Title:

Climate and Weather Services for Disaster Management: A FEMA, NWS, and CLIMAS Collaboration

Competition

Research Partnerships in Support of Regional Climate Adaptation
Federal Funding Opportunity Number: NOAA-OAR-CPO-2012-2003304

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Abstract. The Federal Emergency Management Agency (FEMA) plays a critical role in supporting land, water, and coastal managers prepare for and respond to weather- and climate-driven extreme events. Challenges to accessing, interpreting, and disseminating diverse climate and weather (C&W) information, however, limit FEMA's use of this information, which can hinder the pre-positioning of resources and personnel in high-risk areas, limit the utilization of advanced warnings, and spur misunderstanding. Strategic partnerships that link information producers and consumers and provide opportunities for the co-development of useful C&W information can help agencies like FEMA better fulfill their mission to safeguard life and property. We propose a climate services case study that examines the process of developing strategic partnerships, communication strategies, and relevant C&W information to support FEMA's hazards monitoring efforts in Arizona, Nevada, and California. This study examines the end-to-end process of decision support and will be conducted within a framework advocated by the National Research Council. This incudes: (1) assessing FEMA's C&W information needs and gaps; (2) co-producing a decision support tool; and (3) measuring impacts, successes, and limitations of the decision-support tool, engagement process, and partnership. The objectives are to better understand how to provide climate services and develop strategies that seamlessly transition from research to operations, while assessing the role of 'boundary organizations' (e.g. RISAs) in developing and mediating partnerships that advance climate services and long-term adaptation efforts. This project is a collaboration between the Climate Assessment for the Southwest (CLIMAS), the western regional headquarters of the NOAA-National Weather Service, and FEMA.

1.0 Statement of Problem and Background

1.1. Introduction. The arid West is sensitive to slow-developing climate hazards such as drought (Meko et al 2008) which, in turn, primes the landscape for wildland fires (Williams et al 2010). The West is also prone to fast-developing, catastrophic events such as floods generated by summer monsoon storms, winter atmospheric rivers, rapid snowmelt, and Pacific hurricanes. Many of these and other extreme events unfold in a context preconditioned by natural climate variability and recent trends that are quasi-predictable over seasonal timescales. As a result, skill has been demonstrated in seasonal climate forecasts, and this has helped increase demand for climate information (Solomon and Dole 2009; McPhaden et al 2006), including by those charged with disaster preparation (e.g. Patt et al 2007). The supply of climate information is also on the rise, but connecting supply and demand chains has been challenging. Too often, for example, the spatial and temporal scales of climate and weather (C&W) information produced by operational organizations and those used by practitioners do not match (Srinivasan 2011; McNie 2007). In other cases, C&W information can be (or can be perceived to be) inaccessible and misunderstood by practitioners (NRC 2010; Steinemann 2009). Also, the lack of collaboration between scientists and stakeholders can result in information not aligning with stakeholder needs, scientific literacy, or information processing and management abilities (Srinivasan 2011, Lemos and Morehouse 2005). In disaster management, Choo (2009) noted that the failure to consider disaster early warning systems as comprised of people, resources, and technology can lead to disaster signals to be missed or unheeded.

The Federal Emergency Management Agency (FEMA) has identified several of these C&W information services challenges as barriers to helping their constituent populations, including land, water, and coastal managers, prepare for, respond to, and recover from hazards. Many of the hazards FEMA responds to are directly influenced by climate and weather extreme events and cause billions of dollars in damage each year. Between January 2000 and March

2007, for example, the U.S. President declared 34 climate-related disasters in FEMA's region 9, which includes Arizona, Nevada, California, and the Pacific Islands (Data.gov 2012). The FEMA Public Assistance Program alone distributed more than $2 billion for recovery aid in Arizona, California, and Nevada (hereafter Southwest) since 1999 (Data.gov 2012). Because FEMA annually makes large capital investments in preparing for and responding to hazards, connecting the best available C&W information to FEMA planners and decision makers has the potential to improve FEMA resource allocation and planning which, in turn, can help safeguard life and property.

Many of the challenges in communicating and delivering C&W information can be minimized, if not overcome, by creating processes that avoid separating information creation from its application (NRC 2010; Lemos and Morehouse 2005). Partnerships between C&W information producers like the National Weather Service (NWS) and consumers such as FEMA can facilitate mutual learning where producers advance their understanding of decision contexts and capacities of consumers, while consumers learn the limitations of the information and uncover hidden opportunities. A high-functioning relationship between information producers and consumers can support a more effective and appropriate use of C&W information, helping to advance climate adaptation (Howden et al 2007) and fostering successful climate policy and planning (Solomon and Dole 2009; Moser 2010). A strong and strategic partnership is also vital to transferring experimental climate services to enduring operations.

The NWS is a critical partner for FEMA because reliable weather, climate, and water information—services that the NWS develops and provides—are crucial components of early warnings of extreme events (Srinivasan 2011). Facilitating a partnership between FEMA and the NOAA-NWS that produces tailored C&W services as well as a deeper understanding of the other organization's capacity can help spur action (e.g. Cash et al 2003). It also creates an opportunity to study the strategies and roles in the co-development of decision support tools between two operational organizations mediated by a boundary organization, the Climate Assessment for the Southwest (CLIMAS).

1.2. Problem Statements. Decision-makers in the Southwest portion of FEMA region 9 have difficulty accessing, interpreting, and disseminating C&W information within their network, which impedes the flow of accurate information to on-the-ground disaster preparation and recovery efforts (S. Bryson, *pers. comm.).* These challenges arise, in part, because C&W service providers are unaware of FEMA's information needs and the decision context that influences information use and dissemination, and because FEMA staff need greater C&W literacy in order to more quickly and accurately assess information (S. Bryson, *pers. comm.).* Strategic collaborations between FEMA and operational organizations like the NWS have been under-utilized despite potential for these partnerships to develop customized products and provide expertise that would help FEMA overcome the aforementioned challenges. **We propose to develop and fortify relationships between FEMA, NOAA-NWS, and CLIMAS through a process designed to identify FEMA's C&W information needs, develop a useful decision-support product with an effective delivery strategy, and evaluate the engagement process and the outcome of the collaboration.**

1.3. Motivation. The partnership and co-production of a routine C&W decision-support tool is motivated by three factors. First, FEMA managers approached the NWS seeking a better, more concise way to understand potential hazards to which they may respond. Although FEMA currently uses C&W information, amassing it is time consuming and often causes misinterpretations due to the technical jargon used to communicate it (S. Bryson, *pers. comm.*).

Moreover, based on initial discussions between CLIMAS, the NOAA-NWS, and FEMA representatives it is unclear if FEMA is utilizing the right information. Second, the production of a tangible product, referred to in the literature as a boundary object (Guston 1999), satisfies the different agendas of the parties involved—they allow scholars to study the process and practitioners to use them. In addition, boundary objects can increase the salience, credibility, and legitimacy of the information produced, which research suggests increases the use of science in decision-making (Cash et al., 2003). And finally, CLIMAS has a long history of producing useful climate synthesis products, including the Southwest Climate Outlook (SWCO) and the La Niña Drought Tracker (LNDT). This experience informs the experimental design of this proposal. For example, evaluating the LNDT revealed that climate syntheses that amalgamate and interpret information increases understanding and informs important resource management decisions (Guido et al *in review*). In addition, a test period in which stakeholders provided feedback that refines subsequent versions helped build ownership of the SWCO, which has helped it remain an important resource for decision makers in Arizona and New Mexico since publishing began in 2002. Both of these insights are integral to our research and service strategy (described below).

1.4. Research objectives. The objective of this project is to determine best practices for the provision of C&W services that aid the disaster response and recovery activities of FEMA and, by extension, other emergency management organizations. To accomplish this, we propose to study the end-to-end process of connecting C&W information to emergency management by co-creating a C&W information product.

Research will advance through three phases—assessment, co-production, and evaluation. The objective of each, respectively, is to: (1) understand how C&W information is used by FEMA, including the institutional context that facilitates and hinders use; (2) create a tailored product that synthesizes C&W information to inform FEMA operations and that can be maintained by the NOAA-NWS (a negotiated product that meets the needs and constraints of both institutions); and (3) evaluate the efficacy and sustainability of the information product and process from both NOAA-NWS and FEMA perspectives.

1.5. Decision Support Framework. The research and service objectives will occur within a decision support framework endorsed by the National Research Council (2010). Traditionally, C&W information has been served through the ‘‘loading dock’’ approach where scientists are the primary developers of information, often without specified application for society, and stakeholders are passive recipients of that information (Dilling and Lemos 2011). This approach puts the onus on the users to correctly interpret the information and modify it to meet their needs, which is not always done or even possible. The loading dock approach is often not effective at reaching intended audiences (Cash et al 2006) for, among other reasons, neglect of the decision and institutional context within which information is used (e.g. Rayner et al 2005) and the specific needs of the decision-maker (NRC 2010).

Summarizing lessons learned from a rich body of knowledge, the National Research Council (2010) lists six “Principles of Effective Decision Support.” Our research design follows these principles.

1. **Begin with users’ needs.** An initial needs assessment of FEMA managers will guide all subsequent activities and have mutual benefits that endure after the project ends.
2. **Give priority to processes over products**. Our engagement strategy will focus on co-producing a C&W synthesis decision support product, which will enable meeting mutual goals of the collaboration. Focusing engagement around a “boundary object” has been shown to foster effective collaborations (Guston 1999; Cash et al 2003).

3. **Link information producers and users.** This project will help connect C&W information users (i.e. FEMA) and producers (i.e. NOAA-NWS) with the research goal of assessing the role of a boundary organization in developing and mediating this network.
4. **Build connections across disciplines and organizations.** This project is multidisciplinary, led by a diverse team of physical and social scientists working with operational meteorologists, climatologists, and emergency managers. Social science expertise will develop robust evaluation metrics and assessment methodologies. Expertise in climatology and meteorology will help inform the production of the decision support product, while expertise in emergency management will shape all components of the project.
5. **Seek institutional stability.** The NOAA-NWS will provide an operational environment from which the decision-support product may endure after the end of the project, and is an ideal operational agency to support production beyond the duration of this project. The details of this long-term partnership will be informed by the evaluation and negotiated thereafter. The NRC (2000) stated that successful transitions from research to implementation require: (1) developing and maintaining appropriate transition plans, (2) allocating adequate resource, and (3) enabling continuous feedback between the research and operational activities. These overarching themes will help guide our product development and evaluation.
6. **Design for learning.** A vital component of this proposal is evaluating the effectiveness of the decision support product, its viability, and the process of engagement. The results of the evaluation will inform future product development by the NWS and other similar activities in other regions and with other stakeholders.

2.0 Research Activities and Methods.

2.1. Assessment. The assessment phase will kickoff the project and inform all subsequent activities. It is fundamental to understanding FEMAs decision context and the NOAA-NWS operational capabilities, both of which must be considered during the creation of a sustainable decision support product. The assessment will determine, among other things, how FEMA managers currently access and use C&W information; the characteristics of C&W information that fit best into individual, organizational, and institutional contexts; needed information and formats that may include "smartphone ready" information; and the factors that determine whether potentially useful information is actually used.

The assessment will also focus on understanding the ability of the NOAA-NWS to sustain engagement with FEMA, focusing particularly on its ability to maintain a communication network and the decision support product developed in this project (see next section). The assessment will initially focus on the NOAA-NWS regional headquarter capabilities, but may branch out to include NOAA-NWS Climate Services Focal Points—personnel in NOAA-NWS forecast offices and river forecast centers in charge of delivering national and local climate products, services, and information.

The assessment will utilize a suite of methods, including literature reviews, surveys, site visits, and semi-structured interviews. Initially, a thorough review of FEMA reports and strategic documents as well as peer-reviewed journals will outline how emergency managers currently use C&W information needs. Two site visits to both FEMA and NOAA-NWS offices in the first six months of the project will help us develop relationships with FEMA and NOAA-NWS personnel, reveal the job activities of personnel using C&W information, and provide opportunities for semi-structured interviews. Surveys will be used early in the assessment phase as a form of rapid assessment in order to identify key informants and key issues, which will help create a framework for more in-depth interviews. Interviews will be conducted first with key informants identified initially through FEMA and NWS organizational charts and will also

include FEMA Watch Officers.[1] A process of snowball sampling will help identify key personnel in both agencies who might not be apparent on the organizational charts but who are involved in relevant decisions targeted by the decision support product. Interviews will obtain detailed descriptions of how informants use climate information in his/her duties, how he/she would like to information delivered, and the kinds of decisions informed by C&W information. Interviews will be conducted in-person whenever possible, but may also occur by phone.

Knowledge gained from the assessment phase will inform the development of a tailored, FEMA-specific decision support product that will be co-produced by CLIMAS, NOAA-NWS, and FEMA (see next section). It will also highlight the information uses and needs of a major user of NOAA-NWS products, and therefore directly inform future NOAA-NWS product development not part of this project. Moreover, the assessment may reveal information needs that can be satisfied by other climate and weather service providers, such as the regional climate centers and state climate offices as well as other agencies tasked with climate monitoring like the USDA Natural Resources Conservation Service (i.e. SNOTEL). Finally, the assessment will define short- and long-term metrics that will be used to evaluate project outcomes and the process of developing the product.

2.2. Co-producing a decision-support tool. Building off information obtained in the assessment, key personnel from the NOAA-NWS, FEMA, and CLIMAS will collaboratively develop a C&W synthesis product that will be produced monthly for the duration of the project. The product will be a concise bulletin that synthesizes, contextualizes and interprets C&W information. It will be modeled after the La Niña Drought Tracker (http://www.climas.arizona.edu/outlooks/drought-tracker), which FEMA signal out as a potentially useful product format (S. Bryson *pers. comm.)* and which has been demonstrated to influence resource management decisions in Arizona and New Mexico (Guido et al *in review*). This bulletin will focus on explaining why conditions are the way they are, providing critical context to evolving conditions that is often missing from C&W information services. For example, knowing the Madden Julian Oscillation is in an active phase, which can lead to intense winter storms, and locations of recent wildland fires, which hasten runoff, can help FEMA better anticipate floods. We will also explore desired modes of disseminating the decision support tool. Initial conversations have pinpointed the need for "smartphone ready" information, emphasizing the functionality of short, high-impact, and easily disseminated information. While the bulletin will be developed to best meet FEMA needs, it will also adhere to NOAA-NWS capabilities so that sustaining the product after project completion is a viable option—this project will avoid perpetuating the failures that often accompany efforts to move experimental research to operations.

As a supplement to the C&W bulletin, we will investigate the creation of a communication network—either via an active listserv and/or routine web conferences (a successful example is the U.S. Drought Monitor listserv)—that harnesses diverse expertise on current conditions, hazards, and forecasts across the regions. NWS personnel already contribute to bimonthly

[1] FEMA Watch Officers will be our primary collaborators. Watch Officers are responsible for, among other duties, maintaining situational awareness for activities that could affect the likelihood of an incident; developing and maintaining relationships with all levels of government and non-governmental organizations in order to facilitate planning, response coordination, and exchanges of personnel and equipment; and developing instructional materials for the public about emergency preparedness. There are 13 Watch Officers in FEMA region 9. Stephen Bryson, a Senior Watch Officer based in Oakland, CA, is a collaborator on this project and will help facilitate interaction with FEMA.

webinars informing FEMA's Regional Inter-agency Steering Committee (RISC). We will explore expanding on this existing and other established networks, building off previous CLIMAS successes that include facilitating long-standing knowledge sharing interactions between fire and climatology communities (e.g. Owen et al *in review*). The webinars may initially focus on providing explanations of the information in the bulletin so it remains concise. An additional document containing that information will also be produced as a reference guide.

While CLIMAS will provide expertise interpreting and synthesizing C&W information, the NOAA-NWS will provide expertise in accessing and interpreting a wider range of operational C&W monitoring and forecasting tools. The bulletin will draw information from credible data sources and expert analysis, and after initial development, it will be disseminated to potential FEMA users. These individuals will be surveyed and their insights will feed back into subsequent monthly publications. We note that this is a form of co-production that involves episodic communication and effort of all parties and is not as demanding as some forms of co-production cited in the literature (i.e. Lemos and Morehouse, 2005). We believe this form maximizes resource efficiency and project success.

2.4. Evaluation. Evaluations help make products more useful and ultimately lead to desired outcomes (Moser 2009) and are important aspects of designing projects for learning (the 6th component of the NRC 2010 decision-support framework). This is especially important in an environment in which demand for C&W information is rising and, perhaps, outpacing supply. In these environments, knowing what works can help direct limited resources to useful activities.

Our evaluation will focus on several aspects of the end-to-end process, and will be based on the short-term metrics of success identified in the assessment phase and noted below; longer-term success will be measured in CLIMAS overall evaluation efforts[2].

Short-term evaluation metrics, or measures of success, of the C&W bulletin and the process of creating and disseminating information are those that can be evaluated within the two-year span of this project. While the metrics will ultimately be defined in the assessment, we suspect they will include: (1) the number of people in FEMA using the bulletins; (2) participation in the webinars; (3) user perceptions of the bulletins; (4) changes in climate literacy among FEMA staff; (5) changes in FEMA's organizational structure or policies due to use of the bulletin; and (6) changes in NOAA-NWS's organizational structure to support long-term production and dissemination of the bulletin. Longer-term metrics evaluated after the project ends by CLIMAS include: (1) the interactions of the communication network; and (2) long-term policy changes regarding the role of climate science in FEMA's institutional decision-making.

The evaluation will focus on determining whether the bulletin improved FEMA management decisions, and if so, why it was effective and what decisions the product informed. We will also evaluate the collaborative process to see if and how it changed FEMA's use of C&W information and whether the process led to a better mutual understanding of needs and capacities of FEMA that, in turn, influenced outcomes. Moreover, the evaluation will address the concept of a boundary object (in our case the C&W bulletin), investigating whether it allowed members of the two operational communities to work together effectively to achieve mutually distinct goals. Finally, we will evaluate conditions that favor and limit the long-term implementation of the bulletin by the NWS. This aspect relates to finding suitable strategies for transitioning research to operations.

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[2] CLIMAS, which has been recommended for funding for the 2012–2017 period, has made it a priority to evaluate current and past projects as a core program activity.

Evaluation will include periodic surveys and interviews with key FEMA and NOAA-NWS personnel, and reviews of documents that track organizational and/or policy changes at FEMA and NOAA-NWS and long-term budget and resource allocation changes within FEMA and NOAA-NWS. While evaluation will be conducted principally at the end of the project, the metrics identified in the assessment will be tracked on an ongoing basis. Evaluation will be integrated at various stages in the project, allowing us to continually reassess the efficacy of our plans for the co-development of the C&W bulletin.

3.0. Research Plan

3.1. Roles and Responsibilities. We have assembled an interdisciplinary team to conduct assessment, product development, evaluation, and operations. CLIMAS will provide leadership in the design and acquisition of social data during the assessment and evaluation. Co-PI Meadow, a social scientist, has extensive experience in stakeholder engagement research and evaluation and will lead these activities. PIs Crimmins and Guido, who also have extensive experience in stakeholder engagement and knowledge translation will advise the development and communication of the bulletin, drawing on lessons learned from the production, dissemination, and evaluation of the Southwest Climate Outlook and the La Niña Drought Tracker, two efforts they co-lead. A graduate research assistant (GRA) will focus his or her work on collecting and analyzing assessment and evaluation data. The GRA will hone interdisciplinary skills, while working at the interface between climate science and decision-making.

The NWS will provide a liaison, Andrea Bair, and agree to commit a 0.25 FTE-equivalent to the project (see letter of support). Andrea will help organize interviews and surveys with key personnel, which will enable the assessment and evaluation of NOAA-NWS capacity to sustain the bulletin and a knowledge network. They will also be involved in the evaluation process, participating in meetings and site visits with FEMA. The NOAA-NWS will also provide expertise on both operational and experimental products, which will inform the bulletin's content and will help connect the project to the broader NOAA network. The NWS will help manage the communication process, which may include hosting and organizing teleconferences, webcasts, or listservs. Finally, the NOAA-NWS will be integral in contributing a best practice document produced for FEMA and the NOAA-NWS, a capstone webinar, and peer review publications.

FEMA is committed to this project (see letter of support), and Senior Watch Officer Stephen Bryson will be their lead liaison. They will contribute personnel time and enable access to key personnel who will participate in interviews and surveys in assessment and evaluation activities. The will also be integral in the co-development of the bulletin. Finally, the FEMA will contribute to a capstone webinar and the best practices document.

3.2. Deliverables. This project will develop a C&W bulletin that is published monthly for the majority of the project (see next section). We will also publish peer-review papers on our process of engagement and the impact of climate information in FEMA operations, both of which will illustrate lessons learned and best practices so the broader scientific community can build off our case study. In addition, these papers will advance the literature on developing and providing climate services. We will present our findings at academic conferences. We also intend to convene a capstone virtual conference with FEMA and NOAA/NWS near the end of the project to present findings and best practices and to help facilitate a shared understanding of the data needs and capabilities of both agencies.

We also expect the bulletin will be a concise document that is made compatible with smart phones. To maintain brevity without compromising understanding, we will likely provide webinar training sessions and briefings that discuss in detail the nuances of the information

contained in the bulletin—detailed metadata descriptions for products is often desired by users but rarely provided by producers. We will also produce a hardcopy of this information so FEMA managers have a reference guide as well as a best practices document that summarizes, among other information, effective production and delivery of C&W services.

3.3. Project timeline.
Months 1–12: Needs assessment; development and dissemination of bulletin
Months 12–24: Refine and disseminate bulletin; evaluate process and product

Activities by month	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	Post project
Assessment	*	→	→	→	→	→	→	→	→	→			
Develop tool													
Disseminate tool													
Evaluation													
Share: (publish peer review & other docs.; conferences)				+	+	+	+	+	+	+ <	+ <		

***** Assessment focused in months 1–6 but continues < reference guide & best practices doc. + Webinars

4.0. Relevance

Land, water, and coastal managers within the Southwest portion of FEMA's region 9 interact with FEMA during wildfires, floods, droughts, and hurricanes. FEMA aids all of these managers in their preparations for and responses to extreme climate events. As a result, this project cuts across the three program priorities identified in this federal funding opportunity. Specifically, this proposal "improves literacy and methods of communicating information" by co-developing a C&W bulletin, conducting trainings around the content of that product, disseminating it through FEMA channels, and building a knowledge network. Moreover, the proposal seeks to establish a mechanism from which the product and process can be maintained by the operational entities with the NOAA-NWS. This proposal also addresses the program priority of "evaluation of the use of climate information by public land managers," which will be accomplished through surveys and interviews of NOAA-NWS and FEMA personnel as part of our evaluation of the decision support product and process. This proposal develops regional or cross-regional capacity within FEMA by developing a useable information tool, conducting trainings about its content, and linking FEMA (a consumer of C&W information) with the NOAA-NWS (a producer of C&W information). Strengthening partnerships, assessing information needs, developing decision support tools and metrics of success, and reporting best practices and lessons learned back to the research and service community are all core functions of RISA and objectives this proposal emphases. It will also expand CLIMAS' network to include FEMA, which has not been a traditional stakeholder of CLIMAS.

FEMA's particular application of C&W information is to respond quickly, effectively, and efficiently to disasters, thus limiting damage and injury to the public. Providing FEMA decision-makers with improved, better targeted, and more organizationally appropriate C&W information will help them better serve the public in times of weather- and climate-related disasters. Moreover, collaborating with NOAA-NWS will strengthen FEMA relationships with personnel at the western regional headquarters, river forecast centers, and local field offices.

This proposal fits well into the climate research and experimental service focus of the 2012–2017 CLIMAS program, which was recently recommended for funding. For the next five years, CLIMAS will be focusing on advancing climate adaptation related specifically to climate thresholds and extremes events in the Southwest.

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