AGRICULTURAL STAKEHOLDER VIEWS ON CLIMATE CHANGE

Implications for Conducting Research and Outreach

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Various agricultural stakeholders may respond to climate information differently, and climate scientists may be more effective if they tailor their messages in ways that reduce threats to individual worldviews and increase dialogue among those with differing views.

When there is uncertainty regarding potentially threatening phenomena, people tend to look to trusted institutions for guidance, and trust correlates with public support for policy responses (Dietz et al. 2007). However, groups that profit from the *status quo* can seek to influence discourse and shape public beliefs (Dietz et al. 2002). Climate change, and in particular the role of humans as a cause, has been hotly contested, with varied interest groups seeking to frame the issue and potential responses in ways that favor their positions (Dunlap 2013; Weber and Stern 2011). While organizations such as the U.S. Environmental Protection Agency (USEPA), the Intergovernmental Panel on Climate Change (IPCC), and the U.S. National Climate Assessment (NCA) seek to inform society about the risks of climate change and need for public action, counterefforts to "manufacture uncertainty" or otherwise undermine scientific evidence regarding anthropogenic climate change and shape discourse about how society should or should not respond have been a constant (Dunlap and McCright 2010; Weart 2011). Such framing efforts have largely succeeded in muddling public understanding of climate change and slowing adaptive or mitigative actions (Weber and Stern 2011).

During the 50 years since climate change conversations entered the American policy arena, the climate science community has conducted research and collected and analyzed data establishing strong evidence that anthropogenic greenhouse gas emissions are a primary source of global climate change (Doran and Zimmerman 2009). While the terminology largely changed from "global warming" to "climate change" during this time period, public opinion, particularly in the United States, still has not coalesced around this issue and has instead become polarized (McCright and Dunlap 2011; Read et al. 1994; Weber and Stern 2011). Read et al. (1994)

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examined misconceptions among educated members of the public and found that they typically confused the issue of global warming with the hole in the ozone layer and did not connect the burning of fossil fuels with global warming. As of 2008, fewer laypeople in America (49%) accept anthropogenic climate change than those surveyed in many other nations, including France (63%), Turkey (70%), Brazil (80%), Japan (91%), and South Korea (92%) (Pelham 2013).

The framing of climate change in terms of controversy and uncertainty has increased the disparity of views between experts and the public. For example, a recent poll of a representative sample of the United States revealed that 49% of nonscientists believe the Earth is "getting warmer because of human activity such as burning fossil fuels" compared to 84% of scientists (Pew Research Center 2014). Between 2008 and 2010, there was a decline in the percentage of Americans agreeing that global warming is happening, is more due to human activities than natural variation, and it will seriously threaten them or their way of life in their lifetime (Weber and Stern 2011). Malka et al. (2009) found that the relationship between the public's self-reported knowledge about global warming and concern (personal importance, national, and global seriousness) was moderated by trust in scientists. Nisbet and Myers (2007) completed a comprehensive summary of polls on the American public's opinions on global warming conducted between the mid-1980s and mid-2000s. They found that, while most Americans have heard about global warming, as of 2007 only about 22% felt they understood the issue of global warming "very well." Also, depending on the wording of the question, anywhere from one-third to 60% of Americans believe that a majority of scientists think global warming is real (Nisbet and Myers 2007).

AGRICULTURAL STAKEHOLDERS. While most of the studies about climate change beliefs focus on the general public, we turn our attention in this essay to the agricultural community. Agriculture is directly impacted by weather and climate and is an important sector of the U.S. economy (Walthall et al. 2012). Environmental decision making is influenced by how values and social and cultural factors are linked (or not) to science (Dietz 2013). By studying different beliefs in the agricultural sector, we can better understand the complex factors influencing the wide variety of agricultural decisions associated with climate conditions. These findings may also inform other sectors and industries such as insurance,

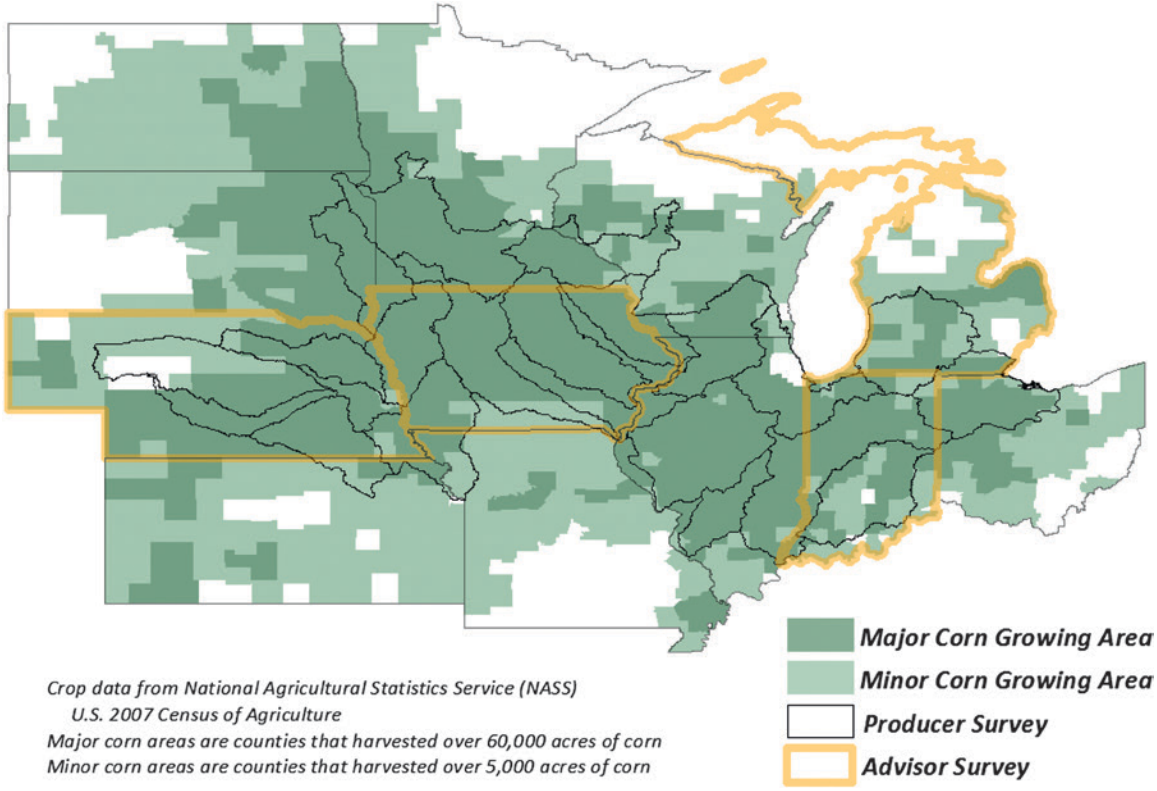

Fig. 1. Map of study area showing major and minor corn areas and coverage areas for producer and advisor surveys.

urban storm water management, transportation, and so on, as they seek to understand how the public will respond (or not respond) to scientific climate information pertaining to a specific issue or decision.

This research centers on the agricultural community in the Midwestern United States, with a particular emphasis on corn production. The 12-state Corn Belt region of the Midwest (Fig. 1) produces 85% of total U.S. corn and 31% of global corn (USDA-FAS 2014; USDA-NASS 2014). Climate change discussions are important to the agricultural sector for two primary reasons: 1) agriculture produces greenhouse gases (GHG) and thus contributes to global climate change, and 2) agriculture will need to adapt to a changing climate (Lobell et al. 2014; Melillo et al. 2014; Walthall et al. 2012). Agriculture accounts for 10%–12% of total global anthropogenic GHG emissions, with nitrous oxide (N_2O) production from agricultural soil management a major GHG source (Smith et al. 2007). The Third National Climate Assessment report finds that climate disruptions to U.S. agricultural production have increased in the past 40 years and are projected to increase in the next 25 (Melillo et al. 2014). Further, the assessment reports evidence that more frequent weather extremes will increase degradation of critical soil and water resources unless innovative conservation methods are implemented. The IPCC Fifth Assessment Report North America report finds that at an increase of 2°C, adaption in agriculture has high potential to offset projected declines in yields for many crops and a number of these strategies have mitigation cobenefits (Romero-Lankao et al. 2014). Climate change presents both opportunities and issues of vulnerability for agriculture due to the wide variability in local growing conditions. Increasing weather variability will necessitate changes in agriculture to adapt to worsening conditions or take advantage of improved conditions.

ACTORS IN THE AGRICULTURAL SECTOR AND THEIR BELIEFS ABOUT CLIMATE CHANGE. Beliefs about the social and physical world are central to most models that attempt to explain human behavior, including the expectancy value (EV) model (Fishbein 1963), the reasoned action approach (formerly theory of planned behavior) (Fishbein and Ajzen 2010), and the values–beliefs–norms (VBN) model (Stern 2000). Each of these models posits that beliefs about phenomena shape attitudes toward objects and actions, and those attitudes can, in turn, influence behavior. There are a number of actors in the agricultural sector who

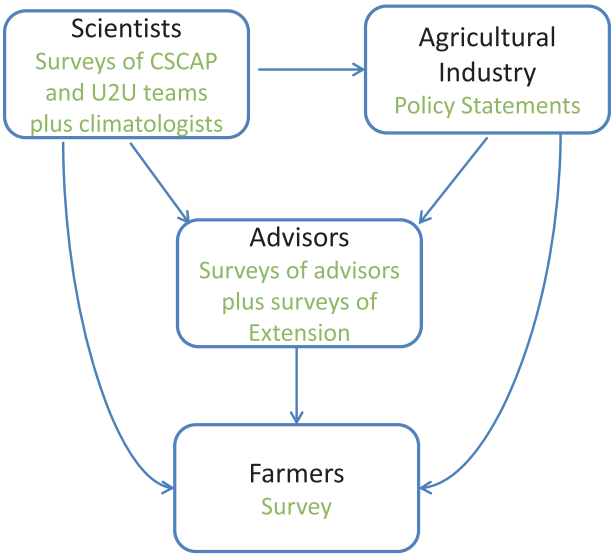

Fig. 2. Flow of climate change information in the agricultural sector. Note that information clearly flows in two directions within this sector but in this figure we are primarily concerned with the flow of information related to climate change. Green text indicates source of evidence regarding climate change beliefs.

are sources of climate information and influence the multidirectional flow of information (Fig. 2). People often depend on intermediary sources, including mass media, to understand complex climate information rather than getting all of their information from scientists (Weber and Stern 2011). Understanding these different intermediary sources, the values attached to information they provide, and their information gatekeeping roles is critical to tracing how climate change information is incorporated into agricultural decision making. One starting point in the agriculture information value chain is with the generation of scientific knowledge by climate and agronomic scientists. Between the scientists and the knowledge they generate and farmers are many intermediaries who supply a variety of information to help farmers cope with weather and climate risks. The process of information exchange is dynamic with different intermediaries filtering and reconstructing the science message based on their values and worldviews and looping it back as new information to other advisors and farmers. These intermediaries selectively choose information they receive and act as gatekeepers by taking the raw science and adding their "spin" to it.

Over the course of 2011/12, we included a question measuring beliefs about climate change in surveys of six different agricultural and climate stakeholder groups. Each of these surveys was conducted before

the 2012 drought that impacted the Midwestern United States. The surveys reported numerous topics that are addressed elsewhere (see, e.g., Arbuckle et al. 2013a; Prokopy et al. 2013); the purpose of this research is to compare answers to a common question about climate change beliefs among agricultural stakeholder groups. In each survey we measured beliefs about climate change using a five-point question first used in the 2011 Iowa Farm and Rural Life Poll (Arbuckle et al. 2011) (see Table 1 for question wording and answer options). The relevance of each of these audiences for the agricultural sector is reviewed below along with results about their climate change beliefs.

Scientists from two different U.S. Department of Agriculture–National Institute of Food and Agriculture (USDA–NIFA)-funded projects were surveyed. These are both large-scale projects that seek to increase the resilience of agricultural systems in the face of a changing climate. The Corn-Based Cropping Systems Coordinated Agricultural Project (CSCAP) is a 5-yr, $20 million project that seeks to increase adaptability of Midwest agriculture to more volatile weather patterns by evaluating a suite of management practices (tillage, cover crops, controlled drainage, and N sensing) to meet crop demand and increase system sustainability (www.sustainablecorn.org). Useful to Usable (U2U) is a 5-yr, $5 million project that aims to make existing climate information usable to actors in the corn production arena (www.agclimate4u.org). The scientists surveyed represent a diversity of disciplines including climate scientists, agronomists, and social scientists. Together, these scientists are producing and disseminating climate change information to the agricultural sector. In August 2011, 121 team members from the CSCAP project completed an online survey about climate and agronomic practices. The 33 team members of the U2U project were surveyed in 2012 through an online survey. Over 90% of both teams' members reported that they believed climate change is occurring, with over 50% of them agreeing that it is caused mostly by human activities and 30% indicating that it is due equally to natural and human factors (Table 1). None of the teams' members believed that climate change is *not* occurring. These findings are consistent with the scientific evidence that human activities are a leading source of a changing climate (Walthall et al. 2012).

Climatologists are a subset of scientists who serve a unique type of intermediary role between basic

Table 1. Different climate change beliefs among key agricultural stakeholders.

Survey question: There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change.	CSCAP 2011 team survey (n = 121), 86% response rate	2012 U2U team survey (n = 33), 56% response rate	Climatologist survey (n = 19) 2012, 100% response rate	2012 extension educators survey across 12 Corn Belt states (n = 239), 35% response rate	2012 Ag advisors survey (n = 1605), 26% overall response rate	Farmer survey (n = 4778) 2012, 26% response rate
Climate change is occurring, and it is caused mostly by human activities.	50.4%	66.7%	53%	19.2%	12.3%	8%
Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities.	30.6%	30.3%	37%	31.4%	37.8%	33%
Climate change is occurring, and it is caused mostly by natural changes in the environment.	10.7%	3%	5%	23.4%	24.9%	25%
There is not sufficient evidence to know with certainty whether climate change is occurring or not.	8.3%	0%	5%	24.7%	22.4%	31%
Climate change is not occurring.	0%	0%	0%	1.3%	2.6%	3.5%

climate scientists and agricultural advisors. In 2012, a total of 22 state and extension climatologists were selected through a purposive sample to represent main outlets of publicly available and location-specific climate information in the region. Of these climatologists, 19 completed a survey that included the climate change question (see Wilke 2013). Consistent with the many disciplinary scientists in the two USDA–NIFA projects, over 90% of the climatologists agreed that climate change is occurring, while none believed that it is not occurring (Table 1). About 53% attributed climate change primarily to human activities.

Agricultural interest groups, principal among them the influential American Farm Bureau Federation, have consistently voiced opposition to climate policy and legislation and have cast doubt on links between human behavior and climate change and the need for mitigation of GHG emissions (American Farm Bureau Federation 2012, 2013; Dunlap and McCright 2010; Union of Concerned Scientists 2014; Winter 2010). While we did not survey the policymakers in these groups directly, they have made their positions clear in their own published documents.

Agricultural advisors play a significant role in modern agriculture and work with farmers on numerous decisions ranging from financial to agronomic to conservation. Many agronomic advisors work as independent consultants or for private industry as Certified Crop Advisors (CCAs). Private industry traditionally connects the sale of agricultural inputs (fertilizer, seeds, crop protection, fuel equipment, etc.) and management decisions to the farmers' production systems. This role has expanded in recent years to include an extensive suite of technologies at the intersection of yield and profitability. Many CCAs also advise farmers on conservation decisions. There are also public sector advisors who focus on conservation decisions (employed by entities like Soil and Water Conservation Districts or the Natural Resource Conservation Service). Finally, financial advice on issues such as crop insurance, marketing, and long-term investments is primarily provided by agricultural bankers. Collectively these advisors tend to have a short time horizon and focus on short-term weather forecasts in their work (Prokopy et al. 2013). An online survey of about 1,600 private and public agricultural advisors was conducted in 2012 in four states (Indiana, Iowa, Michigan, and Nebraska) in the Midwestern United States. Three-quarters of these advisors believed that climate change is occurring with 12% of them believing that it is mostly caused by human activities (Table 1). A quarter believed that climate change is not occurring and 22% believed there is not sufficient evidence to know with certainty whether climate change is occurring or not.

Extension educators are a unique set of agricultural advisors who serve to connect and translate research from universities to farmers in order to decrease risk to the farm enterprise and increase productive capacity and resilience. Typically, extension educators have at least a master's degree and are trained in agronomic sciences, which may not include climate sciences. Extension educators in all 12 states in the region were surveyed during the same time period as the agricultural advisors discussed above. Almost 75% of the extension educators believed in climate change, with over 19% attributing climate change primarily to human activities (Table 1).

Farmers are potential end users of climate science. Weather affects short-term planning and day-to-day management as row-crop farmers work to get crops planted, pests controlled, fertilizers applied, and grain harvested in a timely manner each year. For climate science to be widely used by farmers, it must be packaged as relevant knowledge that will guide the management of the agricultural enterprise (Mase and Prokopy 2014). Almost 4,800 corn producers across the Midwestern United States (see region in Fig. 1) completed a 2012 mail survey about climate beliefs and impacts of drought, flooding, and other weather-related factors on their farms (see Arbuckle et al. 2013a). Of the farmers, 66% believed that climate change is occurring with only 8% of them believing that it is caused mostly by human activities (Table 1). Close to 35% of the farmers believed there is either insufficient knowledge to know with certainty that climate change is occurring or believed that climate change is not occurring.

DIFFERENCES IN CLIMATE CHANGE BELIEFS AND INFORMATION NEEDS. The results of our surveys of six agricultural stakeholder groups indicate that the variation in climate change beliefs between the general public and climate science community extends to agricultural audiences. The primary difference in belief structure is the role of human activity in climate change. While overwhelming majorities of the scientists and climatologists surveyed believed that climate change is occurring and due at least in part to human activity, half or fewer of the advisor and farmer groups believed that climate change is happening and anthropogenic in nature. These results provide strong evidence that a breach of understanding of

climate change and its causes exists between these key agricultural stakeholders.

Leiserowitz et al. (2012) suggest that decreased trust in climate scientists leads to increased skepticism about climate change. Further, efforts by groups like the American Farm Bureau Federation to shape the discourse on climate change may have an impact on agricultural actors' beliefs. Evidence from Iowa suggests that farmers who trust agricultural interest groups as sources of information about climate change are less likely to believe that climate change is occurring and due to human activity (Arbuckle et al. 2015).

It is increasingly evident that social relationships and interactions strongly influence differing perceptions of climate change (Leiserowitz 2006; Kahan and Braman 2006; Weber 2006; Kahan et al. 2011). The frame in which climate science is presented influences individual perceptions that are then reinforced by self-identified social reference groups (Weber and Stern 2011; Gastil et al. 2011). In this case, scientists, extension educators, advisors, and farmers can be influenced by powerful reference groups that help shape and reinforce their opinions of the scientific evidence about climate change.

This phenomenon has been termed the "cultural cognition of scientific consensus" (Kahan et al. 2011). It is postulated that "*cultural worldviews* permeate all of the mechanisms through which individuals apprehend risk, including their emotional appraisals of putatively dangerous activities, their comprehension and retention of empirical information, and their disposition to trust competing sources of risk information" (Kahan 2006, p. 1072). Thus, people accept information that matches their prior conceptions and the conceptions of those with whom they share a worldview (Kahan et al. 2012; Leiserowitz et al. 2012). Agricultural advisors and extension educators are intermediaries in the information chain between scientists and farmers. It appears that farmers, their advisors, and extension educators share similar world views about climate change and may be a reinforcing group. The challenge is to find the places where science and new information can be inserted in the information chain in ways that also begin to shift worldviews toward scientific evidence.

There is a great deal of climate information available to intermediaries and end users, but this information does not necessarily address their primary concerns (Changnon 1992; Mase and Prokopy 2014; Sonka et al. 1992; Wilke 2013). The needs of different stakeholders are also not identical (Morss et al. 2005), but farmers and advisors are by necessity very focused on short-term weather, in-season decisions, and managing immediate risks (Prokopy et al. 2013). Translating existing climate information into formats relevant to farmers' decisions can increase the uptake of information (Hansen et al. 2004; McCown et al. 2012). The disconnect between scientists' and other stakeholders' beliefs about climate change and its causes that this research identified suggests that climate information needs to be packaged in ways that have little to do with anthropogenic causation. Focusing on how climate information can be used to help better manage risks for a farm enterprise can be done in ways that do not address why the climate is changing. For example, using cover crops, increasing biodiversity of grasses/forage, and adding additional crops to rotations are not only ways to mitigate climate change but are also ways to manage risks associated with extreme rain events. Focusing promotion of these practices on how they help a farm enterprise retain soil and enhance nitrogen use efficiency should lead to more uptake than focusing on how they will help to mitigate against geographically and temporally distant climate change.

IMPLICATIONS FOR RESEARCH AND OUTREACH. The Third National Climate Assessment asserts that U.S. "agriculture is a dynamic, self-adjusting system that responds to changes or fluctuations in environmental conditions, trade, policy, markets, and technology" (Walthall et al. 2013, p. 3). Our 2011/12 findings have shown within this sector there is a great deal of variation in beliefs about whether climate change is occurring and the sources of these changes. These findings raise many questions. If indeed agriculture is "self-adjusting," will the divergent beliefs between scientists and farmers eventually converge as environmental conditions change? Will the self-adjusting responses be timely? How important is it that farmers and their advisors recognize human activities as a source of climate change and that their actions can make a difference? How can the variation in beliefs be leveraged to increase receptivity to information in ways that link climate science to personal actions? How could this variation in beliefs about climate influence how climate scientists approach communicating their information? More research is needed to answer these important questions.

Agricultural stakeholder adaptation to changes in climate are primarily reactive to date, with farmers making adjustments in response to perceptions of risks to crops associated with saturated soils, flooding, high humidity, high temperatures, and drought without engaging beliefs about climate

causality (Arbuckle et al. 2013b). Minor adaptations are expected to be successful in the short term, and some of these adaptations will have mitigation cobenefits (Lobell et al. 2013, p. 1). However, if climate change projections for this century occur, it is highly likely that adaptation in some agricultural landscapes will be insufficient and current agricultural systems and land uses will need to be transformed to sustain food security, rural livelihoods, and environmental integrity. More proactive and transformative preparations may be necessary to reduce harm from increasing extreme events and shifting agricultural crop zones in a timely way (Melillo et al. 2014).

This brings us back to worldviews about a changing climate and whether it is a "problem" that requires action. If it is not happening, there is no need to do something. Thus, differences in beliefs among scientists, agricultural advisors, and farmers constitute an underlying lack of agreement not only on whether climate change is occurring but the extent it is a problem caused by humans and thus in their control. This suggests that scientific evidence is not being decoded, analyzed, and transferred by scientists themselves or intermediaries such as advisors or extension educators into relevant information that can be used to frame and understand that climate change can be problem for agriculture. We know that 1) long-term weather patterns/climate affect almost every facet of row crop agriculture and 2) farmers pay attention to weather patterns in making day-to-day decisions and future planning (Walthall et al. 2012). And our data offer evidence that intermediaries, who serve valuable roles in facilitating the bidirectional flow of information and science, are reproducing some cultural beliefs and values but not others.

Climate scientists can do at least two things to increase farmers and their advisors' willingness to learn, better understand global and local climate patterns, and increase willingness to adapt or transform their landscapes: 1) reduce the threat to individual worldviews of believing in climate change and 2) increase opportunities for dialogue among scientists, intermediaries, farmers, and the voluntary organizations to which farmers belong.

Reducing threat to individual worldviews. It is clear from the literature and the evidence presented in this essay that worldviews and values can be incredibly influential in informing beliefs about climate change. Kahan et al. (2012) recommend using communicators who share a worldview with key stakeholders in order to resonate with that particular audience. This suggests the need to develop strategies to engage agricultural advisors in learning how climate science can help farmers adapt to increasingly variable climate conditions. One way to do this is to provide climate tools that meet immediate needs of advisors and then build information into these tools about other ways that climate science can help them to do their job (i.e., help the end users). For example, the U2U project has developed a corn growing degree-day (GDD) tool that tracks real-time GDD accumulations and associated corn development stages during the current growing season. This in-season information is then supplemented with historical climate data and seasonal climate projections, which allows users to integrate climate information into longer-term decisions related to seed selections, planting strategies, and marketing. The challenge will be to get advisors to then feel comfortable linking this type of climate information to farming practices when they engage farmers. Further, scientists need to be cognizant of divergent worldviews as they present their findings and avoid inflammatory statements or assumptions that could block receptiveness to learning about the climate cycle and how farmers can use that information in their decision making.

Enhancing opportunities for dialogue. The call for more effective dialogue between climate scientists and stakeholders is far from novel (Leiserowitz et al. 2013). However, our identification of a breach between understandings of climate change and its causes among scientists/climatologists and farmers/advisors is important because advisors are the change agents who communicate science to farmers. If their beliefs about climate change are more similar to farmers than to scientists and at odds with the scientific consensus, this has major implications for outreach and engagement on climate change adaptation and mitigation in agriculture. While climate scientists may communicate with the broader public through traditional mass media, they will likely have to tailor their communication for the agricultural sector—both in terms of content and format—if they want to promote greater understanding of changing climate conditions and broader use of weather and climate information for agricultural adaptation to climate change. Relatedly, long-term relationships between climate scientists and stakeholders, as well as open-minded dialogue, are essential for impacting decision making (Changnon 2004; Morss et al. 2005). This will require a change in mindset for some scientists. For example, some climate scientists in the north-central region perceive their role in communicating information to agricultural stakeholders as primarily supplying

available data and are less comfortable engaging in a two-way dialogues regarding the relevance of science to a farm enterprise (Wilke and Morton 2015). By enhancing opportunities for two-way communication, scientists can better understand how to make their information relevant to the end users and how to position their science within end users' worldviews.

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