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Perspective

From principles to action: Applying the National Research Council's principles for effective decision support to the Federal Emergency Management Agency's watch office

Alison M. Meadow [a,*], Zack Guido [b], Michael A. Crimmins [c], Jonathan McLeod [d]

[a] University of Arizona, Center for Climate Adaptation Science and Solutions, Tucson, AZ, USA
[b] University of Arizona, Institute of the Environment, Tucson, AZ, USA
[c] University of Arizona, Cooperative Extension Service, Department of Soil, Water and Environmental Science, Tucson, AZ, USA
[d] University of Arizona, Department of Anthropology, Tucson, AZ, USA

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ABSTRACT

The National Research Council (NRC) proposed six principles for effective decision support in its 2009 report *Informing Decisions in a Changing Climate*. We structured a collaborative project between the Federal Emergency Management Agency Region R9 (FEMA R9), the Western Region Headquarters of the National Weather Service (WR-NWS), and the Climate Assessment of the Southwest (CLIMAS) at the University of Arizona around the application of the NRC principles. The goal of the project was to provide FEMA R9's Watch Office with climate information scaled to their temporal and spatial interests to aid them in assessing the potential risk of flood disasters. We found that we needed specific strategies and activities in order to apply the principles effectively. By using a set of established collaborative research approaches we were better able to assess FEMA R9's information needs and WR-NWS's capacity to meet those needs. Despite our diligent planning of engagement strategies, we still encountered some barriers to transitioning our decision support tool from research to operations. This paper describes our methods for planning and executing a three-party collaborative effort to provide climate services, the decision support tool developed through this process, and the lessons we will take from this deliberate collaborative process to our future work and implications of the NRC principles for the broader field of climate services.

Introduction

Emergency managers are charged with making decisions before, during, and after disasters that have direct impacts on the health and well being of people and communities. Most often, these events are caused by climate or weather phenomenon like severe storms or flooding events (which may have a weather event as a proximate cause, but can be influenced by climate conditions such as whether recent precipitation has left the soils saturated). About 80% of the 181 federal disasters declared between 1964 and 2012 in the Federal Emergency Management Agency Region R9 (FEMA R9) – which spans California, Arizona, Nevada, Hawaii and U.S. territories in the Pacific Ocean – were directly related to climate and weather; 33% of the disasters were classified as floods (Federal Emergency Management Agency, 2014). To help FEMA stay abreast of potentially harmful weather events, the Watch Office, within the Response Division, monitors weather, climate and other hazard-related information. The Watch Office keeps FEMA personnel updated on conditions that could escalate into disasters, helps keep incident managers informed about potential disaster conditions, and manages FEMA's initial disaster response, making the Watch Office important users of climate and weather information. Historically, FEMA has utilized weather forecasts, primarily provided by the National Weather Service (NWS), which are skillful for up to about 10 days (Li and Robertson, 2015; Slingo and Palmer, 2011), to monitor weather conditions that could lead to disasters. They have not, however, used climate information as systematically.

In late 2011, leadership within the FEMA R9 Response Division approached the Western Region Headquarters of the NWS (WR-NWS) for information to help them identify potential weather-related threats beyond the 10–14 day forecast; in other words at a climate time scale. FEMA R9 was looking for a way to extend the time horizon of its current disaster early warning system through

* Corresponding author.
E-mail address: meadow@email.arizona.edu (A.M. Meadow).

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the use of climate information. Initial discussions between the two organizations revealed that providing climate information to the FEMA R9 Watch Office would require more than simply directing them to existing information; they were requesting information and interpretation that did not exist at the time (personal communication, A. Bair). The WR-NWS subsequently engaged the NOAA-funded Climate Assessment of the Southwest (CLIMAS) at the University of Arizona to help develop and deliver that information to the FEMA R9 Watch Office. CLIMAS has demonstrated experience in delivering climate and weather information to resource managers and other decision makers through synthesized and value-added products (Guido et al., 2013).

Communicating and using climate information is not without challenges. For example, critical information can be (or can be perceived to be) inaccessible and difficult to understand (Steinemann, 2006), at the wrong temporal and spatial scales for decision-making (Braman et al., 2013; McNie, 2007; Srinivasan et al., 2011), out of alignment with users' climate literacy or information processing and management abilities (Lemos and Morehouse, 2005; Srinivasan et al., 2011), and more uncertain than many managers are comfortable with (Braman et al., 2013). In this paper, we present a case study of a partnership between researchers in CLIMAS, WR-NWS and FEMA R9 that sought to overcome these challenges and improve access to and use of climate information by emergency managers in FEMA R9. We applied the principles for effective decision-support activities outlined by the National Research Council (NRC) in their report *Informing Decisions in a Changing Climate* (National Research Council, 2009) as well as core tenets for the co-production of science knowledge and the delivery of climate services (long-term relationships between producers and users, two-way communication, and focusing on usable products). As we have argued elsewhere (Meadow et al., 2015), successful co-production of usable climate science requires deliberate planning and execution of collaborative research methods and participatory processes to ensure effective collaboration. This paper describes the methods and activities that helped us apply the NRC principles to the development of a disaster early warning decision support system (DSS) and the lessons we learned about providing effective climate services to emergency managers.

Literature review: principles for effective decision support

Climate services have been defined as the provision of timely, tailored information and knowledge to decision makers, generally in the form of tools, products, websites, or bulletins (Vaughan and Dessai, 2014). Weather services can provide decision makers with important information about conditions at a particular time and place, as well as short-term forecasts, but longer-term information about average conditions, departures from those averages, and the occurrence of low-probability events – climate information – are all crucial to the understanding of the potential impact of weather events (Vaughan and Dessai, 2014). The World Meteorological Organization has identified climate services as a key tool to enable climate adaptation and climate risk management and stresses that climate services must include engagement between users and providers of the services (Hewitt et al., 2012). Climate services involve providing climate information in a way that supports decision makers' needs, making their provision an example of a DSS.

Despite the acknowledged need to provide both greater context and longer term outlooks, climate service providers often lack guidance about the most effective strategies for providing that information (Vaughan and Dessai, 2014). General principles, however, have been proposed. For example, research has shown that more engagement and collaboration between the climate information producer and user tends to make that information more usable (Dilling and Lemos, 2011; Jasanoff and Wynne, 1998; Lemos and Morehouse, 2005). Creating more usable science requires two-way communication and long-term engagement between producers and users (Lemos et al., 2012). These activities can also help increase users' perception that the information is credible and legitimate and can help providers tailor information to be more salient to users (Cash et al., 2003, 2006; Clark et al., 2011).

The 2009 NRC report *Informing Decisions in a Changing Climate* condenses these insights, as well as evidence from many other disciplines, into six principles for the provision of effective decision support: (1) begin with user needs; (2) prioritize process over product; (3) link information producers and users; (4) build connections across disciplines and organizations; (5) seek institutional stability; and (6) design the process for learning. The NRC (2009) notes that decision support activities should be driven by the *needs of users*, which should be identified collaboratively among the producers and users (National Research Council, 2009). The focus on user needs distinguishes climate services from more general climate research, in which the goal is a deeper understanding of the physical climate system (Vaughan and Dessai, 2014) but not necessarily application of that information to management or policy decisions. In the second principle, *prioritize process over product*, the NRC points to the importance of spending time and effort to understand how the climate information and DSS will be used by the stakeholder. This process helps to ensure that the information and tools are usable and considered salient, credible, and legitimate by the user (Cash et al., 2006; Feldman and Ingram, 2009; Lemos et al., 2012). Principle three, *link information producers and users*, reflects the NRC's understanding that DSSs require networks and institutions to link information producers and users. The links should allow the distinct cultures and incentives of science and practice to be respected and maintained, while also enabling the strengths and abilities of each to be maximized. The simultaneous linking and boundary maintenance may require the use of a boundary organization, which is one role that CLIMAS plays, to manage the process (National Research Council, 2009). In principle four, *build connections across disciplines and organizations*, the NRC recommends that DSSs account for the multidisciplinary character of the needed information and the numerous organizations that share decision areas and the decision context. The fifth principle, *seek institutional stability*, is crucial to the success of a DSS. Long-term stability depends on establishing and maintaining networks that include information producers and users who can continually interact to refine and revise the necessary information and DSS tool (National Research Council, 2009). Tangible tools, such as our online dashboard, also require stable technical support throughout their lifespan. The sixth principle is to *design decision support activities for learning* in order to allow decision makers to respond to the continually evolving environment (National Research Council, 2009). The DSS should have the ability to incorporate scientific and other factors that influence decisions, products should be created within the decision context they will be applied, and the DSS should be able to respond to policy windows when they open. We broaden this definition to also include evaluation of the development process, the usefulness of the tool, and impacts of the DSS, which we argue allows for the possibility of double-loop learning (Argyris and Schon, 1978). Double-loop learning involves reflecting on the norms in place in an institution and questioning whether and how those norms should be changed to achieve a desired outcome.

Hydro-climate dashboard

We applied the NRC principles and tenets of co-production and climate services to co-design and produce an online hydro-climate dashboard tool for FEMA R9. The hydro-climate dashboard is designed to present a curated set of climate information about flood