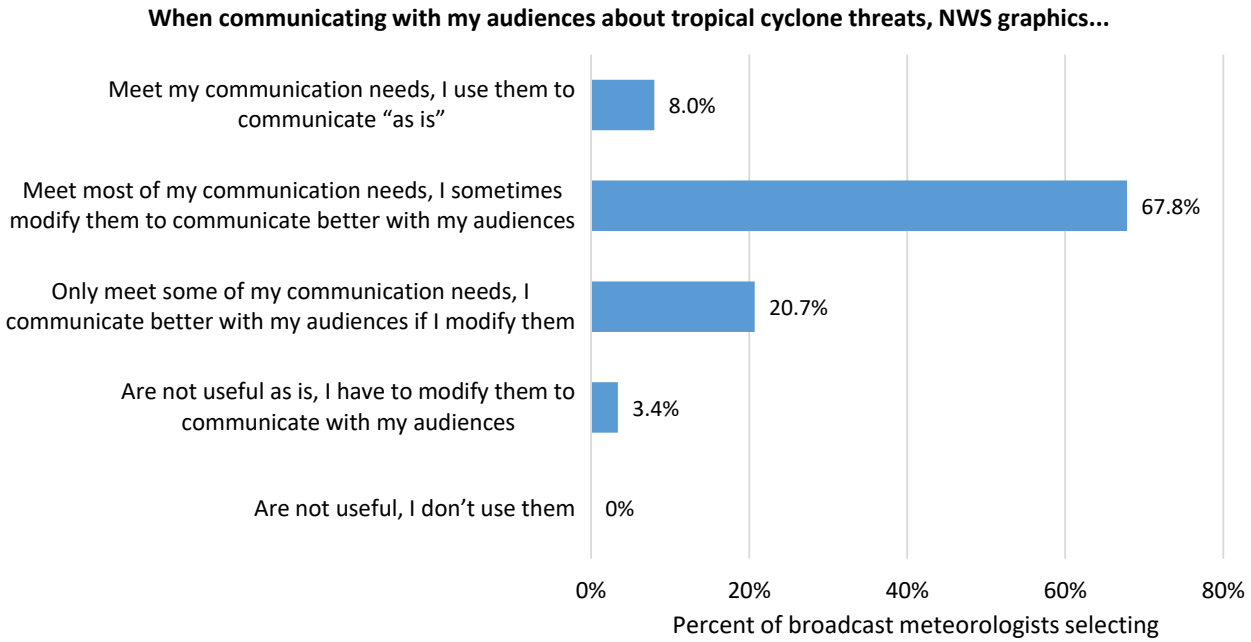

Figure 3.18. Broadcast meteorologists' reported modification of NWS graphics for communicating with audiences. Respondents were asked to select which of the five response options shown best fits their judgment. N=87.

As discussed in Morss et al. (2022b) and section 3.1, BRs communicate visual information with their audiences across multiple channels, including on-air television, web sites, and social media. To explore the usability of NWS graphics in more depth, the survey also asked BRs about the usability of NWS graphics for communicating on these three different channels.

Figure 3.19 shows that a majority of BR respondents find it Somewhat or Extremely easy to use NWS graphics on any of the three communications channels. On average, respondents reported finding it easier to use NWS graphics on social media (mean=1.98, Somewhat easy), than on their station website (mean=2.24) or on-air television (mean=2.31). Paired-sample t-tests indicate that BRs find it easier to use NWS graphics on social media than on-air (t_{85}=2.89, p=0.005) or on their station's website (t_{85}=2.98, p=0.004), but their ratings of on-air and station website are similar (t_{85}=0.70, p=0.49). About 16% of BRs reported some or extreme difficulty using NWS graphics on-air, compared with 11% on their station's website and only 5% on social media).

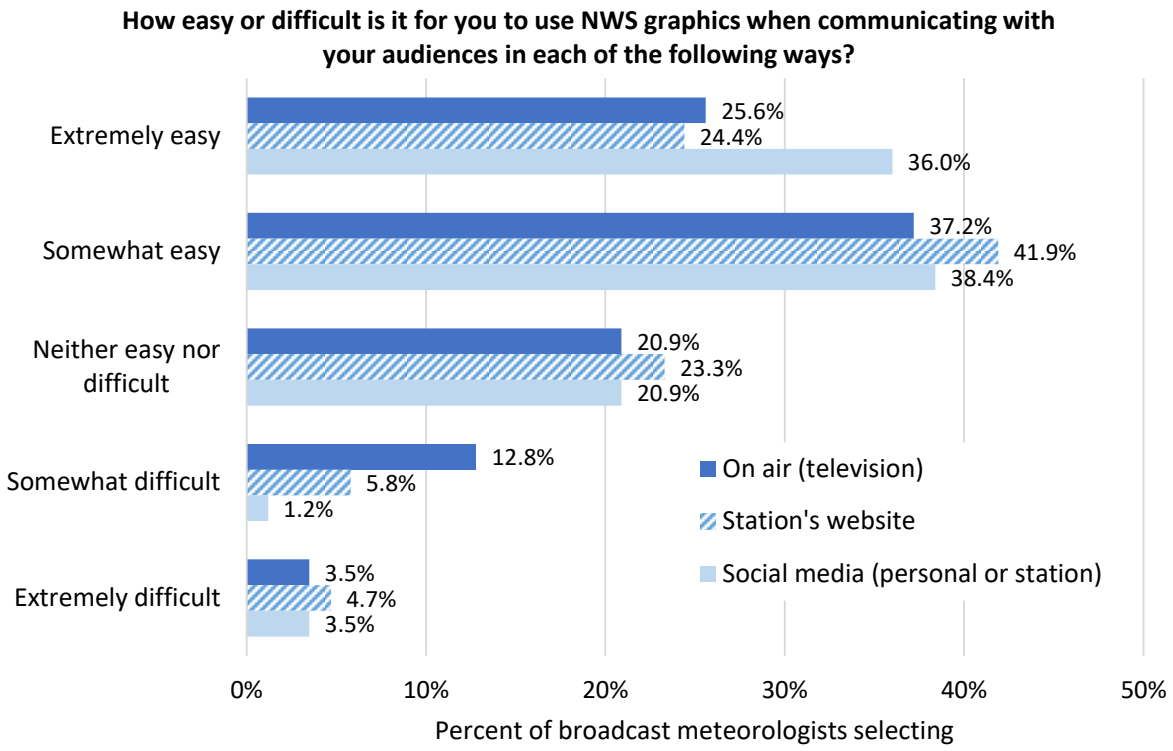

Figure 3.19. Broadcast meteorologists' reported ease of using NWS graphics on different communications channels. Response scale: *1=Extremely easy, 2=Somewhat easy, 3=Neither easy nor difficult, 4=Somewhat difficult, 5=Extremely difficult.* N=86.

3.6.3. Usability of different NWS TC products for BRs

To investigate whether there are NWS TC products that broadcast meteorologists have particular difficulties using, the survey included a question that provided each respondent with a randomly selected subset of four of the NWS products in Figure 3.20 and asked which, if any, they have difficulty using. The products were presented in random order, and respondents could select one or more products, or None of the above.

As shown in Figure 3.20, about half of respondents reported that they did not have difficulty using any of the four products included in their version of the question. The product that BRs most commonly indicated difficulties with was *river stage forecasts (hydrographs)*, which more than half reported having difficulty using. Approximately one-quarter to one-third reported having difficulty using the *Potential Storm Surge Flooding Map*, the *Hurricane Local Statement*, or the *Arrival Time of Tropical Storm Force Winds* product. No or few respondents reported difficulty using any of the three watch/warning products included in the question or the *Track Forecast Cone*, the *SPC Convective Outlook*, or *rainfall outlooks or forecasts*. Given the smaller sample sizes for these questions (26–28), these lower frequency responses (3 or fewer) are indistinguishable from zero (at $p<0.05$).

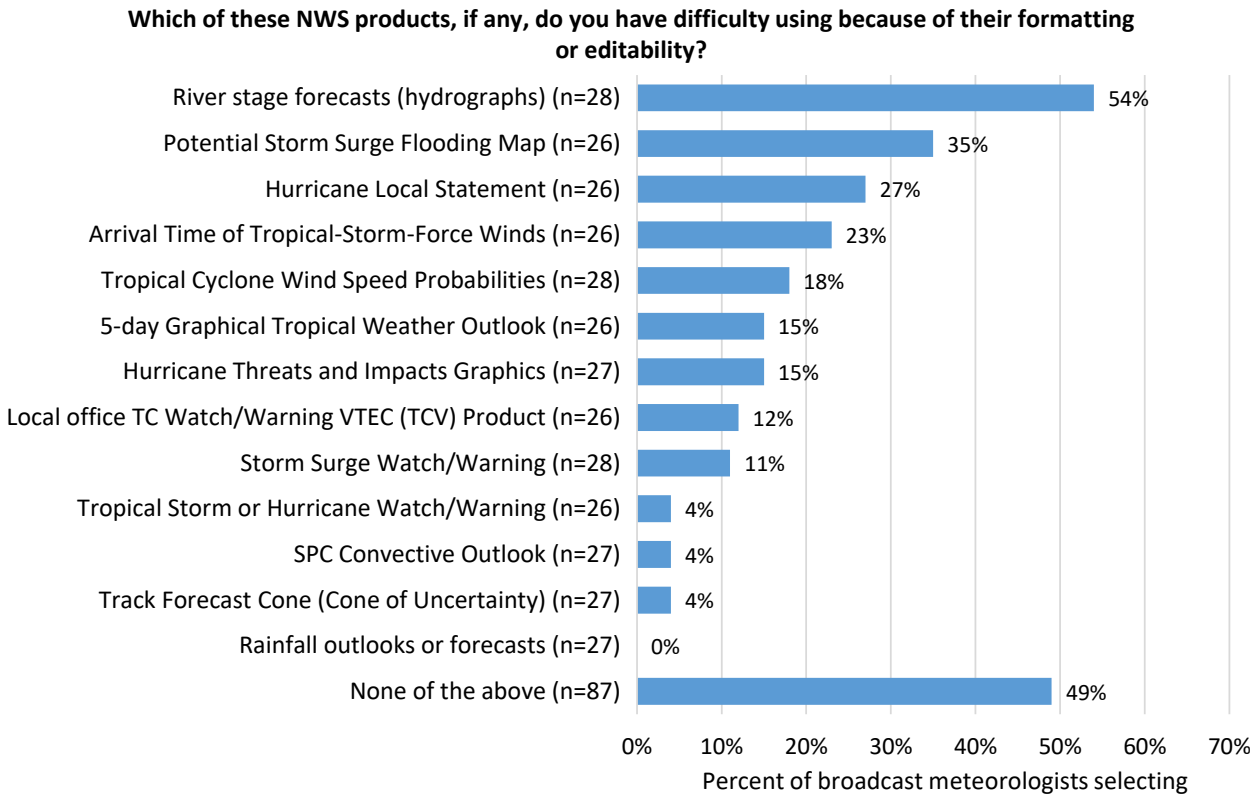

Figure 3.20. Broadcast meteorologists' reported difficulty using different NWS TC products. Products are ordered from the largest to smallest percentage of respondents saying that they had difficulty using the product. *None of the above* indicates that a respondent said they did not have difficulty using any of the four products included in their version of the question. As indicated in the graphic, N=26–28, depending on the product.

3.6.4. Reasons for BR difficulty using NWS TC products

For the 44 broadcast meteorologist respondents who said they had difficulty using one or more of the products, the survey asked a follow-up question about what made that product (if only one had been selected) or a randomly selected one of those products (if more than one had been selected) difficult to use. Four response options were offered, along with an "Other" option (see Figure 3.21); respondents could select one or more options. These response options were developed based on the BR interview findings, other prior research, and discussions with the core NOAA team.

As shown in Figure 3.21, the most commonly selected responses (each chosen by more than 40%) were that the product is hard to edit or the data layer is not available. This is consistent with the results in Figure 3.18 that most BRs modify NWS products for communicating with their audiences. It is also consistent with the BR interview findings that BRs find it important to be able to edit NWS products, including accessing data layers so that they can modify graphics, combine data from different sources to create new visuals, and prepare animations using their station software (Morss et al. 2022b).

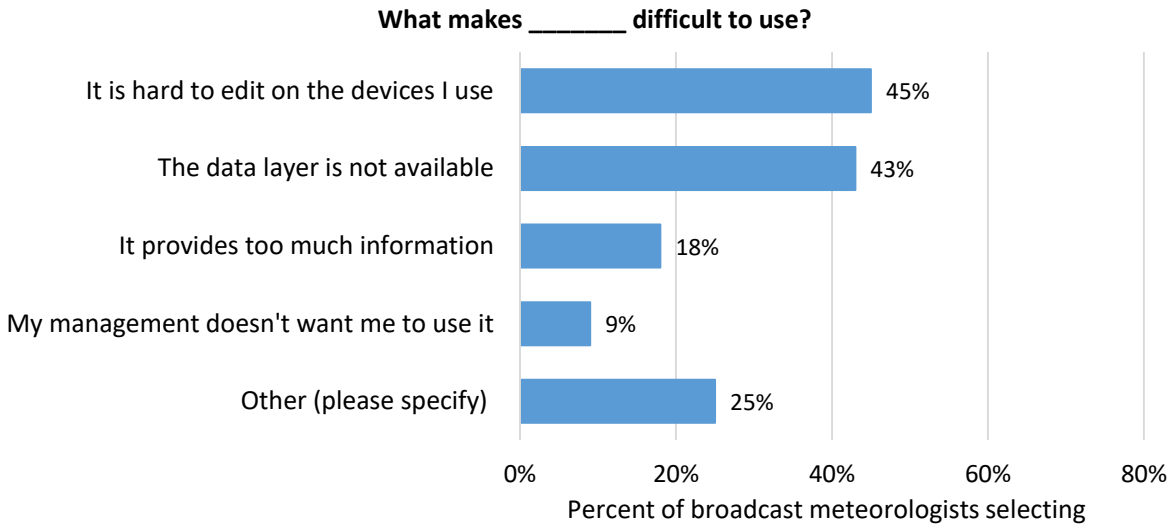

Figure 3.21. Broadcast meteorologists' reported reasons for difficulty using an NWS TC product. Respondents were asked to select all that apply. N=44.

Analyzing these results in further detail, Table 3.6 shows the reasons that BRs reported having difficulty using six specific products. There are few respondents for most of the products, making it difficult to draw clear conclusions. However, the data indicate a pattern of difficulty editing the product and data layer unavailability for many of the products, with a few BRs noting that the product provides too much information or is difficult to understand.

The interview data (Morss et al. 2022b) indicate these reasons intersect: BRs find that some NWS graphical products are too complicated or have too much information to be readily understandable and explainable to a broad public audience, and so BRs prefer (or in some cases need) to modify the graphic in order to communicate effectively. If the data layer for the product is available and a BR can build a revised version in their software, then they can simplify it or make other changes to enhance comprehension, and either post it online or incorporate it into their television or online weathercasts. If not, then they must either use the graphical product in the NWS format or not at all, and it will be difficult or impossible to use in weathercasts. Although a small number of BRs were asked about each of the products included in this question, these results suggest that such issues are particularly prominent for NWS hydrographs and storm surge flooding maps.

Table 3.6. Reasons broadcast meteorologists reported having difficulty using different NWS TC products. Only products that four or more BRs reported having difficulty using and that three or more BRs were asked about their reasons for difficulty using are included. Products are ordered by largest to smallest percentage of respondents saying that they had difficulty using the product.

Product	# (%) of BRs who reported difficulty using the product	# of BRs who were asked reason for difficulty using	Reasons BRs reported having difficulty using: # who selected (% of those asked reason for difficulty using)				
			It is hard to edit on the devices I use	The data layer is not available	It provides too much information	My management doesn't want me to use it	Other
River stage forecasts (hydrograph)	15 (54%)	12	6 (50%)	9 (75%)	2 (17%)	2 (17%)	2 (17%): "Can't use this on air, too much info with very little time slotted. This is used best on social media." "Too much on the graph for the viewer. We have to make our own. Not TV friendly."
Potential Storm Surge Flooding Map	9 (35%)	7	4 (57%)	3 (43%)	2 (29%)	1 (14%)	2 (29%): "Sometimes hard to understand." "Hard to find a KML file for this to input into [software]."
Hurricane Local Statement	7 (27%)	6	3 (50%)	3 (50%)	1 (17%)	1 (17%)	0
Arrival Time of Tropical-Storm-Force Winds	6 (23%)	3	0	1 (33%)	0	0	2 (67%): "We have [vendor] and they have some work to do on their end to get the arrival time product working." "Just too much info on one map."
Tropical Cyclone Wind Speed Probabilities	5 (18%)	5	3 (60%)	0	2 (40%)	0	1 (40%): "Unfortunately, my viewers do not like probabilities. … In light of that, I think we should give the viewer information in this format: 'Plan on the following …' "
Hurricane Threats and Impacts Graphics	4 (15%)	3	1 (33%)	2 (66%)	1 (33%)	0	0

3.7. BR Perceived Audience Understanding of Different Types of TC Information

If broadcast meteorologists perceive that their audiences have difficulty understanding a type of information or product, that may affect (or limit) BRs' use of that information in their communications. Thus, to address another aspect of the usability of current NWS TC products and services (RQ3), the survey asked BRs how well they think their audiences understand different types of TC information. The 13 types of information included in this question were a subset of those in the "importance of communicating" questions discussed in section 3.2. To reduce survey length, the question was asked across all phases of a TC threat, and each respondent was asked to rate only 4 of the 13 types of information.

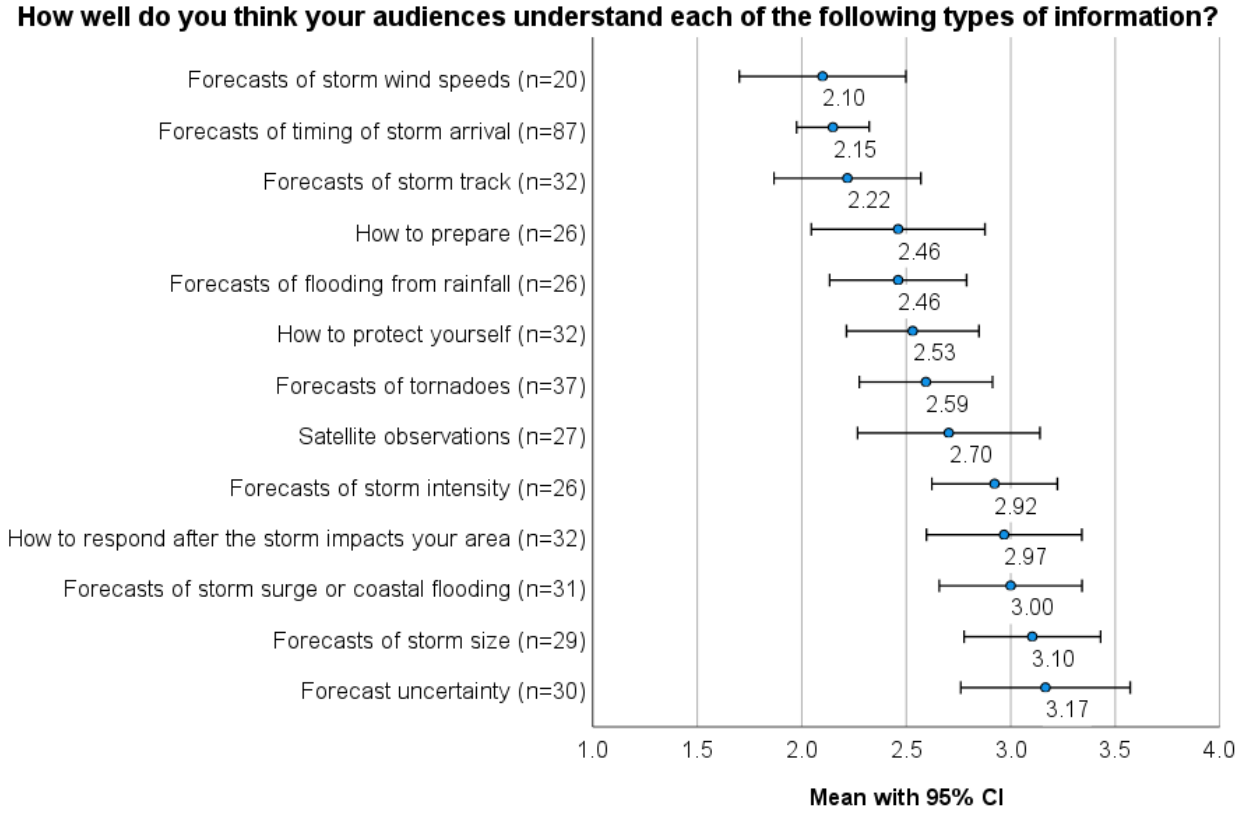

Figure 3.22. Broadcast meteorologists' ratings of audience understanding of different types of TC information. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from highest (1) to lowest (5) mean ratings of audience understanding. Response scale: *1=Extremely well, 2=Very well, 3=Moderately well, 4=Slightly well, 5=Not well at all*. As indicated in the graphic, N=26–87, depending on the question item. Results are not partitioned into coastal and inland BRs because of the small number of respondents.

Figure 3.22 shows that, on average, BRs think that their audiences understand these types of information Moderately to Very well. Most information types had very few ratings at the bottom of the scale (<5%), except for *forecast uncertainty*, which 17% (of the 30 respondents randomly assigned to rate that type of information) said their audiences did not understand well at all.

Although there were more ratings at the top of the scale than the bottom, for most types of information <20% of respondents rated their audience understanding at the top of the scale. The exceptions were *forecasts of storm track* and *forecasts of storm wind speeds*, which approximately one quarter of BRs said that their audiences understand Extremely well.

Many of the ratings in Figure 3.22 cannot be reliably differentiated, given the sample sizes. Some may also vary geographically, which requires a larger data set to investigate. However, the non-overlapping confidence intervals suggest that there are differences between the highest and lowest rated types of information. For example, paired-sample t-tests suggest that BRs think their audiences understand *forecasts of flooding from rainfall* (mean=2.46) better than *forecasts of storm surge or coastal flooding* (mean=3.00) (t_8=4.26, p<0.01) or *forecast uncertainty* (mean=3.17) (t_9=4.88, p<0.01).

3.8. BR Views about Potential Changes to NWS TC Information and Services

Finally, the survey included several questions to address RQ4, broadcast meteorologists' views on potential changes to NWS information, products, and services. This included a set of questions about how helpful it would be for the NWS to provide additional information and tools during each of the three phases of a TC threat. As for the questions about the helpfulness of current NWS information and tools (see section 3.3), in each phase this included a closed-ended question (discussed in section 3.8.1), followed by an open-ended question: "In responding to the previous question, what additional type(s) of information or tools came to mind first?" (discussed in section 3.8.2). This is followed by results from a closed-ended survey question that asked respondents to rate the usefulness of a small set of potential changes (section 3.8.3) and an open-ended survey question that asked respondents what change they think is most important for NWS to make (section 3.8.4).

3.8.1. Helpfulness of additional NWS information and services: BR ratings in different phases of a TC threat

As shown in Figure 3.23, most broadcast meteorologist respondents said that it would be Moderately to Extremely helpful for NWS to provide additional information or tools in Phase I, and Very or Extremely helpful in Phases II and III. A small number (less than 10%) said that NWS providing additional information would not be helpful. The mean response increases from 2.46 in Phase I (between Moderately and Very helpful) to 1.98 in Phase II (Very helpful; paired-sample t-test: t_{87}=3.05, p<0.001); interest in additional information in Phase II (mean=1.90) is similar to that in Phase III.

Figure 3.24 depicts results partitioned into coastal and inland BRs. Although the confidence intervals overlap, one-way ANOVAs suggest that in Phases I and III, additional information or tools were rated more helpful by coastal BRs than inland BRs (Phase I: $F_{(1,84)}$=4.09, p=0.046; Phase II: $F_{(1,85)}$=0.93, p=0.34; Phase III: $F_{(1,84)}$=6.37, p=0.014). The results for inland BRs, however, are likely affected by the small sample size.

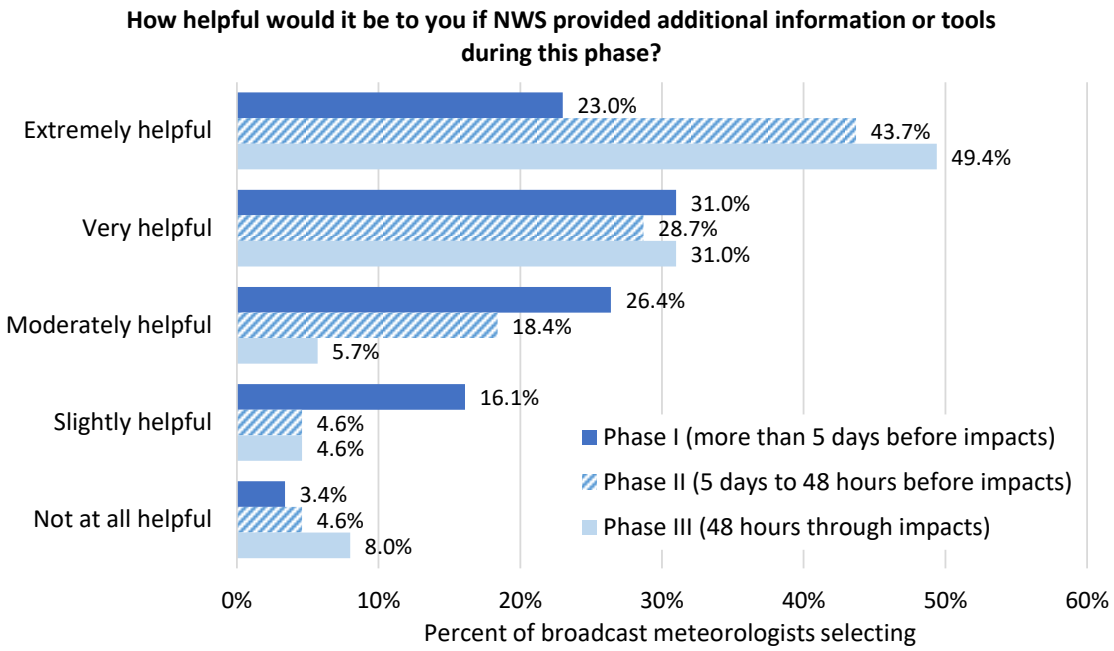

Figure 3.23. Broadcast meteorologists' ratings of the helpfulness of NWS providing additional information and tools during different phases of a TC threat. Response scale: *1=Extremely helpful, 2=Very helpful, 3=Moderately helpful, 4=Slightly helpful, 5=Not at all helpful*. N=86–87.

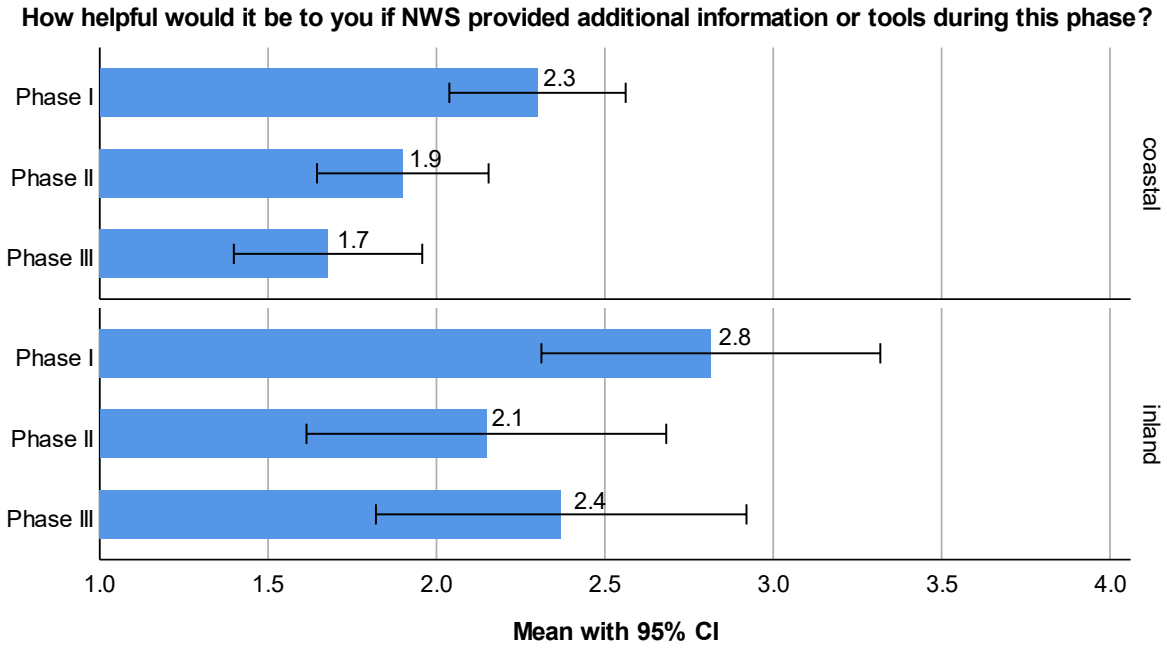

Figure 3.24. Broadcast meteorologists' ratings of the helpfulness of NWS providing additional information and tools during different phases of a TC threat, partitioned into coastal (upper) and inland (lower) respondents. Bars indicate mean ratings, with 95% confidence intervals. Response scale: *1=Extremely helpful, 2=Very helpful, 3=Moderately helpful, 4=Slightly helpful, 5=Not at all helpful*. N=60 (coastal), N=26–27 (inland), depending on the question item.

3.8.2. Helpful additional NWS information and services: BR open-ended responses

Phase I

In response to the open-ended question, broadcast meteorologists' comments on what additional information or tools would be helpful in Phase I (more than five days before impacts) varied widely. Some BRs said that the information already available is very helpful, that they did not know what additional information could be provided during this time frame, or that providing more specific or detailed information during this time frame wasn't needed or feasible. Illustrative quotes include:

- "Right now I feel I have the tools to communicate the forecast and threat"
- "Nothing specific that I can think of. I do not believe in getting specific about local impacts a storm may or may not have until 3 days and less from potential impact."
- "I fear forecast accuracy and public trust would suffer if we focus too much if we focus on fine details of the forecast more than 5 days out"

In contrast, some BRs expressed interest in more detailed information about potential hazards or impacts during this time frame, while others said that any additional information available would be useful. Illustrative quotes include:

- "Storm surge and rain fall estimate products come to mind first."
- "More community detail concerning timing and impacts"
- "The more tools available, the better prepared the audience is ... and the more streamlined the message can be between the media / NWS and NHC."
- "Almost anything that you provide that will help us tell the story and relay the right message will help"

Other areas of BR interest more than five days before impacts (with illustrative quotes) include:

- **Extended TC track information, NHC Track Forecast Cones, or other NWS products** (although some explicitly noted the uncertainty in such forecasts)
    - "Forecast cone that's a little farther out, same with TWO"
    - "Probabilistic outlook for tropical storm force winds"
    - "I would say any additional information would be moderately helpful because the forecast track will likely change with any tropical cyclone that far out. But, basic information on potential track and intensity is always helpful in the preliminary stages."
- **Interpretations of forecast model output**
    - "Likely model trends and bias that may affect the path"
    - "Comparison of different model solutions"
- **Information about forecast confidence, uncertainty, or scenarios**
    - "Comments on confidence in forecast"
    - "Information about steering patterns and reasons for possible changes to the forecast"
    - "Earlier graphic scenarios"

- **Information and interpretations from NWS forecasters**
    - "More detailed discussions for meteorologists"
    - "Written outlook sentence in the discussion (beyond 5 days)"
    - "Briefings with forecast points, confidence rating and limiting factors is helpful."
- **Information about possible areas at risk or potential for impacts**
    - "General impact possibilities"
    - "Impact zones, areas to be alert for a system"
    - "More "conversational" impacts. Any unique details to the forecast that relate to climatology or geography the storm is going to impact."
- **Additional or improved graphics**
    - "Easier, simpler graphics"
    - "It may help us develop more graphics to show the public on TV / digital platforms. We can't get enough graphics when we are facing an impact."
    - "Impact graphics and confidence graphics"

Additional illustrative quotes:

- "Additional impact info. Best case vs worse case scenarios. Timing info."
- "Marine hazards, graphics of earliest possible arrival of impacts"
- "Hazards, possible timeline, forecaster thoughts"
- "It would be nice if more long-range analysis tools were available in one page - SST, wind shear, Saharan dust, etc. - all elements that play a role in tropical cyclone development."
- "Annotated synoptic maps might be helpful, but there are already lots of model forecasts available for this time frame."
- "I like any type of modeling that I can put into a map. We all use the spaghetti plots, but they are both good and not so good depending on the storm. I would like something like a coastal map that might indicate who should watch the forecast closely and what parts of the country are most likely not going to be impacted...kind of a possible threat level map."
- "Again, more technical discussion for broadcast/emergency mgmt. partners, not necessarily general public. It is helpful to know what NWS/NHC see as caveats for strengthening/weakening and track. Are they seeing the models as we are?"
- "History of similar storms in the past"
- "Though often rare, develop bifurcated graphics when a TC most likely tracks left or right rather than a smoothed out cone. Graphics that stress onshore winds vs. offshore winds and the localized storm surge threat."
- "For me, a first look at affected tides or surge is important as far out as we can get. … If we can get a heads up on impacted tide times or issues with storm surge earlier than we do now, we can begin focusing on the extremely important impacts that brings to our area and bringing a larger evacuation time frame as well as forecasting road closures due to this rise in water."

Phase II

BRs responses about additional information or tools in Phase II (5 days to 48 hours before impacts) addressed themes similar to Phase I, with increased emphasis on hazards, impacts, and timing information. As in Phase I, a few BRs said that the information currently available was helpful or sufficient, while others said that any additional information would be useful. More specific areas of BR interest during this time frame (with illustrative quotes) include:

- **Additional or improved information about TC hazards and impacts**
  - "Impacts by county. Timing of impacts arriving and departing."
  - "More storm surge based information"
  - "Localized flooding potential. More of a micro-scale wind profile with expected types of damage."
  - "More info on storm surge, WPC flooding risk past day 3 would be extremely helpful."
- **Additional model output and interpretations**
  - "More model information …"
  - "It would be nice to have more numerical guidance and perhaps more direct model graphics."
  - "Additional discussion regarding model output"
  - "More in depth discussion of differences in models and which are being given more weight and why. Reasoning for sticking to certain models, and acknowledging reality (observed trends) versus model projections. Highlighting new state-of-the-art tools especially for intensity forecasting, and calling out chances for rapid intensification."
- **Information about forecast confidence, uncertainty, or scenarios**
  - "Confidence in forecast. That is, sometimes there is a clear level of confidence that the storm will go a given way. But there are times when things are not clear at all. I think we're better served when we make this distinction."
  - "Confidence table for track and intensity. Show how confidence in the track is often much higher than confidence in intensity forecast."
  - "Different scenarios, possible outcomes"
  - "Another rundown of best case vs worse case scenarios."
- **Information and interpretations from NWS forecasters**
  - "Discussions from individual forecasters on their thoughts rather than a generic impact graphic."
  - "Constant communication... BUT... "reasonable worst case scenario" graphics are NOT helpful and cause more confusion."
  - "Nothing really comes to mind at the moment. Just to say... once the cone is out, the discussions that go along with it are awesome. I love when you tell us what you are thinking and address some of the things we're seeing like differences with models, etc. or especially steering features. I've noticed viewers really like to know what will be steering the storms (where I am at least)."

- **Additional or improved graphics**
    - "I would like easier / simpler graphics. 1 thought/message per graphic is ideal."
    - "I think the storm surge graphics/forecasts put out by the NHC could still be improved."

Additional illustrative quotes for Phase II:

- "Cone needs to be able to change in size based on confidence in forecast."
- "Graphics that indicate the area likely affected by a storm outside the cone; otherwise, NOAA provides plenty of tools for this time frame."
- "Strengthening/limiting factors in the storm environment...We talk to viewers about this constantly."
- "Continue developing experimental graphics for different scenarios."
- "The information that comes to mind first is potential impacts and how that impacts will change based on track shifts."
- "More graphics / impact based forecasts"
- "Products that detail the latest thinking on potential impacts and timing"
- "Again, nothing specific comes to mind. Our local office does a phenomenal job with very detailed impact information. Perhaps more of a head's up when certain products (i.e., when WEA will be triggered) are issued."

<u>Phase III</u>

In Phase III (48 hours before impacts, through impacts), some respondents again noted the value of existing NWS information or said that no additional information came to mind. Other areas of BR interest during this phase (with illustrative quotes) include:

- **More detailed information about TC hazards and impacts, including more geographically specific information and additional timing information**
    - "More detailed information regarding wind speeds, storm surge, and flooding and impact to the local area"
    - "More inland flooding threat information, storm surge even for back bays, tornado threat"
    - "Anything to do with local or regional impacts"
    - "The more detailed the possible impacts and timing info, the better we can alert our audience."
    - "Products that include impacts for smaller areas would be more helpful."
    - "Timing of flooding and wind impacts"
- **Graphical and textual information that better conveys potential impacts and supports public decisions**
    - "Storm surge forecast coupled with street level views of what could be inundated with water."
    - "Easy to understand impact wording — uninhabitable for weeks is one of the great communicators, for example."

    - "Confidence table of impacts. Direct messaging of threats to life and property."
    - "We get a lot, but always looking for ways to help folks make decisions."
- **Information and interpretations from NWS forecasters**
    - "RAMP UP participation in local NWS Chat and HLS."
    - "Facebook lives or other ways to interact with NWS employees on their thoughts, once again rather than getting a generic list of impacts that are often on the extreme end."
    - "Always appreciate more technical discussion... as previously mentioned"
- **Additional or improved graphics**
    - "Graphics of hazards"
    - "I think a more geographic approach to the impacts would help at this point. Takes too long to sift through some of the forecast text to get to specific info for one location or another. Something point and click would be great!"
- **More frequent forecast updates**
    - "Not products, but a more rapid update cycle"
    - "Anything that's grabs viewers' attention. More updates even if forecast is unchanged."
- **Additional or improved observations as a storm approaches and impacts their area, mesoscale information, or nowcasts**
    - "Storm surge observations....I know this is probably difficult to get. Also peak winds in different locations."
    - "Any additional tools to monitor river forecast levels would be extremely helpful. River flooding is typically our greatest concern."
    - "Any mesoscale forecasts or observations that NHC, SPC, WPC or local WFOs deem important, we will use. We eat up any mesoscale information during the event."

Additional illustrative quotes for Phase III:

- "Threats outside of cone (prior to impact) and observed storm surge (post-impact)."
- "Faster calculations to generate potential impacts graphics. Advise partners as soon as graphics are ready."

<u>Geographic variability</u>

Although many of the comments were similar across BRs in coastal and inland areas, several indicated their different information needs based on the different threats to their region. For example, one BR said in Phase I: "Since [location] is fairly far inland we don't need much more detail that far out." and then in Phase III: "Again, since we are inland we don't have as much direct threat locally. Here the rainfall forecast is of prime importance." In response to another question, however, this BR noted that even though their viewing area rarely sees direct effects, "we always cover the [state] coast when tropical cyclones threaten. Forecast track is extremely important to plan locations for live crews."

3.8.3. BR ratings of potential changes to NWS TC information and services

As a more structured way of gauging broadcast meteorologists' interest in potential changes to NWS TC products and risk communication, the survey included a question about eight possible new NWS products and services:

- *forecasts of storm track, provided more than 5 days out,*
- *forecasts of storm intensity, provided more than 5 days out,*
- *forecasts of storm surge, provided more than 48 hours out,*
- *forecasts of timing of onset of storm surge,*
- *forecasts of duration of sustained tropical-storm-force winds,*
- *forecasts of when hazardous conditions will end,*
- *compiling available information in one place, making it easier to access all NWS products that relate to a particular storm,* and
- *a summary product compiling key hazard and risk information for a particular storm*.

These were developed and selected based on the initial interview findings and discussions with the core NOAA team. Each BR respondent was asked to rate the usefulness of four of these candidate new types of information or services, randomly selected from the set of eight.

Results are shown across the full sample in Figure 3.25, and partitioned into coastal and inland BRs in Figure 3.26. Although the number of inland respondents is small, statistical tests suggest that coastal and inland BRs' ratings differed for two of the eight changes: *forecasts of timing of onset of storm surge* (Mann-Whitney U test: Z=-2.34, p=0.019) and *forecasts of storm surge, provided more than 48 hours out* (Z=-2.07, p=0.039), with both rated more useful by coastal than inland BRs. Coastal BRs rated each of these changes to storm surge forecast information Very to Extremely useful (means=1.43–1.92), whereas inland BRs rated them Moderately to Very useful (means=2.27–2.89; Figure 3.26). This is consistent with the results in sections 3.2 and 3.5 that, on average, coastal BRs find storm surge information more important to communicate and more useful than inland BRs.

Since ratings of the other six potential changes did not vary with proximity to the coast, we discuss these across the full sample. As shown in Figure 3.25, four were rated, on average, Very to Extremely useful: *a summary product compiling key hazard and risk information for a particular storm, compiling available information in one place, forecasts of duration of sustained tropical-storm-force winds*, and *forecasts of when hazardous conditions will end*. Two potential changes were rated less useful by BRs, *forecasts of storm track, provided more than 5 days out*, and *forecasts of storm intensity, provided more than 5 days out*, both Moderately useful. BRs also had diverse opinions about these latter two changes, with some saying these would be Extremely useful and some saying Not at all useful.

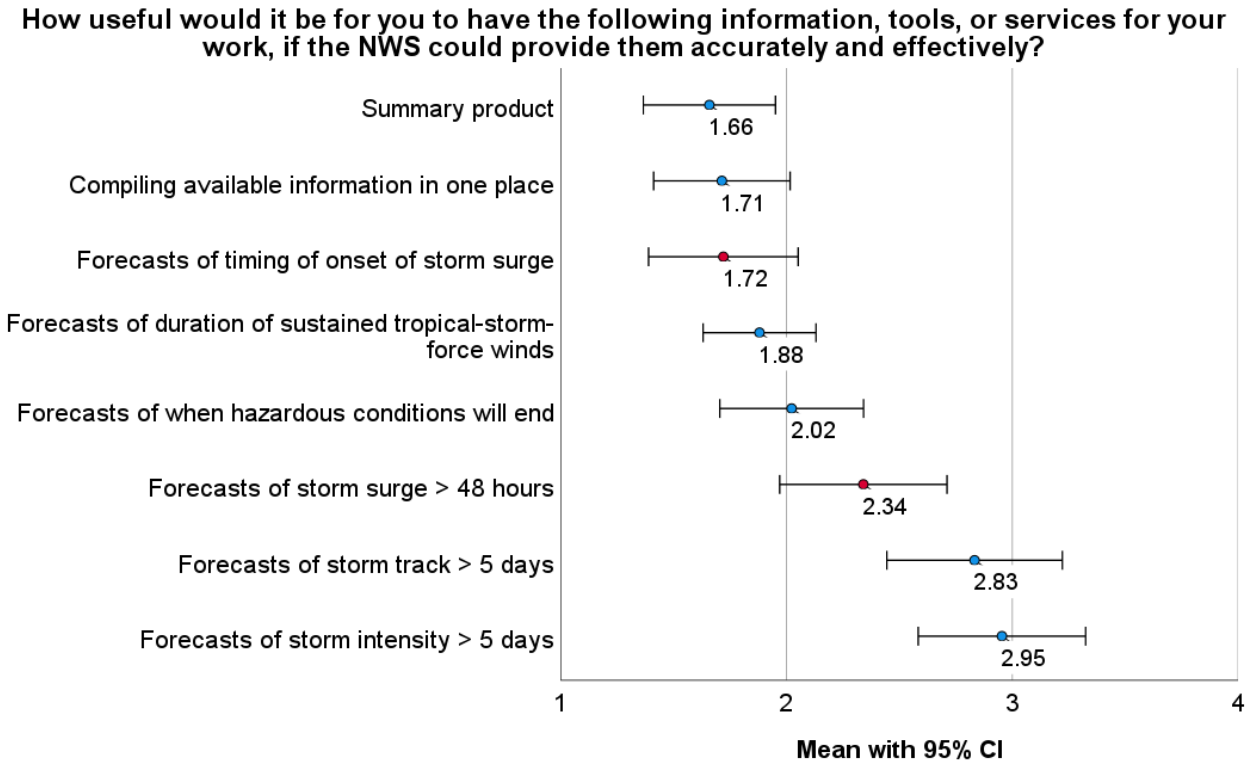

Figure 3.25. Broadcast meteorologists' ratings of the usefulness of eight potential changes to NWS TC information and services. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Figure 3.26). Types of information are ordered from most to least useful. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful.* Several of the potential changes are abbreviated in the figure; the full versions from the survey are provided in the text. N=42–44.

These results indicate the perceived value to BRs of having key updated NWS information about a TC synthesized, in a summary product and/or available in one place. They also indicate the value of additional information about timing of TC hazards. Both of these themes emerged from the interview analysis and are validated here with a larger and more geographically diverse BR sample. More broadly, this suggests that effectively modernizing the TC product suite will involve a combination of addressing targeted gaps and developing new ways to effectively convey the variety of TC forecast information available from different NWS entities.

Improved storm surge information — both longer-lead-time forecasts and forecasts of timing of surge onset — was also perceived to be valuable, especially by coastal BRs. Extending forecasts of TC track and intensity out to more than five days was rated useful by some BRs, but less useful on average. The interview results and other survey data suggest that this result may be related to BRs' understanding of uncertainties in TC track and intensity forecasts at these longer lead times, or associated with the current NWS formats for providing these types of information. For example, some BRs may feel that the useful additional information cannot be reliably provided more than five days out; others may already be accessing these types of forecasts from sources such as numerical model output and believe that additional information may not add substantial value.

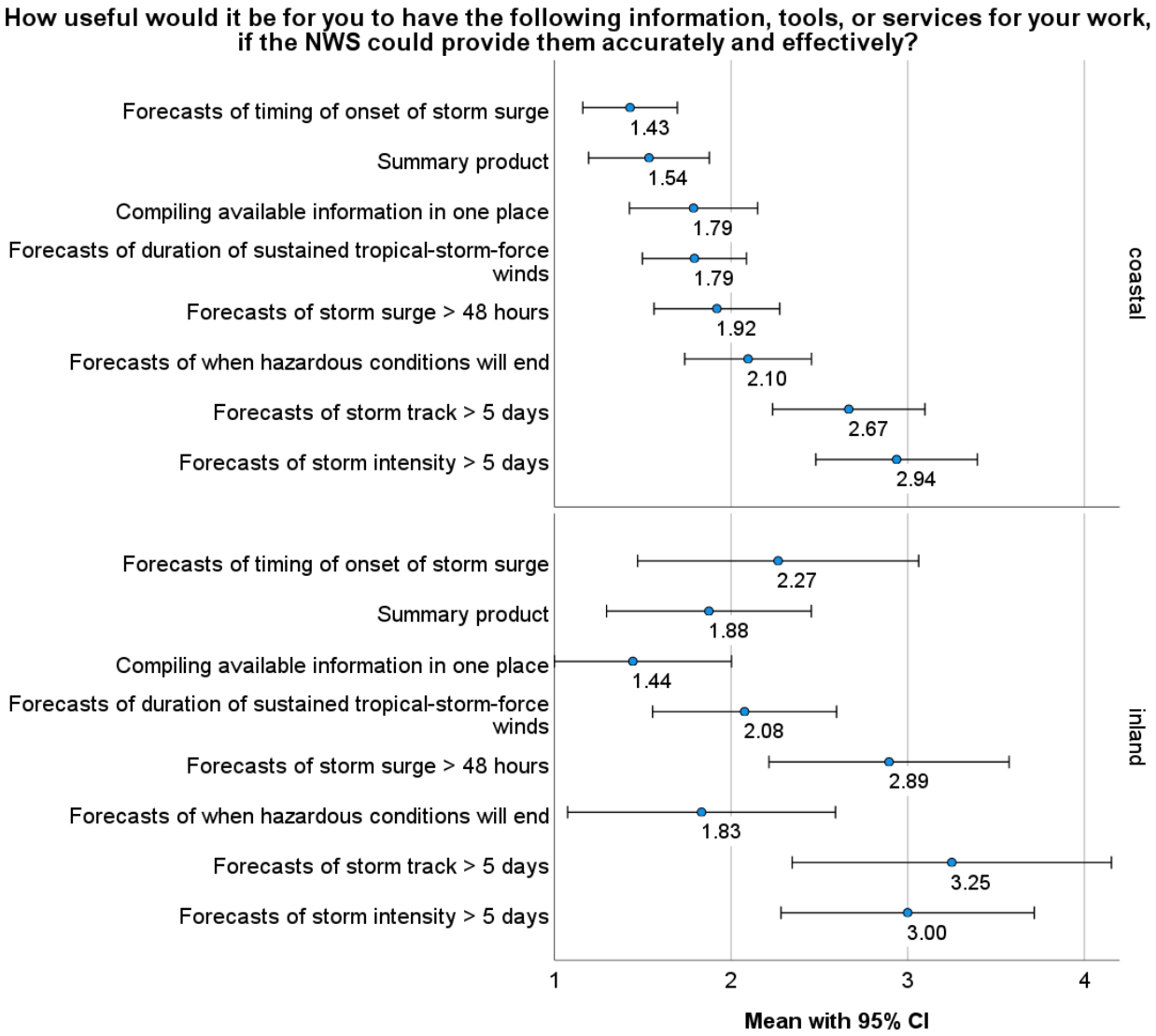

Figure 3.26. Broadcast meteorologists' ratings of the usefulness of eight potential changes to NWS TC information and services, partitioned into coastal (upper) and inland (lower) respondents. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from most to least useful for coastal respondents. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful.* Several of the potential changes are abbreviated in the figure; the full versions from the survey are provided in the text. N=25–32 (coastal), N=9–19 (inland), depending on the question item.

3.8.4. Most important change to NWS TC information and services: BR open-ended responses

At the end of the broadcast meteorologist survey, respondents were asked **"**What, if anything, is the single most important change the NWS could make to improve its tropical cyclone storm forecast and warning information, tools and services?" Many of the BRs' responses echo topics in the other BR survey open-ended responses discussed above (section 3.8.2) as well as topics that emerged from the interviews (Morss et al. 2022b). Note, however, that this open-ended

question appeared toward the end of the survey,[9] and thus may have been influenced by previous survey questions.

Of the 63 BRs who responded to this question, 4 said that they were satisfied with the current information or could not think of any improvements. Examples include:

- "Keep up the good work. I can't think of any blaring issues at this time."
- "At the level of current technology with regards to model data, warning and forecast timing could not be improved upon."

From the remaining responses, several commonly mentioned themes emerged:

- **Changes in timing of NWS product releases:** Regarding NWS TC product timing, the most common change requested by BRs was earlier release of NWS graphical and text products relative to major television newscast times. In particular, as discussed in section 3.6.1, NWS products are typically released at around 5 a.m., 11 a.m., 5 p.m., and 11 p.m. Eastern Time, which corresponds to major newscast times, but BRs need time to read and understand the new information and update graphics before going on air. Describing how insufficient time before newscasts can hinder effective communication of NWS information with the public, one BR wrote:
    - "Give us more lead time when releasing forecast graphics, keeping in mind we need to digest info and build graphics before going on TV. Release info 5–10 minutes before airtime is not helpful and we can sometimes miss things."

  The majority of BRs who mentioned this issue discussed NHC products, but several mentioned WFO products as well.

  Additional issues with product timing raised by a few BRs included requests for more frequent updates and more rapid release of new information. More frequent updates of key graphics used by BRs, especially when the TC forecast and associated risks are changing rapidly, may help alleviate other mismatches between NWS TC product releases and BRs' decision-making timeline, discussed just above. These issues are discussed in further detail, with additional illustrative quotes, in section 3.6.1.

- **Improved graphics and more usable graphical data layers:** Multiple BRs requested changes to NWS graphical TC products, including graphical formats that are easier for public audiences to understand, more modern, or more interactive. They also requested graphics that are easier to edit and use on television and other communication platforms and that better integrate with their vendor-provided software systems. Illustrative quotes include:
    - "… If the graphics are not extremely clear and easy to comprehend...you've lost most of your audience. Far too many of the graphics we get from the NWS for tropical cyclones are just way behind the times. Sometimes I have to try and figure out what the legend means and if I have to do it, think what somebody at

[9] The only questions appearing after this question on the BR survey were those on the usefulness of eight potential changes, importance of monitoring social media and potential helpfulness of a social media tool or service, interactions with local NWS Forecast Offices, effects of COVID-19, and sociodemographic characteristics.

home is going to do."

- "Make it more savvy for social media. … to cater to younger demos. Hard to make a storm impacts graphic for Tik-Tok, but it may soon be necessary. Eyeballs & audiences are not always seeking out the latest forecast on TV or on NHC's website."
- "More interactive graphics. Graphics that can be imported and edited in our on-air equipment."
- "Make it more user-friendly for adapting to TV, though this may partially be an issue with our graphics provider."
- "It would be great if predictive graphics could be seamlessly transferred to our social and website pages, although this may have more to do with our graphics vendor than the NWS/NHC."
- "Keep the graphics coming, and more automatic integration with weather systems made by [private sector vendors]"
- "The wind arrival time graphics do not function well within the [private sector vendor] graphics suite but would be very valuable to our viewers. A better, KML/KMZ file would be a good first step."

The latter quotes indicate the potential value of NOAA/NWS and vendors working together more closely to address these issues and enhance the reach of NWS graphical products.

As discussed in section 3.6.2, most BRs use NWS graphics as a starting point but often modify them for communicating with their audiences. Thus, BRs expressed different opinions about how much emphasis the NWS should place on improving the look of graphical products. For example, one said:

- "… They need to bring in a weather graphics person and overhaul all their graphics and maps. It would literally change everything as far as communicating about tropical cyclones. The television people would be able to use everything on the air and social media would grow too just because the graphics would be more clear and understandable."

However, another said:

- "Though the graphics are helpful from NWS, don't spend a lot of time on them because managers at TV stations like to see those graphics remade with 'our look'."

- **Improved text products and textual information:** Some BRs requested that NWS change the content and organization of its text products, including making the information as concise as possible and starting with the newest and most important information at the top. This is related to the limited time that BRs often have between when they receive new NWS products and when they have to present the information on air. Illustrative quotes include:
  - "Consolidate bulletins as much as possible, and always start with "what changed" since last update."
  - "Sometimes the text data can be difficult to sift through. Continued effort to break

the information up into sections. Sometimes it seems like data is repeated or redundant. When new information is available any attempt to reduce redundancy to make for quicker consumption of the most recent and important information would be appreciated."

In addition, multiple BRs requested that, across its products, NWS use language that is as concise, clear, and non-technical as possible, especially in information intended for communication with the public. More specific comments included:

- "Simple language, at least in the top of the discussion"
- "Simplify, with bullet points, the most important information, in addition to the in depth."
- "Increased eloquence"
- "Use less technical wording. Talk like the folks at home when typing out headlines, discussions, etc."
- "The more simple you can be, the better."

- **TC hazard and impact information:** Multiple BRs also requested additional or improved forecasts of TC hazards and impacts, as well as improved ways to help members of the public interpret this information. Illustrative quotes include:
  - "Less emphasis on category or 1-minute sustained winds. More emphasis on damage potential."
  - "Risk levels for possible wind swaths"
  - "Anything that helps folks understand what inches of rain and storm surge in feet mean for them."

  Similar to the latter quote, several BRs specifically noted the need for improved information about TC storm surge and coastal flooding. Examples include:
  - "More detailed/easier to consume storm surge info/graphics"
  - "It is difficult explaining the potential storm surge flooding potential wording 'greater than 1 foot above ground' and so on. I don't think there is a clear explanation of what 'above ground' is."
  - "I find the general public is very confused by the concept of storm surge. Any additional graphics/information from the NHC would be helpful."

- **More geographically and temporally specific information**: BRs also expressed interest in forecast information that is more specific to their area or to different areas within their region, or improved timing information, especially related to TC hazards and impacts. Illustrative quotes include:
  - "The most important change is breaking down impacts for smaller areas rather than providing info for the whole set of parishes and counties that are covered under the office."
  - "Be more specific in location and timing of impacts, when they are forecast to arrive and when they are forecast to depart."
  - "Again ... think more geography-based info would help. Clickable map with many

sections. Pull downs for max wind, rainfall, surge. Etc."

One BR also explained that localized forecast information is useful not only leading up to TCs, but also during TC events:

- "Mesoscale forecasting for regions impacted DURING the event. While NWS and NHC (and other partners) do a phenomenal job leading up to the event, I feel like during the event we may not get nearly as many mesoscale (1–2-hour forecast) discussion posts as I'd like. … it would be very helpful in communicating the most immediate threats DURING the storm to our viewers while we're in our on-air coverage. The Hurricane Local Statements do a great job, but I feel they're not updated as much as these hyper-local mesoscale discussions could provide."

Along with these themes, a few BRs noted areas for improvement with specific existing NWS information and services, including NWSChat, the phrases "potential tropical cyclone" and "reasonable worst case," the Tropical Weather Outlook, and the Track Forecast Cone. Two respondents requested improvements to TC intensity forecasts, and two requested more conference calls with NWS forecasters. Explaining the value of NWS conference calls with BRs, one said:

- "I really like having calls with NWS leading up to an event. Even though it is with competing station as well, it is nice that we are all on the same page and are communicating the same thing. More of those would be awesome!"

Two BRs requested improved information related to forecast uncertainty, including:

- "Different scenarios and how that could change impacts"
- "More information on agreement/disagreement among various models to better explain forecast uncertainties."

Finally, one BR requested that relevant information be compiled in one place, echoing one of the eight proposed changes that BRs were asked to rate in the survey (section 3.8.3). Explaining why this would be useful, this BR wrote:

- "Develop an all in one resource page so we don't have to leave 10 tabs open to check, tide gauges, hurricane hunter obs, Goes 1KM satellite, any land observations, ocean temperatures, hurricane cone, spaghetti plots, etc."

3.9. Key Broadcast Meteorologist Survey Findings and Opportunities for Improvement

We close this section by summarizing key findings from the broadcast meteorologist survey, synthesized across the results presented in sections 3.1–3.8. We start with BRs' priorities and needs for TC information (RQ1; section 3.9.1), which together with the interview findings in Morss et al. (2022b) provide a foundation for our evaluation of the TC product suite and recommended modernizations. We then briefly summarize findings on how well the NWS is supporting BRs' activities during TC threats (RQ2; section 3.9.2), followed by a discussion of gaps in the TC product suite revealed by the results and associated opportunities for improvement (RQ3 and RQ4; section 3.9.3).

3.9.1. BRs' priorities and needs for TC information (RQ1)

The survey results demonstrate that **visual media are central to broadcast meteorologists' jobs, for communicating on television, websites, and social media** (section 3.1.2). Thus, graphics and other visuals are central to how BRs convey TC risks. However, the majority of BRs also said they use radio to communicate during Phases II and III of a TC threat (five days through impacts). This, along with BRs' comments in the interviews and survey about the **use of text to convey key points and help people interpret complex forecast information**, illustrate the multimodal ways in which BRs communicate with their audiences.

The survey results also indicate that **a variety of types of TC information are important for broadcast meteorologists' jobs** (section 3.2)**, and a variety of NWS TC products and services are useful to them** (section 3.5)**.** This includes products from different NWS entities that convey different aspects of TC risks across a range of lead times, in graphical, text, and hybrid formats. It also includes data underlying NWS products, as well as numerical model output, observations, and products and services provided by human forecasters.

Regarding **broadcast meteorologists' TC information priorities at different lead times**, in Phase I of a TC threat (five days or more before impacts), BRs rated forecast uncertainty and the importance of paying attention to the threat as the most important types of information to communicate (Figure 3.4). The most helpful NWS information and services mentioned by BRs for this phase were the NHC Tropical Weather Outlook and NWS Forecast Discussions (section 3.3.2).

In Phase II (5 days to 48 hours before impacts) and Phase III (48 hours through impacts), BRs rated communicating storm track, intensity, timing of arrival, hazards, impacts, and protective actions most important, along with paying attention to the threat (Figures 3.5 and 3.6). They rated communicating uncertainty less important than in Phase I, although still Very important (Figure 3.7). The most helpful NWS information and services mentioned for Phases II and III were consistent with these ratings, focusing on the NHC Track Forecast Cone, forecast model output, and information about TC intensity, timing, hazards and impacts (section 3.3.2). As a storm approaches, BRs' responses increasingly focused on the importance of more specific, locally relevant information about TC hazards and impacts.

Regarding **broadcast meteorologists' priorities for information about different types of TC hazards**, the survey data indicate that coastal BRs find information about anticipated storm wind speeds in different areas, flooding from rainfall, and coastal flooding due to storm surge highly important to communicate in Phases II and III (Figure 3.8). Inland BRs generally provided similar ratings to coastal BRs for these different types of hazard information — except for storm surge or coastal flooding, which inland BRs rated less important (Figures 3.5 and 3.6). However, even though their media markets are not directly affected by storm surge, inland BRs still rated storm surge or coastal flooding Very important to communicate, and they rated NWS storm surge products Very useful to them (Table 3.3). BRs rated information about potential TC tornadoes less important to communicate than TC wind and flood forecasts during Phase II, but similarly important during Phase III (Figure 3.8).

3.9.2. NWS effectiveness in supporting BRs' decisions (RQ2)

The survey data provide strong evidence that, overall, **NWS is currently supporting most broadcast meteorologists' decisions very well**. Most BR respondents rated NWS TC information and services Extremely or Very helpful throughout a threat (section 3.3.1), and their interactions with NWS WFOs Excellent or Good during TC threats (section 3.4). Moreover, BRs rated a wide variety of types of NWS TC products and information Very or Extremely useful to them (section 3.5). More than two-thirds of BRs said that NWS TC information and services are well-aligned with their decision timeline (section 3.6.1). Approximately three-quarters said that NWS graphics meet most of their communication needs, and more than half said that NWS graphics are Somewhat or Extremely easy to use on air, on their station website, and on social media (section 3.6.2). In addition, about half of respondents reported not having difficulty using any of the (randomly selected) sample of four NWS TC products whose ease of use they were asked to evaluate (section 3.6.3).

3.9.3. Gaps in the TC product suite and opportunities for improvement for BRs (RQ3, RQ4)

Despite this positive feedback, the survey data reveal **several information and usability gaps in the current TC product suite (**RQ3). These suggest **opportunities for NOAA to improve its information and services for broadcast meteorologists** (RQ4)**, leveraging their roles in the forecast and warning system to enhance the reach of NWS-generated information to the public**.

One usability gap raised by some BRs is **better aligning the release of some NWS products and data with their broadcast times** (section 3.6.1). BRs discussed this in terms of needing sufficient time to update graphics in their software systems before showing the graphics on air, and in terms of needing sufficient time to digest new graphical and textual information released by NHC and WFOs and incorporate it into their communications. Although only a subset of BRs said that NWS TC information is misaligned with their timeline or that this was the most important improvement for NWS to make, the interviews together with the survey data suggest that this is one area for improvement, for the standard NHC TC product package as well as WFO products.

A second gap identified in the BR survey analysis is **improving the readability and understandability of textual information in NWS products** (section 3.8.4), so that broadcast meteorologists can quickly find and understand the most critical new information for their audiences and convey it as effectively and soon as possible. Although NOAA has improved text products such as Advisories, Forecast Discussions, and Hurricane Local Statements in recent years, several BRs suggested making such products more concise and better organized to enable rapid comprehension of key points. Across TC products and services, BRs also suggested that NWS forecasters use simpler, non-technical language that is easier for them to quickly sift through and understand and more suitable for relaying to their public audiences.

Given the importance of visual communication for BRs, another important gap to address is **improving the understandability and editability of NWS graphics and data layers, so that**

broadcast meteorologists can use the graphics directly or more readily modify them for communicating with their audiences across different visual media (sections 3.6.4, 3.8.2, and 3.8.4). BRs emphasized the importance of using "public friendly" visuals that convey key information in ways that are easily understood by non-meteorologists. This is especially important on television, when BRs have limited time to explain information, e.g., during the weather segment in a scheduled newscast or a cut-in to other programming. While most BRs said that they modify at least some NWS graphics for communicating with their audiences, in many cases NWS graphical product formats and underlying data provide critical starting points for BRs' visual communications.

Two graphical products stood out as being particularly difficult for BRs to use: river stage forecasts (hydrographs) and potential storm surge flooding maps (section 3.6.3). BRs also rated storm surge and coastal flooding as only moderately well understood by their audiences, one of less-well-understood types of forecast information (section 3.7). NOAA and the research community have invested significant effort in improving communication of flood risks, from storm surge as well as rainfall. However, given the deaths and other significant impacts caused by coastal and inland TC flooding in recent years, developing improved formats for visual communication of TC-related flood risks remains important. **Improving TC flood product formats can help NWS convey flood forecast and warning information to its audiences directly, as well as indirectly by serving as templates that BRs and others can revise for their communications.**

Along with products and data, **many BR respondents indicated that information from NWS forecasters is a critical component of how NWS supports their decisions and communications**. This is illustrated by BRs' positive ratings of interactions with their local WFOs (section 3.4) as well as their responses to open-ended questions (section 3.3.2). BRs rated NWS Forecast Discussions and NWSChat — services that facilitate accessing NWS forecasters' knowledge and interpretations — highly useful (Figure 3.15). They rated NWS briefings or conference calls less useful, on average, suggesting that there is potential for improvement in how NWS uses these mechanisms to communicate and interact with their broadcast meteorology partners. Several BRs explicitly requested more information and interpretations from NWS forecasters (sections 3.8.2 and 3.8.4). More broadly, improving partnerships between broadcast meteorologists and NWS forecasters can help NOAA address the gaps in timing of NWS information release and understandability of NWS textual information noted above.

The BR survey results also revealed **information gaps within the TC product suite during different phases of a TC threat**. **In phase I (more than 5 days before impacts)**, BRs rated forecast uncertainty and paying attention to the threat as the most important types of TC information to communicate (section 3.2.1). However, they perceive that TC forecast uncertainty is not well understood by their audiences (section 3.7). In addition, although BRs rated the Track Forecast Cone Extremely useful and few BRs noted difficulties in using it (sections 3.5 and 3.6.3), some survey respondents and interviewees commented that it is misunderstood by public audiences. This, together with BRs' responses to the open-ended survey questions (sections 3.8.2 and 3.8.4), indicates the importance of **improving communication of TC forecast confidence, uncertainty, and scenarios at lead times of several days or longer**.

BRs expressed the greatest interest in NWS providing additional information or services in

Phases II and III (section 3.8.1). During these time periods, i.e., **less than 5 days before impacts**, BRs' responses to several survey questions indicated interest in **more regional or local information about the risks of different TC hazards and impacts, especially as a storm approaches** (sections 3.8.2 and 3.8.4)**. Such information is important because it helps BRs communicate about an approaching TC threat in ways that are relevant to their audiences in different areas**. Predictability limits currently constrain the potential for providing geographically specific TC forecast information several days before a storm arrives, but improvements in providing locally interpretable information may be feasible, even at lead times when details for a specific location cannot be accurately predicted.

Finally, when BRs were asked about the usefulness of eight possible new types of NWS information and services (section 3.8.3), two of the highest rated were a "**summary product compiling key hazard and risk information for a particular storm**" and information or services "**compiling available information in one place, making it easier to access all NWS products that relate to a particular storm**." These potential additions to the TC product suite echo two distinct, but interrelated, BR needs that emerged from the interviews and other survey data: the importance of 1) quickly digestible highlights and updates, and 2) the ability to rapidly obtain and use the variety of different types of TC information generated by multiple NWS entities.

Additional information about the anticipated timing of TC hazards was also rated highly useful by coastal and inland BRs, as was **additional storm surge forecast information by coastal BRs**. Extending forecasts of storm track and intensity more than five days out (beyond their current time horizon) was rated less useful, on average, than the other proposed changes.

4. EMERGENCY MANAGER (EM) SURVEY RESULTS

As with the broadcast meteorologist survey results, we start by reporting on the characteristics of the emergency manager survey sample and their communications context, in section 4.1, and then address each of the research questions outlined in the introduction. Section 4.2 addresses RQ1 by examining EMs' priorities and needs for TC information in their jobs. Next, we address RQ2 by examining EMs' evaluations of their interactions with NWS WFOs (section 4.3) and the usefulness of different types of TC information and services (section 4.4). These usefulness results transition to addressing RQ3, which as in the BR survey continue with an examination of the usability of NWS TC information and services for EMs (section 4.5) and EMs' perceptions of their audiences' understanding of different types of TC information (section 4.6). Section 4.7 addresses RQ4 by examining EMs' views of potential changes to NWS TC information and services. Section 4.8 then summarizes key findings and opportunities for improvement from the EM survey.

As noted in section 2.2, in addition to the targeted sample that is the focus of this report, the same EM survey instrument was also distributed to a convenience sample. All results presented in this section of the report are for the targeted sample only. Descriptive statistics for the EM survey data, including the targeted and convenience samples, are provided in Appendix E.

4.1. EM Survey Sample and Communications Context

4.1.1. Characteristics of EM survey sample

As shown in Figures 4.1 and 4.2, the 265 emergency manager survey respondents were located in a variety of TC-affected regions of the CONUS, including most of the WFO CWAs within the study area. Massachusetts had the largest number of EM respondents (40), followed by Texas (30) and Georgia (27). One TC-prone state, Florida, was noticeably less well represented in the EM sample, with only 2 respondents. EM respondents reported having between 0–50 years of experience in emergency management (mean=15.6 years), with much of that experience in regions affected by TCs (range: 0–50 years, mean=13.3 years).

As described in Appendix C, an issue with the sample-building methodology led to 12 responses from EMs located outside the targeted study area, as shown in Figure 4.2. Several were regional EMs who did not represent counties in the study area, but were in a state that was partially in the study area; the remainder were local EMs in counties immediately adjacent to the study area.

The majority of respondents (69%) reported holding at least one professional certification or accreditation, and 30% held two or more — the most common were a state emergency management certification or accreditation (51%), FEMA Professional Development Series (PDS) certificate (36%), or FEMA Advanced Professional Series (APS) certificate (14%). A smaller number (8%) had a certification from the International Association of Emergency Managers (IAEM). Eighty-seven percent reported having at least one type of emergency responder training — the most common were firefighter (50%), emergency medical technician or paramedic (43%),

and law enforcement (34%). Approximately 53% reported having a bachelor's degree or higher, and 20% a masters' degree and/or PhD.

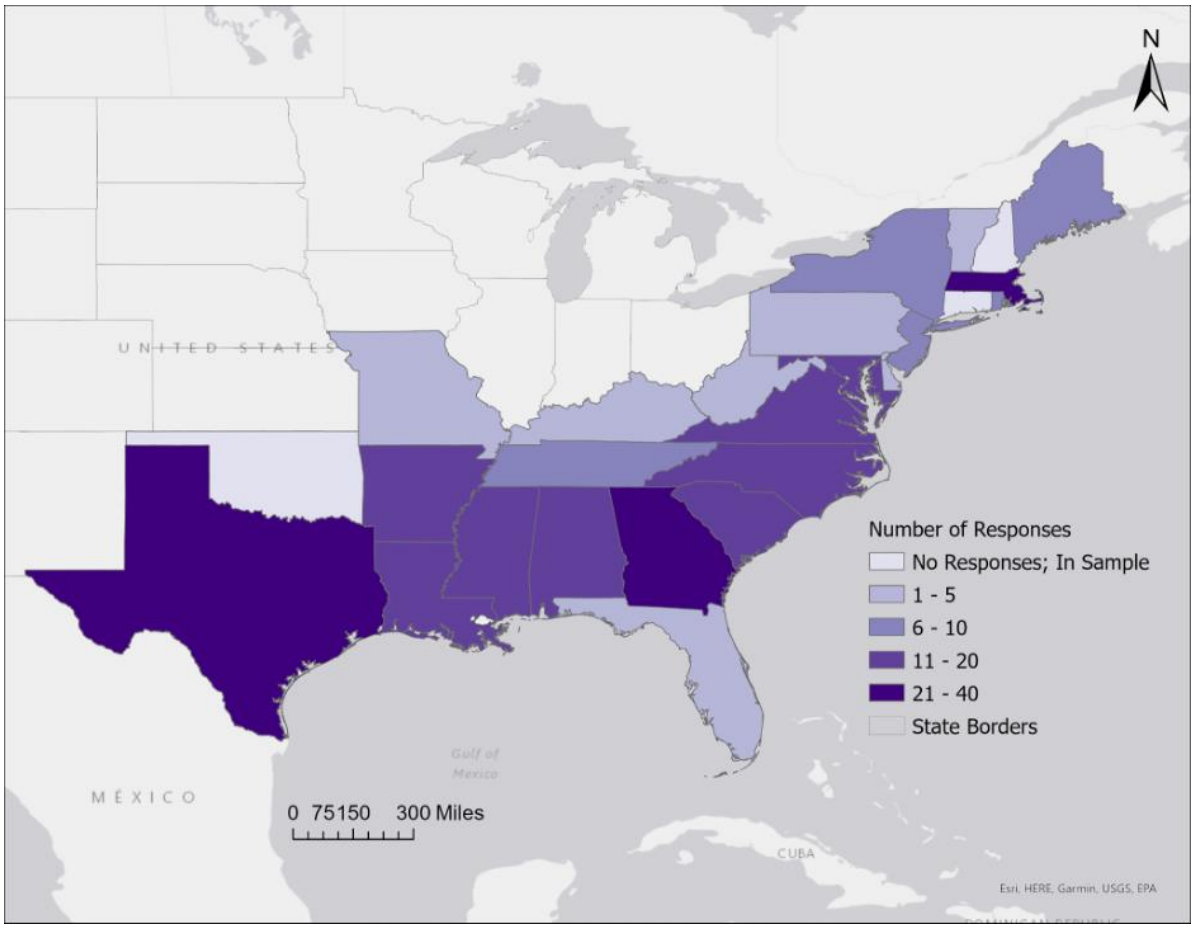

Figure 4.1. Emergency manager survey respondents mapped by state. N=265.

Most (90%) respondents said that their current position was a local (city or county) EM; the remainder were state (5%), multi-state (0.4%), or tribal (0.4%) EMs or worked in other roles. Nearly two-thirds (62%) reported having full-time jobs in emergency management. An additional 18% said that they work full time, but only part of their job is in emergency management, and 14% have part-time emergency management jobs. The remainder were volunteers or interns, worked as contractors, had special arrangements during the pandemic, or had other job situations.

A minority of the EM sample was female (14% female; 83% male); 2% did not report gender. Of those who reported race, a minority of the sample reported being Black or African American (3%), Native American (2%), or Asian (0.4%); 4% were Hispanic.

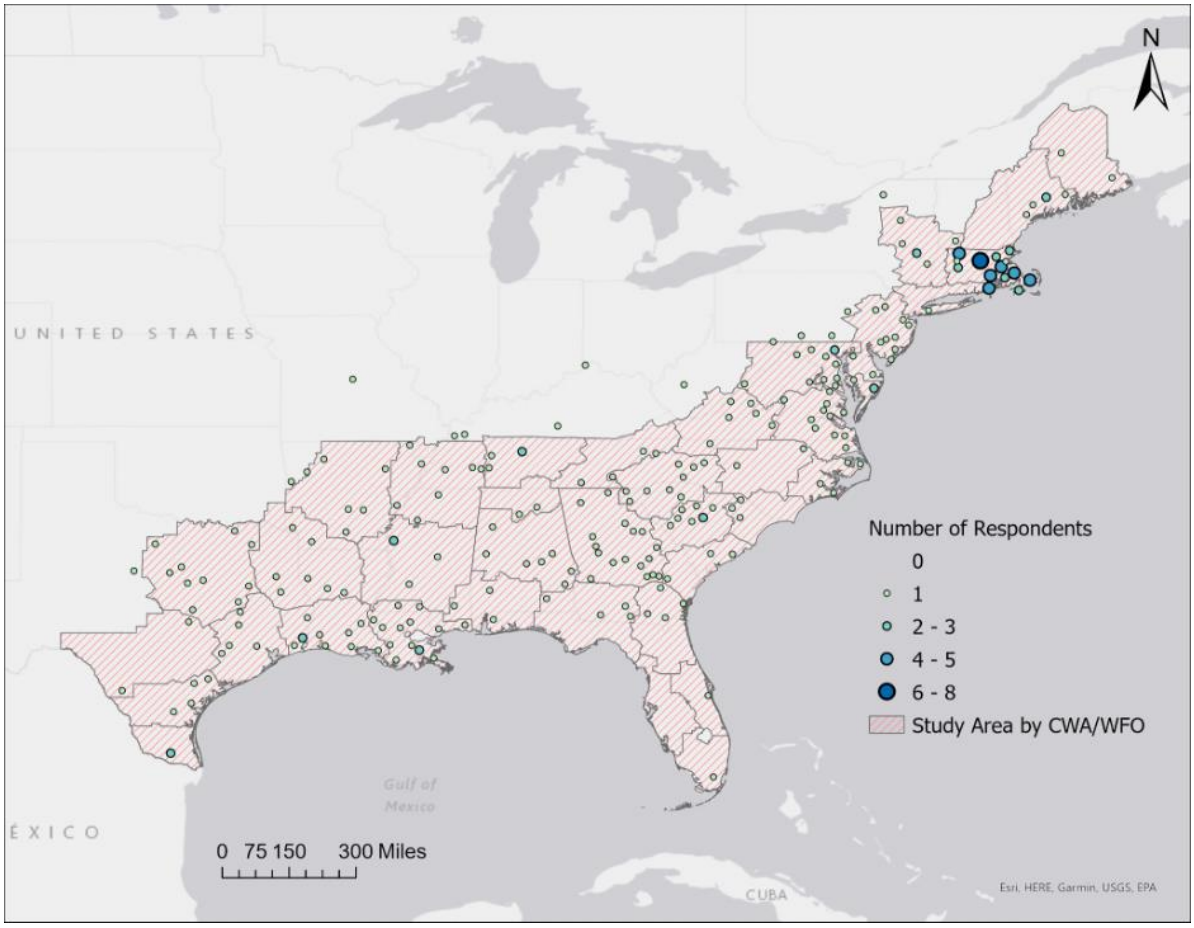

Figure 4.2. Emergency manager survey respondents mapped by county centroid, overlaid with WFO CWAs within the study area. N=265.

4.1.2. EM job roles and COVID-19 impacts

When asked about their major job roles when a TC threatens, the vast majority of respondents said that they make or coordinate emergency management decisions (92%). Large majorities also reported that they track the threat or gather and interpret forecast information (81%), interact with elected government officials during TC threats (80%), and raise situational awareness in their office (77%). Approximately two-thirds also reported that their major roles during TC threats include communicating with the media or members of the public (69%) or supervising or managing staff (66%). Similar to the BR sample, these responses indicate that this EM sample was well suited to provide perspectives on the types of questions asked on the survey.

As with the BR survey, the EM survey was fielded during the COVID-19 pandemic. The pandemic was relevant both as a risk that influences people's responses to TC threats, especially evacuations (which EMs help manage), and as a factor that imposed heavy workloads and stress on those in emergency management (not directly related to TCs). To assess the influence of COVID-19 as a co-occurring risk, the EM survey included the following question: "How much has COVID-19 affected the ways that you prepare or respond to tropical cyclone threats, or advise your communities to prepare? (e.g., making preparation, evacuation or sheltering

decisions given public health guidance)" (Response options: *A great deal*, *A lot*, *A moderate amount*, *A little*, *Not at all*). More than three-quarters of respondents (77%) reported that COVID-19 had affected their preparations, responses, or advice at least a moderate amount, and 36% said that COVID-19 had affected these activities a lot or a great deal. Only 12% reported that COVID-19 had not affected these activities at all. This indicates that the pandemic had an important influence on EMs' TC communication context at the time of our study.

4.2. EM TC Information Priorities and Needs

To investigate emergency managers' priority needs for TC information (RQ1), the survey asked respondents to rate the importance of nine different types of TC forecast information for EM decision making (section 4.2.1). This topic was also included in the BR survey, but to reduce the survey length and response burden for EMs, the EM version of the question included only a subset of the information types included on the BR survey, and it asked about TC threats as a whole (rather than for different phases of threats as in the BR survey). To investigate the importance of forecast information lead time for EMs in a compact, targeted way, this was followed by a question about when during a TC threat several of the types of information are important for EM decisions (section 4.2.2).

4.2.1. Importance of different types of TC information for EMs: Throughout a TC threat

Emergency managers' ratings of the importance of different types of TC information for their decisions are depicted in Figure 4.3, partitioned into coastal, near-coastal, and inland EMs. Except for storm surge or coastal flooding (discussed further below), each of these types of information were rated Very to Extremely important, on average (means=1.11–1.73, on the 5-point response scale), by all three subgroups of EMs. Across the sample, *forecasts of storm track* and *timing of storm arrival* were rated Extremely important by more than three-quarters of respondents. *Forecasts of potential storm impacts*, *storm intensity*, *storm wind speeds in different areas*, *flooding from rainfall*, and *tornadoes* were each rated Extremely important by more than half of respondents. The one type of forecast uncertainty information included in the EM version of this question — *different storm scenarios* — was rated Extremely important by half of respondents.

Although some of the confidence intervals in Figure 4.3 overlap, statistical tests suggest that there are differences between the highest and lowest-rated types of information. For example, paired-sample t-tests indicate that EMs rated *forecasts of storm track* (mean=1.28 across the sample, Extremely important) more important for decisions than *different storm scenarios* (mean=1.67, between Very and Extremely important) (t_{262}=8.25, $p<0.01$). Overall, however, each of these types of information were rated Very or Extremely important by most EMs, across a range of proximity to the coast.

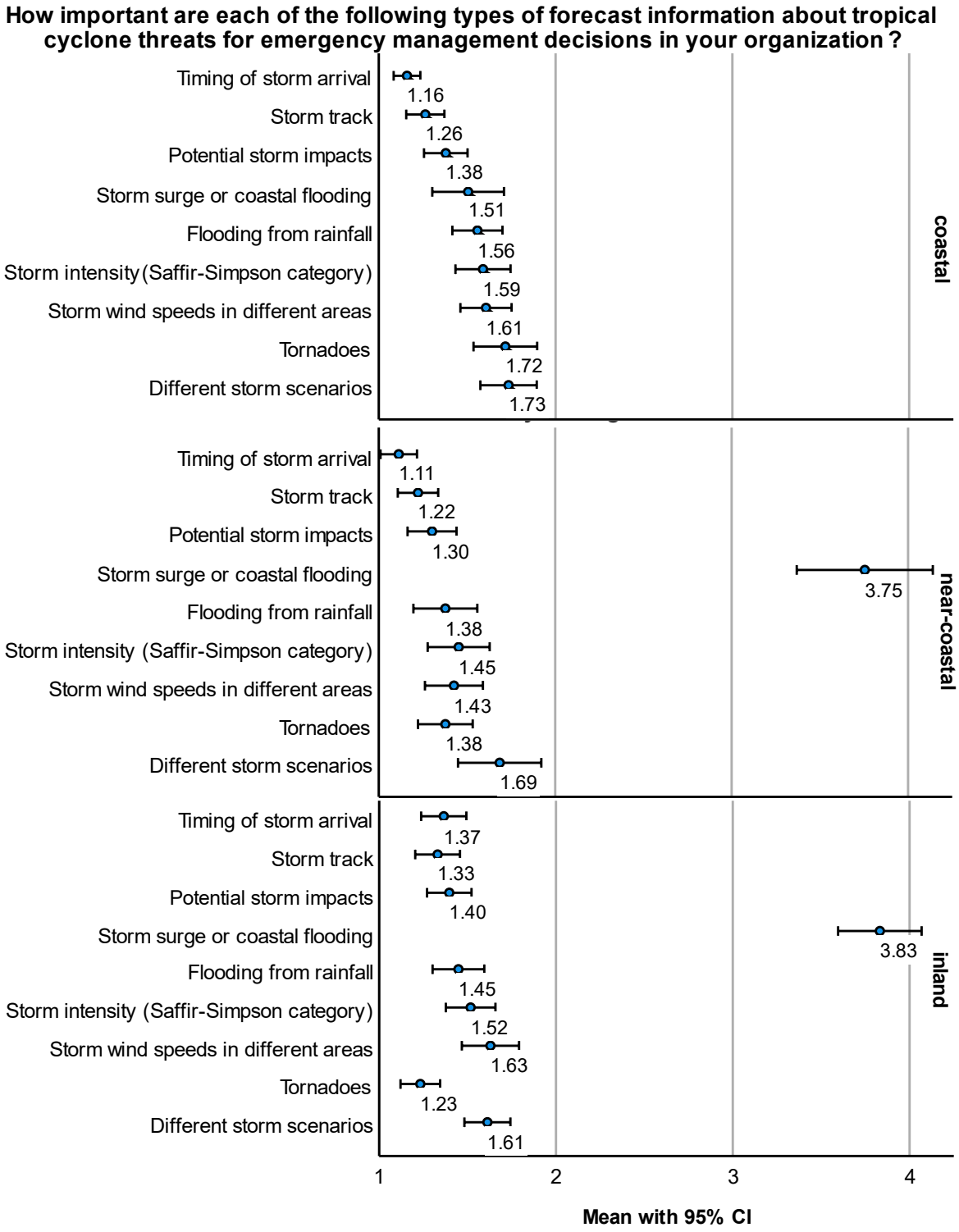

Figure 4.3. Emergency managers' ratings of the importance of different types of TC information for emergency management decisions, partitioned into coastal (upper), near-coastal (middle), and inland (lower) respondents. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from highest (1) to lowest (5) mean importance for coastal respondents. Response scale: *1=Extremely important, 2=Very important, 3=Moderately important, 4=Slightly important, 5=Not at all important*. N=93–95 (coastal), 53–54 (near-coastal), 113–116 (inland), depending on the question item.

For the final type of TC information included on this question — *forecasts of storm surge or coastal flooding* — statistical tests suggest that EMs' ratings varied with their jurisdictions' proximity to the coast. As shown in Figure 4.3, coastal EMs rated this type of TC forecast information, on average, between Very and Extremely important (mean=1.51), similar to the other types of information included on this question. Near-coastal and inland EMs, on the other hand, rated this type of information only Slightly important (means=3.75–3.83; one-way ANOVA: $F_{(2,256)=}109.1$, $p<0.001$; Bonferroni post-hoc tests of mean differences between coastal and inland: $p<0.001$, between coastal and near-coastal: $p<0.001$, between near-coastal and inland: $p=1.00$). Emphasizing this difference, 74% of coastal EMs rated *forecasts of storm surge or coastal flooding* Extremely important, while 42% of near-coastal and inland EMs rated it Not at all important. This suggests that while storm surge forecast information is only important to a subset of EMs, primarily those whose jurisdictions may be directly affected by storm surge, for such EMs this type of forecast information is extremely important for decisions.

EMs' average ratings of *forecasts of tornadoes* also varied with coastal proximity, with coastal EMs rating this information less important than near-coastal and inland EMs. Although average ratings for all three subgroups were between Very and Extremely important (means=1.23–1.72), statistical tests suggest that ratings differ between coastal and other EMs (one-way ANOVA: $F_{(2,261)}=12.22$, $p<0.001$; post-hoc tests between coastal and inland: $p<0.001$, between coastal and near-coastal: $p=0.018$, between near-coastal and inland: $p=0.67$). Similar to the BR results in section 3.5, this may be because storm surge and hurricane-force winds do not typically extend far from the coast, leaving tornadoes as one of the most prominent TC hazards threatening public safety (along with heavy rainfall).

EMs' ratings of one additional type of information, *forecasts of timing of storm arrival*, varied with coastal proximity, although in this case coastal and near-coastal EMs rated this information more important than inland EMs. Although average ratings for all three subgroups were Extremely important (means=1.11–1.37), statistical tests again suggest that these ratings differ (one-way ANOVA: $F_{(2,259)}=5.67$, $p=0.004$; post-hoc tests between coastal and inland: $p=0.019$, between near-coastal and inland: $p=0.015$, between coastal and near-coastal: $p=1.00$).

In general, these results indicate that, compared with information about storm characteristics and forecast uncertainty, the biggest differences in TC forecast information priorities between coastal, near-coastal, and inland EMs are with regard to different TC hazards. A more detailed geospatial analysis based on the risk of storm surge and rainfall flooding in different jurisdictions might further elucidate such differences in information priorities, although EMs' decisions during TC threats are affected by risks to nearby areas as well as their own.

4.2.2. Importance of different types of TC information for EMs: Comparison across phases of a TC threat

Although the emergency manager survey did not investigate the importance of different types of TC forecast information in different phases of a threat in as much detail as the BR survey, it did include a question that asked respondents during which time periods, if any, during a TC threat five types of TC forecast information were important (Figure 4.4). The five types of information included in this question were selected from the nine types in the first EM importance question

(Figure 4.3). The four time periods used in this question were adapted from the three phases of a TC threat used in the BR survey, with Phase II (from 5 days to 48 hours before impacts) subdivided into two periods. Although this question asked respondents to select all time periods that applied, about 75% of respondents selected only a single time period for each type of information, suggesting that they were selecting the *most important* time period rather than *all important* time periods; we interpret the results with this in mind.[10]

We subdivided Phase II for this question on the EM survey because of how EMs' decision timelines and associated forecast information needs intersect with the skill of different types of TC forecasts. More specifically, the interview analysis in Morss et al. (2022b) found that many emergency management decisions must be made more than 48 hours before TC impacts, and so several coastal EM interviewees noted the importance of TC-specific storm surge forecast information at greater than 48 hours of lead time (when they are currently provided). However, due to limited predictability, it is challenging to extend skillful storm surge forecasts out to even to 72 hours, much less 4 or 5 days. Obtaining more detailed information about the lead times needed for such information could therefore help NOAA prioritize investments in improving TC hazard forecasts. Along with forecasts of storm surge or coastal flooding, we also included on this question two other types of TC hazard forecasts that are important for protective decisions but difficult to predict at longer lead times — flooding from rainfall and storm wind speeds in different areas — as well as another type of forecast information that the interviews suggested was important at longer lead times: timing of storm arrival. Given the uncertainties in spatially and temporally specific TC forecasts at longer lead times, we also included on the question a type of uncertainty information that has potential to be useful in lower predictability situations: different storm scenarios.

Figure 4.4 shows results from this question for the full EM sample, and Table 4.1 shows the same data partitioned into coastal, near-coastal, and inland EMs. For *storm surge or coastal flooding* forecasts, Table 4.1 indicates differences by EM proximity to the coast for all five response options. In most cases, the largest differences are between coastal and inland EMs, and statistical tests suggest that these differences are significant ($p \leq 0.001$ in independent-samples proportions tests for all four time periods and Not Important). For the other four types of forecast information, differences between coastal, near-coastal, and inland EMs are smaller and not statistically significant ($p > 0.01$ in independent-samples proportions tests). Thus, we focus primarily on the results partitioned by EM proximity to the coast for *storm surge or coastal flooding* forecasts, and compiled across the EM sample for the other four types of information.

For *timing of storm arrival*, *different storm scenarios*, *flooding from rainfall*, and *storm wind speeds in different areas*, Figure 4.4 shows that nearly all EMs said that the information was important during at least one time period. Figure 4.4 also suggests that different types of information may be most important to EMs at different lead times. For example, forecasts of *timing of storm arrival* were reported most important for EM decisions during all periods 48 hours or more before impacts. Forecasts of *different storm scenarios* were reported most important from 120–48 hours before impacts. And forecasts of *flooding from rainfall* and *storm wind speeds in different areas* peak in importance somewhat later, at 72–48 hours before

[10] We implemented the question in this compact form to reduce the survey response burden on EMs as much as possible; the question design could be modified for future work.

impacts. Note, however, that each of these types of information were important to some EMs in each time period, and further work is needed to draw definitive conclusions.

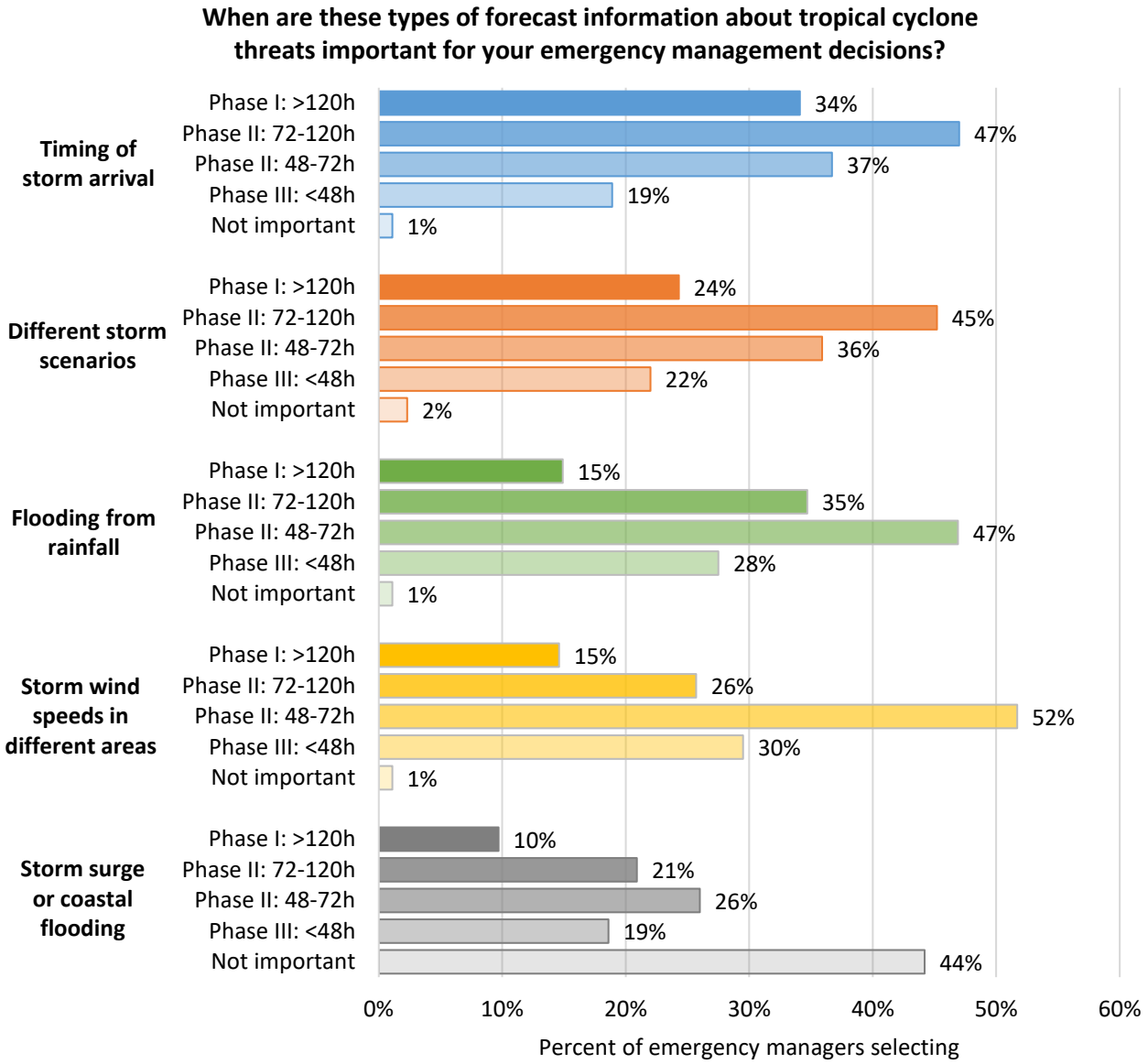

Figure 4.4. Time periods during a TC threat when emergency managers reported that different types of forecast information are (most) important for emergency management decisions. Respondents were asked to select all that apply, with five response options for each type of information: *More than 120 hours (5 days) before a storm impacts your area*, *120 hours (5 days) to 72 hours before a storm impacts your area*, *72 hours to 48 hours before a storm impacts your area*, *48 hours before a storm through impacts*, and *Not important*. N=258–264, depending on the type of information.

Table 4.1. Time periods during a TC threat when emergency managers reported that different types of forecast information are (most) important for emergency management decisions, partitioned into coastal, near-coastal, and inland respondents. Question wording and response options are shown in Figure 4.4; respondents could select more than one time period for each type of information. N=90–94 (coastal), 53–54 (near-coastal), 112–116 (inland)

		% of emergency managers selecting				
		Important during this time period?				
Type of TC forecast information	EM proximity to coast	Phase I: >120h	Phase II: 120h-72h	Phase II: 48h-72h	Phase III: <48h	Not important
Timing of storm arrival	Coastal	38%	53%	38%	19%	0%
	Near-coastal	35%	52%	32%	20%	0%
	Inland	30%	40%	38%	18%	3%
Different storm scenarios	Coastal	28%	50%	34%	20%	3%
	Near-coastal	28%	50%	33%	24%	2%
	Inland	20%	39%	38%	23%	2%
Flooding from rainfall	Coastal	17%	32%	51%	31%	0%
	Near-coastal	17%	41%	46%	26%	0%
	Inland	12%	34%	44%	25%	3%
Storm wind speeds in different areas	Coastal	18%	28%	52%	30%	0%
	Near-coastal	17%	34%	51%	25%	0%
	Inland	10%	20%	52%	31%	3%
Storm surge or coastal flooding	**Coastal**	**20%**	**38%**	**43%**	**26%**	**8%**
	Near-coastal	**4%**	**15%**	**13%**	**25%**	**55%**
	Inland	**4%**	**10%**	**18%**	**10%**	**70%**

Further examination of the data in Table 4.1 indicates that some of these differences in lead times of interest may vary with EMs' proximity to the coast. For example, for *timing of storm arrival*, half (53%) of coastal EMs selected 120–72 hours of lead times as important, compared to 38% for 72–48 hours (McNemar continuity corrected Z=1.80, one-sided p=0.036). Similarly, half (52%) of near-coastal EMs selected 120–72 hours as important for this information, compared to 32% at 72–48 hours (Z=1.86, one-sided p=0.032). In contrast, inland EMs provided similar ratings of importance for these two lead times (40% for 120–72 hours compared to 38% for 72–48 hours; Z=0.121, p=0.90). This suggests that information such as *timing of storm arrival* may be important at longer lead times for coastal and near-coastal EMs' decisions, compared to inland EMs. This is consistent with the large-scale evacuations needed in coastal and some near-coastal jurisdictions for some TC situations, and the interview findings that EMs may require several days or more of planning to successfully implement such evacuations (Morss et al. 2022b). However, additional work is needed to further investigate this topic.

For *storm surge or coastal flooding* forecasts, Table 4.1 shows that 92% of coastal EMs said that the information was important for their decisions during at least one time period leading up to a

TC threat, but only 45% of near-coastal EMs and 30% of inland EMs. As noted above, this is consistent with the results in Figure 4.3 that *storm surge or coastal flooding* forecasts tends to be most important to coastal EMs. Among coastal EMs, more than two-thirds said this information was important at greater than 48 hours of lead time, with 120–72 hours and 72–48 hours selected as most important. This reiterates the results from the interviews that storm surge forecasts at greater than 48 hours of lead time are important for coastal EMs' decisions, along with the shorter-term forecasts that are already available from NWS.

4.3. EM Interactions with NWS Weather Forecast Offices

The interview analysis found that information from and interactions with NWS forecasters are a valuable component of NWS information and services for many emergency managers (Morss et al. 2022b). Thus, as part of assessing how well NWS is currently supporting BRs' decisions (RQ2), the EM survey asked respondents to rate their interactions with their local NWS WFOs during TC threats, in the same format as the BR survey. As shown in Figure 4.5, EMs' ratings were quite positive (mean=1.43, between Good and Excellent). Nearly two thirds of EM respondents reported having Excellent interactions with their local NWS office(s) during TC threats; only one reported Poor interactions, and none reported that their interactions were Terrible. Statistical tests suggest no differences in mean ratings between coastal, near-coastal, and inland EMs (one-way ANOVA: $F_{(2,260)}=0.50$, $p=0.61$). In other words, most EM respondents throughout the study area have positive experiences interacting with WFOs

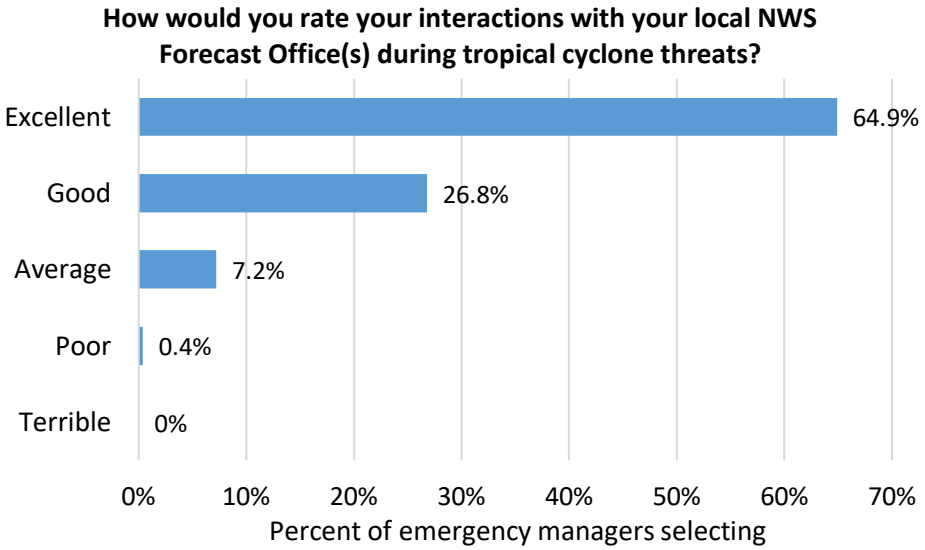

Figure 4.5. Emergency managers' ratings of interactions with their local NWS Forecast Office(s) during TC threats. Response scale: *1=Excellent, 2=Good, 3=Average, 4=Poor, 5=Terrible*. N=263.

In response to other survey questions, the EM who responded Poor to this question indicated that they were a new EM (only 2 years of experience) in an inland jurisdiction in New England who was not very familiar with NWS TC products. They reported having difficulty using several NWS products due to "lack of experience; with more education it should be easier to understand", and at the end of the survey said "Due to being new in this role, more education and

online direct access to NWS and data would tremendously help…" This suggests that newer EMs may need help learning about NWS information and building relationships with their local WFO, especially in small jurisdictions that experience TCs infrequently. Overall, however, these results indicate that most EM respondents throughout the study area have very positive experiences with WFOs.

4.4. Usefulness of Different Types of TC Information and Services for EMs

As in the broadcast meteorologist survey, the emergency manager survey asked respondents to indicate the rate of 25 different types of TC information and services, including various NWS TC products and services. These results address how well NWS is currently supporting EMs (RQ2) as well as how useful and usable EMs find current NWS TC information and services (RQ3) Most of the 25 types of information are the same as those asked about in the BR survey (see section 3.5), with minor adaptations based on EMs' different job roles, feedback from the core NOAA team, and EM pretests. Similar to the BR survey, some items in this question set were received by only a subset of respondents (randomly assigned).

Figure 4.6 depicts ratings for the full set of TC information and services included in the survey. On average, EMs rated most of the types of information and services Very to Extremely useful. Several were rated less useful by the full EM sample (Moderately to Very useful); however, some of these ratings vary with EMs' proximity to the coast. Thus, as in the BR survey, we also examine the same data segmented into four groups of TC information and services:

- **Group 1**: TC overview products provided by NHC and WFOs,
- **Group 2**: TC hazard and impact products (provided by NHC, WFOs, WPC, SPC, RFCs),
- **Group 3**: Forecaster interpretations (from NHC and WFOs), and
- **Group 4**: Numerical model output, observations, and other tools,

for the full sample and comparing coastal, near-coastal, and inland EMs.

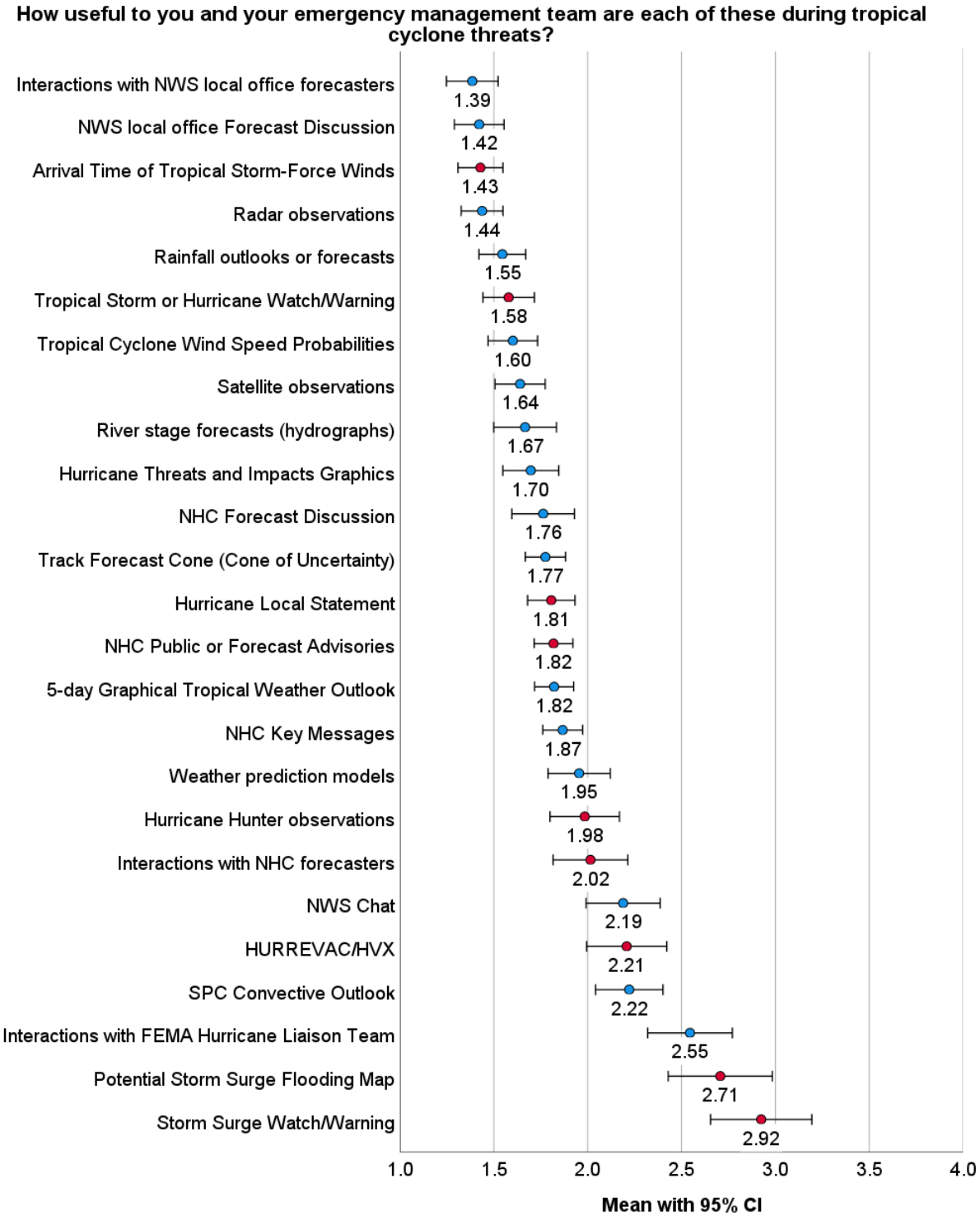

Figure 4.6. Emergency managers' ratings of the usefulness of different types of TC information and services. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Tables 4.2–4.5). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full EM sample. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful*. Several types of information and services are abbreviated in the figure; the full versions provided in the survey are shown in Tables 4.2–4.5. N=131–262, depending on the question item.

Results for the first group of TC information and services — TC overview products — are shown in Figure 4.7 for the full sample, and in Table 4.2 partitioned into coastal, near-coastal, and inland EMs. All of the TC overview products were rated Very to Extremely useful, on average, by coastal, near-coastal, and inland EMs, except for the *Hurricane Local Statement*. Coastal EMs rated the *Hurricane Local Statement* between Very and Extremely useful (mean=1.52) — the most useful of the TC overview products they were asked to rate. Near-coastal EMs rated this product similarly to coastal EMs. Inland EMs, on the other hand, rated the *Hurricane Local Statement* significantly less useful than the other EMs, although still on average Very useful (mean=2.18).

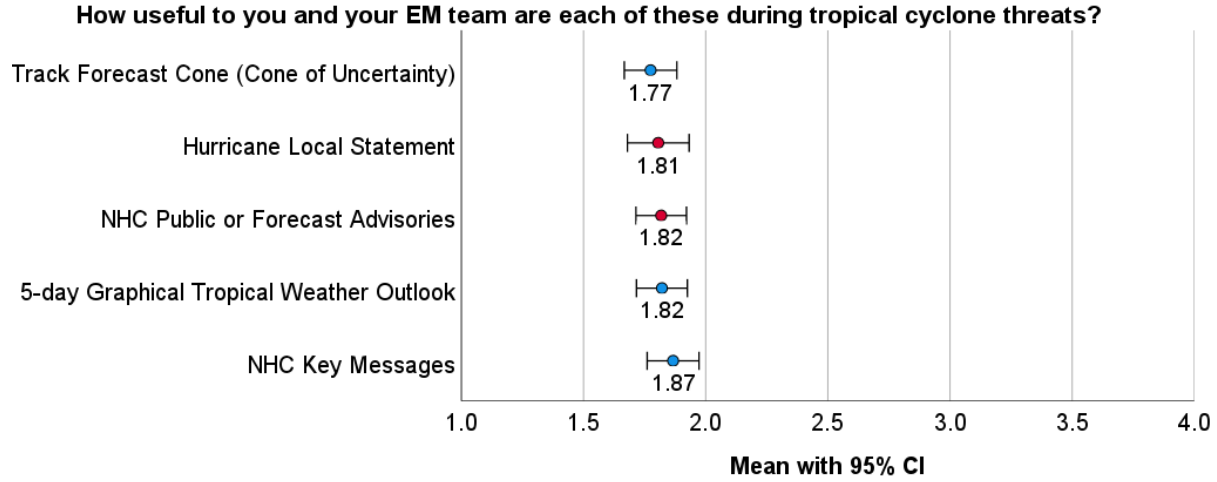

Figure 4.7. Emergency managers' ratings of the usefulness of different types of TC information and services, for Group 1: NWS TC overview products. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Table 4.2). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full EM sample. Response scale is the same as in Figure 4.6. N=262–264.

Table 4.2. Comparison of coastal, near-coastal, and inland emergency managers' ratings of the usefulness of different types of TC information and services, for Group 1: TC overview products. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by EM proximity to the coast ($p<.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal EMs: mean (SD)	near-coastal EMs: mean (SD)	inland EMs: mean (SD)	one-way ANOVA	
					F	p
Hurricane Local Statement	**263**	**1.52 (0.67)**	**1.52 (0.75)**	**2.18 (1.27)**	**14.71**	**<0.001**
5-day Graphical Tropical Weather Outlook	263	1.77 (0.81)	1.74 (0.85)	1.90 (0.90)	0.94	0.40
Track Forecast Cone	262	1.79 (0.84)	1.65 (0.73)	1.82 (0.98)	0.74	0.48
NHC Public or Forecast Advisories	**264**	**1.80 (0.81)**	**1.59 (0.63)**	**1.94 (0.96)**	**3.12**	**0.046**
NHC Key Messages	264	1.81 (0.83)	1.70 (0.74)	1.99 (0.96)	2.31	0.10

Results for the second group — TC hazard and impact products — are shown in Figure 4.8 and Table 4.3. *TC Wind Speed Probabilities* and the two rainfall and river flooding products (*rainfall outlooks or forecasts*, *river stage forecasts (hydrographs)*) were rated on average Very to Extremely useful by coastal, near-coastal, and inland EMs. The convective / tornado product (*SPC Convective Outlook*) was also rated similarly by the three EM subgroups, but less useful than most of the other hazard and impact products (Moderately to Very useful). Paired-sample t-tests indicate that these types of larger differences in usefulness among the products in Figure 4.8 and Table 4.3 are statistically significant; for example, within each EM subgroup, *rainfall outlooks or forecasts* were rated more useful than the *SPC Convective Outlook* (coastal: t_{46}=-4.57, p<0.001; near-coastal: t_{28}=-5.19, p<0.001; inland: t_{54}=-5.01, p<0.001).

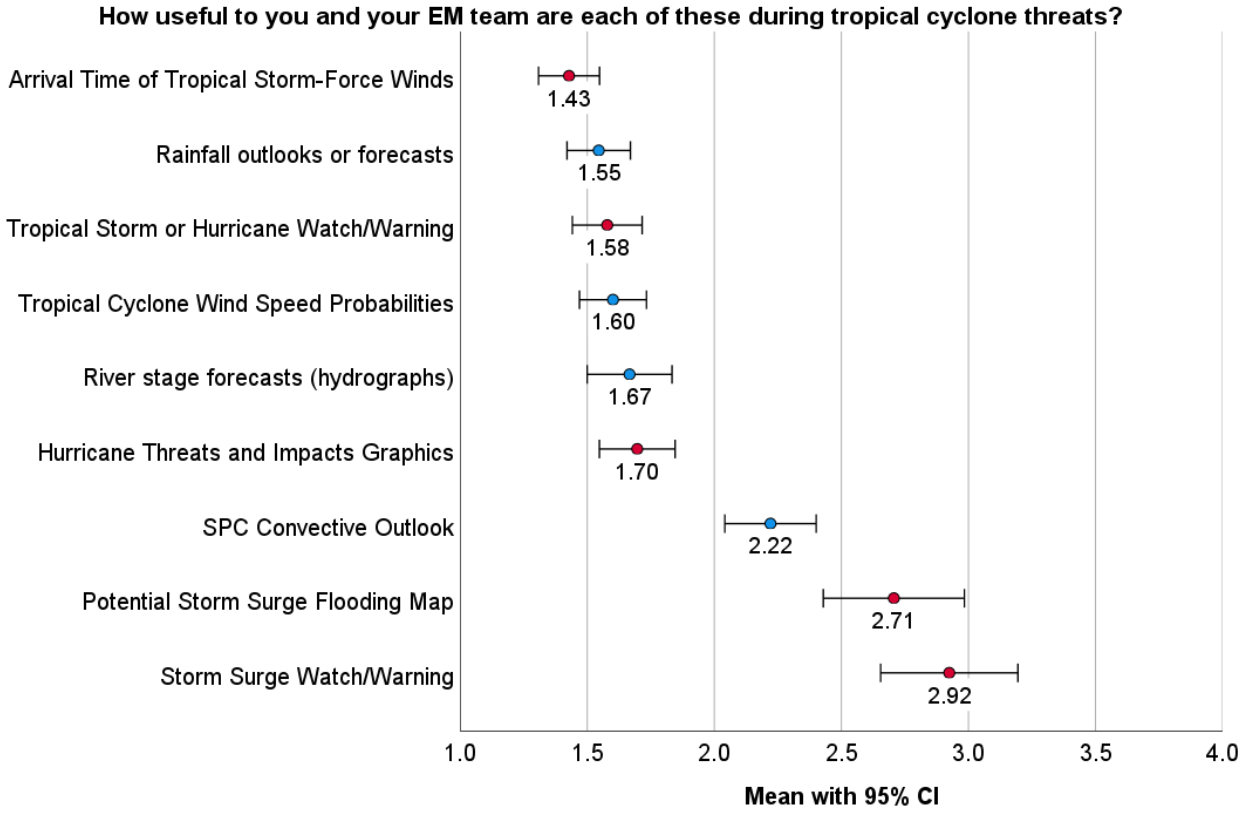

Figure 4.8. Emergency managers' ratings of the usefulness of different types of TC information and services, for Group 2: TC hazard and impact products. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Table 4.3). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full EM sample. Response scale is the same as in Figure 4.6. N=131–133.

Table 4.3. Comparison of coastal, near-coastal, and inland emergency managers' ratings of the usefulness of different types of TC information and services, for Group 2: TC hazard and impact products. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by EM proximity to the coast (p<.05) are indicated in bold.

Type of TC information, product, or tool	N	coastal EMs: mean (SD)	near-coastal EMs: mean (SD)	inland EMs: mean (SD)	one-way ANOVA	
					F	P
Arrival Time of Tropical Storm-Force Winds	**133**	**1.26 (0.44)**	**1.28 (0.46)**	**1.62 (0.88)**	**4.60**	**0.012**
Tropical Storm or Hurricane Watch/Warning	**133**	**1.30 (0.51)**	**1.40 (0.50)**	**1.87 (0.97)**	**8.38**	**<0.001**
TC Wind Speed Probabilities	133	1.47 (0.58)	1.48 (0.65)	1.75 (0.91)	2.27	0.11
Potential Storm Surge Flooding Map	**133**	**1.55 (1.02)**	**3.36 (1.52)**	**3.33 (1.56)**	**25.27**	**<0.001**
Rainfall outlooks or forecasts	132	1.63 (0.67)	1.38 (0.49)	1.56 (0.86)	1.07	0.35
Hurricane Threats and Impacts Graphics	**132**	**1.63 (0.76)**	**1.38 (0.49)**	**1.93 (1.03)**	**4.28**	**0.016**
Storm Surge Watch/Warning	**133**	**1.81 (1.19)**	**3.68 (1.31)**	**3.48 (1.47)**	**25.16**	**<0.001**
River stage forecasts (hydrographs)	132	1.85 (1.13)	1.45 (0.74)	1.62 (0.91)	1.72	0.18
SPC Convective Outlook	131	2.17 (0.96)	2.48 (1.12)	2.13 (1.06)	1.20	0.30

Statistical tests suggest that the remaining five TC hazard and impact products were rated differently by EMs with different proximity to the coast. These differences in usefulness are especially salient for storm surge and coastal inundation information: on average, coastal EMs rated *Potential Storm Surge Flooding Map* and *Storm Surge Watch/Warning* Very to Extremely useful (means=1.55–1.81), while near-coastal and inland-EMs rated these Slightly to Moderately useful (means=3.33–3.68). As discussed in section 4.2, we anticipate that this is because storm surge and coastal flooding are primarily a direct threat (and thus important for EM decisions) in jurisdictions along the coast. Figure 4.8 and Table 4.3 further indicate that EMs' ratings of the usefulness of these two storm surge products are more variable than for many of the other products. This is likely because the risk of TC-induced storm surge and coastal flooding varies significantly even within areas of similar proximity to the coast, and because our EM sample includes jurisdictions of different types and sizes.

Tropical Storm or Hurricane Watch/Warning and *Arrival Time of Tropical Storm-Force Winds* were rated Very to Extremely useful by all three subgroups of EMs, but less useful, on average, by inland EMs than coastal and near-coastal EMs. In fact, both coastal and near-coastal EMs rated *Arrival Time of Tropical Storm-Force Winds* as the most useful product in this group, and both that and *Tropical Storm or Hurricane Watch/Warning* as 2 of the most useful products of the 25 included in the question. We anticipate that this is because strong winds from TCs are most likely to occur along or near the coast.

Results for the third group — Forecaster interpretations — are shown in Figure 4.9 and Table 4.4. Only one type of products or services in this group differed with proximity to the coast:

interactions with NHC forecasters were rated more useful by coastal than inland EMs. One possible explanation for this is that NHC forecasters focus on providing information about larger-scale aspects of TCs and about TC wind and storm surge hazards, which are more likely to occur along and near the coast.

On average, EMs rated *interactions with NWS local office forecasters* and the written *NWS local office Forecast Discussion* product Extremely useful. This is consistent with the interview results that EMs find information from and interactions with local NWS forecasters useful and important (Morss et al. 2022b). EMs also rated the *NHC Forecast Discussion* product between Very and Extremely useful, although somewhat less useful than the *NWS local office Forecast Discussion* product. Together with the results for *interactions with NHC forecasters* just above, this suggests that NHC and WFO forecasters have overlapping, but not identical, EM audiences.

Two of the products and services in this group — *interactions with the FEMA Hurricane Liaison Team* and *NWSChat* — were rated less useful by all three EM subgroups. *Interactions with the FEMA Hurricane Liaison Team* was included on the EM survey because a few EM interviewees discussed the FEMA Hurricane Liaison Team (which is based at NHC) as a useful way to access information and interpretations from NHC forecasters, and we were interested in assessing this with a larger sample. A more in-depth examination of EMs' ratings for this item indicates that *interactions with the FEMA Hurricane Liaison Team* are Extremely useful to some EMs, but Not at all useful to others. EMs may have rated *NWSChat* less useful than other ways of interacting with WFO forecasters because EMs have other options (such as briefings and conference calls) for communication with WFO forecasters, and because use of NWSChat varies by WFO.

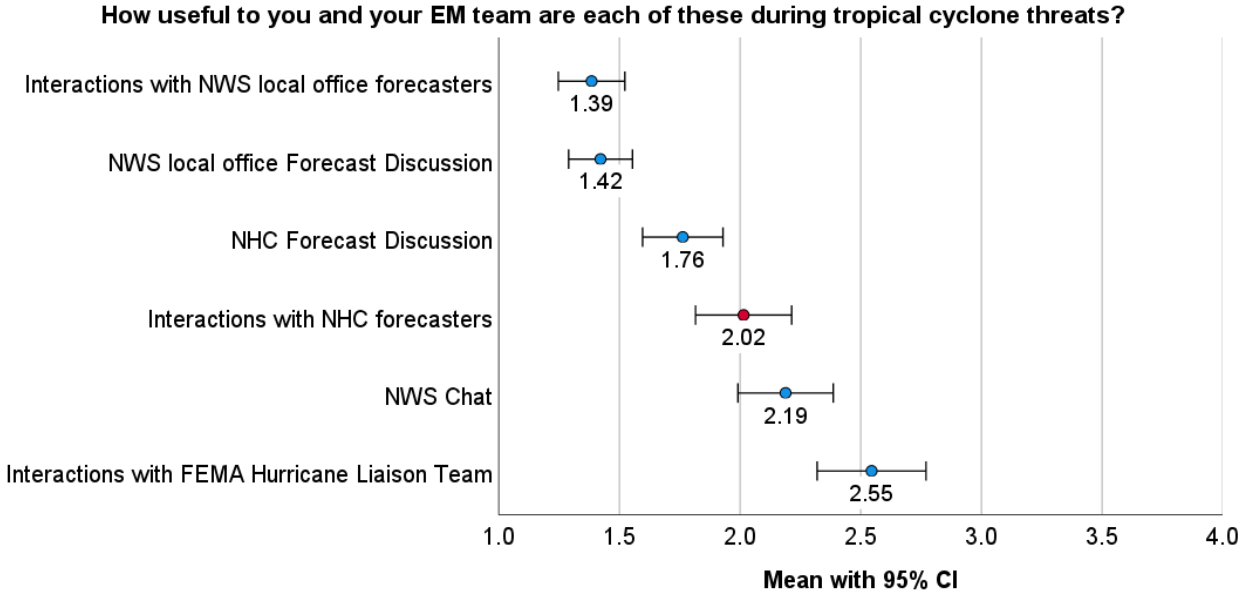

Figure 4.9. Emergency managers' ratings of the usefulness of different types of TC information and services, for Group 3: Forecaster interpretations. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Table 4.4). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full EM sample. The full version of each survey question item is shown in Table 4.4. Response scale is the same as in Figure 4.6. N=127–135.

Table 4.4. Comparison of coastal, near-coastal, and inland emergency managers' ratings of the usefulness of different types of TC information and services, for Group 3: Forecaster interactions. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by EM proximity to the coast (p<.05) are indicated in bold.

Type of TC information, product, or tool	N	coastal EMs: mean (SD)	near-coastal EMs: mean (SD)	inland EMs: mean (SD)	one-way ANOVA F	one-way ANOVA p
Interactions with NWS local office forecasters (e.g., briefings, conference calls)	135	1.44 (0.75)	1.18 (0.39)	1.44 (1.00)	1.15	0.32
NWS local office Forecast Discussion	135	1.44 (0.70)	1.32 (0.55)	1.45 (0.94)	0.30	0.74
NHC Forecast Discussion	135	1.62 (0.82)	1.64 (0.83)	1.96 (1.15)	1.99	0.14
Interactions with NHC forecasters (e.g., briefings, conference calls)	**133**	**1.75 (0.96)**	**1.86 (0.85)**	**2.35 (1.39)**	**4.09**	**0.019**
NWSChat	127	2.15 (1.11)	2.23 (1.11)	2.20 (1.16)	0.05	0.95
Interactions with FEMA Hurricane Liaison Team	132	2.26 (1.21)	2.57 (1.23)	2.80 (1.41)	2.22	0.11

Results for the fourth group of TC information and services are shown in Figure 4.10 and Table 4.5. Both *radar* and *satellite observations* were rated between Very and Extremely useful and *weather prediction models* Very useful by all three EM subgroups. This suggests that many EMs find observational data and model output useful along with other NWS products and services. Ratings of *HURREVAC/HVX* and *Hurricane Hunter observations* differed with EMs' proximity to the coast. Post-hoc tests indicate that *HURREVAC/HVX* was rated more useful by coastal than inland EMs (with no significant differences for non-coastal EMs), and that *Hurricane Hunter observations* were rated more useful by coastal and near-coastal EMs than by inland EMs.

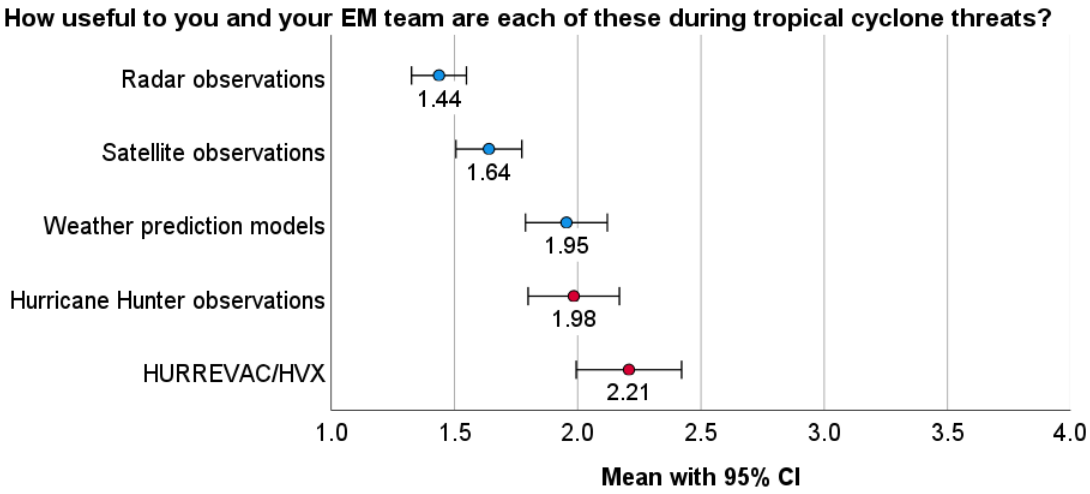

Figure 4.10. Emergency managers' ratings of the usefulness of different types of TC information and services, for Group 4: Numerical models, observations, and other tools. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (see Table 4.5). Types of information are ordered from highest (1) to lowest (5) mean usefulness for the full EM sample. The full version of each survey question item is shown in Table 4.5. Response scale is the same as in Figure 4.6. N=125–132.

Table 4.5. Comparison of coastal, near-coastal, and inland emergency managers' ratings of the usefulness of different types of TC information and services, for Group 4: Numerical models, observations, and other tools. Types of information are ordered from highest (1) to lowest (5) mean usefulness for coastal respondents. Ratings that differed by EM proximity to the coast ($p<.05$) are indicated in bold.

Type of TC information, product, or tool	N	coastal EMs: mean (SD)	near-coastal EMs: mean (SD)	inland EMs: mean (SD)	one-way ANOVA	
					F	p
Radar observations	128	1.43 (0.63)	1.31 (0.55)	1.50 (0.68)	0.83	0.44
Satellite observations	125	1.78 (0.82)	1.52 (0.82)	1.59 (0.67)	1.14	0.32
Hurricane Hunter observations	**127**	**1.78 (0.94)**	**1.54 (0.71)**	**2.32 (1.16)**	**6.62**	**0.002**
HURREVAC/HVX	**125**	**1.85 (1.09)**	**1.96 (1.08)**	**2.57 (1.26)**	**5.24**	**0.007**
Weather prediction models	132	1.88 (0.94)	2.03 (0.87)	1.98 (1.05)	0.28	0.76

Overall, except for a few that were rated less useful by non-coastal EMs, all of the types of information and services asked about were rated on average Very to Extremely useful by EM respondents. This suggests that NWS is currently supporting many EMs' TC decisions quite well. These results also indicate that, similar to BRs, EMs find it useful to have many of the different types of TC information currently available from the NWS and other sources.

4.5. Usability of NWS TC Information and Services for EMs and Usability Gaps

Next we focus in more depth on RQ3, examining the usability of NWS TC information and services from several perspectives. As with the broadcast meteorologists, this includes investigating how NWS TC information aligns with emergency managers' decision timelines (section 4.5.1), how usable NWS graphics are for EMs (section 4.5.2), and what types of difficulties EMs experience using NWS products (sections 4.5.3 and 4.5.4).

4.5.1. Alignment of NWS TC information and services with EM decision-making timeline

The emergency manager survey included a question to evaluate the timing of NWS product releases relative to EMs' timelines for decisions. As shown in Figure 4.11, more than three-quarters of EM respondents said that NWS information was currently well aligned with their decision timeline, whereas about 20% said there was room for improvement. Few respondents said that NWS information was not at all aligned with their timeline.

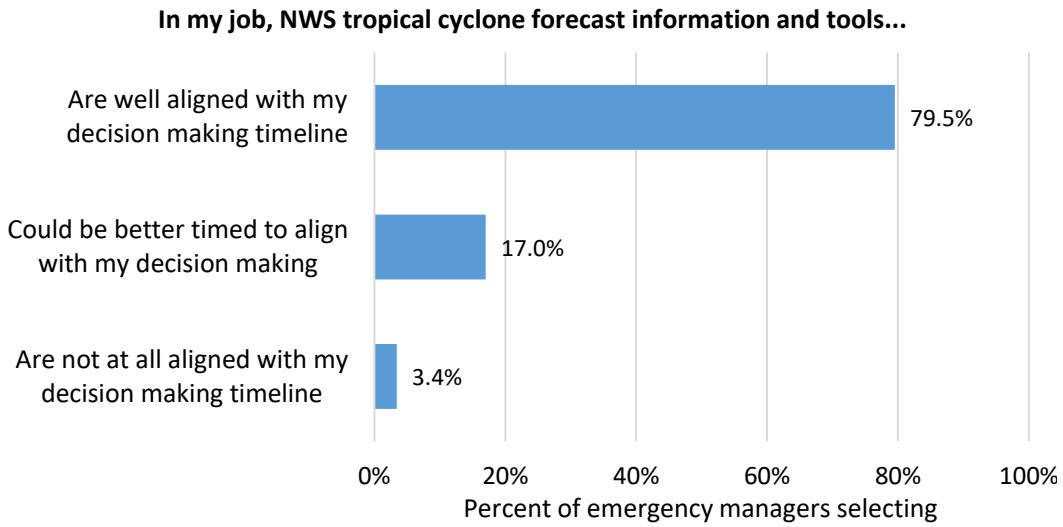

Figure 4.11. EMs' ratings of the alignment of NWS TC forecast information and tools with their decision-making timelines. Respondents were asked to select which of the three response options provided best fit their judgment. N=264.

In their open-ended responses to other survey questions, several EMs indicated ways in which NWS TC information and tools could be better aligned with their decision timeline (although this was not as prevalent as among BRs; see section 3.6.1). These EMs' responses included requests for increased lead time for certain types of NWS products or forecast information and for earlier or improved information to support public safety decisions. Illustrative quotes include:

- "Extending timeframe of the cone of uncertainty if possible."
- "Better and earlier storm surge forecast and graphics."
- "Updated brief that can help us project needs and evaluate available assets."
- "I know this is difficult, but accuracy for decision making purposes."

In addition, similar to BRs, several EMs requested more frequent updates or more rapid release of new information; examples include:

- "Warnings every 8 hours"
- "Always get info out ASAP"
- "Communicate watches and warnings quicker"

These and other topics in the EMs' open-ended responses to the survey questions are also discussed in section 4.7.2.

4.5.2. Usability of NWS TC graphics for EMs

To assess another aspect of the usability of NWS information, the survey asked emergency managers the extent to which NWS graphics meet their needs for communicating and coordinating during TC threats, similar to a question on the BR survey. As shown in Figure 4.12, nearly half of respondents said that they use NWS graphics "as is." Half said that NWS graphics meet most of their needs, and that they sometimes modify NWS graphics to communicate and coordinate better. Very few said that the graphics only meet some of their needs or are not

useful. This indicates that although some EMs sometimes modify NWS graphics, they tend to do so less than BRs; overall, existing NWS graphics meet most of EMs' needs.

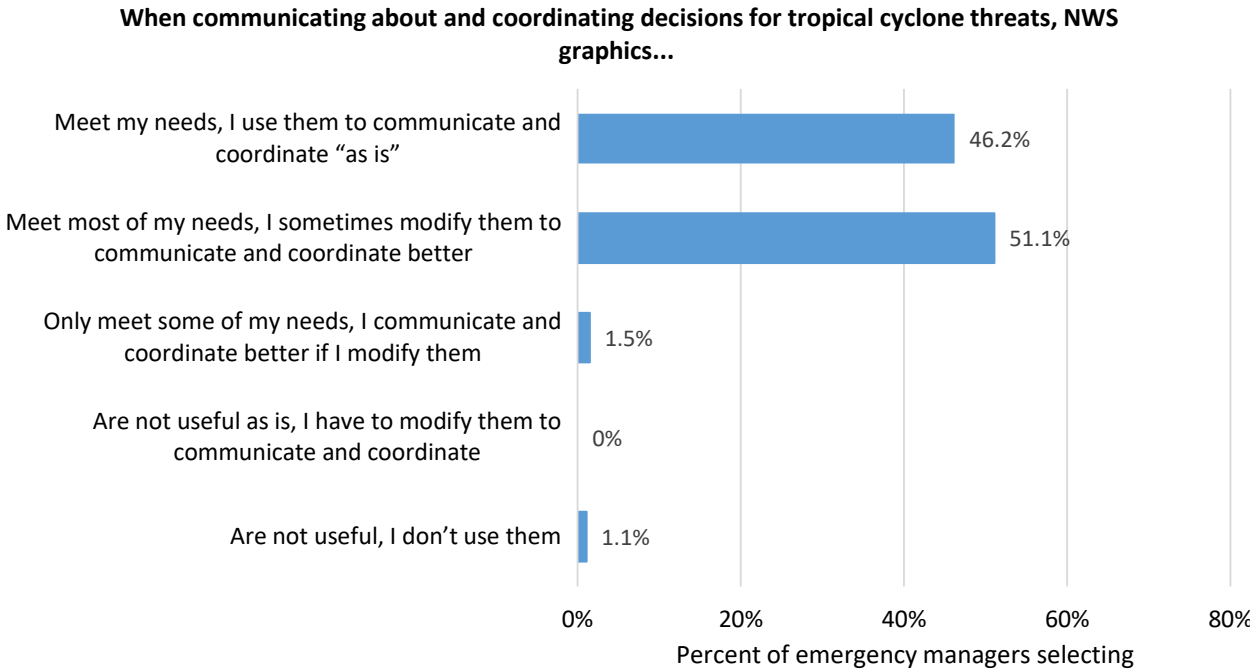

Figure 4.12. Emergency managers' reported modification of NWS graphics for communicating about TC threats and coordinating decisions. Respondents were asked to select which of the five response options shown best fit their judgment. N=262.

4.5.3. Usability of different NWS TC products for EMs

The emergency manager survey also asked respondents whether there are TC products that they have particular difficulties using. Similar to the corresponding question on the BR survey (discussed in section 3.6.3), the EM survey question provided each respondent with a randomly selected subset of three of the products in Figure 4.13, in random order, and asked which, if any, they had difficulty using to communicate with others.[11] Respondents could select one or more products, or None of the above.

As shown in Figure 4.13, about two-thirds of respondents reported no difficulty using any of the three products included in their version of the question. The product that respondents most commonly indicated difficulties with was the *SPC Convective Outlook*, which more than one-quarter reported having difficulty using, followed by the *Track Forecast Cone*, the *Graphical Tropical Weather Outlook*, *river stage forecasts (hydrographs)*, and two NHC wind products. The products that respondents reported the least difficulty with were *rainfall outlooks or forecasts* and *Watches/Warnings on the weather.gov* webpage, with only a few EMs reporting difficulties with each.

[11] Although the survey questions are similar, the percentage of BRs and EMs who selected each option are not directly comparable, because BRs were asked about four products, and EMs only three.

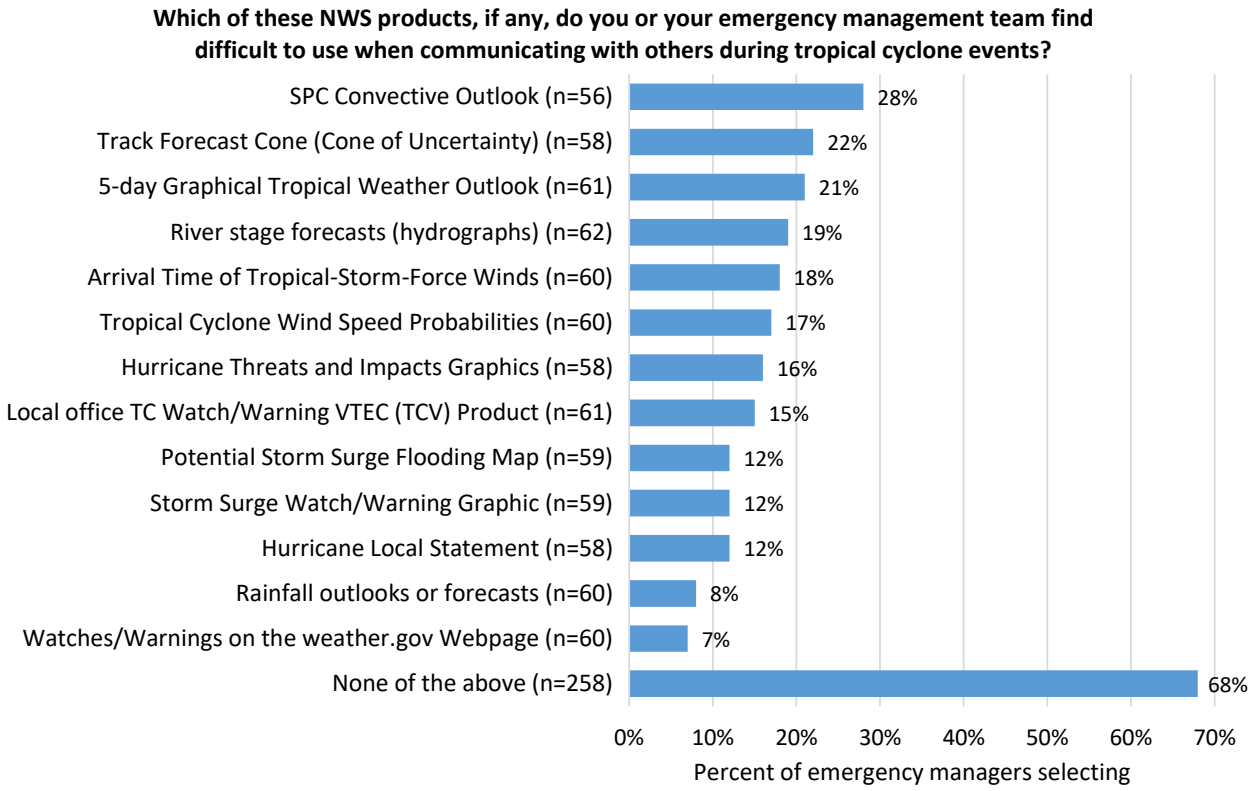

Figure 4.13. Emergency managers' reported difficulty using different NWS TC products. Products are ordered from the largest to smallest percentage of respondents saying that they had difficulty using the product. *None of the above* indicates that a respondent said they did not have difficulty using any of the three products included in their version of the question. As indicated in the graphic, N=58–62, depending on the product.

4.5.4. Reasons for EM difficulty using NWS TC products

For the 83 emergency managers who said they had difficulty using one or more of the products, the survey asked a follow-up question about what made that product (if only one had been selected) or a randomly selected one of those products (if more than one had been selected) difficult to use. Four response options were offered (Figure 4.14), along with an "Other" option; respondents could select one or more options. These response options were developed based on the interview findings, other prior research, and discussions with the core NOAA team.

As shown in Figure 4.14, the most common response — selected by 59% of respondents — was that the product doesn't provide information specific enough to their area. Approximately one-third said that the product takes too much time to understand. Fewer than 10% said that the product provides too much information or those they communicate with do not want them to use it. This is consistent with the interview findings that EMs often require locally interpretable information for their decisions, and that they need information that they and others can understand quickly (Morss et al. 2022b).

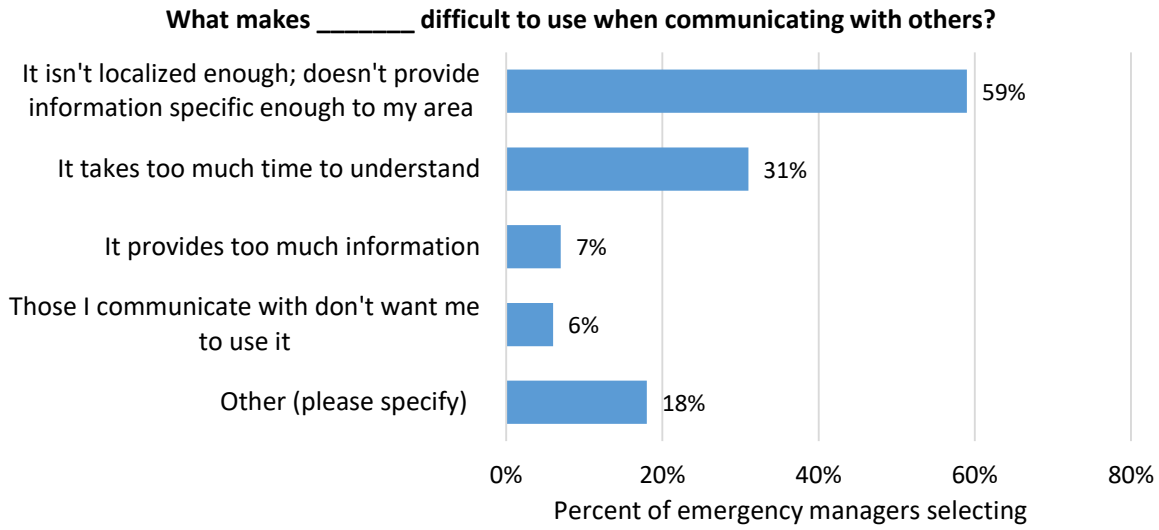

Figure 4.14. EMs' reported reasons for difficulty using an NWS product. Respondents were asked to select all that apply. N=83.

Analyzing these results in further detail, Table 4.6 shows the reasons that EMs reported having difficulty using specific products. There are few respondents for many of the products, making it difficult to draw clear conclusions. However, the data suggest that for many of the products — *5-day Graphical Tropical Weather Outlook*, *Arrival Time of Tropical-Storm-Force Winds*, *Hurricane Threats and Impacts Graphics*, *Storm Surge Watch/Warning Graphic*, *Potential Storm Surge Flooding Map*, and *rainfall outlooks or forecasts* — the primary reason EMs have difficulty using them is that they cannot use them to obtain local information for their area. For the *SPC Convective Outlook*, *river stage forecasts (hydrograph)*, and *Tropical Cyclone Wind Speed Probabilities*, EM responses were approximately evenly split between the product not being localized enough and taking too much time to understand. For the *Track Forecast Cone*, EMs said that it does not provide local information for their area AND is difficult to understand or is misunderstood. For the *Hurricane Local Statement*, EMs primarily said that it provides too much information.

Table 4.6. Reasons emergency managers reported having difficulty using different NWS TC products. Only products that four or more EMs reported having difficulty using and that three or more EMs were asked about their reasons for difficulty using are included. Products are ordered from largest to smallest percentage of respondents saying that they had difficulty using the product. NR=No Response.

			Reasons EMs reported having difficulty using: # who selected (% of those asked reason for difficulty using)				
Product	# (%) of EMs who reported difficulty using the product	# of EMs who were asked reason for difficulty using	It isn't localized enough …	It takes too much time to understand	It provides too much information	Those I communicate with don't want me to use it	Other
SPC Convective Outlook	16 (28%)	16	6 (38%)	7 (44%)	0	1 (6%)	4 (25%): "Not familiar with what it is." "I do not know what this is." "Never used it." NR
Track Forecast Cone	13 (22%)	9	4 (44%)	1 (11%)	0	0	3 (33%): "Cone of uncertainty is not well understood." "Lack of experience; with more education it should be easier to understand." "People don't realize the impacts associated outside the cone. Public main focus is just on the cone."
5-day Graphical Tropical Weather Outlook	13 (21%)	9	8 (89%)	2 (22%)	0	1 (11%)	0
River stage forecasts (hydrograph)	12 (19%)	9	4 (44%)	5 (55%)	1 (11%)	0	1 (11%): "Have to use 2 gauges that are quite some distance from each other to estimate river levels to inhabited areas between the gauges."
Arrival Time of Tropical-Storm-Force Winds	11 (18%)	7	5 (71%)	1 (14%)	1 (14%)	0	1 (14%): "Public doesn't understand."

Tropical Cyclone Wind Speed Probabilities	10 (17%)	7	3 (43%)	3 (43%)	1 (14%)	0	2 (28%): “Complex topic, but the table of percentages is not intuitive.” “N/A”
Hurricane Threats and Impacts Graphics	9 (16%)	5	4 (80%)	1 (20%)	1 (20%)	0	1 (20%): “People misunderstand the “cone” and I would rather see track ensembles.”
Tropical Cyclone Watch/Warning VTEC Product	9 (15%)	3	2 (66%)	1 (33%)	0	0	1 (33%): “I don’t know what VTEC is.”
Storm Surge Watch/ Warning Graphic	7 (12%)	5	5 (100%)	2 (40%)	0	0	0
Potential Storm Surge Flooding Map	7 (12%)	3	2 (66%)	0	0	0	1 (33%): “Hard to explain to the public what the graphic is actually trying to convey.”
Hurricane Local Statement	7 (12%)	5	0	1 (20%)	2 (40%)	1 (20%)	1 (20%): “N/A”
Rainfall Outlooks or forecasts	5 (8%)	3	3 (100%)	0	0	0	0

4.6. EM Perceived Audience Understanding of Different Types of TC Information

To further address information usability (RQ3), the survey asked emergency managers how well they think the people they interact with in their job understand different types of TC information. As with BRs, this is important because it can influence how EMs use different types of information when communicating and coordinating with others, or whether they use certain types of information at all. The eight types of information included in this question were a subset of those in the similar question asked on the BR survey. To limit the length of the survey, these eight types of information were divided into two subsets of four items, and each respondent received one of these two subsets (randomly assigned).

On average, EMs think that those they interact with in their job understand these types of information Moderately to Very well (means=1.90–2.87). One-way ANOVAs with post-hoc tests suggest that EMs' ratings of only two of the eight types of information differed by coastal proximity, for coastal and inland EMs. As shown in Figure 4.15, *forecasts of storm surge or coastal flooding* were rated better understood by coastal EMs ($F_{(2,132)=}6.02$, p=0.003; mean difference between coastal and inland is 0.86, p=0.002), whereas *forecasts of tornadoes* were rated better understood by inland EMs (combined $F_{(2,133)}=4.73$, p=0.01; mean difference between coastal and inland is 0.53, p=0.008).

Although many of the confidence intervals shown in Figure 4.15 overlap, statistical tests suggest that there are differences between the highest and lowest rated types of information. For example, similar to BRs, across the sample EMs rated *forecasts of flooding from rainfall* (mean=1.90) better understood than *forecasts of storm surge or coastal flooding* (mean=2.87) (paired-sample t-test: $t_{135}=8.97$, $p<0.001$). This comparison is similar within each EM subgroup (coastal, near-coastal, inland). EMs also think that *forecasts of timing of storm arrival* (mean=2.03) are better understood than *forecast uncertainty* (mean=2.50) (paired-sample t-test: $t_{125}=7.06$, $p<0.001$).

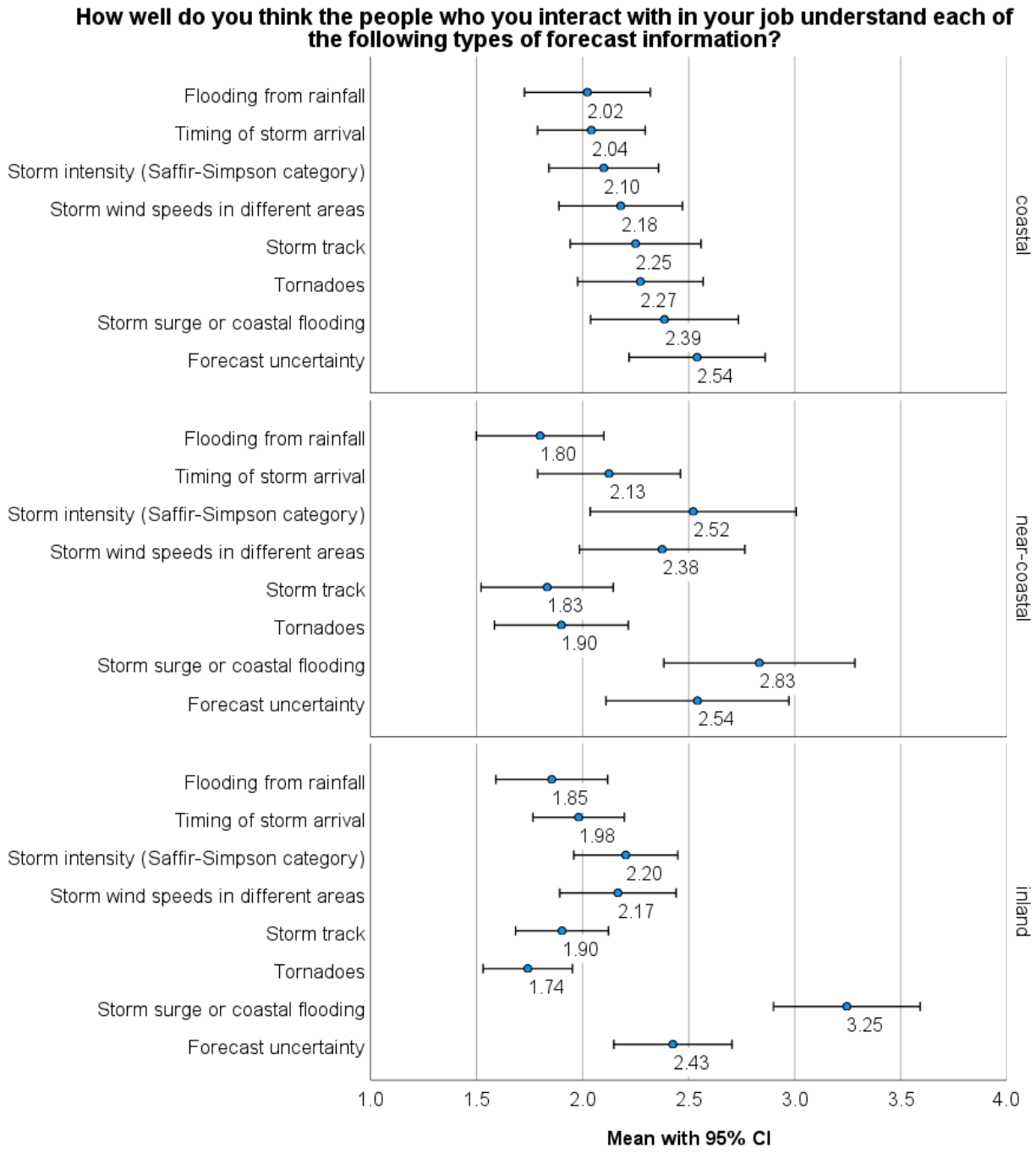

Figure 4.15. Emergency managers' ratings of audience understanding of different types of TC information, partitioned into coastal (upper), near-coastal (middle), and inland (lower) respondents. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from highest (1) to lowest (5) mean perceived understanding for coastal respondents. Response scale: *1=Extremely well, 2=Very well, 3=Moderately well, 4=Slightly well, 5=Not at all well.* N=44–50 (coastal), 23–30 (near-coastal), 54–62 (inland), depending on the question item.

4.7. EM Views about Potential Changes to NWS TC Information and Services

Finally, the survey included several questions to address RQ4, emergency managers' views on potential changes to NWS information, products, and services. As in the BR survey, the EM survey included a closed-ended question that asked to rate the usefulness of a small set of potential changes (section 4.7.1). This was followed by a three-part open-ended question that asked respondents the single most important change that NWS could make in each of the three phases of a TC threat (section 4.7.2).

4.7.1. EM ratings of potential changes to NWS TC information and services

The emergency manager survey included a parallel question to the BR survey question discussed in section 3.8.3, in which respondents was asked to rate the usefulness of four possible new NWS products or services, randomly selected from the same set of eight as in the BR survey:

- *forecasts of storm track, provided more than 5 days out,*
- *forecasts of storm intensity, provided more than 5 days out,*
- *forecasts of storm surge, provided more than 48 hours out,*
- *forecasts of timing of onset of storm surge,*
- *forecasts of duration of sustained tropical-storm-force winds,*
- *forecasts of when hazardous conditions will end,*
- *compiling available information in one place, making it easier to access all NWS products that relate to a particular storm*, and
- *a summary product compiling key hazard and risk information for a particular storm*.

As described in section 3.8.3, the candidate products and services for this question were developed based on the initial interview findings and discussions with the core NOAA team.

Results are shown across the full sample in Figure 4.16, and partitioned into coastal, near-coastal, and inland EMs in Figure 4.17. Statistical tests indicate that EMs' ratings differed by respondents' proximity to the coast for two of the eight changes: *forecasts of timing of onset of storm surge* (Kruskal-Wallis test: $H=53.89$, $p<0.001$) and *forecasts of storm surge, provided more than 48 hours out* ($H=43.55$, $p<0.001$). Coastal EMs rated both of these changes to storm surge forecasts Very to Extremely useful (means=1.34–1.44), whereas near-coastal and inland EMs rated them both Somewhat to Moderately useful (means=3.31–3.48). This is consistent with the EM survey results in sections 4.2 and 4.4, that forecasts of storm surge and coastal flooding are highly useful and important to most coastal EMs, but only somewhat or not useful and important to most non-coastal EMs.

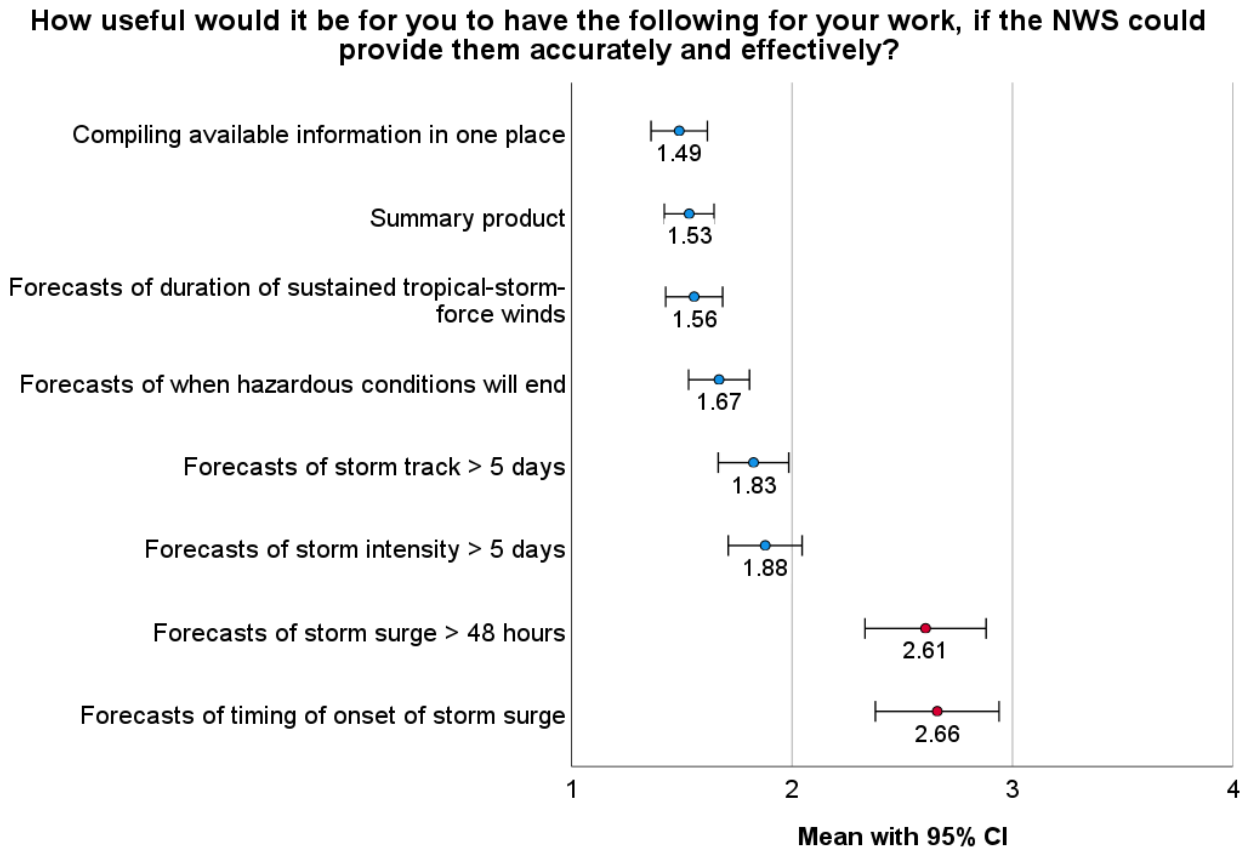

Figure 4.16. Emergency managers' ratings of the usefulness of eight potential changes to NWS information and services. Dots indicate mean ratings, with 95% confidence intervals; red dots indicate types of information for which ratings differed by EM proximity to the coast (Figure 4.17). Types of information are ordered from most to least useful. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful.* Several of the potential changes are abbreviated in the figure; the full versions from the survey are provided in the text. N=132–133.

The six other types of information in Figure 4.17 were rated, on average, Very to Extremely useful by coastal, near-coastal, and inland EMs. EMs expressed strongest interest overall in a *summary product compiling key hazard and risk information for a particular storm* and *compiling available information in one place, making it easier to access all NWS products that relate to a particular storm*, each of which were rated Very or Extremely useful by more than 90% of EMs. *Forecasts of storm track, provided more than 5 days out*; *storm intensity, provided more than 5 days out*; *duration of sustained tropical-storm-force winds*; and *when hazardous conditions will end* were each rated Very or Extremely useful by more than 75% of EMs.

These results indicate that similar to BRs, EMs would like the NWS to better synthesize the collection of available information during TC threats in a summary product, and to have the information available in one place. They also provide evidence that additional information about timing of TC hazards would be useful to EMs. Both of these concepts were suggested by EM interviewees (Morss et al. 2022b) and are confirmed here with a larger and more geographically diverse EM sample. Most EMs also rated *forecasts of storm track and intensity more than five days out* Very or Extremely useful, more useful than BRs. In fact, coastal EMs rated all eight potential changes highly useful, suggesting that they would value all of them.

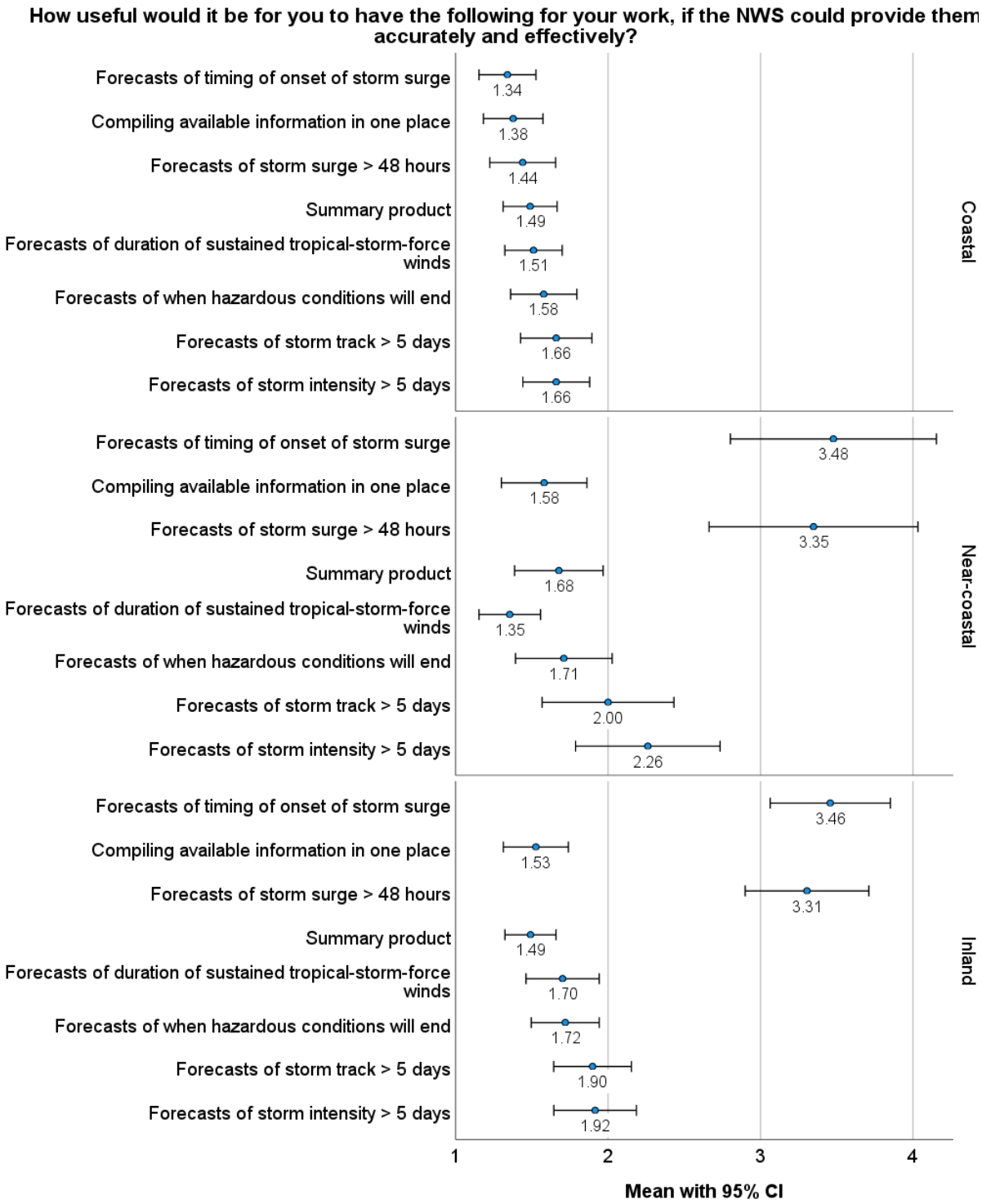

Figure 4.17. Emergency managers' ratings of the usefulness of eight potential changes to NWS information and services, partitioned into coastal (upper), near-coastal (middle), and inland (lower) respondents. Dots indicate mean ratings, with 95% confidence intervals. Types of information are ordered from most to least useful for coastal respondents. Response scale: *1=Extremely useful, 2=Very useful, 3=Moderately useful, 4=Slightly useful, 5=Not at all useful.* Several of the potential changes are abbreviated in the figure; the full versions from the survey are provided in the text. N=45–50 (coastal), 23–31 (near-coastal), 57–59 (inland), depending on the question item.

4.7.2. Most important change to NWS TC information and services: EM open-ended responses

At the end of the emergency manager survey, respondents were asked "What, if anything, is the single most important change the NWS could make to improve its tropical cyclone storm forecast and warning information, tools, and services for one or more of these time frames?" This question was similar to that at the end of the broadcast meteorologist survey (section 3.8.4), but with open-ended response boxes provided for three time frames corresponding to the three phases of a TC threat used in the BR survey. We structured the question this way to enable us to shorten the EM survey, while also prompting EMs to provide feedback on the most needed information in different phases of their decision timeline (as the BR survey did with the questions on additional information or tools in each of the three phases, discussed in section 3.8.2). Similar to the BR survey, this open-ended question appeared toward the end of the EM survey,[12] and thus may have been influenced by previous survey questions.

The percentage of EMs who provided responses for this set of open-ended questions (25–28%) was smaller than the percentage of BRs who provided responses for the similar questions on the BR survey (61–90%). Because the overall number of respondents was approximately three times larger for the EM survey than for the BR survey, we had similar numbers of open-ended responses from the two NWS partner groups. However, the EMs tended to provide shorter responses than the BRs, resulting in less detailed open-ended feedback overall.

Excluding EMs who provided responses such as "n/a", 92 EMs provided responses for at least 1 of the 3 time periods. First, we discuss responses for EMs who provided the same response across the three time periods. This is followed by discussion of the remaining EMs' responses for each of the three time periods, separately.

Eight EMs either entered the same text for each time period or responded to the first time period and then entered "same" or similar text for the other two time periods, indicating that they were suggesting improvements valid across the three time periods. Themes were similar to those that arose in responses for individual time periods (discussed below), including requests for increased forecast accuracy, additional information about TC impacts, more rapid release of new information, and improved access to model output and the collection of information available from NWS. Illustrative quotes include:

- "More accuracy since many times, the storm track changes."
- "Narrow the size of the threat area."
- "Mountain rainfall and related stream and river impacts."
- "Always get info out ASAP"
- "We would like all the data, in one easy place to get. … In order to make the decisions we are required to make, I want all the data. i.e., Spaghetti Models. We actually look at other pages now more than NWS products because they are easier to use and have more data."

[12] The only questions appearing after this question on the EM survey were those on interactions with local NWS Forecast Offices, effects of COVID-19, and sociodemographic characteristics.

- "Provide an online dashboard to review data"

Phase I

For more than 120 hours (5 days) before a storm impacts your area, some EMs who wrote in responses requested no changes, in some cases acknowledging the forecast uncertainty during this phase. Illustrative quotes include:

- "None. Happy with the current products."
- "No changes are necessary; we use the information well"
- "5 days is about as far out as I need"
- "Fine as is due nature of changing weather conditions"
- "At that juncture, it is hard to predict with any degree of accuracy where landfall will occur."

These types of response were especially prevalent among EMs in inland or near-coastal jurisdictions.

Other themes in EMs' responses for this phase (with illustrative quotes) include:

- **Improved accuracy in TC track forecasts**, e.g., by narrowing uncertainty in the Track Forecast Cone
    - "Projected landfall"
    - "Shrink the cone of uncertainty"
    - "Reduce the size of the cone of probability"
- **Increased forecast lead time**, e.g., by providing information currently available less than five days before anticipated TC impacts (during Phase II) further in advance
    - "Extending time frame of the cone of uncertainty if possible"
    - "Tropical Storm Force Wind arrival times"
    - "More time is always helpful"
- **Improved forecasts of TC intensity, timing, or hazards and impacts**
    - "Improved intensity forecasts"
    - "Potential timing"
    - "Forecast of strength and timing and flooding potential"
- **Improved public communication or decision support**
    - "Sharing info with community"
    - "Raise public awareness of the hazard without creating fear"
    - "Provide simple basic preparatory information for the public."
    - "I know this is difficult, but accuracy for decision making purposes."
- **Information about forecast confidence, uncertainty, or scenarios**
    - "Likelihood that storm would make landfall/impact [in our] region"
    - "Clarity of anticipated upper end risk, and certainty/uncertainty regarding significant change"
    - "Communication of possible scenarios of impact"

    - "Environmental conditions that could enhance or degrade the storm"

Other (less prevalent) themes during this time period include requests for information and interpretations from NWS forecasters, more geographically specific information, and forecasts of potential inland impacts. Additional illustrative quotes include:

- "This would be the best time for a conference call with your best set of possibilities of the impact."
- "Provide a national-level briefing that transitions to regional office briefings"
- "Specifics for local area"
- "What the impacts may be inland."
- "Additional information about possible impacts for inland jurisdictions (beyond 2 or 3 counties)"
- "Worst-case scenario of potential impacts affecting evacuations particular to our state"
- "Just a general alert to pay attention to developing scenarios"
- "If cone not accurate ... then don't give."
- "Include models showing what makes up the cone of uncertainty in graphics"
- "Give us the same projections that the media show, i.e. 6 or 7 days out for planning [is] important."

Phase II

For 120 hours (5 days) to 48 hours before a storm impacts your area, some EMs said "No changes needed" or similar, as in Phase I. Such responses were again most prevalent among inland and near-coastal EMs.

Many of the themes in EMs' responses for this time frame were similar to those for Phase I, with increased emphasis in several areas. The most prominent shift was increased emphasis on:

- **Improved forecasts of TC hazards and impacts**. While a few EMs requested improved information about TC intensity or wind hazards or about TC impacts in general, requests for information about **storm surge** (primarily among coastal EMs) and **rainfall and associated flooding** (among coastal and inland EMs) were especially common. Illustrative quotes include:
    - "Projected impacts"
    - "Intensity or impact severity"
    - "Heavy rainfall and flooding"
    - "Rainfall predictions"
    - "Forecast intensity and storm surge prediction"
    - "Better and earlier storm surge forecast and graphics"

Additional themes in Phase II include (with illustrative quotes)

- **More geographically specific information**, often combined with information about TC hazards and impacts
    - "Likelihood that storm would make landfall/impact [in our] state"

    - "Communicate more local advisories of storm impact"
    - "Illustrations on the local impact severity for wind, storm surge and inland flooding"
- **Information about TC timing**, often related to the anticipated timing of TC hazards and impacts
    - "Forecast of strength and timing and flooding potential and surge"
    - "Provide anticipated duration of impacts."
    - "Projected storm track, QPF rainfall amounts, tornado potential, and duration of storm."
    - "Forecast of the intensity and onset of storm surge in our area."
- **Importance of NWS information for decision making in this time frame**
    - "This would help in doing evacuations"
    - "This would be better for us to give us more time to deploy resources"
- **Improved information or forecaster communication for EM decision support**
    - "Updated brief that can help us project needs and evaluate available assets."
    - "Staff to support event"
    - "Send as much info as possible to my phone because during possible storm events I will be out in my county checking on issues."

Additional illustrative quotes for Phase II:

- "Better accuracy"
- "The cone of error pointed at a general area or state."
- "Start transitioning from a new national to regional briefings and start providing ensembles of tracks in EM products."
- "Forecast of how you think the storm track will change as it approaches and hits land and moves inland."
- "Inland rainfall impacts that may influence evacuation/sheltering operations"

<u>Phase III</u>

For 48 hours before a storm impacts your area through impacts**,** some EMs again requested no changes, as in the other two phases. Many of the themes in EMs' responses were similar to Phase I and Phase II, with less emphasis on increased forecast accuracy in general; longer lead times; improved information about forecast confidence, uncertainty, or scenarios; and improved forecasts of TC track (although a few EMs still requested such information). As in Phase II, there was increased emphasis in several areas, including (with illustrative quotes):

- **Improved forecasts of TC hazards and impacts**, especially **storm surge**, **rainfall and flooding**, and **damaging winds**
    - "Accuracy of information regarding specific impacts"
    - "Storm track, rainfall amounts, flooding potential, tornado potential, potential wind speed, flooding impacts."
    - "Wind and rain forecasts"

    - "Rainfall forecasts"
    - "Expected tide, storm surge, river levels - anything water related (i.e. less concern over wind speed at this time as there is nothing that can "stop" the winds. But precautions can be taken for rising waters.)"
    - "Coastal flooding/storm surge"
- **Information about TC timing**, often related to the anticipated timing of TC hazards and impacts
    - "Timing and intensity of system"
    - "More detailed timing broken down by specific impacts (wind, rain, tornado, etc.)"
    - "Increased accuracy of onset and ending of significant impacts"
    - "When hazard conditions are projected to end"
- **More geographically specific information**, often combined with information about TC hazards and impacts
    - "Be more specific in the areas that will be impacted."
    - "Specific impacts to various areas"
    - "Prioritized impact list broken down by state regions (Western, Central, Coastal)"
    - "Further hyper-localized forecasts, perhaps for regional offices to divide the region in to further local sectors and provide how impacts may differ across those sectors"
- **Improved communication and decision support for public and EMs**
    - "Greater emphasis on associated dangers when communicating with the media/public."
    - "Warnings to public about preparations needed given likely scenarios"
    - "Provide relevant direct information to emergency management that will impact decision making processes."
    - "Summary projections that can be forwarded to elected officials - brief high impact with graphics."
- **Importance of NWS information for decision making in this time frame**
    - "This time range has greater certainty and clarity. It is most important for us."
    - "The most helpful with limited staff"
- **More frequent updates or rapid dissemination**
    - "Timing, wind speeds and rainfall estimates on a regular basis."
    - "Communicate watches and warnings quicker"

Additional illustrative quotes for Phase III:

- "Most likely track and storm impacts/duration"
- "Degree of damaging winds/rain, expected end of storm"
- "Focus on local impact statements regardless of landfall predictions"
- "Regional as well as coastal impacts; often inland areas are devastated when public and media focus has been on the coastal portion of the warning area."

- "Reconfigure the p-surge graphic to convey surge in a more intuitive manner"
- "Get rid of "water over ground" forecasts; they are meaningless. Go back to MSL as the reference."
- "Storm surge accuracy and timing with respect to local tides"
- "Ability to receive from NWS forecast impact changes and threats and share to NWS spatial data about actual impacts"
- "I'd like to have more conference calls but I understand staffing is an issue"
- "Consolidate all products in one spot"

4.8. Key Emergency Manager Survey Findings and Opportunities for Improvement

As with the broadcast meteorologist results, we end this section by summarizing key findings from the emergency manager survey, synthesized across the results in sections 4.1–4.7. We begin with EMs' priorities and needs for TC information (RQ1; section 4.8.1), and then briefly summarize how well the NWS is currently supporting EMs' work during TC threats (RQ2; section 4.8.2). Building on these findings and the interview findings in Morss et al. (2022b), we then discuss gaps in the TC product suite and associated opportunities for improvement (RQ3 and RQ4; section 4.8.3).

4.8.1. EMs' priorities and needs for TC information (RQ1)

The survey results reveal that **emergency managers find a variety of types of TC information useful in their work** (section 4.4). This includes multiple types of NWS-generated TC forecast and warning information, in graphical and text formats. It also includes TC observations, weather prediction model output, and information from NWS forecasters. The exception was storm surge forecast and warning information, which was very useful to coastal EMs, and not very useful to most EMs in near-coastal or inland jurisdictions.

Data about **the importance of different types of TC forecast information for emergency managers' decisions** (section 4.2.1) are available in less detail than for BRs, because the EM survey asked about fewer types of information. Across a TC threat, coastal, near-coastal, and inland EMs rated forecasts of storm track, timing of storm arrival, and different storm scenarios Very to Extremely important. Each EM subgroup also provided, on average, Very to Extremely important ratings for multiple types of information related to TC hazards and impacts, including forecasts of storm intensity, storm wind speeds in different areas, and flooding from rainfall. Consistent with the EM ratings of usefulness above, forecasts of storm surge or coastal flooding were rated, on average, Very or Extremely important by coastal EMs, and not very important by near-coastal and inland EMs. Forecasts of tornadoes were rated more important by near-coastal and inland EMs than by coastal EMs, but still Very to Extremely important by all three EM subgroups.

EMs were asked about the **importance of information at different lead times** for five types of TC forecast information: timing of storm arrival, different storm scenarios, storm wind speeds in

different areas, flooding from rainfall, and storm surge or coastal flooding (section 4.2.2). At more than 72 hours before TC impacts, EMs rated forecasts of different storm scenarios (a form of forecast uncertainty information) and timing of storm arrival most important. At less than 72 hours before impacts, they rated forecasts of storm wind speeds in different areas and flooding from rainfall most important. Forecasts of storm surge or coastal flooding were rated similarly important to wind and rainfall flooding hazards by coastal EMs at less than 72 hours before impacts; the majority of non-coastal and inland EMs rated storm surge forecast information not important at any lead time.

The importance of wind, rainfall flooding, and (for coastal EMs) storm surge flooding peaked at 72–48 hours before landfall, and more than two-thirds of coastal EMs said that storm surge flood forecasts were important at more than 48 hours of lead time. This confirms our interview findings that many EMs at risk from storm surge require storm surge forecast information at greater than 48 hours of lead time for decision making (Morss et al. 2022b).

4.8.2. NWS effectiveness in supporting EMs' decisions (RQ2)

Overall, the survey data indicate **NWS is currently supporting most emergency managers' decisions very well**. EMs rated a variety of types of NWS TC products and services Very or Extremely useful to their EM teams (section 4.4), and more than 90% of EM respondents rated their interactions with their NWS WFOs during TC threats Excellent or Good (section 4.3). More than three-quarters said that NWS products are well aligned with their decision-making timeline (section 4.5.1), and nearly half said that they use NWS TC graphics as is, without modification (section 4.5.2). About two-thirds of respondents reported not having difficulty using any of the (randomly selected) sample of three NWS TC products whose ease of use they were asked to evaluate (section 4.5.3). Moreover, when asked how NWS could improve its TC forecast and warning information and services, multiple EMs wrote that no changes were needed or that they were happy with the current products (section 4.7.2).

4.8.3. Gaps in the TC product suite and opportunities for improvement for EMs (RQ3, RQ4)

Despite this positive feedback, as with broadcast meteorologists, the EM survey data reveal **several information and usability gaps in the current TC product suite** for these core NWS partners **(**RQ3). These gaps suggest **opportunities for NOAA to improve its information and services for emergency managers** (RQ4)**, leveraging their roles in the forecast and warning system to help the NWS protect public safety and economic well-being** (RQ4).

Some EMs reported difficulty using certain NWS graphical products, although no product stood out as being difficult to use for many EMs. However, a reason for EM difficulties using NWS products did stand out: that the **product does not provide information specific enough to their area** (section 4.5.4). Our EM sample consisted primarily of local EMs, whose **decisions involve assessing risks to their city or county**. For some decisions, such as selecting locations for evacuation shelters, they must assess risk at an even finer geographic scale, for specific locations in their area. Considering the information these EMs need for decisions, one can see why they

report that many NWS graphical products — from WFOs as well as national centers and RFCs — are not localized enough.

The second most common reason for EM difficulty using NWS products was that they take too much time to understand (section 4.5.4). In addition, some said that an NWS product is commonly misunderstood by or difficult to explain to their audiences. Perhaps for these reasons, about half of EMs reported sometimes modifying graphics to better do their jobs. Together with EMs' open-ended responses about the most important changes to NWS information and services (section 4.7.2), these results suggest that EMs would benefit from **development of product formats that enable users to quickly extract locally relevant information of interest**, even at lead times when predictability limits constrain meteorologists' ability to provide accurate, geographically specific forecasts. EMs also indicated the value of **improving the rapid understandability of NWS graphics for non-technical audiences**, for their own interpretations and for use in communicating with others involved in public safety decisions.

The EM survey data also elucidate the **importance of information from and interactions with NWS forecasters in supporting emergency management decisions** during TC threats, alongside other forecast and warning products (Figure 4.9). This is consistent with the NWS's increasing emphasis on providing effective decision support for core partners such as EMs. NHC and NWS Forecast Discussion products and interactions with WFO forecasters were all rated, on average, Very to Extremely important by coastal, near-coastal, and inland EMs. Interactions with NHC forecasters were rated Very important, but slightly less so, especially by inland EMs. EMs rated NWSChat Very useful, but somewhat less so than interactions with human forecasters through briefings and conference calls. These results illustrate that EMs find it valuable to access NWS forecasters' knowledge through multiple mechanisms, including one-way communications and two-way interactions. They also indicate that the expertise of both NHC and NWS forecasters are valuable to EMs, likely in complementary ways.

In phase I (more than 5 days before impacts), the survey data indicate that EMs would benefit from improved accuracy / decreased uncertainty in TC track forecasts (section 4.7.2). Another opportunity for improvement at these longer lead times is additional information about TC intensity, timing, or hazards and impacts. Such information could be provided by extending the time frame of products currently available less than five days before impacts, such as the Track Forecast Cone, or providing forecaster-interpreted depictions of weather prediction model output (such as spaghetti plots) that many people already obtain from non-NWS sources. EMs also expressed interest in additional information about TC scenarios, indicating that despite wanting more accurate forecasts, they recognize the uncertainties.

In **Phase II (5 days to 48 hours before impacts)**, EMs' interests in improved TC information and services shifted towards forecasts of TC hazards and impacts, with a particular emphasis on flooding due to storm surge and heavy rainfall (section 4.7.2). Key opportunities for improvement include earlier information about projected hazards and impacts (echoing the discussion in section 4.8.1 on EMs' need for TC hazard forecasts at greater than 48 hours of lead time) and information about potential regional or local impacts (echoing the discussion above on EMs' need for locally interpretable forecast information). Other requests included information about hazard timing, and more emergency management-relevant communications or forecaster decision support. Improvements requested by EMs in **Phase III (48 hours through impacts)**

centered around similar themes to Phase II, with an increased focus on more specific TC hazard information.

When EMs were asked about the usefulness of eight possible new types of NWS information and services (section 4.7.1), two of the highest rated were a **summary product compiling key hazard and risk information for a particular storm** and **compiling available information in one place, making it easier to access all NWS products that relate to a particular storm**. Each was rated Very or Extremely useful by more than 85% of coastal, near-coastal, and inland EMs. As elucidated by the interviews and other survey data, the value of these potential additions relates to EMs' need to be able to quickly find and understand the most updated, relevant information for their geographic area of responsibility, regardless of the information's source.

Coastal, near-coastal, and inland EMs also rated **additional information about TC hazard timing** highly useful, along with **providing forecasts of storm track and intensity more than five days out**. In addition, **forecasts of storm surge more than 48 hours out** and of the **timing of storm surge onset** were rated Extremely useful by coastal EMs. This reiterates the importance of storm surge forecasts that align with EMs' decision timelines and information needs for EMs in areas that can be affected by coastal flooding.

5. CROSS-SURVEY SUMMARY AND RECOMMENDATIONS

Building on the summaries of findings from the broadcast meteorologist survey in section 3.9 and the emergency manager survey in section 4.8, this section summarizes key commonalities and differences in results across the two NWS partner groups. We include several figures that synthesize highlighted BR and EM survey results, based on the same data presented in earlier sections. Building on these analyses, we then provide recommendations for NOAA on updating and designing the future TC product suite from a strategic risk communication perspective.

5.1. Commonalities and differences across broadcast meteorologist and emergency manager survey findings

Overall, broadcast meteorologists and emergency managers tended to evaluate current NWS information and services very highly (sections 3.3, 3.4, 3.5, 4.3, and 4.4). For example, as shown in Figure 5.1, the vast majority of broadcast meteorologists and emergency managers rated their interactions with WFOs during TC threats Excellent or Good.

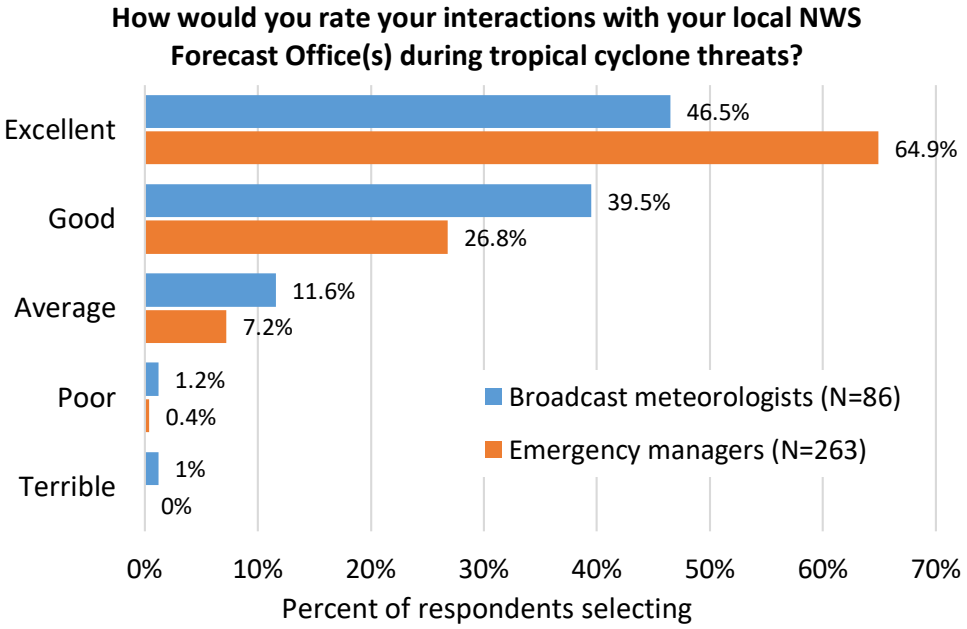

Figure 5.1. Broadcast meteorologists' and emergency managers' ratings of their interactions with local NWS WFOs during TC threats.

In addition, **both NWS partner groups indicated that a variety of types of TC information are important for their jobs, and that a variety of NWS TC products and services are useful to them** (sections 3.2, 3.5, 4.2, and 4.4). BRs and EMs both indicated the importance of multiple types of NWS products conveying different aspects of TC risks, in graphical and text formats. They also indicated the value of data underlying NWS products (especially BRs) as well as TC observations and weather prediction model output. Moreover, the survey data indicate that for both BRs and EMs, information and interpretations from human forecasters serve an

important, complementary role to other types of information provided by NOAA. This includes interpretations from NHC and WFO forecasters provided asynchronously in written form, through Forecast Discussions, as well as mechanisms such as NWS Chat or conference calls that enable NWS partners to interact with forecasters, hear / read their interpretations in real time, and ask questions. BRs rated NWSChat more useful, and EMs rated briefings and conference calls more useful, suggesting that these ways of accessing forecaster expertise play complementary roles for NWS partners.

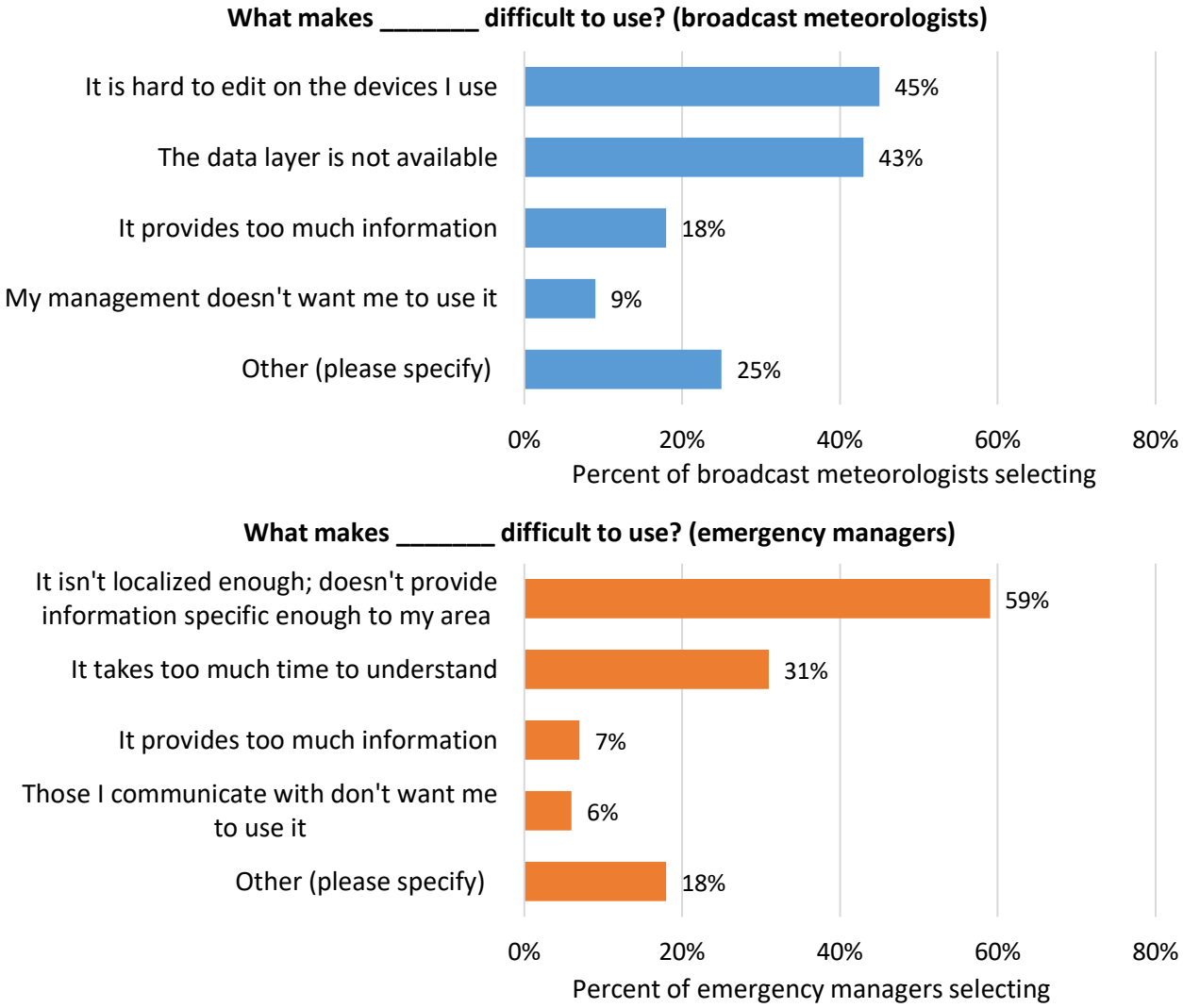

Figure 5.2. Broadcast meteorologists' (upper, N=44) and emergency managers' (lower, N=83) reported reasons for difficulty using an NWS TC product.

At the same time, **many respondents expressed interest in improved and new TC information and services** (sections 3.6, 3.8, 4.5, and 4.7). **Both broadcast meteorologists and emergency managers identified gaps in the usability of some current NWS forecast and warning products, but for somewhat different reasons** (Figure 5.2). The primary reasons that BRs said they have difficulty using NWS products — especially graphics — were that the products are hard to edit on the devices they use or the data layer is not available. This

underscores how BRs frequently use NWS graphics as a template that they revise and customize for their own dissemination and communication. For emergency managers, the primary reason was that the product does not provide information specific enough to their area. This underscores the importance of locally interpretable information for coordinating emergency management decisions. Members of both NWS partner groups also said that some products are difficult to understand, provide too much information, are commonly misunderstood, or are difficult to explain to their audiences. Broadcast meteorologists, in particular, also said that the usability of NWS-provided textual forecast information could be improved, in terms of both more concise, better organized textual TC products and use of simpler, non-technical language.

Another issue with usability of the NWS TC product suite identified by some members of both NWS partner groups was alignment of information issuance with their decision-making timelines (sections 3.6.1, 4.5.1, and 4.7). Some broadcast meteorologists said that releases of new information sometimes do not line up with their broadcast deadlines. When NWS products come at or right before the time BRs need to go on air, they do not have enough time to update the graphics they will use to communicate and to perform essential review of key highlights, changes from previous forecasts, and other important information. This is especially salient as the storm approaches, when BRs are communicating frequently across multiple media channels. Some emergency managers said that they need information earlier in their timeline, especially forecasts that are more geographically specific and include potential TC hazards and impacts, to enable important decisions that require days to plan and effectively implement.

Both broadcast meteorologists and emergency managers said that improved information about anticipated hazard timing would be highly useful to them (Figure 5.3). Across respondents, BRs and EMs expressed interest in information about timing of storm surge onset, duration of tropical-storm-force winds, cessation of hazardous conditions, and other aspects of TC timing. This suggests that expansion of TC hazard timing forecasts beyond the current Arrival Time of Tropical Storm Force Winds product would be beneficial. It is important to note, however, that some BRs and EMs said they experience difficulties using the current Arrival Time products, which should be considered prior to expanding the concept (Tables 3.6 and 4.6).

Both NWS partner groups also expressed strong interest in compiled information about a particular TC, in the form of a summary product synthesizing key hazard and risk information and/or a location where they can easily access all relevant NWS products (Figure 5.3). Developing such products and services effectively is challenging, because it requires balancing different BRs and EMs needs for different types of information, as well as balancing their desire for simplicity and understandability with the complexity and diversity of TC forecast and warning information. Nevertheless, the survey data suggest that providing one or both of these mechanisms as part of modernizing the TC product suite could help accelerate the value of a wide range of NOAA-generated TC products and data.

Regarding an NWS summary product, currently many BRs, EMs, and others use the Track Forecast Cone for this purpose, but it has multiple limitations, including not effectively conveying the potential for TC hazards in different areas. Other NWS products that currently serve this function include NHC Key Messages, which were rated less useful by BRs in inland than coastal media markets, and Hurricane Local Statements, which were rated less useful by EMs in inland than coastal or near-coastal jurisdictions. When deciding to move forward, it is

important to consider the strengths and weaknesses of each of these products and others, for both the forecasters creating them and the different audiences using them. **Regarding compiling available NWS information in one place**, the interview and survey data indicate that non-NWS websites currently serve this purpose for at least some BRs and EMs.

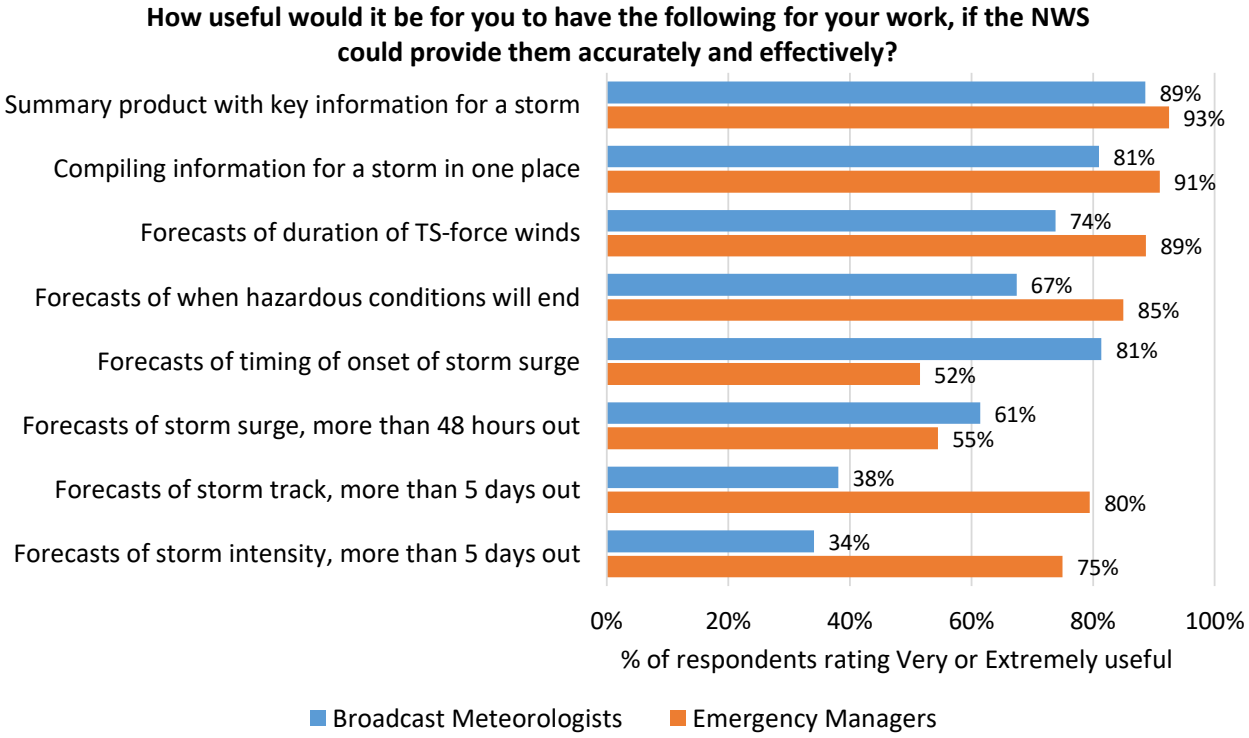

Figure 5.3. Broadcast meteorologists' (N=42–44) and emergency managers' (N=132–133) perceived usefulness of eight potential changes to the current NWS TC product suite, for the full survey samples. See Figure 5.4 for the two potential changes in storm surge forecast information partitioned by respondents' proximity to the coast.

At greater than 5 days of lead time, both broadcast meteorologists and emergency managers expressed interest in additional information about possible TC tracks and scenarios. Emergency managers said that extending track and intensity forecasts out beyond 5 days would be highly useful to them (Figure 5.3). Given the forecast uncertainties at these lead times, however, the format of such information could be different than the current NWS products provided beginning 5 days out. Although some broadcast meteorologists said that extending track and intensity forecasts out beyond 5 days would be highly useful, many rated this as less beneficial. At greater than 5 days of lead time, broadcast meteorologists emphasized the value of additional information and services that can help them communicate forecast uncertainty and the importance of paying attention to the threat.

As a storm approaches, both broadcast meteorologists and emergency managers emphasized the importance of forecasts of TC hazards and impacts, including information that is more regionally and locally interpretable. When possible, members of both NWS partner groups said that more geographically specific TC hazard information would be useful beginning several days before impacts. However, predictability limits constrain meteorologists'

ability to provide such information, at least with current forecasting technologies. Thus, alternate ways of conveying hazard information that is locally relevant at longer lead times, beyond grid-based maps of single-valued or probabilistic forecasts of hydrometeorological parameters, may be needed.

Further, although BRs and EMs overwhelmingly said that TC hazard and impact information was important and useful in their jobs, priorities for different types of information varied across respondents. In particular, forecasts of storm surge and coastal flooding hazards were rated more useful by coastal than non-coastal NWS partners (Figure 5.4). This difference is not surprising, and it was particularly prominent for emergency managers. Inland broadcast meteorologists said that storm surge forecast information as still somewhat important and useful to them, given their roles in communicating about TC risks and impacts in areas beyond their media market. The survey data also suggest that forecasts of TC tornado risks may be more important to inland than coastal BRs and EMs, although the difference is much smaller than for storm surge information.

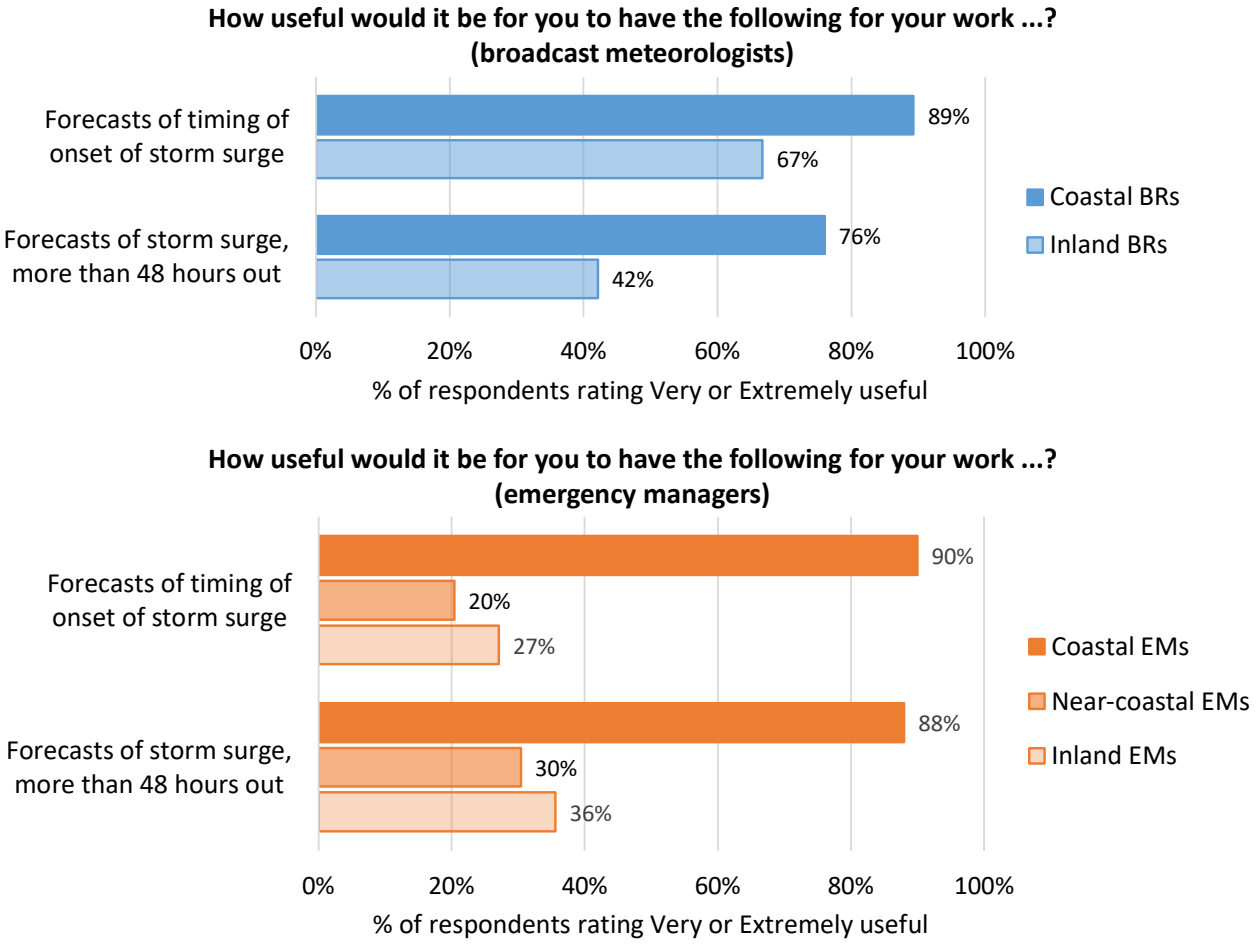

Figure 5.4. Broadcast meteorologists' (N=43–44) and emergency managers' (N=132) perceived usefulness of the two potential changes in storm surge forecast information from Figure 5.3, partitioned by respondents' proximity to the coast.

5.2. Recommendations for NOAA

These results suggest **several priorities for modernizing the NWS TC product suite**:

1. For both broadcast meteorologists and emergency managers, **improved ways to access and quickly understand the most updated TC information available from different NWS entities** are needed. This could take the form of a new summary product that synthesizes key information for a storm (similar to the Track Forecast Cone but with improved information about hazards and impacts), a website that compiles available NWS products and information about a storm, or both.
2. For broadcast meteorologists, priority improvements include **better support in communicating forecast uncertainty and scenarios** more than 5 days before impacts; **more localized information about forecasted hazards and impacts** as a storm approaches; and **improved alignment of NWS information releases with the timing of newscasts**.
3. For emergency managers, priority improvements include **improved information about storm track, timing, and scenarios** more than 5 days before impacts and **more localized information about forecasted hazards and impacts and their timing** as a storm approaches. This includes, for coastal emergency managers, **improved information about storm surge and coastal flooding risks more than 48 hours before impacts**.
4. **For graphical products**, priority modernizations include **improved editability and availability of data layers** for broadcast meteorologists and the **ability to interpret information specific to their area** for emergency managers. Both NWS partner groups also indicated that **some graphical NWS products have too much information or are difficult to quickly understand**.
5. **For text products**, priority modernizations include **improved concision, organization, and non-technical language** to enable rapid understanding of key updates.
6. **Humans in the TC forecast and warning loop continue to be extremely important** for both broadcast meteorologists and emergency managers. Thus, human forecasters should continue to be a core component of the TC product suite, providing forecast information, interpretations, and decision support through both asynchronous and synchronous interactions with NWS partners.

The results also suggest **several principles for NOAA to consider when designing and implementing modernizations to NWS information and services**:

1. Given how useful the currently available TC information and services are for most broadcast meteorologists and emergency managers, **NOAA can and should build on its successes**.
2. **A mix of types of information is important and useful to NWS partners**, including graphical, text, and hybrid products; data layers; numerical model output; observations; and information from and interactions with NWS forecasters. These different types of information are complementary, and each would likely be less useful without the others.
3. Graphical forecast and warning products are rarely used in the NWS format by broadcast meteorologists. Rather, **NWS graphics and associated data layers provide a critical**

foundation for broadcast meteorologists to revise to communicate forecast information with a broad audience across multiple media platforms.

4. **For emergency managers, graphical products are often used as provided by the NWS, and so the understandability of NWS formats as-is is often critical.** However, emergency managers sometimes modify NWS graphics to improve communication about and coordination of decisions, or they use the geospatial data layers underlying NWS products integrated with other information to support decisions.
5. Broadcast meteorologists and emergency managers, and NWS partners in different regions, have overlapping — but not always the same — TC information needs. NWS partners' information needs also vary as a TC threat and their associated communications and decisions evolve**. Clarifying which products and services are designed to serve a broad audience throughout a threat, and which are focused primarily on serving a segment of NWS partners or to be useful during certain time periods, can help NOAA target improvements to TC products and identify remaining gaps in information and services.**

In closing, accelerating improvements to NWS weather forecasts and warnings and their communication and use requires understanding forecast users' decision timelines, the interactions of information with those timelines, and their unmet information needs, alongside advancing forecast science and technology. NOAA can achieve these goals by continuing to conduct periodic multi-method evaluations of NWS products and services as a whole, to obtain a holistic view of how the organization is serving key users and to prioritize investments in improvements over the near- and longer-term.

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APPENDIX A. BROADCAST METEOROLOGIST SURVEY INVITATIONS AND REMINDERS

This appendix presents the schedule and sample text for the email invitations and reminders sent to BRs requesting that they take the survey. The initial invitation was sent on March 16, 2021, to 964 BRs, and the schedule and distribution of subsequent email reminders is provided in Table A-1.

Table A-1. Reminder schedule and distribution for broadcast meteorologist survey.

Reminder	Date sent	Emails sent	Emails bounced
A	March 19, 2021, 7:04 a.m. MDT	934	302
B	March 23, 2021, 6:01 a.m. MDT	915	302
C	March 26, 2021, 6:06 a.m. MDT	892	302
D	April 2, 2021, 6:30 a.m. MDT	869	303
E	April 5, 2021, 6:07 a.m. MDT	859	303
F	April 12, 2021, 11:33 a.m. MDT	848	303

The text of the initial survey invitation is included below, along with three of the six reminders (to illustrate their variations in wording).

Initial email invitation (sent March 16, 2021)

> Subject: Inviting you to participate in a NOAA-funded survey on tropical cyclone information (the Minding the Gap study)
>
> Dear {Firstname Lastname},
>
> We are writing to invite you to participate in a survey because of your role as a broadcast meteorologist within areas of the U.S. that may be affected by tropical cyclones. We are conducting this survey to evaluate your tropical cyclone forecast information needs as a key National Weather Service (NWS) partner, and to assess how well current NWS tropical cyclone forecast information and tools support your work. The survey is part of a study by the University of Washington (UW) and the National Center for Atmospheric Research (NCAR) with funding from the National Oceanic and Atmospheric Administration (NOAA).
>
> **Your participation in the survey will contribute to improving NWS tropical cyclone information and tools, to better support you and your colleagues in broadcast meteorology.** The survey takes about 10-20 minutes to complete.
>
> **To participate, please follow this link to the Survey:**
> Take the Survey
>
> Or copy and paste the URL below into your internet browser:

{individualized link}

Thank you kindly for your consideration, and we look forward to reading your responses to the survey!
If you have any questions about the study, please feel free to reach out to the lead investigators Ann Bostrom, Ph.D. at UW at abostrom@uw.edu or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

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Follow the link to opt out of future emails:
Click here to unsubscribe

Reminder A (sent March 19, 2021)

Subject: Inviting you to participate in a NOAA-funded survey on tropical cyclone information (the Minding the Gap study)

Hello {Firstname Lastname},

This is a reminder following up on an email we sent a few days ago inviting you to participate in a survey about your needs for tropical cyclone forecast information from the National Weather Service (NWS).

Your participation in the survey will contribute to improving NWS tropical cyclone information and tools to better support you and your colleagues in broadcast meteorology when preparing for and responding to tropical cyclone risks.

The survey is part of a study by the University of Washington (UW) and the National Center for Atmospheric Research (NCAR) being conducted with funding from the National Oceanic and Atmospheric Administration (NOAA). Please take a few minutes to help NOAA and the NWS make your job easier. The survey takes about 10 - 20 minutes to complete.

To participate, **please follow this link to the Survey**:
Take the Survey

Or copy and paste the URL below into your internet browser:
{individualized link}

Thank you kindly for your consideration, and we look forward to reading your responses to the survey!
If you have any questions about the study, please feel free to reach out to the lead investigators, Ann Bostrom, Ph.D. at UW at abostrom@uw.edu, or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

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Follow the link to opt out of future emails:
Click here to unsubscribe

Reminder B (sent March 23, 2021)

Subject: Your input will inform improvements in NOAA tropical cyclone information and tools

Hello {Firstname Lastname},

This is a reminder following up on an email we sent March 16th inviting you to participate in a survey about your needs for tropical cyclone forecast information from the National Weather Service (NWS).

Your participation in the survey will contribute to improving NWS tropical cyclone information and tools to better support you and your colleagues in broadcast meteorology when preparing for and responding to tropical cyclone risks.

The survey is part of a study by the University of Washington (UW) and the National Center for Atmospheric Research (NCAR) being conducted with funding from the National Oceanic and Atmospheric Administration (NOAA). Please take a few minutes to help NOAA and the NWS make your job easier. The survey takes about 10 - 20 minutes to complete.

To participate, **please follow this link to the Survey**:
Take the Survey

Or copy and paste the URL below into your internet browser:
{individualized link}

Thank you kindly for your consideration, and we look forward to reading your responses to the survey!

If you have any questions about the study, please feel free to reach out to the lead investigators, Ann Bostrom, Ph.D. at UW at abostrom@uw.edu, or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

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Follow the link to opt out of future emails:
Click here to unsubscribe

Reminder C (sent March 26, 2021)

Subject: Advise NOAA how to improve its tropical cyclone information and tools

Hello {Firstname Lastname},

This is a reminder following up on our email of March 16th inviting you to participate in a survey to inform NOAA about your needs for tropical cyclone forecast information from the National Weather Service (NWS).

Your participation in the survey will contribute to improving NWS tropical cyclone information and tools to better support you and your colleagues in broadcast meteorology when preparing for and responding to tropical cyclone risks.

The survey is part of a study by the University of Washington (UW) and the National Center for Atmospheric Research (NCAR), conducted with funding from the National Oceanic and Atmospheric Administration (NOAA). Please take a few minutes to help NOAA and the NWS make your job easier. The survey takes about 10 - 20 minutes to complete.

To participate, **please follow this link to the Survey**:
Take the Survey

Or copy and paste the URL below into your internet browser:
{individualized link}

Thank you kindly for your consideration! We look forward to reading your responses to the survey and sharing them with NOAA. If you have any questions about the study, please feel free to reach out to the lead investigators, Ann Bostrom, Ph.D. at UW at abostrom@uw.edu, or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

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Ann Bostrom, Ph.D.
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APPENDIX B. EMERGENCY MANAGER SURVEY INVITATIONS AND REMINDERS

This appendix presents the schedule and sample text for the email invitations and reminders sent to EMs requesting that they take the survey. The initial invitation was sent on May 6, 2021, to 1,752 EMs, and the schedule and distribution of subsequent reminders is provided in Table B-1.

Table B-1. Reminder schedule and distribution for emergency manager survey.

Reminder	Date sent	Emails sent	Emails failed	Emails bounced
A	May 10, 2021, 7:30 a.m. MDT	1,667	75	173
B	May 13, 2021, 10:58 a.m. MDT	1,572	75	172
C	May 20, 2021, 8:19 a.m. MDT	1,502	75	175
D	May 24, 2021, 7:37 a.m. MDT	1,464	75	176
E	May 26, 2021, 1:37 p.m. MDT	1,410	75	177

The text of the initial survey invitation is included below, along with two of the five reminders (to illustrate their variations in wording).

Initial email invitation (sent May 6, 2021)

> Subject: Advise NOAA on tropical cyclone information by taking the Minding the Gap survey
>
> Dear {FullName},
>
> Take this 12 minute survey for the Minding the Gap research project and you will help NOAA improve National Weather Service (NWS) tropical cyclone information products and services. The survey asks about your tropical cyclone forecast information needs to assess how well current NWS information and tools support your work as an emergency manager and key NWS partner.
>
> The Minding the Gap project is being conducted with funding from the National Oceanic and Atmospheric Administration (NOAA) by the National Center for Atmospheric Research (NCAR) and the University of Washington (UW).
>
> **To participate, please follow this link to the Survey:**
> Take the Survey
>
> Or copy and paste the URL below into your internet browser:
> {individualized link}
>
> Thank you kindly for your consideration, and we look forward to reading your responses to the survey!

If you have any questions about the study, please feel free to reach out to the lead investigators Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu **or** Ann Bostrom, Ph.D. at the UW at abostrom@uw.edu.

Research Team for "Minding the Gap: Modernizing the Tropical Cyclone Product Suite by Evaluating NWS Partner Information Needs"
National Center for Atmospheric Research (NCAR)
Rebecca Morss, Ph.D.
Julie Demuth, Ph.D.
Heather Lazrus, Ph.D.
Jamie Vickery, Ph.D.
University of Washington
Ann Bostrom, Ph.D.
Nick Hadjimichael, MPP

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Reminder A (sent May 10, 2021)

Subject: Your input will inform improvements in NWS tropical cyclone information and tools

Dear {FullName},

We are writing to invite you as an emergency manager and key National Weather Service partner to participate in a short (12 minute) survey about your needs for tropical cyclone forecast information from the National Weather Service (NWS). This is a follow up in case you missed our earlier email.

Your participation will contribute to improving NWS tropical cyclone information and tools.

The survey is part of a research study conducted by the National Center for Atmospheric Research (NCAR) and the University of Washington (UW) with funding from the National Oceanic and Atmospheric Administration (NOAA). Please take a few minutes to help NOAA and the NWS make your job easier.

To participate, **please follow this link to take the survey**:
Take the Survey

Or copy and paste the URL below into your internet browser:
{individualized link}

Thank you kindly for your consideration, and we look forward to reading your responses to the survey!

If you have any questions about the study, please feel free to reach out to the lead investigators, Ann Bostrom, Ph.D. at UW at abostrom@uw.edu, or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

Research Team for "Minding the Gap: Modernizing the Tropical Cyclone Product Suite by Evaluating NWS Partner Information Needs"

National Center for Atmospheric Research (NCAR)
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Reminder B (sent May 13, 2021)

Subject: Advise the National Weather Service how to improve tropical cyclone information

Dear {FullName},

Take a short survey and you will help the National Weather Service (NWS) better understand your needs for tropical cyclone forecast information. As an emergency manager you are a key NWS partner whose input NWS values.

Follow this link to the Survey:
Take the Survey
Or copy and paste the URL below into your internet browser:
{individualized link}

Your participation in the survey will contribute to improving NWS tropical cyclone information and tools. This is a follow up invitation to take the survey, in case you missed our earlier email.

The survey is part of the Minding the Gap study by the University of Washington (UW) and the National Center for Atmospheric Research (NCAR) being conducted with funding from the National Oceanic and Atmospheric Administration (NOAA). The survey takes about 12 minutes to complete.

Thank you kindly for your consideration, and we look forward to reading your responses to the survey!

If you have any questions about the study, please feel free to reach out to the lead investigators, Ann Bostrom, Ph.D. at UW at abostrom@uw.edu, or Rebecca Morss, Ph.D. at NCAR at morss@ucar.edu.

Research Team for "Minding the Gap: Modernizing the Tropical Cyclone Product Suite by Evaluating NWS Partner Information Needs"

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APPENDIX C. GIS METHODOLOGY FOR SURVEY SAMPLES

This appendix details the GIS data and methodology used by the UW team to create the samples for the broadcast meteorologist (BR) and emergency manager (EM) surveys described in sections 2.1.1 and 2.2.1, respectively. All GIS analyses were performed using Esri ArcGIS Pro.

GIS data used:

i. *County Warning Area (CWA) boundaries*: National Weather Service: County Warning Area Boundaries. Valid date 11/10/2020. Downloaded from: https://www.weather.gov/gis/CWABounds
ii. *State boundaries*: National Weather Service: U.S. States and Territories. Valid date 08/11/2016. Downloaded from: https://www.weather.gov/gis/USStates
iii. *Places within each state in the study area*: U.S. Census Bureau, Geography Division: 2019 Tiger/Line Shapefiles: Places. Downloaded from: https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2019&layergroup=Places
iv. *County boundaries*: National Weather Service National Operational Hydrologic Remote Sensing Center: U.S. County Boundaries. Last modified 10/02/2015. Downloaded from: https://www.nohrsc.noaa.gov/gisdatasets/

To create geospatial layers for the study area, we downloaded GIS data for CWA and state boundaries from the NWS GIS database (i, ii above) and loaded them into ArcGIS Pro. We then used the names of the WFO CWAs in the study area (Table 2.1) to create a new CWA layer containing only those CWAs in the study area. This study-area-CWA layer was then used to clip the state boundary layer to create a study-area-state layer, which includes partial and full areas of states in the study area. A layer with the full state boundaries of all states that are included (partially or fully) within the study area was also created for visualization purposes.

Geospatial analysis for the BR survey sampling involved filtering the list of BRs in the GMU sample (see section 2.1.1) to include only those whose locations (city and state) are in the study area. This included the following steps:

1. The table containing information for the national BR sample obtained from GMU was uploaded and exported into ArcGIS-compatible tables by state, which were indexed by city.
2. GIS data for places (cities, towns, etc.) within each state in the study area (iii above) were then brought in and clipped by the study-area-state layer, creating a layer of study-area-clipped places for each state in the study area.
3. The GMU sample table was joined to the study-area-clipped places layer for each state separately, as a first iteration of matching the cities of BRs in the sample table to cities within the study area. This was done for each state separately because multiple states could have a city with the same name. These tables were then exported to Microsoft Excel.
4. BRs with city names matching those in the places layer were included in the sample, along with BRs with a valid email address and no city/state information.
5. City names in the sample table that were not matched with the places layer were manually checked to see if they were in the study area (due, e.g., to a mismatched city name or the places layer not containing the city). If so, the corresponding BRs were

added into the sample.

6. All remaining BRs were excluded from the sample.

The resulting list of 985 individuals was then further cleaned, as discussed in section 2.1.1, to create the BR survey contact list.

Geospatial analysis for the EM survey sampling involved creating a list of states and counties in the study area, which was then used as a starting point for a manual search for EM contact information as described in section 2.2.1. To do so, GIS data for county boundaries (iv above) was brought into ArcGIS Pro and clipped by the study-area-state layer, creating a layer of study-area-clipped counties. Lists of states and counties were then exported to Microsoft Excel.[13]

[13] An error occurred in the creation of this list of counties, where counties that bordered the study area were added accidentally. Including these 90 additional counties in the list of counties used to build the EM contact list led to several respondents located outside the study area, as discussed in section 4.1.1.

APPENDIX D. BROADCAST METEOROLOGIST SURVEY QUESTIONS AND DESCRIPTIVE STATISTICS

This appendix provides, in Table D-1, the following for the broadcast meteorologist survey data set:

Column A: variable names and wording of the associated survey question
Column B: response options
Column C: descriptive statistics for data from the full broadcast meteorologist sample
Columns D, E: descriptive statistics for data from coastal (column D) and inland (column E) broadcast meteorologists, for selected variables

Percentages shown are out of the number of valid responses (N indicated) for that survey question / item, not including missing responses.

Table D-1. Broadcast meteorologist survey questions and descriptive statistics.

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Duration (in seconds)	None	mean=20126 sec, median=1301 sec, SD=89428 sec N=87		
Q1.3_station What station do you work for?		N=85		
Q1.4_stationzipcode My station's zip code is		N=85		
Q1.5_yearsmet How many years have you worked as a broadcast meteorologist?		mean=20.6, SD=12.5 N=87		
Q1.6_yearsmetcyclones How many years have you worked as a broadcast meteorologist in regions affected by tropical cyclones?		mean=17.7, SD=12.6 N=87		
Q1.7_1_sealsAMSCCM Which, if any, AMS and NWA Seals of Approval or certifications do you have? - AMS Certified Consulting Meteorologist	0 Missing - seen but unanswered multi-value 1 AMS Certified Consulting Meteorologist	1: 3.4% N=87		
Q1.7_6_sealsAMSCBM Which, if any, AMS and NWA Seals of Approval or certifications do you have? - AMS Certified Broadcast Meteorologist	0 Missing - seen but unanswered multi-value 1 AMS Certified Broadcast Meteorologist	1: 41.4% N=87		
Q1.7_2_sealsAMSapproval Which, if any, AMS and NWA Seals of Approval or certifications do you have? - AMS Seal of Approval	0 Missing - seen but unanswered multi-value 1 AMS Seal of Approval	1: 23% N=87		
Q1.7_3_sealsNWAapproval Which, if any, AMS and NWA Seals of Approval or certifications do you have? - NWA Seal of Approval	0 Missing - seen but unanswered multi-value 1 NWA Seal of Approval	1: 27.6% N=87		
Q1.7_4_sealsother Which, if any, AMS and NWA Seals of Approval or certifications do you have? - Other (please specify)	0 Missing - seen but unanswered multi-value 1 Other (please specify)	1: 0% N=87		
Q1.7_5_sealsnone Which, if any, AMS and NWA Seals of Approval or certifications do you have? - None of the above	0 Missing - seen but unanswered multi-value 1 None of the above	1: 31% N=87		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q1.7_4_TEXT_sealsother Which, if any, AMS and NWA Seals of Approval or certifications do you have? - Other (please specify) - Text		N=0		
Q1.8_jobtype Is your job in broadcast meteorology - Selected Choice	1 Part-time 2 Full-time 3 Internship 4 Other (please specify)	1: 2.3% 2: 96.6% 3: 0% 4: 1.1% N=87		
Q1.8_4_TEXT_jobtypeother Is your job in broadcast meteorology - Other (please specify) - Text		N=1		
Q1.9_1_chiefmet Which of these best describe(s) your current position? - Chief meteorologist	0 Missing - seen but unanswered multi-value 1 Chief meteorologist	1: 33.3% N=87		
Q1.9_2_primaryanchor Which of these best describe(s) your current position? - Primary weather anchor	0 Missing - seen but unanswered multi-value 1 Primary weather anchor	1: 11.5% N=87		
Q1.9_3_anchor Which of these best describe(s) your current position? - Weather anchor or meteorologist	0 Missing - seen but unanswered multi-value 1 Weather anchor or meteorologist	1: 56.3% N=87		
Q1.9_5_producer Which of these best describe(s) your current position? - Weather producer	0 Missing - seen but unanswered multi-value 1 Weather producer	1: 4.6% N=87		
Q1.9_6_reporter Which of these best describe(s) your current position? - Reporter	0 Missing - seen but unanswered multi-value 1 Reporter (including environmental reporter)	1: 5.7% N=87		
Q1.9_8_other Which of these best describe(s) your current position? - Other (specify)	0 Missing - seen but unanswered multi-value 1 Other (please specify)	1: 2.3% N=87		
Q1.9_8_TEXT_positionother Which of these best describe(s) your current position? - Other (specify) - Text		N=2		
Q1.10_1_roledevelopingforecasts When a tropical cyclone threatens, what are your major job roles? - Interpreting or developing forecasts	0 Missing - seen but unanswered multi-value 1 Interpreting or developing forecasts	1: 90.8% N=87		
Q1.10_2_rolemanagingstaff When a tropical cyclone threatens, what are your major job roles? - Supervising or managing staff	0 Missing - seen but unanswered multi-value 1 Supervising or managing staff	1: 31% N=87		
Q1.10_3_rolecommunicating When a tropical cyclone threatens, what are your major job roles? - Communicating on air	0 Missing - seen but unanswered multi-value 1 Communicating on air	1: 98.9% N=87		
Q1.10_4_rolesocialmedia When a tropical cyclone threatens, what are your major job roles? - Communicating on social media	0 Missing - seen but unanswered multi-value 1 Communicating on social media (from the station/weather team)	1: 95.4% N=87		
Q1.10_5_rolecontentdevelopment When a tropical cyclone threatens, what are your major job roles? - Developing content for, or pushing content to, apps or websites	0 Missing - seen but unanswered multi-value 1 Developing content for, or pushing content to, apps or websites	1: 85.1% N=87		
Q1.10_6_rolegraphics When a tropical cyclone threatens, what are your major job roles? - Developing forecast graphics	0 Missing - seen but unanswered multi-value 1 Developing forecast graphics	1: 94.3% N=87		
Q1.10_7_rolepartners When a tropical cyclone threatens, what are your major job roles? - Communicating with NWS and other (external) partners	0 Missing - seen but unanswered multi-value 1 Communicating with NWS and other (external) partners	1: 47.1% N=87		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q1.10_8_roleother When a tropical cyclone threatens, what are your major job roles? - Other (specify)	0 Missing - seen but unanswered multi-value 1 Other (please specify)	 1: 4.6% N=87		
Q1.10_8_TEXT_roleother When a tropical cyclone threatens, what are your major job roles? - Other (please specify) - Text		N=4		
Q2.2_Phase1_helpfulNWStools How helpful to you are the information and tools that NWS provides during this phase (more than five days before impacts)?	1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 36.8% 2: 40.2% 3: 16.1% 4: 4.6% 5: 2.3% mean=1.95, SD=0.96 N=87		
Q2.3_Phase1_firsttools In responding to the previous question, which information or tool(s) came to mind first?		N=78		
Q2.4_Phase1_additionalNWStools How helpful would it be to you if NWS provided additional information or tools during this phase (more than five days before impacts)?	1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 23% 2: 31% 3: 26.4% 4: 16.1% 5: 3.4% mean=2.46, SD=1.12 N=87		
Q2.5_Phase1_additionalNWStoolsdescription In responding to the previous question, what additional type(s) of information or tools came to mind first?		N=70		
Q2.6_1_Phase1_importancethreat How important do you think it is to communicate (more than five days before impacts)? - The importance of paying attention to the threat	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	 1: 66.3% 2: 22.1% 3: 9.3% 4: 2.3% 5: 0% mean=1.48, SD=0.76 N=86	 1: 64.4% 2: 25.4% 3: 10.2% 4: 0% 5: 0% mean=1.46, SD=0.68 N=59	 1: 70.4% 2: 14.8% 3: 7.4% 4: 7.4% 5: 0% mean=1.52, SD=0.94 N=27
Q2.6_2_Phase1_importancetiming How important do you think it is to communicate (more than five days before impacts)? - Forecasts of storm track and timing	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 32.2% 2: 31.0% 3: 28.7% 4: 8% 5: 0% mean=2.13, SD=0.96 N=87	1: 36.7% 2: 35.0% 3: 23.3% 4: 5% 5: 0% mean=1.97, SD=0.90 N=60	1: 22.2% 2: 22.2% 3: 40.7% 4: 14.8% 5: 0% mean=2.48, SD=1.01 N=27
Q2.6_3_Phase1_importanceintensity How important do you think it is to communicate (more than five days before impacts)? - Forecasts of storm intensity	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 18.4% 2: 27.6% 3: 41.4% 4: 10.3% 5: 2.3% mean=2.51, SD=0.99 N=87	1: 21.7% 2: 26.7% 3: 43.3% 4: 6.7% 5: 1.7% mean=2.4, SD=0.96 N=60	1: 11.1% 2: 29.6% 3: 37% 4: 18.5% 5: 3.7% mean=2.74, SD=1.02 N=27
Q2.6_4_Phase1_importanceimpacts How important do you think it is to communicate (more than five days before impacts)? - Forecasts of potential storm impacts	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 37.9% 2: 28.7% 3: 17.2% 4: 11.5% 5: 4.6% mean=2.16, SD=1.19 N=87	1: 40% 2: 28.3% 3: 16.7% 4: 11.7% 5: 3.3% mean=2.10, SD=1.16 N=60	1: 33.3% 2: 29.6% 3: 18.5% 4: 11.1% 5: 7.4% mean=2.30, SD=1.27 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q2.6_5_Phase1_importanceuncertainty How important do you think it is to communicate (more than five days before impacts)? - Forecast uncertainty	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 63.2% 2: 31.0% 3: 5.7% 4: 0% 5: 0% mean=1.43, SD=0.60 N=87	1: 66.7% 2: 28.3% 3: 5% 4: 0% 5: 0% mean=1.38, SD=0.59 N=60	1: 55.6% 2: 37% 3: 7.4% 4: 0% 5: 0% mean=1.52, SD=0.64 N=27
Q2.6_6_Phase1_importancechanges How important do you think it is to communicate (more than five days before impacts)? - Changes in forecasts since the last forecast	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 31.0% 2: 39.1% 3: 21.8% 4: 6.9% 5: 1.1% mean=2.08, SD=0.96 N=87	1: 30% 2: 41.7% 3: 21.7% 4: 6.7% 5: 0% mean=2.05, SD=0.89 N=60	1: 33.3% 2: 33.3% 3: 22.2% 4: 7.4% 5: 3.7% mean=2.15, SD=1.1 N=27
Q2.6_7_Phase1_importanceagreement How important do you think it is to communicate (more than five days before impacts)? - How forecasts agree/disagree	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 24.1% 2: 29.9% 3: 31.0% 4: 9.2% 5: 5.7% mean=2.43, SD=1.13 N=87	1: 20% 2: 35% 3: 31.7% 4: 10% 5: 3.3% mean=2.42, SD=1.03 N=60	1: 33.3% 2: 18.5% 3: 29.6% 4: 7.4% 5: 11.1% mean=2.44, SD=1.34 N=27
Q3.2_Phase2_helpfulNWStools How helpful to you are the forecast information and tools that NWS provides during this phase (approximately five days to 48 hours before impacts)?	1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 74.7% 2: 23.0% 3: 2.3% 4: 0% 5: 0% mean=1.28, SD=0.5 N=87		
Q3.3_Phase2_firsttools In responding to the previous question, which information or tool(s) came to mind first?		N=73		
Q3.4_Phase2_additionalNWStools How helpful would it be to you if NWS provided additional information or tools during this phase (approximately five days to 48 hours before impacts)?	1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 43.7% 2: 28.7% 3: 18.4% 4: 4.6% 5: 4.6% mean=1.98, SD=1.11 N=87		
Q3.5_Phase2_additionalNWStoolsdescription In responding to the previous question, what additional type(s) of information or tools came to mind first?		N=61		
Q3.6_1_Phase2_importancetrack How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of storm track	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 72.4% 2: 25.3% 3: 2.3% 4: 0% 5: 0% mean=1.3, SD=0.51 N=87	1: 68.3% 2: 28.3% 3: 3.3% 4: 0% 5: 0% mean=1.35, SD=0.55 N=60	1: 81.5% 2: 18.5% 3: 0% 4: 0% 5: 0% mean=1.19, SD=0.4 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q3.6_2_Phase2_importancetiming How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of timing of storm arrival	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 66.7% 2: 25.3% 3: 6.9% 4: 1.1% 5: 0% mean=1.43, SD=0.68 N=87	1: 66.7% 2: 28.3% 3: 5% 4: 0% 5: 0% mean=1.38, SD=0.59 N=60	1: 66.7% 2: 18.5% 3: 11.1 4: 3.7% 5: 0% mean=1.52, SD=0.85 N=27
Q3.6_3_Phase2_importanceintensity How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of storm intensity	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 52.9% 2: 32.2% 3: 12.6% 4: 2.3% 5: 0% mean=1.64, SD=0.79 N=87	1: 50% 2: 33.3% 3: 15% 4: 1.7% 5: 0% mean=1.68, SD=0.79 N=60	1: 59.3% 2: 29.6% 3: 7.4% 4: 3.7% 5: 0% mean=1.56, SD=0.80 N=27
Q3.6_4_Phase2_importancewindspeeds How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of storm wind speeds in different areas	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 48.3% 2: 29.9% 3: 13.8% 4: 4.6% 5: 3.4% mean=1.85, SD=1.05 N=87	1: 41.7% 2: 40% 3: 11.7% 4: 5% 5: 1.7% mean=1.85, SD=0.94 N=60	1: 63% 2: 7.4% 3: 18.5% 4: 3.7% 5: 7.4% mean=1.85, SD=1.29 N=27
Q3.6_5_Phase2_importancestormsize How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of storm size	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 33.3% 2: 26.4% 3: 29.9% 4: 9.2% 5: 1.1% mean=2.18, SD=1.04 N=87	1: 30% 2: 31.7% 3: 31.7% 4: 6.7% 5: 0% mean=2.15, SD=0.94 N=60	1: 40.7% 2: 14.8% 3: 25.9% 4: 14.8% 5: 3.7% mean=2.26, SD=1.26 N=27
Q3.7_1_Phase2_importancestormsurge How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of storm surge or coastal flooding	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 55.2% 2: 19.5% 3: 16.1% 4: 5.7% 5: 3.4% mean=1.83, SD=1.11 N=87	1: 61.7% 2: 20% 3: 15% 4: 3.3% 5: 0% mean=1.6, SD=0.87 N=60	1: 40.7% 2: 18.5% 3: 18.5% 4: 11.1% 5: 11.1% mean=2.33, SD=1.41 N=27
Q3.7_2_Phase2_importancerainfall How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of flooding from rainfall	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 59.8% 2: 25.3% 3: 9.2% 4: 5.7% 5: 0% mean=1.61, SD=0.88 N=87	1: 55% 2: 26.7% 3: 13.3% 4: 5% 5: 0% mean=1.68, SD=0.89 N=60	1: 70.4% 2: 22.2% 3: 0% 4: 7.4% 5: 0% mean=1.44, SD=0.85 N=27
Q3.7_3_Phase2_importancetornadoes How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of tornadoes	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 34.5% 2: 27.6% 3: 26.4% 4: 9.2% 5: 2.3% mean=2.17, SD=1.08 N=87	1: 30% 2: 31.7% 3: 26.7% 4: 10% 5: 1.7% mean=2.22, SD=1.04 N=60	1: 44.4% 2: 18.5% 3: 25.9% 4: 7.4% 5: 3.7% mean=2.07, SD=1.17 N=27
Q3.7_4_Phase2_importanceimpacts How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecasts of potential storm impacts	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 64.4% 2: 23.0% 3: 11.5% 4: 1.1% 5: 0% mean=1.49, SD=0.75 N=87	1: 70% 2: 20% 3: 10% 4: 0% 5: 0% mean=1.4, SD=0.67 N=60	1: 51.9% 2: 29.6% 3: 14.8% 4: 3.7% 5: 0% mean=1.7, SD=0.87 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q3.8_1_Phase2_importanceuncertainty How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Forecast uncertainty	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 52.9% 2: 32.2% 3: 13.8% 4: 1.1% 5: 0% mean=1.63, SD=0.76 N=87	1: 55% 2: 33.3% 3: 10% 4: 1.7% 5: 0% mean=1.58, SD=0.74 N=60	1: 48.1% 2: 29.6% 3: 22.2% 4: 0% 5: 0% mean=1.74, SD=0.81 N=27
Q3.8_2_Phase2_importancechanges How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Changes in forecasts since the last forecast	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 41.4% 2: 39.1% 3: 18.4% 4: 1.1% 5: 0% mean=1.79, SD=0.78 N=87	1: 43.3% 2: 36.7% 3: 18.3% 4: 1.7% 5: 0% mean=1.78, SD=0.80 N=60	1: 37% 2: 44.4% 3: 18.5% 4: 0% 5: 0% mean=1.81, SD=0.74 N=27
Q3.8_3_Phase2_importanceagreement How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - How forecasts agree/disagree	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 27.6% 2: 26.4% 3: 29.9% 4: 11.5% 5: 4.6% mean=2.39, SD=1.15 N=87	1: 26.7% 2: 35% 3: 28.3% 4: 6.7% 5: 3.3% mean=2.25, SD=1.04 N=60	1: 29.6% 2: 7.4% 3: 33.3% 4: 22.2% 5: 7.4% mean=2.7, SD=1.33 N=27
Q3.8_4_Phase2_importancesatobservations How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Satellite observations	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 26.4% 2: 32.2% 3: 28.7% 4: 10.3% 5: 2.3% mean=2.3, SD=1.05 N=87	1: 23.3% 2: 35% 3: 26.7% 4: 11.7% 5: 3.3% mean=2.37, SD=1.07 N=60	1: 33.3% 2: 25.9% 3: 33.3% 4: 7.4% 5: 0% mean=2.15, SD=0.99 N=27
Q3.9_1_Phase2_importanceattentiontothreat How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - The importance of paying attention to the threat	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 70.9% 2: 20.9% 3: 8.1% 4: 0% 5: 0% mean=1.37, SD=0.63 N=86	1: 72.9% 2: 22% 3: 5.1% 4: 0% 5: 0% mean=1.32, SD=0.57 N=59	1: 66.7% 2: 18.5% 3: 14.8% 4: 0% 5: 0% mean=1.48, SD=0.75 N=27
Q3.9_2_Phase2_importancehowtoprotect How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - How to protect oneself (where to evacuate to, how to evacuate, etc)	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 52.9% 2: 27.6% 3: 12.6% 4: 5.7% 5: 1.1% mean=1.75, SD=0.97 N=87	1: 58.3% 2: 26.7% 3: 13.3% 4: 1.7% 5: 0% mean=1.58, SD=0.79 N=60	1: 40.7% 2: 29.6% 3: 11.1% 4: 14.8% 5: 3.7% mean=2.11, SD=1.22 N=27
Q3.9_3_Phase2_importancehowtoprepare How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - How to prepare (get emergency supplies, prepare your home, etc)	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 52.3% 2: 27.9% 3: 12.8% 4: 7.0% 5: 0% mean=1.74, SD=0.94 N=86	1: 58.3% 2: 28.3% 3: 11.7% 4: 1.7% 5: 0% mean=1.57, SD=0.77 N=60	1: 38.5% 2: 26.9% 3: 15.4% 4: 19.2% 5: 0% mean=2.15, SD=1.16 N=26

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q3.9_4_Phase2_importancehowtorespond How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - How to respond after the storm impacts your area	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 26.4% 2: 31.0% 3: 28.7% 4: 8.0% 5: 5.7% mean=2.36, SD=1.13 N=87	1: 28.3% 2: 33.3% 3: 28.3% 4: 6.7% 5: 3.3% mean=2.23, SD=1.05 N=60	1: 22.2% 2: 25.9% 3: 29.6% 4: 11.1% 5: 11.1% mean=2.63, SD=1.28 N=27
Q3.9_5_Phase2_importanceother How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Other (please specify)	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 50% 2: 50% 3: 0% 4: 0% 5: 0% mean=1.5, SD=0.58 N=4		
Q3.9_5_TEXT_Phase2_importanceother How important do you think it is to communicate (approximately five days to 48 hours before impacts)? - Other (please specify) - Text		N=4		
Q4.2_Phase3_helpfulNWStools How helpful to you in your job are the forecast information and tools that NWS provides during this phase (48 hours through impacts)?	1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 85.1% 2: 12.6% 3: 0% 4: 0% 5: 2.3% mean=1.22, SD=0.67 N=87		
Q4.3_Phase3_firsttools In responding to the previous question, which information or tool(s) came to mind first?		N=68		
Q4.4_Phase3_additionalNWStools How helpful would it be to you if NWS provided additional information or tools during this phase (48 hours through impacts)?	[-99 Missing - seen but unanswered] 1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 50% 2: 31.4% 3: 5.8% 4: 4.7% 5: 8.1% mean=1.9, SD=1.22 N=86		
Q4.5_Phase3_additionalNWStoolsdescription In responding to the previous question, what additional type(s) of information or tools came to mind first?		N=53		
Q4.6_1_Phase3_importancetrack How important do you think it is to communicate (48 hours through impacts)? - Forecasts of storm track	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 72.4% 2: 18.4% 3: 8.0% 4: 1.1% 5: 0% mean=1.38, SD=0.69 N=87	1: 68.3% 2: 21.7% 3: 8.3% 4: 1.7% 5: 0% mean=1.43, SD=0.72 N=60	1: 81.5% 2: 11.1% 3: 7.4% 4: 0% 5: 0% mean=1.26, SD=0.60 N=27
Q4.6_2_Phase3_importancetiming How important do you think it is to communicate (48 hours through impacts)? - Forecasts of timing of storm arrival	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 92.0% 2: 4.6% 3: 2.3% 4: 0% 5: 1.1% mean=1.14, SD=0.55 N=87	1: 90% 2: 6.7% 3: 3.3% 4: 0% 5: 0% mean=1.13, SD=0.43 N=60	1: 96.3% 2: 0% 3: 0% 4: 0% 5: 3.7% mean=1.15, SD=0.77 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q4.6_3_Phase3_importanceintensity How important do you think it is to communicate (48 hours through impacts)? - Forecasts of storm intensity	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 79.3% 2: 14.9% 3: 4.6% 4: 1.1% 5: 0% mean=1.28, SD=0.60 N=87	1: 78.3% 2: 18.3% 3: 3.3% 4: 0% 5: 0% mean=1.25, SD=0.51 N=60	1: 81.5% 2: 7.4% 3: 7.4% 4: 3.7% 5: 0% mean=1.33, SD=0.78 N=27
Q4.6_4_Phase3_importancewindspeeds How important do you think it is to communicate (48 hours through impacts)? - Forecasts of storm wind speeds in different areas	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 86.2% 2: 11.5% 3: 2.3% 4: 0% 5: 0% mean=1.16, SD=0.43 N=87	1: 88.3% 2: 11.7% 3: 0% 4: 0% 5: 0% mean=1.12, SD=0.32 N=60	1: 81.5% 2: 11.1% 3: 7.4% 4: 0% 5: 0% mean=1.26, SD=0.59 N=27
Q4.6_5_Phase3_importancestormsize How important do you think it is to communicate (48 hours through impacts)? - Forecasts of storm size	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 41.4% 2: 31.0% 3: 17.2% 4: 9.2% 5: 1.1% mean=1.98, SD=1.03 N=87	1: 41.7% 2: 35% 3: 18.3% 4: 5% 5: 0% mean=1.87, SD=0.89 N=60	1: 40.7% 2: 22.2% 3: 14.8% 4: 18.5% 5: 3.7% mean=2.22, SD=1.28 N=27
Q4.7_1_Phase3_importancestormsurge How important do you think it is to communicate (48 hours through impacts)? - Forecasts of storm surge or coastal flooding	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 85.1% 2: 6.9% 3: 1.1% 4: 3.4% 5: 3.4% mean=1.33, SD=0.94 N=87	1: 91.7% 2: 8.3% 3: 0% 4: 0% 5: 0% mean=1.08, SD=0.28 N=60	1: 70.4% 2: 3.7% 3: 3.7% 4: 11.1% 5: 11.1% mean=1.89, SD=1.50 N=27
Q4.7_2_Phase3_importancerainfall How important do you think it is to communicate (48 hours through impacts)? - Forecasts of flooding from rainfall	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 90.7% 2: 8.1% 3: 0% 4: 1.2% 5: 0% mean=1.12, SD=0.42 N=86	1: 86.4% 2: 11.9% 3: 0% 4: 1.7% 5: 0% mean=1.17, SD=0.50 N=59	1: 100% 2: 0% 3: 0% 4: 0% 5: 0% mean=1.00, SD=0.00 N=27
Q4.7_3_Phase3_importancetornadoes How important do you think it is to communicate (48 hours through impacts)? - Forecasts of tornadoes	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 70.1% 2: 23.0% 3: 5.7% 4: 1.1% 5: 0% mean=1.38, SD=0.65 N=87	1: 70% 2: 25% 3: 5% 4: 0% 5: 0% mean=1.35, SD=0.58 N=60	1: 70.4% 2: 18.5% 3: 7.4% 4: 3.7% 5: 0% mean=1.44, SD=0.80 N=27
Q4.7_4_Phase3_importanceimpacts How important do you think it is to communicate (48 hours through impacts)? - Forecasts of potential storm impacts	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 82.8% 2: 16.1% 3: 1.1% 4: 0% 5: 0% mean=1.18, SD=0.42 N=87	1: 88.3% 2: 11.7% 3: 0% 4: 0% 5: 0% mean=1.12, SD=0.32 N=60	1: 70.4% 2: 25.9% 3: 3.7% 4: 0% 5: 0% mean=1.33, SD=0.56 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q4.8_1_Phase3_importanceuncertainty How important do you think it is to communicate (48 hours through impacts)? - Forecast uncertainty	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 46.0% 2: 28.7% 3: 14.9% 4: 10.3% 5: 0% mean=1.90, SD=1.01 N=87	1: 45% 2: 33.3% 3: 13.3% 4: 8.3% 5: 0% mean=1.85, SD=0.95 N=60	1: 48.1% 2: 18.5% 3: 18.5% 4: 14.8% 5: 0% mean=2.00, SD=1.14 N=27
Q4.8_2_Phase3_importancechanges How important do you think it is to communicate (48 hours through impacts)? - Changes in forecasts since the last forecast	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 45.3% 2: 34.9% 3: 10.5% 4: 7.0% 5: 2.3% mean=1.86, SD=1.02 N=86	1: 47.5% 2: 37.3% 3: 6.8% 4: 6.8% 5: 1.7% mean=1.78, SD=0.97 N=59	1: 40.7% 2: 29.6% 3: 18.5% 4: 7.4% 5: 3.7% mean=2.04, SD=1.13 N=27
Q4.8_3_Phase3_importanceagreement How important do you think it is to communicate (48 hours through impacts)? - How forecasts agree/disagree	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 23.0% 2: 27.6% 3: 24.1% 4: 20.7% 5: 4.6% mean=2.56, SD=1.19 N=87	1: 21.7% 2: 33.3% 3: 26.7% 4: 15% 5: 3.3% mean=2.45, SD=1.1 N=60	1: 25.9% 2: 14.8% 3: 18.5% 4: 33.3% 5: 7.4% mean=2.81, SD=1.36 N=27
Q4.8_4_Phase3_importancesatobservations How important do you think it is to communicate (48 hours through impacts)? - Satellite observations	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 38.4% 2: 27.9% 3: 20.9% 4: 11.6% 5: 1.2% mean=2.09, SD=1.08 N=86	1: 40% 2: 28.3% 3: 18.3% 4: 11.7% 5: 1.7% mean=2.07, SD=1.1 N=60	1: 34.6% 2: 26.9% 3: 26.9% 4: 11.5% 5: 0% mean=2.15, SD=1.05 N=26
Q4.9_1_Phase3_importanceattentiontothreat How important do you think it is to communicate (48 hours through impacts)? - Importance of paying attention to the threat	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 85.1% 2: 10.3% 3: 4.6% 4: 0% 5: 0% mean=1.20, SD=0.50 N=87	1: 90% 2: 6.7% 3: 3.3% 4: 0% 5: 0% mean=1.13, SD=0.43 N=60	1: 74.1% 2: 18.5% 3: 7.4% 4: 0% 5: 0% mean=1.33, SD=0.62 N=27
Q4.9_2_Phase3_importancehowtoprotect How important do you think it is to communicate (48 hours through impacts)? How to protect oneself	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 77% 2: 19.5% 3: 2.3% 4: 1.1% 5: 0% mean=1.28, SD=0.56 N=87	1: 83.3% 2: 16.7% 3: 0% 4: 0% 5: 0% mean=1.17, SD=0.38 N=60	1: 63% 2: 25.9% 3: 7.4% 4: 3.7% 5: 0% mean=1.52, SD=0.80 N=27
Q4.9_3_Phase3_importancehowtoprepare How important do you think it is to communicate (48 hours through impacts)? How to prepare	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 56.3% 2: 24.1% 3: 16.1% 4: 2.3% 5: 1.1% mean=1.68, SD=0.91 N=87	1: 63.3% 2: 23.3% 3: 11.7% 4: 1.7% 5: 0% mean=1.52, SD=0.77 N=60	1: 40.7% 2: 25.9% 3: 25.9% 4: 3.7% 5: 3.7% mean=2.04, SD=1.09 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q4.9_4_Phase3_importancehowtorespond How important do you think it is to communicate (48 hours through impacts)? How to respond after the storm impacts your area	1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 48.3% 2: 28.7% 3: 18.4% 4: 4.6% 5: 0% mean=1.79, SD=0.90 N=87	1: 48.3% 2: 31.7% 3: 16.7% 4: 3.3% 5: 0% mean=1.75, SD=0.86 N=60	1: 48.1% 2: 22.2% 3: 22.2% 4: 7.4% 5: 0% mean=1.89, SD=1.01 N=27
Q4.9_5_Phase3_importanceother How important do you think it is to communicate (48 hours through impacts)? - Other (specify)	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 50% 2: 25% 3: 25% 4: 0% 5: 0% mean=1.75, SD=0.96 N=4		
Q4.9_5_TEXT_Phase3_importanceother How important do you think it is to communicate (48 hours through impacts)? - Other (specify) - Text		N=3		
Q5.2_1_1_Comm_TV_Phase1 When do you use the following to communicate about a tropical cyclone threat? - On-air (television) Use in Phase I (more than five days before a storm impacts your area)	0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 90.8% N=87		
Q5.2_1_2_Comm_TV_Phase2 When do you use the following to communicate about a tropical cyclone threat? - On-air (television) Use in Phase II (five days to 48 hours before a storm impacts your area)	0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 93.1% N=87		
Q5.2_1_3_Comm_TV_Phase3 When do you use the following to communicate about a tropical cyclone threat? - On-air (television) Use in Phase III (48 hours through impacts)	0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 93.1% N=87		
Q5.2_1_4_Comm_TV_Donotuse When do you use the following to communicate about a tropical cyclone threat? - On-air (television) Do not use	0 Missing - seen but unanswered multi-value 1 Do not use	1: 1.1% N=87		
Q5.2_2_1_Comm_website_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Station	0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 83.9% N=87		
Q5.2_2_2_Comm_website_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Station	0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 90.8% N=87		
Q5.2_2_3_Comm_website_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Station	0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 94.3% N=87		
Q5.2_2_4_Comm_website_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Station	0 Missing - seen but unanswered multi-value 1 Do not use	1: 0% N=87		
Q5.2_3_1_Comm_socialmedia_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Social media Use in Phase I (more than five days before a storm impacts your area)	0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 86.2% N=87		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.2_3_2_Comm_socialmedia_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Social media Use in Phase II (five days to 48 hours before a storm impacts your area)	0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 93.1% N=87		
Q5.2_3_3_Comm_socialmedia_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Social media Use in Phase III (more than five days before a storm impacts your area)	0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 94.3% N=87		
Q5.2_3_4_Comm_socialmedia_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Social media Do not use	0 Missing - seen but unanswered multi-value 1 Do not use	1: 0% N=87		
Q5.2_4_1_Comm_radio_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Radio Use in Phase I (more than five days before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 23.8% N=84		
Q5.2_4_2_Comm_radio_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Radio Use in Phase II (five days to 48 hours before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 52.4% N=84		
Q5.2_4_3_Comm_radio_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Radio Use in Phase III (48 hours through impacts)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 65.5% N=84		
Q5.2_4_4_Comm_radio_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Radio Do not use	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Do not use	1: 28.6% N=84		
Q5.2_5_1_Comm_newspaper_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Newspaper Use in Phase I (more than five days before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 13.0% N=77		
Q5.2_5_2_Comm_newspaper_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Newspaper Use in Phase II (five days to 48 hours before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 18.2% N=77		
Q5.2_5_3_Comm_newspaper_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Newspaper Use in Phase III (48 hours through impacts)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 18.2% N=77		
Q5.2_5_4_Comm_newspaper_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Newspaper Do not use	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Do not use	1: 77.9% N=77		
Q5.2_6_1_Comm_events_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Community events Use in Phase I (more than five days before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 18.9% N=74		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.2_6_2_Comm_events_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Community events Use in Phase II (five days to 48 hours before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 16.2% N=74		
Q5.2_6_3_Comm_events_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Community events Use in Phase III (48 hours through impacts)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 9.5% N=74		
Q5.2_6_4_Comm_events_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Community events Do not use	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Do not use	1: 74.3% N=74		
Q5.2_7_1_Comm_other_Phase1 When do you use the following to communicate about a tropical cyclone threat? - Other (specify) Use in Phase I (more than five days before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase I (more than five days before a storm impacts your area)	1: 66.7% N=6		
Q5.2_7_2_Comm_other_Phase2 When do you use the following to communicate about a tropical cyclone threat? - Other (specify) Use in Phase II (five days to 48 hours before a storm impacts your area)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase II (five days to 48 hours before a storm impacts your area)	1: 66.7% N=6		
Q5.2_7_3_Comm_other_Phase3 When do you use the following to communicate about a tropical cyclone threat? - Other (specify) Use in Phase III (48 hours through impacts)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Use in Phase III (48 hours through impacts)	1: 66.7% N=6		
Q5.2_7_4_Comm_other_Donotuse When do you use the following to communicate about a tropical cyclone threat? - Other (specify) Do not use	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Do not use	1: 16.7% N=6		
Q5.2_7_TEXT_Comm_other When do you use the following to communicate about a tropical cyclone threat? - Other (specify) - Text		N=5		
Q5.3_1_Useful_cone How useful to you are - Track Forecast Cone (Cone of Uncertainty)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 80.2% 2: 16.3% 3: 2.3% 4: 1.2% 5: 0% mean=1.24, SD=0.55 N=86	1: 79.7% 2: 16.9% 3: 1.7% 4: 1.7% 5: 0% mean=1.25, SD=0.58 N=59	1: 81.5% 2: 14.8% 3: 3.7% 4: 0% 5: 0% mean=1.22, SD=0.51 N=27
Q5.3_2_Useful_wxoutlook How useful to you are - 5-day Graphical Tropical Weather Outlook	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 57.5% 2: 28.7% 3: 13.8% 4: 0% 5: 0% mean=1.56, SD=0.73 N=87	1: 58.3% 2: 30% 3: 11.7% 4: 0% 5: 0% mean=1.53, SD=0.70 N=60	1: 55.6% 2: 25.9% 3: 18.5% 4: 0% 5: 0% mean=1.63, SD=0.79 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.3_3_Useful_advisories How useful to you are - NHC Public or Forecast Advisories	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 64.4% 2: 29.9% 3: 2.3% 4: 3.4% 5: 0% mean=1.45, SD=0.71 N=87	1: 65% 2: 31.7% 3: 0% 4: 3.3% 5: 0% mean=1.42, SD=0.67 N=60	1: 63% 2: 25.9% 3: 7.4% 4: 3.7% 5: 0% mean=1.52, SD=0.80 N=27
Q5.3_4_Useful_localstmt How useful to you are - Hurricane Local Statement	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 60.5% 2: 19.8% 3: 12.8% 4: 5.8% 5: 1.2% mean=1.67, SD=0.99 N=86	1: 65% 2: 18.3% 3: 10% 4: 6.7% 5: 0% mean=1.58, SD=0.93 N=60	1: 50% 2: 23.1% 3: 19.2% 4: 3.8% 5: 3.8% mean=1.88, SD=1.11 N=26
Q5.4_1_Useful_probabilities How useful to you are - Tropical Cyclone Wind Speed Probabilities	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 41.4% 2: 33.3% 3: 21.8% 4: 3.4% 5: 0% mean=1.87, SD=0.87 N=87	1: 40% 2: 30% 3: 25% 4: 5% 5: 0% mean=1.95, SD=0.93 N=60	1: 44.4% 2: 40.7% 3: 14.8% 4: 0% 5: 0% mean=1.7, SD=0.72 N=27
Q5.4_2_Useful_hurrwatchwarn How useful to you are - Tropical Storm or Hurricane Watch/Warning	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 52.9% 2: 29.9% 3: 14.9% 4: 2.3% 5: 0% mean=1.67, SD=0.82 N=87	1: 46.7% 2: 38.3% 3: 15% 4: 0% 5: 0% mean=1.68, SD=0.73 N=60	1: 66.7% 2: 11.1% 3: 14.8% 4: 7.4% 5: 0% mean=1.63, SD=1.01 N=27
Q5.4_3_Useful_floodingmap How useful to you are - Potential Storm Surge Flooding Map	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 73.6% 2: 14.9% 3: 3.4% 4: 4.6% 5: 3.4% mean=1.49, SD=1.01 N=87	1: 78.3% 2: 16.7% 3: 3.3% 4: 1.7% 5: 0% mean=1.28, SD=0.61 N=60	1: 63% 2: 11.1% 3: 3.7% 4: 11.1% 5: 11.1% mean=1.96, SD=1.48 N=27
Q5.4_4_Useful_surgewatchwarn How useful to you are - Storm Surge Watch/Warning	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.0% 2: 23.0% 3: 14.9% 4: 4.6% 5: 3.4% mean=1.80, SD=1.07 N=87	1: 58.3% 2: 25% 3: 16.7% 4: 0% 5: 0% mean=1.58, SD=0.77 N=60	1: 44.4% 2: 18.5% 3: 11.1% 4: 14.8% 5: 11.1% mean=2.30, SD=1.46 N=27
Q5.4_5_Useful_windarrivaltime How useful to you are - Arrival Time of Tropical Storm-Force Winds	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.0% 2: 35.6% 3: 8.0% 4: 2.3% 5: 0% mean=1.59, SD=0.74 N=87	1: 53.3% 2: 38.3% 3: 8.3% 4: 0% 5: 0% mean=1.55, SD=0.65 N=60	1: 55.6% 2: 29.6% 3: 7.4% 4: 7.4% 5: 0% mean=1.67, SD=0.92 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.5_1_Useful_impactsgraphics How useful to you are - Hurricane Threats and Impacts Graphics	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 71.3% 2: 23% 3: 4.6% 4: 1.1% 5: 0% mean=1.36, SD=0.63 N=87	1: 73.3% 2: 20% 3: 6.7% 4: 0% 5: 0% mean=1.33, SD=0.60 N=60	1: 66.7% 2: 29.6% 3: 0% 4: 3.7% 5: 0% mean=1.41, SD=0.69 N=27
Q5.5_2_Useful_rainfalloutlooks How useful to you are - Rainfall outlooks or forecasts	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 60.9% 2: 32.2% 3: 6.9% 4: 0% 5: 0% mean=1.46, SD=0.63 N=87	1: 55% 2: 36.7% 3: 8.3% 4: 0% 5: 0% mean=1.53, SD=0.65 N=60	1: 74.1% 2: 22.2% 3: 3.7% 4: 0% 5: 0% mean=1.3, SD=0.54 N=27
Q5.5_3_Useful_riverstageforecasts How useful to you are - River stage forecasts (hydrographs)	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 32.2% 2: 44.8% 3: 18.4% 4: 3.4% 5: 1.1% mean=1.97, SD=0.87 N=87	1: 31.7% 2: 48.3% 3: 15% 4: 3.3% 5: 1.7% mean=1.95, SD=0.87 N=60	1: 33.3% 2: 37% 3: 25.9% 4: 3.7% 5: 0% mean=2.00, SD=0.88 N=27
Q5.5_4_Useful_convectiveoutlook How useful to you are - SPC Convective Outlook	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 44.8% 2: 28.7% 3: 23% 4: 3.4% 5: 0% mean=1.85, SD=0.90 N=87	1: 36.7% 2: 30% 3: 28.3% 4: 5% 5: 0% mean=2.02, SD=0.93 N=60	1: 63% 2: 25.9% 3: 11.1% 4: 0% 5: 0% mean=1.48, SD=0.70 N=27
Q5.5_5_Useful_nhckeymessages How useful to you are - NHC Key Messages	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 62.1% 2: 18.4% 3: 13.8% 4: 5.7% 5: 0% mean=1.63, SD=0.93 N=87	1: 70% 2: 15% 3: 10% 4: 5% 5: 0% mean=1.50, SD=0.87 N=60	1: 44.4% 2: 25.9% 3: 22.2% 4: 7.4% 5: 0% mean=1.93, SD=1.00 N=27
Q5.6_1_Useful_deterministicguidance How useful to you are - Operational weather prediction models - single-model deterministic guidance (e.g., GFS, HWRF, Canadian, or European)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 48.8% 2: 32.6% 3: 16.3% 4: 2.3% 5: 0% mean=1.72, SD=0.83 N=43	1: 56.7% 2: 23.3% 3: 16.7% 4: 3.3% 5: 0% mean=1.67, SD=0.88 N=30	1: 30.8% 2: 53.8% 3: 15.4% 4: 0% 5: 0% mean=1.85, SD=0.69 N=13
Q5.6_2_Useful_ensembleguidance How useful to you are - Operational weather prediction models - single-model ensemble guidance (e.g., GEFS)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 41.9% 2: 41.9% 3: 14.0% 4: 2.3% 5: 0% mean=1.77, SD=0.78 N=43	1: 40% 2: 43.3% 3: 13.3% 4: 3.3% 5: 0% mean=1.80, SD=0.81 N=30	1: 46.2% 2: 38.5% 3: 15.4% 4: 0% 5: 0% mean=1.69, SD=0.75 N=13

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.6_3_Useful_multimodelguidance How useful to you are - Operational weather prediction models - multi-model guidance (e.g., multi-model spaghetti plots)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	 1: 62.8% 2: 27.9% 3: 7.0% 4: 2.3% 5: 0% mean=1.49, SD=0.74 N=43	 1: 63.3% 2: 26.7% 3: 10% 4: 0% 5: 0% mean=1.47, SD=0.68 N=30	 1: 61.5% 2: 30.8% 3: 0% 4: 7.7% 5: 0% mean=1.54, SD=0.88 N=13
Q5.6_4_Useful_inhousemodels How useful to you are - In-house weather prediction models	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	 1: 34.9% 2: 37.2% 3: 20.9% 4: 4.7% 5: 2.3% mean=2.02, SD=0.99 N=43	 1: 40% 2: 30% 3: 20% 4: 6.7% 5: 3.3% mean=2.03, SD=1.10 N=30	 1: 23.1% 2: 53.8% 3: 23.1% 4: 0% 5: 0% mean=2.00, SD=0.70 N=13
Q5.7_1_Useful_workplacediscussions How useful to you are - Discussions with other broadcast meteorologists in your workplace	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	 1: 61.9% 2: 23.8% 3: 14.3% 4: 0% 5: 0% mean=1.52, SD=0.74 N=42	 1: 65.5% 2: 20.7% 3: 13.8% 4: 0% 5: 0% mean=1.48, SD=0.74 N=29	 1: 53.8% 2: 30.8% 3: 15.4% 4: 0% 5: 0% mean=1.62, SD=0.77 N=13
Q5.7_2_Useful_satobservations How useful to you are - Satellite observations	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 51.2% 2: 27.9% 3: 16.3% 4: 4.7% 5: 0% mean=1.74, SD=0.90 N=43	1: 44.8% 2: 34.5% 3: 17.2% 4: 3.4% 5: 0% mean=1.79, SD=0.86 N=29	1: 64.3% 2: 14.3% 3: 14.3% 4: 7.1% 5: 0% mean=1.64, SD=1.01 N=14
Q5.7_3_Useful_radarobservations How useful to you are - Radar observations	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 72.1% 2: 20.9% 3: 7.0% 4: 0% 5: 0% mean=1.35, SD=0.61 N=43	1: 69% 2: 24.1% 3: 6.9% 4: 0% 5: 0% mean=1.38, SD=0.62 N=29	1: 78.6% 2: 14.3% 3: 7.1% 4: 0% 5: 0% mean=1.29, SD=0.61 N=14
Q5.7_4_Useful_hurrhunterobservations How useful to you are - Hurricane Hunter observations	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 67.4% 2: 23.3% 3: 7.0% 4: 2.3% 5: 0% mean=1.44, SD=0.73 N=43	1: 72.4% 2: 17.2% 3: 6.9% 4: 3.4% 5: 0% mean=1.41, SD=0.78 N=29	1: 57.1% 2: 35.7% 3: 7.1% 4: 0% 5: 0% mean=1.50, SD=0.65 N=14
Q5.8_1_Useful_NWSbriefings How useful to you are - NWS briefings or conference calls	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	 1: 39.5% 2: 23.3% 3: 22.1% 4: 12.8% 5: 2.3% mean=2.15, SD=1.15 N=86	 1: 35.6% 2: 27.1% 3: 23.7% 4: 10.2% 5: 3.4% mean=2.19, SD=1.14 N=59	 1: 48.1% 2: 14.8% 3: 18.5% 4: 18.5% 5: 0% mean=2.07, SD=1.21 N=27

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.8_2_Useful_NWSChat How useful to you are - NWSChat	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 67.4% 2: 17.4% 3: 7.0% 4: 5.8% 5: 2.3% mean=1.58, SD=1.01 N=86	1: 63.3% 2: 18.3% 3: 8.3% 4: 8.3% 5: 1.7% mean=1.67, SD=1.05 N=60	1: 76.9% 2: 15.4% 3: 3.8% 4: 0% 5: 3.8% mean=1.38, SD=0.90 N=26
Q5.8_3_Useful_NWSforecastdiscussion How useful to you are - NWS local office Forecast Discussion	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 61.6% 2: 27.9% 3: 8.1% 4: 1.2% 5: 1.2% mean=1.52, SD=0.79 N=86	1: 55% 2: 31.7% 3: 10% 4: 1.7% 5: 1.7% mean=1.63, SD=0.86 N=60	1: 76.9% 2: 19.2% 3: 3.8% 4: 0% 5: 0% mean=1.27, SD=0.53 N=26
Q5.8_4_Useful_NHCforecastdiscussion How useful to you are - NHC Forecast Discussion	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 71.3% 2: 23% 3: 3.4% 4: 2.3% 5: 0% mean=1.37, SD=0.67 N=87	1: 71.7% 2: 26.7% 3: 1.7% 4: 0% 5: 0% mean=1.30, SD=0.50 N=60	1: 70.4% 2: 14.8% 3: 7.4% 4: 7.4% 5: 0% mean=1.52, SD=0.94 N=27
Q5.8_5_Useful_Other How useful to you are - Other key types of information (please specify)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 66.7% 2: 33.3% 3: 0% 4: 0% 5: 0% mean=1.33, SD=0.52 N=6		
Q5.8_5_TEXT_Useful_Other How useful to you are - Other key types of information (please specify) - Text		N=5		
Q5.9_1_Understand_surgeforecasts How well do you think your audiences understand- Forecasts of storm surge or coastal flooding	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 6.5% 2: 19.4% 3: 45.2% 4: 25.8% 5: 3.2% mean=3.00, SD=0.93 N=31		
Q5.9_2_Understand_rainfallforecasts How well do you think your audiences understand- Forecasts of flooding from rainfall	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 7.7% 2: 50% 3: 30.8% 4: 11.5% 5: 0% mean=2.46, SD=0.81 N=26		
Q5.9_3_Understand_tornadoforecasts How well do you think your audiences understand - Forecasts of tornadoes	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 10.8% 2: 37.8% 3: 35.1% 4: 13.5% 5: 2.7% mean=2.59, SD=0.96 N=37		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.9_4_Understand_stormtrackforecasts How well do you think your audiences understand - Forecasts of storm track	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 28.1% 2: 31.3% 3: 31.3% 4: 9.4% 5: 0% mean=2.22, SD=0.98 N=32		
Q5.9_5_Understand_arrivalforecasts How well do you think your audiences understand - Forecasts of timing of storm arrival	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 19.5% 2: 52.9% 3: 20.7% 4: 6.9% 5: 0% mean=2.15, SD=0.82 N=87		
Q5.9_6_Understand_intensityforecasts How well do you think your audiences understand - Forecasts of storm intensity	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 0% 2: 26.9% 3: 57.7% 4: 11.5% 5: 3.8% mean=2.92, SD=0.74 N=26		
Q5.9_7_Understand_stormsizeforecasts How well do you think your audiences understand - Forecasts of storm size	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 3.4% 2: 20.7% 3: 37.9% 4: 37.9% 5: 0% mean=3.10, SD=0.86 N=29		
Q5.9_8_Understand_windspeedforecasts How well do you think your audiences understand - Forecasts of storm wind speeds	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 25% 2: 45% 3: 25% 4: 5% 5: 0% mean=2.10, SD=0.85 N=20		
Q5.9_9_Understand_satobservations How well do you think your audiences understand - Satellite observations	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 18.5% 2: 18.5% 3: 40.7% 4: 18.5% 5: 3.7% mean=2.70, SD=1.10 N=27		
Q5.9_10_Understand_uncertainty How well do you think your audiences understand - Forecast uncertainty	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 3.3% 2: 23.3% 3: 43.3% 4: 13.3% 5: 16.7% mean=3.17, SD=1.09 N=30		
Q5.9_11_Understand_howtoprotect How well do you think your audiences understand - How to protect yourself	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 6.3% 2: 50% 3: 31.3% 4: 9.4% 5: 3.1% mean=2.53, SD=0.88 N=32		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.9_12_Understand_howtoprepare How well do you think your audiences understand - How to prepare	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 15.4% 2: 42.3% 3: 26.9% 4: 11.5% 5: 3.8% mean=2.46, SD=1.03 N=26		
Q5.9_13_Understand_howtorespond How well do you think your audiences understand - How to respond after the storm impacts your area	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 12.5% 2: 12.5% 3: 43.8% 4: 28.1% 5: 3.1% mean=2.97, SD=1.03 N=32		
Q5.10_40_Difficulty_cone Which of these NWS products, if any, do you have difficulty using? - Track Forecast Cone (Cone of Uncertainty)	0 Missing - seen but unanswered multi-value 1 Track Forecast Cone (Cone of Uncertainty)	1: 3.7% N=27		
Q5.10_41_Difficulty_fivedayoutlook Which of these NWS products, if any, do you have difficulty using? - 5-day Graphical Tropical Weather Outlook	0 Missing - seen but unanswered multi-value 1 5-day Graphical Tropical Weather Outlook	1: 15.4% N=26		
Q5.10_42_Difficulty_convectiveoutlook Which of these NWS products, if any, do you have difficulty using? - SPC Convective Outlook	0 Missing - seen but unanswered multi-value 1 SPC Convective Outlook	1: 3.7% N=27		
Q5.10_43_Difficulty_windspeedprobabilities Which of these NWS products, if any, do you have difficulty using? - Tropical Cyclone Wind Speed Probabilities	0 Missing - seen but unanswered multi-value 1 Tropical Cyclone Wind Speed Probabilities	1: 17.9% N=28		
Q5.10_44_Difficulty_surgemap Which of these NWS products, if any, do you have difficulty using? - Potential Storm Surge Flooding Map	0 Missing - seen but unanswered multi-value 1 Potential Storm Surge Flooding Map	1: 34.6% N=26		
Q5.10_45_Difficulty_surgewatchwarning Which of these NWS products, if any, do you have difficulty using? - Storm Surge Watch/Warning	0 Missing - seen but unanswered multi-value 1 Storm Surge Watch/Warning	1: 10.7% N=28		
Q5.10_52_Difficulty_hurrwatchwarning Which of these NWS products, if any, do you have difficulty using? - Tropical Storm or Hurricane Watch/Warning	0 Missing - seen but unanswered multi-value 1 Tropical Storm or Hurricane Watch/Warning	1: 3.8% N=26		
Q5.10_46_Difficulty_windarrivaltime Which of these NWS products, if any, do you have difficulty using? - Arrival Time of Tropical-Storm-Force Winds	0 Missing - seen but unanswered multi-value 1 Arrival Time of Tropical-Storm-Force Winds	1: 23.1% N=26		
Q5.10_47_Difficulty_impactsgraphics Which of these NWS products, if any, do you have difficulty using? - Hurricane Threats and Impacts Graphics	0 Missing - seen but unanswered multi-value 1 Hurricane Threats and Impacts Graphics	1: 14.8% N=27		
Q5.10_48_Difficulty_rainfallforecasts Which of these NWS products, if any, do you have difficulty using? - Rainfall outlooks or forecasts	0 Missing - seen but unanswered multi-value 1 Rainfall outlooks or forecasts	1: 0% N=27		
Q5.10_53_Difficulty_riverstageforecasts Which of these NWS products, if any, do you have difficulty using? - River stage forecasts (hydrographs)	0 Missing - seen but unanswered multi-value 1 River stage forecasts (hydrographs)	1: 53.6% N=28		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.10_50_Difficulty_hurrlocalstatement Which of these NWS products, if any, do you have difficulty using? - Hurricane Local Statement	0 Missing - seen but unanswered multi-value 1 Hurricane Local Statement	1: 26.9% N=26		
Q5.10_51_Difficulty_localofficewatchwarning Which of these NWS products, if any, do you have difficulty using? - Local office Tropical Cyclone Watch/Warning VTEC (TCV) Product	0 Missing - seen but unanswered multi-value 1 Local office Tropical Cyclone Watch/Warning VTEC (TCV) Product	1: 11.5% N=26		
Q5.10_49_Difficulty_none Which of these NWS products, if any, do you have difficulty using? - None of the above	0 Missing - seen but unanswered multi-value 1 None of the above	1: 49.4% N=87		
Q5.11_4_Datalayernotavailable What makes the first of these difficult to use? - The data layer is not available	0 Missing - seen but unanswered multi-value 1 The data layer is not available	1: 43.2% N=44		
Q5.11_5_hardtoeditondevices What makes the first of these difficult to use? - It is hard to edit on the devices I use	0 Missing - seen but unanswered multi-value 1 It is hard to edit on the devices I use	1: 45.5% N=44		
Q5.11_7_managementunsupportive What makes the first of these difficult to use? - Management doesn't want me to use	0 Missing - seen but unanswered multi-value 1 My management doesn't want me to use it	1: 9.1% N=44		
Q5.11_8_toomuchinformation What makes the first of these difficult to use? - Provides too much information	0 Missing - seen but unanswered multi-value 1 It provides too much information	1: 18.2% N=44		
Q5.11_6_Other What makes the first of these difficult to use? - Other (specify)	0 Missing - seen but unanswered multi-value 1 Other (please specify)	1: 25% N=44		
Q5.11_6_TEXT_Other What makes the first of these difficult to use? - Other (specify) - Text		N=11		
Q5.12_infotoolsjudgment In my job, NWS tropical cyclone forecast information and tools... Please select the response that best fits your judgment.	1 Are well aligned with my decision making timeline 2 Could be better timed to align with my decision making 3 Are not at all aligned with my decision making timeline	1: 73.6% 2: 24.1% 3: 2.3% mean=1.29, SD=0.50 N=87		
Q5.13_NWSgraphicsjudgment When communicating with my audiences about tropical cyclone threats, NWS graphics...	1 Meet my communication needs, I use them to communicate “as is” 2 Meet most of my communication needs, I sometimes modify them to communicate better with my audiences 3 Only meet some of my communication needs, I communicate better with my audiences if I modify them 4 Are not useful as is, I have to modify them to communicate with my audiences 5 Are not useful, I don’t use them	1: 8.0% 2: 67.8% 3: 20.7% 4: 3.4% 5: 0% mean=2.20, SD=0.63 N=87		
Q5.14_1_easeTV How easy or difficult is it for you to use NWS graphics - On-air (television)	[-99 Missing - seen but unanswered] 1 Extremely easy 2 Somewhat easy 3 Neither easy nor difficult 4 Somewhat difficult 5 Extremely difficult	1: 25.6% 2: 37.2% 3: 20.9% 4: 12.8% 5: 3.5% mean=2.31, SD=1.10 N=86		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.14_2_easewebsite How easy or difficult is it for you to use NWS graphics - Station	[-99 Missing - seen but unanswered] 1 Extremely easy 2 Somewhat easy 3 Neither easy nor difficult 4 Somewhat difficult 5 Extremely difficult	 1: 24.4% 2: 41.9% 3: 23.3% 4: 5.8% 5: 4.7% mean=2.24, SD=1.04 N=86		
Q5.14_3_easesocialmedia How easy or difficult is it for you to use NWS graphics - Social media (personal or station)	[-99 Missing - seen but unanswered] 1 Extremely easy 2 Somewhat easy 3 Neither easy nor difficult 4 Somewhat difficult 5 Extremely difficult	 1: 36% 2: 38.4% 3: 20.9% 4: 1.2% 5: 3.5% mean=1.98, SD=0.97 N=86		
Q5.14_4_easeother How easy or difficult is it for you to use NWS graphics - Other (please specify)	[-99 Missing - seen but unanswered] 1 Extremely easy 2 Somewhat easy 3 Neither easy nor difficult 4 Somewhat difficult 5 Extremely difficult	 1: 50% 2: 0% 3: 0% 4: 0% 5: 50% mean=3.00, SD=2.31 N=4		
Q5.14_4_TEXT_easeother How easy or difficult is it for you to use NWS graphics - Other (please specify) - Text		N=3		
Q5.15_mostimpchange What, if anything, is the single most important change the NWS could make to improve its tropical cyclone storm forecast and warning information, tools and services?		N=63		
Q5.16_1_Useful_intensitymorethan5days How useful would it be for you to have - Forecasts of storm intensity, provided more than 5 days out	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 13.6% 2: 20.5% 3: 36.4% 4: 15.9% 5: 13.6% mean=2.95, SD=1.22 N=44	1: 15.6% 2: 18.8% 3: 37.5% 4: 12.5% 5: 15.6% mean=2.94, SD=1.23 N=32	1: 8.3% 2: 25% 3: 33.3% 4: 25% 5: 8.3% mean=3.00, SD=1.13 N=12
Q5.16_2_Useful_stormtrackmorethan5days How useful would it be for you to have - Forecasts of storm track, provided more than 5 days out	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	 1: 19% 2: 19% 3: 31% 4: 21.4% 5: 9.5% mean=2.83, SD=1.25 N=42	 1: 20% 2: 20% 3: 40% 4: 13.3% 5: 6.7% mean=2.67, SD=1.16 N=30	 1: 16.7% 2: 16.7% 3: 8.3% 4: 41.7% 5: 16.7% mean=3.25, SD=1.42 N=12
Q5.16_3_Useful_surgeforecasts48hours How useful would it be for you to have - Forecasts of storm surge, provided more than 48 hours out	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 29.5% 2: 31.8% 3: 20.5% 4: 11.4% 5: 6.8% mean=2.34, SD=1.22 N=44	1: 36% 2: 40% 3: 20% 4: 4% 5: 0% mean=1.92, SD=0.86 N=25	1: 21.1% 2: 21.1% 3: 21.1% 4: 21.1% 5: 15.8% mean=2.89, SD=1.41 N=19

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.16_4_Useful_forecastsonsetsurge How useful would it be for you to have - Forecasts of timing of onset of storm surge	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 58.1% 2: 23.3% 3: 11.6% 4: 2.3% 5: 4.7% mean=1.72, SD=1.08 N=43	1: 67.9% 2: 21.4% 3: 10.7% 4: 0% 5: 0% mean=1.43, SD=0.69 N=28	1: 40% 2: 26.7% 3: 13.3% 4: 6.7% 5: 13.3% mean=2.27, SD=1.44 N=15
Q5.16_5_Useful_forecastwindduration How useful would it be for you to have - Forecasts of duration of sustained tropical-storm-force winds	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 38.1% 2: 35.7% 3: 26.2% 4: 0% 5: 0% mean=1.88, SD=0.80 N=42	1: 41.4% 2: 37.9% 3: 20.7% 4: 0% 5: 0% mean=1.79, SD=0.77 N=29	1: 30.8% 2: 30.8% 3: 38.5% 4: 0% 5: 0% mean=2.08, SD=0.86 N=13
Q5.16_6_Useful_forecastendhazconditi ons How useful would it be for you to have - Forecasts of when hazardous conditions will end	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 39.5% 2: 27.9% 3: 25.6% 4: 4.7% 5: 2.3% mean=2.02, SD=1.04 N=43	1: 32.3% 2: 32.3% 3: 32.3% 4: 0% 5: 3.2% mean=2.10, SD=0.98 N=31	1: 58.3% 2: 16.7% 3: 8.3% 4: 16.7% 5: 0% mean=1.83, SD=1.19 N=12
Q5.16_7_Useful_infoinoneplace How useful would it be for you to have - Compiling available information in one place, making it easier to access all NWS products that relate to a particular storm	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.8% 2: 26.2% 3: 14.3% 4: 2.4% 5: 2.4% mean=1.71, SD=0.97 N=42	1: 51.5% 2: 27.3% 3: 15.2% 4: 3% 5: 3% mean=1.79, SD=1.02 N=33	1: 66.7% 2: 22.2% 3: 11.1% 4: 0% 5: 0% mean=1.44, SD=0.73 N=9
Q5.16_8_Useful_summaryproduct How useful would it be for you to have - Summary product compiling key hazard and risk information for a particular storm	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.5% 2: 34.1% 3: 6.8% 4: 0% 5: 4.5% mean=1.66, SD=0.96 N=44	1: 60.7% 2: 32.1% 3: 3.6% 4: 0% 5: 3.6% mean=1.54, SD=0.88 N=28	1: 43.8% 2: 37.5% 3: 12.5% 4: 0% 5: 6.3% mean=1.88, SD=1.09 N=16
Q5.17_importancemonitorsocialmedia How important is it for you to monitor social media to understand what people are thinking or doing about them?	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 43% 2: 27.9% 3: 17.4% 4: 8.1% 5: 3.5% mean=2.01, SD=1.12 N=86		
Q5.18_helpful_analyzesocialmedia To what extent would it be helpful in your job to have a tool or service that collects and analyzes local social media posts about tropical cyclones?	[-99 Missing - seen but unanswered] 1 Extremely helpful 2 Very helpful 3 Moderately helpful 4 Slightly helpful 5 Not at all helpful	1: 30.2% 2: 38.4% 3: 18.6% 4: 8.1% 5: 4.7% mean=2.19, SD=1.10 N=86		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q5.19_rateNWSinteractions How would you rate your interactions with your local NWS Forecast Office(s) during tropical cyclone threats?	[-99 Missing - seen but unanswered] 1 Excellent 2 Good 3 Average 4 Poor 5 Terrible	1: 46.5% 2: 39.5% 3: 11.6% 4: 1.2% 5: 1.2% mean=1.71, SD=0.81 N=86		
Q6.1_COVIDaffect How much has COVID-19 affected the ways that you advise your audiences about how to prepare or respond to tropical cyclone threats?	[-99 Missing - seen but unanswered] 1 A great deal 2 A lot 3 A moderate amount 4 A little 5 Not at all	1: 3.5% 2: 15.1% 3: 32.6% 4: 30.2% 5: 18.6% mean=3.45, SD=1.07 N=86		
Q6.2_gender What is your gender?	1 Male 2 Female 3 Non-binary / third gender 4 Prefer not to say 5 Other	1: 71.3% 2: 21.8% 3: 0% 4: 6.9% 5: 0% mean=1.43, SD=0.82 N=87		
Q6.2_5_TEXT_genderother What is your gender? - Other - Text		N=0		
Q6.3_hispanic Are you Hispanic?	[-99 Missing - seen but unanswered] 1 Yes 2 No	1: 7.1% 2: 92.9% mean=1.93, SD=0.30 N=84		
Q6.4_1_race_asian You identify as - Asian	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Asian	1: 0% N=79		
Q6.4_2_race_black You identify as - Black or African American	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Black or African American	1: 3.8% N=79		
Q6.4_3_race_native You identify as - Native American or Alaska Native	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Native American or Alaska Native	1: 0% N=79		
Q6.4_4_race_islander You identify as - Native Hawaiian or other Pacific Islander	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Native Hawaiian or other Pacific Islander	1: 0% N=79		
Q6.4_5_race_white You identify as - White	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 White	1: 96.2% N=79		
Q6.4_6_race_other You identify as - Other race (write-in)	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Some other race (write-in)	1: 0% N=79		
Q6.4_6_TEXT_race_other You identify as - Other race (write-in) - Text		N=0		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q6.5_1_degree_metcertificate Which educational degrees do you hold? - Certificate in meteorology / broadcast meteorology	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Certificate in meteorology / broadcast meteorology	1: 20.9% N=86		
Q6.5_2_degree_AAorAS Which educational degrees do you hold? - AA or AS	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 AA or AS	1: 1.2% N=86		
Q6.5_3_degree_BSatmscience Which educational degrees do you hold? - BS in meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 BS in meteorology or atmospheric science	1: 68.6% N=86		
Q6.5_4_degree_BSorBASTEM Which educational degrees do you hold? - BS or BA in STEM field other than meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 BS or BA in STEM field other than meteorology or atmospheric science	1: 5.8% N=86		
Q6.5_5_degree_BSorBAbroadmet Which educational degrees do you hold? - BS or BA in broadcast meteorology	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 BS or BA in broadcast meteorology	1: 5.8% N=86		
Q6.5_6_degree_BAcommunication Which educational degrees do you hold? - BA in journalism / mass communication	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 BA in journalism / mass communication	1: 11.6% N=86		
Q6.5_7_degree_BAorBSotherdiscipline Which educational degrees do you hold? - BA or BS in another discipline (please specify):	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 BA or BS in another discipline (please specify):	1: 5.8% N=86		
Q6.5_8_degree_MSatmscience Which educational degrees do you hold? - MS in meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 MS in meteorology or atmospheric science	1: 11.6% N=86		
Q6.5_9_degree_MSSTEM Which educational degrees do you hold? - MS in STEM field other than meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 MS in STEM field other than meteorology or atmospheric science	1: 0% N=86		
Q6.5_10_degree_MSorMAbroadmet Which educational degrees do you hold? - MS or MA in broadcast meteorology	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 MS or MA in broadcast meteorology	1: 5.8% N=86		
Q6.5_11_degree_MAcommunication Which educational degrees do you hold? - MA in journalism / mass communication	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 MA in journalism / mass communication	1: 0% N=86		
Q6.5_12_degree_MAorMSotherdiscipline Which educational degrees do you hold? - MA or MS in another discipline (please specify):	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 MA or MS in another discipline (please specify):	1: 1.2% N=86		
Q6.5_13_degree_PhDatmscience Which educational degrees do you hold? - PhD. or ScD in meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 PhD. or ScD in meteorology or atmospheric science	1: 0% N=86		
Q6.5_14_degree_PhDSTEM Which educational degrees do you hold? - PhD in STEM field other than meteorology or atmospheric science	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 PhD in STEM field other than meteorology or atmospheric science	1: 2.3% N=86		
Q6.5_15_degree_PhDotherdiscipline Which educational degrees do you hold? - PhD in another discipline (please specify):	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 PhD in another discipline (please specify):	1: 0% N=86		

Variable name and wording of survey question / item (BR survey)	Response options and coding	Descriptive statistics	Descriptive statistics - coastal	Descriptive statistics - inland
Q6.5_16_degree_Other Which educational degrees do you hold? - Other degrees, diplomas or credits (please specify):	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Other degrees, diplomas or credits (please specify):	 1: 2.3% N=86		
Q6.5_7_TEXT_degree_BAorBSotherdiscipline Which educational degrees do you hold? - BA or BS in another discipline (please specify): - Text		N=5		
Q6.5_12_TEXT_degree_MAorMSotherdiscipline Which educational degrees do you hold? - MA or MS in another discipline (please specify): - Text		N=1		
Q6.5_15_TEXT_degree_PhDotherdiscipline Which educational degrees do you hold? - PhD in another discipline (please specify): - Text		N=0		
Q6.5_16_TEXT_degree_Other Which educational degrees do you hold? - Other degrees, diplomas or credits (please specify): - Text		N=2		
Q7.1_additionalthoughts Is there anything else you feel we should know to understand your views about any topic(s) on this survey?		N=14		

APPENDIX E. EMERGENCY MANAGER SURVEY QUESTIONS AND DESCRIPTIVE STATISTICS

This appendix provides, in Table E-1, the following for the emergency manager survey data sets:

- Column A: variable names and wording of the associated survey question
- Column B: response options
- Column C: descriptive statistics for data from the full emergency manager targeted sample
- Columns D, E, F: descriptive statistics for data from the emergency manager convenience sample, partitioned into respondents who said they were a local emergency manager (column D), those who said they were a state or federal or regional emergency manager (column E), and those who said they had another position (column F)
- Columns G, H, I: descriptive statistics for data from coastal (column G), near-coastal (column H), and inland (column I) emergency managers in the targeted sample, for selected variables

Results for the convenience sample are shown in three subgroups because, compared to the targeted sample, it includes some respondents working in different types of positions (see Appendix F), who may have different perspectives on TC forecasts and warnings based on their different job roles and decisions during TC threats. As a starting point for accounting for these differences when looking at results across the two samples, we partitioned the convenience sample based on survey Q8, which asked "Which of these best describe(s) your current position?" Each respondent was asked to select one or more of five options: four types of emergency manager positions — local (city or county), state, federal or regional (multi-state), and tribal — and Other (see rows 10–15). Group 1 (column E) includes all respondents who selected state or federal or regional (multi-state) emergency manager; people in such positions were included the targeted sample but were less prevalent than local emergency managers, given the sampling strategy. Group 2 (column D) includes all remaining respondents who selected local (city or county) emergency manager; this group is most comparable to the targeted sample, in which 90% of respondents selected this option. Group 3 (column F) includes all other respondents; these worked in a variety of other types of jobs, described in Appendix F, most of which were not represented in the targeted sample.

Percentages shown are out of the number of valid responses (N indicated) for that survey question / item, not including missing responses. Note that results for only the targeted sample (columns D, E, F) are shown and discussed in the main text.

Table E-1. Emergency manager survey questions and descriptive statistics.

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Duration (in seconds)	None	mean=17876 sec, median=629 sec, SD=87331 sec N=265	mean=14921 sec, median=572 sec, SD=78106 sec N=60	mean=6335 sec, median=589 sec, SD=27799 sec N=44	mean=1061 sec, median=678 sec, SD=1231 sec N=69			
Q3_jurisdiction What jurisdiction, state, or organization do you work for?		N=260	N=60	N=44	N=68			
Q4_EOCzipcode What is the zip code of your Emergency Operations Center, if applicable? - Selected Choice		N=259	N=60	N=38	N=63			
Q4_1_TEXT_zipcode What is the zip code of your Emergency Operations Center, if applicable? - Zip code - Text		N=259	N=60	N=38	N=63			
Q5_yearsEM How many years have you worked... Please round to the nearest year. ... in EM?		mean=15.55 years, median=14 years, SD=10.81 years N=265	mean=13.93 years, median=10.5 years, SD=10.68 years N=60	mean=16.78 years, median=13.5 years, SD=11.06 years N=44	mean=13.92 years, median=12 years, SD=10.70 years N=66			
Q6_yearsEMcyclones ...in EM in regions affected by TCs?		mean=13.26 years, median=12 years, SD=11.06 years N=261	mean=13.69 years, median=9 years, SD=10.95 years N=60	mean=13.99 years, median=12 years, SD=10.63 years N=44	mean=13.06 years, median=10 years, SD=10.36 years N=67			
Q7_jobinEM Is your job in EM - Selected Choice	1 Part-time 2 Full-time 3 Full-time, but only part of it is emergency management 4 Unpaid intern or volunteer 5 Other (please specify)	1: 14% 2: 61.9% 3: 18.1% 4: 1.5% 5: 4.5% N=265	1: 5% 2: 71.7% 3: 20% 4: 1.7% 5: 1.7% N=60	1: 6.8% 2: 54.5% 3: 34.1% 4: 2.3% 5: 2.3% N=44	1: 7.4% 2: 33.8% 3: 41.2% 4: 5.9% 5: 11.8% N=68			
Q7_5_TEXT_jobinEMother Is your job in EM - Other - Text		N=12	N=1	N=1	N=8			
Q8_1_position_StateEM Which of these best describe(s) your current position? - Selected Choice State emergency manager	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 State emergency manager	1: 5.3% N=264	1: 0% N=60	1: 68.2% N=44	1: 0% N=66			
Q8_2_position_LocalEM Which of these best describe(s) your current position? - Selected Choice Local (city or county) emergency manager	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Local (city or county) emergency manager	1: 90.2% N=264	1: 100% N=60	1: 2.3% N=44	1: 0% N=66			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q8_3_position_TribalEM Which of these best describe(s) your current position? - Selected Choice Tribal emergency manager	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Tribal emergency manager	1: 0.4% N=264	1: 0% N=60	1: 0% N=44	1: 0% N=66			
Q8_4_position_Federal_regional_EM Which of these best describe(s) your current position? - Selected Choice Federal or regional (multi-state) emergency manager	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Federal or regional (multi-state) emergency manager	1: 0.4% N=264	1: 0% N=60	1: 31.8% N=44	1: 0% N=66			
Q8_5_position_Other Which of these best describe(s) your current position? - Selected Choice Other	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Other (please specify)	1: 5.7% N=264	1: 6.7% N=60	1: 6.8% N=44	1: 100% N=66			
Q8_5_TEXT_position_Other Which of these best describe(s) your current position? - Other - Text		N=15	N=4	N=3	N=66			
Q9_1_role_makingdecisions When a TC threatens, what are your main job roles? - Selected Choice Making or coordinating EM decisions	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Making or coordinating emergency management decisions	1: 92.4% N=264	1: 88.3% N=60	1: 75% N=44	1: 71% N=69			
Q9_2_role_supervisingstaff When a TC threatens, what are your main job roles? - Selected Choice Supervising or managing staff	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Supervising or managing staff	1: 66.3% N=264	1: 70% N=60	1: 59.1% N=44	1: 52.2% N=69			
Q9_3_role_interactingwithofficials When a TC threatens, what are your main job roles? - Selected Choice Interacting with elected government officials	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Interacting with elected government officials	1: 80.3% N=264	1: 65% N=60	1: 36.4% N=44	1: 23.2% N=69			
Q9_4_role_communicatingmedia When a TC threatens, what are your main job roles? - Selected Choice Communicating with the media or members of the public	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Communicating with the media or members of the public	1: 68.9% N=264	1: 50% N=60	1: 18.2% N=44	1: 15.9% N=69			
Q9_5_role_trackingthreat When a TC threatens, what are your main job roles? - Selected Choice Tracking the threat or gathering and interpreting forecast information	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Tracking the threat or gathering and interpreting forecast information	1: 80.7% N=264	1: 78.3% N=60	1: 59.1% N=44	1: 62.3% N=69			
Q9_6_role_raisingawareness When a TC threatens, what are your main job roles? - Selected Choice Raising situational awareness in your office as the TC threat evolves	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Raising situational awareness in your office as the TC threat evolves	1: 76.5% N=264	1: 71.7% N=60	1: 59.1% N=44	1: 66.7% N=69			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q9_7_role_Other When a TC threatens, what are your main job roles? - Selected Choice Other	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Other (please specify)	1: 4.9% N=264	1: 8.3% N=60	1: 11.4% N=44	1: 29% N=69			
Q9_7_TEXT_role_Other When a TC threatens, what are your main job roles? - Other - Text		N=13	N=4	N=5	N=20			
Q10_1_importancetrack How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Storm track	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 76.9% 2: 18.9% 3: 3.4% 4: 0.4% 5: 0.4% mean=1.28, SD=0.58 N=264	1: 86.4% 2: 11.9% 3: 1.7% 4: 0% 5: 0% mean=1.15, SD=0.41 N=59	1: 88.6% 2: 11.4% 3: 0% 4: 0% 5: 0% mean=1.11, SD=0.32 N=44	1: 92.6% 2: 5.9% 3: 0% 4: 1.5% 5: 0% mean=1.10, SD=0.43 N=68	1: 77.9% 2: 17.9% 3: 4.2% 4: 0% 5: 0% mean=1.26, SD=0.53 N=95	1: 77.8% 2: 22.2% 3: 0% 4: 0% 5: 0% mean=1.22, SD=0.42 N=54	1: 75.7% 2: 18.3% 3: 4.3% 4: 0.9% 5: 0.9% mean=1.33, SD=0.69 N=115
Q10_2_importancetiming How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Timing of storm arrival	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 80.2% 2: 16.8% 3: 2.3% 4: 0.4% 5: 0.4% mean=1.24, SD=0.55 N=262	1: 88.3% 2: 10.0% 3: 1.7% 4: 0% 5: 0% mean=1.13, SD=0.39 N=60	1: 86% 2: 14% 3: 0% 4: 0% 5: 0% mean=1.14, SD=0.35 N=43	1: 91.3% 2: 5.8% 3: 2.9% 4: 0% 5: 0% mean=1.12, SD=0.40 N=69	1: 84.0% 2: 16.0% 3: 0% 4: 0% 5: 0% mean=1.16, SD=0.37 N=94	1: 90.6% 2: 7.5% 3: 1.9% 4: 0% 5: 0% mean=1.11, SD=0.38 N=53	1: 72.2% 2: 21.7% 3: 4.3% 4: 0.9% 5: 0.9% mean=1.37, SD=0.69 N=115
Q10_3_importanceintensity How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Storm intensity (Saffir-Simpson category)	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 59.1% 2: 31.1% 3: 8.0% 4: 1.5% 5: 0.4% mean=1.53, SD=0.74 N=264	1: 66.7% 2: 30% 3: 3.3% 4: 0% 5: 0% mean=1.37, SD=0.55 N=60	1: 68.2% 2: 29.5% 3: 2.3% 4: 0% 5: 0% mean=1.34, SD=0.53 N=44	1: 69.1% 2: 26.5% 3: 2.9% 4: 1.5% 5: 0% mean=1.37, SD=0.62 N=68	1: 55.8% 2: 31.6% 3: 10.5% 4: 2.1% 5: 0% mean=1.59, SD=0.77 N=95	1: 62.3% 2: 30.2% 3: 7.5% 4: 0% 5: 0% mean=1.45, SD=0.64 N=53	1: 60.3% 2: 31.0% 3: 6.0% 4: 1.7% 5: 0.9% mean=1.52, SD=0.76 N=116
Q10_4_importancewindspeeds How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Storm wind speeds in different areas	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 56.8% 2: 30.7% 3: 10.6% 4: 1.5% 5: 0.4% mean=1.58, SD=0.77 N=264	1: 63.3% 2: 26.7% 3: 8.3% 4: 0% 5: 1.7% mean=1.50, SD=0.79 N=60	1: 56.8% 2: 31.8% 3: 11.4% 4: 0% 5: 0% mean=1.55, SD=0.7 N=44	1: 58% 2: 33.3% 3: 8.7% 4: 0% 5: 0% mean=1.51, SD=0.66 N=69	1: 51.1% 2: 38.3% 3: 9.6% 4: 1.1% 5: 0% mean=1.61, SD=0.71 N=94	1: 63.0% 2: 31.5% 3: 5.6% 4: 0% 5: 0% mean=1.43, SD=0.60 N=54	1: 58.6% 2: 24.1% 3: 13.8% 4: 2.6% 5: 0.9% mean=1.63, SD=0.88 N=116

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q10_5_importancestormsurge How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Storm surge or coastal flooding	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 32.8% 2: 7.7% 3: 15.4% 4: 16.6% 5: 27.4% mean=2.98, SD=1.63 N=259	1: 62.7% 2: 6.8% 3: 8.5% 4: 11.9% 5: 10.2% mean=2.00, SD=1.46 N=59	1: 77.3% 2: 11.4% 3: 9.1% 4: 2.3% 5: 0% mean=1.36, SD=0.75 N=44	1: 60.9% 2: 20.3% 3: 10.1% 4: 5.8% 5: 2.9% mean=1.70, SD=1.06 N=69	1: 74.2% 2: 9.7% 3: 9.7% 4: 4.3% 5: 2.2% mean=1.51, SD=0.99 N=93	1: 13.2% 2: 5.7% 3: 15.1% 4: 24.5% 5: 41.5% mean=3.75, SD=1.40 N=53	1: 8.0% 2: 7.1% 3: 20.4% 4: 23.0% 5: 41.6% mean=3.83, SD=1.27 N=113
Q10_6_importancerainfall How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Flooding from rainfall	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 64.4% 2: 26.1% 3: 7.6% 4: 1.5% 5: 0.4% mean=1.47, SD=0.73 N=264	1: 80% 2: 15% 3: 3.3% 4: 1.7% 5: 0% mean=1.27, SD=0.61 N=60	1: 63.6% 2: 29.5% 3: 6.8% 4: 0% 5: 0% mean=1.43, SD=0.63 N=44	1: 60.9% 2: 31.9% 3: 7.2% 4: 0% 5: 0% mean=1.46, SD=0.63 N=69	1: 54.7% 2: 35.8% 3: 8.4% 4: 1.1% 5: 0% mean=1.56, SD=0.70 N=95	1: 71.7% 2: 18.9% 3: 9.4% 4: 0% 5: 0% mean=1.38, SD=0.66 N=53	1: 69.0% 2: 21.6% 3: 6.0% 4: 2.6% 5: 0.9% mean=1.45, SD=0.80 N=116
Q10_7_importancetornadoes How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Tornadoes	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 68.6% 2: 22% 3: 7.2% 4: 1.9% 5: 0.4% mean=1.44, SD=0.74 N=264	1: 66.7% 2: 26.7% 3: 6.7% 4: 0% 5: 0% mean=1.40, SD=0.61 N=60	1: 52.3% 2: 31.8% 3: 15.9% 4: 0% 5: 0% mean=1.64, SD=0.75 N=44	1: 49.3% 2: 30.4% 3: 20.3% 4: 0% 5: 0% mean=1.71, SD=0.79 N=69	1: 52.6% 2: 27.4% 3: 15.8% 4: 4.2% 5: 0% mean=1.72, SD=0.88 N=95	1: 66.0% 2: 30.2% 3: 3.8% 4: 0% 5: 0% mean=1.38, SD=0.56 N=53	1: 82.8% 2: 13.8% 3: 1.7% 4: 0.9% 5: 0.9% mean=1.23, SD=0.61 N=116
Q10_8_importanceimpacts How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Potential storm impacts	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 69.3% 2: 25% 3: 5.3% 4: 0% 5: 0.4% mean=1.37, SD=0.62 N=264	1: 70% 2: 26.7% 3: 1.7% 4: 0% 5: 1.7% mean=1.37, SD=0.68 N=60	1: 72.7% 2: 20.5% 3: 6.8% 4: 0% 5: 0% mean=1.34, SD=0.61 N=44	1: 65.2% 2: 21.7% 3: 11.6% 4: 1.4=% 5: 0% mean=1.49, SD=0.76 N=69	1: 68.4% 2: 25.3% 3: 6.3% 4: 0% 5: 0% mean=1.38, SD=0.61 N=95	1: 71.7% 2: 26.4% 3: 1.9% 4: 0% 5: 0% mean=1.30, SD=0.50 N=53	1: 69.0% 2: 24.1% 3: 6.0% 4: 0% 5: 0.9% mean=1.40, SD=0.68 N=116

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Q10_9_importancescenarios How important are each of the following types of forecast information about TC threats for EM decisions in your organization? - Different storm scenarios	[-99 Missing - seen but unanswered] 1 Extremely important 2 Very important 3 Moderately important 4 Slightly important 5 Not at all important	1: 49.6% 2: 34.8% 3: 14.8% 4: 0.4% 5: 0.4% mean=1.67, SD=0.76 N=264	1: 45% 2: 43.3% 3: 10% 4: 0% 5: 1.7% mean=1.70, SD=0.79 N=60	1: 50% 2: 31.8% 3: 18.2% 4: 0% 5: 0% mean=1.68, SD=0.77 N=44	1: 44.1% 2: 35.3% 3: 17.6% 4: 2.9% 5: 0% mean=1.79, SD=0.84 N=68	1: 45.7% 2: 36.2% 3: 17.0% 4: 1.1% 5: 0% mean=1.73, SD=0.78 N=94	1: 51.9% 2: 31.5% 3: 14.8% 4: 0% 5: 1.9% mean=1.69, SD=0.87 N=54	1: 51.7% 2: 35.3% 3: 12.9% 4: 0% 5: 0% mean=1.61, SD=0.71 N=116
Q11_1_1_timingmorethan120hours When are these types of forecast information about TC threats important for your EM decisions? - Timing of storm arrival More than 120 hours (5 days) before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 More than 120 hours (5 days) before a storm impacts your area	1: 34.1% N=264	1: 48.3% N=60	1: 56.8% N=44	1: 62.3% N=69	1: 38.3% N=94	1: 35.2% N=54	1: 30.2% N=116
Q11_1_2_timing120to72hours When are these types of forecast information about TC threats important for your EM decisions? - Timing of storm arrival 120 hours (5 days) to 72 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 120 hours (5 days) to 72 hours before a storm impacts your area	1: 47% N=264	1: 53.3% N=60	1: 52.3% N=44	1: 46.4% N=69	1: 53.2% N=94	1: 51.9% N=54	1: 39.7% N=116
Q11_1_3_timing72to48hours When are these types of forecast information about TC threats important for your EM decisions? - Timing of storm arrival 72 hours to 48 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 72 hours to 48 hours before a storm impacts your area	1: 36.7% N=264	1: 35% N=60	1: 43.2% N=44	1: 39.1% N=69	1: 38.3% N=94	1: 31.5% N=54	1: 37.9% N=116
Q11_1_4_timing48hourstoimpacts When are these types of forecast information about TC threats important for your EM decisions? - Timing of storm arrival 48 hours before a storm through impacts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 48 hours before a storm through impacts	1: 18.9% N=264	1: 30% N=60	1: 38.6% N=44	1: 29% N=69	1: 19.1% N=94	1: 20.4% N=54	1: 18.1% N=116
Q11_1_5_timingnotimportant When are these types of forecast information about TC threats important for your EM decisions? - Timing of storm arrival Not important	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Not important	1: 1.1% N=264	1: 0% N=60	1: 0% N=44	1: 0% N=69	1: 0% N=94	1: 0% N=54	1: 2.6% N=116
Q11_2_1_windspeeds120hours When are these types of forecast information about TC threats important for your EM decisions? - Storm wind speeds in different areas More than 120 hours (5 days) before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 More than 120 hours (5 days) before a storm impacts your area	1: 14.6% N=261	1: 21.7% N=60	1: 27.3% N=44	1: 20.3% N=69	1: 18.3% N=93	1: 17.0% N=53	1: 10.4% N=115

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Q11_2_2_windspeeds120to72hours When are these types of forecast information important for your EM decisions? - Storm wind speeds in different areas 120 hours (5 days) to 72 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 120 hours (5 days) to 72 hours before a storm impacts your area	1: 25.7% N=261	1: 31.7% N=60	1: 29.5% N=44	1: 39.1% N=69	1: 28.0% N=93	1: 34.0% N=53	1: 20.0% N=115
Q11_2_3_windspeeds72to48hours When are these types of forecast information about TC threats important for your EM decisions? - Storm wind speeds in different areas 72 hours to 48 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 72 hours to 48 hours before a storm impacts your area	1: 51.7% N=261	1: 58.3% N=60	1: 65.9% N=44	1: 56.5% N=69	1: 51.6% N=93	1: 50.9% N=53	1: 52.2% N=115
Q11_2_4_windspeeds48hourstoimpacts When are these types of forecast information about TC threats important for your EM decisions? - Storm wind speeds in different areas 48 hours before a storm through impacts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 48 hours before a storm through impacts	1: 29.5% N=261	1: 30% N=60	1: 47.7% N=44	1: 33.3% N=69	1: 30.1% N=93	1: 24.5% N=53	1: 31.3% N=115
Q11_2_5_windspeedsnotimportant When are these types of forecast information about TC threats important for your EM decisions? - Storm wind speeds in different areas Not important	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Not important	1: 1.1% N=261	1: 0% N=60	1: 0% N=44	1: 1.4% N=69	1: 0% N=93	1: 0% N=53	1: 2.6% N=115
Q11_3_1_stormsurgemorethan120hours When are these types of forecast information important for your EM decisions? - Storm surge or coastal flooding More than 120 hours (5 days) before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 More than 120 hours (5 days) before a storm impacts your area	1: 9.7% N=258	1: 15% N=60	1: 25% N=44	1: 21.7% N=69	1: 20.4% N=93	1: 3.8% N=53	1: 3.6% N=112
Q11_3_2_stormsurge120to72hours When are these types of forecast information important for your EM decisions? - Storm surge or coastal flooding 120 hours (5 days) to 72 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 120 hours (5 days) to 72 hours before a storm impacts your area	1: 20.9% N=258	1: 31.7% N=60	1: 38.6% N=44	1: 33.3% N=69	1: 37.6% N=93	1: 15.1% N=53	1: 9.8% N=112
Q11_3_3_stormsurge72to48hours When are these types of forecast information about TC threats important for your EM decisions? - Storm surge or coastal flooding 72 hours to 48 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 72 hours to 48 hours before a storm impacts your area	1: 26% N=258	1: 45% N=60	1: 59.1% N=44	1: 46.4% N=69	1: 43.0% N=93	1: 13.2% N=53	1: 17.9% N=112

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q11_3_4_stormsurge48hourstoimpacts When are these types of forecast information about TC threats important for your EM decisions? - Storm surge or coastal flooding 48 hours before a storm through impacts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 48 hours before a storm through impacts	1: 18.6% N=258	1: 30% N=60	1: 43.2% N=44	1: 33.3% N=69	1: 25.8% N=93	1: 24.5% N=53	1: 9.8% N=112
Q11_3_5_stormsurgenotimportant When are these types of forecast information about TC threats important for your EM decisions? - Storm surge or coastal flooding Not important	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Not important	1: 44.2% N=261	1: 20% N=60	1: 2.3% N=44	1: 8.7% N=69	1: 7.5% N=93	1: 54.7% N=53	1: 69.6% N=112
Q11_4_1_rainfallmorethan120hours When are these types of forecast information about TC threats important for your EM decisions? - Flooding from rainfall More than 120 hours (5 days) before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 More than 120 hours (5 days) before a storm impacts your area	1: 14.9% N=262	1: 20% N=60	1: 25% N=44	1: 20.3% N=69	1: 17.2% N=93	1: 16.7% N=54	1: 12.2% N=115
Q11_4_2_rainfall120to72hours When are these types of forecast information about TC threats important for your EM decisions? - Flooding from rainfall 120 hours (5 days) to 72 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 120 hours (5 days) to 72 hours before a storm impacts your area	1: 34.7% N=262	1: 33.3% N=60	1: 31.8% N=44	1: 21.7% N=69	1: 32.3% N=93	1: 40.7% N=54	1: 33.9% N=115
Q11_4_3_rainfall72to48hours When are these types of forecast information about TC threats important for your EM decisions? - Flooding from rainfall 72 hours to 48 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 72 hours to 48 hours before a storm impacts your area	1: 46.9% N=262	1: 51.7% N=60	1: 61.4% N=44	1: 53.6% N=69	1: 50.5% N=93	1: 46.3% N=54	1: 44.3% N=115
Q11_4_4_rainfall48hourstoimpacts When are these types of forecast information about TC threats important for your EM decisions? - Flooding from rainfall 48 hours before a storm through impacts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 48 hours before a storm through impacts	1: 27.5% N=262	1: 38.3% N=60	1: 47.7% N=44	1: 39.1% N=69	1: 31.2% N=93	1: 25.9% N=54	1: 25.2% N=115
Q11_4_5_rainfallnotimportant When are these types of forecast information about TC threats important for your EM decisions? - Flooding from rainfall Not important	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Not important	1: 1.1% N=262	1: 0% N=60	1: 0% N=44	1: 2.9% N=69	1: 0% N=93	1: 0% N=54	1: 2.6% N=115

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q11_5_1_scenariosmorethan120hours When are these types of forecast information important for your EM decisions? - Different storm scenarios More than 120 hours (5 days) before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 More than 120 hours (5 days) before a storm impacts your area	1: 24.3% N=259	1: 38.3% N=60	1: 50% N=44	1: 44.9% N=69	1: 27.8% N=90	1: 27.8% N=54	1: 20.0% N=115
Q11_5_2_scenarios120to72hours When are these types of forecast information about TC threats important for your EM decisions? - Different storm scenarios 120 hours (5 days) to 72 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 120 hours (5 days) to 72 hours before a storm impacts your area	1: 45.2% N=259	1: 35% N=60	1: 50% N=44	1: 34.8% N=69	1: 50% N=90	1: 50.0% N=54	1: 39.1% N=115
Q11_5_3_scenarios72to48hours When are these types of forecast information about TC threats important for your EM decisions? - Different storm scenarios 72 hours to 48 hours before a storm impacts your area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 72 hours to 48 hours before a storm impacts your area	1: 35.9% N=259	1: 45% N=60	1: 47.7% N=44	1: 49.3% N=69	1: 34.4% N=90	1: 33.3% N=54	1: 38.3% N=115
Q11_5_4_scenarios48hourstoimpacts When are these types of forecast information about TC threats important for your EM decisions? - Different storm scenarios 48 hours before a storm through impacts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 48 hours before a storm through impacts	1: 22% N=259	1: 26.7% N=60	1: 40.9% N=44	1: 34.8% N=69	1: 20.0% N=90	1: 24.1% N=54	1: 22.6% N=115
Q11_5_5_scenariosnotimportant When are these types of forecast information about TC threats important for your EM decisions? - Different storm scenarios Not important	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Not important	1: 2.3% N=259	1: 1.7% N=60	1: 2.3% N=44	1: 0% N=69	1: 3.3% N=90	1: 1.9% N=54	1: 1.7% N=115
Q12_1_Useful_cone How useful to you and your EM team are each of these during TC threats? This is the first of three short sets of questions like this about usefulness. - Track Forecast Cone (Cone of Uncertainty)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 45.8% 2: 36.3% 3: 14.1% 4: 2.3% 5: 1.5% mean=1.77, SD=0.88 N=262	1: 58.3% 2: 28.3% 3: 13.3% 4: 0% 5: 0% mean=1.55, SD=0.72 N=60	1: 65.9% 2: 22.7% 3: 11.4% 4: 0% 5: 0% mean=1.45, SD=0.7 N=44	1: 72.5% 2: 15.9% 3: 10.1% 4: 1.4% 5: 0% mean=1.41, SD=0.73 N=69	1: 46.8% 2: 28.7% 3: 23.4% 4: 1.1% 5: 0% mean=1.79, SD=0.84 N=94	1: 48.1% 2: 40.7% 3: 9.3% 4: 1.9% 5: 0% mean=1.65, SD=0.73 N=54	1: 43.9% 2: 40.4% 3: 8.8% 4: 3.5% 5: 3.5% mean=1.82, SD=0.98 N=114

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q12_2_Useful_wxoutlook How useful to you and your EM team are each of these during TC threats? This is the first of three short sets of questions like this about usefulness. - 5-day Graphical Tropical Weather Outlook	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 42.2% 2: 37.6% 3: 16.7% 4: 2.7% 5: 0.8% mean=1.82, SD=0.86 N=263	1: 58.3% 2: 28.3% 3: 13.3% 4: 0% 5: 0% mean=1.55, SD=0.72 N=60	1: 65.9% 2: 31.8% 3: 2.3% 4: 0% 5: 0% mean=1.36, SD=0.53 N=44	1: 70.6% 2: 20.6% 3: 7.4% 4: 1.5% 5: 0% mean=1.40, SD=0.69 N=68	1: 43.2% 2: 40.0% 3: 13.7% 4: 3.2% 5: 0% mean=1.77, SD=0.81 N=95	1: 50.0% 2: 27.8% 3: 20.4% 4: 1.9% 5: 0% mean=1.74, SD=0.85 N=54	1: 37.7% 2: 40.4% 3: 17.5% 4: 2.6% 5: 1.8% mean=1.90, SD=0.90 N=114
Q12_3_Useful_NHCmessages How useful to you and your EM team are each of these during TC threats? This is the first of three short sets of questions like this about usefulness. - NHC Key Messages	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 38.4% 2: 42.2% 3: 15.2% 4: 2.7% 5: 1.5% mean=1.87, SD=0.87 N=263	1: 48.3% 2: 41.7% 3: 8.3% 4: 1.7% 5: 0% mean=1.63, SD=0.71 N=60	1: 48.8% 2: 37.2% 3: 9.3% 4: 4.7% 5: 0% mean=1.70, SD=0.83 N=43	1: 55.1% 2: 30.4% 3: 11.6% 4: 1.4% 5: 1.4% mean=1.64, SD=0.86 N=69	1: 41.1% 2: 41.1% 3: 13.7% 4: 4.2% 5: 0% mean=1.81, SD=0.83 N=95	1: 44.4% 2: 42.6% 3: 11.1% 4: 1.9% 5: 0% mean=1.70, SD=0.74 N=54	1: 33.3% 2: 43.0% 3: 18.4% 4: 1.8% 5: 3.5% mean=1.99, SD=0.96 N=114
Q12_4_Useful_NHCadvisories How useful to you and your EM team are each of these during TC threats? This is the first of three short sets of questions like this about usefulness. - NHC Public or Forecast Advisories	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 40.5% 2: 42% 3: 14% 4: 1.9% 5: 1.5% mean=1.82, SD=0.85 N=264	1: 55% 2: 28.3% 3: 15% 4: 1.7% 5: 0% mean=1.63, SD=0.80 N=60	1: 56.8% 2: 25% 3: 11.4% 4: 6.8% 5: 0% mean=1.68, SD=0.93 N=44	1: 56.5% 2: 26.1% 3: 15.9% 4: 1.4% 5: 0% mean=1.62, SD=0.81 N=69	1: 42.1% 2: 37.9% 3: 17.9% 4: 2.1% 5: 0% mean=1.80, SD=0.81 N=95	1: 48.1% 2: 44.4% 3: 7.4% 4: 0% 5: 0% mean=1.59, SD=0.63 N=54	1: 35.7% 2: 44.3% 3: 13.9% 4: 2.6% 5: 3.5% mean=1.94, SD=0.96 N=115
Q12_5_Useful_localstmt How useful to you and your EM team are each of these during TC threats? This is the first of three short sets of questions like this about usefulness. - Hurricane Local Statement	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 49.4% 2: 32.3% 3: 10.6% 4: 3.4% 5: 4.2% mean=1.81, SD=1.04 N=263	1: 60% 2: 25% 3: 15% 4: 0% 5: 0% mean=1.55, SD=0.75 N=60	1: 59.1% 2: 22.7% 3: 11.4% 4: 6.8% 5: 0% mean=1.66, SD=0.94 N=44	1: 68.1% 2: 20.3% 3: 10.1% 4: 1.4% 5: 0% mean=1.45, SD=0.74 N=69	1: 57.9% 2: 32.6% 3: 9.5% 4: 0% 5: 0% mean=1.52, SD=0.67 N=95	1: 61.1% 2: 27.8% 3: 9.3% 4: 1.9% 5: 0% mean=1.52, SD=0.75 N=54	1: 36.8% 2: 34.2% 3: 12.3% 4: 7.0% 5: 9.6% mean=2.18, SD=1.27 N=114
Q13_1_Useful_windspdprob How useful to you and your EM team are each of these during TC threats? - TC Wind Speed Probabilities	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 53.4% 2: 36.1% 3: 8.3% 4: 1.5% 5: 0.8% mean=1.6, SD=0.77 N=133	1: 63% 2: 33.3% 3: 3.7% 4: 0% 5: 0% mean=1.41, SD=0.57 N=27	1: 50% 2: 45.8% 3: 4.2% 4: 0% 5: 0% mean=1.54, SD=0.59 N=24	1: 68.8% 2: 28.1% 3: 3.1% 4: 0% 5: 0% mean=1.34, SD=0.55 N=32	1: 57.4% 2: 38.3% 3: 4.3% 4: 0% 5: 0% mean=1.47, SD=0.58 N=47	1: 60.0% 2: 32.0% 3: 8.0% 4: 0% 5: 0% mean=1.48, SD=0.65 N=25	1: 47.5% 2: 36.1% 3: 11.5% 4: 3.3% 5: 1.6% mean=1.75, SD=0.91 N=61

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q13_2_Useful_hurrwatchwarn How useful to you and your EM team are each of these during TC threats? - Tropical Storm or Hurricane Watch/Warning	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 56.4% 2: 33.1% 3: 8.3% 4: 0.8% 5: 1.5% mean=1.58, SD=0.80 N=133	1: 66.7% 2: 25.9% 3: 3.7% 4: 3.7% 5: 0% mean=1.44, SD=0.75 N=27	1: 58.3% 2: 33.3% 3: 8.3% 4: 0% 5: 0% mean=1.5, SD=0.66 N=24	1: 78.1% 2: 21.9% 3: 0% 4: 0% 5: 0% mean=1.22, SD=0.42 N=32	1: 72.3% 2: 25.5% 3: 2.1% 4: 0% 5: 0% mean=1.30, SD=0.51 N=47	1: 60.0% 2: 40.0% 3: 0% 4: 0% 5: 0% mean=1.40, SD=0.50 N=25	1: 42.6% 2: 36.1% 3: 16.4% 4: 1.6% 5: 3.3% mean=1.87, SD=0.97 N=61
Q13_3_Useful_floodingmap How useful to you and your EM team are each of these during TC threats? - Potential Storm Surge Flooding Map	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 36.1% 2: 17.3% 3: 9.8% 4: 13.5% 5: 23.3% mean=2.71, SD=1.62 N=133	1: 55.6% 2: 11.1% 3: 11.1% 4: 14.8% 5: 7.4% mean=2.07, SD=1.41 N=27	1: 62.5% 2: 25% 3: 12.5% 4: 0% 5: 0% mean=1.50, SD=0.72 N=24	1: 62.5% 2: 28.1% 3: 3.1% 4: 0% 5: 6.3% mean=1.59, SD=1.04 N=32	1: 68.1% 2: 19.1% 3: 6.4% 4: 2.1% 5: 4.3% mean=1.55, SD=1.02 N=47	1: 20.0% 2: 12.0% 3: 8.0% 4: 32.0% 5: 28.0% mean=3.36, SD=1.52 N=25	1: 18.0% 2: 18.0% 3: 13.1% 4: 14.8% 5: 36.1% mean=3.33, SD=1.56 N=61
Q13_4_Useful_surgewatchwar How useful to you and your EM team are each of these during TC threats? - Storm Surge Watch/Warning	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 29.3% 2: 14.3% 3: 15.8% 4: 15.8% 5: 24.8% mean=2.92, SD=1.60 N=133	1: 55.6% 2: 14.8% 3: 11.1% 4: 11.1% 5: 7.4% mean=2.00, SD=1.36 N=27	1: 58.3% 2: 25% 3: 12.5% 4: 4.2% 5: 0% mean=1.63, SD=0.88 N=24	1: 68.8% 2: 18.8% 3: 6.3% 4: 3.1% 5: 3.1% mean=1.53, SD=0.98 N=32	1: 61.7% 2: 10.6% 3: 17.0% 4: 6.4% 5: 4.3% mean=1.81, SD=1.20 N=47	1: 8.0% 2: 16.0% 3: 8.0% 4: 36.0% 5: 32.0% mean=3.68, SD=1.31 N=25	1: 13.1% 2: 16.4% 3: 18.0% 4: 14.8% 5: 37.7% mean=3.48, SD=1.47 N=61
Q13_5_Useful_windarrivaltime How useful to you and your EM team are each of these during TC threats? - Arrival Time of Tropical Storm-Force Winds	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 65.4% 2: 29.3% 3: 3.0% 4: 1.5% 5: 0.8% mean=1.43, SD=0.70 N=133	1: 85.2% 2: 11.1% 3: 3.7% 4: 0% 5: 0% mean=1.19, SD=0.48 N=27	1: 70.8% 2: 29.2% 3: 0% 4: 0% 5: 0% mean=1.29, SD=0.46 N=24	1: 78.1% 2: 15.6% 3: 6.3% 4: 0% 5: 0% mean=1.28, SD=0.58 N=32	1: 74.5% 2: 25.5% 3: 0% 4: 0% 5: 0% mean=1.26, SD=0.44 N=47	1: 72.0% 2: 28.0% 3: 0% 4: 0% 5: 0% mean=1.28, SD=0.46 N=25	1: 55.7% 2: 32.8% 3: 6.6% 4: 3.3% 5: 1.6% mean=1.62, SD=0.88 N=61
Q14_1_Useful_impactsgraphics How useful to you and your EM team are each of these during TC threats? - Hurricane Threats and Impacts Graphics	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 47.7% 2: 41.7% 3: 6.1% 4: 2.3% 5: 2.3% mean=1.70, SD=0.86 N=132	1: 63.6% 2: 33.3% 3: 3% 4: 0% 5: 0% mean=1.39, SD=0.56 N=33	1: 90% 2: 10% 3: 0% 4: 0% 5: 0% mean=1.10, SD=0.31 N=20	1: 73% 2: 27% 3: 0% 4: 0% 5: 0% mean=1.27, SD=0.45 N=37	1: 52.1% 2: 35.4% 3: 10.4% 4: 2.1% 5: 0% mean=1.63, SD=0.76 N=48	1: 62.1% 2: 37.9% 3: 0% 4: 0% 5: 0% mean=1.38, SD=0.49 N=29	1: 36.4% 2: 49.1% 3: 5.5% 4: 3.6% 5: 5.5% mean=1.93, SD=1.03 N=55

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q14_2_Useful_rainfalloutlooks How useful to you and your EM team are each of these during TC threats? - Rainfall outlooks or forecasts	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.5% 2: 39.4% 3: 4.5% 4: 0% 5: 1.5% mean=1.55, SD=0.72 N=132	1: 48.5% 2: 45.5% 3: 6.1% 4: 0% 5: 0% mean=1.58, SD=0.61 N=33	1: 55% 2: 40% 3: 5% 4: 0% 5: 0% mean=1.50, SD=0.61 N=20	1: 27% 2: 64.9% 3: 8.1% 4: 0% 5: 0% mean=1.81, SD=0.57 N=37	1: 47.9% 2: 41.7% 3: 10.4% 4: 0% 5: 0% mean=1.63, SD=0.67 N=48	1: 62.1% 2: 37.9% 3: 0% 4: 0% 5: 0% mean=1.38, SD=0.49 N=29	1: 56.4% 2: 38.2% 3: 1.8% 4: 0% 5: 3.6% mean=1.56, SD=0.86 N=55
Q14_3_Useful_riverstageforecasts How useful to you and your EM team are each of these during TC threats? - River stage forecasts (hydrographs)	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 56.8% 2: 28.8% 3: 8.3% 4: 3.0% 5: 3.0% mean=1.67, SD=0.97 N=132	1: 39.4% 2: 36.4% 3: 21.2 4: 3% 5: 0% mean=1.88, SD=0.86 N=33	1: 40% 2: 50% 3: 5% 4: 5% 5: 0% mean=1.75, SD=0.79 N=20	1: 37.1% 2: 31.4% 3: 25.7% 4: 2.9% 5: 2.9% mean=2.03, SD=1.01 N=35	1: 52.1% 2: 25.0% 3: 12.5% 4: 6.3% 5: 4.2% mean=1.85, SD=1.13 N=48	1: 69.0% 2: 17.2% 3: 13.8% 4: 0% 5: 0% mean=1.45, SD=0.74 N=29	1: 54.5% 2: 38.2% 3: 1.8% 4: 1.8% 5: 3.6% mean=1.62, SD=0.91 N=55
Q14_4_Useful_convectiveoutlook How useful to you and your EM team are each of these during TC threats? - SPC Convective Outlook	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 26% 2: 40.5% 3: 23.7% 4: 5.3% 5: 4.6% mean=2.22, SD=1.04 N=131	1: 21.2% 2: 45.5% 3: 30.3 4: 3% 5: 0% mean=2.15, SD=0.80 N=33	1: 21.1% 2: 47.4% 3: 26.3% 4: 0% 5: 5.3% mean=2.21, SD=0.98 N=19	1: 21.6% 2: 43.2% 3: 29.7% 4: 5.4% 5: 0% mean=2.19, SD=0.85 N=37	1: 25.5% 2: 42.6% 3: 23.4% 4: 6.4% 5: 2.1% mean=2.17, SD=0.96 N=47	1: 20.7% 2: 31.0% 3: 34.5% 4: 6.9% 5: 6.9% mean=2.48, SD=1.12 N=29	1: 29.1% 2: 43.6% 3: 18.2% 4: 3.6% 5: 5.5% mean=2.13, SD=1.06 N=55
Q14_5_Useful_wxpredictmodels How useful to you and your EM team are each of these during TC threats? - Weather prediction models (e.g., GFS, European, spaghetti models)	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 37.9% 2: 37.1% 3: 18.9% 4: 3.8% 5: 2.3% mean=1.95, SD=0.96 N=132	1: 36.4% 2: 39.4% 3: 18.2 4: 6.1% 5: 0% mean=1.94, SD=0.9 N=33	1: 55% 2: 45% 3: 0% 4: 0% 5: 0% mean=1.45, SD=0.51 N=20	1: 56.8% 2: 37.8% 3: 5.4% 4: 0% 5: 0% mean=1.49, SD=0.61 N=37	1: 39.6% 2: 41.7% 3: 12.5% 4: 4.2% 5: 2.1% mean=1.88, SD=0.94 N=48	1: 31.0% 2: 37.9% 3: 27.6% 4: 3.4% 5: 0% mean=2.03, SD=0.87 N=29	1: 40.0% 2: 32.7% 3: 20.0% 4: 3.6% 5: 3.6% mean=1.98, SD=1.05 N=55
Q15_1_Useful_NWSlocalinteractions How useful to you and your EM team are each of these during TC threats? - Interactions with NWS local office forecasters (e.g., briefings, conference calls)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 75.6% 2: 15.6% 3: 5.2% 4: 2.2% 5: 1.5% mean=1.39, SD=0.81 N=135	1: 77.4% 2: 19.4% 3: 0% 4: 3.2% 5: 0% mean=1.29, SD=0.64 N=31	1: 50% 2: 25% 3: 8.3% 4: 16.7% 5: 0% mean=1.92, SD=1.14 N=24	1: 60% 2: 27.5% 3: 12.5% 4: 0% 5: 0% mean=1.53, SD=0.72 N=40	1: 69.2% 2: 19.2% 3: 9.6% 4: 1.9% 5: 0% mean=1.44, SD=0.75 N=52	1: 82.1% 2: 17.9% 3: 0% 4: 0% 5: 0% mean=1.18, SD=0.39 N=28	1: 78.2% 2: 10.9% 3: 3.6% 4: 3.6% 5: 3.6% mean=1.44, SD=1.0 N=55

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q15_2_Useful_NWSforecastdiscussion How useful to you and your EM team are each of these during TC threats? - NWS local office Forecast Discussion	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 70.4% 2: 20.7% 3: 6.7% 4: 0.7% 5: 1.5% mean=1.42, SD=0.78 N=135	1: 72.4% 2: 13.8% 3: 6.9% 4: 6.9% 5: 0% mean=1.48, SD=0.91 N=29	1: 47.8% 2: 34.8% 3: 0% 4: 17.4% 5: 0% mean=1.87, SD=1.10 N=23	1: 55% 2: 35% 3: 10% 4: 0% 5: 0% mean=1.55, SD=0.68 N=40	1: 65.4% 2: 26.9% 3: 5.8% 4: 1.9% 5: 0% mean=1.44, SD=0.70 N=52	1: 71.4% 2: 25.0% 3: 3.6% 4: 0% 5: 0% mean=1.32, SD=0.55 N=28	1: 74.5% 2: 12.7% 3: 9.1% 4: 0% 5: 3.6% mean=1.45, SD=0.94 N=55
Q15_3_Useful_NHCforecastdiscussion How useful to you and your EM team are each of these during TC threats? - NHC Forecast Discussion	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 50.4% 2: 32.6% 3: 9.6% 4: 5.2% 5: 2.2% mean=1.76, SD=0.98 N=135	1: 48.3% 2: 37.9% 3: 6.9% 4: 6.9% 5: 0% mean=1.72, SD=0.88 N=29	1: 41.7% 2: 41.7% 3: 4.2% 4: 12.5% 5: 0% mean=1.88, SD=0.99 N=24	1: 42.5% 2: 47.5% 3: 10% 4: 0% 5: 0% mean=1.68, SD=0.66 N=40	1: 55.8% 2: 30.8% 3: 9.6% 4: 3.8% 5: 0% mean=1.62, SD=0.82 N=52	1: 53.6% 2: 32.1% 3: 10.7% 4: 3.6% 5: 0% mean=1.64, SD=0.83 N=28	1: 43.6% 2: 34.5% 3: 9.1% 4: 7.3% 5: 5.5% mean=1.96, SD=1.15 N=55
Q15_4_Useful_NHCinteractions How useful to you and your EM team are each of these during TC threats? - Interactions with NHC forecasters (e.g., briefings, conference calls)	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 44.4% 2: 26.3% 3: 18% 4: 6% 5: 5.3% mean=2.02, SD=1.61 N=133	1: 53.3% 2: 30% 3: 10% 4: 6.7% 5: 0% mean=1.70, SD=0.92 N=30	1: 52.2% 2: 13% 3: 17.4% 4: 17.4% 5: 0% mean=2.00, SD=1.21 N=23	1: 45% 2: 40% 3: 12.5% 4: 2.5% 5: 0% mean=1.73, SD=0.78 N=40	1: 52.9% 2: 25.5% 3: 17.6% 4: 2.0% 5: 2.0% mean=1.75, SD=0.96 N=51	1: 39.3% 2: 39.3% 3: 17.9% 4: 3.6% 5: 0% mean=1.86, SD=0.85 N=28	1: 38.9% 2: 20.4% 3: 18.5% 4: 11.1% 5: 11.1% mean=2.35, SD=1.39 N=54
Q15_5_Useful_FEMAinteractions How useful to you and your EM team are each of these during TC threats? - Interactions with FEMA Hurricane Liaison Team	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 27.3% 2: 24.2% 3: 27.3% 4: 9.1% 5: 12.1% mean=2.55, SD=1.31 N=132	1: 23.3% 2: 26.7% 3: 23.3% 4: 13.3% 5: 13.3% mean=2.67, SD=1.35 N=30	1: 52.2% 2: 13% 3: 17.4% 4: 13% 5: 4.3% mean=2.04, SD=1.30 N=23	1: 27.5% 2: 25% 3: 32.5% 4: 12.5% 5: 2.5% mean=2.38, SD=1.10 N=40	1: 36.0% 2: 20.0% 3: 34.0% 4: 2.0% 5: 8.0% mean=2.26, SD=1.21 N=50	1: 21.4% 2: 28.6% 3: 32.1% 4: 7.1% 5: 10.7% mean=2.57, SD=1.23 N=28	1: 22.2% 2: 25.9% 3: 18.5% 4: 16.7% 5: 16.7% mean=2.80, SD=1.41 N=54

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q16_1_Useful_HURREVAC How useful to you and your EM team are each of these during TC threats? - HURREVAC/HVX	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 38.4% 2: 22.4% 3: 24.8% 4: 8.8% 5: 5.6% mean=2.21, SD=1.21 N=125	1: 65.5% 2: 27.6% 3: 3.4% 4: 0% 5: 3.4% mean=1.48, SD=0.87 N=29	1: 50% 2: 25% 3: 25% 4: 0% 5: 0% mean=1.75, SD=0.85 N=20	1: 46.4% 2: 21.4% 3: 21.4% 4: 7.1% 5: 3.6% mean=2.0, SD=1.20 N=28	1: 53.7% 2: 17.1% 3: 22.0% 4: 4.9% 5: 2.4% mean=1.85, SD=1.09 N=41	1: 46.2% 2: 19.2% 3: 30.8% 4: 0% 5: 3.8% mean=1.96, SD=1.08 N=26	1: 24.1% 2: 27.6% 3: 24.1% 4: 15.5% 5: 8.6% mean=2.57, SD=1.26 N=58
Q16_2_Useful_NWSChat How useful to you and your EM team are each of these during TC threats? - NWSChat	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 34.6% 2: 28.3% 3: 24.4% 4: 8.7% 5: 3.9% mean=2.19, SD=1.13 N=127	1: 41.4% 2: 34.5% 3: 17.2% 4: 6.9% 5: 0% mean=1.90, SD=0.94 N=29	1: 40% 2: 10% 3: 40% 4: 5% 5: 5% mean=2.25, SD=1.21 N=20	1: 32.1% 2: 21.4% 3: 32.1% 4: 7.1% 5: 7.1% mean=2.36, SD=1.22 N=28	1: 34.1% 2: 31.7% 3: 24.4% 4: 4.9% 5: 4.9% mean=2.15, SD=1.11 N=41	1: 34.6% 2: 23.1% 3: 26.9% 4: 15.4% 5: 0% mean=2.23, SD=1.11 N=26	1: 35.0% 2: 28.3% 3: 23.3% 4: 8.3% 5: 5.0% mean=2.20, SD=1.16 N=60
Q16_3_Useful_satobservations How useful to you and your EM team are each of these during TC threats? - Satellite observations	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 51.2% 2: 35.2% 3: 12% 4: 1.6% 5: 0% mean=1.64, SD=0.76 N=125	1: 51.7% 2: 17.2% 3: 24.1% 4: 6.9% 5: 0% mean=1.86, SD=1.03 N=29	1: 50% 2: 35% 3: 15% 4: 0% 5: 0% mean=1.65, SD=0.75 N=20	1: 72.4% 2: 20.7% 3: 6.9% 4: 0% 5: 0% mean=1.34, SD=0.61 N=29	1: 43.9% 2: 36.6% 3: 17.1% 4: 2.4% 5: 0% mean=1.78, SD=0.82 N=41	1: 64.0% 2: 24.0% 3: 8.0% 4: 4.0% 5: 0% mean=1.52, SD=0.82 N=25	1: 50.8% 2: 39.0% 3: 10.2% 4: 0% 5: 0% mean=1.59, SD=0.67 N=59
Q16_4_Useful_radarobservations How useful to you and your EM team are each of these during TC threats? - Radar observations	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 64.1% 2: 28.1% 3: 7.8% 4: 0% 5: 0% mean=1.44, SD=0.64 N=128	1: 62.1% 2: 20.7% 3: 17.2% 4: 0% 5: 0% mean=1.55, SD=0.78 N=29	1: 60% 2: 25% 3: 15% 4: 0% 5: 0% mean=1.55, SD=0.76 N=20	1: 72.4% 2: 24.1% 3: 3.4% 4: 0% 5: 0% mean=1.31, SD=0.54 N=29	1: 64.3% 2: 28.6% 3: 7.1% 4: 0% 5: 0% mean=1.43, SD=0.63 N=42	1: 73.1% 2: 23.1% 3: 3.8% 4: 0% 5: 0% mean=1.31, SD=0.55 N=26	1: 60.0% 2: 30.0% 3: 10.0% 4: 0% 5: 0% mean=1.50, SD=0.67 N=60

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q16_5_Useful_hurrhunterobservations How useful to you and your EM team are each of these during TC threats? - Hurricane Hunter observations	[-99 Missing - seen but unanswered] 1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 41.7% 2: 29.9% 3: 18.9% 4: 7.1% 5: 2.4% mean=1.98, SD=1.05 N=127	1: 41.4% 2: 31.0% 3: 27.6% 4: 0% 5: 0% mean=1.86, SD=0.83 N=29	1: 55% 2: 20% 3: 25% 4: 0% 5: 0% mean=1.70, SD=0.87 N=20	1: 62.1% 2: 27.6% 3: 10.3% 4: 0% 5: 0% mean=1.48, SD=0.69 N=29	1: 48.8% 2: 31.7% 3: 12.2% 4: 7.3% 5: 0% mean=1.78, SD=0.94 N=41	1: 57.7% 2: 30.8% 3: 11.5% 4: 0% 5: 0% mean=1.54, SD=0.71 N=26	1: 30.0% 2: 28.3% 3: 26.7% 4: 10.0% 5: 5.0% mean=2.32, SD=1.16 N=60
Q17_1_Understand_stormsurge How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Storm surge or coastal flooding	[-99 Missing - seen but unanswered] 1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 17.8% 2: 23.7% 3: 25.9% 4: 18.5% 5: 14.1% mean=2.87, SD=1.30 N=135	1: 25% 2: 17.9% 3: 25% 4: 21.4% 5: 10.7% mean=2.75, SD=1.35 N=28	1: 27.8% 2: 33.3% 3: 22.2% 4: 11.1% 5: 5.6% mean=2.33, SD=1.19 N=18	1: 28.2% 2: 30.8% 3: 33.3% 4: 7.7% 5: 0% mean=2.21, SD=0.95 N=39			
Q17_2_Understand_flooding How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Flooding from rainfall	[-99 Missing - seen but unanswered] 1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 42.6% 2: 33.1% 3: 17.6% 4: 5.1% 5: 1.5% mean=1.90, SD=0.97 N=136	1: 32.1% 2: 32.1% 3: 25% 4: 7.1% 5: 3.6% mean=2.18, SD=1.09 N=28	1: 50% 2: 22.2% 3: 16.7% 4: 11.1% 5: 0% mean=1.89, SD=1.08 N=18	1: 33.3% 2: 35.9% 3: 28.2% 4: 2.6% 5: 0% mean=2.00, SD=0.86 N=39			
Q17_3_Understand_tornadoes How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Tornadoes	[-99 Missing - seen but unanswered] 1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 38.2% 2: 33.8% 3: 22.8% 4: 5.1% 5: 0% mean=1.95, SD=0.91 N=136	1: 28.6% 2: 32.1% 3: 28.6% 4: 7.1% 5: 3.6% mean=2.25, SD=1.08 N=28	1: 33.3% 2: 33.3% 3: 33.3% 4: 0% 5: 0% mean=2.00, SD=0.84 N=18	1: 33.3% 2: 33.3% 3: 30.8% 4: 2.6% 5: 0% mean=2.03, SD=0.87 N=39			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q17_4_Understand_stormtrack How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Storm track	[-99 Missing - seen but unanswered] 1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 35.3% 2: 36% 3: 22.1% 4: 6.6% 5: 0% mean=2.00, SD=0.92 N=136	1: 35.7% 2: 32.1% 3: 21.4% 4: 7.1% 5: 3.6% mean=2.11, SD=1.10 N=28	1: 44.4% 2: 38.9% 3: 16.7% 4: 0% 5: 0% mean=1.72, SD=0.75 N=18	1: 48.7% 2: 33.3% 3: 15.4% 4: 2.6% 5: 0% mean=1.72, SD=0.83 N=39			
Q18_1_Understand_timingarrival How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Timing of storm arrival	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 30.2% 2: 38.1% 3: 30.2% 4: 1.6% 5: 0% mean=2.03, SD=0.82 N=126	1: 50% 2: 31.3% 3: 15.6% 4: 3.1% 5: 0% mean=1.72, SD=0.85 N=32	1: 50% 2: 30.8% 3: 19.2% 4: 0% 5: 0% mean=1.69, SD=0.79 N=26	1: 53.3% 2: 20% 3: 16.7% 4: 10% 5: 0% mean=1.83, SD=1.05 N=30			
Q18_2_Understand_stormintensity How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Storm intensity (Saffir-Simpson category)	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 26.8% 2: 33.1% 3: 32.3% 4: 7.1% 5: 0.8% mean=2.22, SD=0.95 N=127	1: 53.1% 2: 25% 3: 15.6% 4: 6.3% 5: 0% mean=1.75, SD=0.95 N=32	1: 57.7% 2: 26.9% 3: 11.5% 4: 3.8% 5: 0% mean=1.62, SD=0.85 N=26	1: 46.7% 2: 26.7% 3: 23.3% 4: 3.3% 5: 0% mean=1.83, SD=0.91 N=30			
Q18_3_Understand_windspeeds How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Storm wind speeds in different areas	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 30.5% 2: 27.3% 3: 33.6% 4: 7.8% 5: 0.8% mean=2.21, SD=0.99 N=128	1: 43.8% 2: 15.6% 3: 37.5% 4: 3.1% 5: 0% mean=2.00, SD=0.98 N=32	1: 46.2% 2: 34.6% 3: 19.2% 4: 0% 5: 0% mean=1.73, SD=0.78 N=26	1: 43.3% 2: 26.7% 3: 23.3% 4: 6.7% 5: 0% mean=1.93, SD=0.98 N=30			
Q18_4_Understand_uncertainty How well do you think the people who you interact with in your job understand each of the following types of forecast information? - Forecast uncertainty	1 Extremely well 2 Very well 3 Moderately well 4 Slightly well 5 Not well at all	1: 21.9% 2: 24.2% 3: 40.6% 4: 9.4% 5: 3.9% mean=2.49, SD=1.06 N=128	1: 31.3% 2: 28.1% 3: 28.1% 4: 9.4% 5: 3.1% mean=2.25, SD=1.10 N=32	1: 42.3% 2: 19.2% 3: 30.8% 4: 7.7% 5: 0% mean=2.04, SD=1.04 N=26	1: 30% 2: 30% 3: 26.7% 4: 13.3% 5: 0% mean=2.23, SD=1.04 N=30			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q19_1_Difficult_cone Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Track Forecast Cone (Cone of Uncertainty)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Track Forecast Cone (Cone of Uncertainty)	1: 22.4% N=58	1: 27.8% N=18	1: 0% N=9	1: 0% N=15			
Q19_2_Difficult_fivedayoutlook Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? 5-day Graphical Tropical Weather Outlook	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 5-day Graphical Tropical Weather Outlook	1: 21.3% N=61	1: 0% N=14	1: 18.2% N=11	1: 0% N=15			
Q19_3_Difficult_SPCoutlook Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? SPC Convective Outlook	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 SPC Convective Outlook	1: 27.6% N=58	1: 28.6% N=14	1: 25% N=8	1: 37.5% N=16			
Q19_4_Difficult_windspeedprobabilities Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? TC Wind Speed Probabilities	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Tropical Cyclone Wind Speed Probabilities	1: 16.7% N=60	1: 14.3% N=14	1: 20% N=10	1: 11.1% N=18			
Q19_5_Difficult_surgemap Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Potential Storm Surge Flooding Map	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Potential Storm Surge Flooding Map	1: 11.9% N=59	1: 7.1% N=14	1: 14.3% N=14	1: 8.3% N=12			
Q19_6_Difficult__stormsurgegraphic Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Storm Surge Watch/Warning Graphic	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Storm Surge Watch/Warning Graphic	1: 11.9% N=59	1: 0% N=14	1: 16.7% N=6	1: 11.8% N=17			
Q19_7_Difficult_weathergovwtchwrn Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Watches/Warnings on the weather.gov Webpage	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Watches/Warnings on the weather.gov Webpage	1: 6.7% N=60	1: 14.3% N=14	1: 11.1% N=9	1: 6.7% N=15			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q19_8_Difficult_arrivaltimewinds Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Arrival Time of Tropical-Storm-Force Winds	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Arrival Time of Tropical-Storm-Force Winds	1: 18.3% N=60	1: 28.6% N=14	1: 0% N=13	1: 8.3% N=12			
Q19_9_Difficult_hurrthreatgraphics Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Hurricane Threats and Impacts Graphics	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Hurricane Threats and Impacts Graphics	1: 15.5% N=58	1: 8.3% N=12	1: 7.7% N=13	1: 5.9% N=17			
Q19_10_Difficult_rainfalloutlooks Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Rainfall outlooks or forecasts	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Rainfall outlooks or forecasts	1: 8.3% N=60	1: 13.3% N=15	1: 0% N=10	1: 14.3% N=14			
Q19_11_Difficult_riverstageforecasts Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? River stage forecasts (hydrographs)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 River stage forecasts (hydrographs)	1: 19.4% N=62	1: 7.7% N=13	1: 30% N=10	1: 23.5% N=17			
Q19_12_Difficult_hurrlocalstatement Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Hurricane Local Statement	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Hurricane Local Statement	1: 12.1% N=58	1: 0% N=11	1: 0% N=5	1: 4.8% N=21			
Q19_13_Difficult_VTECproduct Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? Local office TC Watch/Warning VTEC (TCV) Product	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Local office Tropical Cyclone Watch/Warning VTEC (TCV) Product	1: 14.8% N=61	1: 7.7% N=13	1: 0% N=11	1: 0% N=18			
Q19_14_Difficult_none Which of these NWS products, if any, do you or your EM team find difficult to use when communicating with others during TC events? None of the above	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 None of the above	1: 68.2% N=258	1: 71.7% N=60	1: 76.7% N=43	1: 78.3% N=69			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q20_1_notenoughspecificinfo What makes this or the first of these difficult to use when communicating with others? - Selected Choice It isn't localized enough; doesn't provide information specific enough to my area	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 It isn't localized enough; doesn't provide information specific enough to my area	1: 59% N=83	1: 46.7% N=15	1: 44.4% N=9	1: 53.3% N=15			
Q20_2_toomuchtimetoundstd What makes this or the first of these difficult to use when communicating with others? - Selected Choice It takes too much time to understand	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 It takes too much time to understand	1: 31.3% N=83	1: 40% N=15	1: 55.6% N=9	1: 13.3% N=15			
Q20_3_stakeholdersdontwant What makes this or the first of these difficult to use when communicating with others? - Selected Choice Those I communicate with don't want me to use it	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Those I communicate with don't want me to use it	1: 6.0% N=83	1: 13.3% N=15	1: 22.2% N=9	1: 0% N=15			
Q20_4_toomuchinformation What makes this or the first of these difficult to use when communicating with others? - Selected Choice It provides too much information	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 It provides too much information	1: 7.2% N=83	1: 20% N=15	1: 0% N=9	1: 6.7% N=15			
Q20_5_other What makes this or the first of these difficult to use when communicating with others? - Selected Choice Other	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Other (please specify)	1: 18.1% N=83	1: 20% N=15	1: 33.3% N=9	1: 26.7% N=15			
Q20_5_TEXT_other What makes this or the first of these difficult to use when communicating with others? - Other - Text	[-99 Missing - seen but unanswered]	N=14	N=3	N=3	N=4			
Q21_NWSTCinfotools In my job, NWS TC forecast information and tools... Please select the response that best fits your judgment.	1 Are well aligned with my decision making timeline 2 Could be better timed to align with my decision making 3 Are not at all aligned with my decision making timeline	1: 79.5% 2: 17% 3: 3.4% mean=1.24, SD=0.5 N=264	1: 76.7% 2: 23.3% 3: 0% mean=1.23, SD=0.43 N=60	1: 81.8% 2: 15.9% 3: 2.3% mean=1.2, SD=0.46 N=44	1: 88.2% 2: 11.8% 3: 0% mean=1.12, SD=0.33 N=68			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q22_NWSgraphics When communicating about and coordinating decisions for TC threats, NWS graphics... Please select the response that best fits your judgment.	1 Meet my needs, I use them to communicate and coordinate "as is" 2 Meet most of my needs, I sometimes modify them to communicate and coordinate better 3 Only meet some of my needs, I communicate and coordinate better if I modify them 4 Are not useful as is, I have to modify them to communicate and coordinate 5 Are not useful, I don't use them	1: 46.2% 2: 51.1% 3: 1.5% 4: 0% 5: 1.1% mean=1.59, SD=0.64 N=262	1: 43.3% 2: 55% 3: 1.7% 4: 0% 5: 0% mean=1.58, SD=0.53 N=60	1: 65.1% 2: 30.2% 3: 4.7% 4: 0% 5: 0% mean=1.4, SD=0.58 N=43	1: 60.9% 2: 34.8% 3: 2.9% 4: 0% 5: 1.4% mean=1.46, SD=0.7 N=69			
Q23_1_Useful_intensityfivedays How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively? - Forecasts of storm intensity, provided more than 5 days out	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 44.7% 2: 30.3% 3: 18.9% 4: 4.5% 5: 1.5% mean=1.88, SD=0.97 N=132	1: 54.5% 2: 27.3% 3: 18.2% 4: 0% 5: 0% mean=1.64, SD=0.78 N=33	1: 60% 2: 30% 3: 10% 4: 0% 5: 0% mean=1.5, SD=0.69 N=20	1: 68.8% 2: 15.6% 3: 9.4% 4: 6.3% 5: 0% mean=1.53, SD=0.92 N=32	1: 52.0% 2: 30.0% 3: 18.0% 4: 0% 5: 0% mean=1.66, SD=0.77 N=50	1: 30.4% 2: 30.4% 3: 21.7% 4: 17.4% 5: 0% mean=2.26, SD=1.10 N=23	1: 44.1% 2: 30.5% 3: 18.6% 4: 3.4% 5: 3.4% mean=1.92, SD=1.04 N=59
Q23_2_Useful_stormtrackfivedays How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively? - Forecasts of storm track, provided more than 5 days out	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 44.7% 2: 34.8% 3: 15.2% 4: 3.8% 5: 1.5% mean=1.83, SD=0.93 N=132	1: 60.6% 2: 24.2% 3: 15.2% 4: 0% 5: 0% mean=1.55, SD=0.75 N=33	1: 60% 2: 30% 3: 5% 4: 5% 5: 0% mean=1.55, SD=0.83 N=20	1: 65.6% 2: 18.8% 3: 9.4% 4: 6.3% 5: 0% mean=1.56, SD=0.91 N=32	1: 54.0% 2: 28.0% 3: 16.0% 4: 2.0% 5: 0% mean=1.66, SD=0.82 N=50	1: 39.1% 2: 30.4% 3: 21.7% 4: 8.7% 5: 0% mean=2.0 0SD=1.00 N=23	1: 39.0% 2: 42.4% 3: 11.9% 4: 3.4% 5: 3.4% mean=1.90, SD=0.98 N=59
Q23_3_Useful_stormsurge48hours How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively? - Forecasts of storm surge, provided more than 48 hours out	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 38.6% 2: 15.9% 3: 13.6% 4: 9.8% 5: 22% mean=2.61, SD=1.60 N=132	1: 48.5% 2: 18.2% 3: 6.1% 4: 15.2% 5: 12.1% mean=2.24, SD=1.50 N=33	1: 60% 2: 15% 3: 10% 4: 15% 5: 0% mean=1.8, SD=1.15 N=20	1: 53.1% 2: 25% 3: 12.5% 4: 3.1% 5: 6.3% mean=1.84, SD=1.17 N=32	1: 70.0% 2: 18.0% 3: 10.0% 4: 2.0% 5: 0% mean=1.44, SD=0.76 N=50	1: 21.7% 2: 8.7% 3: 17.4% 4: 17.4% 5: 34.8% mean=3.35 SD=1.58 N=23	1: 18.6% 2: 16.9% 3: 15.3% 4: 13.6% 5: 35.6% mean=3.31, SD=1.56 N=59

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q23_4_Useful_forecastsonsetsurge How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively? - Forecasts of timing of onset of storm surge	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 39.4% 2: 12.1% 3: 15.9% 4: 8.3% 5: 24.2% mean=2.66, SD=1.63 N=132	1: 48.5% 2: 18.2% 3: 6.1% 4: 15.2% 5: 12.1% mean=2.24, SD=1.50 N=33	1: 65% 2: 10% 3: 20% 4: 5% 5: 0% mean=1.65, SD=0.99 N=20	1: 59.4% 2: 18.8% 3: 12.5% 4: 3.1% 5: 6.3% mean=1.78, SD=1.18 N=32	1: 76.0% 2: 14.0% 3: 10.0% 4: 0% 5: 0% mean=1.34, SD=0.66 N=50	1: 17.4% 2: 13.0% 3: 13.0% 4: 17.4% 5: 39.1% mean=3.48 SD=1.56 N=23	1: 16.9% 2: 10.2% 3: 22.0% 4: 11.9% 5: 39.0% mean=3.46, SD=1.51 N=59
Q24_1_Useful_durationtropicalwinds How useful would it be for you to have the following, if the NWS could provide them accurately and effectively? - Forecasts of duration of sustained tropical-storm-force winds	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 57.9% 2: 30.8% 3: 9.0% 4: 2.3% 5: 0% mean=1.56, SD=0.75 N=133	1: 70.4% 2: 25.9% 3: 3.7% 4: 0% 5: 0% mean=1.33, SD=0.55 N=27	1: 54.2% 2: 41.7% 3: 4.2% 4: 0% 5: 0% mean=1.5, SD=0.59 N=24	1: 62.2% 2: 32.4% 3: 5.4% 4: 0% 5: 0% mean=1.43, SD=0.60 N=37	1: 55.6% 2: 37.8% 3: 6.7% 4: 0% 5: 0% mean=1.51, SD=0.63 N=45	1: 67.7% 2: 29.0% 3: 3.2% 4: 0% 5: 0% mean=1.35 SD=0.55 N=31	1: 54.4% 2: 26.3% 3: 14.0% 4: 5.3% 5: 0% mean=1.70, SD=0.91 N=57
Q24_2_Useful_endofhazconditions How useful would it be for you to have the following for your work, if the NWS could provide them accurately and effectively? - Forecasts of when hazardous conditions will end	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 51.1% 2: 33.8% 3: 12% 4: 3% 5: 0% mean=1.67, SD=0.81 N=133	1: 63.0% 2: 33.3% 3: 3.7% 4: 0% 5: 0% mean=1.41, SD=0.57 N=27	1: 62.5% 2: 33.3% 3: 4.2% 4: 0% 5: 0% mean=1.42, SD=0.58 N=24	1: 64.9% 2: 27% 3: 5.4% 4: 2.7% 5: 0% mean=1.46, SD=0.73 N=37	1: 55.6% 2: 31.1% 3: 13.3% 4: 0% 5: 0% mean=1.58, SD=0.72 N=45	1: 51.6% 2: 29.0% 3: 16.1% 4: 3.2% 5: 0% mean=1.71 SD=0.86 N=31	1: 47.4% 2: 38.6% 3: 8.8% 4: 5.3% 5: 0% mean=1.72, SD=0.84 N=57
Q24_3_Useful_compilingNWSproducts How useful would it be to have - Compiling available info in one place, making it easier to access all NWS products that relate to a particular storm	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 63.2% 2: 27.8% 3: 6.0% 4: 3.0% 5: 0% mean=1.49, SD=0.75 N=133	1: 70.4% 2: 25.9% 3: 0% 4: 3.7% 5: 0% mean=1.37, SD=0.69 N=27	1: 62.5% 2: 25% 3: 8.3% 4: 4.2% 5: 0% mean=1.54, SD=0.83 N=24	1: 73% 2: 21.6% 3: 5.4% 4: 0% 5: 0% mean=1.32, SD=0.58 N=37	1: 71.1% 2: 20.0% 3: 8.9% 4: 0% 5: 0% mean=1.38, SD=0.65 N=45	1: 54.8% 2: 35.5% 3: 6.5% 4: 3.2% 5: 0% mean=1.58 SD=0.77 N=31	1: 61.4% 2: 29.8% 3: 3.5% 4: 5.3% 5: 0% mean=1.53, SD=0.80 N=57
Q24_4_Useful_compilinghazriskinfo How useful would it be to have, if the NWS could provide them accurately and effectively? - Summary product compiling key hazard and risk information for a particular storm	1 Extremely useful 2 Very useful 3 Moderately useful 4 Slightly useful 5 Not at all useful	1: 54.9% 2: 37.6% 3: 6.8% 4: 0.8% 5: 0% mean=1.53, SD=0.66 N=133	1: 74.1% 2: 22.2% 3: 3.7% 4: 0% 5: 0% mean=1.30, SD=0.54 N=27	1: 70.8% 2: 20.8% 3: 0% 4: 8.3% 5: 0% mean=1.46, SD=0.88 N=24	1: 73% 2: 16.2% 3: 10.8% 4: 0% 5: 0% mean=1.38, SD=0.68 N=37	1: 55.6% 2: 40.0% 3: 4.4% 4: 0% 5: 0% mean=1.49, SD=0.59 N=45	1: 48.4% 2: 38.7% 3: 9.7% 4: 3.2% 5: 0% mean=1.68 SD=0.79 N=31	1: 57.9% 2: 35.1% 3: 7.0% 4: 0% 5: 0% mean=1.49, SD=0.63 N=57

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q25_mostimpchangemorethan120hours Single most important change the NWS could make to improve its TC storm forecast and warning information, tools and services? For more than 120 hours (5 days) before a storm		N=66	N=25	N=19	N=27			
Q26_mostimpchange120to48hours For 120 hours (5 days) to 48 hours before a storm impacts your area:		N=74	N=23	N=18	N=23			
Q27_mostimpchange48hourstoimpacts For 48 hours before a storm impacts your area through impacts:		N=71	N=24	N=18	N=28			
Q28_rateWFOduringtropicalcyclone How would you rate your interactions with your local NWS Forecast Office(s) during TC threats?	1 Excellent 2 Good 3 Average 4 Poor 5 Terrible	1: 65.4% 2: 27% 3: 7.2% 4: 0.4% 5: 0% mean=1.43, SD=0.64 N=263	1: 81.7% 2: 15% 3: 3.3% 4: 0% 5: 0% mean=1.22, SD=0.49 N=60	1: 65.9% 2: 22.7% 3: 11.4% 4: 0% 5: 0% mean=1.45, SD=0.70 N=44	1: 57.4% 2: 39.7% 3: 2.9% 4: 0% 5: 0% mean=1.46, SD=0.56 N=68			
Q29_covidaffectpreparation How much has COVID-19 affected the ways that you prepare or respond to TC threats, or advise your communities to prepare?	1 A great deal 2 A lot 3 A moderate amount 4 A little 5 Not at all	1: 17% 2: 18.9% 3: 29.1% 4: 23.4% 5: 11.7% mean=2.94, SD=1.25 N=265	1: 20% 2: 21.7% 3: 30% 4: 16.7% 5: 11.7% mean=2.78, SD=1.28 N=60	1: 16.3% 2: 23.3% 3: 32.6% 4: 20.9% 5: 7% mean=2.80, SD=1.20 N=43	1: 17.6% 2: 23.5% 3: 30.9% 4: 20.6% 5: 7.4% mean=2.76, SD=1.19 N=68			
Q30_gender What is your gender? - Selected Choice	1 Male 2 Female 3 Non-binary / third gender 4 Prefer not to say 5 Other	1: 83.4% 2: 14.3% 3: 0% 4: 1.9% 5: 0.4% mean=1.22, SD=0.57 N=265	1: 60% 2: 38.3% 3: 0% 4: 1.7% 5: 0% mean=1.43, SD=0.59 N=60	1: 75% 2: 20.5% 3: 2.3% 4: 2.3% 5: 0% mean=1.32, SD=0.64 N=44	1: 63.2% 2: 33.8% 3: 1.5% 4: 1.5% 5: 0% mean=1.41, SD=0.60 N=68			
Q30_5_TEXT_gender_other What is your gender? - Other - Text		N=1	N=0	N=0	N=0			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q31_hispanic Are you Hispanic?	[-99 Missing - seen but unanswered] 1 Yes 2 No	1: 3.8% 2: 96.2% mean=1.96, SD=0.19 N=260	1: 5.1% 2: 94.9% mean=1.95, SD=0.22 N=59	1: 6.8% 2: 93.2% mean=1.93, SD=0.26 N=44	1: 10.3% 2: 89.7% mean=1.90, SD=0.31 N=68			
Q32_1_race_asian Please indicate all that you identify as. - Selected Choice Asian	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Asian	1: 0.4% N=259	1: 3.4% N=58	1: 2.3% N=44	1: 0% N=67			
Q32_2_race_black Please indicate all that you identify as. - Selected Choice Black or African American	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Black or African American	1: 2.7% N=259	1: 5.2% N=58	1: 4.5% N=44	1: 1.5% N=67			
Q32_3_race_native Please indicate all that you identify as. - Selected Choice Native American or Alaska Native	[-99 Missing - seen but unanswered] 0 Missing - seen but unanswered multi-value 1 Native American or Alaska Native	1: 2.3% N=259	1: 1.7% N=58	1: 2.3% N=44	1: 4.5% N=67			
Q32_4_race_islander Please indicate all that you identify as. - Selected Choice Native Hawaiian or other Pacific Islander	[-99 Missing - seen but unanswered 0 Missing - seen but unanswered multi-value 1 Native Hawaiian or other Pacific Islander	1: 0% N=259	1: 1.7% N=58	1: 0% N=44	1: 0% N=67			
Q32_5_race_white Please indicate all that you identify as. - Selected Choice White	[-99 Missing - seen but unanswered 0 Missing - seen but unanswered multi-value 1 White	1: 95% N=259	1: 96.6% N=58	1: 93.2% N=44	1: 97% N=67			
Q32_6_race_other Please indicate all that you identify as. - Selected Choice Some other race (write-in)	[-99 Missing - seen but unanswered 0 Missing - seen but unanswered multi-value 1 Some other race (write-in)	1: 2.3% N=259	1: 3.4% N=58	1: 6.8% N=44	1: 1.5% N=67			
Q32_6_TEXT_race_other Please indicate all that you identify as. - Some other race (write-in) - Text	[-99 Missing - seen but unanswered]	N=5	N=2	N=2	N=1			
Q33_1_training_EMT What types of emergency responder training do you have? - Selected Choice Emergency medical technician or paramedic	0 Received question - did not check 1 Emergency medical technician or paramedic	1: 43.4% N=265	1: 42.4% N=59	1: 14% N=43	1: 20.6% N=68			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q33_2_training_firefighter What types of emergency responder training do you have? - Selected Choice Firefighter	0 Received question - did not check 1 Firefighter	1: 59.6% N=265	1: 37.3% N=59	1: 23.3% N=43	1: 17.6% N=68			
Q33_3_training_lawenforce What types of emergency responder training do you have? - Selected Choice Law enforcement	0 Received question - did not check 1 Law enforcement	1: 34% N=265	1: 23.7% N=59	1: 16.3% N=43	1: 14.7% N=68			
Q33_4_training_other What types of emergency responder training do you have? - Selected Choice Other	0 Received question - did not check 1 Other (please specify)	1: 30.2% N=265	1: 28.8% N=59	1: 27.9% N=43	1: 39.7% N=68			
Q33_5_training_none What types of emergency responder training do you have? - Selected Choice None of the above	0 Received question - did not check 1 None of the above	1: 13.2% N=265	1: 28.8% N=59	1: 41.9% N=43	1: 35.3% N=68			
Q33_4_TEXT_trainingother What types of emergency responder training do you have? - Other - Text		N=79	N=15	N=12	N=25			
Q34_1_certification_IAEM_AEM Certification - Selected Choice IAEM Associate Emergency Manager (AEM®)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 IAEM Associate Emergency Manager (AEM®)	1: 1.2% N=252	1: 3.6% N=56	1: 0% N=41	1: 3.2% N=63			
Q34_2_certification_IAEM_CEM Certification - Selected Choice IAEM Certified Emergency Manager (CEM®)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 IAEM Certified Emergency Manager (CEM®)	1: 6.3% N=252	1: 14.3% N=56	1: 7.3% N=41	1: 3.2% N=63			
Q34_3_certification_FEMA_PDS Certification - Selected Choice FEMA Professional Development Series (PDS)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 FEMA Professional Development Series (PDS) certificate	1: 36.1% N=252	1: 60.7% N=56	1: 22% N=41	1: 20.6% N=63			
Q34_4_certification_FEMA_APS Certification - Selected Choice FEMA Advanced Professional Series (APS) cer	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 FEMA Advanced Professional Series (APS) certificate	1: 13.5% N=252	1: 41.1% N=56	1: 12.2% N=41	1: 9.5% N=63			
Q34_5_certification_StateEM Certification - Selected Choice State EM accreditation or	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 State Emergency Management accreditation or certification	1: 50.8% N=252	1: 46.4% N=56	1: 36.6% N=41	1: 14.3% N=63			
Q34_6_certification_Other Certification - Selected Choice Other (please describe)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Other (please describe)	1: 5.2% N=252	1: 10.7% N=56	1: 4.9% N=41	1: 6.3% N=63			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q34_7_certification_None Certification - Selected Choice None of the above	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 None of the above	1: 31.3% N=252	1: 23.2% N=56	1: 43.9% N=41	1: 63.5% N=63			
Q34_6_TEXT_Other Certification - Other (please describe) - Text		N=13	N=6	N=2	N=4			
Q35_1_degree_highschool Degree - Selected Choice High school diploma or GED	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 High school diploma or GED	1: 39.6% N=260	1: 30.5% N=59	1: 9.1% N=44	1: 22.1% N=68			
Q35_2_degree_degree_AAorAS Degree - Selected Choice AA or AS	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 AA or AS	1: 19.2% N=260	1: 16.9% N=59	1: 15.9% N=44	1: 16.2% N=68			
Q35_3_degree_BAorBS_EM Degree - Selected Choice BA or BS in EM	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 BA or BS in emergency management	1: 5.4% N=260	1: 6.8% N=59	1: 4.5% N=44	1: 5.9% N=68			
Q35_4_degree_BAorBS_other Degree - Selected Choice BA or BS in another discipline	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 BA or BS in another discipline (please specify)	1: 36.5% N=260	1: 45.8% N=59	1: 50% N=44	1: 42.6% N=68			
Q35_5_degree_MAorMS_EM Degree - Selected Choice MA or MS in EM	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 MA or MS in emergency management	1: 5% N=260	1: 11.9% N=59	1: 6.8% N=44	1: 5.9% N=68			
Q35_6_degree_MAorMS_other Degree - Selected Choice MA or MS in another discipline	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 MA or MS in another discipline (please specify)	1: 15% N=260	1: 32.2% N=59	1: 18.2% N=44	1: 27.9% N=68			
Q35_7_degree_PhD Degree - Selected Choice PhD (please specify discipline)	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 PhD (please specify discipline)	1: 2.3% N=260	1: 3.4% N=59	1: 2.3% N=44	1: 1.5% N=68			
Q35_8_degree_Other Degree - Selected Choice Other degrees, diplomas or credits	[-99 Missing - seen but unanswered] 0 Received question - did not check 1 Other degrees, diplomas or credits (please specify)	1: 10.8% N=260	1: 5.1% N=59	1: 2.3% N=44	1: 16.2% N=68			
Q35_4_TEXT_degree_BAorBS_other Degree - BA or BS in another discipline - Text		N=83	N=22	N=16	N=28			

Variable name and wording of survey question / item (EM survey)	Response options and coding	Descriptive statistics - targeted sample	Descriptive statistics - convenience sample, group 2	Descriptive statistics - convenience sample, group 1	Descriptive statistics - convenience sample, group 3	Descriptive statistics - targeted sample - coastal	Descriptive statistics - targeted sample - near-coastal	Descriptive statistics - targeted sample - inland
Q35_6_TEXT_degree_MAorMS_other Degree - MA or MS in another discipline - Text		N=35	N=18	N=6	N=18			
Q35_7_TEXT_degree_PhD Degree - PhD (please specify discipline) - Text		N=4	N=1	N=1	N=1			
Q35_8_TEXT_degree_Other Degree - Other degrees, diplomas or credits - Text		N=27	N=3	N=0	N=10			
Q36_additionalthoughts Is there anything else you feel we should know to understand your views about any topic(s) on this survey? If so, briefly tell us here:		N=43	N=17	N=8	N=17			

APPENDIX F. COMPARISON OF TARGETED AND CONVENIENCE EMERGENCY MANAGER SAMPLES

As described in section 2.2 and Appendix E, in addition to the targeted survey sample that is the focus of this report, the research team also obtained survey data from a second, convenience sample. The convenience sample was recruited by several members of the NEMA Hurricane Subcommittee via email to their emergency management networks. To help inform design and implementation of future emergency management surveys, this appendix provides additional information about the two samples, including a high-level comparison of the types of respondents.

Key characteristics of the two samples are summarized in Table F-1; additional data can be found in Appendix E. Although there is overlap in the types of emergency managers in the two samples, there are also noticeable differences. In particular, compared to the targeted sample, the convenience sample includes fewer local emergency managers, and it includes more respondents who selected "other" for their type of emergency management position as well as those who said their jobs are full time but involve emergency management part time (Table F-1). Consistent with this, when asked "What jurisdiction, state, or organization do you work for?", most respondents in the targeted sample said they worked for cities, counties, or governmental emergency management organizations. Some respondents in the convenience sample worked for these same types of organizations; however, many worked for other types of governmental organizations, businesses, or non-profits, in sectors such as health care, transportation, utilities, education, or social services. As one might anticipate given these differences, the convenience sample also differs from the targeted sample in terms of job roles when TCs threaten, as well as training and education (Table F-1).

An additional difference between the samples is their geographic distribution. Approximately two-thirds of respondents in the convenience sample were located in Florida, likely due to more effective email distribution of the survey within the Florida emergency management network. As discussed in section 4.1.1, respondents in the targeted sample are more evenly distributed across the study area, although this sample included few respondents in Florida. In this regard, the two samples are complementary, suggesting the potential for combining them after further curation of the data.

As a first step towards understanding the underrepresentation of Florida in the targeted sample, Table F-2 shows the number of EM survey respondents in each state, along with the number of EMs in each state on the list of 1,833 EMs gathered in the initial search for contact information (described in section 2.2.1). The contact list included 74 EMs in Florida, but only 2 responded; this suggests that the contact list may have included more out-of-date information for Florida EMs, or that a large number of the Florida EM emails may have bounced or been filtered as spam. Massachusetts, on the other hand, had the largest number of respondents not because of an atypically high response rate, but because of the larger number of EMs for whom contact information was collected. This suggests that the inconsistency in EM contact information available across different states may have contributed to some imbalances in geographic representation, which may be valuable to address in future work.

Overall, this comparison indicates that the targeted sampling strategy had several advantages for this study. These include recruiting a sample that exhibits much of the desired geographic diversity and that focuses on respondents who work in emergency management job roles that serve as core NWS partners when TC threatens. The convenience sampling strategy was less successful at accomplishing these two goals. However, the targeted sampling strategy took significant time and effort to design and implement, and it resulted in some biases (such as the geographical bias noted) that would be beneficial to address in future studies. Thus, these two sampling strategies have complementary strengths and weaknesses for consideration in future related work, based on study goals and available resources. Recent survey analysis methods for combining convenience and random samples may also be worth exploring (e.g., Elliott and Haviland 2007, Wiśniowski et al. 2020).

Table F-1. Characteristics of the targeted and convenience emergency manager survey samples. Data shown are for valid (non-missing) responses for each question, out of N=265 (targeted sample) and N=173 (convenience sample). EM=emergency manager or emergency management.

Characteristic	**Targeted sample**	**Convenience sample**
Time to complete survey: median, in seconds	629	630
Years working in EM: mean (range)	15.6 (0–50)	14.7 (0–42)
Years working in EM in regions affected by TCs: mean (range)	13.3 (0–50)	13.5 (0–42)
Type of job in EM (select one)		
Full-time	61.9%	52.3%
Part-time	14.0%	6.4%
Full-time, but only part in EM	18.1%	32.0%
Unpaid intern or volunteer	1.5%	3.5%
Other	4.5%	5.8%
Best description of current position (select all that apply)		
Local (city or county) EM	90.2%	35.9%
State EM	5.3%	17.6%
Federal or regional (multi-state) EM	0.4%	8.2%
Tribal EM	0.4%	0%
Other	5.7%	42.9%
Main job roles when a TC threatens (select all that apply)		
Making or coordinating EM decisions	92.4%	78.0%
Tracking threat / gathering and interpreting forecast information	80.7%	67.1%
Interacting with elected government officials	80.3%	41.0%
Raising situational awareness in office	76.5%	66.5%
Communicating with the media or members of the public	68.9%	28.3%
Supervising or managing staff	66.3%	60.1%
Other	4.9%	17.3%
Types of emergency responder training (select all that apply)		
Firefighter	59.6%	25.9%

Characteristic	Targeted sample	Convenience sample
Emergency medical technician or paramedic	43.4%	26.5%
Law enforcement	34.0%	18.2%
Other	30.2%	32.9%
None	13.2%	34.7%
Certifications (select all that apply)		
State EM accreditation or certification	50.8%	31.3%
FEMA Professional Development Series certificate	36.1%	35.0%
FEMA Advanced Professional Series certificate	13.5%	21.3%
IAEM Certified Emergency Manager	6.3%	8.1%
IAEM Associate Emergency Manager	1.2%	2.5%
Other	5.2%	7.5%
None of the above	31.3%	44.4%
Educational degrees (select all that apply)		
High school diploma or GED	39.6%	21.6%
AA or AS	19.2%	16.4%
BA or BS in emergency management	5.4%	5.8%
BA or BS in another discipline	36.5%	45.6%
MA or MS in emergency management	5.0%	8.2%
MA or MS in another discipline	15.0%	26.9%
PhD	2.3%	2.3%
Other degrees, diplomas, or credits	10.8%	8.8%
Gender (select one)		
Male	83.4%	65.1%
Female	14.3%	32.0%
Non-binary / third gender	0%	1.2%
Prefer not to say	1.9%	1.7%
Other	0.4%	0%
Race (select all that apply)		
White	95.0%	95.9%
Black or African American	2.7%	3.6%
Native American or Alaska Native	2.3%	3.0%
Asian	0.4%	1.8%
Native Hawaiian or other Pacific Islander	0%	0.6%
Other	2.3%	3.6%
Hispanic (% yes)	3.8%	7.6%

Table F-2. Number of emergency manager survey respondents in each state in the targeted sample, compared with the number of emergency managers in each state on the initial contact list.

State	Number of EM survey respondents	Number of EMs on contact list	% of EMs responding to survey
Alabama	12	68	17.6%
Arkansas	12	74	16.2%
Connecticut	0	5	0.0%
Delaware	1	4	25.0%
District of Columbia	0	9	0.0%
Florida	2	74	2.7%
Georgia	27	161	16.8%
Kentucky	4	23	17.4%
Louisiana	19	79	24.1%
Maine	7	21	33.3%
Maryland	12	32	37.5%
Massachusetts	40	373	10.7%
Mississippi	11	89	12.4%
Missouri	1	12	8.3%
New Hampshire	0	4	0.0%
New Jersey	8	43	18.6%
New York	7	40	17.5%
North Carolina	13	102	12.7%
Oklahoma	0	31	0.0%
Pennsylvania	5	30	16.7%
Rhode Island	8	37	21.6%
South Carolina	16	55	29.1%
Tennessee	10	96	10.4%
Texas	30	168	17.9%
Vermont	1	18	5.6%
Virginia	17	159	10.7%
West Virginia	2	26	7.7%